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# Water Pollution Control Technology Manual

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Overseas Environmental Cooperation Center

# Preface

Japan has manifested, both domestically and internationally, a policy of strengthening support for environmental conservation in developing countries, and it is hoped that Japan will play a major role in technological cooperation by translating this policy into more "visible assistance" and dispatching capable personnel to developing countries so that specialists from both Japan as well as developing countries will be able to collaborate in problem solving.

A distinguishing feature of the environmental problems in developing countries is that environmental deterioration on a global scale is occurring at the same time as serious environmental pollution like that Japan experienced during its high growth period. In addition, regardless of the present situation, the pressures involved in the economic development that these countries are seeking is growing all the more while they continue to neglect paying sufficient consideration to the environment.

When Japanese specialists are dispatched to developing countries that are facing such circumstances, they are often questioned about a wide-range of issues concerning environmental conservation which are not limited to their personal fields of specialty. An obvious need has arisen to provide materials with such a wide range of content in order to support these types of specialists.

With this situation in mind, extensive materials on conservation technology, within the field of water quality conservation, which has become a serious issue and there has been much demand for technology transfer from developing countries, have been put together in this "Water Pollution Control Technology Manual". It would give me great pleasure for this manual to be utilized not only for the transfer of technology concerning the environmental field from Japan to these developing countries but also as research material for the training of international environmental cooperation specialists.

This manual was written by the Japan Society on Water Environment, and it was put together with advice from the members involved in The Investigation Committee for the Manual on the Transfer of Water Pollution Control Technology, which was established by this same society. I would also like to thank Professor Mitsumasa Okada from Hiroshima University and Professor Takuya Okubo from the Shiga Prefecture Biwa Lake Research Institute for taking time out from their busy schedules to proofread and edit the manual. I would like to extend my greatest appreciation to all those who have been involved in the making of this manual.

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# Chapter 1 MODERN HISTORY OF WATER POLLUTION

## 1. Environmental Problems during the Initial Industrial Development Period and the War

In Japan, environmental problems were already recognized during the Meiji era, when Japan promoted the industrial development as a principal national policy to cope with major western countries after she had opened the door to foreigners.

In around 1887, for example, the local residents suffering from the mine pollution by the Ashio Copper Mine appealed to the prefectural government and submitted a written inquiry to the Diet. This was followed by a debate on the mine pollution of the Ashio Copper Mine during the Diet session in 1891. In spite of these actions, no practical measure was taken for the pollution control by the mining company. Mine pollutions such as this occurred in early 1890's, and they became obvious problems as the modern industry had developed against the agriculture and fishery in the areas far from the city. National government recognized this as an issue of coordination among the industrial sectors and dealt with it primarily within the system of the Industry Law.

Although the Factory Law was adopted in 1911, this law focused mainly on the protection of laborers and there was little implication of pollution control.

Sanitation was not appropriately considered for the treatment of the drinking water and waste water until the construction of the water supply and sewage system, and many people got sick and died by the epidemic diseases.

As there occurred a sift to the heavy chemical industry after the First World War, many people claimed the damages by the waste water discharged from the factories. One example is the damage by the upstream discharge of waste water on the local agriculture along the Arata River in Gifu Prefecture. It should be noted that damages were claimed mainly for the physical ones in these cases.

During the Second World War, the National Mobilization Law was adopted and a top priority was given to the military actions. There was no space for an action for environmental protection. Japanese territory was devastated by the war, and it took long time until the national government considered the importance of the environmental resources such as water in its policy development in the midst of economic recovery.

## 2. Rapid Economic Growth and Water Pollution

### 2.1 Changes of Social and Economic Situations

Special procurements by the U.S. military for the Korean War, which broke out in June, 1950, recovered the mining production to the level before the Second World War. After the Zinmu business upturn in 1955, Japanese economy entered the period of unprecedented growth.

The economic growth since 1955 was a process of the sift to the heavy chemical industry, which was led by the intensive public investment, capital investment in private sectors and the increase of export. Efforts were made to bring the potential ability for growth into full play.

The heavy chemical industry generally releases larger amount of potential pollutants per output and it is called "polluting industry". Since the products for export are also processed in Japan, the process releases more pollutants than those from the production for domestic consumption. This is one of the factors which led to much more serious industrial pollution in Japan compared to other countries.

### 2.1.1 Changes of the National Land Use such as Industrial Land Use

As is referred in the 1974 edition of the Economic Survey of Japan or economic white paper, 'comparison of the use of land and water, which are considered to be a kind of pubic assets, for the production of export goods, with their savings by import instead of the domestic production indicates that Japan uses more land and water for export than saved by import while in other countries, the saving by import is generally more than the use.', 'in Japan, large export by the resource processing industries requires more land and water for trade than needed to satisfy the domestic demand'. The industrial structure in Japan consumed more environmental resources such as land and space than in other countries.

This had led to the construction of major industrial complexes by the reclamation in the coastal zone at the early stage of the rapid growth, which in turn further aggravated the industrial pollution. Originally, the habitable area in Japan was smaller than in other countries, and the human activity in this small area was very intensive. Addition of large factories to the existing various land uses, together with the defective city planning which allowed for the allocation of residential area next to the factories, had led to the deterioration of the environment in the coastal industrial zone.

### 2.1.2 Widespread of Mass Consumption as a New Life Style

On one hand, the rapid economic growth referred to the sharp increase of productivity, but on the other hand, it meant the substantial expansion of life for consumers. Durable consumer goods such as television sets became widespread rapidly after around 1960, and many people began to go to overseas travel after 1965. There was more consumption for leisure, and the consumer's life was expanded in scale and also in variety.

As consumer's life was fulfilled, impacts of household consumption on environment had also changed both qualitatively and quantitatively. Corresponding to the increase of the overall energy demand, energy consumption by private sectors such as households had increased 3.4 times from fiscal year 1960 to 1970. This was the result of household electrification.

Increase of production, which supported the expansion of consumer's life, was accomplished with environmental damages, but general public were not always aware of this. Effluents and emissions of factories were often regarded as a symbol of vitality of the local industry rather than environmental pollutions.

### 2.1.3 Delay of the Preparation of Social Infrastructure related to the Living Environment

Investment for the living environment, which competed for the government funding with the preparation of the social infrastructure for industry, was expanded intentionally during this period. Operation cost of the public works or the preparation of the facilities for living environment such as the sewage systems, industrial waste treatment plants and parks increased more than that of the preparation of the infrastructure for industry.

Even at the end of the rapid economic growth period, operation cost of the preparation of the facilities for living environment occupied only 5.3% of the total operation cost of public works, and it was equivalent to about one-eighth of the operation cost of the road preparations.

The extensive preparation of the facilities for living environment did not necessarily produce a successful result as shown, for example, by the fact that only 14% of the population were provided with sewage systems in the fiscal year 1965. A major reason of this is the increase of land prices, which was remarkable especially in the three large cities with dense population. Sufficient preparation of the facilities for living environment was more difficult in the areas where they were required.

Although the governmental investment for the living environment had increased throughout the period of rapid economic growth, its smaller amount compared to the expenditure for industry was yet to be improved.

## 2.2 Aggravation of Water Pollution

### 2.2.1 Deteriorating Water Quality

Water pollution was aggravated as the development of human activities such as industry. For example, until around 1945 the Sumida River used to have clear water with a lot of fish, and it provided a place for recreation for local people and also resources of income for local fishermen. However, these fish could not survive in the river after about 1955, and there came an offensive odor from the dirty river. The survey of Shizuoka Prefecture in 1961 reported that an area of $14km^2$ in and around the Tagonoura Bay was polluted by black sludge, which indicated the aggravation of pollution.

In these days, the water pollution was aggravated mainly by the waste water discharged from the factories and business establishments as described below.

### 2.2.2 Health Damage

In Minamata City, the Japan Carbide & Co., which was succeeded by the Chisso Corporation, established its Minamata Factory in 1908, and since then the waste water with residue of carbide was discharged to the coastal water, which aggravated the water pollution. By 1955, bodies of fish were recognized to be floating on the sea surface in Minamata Bay, and even the local cats and pigs on land began to die raving. In 1956, the hospitalization of a patient with mainly brain damage by unknown cause was reported to the Minamata Public Health Center in Kumamoto Prefecture, and the Minamata disease was officially identified. The Minamata disease is caused by the ingestion of fish and shellfish from the water polluted by the waste water from the factory. Organomercury accumulated in these fish and shellfish is taken into the human body, and this makes damages on the nervous system. The Minamata disease is well-known worldwide because of its tragic nature. It took long time to clarify the cause of this disease. Patients were discriminated due to their suspected infection by some epidemic disease. For a fisherman engaged in the small-scale local fishery, the Minamata disease meant the sudden poverty of his family. The Minamata disease caused not only physical pains to its patients but also mental and economical pains to them and their families, which led to a serious social problem. Lack of the appropriate consideration for environmental protection by a company when engaged in production further caused an additional occurrence of the Minamata disease along the Agano River in around 1965.

On the other hand, water of the Zinzu River containing metals such as cadmium, lead and zinc had flown into the paddy fields since the Taisho era, and this had resulted in the damages on local agriculture. In the meantime, there appeared patients of a strange disease in this area. Patients were suffering from the severe pains, and even a little movement of their body had led to the fracture for those seriously injured. They cried "itai-itai, or ouch-ouch " in the midst of intolerable pains, and this disease was called "Itai-itai disease". The Itai-itai disease was reported to the medical academy in 1955, followed by intensive research. In 1968, it was officially announced that cadmium contained in the waste water from the mineral mining company in the upstream caused this disease.

### 2.2.3 Damage on Fishery

Besides the health damage, the aggravation of water pollution invited many disputes and complaints in various places.

For example, in 1958, a paper mill discharged its semichemical pulp sewage to the Edogawa River without treatment, and this had created substantial damage to the shellfish cultures in the downstream. Some 700 angry fishermen had rushed to this paper mill and clashed against the police force on duty for the paper mill.

Water pollution was further aggravated since about 1960 in the rivers flowing through the large cites and industrial areas such as the Yodogawa River, and the bodies of many fish like *Ayu*, or sweet fish, were found to be floating on the rivers. Intakes for the water supply were suspended in a series.

In 1960, abnormal odor was recognized from the fish in Ise Bay, and the local fishermen's union demanded 3 billion yen as a fishery promotion fund. In 1962, an electroplating plant along the Tama River discharged substantial amount of cyanide compounds.

### 2.3 Social Responses

#### 2.3.1 Citizens' Movement

Frequent occurrences of the environmental problems during the course of the rapid growth of economy had attracted attentions from various parties including general public, and this made it impossible to continue regular industrial activities without assistance from public authorities. Legal control of pollution was gradually introduced. For example, the above-mentioned violence between the fishermen and the factory over the damage on local fishery by the waste water from the paper mill in 1958 had led to the enactment of the Public Water Quality Protection Law and the Industrial Effluent Water Law this year. Although these laws did not produce successful results, they marked the beginning of the preparation of the legal instruments for the water pollution control

As for the Minamata disease, which was the landmark of the environmental pollution in Japan, there continued firmly-rooted activities to seek for compensations for the damages not only on fishery but also on health.

#### 2.3.2 Efforts by Local Governments

Orientation for the rapid economic growth was also apparent in the local governments. They adopted ordinances to attract businesses, but their advance investments in the business attractions put pressure on the local finance and did not necessarily produce what had been expected. In the meantime, there occurred environmental pollutions, and the local governments had to face the criticisms and actions by local people.

Nature of environmental problems differed depending on the local natural conditions such as geography and meteorology and the social settings such as the developmental stage of the local industry. Initially, they appeared as local issues which differed to each other. Local governments were the first to cope with these local but serious issues to the people there. They were obliged to solve these issues by themselves before the national government took actions.

Because of this, local governments began to adopt the pollution control ordinances since around 1949. Most of these ordinances, however, simply provided the licensing procedure for the establishment which may cause water pollution, and they did not control the effluent by the quantitative standard. Although it should be noted that the local governments took the initiative in the administration against the environmental pollutions, they could not fully control them in practice and allowed their aggravation. On the other hand, effective measures by the national government were yet to be implemented during this period.

Local governments implemented various innovative measures for pollution control in addition to the adoption of their pollution control ordinances. One of them is the agreement on pollution control by Yokohama City in 1964 with the companies which purchased the reclaimed lands in the industrial estate along the coast in Isogo Ward. Since then, the agreement on pollution control became common in Japan as an important measure for pollution control to supplement the regulation by laws and ordinances.

### 2.3.3 Efforts by National Governments

On national level, the Coordination Council on Water Pollution was established in 1953 by the relevant ministries and agencies to prepare for the enactment of the pollution control measures. The function of this council was taken over by the Economic Planning Agency, and the Water Pollution Control Guideline was approved by the Cabinet in 1958. On the basis of this guideline, the Public Water Quality Protection Law and, to implement its regulation, the Industrial Effluent Water Law, which together are called as the 'previous two laws on water quality', were enacted. These laws established the water quality standards for the certain public water areas designated by the national government, and they allowed the national government to take necessary regulatory actions to enforce the compliance of the factories to these laws.

However, only a few water areas were actually designated. These laws aimed at the concord between the industries together at the protection of public health and the protection of living environment, and we could hardly say that the sufficient emphasis had been placed on the pollution control.

Pollution problems used to be treated by the civil law, and the insufficiency of pollution control laws could result in immediate damages if the polluters failed to take required precautions adequately. This had invited the tragic health damages and severe environmental damages in various areas.

## 3. Comprehensive Measures against Water Pollution

### 3.1 Commencement of Fundamental Efforts

Under this situation, it was keenly felt that the pollution control effort, especially, had to be a comprehensive one, which is an combination of various measures on the basis of integrated idea, and that it should be a preventative and deliberate measure rather than a temporary one for emergency. There was a growing demand for the basic foundation such as the definitions of the scope of environmental pollution, responsibility of polluters, and the role of the national and local governments.

First, the Liaison Conference for the Promotion of Pollution Control was established in the Prime Minister's Office by the Cabinet decision in March, 1964 to coordinate the multiple administrations on the environmental pollution which were managed separately by the individual ministries. The purpose of this conference was to promote the overall and efficient pollution controls by the close communications between the relevant administrative bodies on their actions for pollution control. In the midst of the gradually increasing demand for the enactment of a basic law for pollution control, the Ministry of Health and Welfare established the Environmental Pollution Council in September, 1965 as an advisory body for the Minister of Heath and Welfare to collect the knowledge on environmental pollution from various communities. One year later, this council prepared a report roughly with the following contents.

1. Pollution control should be based on the environmental quality standards and by comprehensive methodologies.
2. From now on, the pollution control administration should be generalized with the local preventative measures focusing on the land uses themselves, such as the Pollution Control Plan, as a keynote.
3. It is important to identify the responsibility of the polluters in the management of the environmental pollutions. National and local governments have major responsibilities for the fact that the public investment has fallen behind the environmental pollutions.
4. Environmental quality standards should be established for each category of pollutions as the requirements to be fulfilled for the protection of the interests such as the public health and living environment from environmental pollutions, and they should be objectives for administrations and should not be regulatory standards. In the meantime, environmental quality standards should be established for the air pollution, water pollution and noise.
5. A governmental organization should be established for the overall coordination between the pollution control administrations in various ministries and agencies and for the preparation of the basic policies for pollution control.
6. A basic law should be enacted to provide the common principles and the basic policies for pollution control.

   Bases on the report from the Environmental Pollution Council, the national government decided in 1967 in the Liaison Conference for the Promotion of Pollution Control to enact the basic law for pollution control.

### 3.2 "Pollution Session" of the Diet

Even after the enactment of the Basic Law for Environmental Pollution Control, environmental pollutions were further aggravated. In the meantime, more the systematic efforts of the administration were required, more obvious the differences in opinions among various ministries and agencies and the following delay of action had become. Public concerns and dissatisfactions became more serious, and they gradually led to the social crisis.

Under these circumstances, the Pollution Control Head Office was established in the Cabinet by the Cabinet decision in 1970 to implement appropriate and systematic pollution controls timely. Establishment of the Pollution Control Head Office identified the location of the ultimate responsibility for the pollution control administrations, and a center for policy developments to deal with the accumulated problems was finally created.

The 64th session of the Diet was called primarily for the fundamental preparation of the pollution control legislation in the midst of the environmental pollutions which conventional legislation could not cover. Intensive discussions were made on environmental pollutions in this session, and it was call "pollution session". Extremely wide variety of 14 innovative bills on environmental pollutions were submitted during this session, and they were passed and adopted.

Followings are the summary of the preparations of the pollution control legislation in this session;

1. Identification of the basic position of the national government on pollution control
   So-called "harmonization provision", which referred to the harmonization between the sound economic development and the pollution control, was deleted from the pollution control legislation including the Basic Law for Environmental Pollution Control to clear the public suspicion that the priority might be given to the economy rather than the pollution control.
2. More stringent control
   As for the water pollution, for example, the previous control only in the already polluted areas was extended to the whole country, and additional pollutants and items came under control.
3. Identification of the responsibility of entrepreneurs
   Business activities which might cause environmental pollutions became subject to the stringent control, and the Pollution Control Public Works Cost Allocation Law was enacted to specify the requirement of the cost of pollution control programs to the entrepreneurs.
4. Increased authority of local governments
   The Water Pollution Control Law specifically recognized the fact that the environmental pollutions were local issues and the local conditions should be considered in their solutions. The Law expressly provided the local governments with the authority to implement more stringent local controls in addition to the uniform national regulatory standards. Enforcement authority to achieve the standards was almost completely transferred to the governors.

### 3.3 From the Pollution Control Head Office to the Environment Agency

Although the Pollution Control Head Office was established by the Cabinet decision, it remained as a provisional organization, and the authority to implement the regulations against the environmental pollutions scattered among the various ministries and agencies. It was recognized that a permanent administrative organization with authority to implement the regulations again the pollution had to be established to strongly promote the pollution control.

Integration of the pollution regulations and the requirement of an organization as a center for policy development were discussed in the "pollution session" of the Diet, and the consensus was formed on the importance of the environmental pollutions and environmental problems through the process of enactment and amendment of the 14 laws on pollution control.

These had led to the foundation of the Environment Agency in July, 1971 as a planning agency with its mission to generally promote the administration for the environmental protection. The Environment Agency solely had all basic functions for the pollution control within its jurisdiction including its implementations. The Agency had a function to design and develop the basic actions for the protection of environment such as the pollution control. The Agency also had a strong general coordination authority over the relevant works under the jurisdiction of various ministries and agencies including those under its own jurisdiction.

### 3.4 Foundation of the National Institute for Environmental Studies

Surveys and researches on the causes of the environmental problems and the development of the pollution control technologies provide a basis for the environmental administration, and it is essential for a national government to take a major role in their promotions. However, the lack of a research institute specialized in the environmental problems and the wide variety of the environmental problems and their interdisciplinary nature had led to the establishment of the National Institute for Environmental Studies in March, 1974, together with the Environment Agency, as a general research organization for environmental pollutions to oversee their researches by various laboratories and research institutes of the relevant administrative organizations. The National Environment Training Institute was also established together with the Environment Agency for the training of the administrative and research personnel of the Environment Agency and local governments to improve their ability, which was essential for the promotion of the environmental administrations.

## 4. Introduction of the Basic Law for Environmental Pollution Control and the Environmental Quality Standards

The Basic Law for Environmental Pollution Control identified the air pollution, water pollution, soil pollution, noise, vibration, ground subsidence and offensive odor as the seven major environmental pollutions. The law required the establishment of environmental quality standards as the environmental conditions which are desired to be maintained for the protection of human health and living environment, and also the controls including those on the releases which the entrepreneurs should comply with. Initial pollution controls could not function effectively against the absolute increase of the pollution load by accumulation, and this had led to the introduction of the environmental quality standards, the new instruments, by this law. On the basis of the lessens learned from this, the environmental quality standards were established in 1970 as objectives for the actions to control the aggravating environmental pollutions. The Basic Law for Environmental Pollution Control required to consistently consider the latest scientific knowledge to revise the environmental quality standards when appropriate, and the standards have been properly revised since then.

Since many pollution problems had occurred due to the lack of the appropriate land uses and facility preparations with environmental considerations, this law also identified the regulations on the land uses and facility installations and the promotions of the preparation of facilities for pollution control as the actions for pollution control. In addition, this law further provided the subsidies for entrepreneurs to promptly take actions in response to the pollution control regulations.

The Regional Environmental Pollution Control Programs have been prepared one after another since 1970 for the areas where the environmental pollution was already serious or could become so due to the rapid concentration of population and industry, when actions such as the emission and effluent controls, land use planning and facility preparations were generally required for pollution control. Various actions have been generally and deliberately implemented on the basis of these programs.

## 5. Promotion of the Pollution Controls by the Water Pollution Control Law

The Water Pollution Control Law was established to control the water discharged from the factories and business establishments to public waters and the water permeating into underground and to promote the control of domestic waste water for the prevention of the pollution of public water areas and groundwater and the protection of the public health and living environment. This law also stipulated the liabilities of the entrepreneurs for the damages to public health by the waste water discharged from their factories and business establishments. This law was enacted by the "Pollution Session" of the Diet in 1970 to substitute the two previous laws on water quality, reflecting the lessens learned from the various actions implemented to protect the water quality under the previous laws.

The followings are the summary of the controls more stringent than the previous two laws on water quality, which were introduced by the Water Pollution Control Law;

1. The water area designations in the Water Quality Preservation Law were repealed, and the areas to be regulated were extended to the whole country. The scope of the public water was also expanded.
2. Control of waste water discharge became more stringent by the direct application of punishment provisions for the breaches of the effluent standards.
3. Establishment of the effluent standards more stringent than the national ones became possible by the prefectural ordinances.
4. It was generally allowed to extend the scope of the industrial sectors to be regulated (specified facilities).
5. Effluent standards for the total discharge were replaced with those for individual drainage ditches.

## 6. Establishment of Various Water Pollution Controls

Steady economic growth and the establishment of environmental policies had led to the general improvement of environment in Japan. As for the non-attainment rate of the water quality standards for the protection of human heath, values exceeding these standards were detected at substantial number of locations throughout Japan in 1971. By the introduction of more stringent effluent controls by the Water Pollution Control Law for the factories and business establishments, the water quality standards have been mostly attained by now.

However, the changes of public life style and the progress of urbanization had made the impacts of various human activities on environment more complicated and diverse. Especially, the pollution of the closed water areas such as lakes and inner bays could not be controlled solely by the regulations of individual sources, and the extensive actions were required including the deliberate and precedent preparation of the social infrastructures such as sewerage systems. Although the attainment rate of the water quality standards for the protection of living environment has been increasing gradually, the rate still remains low.

In the highly closed water areas, the concentrations of nitrogen and phosphorus, the primary factors to control the reproduction of algae, must be reduced to prevent their reproduction which would lead to eutrophication. For their reductions, environmental quality standards were established for the total nitrogen and total phosphorus in 1982 for lakes and ponds and in 1993 for sea areas.

### 6.1 The Law Concerning Special Measures for Conservation of the Environment of Seto Inland Sea (The Law Concerning Provisional Measures for Conservation of the Environment of Seto Inland Sea)

The Seto inland sea was blessed with the excellent landscape from ancient times with white sands and green pine trees along the coast. It was also rich in the invaluable fishery resources. In spite of these favorable natural conditions, industries and populations had concentrated to its vicinity, and the water pollution was aggravated and the coastal lines were significantly modified in 1970s.

In 1972, a large-scale red tide occurred in the Sea of Harima and caused a damage of 7.1 billion yen in total on local fishery, mainly on aquacultures. Measures for environmental protection were strongly required for the Seto Inland Sea. In 1973, the following year, the Law Concerning Provisional Measures for Conservation of the Environment of Seto Inland Sea was enacted, and the system was introduced to require a license to the installation of specified facilities over a certain scale.

"In view of the benefits of the Seto Inland Sea, both as a place of scenic beauty unparalleled by any in Japan or elsewhere in the world, and as a storehouse of rich fishery resources, and the fact that the Sea should rightly be preserved for being enjoyed equally by all citizens of the nation and bequeathed to posterity", this law required the national government to immediately establish a basic plan for the environmental protection in the Seto Inland Sea to implement the effective measures. As special measures until the establishment of the basic plan, it also required to reduce the pollution load of industrial effluents in terms of COD (chemical oxygen demand), introduce the licensing system for the installation of specified facilities, and to consider the special characteristics of the Seto Inland Sea when land reclamation was permitted there. The law went through the major amendment in 1978 to become a permanent law entitled the "Law Concerning Special Measures for Conservation of the Environment of Seto Inland Sea" by incorporating the area-wide total pollutant load control for COD and the reduction of phosphorus to prevent the damages by eutrophication.

In addition to the requirements by the provisional law, which were deemed to be retained, such as the licensing of the installation of specified facilities and the special consideration for permitting the land reclamation, the following actions were newly introduced by the permanent law:

1. Preparation of a plan by individual prefectures on the basis of the basic plan.
2. Implementation of the area-wide total pollutant load controls.
3. Reduction of phosphorus to prevent the damages by eutrophication.
4. Protection of natural coasts by the designation of the natural seashore conservation areas
5. Prevention of the oil spills by disasters at sea and the clarification of the mechanism of red tides.

### 6.2 The Law Concerning Special Measures for Prevention of Lake Water Quality

In 1984, the Law Concerning Special Measures for Prevention of Lake Water Quality was adopted to control the water pollution in lakes and ponds, one of the closed water areas. This law required the overall and deliberate implementation of the projects to contribute to the protection of the water quality, such as the construction of sewage systems, and the strict regulations of the various pollution sources, in the designated lakes and ponds, where the water quality standards needed to be urgently attained. Systematic efforts against the urban pollution by domestic sources were commenced by this law.

The followings are the summary of the law.

1. The national government prepares the Basic Policy for Conservation of Lake Water Quality, which describes the basic strategy for the protection of water quality in lake and ponds.
2. The Prime Minister designates the lakes and ponds, where extensive measures should be taken to protect the water quality, and he shall also designate the areas which would influence the water pollution in these designated lakes and ponds.
3. On the basis of the Basic Policy for Conservation of Lake Water Quality, governors prepare a Plan for Conservation of Lake Water Quality for each of the designated lakes and ponds, which describes the policy for the protection of water quality and the projects, such as the construction of sewage systems,

to contribute to the protection of the water quality there.

4. The following special measures are taken for the protection of water quality in the designated lakes and ponds.
   The first is the regulation of the effluents from the factories and business establishments in the designated area. In addition to the conventional regulations on the concentration of pollutants, governors can set regulatory standards on the pollution load in their effluents. When he recognizes that an effluent from the new establishment or extension of the facilities specified by the Water Quality Control Law does not comply with these regulatory standards, he can make an order so that the necessary measures are taken for the improvement.
   The second is the regulation of the effluents from those which are not the specified facilities but regarded as such. Those specified by cabinet orders as the facilities which may discharge the waste water to lakes and ponds with potential damage on the living environment, including the private sewage treatment tanks smaller than a certain size, are regarded as equivalents to the specified facilities under the Water Quality Control Law, and they are subject to the provisions of this law.
   The third is the requirement of a notification for the establishment of the designated facilities. Those who wish to establish the facilities designated by cabinet orders as those which could be hardly regulated by the effluent standards, including the feed lots smaller than a certain size, have to notify their intentions. When the governors recognize that they do not comply with the standards such as those on structure, he can make a recommendation of improvement and also an improvement order.
   The forth is the reduction of pollution loads. Measures are taken to reduce the total pollution load in those of the designated lakes and ponds, where the water quality standards are hardly attainable by the effluent controls due to the concentration of industries and populations.
   The fifth is the requirement to make efforts for the protection of natural environment around the lakes, such as the preservation of green areas, to contribute to the protection of the water quality in the designated lakes and ponds.
5. In addition to the above, the law provides, if appropriate, the guidance and assistance required for the protection of the water quality in lakes and ponds, and the cooperation among the relevant administrative organizations.

### 6.3 Promotion of the Controls on Domestic Waste Water

Due to the increasing use of water for domestic consumption, the pollution loads from households have become more and more important since around 1975 as a source of pollution of the public water areas such as small and medium-size rivers in the cities. Therefore, the Environment Agency amended the Water Pollution Control Law in 1990.

The amendment identified the responsibilities of the national government and the prefectural and local governments in the efforts to control the domestic waste water and also what is required to do with it for general public. The amendment provided the designation by prefectures of the areas for the intensive control of domestic waste water and the preparation by local governments of the plans to promote the control of the domestic sewage. The amendment further created a special category of facilities which were subject to the regulation only in the areas with the area-wide total pollutant load control.

### 6.4 Introduction of the Groundwater Pollution Prevention System

The general survey on the groundwater throughout Japan in 1982, which covered 1,360 wells in 15 cities, detected the two chemicals, trichloroethylene and tetrachloroethylene, in nearly 30% of the wells, respectively. It also found that the WHO drinking water quality guidelines for these chemicals were exceeded in 3% and 4% of the wells, respectively. Based on the results of this baseline survey, provisional guidelines for guidance were prepared for the chemical such as trichloroethylene in 1984, and the administrative guidance was provided to the factories and business establishments by the prefectural governments. However, they were not adequate to be effective, and the groundwater quality had not been improved since then. This had led to the amendment of the Water Pollution Control Law by the Environmental Agency in 1989 to prevent the groundwater pollution. The amendment prohibited the infiltration of the water contaminated with toxic substances by the specified facilities which used these substances, and the provisions similar to the effluent control, which required the notification and provided the authority to issue the orders for plan modification were prepared to guarantee the prohibition. The amendment also required the governors to continuously monitor the pollution of groundwater.

The slow flow of groundwater makes it difficult to purify it naturally once it is polluted. The quality of groundwater was not improved, and the Water Pollution Control Law was amended again in 1996 to create the groundwater purification order system to allow the governors to take measures for its purification against the polluters.

Quality standards for groundwater were notified in March, 1997.

### 6.5 The Law to Take Special Measures for the Prevention of Water Quality in Headwaters Area for the Purpose of Preventing Specific Trouble in the Drinking Water Supply

Drinking water supply is one of the most important use of public water. Protection of the quality of public water has played an extremely important role for the protection of the quality of headwaters for drinking water supply.

However, the hazardous substances such as trihalomethane, a suspected carcinogen, which is produced in the purification process for drinking water, have created problems, and not only the efforts within the drinking water supply system such as the improvement of purification methods but also a wide range of water quality protection measures in the public water are required for the drinking water supply, such as the reduction of the organic substances like harmless humin, which exists in the ambient water and causes the trihalomethane formation.

Under this circumstance, "The Law to Take Special Measures for the Prevention of Water Quality in Headwaters Area for the Purpose of Preventing Specific Trouble in the Drinking Water Supply" came into force in 1994, and a system to regulate the organic substances, such as humin, which lead to the trihalomethane formation was created.

In the same year, the "Law Concerning the Promotion of the Implementation of the Quality Protection of the Headwaters for the Drinking Water Supply" was enacted to promote the constructions of the sewage systems and consolidated private sewage treatment facilities and the river projects and to control the pollution of the headwaters for drinking water supply by trihalomethane and offensive odor.

# Chapter 2 RESENT ACTIVITIES FOR WATER POLLUTION CONTROL

The efforts mentioned in the previous sections are directly for the water pollution control. Besides these, production and the use of chemicals and pesticides which may cause hazardous impacts on human health and animals and plants are also regulated. In addition, treatment standards are set for each stage of the waste treatment, and the systems to assure the appropriate treatment such as those for pollution control are established.

## 1. The Law Concerning the Examination and Regulation of Manufacture, etc. of Chemical Substances

The environmental pollution by PCB had led to the enactment of the "Law Concerning the Examination and Regulation of Manufacture, etc. of Chemical Substances" in 1973. This law required the examinations of the newly manufactured or registered chemicals before their production or import about the following three natures. The chemicals with all of these natures were designated as the Class 1 Specified Chemical Substances, and their production or import and their use came under regulation.

1. Persistency, or the nature not to change chemically through the natural process.
2. High bio-accumulation, or the tendency to be easily accumulated in the body of organisms.
3. Chronic toxicity, or the damage to human health by the continuous intake.

On the other hand, the law generally requires the national government to confirm the safety of the existing chemicals. The Ministry of International Trade and Industry studies their degradability by micro-organisms and their accumulation in fish and shellfish. The Ministry of Health and Welfare examines their toxicity to human body, and the Environment Agency investigates their residual tendency in general environment and their impacts on ecosystems. By December, 1996, nine substances, or PCB, HCB, PCN, aldrin, dieldrin, endrin, DDT, chlordane, and bis (tributyltin) oxide have been designated as the Class 1 Specified Chemical Substances.

The law was amended in 1986 to designate the persistent and chronically toxic chemicals with low bio-accumulation as the Specified Chemical Substances and to require the monitoring of their production and import. When there is a potential damage to human health by the environmental pollution of these Specified Chemical Substances, their manufacturers are required to investigate and report their toxicity. When they are found to be toxic, they will be designated as the Second Class Specified Chemical Substances, and their production and import will be regulated. By December, 1996, twenty-three chemicals including carbon tetrachloride, tetrachloroethylene and trichloroethylene have been designated as the Second Class Specified Chemical Substances, and 257 chemicals including chloroform and 1,2-dichloroethane have been designated as the Specified Chemical

Substances.

## 2. Agricultural Chemicals Regulation Law

As for the demand for legislation to control the pesticides, the Agricultural Chemicals Regulation Law was adopted in 1948 to exclude the various damages on the agricultural production by the distribution of the illegal products of low quality since before the Second World War. Then, a system was introduced in 1963 to withhold the registration of those with extreme toxicity to the animals and plants of commercial values, to order the improvement of their quality and to regulate the use of the Specified Agricultural Chemicals. In 1971, the law was amended to intensify the examination and registration of the residual tendency of pesticides and to create a provision on the cancellation of their registrations so that the measures were taken or reinforced to deal with the problems such as the residual pesticide in food and their soil and water pollutions.

Agricultural chemicals are not allowed to be sold without their registration to the Minister of Agriculture, Forestry and Fisheries. Submission of the results of the experiments on their toxicity and residual tendency are required together with those on their effectiveness and harmful effects.

In any of the following cases, the pesticide registration may be withheld and the quality improvement may be ordered when an application is made for the registration. In addition, when the already registered pesticides are found to fall in any of the following cases after the registration, their registration may be canceled and their sales may be restricted or prohibited.

(1) There occurs a harm from the use of pesticide
(2) There is a potential danger to the human health and animals
(3) There is a significant potential damage on the animals and plants with commercial values
(4) Crop-residue-prone pesticides, or those with a potential damage to the human health and animals through their residue in agricultural products
(5) Soil-residue-prone pesticides, or those with a potential damage to the human health and animals through their residue in the soil of agricultural lands
(6) Water-quality-pollution-prone pesticides, or those with a potential damage to the human health and animals through their pollution of public water and the use of such water

## 3. Waste Disposal and Public Cleansing Law

The Waste Disposal and Cleansing Law is a basic law on the waste treatment, and most of the treatments of the wastes from land-based sources have to follow this.

The Waste Disposal and Cleansing Law has been amended several times to catch up with changes of social conditions. The increase of the generation and variety of waste by the economic growth and improvement of public life, the shortage of final disposal sites and the frequent illegal dumping had led to the amendment of the Waste Disposal and Public Cleansing Law in 1997 to implement the general measures to promote the reduction and recycle of wastes, to improve the reliability and safety of treatment facilities and to prevent the illegal dumping, for the assurance of the appropriate treatment of wastes.

### 3.1 Standards for Waste Treatment Facilities

The Waste Disposal and Public Cleansing Law designated certain incineration plants and final disposal sites as the Waste Treatment Facilities and established standards for their structure and maintenance. The Waste Treatment Facilities are divided to the Domestic Waste Disposal Facilities and the Industrial Waste Disposal Facilities. Some of the Waste Treatment Facilities are regulated for their effluents as the specified facilities under the Water Pollution Control Law.

Depending on the potential impacts of the industrial wastes to the disposed by landfill, their final disposal sites are divided to the three categories such as the strictly controlled landfill sites for hazardous industrial wastes, the least controlled landfill sites for those with less potential impacts on living environment due to their stable nature such as the construction wastes and waste glass, and the controlled landfill sites for the other industrial wastes and the domestic ones. Standards are set for each category.

### 3.2 Standards for Final Disposal of Wastes

The standards for the final disposal of wastes by landfill were set after the following considerations.

(1) Pollution of the public water and groundwater by the leachate from landfill sites should be prevented.
(2) Wastes should be reduced and stabilized.
(3) Sanitary problems by the disposal by landfill should be avoided.

As for (1), there is a general provision that "appropriate measures shall be taken to prevent the potential pollution of the public water and groundwater by the leachate from landfill sites".

The disposal by landfill of the industrial wastes containing heavy metals more than their criteria is subject to the more stringent regulation, and "it shall be conducted at the sites isolated from the public water and groundwater" since the environmental pollution by these regulated substances may have potential impacts on human health.

## 4. Environmental Cooperation for Developing Countries

### 4.1 Dispatch of Experts and Training Program

Many developing countries are facing the shortage of the administrative officials and engineers with general expertise on environmental protection.

Through JICA, environmental experts are dispatched to the developing countries to provide them with advice on site and the trainees are accepted from these countries, to protect their environment.

The experts were first dispatched in the fiscal year of 1975. Local governments joined in this program in the fiscal year of 1984, and then the universities and private companies also participated in the program, which resulted in the rapid increase of the dispatched experts. In the fiscal year of 1995, a total of 83 experts were dispatched to the countries like Chile, Thailand and China. Some 20 long-term experts are always providing assistance at various places around the world for more than one year.

Trainees have been accepted since the fiscal year of 1973. At present, training programs such as those on the Environmental Engineering (Water Quality Management), the Environmental Monitoring (Water Quality) and the Lakes Water Quality Management are provided, and over ten trainees are accepted for each program every year. By the end of the fiscal year of 1990, 501 trainees from 53 countries have participated in these group training programs. In addition, three group training programs were provided for individual countries in the fiscal year of 1990. A program on the River Purification was provided to those from Indonesia, and a program on the Environmental Protection was provided separately to those from Poland and Hungary in the fiscal year of 1990. Upon the request by developing countries, training programs for a single country are provided at all times to meet the specific need of individual countries.

The project-type technical cooperation, a combination of the dispatch of experts and training programs, is also carried out by JICA under the cooperation of the relevant ministries and agencies.

Some examples of the project-type technical cooperation are the Environmental Research and Training Center in Thailand in 1990, the Japan-China Friendship Environmental Protection Center, the Research Center for Water Pollution and Water Re-use, the Environmental Management Center in Indonesia, and the Water Quality Improvement System Development in Korea.

### 4.2 Financial Cooperation

The international cooperation for developing countries in the area of environment protection has long been carried out under the framework of JICA. However, to promote more various environmental cooperation, the Environment Agency started to appropriate its own budget for ODA in 1986.

At present, Japan is providing both of the grant aid and loan assistance.

The loan assistance makes significant contributions to the sustainable development of the developing countries through the assistance to the economic infrastructure projects. Japan has actively provided the loan assistance also to the projects in environmental fields through the Overseas Economic Cooperation Fund or OECF. The projects financed by the loan assistance are mainly those for the drinking water supply and sewerage, which could be hardly covered by the grant aid or technical cooperation due to their large scale.

The grant aid is provided in combination with the project-type technical cooperation to construct and operate the facilities to make it more effective.

## 5. From the Basic Law for Environmental Pollution Control to the Environment Basic Law

### 5.1 The Environment Basic Law and the Basic Environment Plan

In Japan, environmental administrations have been conducted mostly under the framework of the Basic Law for Environmental Pollution Control, and they have considerably succeeded in the abatement of pollutions. At present, however, driven by the social and economic activities based on the mass production, mass consumption and mass disposition, the urban public nuisances and household pollution problems and the global environmental problems have become more serious. Conventional approaches based on the command-and-control mechanism have not been sufficient to cope with such problems. This made it necessary to enact the Environment Basic Law in 1993, which provided the philosophy for environmental policies, the direction for basic actions and the general framework for environmental policy developments.

Also for the protection of water environment, comprehensive measures are to be developed under the Environment Basic Law.

In 1994, under the Environment Basic Law, the Cabinet decided the Basic Environment Plan to provide fundamental directions for the environmental protection in Japan. Long-term objectives listed in this Plan are "building a socioeconomic system fostering an environmentally-sound material cycle", "ensuring harmonious coexistence between humankind and nature", "achievement of participation by all sectors of society, each sharing a fair burden" and "promotion of international activities." To achieve these objectives, the roles and efforts expected to be taken by the local governments, entrepreneurs, general public and private organizations in addition to the efforts by the national government are presented in the Plan.

### 5.2 Future Protection of Water Environment by the Environment Basic Law and the Basic Environment Plan

The Basic Environment Plan stresses about the protection of water environment that the loads on environment should be kept within the purification capacity of the natural cycle processes of water. Taking whole of the water quality and quantity, aquatic organisms and watersides into consideration, the Plan generally promotes various actions while inviting those interested in water environment to participate.

It illustrates that the protection of water environment should be considered as a part of the efforts for the general water cycle and the previous efforts concentrating on the protection of water quality should be extended to include various elements for the overall development of actions with the sound material cycle, harmonious coexistence and participation as basic philosophies.

Preparation of this Basic Environment Plan has significantly expanded the scope of water environment administration. Innovative actions have to be developed on the basis of the ideas different from the previous ones both in the purpose of protection, or what the protection of water environment is for, and in the elements to be protected, or what should be protected for water environment.

First, as for the purpose of the protection of water environment, previous efforts aimed to protect two elements such as human health and living environment as, for example, shown in the quality standards. However, in addition to this, the Environment Basic Law makes it also important to maintain the sound water environment, to protect the diverse nature of watersides with consideration of their local conditions, and to keep the contact of people with nature, for the appropriate protection of natural environment. In other words, it requires to preserve the water-derived benefits in the forms and by the methods suitable to the local conditions and to pass them over to the next generation. Previous administrations of water environment concentrated on the objective evaluations of the numerical values by specific chemical analyses and a little attention was paid to other areas. Future administrations should consider the historical and cultural values of the water environment and also its value as landscape.

Second, as for those to be protected as the elements constituting the water environment, the Environment Agency centered its administration of water environment on the protection of water quality, and the protected elements were limited when it was considered that the water environment comprised of various elements such as the water quantity and watersides in addition to the water quality as stated in the Basic Environment Plan.

As for the water quantity, it is desirable to secure the minimum flow of rivers to realize the sound cycle of water throughout an entire basin, including the allocation of water not only to the users of water resources but also to the various organisms and ecosystems in water environment. Efforts are required to improve the overall water cycle by the measures such as the reuse of highly treated sewage, the protection of forests and the recharge of groundwater.

Such approaches may be applicable also to the water cycle in the cities. Implementation of a variety of measures including the installation of the infiltration inlets, permeable paving and tree planting to restore the spring water, which is an example of the important water environment in the cities, also follows the general flood control approach. How to organize a forum and what kind of support should be provided by the national government to adjust the water flow between the upstream and downstream communities should be studied as well.

As for the watersides, a single argument cannot be made to all of them since their forms vary to each other. Many of the existing watersides are artificial, and it must be also considered to elaborate more natural watersides.

Watersides are the ecotones between the water and land areas and they are important as habitats for various organisms. It is required to protect the watersides not only for the human health and amenity but also for the conservation of organisms and ecosystems. The administration of water environment, therefore, should be modified so that much wider areas could be dealt with, including the water quantity and watersides as well as the water quality, to secure the sound water cycle.

Third, the sound water environment is supported by local people. During the construction of the safer and more efficient economy and society after the Second World War, many watersides disappeared, people's awareness of water-derived benefits faded out and the water environment became deteriorated. The role sharing and active involvement of the local people are essential for the protection and restoration of rich water environment. It is expected to develop new measures to increase the people's intention to participate in the programs to protect the water environment, like the "listing of 100 spots with famed delicate water".

Following the significant extension of the scope of the water environment protection by the Environment Basic law and the Basic Environment Plan, the national government is required to prepare the guidelines for water environment protection and to promote various programs. Following the national guidelines for water environment protection, local governments are required to determine the water environment objectives and plans appropriate to their local conditions and to generally coordinate and promote the various water environment-related programs. The issues which take place in wider areas and go beyond the administrative boundaries of the local governments, such as the large-scale water cycle and quality, definitely require the coordination and cooperation among the relevant administrative organizations.

# Chapter 3 WATER POLLUTION CONTROL LAW

## 1. Historical background on enactment of water pollution control low

In Japan, river water pollution problems had been observed even before the industrial modernization of the country. One of the first recorded cases of river water pollution affecting human activity was the outflow of pit water from the Asio Copper Mines into the Watarase River during the late 19th century. The outflow of mine pit waters damaged paddy fields on the riverside. With the advent and growth of industrial activities, there had been a subsequent increase in wastewater flowing into rivers, giving rise to pollution problems in various parts of Japan. During the period of industrial reconstruction after World War II, there were social disputes related to problems arising out of river water pollution by industries. Great damage to fisheries had been observed at that time as a result of wastewater from paper mills being discharged into the Edo River in Tokyo. The problem also began to affect people's health, as in the case of the Minamata incident in the late 1950s, when mercury from the chemical industry caused a previously unknown disease among people who ingested the waste-contaminated fishes caught in the area around the factory. In the 1960s, during the period of rapid economic growth, water pollution became more widespread and severe. Reports of mercury contamination in the Agano River and cadmium in the Jinzu River were seen to lead to Itaiitai disease and Minamata disease as in earlier years.

Several countermeasures have been taken by the Japanese government and people to control and abate water pollution, specifically that which affected human health and the living environment in water systems.

Based upon the above mentioned serious water pollution problems, "Water Quality Conservation Low" and "Factory Effluent Control Low" have been enacted in 1958. Water quality standard (WQS) was established for the Edo river based on the above two lows. WQS for the Yodo river, the Kiso river, the Ishikari river, the Ara (Sumida) river were established as well soon after the enactment of those two lows.

"Water Quality Conservation Low" requires, 1)central government establish the water quality control basic plan of public waters based upon the opinion of the local governor(s), 2)central government sets up designated water bodies, 3)Organization of council for water quality control is required in the local government. "Factory Effluent Control Low" requires the factories to set up the designated facilities and to report it to the government. The government can enforce the factory to revise the reported plan and to improve the facility if the effluent water quality does not meet the water quality standard of the water bodies where the effluent is discharged. "Water Quality Conservation Low" and "Factory Effluent Control Low" were applied to the Edo river (water quality standards: pH, COD, SS) in 1962, the Mizushima water area (water quality standards: pH, COD, SS, oil content, cyanide, total chromium, phenols, alkylated mercury, organic phosphorus, cadmium, lead, arsenic, total mercury, chromate). During these period number of water quality parameters increased due to the deterioration of water quality in the public water areas. 81 areas had been set up as the designated water bodies.

## 2. Enactment of Water Pollution Control Low and Outline

Japan has a long and rich experience in controlling and abating river water pollution. In the 1950s, in response to the many concerns raised relating to industrial pollution, local ordinances were enacted to enable local government to take measures against water pollution. In 1958, the central government promulgated two laws on water pollution control. One dealt with water quality protection in public water areas while the other was a law regulating effluents from factories. These two laws, however, were not sufficient to prevent water pollution. The regulations were applied only to some designated water areas.

In 1967, the government enacted the Basic Law for Environmental Pollution Control to promote comprehensive measures against various forms of environmental pollution. In 1970, the so-called "pollution Diet" adopted several environmental laws to reinforce laws on environmental pollution control. Several old laws were unified in the form of a new reinforced Water Pollution Control Law. The national government then set the Environmental Quality Standards and the Effluent Standards, and enacted or revised other laws related to water quality management. Local governments have likewise enacted many laws and regulations for their specific areas of concern.

In 1971, concentration of pollutants in the effluent was regulated based upon the Water Pollution Control Law. The Water Pollution Control Law was rectified for closed water area such as Tokyo bay, Ise bay, Seto inland sea using COD as water quality parameter to conserve the designated environmental water quality standard.

The objectives an outline of the water pollution control law are as follows:

1)The purpose of the low is to prevent the pollution in public water areas , thereby, to protect human health and to conserve the living environment, by regulating effluents from factories and establishment into the public water areas, and protect the suffers by deciding the liability of the proprietor of the factories and establishments to compensate for the damage in cases when human health has been damaged by the polluted water and waste liquid to be discharged from the factories and establishments.

2)Effluent wastewaters from factories and establishments are widely regulated regardless of kind of industries.

3)Effluent standards are set in terms of permissible concentration of each harmful substance for protecting human health and each parameter for preserving the living environment. Effluent standards are classified into common national standards and the more stringent effluent standards. The uniform national effluent standards shall be set by the Prime Minister's Office Order. For Public water areas where it is reorganized that the common national minimum effluent standards are insufficient for protecting human health to preserve the environment water quality for Cabinet order Effluent water and/or for preserving the living environment to attain the environmental quality standards of water, the water pollution control law provides that the more stringent effluent standards may be decided by enacting necessary prefectural regulations in accordance with national minimum standards.

4)Public sewer systems and river basin sewerage systems connected to wastewater treatment plants are excluded from the public water area.

5)Prefectural governors and mayors designated by Prime Ministers Office order may call for necessary reports from persons who discharge effluent from specified factories and establishments and may inspect the specified factories and other related matters. And the governors and the mayors, when they acknowledge that it is possible that unsatisfactory effluent is discharged, may order the persons who discharge the effluent into pubric water areas to improve the structure of the wastrewater treatment facility. Absolute liability concept was applied to the health hazard derived by the water pollution in 1972. Factories and establishment are responsible to their effluent into the public water areas.

6)Area wide total pollution Load control system was introduced to preserve water environment in closed sea area in 1978. The governor of each prefecture concerned must determine, according to the plan for reducing the total pollution load, pollution load control standards for the pollutant loads of the effluents from those designated factories and establishments in the specified area which have wastewater discharged in 50 m3 or more in daily average.

The Environmental Water Quality Standards were first established by a Cabinet decision in 1970. These standards are divided into two types - those that need to be achieved and maintained to protect human health and those that need to be achieved and maintained to conserve the living environment (refer to Table 3-1). The standards set are almost equivalent to drinking water quality standards with regard to the items related to the protection of human health. Standards relating to the protection of human health are applied as minimum criteria nationwide, while those relating to the conservation of the living environment are set for each category according to water usage, the level of pollution, and other factors. Prefectural governments are responsible for setting standards for water bodies in their respective areas except for the 47 inter-prefectural water bodies administered by the national Environment Agency. Prefectural governments also have the power to establish standards more stringent than the national standards when the latter are not enough to conserve the water quality of public water bodies within their area of jurisdiction. Effluent standards have also been set to control discharges into public waters by factories or establishments which have specified facilities (see Table 3-1).

## 3. Environment Quality Standard for Water

### 3.1 Out line of Environment Quality Standard

The water quality standards are established as standards which should be maintained to protect the health of the people and to preserve the living environment. They are standards which will serve as goals when national and local governments draft measures to prevent pollution. In the environmental quality standards for water, there are the standards concerning protection of the human health and those for the preservation of living environments. Different criteria are applied to the water area according to the utilization water, while the standards for human health are applied to the water area uniformly throughout the country.
The general outline of the environment quality standards is shown in Table-1. In the notification of Environment Agency the parameters and their analytical procedures are shown as well.

### 3.2 Standards for human health

The parameters of standards for human health are 23 as shown in Table-2. Nine organochlorine compounds and 4 agricultural chemicals are included. Criteria of each parameter was decided for the supply of safe drinking water. Biological concentration in fishes, shell fishes were taken into consideration to determine the criteria.

**Table 3-1** Standards related to the protection of human health (mg/L or less)

| Parameters and criteria | reference and related information (unit: mg/L) |
|---|---|
| Cd 0.01 | Same with the water quality standard for drinking water: 0.01---- 1/100 through 1/50 of Zinc concentration in surface water and in ground water.<br>World standard suggested by WHO, standards in the United States and in Russia: 0.01<br>Europa standard suggested by WHO: 0.05<br>No information is available on the accumulation of Cd in fishes and plants. |
| CN ND | LD50 of KCN:150-300mg/person (LD50 of CN:60-120mg/person). 100 times safety factor was considered. The criteria in Japan was decided as ND (<0.1) by referring the criteria in U.S.: 0.01, Russia: 0.1, and in Europe by WHO: 0.2 by taking the 100times safety factor into account. |
| Organic phosphorus* ND | Agricultural organic phosphorus: parathion, methyl parathion, EPN, methyl demeton, LD50 of parathion (6mg/kg-mouse) was referred to decide the criteria:ND (<0.1) |
| Pb** 0.01 | acute toxicity and long term exposure. unclear threshold value. AWWA reported that daily uptake more than 1.0 mg/person may bring about the accumulation in human body. Same criteria with drinking water standard was set due to poor removal efficiency in drinking water treatment. |
| Cr (VI) 0.05 | Symptoms of poisoning: vomiting, convulsions, coma, dermatitis,<br>Poor removal efficiency in drinking water treatment. No toxicity less than 0.1 mg/L. Criteria in drinking water quality standard is 0.05 mg/L. Same criteria with the drinking water was selected. |
| As** 0.01 | Symptoms of chronic poisoning: sensory disturbance, cirrhosis, edema. skin cancer, etc.<br>Poor removal efficiency in drinking water treatment. Same criteria with the drinking water was selected. |
| Hg (total) 0.0005<br>Hg (alkylated) ND(<0.0005) | Substance caused Minamata disease.<br>Symptoms of poisoning: decease by central nervous system paralysis<br>Bio-concentration factor via fishes and accuracy of analyses were considered for food.<br>Temporal criteria of fishes for food: Total mercury-0.4 mg/kg, methylated mercury-0.3 mg/kg. |
| PCBs ND(<0.0005) | Symptoms of poisoning: eyelid edema, amblyopia, skin ailment.<br>Accumulation of PCBs in water and in sediments by food chain was considered to determine the criteria. Bio-concentration factor was estimated as 7360 (average) through 10000. The criteria was determined as ND not to exceed the temporal value of food (3 mg/kg) after bio-concentration. |

b)Additional parameters and standards

| Parameters | Standard values |
|---|---|
| Trichloroethlene | 0.03 |
| Tetrachloroethlene | 0.01 |
| Carbon tetrachloride | 0.002 |
| Dichloromethane | 0.02 |
| 1,2-dichloromethane | 0.004 |
| 1,1,1-trichloroethane | 1.0 |
| 1,1,2-trichloroethane | 0.006 |
| 1,1-dichloroethylene | 0.02 |
| cis-1,2-dichloroethylene | 0.04 |
| 1,3-dichloropropene(D-D) | 0.002 |
| Thiuram | 0.006 |
| CAT (simazine) | 0.003 |
| Thiobencarb | 0.02 |
| Benzene | 0.01 |
| Selenium | 0.01 |

*These parameters are added to the Standards related to the protection of human health in 1993

### 3.3 Standards for Living Environment

Environment Agency has announced in 1971 the parameters of environment quality standards such as BOD, COD, Suspended solids, Dissolve oxygen, Number of coliform group as shown in Table 3-2. Criteria of nitrogen and phosphorus were set for the preservation of environmental water quality in lakes.

**Table 3-2** Standards for rivers related to the conservation of living environment (mg/L)

| category | water use | pH | BOD | SS | DO | CG* |
|---|---|---|---|---|---|---|
| AA | Water supply class 1, conservation of natural environment, and uses A-E | 6.5-8.5 | 1 | 25 | 7.5 | 50 |
| A | Water supply class 2, fishery class 1, bathing, and uses B-E | 6.5-8.5 | 2 | 25 | 7.5 | 1,000 |
| B | Water supply class 3, fishery class 2, and uses C-E | 6.5-8.5 | 3 | 25 | 5.0 | 5,000 |
| C | Fishery class 3, industrial water class 1 and uses D-E | 6.5-8.5 | 5 | 50 | 5.0 | - |
| D | Industrial water class 2, irrigation water and use E | 6.0-8.5 | 8 | 100 | 2.0 | - |
| E | Industrial water class 2, conservation of environment | 6.0-8.5 | 10 | no floating matters | 2.0 | - |

*CG: number of coliform groups, MPN/100ml

Note: Category of water area is specified by the minister of Environment Agency or by prefectural governor.

1.Conservation of natural environment: conservation of nature and natural resources

2.Water supply class 1: no or simple purification, slow sand-filtration
Water supply class 2: conventional purification, coagulation and rapid sand-filtration
Water supply class 3: advanced purification, biofilter, ozone, activated carbon, etc.

3.Fishery class 1:Oncorhynchus masou, Salvelius pluvius, etc.
Fishery class 2: Salmon, sweet fish (ayu), etc.
Fishery class 3: Carp, Prussian carp, etc.

4.Industrial water supply class 1: simple treatment such as sedimentation before distribution
Industrial water supply class 2: advanced treatment required before distribution
Industrial water supply class 3: high level advanced treatment required before distribution

5.Conservation of environment: no unpleasant odor at riverside or beach

## Chapter 4 THE ENVIRONMENTAL QUALITY STANDARDS FOR PROTECTING HUMAN HEALTH

1. The Environmental Quality Standards for Protecting Human Health

The Environmental Quality Standards for Water Pollution was established in 1970, based on the Articles 16 of the Environment Basic Law (the Articles 9 of the former law named the Basic Law for Environmental Pollution Control), as the standards (or standard values) that we should maintain for the purpose of protecting our health and preserving our living environment. Each exhaust, from factories, enterprises and houses, might not be so serious but the result of accumulation of pollutants makes trouble. These standard values are the administrative goals in actual enforcement of policies to prevent pollutions of public waters and groundwater by enterprisers, the government and local authorities. In other words, it is the authority to carry out the countermeasure for protection against pollution in the clean area or low contaminated area. In seriously polluted area, it is the goal to reach the level of the Environmental Quality Standards for Protecting Human Health in public water.

2. Selection of Items for the Environmental Quality Standards for Protecting Human Health

In 1971, the standards (or standard values) were notified by the Environment Agency with regard to syanide, total mercury, alkyl mercury, specified organophosphorus (parathion, methyl parathion, methyl dimeton, EPN), cadmium, lead, hexavalent chromium, arsenic.

The four specified organophosphorus had been already prohibited to use in Japan at that time. But the environmental standard values were set up about four these items. Because these items were strong residual agricultural chemicals and had been still detected in fish and shellfishes. It was pointed out the possiblity that trivalent chromium would be oxdized to hexavalent chromium in public waters. But the environmental standard value of trivalent chromium was not set up, because there were not have data to prove this possiblity in public waters. Inorganic mercury was added one of the items of the Environmental Quality Standards for Protecting Human Health as total mercury, because there was risk that inorganic mercury was accumulated in body.

BHC, trichloroethylene and PCB were investigated because these compounds were thought to be risk of biological accumulation in according to environmental pollution. BHC was stopped producing and using for domestic needs in Japan. Trichloroethylene, for instance, was recovered so that there was no danger of discharge into the environment. Regarding PCB, the analytical methods were not established yet. For these reasons, BHC, trichloroethylene and PCB were not set up the Environmental Quality Standards for Protecting Human Health at that time.

In 1975, PCB and alkyl mercury were added into items of the Environmental Quality Standards for Protecting Human Health.

In 1993, the Environmental Quality Standards for Protecting Human Health was revised on the basis of the scientific data about health effects. After enforcement of this law, various chemicals had been produced and used in according to industrial development. It was worried the quality of public waters and groundwater became worse. In 1992, the Water Quality Srandards for Drinking Water in Japan was revised in parallel with the revise of theGuideline of Water Quality Standards for Drinking Water by WHO, the Clean Water Act (USA), Water Quality Standards for Drinking Water (USA) and Safe Drinking Water Act (USA). The items, which had bad effects on human health, were examined into new scientific data. The examination of un-listed items and the re-examination of listed items were done on basis of the effects on human health with due consideration to the amount of production, the quantity of use, the detected level in public waters and groundwater.

The new Enviromnetal Quality Standards for Water Pollution was established with the following idea. All compounds, which are able to be determined the standard values on the basis of scientific data, should not be determined the standard values. Because it is important to monitor the quality of waters and to consider a counterplane of emission control for the purpose of protecting human health and that of preserving our living environment. Such reasons, only compounds, which were detected actually at near risk level in public water and groundwater, should be listed on the Environmental Quality Standards for Protecting Human Health.

3. Foundation for the Determination of the Standard Values

There is fear of using contaminated public water for the sourse of human's drinking water. So, the standard values of the items listed in the Water Quality Standards for Drinking Water on the basis of Waterworks Law, are calculated with the similar concept to the Water Quality Standards for Drinking Water. About other items, the standard values were calculated with consideration of the contribution of drinking water to total absorption, the other countries' environmental standard values for water quality and new scientific data for health effects. The influence resulted from drinking water were estimated on basis of the idea of WHO's guideline for drinking water. The standard values were determined based on the information of the no-effective level about health,while we intake all our lives continuously.

In 1993, items shown the new data about health effects were assessed whether they were added into the list of the Environmental Quality Standards for Protecting Human Health. Among those items, 16 items were added into the list of the Environmental Quality Standards for Protecting Human Health with consideration of the amount of production, the quantity of using, the concentration in public water and gorundwater. For instance, it was worried that wide area or many points were polluted by simazin, because simazin was used not only as pesticide but also as accelerator for sulfurating rubber. From this worry, simazine was added into the list of the Environmental Quality Standards for Protecting Human Health.

4. Health Risk Assesment

(1) Assesment of Noncarcinogenic Risks

It is based on data about health effects resulting from laboratory animal or human studies that can be used. The value of human investigations is limited, owing to lack of enough information on the concentrations to which people are exposured or on simultaneous exposur to other chemicals. So, the toxicity data from laboratory animals are often used for risk assesment.

For this kind of chemicals, it is believed that there is a highest dose which no adverse effects will oocur (NOAEL) and the lowest dose at which detectable adverse effects is observed (LOAEL). A Tolerable Daily Intake (TDI) about these chemicals is derived using the following formula:

$$TDI = \frac{\text{NOAEL or LOAEL}}{\text{UF}}$$

NOAEL = No-Observed-Adverse-Effect Level
LOAEL = Lowest-Observed-Adverse-Effect Level
UF = Uncertainty Factor

If a NOAEL is not available, a LOAEL may be used with additional uncertainty factor.

The derivation of uncertainty factors is necessary of expert judgement. For instance, in the Guidelines for Drinking-Water Quality of WHO, " In the derivation of the WHO drinking-water quality guideline values, uncertainty factoes were applied to the lowest NOAEL or LOAEL for the response considered to be the most biologically significant and were determined by consensus among a group of experts using the approach outline below:

| Source of uncertainty | Factor |
|---|---|
| Interspecies variation(animals to humans) | 1-10 |
| Intraspecies variatio (individual variations) | 1-10 |
| Adequacy of studies or database | 1-10 |
| Nature and severity of effect | 1-10 |

Inadequate studies or databases include those that used a LOAEL instead of a NOAEL and studies considered to be shorter in duration than desirable. Situations which the nature or severity of effect might warrant an additional uncertainty factor include studies in which the end-point was malformation of a fetus or in which the end-point determining the NOAEL was directly related to possible carcinogenicity. " . The total uncertainty factor should not exceed 10000.

(2) Assesment of Carcinogenic Risks

On the basis of the available evidence of long-term animal studies, sometimes of exposure in humans, IARC(3) or EPA categorize chemical substances as regards to their potential carcinogenic risk (Table 4-6).

| IARC | EPA | |
|---|---|---|
| Group 1 | (Group A): | the agent is carcinogenic to humans |
| Group 2A | (Group B): | the agent is probably carcinogenic to humans |
| Group 2B | (Group C): | the agent is possibly carcinogenic to humans |
| Group 3 | (Group D): | the agent is not classifiable as to its carcinogenicity to humans |
| Group 4 | (Group E): | the agent is probably not carcinogenic to humans |

If chemicals are classified as human (Group 1) or probable human (Group 2A) carcinogen, mathematical models are used to estimate upper bound excess lifetime cancer risk. Upper bound excess lifetime cancer risk estimates may be calculated with the models such as the one-hit, Weibull, logit, probit, or multistage models (4). The U.S. EPA generally uses the linearized multistage model, which uses dose-response data from the life time exposure carcinogenic study. In the case of drinking water, for example, the values are determined the concentration in drinking-water associated with a theoretical upper bound excess life-time cancer risk of $10^{-4}$ (concentration predicted to contribute one additional cancer case per 100,000 of the population for 70 years), $10^{-5}$ and $10^{-6}$.

Syanide

For calculation of standard value, the effects of acute toxicity were mainly considered. There were not so many of toxicological studies which are suitable to consider effects on humans. The lethal dose of cyanide in oral is 150mg-300mg KCN/body, namely 60-120mg CN/body, based on an incident of human absorption or several results in animals. From these data, the LOAEL could be described about 2mg/body. People would be drink 500ml once so that the permissible value of drinking water was calculated as 1mg/l. For human health, cyanide should not be detected in public water and groundwater. The lowest detectable concentration of cyanide by recomended method in law is 0.1mg/l. In the Water Quality Standards for Drinking Water and the Standard of Fisheries Water, the standard value was 0.01mg/l. It was pointed that its concentration, 0.1mg/l, was not enough to protect human health and aquatic lives. However, syanide of Complex forms with metal, which are less farmful, are also detected by the method recomended in the Environmental Quality Standards for Water Pollution. If the concentration in the environment was 0.1mg/l, it would not occur trouble actually. Cyanide would be destroyed in short time in the river or sea. From these, the standard value was determined as " not detectable " , which means " less than 0.1mg/l " in total of cyanide ion and complex forms with metal.

Total Mercury and Alkyl Mercury

For calculation of standard value, the effects of chronic toxicity were considered. Long-term exposure of alkyl mercury compounds causes the onset of neurological damage. So, alkyl mercury, especially methyl mercury, would be expected not to detect. It is difficult to remove it and to destroy in process for drinking water. From these, the standardvalue was determined as " not detectable " , which means " less than 0.0005mg/l " .
This concentration means the quantitative limit by recomended method in the law.

Cadmium

For calculation of standard value, the effects of chronic toxicity were considered. Cadmium co-moves with zinc at the ratio of about 1:100 in surface water and ground water, so that drinking water usually contains cadmium less than 0.01mg/l in according to the level of zinc. The absorbed cadmium was almost excreted, but accumulated cadmium has a long biological half-life in human about 10 ~ 30 years. Assuming that an absorpting ratio of dietary cadmium was 5% and a daily excretive ratio was 95% of body burden, a total intake of cadmium should not exceed 0.05mg/body. From the allocation of the TDI to drinking water, the concentration in drinking water should be less than 0.01mg/l. Although there are a few data about an accumulation of cadmium to the lives of environment, this standard value would not be trouble for human health and lives in the environment.

5. The Environmental Quality Standards for Protecting the Living Environment

25 items listed in the Environmental Quality Standards for Protecting the Living Environment had a lot of effect on human health, but these were detected at low level in public water. However, it was important that we should continue to collect the data about health effects and to monitor the concentration in public water. For these items, the target values were recomended to keep the concentration (Table 4-2). Chloroform, for instance, was used a lot. And chloroform is a disinfection by-product and it is one of the standard items in the Water Quality Standards for Drinking Water. Fluoride originates from natural sourse in the high proportion of the environmental content. The concentration of nitate and nitrite might be depended on the quantity of pesticide used. These items are difficult to consider how to lower the concentration in public water. For these reasons, these items are listed in the Environmental Quality Standards for Protecting the Living Environment.

6. Application of the Environmental Quality Standards for Protecting Human Health

The protection of human health should be given top priority to all. The effects on human health would be understood on the basis of the total influence of drinking water, ingestion of fish and shellfishes, and the circulation of water between hydrosphere and atmosphere and so on. From these idea, the Environmental Quality Standards for Protecting Human Health should be applied uniformly to all public waters.
The concentration of these items in public waters should be always maintained below the level of standard values regardless of the conditions of utilization, the site of pollution source, and the quantity of water. Waterer from rivers and lakes is used for a source of drinking water, there is the risk to absorb these compounds through tap-water contaminated without removing or degradation in process of drinking water. In the other area, there is risk also to ingest these items through fish and shellfishes. According to the application of the Environmental Quality Standards for Protecting Human Health with these idea, it is expected to decrease the risk for aquatic organism and to protect the environmental water pollution with harmful compounds.

7. The Evaluation of Achievement of the Environmental Quality Standards for Protecting Human Health

The standard methods are shown in Table 4-1. The quantitative limit will become lower according to a development of analytical methods and to an improvement of instrument. The quantitative limits of the items, excetp total syanide, total mercury, alkyl mercury and polychlorobiphenyl, are decided to detect the concentration of one-tenth of the standard values.

The standard values mean the average through a year. The standard values are determined with regard to consider the health effects during a long-term ingestion. If the detected values exceed a little the standard values transitionally, it might be not so serious condition. Because the counterplane would be performed to keep the level below the standardvalues on basis of the safety program. Namely, the Environmental Quality Standards for Protecting Human Health is based on the idea that the quality of water for long term should be continued to keep safety at the standard values on an average.

But the quantitative limit of total syanide is decided to have to be evaluated with the maxmal value in according to considering the effects of acute toxicity. The detected value should be less than 0.1mg・$l^{-1}$ every time through a year. The standard values of total mercury, alkyl mercury and polychlorobiphenyl are determined as " not detectable ". So, the quantitative limit of the detectable values of total mercury, alkyl mercury and polychlorobiphenyl should be less than 0.0005mg・$l^{-1}$ every time through a year.

The standard values do not mean that the condition polluted at this concentration is permitted. It is important that the good quality of water is kept on the good condition below the level of the Environmental Quality Standards for Protecting Human Health and that the quality of water should be improved as clean as possible. When the detected values exceed the standard values transitionally, it is necessary that the cause should be investigated and that the monitoring of the subsequent level should be continued. Additionally, if necessary, we should consider and perform a suitable counterplane.

## 8. Achievement Frequency

Recently, the quality of public water and goundwater tends to become better and better. Especially, parameters about health items in the Environmental Quality Standards for Protecting Human Health are almost less than the levels of the standard values in most aera.

In 1995, 294,491 samples at 5,471 points (3,973 points at rivers, 260 points at lakes and 1,238 points at sea) were monitored. The ratio of the samples exceeded the standard values was 0.79% (Table 4-3, Table 4-4, Table 4-5). The ratio was 0.85% in 1994, 0.58% in 1993. The number of points, where arsenic was exceeded the standard value, resulted in increasing of the frequency of exceeded points. Cadmium, total syanide, lead, arsenic, dichloromethane, 1,2-dichloroethane, tetrachloroethylene and serenium are also items exceeded the standard values.

References


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3. International Agency for Research on Cancer (1992) Lyon, IARC Monographs on the Evaluation of Carcinogenic Risks to Humans, Vol.54.
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Table 4－1 Environmental Quality Standards for Water-Items Related to the Protection of Human Health

| Items | Standard Value | Method |
|---|---|---|
| Cadmium | less than 0.01mg・$l^{-1}$ | Frame Atomic Absorption Spectrometric Method |
| | | Electrothermal Atomic Absorption Method |
| | | Inductively Coupled Plasma Method |
| | | Inductively Coupled Plasma/Mass Spectrometric (MS) Method |
| Total Cyanide | not detectable(*1) | Pyridine-Pyrazolone Colorimetric Method |
| | | Pyrrolidine-4-Carbonic acid/Pyrazolone Colorimetric Method |
| Lead | less than 0.01mg・$l^{-1}$ | Frame Atomic Absorption Spectrometric Method |
| | | Electrothermal Atomic Absorption Method |
| | | Inductively Coupled Plasma Method |
| | | Inductively Coupled Plasma/Mass Spectrometric (MS) Method |
| Hexavalent Chromium | less than 0.05mg・$l^{-1}$ | Diphenylcarbazide Colorimetric Method |
| | | Frame Atomic Absorption Spectrometric Method |
| | | Electrothermal Atomic Absorption Method |
| | | Inductively Coupled Plasma Method |
| | | Inductively Coupled Plasma/Mass Spectrometric (MS) Method |
| Arsenic | less than 0.01mg・$l^{-1}$ | Hydride Generation/Atomic Absorption Spectrometric Method |
| | | Hydride Generation/Inductively Coupled Plasma Method |
| Total Mercury | less than 0.0005mg・$l^{-1}$ | Cold-Vapor Atomic Absorption Spectrometric Method |
| Alkyl Mercury | not detectable(*2) | Liquid-Liquid Extraction/Gas Chromatographic Method (Electron Capture Detector) |
| Polychlorobiphenyl | not detectable(*2) | Liquid-Liquid Extraction/Gas Chromatographic Method (Electron Capture Detector) |
| Dichloromethane | less than 0.02mg・$l^{-1}$ | Purge and Trap Gas Chromatographic/Mass Spectromeric Method |
| | | Purge and Trap Gas Chromatographic Method (Flame Ionization Detector) |
| | | Head-space Gas Chromatographic/Mass Spectromeric Method |
| Tetrachloroethane | less than 0.002mg・$l^{-1}$ | Purge and Trap Gas Chromatographic/Mass Spectromeric Method |
| | | Purge and Trap Gas Chromatographic Method (Electron Capture Detector) |
| | | Head-space Gas Chromatographic/Mass Spectromeric Method |
| | | Head-space Gas Chromatographic/Mass Spectromeric Method(Electron Capture Detector) |

Table 4－1 Environmental Quality Standards for Water-Items Related to the Protection of Human Health (continued)

| | | |
|---|---|---|
| 1,2-Dichloroethane | less than 0.004mg・$l^{-1}$ | Purge and Trap Gas Chromatographic/Mass Spectromeric Method<br>Purge and Trap Gas Chromatographic Method (Electron Capture Detector)<br>Purge and Trap Gas Chromatographic Method (Flame Ionization Detector)<br>Head-space Gas Chromatographic/Mass Spectromeric Method |
| 1,1-Dichloroethylene | less than 0.02mg・$l^{-1}$ | Purge and Trap Gas Chromatographic/Mass Spectromeric Method<br>Purge and Trap Gas Chromatographic Method (Flame Ionization Detector)<br>Head-space Gas Chromatographic/Mass Spectromeric Method |
| cis-1,2-Dichloroethylene | less than 0.04mg・$l^{-1}$ | Purge and Trap Gas Chromatographic/Mass Spectromeric Method<br>Purge and Trap Gas Chromatographic Method (Flame Ionization Detector)<br>Head-space Gas Chromatographic/Mass Spectromeric Method |
| 1,1,1-Trichloroethane | less than 1mg・$l^{-1}$ | Purge and Trap Gas Chromatographic/Mass Spectromeric Method<br>Purge and Trap Gas Chromatographic Method (Electron Capture Detector)<br>Head-space Gas Chromatographic/Mass Spectromeric Method<br>Head-space Gas Chromatographic/Mass Spectromeric Method(Electron Capture Detector)<br>Liquid-Liquid Extraction/Gas Chromatographic Method (Electron Capture Detector) |
| 1,1,2-Trichloroethane | less than 0.006mg・$l^{-1}$ | Purge and Trap Gas Chromatographic/Mass Spectromeric Method<br>Purge and Trap Gas Chromatographic Method (Electron Capture Detector)<br>Head-space Gas Chromatographic/Mass Spectromeric Method<br>Head-space Gas Chromatographic/Mass Spectromeric Method(Electron Capture Detector)<br>Liquid-Liquid Extraction/Gas Chromatographic Method (Electron Capture Detector) |
| Trichloroethylene | less than 0.03mg・$l^{-1}$ | Purge and Trap Gas Chromatographic/Mass Spectromeric Method<br>Purge and Trap Gas Chromatographic Method (Electron Capture Detector)<br>Head-space Gas Chromatographic/Mass Spectromeric Method<br>Head-space Gas Chromatographic/Mass Spectromeric Method(Electron Capture Detector)<br>Liquid-Liquid Extraction/Gas Chromatographic Method (Electron Capture Detector) |
| Tetrachloroethylene | less than 0.01mg・$l^{-1}$ | Purge and Trap Gas Chromatographic/Mass Spectromeric Method<br>Purge and Trap Gas Chromatographic Method (Electron Capture Detector)<br>Head-space Gas Chromatographic/Mass Spectromeric Method<br>Head-space Gas Chromatographic/Mass Spectromeric Method(Electron Capture Detector)<br>Liquid-Liquid Extraction/Gas Chromatographic Method (Electron Capture Detector) |

Table 4－1 Environmental Quality Standards for Water-Items Related to the Protection of Human Health (continued)

| | | |
|---|---|---|
| 1,3-Dichloropropene | less than 0.002mg・$l^{-1}$ | Purge and Trap Gas Chromatographic/Mass Spectromeric Method<br>Purge and Trap Gas Chromatographic Method (Electron Capture Detector)<br>Head-space Gas Chromatographic/Mass Spectromeric Method |
| Thiram | less than 0.006mg・$l^{-1}$ | Liquid-Liquid Extraction/High-Performance Liquid Chromatographic Method<br>Solid Phase Extracton/High-Performance Liquid Chromatographic Method |
| Simazine | less than 0.003mg・$l^{-1}$ | Liquid-Liquid Extraction/Gas Chromatographic/Mass Spectromeric Method<br>Liquid-Liquid Extraction/Gas Chromatographic/Mass Spectromeric Method (Flame Thermionic Detector)<br>Solid Phase Extracton/Gas Chromatographic/Mass Spectromeric Method<br>Solid Phase Extracton/Gas Chromatographic/Mass Spectromeric Method (Flame Thermionic Detector) |
| Thiobencarb | less than 0.02mg・$l^{-1}$ | Liquid-Liquid Extraction/Gas Chromatographic/Mass Spectromeric Method<br>Liquid-Liquid Extraction/Gas Chromatographic/Mass Spectromeric Method (Flame Thermionic Detector)<br>Liquid-Liquid Extraction/Gas Chromatographic/Mass Spectromeric Method(Electron Capture Detector)<br>Solid Phase Extracton/Gas Chromatographic/Mass Spectromeric Method<br>Solid Phase Extracton/Gas Chromatographic/Mass Spectromeric Method (Flame Thermionic Detector)<br>Solid Phase Extracton/Gas Chromatographic/Mass Spectromeric Method(Electron Capture Detector) |
| Benzene | less than 0.01mg・$l^{-1}$ | Purge and Trap Gas Chromatographic/Mass Spectromeric Method<br>Purge and Trap Gas Chromatographic Method (Flame Ionization Detector)<br>Head-space Gas Chromatographic/Mass Spectromeric Method |
| Selenium | less than 0.01mg・$l^{-1}$ | Hydride Generation/Atomic Absorption Spectrometric Method<br>Hydride Generation/Inductively Coupled Plasma Method |

The standard values indicate the average concentratin in the year. But the standard value of the total cyanide means the maximum concentration. " not detectable " means that the concentration is below the quantitative limit measured by standard method in this table.
not detectable(*1):the quantitative limit is 0.1mg・$l^{-1}$.
not detectable(*2):the quantitative limit is 0.0005mg・$l^{-1}$.

## Table4-2 Monitaring Items and Their Guideline Values

| Items | Guideline Value | Water Quality Standards Value for Drinking Water | WHO Drinking Water Guideline Value |
|---|---|---|---|
| Chloroform | less than 0.06mg・$l^{-1}$ | less than 0.06mg・$l^{-1}$(a) | 0.2mg・$l^{-1}$ |
| trans-1,2-Dichloroethylene | less than 0.04mg・$l^{-1}$ | less than 0.04mg・$l^{-1}$(a) | 0.05mg・$l^{-1}$ |
| 1,2-Dichloropropane | less than 0.06mg・$l^{-1}$ | less than 0.06mg・$l^{-1}$(b) | 0.02mg・$l^{-1}$ |
| p-Dichlorobenzen | less than 0.3mg・$l^{-1}$ | less than 0.3mg・$l^{-1}$(b) | 0.3mg・$l^{-1}$(P) |
| Isoxathion | less than 0.008mg・$l^{-1}$ | less than 0.008mg・$l^{-1}$(b) | |
| Diazinon | less than 0.005mg・$l^{-1}$ | less than 0.005mg・$l^{-1}$(b) | |
| Fenitrothion(MEP) | less than 0.003mg・$l^{-1}$ | less than 0.003mg・$l^{-1}$(b) | |
| Isoprothiolane | less than 0.04mg・$l^{-1}$ | less than 0.04mg・$l^{-1}$(b) | |
| Oxine-copper | less than 0.04mg・$l^{-1}$ | | |
| Chlorothalonil(TPN) | less than 0.04mg・$l^{-1}$ | less than 0.04mg・$l^{-1}$(b) | |
| Propyzamide | less than 0.008mg・$l^{-1}$ | less than 0.008mg・$l^{-1}$(b) | |
| EPN | less than 0.006mg・$l^{-1}$ | less than 0.006mg・$l^{-1}$(b) | |
| Dichlorvos(DDVP) | less than 0.01mg・$l^{-1}$ | less than 0.01mg・$l^{-1}$(b) | |
| Fenobucarb(BPMC) | less than 0.02mg・$l^{-1}$ | less than 0.02mg・$l^{-1}$(b) | |
| Iprobenfos(IBP) | less than 0.008mg・$l^{-1}$ | less than 0.008mg・$l^{-1}$(b) | |
| Chlornitrofen(CNP) | − | − | |
| Toluene | less than 0.6mg・$l^{-1}$ | less than 0.6mg・$l^{-1}$(b) | 0.7mg・$l^{-1}$ |
| Xylene | less than 0.4mg・$l^{-1}$ | less than 0.4mg・$l^{-1}$(b) | 0.5mg・$l^{-1}$ |
| Di-2-ethylhexyl phthalate | less than 0.06mg・$l^{-1}$ | less than 0.06mg・$l^{-1}$(b) | |
| Boron | less than 0.2mg・$l^{-1}$ | less than 0.2mg・$l^{-1}$(b) | 0.3mg・$l^{-1}$ |
| Fluoride | less than 0.8mg・$l^{-1}$ | less than 0.8mg・$l^{-1}$(a) | 1.5mg・$l^{-1}$ |
| Nickel | less than 0.01mg・$l^{-1}$ | less than 0.01mg・$l^{-1}$(b) | 0.02mg・$l^{-1}$ |
| Molybdenum | less than 0.07mg・$l^{-1}$ | less than 0.07mg・$l^{-1}$(b) | 0.07mg・$l^{-1}$ |
| Antimony | less than 0.002mg・$l^{-1}$ | less than 0.002mg・$l^{-1}$(b) | 0.005mg・$l^{-1}$(P) |
| Nitrate and Nitrite | less than 10mg・$l^{-1}$ | less than 10mg・$l^{-1}$(b) | 50mg・$l^{-1}$(Nitrate)(*)<br>3mg・$l^{-1}$(Nitrite)(P)(*) |

Water Quality Standard Value for Drinking Water (a):Standard Items   Standard Value
Water Quality Standard Value for Drinking Water (b):Monitoring Items   Guigeline Value
WHO Drinking Water Guideline Value (P) : Provisional Value
(*) $\frac{\text{Nitrate}}{50} + \frac{\text{Nitrite}}{3} \leqq 1$

Table 4-3 Number of Points Exceeding Environmental Quality Standards for Water-Items Related to the Protection of Human Health in 1995

| Items | Rivers | | | Lakes and Ponds | | | Sea Areas | | |
|---|---|---|---|---|---|---|---|---|---|
| | a:Number of Points Exceeding ESV* | b:Number of Sampling Points | a/b: Ratio (%) | a:Number of Points Exceeding ESV* | b:Number of Sampling Points | a/b: Ratio (%) | a:Number of Points Exceeding ESV* | b:Number of Sampling Points | a/b: Ratio (%) |
| Cadmium | 1 | 3, 463 | 0. 03 | 0 | 253 | 0 | 0 | 1, 172 | 0 |
| Total Cyanide | 1 | 3, 170 | 0. 03 | 0 | 231 | 0 | 0 | 945 | 0 |
| Lead | 9 | 3, 567 | 0. 25 | 0 | 253 | 0 | 0 | 1, 182 | 0 |
| Hexavalent Chromium | 0 | 3, 206 | 0 | 0 | 229 | 0 | 0 | 1, 073 | 0 |
| Arsenic | 26 | 3, 492 | 0. 74 | 1 | 252 | 0. 40 | 0 | 1, 153 | 0 |
| Total Mercury | 0 | 3, 332 | 0 | 0 | 235 | 0 | 0 | 1, 153 | 0 |
| Alkyl Mercury | 0 | 1, 368 | 0 | 0 | 129 | 0 | 0 | 562 | 0 |
| Polychlorobiphenyl | 0 | 1, 798 | 0 | 0 | 116 | 0 | 0 | 616 | 0 |
| Dichloromethane | 3 | 2, 742 | 0. 11 | 0 | 150 | 0 | 0 | 739 | 0 |
| Tetrachloroethane | 0 | 2, 815 | 0 | 0 | 161 | 0 | 0 | 736 | 0 |
| 1, 2-Dichloroethane | 0 | 2, 739 | 0 | 0 | 150 | 0 | 1 | 728 | 0. 14 |
| 1, 1-Dichloroethylene | 0 | 2, 730 | 0 | 0 | 150 | 0 | 0 | 726 | 0 |
| cis-1, 2-Dichloroethylene | 0 | 2, 739 | 0 | 0 | 150 | 0 | 0 | 726 | 0 |
| 1, 1, 1-Trichloroethane | 0 | 2, 843 | 0 | 0 | 161 | 0 | 0 | 743 | 0 |
| 1, 1, 2-Trichloroethane | 0 | 2, 738 | 0 | 0 | 150 | 0 | 0 | 727 | 0 |
| Trichloroethylene | 0 | 3, 043 | 0 | 0 | 172 | 0 | 0 | 761 | 0 |
| Tetrachloroethylene | 1 | 3, 047 | 0. 03 | 0 | 172 | 0 | 0 | 766 | 0 |
| 1, 3-Dichloropropene | 0 | 2, 825 | 0 | 0 | 154 | 0 | 0 | 711 | 0 |
| Thiram | 0 | 2, 793 | 0 | 0 | 153 | 0 | 0 | 709 | 0 |
| Simazine | 0 | 2, 817 | 0 | 0 | 153 | 0 | 0 | 702 | 0 |
| Thiobencarb | 0 | 2, 812 | 0 | 0 | 153 | 0 | 0 | 697 | 0 |
| Benzene | 0 | 2, 716 | 0 | 0 | 150 | 0 | 0 | 731 | 0 |
| Selenium | 1 | 2, 696 | 0. 04 | 0 | 147 | 0 | 0 | 774 | 0 |
| Total | 41 | 3, 973 | 1. 03 | 1 | 260 | 0. 38 | 1 | 1, 238 | 0. 08 |

* Environmental Quality Standards Value

Table 4-4 Transition of Number of Points Exceeding Environmental Quality Standards for Water-Items Related to the Protection of Human Health (Assesment in Cnformity to New Environmental Quality Standard Value)

| Items | 1995 | | | 1994 | | | 1993 | | |
|---|---|---|---|---|---|---|---|---|---|
| | a:Number of Points Exceeding ESV* | b:Number of Sampling Points | a/b: Ratio (%) | a:Number of Points Exceeding ESV* | b:Number of Sampling Points | a/b: Ratio (%) | a:Number of Points Exceeding ESV* | b:Number of Sampling Points | a/b: Ratio (%) |
| Cadmium | 1 | 4,888 | 0.02 | 1 | 4,910 | 0.02 | 1 | 5,171 | 0.02 |
| Total Cyanide | 1 | 4,346 | 0.02 | 1 | 4,340 | 0.02 | 1 | 4,517 | 0.02 |
| Lead | 9 | 5,002 | 0.18 | 10 | 5,017 | 0.20 | 7 | 5,174 | 0.14 |
| Hexavalent Chromium | 0 | 4,508 | 0 | 0 | 4,520 | 0 | 0 | 4,758 | 0 |
| Arsenic | 27 | 4,897 | 0.55 | 28 | 4,874 | 0.57 | 16 | 5,004 | 0.32 |
| Total Mercury | 0 | 4,720 | 0 | 0 | 4,722 | 0 | 0 | 4,918 | 0 |
| Alkyl Mercury | 0 | 2,059 | 0 | 0 | 2,179 | 0 | 0 | 2,267 | 0 |
| Polychlorobiphenyl | 0 | 2,530 | 0 | 0 | 2,451 | 0 | 0 | 2,463 | 0 |
| Dichloromethane | 3 | 3,631 | 0.08 | 4 | 3,510 | 0.11 | 2 | 2,496 | 0.08 |
| Tetrachloroethane | 0 | 3,712 | 0 | 1 | 3,598 | 0.03 | 1 | 2,695 | 0.04 |
| 1,2-Dichloroethane | 1 | 3,617 | 0.03 | 4 | 3,506 | 0.11 | 4 | 2,497 | 0.16 |
| 1,1-Dichloroethylene | 0 | 3,606 | 0 | 0 | 3,496 | 0 | 0 | 2,496 | 0 |
| cis-1,2-Dichloroethylene | 0 | 3,615 | 0 | 0 | 3,502 | 0 | 0 | 2,497 | 0 |
| 1,1,1-Trichloroethane | 0 | 3,747 | 0 | 0 | 3,639 | 0 | 0 | 2,936 | 0 |
| 1,1,2-Trichloroethane | 0 | 3,615 | 0 | 0 | 3,501 | 0 | 0 | 2,601 | 0 |
| Trichloroethylene | 0 | 3,976 | 0 | 0 | 3,942 | 0 | 0 | 3,389 | 0 |
| Tetrachloroethylene | 1 | 3,985 | 0.03 | 1 | 3,942 | 0.03 | 1 | 3,396 | 0.03 |
| 1,3-Dichloropropene | 0 | 3,690 | 0 | 0 | 3,622 | 0 | 0 | 2,608 | 0 |
| Thiram | 0 | 3,655 | 0 | 0 | 3,593 | 0 | 0 | 2,681 | 0 |
| Simazine | 0 | 3,672 | 0 | 0 | 3,621 | 0 | 0 | 2,686 | 0 |
| Thiobencarb | 0 | 3,662 | 0 | 0 | 3,617 | 0 | 0 | 2,691 | 0 |
| Benzene | 0 | 3,597 | 0 | 0 | 3,496 | 0 | 1 | 2,494 | 0.04 |
| Selenium | 1 | 3,617 | 0.03 | 1 | 3,583 | 0.03 | 1 | 2,508 | 0.04 |
| Total | 43 | 5,471 | 0.79 | 47 | 5,516 | 0.85 | 33 | 5,708 | 0.58 |

* Environmental Quality Standards Value

Table 4-5 Transition of Disqualified Ratio of Points Exceeding Environmental Quality Standards for Water-Items Related to the Protection of Human Health (Assesment in Cnformity to New Environmental Quality Standard Value)

| Items | 1995 | | | 1994 | | | 1993 | | |
|---|---|---|---|---|---|---|---|---|---|
| | a:Number of Points Exceeding ESV* | b:Number of Sampling Points | a/b: Ratio (%) | a:Number of Points Exceeding ESV* | b:Number of Sampling Points | a/b: Ratio (%) | a:Number of Points Exceeding ESV* | b:Number of Sampling Points | a/b: Ratio (%) |
| Cadmium | 10 | 21,495 | 0.05 | 14 | 21,794 | 0.06 | 10 | 25,035 | 0.04 |
| Total Cyanide | 1 | 18,749 | 0.01 | 1 | 18,875 | 0.01 | 1 | 21,636 | 0 |
| Lead | 137 | 22,053 | 0.62 | 138 | 22,231 | 0.62 | 87 | 24,906 | 0.35 |
| Hexavalent Chromium | 0 | 18,894 | 0 | 0 | 19,104 | 0 | 0 | 22,061 | 0 |
| Arsenic | 193 | 20,846 | 0.93 | 190 | 20,861 | 0.91 | 143 | 22,961 | 0.62 |
| Total Mercury | 0(17§) | 22,463 | 0 | 0(6§) | 22,915 | 0 | 0(0§) | 27,545 | 0 |
| Alkyl Mercury | 0 | 5,598 | 0 | 0 | 6,216 | 0 | 0 | 6,606 | 0 |
| Polychlorobiphenyl | 0 | 4,109 | 0 | 0 | 4,012 | 0 | 0 | 3,821 | 0 |
| Dichloromethane | 15 | 9,992 | 0.15 | 17 | 9,497 | 0.18 | 6 | 4,594 | 0.13 |
| Tetrachloroethane | 0 | 11,297 | 0 | 1 | 10,917 | 0.01 | 1 | 6,298 | 0.02 |
| 1,2-Dichloroethane | 3 | 9,969 | 0.03 | 27 | 9,502 | 0.28 | 9 | 4,541 | 0.20 |
| 1,1-Dichloroethylene | 0 | 9,954 | 0 | 0 | 9,479 | 0 | 0 | 4,538 | 0 |
| cis-1,2-Dichloroethylene | 0 | 9,964 | 0 | 0 | 9,487 | 0 | 0 | 4,553 | 0 |
| 1,1,1-Trichloroethane | 0 | 11,647 | 0 | 0 | 11,264 | 0 | 0 | 7,473 | 0 |
| 1,1,2-Trichloroethane | 1 | 9,964 | 0.01 | 1 | 9,487 | 0.01 | 0 | 4,760 | 0 |
| Trichloroethylene | 5 | 14,519 | 0.03 | 6 | 14,717 | 0.04 | 6 | 12,529 | 0.05 |
| Tetrachloroethylene | 8 | 14,528 | 0.06 | 5 | 14,716 | 0.03 | 1 | 12,535 | 0.01 |
| 1,3-Dichloropropene | 0 | 9,958 | 0 | 0 | 9,602 | 0 | 0 | 4,361 | 0 |
| Thiram | 0 | 9,764 | 0 | 0 | 9,462 | 0 | 0 | 4,435 | 0 |
| Simazine | 1 | 9,800 | 0.01 | 3 | 9,570 | 0.03 | 0 | 4,449 | 0 |
| Thiobencarb | 1 | 9,804 | 0.01 | 0 | 9,592 | 0 | 0 | 4,541 | 0 |
| Benzene | 1 | 9,601 | 0.01 | 2 | 9,153 | 0.02 | 3 | 4,242 | 0.07 |
| Selenium | 13 | 9,526 | 0.14 | 11 | 9,295 | 0.12 | 1 | 4,245 | 0.02 |
| Total | 389 | 294,491 | 0.13 | 416 | 291,748 | 0.14 | 268 | 242,575 | 0.11 |

* Environmental Quality Standards Value

§ Number of sampling points exceeded Environmental Quality Standards Value at $0.0005 mg \cdot l^{-1}$

Table 4-6 Classification According to Their Carcinogenic Potential

| Items | IARC(*1) | U.S. EPA(*2) |
|---|---|---|
| Cadmium | 2A | D |
| Lead(Inorganic Lead) | 2B | B2 |
| Lead(Organic Lead) | 3 | B2 |
| Hexavalent Chromium | 1 | D |
| Arsenic | 1 | A |
| Mercury | | D |
| Dichloromethane | 2B | B2 |
| Carbon Tetrachloride | 2B | B2 |
| 1, 2-Dichloroethane | 2B | B2 |
| 1, 1-Dichloroethylene | 3 | B2 |
| cis-1, 2-Dichloroethylene | | D |
| 1, 1, 1-Trichloroethane | 3 | D |
| 1, 1, 2-Trichloroethane | 3 | C |
| Trichloroethylene | 3 | B2 |
| Tetrachloroethylene | 2B | B2 |
| 1, 3-Dichloropropene | 2B | B2 |
| Simazine | | C |
| Benzene | 1 | A |
| Selenium | 3 | |
| Chloroform | 2B | B2 |
| trans-1, 2-Dichloroethylene | | D |
| 1, 2-Dichloropropane | 3 | 2 |
| p-Dichlorobenzen | 2B | D |
| Diazinon | | E |
| Chlorothalonil (TNP) | | B2 |
| Dichlorvos(DDVP) | 3 | B2 |
| Toluene | | D |
| Xylene | | D |
| Boron | | D |
| Fluoride | 3 | |
| Nickel | 3 | D |
| Molybdenum | | D |
| Antimony | | D |

# Chapter 5 ENVIRONMENTAL QUALITY STANDARDS FOR WATERS

## --- STANDARDS RELATED TO CONSERVATION OF LIVING ENVIRONMENT ---

### 1. Basic Concept for the Legislation

#### 1.1 Background

Under the Basic Environment Law, environmental water quality standards consist of items that deal mainly with the protection of human health and conservation of living environment. For the protection of human health uniform standards were set for all public water bodies, while for the conservation of living environment the standards were set considering the type of water body and its water use.

Public water bodies can be categorized into three kinds that are rivers, Lakes and coastal waters. Each type of water body is further categorized into several groups, based on the water usage, and the standards were fixed for each group.

The classification method was introduced for the conservation of living environment, because the standards should be associated with wide and diverse water usage. In other words, it is considered inappropriate to set a uniform standard for water pollution control. The word "living environment" is defined as wider than usual, because it include properties of natural living things deeply related to human life and its surrounding environment. Domestic and industrial water supply, agriculture and fishery are within the range of the definition.

Therefore, each water category corresponds to various purposes such as conservation of natural environment, water supply, fishery, industrial water, agriculture and water conservation of environment. The categorization and classification were carried out referring exiting standards and establishing standards at the same time, as listed below.

1) Standards for fishery (1965)
2) Drinking water standards (1970)
3) Standards for agricultural water (1970)
4) Standards for industry water (1971)

Six categories for rivers, four categories for lakes, and three categories for coastal waters were set for the standards. Later nitrogen and phosphorus standards were included for lakes and coastal waters to deal with eutrophication problem.

#### 1.2 Standards as an Administrative Goal

The environmental water quality standard is an administrative goal or regulations that express a desirable situation maintained. However it is not simply an ideal vision but the goal which should be attained and maintained by implementing effective measures.

From the viewpoint of living environment, the standards should be satisfied under normal conditions. Under exceptional conditions such as drought, the standards might not be satisfied. Although it is possible to set standards as the maximum allowable limit, and the established standard were taken as desired one to be maintained. Therefore, in case of less pollution, the standards should established not such that causing deterioration of water environment.

### 1.3 Designation of category of Water Bodies

Water bodies can be classified into different groups according to the water use. The different categories were designated in 1971, since then, these are authorized by prefecture authorities, except 47 interstate water regions, i.e., 37 rivers such as Kitakami river and 10 coastal waters including Tokyo Bay.

Before designation of each category the following points were considered.

* Water Pollution problems
* Present as well as future water usage
* Pollution conditions and the location of pollution source
* Categorization of water body according to the present level of pollution
* Designation of compliance period according to the present status of pollution control technologies.

### 1.4 Compliance Period

It is defined in Notification Letter no. 126 from environmental agency 1985. Water quality standard is an administrative goal therefore the determined period to achieve the desired level of water quality is needed. But the determined or compliance period should not be considered as established or fixed time, but it should be enforced as early as possible but for the protection of human health. For the conservation of living environment, the compliance period should be defined according to the present level of pollution, population and industrial developments. The normal compliance period should be no further than five years, if in case it is not possible to achieve the desired water quality standards within five years, relaxation of extra 5 years can be provided but the final period should be fixed. Each water body has its own characteristics. Therefore compliance period will have to be individually tailored.

In case of Lake Water quality, if the desired standards would not achieved within 10 years, the government has to set a tentative pollution level for the next five-year period and then the level should be subsequently improved. The water bodies excluding in previous, once the water quality standard were set, the water pollution control should be hastened to achieve better standards. In 1995, more than 40% of polluted water bodies in Japan were applied for certain compliance period.

### 1.5 Amendment/rechecking of Water Quality Standards

The water quality standards should not rigidly fixed; it can be amended considering following viewpoints.

1. Improvement and amendment in water quality standards based on rational and scientific approaches.
2. Incorporation of additional water quality parameters, according to the additional pollution source, example organochlorines (pesticide) and arsenic and lead for human health.
3. Exclusion of water quality parameters that are banned, such as organophosphorus pesticides were omitted to use, their standards would be excluded.
4. Changes in water use
5. Considering compliance period according to the usage
6. If present standard is at higher level but the specified category was lower, the category should be increased to the higher one. In Japan about 20 years ago, usage of many water bodies were changed, but standards were not amended only until recently, amendment in standards were made for water bodies having inconsistency in present water usage and the designated category of water quality standard. Nitrogen and phosphorus standards were added to prevent coastal water and lakes eutrophication

2. Water quality standards for different water bodies

The water quality items considered are pH, DO, BOD, COD, Coliform groups and N-Hexane Extract. Total Nitrogen and Phosphorus were added to standards to prevent eutrophication in lakes in 1982 and for coastal waters in 1993 respectively.

The following points were considered for selecting the water quality items.

1) Several common water quality items were considered to establish ambient water quality standards. Less common items such as electric conductivity, Total Nitrogen, color, manganese and irons are not considered

2) pH and DO are important parameters for agriculture use of river and lakes waters while Ecoli and COD for coastal waters. Oil has also been added as a standard for coastal waters, because of important significance for fisheries.

3) BOD for rivers and COD for lakes and coastal water were taken as index of organic pollution, COD is selected for lakes and coastal waters instead of BOD, because of following reasons.

* The lack of BOD monitoring data compared to COD (Mn).
* Mostly COD (Mn) data is available at intake of water treatment plants to account the quality of raw water for drinking purpose.
* For coastal water alkali-permanganate method was quite commonly used to monitor the organic pollution, therefore when standards were established, these points were taken into consideration.
* Standard method for BOD analysis for sea and Lake Waters are also not well established. COD is considered more suitable than BOD, as it can account the organic pollution due to phytoplanktons.
* In the closed water bodies such as lakes, because of long retention time, biological degradation of organic matter is also different i.e., much slowly than rivers, therefore five day BOD test was not found suitable, COD is rather proper for organic pollution index.
* Although there is a limited data to correlate COD (Mn) and BOD, as shown in Fig. 5.1, and also no fixed relationship between the two was observed.

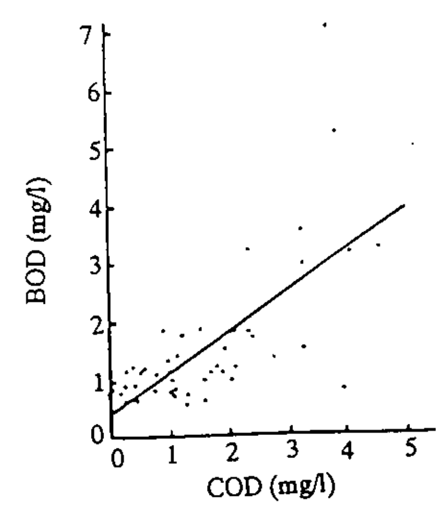


Fig. 5.1 Relationship between BOD and $COD_{Mn}$ for Coastal Waters

2.1 Water Quality Standards for River

Water quality standards for river are listed in Table 5.1. Five important water quality items such as pH and BOD, and six categories from AA to E. Reservoirs of capacity less than 10 million cubic meters have been dealt as a river instead of lake. All standards are defined as the daily average values. The reason for the standard for each item were described as following:

TABLE 5-1 Water quality standards for river related to the conservation of the living environment

| Category | Item / Purposes of water use | Standard values | | | | |
|---|---|---|---|---|---|---|
| | | pH | BOD | SS | DO | Number of coliform groups |
| AA | Water supply, class 1 conservation of natural environment, and uses listed in A-E | 6.5-8.5 | 1mg/ℓ or less | 25mg/ℓ or less | 7.5mg/ℓ or more | 50MPN/100ml or less |
| A | Water supply, class 2 fishery, class 1 bathing and uses listed in B-E | 6.5-8.5 | 2mg/ℓ or less | 25mg/ℓ or less | 7.5mg/ℓ or more | 1000MPN/100ml or less |
| B | Water supply, class 3 fishery, class 2 and uses listed in C-E | 6.5-8.5 | 3mg/ℓ or less | 25mg/ℓ or less | 5mg/ℓ or more | 5000MPN/100ml or less |
| C | Fishery, class 3 industrial water, class and uses listed in D-E | 6.5-8.5 | 5mg/ℓ or less | 50mg/ℓ or less | 5mg/ℓ or more | – |
| D | Industrial water, class agricultural water and uses listed in E | 6.0-8.5 | 8mg/ℓ or less | 100mg/ℓ or less | 2mg/ℓ or more | – |
| E | Industrial water, class conservation of the environment | 6.0-8.5 | 10mg/ℓ or less | Floating Matter such as garbage should not be observed | 2mg/ℓ or more | – |

(BOD : Biochemical Oxygen Demand, SS : Suspended Solids, DO : Dissolved Oxygen)

Notes : 1.The standard value is based on the daily average value. The same applies to the standard values of lakes and coastal waters.

2.At intake for agriculture, ph shall be between 6. 0 and 7. 5 and DO shall not be less than 5mg/ℓ The same applies to the standard values of lakes.

1) pH

Generally pH of the rivers in Japan is around 7, barring estuaries. As it can be shown in Figure 5.2, at most water intake facilities of more than 5000 m3/days, pH was around 7.0. pH above than 8.5, interferes chlorination in water treatment plant as well as causes corrosion in distribution system. To ensure prevention of corrosion in treatment plant and distribution system pH range 6.5-8.5 is desirable. pH outside the abovementioned range also causes irritation of eyes of swimmer and also retards the growth of plants and marine organisms. Low pH affects the root of rice plant owing to the dissolution of salts, while high pH causes decoloration of leaves. Generally speaking the optimum pH range for proper plant growth should between 6.5-7.5, therefore pH standard at the intake point for agriculture use is set as 6.0-7.5.

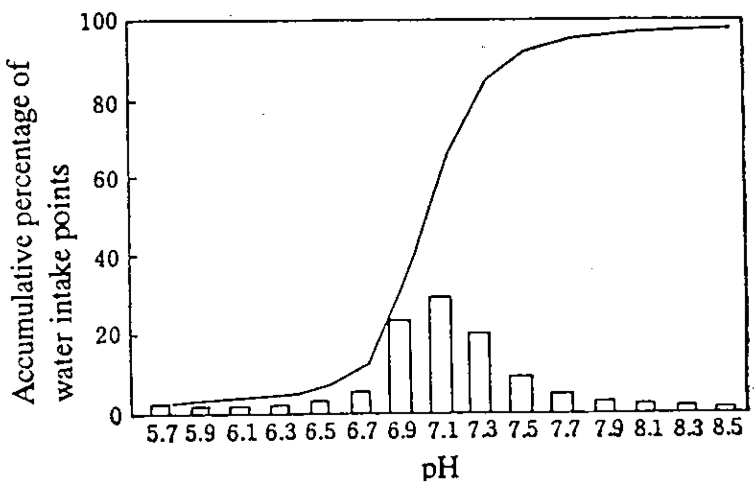


Fig. 5-2 Distribution of pH values at intake points for water supply

2) BOD

The BOD standards have been selected mainly considering the self-purification aspect of the rivers. BOD less than 1 mg/L can be assumed by nonanthropogenic sources and considered for conservation of natural resources. As it is shown in Table 5-2, that about 31.4 %, 29.9% and 13.8% of drinking water sources in Japan have BOD less than 1 mg/L, 2mg/L and 3 mg/L respectively. BOD more than 3 mg/L affects primary sedimentation and filtration processes in conventional water treatment plants, resulting in upgradation to advanced water treatment. Therefore for class 2 and 3, BOD standards are set as 2 and 3 mg/L respectively.

For fisheries class I, BOD would be less than 1 mg/L, as Oligosaprobic fish such as salmon and smelt survive at BOD less than 2 mg/L, For fisheries class II, BOD would be less than 2 mg/L, as Omesoprobic fish such as carp survive at BOD less than 3 mg/L, For fisheries class III, BOD would be less than 3 mg/L, as class III fisheries survive at BOD less than 5 mg/L. For the conservation of environment, of class E, BOD should be less than 10 mg/L to prevent odor caused by the anaerobic decomposition of organic matter.

TABLE 5-2 Potassium Permanganate Consumption value at Surface Water Intake Points For Water supply in 1967

| $KMnO_4$ Consumption | 0 ~ 4.0mg/l | 4.1 ~ 8.0mg/l | 8.1 ~ 12.0mg/l | 12.1mg/l ~ | Total |
|---|---|---|---|---|---|
| Estimated BOD | ~ 1mg/l | 1~2mg/l | 2~3mg/l | 3mg/l ~ | |
| Number of water intake points (%) | 154 (40.2) | 150 (39.2) | 5 (13.0) | 29 (7.6) | 383 (100) |
| Average Intake Water $x10^3m^3/d$ (%) | 3409 (31.2) | 3267 (29.9) | 2731 (25.0) | 1511 (13.8) | 10913 (100) |

Note Assuming that the ratio of BOD to $COD_{Mn}$ is 1 in the BOD range of 1~3mg/l

3) SS

Related to the growth of aquatic organisms, generally SS should be less than 25 mg/L to prevent any harmful effect to the aquatic environment (Table 5-3). SS concentration more than 50 mg/L affect the proper functioning of gills of fish. Turbidity less than 30 NTU, equivalent to 30 mg/L SS required for proper functioning slow sand filtration. Therefore SS standards of 25 mg/L and 50 mg/L were adopted for water supply use and fisheries respectively.

SS are also significant for agriculture water use, as high SS disperse the soil pore size and causes decrease in permeability. From the field results, 3-cm deposition is reported to be permissible, therefore SS standards for agriculture water are restricted to 100 mg/L. From the viewpoint of environmental conservation, no SS limitations were provided, but it should be free of materials such as solid refuse and floating solids that produce undesirable physiological responses to human beings.

TABLE 5-3 Effects of SS on Fisheries

| SS | Effects |
|---|---|
| ~25 mg/l | No effects |
| 25~80mg/l | Good enough |
| 80~400mg/l | Poor fishery |
| 400mg/~ | Not possible |

Report by EIFAC
(European Inland Fisheries Advisory Commission)

4) DO

The DO standards were formulated considering fisheries criteria. The national committee on resources on water pollution control established guidelines in 1958 on DO for water use as shown in Table 5.4. Relatively good water bodies have more than 7.5 mg/L of DO. For fisheries, hatching of salmon and trout requires more than 7mg/L of DO, other organisms also require more than 6 mg/L of DO. In Ohio State, the DO standard for fisheries is 5 mg/L, therefore for fishery class 3 same standard were adopted in Japan.

For agriculture use, DO should be more than 5 mg/L, as DO less than 5 mg/L interferes root growth. For the conservation of environment, DO should be kept more than 2 mg/L to prevent anaerobic conditions that causes bad odors.

TABLE 5-4 Guidelines of water quality classification and water usage
(Council on Resources, 1958)

| Class | DO (mg/l) | Water usage |
|---|---|---|
| A | 7.5 or more | Bathing, Water supply |
| B | 7.5 or more | Bathing, Water supply, Industrial water, Fishery |
| C | 5 or more | Industrial water, Fishery, Agricultural water |
| Limit | 5 | |
| D | | Industrial water after treatment with sedimentation and settling, Agricultural water |
| E | | Not suitable for water supply and fishery, Industrial water after advanced treatment, questionable for agricultural water |

5) Coliforms

Indicator organism, coliforms itself not harmful for human health, but has been used as an indicator for existence of pathogenic bacteria. For drinking water standard, coliform organisms should be non-existent, and MPN equal to 1/100 ml at the normal expected efficiency of 98% kill during chlorination. Therefore safety limit to control for chlorination is 50 MPN/100mL to disinfect coliforms.

The council on living environment in the Ministry of Health and Welfare reports that removal rate of coliforms is 99%, 95% by slow and rapid sand filter, if the advanced maintenance is available for rapid sand filter it can be increase to 98%. Based on these removal rates, water supply class 2 in which normal operation and management is expected the standard was set as 1000 MPN /100 ml for class 2. For water supply of class 3 in which high level management and operation can be expected, the limit is around 2500-5000, therefore the standard were set as 5000 MPN/100 ml. For bathing 1000 MPN/100 ml was considered as standard.

## 2.2 Water Quality Standards for Lake

Lake includes natural lakes or artificial reservoir having more than 10 million cum capacity. As shown in Table 5.5, seven water quality items are selected including total nitrogen and phosphorus. There are four categories from AA to C are set for water quality items such as pH and COD. There are five categories for nitrogen and phosphorus. Standard value of five water qualities are defined as daily average value, total nitrogen and phosphorus are defined as annual average. pH and Ecoli standards follow the scientific background as that for river standards. The discussion on total nitrogen and phosphorus standards values is shown in Chapter 6.

TABLE 5-5 Water Quality Standards for Lakes Related to the Conservation of the Living Environment

Lakes (natural lakes and artificial lakes (10 million cubic meters of water or more)

| Category | Item / Purposes of water use | Standard values: pH | COD | SS | DO | Number of coliform groups |
|---|---|---|---|---|---|---|
| AA | Water supply, class 1<br>fishery, class 1<br>conservation of natural environment, and uses listed in A-C | 6.5-8.5 | 1mg/ℓ or lsee | 1mg/ℓ or lsee | 7.5mg/ℓ or more | 50MPN/100ml or less |
| A | Water supply, class 2, 3<br>fishery, class 2<br>bathing and uses listed in B-C | 6.5-8.5 | 3mg/ℓ or lsee | 5mg/ℓ or lsee | 7.5mg/ℓ or more | 1000MPN/100ml or less |
| B | Fishery, class 3<br>industrial water, class agricultural water and uses listed in C | 6.5-8.5 | 5mg/ℓ or lsee | 15mg/ℓ or lsee | 5mg/ℓ or more | – |
| C | Industrial water, class conservation of the environment | 6.5-8.5 | 8mg/ℓ or lsee | Floating matter such as garbage shall not be observed | 2mg/ℓ or more | – |

(COD : Chemical Oxygen Demand, SS : Suspended Solids, DO : Dissolved Oxygen)

Lakes (Cantinued)

| Category | Items / Purpose of water use | Standard values: Total nitrogen | Total phosphorus |
|---|---|---|---|
| I | Conservation of natural environment and uses listed in II-V | 0.1mg/ℓ or less | 0.005mg/ℓ or less |
| II | Water supply classes 1, 2 and 3 (excluding special types) ; fishery class 1 ; bathing and uses listed in III-V | 0.2mg/ℓ or less | 0.01mg/ℓ or less |
| III | Water supply class 3 (special typse) and uses listed in IV-V | 0.4mg/ℓ or less | 0.03mg/ℓ or less |
| IV | Fishery class 2 and uses listed in V | 0.6mg/ℓ or less | 0.05mg/ℓ or less |
| V | Fishery class 3 ; industrial water conservation of the environment | 1mg/ℓ or less | 0.1mg/ℓ or less |

Notes :

1. Standard values are set in terms of annual averages.
2. Standard values for total nitrogen are applicable to lakes and reservoirs where nitrogen limits phytoplank ton growth.
3. Standard values for total phosphorus are not applicable to agricultural water uses.

1) COD (Mn)

COD (Mn) considered as organic pollution index for phytoplankton growth. COD less than 1 mg/L can assumed to be caused by non-anthropogenic pollution and the condition was found suitable for natural environment conservation. According to the drinking water law, the standard value for KMnO4 consumption is 10 mg/L, that is equivalent to 2.5 mg/L of COD. From the survey conducted by the Ministry of Health and Welfare, it was found out that for most lakes utilized for drinking water source have COD less than 3 mg/L, as shown in Table 5.6.

TABLE 5-6 Potassium Permanganate Consumption at Lake water Intake Points for Water Supply in 1967

| $KMnO_4$ Consumption | 0 ~ 4.0mg/l | 4.1 ~ 8.0mg/l | 8.1 ~ 12.0mg/l | 12.1mg/l ~ |
|---|---|---|---|---|
| $COD_{Mn}$ | ~1.0mg/l | 1.1 ~ 2.0mg/l | 2.1 ~ 3.0mg/l | 3.1mg/l ~ |
| Number of water intake point (%) | 29 (42.0) | 26 (37.6) | 12 (17.3) | 2 (2.8) |
| Average Intake Water $x10^3m^3/d$ (%) | 2166 (67.1) | 756 (23.4) | 273 (8.4) | 27 (0.8) |
| Total Number of Water Intake points= 64 · Total Intake Water = $3,224,400m^3/d$ | | | | |

Data for water supply authorities whose population in service were more than 5000.

Water quality for fishery was categorized into Oligotrophs and eutrophs. In Oligotrophic lakes having very clear water, COD should be less than 1 mg/L required for breeding of oligosaprobic fish such as rainbow trout. In general Oligotrophic and eutrophic lake for oligosaprobic fish such as smelt, COD should be less than 3mg/L. In eutrophic lake where carp habitats, the COD should be less than 5 mg/L according to the water quality standards for fisheries, 1965. To prevent any nuisance during bathing COD should be less than 8 mg/L. For agricultural use, high COD interferes the oxygen transfer to the soil resulting death of rice plant in paddy. Experimental result also shows that COD less than 6 mg/L was desirable for agriculture use. For industrial use and conservation of environment, 8 mg/L of COD was acceptable.

2) SS

Related to the growth of aquatic life. Generally speaking, if transparency (Secchi Depth) is more than 3 meters, the SS concentration is assumed to be less than 1 mg/L. For Oligotrophic and eutrophic lakes the transparency should be less and more than 5 m respectively. According to the OECD criteria, the annual average transparency is 1.5-3 m for eutrophic lake and more than 6 meter for oligotrophic lake. These standard values are determined considering the representative lake in Japan such as Lake Biwa, Lake Suwa, and Lake Imba. Therefore, for the purpose of natural conservation of environment the SS should be less than 1 mg/L. From the viewpoint of environmental conservation, no SS limitations were provided, but it should be free of materials such as solid refuse and floating solids that produce undesirable physiological responses to human beings.

3) DO

DO concentration is generally more than 7.5mg/L in clean lakes. The DO standard for fishery was set as 7.5 mg/L and 6 mg/L for smelt, salmon and carps. The acceptable DO limit for fisheries is 5 mg/L. In some case existing plankton cause lower DO in night, therefore DO limit is 5 mg/L. For the conservation of environment, DO should be kept more than 2 mg/L to anaerobic conditions that causes bad odors.

### 2.3 Water Quality Standards for Coastal Water Bodies

Seven water quality items were set for coastal water standards as shown in Table 5.7. Main use for coastal water is fisheries. Oil content, total nitrogen and phosphorus were also added for oil pollution and eutrophication control. The three categories A to C is set for general water quality parameters, such as COD. With respect to nitrogen and phosphorus four categories were set, similar to lake daily average values are applied for general water quality items while annual average value is applied for total nitrogen and phosphorus.

TABLE 5-7 Water Quality Standards for Coastal Waters related to the Conservation of the Living Environment

| Category | Item / Purposes of water use | Standard values | | | | |
|---|---|---|---|---|---|---|
| | | pH | COD | DO | Number of Coliform Groups | N-hexane Extracts (oil content etc.) |
| A | Fishery, class 1 ; bathing conservation of the natural environment, and uses listed in B-C | 7.8-8.3 | 2mg/ℓ or less | 7.5mg/ℓ or more | 1000MPN/ 100ml or less | Not detectable |
| B | Fishery, class 2 industrial water and the uses listed in C | 7.8-8.3 | 3mg/ℓ or less | 5mg/ℓ or more | — | Not detectable |
| C | Conservation of the natural environment | 7.0-8.3 | 8mg/ℓ or less | 2mg/ℓ or more | — | — |

(COD : Chemical Oxygen Demand, DO : Dissolved Oxygen)

Notes :

1. The permissible number of coliform groups for fishery class 1 for the cultivation of oysters shall be 70MPN/100 ml or less.

| Category | Items / Purpose of water use | Standard values | |
|---|---|---|---|
| | | Total nitrogen | Total phosphorus |
| I | Conservation of the natural environment and uses listed in II-IV (excluding fishery classes 2 and 3) | 0.2mg/ℓ or less | 0.02mg/ℓ or less |
| II | Fishery class 1, bathing and the uses listed in III-IV (excluding fishery class 3) | 0.3mg/ℓ or less | 0.03mg/ℓ or less |
| III | Fishery class 2 and the uses listed in IV (excluding fishery class 3) | 0.6mg/ℓ or less | 0.05mg/ℓ or less |
| IV | Fishery class 3, industrial water, and conservation of habltable environments for marine biota | 1mg/ℓ or less | 0.09mg/ℓ or less |

Notes :

1. Standard values are set in terms of annual averages.
2. Standard values are applicable only to marine areas where marine phytoplankton blooms may occur.

#### 1) pH

In general pH of coastal waters varies between 7.8 to 8.3. Standard values for category A and B were determined according to the natural conditions. Within this range aquatic plants and organisms thrive best and also the buffer capacity of coastal water is very high, the pH range of 7-8.3 is acceptable for the conservation of environment.

#### 2) COD

Related to the protection of fisheries due to red tide. Under stagnant water condition if the number of diatoms were found more than several thousand per liters, red tide was clearly recognized. Algal count less than 1000 /ml, equivalent to 1 mg/L COD is adequate to control red tide. If COD more than 3 mg/L and DO concentration less than 5 mg/L, fish growth was affected. For standard class A, 1 mg/L was subtracted from 3 mg/L to exclude the effect of algae and red tide. Therefore standard was 2 mg/L.

Seaweed culturing needs relatively low COD, based on monitoring COD data using alkali method, less than 3 mg/L COD is needed for proper growth of sea weed and control growth of filamentous bacteria. For industrial use COD should be less than 3 mg/l, if the water has been used for cooling purpose. For the conservation of environment 8 mg/L of COD was set to prevent bad odor caused by anaerobic decomposition.

4) DO

The DO concentration in coastal water is lower than that of rivers and lakes due to high salinity. For fisheries, more than 5 mg/L of DO is desirable, monitoring data, also showed that DO more than 7.5 mg/L was recorded under natural conditions. For the conservation of environment, DO should be kept more than 2 mg/L to prevent anaerobic conditions that causes bad odors.

5) Coliforms

The standard values are set based on the background of river standards. The permissible number of coliform group for fisheries class 1, and for the cultivation of oyster was 70 MPN/100 ml, derived from food and safety law by the ministry of health.

6) N -Hexane Extract

Represents the dissolved oily material in terms of normal hexane. Oil pollution problem in coastal water averts the consumption of fish due to odor problems. Oil film on the water surface interferes recreational bathing and respiration of marine organisms. The research report by STA (Science and Technology Agency) reported the relationship between the petroleum oil concentration and absorbed oil on fish. The limit of concentration to fish absorption is 0.01 to 0.1 mg/L. On the contrary Ministry of International Trade and Industry (MITI ) reported 0.2-3 mg/L, data from fishery agency reported 0.002-0.1 mg/L. It can be inferred that even for very low concentration, fisheries was affected, therefore it is necessary to keep the oil concentration as low as possible in coastal waters.

However there was no standard method available for determination of very low oil content. N-Hexane extract method (Japan Industry Method) has been commonly used. Detection limit of this method is 0.5 mg/L for 10-L sample, which is very low, therefore the standard value has been defined as non-detected. The present method cannot be applicable to determine the oil pollution in rivers and lakes, because of the interference of other form of organic matters. Therefore this method is only applicable for the detection of oil in marine waters.

3. Future amendments/ modification

There have been several revisions and amendments carried out, however still arguments are existing to develop the rational standards. The following problems need to be discussed for future modifications:

3.1 Coastal Waters

DO standard was set as 7.5 mg/L for category A, but even under normal condition in summer DO does not satisfy the standard. Since salinity and temperature affected DO concentration, therefore saturation percentage can be applied as the standard value. In stagnant coastal region the DO concentration is affected by photosynthesis, although the water quality was deteriorated, but DO satisfies standard. Therefore upper DO limit should also be set as the standard. The COD standards for category C has been set as 8 mg/L, but it seemed to be relatively high, it can be possible to include new category between B and C. The standard should be different for coastal waters closed to the land, as exchange of waters is less. Therefore the standards C should be divided into two parts, one for nearby coastal area and the other for the nearby main sea.

The detection limit of N-Hexane method is very high, therefore some other sensitive analytical method needs to be developed that doesn't consume hazardous chemicals.

### 3.2 Coliform Analytic methods

Coliform counting group has been used as the indicator for fecal pollution, the present analytical method counts total coliform rather than fecal coliform. The monitoring data may not correspond to actual fecal pollution. The water quality standards for bathing already introduced fecal coliform count as an index.

### 3.3 Organic pollution index

Different water pollution indices were used for different water environment. Like in river BOD has been considered as organic pollution indicator, but for lake and coastal water bodies COD. This causes inconstancy in management of interconnected water environment. Therefore a common indicator needs to be developed for water environment. Although it is necessary to accumulate the monitoring data based on new indicator. COD (Mn) method was adopted only in Japan but COD dichromate is commonly used in other countries. Therefore a precise quantitative relationship needs to be developed between these parameters. For COD (Mn) measurement, if COD concentration is low, acid method was not accurate, as it is mainly developed for high concentration.

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# Chapter 6 ENVIRONMENTAL QUALITY STANDARDS FOR WATERS

## --- NITROGEN AND PHOSPHORUS STANDARDS FOR LAKES AND RESERVOIRS ---

### 1. Historical Backgrounds for the Legislation

Environmental water quality standards (EWQS) in terms of COD for lakes and reservoirs were legislated in 1945 to control organic pollution and extensive efforts like effluent regulations were made to comply with the EWQS. Unfortunately, percent compliance has been around 40 %, and various problems on water use associated with eutrophication became explicit after mid 1970's. Typical problems associated with the deterioration of water quality are decrease in transparency, colored water, clogging of sand filters in water treatment plants, taste and odor in finished water, and fish kills caused by massive growth of phytoplankton.

All of these problems are originated from massive growth of phytoplankton in lakes and the growth is known to be controlled by nitrogen and phosphorus concentrations. Thus, nitrogen and phosphorus standards for phosphorus were legislated in 1982 as one of the environmental water quality standards to maintain living environment.

### 2. Basic Concepts for the Legislation

It is necessary to determine both nitrogen and phosphorus concentration to satisfy water uses or to prevent damages in water use caused by eutrophication in lakes and reservoirs. The first step was to identify expected water quality to prevent the problems and possible nutrient concentration.

It is known that nitrogen and phosphorus are limiting nutrients in most lakes. The changes in water quality by eutrophication are caused by the increase in organic substances originated from primary production of phytoplankton. Primary production is controlled not only by chemical parameters like nutrients but also by physical factors like light intensity, water temperature, mixing of water, hydraulic retention time and shape of lake basin. It is impossible to take all of these parameters into consideration into the expected water quality. These factors should be considered when the expected water quality is applied for specific lakes.

### 3. Expected Nitrogen and Phosphorus Concentration for Lakes

The expected nitrogen and phosphorus concentration for lakes and reservoirs are shown in Table 6-1. Annual average concentration in surface water (0.5 m) was adopted as representative water quality because eutrophication is associated with phytoplankton growth in photic zone. Corresponding water quality parameters are expected values corresponding to annual average total nitrogen and phosphorus concentration.

#### 3.1 Correlation between Total Nitrogen/Phosphorus Concentration and Chlorophyll-a Concentration

Fig. 6-1 shows relationships between summer chlorophyll-*a* concentration in the surface and total nitrogen and phosphorus concentration reported by Sakamoto (1966). It is clear that higher nitrogen and phosphorus concentration support the higher concentration of chlorophyll-*a*. The increase in nitrogen concentration associated with the increase in phosphorus concentration in most lakes. Especially, linear relationship was noted within the range of N/P from 10/1 to 25/1. Thus, trophic level of lakes can be estimated either by nitrogen or phosphorus in most waters.

The relationships shown in Fig. 6-1 between summer chlorophyll-*a* concentration in the surface and total phosphorus concentration is expressed as;

$$\log[\text{chl}] = 1.583 \log[\text{T-P}] + 3.615 \quad \text{......(1)}$$

Similar correlation is also reported from many circles. Table 6-2 summarized some of these reported values.

Table 6-1 Expected nitrogen and phosphorus concentration in lakes and reservoirs.

| category | annual average total nitrogen (mg/l) | reference parameters | | |
|---|---|---|---|---|
| | | summer chlorophyll-*a* (mg/l) | transparency (m) | hypolimnetic DO in summer |
| | less than | less than | more than | more than |
| I | 0.07 | 1 | 6 | 50 % |
| II | 0.15 | 3 | 4 | - |
| III | 0.40 | 20 | 2 | - |
| IV | 0.60 | 40 | 1 | - |
| V | 1.00 | - | - | - |

| category | annual average total phosphorus (mg/l) | reference parameters | | |
|---|---|---|---|---|
| | | summer chlorophyll-*a* (mg/l) | transparency (m) | hypolimnetic DO in summer |
| | less than | less than | more than | more than |
| I | 0.005 | 1 | 7 | 50 % |
| II | 0.01 | 3 | 4 | 50 % |
| III | 0.03 | 20 | 2 | - |
| IV | 0.05 | 40 | 1 | - |
| V | 0.10 | 100 | - | - |

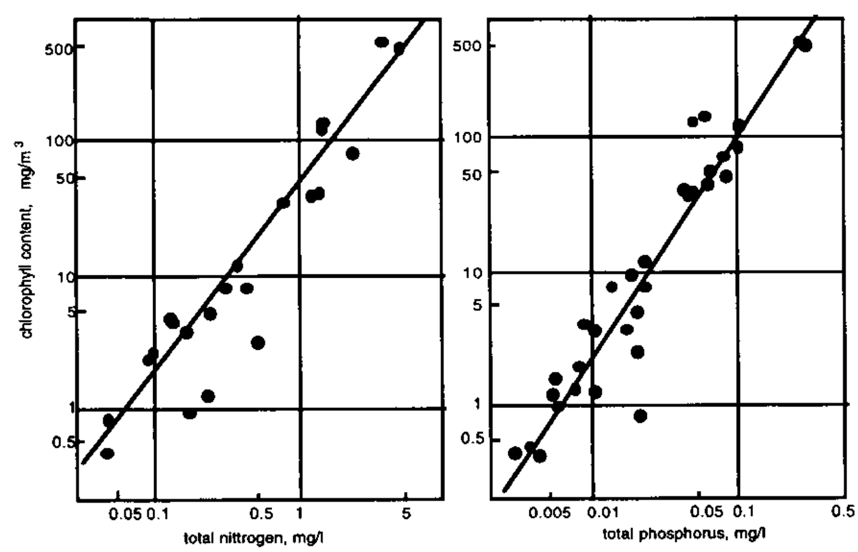



Fig. 6-1 Relationships between summer chlorophyll-a concentration in the surface and total nitrogen and phosphorus concentration (Sakamoto 1966).

Table 6-2 Estimated Chlorophyll-a concentration form T-P.

| T-P (mg/l) | Chlorophyll-a concentration (mg/l) | | | | |
|---|---|---|---|---|---|
| | Expected | Sakamoto (1966) | Dillon & Rigler (1974) | USEPA (1972) | Carlson (1977) |
| 0.005 | 1 | 0.9 | 0.8 | 1.2 | 0.9 |
| 0.01 | 3 | 2.8 | 2.1 | 2.6 | 2.4 |
| 0.03 | 20 | 16 | 10 | 9.6 | 12 |
| 0.05 | 40 | 36 | 21 | 18 | 25 |
| 0.10 | 100 | 108 | 58 | 40 | 69 |

The relationships shown in Fig. 6-1 between summer chlorophyll-*a* concentration in the surface and total nitrogen concentration is expressed as;

$$\log[chl] = 1.393 \log[T\text{-}N] + 1.660 \quad \text{.......(2)}$$

The values in Table 6-1 were estimated from Eq. (2) and other reported values.

3.2 Correlation between Total Nitrogen/Phosphorus Concentration and transparency

Ichimura (1956) reported the following correlation between transparency (m) and chlorophyll-a concentration from Japanese lakes.

$$\log[Tr] = 0.789 - 0.49\log[Chl] \quad \text{.......(3)}$$

$$\log[Tr] = -0.776\log[T\text{-}P] - 0.982 \quad \text{.......(4)}$$

$$\log[Tr] = -0.683\log[T\text{-}N] - 0.0244 \quad \text{.......(5)}$$

Substitution of Eq. (3) into Eqs. (1) and (2) give Eqs. (4) and (5). The values in Table 6-1 were estimated from Eqs. (4) and (5) and other reported values.

3.3 Correlation between Total Phosphorus Concentration and Hypolimnetic Dissolved Oxygen Concentration

One of the most significant changes in water quality with direct impacts on aquatic organisms associated with eutrophication is decrease in hypolimnetic oxygen deficit. Thus, it is necessary to define expected water quality to prevent these problems.

Summer stratification develops in many of deep lakes in Japan. Most of phytoplankton produced is decomposed in the productive zone. However, a part of them precipitates into hypolimnetic zone and is decomposed. Although the percent precipitate is estimated to be from 10 to 15%, the decomposition consume dissolved oxygen and decrease hypolimnetic DO. Allochthonous organic matter is also decrease DO.

The rate of decrease in hypolimnetic DO is dependent on the amount of organic substances supplied from the productive zone. This amount is dependent on T-P. Thus the hypolimnetic DO deficit can be estimated from T-P, the period after the start of stratification, volume ratio between productive and hypolimnetic zone.

Based on the assumptions that the percent organics decomposed in hypolimnetic zone is 15 % of the produced, the rate of production in the productive zone is 10 mg C/mg Chl/day, and the volume ratio of productive zone is 50 %, hypolimnetic DO is estimated to decrease down to zero in four months from the start of stratification if T-P is 0.03 mg/l. Saturation percent of DO will be 50% if T-P is 0.018 mg/l. Therefore, we can expect hypolimnetic DO more than 50 % if we maintain T-P less than 0.01 mg/l.

Table 6-3 shows estimated hypolimnetic DO values in 4 months after summer stratification and corresponding T-N in Japan with the assumption that hypolimnetic water temperature is 10 deg. C. The table shows that 0.07 mg T-N/l or less will be enough to maintain hypolimnetic DO more than 50 % as shown in Table 6-1.

Table 6-3 Estimated hypolimnetic DO values at 4 months after summer stratification and T-N.

| hypolimnetic DO (%) | 0 % | 50 % | 80 % | net primary production rate |
|---|---|---|---|---|
| T-N in surface (mg/l) | 0.21 | 0.072 | - | 10 mg C/chl-a mg/day |
| | 0.59 | 0.22 | 0.055 | 5 mg C/chl-a mg/day |

4. Water Use and Nitrogen and Phosphorus Standards for Lakes

The standard values both for nitrogen and phosphorus were determined based on expected uses of lake waters. The uses presumed as a basis of the standard are as follows;

1) Conservation of natural environment
2) Drinking water supply: class 1, 2, 3
3) Recreation/ bathing
4) Fisheries: class 1, 2, 3
5) Irrigation
6) Industrial water supply
7) Conservation of environment

4.1 Conservation of natural environment

The use specified for this category presumed the use of lakes as recreational purpose such as sightseeing and scenic beauty. Water quality must be kept as natural as possible. The expected chlorophyll-a concentration for this category was 1 mg $m^{-3}$ or less. Taking water quality in Lake Mashu and Lake Shikotsu with high transparency, the standard was less than 0.005 mg $l^{-1}$ in T-P and 0.1 mg $l^{-1}$ in T-N.

4.2 Drinking water supply

Eutrophication of lakes and reservoirs cause various detrimental effects on drinking water supply. Clogging of slow and rapid sand filtration or musty odor in finished water frequently happens in water works taking their raw water from mesotrophic lakes. However, these troubles are not uniform for all treatment trains. The standards were determined taking treatment process into consideration.

(1) Water supply class 1

Water supply class 1 is applied to purification plants with slow sand filtration. Musty odor seldom happens in this process because odorous compounds are decomposed in filters. However, phytoplankton may clog filters.

Table 6-4 shows phosphorus and nitrogen concentration in raw water where troubles in slow sand filtration were reported. Based on this information, we estimated that there will be little troubles in filtration if T-P is less than 0.01 mg/l and T-N is less than 0.15 mg/l in Japanese water purification plants. Thus the phosphorus and nitrogen standards for class 1 are 0.01 mg T-P $l^{-1}$ or less and 0.2 mg T-N $l^{-1}$ or less, respectively .

Table 6-4 Nitrogen and phosphorus concentration in lakes and reservoirs for raw waters with troubles in slow sand filtration.

| plants | lakes | T-N (mg/l) | lakes | T-P (mg/l) |
|---|---|---|---|---|
| with troubles | Michihara Reservoir | 0.35-0.68 | Yamaguchi Reservoir | 0.03 - 0.07 |
| | Lake Nojiri | 0.15-0.41* | Murayama Reservoir | 0.02 -0.05 |
| | Yamanoda Reservoir | 0.26-0.57* | Lake Biwa (South) | 0.014 - 0.071 |
| | Komoda Reservoir | 0.27-0.39* | Lake Asahikawa | 0.03* |
| w/o troubles | - | - | Ogouchi Reservoir | 0.012 - 0.033 |

* estimated from inorganic N and P concentrations

(2) Water supply class 2 and 3

The class 2 water presumes conventional coagulation and rapid sand filtration process for purification. Table 6-5 shows phosphorus and nitrogen concentration in raw water where troubles in rapid sand filtration such as frequent clogging and increase in chemical doses were reported. There will be little troubles in rapid sand filtration if T-P is less than 0.03 mg/l and T-N is less than 0.4 mg/l.

Table 6-5 Nitrogen and phosphorus concentration in lakes and reservoirs for raw waters with troubles in rapid sand filtration.

| plants | lakes | T-N (mg/l) | lakes | T-P (mg/l) |
|---|---|---|---|---|
| with troubles | Lake Kasumigaura | 1.21 | Lake Kasumigaura | 0.10-0.24 |
| | Tonden Reservoir | 0.76-1.57 | Lake Sagami | 0.2* |
| | Hata Reservoir | 0.40-0.66 | - | - |
| w/o troubles | - | - | Yamaguchi Reservoir | 0.03-0.07 |

* estimated from inorganic N and P concentrations

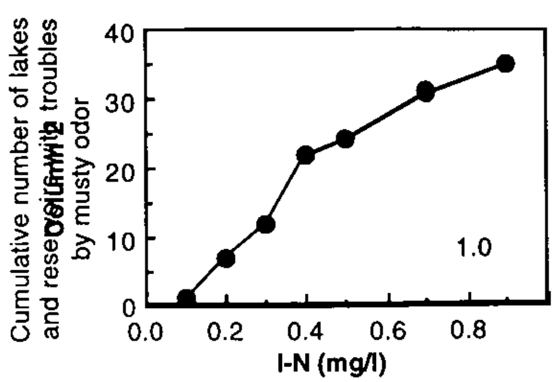



Fig. 6-2 Relationship between number of troubles by musty odor and inorganic nitrogen concentration

Another troubles associated with eutrophication is musty odor problems mainly caused by actinomycetis and/or cyanobacteria. Japan Water Works Association reported that musty odor problems are frequently reported from reservoirs with inorganic nitrogen and ortho-phosphate concentrations of more than 0.3 mg $l^{-1}$ and 0.006 mg $l^{-1}$ in circulation period. This phosphorus concentration generally corresponds to total phosphorus of 0.009 mg $l^{-1}$.

Lakes and reservoirs where cyanobacteria is abundant frequently encounter troubles by musty odor. As shown in Fig.6-2, the number of lakes with musty odor increases if inorganic nitrogen concentration is more than 0.1 mg $l^{-1}$. This concentration was estimated to correspond to 0.15 mg $l^{-1}$ as T-N. Therefore, the critical T-N and T-P to prevent musty odor are 0.1 mg $l^{-1}$ and 0.01 mg $l^{-1}$ respectively.

To prevent increase in chemical dose and frequent clogging, total phosphorus concentration must be less than 0.03 mg $l^{-1}$ as shown above. However, this criterion is not enough to prevent musty odor. Thus the standards for the class 2 are less than 0.01 mg T-P $l^{-1}$ and 0.2 mg T-N $l^{-1}$.

If the raw water is categorized as class 3, advanced water treatment processes including pretreatment are necessary. If the additional treatment can remove musty odor, the standards are less than 0.03 mg T-P $l^{-1}$ and 0.4 mg T-N $l^{-1}$. However, removal of odorous compounds is not expected by the advanced treatment, the same standards are applicable to prevent odor, i.e. 0.01 mg T-P $l^{-1}$ and 0.2 mg T-N $l^{-1}$ .

Iron and manganese are also serious problem for drinking water supply. These problems are caused by the decrease in hypolimnetic DO. Maximum allowable T-N and T-P concentration to prevent DO deficit in lakes with productivity of 5 mg C $mg^{-1}$ chl $day^{-1}$ were estimated to be 0.6 mg $l^{-1}$ and 0.05 $mgl^{-1}$, respectively.

### 4.3 Recreation/bathing

The use specified for this category are the use of lake environment as recreational purpose for bathing/swimming. The data used was from northern basin of Lake Biwa, because some beaches are still being used as bathing area. Taking the water quality in 1960's when all the beaches were in excellent condition, the standard was 0.01 mg T-P $l^{-1}$ and 0.2 mg T-N $l^{-1}$.

### 4.4 Fisheries: class 1, 2, 3

It is known that the increase in primary production, i.e. phytoplankton production, increases the production of secondary and higher producers, i.e. fish production. Some circles claimed that nutrient control may decrease phytoplankton production and, hence, decrease fishery production. Although fishery production increased with the increase in primary production, it leveled of at a certain level of primary production and decreased if primary productivity is too high.

Not only the amount of fishery production, but also species changed drastically with the increase in the primary production: Salmons and trout are common in oligotrophic lakes in Japan, but carps and roaches are known to be abundant in eutrophic lakes.

Fisheries class 1 corresponds to water quality to keep populations of salmons and trout. Taking the water quality of lakes where these fishes are inhabiting such as Lake Chuzenji and Lake Biwa, the standard was 0.01 mg T-P $l^{-1}$ and 0.2 mg T-N $l^{-1}$.

Fisheries class 2 is expected to keep populations of intermediate pollution tolerant species such as pond smelts. Typical lakes with high production of pond smelts are Lake Suwa and Lake Hachirogata. From the water quality of these lakes the standard was determined as 0.05 mg T-

P $l^{-1}$ and 0.6 mg T-N $l^{-1}$.

Production of carps and roaches increases with the increase in nitrogen and phosphorus, whereas it levels off and frequent damages like fish kills by anoxic water and odorous fishes become common if T-P is more than 0.01 mg $l^{-1}$ and T-N is more than 0.2 mg $l^{-1}$. These values are adopted as standard for class 3.

### 4.5 Irrigation

Agricultural productions are also impaired when farmlands are irrigated by water taken from eutrophic water bodies. Particularly, nitrogen concentration higher than 1 mg $l^{-1}$ is regarded to damage rice production by excessive growth of plant and by intolerance to diseases. Taking the water quality criteria for irrigation, the standard was determined as 1.0 mg T-N $l^{-1}$ or less.

### 4.6 Industrial water supply

Another important use of lake water is industrial water supply. Surveys on the water quality of lakes being used as raw water for industrial purpose, such as Lake Biwa and Lake Kasumigaura, indicated that little problems are reported if T-N and T-P were less than 1.0 mg $l^{-1}$ and 0.1 mg $l^{-1}$, respectively. These values are adopted as standard for industrial water supply.

### 4.7 Conservation of environment

Lake Inbanuma and Lake Kojima are among the worst in water quality. The waters frequently bother daily life of people living in the lake sides either by the odor come from massive growth and death of phytoplankton and macrophytes. T-P and T-N in these lakes are shown in Table 4. From these values, the standard for the conservation of environment was determined as 0.1 mg T-P $l^{-1}$ and 1.0 mg T-N $l^{-1}$ or less.

Table 6-6 Nitrogen and phosphorus concentration in the most eutrophic lakes in Japan (1995)

| lakes | T-N (mg $l^{-1}$) | T-P (mg $l^{-1}$) |
|---|---|---|
| Lake Teganuma | 5.3 | 0.51 |
| Lake Inbanuma | 2.1 | 0.14 |
| Lake Kojima | 2.0 | 0.20 |

Table 6-7 Nitrogen and phosphorus standards for lakes and reservoirs (mg $l^{-1}$)

| category | water use | T-N | T-P |
|---|---|---|---|
| I | conservation of natural environment, and uses II-V | 0.1 | 0.005 |
| II | water supply class 1, 2, and 3, fishery class 1, bathing , and uses III-V | 0.2 | 0.01 |
| III | water supply class 3, and uses IV-V | 0.4 | 0.03 |
| IV | fishery class 2, and use V | 0.6 | 0.05 |
| V | fishery class 3, industrial water, irrigation water, conservation of environment | 1.0 | 0.1 |

water supply: class 1: sand filtration
class 2 : coagulation/ rapid filtration
class 3: pretreatment, advanced water treatment

fisheries: class 1: salmon, trout, ayu
class 2: pond smelt (wakasagi)
class 3: carp, catfish, roach

environmental protection: no odor in the vicinity

5. Classification of lakes and reservoirs

The standards for nitrogen and phosphorus mentioned above are listed in Table 6-7. There are five categories in terms of annual average total nitrogen and phosphorus concentrations. This is because basic data adopted to determine EWQS were annual average values taking large fluctuation of concentration. All of these values correspond to surface water quality at 0.5 m and phosphorus standards should not be applied for irrigation water. Not all the lakes and reservoirs, but those with high possibility of massive growth of phytoplankton are classified.

It is well known that the limiting nutrient in freshwater is generally phosphorus. Nitrogen standards, therefore, are applicable to lakes whose primary productivity might be limited by nitrogen by the following criteria;

1)T-N/T-P is less than 20, and
2)T-P is more than 0.02 mg/l.

6. Criteria for Compliance and Present State of Eutrophication

6.1 Criteria for Compliance

The compliance for the standard is evaluated based on the maximum value of annual averages of all the environmental standard points (ESP). Basic data to legislate nitrogen and phosphorus standards for lakes were annual average values of the ESP located at the center of lakes. It is reported that historical changes in water quality in various ESPs showed similar trends both in Lake Biwa and Lake Kasumigaura. The maximum value, therefore, was adopted as a criterion to represent water quality of whole lake.

6.2 Present State of Eutrophication

Table 6-8 shows total number of lakes and reservoirs where nitrogen and/or phosphorus standard are being applied and their compliance with the standard. Percent compliance was 41.7 % in 1994. As shown in Fig 6-3, however, significant improvement in the percent compliance was not noted after the start of regulation, i.e. 38.6 % in 1989.

Table 6-8 Number of lakes with N and/or P standard and compatibility (1994)

| category | lakes with standard | compatible | % compliance |
|---|---|---|---|
| I | 7 | 5 | 71 |
| II | 18 | 12 | 67 |
| III | 11 | 3 | 27 |
| IV | 9 | 0 | 0 |
| V | 3 | 0 | 0 |
| total | 48 | 20 | 41.7 |

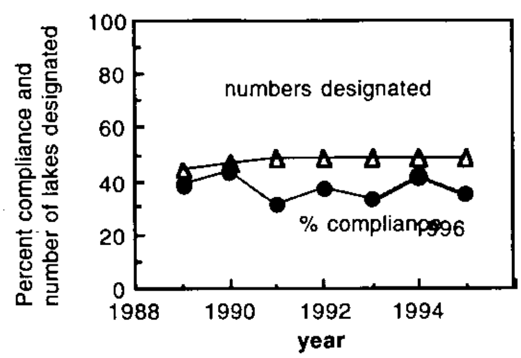



Fig.6-3 Numbers of lakes classified and percent compliance after the start of regulation.

# Chapter 7 ENVIRONMENTAL QUALITY STANDARDS FOR WATERS

## --- NITROGEN AND PHOSPHORUS STANDARDS FOR ESTUARIES AND INLAND SEAS ---

### 1. Backgrounds

In 1970's, various efforts to study the mechanism of eutrophication, to develop strategies, technologies, laws and regulations was made to control the eutrophication of closed freshwater bodies. However, little attention has been directed to the similar problems observed in marine water. In recent years, similar phenomena as the eutrophication in lakes and reservoirs have been observed in many bays and inland seas. In spite of the strict regulation of organic loading such as the regulation of total maximum loads of COD, remarkable recovery of water quality has not been noted in closed marine waters such as Tokyo bay, Mikawa Bay and Seto Inland Sea as shown in Fig.7-1.

It is clear that, in these water bodies, the increase in nutrient discharge, either directly or through the inflow of river water, into the water in addition to organic loading resulted in the increase in the phytoplankton production and, subsequently, in the deterioration of water quality in terms of COD. Fig.7-2 shows percent contribution of internal production of COD out of total COD loading estimated by δCOD method and chlorophyll-a method. The contribution was high in summer (50 to 60%). Also percentages were dependent on the methods adopted, i.e. δCOD method gave higher value than chlorophyll-a method. Annual average contribution of internal COD production ranged from 40% to 50%. Eutrophication control, therefore, is essential to comply with the water quality standards in terms of COD.

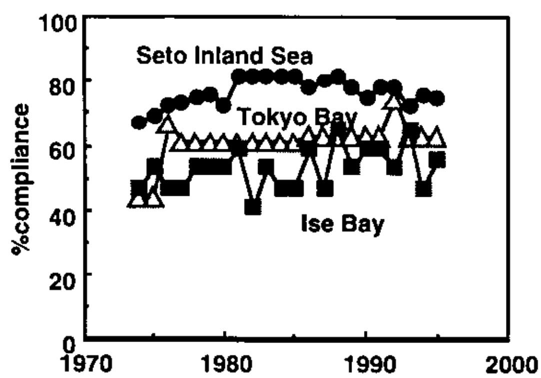



Fig. 7-1 Percent of compliance on COD in major estuaries.

To reduce COD loading, the Regulation of Total Maximum Daily Loads started in 1978 for three major estuaries, i.e. Tokyo Bay, Ise Bay and Seto Inland sea (see Chapter 11). However, by the increase in nitrogen and phosphorus loading, typical problems associated with eutrophication such as deterioration of water quality by the increase in primary production of phytoplankton has been frequently happened. Serious damage on aqua cultures by red-tide has been reported in these estuaries (Fig. 7-3). Also recreational use and scenery were damaged.

The massive growth of phytoplankton results in the increase in the concentration of organic matter, and decrease in dissolved oxygen concentration in bottom layer in summer. The DO deficit is known to be a cause of so-called blue-tide, and deteriorate bottom environment (See 7-4). Thus the increase in organic matter and, therefore, organic loading seemed to be a major reason of the unexpected low compliance of environmental water quality standards in terms of COD.

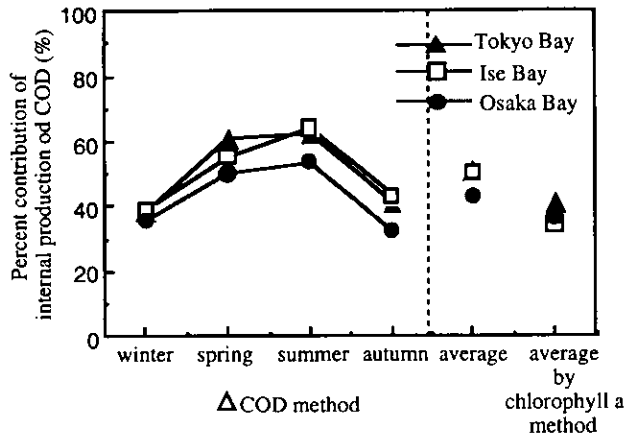



Fig. 7-2 Percent contribution of internal production of COD out of total COD loading.

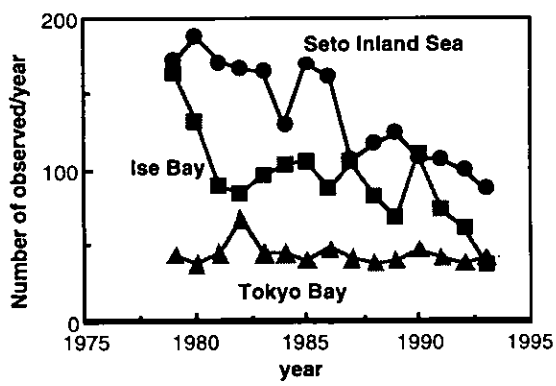



Fig. 7-3 Red-tide observed at three major estuaries.

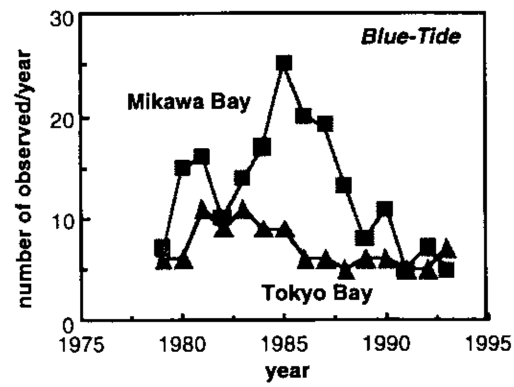



Fig. 7-4 Blue-tide observed at Tokyo Bay and Mikawa Bay in Ise Bay.

Main factors responsible for the above mentioned phenomena are inflow of nitrogen and/or phosphorus into estuaries. As shown in Fig.7-5, it is necessary to reduce nutrient loading as major factor of eutrophication in addition to conventional reduction of COD to restore marine environment.

The restoration of eutrophic water is hard task. Therefore, we must keep nutrient concentration as low as possible even in the waters with satisfactory environmental condition to prevent eutrophication and to conserve the environment to next generation. The environmental water quality standards for nitrogen and phosphorus are an allowable condition of water for the conservation of estuarine environment. The standard was legislated in 1993 based on "Basic Environment Law". Also effluent quality standards were legislated based on "Water Pollution Control Law".

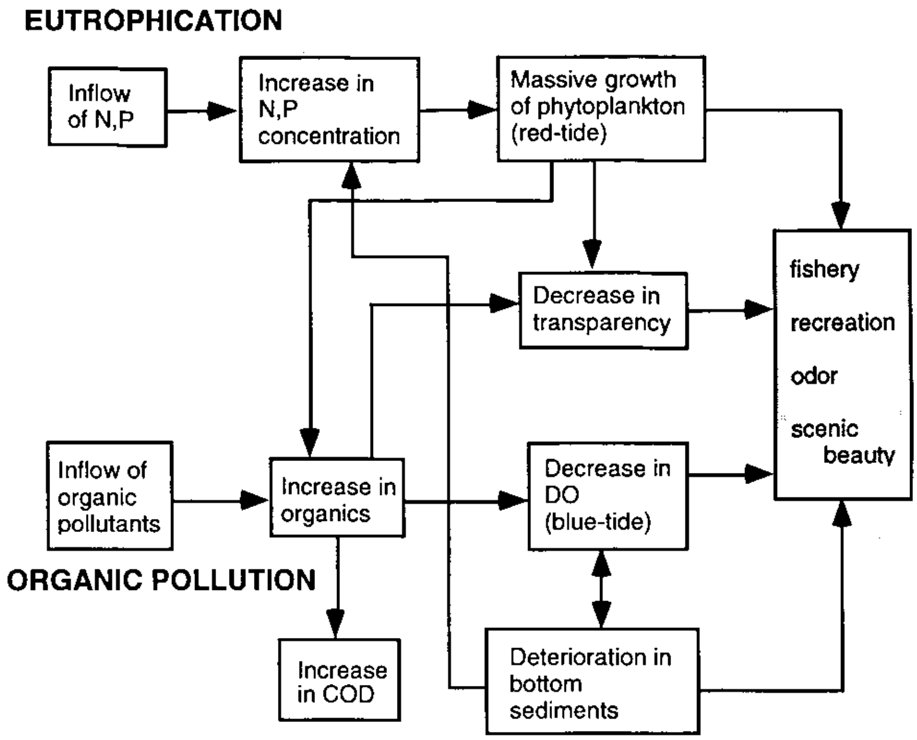



Fig. 7-5 Eutrophication and organic pollution.

## 2. Nitrogen and Phosphorus Standards for Estuaries

### 2.1 Limiting nutrients

Similar to the eutrophication in lakes and reservoirs, the identification of limiting nutrient has been one of the most important issues in the control of estuarine eutrophication. It is generally acknowledged that nitrogen and phosphorus are the most probable nutrient that limits phytoplankton growth both in freshwater and marine environment. However, the control and regulation of a single limiting nutrient are preferable. If only phosphorus is the limiting nutrient, we may install phosphorus removal process in wastewater treatment process.

There is little question that phosphorus is the limiting nutrient in most freshwater. Nitrogen fixation may compensate nitrogen deficit and nitrogen will not be the limiting nutrient for phytoplankton growth. However, in marine waters, it is commonly accepted that nitrogen is the limiting nutrient. Contrary to freshwater, it is understood that the nitrogen fixation does not play significant role in marine waters. One of the exceptional case ever reported is in Baltic Sea where nitrogen input into the sea by the nitrogen fixation contribute similar amount as that by river inflow. The reason why nitrogen fixers cannot predominate in the nitrogen limiting marine environment is not well understood yet.

Table 7-1 shows intracellular N/P ratio for various marine phytoplankton obtained from various environmental conditions. The most referred number for the N/P ratio is so-called Redfield ratio; 16:1 in atomic ratio and 7.2:1 in weight ratio. Most of the ratios listed are similar to this value, whereas there are values as small as 2.0 and also as large as 43.5. As the supply side for phytoplankton growth, N/P ratios in Japanese estuaries are shown in Fig. 7-6. The ratio ranged from 5 to 20. Nitrogen might be a sole limiting nutrient if N/P ratio in marine water is always smaller than that in phytoplankton. On the contrary, phosphorus would be the limiting if N/P in water is always larger than that in plankton.

In Tokyo Bay, N/P was relatively large in winter (P limiting), whereas they were small in summer (N limiting). Fig. 7-7 shows seasonal variation of N/P in Hiroshima Bay. It is well known that seasonal variation in N/P in Chesapeake Bay is induced by the inflow of snow melt, i.e. phosphorus limitation by snow melt in early spring and nitrogen limiting in late summer. Hiroshima Bay is limited by nitrogen in most cases. However, large inflow of stormwater (limited by phosphorus) changed limiting nutrient from nitrogen to phosphorus. Thus, N/P ratio in water changes in time and space and that in phytoplankton also varies among species.

It is difficult, therefore, to identify one of these is always limiting phytoplankton growth. Both nitrogen and phosphorus are adopted as limiting nutrients to be controlled in the environmental standards for estuaries in Japan in 1993. Also we have little information on the change in ecosystem if we changed N/P ratio in estuaries to extremely high or low values. The uncertainty in the response of ecosystem was another reason to take both nutrients into consideration.

Table 7-1 Intracellular N/P ratio in marine phytoplankton

| Algal species | N:P (mole) | source | remarks |
|---|---|---|---|
| CYANOPHYCEAE | | | |
| *Agmenellum quadruplicaatum* | 10.6 | BC | exp. phase |
| CHLOROPHYCEAE | | | |
| *Dunaliella salina* | 6.1 | BC | exp. phase |
| BACILLARIOPHYCEAE | | | |
| *Chaetoceros affinis* | 7.9-43.5 | BC | exp. phase |
| *C. deblis* | 4.6 | CC | N-limited |
| | 12.0 | CC | non-limited |
| *Chaetoceros* sp. | 8.3 | BC | exp. phase |
| *Skeletonema costatum* | 7.7 | BC | exp. phase |
| | 4.8 | CC | N-limited |
| | 10.0 | CC | non-limited |
| | 5.5-29.4 | BC | exp. phase |
| | 5-20 | CC | N/P changed |
| | 9.1-26.0 | N | |
| *Thalassiosira graavida* | 2.0 | CC | N-limited |
| | 8.8 | CC | non-limited |
| DINOPHYCEAE | | | |
| *Ceratium tripos* | 12 | SC | non-limited |
| | 12 | SC | P-limited |
| *Prorocentrum minimum* | 15 | SC | non-limited |
| | 18 | SC | P-limited |
| | 14.8-17.4 | SC | |
| RAPHIDOPHYCEAE | | | |
| *Chattonella antiqua* | 11 | BC | stationary phase |
| *Heterosigma akshiwo* | 15.2 | BC | stationary phase |
| | 11.1-25 | CC | N/P changed |

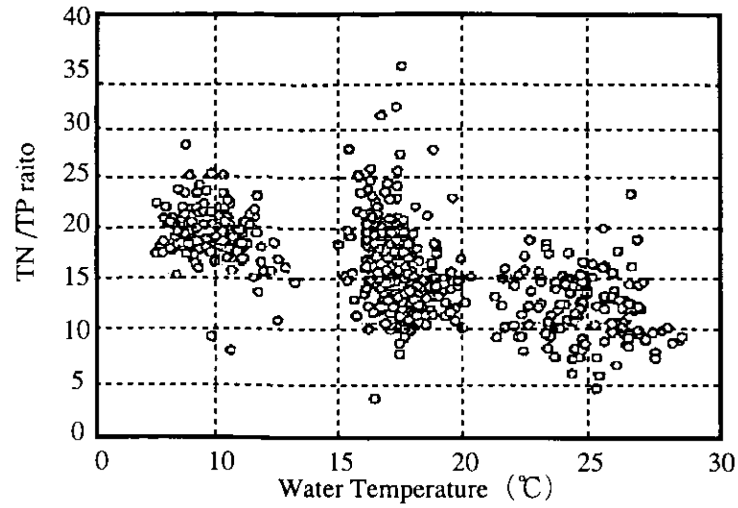



Fig.7-6 N/P ratio (weight) in Tokyo Bay (1986-1990)

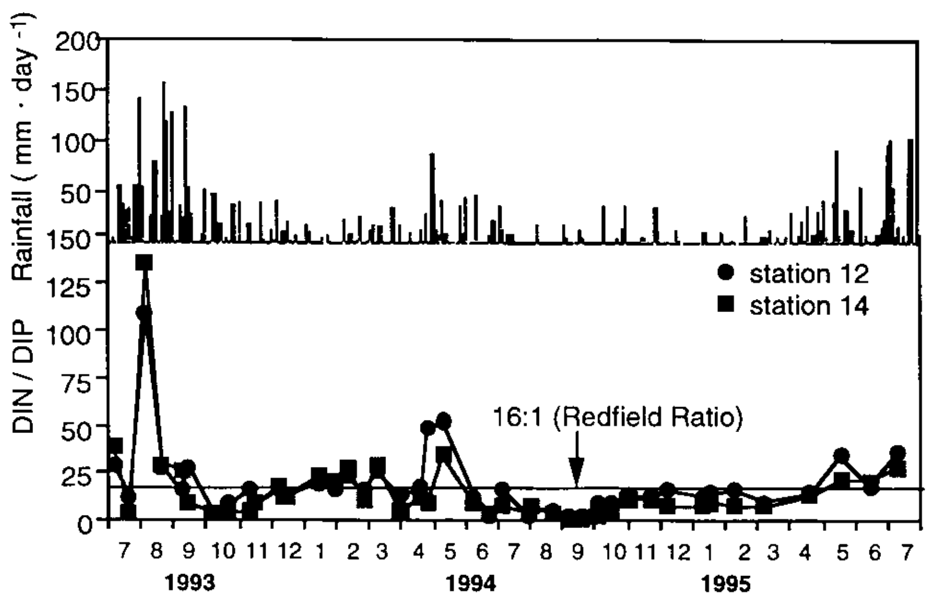



Fig. 7-7 Seasonal variation of DIN:DIP ratio at stations 12 and 14 in Hiroshima Bay

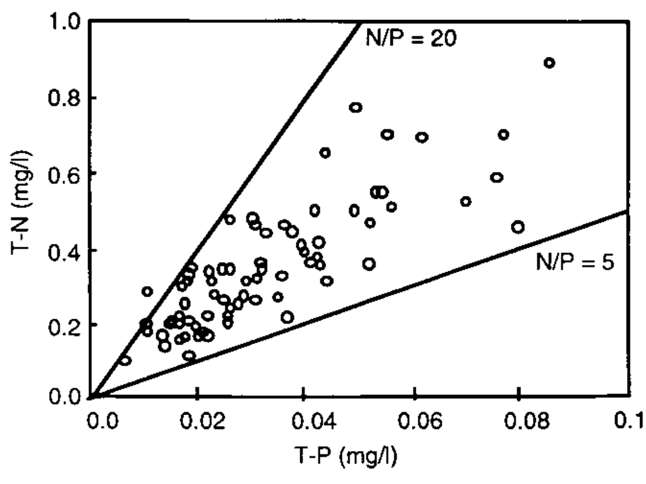



Fig. 7-8 N/P ratio in Japanese estuaries

2.2 Correlation between Water Use and Standards

The environmental standard for estuaries to control eutrophication was legislated in 1993 in addition to the former regulation on organic pollution (COD) and toxic substances (heavy metals). The standard values both for nitrogen and phosphorus were determined based on expected uses of estuarine waters. The uses presumed as a basis of the standard are:

1) Conservation of natural environment,
2) Marine recreation/bathing,
3) Protection of benthic organisms,
4) Fisheries: class 1, 2, and 3, and
5) Industrial water supply.

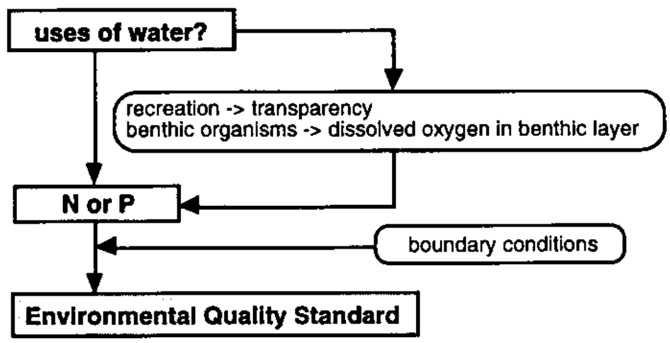



Fig. 7-9 Correlation between the use of water and environmental quality standards

*Correlation between water quality parameters*

The standard values are determined based on water use above mentioned. It is necessary to define or estimate concentrations of nitrogen and phosphorus that are appropriate or necessary to fulfill each water use.

In most cases, both nitrogen and phosphorous concentrations do not directly relate with the use of water as shown in Fig. 7-9. For example, transparency would be the most important parameter to assess the quality of natural marine environment and bathing water. Dissolved oxygen concentration in the bottom in summer would be the critical parameter for the survival of benthic organisms. Correlation between water quality parameters was formulated to estimate corresponding nitrogen and phosphorus concentrations. Some examples of the correlation are shown in Fig. 7-10. All the basic data were monitored in coastal and estuarine waters in Japan.

2.3 Environmental Water Quality Standards for Each Water Use

1) Conservation of natural environment

The use specified for this category presumed the use of marine environment as recreational purpose such as sightseeing and diving. Water quality must be kept as natural as possible. Major parameter adopted in this category was transparency taking clear water would be the most important factor for this use. The data base used was water quality in marine parks in Japan. Table 7-2 summarize water quality parameters. T-P and T-N concentrations not determined in the monitoring were estimated from the above mentioned correlation (Fig. 7-10). The standard values both for T-N and T-P were determined to be less than 0.2 mg $l^{-1}$ and 0.02 mg $l^{-1}$, respectively based on the correlation and taking the followings into consideration;

- Clear water is expected to have transparency more than 10 m,
- Better water quality than open seas around Japan can not be expected (Table 7-4).

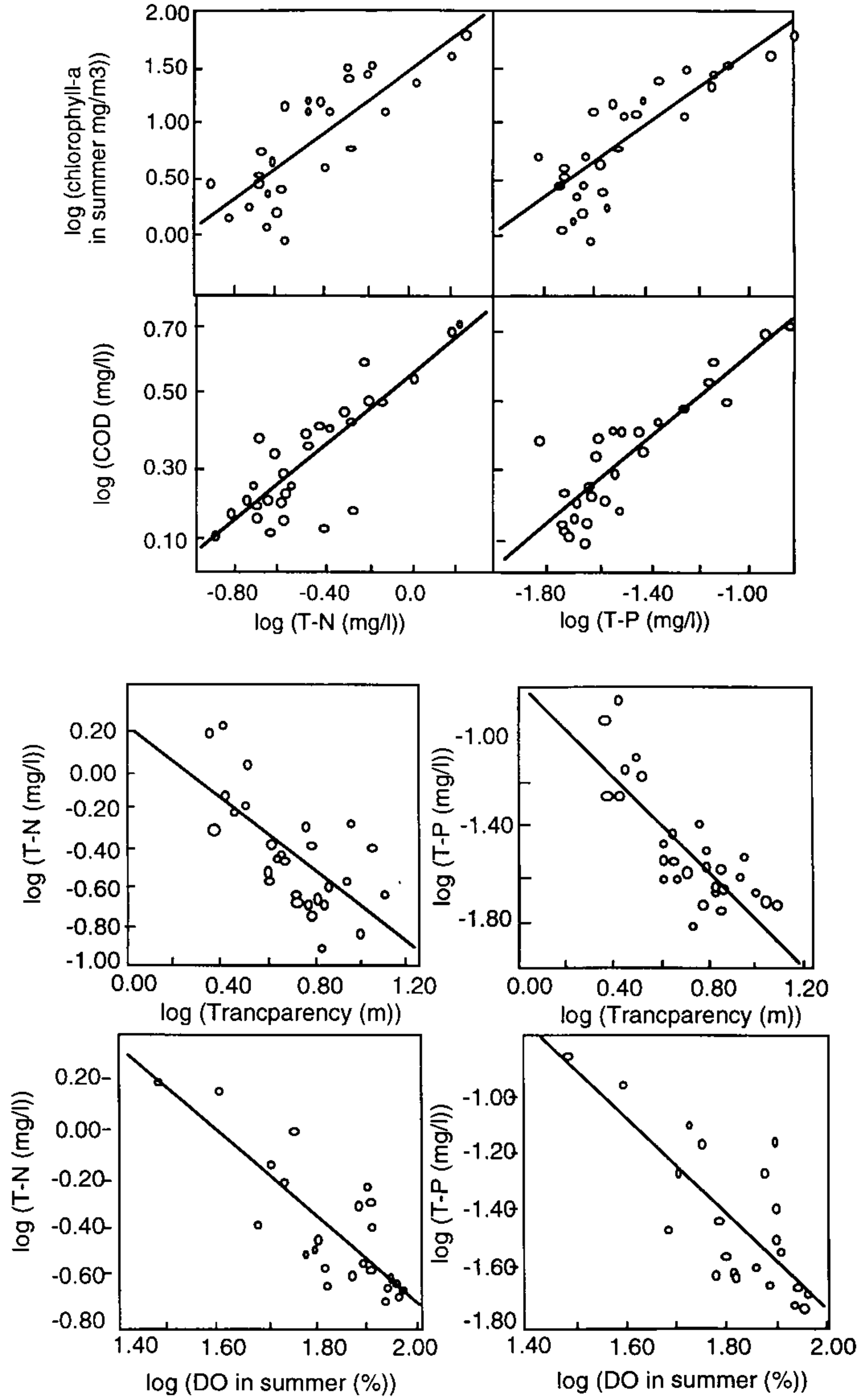



Fig. 7-10 Correlation between water quality parameters

Table 7-2 Water quality parameters in marine parks

| parameter | no. of stations | no. of data | average | min. | max. | % less than std.* |
|---|---|---|---|---|---|---|
| T-N (mg/l) | 6 | 16 | 0.16 | 0.07 | 0.24 | 88 |
| T-N (calculated) | 19 | 55 | 0.15 | 0.07 | 0.24 | 95 |
| T-P (mg/l) | 6 | 16 | 0.015 | 0.010 | 0.024 | 88 |
| T-P (calculated) | 19 | 55 | 0.013 | 0.008 | 0.024 | 96 |
| COD (mg/l) | 16 | 48 | 1.0 | 0.5 | 2.2 | 98 |
| Transparency (m) | 18 | 54 | 13 | 7 | 20 | 83 |

* standard value: T-N<0.2 mg/l, T-P<0.02 mg/l, COD<2 mg/l, Transparency>10 m

* * calculated from the correlation

Table 7-3 Water quality parameters in open seas

| | oyashio | | kuroshio | | tsushima C. |
|---|---|---|---|---|---|
| station | A-6 | B-2 | C-3 | D-2 | E-4 |
| T-N (mg/l) | 0.08 | 0.09 | 0.08 | 0.08 | 0.09 |
| T-P (mg/l) | 0.02 | 0.01 | 0.01 | 0.01 | 0.01 |
| COD (mg/l) | - | 0.9 | 0.7 | 0.7 | 0.9 |

2) Marine recreation/bathing

The use specified for this category presumed the use of marine or coastal environment as recreational purpose for bathing/swimming. The data base used was coastal water quality around beach resorts for bathing and swimming in Japan. Only beach resorts in good condition were selected. Table 7-4 summarize water quality parameters. T-P and T-N concentrations not determined in the monitoring were estimated from the correlation.

The standard values both for T-N and T-P were determined to be less than 0.3 mg $l^{-1}$ and 0.03 mg $l^{-1}$, respectively based on the correlation and taking the followings into consideration;

- Transparency more than 6 m is expected for comfortable bathing,
- Table 7-5 summarize water quality around beaches where bathing was abandoned due to excessive phytoplankton growth. Better water quality than these is expected.

Table 7-4 Water quality parameters around beach resorts

| parameter | no. of stations | no. of data | average | min. | median | 75% | max. |
|---|---|---|---|---|---|---|---|
| T-N (mg/l) | 47 | 141 | 0.36 | 0.05 | 0.30 | 0.41 | 1.45 |
| T-N (calculated) | 86 | 257 | 0.33 | 0.05 | 0.29 | 0.38 | 1.45 |
| T-P (mg/l) | 48 | 144 | 0.027 | 0.008 | 0.023 | 0.030 | 0.12 |
| T-P (calculated) | 86 | 257 | 0.027 | 0.008 | 0.024 | 0.032 | 0.12 |
| COD (mg/l) | 101 | 302 | 1.4 | 0.5 | 1.4 | 1.7 | 6.9 |
| Transparency (m) | 76 | 227 | 6.7 | 2.0 | 6.2 | 8.6 | 16 |

* * calculated from the correlation

Table 7-5 Water quality parameters around beach resorts in trouble

| parameter | no. of data | min. | max. |
|---|---|---|---|
| T-N (mg/l) | 10 | 0.30 | 0.90 |
| T-P (mg/l) | 10 | 0.03 | 0.14 |
| COD (mg/l) | 10 | 1.7 | 3.6 |

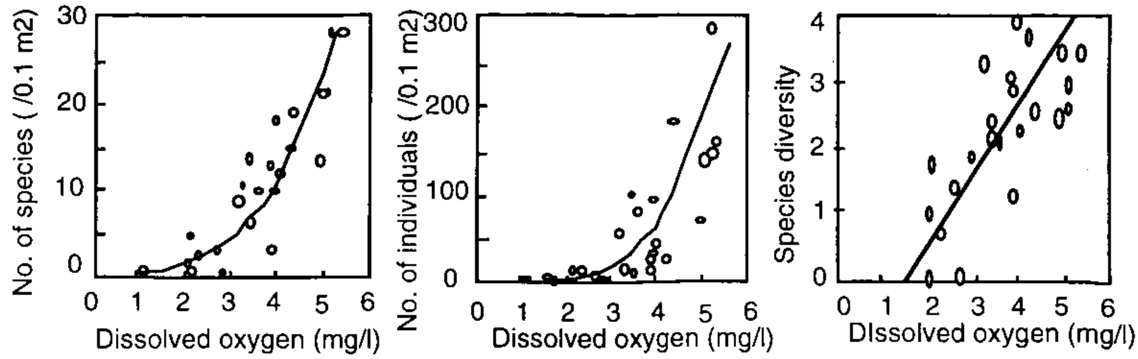



Fig. 7-11 Relationships between benthic community structure and dissolved oxygen concentration in the bottom

3) Protection of benthic organisms

Estuaries designated to this category guarantees minimum quality of water for the survival of benthic organisms. Eutrophication and associated internal production of organic matter decreases dissolved oxygen concentration in the bottom especially in summer. The most vulnerable organisms from the oxygen deficit are benthos.

The main parameter adopted was dissolved oxygen concentration in the bottom during summer. A report based on the field survey in Seto Inland Sea to evaluate the relationship between benthic community structure and dissolved oxygen concentration in the bottom was adopted as the basis for the standard (Fig. 7-11).

The criteria adopted was 2 ml $l^{-1}$ ( = 2.9 mg $l^{-1}$) in DO in the bottom in summer. The standard values both for T-N and T-P were determined to be less than 1.0 mg $l^{-1}$ and 0.09 mg $l^{-1}$, respectively based on the correlation and taking the followings into consideration;

- Detrimental effects are noted in some species at DO less than 4 ml $l^{-1}$ ( = 5.7 mg $l^{-1}$),
- Numbers of species, population density, and species diversity are extremely low if DO is less than 3 ml $l^{-1}$ ( = 4.3 mg $l^{-1}$),
- Most species were killed at DO less than 2 ml $l^{-1}$ ( = 2.9 mg $l^{-1}$).

4) Fisheries: class 1, 2, 3

It is known that the increase in primary production, i.e. phytoplankton production, increases the production of secondary and higher producers, i.e. fish production. Some circles claimed that nutrient control may decrease phytoplankton production and, hence, decrease fishery production. Although fishery production increased with the increase in primary production, it leveled of at a certain level of primary production and decreased if primary productivity is too high as shown in Fig. 7-12.

Not only the amount of fishery production, but also species changed drastically with the increase in the primary production. Remarkable decreases in the catch of all kinds of fishes were noted in Tokyo Bay by water pollution and eutrophication especially after 1970's. Even in the less polluted bays, total fish catch increased gradually. However, only free swimming plankton feeders such as sardine, anchovy, gizzard shad increased and remarkable decrease in clams, shrimps, crabs are noted probably affected by the dissolved oxygen deficit in the bottom.

Taking these relationships between fish catch both in quantity and quality and water quality in Tokyo Bay and other estuaries, the following three criteria on fishery and corresponding nitrogen and phosphorus concentration were determined.

[**Class 1**: T-N < 0.3 mg l-1, T-P < 0.03 mg $l^{-1}$]

Bottom fishes (black porgy), shrimps, crabs, octopus, squid, clams are rich. Especially, even those intolerable to oxygen deficit in bottom water are abundant. Estuarine ecosystem in this class are regarded to be maintained well and high in species diversity.

[**Class 2**: 0.3 mg $l^{-1}$ < T-N < 0.6 mg l-1, 0.03 mg $l^{-1}$ < T-P < 0.05 mg $l^{-1}$]

Both bottom and free swimming fish such as sardine, gizzard shad, sea bass, flatfish are abundant. However, catches for those intolerable to oxygen deficit such as shrimps and crabs are decreased. Environmental conditions are not suitable for bottom fishes.

[**Class 3**: 0.6 mg $l^{-1}$ < T-N < 1.0 mg l-1, 0.05 mg $l^{-1}$ < T-P < 0.09 mg $l^{-1}$]

Although catches for sardine, gizzard shad, sea bass is possible, most of them are sardines feeding phytoplankton. In estuaries such as Tokyo Bay, detritus feeders such as clams are major catches. Catches for bottom fish, crabs and shrimps are damaged. Organisms in low trophic level predominates and estuarine ecosystem is regarded to be unstable.

It must be noted that estuarine waters more polluted than class 3 are regarded to face with frequent depletion of dissolved oxygen and blue-tide.

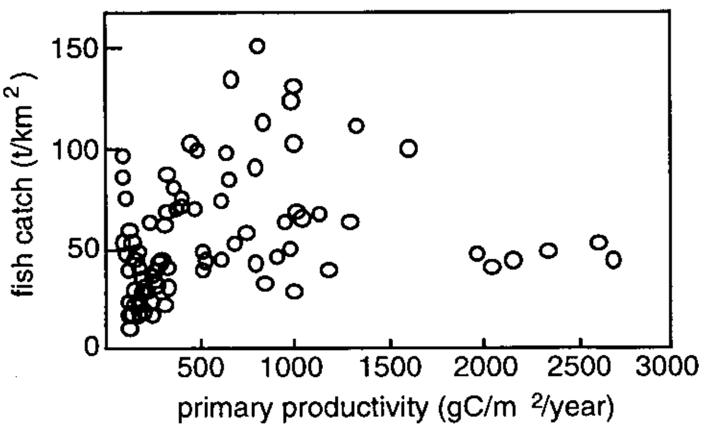



Fig. 7-12 Fish catch as affected by primary productivity

5) Industrial water supply

Major use of estuarine water for industrial purpose is cooling water. Some amount is used as raw material for salt production. Surveys on the water quality both for cooling water and raw water in use are summarized in Table 7-6. The standard values both for T-N and T-P were determined to be less than 1.0 mg $l^{-1}$ and 0.09 mg $l^{-1}$, respectively based on the above mentioned use and the standard for organic pollution.

Table 7-6 Water quality for cooling water and raw water in use

| use | parameter | no. of data | average | min. | median | 75% | max. |
|---|---|---|---|---|---|---|---|
| raw water | T-N (mg/l) | 8 | 0.15 | 0.57 | 0.42 | 1.00 | 1.5 |
| | T-P (mg/l) | 10 | 0.007 | 0.041 | 0.036 | 0.05 | 0.13 |
| cooling water | T-N (mg/l) | 28 | 0.1 | 0.79 | 0.78 | 0.88 | 3.9 |
| | T-P (mg/l) | 28 | 0.02 | 0.074 | 0.06 | 0.08 | 0.37 |

6) Water quality standard for estuaries

The standard for nitrogen and phosphorus mentioned above are summarized in Table 7-7. The corresponding qualities of water for other parameters are also shown in the table. The values of parameters were estimated from the correlation.

Table 7-7 Water quality standard for estuaries and related parameters

| category | use of water | standard | | related parameters | | |
|---|---|---|---|---|---|---|
| | | T-N ($mg\ l^{-1}$) | T-P ($mg\ l^{-1}$) | DO ($ml\ l^{-1}$) | COD ($mg\ l^{-1}$) | Transparency (m) |
| I | Conservation of natural environment and II, III, IV | < 0.2 | < 0.02 | > 5 | < 1.7 | > 7 - 9 |
| II | Fisheries class 1, Marine recreation/bathing and III, IV | < 0.3 | < 0.03 | > 4 | < 2.0 | > 5 - 6 |
| III | Fisheries class 2 and IV | < 0.6 | < 0.05 | > 3 | < 3.0 | > 3 - 4 |
| IV | Fisheries class 3, Protection of benthic organisms, Industrial water supply | < 1.0 | < 0.09 | > 2 | < 4 - 5 | > 2 - 3 |

* all the standard values are applied on annual average basis

** Only waters where massive growth of phytoplankton are expected should be designated to a category mentioned above

## 3. Standard Values and Categorization of Estuaries

### 3.1 Estuaries to be Categorized

All the water bodies required to control nutrients are categorized either by national or prefecture government. The criteria on categorization are as follows;

1) Categorization is necessary for all the waters with high possibilities of eutrophication. However, hypertrophic waters at present and in near future should have high priority.
2) Previous water use must be taken into consideration as potential water uses in addition to present uses.
3) Deadlines to comply with the standards should be determined based on the prediction of water quality in future. The prediction should take water quality at present, changes in population and industrial production, and possible management strategies.

## 4. Criteria to Judge Compliance

### 4.1 Criteria

Different from the method for lakes and reservoirs' standards, the compliance for the standard is evaluated based on the average value of annual averages of all the environmental standard points (ESP).

Basic data to legislate nitrogen and phosphorus standards for estuaries were annual average values of water quality in 30 Japanese estuaries and their water use. If there were more than two environmental standard points, we adopted the average of all the points. The maximum values were not adopted because water quality of estuarine water shows large fluctuation by tidal motion and does not give representative information on water quality.

### 4.2 Allocation of environmental standard points

Allocation of ESPs has significant effects on percent compliance of environmental water quality standards. Because of the fact that the representative values are average of annual mean values of all the standard points in an estuary, allocation of ESPs in off-shore area with high water quality should result in higher rate of compliance. Thus the basic criteria for allocation are recommended by the government as follows;

1) Select central area as representative points for the quality of the estuary without direct effects of inflow water.

2) Use conventional ESP for COD to save monitoring efforts.
3) Select one point for the area raging from 30 to 140 $km^2$.
4) Select ESPs in the following small water body like harbors.
  -enclosed and independent water body form other area,
  -the area is more than 5 $m^2$,
  -the area has different water use from others.

5. Present water quality

Table 7-8 shows percent compliance of environmental water quality standards for nitrogen and phosphorus in estuaries in 1995. Number of estuaries that could comply with the standards corresponds to the number of estuaries where both nitrogen and phosphorus were satisfactory. Percent compliance for categories II and III where better qualities were expected were very low, 0 percent. Tokyo Bay was 33.3 % and all the area in Osaka Bay could not satisfy with the standards.

Table 7-8 Percent compliance of environmental water quality standards for nitrogen and phosphorus in estuaries in 1995

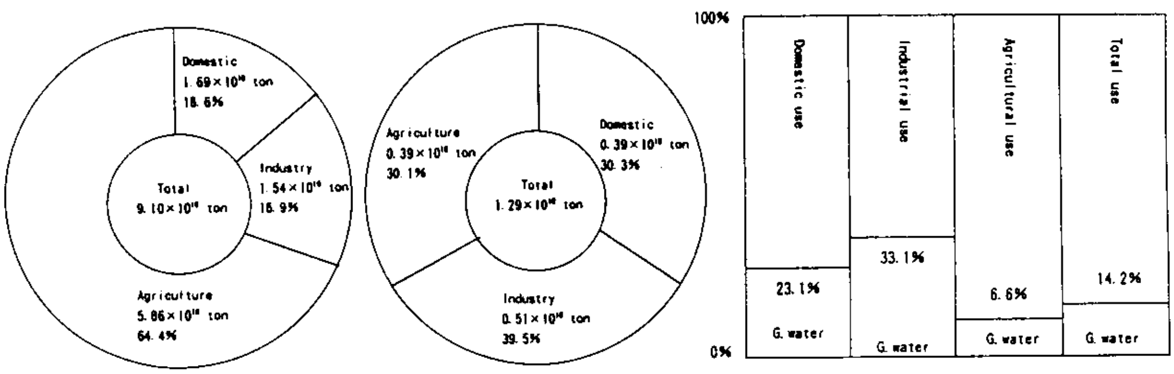
| category | number of waters categorized | complied estuaries | percent compliance |
|---|---|---|---|
| I | - | - | - |
| II | 2 | 0 | 0 |
| III | 2 | 0 | 0 |
| IV | 5 | 2 | 40 |
| total | 9 | 2 | 22.2 |

## Chapter 8 ENVIRONMENTAL WATER QUALITY STANDARDS FOR GROUNDWATER

### 1. Water Resource of Groundwater

The migration of water in subsurface environment is extremely slow compared to surface water, through which numerous numbers of microorganisms living in soil keep removing organic substances and some parts of hazardous anthropogenic chemicals, coupling with the natural capability of biodegradation and ion exchange in soil. The groundwater is believed to be clean enough for drinking water, and not few countries of the world supply the potable water totally from abstracting groundwater. Approximately one fourth of the potable water of Japan are obtained from groundwater.

Fig. 8.1 shows the water use of Japan. The total water use across the nation counts for 91 billion ton per year, 16.9 billion ton (18.6%) of which is for domestic use, 15.4 billion ton (16.9%) for industrial use, and 58.6 billion ton for agricultural practice. Basically the groundwater contributes to water resource with 12.9 billion ton, which covers 23.1 % of domestic use, 33.1 % of industrial use, and 6.6 % of agricultural practice. Totally the groundwater extraction supplies 14.2 % of water use of Japan.




**(a) Total water use (b) Groundwater use (c) Contribution of groundwater**
**Fig. 8.1 Groundwater use of Japan (1996)**

### 2. Background of Groundwater Pollution

The subsurface water including groundwater contains various sorts of substances, some of which are of natural/anthropogenic origin. There exist many potential sources of groundwater pollution around human living sites. It is well known that some of waterborne diseases originate from groundwater pollution. The groundwater is likely to become contaminated in situation of domestic sewage land application and poorly constructed septic tank. This is because most of pathogenic organisms are removed with the filtering capability of soil, however, some viruses can easily penetrate through soil zone to groundwater.

The industrial sewage and sludge contain sometimes high level of heavy metals like cadmium, copper, iron, lead, manganese etc., so their land application can be a source of soil and groundwater pollution. In particular many metals tend to accumulate in the top layer of the soil, which will affect in many ways the soil ecology and sometimes agricultural products. In addition, During the last decade in Japan, volatile organochlorines like trichloroethylene and tetrachloroethylene were detected nation-widely in groundwater taken from industrial and urban areas. These organic chemicals have been utilized as solvent in many hi-tech industries, laundry firms and domestic usage.

Agricultural practice is also a potential source of groundwater pollution. Many chemicals including fertilizer are applied to cropland to raise the agricultural products, and consequently pesticides and constituents of fertilizer are discovered in cropland groundwater. In particular, nitrate-nitrogen groundwater pollution is becoming a great environmental issue in Japan as well other many countries.

### 3. Nationwide Survey Results

Over the last decade there have been warnings of a potential risk of environmental pollution by volatile organochlorines which are widely and effectively used in cleansing processes by many and various industries producing huge amounts of fine products. In Japan in 1974 the presence of trichloroethylene was first detected in well water of Tokyo Metropolitan. In 1981 the serious state of groundwater pollution in so-called Silicon-Valley, US was unveiled, revealing that some of the well-waters were highly contaminated at the concentration of up to 6.4 mg/L in 1,1,1-trichloroethane.

Considering the serious state of groundwater pollution in US and other developed nations, Japan Environment Agency (JEA) started across the country groundwater pollution surveys due to organochlorines in 1982. The total number of water samples analyzed was up to 1,499, of which 1,083 samples were from shallow groundwater, 277 samples from deep groundwater and 139 samples from surface water. Chemical analysis was done mainly on volatile organochlorines including nitrate/nitrite nitrogen, and detection rates for chemicals are demonstrated in Fig. 8.2,

1)the highest detection rate among eighteen chemicals took place in nitrate/nitrite nitrogen, and the highest concentration of nitrate nitrogen was raised to 80 mg/L. In addition, ten percentage of well water samples of 1,360 overshot the drinkable limit for nitrate, which is 10 mg/L in Japan and 11.3 mg/L directed by WHO(World Health Organization),

2)the nitrogen compounds distributed widely in the natural field, so except them, trichloroethylene, tetrachloroethylene and 1,1,1-trichloroethane were found at a high detection rate in the well-waters,

3)in particular trichloroethylene and tetrachloroethylene among three were detected at the rate of about one in three well-water samples, and also three percent of 1,360 well-water samples in both materials exceeded the guidelines for drinking water directed by WHO at that time.

### 4. Set-up of Groundwater Standard

#### 4.1 Groundwater standards

Some legislation was compelled to be changed and modified to prevent and conserve groundwater environment, and a partial amendment of the Law of Water Pollution Control by JEA was implemented in 1989. Consequently any water containing hazardous chemicals including trichloroethylene and tetrachloroethylene is now prohibited in Japan from being injected and recharged into subsurface environment. Such legislation is capable of reducing new occasions of groundwater pollution. However, hazardous chemicals such as organochlorines are originally long-term resistant to biodegradation. Appropriate remediation operation should be taken place, otherwise, hazardous chemicals stay in soil and groundwater environment for many years.

In this context the JEA launched the standards for groundwater in 1997, in which 23 hazardous chemicals were designated and plus 25 chemicals to be monitored were determined. They are consistent with the standards for surface waters in order to meet the systematic control of water environment.

**4.2Monitoring for Groundwater Environment**

The nationwide groundwater surveys have been done, as following items so far,

(a)setting up the mesh scheme for example 5km×5km, sometimes narrower, groundwater are sampled and analyzed in each scheme,

(b)further surveys in order to determine the pollution area for groundwater region detected by the general inspection survey mentioned above, and

(c)the subsequent monitoring for the polluted groundwater confirmed by the survey (b).

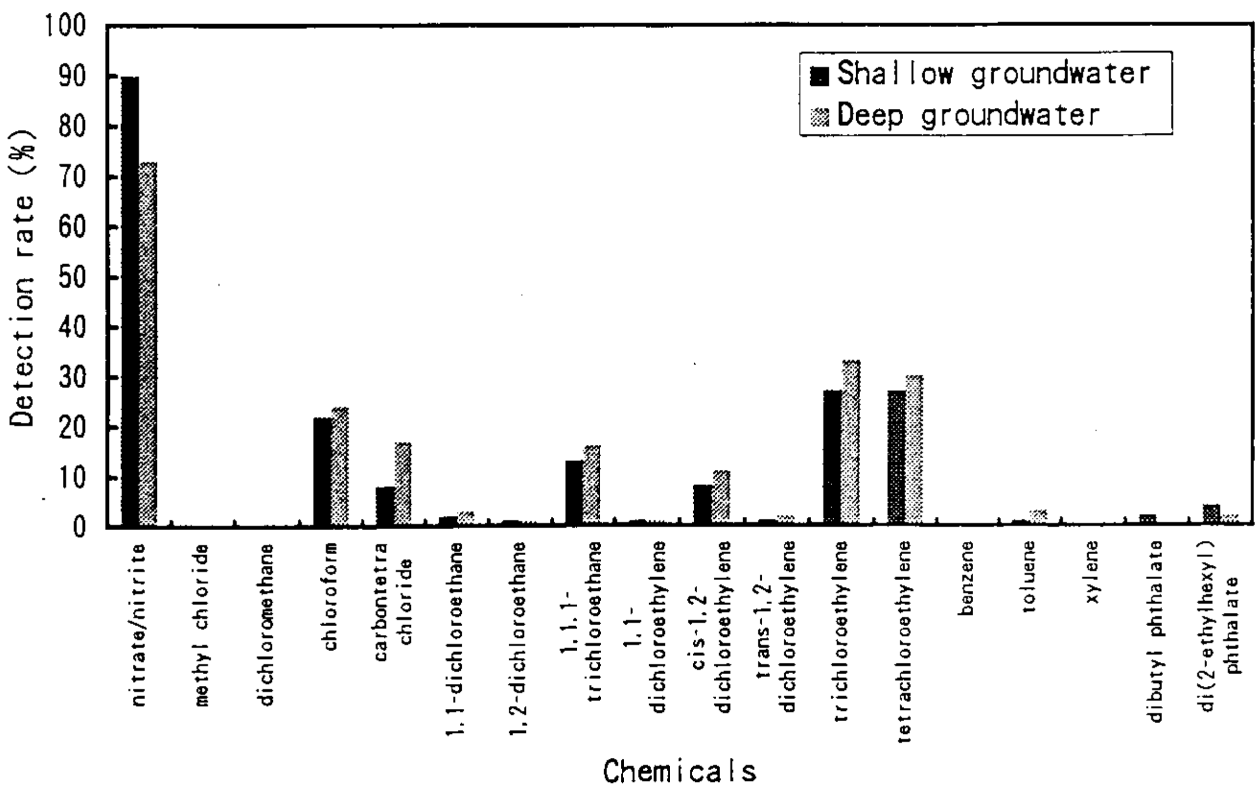



**Fig. 8.2 Detection rate of chemicals discovered in the groundwater sample across the nation in 1982. The survey was conducted by Japan Environment Agency and the number of 1360 well water was analyzed.**

The local government proceeds the groundwater monitoring every year, changing and extending the survey area. The groundwater is existing layered in subsurface environment, so that the only one survey for some scheme is not enough to detect the groundwater pollution. It is desired to check the groundwater quality, changing location and depth several times.

### 4.3 Evaluation of Establishment of Groundwater Standards

When hazardous chemical is detected in groundwater and over the standards, immediately groundwater standards should be remained. In many occasions wider range surveys are taken place according to the groundwater use. However, not always but sometimes, lead and arsenic in groundwater are coming from natural soil and rock. Even in this case, the groundwater standards are applied.

In addition the migration speed of groundwater is extremely slow, compared to surface water, monitoring frequency is determined, considering the groundwater use and flow scale. In this planning the seasonal change of groundwater quality is also considered. The results of groundwater surveys are basically evaluated with the annual mean value of hazardous chemicals in groundwater except of cyanide, which is concerned with acute toxicity.

# Chapter 9 TRANSACTIONS FOR WATER POLLUTION CONTROL AND RESULTS

## 1. Effluent Pollution Control and Standards

### 1.1 Enforcement system

In general, measures taken by the national and prefectural governments to control water pollution and to maintain the water quality of water bodies within the set standards include strict regulation of discharges, expansion and improvement of sewerage systems and treatment facilities, river flow improvement and dredging, and environmental impact assessment of new projects and facilities. A typical river water management practice at the prefectural level will be presented later using the experience of Kanagawa Prefecture and Shiga Prefecture.

The Japan's administration of water quality management is handled by the Environment Agency which was established in 1971 as a ministry. The Director General of the Agency is a Minister of State who is a member of the Cabinet. The Agency is responsible for the coordination and promotion of the protection of the environment as well as the implementation of pollution control. In the field of water quality management, the main role of the Agency is as follows: enforcement of the Water Pollution Control Law and some other laws relating to water quality management; establishment and amendment of the standards including the Environmental Water Quality Standards and the nationwide Effluent Quality Standards; and the promotion of research for water pollution control.

Some ministries of the national government also have responsibilities related to water quality management. The Ministry of Health and Welfare is responsible for waste disposal and night soil treatment as well as for the protection of the drinking water system. The Ministry of International Trade and Industry is responsible for research on environmental conservation and technology and the promotion of various environment-friendly industries. The Ministry of Transport is in charge of the prevention of marine pollution by shipping. The Ministry of Construction is responsible for the sewerage system and for flood control and river flow management systems. Other ministries with responsibilities related to water quality management are the Ministry of Agriculture, Forestry and Fisheries and the Ministry of Foreign Affairs.

Prefectural governments are also playing very important roles in environmental water quality management. Their responsibilities include establishing more stringent standards, as mentioned earlier; inspection of specified factories and regulating the effluents discharged by those firms; and establishing and implementing the environmental water quality monitoring program in their localities.

Aside from prefectural governments, city governments in 71 cities specified in the Water Pollution Control Law as "designated cities" are empowered to inspect and regulate the effluent discharges of factories in their respective areas. To illustrate the water quality management practices of Japan's prefectural governments, the experience in Kanagawa Prefecture is included in this chapter.

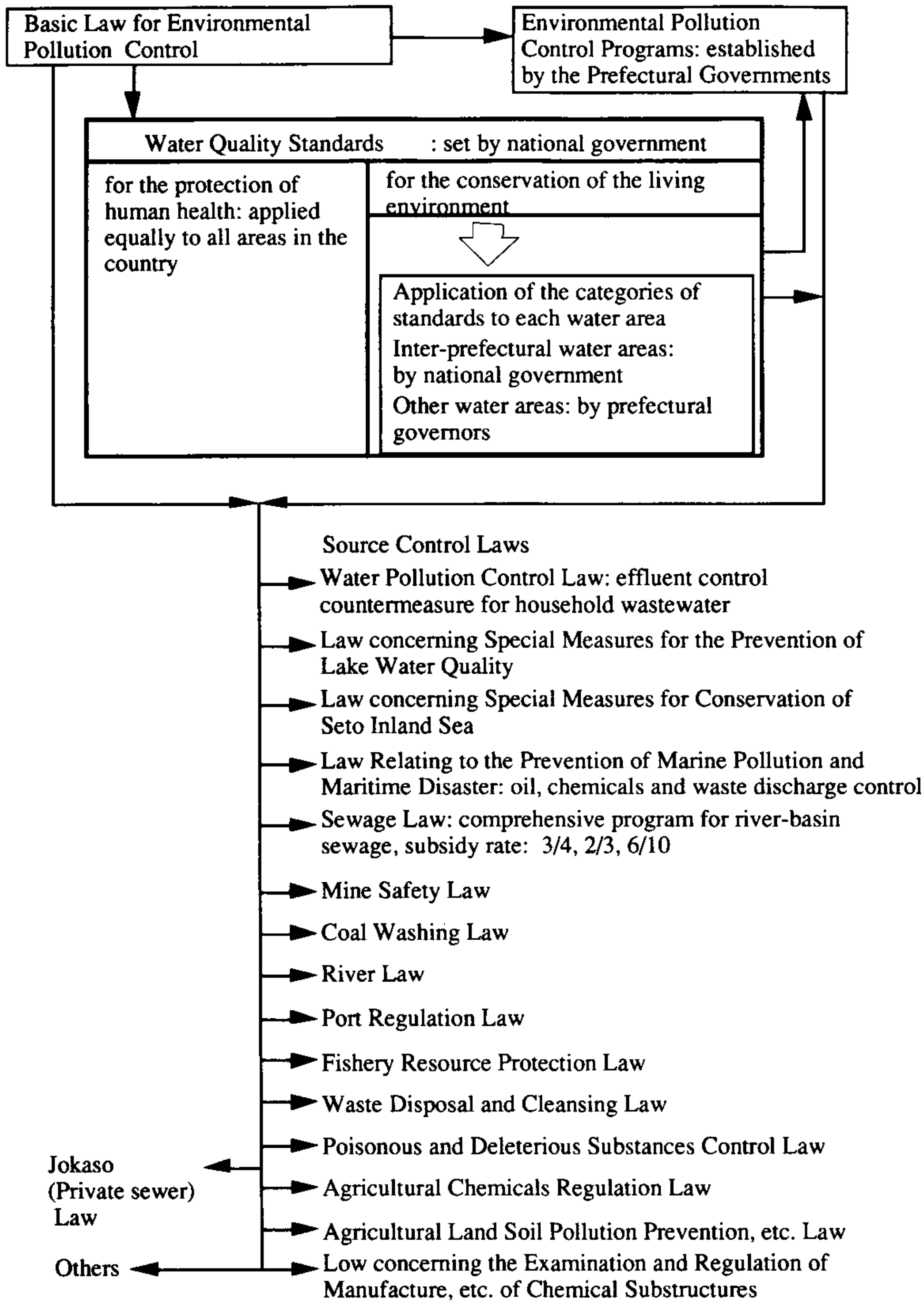



**Fig.9-1** Legal System for Water Quality Management.

### 1.2 Designation of specified factories and establishments

Effluent wastewaters from factories and establishments are widely regulated regardless of kind of industries. Factories and establishments those discharge wastewater into public water areas are designated as "specified factories" based upon the criteria shown in Table 9-1. The effluent from those specified factories are strictly regulated by applying the effluent water quality standard set up by the central government or by more stringent standard set up by local government based upon the Water Pollution Control Law.

**Table 9-1** Designation of Specified Factories

| Date Specified | Specified Factories |
|---|---|
| Oct.1 '72 | Livestock facilities except smaller than 50 m2 for pig, 200 m2 for cow and $500m^2$ for house |
| Dec.1 '74 | 1.Spinning facilities, textile and fiber processing facilities for desizing<br>2.Kitchen, laundering facilities and bath of Japanese style inn<br>3.Cleaning facilities and quenching in research institute, experimental stations |
| Jan.3 '86 | Vocational training school |
| June 1'86 | Facilities for water works and industrial water works with sedimentation and filtration. Capacity of which is larger than $10000m^3$/day<br>Wholesale market dealing aquatic products. |
| May 5 '79 | Kitchen, laundering facilities and bath of hospital with beds more than 300<br>Incineration facilities of Municipal wastes treatment plant |
| Jan.1 '82 | Frozen food processing factories with washing, cooking and unpacking.<br>Cigarette factories with washing and deodorization by water washing<br>Sawmill and wood chipping with glue washing facilities<br>Plywood processing factories with wet barker and washing facilities<br>New paper, publishing, printing, plate makers with automatic film developing facility and automatic printing facility.<br>Tire and tube manufactures, rubber horse manufactures, industrial rubber product manufactures, reforming tire manufactures with vulcanization process<br>Latex forming facility with washing for medical and sanitary rubber products, rubber gloves, rubber band, etc.<br>Automatic bottle washing facilities for reuse<br>Car washing facility in auto shop<br>Industrial wastes treatment and disposal facilities |
| July 1 '82 | Wholesale market in regional cities with floor area larger than 1000 $m^2$ |

### 1.3 Effluent water quality standard

Effluent standards are set in terms of permissible concentration of each harmful or environment polluting substance for protecting human health and each parameter for preserving the living environment. Effluent standards are classified into common national standards set up by the central government and the more stringent effluent standards set up by the local government, i.e. Prefecture. The national effluent standards, which is common nation-widely, shall be set by the Prime Minister's Office Order as shown in Table 9-2.

**Table 9-2** National Effluent Standards for Rivers (mg/L or less)

a) Standards related to the preservation of the living environment

(mg/L or less except pH)

| Parameters | Standard Values |
| --- | --- |
| pH | 5.8 - 8.6<br>5.0 - 9.0 (for estuaries) |
| BOD, COD* | 160 (daily average: 120) |
| SS | 200 (daily average: 150) |
| n-Hexane extract | 5.0 (mineral oil)<br>30 (animal fat and vegetable oil) |
| Phenols | 5.0 |
| Cu | 3.0 |
| Zn | 5.0 |
| Dissolved iron | 10.0 |
| Dissolved manganese | 10.0 |
| Cr | 2.0 |
| F | 15.0 |
| Number of coliform groups | 3,000/mL (daily average) |
| Nitrogen | 120 (daily average: 60) |
| Phosphorus | 16 (daily average: 8) |

* COD is applied to lakes and estuaries

b) Standards related to the protection of human health (mg/L or less)

| Parameters | Standard Criteria |
| --- | --- |
| Cd and compounds | 0.1 |
| CN and compounds | 1.0 |
| Organic phosphorus (Parathion, Methylparathion, Methyl dimethion and EPN) | 1.0 |
| Pb and compounds | 0.1 |
| Cr (VI) and compounds | 0.5 |
| As and compounds | 0.1 |
| Hg (total) | 0.005 |
| Hg (alkyl) | ND. |
| PCBs | 0.003 |
| Trichloroethylene | 0.3 |
| Tetrachloroethylene | 0.1 |
| Dichloromethane | 0.2 |
| Carbon tetrachloride | 0.02 |
| 1,2-dichloroethane | 0.04 |
| 1,1-dicloroethylene | 0.2 |
| cis-1,2-dichloroethylene | 0.4 |
| 1,1,1-trichloroethane | 3 |
| 1,1,2-trichloroethane | 0.06 |
| 1,3-dichloropropene | 0.02 |
| Thiuram | 0.06 |
| Simazine | 0.03 |
| Thiobencarb | 0.2 |
| Benzene | 0.1 |
| Selenium and compounds | 0.1 |

For Public water areas where it is reorganized that the national effluent standards are insufficient for protecting human health to preserve the environment water quality for Cabinet Order effluent water quality and/or for preserving the living environment to attain the environmental quality standards of water, the water pollution control law provides that the more stringent effluent standards may be decided by enacting necessary prefectural regulations in accordance with the national standards. Examples of more stringent effluent water quality standard set up by Kanagawa Prefecture and by Shiga Prefecture are shown in Table 9-3.

**Table 9-3** More Stringent Effluent Water Quality Standards by Local governments (Kanagawa Prefecture and Shiga Prefecture).

| Parameters | Kanagawa Prefecture | | | Shiga prefecture |
|---|---|---|---|---|
| | "A" area | "B" area | Sea | |
| Cd & its compounds | ND | / | / | 0.01 |
| CN compounds | - | / | / | 0.1 |
| Organic phosphorus compounds | ND | 0.2 | 0.2 | ND |
| Pb and its compounds | 0.05 | / | / | 0.1 |
| Cr (VI) | 0.05 | / | / | 0.05 |
| As and its compounds | 0.01 | / | / | 0.05 |
| Hg (total) | / | / | / | 0.005 |
| Hg (alkyl) compounds | / | / | / | ND |
| PCBs | / | / | / | 0.003 |
| pH | / | / | 5.8 ~ 8.6 | 6.0~8.5 |
| BOD | 15 (10) | 25 (20) | / | 70~100* 50~80# |
| COD | 15 (10) | 25 (20) | 25 (20) | 70~120* 50~80# |
| SS | 35 (20) | 70 (40) | 70 (40) | 90* 70# |
| n-Hexane extracts (mineral oil) | 3 | / | / | 5 |
| do. (animal fat & vegetable oil) | 3 | 5 | 5 | 20 |
| Phenols | 0.005 | 0.5 | 0.5 | 1 |
| Cu | 1 | 1 | 1 | 1 |
| Zn | 1 | 1 | 1 | 1 |
| Dissolved iron | 0.3 | 3 | 3 | 10 |
| Dissolved manganese | 0.3 | 1 | 1 | 10 |
| Cr | 0.1 | / | / | 0.1 |
| Fl | 0.8 | / | / | 8 |
| Number of coliform group (/ml) | / | / | / | 3000 |
| (Ni) | 0.3 | 1 | 1 | / |

ND: Not detectable, - : Prohibited to discharge by other Kanagawa Prefectural Ordinances

( ) : Daily average (Ni): Regulated by other Kanagawa Prefectural Ordinances

*Wastewatar: 30~50m$^3$/day. #Wastewatar > 50m$^3$/day

Kanagawa Prefecture is located immediately to the south of Tokyo and is part of the national capital region. It is one of the smallest of Japan's 47 prefectures but has the third largest population, centered in Japan's third largest city, Yokohama. Kanagawa has three international ports and thousands of industries, especially the so-called high-tech ones, located within its boundaries. Kanagawa was among the first prefectures to handle industrial pollution control. Environmental Research Center (ERC) was established by the prefectural government. The ERC is entrusted with tasks related to water quality management such as monitoring of water bodies, inspection and regulation of industrial effluents, research to improve or enhance pollution control measures and others.

Shiga prefecture, located immediately to the north-east of Kyoto and Osaka Prefectures, centered in Japan's biggest lake, Biwa Lake. The lake supplies the industrial and drinking waters to Osaka and Kyoto Prefectures, whereas the quality of water in it has been deteriorated lately due to the urbanization and the industrialization in the surrounding area. Water pollution is one of the serious problems in each prefecture.

## 2. Countermeasures to Preserve Sound Water Environment

The government of Kanagawa had enacted a Prefectural Ordinance to Prevent Pollution, a Effluent Concentration Regulations Ordinance and a Areawide Total Pollution Load Regulation Ordinance. Its Effluent Standards are more stringent than the national standards (compare Tables 9-2 with 9-3). The prefectural government, through the Environment Research Center (ERC) of Kanagawa Prefecture, has also established a regular monitoring program of all public waters, including groundwater, in the prefecture. Monitoring points, monitoring parameters and monitoring frequencies are given in Table 9-4 and 9-5.

**Table 9-4** Monitoring Parameters.

| Categories | Parameters |
|---|---|
| Human health | Cd, CN, Pb, Cr (VI), As, Hg (total), Hg (alkyl), PCBs, Trichloroethylene, Tetrachloroethylene, Dichloromethane, Carbon tetrachloride, 1,2-Dichloroethane, 1,1-Dichloroethylene, Cis-1,2-Dichloroethylene, 1,1,1-Trichloroethane, 1,1,2-Trichloroethane, 1,3-Dichloropropene, Thiuram, Simazine, Thiobencarb, Benzene, Selenium and compounds, |
| Living environment | pH, BOD, $COD_{Mn}$, SS, DO, Number of Coliforms, n-Hexane extracts, Total nitrogen, Total phosphorus |
| Special items | Phenols, Copper, Zinc, Dissolved ion, Dissolved manganese, Chromium, Fluorine, Nickel, ENP |
| Other items | Ammoniacal nitrogen, Nitrite, Nitrate, Phosphorus, Chloric ion, Salts, 1,1,1-Trichloroethane, Anionic surfactant, Chlorophyl a |
| Physical items | Weather, Weather of previous day, Water depth, Sampling depth, Water flow rate, Flow, Atmospheric temperature |

**Table 9-5** Monitoring Frequency of Water Quality in Rivers, Lakes and Seas Implemented in Kanagawa Prefecture.

| Site | Frequencies |
|---|---|
| River | 4 times a day at 6 hourly intervals each month and 48 times (12 days) a year |
| Lake and Sea | Once a day from the upper and the lower layers of water each month and 12 times a year |

Pollution control measures undertaken by Kanagawa prefectural government are as follows:

1)regulating factories based on laws and ordinances;

2)maintenance and construction of additional sewerage and sewage treatment systems;

3)aeration of Sagami Lake;

4)water quality purification in waterways; and control of pollution from new high-tech industries.

Reports which indicate pollution control plans and measures are required for all factories and establishments discharging effluents into public water bodies. Such reports are examined, and the establishments inspected by the government through the ERC, before operating approval is given. Administrative disposition or guidance has been used to correct pollution problems by those establishments found violating the set standards for effluents.

To support the governmental system of environmental guidance and regulation of industries, the government has instituted a system of Pollution Control Officers (PCO) in all designated industries. The PCOs have been given the task of supervising the control of pollutants in the plants, more specifically to ensure that effluents released to water bodies are within the set standards. To become a PCO, one has to pass a qualifying examination administered by the Ministry of International Trade and Industry. There are several levels of PCOs ranging from supervisors to managers of different staff which are designated by the firms, especially in large establishments, to handle pollution control. The prefectural government institutes educational meetings yearly or more frequently for lower-level PCOs, to update their knowledge and skill in pollution control.

The prefectural government has been constructing and maintaining sewerage systems, treatment plants and special tanks for night soil and household wastewater to control pollution from domestic sources. To date, 79.4% of the population is served by a sewerage system. The cities of Yokohama and Kawasaki are almost completely sewered.

The government of Kanagawa, through the ERC, has also started studying and monitoring chemical pollutants from high-tech industrial firms such as those engaged in electronics, new materials technology and biotechnology. The government has given guidance and information on the safe use of some chemicals used in these plants. The monitoring of some chemical substances, such as tetrachloroethylene which penetrates the soil and accumulates in the groundwater, had also been conducted by the ERC. Research on how the pollutants are produced and proper disposal procedures is conducted on these chemical pollutants.

The efforts of the prefectural government in Kanagawa have produced positive results. The water quality of public water bodies in this area has been improving. The health of the people has been protected and the living environment has been conserved.

### 3.Countermeasures Taken in Industries

Figure 9-2 shows the combination of production process and wastewater treatment process. The top figure shows the conventional, i.e., previous type combination, where the wastewaters from each unit production process are mixed and treated with together. Additional and complicated treatment processes could be required to meet the more stringent regulation applied to the effluent. No advantage is available to introduce such wastewater treatment process for the production side since productivity is not improved by the introduction of such treatment process. The bottom figure shows the production process combined with on-site wastewater treatment and recycle system. Pollutants discharged from each unit process will be easily removed by the corresponding and simple treatment process and the effluent can be recycled for the same unit process. The amount of industrial water required for the production can be reduced by the reuse of treated wastewater. Moreover the wastewater treatment process can be simplified by incorporating the on-site treatment because the wastewaters are treated separately without mixing.

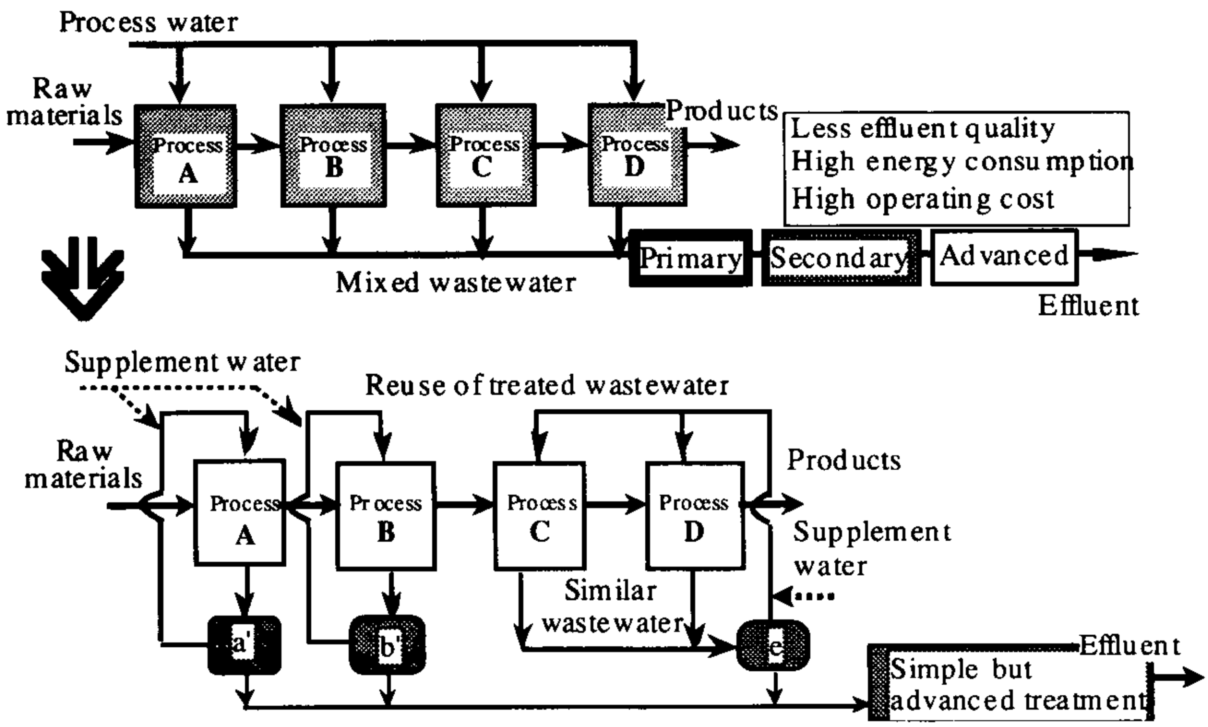



**Fig.9-2** Onsite wastewater treatment and recycle system

**Table 9-6** shows an example in the reduction of wastewater discharged from polymerization process. The counter measures have taken to reduce the wastewaters from the process are summarized in the table. The amount of wastewater from the polymerization process was drastically reduced by the introduction of onsite wastewater treatment process with recycle.

**Table 9-6** Reduction of the wastewaters from polymerization process

| Month & Year | Jan. 1965 | Jan 1973 | Nov. 1973 | Feb. 1974 |
|---|---|---|---|---|
| Wastewater ($m^3$/t-polymer) | 36.2 | 17.0 | 8.8 | 0.2 |
| Counter measure | (A) | (B) | (C) | |

(A)Increase in polymer concentration in liquid, (B)Wastewater recycle from separation process, (C)Wastewater recycle from catalyst washing and polymer drying processes.

Information on the constituents of raw and supplemental materials in the production process and the constituents in the wastewaters are very much useful to improve the production process. Wastewater discharge was reduced by introducing counter current washing system as shown in Fig.9-3. Note that the fresh washing water is supplied counter currently to the products.

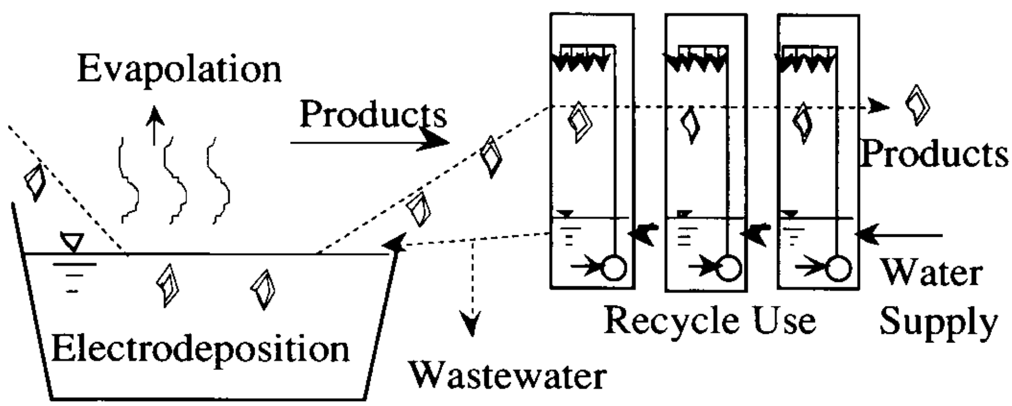



**Fig.9-3** Counter current washing system for reduction of washing water

Production process should be replaced with an alternative process to reduce or to eliminate the pollutants discharge. Electrolysis using mercury electrode to produce sodium hydroxide and chlorine from sodium chloride was replaced that with the electrolysis using ion exchange membrane to eliminate the wastewater containing toxic mercury. Wastewaters from polymerization process can be eliminated by replacing the liquid phase polymerization with the gas phase or bulk polymerization processes.

Any materials including raw and sub-materials (supplemental materials for production) used in production processes should be totally managed appropriately to know the input and the output in the factory. Total management system of materials should be introduced to reduce the excess use of materials and to know the effluent discharge, i.e., the wastes, from the production process. Then we can expect the amount of wastes from the process in the forms of gas, liquid and solid by subtracting the mass of products from the input. Once such total management system is introduced, it is easy to know the constituents and the concentration of pollutants in the wastewater, exhaust gas and in the solid wastes. In case some materials are difficult to treat, those should be removed from the input readily. Pre-evaluation system of materials and supplements used in factories should be preliminary evaluated from view point of environmental pollution loading before using.

## 4. Effect of Countermeasures for Water Quality Management in Japan

### 4.1 Sewerage system and household treatment tank

Figure 9-4 shows the diffusion of sewerage system and household treatment tank (Jokaso) for municipal wastewater treatments.More than 50 % domestic wastewater is accepted by municipal plant with secondary or more advanced treatment system. The household treatment tank shears about 30 % domestic wastewater to treat. Night soil collected from the privy is treated by treatment plant with advanced system exclusively used for night soil.

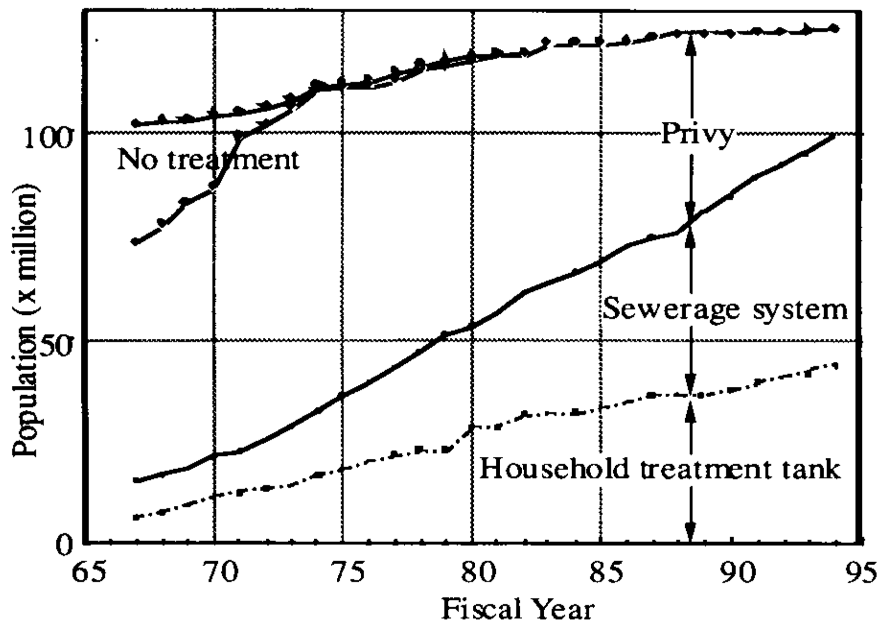



**Fig.9-4** Diffusion of sewerage system and household treatment tank for domestic wastewater treatment.

### 4.2 Reduction of Industrial Wastewater with Recycle Use

The more stringent water pollution control regulation and two times energy crises brought about the reduction of water usage in factories for production. Figures 9-5 and 9-6 show the required amount of water for the production of commodities in Japan for past 25 years. Required water for production was reduced to one-third for the past 25 years. Appreciable reductions can be seen in the pulp and food industries.

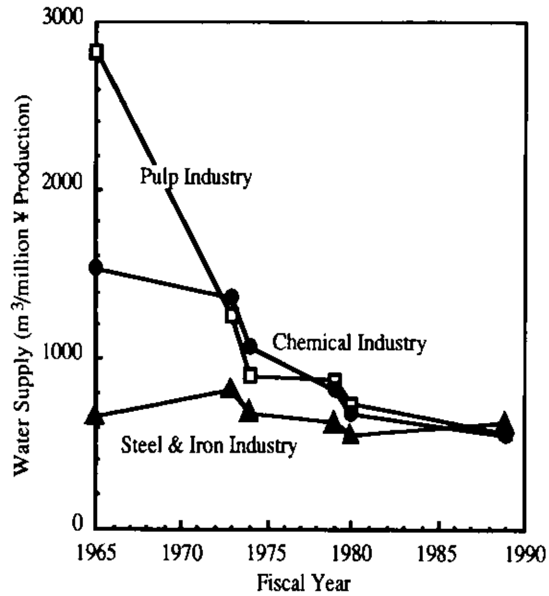



**Fig.9-5** Water use in production processes

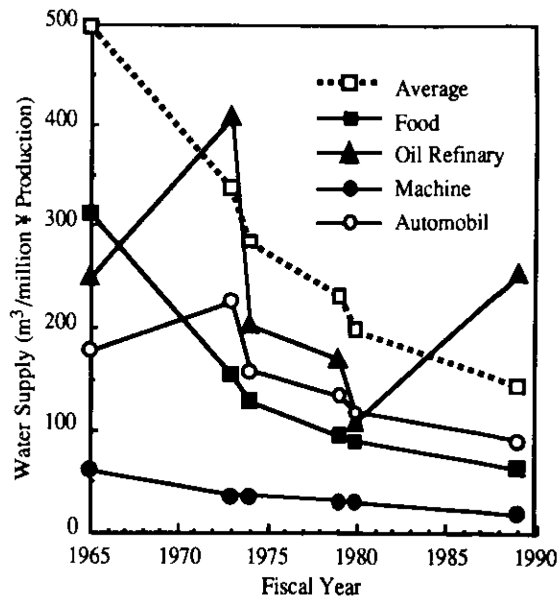



**Fig.9-6** Water use in production processes

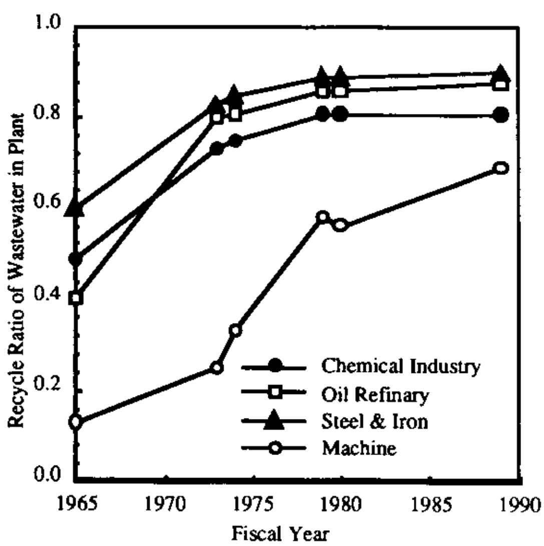



**Fig.9-7** Recycle ratio of wastewater in plant

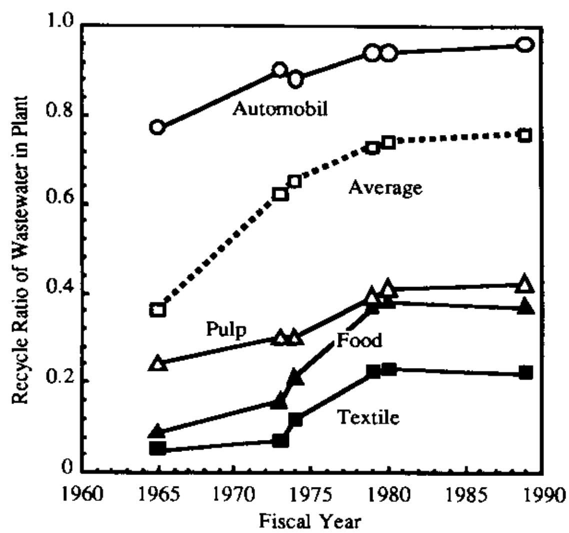



**Fig.9-8** Recycle ratio of wastewater in plant

Figures 9-7 and 9-8 show the recycle ratio of wastewater to the production process after appropriate treatment in the plant. The recycle ratios in steel and iron industries, oil refinery plants, chemical industries and automobile industries are as high as 80% through 90%. The recycle ratio, however, in pulp, food and textile industries are still low compared to the average recycle ratio in Japan, i.e. 75% in 1990. Appreciable increase in the recycle rations has been attained through two times oil crises, i.e. 1973 and 1979 as shown in Figs.9-3 through 9-6. The oil crisis brought about the conservation of energy and the increase in the recycle ratio of wastewater in plants as well.

Figure 9-9 shows the water consumption by industries in Japan. More than 100 million m3 of water is used for the production. Large part is occupied by steel and iron industries, chemical industries and pulp and paper industries.

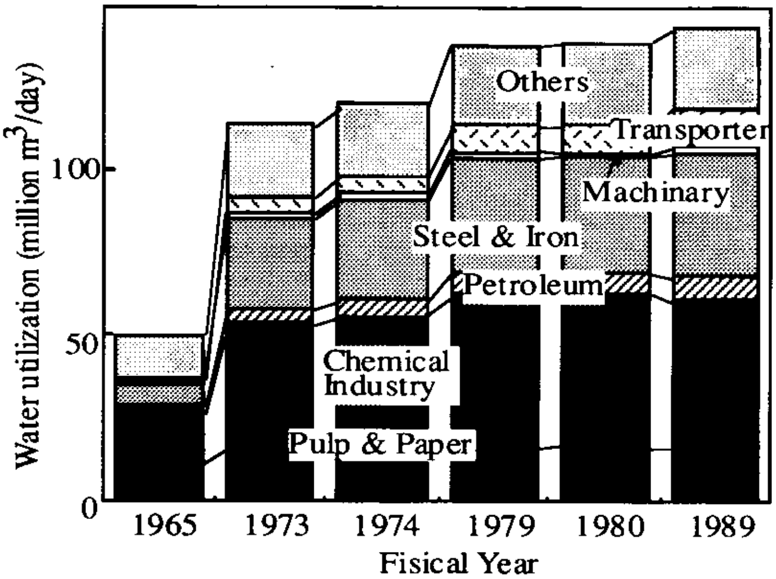



Fig.9-9 Water utilization by industries in Japan

### 4.3 Compliance to the Environment Quality Standards for Water Area

Due to the countermeasure for the management of water quality in the rivers, recently, there has been a general improvement in terms of controlling water pollution and raising the water quality of rivers and other water bodies in Japan. In particular, the levels of toxic substances, such as cadmium and cyanide, have decreased remarkably in water bodies (see Fig.9-10). The improvement of river water quality in terms of a reduction of organic waste pollutants is also seen in rivers. The compliance ratio with respect to environmental quality standards for BOD and COD in various aquatic environments is increasing as seen in Fig.9-11.

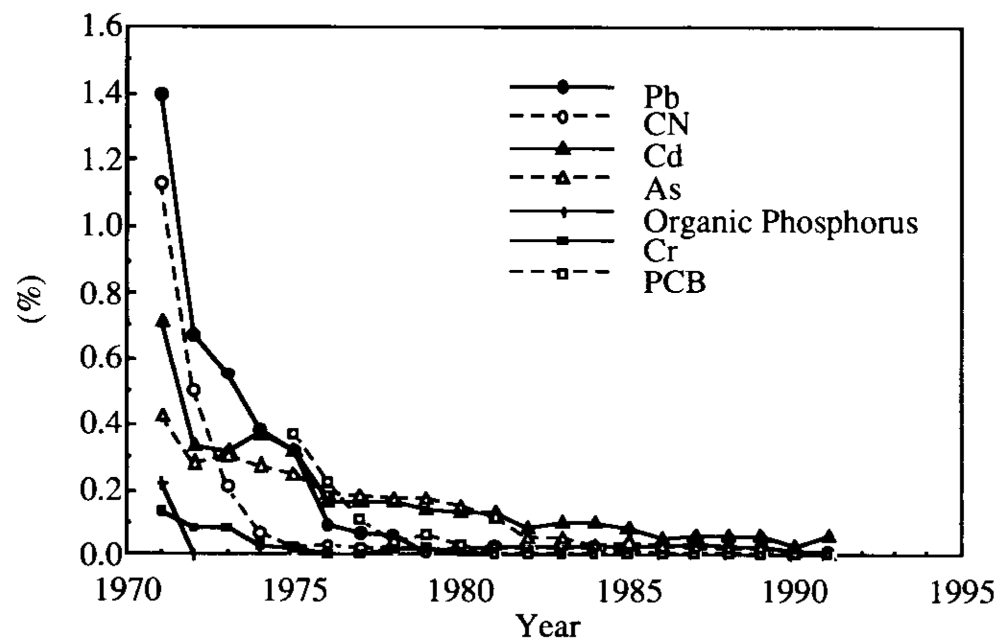



**Fig.9-10** Non-compliance Ratio to the Water Quality Standards of Toxic Substances.

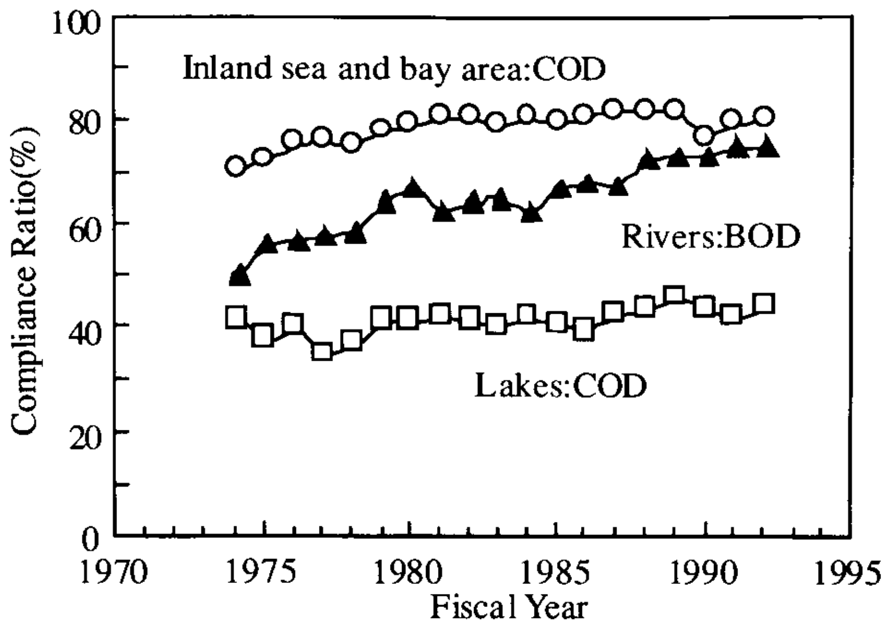



**Fig.9-11** Compliance ration to the water quality standards of BOD in rivers and COD in lakes and bays.

# Chapter 10 LAW CONCERNING SPECIAL MEASURES FOR THE PRESERVATION OF LAKE WATER QUALITY AND THE EFFECTS OF THE LAW

## 1. The Present Condition of Lakes of Japan

### 1.1 Types and Number of Lakes in Japan

The number of lakes in Japan, including those being made artificially with diameter more than 100 m, is approximately 11,600 [1]. According to a national wide survey which was carried out by Environment Agency in 1984, total number of lakes having water area more than 0.1 $km^2$ and watershed area more than 1$km^2$ is 1,120. Approximately 80% of those are artificial lake, e.g., dams for water supply and ponds for irrigation use. When comparing by water volume, however, about 90 % of lake's volume is occupied by natural lakes (**Table 10-1**) [1].

When we take account of small-scale lakes and ponds, the number of dams with bank which

**Table10-1** Number of lakes and dams in Japan*

| Lake type | Number** | Total volume $10^6 m^3$ |
|---|---|---|
| Natural lakes | 197 (17.6%) | 117,435 (89.4%) |
| Dams | 763 (68.1%) | 13,521 (10.3%) |
| Ponds | 160 (14.3%) | 346 ( 0.3%) |
| Sum | 1,120 | 131,302 |

* source: Research results by Japan Environmental Agnecy (1984)
**lakes with area more than 0.1$km^2$ and with watershed area more than 1 $km^2$ except salt lake

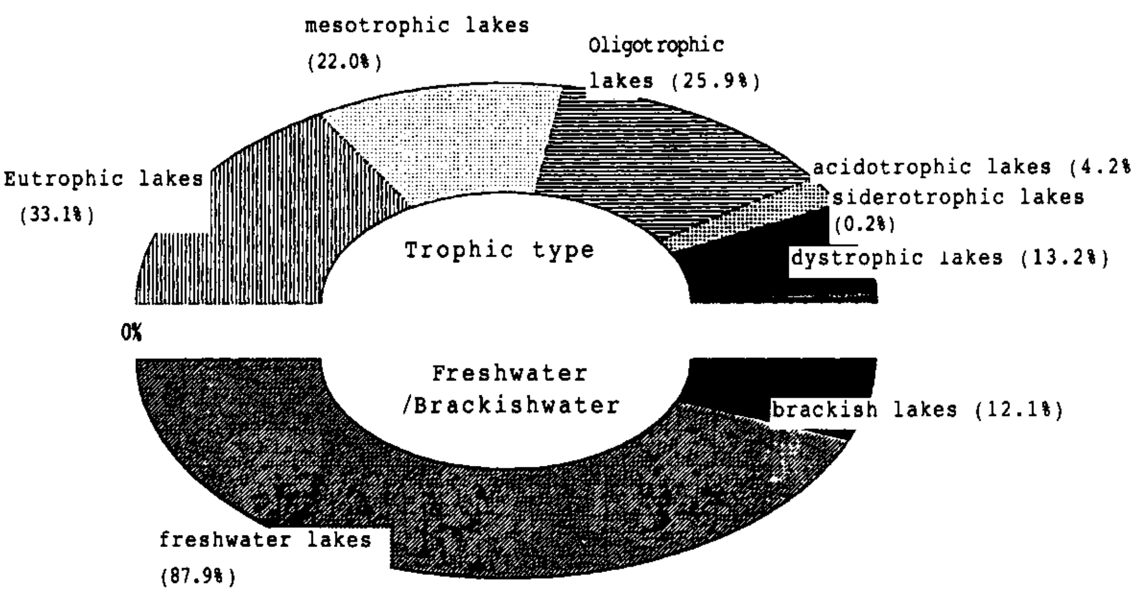



**Fig.10-1** Types of lakes in Japan

height more than 15 m constructed by 1983 are 2462, and irrigation ponds with served area more than 1.0 ha are 97,564 in 1981.

Japan Environment Agency is conducting the surveys on lakes with water area more than 1 ha (app. 480 lakes) for investigating water quality, lake shore condition, species of fishes, etc. every five year from 1979 [2)3)]. According to the survey, as shown in **Fig. 10-1**, when lakes are classified by nutritional state, number of eutrophic lake is largest (33%), secondary oligotrophic lake (26%), thirdly mosotrophic lakes (22%). On the other hand, when lakes are classified by fresh water lake and brackish-water lake, the number of former is larger than latter: app. 88% is freshwater lake.

### 1.2 Water Quality of Lakes

Water quality of lakes in Japan is deteriorated remarkably in recent years, due to the increase in pollution load associated with the land developments and economic activities around lakes. Achievement rate of environmental standards of lake water quality measured by chemical oxgen demand (COD) is lower ( around 40% ) than that of rivers or sea area ( **Fig. 10-2** ). Furthermore, problems on water use by eutrophication are becoming serious in a part of lakes, e.g., problems on filtration at water treatment plants, odor of drinking water, occurrence of freshwater red tide and bloom of blue-green algae. The condition of water quality and problems for water use at main lakes in Japan are shown in **Table 10-2** [1)].

## 2. Law Concerning Special Measures for the Preservation of Lake Water Quality (the Lake Law)

### 2.1 Circumstances of the Establishment of the Law

The improvement of water quality of lakes in Japan is not clear, although we have carried out such measures as establishment of national effluent standard, upgrading of the effluent standard and construction of sewerage system. The reason of the stagnation of improvement of lake water quality is considered as follows:

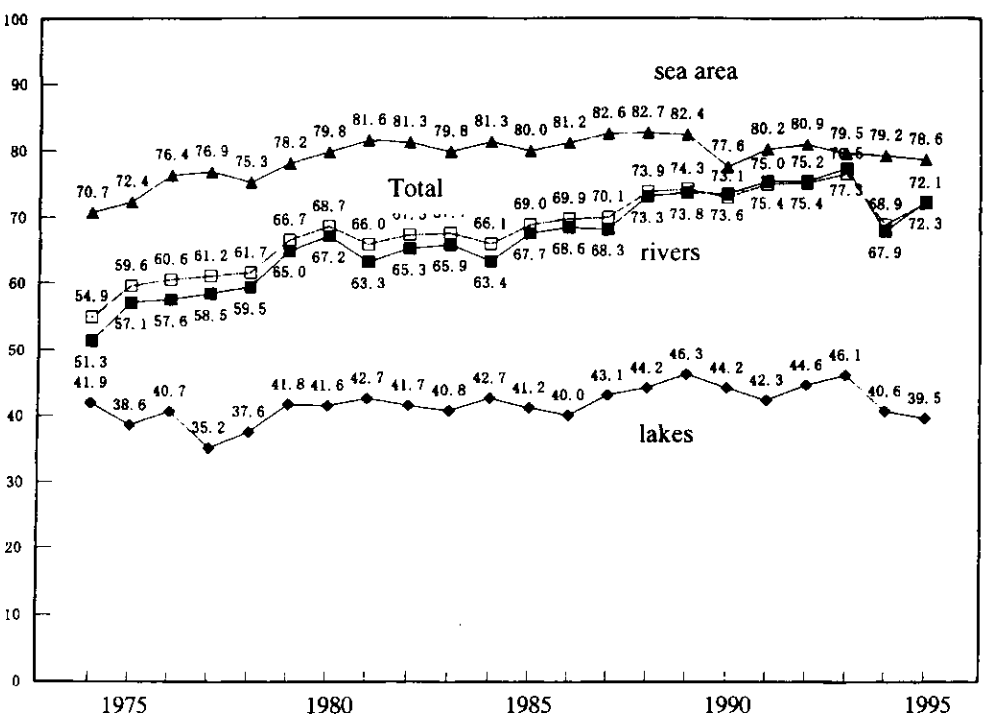



**Fig.10-2** Changes in attainment rate of environmental standard of BOD、COD.

**Table10-2** Condition of lake water quality in Japan.

| lakes | prefecture | COD | COD | | | water use | problems of water use (1972-) |
|---|---|---|---|---|---|---|---|
| | | | 1982 | 1994 | | | |
| | | Environmental standard | 75% value | 75% value | attainment | | |
| | | mg/l | mg/l | mg/l | | drinking, irrigation, | odor of tap water |
| | | | | | | industrial use, | clogging of sand filter |
| Lake Biwa | Shiga | Northern lake 1.0 | 2.6 | 2.9 | × | aquaculture, fishing, | death of fish |
| | | Southern lake 1.0 | 3.9 | 3.8 | × | boating, leasure | unsuitable for water bathing |
| | | | | | | drinking, irrigation, | odor of tap water |
| Lake Kasumigaura | Ibaraki | 3.0 | 11 | western lake 10 | × | industrial use, | death of carp in aquacultute |
| | | | | Northern lake 8.8 | | aquaculture, fishing, boating | unsuitable for water bathing |
| | | | | | | irrigation, aquaculture, | death of carp in aquacultute |
| Lake Suwa | Nagano | 3.0 | 8.3 | 7.3 | × | fishing, boating | decrease in value of sightseeing |
| Lake Shinji | Shimane | 3.0 | 6 | 5.6 | × | aquaculture, fishing, leasure | decrease in value of sightseeing |
| Lake Nakaumi | Shimane Tottori | 3.0 | 5.6 | 6.6 | × | aquaculture, fishing, leasure | decrease in value of sightseeing |
| | | | | | | drinking, irrigation, | odor of tap water |
| Lake Inbanuma | Chiba | 3.0 | 15 | 12 | × | industrial use, | decrease in value of sightseeing |
| | | | | | | aquaculture, fishing, | decrease in population for fishing |
| | | | | | | irrigation, aquaculture, | damage on rise, |
| | | | | | | fishing, boating | decrease in population for fishing, |
| Lake Teganuma | Chiba | 5.0 | 25 | 24 | × | | decrease in value of sightseeing, |
| | | | | | | | damege on fishes and shells |
| Lake Kojima | Okayama | 5.0 | 9.8 | 11 | × | irrigation, aquaculture, fishing | damage on rise, |
| | | | | | | drinking, irrigation, | odor of tap water |
| Kamafusa Dam | Miyagi | 1.0 | 2.7 | 1.9 | × | industrial use, | clogging of sand filter |
| | | | | | | aquaculture, fishing, | |

1) Lakes are easy to accumulate pollutants because lakes are enclosed water body and water stays there. Therefore, it is necessary to reduce inflowing pollution load more thoroughly for improvement of lake water quality than that of river water quality.

2) Water pollution of lakes is caused by various nutrients sources such as industrial wastewater, domestic wastewater, agricultural wastewater, livestock wastewater, nutrients load by aquatic culture, etc. Therefore, conventional measures, e.g., establishment of effluent standard for industrial and domestic wastewater and construction of sewerage system, are not sufficient. It is necessary to carry out overall measures.

3) Condition of water quality and causes of water pollution are various among lakes. Therefore, conventional common measures are not sufficient. Unique measures based on a condition of each lake should be considered for water quality improvement, and measures should be carried out intentionally.

In order to progress those integrated measures, it is important to cooperate among related ministries and divisions of national government, local government, industries and citizens.

Making a draft of the Lake Law was proceeded considering those background of water pollution of lakes.

In the process of making the draft of the Lake Law, firstly, the Director General of Environment Agency request the Central Environment Protection Committee to make a report for establishment of measures for lake water conservation in 1980. Then the report was submitted from the committee in 1981. The Environment Agency made a draft of the Law based upon this report in 1983. The draft was submitted to the Diet in 1983, approved by the Diet in 1984, and enforced in 1985.

### 2.2 Contents of the Lake Law

#### (1) Purpose

The purpose of the law is to establish the basic policy for the preservation of lake water quality and formulate a plan regarding the measures to be taken for the preservation of water quality of such lakes where it is eminent to establish an environmental standard regarding the pollution of water quality and take special measures such as enacting necessary regulations relative to the facilities discharging polluted water, waste liquids and other substances causing the water pollution whereby contributing to ensure a healthy and cultural life of the people.

The report in 1981 submitted by the Central Environment Protection Committee proposed a law system that protect natural environment around lakes in addition to improvement of lake water quality. However, it was considered that protection of natural environment around lakes was possible by application of the existing laws such as "Natural Environment Protection Law", "Forest Law", "Urban Planning Law". Consequently, The Lake Law was written aiming at lake water quality protection.

#### (2) Structure of the Law

The Law focuses on lakes where improvement of water quality is urgent. Prime Minister designates those lakes as "designated lakes", and central and local government have obligation to improve those lake water quality using various kinds of measures. The aims of the law are summarized as follows:

1) Introduction of special regulations to pollutant discharges in the watershed area of the designated lakes in addition to the regulations by the Water Pollution Control Law.

2) Carrying out various measures for lake water improvement comprehensively with corporation between central government and local government according to the plan based on the Lake Law. The system of the Lake Law is shown in **Fig. 10-3**.

Designated lakes are designated by Prime Minister on the basis of the proposal of Prefectural governor. Needed lake conditions for the designation are as follows:

1) Water quality environmental standards are not satisfied in the lake, or it is predicted in the near future that water quality environmental standards become unsatisfied in the lake.

2) Comprehensive measures for water quality preservation are needed in consideration to the changes in water quality.

There are ten designated lakes in 1997 (Kamafusa dam, Lake Kasumigaura, Lake Inbanuma, Lake Teganuma, Lake Suwa, Lake Nojiri, Lake Biwa, Lake Nakaumi, Lake Shinji, and Lake Kojima ).

#### (3) Establishment of Basic Policy for the Preservation of Lakes Water Quality by the National Government

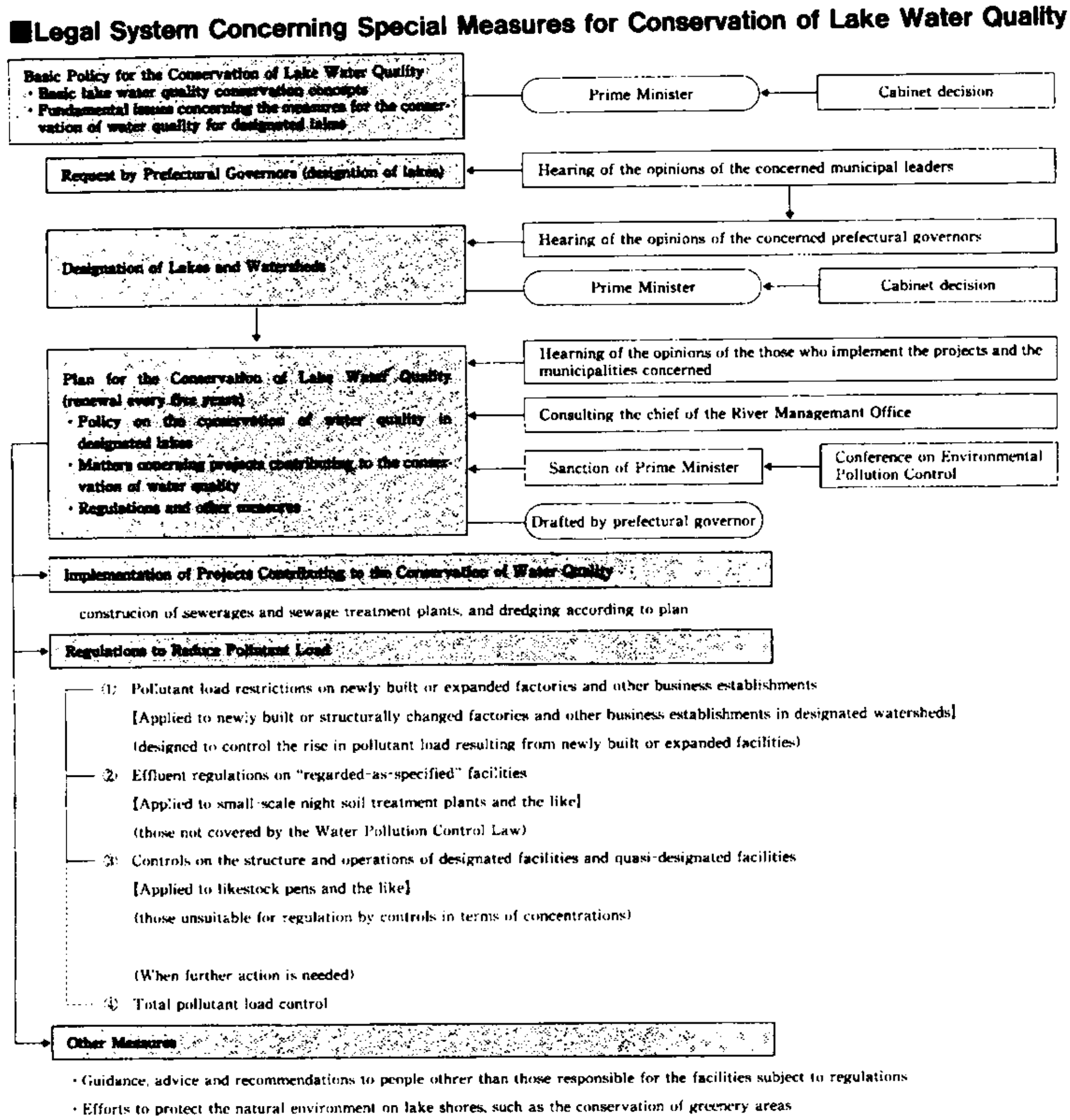



**Fig. 10-3** Legal System concerning the Lake Law

Intimate cooperation among the national government, local governments, enterprises, and residents is indispensable to execute various measures to improve water quality of lakes. Therefore, the national government was assumed to have to provide for "Basic Policy for the Preservation of Lakes Water Quality" considering the conditions of lakes in the Japan besides the designated lakes. Moreover, the basic policy had to be a basic idea to carry out water quality improvement measures corresponding to the characteristic of lakes and the causes of water pollution with due consideration to the public functions of lakes such as a flood control function, resources of tap water, irrigation water and industrial water, and fishery.

"Basic Policy for the Preservation of Lakes Water Quality" was established as a Prime Minister's Office notification based on the Lake Law in 1984. A basic direction of the measures for lakes water quality improvement is mentioned in the basic policy as follows:

(1) It is easy to deteriorate lake water quality, however, it is very difficult to improve lake water quality once it is deteriorated. Therefore, we should keep water quality of a lake where its water quality is maintained good condition for water use in the region. On the other hand, we should enhance and reinforce water quality improvement measures for lakes where

preferable water quality for the water use is not secured.

(2) Most serious problem of lake water quality in Japan is eutrophication caused by the increase in algal production with increase in inflow of nutrients and the increase in inflow of organic matter into the lake from its watershed area. Growth of algae, concentration of organic matter and that of nutrients are affecting each other. Therefore, objectives for improvement of lake water quality should be expressed by appropriate parameters such as COD, nitrogen and phosphorus considering each characteristic of lakes.

(3) Improvement of lake water quality is not always realized by reduction of a pollution load from a specific source because water pollution of lakes is originated from various causes. Therefore, we should promote integrated measures in cooperation with related organizations and people.

(4) In addition, we should consider and utilize the potential ability of flora, fauna, soil and other things which composes the ecosystem for water purification when we make plan for water purification in agricultural land, forest and lakeside area.

**(4) Establishment of a Plan for Preserving the Lake Water Quality by Local Government**

When designated lakes and designated areas are established in accordance with the Lake Law, the governor of prefectures, as stipulated in "the Basic Policy for Preservation of Lake Water Quality", shall prepare a plan (hereinafter referred to as "Plan for the Preservation of Lake Water Quality"), every 5 years, regarding the measures to be taken for preserving the water quality of designated lakes. The Plan for the Preservation of Lake Water Quality shall stipulate the following particulars:

(1) Policy regarding the preservation of lake water quality.
(2) Plan of works relating to the construction of sewers and septic tanks, dredging and other works contributing to the preservation of lake water quality.
(3) Legal measures such as regulations for the preservation of lake water quality.
(4) In addition to the preceding 3 particulars, other measures for the preservation of lake water quality.

When preparing the Plan for the Preservation of Lake Water Quality, the governor of prefecture should obtain opinions of the person implementing the enterprise as stipulated in the Plan for the Preservation of Lake Water Quality, that of the mayors of the cities, towns and villages concerned, and that of the person in charge of managing rivers, then the governor shall obtain the approval of the Prime Minister.

Outline of the process of making the plan are shown as follows:

(1) The water quality of a designated lake and the amount of pollution load discharged into the lake from the watershed area are determined. Then, the changes in the amount of the pollution load in the future are estimated considering trends of the population, industries and other human activities, and the effects of the changes in pollution load on the water quality of the lake is predicted.
(2) All measures that may improve the water quality of the lake are listed up, and effects of those measures on lake water quality are evaluated.
(3) Target of the plan and measures for achieving the target are summarized based on the result of the above-mentioned investigation. In the process of drawing the plan, they should give consideration to the public functions of lakes such as flood control ability, resources of water, resources of fishery and other public functions. They should also take account of regional development plans in the area around the lakes and adjust the plan for lake water preservation with these other plans.

Guideline of measures for water quality preservation of designated lakes were mentioned in the Basic Policy for the Preservation of Lakes Water Quality as follows:

(1) Construction of sewerage and night soil treatment facilities

The construction of public sewerage system should be promoted because sewerage system is effective to reduce pollution load from households and industries.
Moreover, construction of treatment facilities of night soil and gray water should be promoted by considering the condition of each area.

(2) Reduction of pollution load from industries

Control of pollutants discharges from industries by installation of effluent standard and/or regulation of total quantity of pollution load. Effluent standard is applied to industrial or business facilities based on Water Pollution Control Law, but the Lake Law can apply the effluent standard to facilities which are not applied by Water Pollution Control Law.

(3) Reduction of pollution load from households

A proper installation and maintenance of septic tanks (Joukasou) are promoted considering the progress of construction of public sewerage and small scale sewerage.
Moreover, treatment of gray water should be promoted by proper facilities, e.g., Joukasou. Prevention of suspended solids discharges by kitchen works also should be promoted in order to reduce pollution load from households.

(4) Reduction of pollution load from livestock

Pollution load from livestock should be reduced by application of effluent standard, maintenance of livestock sheds, and construction of treatment facilities for livestock excretions.

(5) Reduction of pollution load from fishes cultivation facilities

Structure and maintenance method of fishes cultivation facilities should be improved for reduction of pollution load.

(6) Reduction of pollution load from nonpoint sources

Nonpoint pollution load from farmland should be decreased giving consideration to livelihood of farmers and actual activities in farmland in addition to the measurement of pollution load from farmland.
Nonpoint sources by runoff from urban areas should be also decreased by appropriate measures based on the measurement of the pollution load by runoff and its effects on lake water quality.

(7) Dredging of bottom sediment and other measures for improvement of lake water quality

Dredging of bottom sediment, aeration, introduction of clear water and removal of aquatic weed should be applied to the area where organic substances are accumulated on bottom sediment of a lake or rivers inflowing to the lake.

(8) Protection of forests in watershed area of a lake and natural environment along the lakeshore.

Besides the above mentioned measures for reducing pollution load into a lake, protection of forests in the lake watershed area and natural environment along the lakeshore should be promoted according to the existing laws, i.e., Natural Environment Protection Law, Natural Park Law, Forest Law, Urban Planning Law, Urban Green Area Conservation Law and River Law.

**(5) Restriction for Pollution Load Reduction**

In designated areas, the governor of prefecture shall establish a regulation standard with the parameter of COD, total nitrogen and total phosphorus aiming at wider application of effluent standard to industries and households than that by the Water Pollution Control Law. The Lake Law regulates the effluent from the following facilities as quasi specified facilities.

1. The following facilities installed in hospitals having more than 120 but less than 299 beds.

a) Kitchen facility
b) Washing facility
c) Bathing facility

2. Septic tanks with daily flow rate more than 50m3 with a capacity for more than 201 and less than 500 persons.

On the other hand, the next facilities considered that the increase leads to reduction of the pollution load to specified lakes are removed from the restriction object.

(a) public sewerage treatment plant
(b) public night soil treatment plant
(c) small scale treatment plant constructed in agricultural area

The restriction by regulation standard according to the Lake Law is not, however, seemed to be sufficient because restriction to the quasi specified facilities is applied only to newly constructed facilities or enlarged facilities. The restriction is not applied to existing facilities. The restriction by the Lake Law is considered to be supplementation of the restriction by the Water Quality Control Law. The lake Law is devised to be, rather than the law which gives priority to the pollution load reduction by effluent standard or pollution load allowance, the law which gives priority to the load reduction by integrated measures according to the Lake Water Quality Conservation Plan.

**(6) Improvement Advice and Improvement Order**

When a person having a specified facility in a designated area is seemed to be in violation of the standards set forth, the governor of prefecture may advise such person to improve the structure or the method of usage within a specified period. And when the person receiving the advice mentioned in the preceding paragraph continues to use the designated facility concerned failing to follow the advice, the governor of prefecture may order the person to improve the structure or the method of usage within a specified period. The governors of prefectures, however, should pay attention to management condition of enterprises in applying the actions to small scale enterprises.

**(7) Designated Facilities**

In designated areas, facilities which are not appropriate for regulation by the effluent standards are named "designated facilities", i.e., such facilities as follows:

1. The following facilities to be used for livestock farming and service industry:
a) Pig shed (relative only to work areas with pig sheds occupying a total area of more than 40 square meters but less than 50 square meters).
b) Cow shed (relative only to work areas with cow sheds occupying a total area of more than 160 square meters but less than 200 square meters).
c) Horse shed (relative only to work areas with horse sheds occupying a total area of more than 400 square meters but less than 500 square meters).

2. Facilities to breed carps (applicable only to net crawls occupying an area of more than

500 square meters).

Persons intending to install such facilities should submit a notice stating the following particulars to the governor of prefecture.

(1) Name of individual or name, address and the name of representative in case of a company.
(2) Location of the specified facility
(3) Classification of the specified facility
(4) Structure of the specified facility
(5) Method of usage of the specified facility
(6) Other matters specified by the Order of the Prime Minister's Office

This written report system may give the chance to the business persons to consider the necessity of the control of facilities in order to decrease pollution load, and may gives the chance to administrator to state some advices to the business person for decreasing pollution load from those facilities.

### (8) Guidance to Persons who Don't Have Specified or Designated Facilities

The governors of prefectures may offer guidance, advice and suggestions necessary to accomplish the Plan for the Preservation of Lake Water Quality to persons, other than persons having a specified facility, who are discharging into Public Water Area polluted water, waste liquids and other substances causing the pollution of water.

### (9) Penal Provisions

Persons in violation of the order of prefectural governor shall be sentenced to a prison term of not more than 1 year or be fined not more than 500 thousand yen.

### (10) Other Important Aspects for Improvement of Lake Water Quality

In addition to those things mentioned above, it was assumed that the following aspect was important for promoting the improvement of lake water quality.

(a) Water quality improvement works for lakes other than designated lakes.
(b) Improvement of water quality monitoring system.
(c) Promotion of investigation research and development of technology for water quality conservation.
(d) Investigation of lake ecosystem

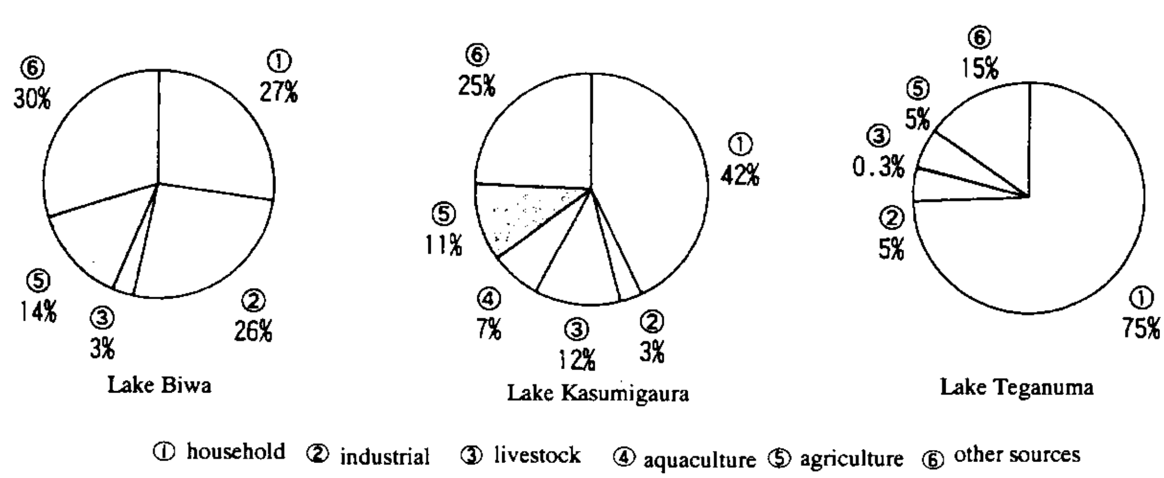



**Fig.10-4** COD load into lakes (1993年) [5]

(e) Investigation of generation mechanism of fresh water red tides
(f) Measurement of pollution load from forest area, farmland and urban area.
(g) Evaluation of water purification ability in forest, wetland and lake itself.
(h) Development of treatment technology for various kind of wastewater.
(i) Development of measures for improving lake water quality.
(j) Development of technology for water quality monitoring.
(k) Spread of the information concerning lake water quality and its improvement measures.

Voluntary activities by farmers and citizens are important for decreasing pollution load from farmland and non-sewered residential area. In that means, spread of the information concerning lake water quality and its improvement measures to farmers and citizens should be promoted.

**3. Effect of Enactment of the Lake Law on the Water Quality of Designated Lakes**

More than ten years have already passed from the plans were enacted (1985) in five lakes, e.g., Lake Kasumigaura, Lake Inbanuma, Lake Teganuma, Lake Biwa and Lake Kojima. The plans for the five lakes are now in third stage. Have the water quality of lakes been improved by executing the plans in ten years? Let's see the effect of the plan on the water quality in the case studies of Lake Biwa and Teganuma Lake. The former lake is polluted by both point sources (households and industries) and nonpoint sources (farmland and forest). On the other hand, the latter lake is mainly polluted by point sources, i.e., households wastewater as shown in **Fig.10-4**.

**3.1 Lake Biwa**

**Figure 10-5** shows the changes in water quality of northern and southern lake of Lake Biwa with the target value of the Plan of Water Quality Conservation in Lake Biwa.
Water quality in Lake Biwa have not been improved clearly, as a results, the target value have not been achieved. Changes in pollution load into the lake does not correspond to the changes in water quality as shown in **Fig.10-6**. The water quality in Lake Biwa have not been improved although the amount of pollution load into the lake have decreased.

The following explanation is considered for reasons of the contradiction.

(1) There is a possibility that pollution load from farmland is underestimated. If pollution load from nonpoint sources such as farmland is large compared to point sources, lake water quality will not improved easily by the decrease in pollution load from point sources.
(2) An increase in the amount of pollution load of nitrogen and phosphorus according to spread of septic tank (Joukasou). The amount of the nitrogen and phosphorus load increases when pit latrine is changed to flush toilet by the construction of Joukasou.
(3) There must be a possibility that the amount of pollution load from households increases by the change in the lifestyle.
(4) The hydraulic retention time in Lake Biwa is long (estimated to be about five years), therefore changes in water quality in Lake Biwa is slow comparing to the changes in pollution load from watershed area.
(5) The pollution load from bottom sediment, i.e., nutrients release, may not decrease corresponding to the decrease in pollution load from watershed area. However, the contribution of the nutrient release from bottom sediment in Lake Biwa may be small because bottom of the lake is maintained aerobic.

On the other hand, **Fig.10-7** is calculated changes in pollution load into Lake Biwa if measures for improving the lake water quality had not been done. It is clear that pollution load would increase if we did not carry out the measures according to the Lake Law and other prefectural ordinance. Especially, the amount of the load from households would increase if there were no measures. It is assumed that increased pollution load is decreased mainly by the construction of sewerage system.

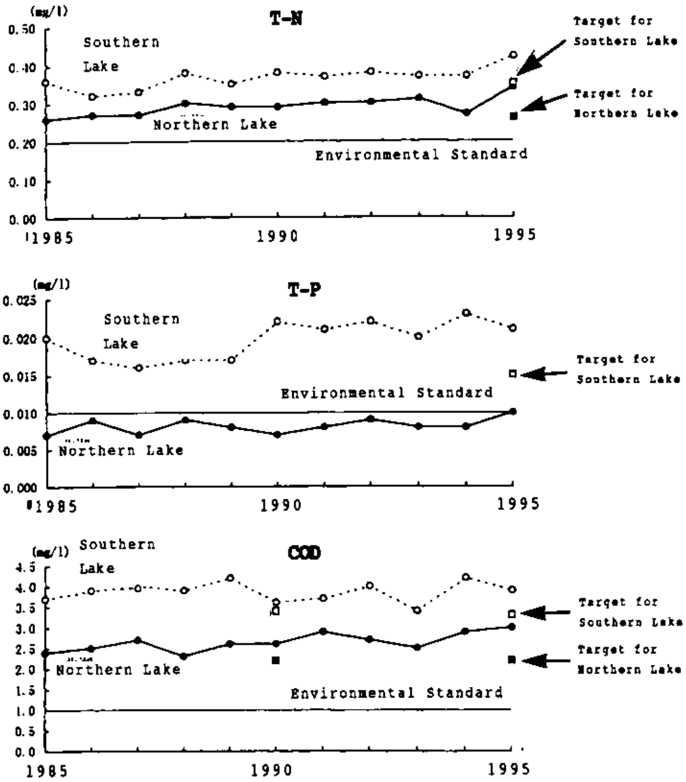



Fig.10-5 Changes in water quality in Lake Biwa.

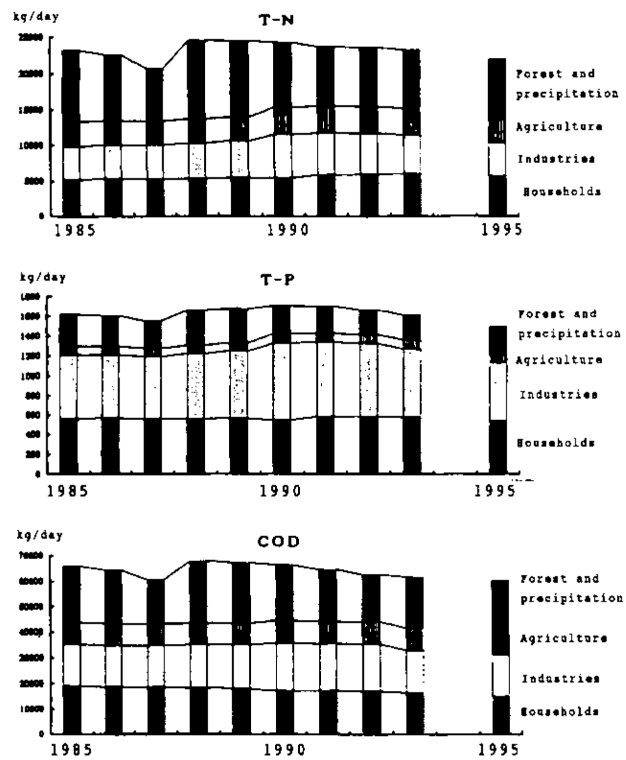



Fig.10-6 Changes in pollution load into Lake Biwa.[4]

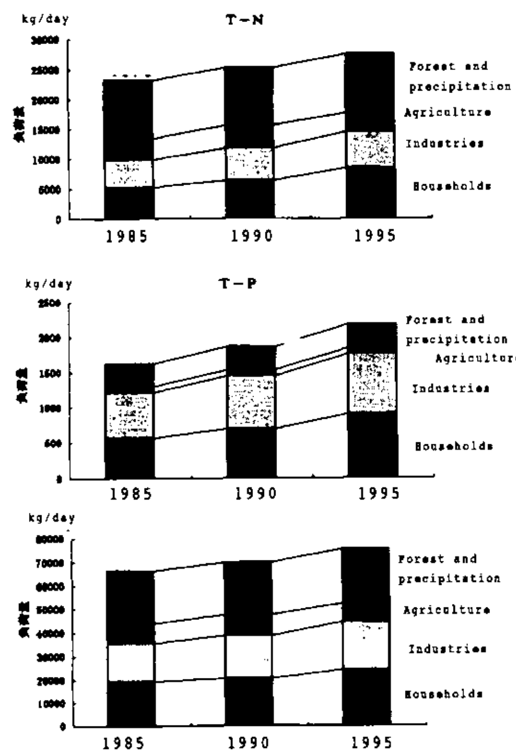



Fig.10-7 Changes in pollution load into Lake Biwa if any measures were not carried out.[4]

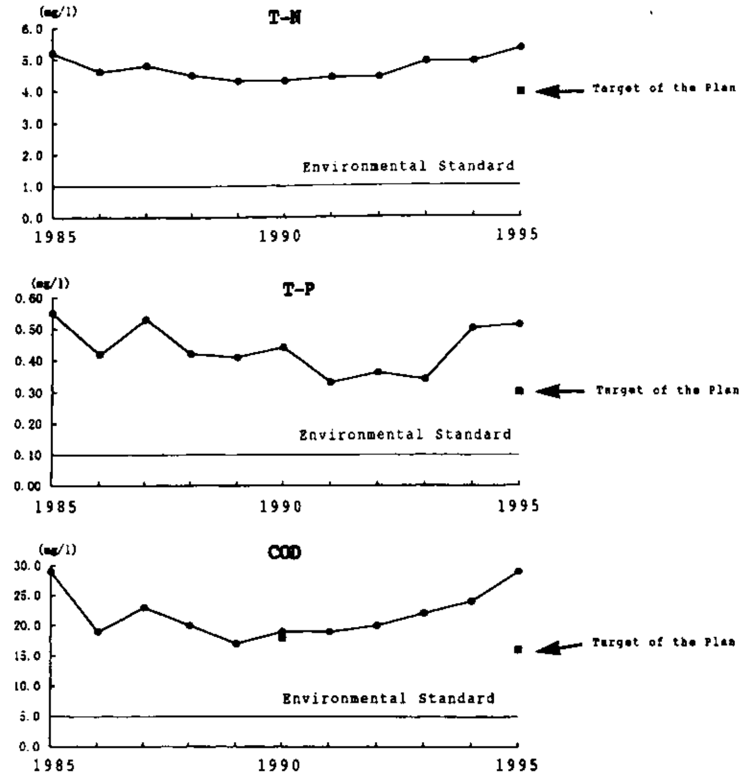



Fig.10-8 Changes in water quality in Lake Teganuma.

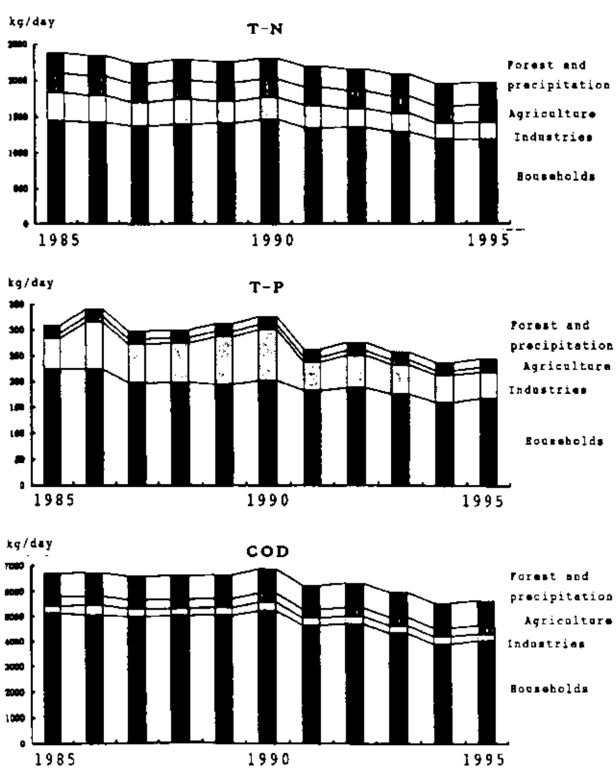



Fig.10-9 Changes in pollution load into Lake Teganuma.[4]

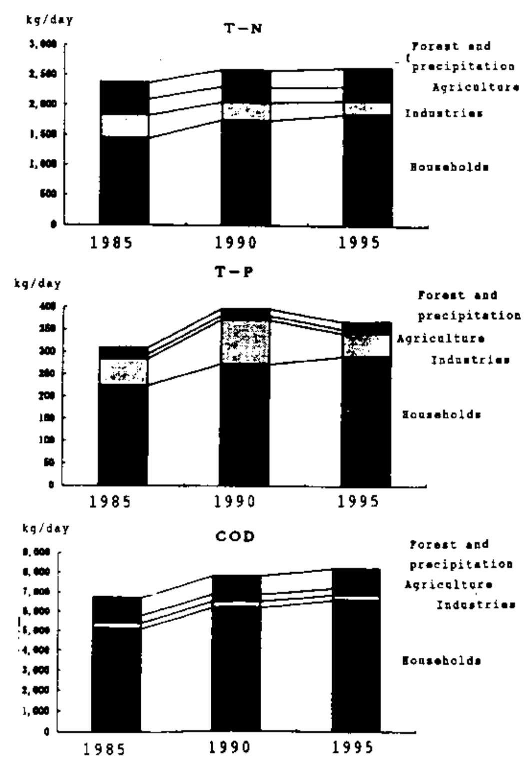



Fig.10-10 Changes in pollution load into Lake Teganuma if any measures were not carried out.[4]

### 3.2 Lake Teganuma

Changes in water quality in Lake Teganuma is shown in **Fig.10-8**. Changes in pollution load into the lake is shown in **Fig.10-9**. **Figure 10-10** shows the estimated changes in pollution load when measures for improving the lake water quality based on the plan have not been done. The lake water quality have not been improved though the pollution load might have decreased. Because the hydraulic retention time of the lake is mush shorter than that of Biwako, the water quality of the lake has strongly be influenced by the water quality of inflowing rivers. The changes in the water quality in the rivers have not been improved [4).

The case study in Lake Teganuma shows that measures aiming at the reduction of the amount of pollution load are not already effective to improvement of lake water quality.

## 4. Summary

The improvement of the lakes water quality is not advanced although various kinds of measures for improving the water quality have been carried out, eg., legal restriction of effluent quality and construction of sewerage system. It is clearly shown in Japan's experience that once deterioration of lake water quality have proceeded, restoration of the water quality is extremely difficult.

The followings are subjects we should carry out for the improvement of lake water quality.

(1) Reduction of pollution load from nonpoint sources.
(2) Nitrogen and phosphorus removal in septic tanks (Joukasou).
(3) Nitrogen and phosphorus load reduction in small-scale factories and business facilities, e.g., small food processing factories, restaurants, hotels, leisure facilities and fish breeding facilities.

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## Chapter 11 REGULATION OF TOTAL MAXIMUM DAILY LOADING

### 1. Introduction

#### 1.1 The outcome and problems of Water Pollution Control Law

The Water Pollution Control Law legislated in 1970 defined Environmental Water Quality Standards (EWQS) as targets of water quality management and regulated effluent quality from industries to comply with the targets. In addition to these regulations, prefectural governments legislated stringent effluent standards.

As shown in previous chapters, quality of waters for the parameters on human health improved remarkably. The quality of river waters for the parameters on living environment also improved as shown in Fig.11-1. However, there have been little improvement in lake water. Percent compliance for estuaries was generally good even at the start of the regulation, whereas little improvement has been noted. As shown in Fig.11-2, large estuaries in Japan like Tokyo Bay, Ise Bay and Seto Inland Sea with intensive industrial activities and high population density in the basin are low in percent compliance. There are still high possibilities of further deterioration in water quality in these estuaries and more efforts to restore these estuaries are necessary.

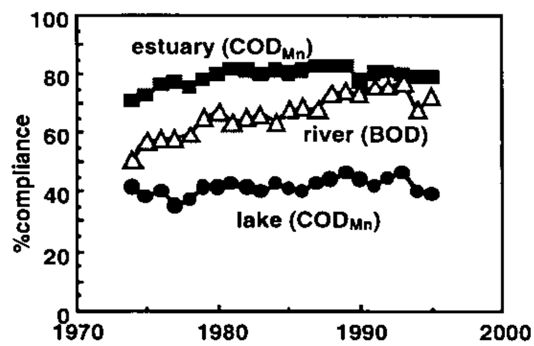



Fig.11-1 Percent compliance of environmental water quality standards.

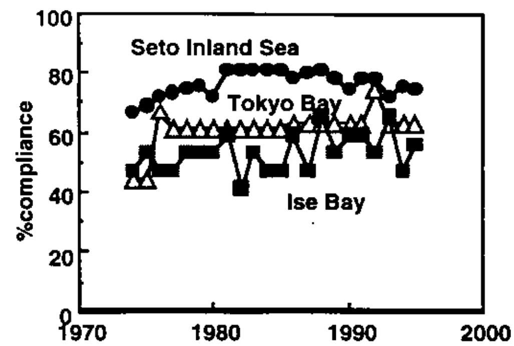



Fig.11-2 Percent compliance of environmental water quality standards for estuaries.

#### 1.2 Limitation of regulations for effluent water quality

The regulations for effluent water quality were effective as shown above, whereas the following legal limitations have been pointed out;

1) Although the decrease in total loading is necessary to comply with the EWQS, loadings from inland area are difficult to control. This is because prefectural stringent effluent standards are legislated by each prefectural government and not necessarily based on water quality in estuaries.
2) The loading from industries decreased significantly by the effluent regulations. However, domestic wastewaters have not been controlled effectively except for sewage effluents and their contribution increased relatively,. Especially, little efforts have been made to control gray waters.
3)The effluent quality regulations could not prevent the increase in total loading associated with the increase in productivity nor the dilution of effluents to comply with the regulation.

#### 1.3 Regulation of total maximum daily loading

Thus the effluent quality was not enough to restore water quality in large-scale closed waters. Regulations for total amount of loadings not only from industrial and domestic sources but also non-point and internal sources are necessary. The regulation of total maximum daily loading

(TMDL) started in 1978 in order to comply with the EWQS as amendments of "Water Pollution Control Law (WPCL)" and "the Law Concerning Special Measures for Conservation of the Environment of Seto Inland Sea".

Prior to the legislation of TMDL, "Tentative Law Concerning Measures for Conservation of Environment in Seto Inland Sea" was legislated in 1973 to conserve environment in Seto Inland Sea. The target of this regulation was to reduce industrial COD loading into Seto Inland Sea down to 1/2 from that of 1972. All the prefectural governments in the basin legislated stringent effluent standards to satisfy with their duties for the reduction. This was the first regulation not based on effluent concentration but based on total loading.

The law recommended other estuaries to have similar regulatory system as Seto Inland Sea. Although some prefectural governments started similar regulations, these are different from the regulation of TMDL in the following aspects;

*only industrial effluents were regulated in most cases,
*regulatory systems are based on stringent effluent quality.

## 2. Regulatory System of TMDL in Japan

### 2.1 Basic policy

The purpose of the regulation of TMDL is to reduce total amount of loading into large scale closed water bodies facing with serious pollution. The reduction must be uniform and effective for all the activities in the basin including inland area.

The basic policy for the regulation is as follows;

*(specified basin) all drainage basin for the specified waters. The prime minister formulates basic policy for TMDL to avoid inequality among prefectures,
*(total loading) total amount of loadings to be reduced includes not only those from industries under control by the WPCL but also those without regulation such as domestic wastewater,
*(target of TMDL) should be specified for each source,
*(implementation) all the industries in the specified basin are required to satisfy with the target of TMDL. Also, the regulation of TMDL requires construction and improvement of sewerage system, on-site treatment plants, and small scale industrial wastewater treatment processes, and environmental education,
*(loadings to be regulated) total daily loading by the specified effluents originating mainly from production processes. No regulation for indirect cooling water and rainwater,
*(monitoring) each industry must monitor and file daily loading based on the specified procedure to estimate total daily loading.

It is well known that the regulations of TMDL in terms of sulfur oxides in Air Pollution Control Law and TMDLs in U.S. are called as environmental quality based approach and directly based on environmental quality standards. TMDLs in U.S. define the target of loadings to comply with environmental quality standards. EWQS in Japan is an administrative target to be satisfied. However, it was not necessarily realistic and sufficient scientific understandings and data base was not available to define the target of TMDL directly based on EWQS for waters with concentrated industrial activities and population.

Therefore, the target of TMDL was defined to the realistic and possible limit in the target year taking the increase in loading associated with the development of industrial activities and population growth, developments of wastewater treatment technology and percent service of sewerage systems in the basin into consideration. Also the regulation specified tentative target and period if it seemed difficult to satisfy with the target within the target year. For the implementation of the regulation, the government specified standard methods applicable for various industries to monitor and file total daily loading. A schematic diagram of the regulatory system of TMDL is shown in Fig.11-3.

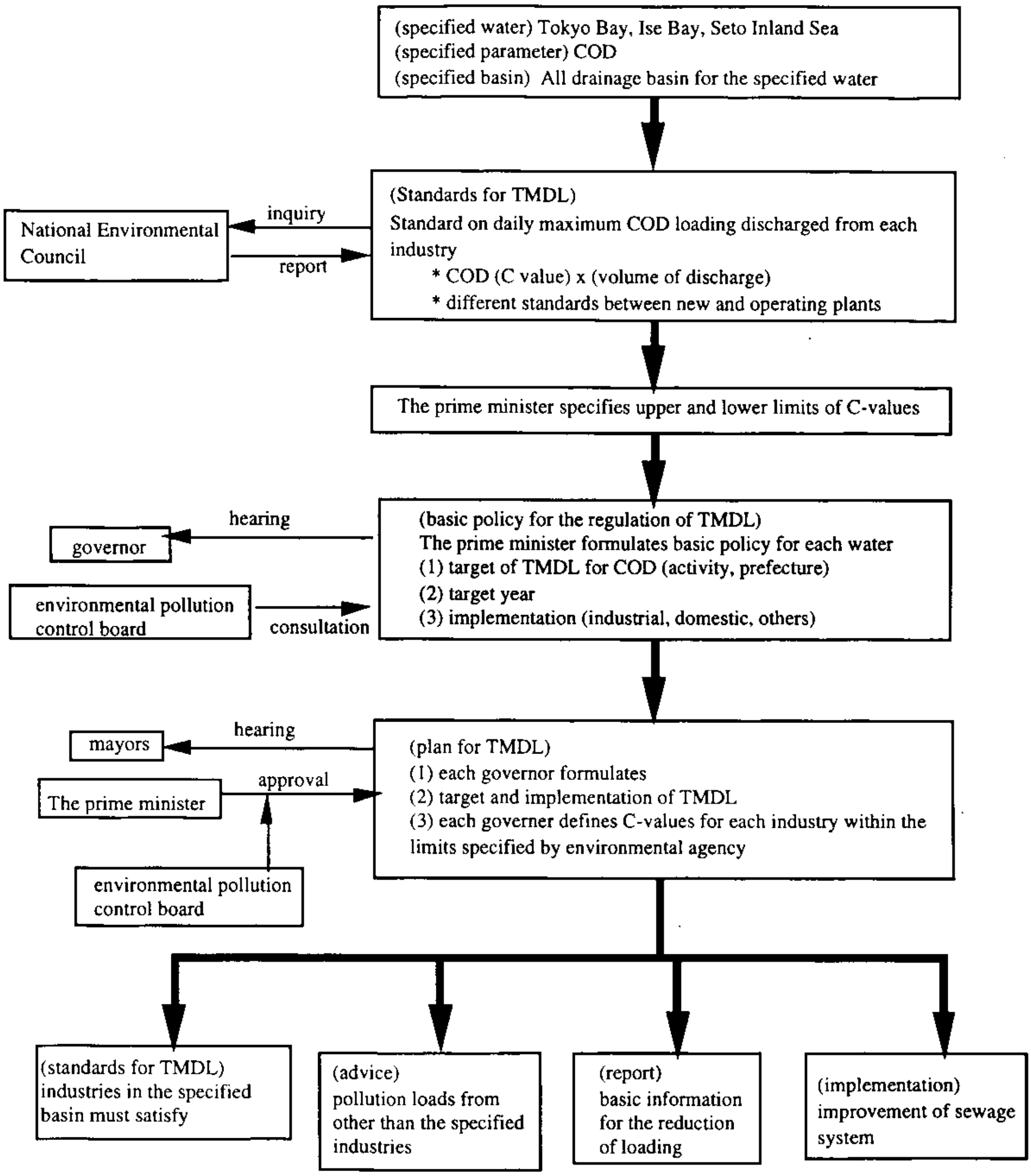



Fig. 11-3 Schematic diagram of the system of the regulation of TMDL

2.2. Specified water, basin,and parameters

The governmental ordinance defines specified water, basin (drainage basin for the water), and parameters (parameters to be regulated) for the regulation of TMDL. Specified water is large polluted enclosed water body with a drainage basin of concentrated human activities with high potential of pollution loadings. Specified basin is the drainage basin of the specified water.

These are as follows at present;

*specified water: Tokyo Bay, Ise Bay, Seto Inland Sea
*specified parameter: COD
*specified basin: all the drainage basins of the specified water in 20 prefectures

## 2.3 Basic policy for TMDL

The prime minister is responsible for the basic policy for TMDL. The policy for the 1st TMDL in 1979 was based on the following information;

* present loading of COD,
* target and year of TMDL within the possible limit taking the increase in loading associated with the development of industrial activities and population growth, developments of wastewater treatment technology, and percent service of sewerage systems in the basin into consideration,
*target of TMDL for each activity and prefecture.

The regulation of TMDL requires to define the target of the maximum daily loading of COD into the specified water from each activity in each prefecture in the target year. Therefore, Environmental Agency surveyed the amount of generated loadings from all the activities. Loadings are classified into three major categories, i.e. domestic, industrial, and others (livestock, non-points) as shown in Table 11-1.

Table 11-1 Classification of generated loading

| | class | category |
|---|---|---|
| domestic | point sources | domestic sewage treatment plant<br>night soil treatment plant<br>gappei Jokaso (population 201-500, > population 500)<br>tandoku Jokaso (population 201-500, > population 500) |
| | non-point sources | gappei Jokaso (< population 201)<br>tandoku Jokaso (< population 201)<br>graywater |
| industrial | point sources | industrial wastewater treatment plants (> 50 $m^3$)<br>industrial sewage treatment plant |
| | non-point sources | small scale industrial wastewater treatment plants (< 50 $m^3$)<br>small scale industries without regulation |
| others | point sources | barns<br>wastewater treatment plants for feed lot<br>other wastewater treatment plant |
| | non-point sources | pasture (cattle, pig, horse)<br>land (forest, paddy field, others)<br>landfill sites for solid wastes |

## 2.4 Plan for TMDL

The governor of each prefecture is responsible for making the plan for TMDL based on the basic policy for TMDL as follows. The plan for the 1st TMDL was issued in 1980.

*target of TMDL for each activity
*measures to implement the target

Although the purpose of the regulation of TMDL is to comply with the EWQS, target of TMDL was defined to the possible limit taking the increase in loading associated with the development of industrial activities and population growth, developments of wastewater treatment technology and percent service of sewerage systems in the basin into consideration. Especially, the regulation requires balanced reduction of loadings between industrial and domestic wastewaters.

Major measures to attain the target of TMDL are as follows;

a) domestic wastewater: reduction of the large loading of domestic wastewater,
*increase in the percent service by public owned sewer system and domestic wastewater treatment system (gappei-Jokaso, sewage system for farming village, community plants)
*advanced treatment processes and improved maintenance
*environmental education to reduce domestic loading

b) industrial wastewater: reduction of loading with equality among industries
*regulation of industrial effluents by the standards for TMDL
*guidances for small scale and non-controlled industries, and increase in the number of industries to be regulated,

c) others: reduction of loadings by controls of non-point sources
*management of livestock wastewaters
*improved system for the control of combine sewer overflow
*management of bottom sediments
*improved aquaculture
*ecosystem management to restore and maintain natural purification capacity

## 2.5 Standards for TMDL

### 2.5.1 Basic policy for the Standards for TMDL

The contemporary regulations controlled the concentration of effluents at the point of discharge. The regulation of TMDL, however, controls the maximum allowable daily loading from industries located in the specified basin with daily discharge more than 50 $m^3$ as follows,

$$L = C \cdot Q \times 10^{-3}$$

where, L: maximum allowable loading (kg/day)
C: COD value specified by the governor (mg/l)
Q: volume of specified effluent ($m^3$/day)

The specified effluents are effluents from specified industries by industrial and domestic activities except for waters without pollution load like cooling water. As in the 4th TMDL, the regulation requires more stringent control of loadings from new and expanded plants after 1980. The following is an equation for the 4th TMDL.

$$L = (C_0Q_0 + C_iQ_i + C_jQ_j) \times 10^{-3}$$

where, L: maximum allowable loading (kg/day)
$C_0$: COD values for $Q_0$ specified by governor (mg/l)
$C_i$: COD values for $Q_i$ specified by governor (mg/l)
$C_j$: COD values for $Q_j$ specified by governor (mg/l)
$Q_0$: volume of specified effluent discharge (except for $Q_i$ , $Q_j$) ($m^3$/day)
$Q_i$ : volume of specified effluent discharge from new and/or expanded plants in operation between July 1, 1980 and June 30, 1991 (except for $Q_j$) ($m^3$/day)
$Q_j$: volume of specified effluent discharge from new and/or expanded plants in operation after July 1, 1991 ($m^3$/day)

The above mentioned COD values are called as C-values. Each governor determines C-values for each industrial category based on the allowable upper and lower limits specified by Environmental Agency. Number of industrial categories was 217 in the first TMDL. It increased to 232 in the 4th TMDL.

Table 11-2 Influent and effluent COD (mg/l) and BOD/COD ratio

| industry | parameter \ process | influent (biological treatment) | influent (biological+coagulation) | average |
|---|---|---|---|---|
| food | COD | 600 | 680 | 630 |
| | BOD | 990 | 1190 | 1060 |
| | BOD/COD | 1.65 | 1.75 | 1.68 |
| fiber | COD | 450 | 400 | 390 |
| | BOD | 380 | 381 | 370 |
| | BOD/COD | 0.84 | 0.95 | 0.95 |
| paper & pulp | COD | 420 | 460 | 360 |
| | BOD | 370 | 400 | 320 |
| | BOD/COD | 0.88 | 0.87 | 0.89 |
| chemical (organic) | COD | 450 | 780 | 540 |
| | BOD | 860 | 1060 | 860 |
| | BOD/COD | 1.91 | 1.36 | 1.59 |
| domestic | COD | 390 | 520 | 390 |
| | BOD | 500 | 830 | 520 |
| | BOD/COD | 1.28 | 1.60 | 1.33 |

| industry | parameter \ process | effluent (biological treatment) | effluent (biological+coagulation) | average |
|---|---|---|---|---|
| food | COD | 17.8 | 15.2 | 18.0 |
| | BOD | 10.8 | 10.2 | 11.9 |
| | BOD/COD | 0.61 | 0.67 | 0.66 |
| fiber | COD | 48.3 | 37.4 | 45.3 |
| | BOD | 21.7 | 19.8 | 25.6 |
| | BOD/COD | 0.45 | 0.53 | 0.57 |
| paper & pulp | COD | 59.3 | 45.2 | 47.6 |
| | BOD | 27.4 | 17.9 | 30.4 |
| | BOD/COD | 0.46 | 0.40 | 0.64 |
| chemical (organic) | COD | 20.8 | 25.2 | 24.6 |
| | BOD | 11.0 | 19.7 | 17.1 |
| | BOD/COD | 0.53 | 0.78 | 0.69 |
| domestic | COD | 13.4 | 13.0 | 13.6 |
| | BOD | 8.5 | 7.7 | 8.7 |
| | BOD/COD | 0.63 | 0.59 | 0.64 |

Table 11-3 Median quality of effluents from industries with common and best available wastewater treatment processes

| code | industry | median influent COD (mg/l) | effluent COD (mg/l) | | | |
|---|---|---|---|---|---|---|
| | | | common process I | | best available process II | |
| | | | process | median | process | median |
| 2 | livestock farming (<1,000 t/day) | 1,970 | B | 75 | B+C+F | 117 |
| 6 | dairy products | 270 | B | 19 | B+C+F | 14 |
| 18 | soy source, amino acids | 483 | B | 21 | B+C+F | 15 |
| 41 | non-alcoholic drinks | 240 | B | 18 | B+C+F | 14 |
| 79 | non-bleached chemical pulp | 1,140 | C+B | 50 | C+B+F | 45 |
| 102 | phosphorus & nitrogen fertilizer | 87 | C | 12 | B+C+F | 18 |
| 120 | plastic products | 166 | B | 26 | B+C+F | 20 |
| 147 | oil refinery | 87 | B | 12 | B+C+F | 9 |
| 149 | coke oven | 4,420 | B | 23 | B+C+F | 17 |
| 169 | stone & gravel | 8 | C | 7 | C+F | 7 |
| 209 | sewage | 85 | B | 12 | B+C+F | 9 |
| 213 | restaurants | 150 | B | 14 | B+C+F | 10 |
| 221 | tandoku Jokaso (>501) | 92 | B | 12 | B+C+F | 9 |

B: biological treatment, C: coagulation, F: sand filtration

### 2.5.2 The upper and Lower limits of C-values

The most common wastewater treatment processes and average effluent concentration are the basis to determine the lower limit (the most stringent) of C-values. $C_j$ values for new and expanded plants are based on the best available technology for COD removal. Governors are responsible to determine C-values within the limits.

Table 11-2 shows average quality of wastewater from industries used to determine the limits of C-values. Influent COD ranged from 400 mg/l to 600 mg/l. Food and organic chemical industries discharged higher COD. Effluent COD from food, organic chemicals and domestic wastewater were around 20 mg/l, whereas those from fiber and paper & pulp industries were relatively high, more than 40 mg/l, with lower percent of removal. This may be due to low BOD/COD ratio and, hence, lower removal of COD by the most common biological treatment processes.

Table 11-3 shows examples of influent COD (50 percentile), the most common available wastewater treatment technologies (process I), the best available technologies (process II) and corresponding effluent COD values (50 percentile) from the surveillance carried out in 1994 for 4th TMDL. The process I for industries with organic discharges was biological treatment. The process II was biological treatments followed by coagulation and sand filtration. However, process I was coagulation and sedimentation and process II was followed by sand filtration for industries like inorganic chemicals, pottery, metal, machinery and electric.

Table 11-4 shows examples of the upper and lower limits of C-values for the 1st and the 4th regulations of TMDL. The 4th specified the lower C-values than the 3rd in 97 categories taking present effluent quality, available treatment technology, reduction of loadings during previous TMDLs and equality among industries into consideration. There were 18 categories with C-values higher than the national minimum effluent regulation (160 mg/l) until the 3rd. They are only 4 in the 4th, i.e. pulp, coal tar, ion exchange and coke oven. There were significant improvements in C-values between the 1st and the 4th for industries with high C-values like pulp, coal tar and coke oven. There are industries like dairy products, however, with little improvement from the 1st to the 4th.

Table 11-4 Examples of lower and upper limits of C values for the first and the fourth TMDL

| code | industry | 1 st | | 4 th | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | $C_0$ | | $C_0$ | | $C_i$ | | $C_j$ | |
| | | lower | upper | lower | upper | lower | upper | lower | upper |
| 2 | livestock farming (<1,000 t/day) | 70 | 140 | 70 | 120 | 70 | 100 | 60 | 90 |
| 6 | dairy products | 30 | 60 | 30 | 50 | 30 | 50 | 20 | 40 |
| 18 | soy source, amino acids | 90 | 120 | 70 | 100 | 70 | 90 | 40 | 80 |
| 41 | non-alcoholic drinks | 20 | 120 | 20 | 60 | 20 | 50 | 20 | 40 |
| 57 | fiber (linen) | 100 | 120 | 90 | 110 | 90 | 110 | 90 | 110 |
| 79 | non-bleached chemical pulp | 210 | 330 | 140 | 170 | 130 | 170 | 130 | 170 |
| 102 | phosphorus & nitrogen fertilizer | 30 | 120 | 30 | 90 | 30 | 70 | 30 | 60 |
| 120 | plastic products | 30 | 50 | 30 | 50 | 30 | 50 | 30 | 50 |
| 147 | oil refinery | 20 | 60 | 20 | 50 | 20 | 40 | 20 | 40 |
| 149 | coke oven | 250 | 350 | 180 | 220 | 180 | 200 | 90 | 160 |
| 169 | stone & gravel | 20 | 40 | 20 | 40 | 20 | 40 | 20 | 40 |
| 209 | sewage | 30 | 110 | 20 | 60 | 20 | 40 | 20 | 40 |
| 213 | restaurants | - | - | 50 | 70 | 40 | 60 | 30 | 50 |

## 2.6 Monitoring of loading

It is essential for the regulation of TMDL to monitor and file daily loading appropriately by plant owners. The ideal procedure of monitoring is on-line automatic monitoring of loadings. However, it is impossible to monitor COD loading based on the standard method. Therefore, the recommended methods are monitoring both for the volume of effluent and concentration of COD to make the product of them as loading. Although flow meter and automatic monitor of COD are recommended, small industries can adopt simpler methods as shown in Table 11-5.

Table 11-5 Methods allowable (A) for the determination of loading and required frequency

| methods \ plants | | daily discharge $> 400m^3$ | daily discharge $< 400m^3$ | with correlation between flow and COD | | others (difference |
|---|---|---|---|---|---|---|
| | | | | $> 400m^3/d$ | $< 400m^3/d$ | |
| COD mg/l | (1) continuous monitoring both for flow and COD (COD, TOC, TOD, UV monitors and automatic sampler with recorder | A | A | - | - | |
| | (2) composite sampler + standard manual analysis for COD | allowable if procedure (1) is not applicable nor possible | A | - | - | allowable if procedure (1) is not applicable nor possible |
| | (3) 3 samplings/day followed by the standard manual analysis | allowable if approved by governor | A | - | - | allowable if approved by governor |
| | (4) 3 samplings /day followed by quick analysis without automatic sampler and recorder | allowable if approved by governor | A | - | - | allowable if approved by governor |
| flow $Qm^3/d$ | (1) flow meter with recorder | A | A | A | A | A |
| | (2) cumulative flow volume recorder | A | A | A | A | A |
| | (3) Quick analysis like JISK0094-8 | allowable if approved by governor | A | - | A | allowable if approved by governor |

| daily discharge | monitoring frequency |
|---|---|
| $400m^3$ - | everyday with wastewater discharge |
| $200m^3$ - $400m^3$ | at least once per 7 days of wastewater discharge |
| $100m^3$ - $200m^3$ | at least once per 14 days of wastewater discharge |
| $50m^3$ - $100m^3$ | at least once per 30 days of wastewater discharge |

## 3. History of Basic Policy for TMDL

The 1st regulation of TMDL started in 1979 with the target year of 1984. As shown in Fig.11-4, COD loading decreased in all the specified water. However, improvement of water quality was not as expected and both red-tides and blue-tides were observed (see Figs.11-15 and 11-16 later on). The second and third regulations of TMDL, therefore, were legislated with the target years of 1989 and 1994, respectively.

The 3rd regulation of TMDL started from 1989 with the targets of 12 %, 9 % and 2 % reductions for domestic, industrial and other loadings, respectively until 1994. The targets were 13 %, 8 % and 9 % for Tokyo Bay, Ise Bay and Seto Inland Sea, respectively. The targets for each prefecture were different taking the difference in percent service of sewerage system, the reduction in previous regulations into consideration.

The needs for further improvement of water quality in the specified waters legislated the 4th regulation in 1996 with the target year of 1999. The targets are 8 %, 7 % and 4 % reduction for Tokyo Bay, Ise Bay and Seto Inland Sea, respectively. The targets for activities are 9 % and 3 % respectively for domestic and industrial loadings, whereas the target for other sources is 5 % increase. This is because the loading in the reference year, 1994, was smaller than that of normal years by draught. There will be no increase in the loading based on normal year.

4. Reduction of Total Daily Loading

Fig. 11-4 shows the reduction of total daily loadings into specified waters from the beginning of the 1st to the end of 3rd and the target values for the 4th in 1999. The reduction for domestic sources in Tokyo Bay was significant, whereas that for industrial sources was not enough. Both domestic and industrial sources decreased in Seto Inland Sea. The rate of decrease, however, was small compared to Tokyo Bay. Little improvement was noted in other sources.

Percent contributions of pollution sources into the specified waters in 1984 and 1992 are shown in Fig. 11-5. The contribution of domestic sources was as high as 70 % in Tokyo Bay. Those in Ise Bay and Seto Inland Sea were 53 % and 49 %, respectively. It must be noted that from 65 to 80 % of domestic sources were graywaters.

Implementations of various measures to control domestic wastewater decreased its contribution in 1992. Especially, contributions of graywater decreased significantly in all the waters. Contrarily, the percent contribution of industrial wastewaters increased in Tokyo Bay and Seto Inland Sea.

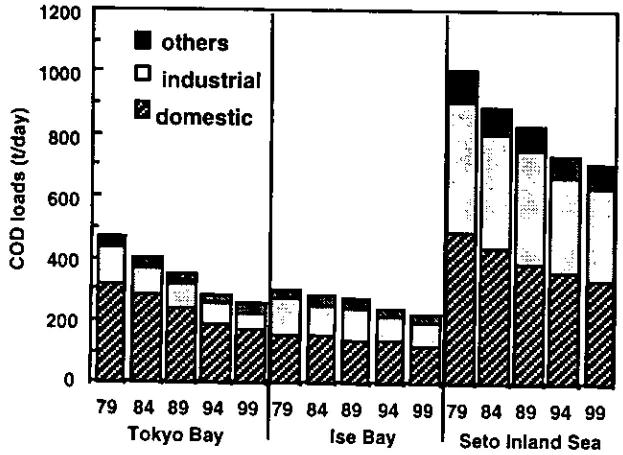



Fig. 11-4 Total daily loadings (1979-1994) and target values for the regulations of TMDL.

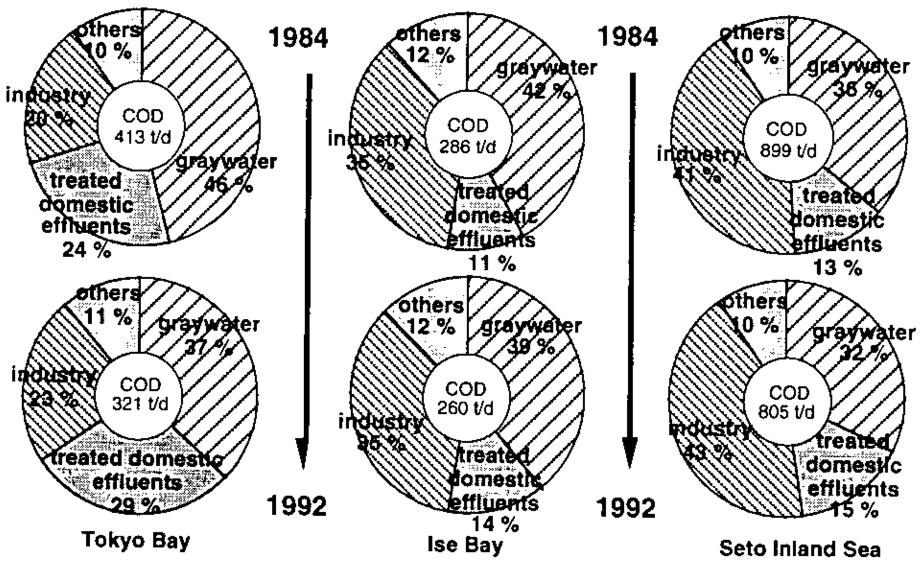



Fig. 11-5 Changes in total daily loadings from 1984 to 1992.

4.1 Reduction of loadings by domestic wastewater

The slight increase in population in the specified basin is shown in Fig. 11-6. Fig. 11-7 shows populations served by each domestic wastewater treatment system. The population served by public owned sewer system increased significantly. Contrary, those who rely on night-soil treatment are decreasing every year. The population using Jokaso is decreasing in Tokyo Bay, whereas that in Seto Inland Sea is constant. The delayed construction of sewer system in Ise Bay increased the population using Jokaso. The population discharging gaywater without treatment is decreasing and the percent contributions are now 25.2 %, 54.6 % and 45.5 % in Tokyo Bay, Ise Bay and Seto Inland Sea, respectively.

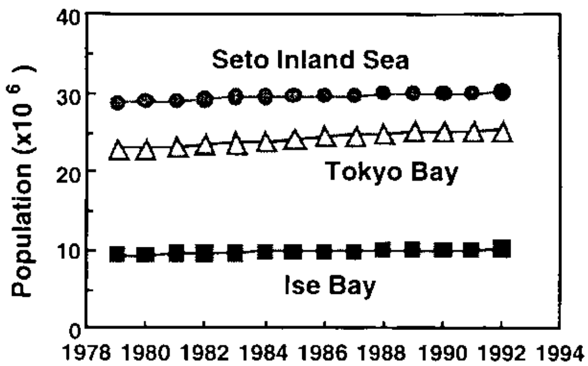



Fig. 11-6 Population growth in the specified basin

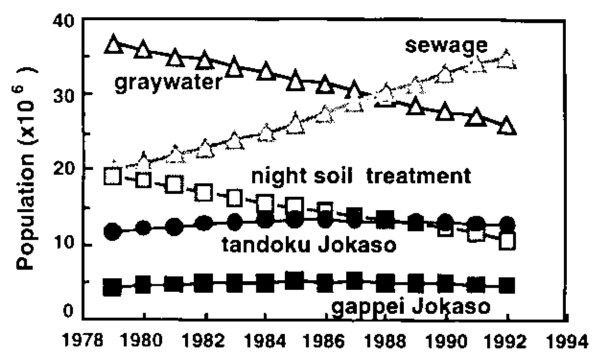



Fig. 11-7 Populations served by each domestic wastewater treatment system

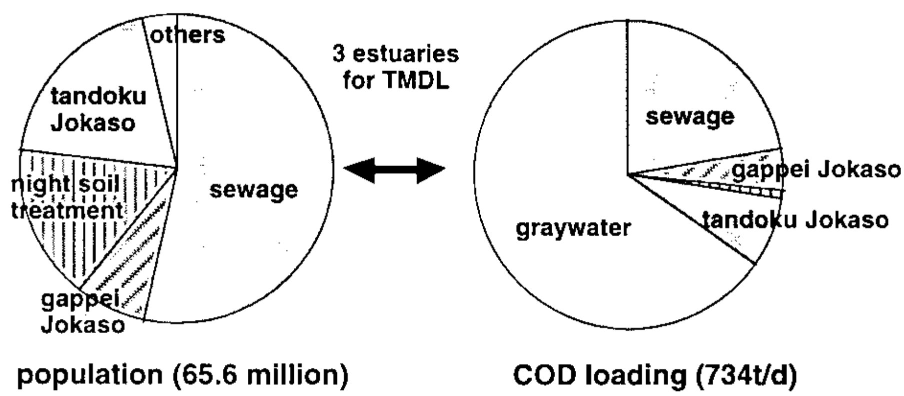



Fig. 11-8 Population vs. treatment systems in the specified basin.

Fig. 11-8 shows percent population served by and percent loading from each treatment system in the specified basins in 1992. The percent population served by sewage and gappei Jokaso was ca. 60.1 %, whereas the corresponding loading was only 27 %. Night soil treatments served 16.5 % of population and discharge less than only 1 % of total loading. However, population using night-soil treatment and Tandoku Jokaso is discharging graywater without treatment and their loading is as large as 65 %. This indicates that the contribution of graywater to the total domestic wastewater loading is remarkably large.

4.2 Reduction of loadings by industrial wastewater

Industries have carried out various measures to reduce pollution loading. They tried to save water, improved production processes and maintenance of treatment plants. Table 11-6 summarizes numbers of renewal and expansion of wastewater treatment plants in specified basin from 1990 to 1993. Most of processes adopted were biological treatment processes such as activated sludge process and processes for the removal of suspended solids like coagulation, sedimentation and sand filtration. Some plants have adopted advanced processes like activated carbon adsorption.

Table 11-7 shows numbers of process improvements for the same period. The numbers indicates that industries carried out not only improvement of treatment processes but also better maintenance, water use and process modification.

Table 11-6 Renewal and expansion of wastewater treatment plants in the specified basin for TMDL

| process | number of plants |
|---|---|
| activated sludge | 197 |
| other biological treatment | 117 |
| coagulation and precipitation | 118 |
| sand filtration | 71 |
| oil separation | 13 |
| ozonation | 4 |
| activated carbon adsorption | 50 |
| other advanced treatments | 9 |
| other treatment processes | 98 |
| total | 677 |

Table 11-7 Improvements of production and wastewater treatment processes in specified area for TMDL

| procedure | number of plants |
|---|---|
| water use | 123 |
| production processes | 98 |
| maintenance of treatment plants | 116 |
| others | 37 |
| total | 374 |

Table 11-8 summarizes various measures adopted by each industry to decrease COD loading. Industries which improved wastewater treatment plants are from 5 to 20 %. Coal and oil industries are the highest in the percentage indicating dependency on wastewater treatments rather than process modifications. Table 11-9 shows summary of industrial surveys in 1994 for procedures to improve production processes to decrease loadings. Process improvements seem to be as effective as construction/expansion of wastewater treatment plants.

Table 11-8 Improvements of production processes and renewal/expansion of wastewater treatment processes in the specified basin for TMDL

| industry | total number of plants (1992) | number of new and expanded plants | % new & expansion | process improvement | % improved |
|---|---|---|---|---|---|
| food | 1,253 | 69 | 5.5 | 49 | 3.9 |
| fiber | 589 | 26 | 4.4 | 27 | 4.6 |
| paper & pulp | 220 | 17 | 7.7 | 25 | 11.4 |
| chemical | 603 | 74 | 12.3 | 68 | 11.3 |
| coal/petroleum | 48 | 9 | 18.8 | 5 | 10.4 |
| steel | 204 | 13 | 6.4 | 4 | 2.0 |
| other industries | 5,070 | 223 | 4.4 | 13 | 2.6 |
| domestic wastewater | - | 37 | - | - | - |
| total | | 468 | | 309 | |

Table 11-9 Procedures to improve production processes

| procedure | |
|---|---|
| improvement of production processes (742) | - better process management (238)<br>- machine renewal (209)<br>- introduction of automation (157)<br>- others (138) |
| replace raw materials (97) | - using processed (ex. washed) raw materials (38)<br>- out sourcing of raw material processing (5)<br>- others (54) |
| replace chemicals (534) | - proper use/application/waste (263)<br>- replace to those without N and P (190)<br>- others (81) |
| others (411) | - improve product yield (180)<br>- in-process recycling (103)<br>- reuse of wastes (94)<br>- others (34) |
| separate treatment of concentrated wastes (117) | - incineration (51)<br>- contract as industrial wastes (51)<br>- composting (15) |

Compliance for the regulation of TMDL in the specified basins is shown in Table 11-10. Around seven percent of plants could not satisfy with the standards more than 1 day. Reasons for the violations are shown in Table 11-11. Most of the plants had treatment plants but were poor in maintenance and operations. Other reasons were troubles and/or worn-out in treatment plants or increase in flow rate and/or influent concentration by the change in production processes. The failures in TMDL regulation are subjected to the order of the governor to improve treatment plants and not by penalties. Actually, local governments recommended various procedures to satisfy with the standards.

Table 11-10 Compliance for the regulation of TMDL in 3 specified estuaries

| | total plants | plants not complied* | (%) |
|---|---|---|---|
| 1990 | 10,669 | 813 | 7.6 |
| 1991 | 10,688 | 743 | 7.0 |
| 1992 | 10,886 | 745 | 6.8 |

*Plants could not comply with TMDL more than 1 day except for Jokaso (201-500)

Table 11-11 Failure to TMDL in 3 specified estuaries

| cause | % |
|---|---|
| no treatment plants | 3.6 |
| old and/or troubled treatment plants | 14.6 |
| poor maintenance of treatment plant | 40.9 |
| increase in wastewater flow and concentration | 15.6 |
| monitoring error, unknown | 25.3 |

Table 11-12 Recommendations by local governments to decrease loading from plants violated TMDL regulation

| contents | % | instructions |
|---|---|---|
| better maintenance of treatment plants | 54 | - adjust aeration time<br>- chemical dose based on pH meter<br>- proper pumping time<br>- better operation of coagulation and sedimentation |
| improvement of treatment plants | 25 | - replace catalysı<br>- better aeration scheme<br>- install of floating scum skimmer<br>- batch to continuous operatior<br>- install of foam breaker |
| increase treatment capacity and saving water | 8 | - install aeration equipment<br>- install pretreatment (sedimentation)<br>- install multi-filter, sand filtration<br>- install oxidation, coagulation-sedimentation processes |
| others | - | - increase frequency of plant inspection<br>- improve high loading process<br>- inspection and cleaning<br>- prevent rainwater and groundwater inflow<br>- install gappei Jokaso<br>- disposal of high strength wastewater as industrial wastes<br>- replace chemicals and raw materials |

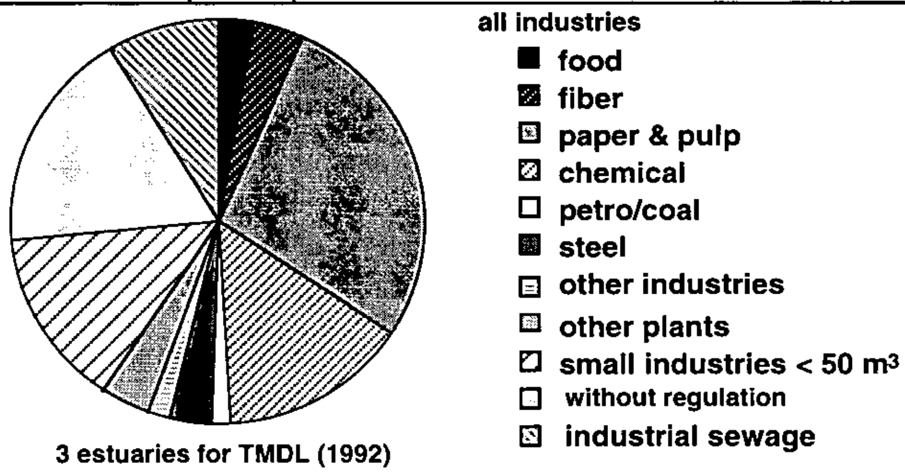



Fig.11-9 Percent contribution of industrial sectors to total COD loading to the specified waters

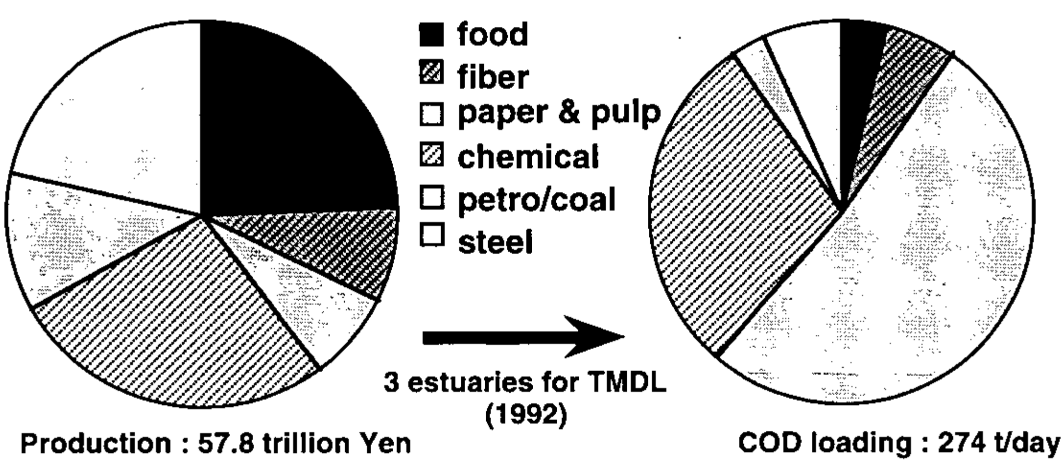



Fig. 11-10 Percent contributions of loadings and productivity for major industries.

Fig.11-9 shows percent contribution of each industrial sector to total COD loading into the specified waters. The largest is paper & pulp industries followed by chemical industries. The percent contribution from small industries with daily discharge less than 50 m3 or without regulation is more than 30 %. Prefectural governments are making efforts to reduce these loadings either by local ordinance or guidelines and manuals.

A comparison between percent contribution of loadings and productivity for major industries is shown in Fig. 11-10. Loadings from paper & pulp industries are relatively high compared to their productivity. Those from food and steel industries are relatively small.

There are industries with relatively higher loadings. However, it must be noted that effluents from industries are not the same quality. Treatability of industrial effluents are significantly different. Some wastewater are still difficult to handle even with the most advanced treatment technology. Also, productivity is not the sole indicator to evaluate loadings. Other factors like economic situations and employment must be taken to evaluate allowable or permissible loadings from industries. C values, therefore, were determined based on all of these factors to secure equality among industries.

It is common that the improvement of treatment facility results in the increase in treatment cost per volume of wastewater. The further decrease in loading, therefore, is not easy for industries that have decreased loading remarkably. Figs. 11-11 shows historical reduction of loading into the specified waters from some industries and sewage works. All the loadings are relative values based on those in 1992.

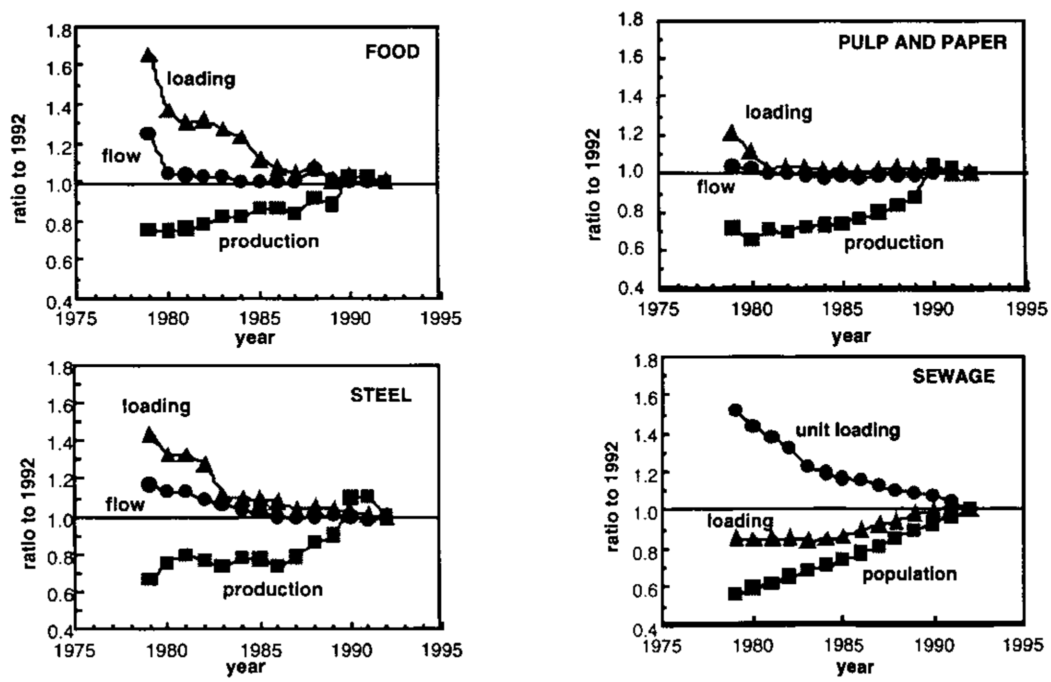



Fig. 11-11 Relative production, volume of discharge and COD loading from food, paper & pulp, steel industries and sewage.

In 1979, food industries discharged 1.7 times as large loadings as that in 1992. Remarkable reduction was noted in the beginning of the 1st TMDL. More than 20 % of water was saved at the same time. However, the rate of decrease is small after that and little decrease is noted after 1987. It must be noted that the loading did not increase in spite of the significant increase in production. The regulation, therefore, seemed to be effective.

Similar trend is also noted in steel industries. Although pulp & paper industries could decrease loading, the percent decrease is small compared to other industries. However, the increase in the production indicates that the loading should have increased remarkably without the regulation. Contrary to industrial circles, loading by sewage increased gradually. This is because percent population served by sewage increased and not because no efforts were made to decrease loading. Actually, per capita loading by sewage decreased remarkably from 1979 to 1992 indicating that wastewater treatment technology has been improved.

Table 11-13 Initial investment and operational costs for wastewater treatment plants

| initial investiment | total ($10^6$ Yen) | | | per volume ($10^6$ Yen/$m^3$) | | | per sales ($10^3$ Yen/ $10^6$ Yen sales) | | | per profit ($10^3$ Yen/ $10^6$ Yen profit) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | C | B | B+C | C | B | B+C | C | B | B+C | C | B | B+C |
| livestock farm | - | 11.8 | - | - | 119 | - | - | 112 | - | - | - | - |
| food | - | 25.4 | 32.8 | - | 256 | 331 | - | 11 | 14 | - | 309 | 399 |
| fiber | 24.4 | 32.0 | 56.3 | 115 | 151 | 267 | 26 | 34 | 60 | 1,139 | 1,494 | 2,632 |
| paper/pulp | 22.1 | 84.1 | 106.2 | 12 | 45 | 57 | 9 | 32 | 41 | 1,668 | 6,350 | 8,018 |
| inorganic chemical | 26.8 | - | - | 99 | - | - | 5 | - | - | 613 | - | - |
| organic chemical | 37.6 | 114.7 | 152.3 | 63 | 193 | 256 | 5 | 14 | 19 | 73 | 223 | 296 |
| pottery | 16.3 | - | - | 129 | - | - | 4 | - | - | 140 | - | - |
| metal/machine /electric | 50.5 | 68.1 | 101.5 | 113 | 152 | 226 | 5 | 7 | 11 | 240 | 323 | 481 |
| domestic/ others | 21.8 | 28.6 | 46.2 | 279 | 367 | 464 | - | - | - | - | - | - |

| operational cost* | C:coagulation | B:biological | B+C |
|---|---|---|---|
| livestock farm | - | 68 | - |
| food | - | 50 | 67 |
| fiber | 60 | 39 | 99 |
| paper/pulp | 9 | 19 | 28 |
| inorganic chemical | 37 | - | - |
| organic chemical | 37 | 40 | 72 |
| pottery | 31 | - | - |
| metal/machine/electric | 60 | 46 | - |
| domestic/others | 40 | 44 | 56 |

* median costs for electricity and chemicals

Table 11-13 shows initial investment sand operational costs for wastewater treatment plants of industries. Cost of initial investment was estimated from median values of wastewater discharge and the correlation between initial investments and volume of wastewater for corresponding industry. The fact that initial investments per unit volume of wastewater ranged from 12 to 464 thousand Yen indicates large difference among industries and treatment systems. The unit costs for fiber and paper & pulp industries were relatively small. However, their costs per ordinary profit were extremely large.

On the basis of on the above mentioned view point, historical decrease in loadings per unit production is shown in Fig. 11-12. Most industries decreased the loading constantly after the start of the regulation of TMDL. The unit loading decreased down to a half of that in the stating year, 1979. The percent decrease was almost constant and around 4 % per year.

However, the percent decreases in paper & pulp and petroleum/coal industries were only 40 % and 25 %, respectively.

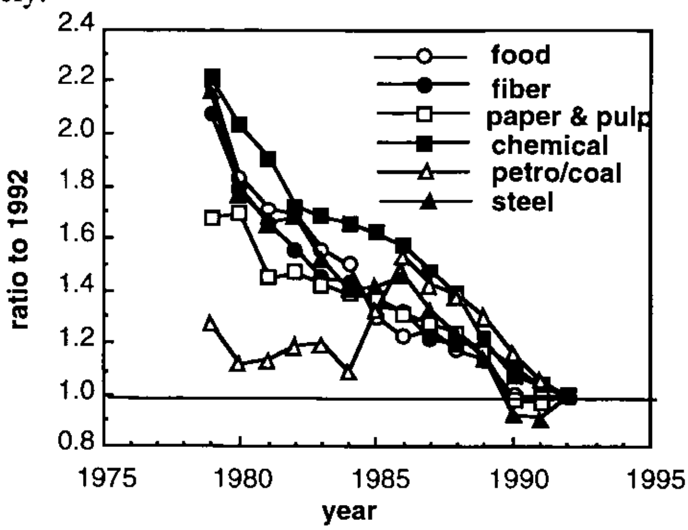



Fig. 11-12 Historical decrease in loadings per unit production

Table 11-14 Difference between target and realized values of 3rd TMDL

| | 1994 | domestic | industrial | others | total |
|---|---|---|---|---|---|
| Tokyo Bay | target | 203 | 69 | 36 | 308 |
| | realized | 197 | 59 | 30 | 286 |
| Ise Bay | target | 127 | 91 | 33 | 251 |
| | realized | 134 | 83 | 29 | 246 |
| Seto Inland Sea | target | 359 | 321 | 80 | 760 |
| | realized | 365 | 309 | 72 | 746 |

5. Effects of the regulation of TMDL on Water Quality

Table 11-14 compares the target of TMDL in the 3rd and the loading attained estimated prior to the 4th regulation. The attained loadings are almost smaller than the targets of TMDL. Therefore, we may regard that the reduction of total loading was successful. The loadings at the end of the 4th TMDL (1999) will be 55 %, 75 % and 71 % of those in the start of the 1st (1979) in Tokyo Bay, Ise Bay and Seto Inland Sea, respectively.

Fig. 11-2 shows the corresponding changes in water quality and outbreaks of blue-tide and red-tide are shown in Figs. 11-13 and 11-14, respectively. The number of the outbreaks of both tides decreased compared to 1980's. However, the percent compliance for EWQS is still low. This can be attributed to eutrophication as mentioned in Chapter 6. The regulations of TMDL in terms of COD could reduce external loading of COD, whereas they do not necessarily control internal production of COD associated with eutrophication. The percent contribution of internal COD production is estimated to range from 30 % to 60 %. Thus, the control of internal production is as important as that of external inputs. Regulation of TMDL not only for COD but also for nitrogen and phosphorus will be urgent needs.

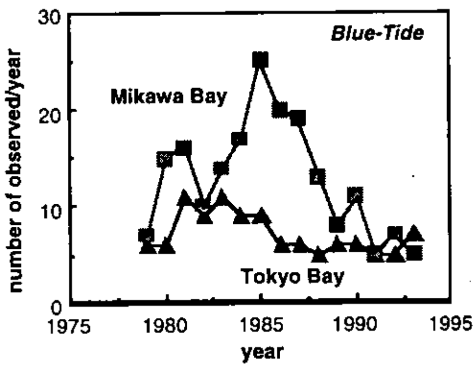



Fig. 11-13 Outbreaks of blue-tide

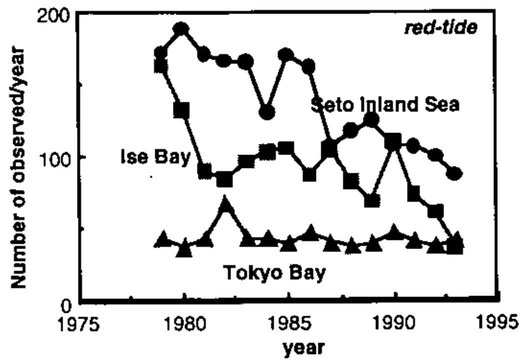



Fig. 11-14 Outbreaks of red-tide

# Chapter 12 COUNTERMEASURES FOR WATER POLLUTION IN THE SETO INLAND SEA

## 1. Introduction

The Seto Inland Sea (S.I.S.) blessed with gentle climate and marine resources had been deeply connected with human life and culture and offered the natural grace to our nation since old time. The beautiful landscape combined with many small islands and beach lines called "white sand and blue pine" makes people's minds refreshing and wealthy, which is designated as the first national park in our country in 1934.

However, the shallow coastal areas with tidal flat, sand beach and sea weed bed were buried on large scale and coastal water pollution got serious with the expansion of industrial production during postwar high economic development period. Oil smell fishes or malformed fishes were often found in coastal areas near industrial effluent and large scale red tides or fishery damages due to aquatic eutrophication had used to break out in the summer season. For this reason, national government decided to introduce a special law to take countermeasure against the water pollution in the S.I.S. in 1973 except for general environmental laws. As the result, partial water pollution in coastal area strongly affected by industrial effluent and numbers of red tide outbreaks were improved, but overall water pollution in the S.I.S. shows no improvement in spite of the various measurements.

In this chapter, outlines of the countermeasures and changes of water quality in the S.I.S. are explained focusing the period after 1970 when the water pollution got serious.

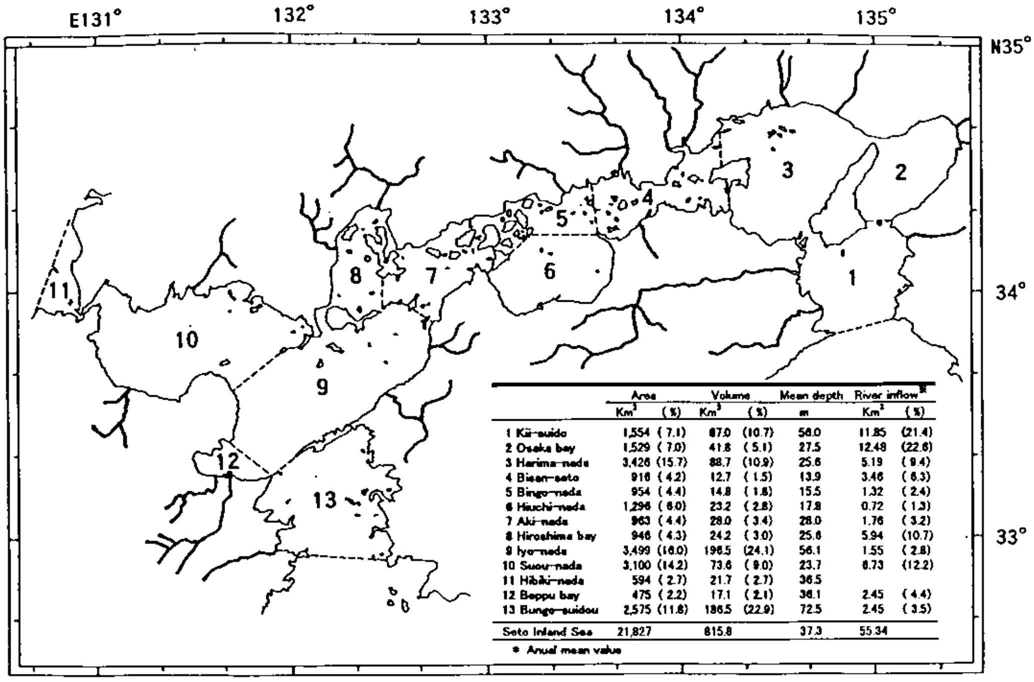
## 2. Overview of the Seto Inland Sea

### 2.1. General characteristics

The chain of Japan islands was constructed by separation from the Asiatic Continent due to earth crust change. It's said the present shape of the S.I.S. was almost formed about 10 thousand years ago.[1)]

The Seto Inland Sea surround by three large islands, Honshu, Kyushu and Shikoku is a long shape enclosed sea, 15~55km wide from north to south and 450km long from east to west, and about 22,000km$^2$ area with mean depth of 37m. The average temperature of 15℃ with average annual precipitation of 1,000~1,600mm makes it mild climate. It is dotted with about 700 large or small islands and has total coastline of 6,800km. There are 662 rivers in the basin and total annual flow rate from rivers is about 55 billion tons (Fig.12-1).

Though it was said exchange characteristic of the sea was bad by the reason for the typical enclosed shape, the mean residence time turned out to be about 15 months from recent researches [2)].




| | Area Km² | (%) | Volume Km³ | (%) | Mean depth m | River inflow* Km³ | (%) |
|---|---|---|---|---|---|---|---|
| 1 Kii-suido | 1,554 | (7.1) | 87.0 | (10.7) | 56.0 | 11.85 | (21.4) |
| 2 Osaka bay | 1,529 | (7.0) | 41.8 | (5.1) | 27.5 | 12.48 | (22.6) |
| 3 Harima-nada | 3,426 | (15.7) | 88.7 | (10.9) | 25.6 | 5.19 | (9.4) |
| 4 Bisan-seto | 916 | (4.2) | 12.7 | (1.5) | 13.9 | 3.46 | (6.3) |
| 5 Bingo-nada | 954 | (4.4) | 14.8 | (1.8) | 15.5 | 1.32 | (2.4) |
| 6 Hiuchi-nada | 1,296 | (6.0) | 23.2 | (2.8) | 17.8 | 0.72 | (1.3) |
| 7 Aki-nada | 963 | (4.4) | 28.0 | (3.4) | 28.0 | 1.76 | (3.2) |
| 8 Hiroshima bay | 946 | (4.3) | 24.2 | (3.0) | 25.6 | 5.94 | (10.7) |
| 9 Iyo-nada | 3,499 | (16.0) | 196.5 | (24.1) | 56.1 | 1.55 | (2.8) |
| 10 Suou-nada | 3,100 | (14.2) | 73.6 | (9.0) | 23.7 | 6.73 | (12.2) |
| 11 Hibiki-nada | 594 | (2.7) | 21.7 | (2.7) | 36.5 | | |
| 12 Beppu bay | 475 | (2.2) | 17.1 | (2.1) | 36.1 | 2.45 | (4.4) |
| 13 Bungo-suidou | 2,575 | (11.8) | 186.5 | (22.9) | 72.5 | 2.45 | (3.5) |
| Seto Inland Sea | 21,827 | | 815.8 | | 37.3 | 55.34 | |

* Anual mean value

Fig.12-1 Overview of the Seto Inland Sea

### 2.2. Fishery resources

There are about 500 species in seaweed, 3,000 species in animal and 600 species in fish, about 100 species of which are associated with fishery resources. Annual fishery catches were under 150 thousand ton before the world war II but increased over 250 thousand ton after the war. Then the amounts continued to increase from the middle of 1960 and reached to 450 thousand ton. However, after the peak, it decreased under 300 thousand ton in 1993 [3,4](Fig.12-2).

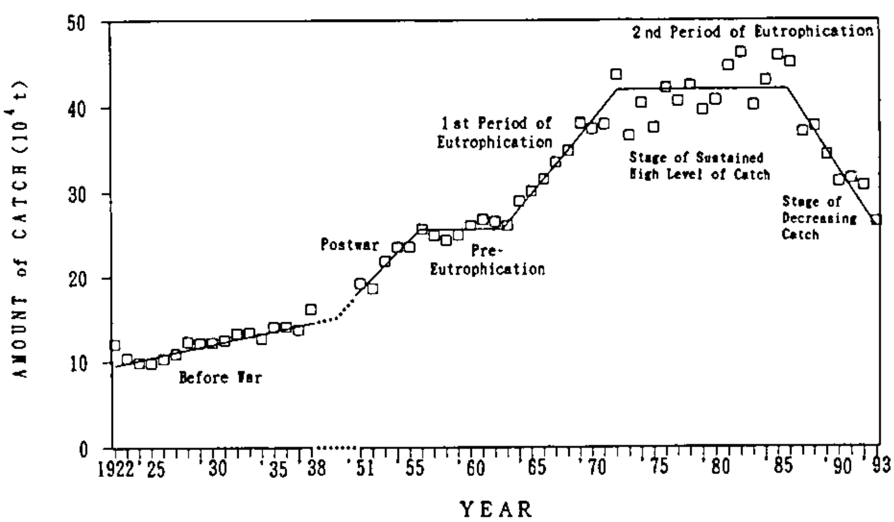



Fig.12-2 Shifts in fish catch amount

The expansion period of the caches after 1965 corresponds to the period of high economic development, when reclamation of coastal area suitable for fishery and environmental pollution has been advanced rapidly. Never the less, fishery production increased due to development and rationalization of fishery technology. However, high price species like sea bream decreased in this period, although low price species like anchovy, cutlass fish, sand eel and Shirasu etc. increased. Recently, sea bream maintained the amounts due to the artificial seed release but low price species tend to decrease by the reason for reckless fishing.

## 2.3. Changes of social condition in the basin

The changes of social condition are briefly mentioned here as basic data associated with pollutant loading (Table 12-1).

Many heavy and chemical industrial complexes were constructed around the coastal areas in high economic development period since 1955, because it has various advantages in aquatic transportation and many shallow areas for reclamation of industrial adjustment. Though the production amounts had once occupied one half of all our country in steel, petrochemical and chemical industries and one third in food, textile and paper & pulp industries, the rates is decreasing little by little at present. Overall industrial production in the area occupied 38% in our country in 1960 but decreased to 28% in 1993. To compare the production amounts among industries, the rates decrease in primary and secondary industries, and increase in tertiary industry.

The population in the basin increased by 1.2 million during these 20 years and reached to 30.1 million in 1993. On the other hand, the population treated by sewerage system increased from 7.92 to 14.8 million, and the popularization percentages became from about 30 to 50%. The pollution treated with combined type and single type private sewage also increased from 1.78 to 2.08 million, from 4.65 to 5.31 million, respectively. So, population treated by some systems increased nearly by 8 million on the whole.

The numbers of farm animals bred in the basin are 604 thousand, 974 thousand, 1.22 thousand and 175 million in cattle, pig, horse and chicken. The percentages of them to total number in our country are 10, 10, 5, 25 %, respectively.

The area of forest in the basin is 4.64 million ha, 20% in all forest areas in Japan. It increased by 0.21 million ha during these two decades.

Table12-1 Sensus data in the Seto Inland Sea baisin

| Year | | 1970 | 1975 | 1980 | 1985 | 1990 | 1993 |
|---|---|---|---|---|---|---|---|
| Population (million) | | 26.2 *1 | 28.0 *1 | 29.0 | 29.6 | 29.9 | 30.1 |
| Population in sewerage system (million) | | 6.73 *2 | 9.44 *2 | 9.52 | 10.9 | 13.3 | 14.8 |
| Sewerage percentage (%) | | 25.7 *2 | 33.7 *2 | 32.8 | 36.7 | 44.4 | 49.2 |
| Population in private sewage system (million) | | | | 1.78 | 2.12 | 2.08 | 2.08 |
| Population in combined sewage systen (million) | | | | 4.65 | 5.27 | 5.29 | 5.31 |
| Industrial production amount (¥trillion) | | 23.4 | 42.5 | 67.8 | 78 | 89.5 | 86.4 |
| Production amount | Primary (¥trillion) | 0.963 | 1.58 | 1.66 | 1.73 | 1.71 | 1.57 |
| | Secondary (¥trillion) | 10.2 | 17.6 | 27.3 | 32.7 | 44.9 | 45.1 |
| | Tertiary (¥trillion) | 12.8 | 27.6 | 46.1 | 61.6 | 80.7 | 87.2 |
| Number of farm animal | Cattle ( thousand ) | 699 | 576 | 632 | 659 | 621 | 604 |
| | Pig ( thousand ) | 927 | 967 | 1,190 | 1,230 | 1,110 | 974 |
| | Horse ( thousand ) | 4.13 | 1.21 | 0.63 | 1.53 | 1.49 | 1.22 |
| | Chicken ( million ) | 77.5 | 70.6 | 75.5 | 74.2 | 95.5 | 175 |
| Area of forest ( thousand ha ) | | 4,430 | 4,440 | 4,640 | 4,640 | 4,640 | |

Note: Data except for population and sewerage% indicate total values in 13 prefecture around the S.I.S.
Population data (＊1) in the basin are got by converting total values in 13 prefectures into vasin values on the basis of the value in 1980 considering population expantion rate during 1970～1980.
Sewerage percentage(＊2) are estimaated on the assumption that sewerage area% are equal to sewerage population %.

## 2.4. Reclamation of coastal line

Reclamation area in the S.I.S. amounts to 26,400ha during 70 years between 1900 and 1970, whose 33% has been buried during only 5 years after 1965. The reclamation condition after 1965 is shown in Fig.12-3. As the restriction against reclamation was enforced by two special laws, "Law concerning provisional measures for conservation of environment of the S.I.S.(LCPMCE)" in 1973 and " Law concerning special measures for conservation of the environment of the S.I.S. (LCSMCE )" in 1978, the rate decreased after 1974.

However 41,900ha of shallow areas have been lost by reclamation between 1900 and 1993. About 50% in all coastal lines, 6,800km have been covered with artificial concrete instead of natural shore-line, only 38% of which remain in the basin [3] (Fig.10-4).

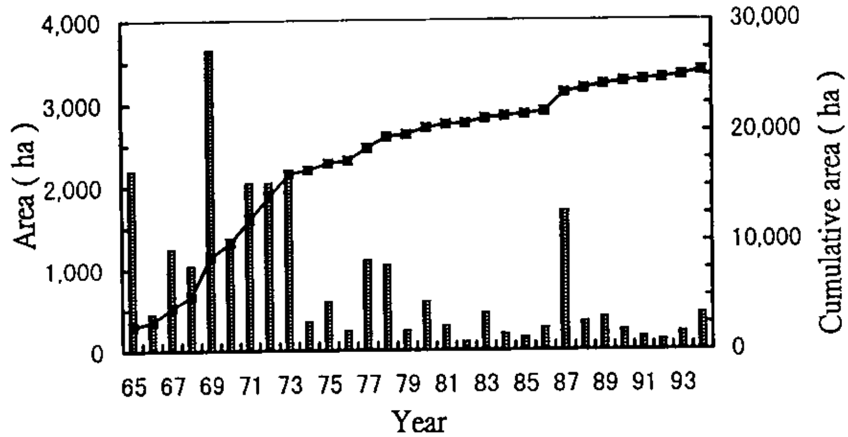



Fig.12-3 Yearly change in reclamation areas in the S.I.S.

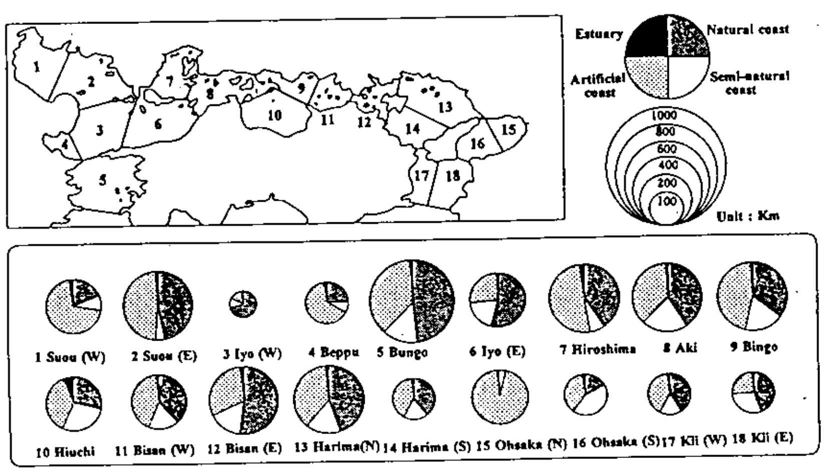



Fig.12-4 Present circumstance in natural coast line

## 2.5. Oil pollution

The numbers of oil spill affairs after 1970 are shown in Fig. 12-5. Maximum numbers of 874 are recorded in 1972. In 1974, there was a large scale of oil spill from oil tanks at Mizushima combination in Okayama prefecture by accident. Heavy oil of 43,000kl exhausted from tanks, 7,500~9,000kl of which flowed into coastal sea. It was the largest oil pollution at that time in our country and the damage had amounted to over 16 billion yen [2,7]. Oil spill numbers in the S.I.S. showed a peak between 1971 and 74, and decreased. However, the numbers even now amount to 101 affairs and occupy about 30% in our country.

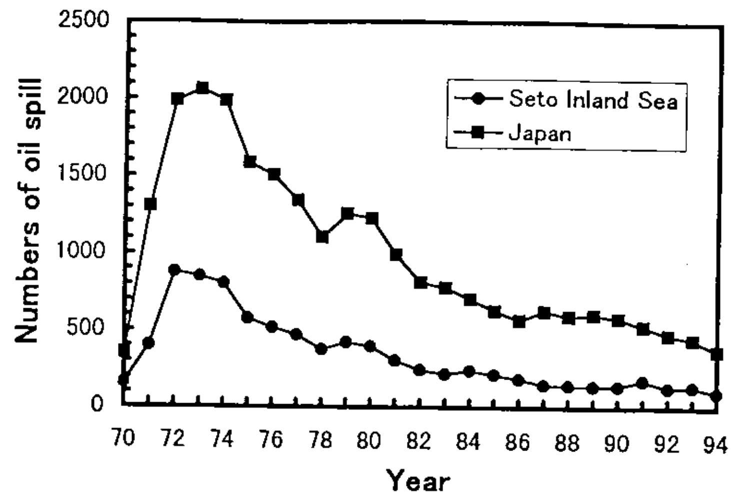



Fig.12-5 Yearly change in oil spill affairs in the sea.

### 3. Red tide and fishery damage

Red tide by *Noctiluca* and *Skeltonema* had been seen in the S.I.S. since old time. However, they were on small scales and not serious until *Gymnodinum* red tide with fishery damage happened in Tokuyama Bay in 1957. After that, red tides and fishery damages by Diatom and Dinophyceae had used to happen every year and expanded the scales[8~10]. Red tides and fishery damages since 1962 are shown in Table 12-2 [3].

Table 12-2 Damages to fisheries by red tide in the S.I.S.

| Year | Location | Case species | Damage to fisheries | Fish mortalities | Damage (¥millions) |
|---|---|---|---|---|---|
| 1970 | Hiroshima Pref. Coast | *Chattonella* | Young yellowtail | 500,000 | 620 |
| 1972 | Harima-Nada | *Chattonella* | Young yellowtail | 14,000,000 | 7,100 |
| 1975 | Harima-Nada | *Prorocentrum* | Young yellowtail | 35,000 | Unknown |
| 1977 | Harima-Nada etc. | *Chattonella etc.* | Young yellowtail etc. | 3,560,000 | 2,940 |
| 1978 | Harima-Nada etc. | *Chattonella etc.* | Young yellowtail | 2,830,000 | 3,320 |
| 1979 | Harima-Nada etc. | *Chattonella etc.* | Young yellowtail etc. | 1,820,000 | 1,110 |
| 1980 | Bungo-Suido etc. | *Photogonyaulax* | Young yellowtail etc. | 523,000 | 390 |
| 1983 | Kii-Suido etc. | *Chattonella etc.* | Young yellowtail etc. | 286,000 | 281 |
| 1985 | Suo-Nada, Bungo-Suidou | *Gymnodinium* | Young yellowtail etc. | Unknown | 10,210 |
| 1987 | Harima-Nada etc. | *Chattonella etc.* | Young yellowtail | 1,900,000 | 2,400 |
| 1991 | Hiroshima Bay etc. | *Gymnodinium* | Sea bream etc. | 2,050,000 | 1,500 |
| 1995 | Bungo-Suido etc. | *Gonyolux* | Sea bream etc. | 5,500,000 | 1,270 |

In 1972, an unprecedented large scale red tide by *Chattonella* happened in Harima-Nada and many fishes in artificial rafts were killed by the red tide. By this affair, eutrophication and red tide became a social issue in the sea, and national government decided to enact the special law "LCPMCE" to cope with water pollution in the S.I.S. Yearly change in breakout numbers of red tide is shown in Fig.12-6. The red tides tend to decrease after the peak in 1976.

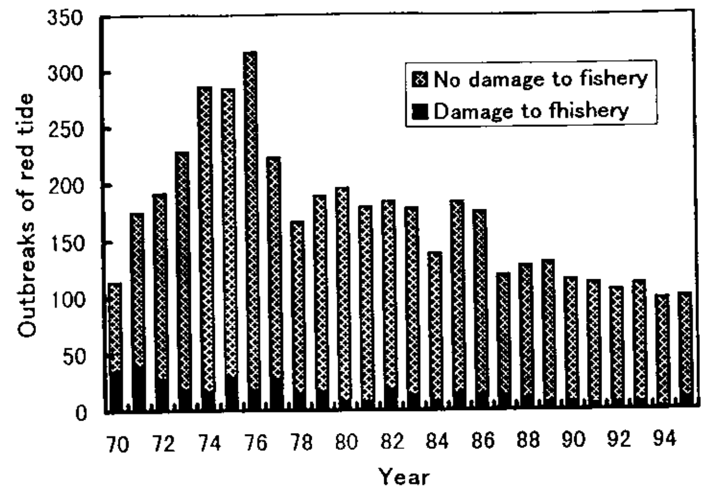



Fig.12-6 Yearly changes in red tide outbreaks

The fishery damage by red tide is largely divided into two, one is due to toxin of plankton and the other due to oxygen deficit. There are various harmful species in plankton. *Shattonella* and *Gymnodinum* are representative species to kill fishes by their toxin.

Recently, red tide by Dinophyceae (*Alexandrium*) which is one of the species of paralytic shellfish toxin such as gonyautoxin or saxitoxin has often happened in the area. The shellfish uptaking this plankton sometimes shows paralytic toxin to human beings.

The reason why fishery damages by red tide happen frequently is that artificial fishery is popular in our country and that fishes bred in raft can't get away from red tide. Though basic countermeasure for these damages is to reduce eutrophic level in the sea, following devices are adapted in this area at present; 1) Establishment of monitoring systems of red tide, 2) Movement of fish raft in the early stage of red tide outbreak, 3) Descent of feed amounts which is one of the causes of red tide outbreaks.

**4. Restriction and countermeasure against water pollution**

Effluent and environmental standard are defined by "Water Pollution Control Law ( WPCL )", and monitored and restricted by local governments in our country. However, as the effect on improvement in the environment pollution by only this law is assumed to be low, two special laws, " LCPMCE" and " LCSMCE" were introduced to the S. I.S. The outlinesof two special laws are introduced here.

**4.1. " LCPMCE"**

As red tide and fishery damage had often happened on large scales in the S.I.S., provisional law, "LCPMCE" was enacted urgently to cope with these issues in 1973 under the limit of 5 years legislation at the instance of House members and succeeded automatically by formal law, " LCSMCE" in 1978. Though the content is almost same with "LCSMCE", following two are peculiar in this law.

1) An express statement of early introduction of mass emission restriction system against pollutant effluent.

2) 50% reduction of COD load during 5 years.

As the system for pollutant load restrictions was not one by total mass emission, but by concentration in 1973, national government declared the necessity of early introduction of the mass emission restriction system and also decided a 50% reduction for COD load in 1972 until 1976 in this law, considering that the countermeasure need to be emergency and that it will fairy contribute to water quality improvement in the sea, although there was no evidence for scientific basis [12,13].

### 4.2. "LCSMCE"

As mass emission regulation system was introduced in the " WPCL" in 1978 according to the law "LCPMCE" and the system was applied to the S.I.S. besides Tokyo Bay and Ise Bay. For this reason, mass emission regulation system for COD load and guidance for nutrient load reduction were incorporated in this law.

Each prefecture made regional plan for environmental protection according to the basic plan by national government.

⟨View point of the basic plan⟩

Local governments must make the effective plans for environmental protection according to the idea that all people will accept equally the values of beautiful scenery and abundant resources, and succeed them to descendants.

⟨Contents of the regional plan ⟩

1) Restriction of settlement of effluent source called "specific facility".

The settlement of specific facility is notification system in " WPCL " ,but permission system in this law. New settlement of specific facility is under an obligation to carry out environmental assessment.

2) Enforcement of total mass emission restriction for COD load.

National government plans the goal of total mass reduction for COD load in the whole Inland Sea and local governments carry out the plan. The reduction goal of COD is decided every 5 years in the range of technical realization. The goal is shown in Table 12-3.

Table 12-3 Reducing plan for COD and nutrient loads in the S.I.S.

| Stage | Final year | Goal in COD load | | Designated |
|---|---|---|---|---|
| | | Reduction % | Actual % | substance |
| I | 1984 | 7.4 | 10.9 | P |
| II | 1989 | 6.1 | 6.8 | P |
| III | 1994 | 9.1 | 10.9 | P |
| IV | 1999 | 3.9 | | N and P |

3) Reducing guidance for designated substance (nutrient) load.

Only phosphorus had been designated as reducing guidance substance between 1~3 stages (Table 12-3), because nitrogen can be fixed in the sea by bacteria or algae, and the treatment technology for nitrogen had not yet established sufficiently. However nitrogen was also designated the reducing guidance substance from the forth stage because of following two reasons.[15]

① Phosphorus is not always a limiting element of nutrients for algal growth because the N/P ratios show the variation in each season and region in the S.I.S.

② Large shift of N/P ratio from natural values will not be favorable for environmental ecosystems.

Local governments make the plan for reducing guidance of nutrient load considering regional features. The main countermeasures for reducing guidance are as follows;

① Countermeasures for industrial load.

- Restriction of nutrient load by effluent standard
- Improvement of sub-materials containing nitrogen and phosphorus
- Convert to phosphorus-free detergent
- Appropriate maintenance of treatment facility
- Introduction of effective treatment system

② Countermeasures for domestic load

- Promotion and proper maintenance of municipal sewerage, treatment facility in agricultural area, raw sewage treatment plant and private sewage system, etc.
- Convert to phosphorus-free detergent
- Education and public relation to enlighten citizen's consciousness for domestic effluent load

③ Countermeasures for the other load

- Livestock farming: Appropriate treatment of animal discharge and the effective utilization
- Agriculture: Observance of proper usage of fertilizer
- Fish culture: Observance of proper feeding
- Other : Positive application of environmental purification ability for water quality

However, these countermeasures for T-N and T-P are only guidance and there is not yet emission regulation system like COD load.

4) Conservation of natural coast beach.

National and local government must designate the areas such as natural sand beach, tidal flat and reef used in swimming, gathering shellfish and fishing as natural conservation districts and protect them. 91 areas are designated as the conservation districts in the S.I.S. until 1995.

5) Restriction against reclamation of shallow coastal area

The reclamation of public water is under obligation to be researched and admitted in Srto Inland Sea Environmental Conservation Council before the implementation.

6) Promotion of environmental protection project as followings

① Waste, municipal sewerage and river-basin sewerage treatment facility

② Disposal facility for waste oil from ship

③ Research and monitoring system for red tide outbreaks

④ Relief for fishermen affected fishery damage by red tide

## 5. Changes in pollutant effluent load

COD load from the basin was reduced to one half by "LCPMCE" and reduced farther according to the reduction goal in every 5 years by "LCSMCE" to cope with water pollution and fishery damage by red tide. Though load reduction was mainly carried out by industrial effluent restriction and municipal sewerage expansion at first and second stages in "LCSMCE", overall countermeasures for domestic load were promoted such as community plant, raw sewage treatment facility in agricultural area and combined sewage system, etc. from the third stage. On the other hand, nutrient load countermeasure was also carried out by guidance plan of local government under these two laws. The Changes in COD and nutrient loads are shown during these periods in Fig 12-7 [6].

The COD load increased between 1961 and 1968, then decreased rapidly, especially between 1972 and 1979. The increase means load expansion according to industrial development and the decrease is due to load restriction by "LCPMCE". After 1979, it decreased gradually from 1,000 to 800 ton/day during 15 years, reflecting the mass emission restriction by "LCSMCE". Though industrial load was three times larger than domestic one in 1972, it is under domestic load at present by strict restriction of industrial load. To compare their reduction rates, they are respectively 75% in industrial load and 20% in domestic one during past 20 years.

On the other hand, the reduction in T-N and T-P loads are smaller than COD. T-P load reduced by 28% reflecting the reducing guidance but T-N is only 10% during these 10 years. To compare the changes in T-P load sources, domestic load which had occupied about 50% of all loads in 1979 decreased, and the rates of domestic, industrial and the other load became almost even in 1989. The conversion to phosphorus-free detergent contributed to the domestic T-P load reduction.

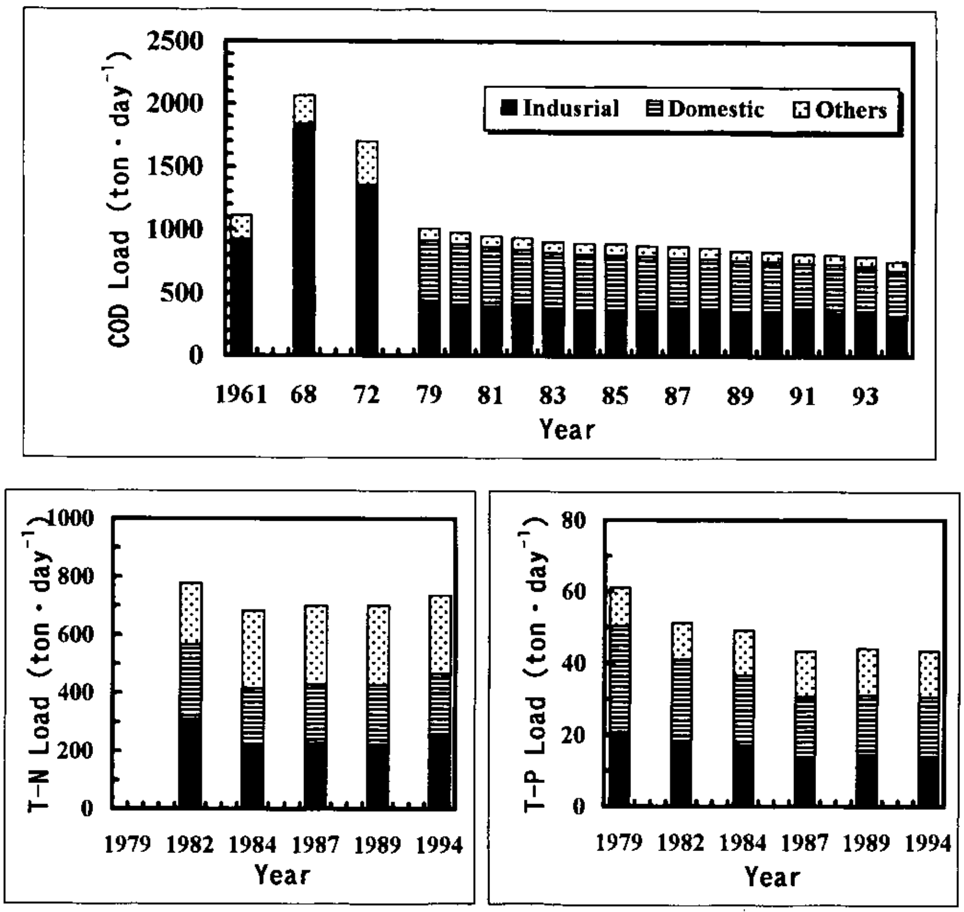



Fig.12-7 Shifts in COD,T-N and T-P loads from effluent

## 6. Water environment in the S.I.S.

### 6.1 Changes of water quality

Though various countermeasures have been taken against water pollution in the S.I.S., achievement rate in the environmental standard for COD, etc. has remained at the same level, about 80% for 20 years in spite of the severe reduction of COD load due to "LCPMCE" and "LCSMCE". In each category, the achievement rate is lowest, only 43% in category A, cleanest area, in 1994. Annual mean values for COD, T-N, T-P and Chl.a at surface water of all monitoring stations in comprehensive research in the

S.I.S. are shown in Fig. 12-8. An improving trend is rarely found in each item, except for abnormal peak of Chl.a in 1985 ~ 86. Annual mean values are 6 ~7m in transparency, 1.5 ~ 2.0 mg/L in COD, 3 ~4 μg/l in Chl.a, 0.25 ~ 0.3 mg/l in T-N and 0.025 mg/l in T-P, although they show a little variations in seasons.

Horizontal distribution of COD in the same research is shown in Fig. 12-9. These data represent mean values during 5 years. Osaka Bay and northern Hiroshima Bay show the highest concentration. The Chl.a concentration shows a similar distribution to COD. We can easily infer that organic pollution in the S.I.S. is associated with algal growth from a good relationship between them. T-N and T-P concentration in each bay and water are shown in Fig.12-10.

Though there was no improving tendency in water quality on the whole, COD concentration got recover in Osaka Bay but increase a little in Hiroshima Bay, Bisan-Seto and Bingo-Nada [6].

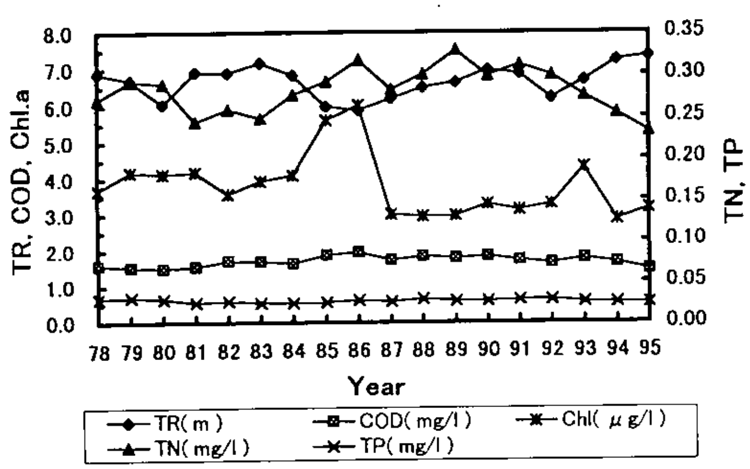



Fig.12-8 Yearly change in mean water quality in the S.I.S.

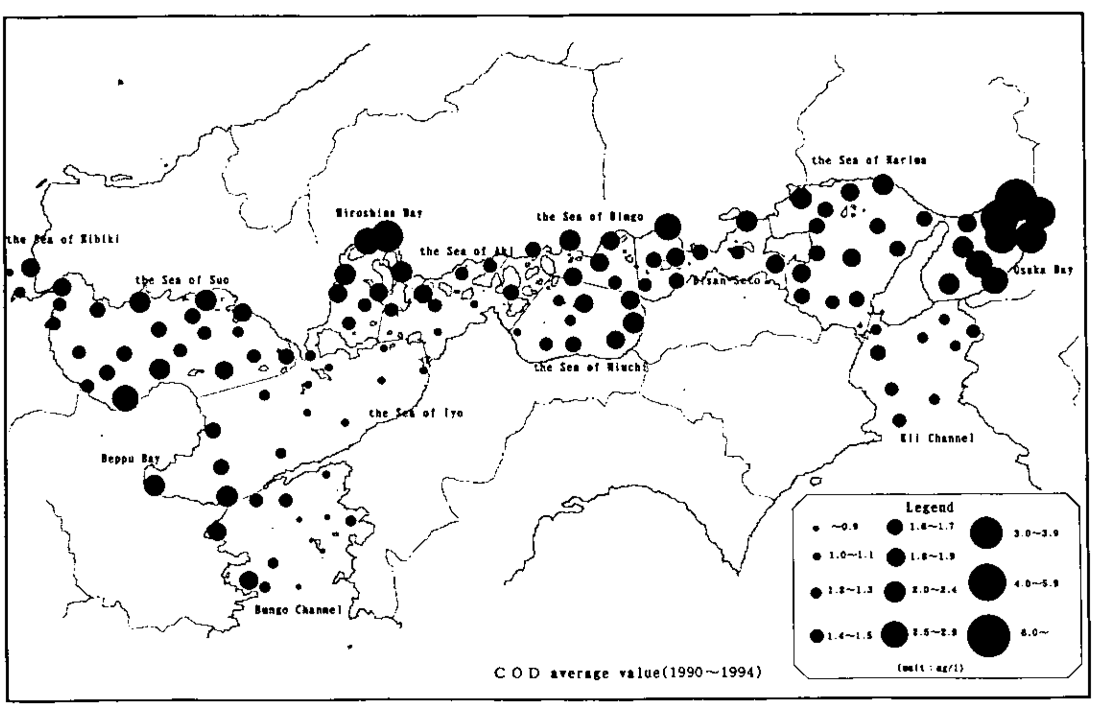



Fig.12-9 Horizontal distribution in mean COD concentration during 1990~94

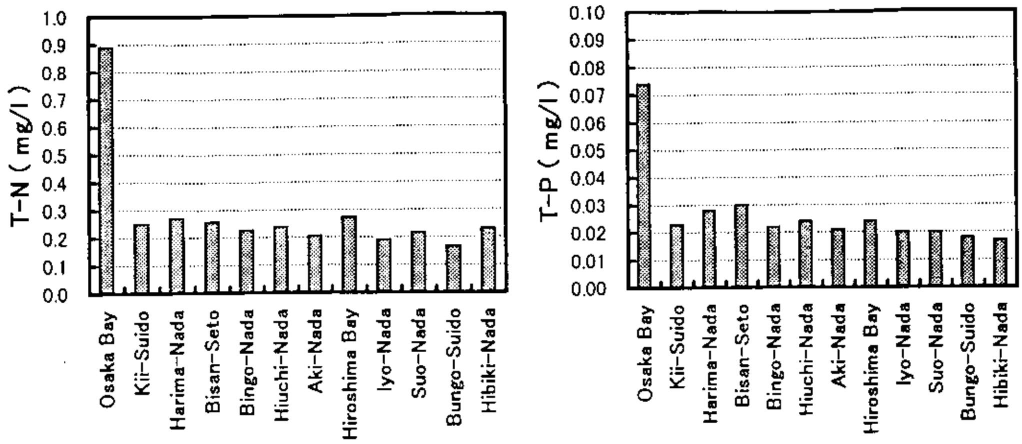



Fig.12-10 Nutrient concentration level in each water area

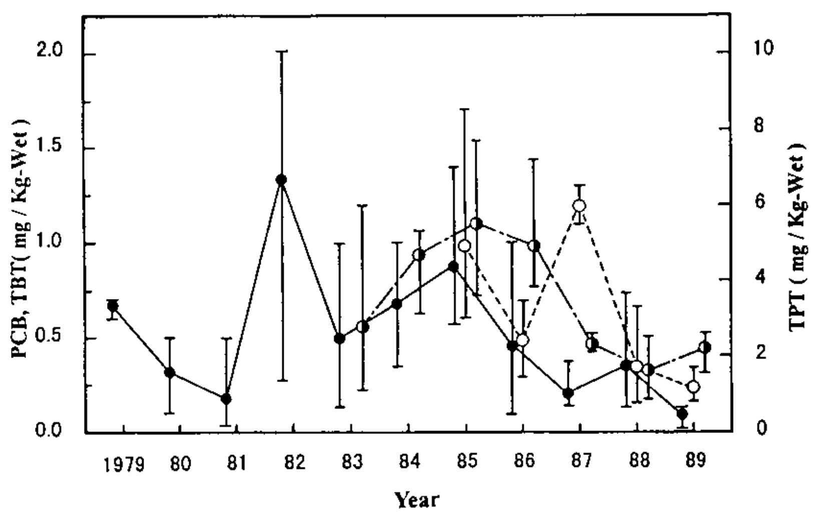



Fig.12-11 Changes in concentrations of chemical substances contaminated in fishes
●:PCB, ○:TBT, ◑:TPT, Bar means maximum and minimum

Besides organic pollution, there has been pollution by various toxic substances. For example, early in 1970, fishes and oysters highly contaminated by mercury and cadmium were found in Tokuyama Bay and the central coast area in Hiroshima prefecture, respectively. However, water pollution by these heavy metals have been improved due to effluent restriction by "WPCL", and water quality in the whole area has now been kept under environmental standards for human health. But it is pointed out that there is other pollution by non-regulated organic substances such as organic tin used in ship bottom coat in the coastal area at present[16].

Though there is a environmental standard in PCBs whose pollution is observed inter-nationally, the concentrations at all datum points in the coastal sea are ND ( less than 0.5 $\mu$ g/l ). However, Kankyo-Cho is monitoring various toxic substances in environmental water, sediments and fishes including non-regulated substances from 1978, because chemical substances tend to be concentrated into fishery resources. Some examples of yearly changes in these toxic substances contaminated in fish (Perch) in the S.I.S. are shown in Fig. 12-11. In Japan, the production, import and usage of PCBs had been prohibited by the " Law Concerning the Examination of Manufacture, etc. of Chemical Substances (LCEMCS)" in 1973 and the concentration shows decreasing after 1982. Organic tin was also applied to " LCEMCS " in 1990. Organic tin in fish had exceeded acceptable daily intake (ADI) level for food

( 1.6 μ g/kg/day in TBTO, 0.5 μ g/kg/day in TPT ) shown by Kosei-Sho in middle 1980 but fishes over the level are rarely found at present, because related industries regulated the production by themselves before several years of 1990 [17,18].

### 6.2 Sediment pollution

Horizontal distribution of total organic carbon (TOC ) in sediments is shown in Fig 12-12 [19]. Narrow areas or areas near the ocean with rapid current and little settlement of particles in the water have the lower silt content and TOC concentration than other areas. Sediment in Osaka Bay, central Hiuchi-Nada, Hiroshima Bay, western Shuo-Nada and Beppu Bay show polluted conditions over 20 mg/g in TOC.

These distributions were surveyed by Kankyo-Cho during 1981 ~ 1985, and same survey ( Mud content, IL, COD, TOC T-N,T-P and Macrobenthos ) was carried out again 10 years later to research the change in the sediment pollution. The result showed no improving tendency in the sediments statistically. In the second survey, heavy metals are also measured with these items.

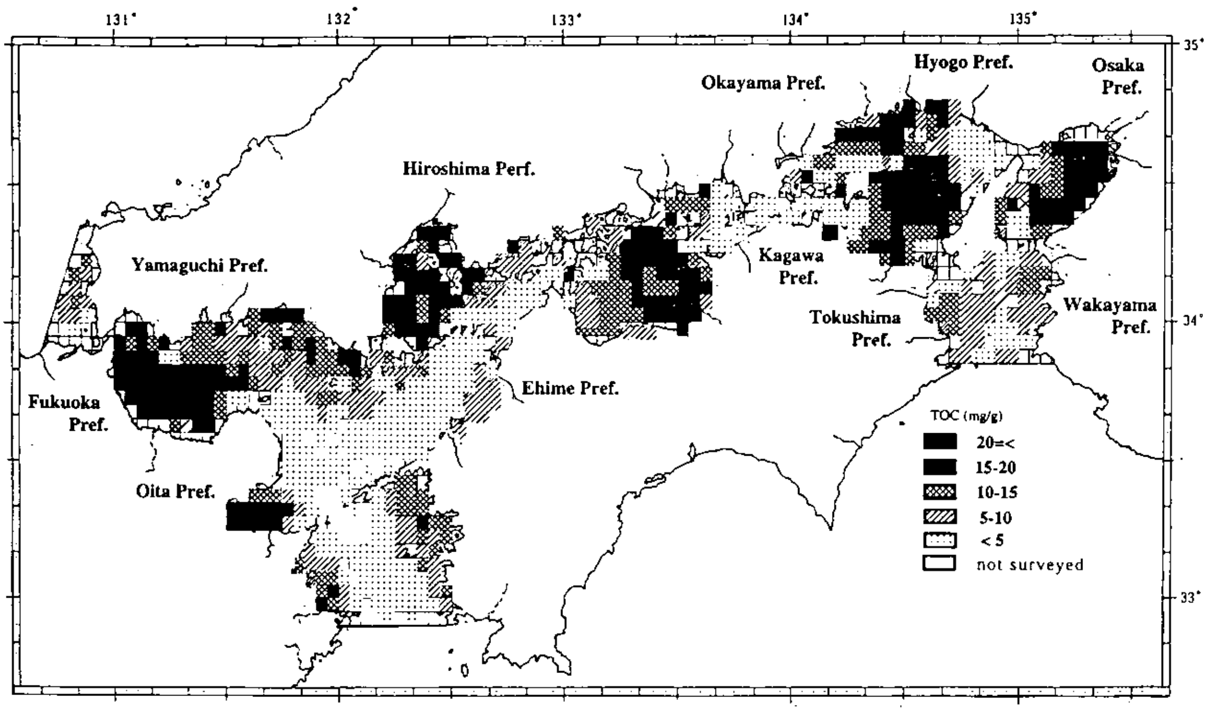



Fig.12-12 Horizontal distribution in TOC in the sediments

### 7. Prospective subject

The water and sediment qualities don't show improving tendency in spite of various countermeasures such as effluent load reduction, promotion of monitoring and sewerage systems and restriction of reclamation. However, decrease of red tide outbreaks, improvement of water quality in Osaka Bay and maintenance in overall water quality without getting worse will be their own results by the countermeasures.

The main reason of little improvement in the environment is considered water pollution to be controlled by algal growth due to eutrophication besides direct effluent organic load. Hoshika et. al. reported organic matter resulted from primary production occupied 80% of all in Osaka Bay[20]. In Hiroshima Bay , it's also reported that about 90% of organic matter is originated from primary production by phytoplankton [21]. The COD load had reduced by 60% according to effluent restriction. However, reducing rate for nutrient load is low, only 10% in T-N. Coastal eutrophication causes oxygen deficit at bottom water layer to influence ecosystem of inhabitants except for red tide outbreaks. Oxygen deficit under 2mg-$O_2$/l, threshold level for benthos is confirmed at bottom layer both in Osaka and Hiroshima Bay in summer [22]. Though T-N was also designated as reducing guidance substance with T-P at the forth stage during 1994~99 in "LCSMCE", more effective and drastic countermeasures will be hoped..

Though many countermeasures for organic pollution have been carried out from various points of view until now in the S.I.S., water pollution by toxic substances of new types such as organic tin used in fishery net and ship bottom paint or organophosphorus- and carbamate- pesticides have happened in the coastal water . Moreover, several toxic substances were added to environmental standard for human health, and environmental guideline values for 25 monitoring items were newly introduced since 1993. As environmental pollution by unknown chemical substances is considered to get more serious and significant, monitoring system and countermeasures for these substances should be more focused on.

Finally, public consciousness and policy to conserve the natural beautiful landscapes and to succeed them to descendants for ever will be also important, simultaneously with these countermeasures for environmental water pollution.

Chapter 13 GROUNDWATER QUALITY MANAGEMENT

## 1 Present State of Groundwater Pollution

### 1.1 Organochlorines

Following the results of the nationwide survey, a large number of local authorities carried out their own investigations on the state of groundwater pollution with regard to three substances. Until 1995 fifty-nine thousand groundwater samples were collected, and the results made the temporal trends of excess rates for three substances over drinking water standards as illustrated in Fig. 13.1. Data are coming from a general inspection survey to investigate the state of pollution by dividing the survey area in a mesh grid, and investigation sites are not duplicated at all. Since 1989, the statistical incidence of excess rate for standards has reduced to be 0.3 through 0.6 % at present, however, this is totally attributed to the fact that at the initial stage the nationwide surveys focused on areas with a high risk of pollution such as those surrounding industrial-commercial users of the chemicals and now are extending to residential area and country side with a less potential of pollution.

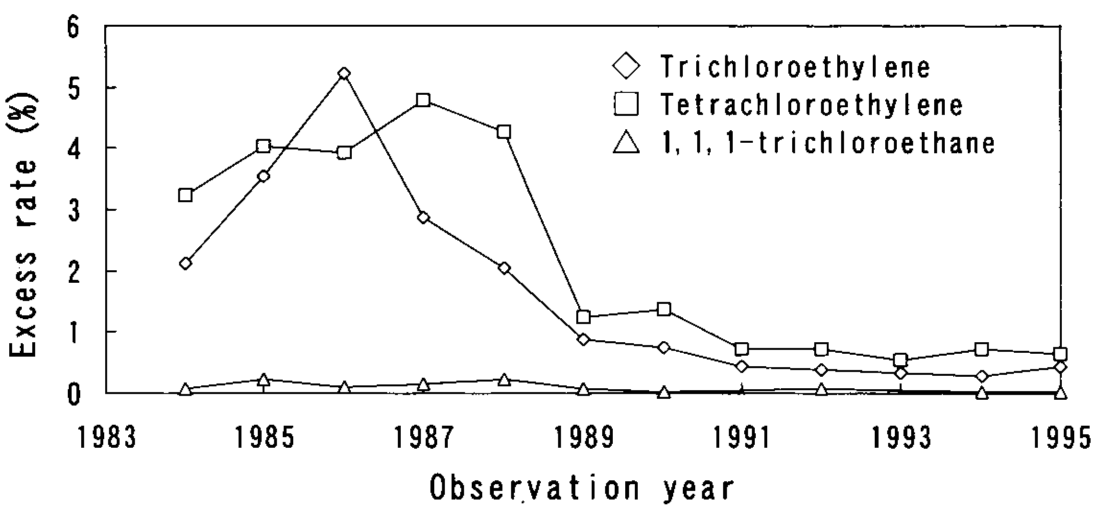



**Fig.13.1 Temporal trends of excess rates for trichloroethylene, tetrachloroethylene and 1,1,1-trichloroethane over drinking water standards.**

### 1.2 Heavy Metals

The groundwater pollution due to heavy metals has been systematically surveyed since 1989. The results show that except PCB, alkyl mercury and organic phosphorus, heavy metal pollution in groundwater was discovered. In particular the concentrations of arsenic and mercury over environmental quality ex-standards for groundwater was detected at high rate as listed in Table 13.1. The arsenic and lead controls were intensified, changing the standards from 0.05 and 0.1 mg/L respectively to 0.01 mg/L each. The subsurface pollution by arsenic and lead is thought to steadily increase in the future. Furthermore heavy metal soil pollution in urban area is also increasing, for example, chromium(VI) , lead, mercury and cadmium in plating and chemical industries and research laboratory etc.

The elements of arsenic and chromium are basically contained in natural soil and rock, the average existing amounts of which count for 1.8mg/kg and 100mg/kg, respectively. Therefore natural pollution are possible to originate from virgin soil and rock. The arsenic groundwater pollution is well known in Bengal district of India to be caused by natural geology. The intensive agriculture practice facilitated taking deep groundwater, which induced shallow groundwater penetration through arsenic mining to deep groundwater zone. Consequently deep groundwater use for drinking water produced human skin disease and cancer.

**Table 13.1 Detection rate of heavy metals in groundwater**

| | Detection rate ocer standards (%) | | | | | |
|---|---|---|---|---|---|---|
| Survey year | 1989 | 1990 | 1991 | 1992 | 1993 | Standards(mg/l) |
| Chromimum(VI) | 0.0 | 0.03 | 0.03 | 0.0 | 0.04 | 0.05 |
| Arsenic | 0.26 | 0.16 | 0.14 | 0.18 | 1.44 | 0.01 |
| Mercury | 0.0 | 0.12 | 0.10 | 0.11 | 0.11 | 0.0005 |

Detection rate for arsenic until 1992 is based on ex-standards 0.05mg/l

### 1.3 Nitrate Nitrogen

The nitrogen origin in water environment is the atmospheric constituent, which is converted to fixed forms by biological or industrial fixation. The biological fixation amount on the globe is estimated to be $4x10^{10}$ - $1.4x10^{11}$kg/y, and the industrial fixation to be $8x10^{10}$kg/y, which is approximately equal to the natural abundance fixed. The excess nitrogen over the denitrification capability in the natural field results in nitrogen accumulation in water environment in many ways.

The rainwater contains nitrogen oxides, however, the inorganic nitrogen concentration takes 0.52mg/L and the annual load is estimated to be 9.1kg/ha/y in the averaged value of the whole Japan. The main source of nitrate in groundwater in Japan is coming from the loss of fertilizer application and the soil treatment of the domestic wastewater.

The field measurement shows that the half amount of fertilizer applied in Japan appears to be leaching out to the groundwater. With respect to the arable lands, paddy field is usually in anaerobic condition and annual amount of nitrogen fertilizer applied is within 100kg/ha, so it is rather acting as the reduction of nitrate concentration, compared the input and output loads.

The intensive field surveys have been done in Miyakojima Isle, Okinawa Pref. and Kagamihara basin, Gifu Pref. The drinking water of Miyakojima totally depends on groundwater abstraction. During the past three decades, increase of chemical fertilizer application to the sugar cane caused the groundwater pollution. In addition, soil treatment of the domestic wastewater was accelerating the rise of the nitrate concentration. The steady increase of nitrate concentration is also observed in the whole isle to become nearly four times high from 1.92mg/L in 1966 to 7.58mg/L in 1989 as illustrated in Fig. 13.2.

### 1.4 Other Chemicals

The environment Agency's 1982 survey led to the detection of three types of aromatic hydrocarbons (benzene, toluene and xylene) and two types of phthalates (dibutyl and di(2-

ethylhexyl phthalates) in groundwater. Four of these substances, except for dibutyl phthalate, were added to the standard for water environment and guideline, but only one well showed the presence of benzene in excess level as compared with their standards.

Benzene, toluene and xylene were tested for in the 1989 inspection survey when only toluene was found to be present, and that was at levels below the standard values. In an incidence in which gasoline had leaked from a tank into ground, aromatic hydrocarbon pollution was observed to have spread, with both benzene and toluene clearly exceeding the standard levels.

In the 1992 inspection survey, 1,4-dioxane, one of the Designated Chemicals under the Chemical Substance Control Law, was discovered at a high incidence. This substance has also been detected at a high rate of incidence in surface waters. The maximum concentration found in groundwater is higher than that in surface water. The maximum level exceeded 0.07 mg/L, a concentration the USEPA considers as being equivalent to a $10^{-5}$ cancer causing risks. This chemical has a high solubility in water and is therefore difficult to separate from water.

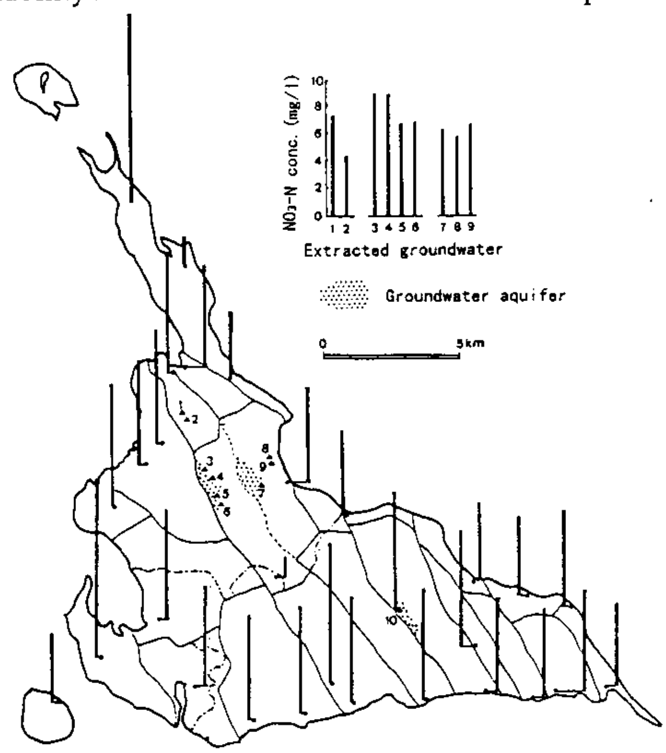



**Fig.13.2 Areal distribution of nitrate nitrogen in the groundwater of Miyakojima Isle(1989)**

## 2 Remediation Action for Groundwater Pollution

### 2.1 Prevention of Groundwater Pollution

The groundwater quality management comprises two parts of prevention from being polluted and pollution remediation. When the groundwater pollution is discovered in regional groundwater, at first the inspection survey is conducted to depict the groundwater pollution plume around the polluted well. In addition, emergency measure is taken place according to the groundwater use. In case that the groundwater is utilized for drinking water, the remediation for contaminant removal from polluted groundwater to meet the drinking water standard or alternative water resource is required. In addition, under the Water Control Law any water containing the hazardous chemicals is prohibited to be infiltrated to the subsurface environment, and plus the effluent concentration of hazardous chemicals into public surface water is determined not to be over ten times the water quality standards.

## 2.2 Classification and Availability of Technologies

The pollutant entering into the soil and groundwater results in the following conditions, depending on its chemical feature: (1) adsorption on the soil particles; (2) dissolution in the water; and (3) vaporization in air of soil pore if the pollutant is volatile substance. When pollutant enters the soil in large quantity as undiluted liquid, another possibility exists, namely (4) that the pollutant occupies the pore spaces in undiluted liquid form. In any of existing forms, the determination of concentrations is totally attributed to partitioning characteristics among the gas, liquid and solid phases. When the distribution is biased toward any particular phase, the most effective way to repair the pollution situation is to eliminate the high-concentration medium.

Remediation technology for subsurface pollution consists of removal of pollutants from the soil or groundwater and their detoxification. Generally it is classified into two categories i.e. (1) diffusion control of the pollutants and (2) removal and decomposition of pollutants as collected in Fig. 13.3. In the pumping up of groundwater, diffusion control comes about with the use of a barrier well. When it takes place close to the pollutant source, the element of pollutant removal technology predominates. These measures are thus closely interrelated and should be used in a proper combination to achieve an improved remediation effect.

Solidification technology as one of these techniques is not applicable to such liquid pollutants as trichloroethylene. Chemical reaction and vitrification techniques, however, are primarily reserved for heavy metals. Microbial decomposition is in widespread use as a decontamination and detoxification technique for hydrocarbons such as petroleum and petroleum products which are relatively readily degradable. Recently, however, it has become possible to discover microorganisms capable of decomposing at high efficiency volatile organochlorines. Their use is now being developed for commercial-base application, with the technology having reached the stage of site verification tests.

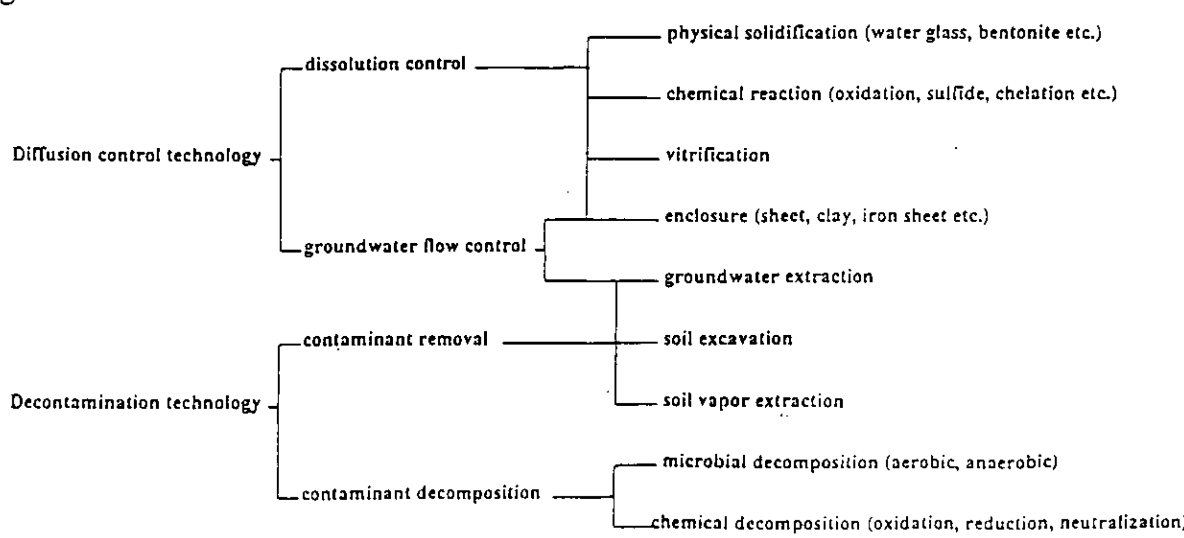



**Fig. 13.3 Classification of remediation technology for subsurface pollution**

## 3. Remediation Technology for Groundwater Pollution

### 3.1 Heavy Metals

#### (a) Physical treatment

Various sorts of heavy metals are detected from soil environment, for example, copper, cadmium, arsenic from arable land, and mercury, cadmium, lead, arsenic from urban area. Basically heavy metals in soil are not easily soluble with water. In addition the cation like cadmium is likely to be adsorbed on the surface soil, so physical treatments of ploughing with deeper soil, placing clear soil, in-situ solidification, enclosing into water-tight container are used so far. In the arable land, the area of 6140 ha was planned to be treated mainly for cadmium pollution, and 80 % of the area is already established until 1994. The inquiries of Japan Environment Agency in 1994 showed that the technology of solidification and enclosure occupies 30% of 318 soil remediation practices, and soil placing is up to 16%.

#### (b) Chemical treatment

The solubility with water is quite different with chemical structure of heavy metals, and this property was utilized for remediation as oxidation or reduction technologies. For example, the sodium sulfide is added to cadmium, lead, mercury compounds in order to reduce the water solubility,

$Cd^{2+} + Na_2S = CdS + 2Na^+$,
$Pb^{2+} + Na_2S = PbS + 2Na^+$,
$Hg^{2+} + Na_2S = HgS + 2Na^+$,

chromium(Ⅵ) is reduced to chromium(Ⅲ) with iron sulfate, lignite, poultry manure etc.

$$Cr_2O_7^{2-} + 6FeSO_4 + 14H^+ = 2Cr_3^{+} + 6Fe^{3+} + 6SO_4^{2-} + 7H_2O$$

Cyanide compounds is oxidized with sodium hypochlorite as follows.

$$2NaCN + 5NaOCl + H_2O = N_2 + 2NaHCO_3 + 5NaCl$$

The success of chemical treatment mentioned above depends on how long time the chemical reaction continues. In this context after the chemical treatment, extraction test with water from treated soil is conducted, and when the solution concentration is over the standards, the treated soil should be controlled in the watertight container.

After the soil treatment by physical enclosure and chemical reaction, the contaminants still stay in the in-situ soil. Taking an example on the chromium pollution in Tokyo Metropolitan, the soil and groundwater pollution reappeared after the effective period of chemical reaction. In place of these conventional methods, innovative technologies for contaminant detoxification and removal from polluted site have been developed. The vitrification technique of contaminated soil is used, mainly in America, for heavy metals and radio active material, controlling high current electricity in the soil. The vitrification technique is capable of closing the contaminants within glass solidification. The soil washing and classification are thought to remove highly contaminated parts from soil excavated. In addition, when the extraction test with water meets the environmental standards, the treated soil is able to get back to the original position.

There exists a remediation practice in in-situ groundwater contaminated with chromium(VI). Fig.13.4 shows a remediation system, where the remediation wall of 6 m depth was installed, and lignite and acid clay were placed in the bottom of the wall in order to reduce chromium(VI) in perched groundwater. This groundwater treatment was performed as an emergency measure until contaminated soil was removed.

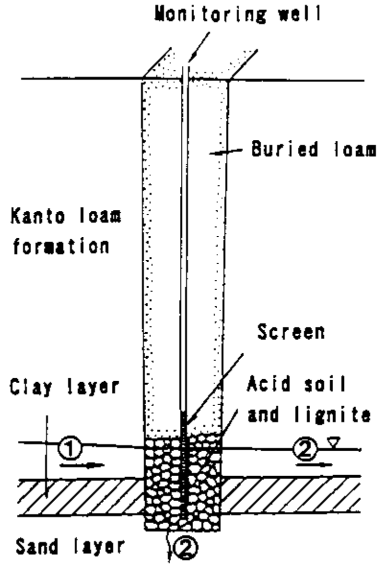



**Fig. 13.4 Remediation wall for chromium(VI) treatment in perched groundwater. The number in a circle ① is for inflow of contaminated groundwater and ② for outflow of treated groundwater.**

### 3.2 Organochlorines Pollution

#### (1) Pollution features

The volatile organochlorines like trichloroethylene and tetrachloroethylene are widely and effectively used in cleansing process by many and various industries producing huge amounts of fine products. They tend to be little adsorbed on soil. In addition the organochlorine liquids are heavier in weight and less in surface tension and viscosity than water, therefore, they are rather mobile in unsaturated soil compared to water.

Table 13.2 gives the maximum values for the soil and groundwater concentrations collected so far. In some cases with concentrations in the range of a few tens to a few hundreds of thousands of mg/kg, the pollutant is present in the soil in the form of undiluted liquid. The vertical soil concentration profile exhibits that while maximum pollutant concentrations occur at different depths, in many cases the pollutant tends to raise its concentration at or near the gravel/clay layer boundary at the bottom of the aquifer.

Also in groundwater the concentrations for trichloroethylene and tetrachloroethylene overshoot their solubility in water of 1100 and 150 mg/l respectively. It is reasonably assumed that the organochlorines form the pools of undiluted liquid mainly in the vicinity of the pollutant source and are present in groundwater at high concentration nearly at their solubility in water. In the presence of undiluted liquid, the concentrations measured for the soil gases should be equal to their vapor pressure, i.e. trichloroethylene:76300ppmv and tetrachloroethylene:18400 ppmv. Actual measurements for soil gas concentrations have shown evidence of high concentration of soil gas in excess of 10000 ppmv.

**Table 13.2 The maximum concentration of organochlorines in soil and groundwater in pollution incidents of Japan with their soil feature**

| Locations | Solvent | Depth (m) | Soil feature | Soil conc. ($mg \cdot l^{-1}$) | Groundwater conc. ($mg \cdot l^{-1}$) |
|---|---|---|---|---|---|
| TK-A | TCE | 7 | Clay | 64 | 11 |
| | cis-DCE | 7 | | 39 | 19.2 |
| TK-B | TCE | 11.5 | Silt | 0.2 | 1.9 |
| | cis-DCE | 6.3 | | 3.43 | 5.5 |
| T1 | TCE | 2 | · | 6,600 | 42 |
| | TCE | 37 | Silty sand | 5.4 | 103 |
| KT-U | TCE | 25-27 | Silt | 40 | 360,000 |
| KT-K | TCE | 0.7 | Surface soil | 10 | >10 |
| KM-K | PCE | 5.5 | Silt | 360 | 80 |
| KM-T | TCE | 46 | Silty sand | 138 | 294 |
| SZ-A | PCE | 2.1 | Coarse sand | 8,100 | 8.6 |
| SZ-B | PCE | 0.8 | Clay | 25,000 | 22 |
| IT-S | TCE | 3 | Coarse sand | 232 | 1,390 |
| IT-M | TCE | 7-8 | Silty sand | 210,000 | 40 |

Solvents are:TCE – trichloroethylene, PCE – tetrachloroethylene,and,
Cis-DCE – cis-1,2-dichloroethylene.

### (2) Remediation technology

### (a)Soil Excavation

In many pollution incidents of shallow groundwater, the countermeasure of soil excavation is first considered. In 1983 during monitoring the quality of groundwater, in particular used for public water supply, volatile organochlorines were found here and there in regional groundwaters. At the upper part of the region, an electric firm, one of the biggest world enterprises, is in operation, utilizing trichloroethylene to clean the component parts of television and semi-conductor. Immediately after detecting trichloroethylene in water for the public supply, surrounding shallow well-waters of 427 points for domestic usage were investigated, revealing that the maximum concentration in the shallow groundwater was up to 10mg/L just down from the firm, and the trichloroethylene plume over 0.03mg/L covered the area of more than three kilometers toward the down stream gradient.

In order to solve the pollution mechanism, borehole investigations were conducted inside the firm site, and consequently highly polluted groundwaters were collected around the building installing the trichloroethylene groundwater pollution storage tank situated at the southeast part of the firm area. The trichloroethylene concentration in groundwater rose to 40mg/L at 7m depth and 4mg/L at 10m depth.

At first the firm shifted the solvent to 1,1,1-trichloroethane, and evacuated polluted soil of more than 1mg/kg in concentration underlying the storage tank, of which amount counted for 1,000$m^3$ in volume. The trichloroethylene highest concentration in soil reached 6,600mg/kg at 2m depth. Immediately after that, the concentration in shallow groundwater taken from the well near the building began to markedly decline, however, no discernible decrease was gained in deep groundwater, as illustrated in Fig.13.5. The implication is that the soil removal operation was forced to terminate due to groundwater appearance at the depth of 7m, so appreciable quantity of contaminant is still present within the deep aquifer. Consequently seventeen tons of trichloroethylene were removed from 1984 to1989 by means of groundwater extraction.

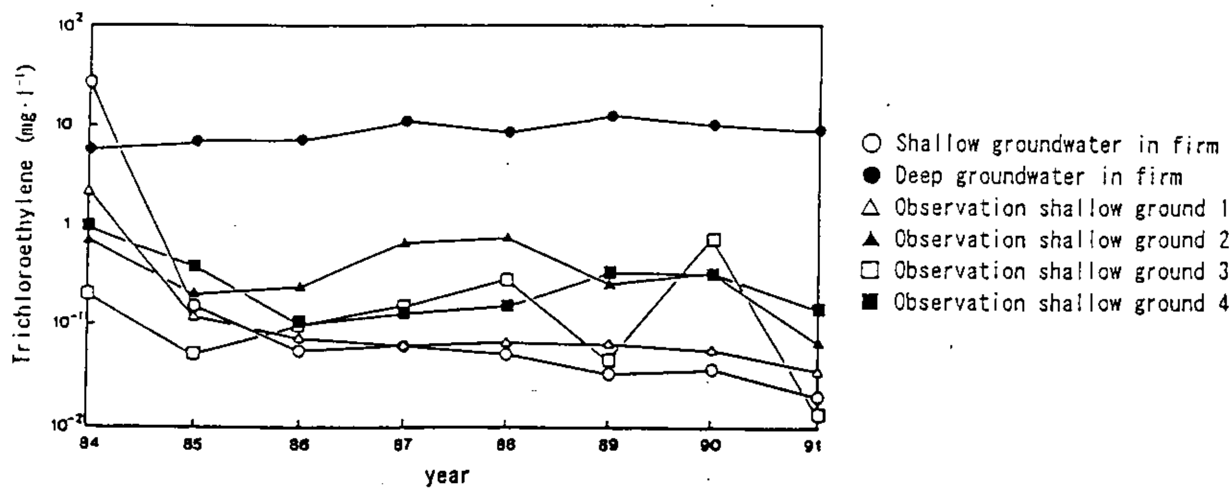



**Fig. 13.5 Time-varied changes of trichloroethylene concentration in shallow groundwater after polluted soil excavation and subsequent groundwater extraction for remediation**

**(b)Dual Extractions of Soil Gas and Groundwater**

Soil vapor extraction technique is to remove pollutants, which have vaporized in the soil vapors in the vadose zone. The remediation technique is reported to have removed a few hundred kilograms to one ton volatile organochlorines in operations for a period of a few months to a year. However it is available only for vadose zone, so that when the groundwater is also polluted, the operation to pump up groundwater is inevitable.

In a shallow groundwater region where the highly residual part of trichloroethylene is existing in both sides of vadose and groundwater zones, the soil vapor extraction method was employed for vadose zone remediation with pumping up the groundwater at the same time. In order to extract both of soil gas and groundwater from a same remediation well, four dual extraction wells were constructed around the hotspot for the soil gas flow reach to cover the highly polluted area (Hirata and Nakasugi, 1993). The remediation operation using two technologies resulted in removing the trichloroethylene amounts of 472 kg by soil vapor extraction and 1764 kg by groundwater extraction during the period of 27700 hours (1154 days).

Fig. 13.6 compares the time-varied changes of the trichloroethylene removal rate in the unit of kg per hour. Both removal rates indicate the total rate of the four extraction wells. It appears that at the initial stage of the remediation, the soil vapor extraction operation has been successful in removing by suction 1 kg/hr of trichloroethylene, which shows one order higher than the removal rate achieved with groundwater extraction. Yet the removal rate due to soil vapor extraction does begin to decline much earlier than in case of groundwater extraction, so that the removal rates of these two methods develop inversely with the progress of remediation. In particular the removal behavior of pollutant totally depends on the chemical feature of trichloroethylene liquid being highly volatile and little soluble in water (Hunt and Sitar, 1988) and the change of existing form of pollutant affects the effectiveness of applied remediation technologies with the operation time going on. The groundwater extraction requires so many years to cleanup the polluted aqueous phase, contrary to this, it is likely to eliminate much more pollutant with groundwater extraction than other technologies.

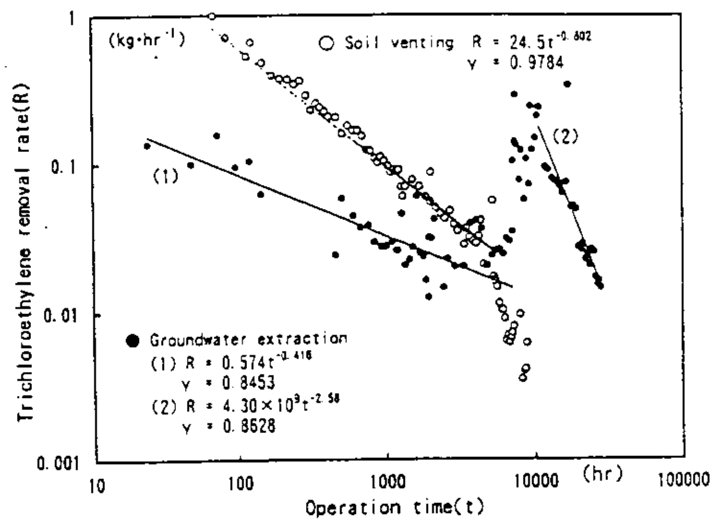



**Fig. 13.6 Comparison of trichloroethylene removal rates due to soil vapor and groundwater extractions. The numerals a and b in the figure denote the constants, when the removal rate R is formulated with the operation time t by $R = at^b$.**

**(c)Bioremediation**

Physical remediation technologies such as soil vapor extraction and groundwater extraction involve the removal of pollutant substances from the subsurface zone and their ultimate vaporization and recovery by adsorption on activated carbon. Though these techniques are ideal for the treatment of low-boiling point chemicals, the issue still remains that the solutions desorbed from the activated carbon and the activated carbon itself will need to be eventually disposed of by incineration treatment. This implies that in some sense, the situation is that of a merry-go-round of the pollution burden which is shifted from the subsurface to the atmospheric environment. In contrast to this, bioremediation technology holds out significant hopes for the possibility and practical availability of a process for the complete decomposition of the pollutant substances to carbon dioxide.

Biodegradation is already in practical use in the industrialized Europe and America as a remediation technology for relatively easy-to-decompose hydrocarbons such as gasoline. Similarly, for substances such as trichloroethylene, it has been possible to discover microorganisms that are capable of decomposing pollutants at high efficiency under anaerobic conditions. In situ Bioremediation gives rise to certain problems, which need to be resolved such as the issues of the toxicity of the intermediate products and the public acceptance of the technique. Bioremediation is a promising measure in the final stage after the implementation of physical remediation procedures such as soil vapor extraction and groundwater extraction technologies. In Japan, site verification of bioremediation technology for volatile organochlorines has now commenced with a view to developing it for practical application. Fig. 13.7 illustrates a result of the test for in situ bioremediation for trichloroethylene groundwater pollution, injecting oxygen and methane into polluted groundwater. It proves that the groundwater concentration for trichloroethylene keeps nearly zero value, even after the injection of oxygen and methane stopped. During 40 days through 40[th] day to 80[th] day from the onset of the test, the amount of 1.2kg trichloroethylene is estimated from the mass balance calculation of groundwater flow to be decomposed.

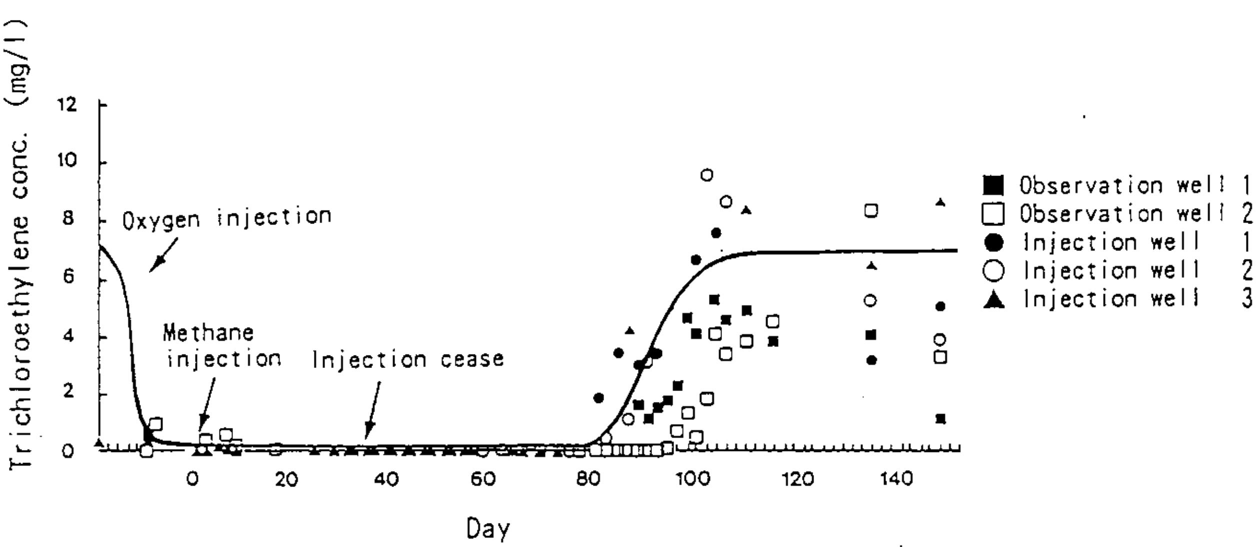



**Fig. 13.7 In situ bioremediation for trichloroethylene pollution in shallow groundwater**

### 3.3 Nitrate Pollution

When the nitrate concentration in groundwater is in steady upward trend and about to approach or exceed the drinkable limit (10mg/L in Japan), the easiest measure is to close the groundwater abstraction. In addition, making deeper borehole to take clean groundwater and blending with less contaminated water etc. are introduced. In case of no proper water resource except polluted groundwater, the drinkable water treated with the techniques like ion exchange method is supplied.

In order to conserve and prevent the groundwater from being polluted, it is urgently desired to reduce the leaching loss of nitrogen in agricultural practice and how to reuse and repair the groundwater with high nitrate concentration. In many cases of the nitrate pollution in groundwater, however, it initiates in leaching out the fertilizer constituent from non-point source. The definite measures applicable to the various sorts of nitrate problems are not easy to be discovered and determined. Several options about this are picked up as follows;

1)predictions of nutrient need and timing of inorganic and organic fertilizer use, and application of proper amount of fertilizer,

2)avoiding the unnecessary irrigation which promotes the leaching out of fertilizer applied in cropland field, 3)establishing the crop rotation introducing pea and bean,

4)utilizing organic fertilizer and introducing slow-acting fertilizer in place of some parts of chemical fertilizer,

5)reuse of groundwater from upgradient to downgradient,

6)careful management of ploughing-in in wet season, and

7)use of uncultivated paddy field to remove the nitrate due to the denitrification capability.

In Kagamihara City, the whole potable water of which is coming from groundwater, the nitrate concentration in shallow groundwater tends to rise since 1970s. The city authority, known as carrot production, has studied the management of fertilizer use to recover the groundwater quality. The field experiment showed that the 25% reduction of fertilizer application(300kg-N/ha/y) compared to the usual one(400kg-N/ha/y) is able to produce nearly the same amount of carrot without damaging the carrot quality and harvest amount. As a result of improvement of fertilizer use commenced at early 1990s, the groundwater in carrot field located in the east part of the city, where the nitrate nitrogen concentration overshot 25mg/l, began to exhibit a bit decline in the nitrate concentration and heavily polluted area as illustrated in Fig. 13.8.

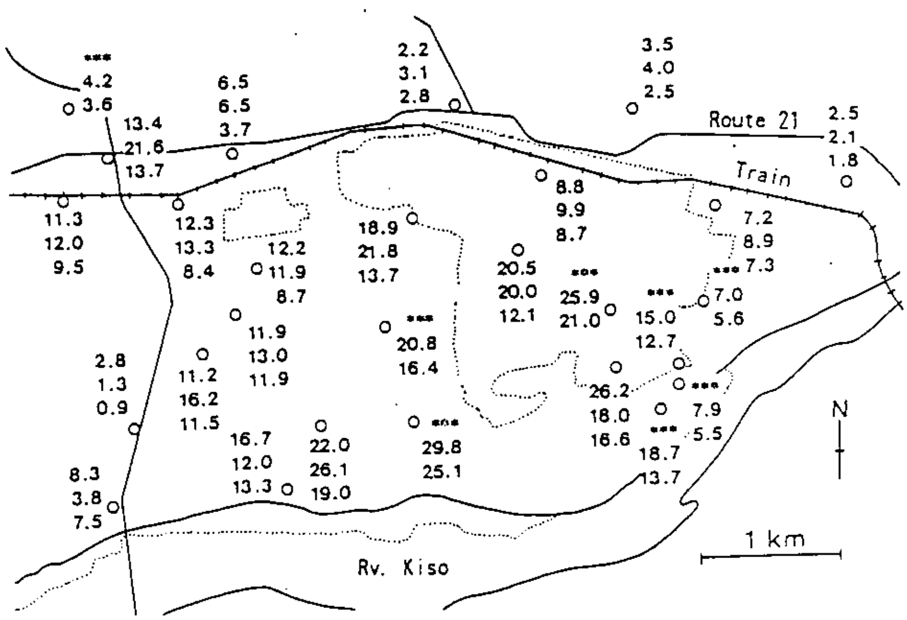



**Fig. 13.8 Changes of nitrate nitrogen concentration in shallow groundwater observed in Kagamihara basin. Three values in the figure denote the nitrate nitrogen concentrations observed in July 1984, July 1990 and July 1994 respectively from the top.**

## 4 Summary

For the remediation of soil and groundwater pollution by volatile organochlorines, innovative technologies are being developed and introduced, and their effectiveness in pollution removal has been demonstrated. Some technologies are naturally still in the in-situ or indoor verification stage as is the case with bioremediation using microbial activity. In general, however, it is emphasized that remediation technology has been approximately established. It is definitely possible to achieve polluted soil and groundwater remediation and restoration with the expenditure of large amounts of time and money. Remediation measures have thus been enforced in practice on large-scale operating sites. Yet, in many pollution cases, the operating sites are small in scale, and cost is the major problem in the implementation of remediation.

To facilitate positive advances in remediation, it is necessary to develop suitable survey methods and efficient pollutant removal technologies. With the benefit of soil and groundwater pollution surveys, it should definitely be possible to carry out effective measures on the basis of preliminary pollution survey. The fact does remain, however, that there are limits as to the funds that can be expended in remediation. It will therefore also be significant to strive for a proper balance in the whole package of remediation operations. The need is to establish a completely integrated package of remediation measures starting with survey programs, including measures such as the planning of feasible remediation operations consistent with the use of the groundwater and also including a clear definition of the objectives of the remediation program.

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# Chapter 14 COUNTERMEASURES FOR CONSERVATION OF DRINKING WATER SOURCE

## 1. Introduction

Among every use of public water bodies, the one as a source for drinking water supply is the most important. The water supply as a social infrastructure is indispensable not only for our healthy and comfortable daily life, but also for our social and economic activities in a modern society. Therefore, it is always required to secure water of good quality and enough quantity by a public water supply system.

However, it became difficult to secure good-quality water for a drinking water supply in Japan in recent years. Then, the two laws, "Law of Execution of Preservation Project of Water Resource for Water Supply" and "Law Concerning Special Measures to Preserve Water Quality of Water Resource for Drinking Water", (hereinafter referred to as "the two laws for water source conservation") were newly established for the purpose of protecting water sources for drinking water supply in March, 1994.

So far, although not much time has passed since their establishment or no effect of their application has been observed yet, the two laws for water source conservation were applied to some water bodies, and plans for the water quality conservation of drinking water sources were elaborated. Successful and effective implementation of countermeasures for water source conservation can be expected through the application of the two laws.

In this chapter, background, outlines and the present status of application of the two laws are described.

## 2. Background and consequences of establishment of the two laws

An important background of the establishment of the two laws for water source conservation was the fact that it was difficult to cope with the deterioration of the quality of raw waters for drinking water supply under the legislation at the previous time. Background and consequences of the establishment of the two laws are described below.

### 2.1 Deterioration of drinking water quality

Various problems of drinking water quality, such as trihalomethane formation caused by chlorination, groundwater contamination with organic solvents like trichloroethylene, contamination with agricultural chemicals, and occurrence of offensive taste and odor due to eutrophication, emerged in recent years. Trihalomethanes (THMs) are a part of disinfection by-products to be formed in the course of chlorination for disinfection and other purposes, and they consist of chloroform, bromodichloromethane, dibromochloromethane and bromoform. Results of animal experiment show that THMs are carcinogenic.

The waterworks tried to make every effort in order to cope with the problems as mentioned above and to secure good quality drinking water so as to meet the Water Quality Standards for Drinking Water Supply. The effort included change in treatment system from prechlorination to intermediate chlorination and introduction of advanced processes such as activated carbon treatment, ozonation, and biological treatment. It was, however, impossible to control every contaminant in water treatment, and the establishment of essential measures for raw water contamination control was needed.

A typical example of drinking water contamination problem was offensive taste and odor as shown in Fig. 14-1, and about twenty million people suffered from offensive taste and odor every year all over Japan. On the other hand, the result of a nationwide survey as of FY 1991 on THMs concentration in

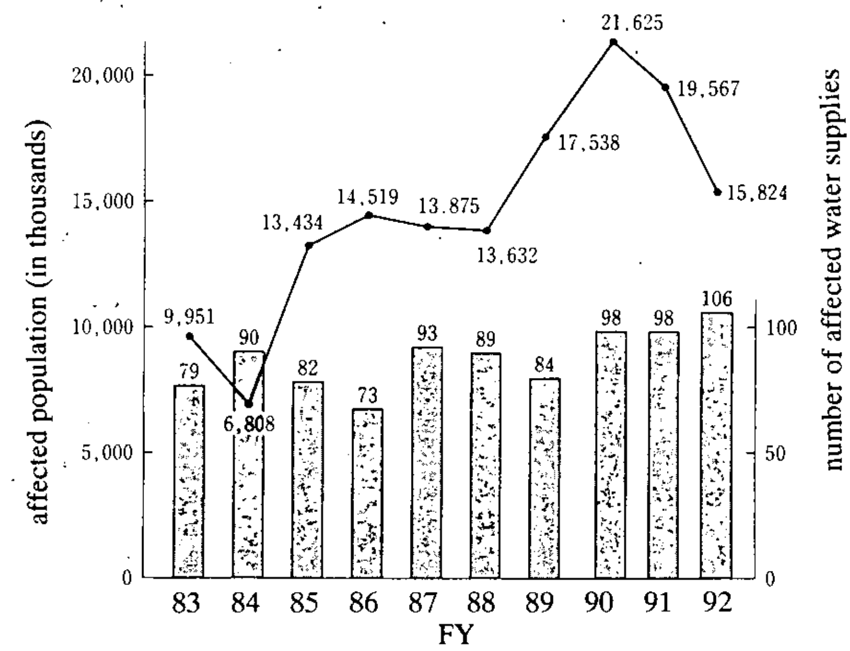



Fig. 14-1 Occurrence of abnormal odor of drinking water

drinking water conducted by the Ministry of Health and Welfare showed that at least anyone of the concentrations of five items related to THMs exceeded 70% of its standard value in 63 drinking water supplies (about 4% of the total), corresponding to served population of about 2.5 million, out of totally about 1,600 drinking water supplies (including bulk water supplies) in Japan excluding the ones depending only on groundwater as shown in Table 14-1 (70% of the standard value is used as a target taking the change in their concentrations into account). Moreover, the contamination of drinking water with various chemical substances took place in many drinking water supplies, and frequent accidental raw water contamination due to the discharge of industrial effluents sometimes obliged a waterworks to interrupt taking raw water.

Table 14-1 Number of waterworks where THM concentration exceeded 70% of its standard value

| Item | Number of waterworks exceeding 70% value |
|---|---|
| Total THMs | 39 |
| Chloroform | 27 |
| Bromodichloromethane | 39 |
| Dibromochloromethane and bromoform | 0 |

Note 1) The sum of numbers exceeding 70% value is not 63 because more than two items exceeded 70% values in some waterworks.

2) The standard values are as follows:

| | | | |
|---|---|---|---|
| Total THMs | 0.1 mg/L | Dibromochloromethane | 0.1 mg/L |
| Chloroform | 0.06 mg/L | Bromoform | 0.09 mg/L |
| Bromodichloromethane | 0.03 mg/L | | |

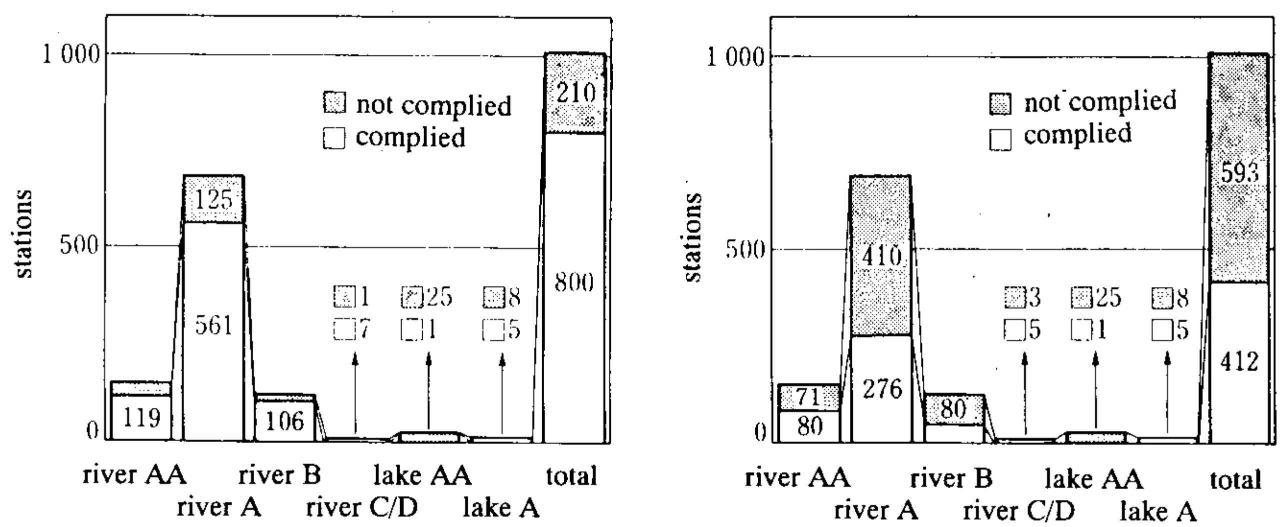
As a consequence, people became to feel more and more uneasy about the safety of drinking water. This was clearly reflected in the prevalence of household water purifiers and bottled waters, and it became remarkable especially in recent years that people tended not to drink tap waters.

2.2 Legislation regarding conservation of drinking water source at previous time .

There was no adequate legislation regarding the conservation of a drinking water source before the establishment of the two laws for water source conservation.

On the side of drinking water supply administration, the Water Works Law states that the central and local governments shall take measures necessary for cleansing a source for drinking water supply while the nation shall try to keep it clean, and the waterworks can, if necessary, request a relevant administrative agency to take appropriate measures for the pollution control of drinking water sources. Nevertheless, since no clear procedures to be taken in response to such a request were defined in any regulation, this section of the law was rarely applied.

On the side of environmental administration, the Environment Agency has implemented the.category designation of the Environmental Quality Standards for a public water body based on the Basic Environment Law (formerly the Basic Law for Environmental Pollution Control) and application of the Effluent Standards based on the Water Pollution Control Law. However the effectiveness of the category designation of the Environmental Quality Standards is limited because there is no provisions on punishment for a case when it is not observed. Therefore, the compliance with the Environmental Quality Standards for drinking water sources as of FY 1990 was not satisfactory as shown in Fig. 14-2. Furthermore, the Environmental Quality Standards were applied only to 28.6% sources out of the total drinking water sources (including the ones for bulk water supply), but no standards were applied to the remaining 71.4% sources.




(a) Compliance with the standards at monitoring stations on BOD and COD in FY 1990

(b) Compliance with the standards at monitoring stations on all items in FY 1990

Fig. 14-2 Compliance with the Environmental Quality Standards at drinking water sources

Other laws concerning the water quality conservation of drinking water sources include the Law Concerning Special Measures for Conservation of Lake Water Quality, Sewage Works Law, River Law, Agricultural Chemicals Regulation Law, the Law Concerning the Examination and Regulation on Manufacture etc. of Chemical Substances, etc. Nevertheless, all of these laws are not directly related to the water quality conservation of drinking water sources, and they have no clear provisions on methods and procedures for its effective implementation as is in the case of the Water Works Law.

2.3 Amendment of the Water Quality Standards for Drinking Water Supply

As a consequence of growing uneasiness for possible adverse health effects caused by the contamination of drinking water, accumulation of scientific knowledge on the health effect of contaminants in drinking water, and revision of the Guidelines for Drinking-Water Quality by the World Health Organization, the Water Quality Standards for Drinking Water Supply were amended in December, 1992, as shown in Table 14-2. The amendment was for the first time since the last one in 1978 and after thirty-five years interval since the extensive one in 1957. As a result, the standards were strengthened with increasing the number of the standard items from 26 to 46. In addition, the Items Relating to the Comfortableness of Water Quality (13 items) and their target values, as shown in Table 14-3, and the Items Relating to Monitoring (26 items) and their guideline values, as shown in Table 14-4, were newly established.

Besides, the Environmental Quality Standards for Water-Items Related to the Protection of Human Health were also amended in March, 1993, in accordance with the amendment of the Water Quality Standards for Drinking Water Supply as mentioned above. In addition, the Monitoring Substances (25 items) and their guideline values were established as a supplement to the standards, and the Effluent Standards were amended accordingly in December, 1993.

Table 14-2 Water Quality Standards for Drinking Water Supply

| | Item | Standard value |
|---|---|---|
| 1 | Standard plate count | not more than 100 /mL |
| 2 | Coliforms | not to be detected |
| 3 | Cadmium | not more than 0.01 mg/L |
| 4 | Mercury | not more than 0.0005 mg/L |
| 5 | Selenium | not more than 0.01 mg/L |
| 6 | Lead | not more than 0.05 mg/L |
| 7 | Arsenic | not more than 0.01 mg/L |
| 8 | Chromium (hexa-valent) | not more than 0.05 mg/L |
| 9 | Cyanides | not more than 0.01 mg/L |
| 10 | Nitrate- and nitrite-nitrogen | not more than 10 mg/L |
| 11 | Fluorides | not more than 0.8 mg/L |
| 12 | Carbon tetrachloride | not more than 0.002 mg/L |
| 13 | 1,2-Dichloroethane | not more than 0.004 mg/L |
| 14 | 1,1-Dichloroethylene | not more than 0.02 mg/L |
| 15 | Dichloromethane | not more than 0.02 mg/L |
| 16 | *cis*-1,2-Dichloroethylene | not more than 0.04 mg/L |
| 17 | Tetrachloroethylene | not more than 0.01 mg/L |
| 18 | 1,1,2-Trichloroethane | not more than 0.006 mg/L |
| 19 | Trichloroethylene | not more than 0.03 mg/L |
| 20 | Benzene | not more than 0.01 mg/L |
| 21 | Chloroform | not more than 0.06 mg/L |
| 22 | Dibromochloromethane | not more than 0.1 mg/L |
| 23 | Bromodichloromethane | not more than 0.03 mg/L |
| 24 | Bromoform | not more than 0.09 mg/L |
| 25 | Total trihalomethanes | not more than 0.1 mg/L |
| 26 | 1,3-Dichloropropene (DD) | not more than 0.002 mg/L |
| 27 | Simazine (CAT) | not more than 0.003 mg/L |
| 28 | Tiuram | not more than 0.006 mg/L |
| 29 | Thiobencarb (Benthiocarb) | not more than 0.02 mg/L |
| 30 | Zinc | not more than 1.0 mg/L |
| 31 | Iron | not more than 0.3 mg/L |
| 32 | Copper | not more than 1.0 mg/L |
| 33 | Sodium | not more than 200 mg/L |

Table 14-2 Water Quality Standards for Drinking Water Supply (continued)

| Item | Standard value |
|---|---|
| 34 Manganese | not more than 0.05 mg/L |
| 35 Chlorides | not more than 200 mg/L |
| 36 Calcium, magnesium, etc. (Hardness) | not more than 300 mg/L |
| 37 Total solids | not more than 500 mg/L |
| 38 Anionic surfactant | not more than 0.2 mg/L |
| 39 1,1,1-Trichloroethane | not more than 0.3 mg/L |
| 40 Phenols | not more than 0.005 mg/L (as phenol) |
| 41 Organic substances (Potassium permanganate consumption) | not more than 10 mg/L |
| 42 pH | not less than 5.8 or not more than 8.6 |
| 43 Taste | not abnormal |
| 44 Odor | not abnormal |
| 45 Color | not more than 5 degrees |
| 46 Turbidity | not more than 2 degrees |

Note 1) Items 1-29 are those Relating to Human Health, and items 30-46 are those Relating to the Acceptability of Drinking Water to Consumers.
2) The standards were enforced on December 1, 1993.

Table 14-3 Items Relating to Human Health

| Item | Target value |
|---|---|
| 1 Manganese | not more than 0.01 mg/L |
| 2 Aluminum | not more than 0.2 mg/L |
| 3 Residual chlorine | not more than approx. 1 mg/L |
| 4 2-Methylisoborneol | Powdered activated carbon treatment: not more than 0.00002 mg/L<br>Granular activated carbon treatment: not more than 0.00001 mg/L |
| 5 Geosmin | Powdered activated carbon treatment: not more than 0.00002 mg/L<br>Granular activated carbon treatment: not more than 0.00001 mg/L |
| 6 Threshold odor number (TON) | not more than 3 |
| 7 Free carbon dioxide | not more than 20 mg/L |
| 8 Organic substances (Permanganate consumption) | not more than 3 mg/L |
| 9 Calcium, magnesium, etc. (Hardness) | not less than 10 mg/L or not more than 100 mg/L |
| 10 Total solids | not more than 30 mg/L or not more than 200 mg/L |
| 11 Turbidity | not more than 1 degree at tap or not more than 0.1 degree at inlet of distribution facility |
| 12 Langhelier's Index (Corrosiveness) | not less than approx. -1 and as near 0 as possible |
| 13 pH | Approx. 7.5 |

Note 1) Although the standard values are established on manganese, permanganate consumption, hardness, total solids, turbidity and pH, the values as listed above are additionally established considering better quality drinking water.
2) The value on residual chlorine should be referred to on the condition that disinfection is implemented according to the regulation.

Table 14-4 Items Relating to the Acceptability of Drinking water to Consumers

| | Item | Guideline value |
|---|---|---|
| 1 | *trans*-1,2-Dichloroethylene | not more than 0.04 mg/L |
| 2 | Toluene | not more than 0.6 mg/L |
| 3 | Xylene | not more than 0.4 mg/L |
| 4 | *p*-Dichlorobenzene | not more than 0.3 mg/L |
| 5 | 1,2-Dichloropropane | not more than 0.06 mg/L |
| 6 | di(2-Ethylhexyl)phthalate | not more than 0.06 mg/L |
| 7 | Nickel | not more than 0.01 mg/L |
| 8 | Antimony | not more than 0.002 mg/L |
| 9 | Boron | not more than 0.2 mg/L |
| 10 | Molybdenum | not more than 0.07 mg/L |
| 11 | Formaldehyde | not more than 0.08 mg/L |
| 12 | Dichloroacetic acid | not more than 0.04 mg/L |
| 13 | Trichloroacetic acid | not more than 0.3 mg/L |
| 14 | Dichloroacetonitrile | not more than 0.08 mg/L |
| 15 | Chloral hydrate | not more than 0.03 mg/L |
| 16 | Isoxathion | not more than 0.008 mg/L |
| 17 | Diazinon | not more than 0.005 mg/L |
| 18 | Fenitrothion (MEP) | not more than 0.003 mg/L |
| 19 | Isoprothiolane | not more than 0.04 mg/L |
| 20 | Chlorotharonil (TPN) | not more than 0.04 mg/L |
| 21 | Propyzamide | not more than 0.008 mg/L |
| 22 | Dichlorvos (DDVP) | not more than 0.01 mg/L |
| 23 | Fenobcarb (BPMC) | not more than 0.02 mg/L |
| 24 | Chlornitrofen (CNP) | not more than 0.0001 mg/L(see Note) |
| 25 | Iprobenfos (IBP) | not more than 0.008 mg/L |
| 26 | EPN | not more than 0.006 mg/L |

Note) The value is a provisional one.

2.4 Movement towards enactment

Following the circumstances as written above, the Ministry of Health and Welfare, which is responsible for supervising waterworks, convened the "Wise Men Meeting Concerning Water Quality Conservation of Drinking Water Sources" several times in order to obtain opinions on measures for the conservation of drinking water sources. As a result, from the viewpoints, that measures taken by waterworks are limited, and countermeasures for the water quality conservation of drinking water sources are important for securing the safety of drinking water, the council prepared a report including the recommendations as follows in February, 1993:

1) Enhancement of the regulation concerning effluent discharge from industries and other facilities considering the circumstances of each area,
2) Proper use of agricultural and other chemicals,
3) Implementation of various projects for proper treatment of domestic wastewaters, and
4) Protection of a small-scale water supply from the development activities in its upstream area.

Moreover, the Living Environment Council of the Ministry of Health and Welfare pointed out in its report, "Regulatory system concerning the promotion of implementation of projects for the water quality conservation of drinking water sources" (November, 1993), that it was necessary to develop a new regulatory system in an early stage in order to promote projects for the water quality conservation of drinking water sources.

On the other hand, the Central Council for Environmental Pollution Control of the Environment

Agency also pointed out in its report, "Measures to be taken for the water quality conservation of public water bodies with respect to drinking water supply" (December, 1993), that new measures including legislation were necessary from the viewpoint of securing safe and good quality drinking water if the existing regulatory system was not adequate.

Based on the above consequence, both the "Law of Execution of Preservation Project of Water Resource for Water Supply" (under the jurisdiction of the Ministry of Health and Welfare, the Ministry of Agriculture, Forestry and Fisheries, and the Ministry of Construction) and the "Law Concerning Special Measures to Preserve Water Quality of Water Resource for Drinking Water" (under the jurisdiction of the Environment Agency) were established in March, 1994 for the purpose of promoting measures for the water quality conservation of drinking water sources from the viewpoints as shown in Fig. 14-3, and they were enforced in May, 1994.

## 3. Outlines of the two laws for water source conservation and their application

Outlines of the two laws for water source conservation, which were newly established as written above, and the present status of their application are described here. Since the cases of their application include some where a relevant prefecture government already prepared a plan for promoting the implementation of projects for the water quality conservation of drinking water sources, such an example will be introduced.

### 3.1 Outlines

Outlines of the two laws for water source conservation are as described below. The "Law of Execution of Preservation Project of Water Resource for Water Supply" (hereinafter referred to as the "Project Execution Law") aims at promoting the implementation of projects concerning the development of a sewerage system and a combined-type private sewage treatment system, and river environment improvement for the purpose of coping with the contamination of drinking water sources with THM precursors, off-flavor substances, and other contaminants. The "Law Concerning Special Measures to Preserve Water Quality of Water Resource for Drinking Water" (hereinafter referred to as the "Special Measures Law") mainly aims at regulation of industrial wastewaters for the purpose of coping with the contamination of drinking water sources only with THM precursors.

The two laws for water source conservation will be applied to a case where it is difficult that the efforts only by a relevant waterworks are not satisfactory for securing drinking water as to meet with the Water Quality Standards for Drinking Water Supply because the level of contamination is too high. The two laws will be applied based on a request of a waterworks, and a plan for the water quality conservation including such measures as mentioned above, according to their necessity, will be prepared for each area.

The Project Execution Law requires that the projects for the water quality conservation of drinking water sources based on the law shall be designated with their implementation period of about five years and their target area along a stretch of the water body from the raw water intake to a 15-20 km upstream point.

The Special Measures Law also requires that the effluent standards on THMs formation potential for industrial discharges shall be established within the ranges as shown in Table 14-5 in a plan for the water quality conservation. When establishing the effluent standards, a 75 percentile value × (4/3) was selected as a lower limit and a 95 percentile value × (4/3) as an upper limit based on the distribution of typical daily-average effluent quality data of each industry taking available technologies for industrial wastewater treatment and adequate effluent quality level necessary for securing water source conservation. The lower limit corresponds to a level which is feasible from the technical point of view and will not be an excessive burden to industries. The upper limit corresponds to a level which is attainable through proper operation of a treatment facility considering the present level of wastewater treatment technology. The coefficient of 4/3 is a ratio of the maximum and the daily-average.

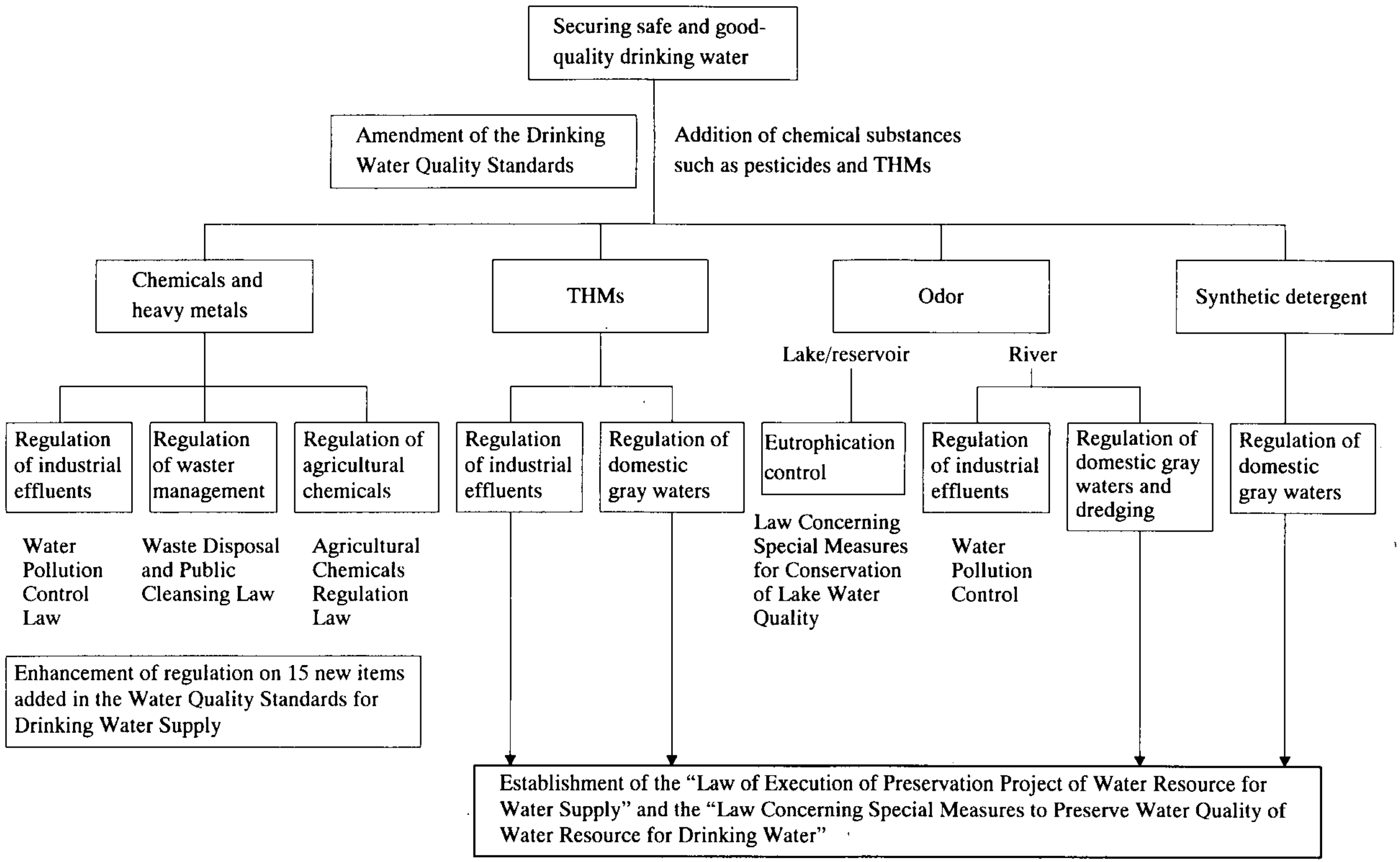



Fig. 14-3 Countermeasures for the water quality conservation of drinking water sources

Table 14-5 Effluent Standards on THMs formation potential for Industrial discharges

| Code | Category | Lower limit | Upper limit |
|---|---|---|---|
| 012 | Livestock feeding | 1.3 | 5.2 |
| 121 | Meat and dairy processing industry | 0.4 | 0.6 |
| 122 | Seafood processing industry | 0.4 | 3.6 |
| 123 | Vegetable and fruit canning industry, Agricultural product processing industry | 0.8 | 1.1 |
| 129 | Other food industry | 0.3 | 0.8 |
| 131 | Beverage industry | 0.6 | 1.4 |
| 132 | Brewing industry | 0.4 | 0.5 |
| 14 | Textile industry(excluding garment industry) | 0.6 | 1.7 |
| 181 | Pulp industry | 1.0 | 1.7 |
| 182 | Paper industry | 0.4 | 0.8 |
| 202 | Inorganic chemical industry | 1.0 | 4.3 |
| 203 | Organic chemical industry | 1.0 | 4.5 |
| 206 | Medical industries | 0.4 | 0.6 |
| 286 | Metal-plating and chasing industry, heat processing industry (excluding enameling industry) | 0.4 | 1.0 |
| 30 | Electric devise industry | 0.2 | 0.4 |
| 383 | Sewage works | 0.2 | 0.3 |
| 721 | Laundry | 0.2 | 0.3 |
| 8712 | Night soil disposal facility (excluding on-site treatment facility) | 0.4 | 0.8 |
| 9521 | Slaughterhouse | 0.4 | 0.6 |
| On-site domestic wastewater treatment facility | | | |
| | Facility other than rural wastewater treatment facility | 0.2 | 0.6 |
| | Rural wastewater treatment facility | 0.2 | 0.3 |
| Others | | 0.2 | - |

3.2 Application

The way of application of the Project Execution Law is shown in Fig. 14-4. A prefecture plan in the figure means a plan to be prepared by a prefecture for promoting the implementation of projects for the water quality conservation of drinking water sources.

If a waterworks propose a request as specified in the Special Measures Law, the waterworks is considered that it also proposed a request as specified in the Project Execution Law, and vice versa.

The two laws for water source conservation are applied in the areas as shown in Table 14-6 based on the requests by 10 waterworks until the end of FY 1996, and a prefecture plan has been prepared in 4 cases.

4. Example of application: Takuma Town Waterworks in Kagawa Prefecture

An example of Takuma Town Waterworks in Kagawa Prefecture, where the application of the two laws for water source conservation were requested and a plan for promoting the implementation of projects for the water quality conservation of drinking water sources has been prepared, is introduced below.

Waterworks

↓ Proposal of a request for promoting the implementation of projects for water quality conservation of drinking water sources

Prefecture government governing the service area of a waterworks whose drinking water is of concern

↓

If necessary

↓

To prepare a prefecture plan

↓

If it is necessary to promote the implementation of projects for water quality conservation of drinking water sources in upstream prefectures considering the status and extent of pollution of the objective raw water

↓

To request upstream prefectures to prepare prefecture plans

↓

If necessary

↓

The upstream prefectures receiving a request prepare prefecture plans.

↓ To give information about the proposal of a request together with opinions about the implementation of the projects concerning the water quality conservation of drinking water sources

River management authority managing a stretch of the river including the intake point of the raw water

↓

If necessary

↓

Preparation of a plan on the project implementation by a river management authority

Fig. 14-4 Application procedure of the "Law of Execution of Preservation Project of Water Resource for Water Supply"

4.1 Profile of the waterworks and reasons for request proposal

Takuma Town Waterworks in Kagawa Prefecture, whose profile is shown in Table 14-7, was founded in 1951, and its planned served population as of 1995 was 18,700 persons with a planned water supply capacity of 17,200 $m^3$/d. Shioki Water Purification Plant of Takuma Town Waterworks took raw water from Takase River of Takase River Basin (a second-class river). Total THMs formation potential of its raw water exceeded 100 $\mu$g/L, and total THMs concentration in drinking water also sometimes exceeded 70% of its standard value of 100 $\mu$g/L, i.e. 70 $\mu$g/L. Therefore, the waterworks took or tried to take the measures as follows:

1) Proper operation of granular activated carbon adsorption facility, mixing of the purified water with other purified water supplied by a prefecture waterworks, etc. (implemented in FY 1994)
2) Change in water purification system from prechlorination to intermediate chlorination (planned to implement in FY 1995)

Table 14-6 Application of the Project Execution Law

| | Implementing organization (River) | Prefecture | Proposal | Status of plan preparation |
|---|---|---|---|---|
| 1 | Ishikawa Town (Kitasu River) | Fukushima | June, 1994 | Completed (Dec., 1994) |
| 2 | Sukagawa City (Shakado River) | Fukushima | June, 1994 | Completed (Dec., 1994) |
| 3 | Takuma Town (Takase River) | Kagawa | Sep., 1994 | Completed (June, 1995) |
| 4 | Kakogawa City (Kako River) | Hyogo | Sep., 1994 | Under preparation |
| 5 | Prefecture waterworks (Yoro River) | Chiba | Oct., 1994 | Completed (March, 1995) |
| 6 | Prefecture waterworks (Kako River) | Hyougo | Nov., 1994 | Under preparation |
| 7 | Toso Regional Water Supply Authority (Kurobe River) | Chiba | Nov., 1994 | Under preparation |
| 8 | Prefecture waterworks (Okukubi River) | Okinawa | July, 1995 | Under preparation |
| 9 | Prefecture waterworks (Taiho River) | Okinawa | July, 1995 | Under preparation |
| 10 | Prefecture waterworks (Tengan River) | Okinawa | July, 1995 | Under preparation |

Table 14-7 Profile of Takuma Town Waterworks in Kagawa Prefecture

| | |
|---|---|
| Name of water source (Intake point) | Takase River of Takase River Basin |
| Upstream area within 20 km | Takuma Town, Mino Town and Takase Town |
| Name of water purification plant | Shioki Water Purification Plant (No.1 and 2) (Treatment capacity: 5,190 $m^3$) |
| Planned served population | 18,700 persons |
| Served population | 14,866 persons |
| Planned water supply capacity | 17,200 $m^3$ (10,000 $m^3$ from Kagawa Aqueduct, 2,000 $m^3$ from Toyonaka Town) |
| Average water supply capacity | 11,101 $m^3$ |

The waterworks concluded that the standard value might be exceeded only with the measures as written above because measures to be taken solely by the waterworks were limited, even if improvement to some extent could be expected with the second measure, and BOD of the drinking water source did not comply with the environmental quality standards whereas discharges of domestic wastewaters tended to increase.

Takuma Town Waterworks proposed a request to Kagawa Prefecture for the application of the two laws concerning water source conservation in September, 1994, based on the reasons as mentioned above.

4.2 Preparation of a prefecture plan

Receiving the request as written above, Kagawa Prefecture Government immediately organized a task force for the preparation of a plan consisting of staffs in charge from relevant departments of the government with recognizing the appropriateness of the request and the necessity of promoting the implementation of projects concerning the water quality conservation of drinking water sources. Kagawa Prefecture Government completed "a Plan for Promoting the Implementation of Regional Projects Concerning the Water Quality Conservation of Drinking Water Sources: Upstream Areas of the Raw Water Intake of Shioki Water Purification Plant of the Takuma Town Waterworks" with taking three upstream municipalities into its scope in June, 1995.

The plan included descriptions on implementing organizations, target areas, number of facilities, served population, treatment system, implementation period and rough cost estimates concerning three projects on the development of rural wastewater treatment systems and the other three projects on the development of on-site household wastewater treatment facilities as regional projects necessary for the water quality conservation of drinking water sources. The plan also mentioned proper management of livestock wastes.

In addition, it is described in the plan that the quality of drinking water sources were deteriorated; BOD concentration at the intake point was 2.2-11 (5.2 in average) mg/L, which did not comply with the environmental quality standard, and total THMs formation potential of the raw water was so high as 0.134-0.464 (0.299 in average) mg/L according to a result of water quality monitoring in FY 1993.

# Chapter 15 WATER QUALITY MONITORING

## 1. Monitoring of Water Pollution

It is required to prepare a system to measure and monitor the water pollution to understand the progress of pollution of the public water and groundwater and to implement appropriate regulatory actions to control the water pollution. As both the national and local governments share the quality standards as their common administrative objectives, they need to integrate their various surveys comprehensively. This requires to provide a water quality measurement and monitoring system, which is reasonably organized as a whole, by not only ensuring integrity and comprehensiveness of these various surveys but also supplementing them with necessary ones.

Based on these considerations, the Water Pollution Control Law aims at spreading such a measurement and monitoring system throughout Japan by requiring governors (1) to continuously monitor the progress of pollution of the public waters and groundwater, (2) to prepare the monitoring plan to uniform the elements of the measurement and monitoring to be conducted by the national and local governments, including the items to be monitored, and the monitoring locations and methods, in cooperation with the relevant national organizations, (3) to have the measurement results obtained in accordance with the plan reported to them, and (4) to publish the progress of pollution (Articles 15 to 17 of the Law).

### 1.1 Water Quality Survey Methods

"Standard Survey Methods of Water Quality" published by the Environment Agency in 1971 provide the standard methods for the water quality survey. They should be followed in the surveys including the continuous monitoring of the pollution of public water by governors, the surveys required for the designation of the types of water areas for the quality standards, those to establish the local effluent standards more stringent than the national ones, those on the effluents from the factories and business establishments, and those on the sediment in public water.

#### 1.1.1 Monitoring Items and Frequencies

Health Items of the Quality Standards

As for the health items of the quality standards, water samples should be collected and analyzed in principle at least 1 day every month, approximately 4 times a day. All of the items should be surveyed at least 1 day among them, and, for the rest of the days monitored, only those required on the basis of the consideration of the progress of pollution of the ambient water and effluents may be surveyed if appropriate.

Items of the Quality Standards related to Living Environment

As for the items related to living environment, at the reference stations, or those located in the types of water areas designated for the quality standards and to be monitored for their attainment of the standards, or at the locations of important water utilization, water samples should be collected and analyzed in principle at least 1 day every month, approximately 4 times a day. However, the sampling frequency may be reduced depending on the situation, if appropriate, at the locations with minor water quality fluctuations, such as those in the upstream of rivers and those off the shore.

At the locations with major daily water quality fluctuations among those surveyed throughout a year, water samplings and analyses should be conducted 13 times a day at 2 hour intervals, approximately 2 days a year.

In the complementary surveys at the locations other than those mentioned above, water samples should be collected and analyzed at least 4 days a year.

### 1.1.2 Timing of Surveys and Sampling Locations

Rivers

Survey period should cover the lowest water level and the period of water use. Sampling should be conducted in a day with stable water quality after successive days of relatively fine weather.

Sampling locations should be selected after the following considerations; (1) the location of water use, (2) the location where the polluted water is sufficiently diluted after it has been discharged to the river and the location upstream to such discharge, (3) the location where the water from tributary is sufficiently mixed with the water of main stream, and the locations of the main stream and tributary upstream to their junction, and (4) any other location to be established as required. Reference stations for the quality standards must be always included in the ambient water quality monitoring survey.

Lakes and Reservoirs

Since the water quality differs significantly between the stagnation and circulation periods, survey should be arranged so that the water quality in both periods is measured. In addition, the period when water quality adversely affects the water use should be included.

Sampling should be conducted in a day with stable water quality after successive days of relatively fine weather prior to the sampling.

Sampling locations should be selected after the following considerations; (1) the center of a lake, (2) the location of water use, (3) the location where the polluted water is sufficiently diluted after it has entered to the lake or pond, (4) the location where the water from the river is sufficiently mixed with the water of the lake or pond, and the location of the lake or pond upstream to the inflow of the river, and (5) the location where the lake or pond water flows our. Reference stations for the quality standards must be always included in the ambient water quality monitoring survey.

Sea Areas

Survey should cover the period when water quality adversely affects the water use. It is desirable to arrange the survey of sea area during the same period with that of the influent river. Samples should be collected principally at spring tides in a day with minor influence by rain and wind.

Sampling locations should be selected after the considerations of the topography of the area, local currents and tides, local water uses, the locations of the major pollution sources and the influent rivers, to generally understand the pollution of the water area. Sampling stations should be located at least around 500m to 1km apart to each other. Reference stations for the quality standards must be always included in the ambient water quality monitoring survey.

## 1.2 Monitoring of Groundwater Quality

As for the survey methods of groundwater quality, a notice of the "Standard Survey Methods of Groundwater Quality" was issued in 1991, when the amendment of the Water Pollution Control Law introduced a ban on the infiltration of water with hazardous substances into underground and the continuous monitoring of groundwater quality by the governors. Summary of the "Standard Survey Methods" is provided below.

### 1.2.1 Types of Groundwater Quality Surveys

There are 3 types of the groundwater quality surveys such as the general survey, survey of the area around the contaminated well and regular monitoring survey. Their purposes are:

(1) General survey

It is a groundwater quality survey to identify its general condition in the area, and it should be conducted following an annual plan with consideration of the local situation.

As a part of this survey, it is desirable to monitor the long-term annual changes of groundwater quality at certain locations representing the area.

(2) Survey of the area around the contaminated well

This is a groundwater quality survey to identify the contaminated area for the pollution newly detected by the general survey.

(3) Regular monitoring survey

This is a regular groundwater quality survey, or annual monitoring, to continuously observe the contamination identified by the survey of the area around the contaminated well.

### 1.2.2 Survey Items and Frequencies

(1) Survey items

Groundwater quality should be surveyed on the items specified in the quality standards concerning groundwater contamination. When the contamination is significantly unlikely, the number of substances to be surveyed may be reduced, if appropriate.

Technical specifications of the well to be surveyed should be collected as many as possible in the survey.

Any other item should be surveyed for the characterization of the groundwater quality, if appropriate.

(2) Frequencies

i. General survey

When an annual survey plan is prepared, the survey wells should be measured at least once a year. It is desirable to take seasonal variations into consideration.

It is recommended to survey the same wells again after several years to consider the possible change of the groundwater flow and the use of pollutants.

ii. Survey of the area around the contaminated well

A survey should be conducted as soon as possible after the detection of contamination. It is desirable to complete the survey for each well as quickly as possible to avoid the impacts of the factors such as precipitation.

iii. Regular monitoring survey

The survey wells should be measured at least once a year during the same period every year. It is desirable to take seasonal variations into consideration.

### 1.2.3 Survey locations

Survey locations should be selected for each type of surveys after consideration of the followings. Vertical spreading of the contamination should also be considered.

(1) General survey

a. Survey should be designed to identify the general condition of groundwater quality throughout the survey area.
b. Survey should concentrate on the areas with significant potential contamination and those with potential impacts of the contamination on the local water use after the consideration of the locations of factories and business establishments and the local groundwater use .
c. Priority should be given to the well with significant potential impacts on the health of large population in the case of contamination.
d. Priority should be given to the well with significant potential contamination suggested by the locations of factories and business establishments.

(2) Survey of the area around the contaminated well

a. Survey area should be determined to include whole of the predicted contaminated area.
b. When the flow direction of groundwater is known, the survey should be conducted in a zone along this direction.
c. It is desirable to survey the wells for drinking water.
d. When a survey area is wide with many wells to be surveyed, it should be divided into subareas, and they should be surveyed one after another.
e. Although the existing wells should be surveyed in principle, it should be considered to establish a well for observation in an area with no well.

(3) Regular monitoring survey

a. Representative locations should be determined to observe the annual changes of groundwater quality in the area after consideration of the locations of factories and business establishments and the local groundwater use. It is desirable for the regular monitoring of contaminated areas to cover the locations close to the pollution source and the uncontaminated locations in the downstream.
b. Wells for observation should be established for more effective monitoring, if appropriate.

## 1.3 Water Quality Monitoring in Japan

As for the surveys on public water, the national and local governments, in the fiscal year of 1995, measured 294,491 samples from 5,471 locations – 3,973 in rivers, 260 in lakes and ponds and 1,238 in sea areas – for the items in quality standards related to human health, and 426,701 samples from 7,903 locations in the water areas categorized and designated for the quality standards – 4,533 in rivers, 428 in lakes and ponds and 2,132 in sea areas – for the items in quality standards related to living environment.

In the fiscal year of 1995, the groundwater quality was measured at 4,357 wells for the general surveys, at 1,659 wells for the surveys of the area around the contaminated well and at 4,395 wells for the regular monitoring surveys.

## 2. Monitoring of Effluent Quality

As for the effluent, governors and mayors of the government ordinance-designated cities request the factories and business establishments to report the quality of their effluents or inspect them, when required under the Water Pollution Control Law, to monitor their compliance with the effluent standards. Necessary administrative measures, such as the improvement orders, are taken against the factories and business establishments on the basis of such monitoring.

Further, the Water Pollution Control Law requires those discharging effluents from the business establishments within the designated areas, which the Standard for Areawide Total Pollutant Load Control applies to, to measure the pollution loads and record them.

### 2.1 Effluent Quality Survey Methods

#### 2.1.1 Survey Items and Frequencies

Health Items of the Quality Standards

As for the health items of the quality standards, water samples should be collected and analyzed in principle at least 1 day every month, approximately 4 times a day. All of the items should be surveyed at least 1 day among them, and, for the rest of the days surveyed, only those required on the basis of the consideration of the progress of the pollution of effluents may be surveyed if appropriate.

Items of the Quality Standards related to Living Environment

As for the items related to living environment, those specified by the effluent standards should be surveyed in the effluent quality monitoring surveys to identify the compliance of the factories and business establishments with these standards. Frequent surveys and intensive samplings are required for the factories and business establishments suspected for their possible violation of the effluent standards and those with significant negative impacts on the quality of public water.

In the surveys to establish the effluent standards, actual discharges of effluents from the factories and business establishments should be considered, and water samples should be collected and analyzed at least 4 days a year for the items required for the establishment of the effluent standards.

#### 2.1.2 Timing of Surveys and Sampling Locations

Surveys should be conducted after the considerations of the category of the factories and business establishments, their operations and their seasonal variations. However, in principle, the effluent quality survey should be synchronized with the ambient water quality monitoring survey since they are inseparable from each other.

Water samples should be collected at the outlets of the factories and business establishments. If it is not possible, they should be collected at the outlets of the facilities such as the final effluent treatment plants where equivalent samples may be obtained. In the surveys to establish the effluent standards, water samples should be collected, if necessary, also before the intake to the wastewater treatment plants.

## 3. Measurements in the Private Sectors

Compliance with the regulations by the legislation such as the Water Pollution Control Law requires the measurement of the quality of effluents. In Japan, continuous monitoring of the public water and groundwater is the responsibility of governors, and their measurements are conducted by the national and local governments. However, the Article 14 of the Water Pollution Control Law requires the entrepreneurs to measure and record the effluents from their factories and business establishments.

This has led to the certifications of the pollution control managers and the environmental certified public measurers for the enterprises to have expertise for the water quality measurements by themselves and the management of their accuracy.

### 3.1 Establishment of Pollution Control Organizations

"Law Concerning the Improvement of Pollution Prevention Systems in Specific Factories" enacted in 1971 requires a pollution control organization to establish an institution for pollution control in the factories.

Specific factories such as those of the manufacturing industry and electric utilities are subject to this requirement among the factories with the facilities regulated as the polluting ones, such as the wastewater discharge facilities and the smoke and soot emission facilities, under the various law for pollution control including the Water Pollution Control law and the Air Pollution Control Law. These factories are required to establish an organization and responsibility for the pollution control. The organization for pollution control basically consists of the "supervisor of pollution control," the "pollution control manager" and the "chief pollution control manager."

### 3.2 Environmental Certified Public Measurers

The "Measurement Law," as an institution on the measurement, provides the standards for measurement and ensures the practice of proper measurements.

Certification of the water quality measurement and the accuracy of measured values require the management of measurement including the meter maintenance, maintenance of the measurement accuracy, improvement of the measurement methods and the practice of appropriate measurement. The Measurement Law requires to register not only the measurement certifiers but also the certified public measurers with their job descriptions.

The public measurer system qualifies and registers those who have passed the national examination and shown their expertise and experience, as the certified public measurers and lets them shoulder a job on the measurement management. As for the measurement related to the environmental problems, the "environmental certified public measurer" was introduced in 1974, as noise, vibration and the concentration of hazardous substances had become especially important. Later, due to its wide fields, the environmental certified public measurers were divided to two categories such as those of the chemical concentrations and those of the physical components such as noise and vibration. At present, there are 3 categories such as the "environmental certified public measurers of concentrations," the "environmental certified public measurers of noise and vibration" and the "general certified public measurers."

## 4. Water Quality Monitoring by Local Government

Local governments are carrying out various administrative measures regarding the aquatic environment for the conservation of the environment and to ensure a healthy and comfortable life for local residents. Among these environmental administration efforts, the monitoring of water quality plays an important role by not only checking current water conditions but also by contributing to the analysis the effects of past water quality measures, as well as by keeping authorities ready to respond with appropriate measures in case of aquatic problems arising and by planning the prevention of future the environmental problems.

### 4.1 Kinds of Surveys for Water Quality Monitoring

Aquatic monitoring surveys carried out by local governments are grouped into four kind of broad categories as follows .

#### 4.1.1 Monitoring Surveys under the Laws and Notification

Each local government has carried out surveys to monitor the water quality based on the Environment Basic Law and/or the Water Pollution Control Law under the supervision of the Environment Agency as shown in **Table 15-1**.

**Table 15-1** Surveys for the water quality monitoring by local governments based on the laws and notifications

| survey | Year* | Objectives | Parameters** |
|---|---|---|---|
| (1) Water quality survey on public waters | 1970～ | Regular monitoring of water quality in public waters including rivers, lakes, reservoirs and coastal waters | Health parameters (23)<br>Parameters relating to the living environment (9)<br>Precautionary monitoring parameters (25)<br>Guideline parameters for evaluating the water quality contaminated with Agricultural chemicals (27)<br>Bathing beach parameters (5)<br>Bottom sediment survey parameters (22) |
| (2) Water quality survey on effluents from factories and business establishments | 1971～ | Monitoring of water quality of effluents from specified facilities | Health parameters (23)<br>Parameters relating to the living environment (16) |
| (3) Water quality survey on ground water | 1989～ | Continuous monitoring of the quality of ground water | Health parameters (23) |
| (4) Water quality survey on effluents from golf course | 1994～ | Evaluation of conformity with provisional guideline of agricultural | Agricultural chemicals of golf course (35) |

chemicals of golf course

* Year when the laws and notifications were established.
** Figure in parentheses is the numer of parameters.

### 4.1.2 Monitoring Surveys Contracted with National Government

With recent advanced industrial activity, different kinds of chemicals as shown in **Table 15-1** are beginning to appear in the aquatic environment. Then there arose the necessity to survey and monitor the contamination by such uncontrolled chemicals in aquatic environment and their biological effects and on the ecosystem. Agency of the national government, such as the Environment Agency have local governments carry out survey to collect reports on the presence of uncontrolled chemicals in order to make a comprehensive policy capable of adequately dealing with these toxic chemicals. Some instances of such entrusted surveys approved by the Environment agency are shown in **Table 15-2**. Surveys **(1)〜(3)** were carried out by Kitakyushu City which is a designated city with a population of a million people.

**Table15-2** Instances of monitoring surveys requested by national ministries and agencies to local governments

| survey | Year | Objectives | Parameters* |
|---|---|---|---|
| (1) Survey on uncontrolled chemicals in the aquatic environment | 1974〜 | Prevention of contamination in the aquatic environment by uncontrolled chemicals | Organotin, agricultural chemicals and poly-aromatic compounds in the water, sediment and organisms in sea areas |
| (2) Soil survey | 1979〜'95 | Control for chemical contamination in the soil | Organochlorine compounds in soil and ground water |
| (3) Survey of the water quality of ground water | 1989〜 | Tests for uncontrolled chemicals in the ground water | Precautionary monitoring parameters (25) |
| (4) Large area comprehensive water quality survey | 1979〜 | Comprehensive measures to the eutrophication in the Seto Inland Sea | Nutrients and plankton etc. (18)<br>Sediment parameters(10) |

* Figure in parentheses is the number of parameters tested.

Some local governments located around large bodies of water such as Tokyo Bay, Ise Bay and the Seto Inland Sea, have also carried out surveys approved by the Environment Agency to check special parameters in order to prepare and enforce comprehensive and effective measures to control eutrophic conditions. In the "Large Area Comprehensive Water Quality Survey" shown in **Table 15-2(4)**, local governments including prefectures and cities located around the Seto Inland Sea carry out the survey four times a year simultaneously in order to take measures to prevent eutrophication.

### 4.1.3 Original Monitoring Surveys and Researches by Local Government

In order to execute the careful environmental administration required to meet the special local needs, each local government carrys out its own monitoring surveys. For instance, local governments add special water quality parameters to the standard legal parameters of the survey of public waters or effluents shown in **Table15-1(1)(2)**. Local governments also have monitored the effluent water quality from factories which are not specifically designated in the Water Pollution Control Law.

Recently, local governments attempted to carry out biological monitoring of water quality. This method utilizes indicator organisms such as water insects. Such biological survey is also evaluated as a useful means for environmental education, and furthermore is valued as a new monitoring style which involves residents' participation.

With physico-chemical and biological methods, local governments also have carried out different investigations and research on subjects such as "Endocrine-Disrupting Chemicals" or "Eutrophication", as these are difficult to take measures against with only the data from routine monitorings.

### 4.1.4 Monitoring Surveys of Unexpected Incidents

In the case of an occurrence of an unexpected incident or disaster such as an oil spillage accident or an earthquake, local governments carry out monitoring survey in cooperation with other local governments or the national government. The survey institution, scale, period, and parameters for monitoring are decided according to the scale and situation of the accident or disaster.

Whenever there are unnatural occurrences of fish kill or malformation phenomena in aquatic environments such as rivers and ponds, the local governments investigates the cause and the extent of such phenomena in order to execute the appropriate corrective measures.

### 4.2 Survey of Water Quality in Public Water Areas

Among the various monitoring surveys, public water areas monitoring survey have carried out for twenty six years since 1971 by local governments. The actual survey frequency is shown in **Fig. 15-1.** It shows the results of public water areas surveys carried out by local governments in the country in the 1992 fiscal year. According to the "Method for the Water Quality Survey", a notification from the Water Quality Conservation Bureau in 1973, the sampling frequency is prescribed as more than one day a month and about four times on each survey day, as a rule. The number of environmental quality standard monitoring points where sampling

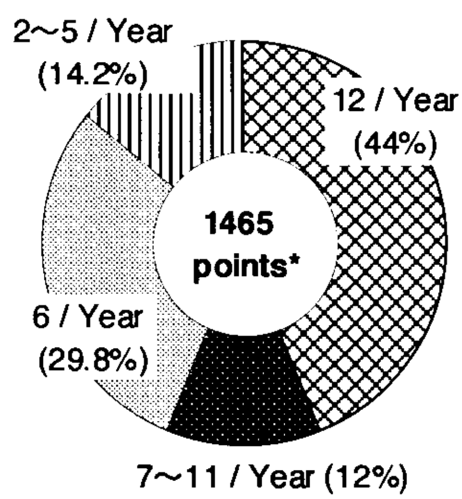



**Fig. 15-1** Survey frequency at environmental quality standard monitoring points in public water areas by local government in the 1992 fiscal year.
* Total number of environmental quality standard monitoring point

frequency reached twelve times a year were only a roughly half of all the monitoring points 1,465. The points where sampling frequency was six times or below a year were about forty four percent of total monitoring points.

Also the "Method for the Water Quality Survey" prescribes that the sampling layer is, as a rule, two layers, the surface and middle layer. The lower layer is added in cases where water depth is over ten meters. Environmental quality standard monitoring points located in category A areas are assumed to be as deep as ten meters. However, the number of points sampled from the three layers, surface, middle and lower layer, were only 135, fifteen percent of the total 927 monitoring points in category A areas.

Such reduction of sampling frequency and layer by the local governments has resulted from long term monitoring. Coping with recent increases in the number of monitoring parameters shown in **Table 15-1** and new issues of water quality, local governments have planned the contents of monitoring, including survey frequency and monitoring parameters with consideration of the budgets of monitoring surveys.

### 4.3 Contract with the Private Sector

Among the various surveys by local governments, governments have recently entrusted some work such as sampling and analysis work to private measurement institutions instead of their internal measuring institutions, though the governments themselves have carry out the planning and the actual process of the surveys. The aim of contracts with the private companies is that local governments have made their internal institutions focus on research of new aquatic issues in order to enforce the current and future environmental administration. Another cause is that the measuring systems of private institutions have been fully developed in recent years.

During the monitoring survey of public water areas in the 1996 fiscal year, only ten did not contract with the privates sector among the nations total of fourty-seven prefectures. Other prefectures have entrusted some of the work to the private sector. Nine prefectures including Tokyo prefecture and Osaka prefecture have even contracted all sampling and measuring work of water quality to the private sector. Seventy seven cities designated by ordinance in this county have contracted with the private sector at the same rate as the prefectures where these designated cities are located.

Referring to parameters, fifty to sixty percent of the total sample numbers of health parameters, parameters relating to the living environment, and special parameters were entrusted to the private sector by local governments in the monitoring survey of public

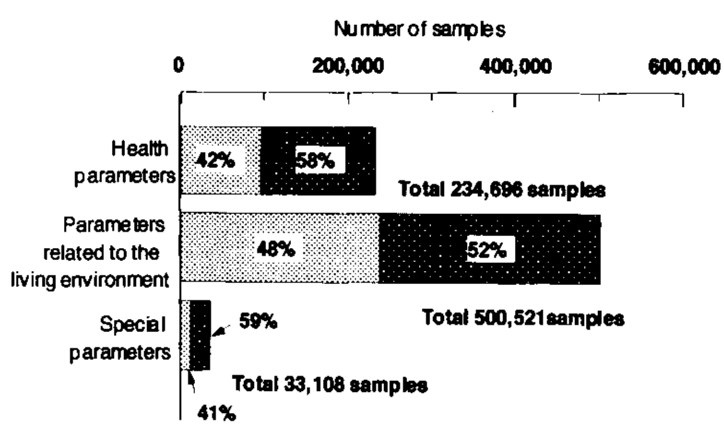



**Fig. 15-2** Private contracts for monitoring public water areas for local governments. (fourty-seven prefectures and seventyseven degignated citys.)
▒, Direct management ; ■, Private contract.

water areas in the 1996 fiscal year, as shown in **Fig. 15-2**.

### 4.4 The Status of Monitoring Surveys on Effluents from Factories

Local governments have also monitored the effluents from specified factories according to the water quality measuring plan made by each prefecture's governor. Among 36 monitoring parameters (23 health parameters and and 13 parameters relating to the living environment), practical parameters to be monitored have been determined according to the kind of specified factory. The frequency of the survey for monitoring is usually once or twice a year, and rarely as much as once a month. This depends on such factors as the scale of factory, effluent discharge conditions and past effluent standard violation. If necessary, local governments execute the sampling of effluents at night.

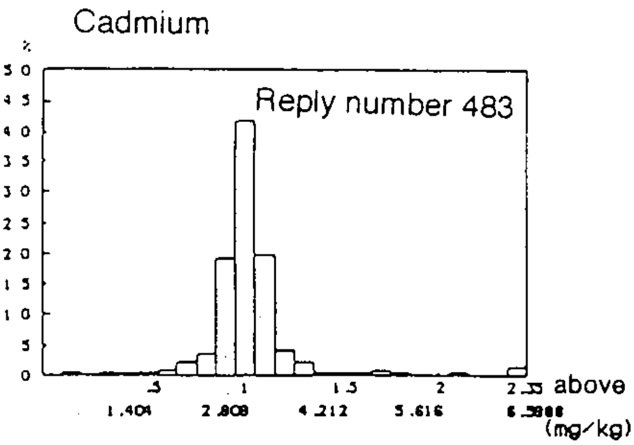
Violations of National Uniform Effluent Standard and local more stringent effluent standards are evaluated according to allowable daily average and maximum concentration standards. Because the Water Pollution Control Law has put the business sector under obligation to monitor effluent from their specified factories, the measuring frequency by the local government is usually limited once a day. Local government is also able to demand the results of effluents surveys from business sector. In such cases when the concentration measured is higher than the maximum concentration allowed for effluent standards, the local government gives an improvement order to the business.

### 4.5 Quality Control and Quality Assurance ( QC/QA) of Water Analysis

With the recent increase of the number of parameters and the heightening of analysis technology, quality control and quality assurance ( QC/QA) of water analysis is one of the most important works of water quality monitoring by local governments. Currently, each local government carries out internal QC/QA in order to ensure its reliability and improve the precision of the analysis.

In addition to such particular checks on QC/QA, the Environment Agency has also carried out the "Standardized QC/QA for Environmental Measurements and Analyses" annually since 1975. In order to evaluate QC/QA, the Environment Agency analyzes and evaluates data from each participating organization and then makes out reports and sends them to the participating organizations. Local governments check their own analysis precision by referring to this report. Incidentally the number of participating organization has tended to increase year by year, and the total number of participating organizations has reached 550 including 51 prefectural institutions, 43 municipal institutions, and 456 private organizations in the 1995 fiscal year.

During the 1995 fiscal year's Standardized QC / QA evaluation, contents and elusion tests were carried out for six heavy metals including cadmium and arsenic in a soil sample from a factory site. Further, concentration of three organochlorine compounds such as dichlorometane in the synthesized effluents were tested. Among these tests, the results of two parameters, cadmium and dichloroetane, are shown in **Fig. 15-3** as a typical result among them. In cadmium, as forty percents of the total number of replies were distributed in the class containing the mean value, the analysis precision of cadmium could be said to be good. In dichlorometane, the maximum frequency of the relative value to mean value were distributed in the class "from 0.95 under 1.05". The mean concentration of dichloroetane analyzed was 0.112 mg/l. This value was five to seven percent lower than the adjusted concentration 0.12 mg/l. However, in the case of the results from seventy four public institutions, the mean concentration of 0.114 mg/l and the relative standard deviation(RSD%) of 18.8 were both satisfied in terms of precision and accuracy.



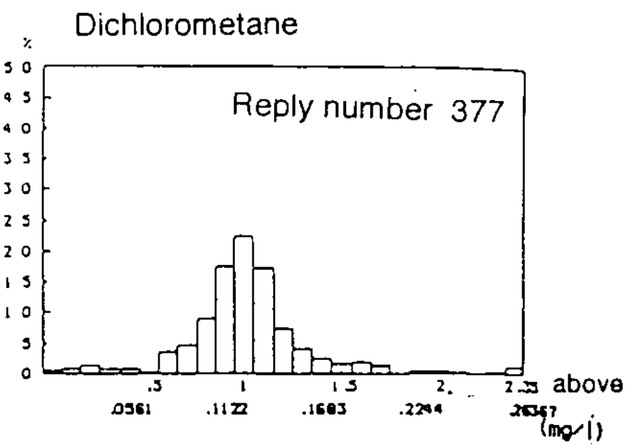




**Fig. 15-3** Histogram of cadmium content in a soil sample and dichlorometane concentration analyzed in the synthesized effluents.
X axis is the relative value of the analysis results to the mean value after the rejection of unusual values
Y axis is the rate for reply numbers in each class to the total reply numbers(%).

### 4.5 To Future Monitoring Survey

Participation in the "Standardized QC/QA for Environmental Measurements and Analyses" in this country is not mandatory. Furthermore, even if the data analyzed has been shown to be inaccurate, the work of analysis improvement is left to each participating organization, so the results of such analysis improvement effort is not evaluated objectively. Therefore the Environment Agency's QC/QA system can be said to be useful to some extent but is still not sufficient. In the future, it is necessary to introduce an internal and external precision inspection system for water analysis which is available internationally.

These day, water pollution is becoming more diverse and complicated, and this tendency is expected to grow more rapidly in the future. In order to execute appropriate monitoring, reconsideration and improvement of monitoring systems is needed, such as reconsideration of the environmental quality standard monitoring points and parameters, as well as the preparation of a, Standard Operation Procedure (SOP) manual, which prescribes the monitoring methods that enable everyone to carry out all the processes of monitoring not only analytical methods but also including sampling work with extreme precision and reliability. Then in order to cope with increasing sample numbers, the introduction of automatic analysis equipment will be needed. Also, to help deal with analytical technology and equipment cost, sharing analysis systems among neighboring local governments will be necessary. Furthermore, as specialists to plan and execute monitoring will need more knowledge and experience, a system for personnel promotion should also be considered.

## 5. References


1) The Environment Agency Water Quality Bureau supervision (1996) "Seriatim Explanation of the Water Pollution Control Law", the Research Group on Water Pollution Control Laws ed., Chuohouki Shuppan, Tokyo, 606pp.
2) The Environment Agency Water Quality Bureau (1996) "The 1995 Fiscal Year Report on the Survey on Environmental Quality Standard, the second chapter", The Reconsideration of the Water Quality Standard. , 42pp.
3) The Environment Agency Planning and Coordination Bureau Environmental Research and Technology Division (1996) " The 1995 Fiscal Year, The Results of the Survey of Standardized QC/QA for Environmental Measurements and Analyses - The Soil of the Factory Site and the Synthesized Effluent", 403pp.

# CASE STUDY

# Chapter 16 MINAMATA BAY

## 1. An Outline

In 1932, Nippon Chisso Hiryo K.K. (NCH) started to operate the acetaldehyde compound acetic acid facilities using mercury as a catalyst, at the bayside of Minamata facing toward the Yatsushiro Sea (Shiranui Sea). After that, those facilities had been operated for 36 years, exhausting waste liquid actually with no treatment. The contaminant, especially methyl mercury turned Minamata Bay to a sea of death. A lot of years had been spent, however, for people understand those facts. Instead, many victims suffered a pollution-induced disease, Minamata Disease, during those years.

An official recognition of Minamata Disease was first issued in 1956. Then, in 1968, the year in which the facilities suspended operation, Ministry of Japan officially set forth the methyl mercury in the waste liquid from the facilities as a cause of Minamata Disease. In 1977, a dividing net was set up to trap contaminated fishes within the Bay as well as the sludge disposal project effectuated.

The sludge disposal program, however, remained to be suspended until 1980, when a guarantee of protection from secondary pollution was admitted by the residents.

The dredging program was completed in 1988, the Hyakken Port in which most high level pollution was found, had been reclaimed. And then, the dividing net, which was regarded as a symbol of Minamata Disease incident, had been completely removed in September 1997. The mercury pollution, called as an origin of the environmental pollution, is coming to an end. The reclaimed land was made as a modern looking park, and then the topography and the scenery of Minamata Bay have changed drastically.

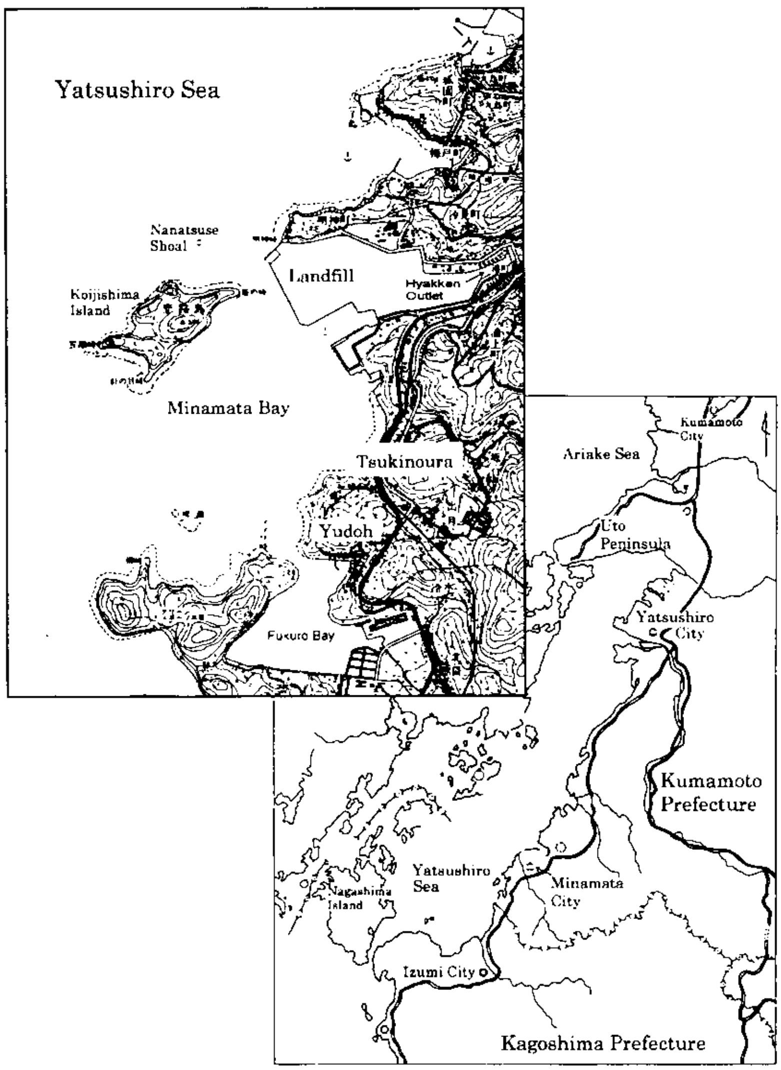



Fig. 16-1. Yatsushiro Sea and Minamata Bay

2. Minamata Bay before the cause of Minamata Disease

Yatsushiro Sea spreads with 1,200 km$^2$, depth of which is 20~50 m. The deepest record is about 70 m at the south end called Nagashima Channel. Through this channel, largest tidal current is observed (Fig 16-1).

Minamata Bay is divided off by Nishinoura peninsula, in the southern end, surrounding a tiny inlet, Fukuro Bay. Myoujin Point and Koijishima Islet (Fig 16-1) make the northern boundary. The long axis of the Bay is 2.6 km long from northeast to Southwest, the short axis is 1.3 km from northwest to southeast, with an ellipse shape, and the spread of it is about 3 km$^2$. The interval from Koijishima islet and Nishinoura peninsula, about 1.1 km distance, opens to Yatsushiro Sea. This region is deepest as about 20 m, the bottom incline slowly to the outside. On the other side, the interval between Koijishima islet and Myoujin point had a distance of 370 m (at present that shortened to 190 m by a bank protection), the bottom slants gently to the Yatsushiro Sea.

Minamata Bay had once provided a spawning ground for the migratory fishes, and had been especially abundant of fish and shellfish. This is shown by many of materials and Tele by residents. That abundance makes residents depend their life on the flesh fish and shellfish which can be caught quite easily in the neighboring sea, rather than the rice which had to be purchased.

The population of Minamata Village at the beginning (1889) was more than 12,000. The area of Minamata Village locates in between mountains behind and sea in front, and is narrow place providing only a limited farmland. Therefore, the key industry before Meiji Era were a production of nuts of wax tree as a land tax instead of rice, or a production of salt in the salt pan. That salt was valued highly because of the good taste, which is a specialty of Shiranui Sea. Along the estuary of Minamata River, there was a fishing village, fish and shellfish, which were abundant as described above, were eaten as a basic food.

In 1908, nine years after the official designation of Minamata Village upon nationwide adoption of the Village system, Nippon Carbide Co. began manufacturing in this solitary village. Right after that, Sogi Electric Co. (located at Okuchi village in Kagoshima Prefecture), which had been supplying electricity to Minamata Village, merged with Nippon Carbide to form Nippon Chisso Hiryo K.K. (NCH) in August 20$^{th}$. The NCH much contributed to the re-designation of the Village as Minamata Town in 1912, since the manufacture such as lime nitrogen production grew smoothly assisted in part by a kind of good luck.

As the factory advances, the fishing village around the estuary of Minamata River disappeared by the beginning of Showa Era. On the other hand, Immigrant from Amakusa Islands the opposite bank of Minamata settled the southern area near the boundary with Kagoshima Prefecture, making other fishing village named Yudo, Dezuki, Fukuro, Modo and so on[1)]. Including those people, residents in Minamata area favored to earn the cash income by working in NCH rather than fishery. That could be why many of the fishermen came from periphery and opposite bank to Minamata Bay to engage in fishery[1)]. The fishes from around Minamata Bay were important source of protein for the people living in the widespread area of Minamata region including the remote place in mountain. This fact was a specific reason of wide spread destruction caused when the mercury pollution of fish and shellfish arose by exhaust liquid.

3. Detail of mercury pollution in Minamata Bay

NCH was expected a great deal of an important role as a key of organic chemical industry during dawn of modern Japan. Moreover, assisted by the electricity provided with the abundant water resource and the low labor cost, and depend on a social situation such as playing a role as the munitions industry, NCH developed abruptly.

NCH started to operate acetaldehyde compound acetic acid facilities in 1932, in this year the history of mercury pollution in Minamata Bay originated. This production facilities are called as first stage (of operations), followed expansion of second to fifth stage in 1933, 34, 35 and 37 (Fig. 16-2). Only those preliminary plants were sufficient for producing 50% of acetic acid of whole in Japan in those early periods. The production of acetaldehyde, in those period, aroused up to over 9,000 t / year maximum, though, since the plant bared devastating destruction by the bombing done just before the end of World War II, resulted to stop operation temporarily in 1945. But after only a half of year from the cessation, the operation resumed. The first and second stages were carried on to 1955, the third and fourth stages to 1949, and the fifth had lasted until 1956, then that was taken over by the new fifth stage of operation. During those period, especially from 1950 when NCH changed its name to Shin-Nippon Chisso Hiryo K.K. (SNCH), in accordance with the industrial restoration of postwar Japan, the production of the Minamata factory abruptly enlarged through a repeated improvement of production facility. Those growth resulted in production exceed the maximum level in pre-war period during 1954 to 55. In those periods, the sixth stage had started its operation in 1953, and the seventh in 1959, both were expected as the latest facility (Fig. 16-2). As a result of those abrupt growth, especially during the term of scrap and build, amount of exhaust could became huge which extremely exceeds those in the usual operation. It is, therefore, thought that unexpected amount of mercury containing exhaust liquid flew out into Minamata Bay due to such an abrupt improvement (see below)[2].

By the way, NCH had started to produce vinyl chloride for the first time in Japan in 1941, which grew the another mainstay of the company later. That facility included the acetylene method using mercury as a catalyst also. In that facility also After NCH resumed to produce vinyl chloride in 1949, this plant had also increased production expanding the facilities supplying the expanding demand in those post-war periods.

SNCH renamed as Chisso Corporation (Chisso) in 1965. Then, when Chisso closed the acetaldehyde compound acetic acid facility in 1968, the maximum output (62,925 t/year) had been recorded. That facility came to an end by switching over to petrochemical plant in 1971. In duration of producing vinyl chloride, methyl-mercury containing exhaust liquid was also flown out into Minamata Bay. The amount of total mercury was less than that from acetaldehyde producing facility, however, that could be 30.6 t[2] as a whole loss of mercury used.

In 1958, SNCH had switched the outlet of drainage canal of acetaldehyde compound acetic acid facilities from Minamata Bay to the estuary of Minamata River, which flew out the pollution enlarging over the Yatsushiro Sea, and resulted to increase victims. Such line of

Fig. 16-2 Change of Acetaldehyde compound facility and production amount[2)]

| Year | Production Results of Acetaldehyde (t) | Stage of Acetardehyde Compound Facility (Period of Operation ◀━▶ ) | | | | | | | | Notes |
|---|---|---|---|---|---|---|---|---|---|---|
| | | ] | 2nd | 3rd | 4th | 5th | New 5th | 6th | 7th | |
| 1932 | 209.763 | May | | | | | | | | Start to exhaust effluent into Minamata Bay |
| 1933 | 1297.41 | ▲ | Apr | | | | | | | |
| 1934 | 2583.18 | | ▲ | Oct | | | | | | Start to produce acetic angydride, cellulose acetate |
| 1935 | 3628.33 | | | ▲ | Sep | | | | | |
| 1936 | 5133.75 | | | | ▲ | | | | | Start to produce acetone |
| 1937 | 6252.12 | | | | | Sep | | | | Start to produce acetic acid rayon |
| 1938 | 7386.13 | | | | | ▲ | | | | |
| 1939 | 9063.108 | | | | | | | | | Start to produce vinyl acetate, acetate staple fiber (both 1st in Japan), and ethyl acetate |
| 1940 | 9159.187 | | | | | | | | | |
| 1941 | 8700.148 | | | | | | | | | Start to produce vinyl chloride (1st in Japan) |
| 1942 | 8480.196 | | | | | | | | | |
| 1943 | 7469.934 | | | | | | | | | |
| 1944 | 7295.541 | | | | | | | | | |
| 1945 | 2263.815 | | | | | | | | | Interrupted by bombing in Aug |
| 1946 | 2252.83 | | | | | | | | | Resumed in Feb |
| 1947 | 2362.703 | | | | | | | | | |
| 1948 | 3326.256 | | | ▼ | ▼ | | | | | |
| 1949 | 4391.208 | | | Apr | Apr | | | | | |
| 1950 | 4484.016 | | | | | | | | | |
| 1951 | 6248.467 | | | | | | | | | Changed promoter from MnO2 to FeO |
| 1952 | 6147.777 | | | | | | | | | Start to produce octanohl (1st in Japan) |
| 1953 | 6592.261 | | | | | | | Aug | | |
| 1954 | 9059.14 | ▼ | ▼ | | | | | ▲ | | |
| 1955 | 10632.776 | Sep | Sep | | | ▼ | | | | |
| 1956 | 15919.042 | | | | | May Dslv | May ▲ | | | May->Minamata Disease recognized first<br>Dslv:dissolve |
| 1957 | 18085.091 | | | | | | | | | |
| 1958 | 19191.351 | | | | | | | | | Feb->Facility for continuous oxidation of reaction mixture completed<br>Sep->drain rout changed to Minamata River |
| 1959 | 31921.222 | | | | | | | | Nov | |
| 1960 | 45244.79 | | | | | | | | ▲ | |
| 1961 | 42287.97 | | | | | | | | | |
| 1962 | 26500 | | | | | | | | | |
| 1963 | 38500 | | | | | | | | | |
| 〃 | 41029* | | | | | | | | | |
| 1964 | 26581* | | | | | | | | | |
| 1965 | 17960* | | | | | | | | | |
| 1966 | 16115* | | | | | | | | ▼ | |
| 1967 | 11961* | | | | | | ▼ | ▼ | May | |
| 1968 | 783* | | | | | | May | May | | May->Acetaldehyde production came to an end |
| | *Amount in every fiscal year | Normal pressure fractional distillation | | | | | Reduced pressure fractional distillation | | | |

drainage canal was again changed to flow out into Minamata Bay in September of the next year.

It was not until the Minamata Disease Medical Study Group in Kumamoto University Medical School had struggled along to mercury as a cause of the disease in 1959, that the evidence of mercury pollution in Minamata Bay had been uncovered. In that year, Kitamura et al. had first investigated the pollution of Minamata Bay, the data of which is quite valuable today to study the situation of mercury pollution over the Bay[4] (Fig 16-3). According to them, on the sludge pollution, maximum was 2010 ppm per wet weight at the outlet of drainage from the factory in the deep end of Bay, then decreased as went to outer sea.

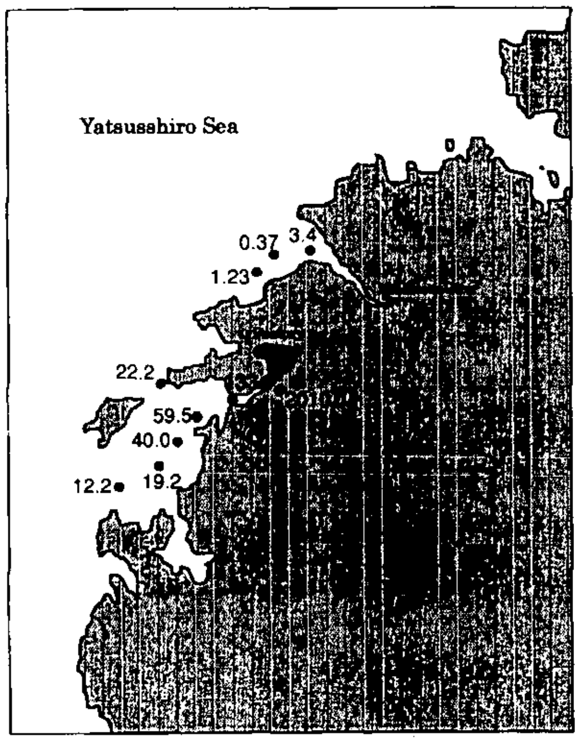



Fig. 16-3. Mercury concentration in the sludge of Minamata Bay (ppm wet weight)[4]

Measurement of total mercury content at sixteen fixed points within the Bay in every 1963, 1969, 1970 and 1971[4], the averaged concentrations were 146.3 ± 173.5, 141.6 ± 214.6, 67.2 ± 65.1 and 129.6 ± 147.3 ppm dry weight, respectively. The sludge made by the accumulation of mercury containing waste in Minamata Bay showed its maximum depth of 4 m. According to the inspection conducted by Kumamoto Prefecture prior to the beginning of sludge disposal in 1974, the sludge containing over 25 ppm of mercury distributed throughout the Bay. It was deeper at the inner end of the Bay, which indicated maximum

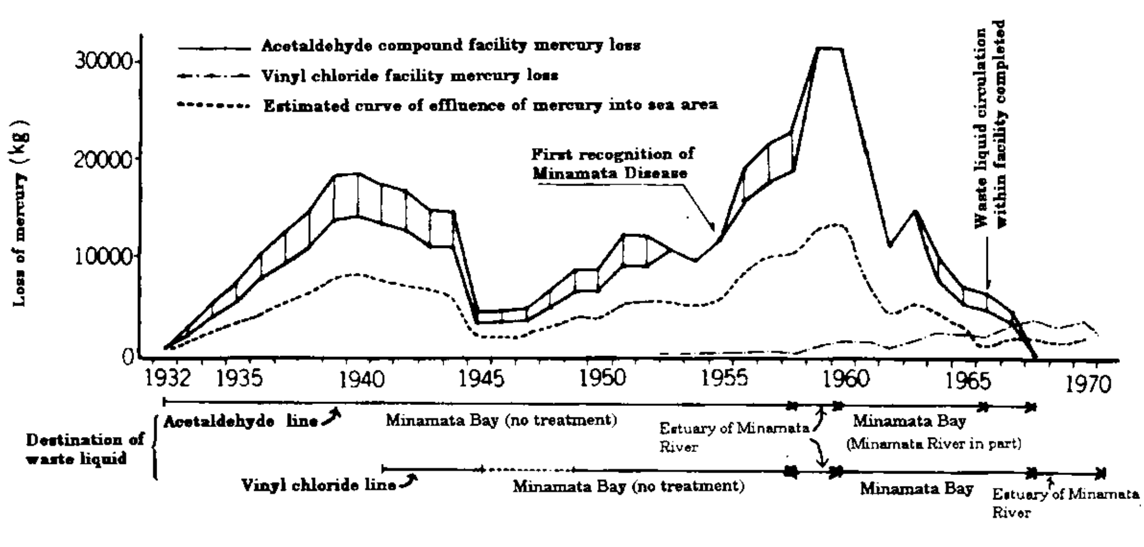



Fig. 16-4. Annual change of mercury loss amount from acetaldehyde compound facility[2]

2,700 ppm per dry weight, decreased with going through out the Bay. Total amount of such a contaminated sludge is announced as 1.5 million cubic meter. On the methyl-mercury, however, the concentration was 0.03 ppm per dry weight as a maximum, and majority of other points was under the minimum limit of detection. Thereafter, disposal of sludge including more than 25 ppm total mercury had been completed by 1990 as described below. In the inspection post-dredging project, the maximum mercury concentration had decreased to around 12 ppm that is much lower than the provisional regulatory standard.

Then, how much mercury had been exhausted into the sea? It is impossible to reply that question because we have a limited data available for figuring out an exact value, but only we can estimate those using such an operation diary recorded in the factory. According to the official announcement by Kumamoto Prefecture or by Minamata City, the whole amount of sediment could be Minamata Bay is 150 t or more. On the other hand, There were a few investigators who performed those calculations more accurately. One of those results is indicated in Fig. 16-4 as an annual transition of mercury loss from the acetaldehyde

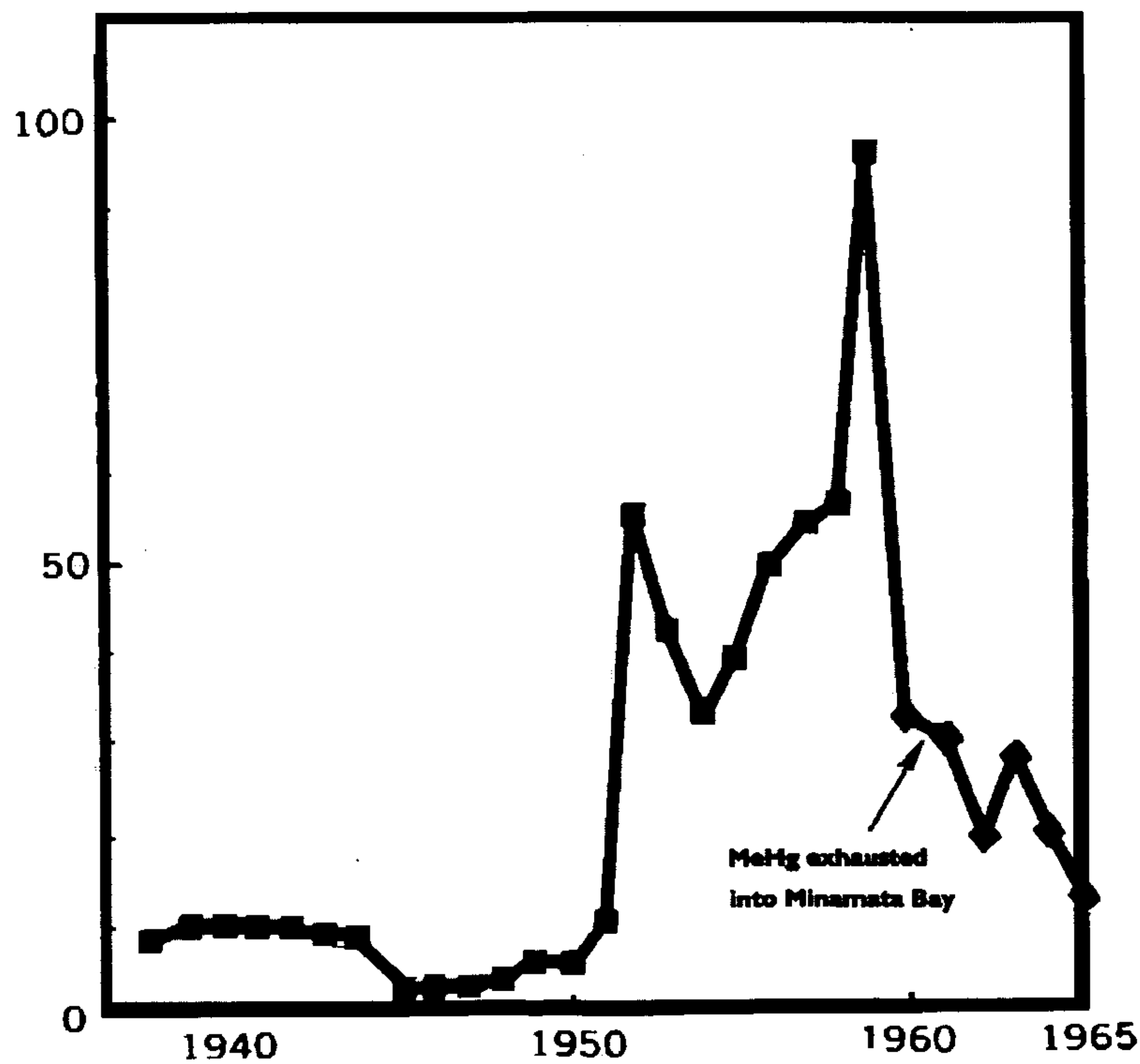



Fig. 16-5 Annual change of MeHg exhaustion amount into Minamata Bay[3)]

production process[2]. As shown in that figure, from 1956 when Minamata Disease was recognized officially, the amount of mercury loss had increased abruptly till 1960, the year when a kind of liquid-waste treatment facility named cyclator-sedifloater (named by SNCH) started to work in SNCH. The period of mercury loss peak coincides with the term of the innovation of facility described above, as well as with the period when acute patients of Minamata Disease had been discovered one after another. There is another dull peak around 1939 in Fig 16-4, which indicates the amount of mercury loss increased in accordance with the growth of acetaldehyde manufacturing process from the start in 1932, and decreased along the deterioration of war situation.

Oxidized mercury, catalyst, forms methyl mercury within the mother liquor of acetaldehyde production[5]. The efficiency of methyl mercury formation is unexpectedly as high as 75% or more of added mercury in the last exhaustion liquid. However, the victims of Minamata Disease were mainly reported during the term of the later peak, but scarcely in the former peak of pre-war period. The reason of which is unknown, but recently Nishimura[3] has shown that NCH first used manganese + oxidized iron as a sub-catalyst for reducing deterioration rate of oxidized mercury, which by chance reduced the formation of methyl mercury, but later (from 1951) SNCH had changed the sub-catalyst to oxidized iron[6]. His report infers such change increased the rate of methyl mercury formation. He also indicated that SNCH used a crude iron (III) oxide derived from a sulfuric acid production process instead of purified ferric sulfate, which caused the repeated bumping accident by reacting with nitric acid included in the mother liquor. Those accidents extraordinary increased the exhaust of methyl mercury into the Minamata Bay. The other primary factor for increasing methyl mercury formation was also disclosed by those researchers that SNCH used seawater in part for the industrial purpose. The chloride ion in the seawater contributed to turn methyl mercury ion into methyl mercury chloride, volatile form, which easily contaminate into the exhaust liquid within the rectifying column. This could be one of the main causes why only the SNCH out of 7 factories using mercury in that period brought about such an devastating public hazards. As a conclusion, they have figured out the annual change of methyl mercury amount exhausted from SNCH Minamata factory, such as 50 kg/year as an average between 1951 to '60, and 95 kg as a peak in 1959. On the other hand, in the term before 1951 and after 1960, the average could be lower than 10 kg/year (see Fig 16-5).

Table 16-1. Changes of mercury concentration in shell fish[5]

(μg/g per wet wt.)

| | Year, Month | 1960 | | | 1961 | | | 1962 | 1963 | 1965 | 1966 | | 1967 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Place | Species | 1 | 4 | 8 | 1 | 4 | 12 | 1 | 10 | 5 | 10 | 12 | 4 | 6 | 8 | 10 | 12 |
| Midori | Mussel* | 85 | 50 | 31 | 56 | 30 | 9 | 12 | 12 | | | 8 | | | | | |
| Midori | Asari clam | | | | | | | | 28 | 33 | 84 | | 8 | 15 | 26 | 24 | 20 |
| Myoujin | Asari clam | | | | | | | 28 | 12 | 16 | 21 | | 7 | 8 | 3 | 16 | 13 |
| Koijishima | Asari clam | | | | | | | 43 | 40 | | 81 | | 60 | 19 | 48 | 32 | 14 |
| Oosaki | Asari clam | | | | | | | 5 | 5 | 5 | | | 6 | 3 | 6 | 5 | 9 |

| | Year, Month | 1968 | | | | 1969 | | | | | 1970 | | | | 1971 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Place | Species | 3 | 6 | 7 | 8 | 2 | 6 | 8 | 10 | 12 | 2 | 6 | 8 | 12 | 2 | 3 |
| Midori | Mussel* | | | | | | | | | | | | | | | |
| Midori | Asari clam | 12 | 8 | 9 | 4 | 4 | 2 | 1 | 1 | 1 | 2 | 1 | 16 | 3 | 18 | 3 |
| Myoujin | Asari clam | 9 | 10 | 12 | 2 | 6 | 7 | 3 | 4 | 6 | 5 | 14 | 2 | 6 | 3 | 4 |
| Koijishima | Asari clam | 45 | 30 | | 5 | 2 | 12 | 16 | 4 | 2 | 10 | 7 | 7 | 4 | 4 | 4 |
| Oosaki | Asari clam | 4 | 3 | 1 | 0.7 | 1 | 0.6 | 0.3 | 0.4 | 0.5 | 0.4 | 0.3 | 0.4 | 0.6 | 0.3 | 0.7 |

* Hormomya mutabilis

On fish and shellfish, the level of mercury pollution has attracted the attention since Minamata Disease caused by eating them. For such subject, however, the earliest data is also those taken by Kitamura et al. in 1959. According to their inspection, total mercury concentrations in a bivalve *Hormomya mutabilis* obtained inside of the Bay were 11.4-39.0 ppm wet weight, and those outside of the Bay were 2.4-20.4 ppm. For other species in wet

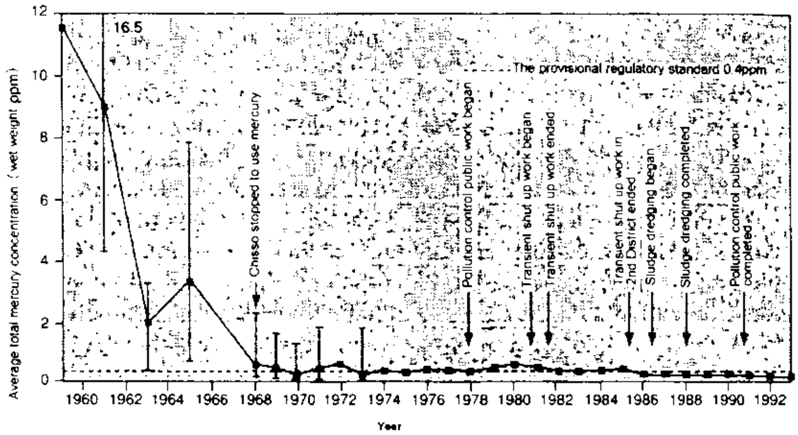



Fig. 16-6. Changes of mercury concentration in fishes of Minamata Bay[7]

weight, small sized crabs 35.7 ppm, croaker fishes 14.9 ppm, short-necked clams 24.1 ppm, black porgies 24.1 ppm and so on. Those values correspond about 40 to 100 times of the provisional regulatory standard 0.4 ppm wet weight provided in the Food Sanitation Low in 1974, that indicate the extraordinary pollution of Minamata Bay in those periods.

The change of mercury concentration in fish and shellfish of Minamata Bay after the inspection described above can be realized from the data of a fixed-point survey performed by Irukayama et al. between 1960 and 1971[4] (Table 16-1). For the initial two years from 1960, we can obtain data only for *Hormomya mutabilis* (mentioned as mussels in the report) collected at Midori seashore (Tsukinoura region); those decreased from 85 ppm dry weight to 12 ppm in October 1963. On the short-necked clams at the same place, the change is from about 30 ppm during 1963-65, which increased to 84 ppm in 1966, then decreased to less than 20 ppm after 1970. Those changes tell that mercury level in those zoobenthos is hard to decrease. On the other hand, on the mercury level changes in fish and shellfish after 1971 there is a huge pile of data produced by Kumamoto Prefecture[7] (Fig. 16-6). Reading the change by average of whole species of fishes inspected between 1961-74, the mercury level rapidly decreased from 9 ppm wet weight in 1961 to the level of 0.5 ppm in 1969, then transit around 0.5 ppm for several years. Except 1980 and 1981 when temporal increase of mercury level was observed, the level decreased little by little, finally after 1986 when Sludge Dredging Project started, the level was below the provisional standard value 0.4 ppm. Unfortunately, however, there were 16 species with higher level than 0.4 ppm in Minamata Bay after the Dredging Project completed, such as greenlings, scorpion fishes, striped grunts, nibblers, porgies, smelts, flounders and so on. For this reason, Kumamoto Prefecture enforced capture and disposal of the fishes inside of the separate nets bordering Minamata Bay at a periodic interval in order to exterminate the polluted fishes. As a result, there is no fish with the level over the standard value after 1994.

4. Process of inquiry into the cause of Minamata Disease, and situation around Minamata Bay

The severe neurological illness (called, afterwards, Minamata Disease), that actually had been found since 1953 or before in Minamata area, was officially recognized in May 1956. Such an illness had been called as a strange disease of Minamata in those days, and was initially thought a kind of infectious disease. Even after the possibility of infections was denied, a lot of candidates for the cause of the illness were taken up for discussion, such as selenium, tallium or manganese. In August 1956, a study group was organized in Kumamoto University Medical School. The members of that group announced an opinion that the cause of the disease was some material contaminated in fish and shellfish in Minamata Bay, and the source of contamination could be the exhaust liquid from SNCH Minamata Factory, as early as in the next year. The opinion, however, had been obscure among the complicated arguments mentioned above.

Cats in Minamata area had been known to show the same neurological disorder of movement as Minamata Disease before the disease was recognized officially. That forced some researchers to design the experiment of fish administration to cats. Itoh et al. showed the cat given shellfish derived from Minamata Bay developed the symptom of Minamata Disease on 7-48$^{th}$ day of administration in 1957[8]. In other case, Sera et al. had committed fishermen live in Minamata area to keep cats derived from outside of Minamata area[9]. All eight cats in that experiment had shown symptom in 32-65 days. In a case, for example, a cat given 40 dried fries (about 10 g) three times a day developed symptom in 51$^{st}$ day of administration.

Table 16-2. Mercury concentration in cats (ppm)[4]

| | liver | kidney | brain | hair | blood |
|---|---|---|---|---|---|
| Cats suffering from spontaneous Minamata disease | 54.0 | 30.0 | – | – | – |
| | 37.0 | 17.2 | – | – | – |
| | 58.5 | – | – | – | – |
| | 101.1 | – | – | – | – |
| | 54.5 | 12.2 | 8.08 | 52.0 | 10.6 |
| | 68.0 | – | 10.4 | 39.8 | 15.8 |
| Cats suffering from experimental Minamata disease | 66.0 | – | – | – | – |
| | 105.6 | – | – | – | – |
| | 145.5 | – | 18.1 | – | – |
| | 53.5 | – | 8.05 | – | – |
| | 57.5 | 36.1 | – | – | – |
| | 78.3 | 12.8 | – | – | – |
| | 62.0 | – | 18.6 | – | – |
| | 47.6 | 15.6 | 10.0 | 70.0 | – |
| | 52.5 | 15.9 | 9.14 | 21.5 | – |
| Healthy cats in the control district | 0.9 | 0.7 | – | – | – |
| | 3.66 | 0.52 | – | – | – |
| | 3.01 | – | – | – | – |
| | 1.18 | 0.82 | 0.05 | 2.2 | – |
| | 1.28 | 0.09 | 0.05 | 0.51 | 0.13 |
| | 1.56 | 0.28 | 0.12 | 3.34 | – |
| | 1.64 | 0.55 | 0.13 | 3.45 | – |
| | 0.99 | 0.25 | 0.09 | 1.91 | – |
| | 1.25 | 0.16 | 0.04 | 3.05 | 0.08 |
| | 0.64 | 0.28 | 0.02 | 0.8 | 0.06 |
| | – | – | – | – | 0.26 |
| | 1.7 | – | – | 9.0 | – |
| | 2.7 | – | – | 0.16 | 0.05 |
| | 6.58 | 0.05 | 0.12 | 29.2 | 0.68 |

Kitamura et al. had confirmed an extraordinary high level of mercury contamination in the sludge or the bivalve *Hormomya mutabilis* derived from Minamata Bay after analyzing various toxic metals in 1959[3]. They, further, measured mercury content in the major organs of cats shown symptom after taking seafood from the Bay, and the cats living along Shiranui Sea. They confirmed that those organs contain significantly high level of mercury comparing the control cats[3] (Table 16-2). In addition, on the victim died after showed symptom, the mercury level was remarkably higher than the autopsy died due to another disease. The earlier, in particular, the victim died after symptom appearance, the higher the level of mercury (Table 16-3). In the inspection of mercury content in hair of the patient, the content was extremely high[3] (140.1 ± 188.7).

Based on those results, the Minamata Disease Study Group officially announced that for the candidate of toxic material contaminated in the fish and shellfish of Minamata Bay, mercury was thought with great deal in September 1959. Thereafter, the group extracted and crystallized methyl mercury compound from *Hormomya mutabilis,* short-necked clams and sludge in the factory, one after another. Also, the group succeeded to show symptom in the experimental animals administered the extracted and crystallized material[10][11]. Acetaldehyde is produced by a water addition reaction of acetylene under blowing acetylene into the solution containing sulfuric acid and inorganic mercury, and is separated through a distillation apparatus. Because methyl mercury was separated as crystal out of the sludge obtained from the distillation apparatus for the acetaldehyde-acetic acid production facilities; it was uncovered that methyl mercury was formed as a by-product from inorganic mercury within the acetaldehyde manufacturing process. That was a great result the Study Group performed.

Table 16-3. Mercury concentration in human organs[4)]

| Autopsy cases of Minamata disease | | | | Autopsy cases of other diseases | | |
|---|---|---|---|---|---|---|
| Approximate days from suffering to death | Liver | Kidney | Brain | Liver | Kidney | Brain |
| 20 | 70.5 | 144.0 | 9.60 | 0.18 | – | – |
| 25 | 38.2 | 47.5 | 15.4 | – | – | 0.11 |
| 50 | 34.6 | 99.0 | 7.80 | 0.84 | – | – |
| 50 | 39.5 | 40.5 | 8.95 | 0.45 | – | – |
| 60 | 42.1 | 106.0 | 21.3 | 0.2 | – | – |
| 60 | 38.8 | 68.2 | 24.8 | 0.38 | – | – |
| 60 | 34.7 | 64.2 | 7.8 | 1.06 | – | – |
| 90 | – | – | 9.45 | 1.02 | 3.02 | – |
| 90 | 36.2 | 21.2 | 4.85 | – | 0.37 | 0.11 |
| 95 | 30.0 | 22.6 | 4.63 | – | 0.25 | 0.08 |
| 100 | 22.0 | 42.0 | 2.6 | – | 1.08 | 0.12 |
| 550 | 26.0 | 37.4 | 5.32 | 0.07 | 10.7* | 0.05 |
| 860 | 6.35 | 12.8 | 1.30 | – | 0.53 | 0.09 |
| 1000 | 2.05 | 3.11 | 0.09 | 0.60 | 2.04 | 0.47 |
| 1470 | 5.44 | 5.9 | 2.22 | 0.97 | 1.01 | 1.54 |

*: The patient had been treated with a mercury-containing drug.

Emission of waste liquid from the acetaldehyde-acetic acid production facilities into Minamata Bay had not been abolished until the drainage facility was switched to the complete circulatory system in 1965 owing to the outbreak of another Minamata Disease in Niigata Prefecture. Acetaldehyde production came to end in May 1968. And then, in September of the same year, Japan Government announced that Minamata Disease in Kumamoto was caused by the methyl mercury formed within the acetaldehyde-acetic acid production facilities in SNCH Minamata Factory, which make Minamata Disease recognized as a pollution induced disease.

Afterwards, the Minamata Disease patients has been certified one another by Kumamoto Prefecture and Kagoshima Prefecture, resulted 1,770 patients among 13,408 applicants for certification in 1994 were certified as Minamata Disease patients and are receiving compensation, such as medical care expenses, from Chisso Corporation (Fig. 16-7). The history of patient certification, which originated with the enforcement of "Relief Law" (exactly, the Law Concerning Special Measures for the Relief of Pollution Related Patients, effective February 1$^{st}$ 1970), is that of conflict, that is, many of lawsuit had been started. In Fig. 16-7, which displays the annual change of certified patient number, remarkable change of data can be seen in several columns, reflecting some transition of social situation or opinion of the judiciary at each point of time. For example, in 1971, the year when Environment Agency established, a notification concerning the certification of Minamata Disease based on the Special Measures Law (Relief Law) was given by the Agency, by which the criterion for certification became not only clearer but also acquiring its publicity.

Moreover, in September of the same year, the Niigata District court decided in accuser's favor, which is a first pollution litigation in Japan. Those situations can be thought to influence on the increase of number of application (see Fig. 16-7). In the meantime, in 1986 court ruled in favor of accusers in the Minamata Disease Certification Suit. This implied the tendency that opinion of the judiciary acknowledges responsibility on government concerning the elongation of conflict. Government, on the other hand, worked out a policy, which included a variety of means such as the Special Medical Project. The Special Medical Project was a measure to provide people who can not be certified as Minamata Disease with a certain medical compensation in order to reduce or get rid of the anxiety for health due to the mercury pollution. That measure was further expanded as the Comprehensive Measures for Minamata Disease in 1992. Finally, in July 1995, Three ruling coalition parties submitted a solution for problem of Minamata Disease based on the Comprehensive Measures for Minamata Disease. The outline of the agreement is that "any conflict should be early, finally and totally settled under the framework that 1) the enterprise (Chisso Co. Ltd.) should pay 2.6 million yen to people who should be relieved, 2) the Prime Minister and the Governor of Kumamoto Prefecture should express regrets, 3) people who will be relieved by this solution should end the conflicts completely, for example, by withdrawing the suits. In the event of the end of suits and conflicts, the government and the prefectures concerned have to continue the financial support to the program of the Comprehensive Measures of Minamata Disease. They also have to resume to accept applications for that program, and should take measures to support Chisso Co., Ltd. financially, and to recover and promote the region affected by Minamata Disease"[11]. Since most of the victim's organizations had accepted that solution, conflicts concerning Minamata Disease extended over a long period of time turn to settle promptly. Kumamoto Prefecture organized the certification Board based on the Comprehensive Measures, applied to its work of screening for the lump-sum compensation, and recognized 10,329 people by March 1997.

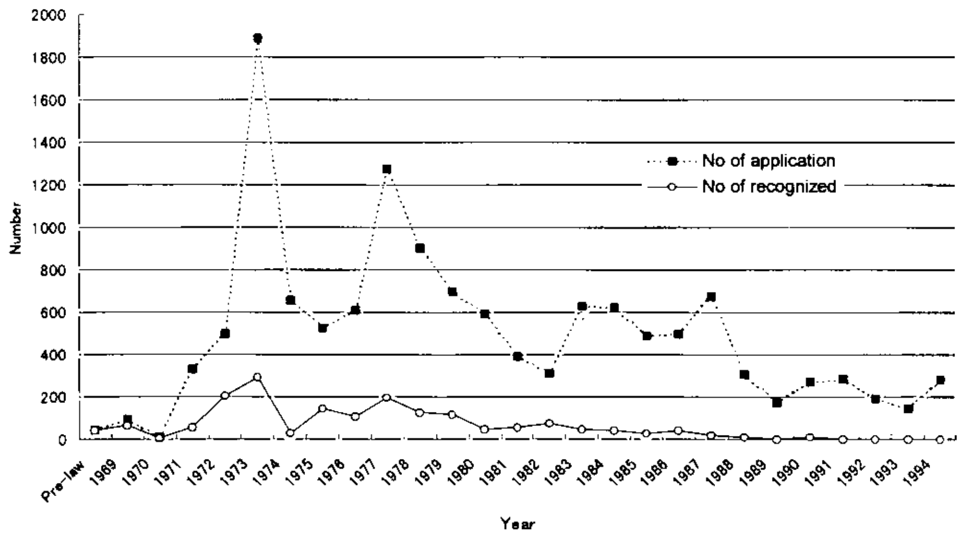


Fig. 16-7. Changes of number of application and recognized victims

5. Sludge Dredging from Minamata Bay

The mercury-contaminated sludge accumulated in Minamata Bay was thought to be inevitable to remove by resident and all classes of people. However, the project for sludge removal attracted attention from all over the world for a long term due to the problems such as bearing the expense, the method for preventing secondary pollution, and the regulatory standard.

Initially, a Sub-committee on Water Quality under the Central Council for Environmental Pollution Control, an advisory body of government, had submitted a report in June 1973 that the regulatory standard for sludge removal should be provisionally 25 ppm in Minamata Bay. Kumamoto Prefecture, being prompted by the government, introduced that value of standard and decided to process by drainage and reclamation of 1.5 million cubic meters of sludge, which contain more than 25 ppm of mercury. Kumamoto Prefecture and the government started the project with payment of 65% of total expense by the company responsible for the pollution and the remaining 35%. Prior to begin the project, various procedures for blocking the diffusion of contaminated materials were tried in order to avoid secondary pollution. Those included many things such as setting separation net with total 3.6 km length to confine the fishes within the Bay, using a cutter-less pump in dredging, setting a treatment apparatus for the exceed water, and mercury monitoring system for water and fish, which spent a long time and expense (Fig. 16-8).

On the procedure of calculating the regulation standard C (25 ppm), the factors on which the standard is based are as follows. 1) Permissible value of mercury contamination in the edible fish as 0.4 ppm reported as a provisional standard by Ministry of Health and Welfare, 2) elution index from sludge to sea water determined by experiment j, 3) the range of the tide □H, 4) concentration coefficient of mercury from sludge to fish (that was decided as 1,000 in Minamata's case), and 5) safety coefficient determined by considering the extent of utilizing fish as food S (that was considered as100 in Minamata). That means there should not be more than 25 ppm of mercury in sludge to prevent fish contamination over 0.4 ppm in Minamata Bay. Against this procedure, however, there have been some arguments. For example, the permissible standard of Ministry of Health and Welfare was figured out based on the biological half-life of methyl mercury, 70 days. Some researchers, however, think to need more consideration on that value, since the half life within the central nervous system is much longer as 230 days, and referring that the true nature of methyl mercury intoxication is the defect of central nervous system. On the concentration coefficient and safety coefficient, those were also thought as subjects to be considered in some cases. Anyway, those values are the 'provisional' standards for the situation of those days in Minamata Bay.

$$C = 0.18 \cdot \frac{\Delta H}{j} \cdot \frac{1}{S}$$

Sludge disposal was started as a preliminary construction to prevent secondary pollution in 1977, the transient shutting up work had then been done in 1980, and thereafter, the full-scaled dredging and reclamation work had barely started in 1981. It was 1990 when whole works had completed, concluding the dredging of Marushima Port and the drainage ditch where contaminated by waste liquid, as well as Minamata Bay. Those were a huge scaled project spending as long as 10 and several years and total expense of 48.5 billion yen. As a result, the sea of 58 ha which had been a fishing port was reclaimed and the pollution control public work of severely polluted Minamata Bay and surrounding sea has been completed. However, the mercury concentration of the fish in the Bay is not necessarily decrease to the background level within a short period. Even for judging the effect of that project, the monitoring of mercury level in fish and shellfish is important to continue, which has been performed by Kumamoto Prefecture and Fishery Agency.

According to the report of Fishery Agency in 1995, even in the scorpion fishes which always shows highest level of mercury concentration within the fishes in the Bay, the level was below 0.4 ppm. Kumamoto Prefecture declared the safety on the mercury level of the fishes in the Bay based on no fish has been found to exceed the standard level for the latest three years. Then, Kumamoto Prefecture had removed the dividing nets between August and September, after getting permission of the fishery cooperative and other organizations. Now, the landscape of Minamata Bay has changed seriously, and the Bay is acquiring a value of existence as a symbol for constructing the new Minamata City with a slogan of environmental conservation. Also, it is worth to notice how Minamata Bay, which has lost the value as fishing ground since the outbreak of Minamata Disease, restores under the measures on environmental restoration.

6. Concluding remarks

Minamata Bay, which experienced most disastrous mercury pollution on record, has been restored spending huge amounts of time and cost. Chisso Co. Ltd. has to continue to pay for various compensations based on the principle of the responsible company bearing the burden. Here, the government and Kumamoto Prefecture are under the pressure of necessity to sustain supporting Chisso from bankruptcy in being short of paying.

On the other hand, it is possible that the reason why the fish with the mercury level over the standard value has disappeared is due to the decrease of such fishes as an appearance. Because there is no fish other than the small sized (young) one as a result of the intensive catching operation of the polluted fish within the dividing nets. It is well known so far that most amount of mercury accumulated in fish is methyl mercury, however, methyl mercury concentration in sediment is as low as hard to detect. Moreover, total mercury

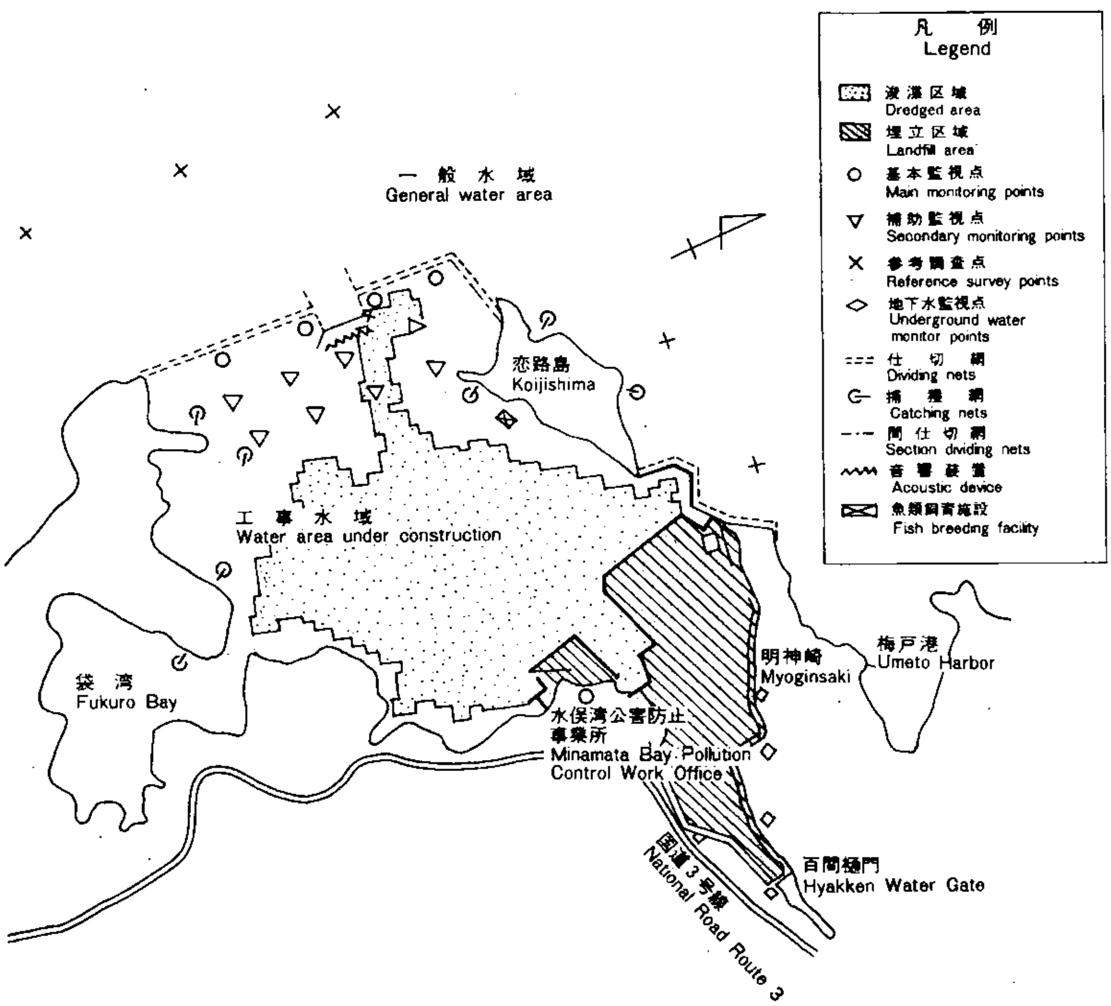



Fig. 16-8 Sludge removal project in Minamata Bay

concentration in seawater of Minamata Bay is also under the detection limit. Therefore, many problems are remaining to be studied on the mechanism of methyl mercury accumulation in fish and shellfish. The mercury level in Minamata Bay must be monitored from now on including whether no polluted fish appears or not.

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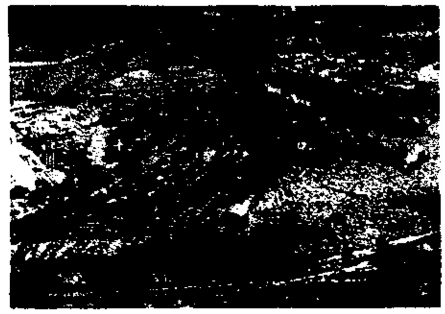
## Chapter 17 DOKAI BAY

### 1. Introduction

Dokai Bay located in the northern part of Kyushu island had once been called as "the Dead Sea", because of no aquatic organisms could live in the bay due to the harmful effects of untreated industrial waste water flowing into the bay. However, after the enforcement of waste water purification measures instigated by the joint efforts of citizens, industry, scholars and government, the improvement of the aquatic environment, shown not only by chemical analysis but also by the rebirth of the aquatic ecosystem, was dramatic. The recovery of Dokai Bay is evaluated as one of the most successful instances of water purification measures reviving a terribly polluted and damaged aquatic environment in a short period. This drastic improvement of the aquatic environment is therefore called the "Dokai Bay Success Story".

In this paper, I consider and discuss the Dokai Bay success story, including the status of Dokai Bay's serious industrial pollution, the contents of the purification measures devised through trial and error, and finally the lessons learned from the experience.



The later half of the 1960's when Dokai Bay was heavily polluted

Present day when water quality of the bay is improved

**Fig. 17- 1** Improvement of water quality of Dokai Bay.

### 2. From "A Rich Sea, Dokai Bay" to the Industrial Port of Kitakyushu's Heavy and Chemical Industrial Area[1,2]

Although Dokai Bay is a fairy small bay, with a total length of 13 km, it had been a rich source of marine products for the inhabitants living along the coastal line of the bay for 5,000 to 6,000 years. Dokai Bay was so rich with marine life that it was called "a rich sea, a treasure chest of Kuruma prawns" in the Meiji era about a hundred years ago.

In the beginning of the 20th century, as part of the national government's efforts measure to enrich and strengthen the country, the government managed Yawata Steel Company (now Nippon Steel Company) was constructed in 1901 along the coastal line of the bay for the purpose of providing the country with iron. After construction, land reclamation and dredging activities intensified in the bay, and eventually the Kitakyushu heavy and chemical industrial area developed as one of the four biggest industrial areas of Japan, supporting Japanese key industries. In this period, a lot of factories, as many as 1,035, were constructed along the coastal line of the bay. These factories were mainly related to the steel, metal working, machine, shipbuilding, chemical industry, ceramic, cement, and food industries.

### 3. The Degradation of Water Quality Leading up to the " Dead Sea" [1,2]

With the increased demand for fishery products from Dokai Bay that accompanied the industrial development, the peak fishery catch from Dokai Bay was reported in 1928. However, fishery catch decreased rapidly from 1928, and in 1932, just 4 years later, for the catch of fish was reduced by half. It was revealed by a simple bioassay as shown in **Table 17-1**, that the cause of serious damage to marine organisms was due to the effect of untreated industrial effluent from factories. This is a very important point when tracing the history of pollution in Dokai Bay.

After that, water conditions became worse and worse with the development of many heavy chemical factories along the coastline of the Bay. After 1942, the fishermen of Dokai Bay could not catch anything except for the few years immediately after the Second World War. Then due to the rapid progress of serious water pollution with industrial development after the war, the no catch phenomenon was repeated and eventually fishing from the inner part of the bay to the area under the present Wakato Bridge was abandoned between 1951 and '63.

**Table 17-1** Bioassay of seawater sampled from Dokai Bay in 1933

| Sampling station | Average minutes for test fish* to die |
|---|---|
| Near the drainage mouth of a glass factory | 12 |
| Near the drainage mouth of a food factory | 34 |
| Near the drainage mouth of a sulfuric acid factory | 46 |
| The inner point of the dock of Factory A | 57 |
| The outer point of the dock of Factory A | 63 |
| Old Wakamatsu port | 75 |
| Near the Tobata fish market | 83 |
| Near Hirase | 90 |
| Under the harbor police station | 115 |
| Near the drainage mouth of the bandage factory | 164 |
| Near Wakamatsu light house (Unpolluted sea water) | 180< |

* Juvenile sea bream etc.

Thus water pollution of Dokai Bay became a serious issue among fishermen as early as the 1930's, however at that time, citizens were not so aware of such issues as water pollution. In 1965、 residents near the inner part of the bay began to complain to the city government about offensive odors produced by Dokai Bay's heavy water pollution. Later, the news paper reported that marine life, such as mollusks, attached to the bottom of ships would die and drop from ships entering Dokai Bay after just a few days. After this report, citizens finally recognized the seriousness of the environmental crisis. Consequently, citizens including Women's Associations began to petition the local government to improve the water quality in

Dokai Bay.

## 4. Three Big Purification Measures

In the period of groping for effective purification methods for water pollution in this country, three major measures for the improvement of the aquatic environment of Dokai Bay were executed. These were the control of industrial waste waters, the establishment of a sewage system and the dredging of polluted sediment. These new projects developed as follows.

### 4.1 Control of Industrial Waste Water

#### 4.1.1 Devastating Water Pollution in Dokai Bay[1,2)]

Kitakyushu City carried out the first examination of the water quality in Dokai Bay in 1966 to meet the strong demand from citizen and this added to the crisis concerning water pollution. With the results of the examination, it was revealed that Dokai Bay could no longer be called "a sea" because the water color was reddish black or yellowish black. At that time, chemical analysis of samples taken at the depth of 3m from inner most to middle parts of the bay revealed the following results: DO 0 mg/l, SS 765～1,082 mg/l, and pH 6.6～7.2 etc.

In order to begin combating such horrible water conditions, Kitakyushu City enthusiastically petitioned the Economic Planning Agency (at that time, the Environment Agency had not yet been established and the Economic Planning Agency had taken charge of environmental administration) and Dokai Bay was eventually appointed a designated sea area. "The Water Quality Conservation Law", the environmental law of those days, required that polluted bodies of water had to first be appointed as a designated area based on the results of water quality investigations carried out by the Economic Planning Agency before any measures to control waste water would be implemented.

The water quality of Dokai Bay and waste water was investigated twice, a preliminary survey in 1968 and the main survey in 1969. The level of COD in the sea water was as high as 74.6 mg/l and harmful substances such as cyanide and arsenic were analyzed at levels as high as 0.64 mg/l and 0.15 mg/l, respectively. From these results、it was revealed that Dokai Bay was polluted with different kinds of organic matter and harmful substances of a very high concentration. After these investigations, Dokai Bay was reported all over the country as "the Dead Sea".

#### 4.1.2 Structure of Dokai Bay's water pollution[1,2)]

With these investigations by the Economic Planning Agency, it was also reported that the total volume of effluent, sewage and waste water discharged into Dokai Bay from the twenty biggest companies was about four million and eighty thousand cubic meters a day in 1969 and the total load of COD of them was about two hundred and thirty three tons a day, as shown in **Fig. 17-2**. As 98.5 % of the total volume of effluent and 97.3 % of the total load of

COD were produced by these twenty biggest companies, it was found that the cause of the serious water pollution of Dokai Bay was waste water from industrial plants.

According to test results of the water quality of waste waters from 75 drainage mouths of 22 industrial plants, COD and harmful substances such as phenol and cyanide were at levels as high as 400 mg/l、45.0 mg/l、25.0 mg/l respectively, as shown in **Table 17-2**. These results indicated that almost all waste waters from industrial plants to Dokai Bay were seldom treated at that time.

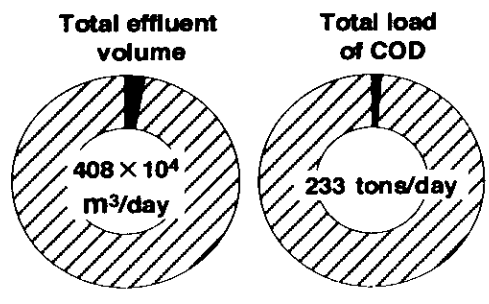



**Fig. 17-2** The load of effluent and COD to Dokai Bay in 1996.
■, Sewage;
▨, Twenty big companies.

**Table 17-2** Water quality of effluents from industrial plants to Dokai Bay

| parameters | Number of samples | Unit | Concent-ration |
|---|---|---|---|
| Transparency | 16 | cm | 1.0～27.0 |
| pH | 16 | | 3.0～10.1 |
| COD | 16 | mg/l | 8.0～400 |
| SS | 16 | mg/l | 10～2,366 |
| Oil | 16 | mg/l | 0.6～5.5 |
| Phenol | 14 | mg/l | 2.0～45.0 |
| Cyanide | 18 | mg/l | 0.55～25.0 |

### 4.1.3 Appointment as a Designated Sea Area and the Strict Old Effluent Standard

After these investigations, an open hearing with local residents, companies and public bodies was held by an environmental advisory committee of the Economic Planning Agency. After that Dokai Bay was appointed as a designated sea area in November of 1970. The "effluent water quality standard (referred to as 'the "old effluent standard' hereafter) was also announced at this time. The designation of the sea area was broadened from Dokai Bay to the Hibiki Sea to where Dokai Bay's mouth opens. The old effluent standard had been established based on the assumption of categories of water condition(purpose of water use) which was applied on there the next year.

The old effluent standard set maximum limits on the amount of pollutants permissible in effluent. These varied depending on the kind of industry. For instance, the old cyanide standard of effluent for the steel industry and the organic chemicals manufacturing industry was set at 0.5 mg/l, which was a concentration standard stricter than the national uniform effluent standard of 1.0 mg/l based on the Water Pollution Control Law, the present environmental law" notified on September in the same year. Because there were so many factories discharging cyanide into the bay, it was estimated that implementation of the 1.0 mg/l standard would not be sufficient to load to improvement the water quality of the bay. Also the old COD effluent standard of 15-60 mg/l was much stricter than the COD national uniform effluent standard of 160 mg/l. This strict COD standard value was established according to the results of the box model equation used by the Economic and Planning

Agency. The model indicated the necessity of the reduction of the total COD load of Dokai Bay by a seventh in order to recover the self-purification action of the sea water within 5 years. On the other hand, the old oil effluent standard for the steel industry of 6 mg/l was not so strict compared to today's standards, because in those days sea water taken from Dokai Bay to be used as a coolant was already contaminated with oil at levels as high as 5 mg/l.

On May 1971, categories of water conditions of Dokai Bay, the Hibiki Sea and two rivers flowing into Dokai Bay were designated under the Basic Law for Environmental Pollution Control. Then Environmental Quality Standards (EQS) which are targets for environmental preservation administration, were applied.. Although the national uniform effluent standards were established in June of 1971 under the Water Pollution Control Law, control of effluents from factories was carried out according to the old effluent standards because it was stricter than the new national uniform effluent standards. Afterwards, additional more stringent effluent standards were established by Fukuoka Prefecture in 1973. Thus effluents were controlled with these new effluent standards which had almost the same values as those of the old effluent standards.

Based on the Water Pollution Control Law, Kitakyushu City was authorized to inspect factories and business establishments. Furthermore, legal authority concerning effluent control including the handling of related official documents and reports, the inspection of effluent from specified factories, and issuing of orders for the improvement of facilities was transferred from the governor of Fukuoka Prefecture to the mayor of Kitakyushu City. Kitakyushu City was then able to carry out its own water quality conservation administration. Consequently, the number of effluent standard violations by the factories discharging effluents into the Bay decreased rapidly. In recent years, the number of violations has been reduced to one or two as shown in **Fig. 17-3**.

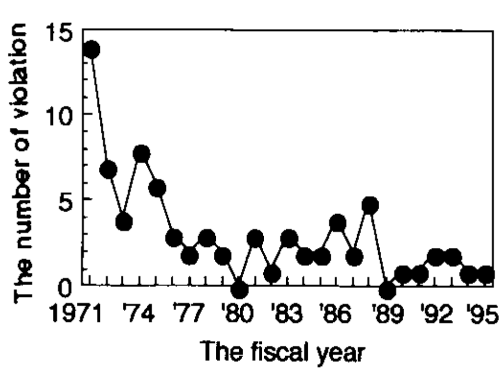



**Fig. 17-3** The number of effluent standard violation in the Dokai Bay area.

### 4.1.4 Conclusion of "Agreement on Environmental Pollution Control"[3)]

The agreement on environmental pollution control, an administrative method used by the city based on the Municipal Pollution Prevention Ordinance system, is a non-legally binding pact made with companies. Some large scale companies which were planning to construct factories in the city were forced to conclude this agreement with the city. Also once the existing factories concluded the agreement, they were subject to strict checks such as reports on the water quality of effluents or on the spot inspections. The companies however received city's recommendation openly and then invested large amounts of money in order to establish effective industrial treatment plants. Fifteen agreements were concluded between Kitakyushu City and companies discharging effluents into Dokai Bay and the Hibiki Sea during the fifteen years from 1970 to '94.

### 4.1.5 Efforts by Companies [4]

Big companies locating along the coastal line of Dokai Bay had begun to recognize their social responsibility for industrial pollution. Since around 1968, each company started full scale research of effluent treatment methods by gathering the engineering technology accumulated by each company. Then new treatment methods were developed and effective treatment plants were constructed in the factories, one after another. For example, an activated sludge method had developed instead of a phenol extraction method for the treatment of the coke oven waste water from the steel industry and waste water contaminated with oil was treated by new separation technology. In this way, new treatment plants were constructed successively along the coast line of Dokai Bay. As shown in **Fig. 17-4**, the total quantity of both COD and oil in the effluent from Yawata Steel Company in 1971 was reduced by half compared with 1970 levels. These facts revealed that the construction of treatment plants was effectively reducing the load of pollutants to the bay.

The steel company's effluents control efforts had extended from reducing pollutants concentration to also reducing the effluent volume. For instance, as closed systems of water used in the manufacturing process had already developed, the circular rate(reuse rate) of water increased only 12 points during the 27 years from 1970 to '96, as shown in **Fig. 17-4**. However, the total volume of effluent including indirect cooling water had been reduced by 2% over a 26 year period, by employing such methods as the cascade method for water processing. These results show that the amount of effluent itself was reduced, while processes for steel production were actually improved. Technological innovation concerning the steel production process not only made the total effluent volume reduction, but also saved energy and other resources, thus minimizing industrial waste and at the same time improving the quality of pig iron. It can be said that these positive developments in steel production resulted from the "cleaner production system" developed by the company over time.

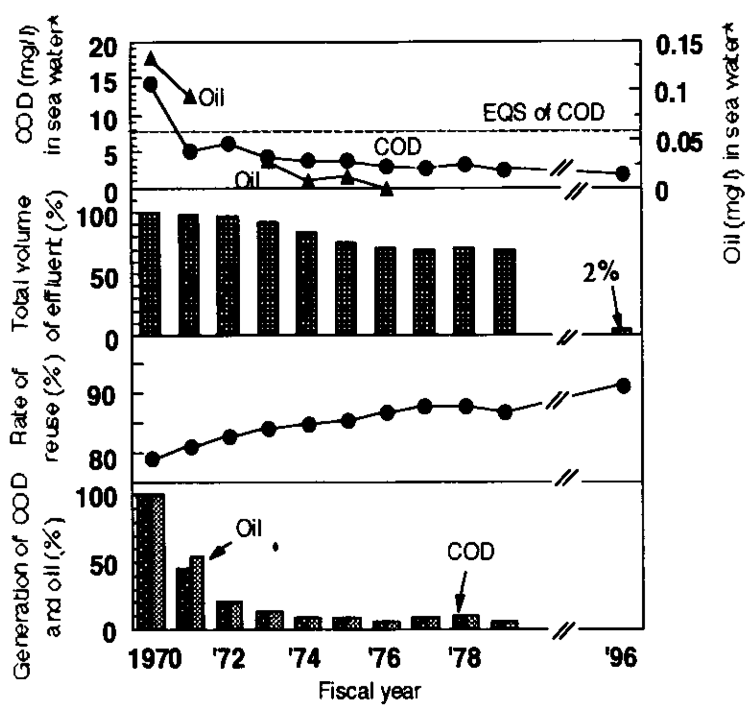



Fig. 17-4 The results of measures for the effluent from Nippon Steel Company Yawata
* The sea water was sampled from the surface layer of the middle part in the bay.

### 4.2 Improvement of the Sewerage System

As a part of the preparation of the infrastructure of Kitakyushu City, improvement of the sewerage system had been started around Dokai Bay. Kogasaki sewage treatment plant located at the inner most part of Dokai Bay started its operation from 1963. This plant cleared the old effluent standards such as BOD 20 mg/l, SS 70 mg/l, and coliform group 3,000 ind./$m^3$ in 1970. On the other hand, as the effluent from night soil treatment plant could not clear the old effluent standards, improvement of the treatment was necessary. Incidentally, the percentage of sewered population in Kitakyushu City reached 95.4 % at the end of fiscal year '96 (shown in **Fig. 17-5**) as the improvement of the sewerage system was promoted under the Environmental Pollution Control Program.

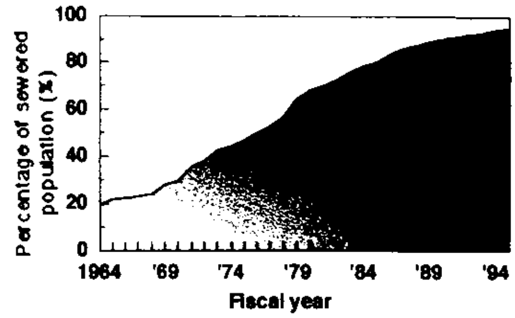


**Fig. 17-5** Increase in the percentage of sewered population in Kitakyushu City.

### 4.3 the Dredging of Polluted Sediment

During the course of the investigations in Dokai Bay by the Economic and Planning Agency in 1968 and '69, the sediment quality was surveyed as well as water quality. From these surveys it was revealed that sediment pollution had progressed to include almost the whole area of the bay and had become serious as the concentration of N-hexan extract in the sediment was as high as 2.9-17.0 mg/kg dry. At that time, polluted sediment was called "Hedoro" in Japanese, and Dokai Bay was reported as one of the two most markedly polluted sea areas in Japan where tremendous amounts of Hedoro had accumulated.

Although dredging the polluted sediment had been proposed by the Economic and Planning Agency as the most effective means for purifying the aquatic environment of Dokai Bay, such a dredging project of so polluted sediment had never been executed before. Therefore the Kitakyushu Port Management Association (the former Kitakyushu Port and Harbor Bureau) had started the investigation of the physico-chemical characteristics of polluted sediment in Dokai Bay in detail from 1971, and then began discussing dredging methods[1,5].

#### 4.3.1 Status of the Polluted Sediment [1,5]

The results of this detailed investigation recovered a thickness of the polluted sediment reaching 4 m, and the total volume of polluted sediment was estimated as much as 4,080,000 $m^3$. Vertically, the layer where the maximum concentration of hazardous substance such as cyanide had been detected was 2.25-3.05 m deep, not just on the surface layer. Geographically, harmful substances had been found to be concentrated at the inner part of the bay and the Yahata Basin, as shown in **Fig. 17-7**. The minimum concentrations of cyanide,


**Fig. 17-6** Polluted sediment in Dokai Bay in 1971

cadmium and arsenic were as high as 327 mg/kg, 603 mg/kg, and 670 mg/kg respectively. These concentrations were the highest in Japan in those days. Other hazardous substances including total mercury (551 mg/kg), total chromium, lead, zinc, organic phosphate, and tar had also been found to contaminate the sediment of the bay in high concentrations.

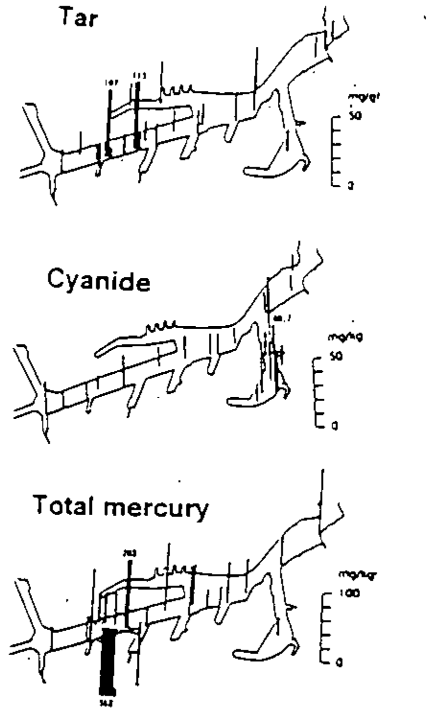



Fig. 17-7 The status of polluted sediment in Dokai Bay in 1971

### 4.3.2 Crisis Management and the Aim of Dredging the Polluted Sediment[1,6]

When a big project costing a lot of money is to be carried out, there is often a tendency to place more weight on minimizing expenditures than maximizing the effectiveness of the project. However, during the dredging of Dokai Bay, the effectiveness of the operation was given complete priority in on effort to reduce the risk of harmful after effects.

"In those days, there were no adverse affects on human health because no fishery products were being taken from the bay. However, when aquatic organisms begin to come back to Dokai Bay after the improvement of the water quality, there arises the anxiety that hazardous substances will be accumulated in the different kinds of aquatic organisms through the food chain and finally be passed on to humans. Also, though the elusion of mercury from the contaminated sediment was not observed in these days, there was concern that the dissolved oxygen in the aquatic environment would become overly rich, and the chance that inorganic mercury would be organized by bacteria and eventually be accumulated in aquatic organisms. Therefore, aiming for the prevention of such serious conditions, the dredging of the polluted sediment contaminated with mercury in high concentration had been decided. At that time, Japan was also dealing with effect of the environmental disaster in Minamata, such environmental problems and public safety was becoming the big issue. Thus while struggling with the difficulty for predicting the future risk scientifically, dredging the polluted sediment in Dokai Bay was begun in 1974.

### 4.3.3 Removal Standards for Polluted Sediment and Deciding the Areas to be Dredged [1,5]

The removal concentration standard for polluted sediment was calculated by referring to the elusion rate of hazardous substances and based on figures from the Environment Agency. However the mercury, which had an average concentration in the sediment of Dokai Bay was 49.5 mg/kg, never elutted from the sediment, therefore it did not meet this standard. Finally a removal standard was established based on the case of Tokuyama Bay. The bay was located in the Seto Inland Sea, where sediment had been contaminated with mercury at the average concentration of 22.6 mg/kg.

When environmental concerns about Tokuyama Bay surfaced, Minamata Disease had not yet broken out, but some persons who took a lot of fishery products from Tokuyama Bay had already accumulated high levels of methyl mercury in their hair. It was calculated by the arithmetical mean method that the mercury concentration in the sediment for dredging in Dokai Bay was to be at 60 mg/kg or above in order to reduce the mercury concentration to be no more than Tokuyama Bay's 22 mg/kg. Furthermore, the Environment Agency and the Kitakyushu Port Management Association had decided to dredge sediment contaminated with total mercury at the concentration 30 mg/kg or above, taking the safety factor into consideration. The total volume of the sediment for dredging was as much as 350,000 $m^3$ which covered nine areas as shown in **Fig. 17-8**.

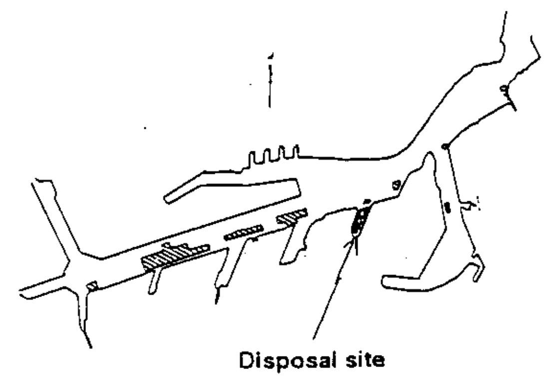



**Fig. 17-8** Dredging areas and the disposal site of polluted sediment in Dokai Bay

### 4.3.4 New Dredging Method for Polluted Sediment [1,5]

Based on various investigations, Kitakyushu Port Management Association started the dredging project in 1974 and completed it in '75. As shown in **Fig. 17-9**, fences had been placed around the dredging sites to prevent the diffusion of polluted sediment. Improved closed type grave dredging ship and closed type burgs were developed to prevent the leakage of polluted sediment and a following second contamination.

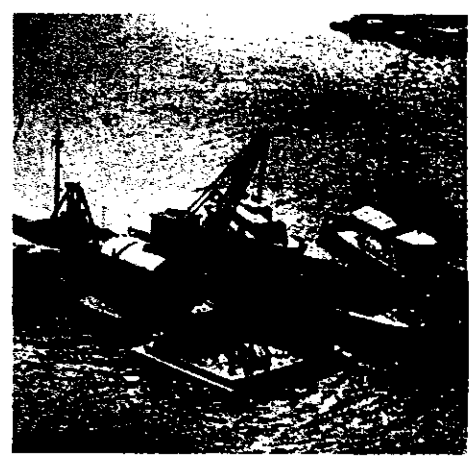


**Fig. 17-9** Dredging of polluted sediment in Dokai Bay from 1974.

### 4.3.5 A New Method for Depositing the Polluted Sediment [1,5]

The disposal site chosen for the polluted sediment was Nishiyahata Basin with an area of 57,200 $m^2$. It was actually located in the middle part of the bay, not outside of the bay. Before the dredging, a barrier ( a closing bank protection) was constructed in 1973 in order to wall off Dokai Bay from the disposal site.

A synthetic rubber sheet was spread on the ground of the deposit site to prevent the leaching of pollutants from the sediment into the ground, before the disposal of any polluted sediment. After the disposal of the polluted sediment, as much as 350,000 m3, ultra unstable ground was formed of 7 m thickness. As part of the sanding method of such weak ground, the bamboo net construction method was developed. This method involved the laying of a bamboo net, sheet, sand(1.0 m) and mountain soil(0.5 m) in this order on the unstable ground. This series of dumpings and sanding projects was completed in 1976. After that, the sanded disposal site was bought from Kitakyushu City by a company located adjacent to the disposal site. It has been used as a storage place for materials ever since.

### 4.3.6 Cost for Dredging [5,6]

The dredging project cost a total of six million US dollars. These costs were shared by the public and private sector over 1972 and '73. The private sector's rate was calculated by referring to the two parameters of suspended solids and hazardous substances for human health, according to the "Polluter Pays Principle" (PPP). The remaining cost was covered by the public sector.

As shown in **Table 17-3**, the private sector ( companies located along the coastal line of Dokai Bay) paid 4.3 million or 71% of the total costs, as the dredging expense originated primarily from industrial waste water. On the other hand, public sector paid 1.7 million or 29% of the expenses reflecting the public's share for domestic waste water as well as covering the share of bankrupt businesses. In the public sector, the national government paid a half, and the prefecture and the city shared a quarter respectively.

## 5. Drastic Improvement of the Water Quality and the Following Return of Aquatic Organisms [1,2]

Water quality in Dokai Bay improved rapidly since 1971, as shown by decreases in COD and oil concentration of sea water at D6, the middle part of the bay, in **Fig. 17-4**. Almost all the parameters of the EQS at all sampling points in the bay achieved each standard value by '73.

Kurumaebi Prawn were again harvested from the Bay in 1983, and then 527 kinds of species of organisms were confirmed to have returned to the bay by biological investigations carried out over 5 years from '89. Organisms conformed to have returned to Dokai Bay

**Table 17-3** Cost sharing rate of dredging work of polluted sediment in Dokai Bay

| Sector | Responsable for: | Proportion by pollution amount (%) | | Total percentage to be shared (%) | Share in the cost (US million $)* |
|---|---|---|---|---|---|
| | | Amount of suspended solids | Amount of hazardous substances | | |
| Private sector | Industrial waste water | 54 | 87 | 71 | 4.3 |
| Public sector (Government, Prefecture, City) | Domestic waste water & the Industrial waste water of bankrupt businesses etc. | 46 | 13 | 29 | 1.7 |
| | | 100 | 100 | 100 | 6.0 |

*Exchange rate, 1$=300¥ in 1972.

included organisms from up and down the food chain; from phytoplankton,at the bottom to fish and birds at the top. This return of so many organisms has proved the improvement of water quality of the bay biologically.

## 6. Conclusion

Dokai Bay's experience in controlling industrial pollution has been evaluated as a "success story", nevertheless due to delays in implementing purification measures, there was a lot of damage to the aquatic environment of the bay. In the early 20th century, the Japanese sense of values had given way to the priority of economic development. Awareness of the water pollution that always accompanies industrial development had not yet spread among citizens, companies, and the government. Even if citizens had been more critical of industrial pollution, it would have been difficult to prosecute the companies because Kitakyushu City was very dependent of the local industries.

In that difficult situation, measures for controlling industrial pollution were only implemented after citizens suffered damage from water pollution. Citizens' compliants about offensive odor caused by the water pollution of Dokai Bay led the first survey of water quality by a city government. With the scientific results from this survey as a tuning point, efforts for the purification of the aquatic environment of Dokai Bay were increased. From this progress, it can be said that citizens' power made the first opportunity of the enforcement of the measures for purification by government and companies. The role of journalism also can not be ignored for making the citizens' consensus regarding the urgency with which measures against pollution needed to be enforced.

On the other hand, regrettably, in those days the local government of Kitakyushu City had not been given the legal authority for environmental administration. The only thing that the Kitakyushu City government could do was to try response to citizens' demands for the Economic Planning Agency to carry out the preliminary survey. The results of this survey were eventually used to judge whether effluent discharged into Dokai Bay would be controlled or not. After the preliminary survey of Dokai Bay, the Economic Planning Agency had expressed the opinion that " As Dokai Bay is a sea almost beyond rescue, this bay may never be appointed a designated area" . Even faced with such a negative response, the citizens and the local government earnestly appealed to the agency for the appointment until they finally won the appointment.

Companies had started the treatment of the waste waters with all their strength even before the establishment of the old effluent standards. Companies realized their social responsibility for the water pollution because the connection between polluters and the resulting damage was very clear. The development of waste water treatment technology and the enormous investment by plants in equipment led to the brilliant achievements of the satisfaction of environmental quality standards and the following development of cleaner production technology. It can be said that Dokai Bay's success story was the result of joint efforts by the citizens, companies, government and universities. Each branch played an important role, communicating amongst each other, and enforcing the protection measures with trial and error.

Through the experience of combating industrial pollution, citizens group found that the most important role of citizens is to continually monitor the environment and to make mutual agreements on behalf of environmental conservation. Companies have also demonstrated that industrial water pollution can be overcome with the effluent treatment and furthermore have proved that saving energy and resources can be consistent with quality improvement of products if you consider the lower costs of cleaner production technology.

Government groups have formed or improved legal, institutional, and organizational systems. For instance, the national government established the Water Pollution Control Law which contains the idea of national minimum. Local government also established the Pollution Prevention Ordinance System which is adaptable to each local situation. Various other new methods, such as agreements of pollution prevention and favorable tax treatment and financing for pollution prevention projects were created. Then the Environment Agency and Pollution Measures Bureau were established in national government and local governments respectively to jointly manage environmental administration. Government groups have recognized that scientific research of actual conditions are important work and free access to such information is necessary in order to foresee the outbreak of serious conditions and to begin working towards the enforcement of corresponding measures. In order to facilitate more complete and real time environmental administration, local governments recognized that it is important to environmental administration authority transferred from national to local governments. Kitakyushu City plans to make use of these lessons and the technologies acquired in the course of the experience of Dokai Bay's Success Story for future international environmental cooperation.

## 7. References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## Chapter 18 LAKE BIWA

### 1. Introduction

Lake Biwa is the largest lake in Japan, being located in the uppermost reaches of the Yodo River Basin in central Honshu Island. The lake occupies one sixth of the prefectural territory of Shiga as shown in **Fig.18-1**. In the downstream reaches of the basin, there are metropolises such as Kyoto, Osaka and Kobe and other small municipalities in Kyoto, Osaka and Hyogo Prefectures. The total population of this region is 13 million. The lake supplies water for domestic, industrial, hydroelectric and irrigation purposes in the region.

In this paper, firstly, we will survey the changes in social and natural condition of the catchment area and the water quality in Lake Biwa with increase in human activities including LBCDP. Secondly, measures for improvement of water quality carried out or planned by Shiga Prefectural government will be presented.

### 2. Lake Biwa-Yodo River Basin

To understand the history of water resource development and water quality conservation of Lake Biwa, it is important to recognize the unique geographical feature of the Lake Biwa-Yodo River Basin and upstream-downstream relations with respect to water resource development of Lake Biwa.

### 2.1 Lake Biwa

Outline of the lake is shown in **Fig.18-2**. The lake has a total surface area of 671 $km^2$, a volume of 27.5 billion $m^3$. Its catchment area is 4.7 times the area of the lake itself, and its boundary more or less coincides with that of the prefecture, constituting 96% of prefectural land (**Fig.18-3**). The catchment area consists of forest-covered hills and mountains (60%), paddy fields and other farmlands (25%), and urban and industrial areas (**Fig.18-4**). The prefectural capital, Otsu, has an approximate population of 270,000 and is located at the southern end of the lake. Some 400 rivers and streams flow into the lake, but there is only one natural water course flowing out of the lake, Seta River, and two canals passing lake water to Kyoto.

The lake serves as a source of domestic and industrial water for both populations within the lake catchment area and the downstream population and industrial centers in the Keihanshin Area (**Fig.18-5**). It also serves for irrigation of paddy fields in the lake basin flat lands and for hydropower generation at some distance downstream of the outflowing river. Lake Biwa has been the most important natural asset for the prefecture, and Shiga residents have had a special attachment to the lake throughout history because of their dependency on the lake for fishing and transportation.

In the past century or so. the water-use pattern has changed significantly due to various water resource development activities (**Fig.18-6**). The two canals linking the lake and Kyoto were constructed in 1890 and 1912, respectively. The City of Kyoto, therefore, has had direct access to lake water unlike other downstream metropolises. The Seta River reaches to the prefectural boundary between Shiga and Kyoto. Within Kyoto Prefecture, it is called Uji River. Uji River is met by Kizu River and Katsura River at the Kyoto-Osaka Prefectural boundary, and the downstream stretch from this point is popularly called the Yodo River. The flow contribution to the Yodo River of the Uji, Kizu and Katsura Rivers are, respectively, 64%, 18% and 15%.

Economics in Shiga Prefecture was primarily dependent on agriculture before World War II, however, the prefecture has experienced remarkable economic growth from 1960's. The economic growth was realized by the advantageous location of the prefecture, i.e., easy

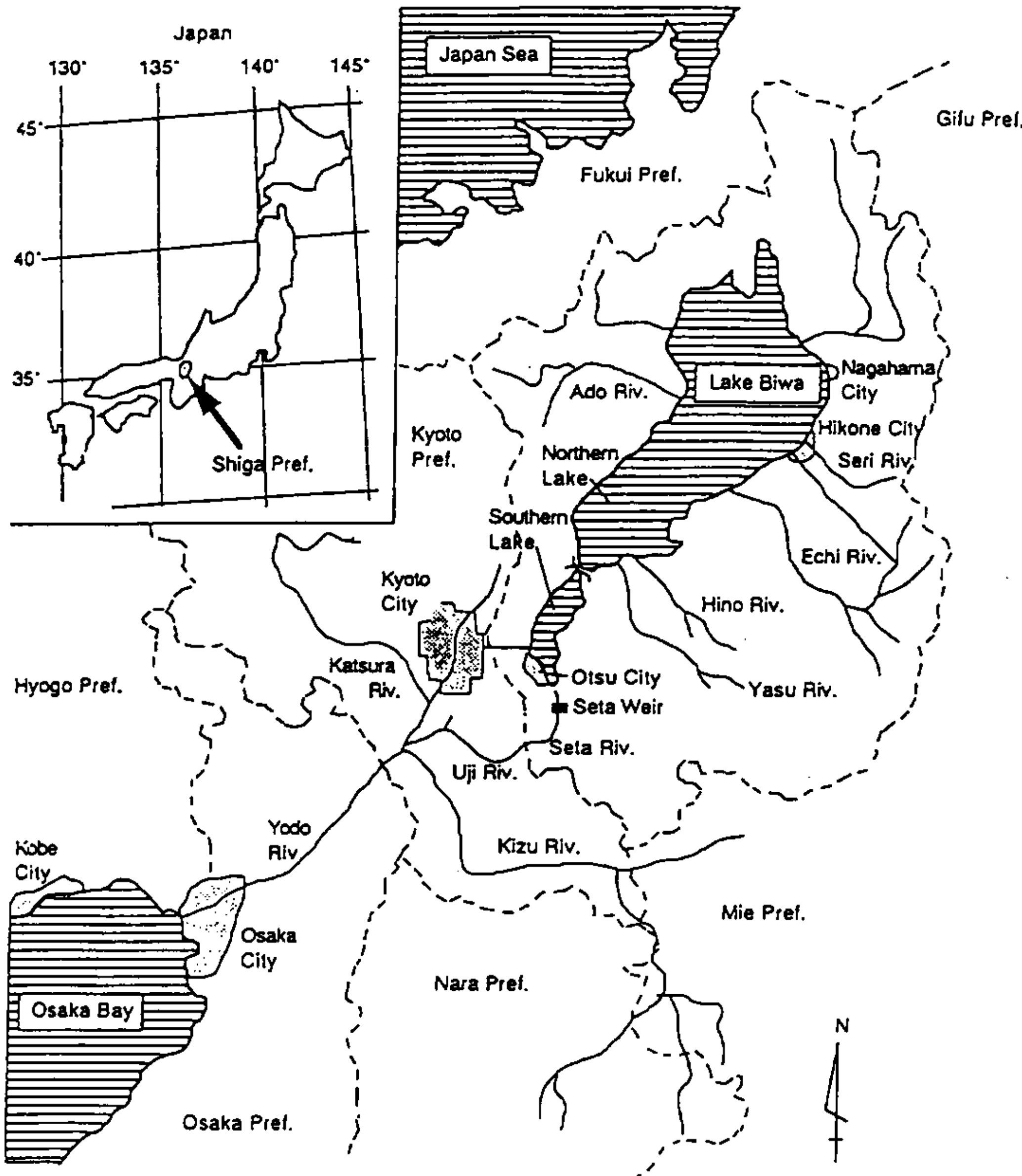



**Fig.18-1** Lake Biwa and the Yodo River Region

Source: "Lake Biwa", Shiga Prefectural Government, 1991 accessibility to national-wide transportation network (Meishin Highway and Shin-kansen), which accelerated shipments of factories into the prefecture. As a results, the prefecture became an active inland industrial area. In addition, population migration, seeking for low cost house or apartment, into the prefecture from Kyoto, Osaka and Kobe increased the prefectural population up to 1.3 million in 1996 (**Fig.18-7**).

## 2.2 Yodo River System

The official designation of the whole of the Yodo-Uji and Lake Biwa water bodies is the Yodo River System. Its total catchment area, as observed at Hirakata, some 20 km upstream of the river mouth, is 7231 $km^2$.

At present, the metropolitan regions of Osaka, Kyoto and Kobe depend almost exclusively on the Yodo River for industrial and municipal water supplies. Thus, Lake Biwa accounts for water supplies amounting to 20 billion tons per year, and serving as many as 13 million people living in the Keihanshin Area including Shiga. Lake pollution, therefore, has been of serious concern not only for those living around the lake but also for those receiving water from the Yodo River.

The outline of Lake Biwa.

| | |
|---|---|
| The whole area of Shiga | 4,017㎢ |
| The catchment area of Biwa | 3,174㎢ |
| The area of Lake Biwa | 670.51㎢ |
| The length from north to south | 63.49㎞ |
| The widest part | 22.80㎞ |
| The narrowest part | 1.35㎞ |
| The circumference of Lake Biwa | 235.20㎞ |
| The deepest point | 103.58 m |
| The average depth | 41.20 m |
| The amount of water stored in the lake | 275×$10^8$ $m^3$ |
| The average depth of the northern basin | ca. 43 m |
| The average depth of the southern basin | ca. 4 m |

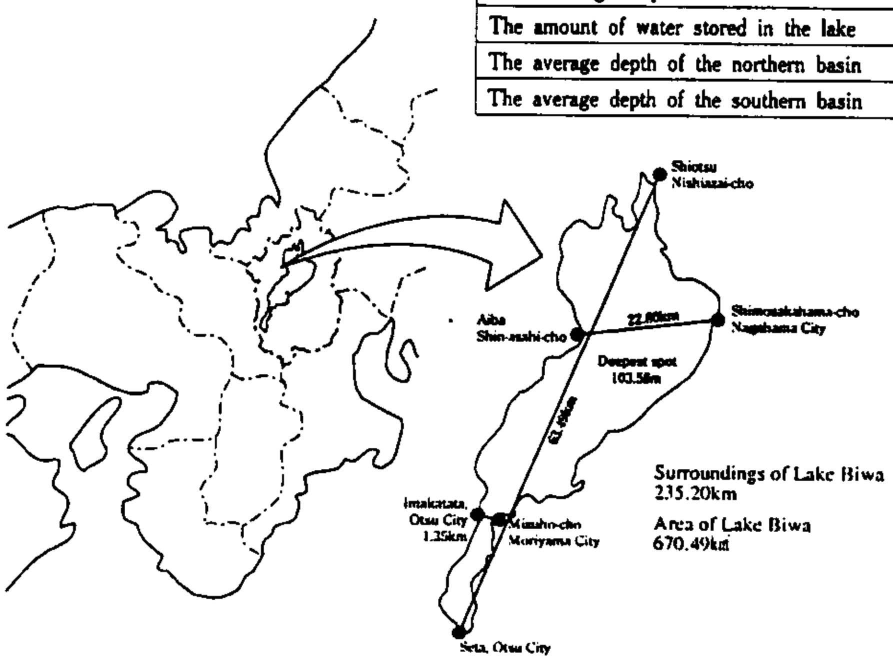



Fig.18-2 The Location of Shiga. (Source:ref.5)

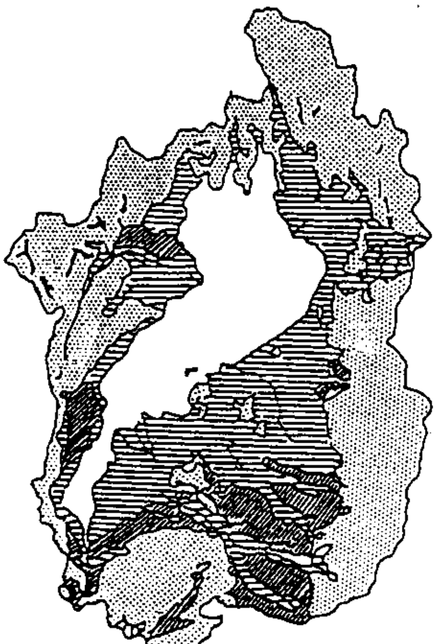
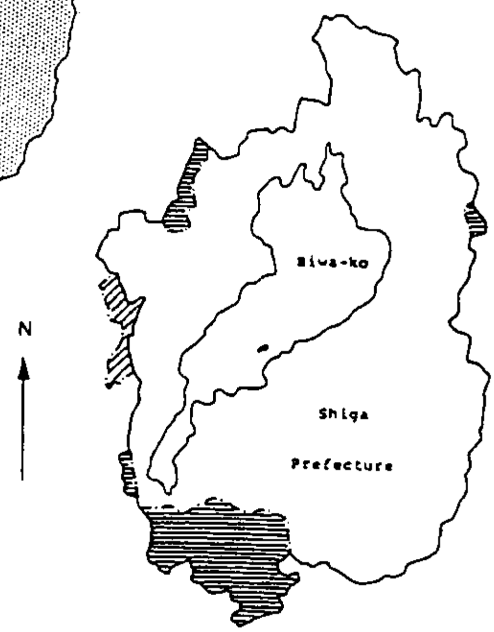


**Fig.18-3** Topography in the Lake Biwa catchment area: (☐) mountains; (▨) hills; (■) low areas. Comparison of the boundaries of Shiga Prefecture and Lake Biwa drainage basin: (—··—) drainage basin boundary; (——) prefecture boundary; (▤) in the prefecture, but outside the drainage basin; (▨) in the drainage basin, but outside the prefecture. From LBRI and NIRA (1984).




(Source:ref.7)

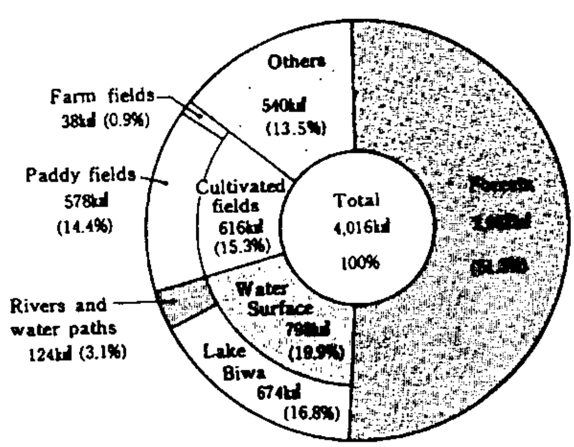



**Fig.18-4 Land Use** (Source:ref.1)

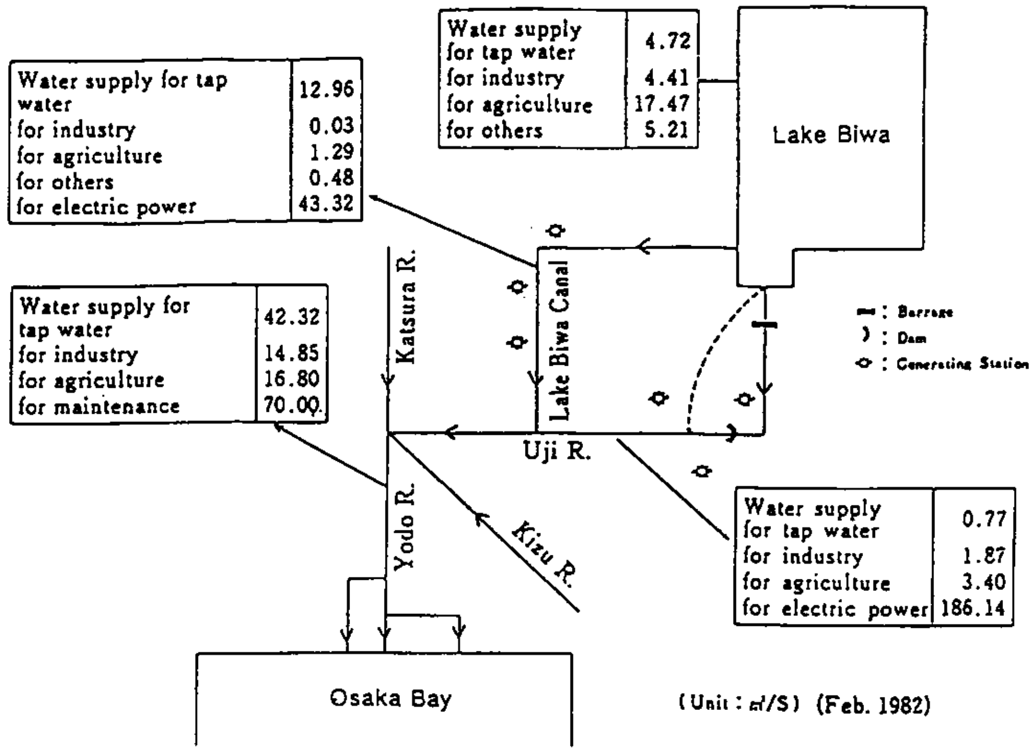



**Fig.18-5 Water uses in the Lake Biwa-Yodo Basin (Source: ref.1)**

The history of Lake Biwa and Yodo River water management was one of a conflict of interests and the resolution between Keihanshin Area downstream, particularly the Greater Osaka Region, and the Shiga Prefecture upstream For centuries. The communities in the immediate surroundings of Lake Biwa experienced severe flooding of their agricultural fields before the government finally agreed, about a century ago, to a major dredging of the Seta River at the outlet of the lake, in combination with the construction of Seta Weir, the only artificial water-flow control facility of the lake outflow. It is located a few kilometers downstream from the lake outlet. The weir, constructed in 1905 and renovated in 1961, controls the lake water level and discharge rate to Yodo River. The flood frequency and the flood damage in the lake catchment were drastically reduced after the weir construction. The demand for water, particularly for industrial uses, began to increase sharply as the country entered the era of economic growth a decade or so after the end of the War.

In the downstream stretch of Yodo River, the Hanshin Industrial Belt established in pre-war years began to thrive with unfulfilled demands for more water. Exploitation of groundwater soon became constrained due to competition of use among industrial establishments and to land subsidence caused by overdrafts of water. Industries were then forced to look for alternative sources of water. Domestic water supply needs also began to increase in the Yodo River areas after suburban cities joined Osaka in gaining access to Yodo River water.

Japanese economic growth gained momentum by the mid-1950s, and there was significant interest in the development of a comprehensive development plan of Lake Biwa water resources by the down stream population and industrial centers. After nearly two decades of political pressure on Shiga Prefecture, consisting of demands by downstream interests and the initiatives by the national government ministries, Shiga Prefectural Government finally agreed to a scheme for the comprehensive development of Lake Biwa.

**3. Social and natural environment of Lake Biwa**

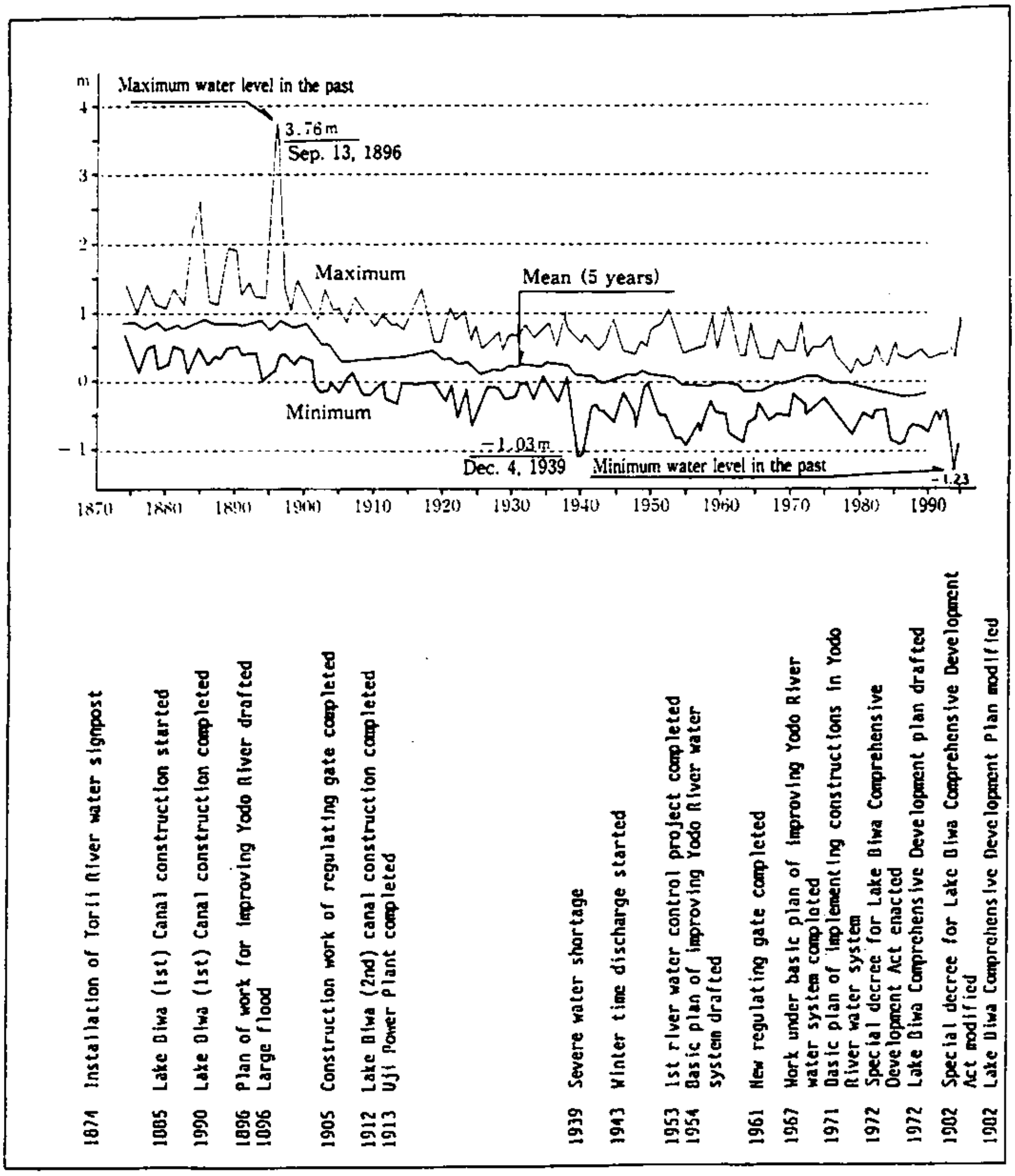



**Fig.18-6** Changes in Water Level of Lake Biwa

Source: "Lake Biwa", a brochure published by Kinki Regional Construction Bureau, Ministry of Construction, Japan

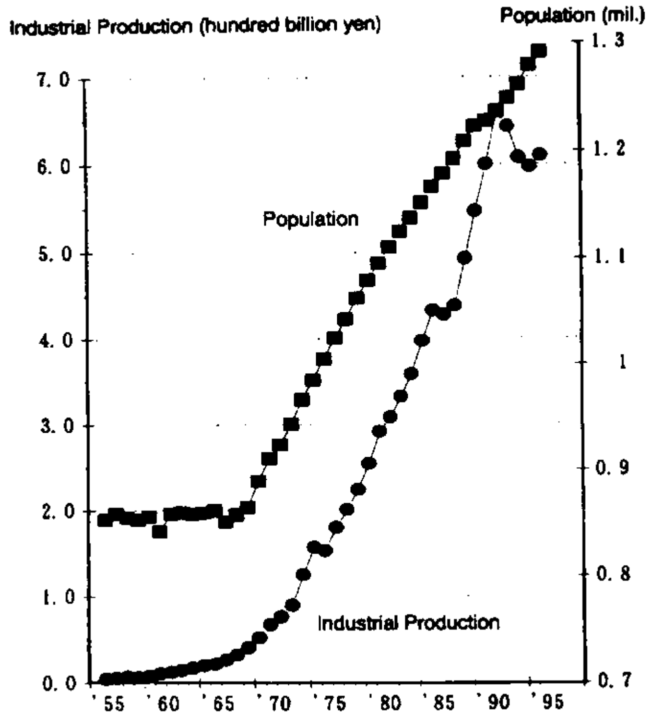



**Fig.18-7** Annual trend of population growth and industrial production in Shiga Prefecture.

(Source:ref.1)

### 3.1 Outlook

Lake Biwa is among the oldest lakes in the world, to be compared with the Caspian Sea in the central Asia, Baikal in Russia and Lake Tanganyika in East Africa. As one manifestation of Lake Biwa's longevity, there are approximately 60 different species of fish and 40 kinds of shellfish, and various kinds that can be identified as indigenous to Lake Biwa.

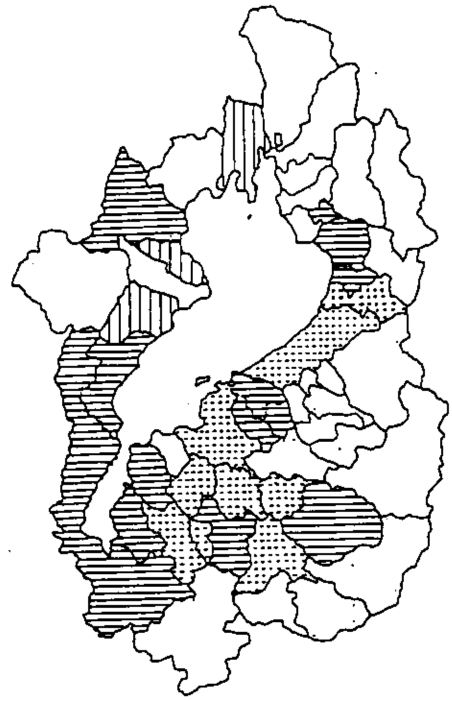
At the mouth of the Yasu River, Lake Biwa narrows to a width of 1.35 kilometers. At this narrowest point we have the Biwako Bridge. From the bridge upwards, we have designated the northern Lake as the main basin and downwards, the southern lake, the secondary basin. The average depth of the northern lake is 43 meters, while that of the southern lake is only 4 meters. Owing to the difference in the basin configuration between these two lakes, the one is a striking contrast to the other in many respects, such as water quality and aquatic organisms.

The surface area of the northern lake is 616 square kilometers and it occupies approximately 90 percent of the whole Lake. As shown in **Fig.18-2**, the northern lake (mean depth 43 meters) is deeper in depth than the southern lake (mean depth 4 meters) and it has two concavities in the bottom on the western side. The southern lake is very shallow and with a surface area of about 58 square kilometers.

### 3.2 Water use

One of the most outstanding modern features of Lake Biwa water use and allocation is that the agricultural sector has the biggest share (amounting to 93% of the total) of the water withdrawn from the lake, despite the fact that the prefecture has undergone significant industrialization and urbanization in recent decades. Throughout history also, the agricultural sector has had the oldest and most complex water-use practices and well-established customary rules of withdrawal. Industrial and municipal demands, which began to increase in the 1960s, had to compete against agricultural demand. The resulting impacts were twofold: (i) the establishment of a new rule to supersede the current destabilized and ad hoc water use and allocation rules; and (ii) the need for serious efforts to control of point as well as non-point pollution. It became clear also that there was a need to balance water uses where they competed for scarce water supplies. The variety of sources serving to supply Shiga communities is indicated in **Fig.18-8**.

Because of this importance of Lake Biwa as water resources for residents and industries in the Yodo River Basin, especially for those in downstream megalopolises, the Lake Biwa Comprehensive Development Project (LBCDP) commenced in 1972 (Nakamura 1991; Nakamura and Akiyama 1991). In this projects, the development of new water resources amounting to 40 m3/s has been agreed upon by Shiga and downstream prefectural and municipal governments, as well as by the National Government.



All or more than 2/3 are from lake water

Lake water + underground water

Lake water + surface water

All or more than 2/3 are from underground water

Underground water + surface water

**Fig.18-8** Water Sources Serving Shiga Communities (Source:ref.8)

This additional amount of water was to be made available upon completion of all originally scheduled lakeshore reinforcement works and other compensatory public works projects for Shiga Prefecture (**Appendix 1**). This project was scheduled to be terminated in 1982, however, experiencing difficulties in implementation of an array of component projects, the project term was extended for an additional 15 years up to the end of 1996, with integration of additional projects for environmental conservation.

### 3.3 Fisheries

Long term changes in annual catch of fish and shellfish in the lake is shown in **Fig.18-9.** Total catch of fish and shellfish decreased from about 1955 to now gradually due to the decrease in shellfish catch. On the other hand, fish catch did not decreased. The decrease in shellfish is considered to be caused by discharge of agricultural pesticides and deterioration of environment at lake bottom.

### 3.4 Water quality

#### 1) Long term Changes in Water Quality

As stated, the Lake Biwa catchment saw significant changes taking place following

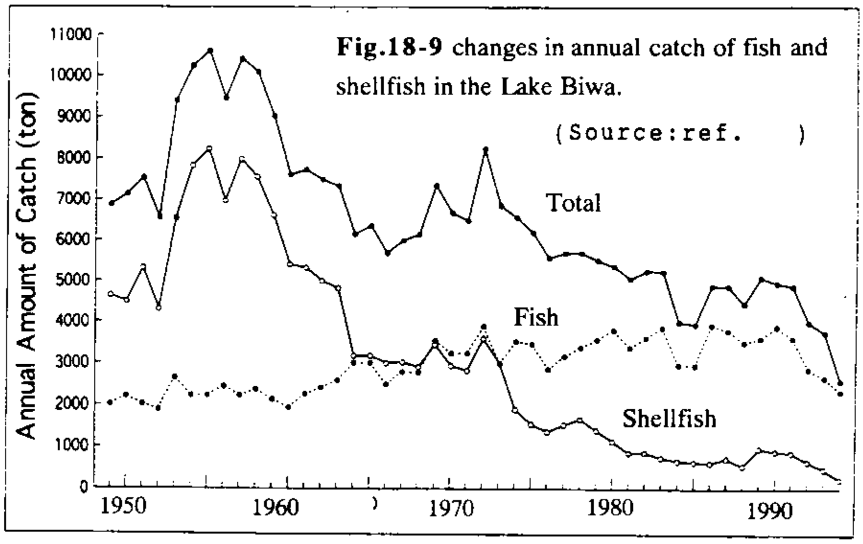



**Fig.18-9** changes in annual catch of fish and shellfish in the Lake Biwa.
(Source:ref. )

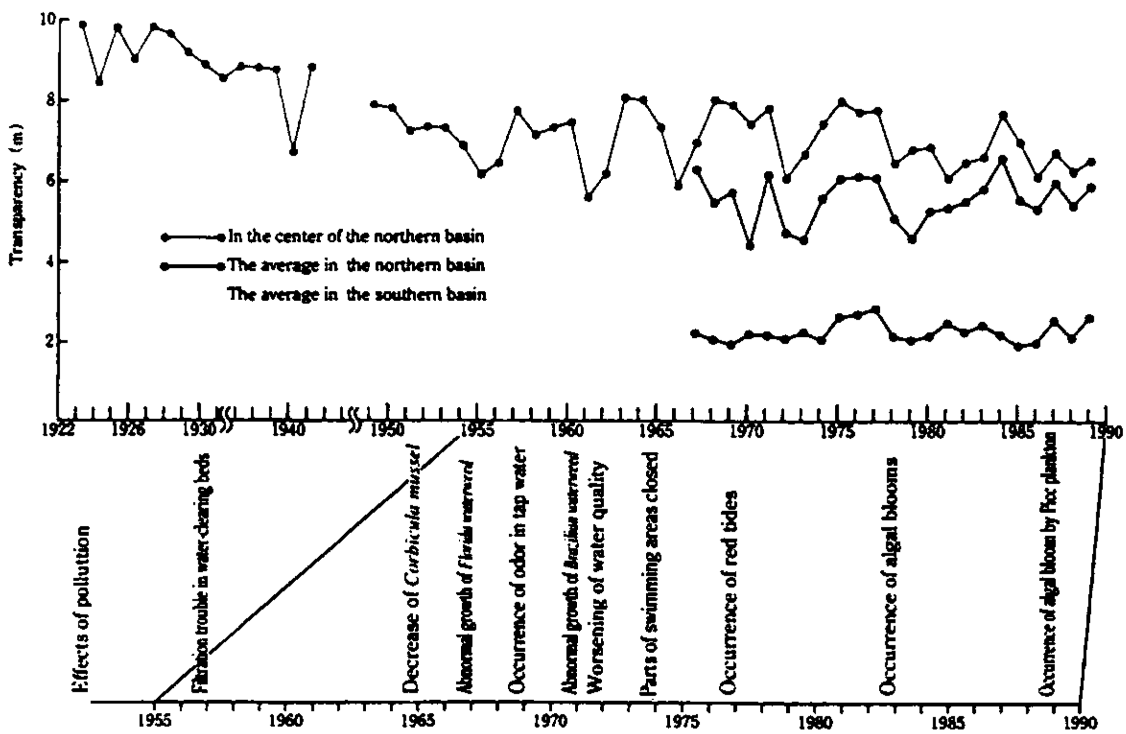



**Fig.18-10 Annual changes of water transparency.**
(Source:ref.1)

insurmountable development pressure exerted by the national development policy and which resulted in intensification of development activities downstream of the lake system (Imai et al. 1988, 1989). The most obvious outcome was an almost sudden surge of environmental stress on the lake, particularly its southern basin (the Southern Lake). To illustrate this, **Fig.18-10** indicates the long term decrease in lake transparency and shows major events attributed to lake pollution.

## 2) Eutrophication of Lake Biwa

The changes in water quality in the lake and inflowing rivers for recent two decade are shown in **Fig.18-11** and **Fig.18-12**.

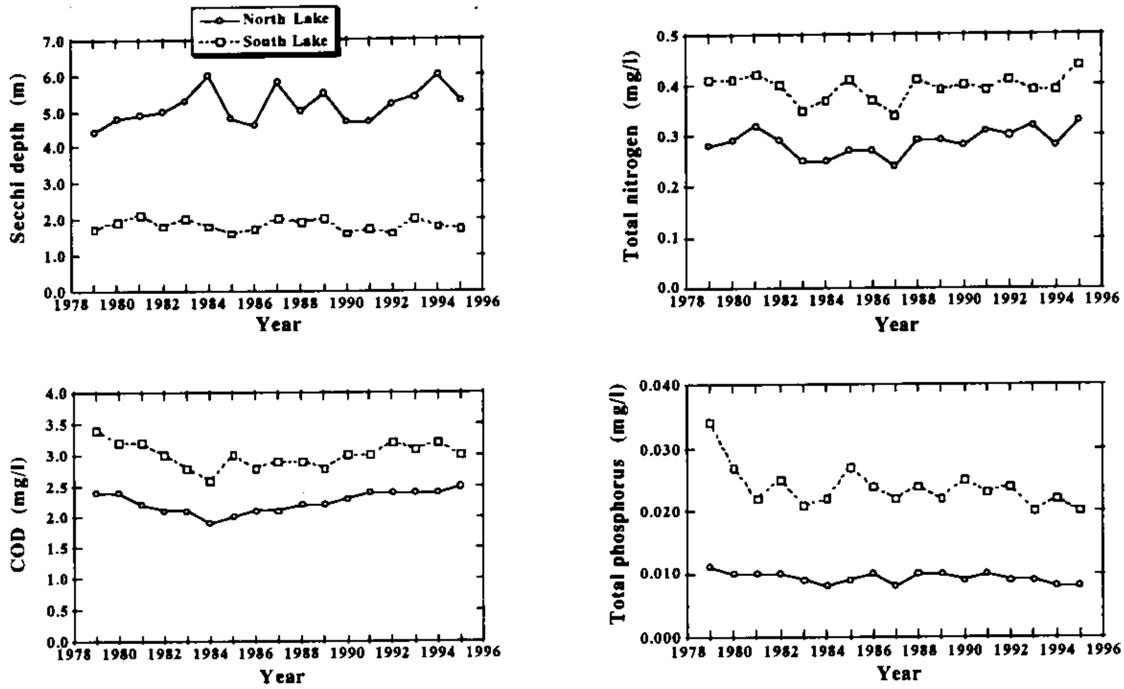



**Fig.18-11** Long term changes in water quality of Lake Biwa.

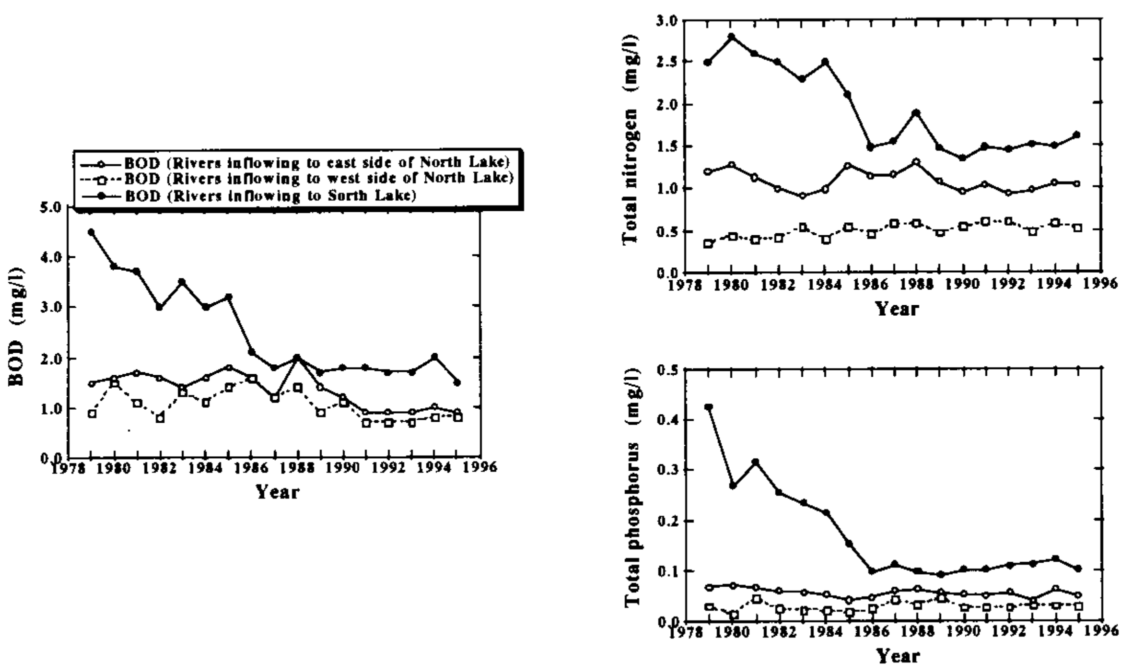



**Fig.18-12** Long term changes in water quality of rivers inflowing to Lake Biwa.

In the past, Lake Biwa was oligotrophic but in recent years it has become eutrophic. From guidelines adapted from the OECD (Organization for Economic Cooperation and Development), it was determined that the northern lake is mesotrophic and the southern lake has gradually shifted from mesotrophic to eutrophic.

when the number of plankton increase up to certain level, bad effects such as freshwater red tide and/or uncomfortable odor in water occur. Those types of phenomena have observed in the southern lake in recent years.

Outbreaks of fresh water red tide from 1977, to this year (1996), excluding 1986, indicate eutrophication of Lake Biwa. This red tide phenomenon extends from the end of April until the beginning of June. The water temperature ranges from 15°C to 20°C. Large outbreaks of the flagellate *Uroglena americana* cause the Lake to change color to a reddish brown and are accompanied with a rotten fish smell.

On 21 September 1983, "water bloom" by *Anabaena* mixed with *Microcystis*, typical indicators of entrophication, occurred for the first time in Lake Biwa. This phenomenon was observed intermittently along the shore of Otsu City, some 10 kilometers long and 10 meters wide, though it disappeared in a day. Since then "water bloom" has occurred in the southern lake on a small scale every year to this year (1996) except in 1984.

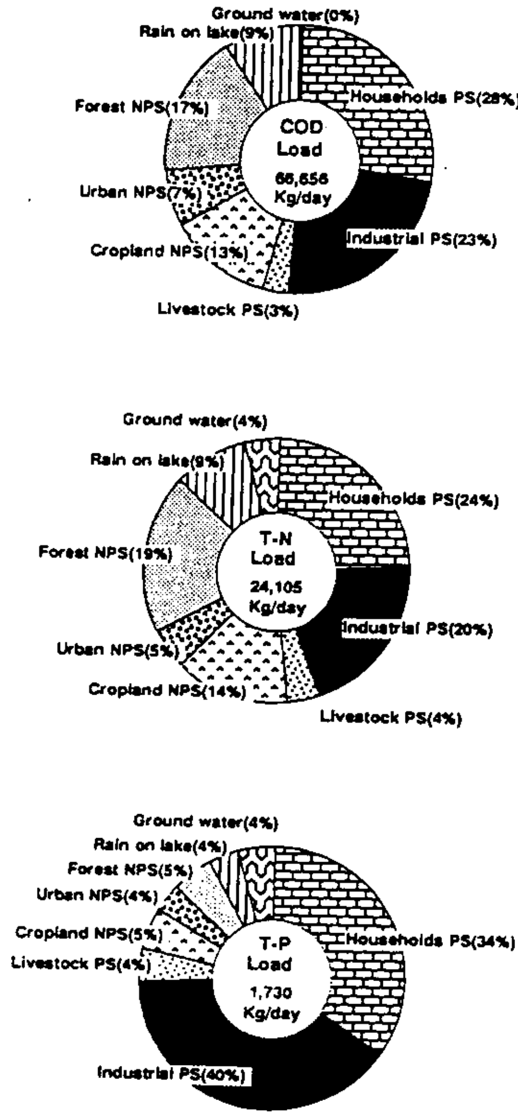



Fig.18-13 Pollution load into Lake Biwa (1990)

### 3.5 Water plants

There are about 70 kinds of water plants confirmed in Lake Biwa at present. Nutrients inflow to Lake Biwa have increased suddenly in recent years. For this reason native species such as *Vallisneria biwaensis (Miki) Ohwi* and *Potamogeton biwaensis Miki*, which are not suited to the changes in such environment decreased while naturalized species such as *Elodea nuttallii St. John* and *Egeria densa Casp.*, which, did not exist in Lake Biwa formerly, invaded the Lake and live in stock.

In order to mow and remove these growing water plants, a water plant mowing boat, "Kaitsuburi I" and a carrying boat, "Kaitsuburi II" were built in 1977. Furthermore, a water plant mowing machine, "Super Kaitsuburi," was purchased in 1988 and these water plants are now being mowed.

### 4. Pollution load into the lake

Percentages of pollution load from various sources in total load into the lake in 1990 are shown in **Fig.18-13**. As for every parameter (COD, T-N, T-P), loads from households and industrial activities occupy relatively larger ratio in total. However, pollution load from non-point sources, e.g., crop land, urban area, forest, is not determined sufficiently. It is difficult to determine the load from non-point sources because such load is discharged into a lake with runoff during short period in rainy day. Furthermore, effects of the discharged nutrients, mainly particulate form, from non-point sources on the growth of algae are not well known.

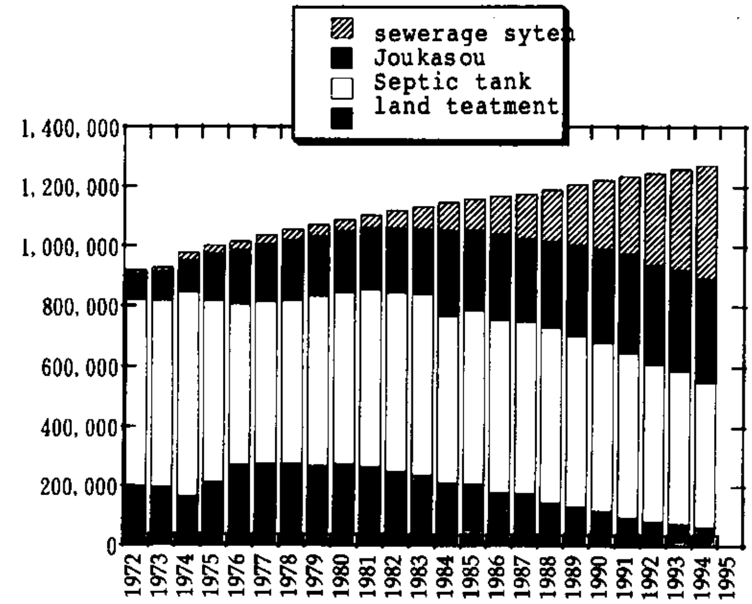



**Fig.18-14** Changes in population characterized by the treatment types of human wastes

**Figure 18-14** shows changes in population in Shiga Prefecture and several types of population characterized by the treatment types of human wastes. Increase rate in sewered population is not enough comparing to the rate of total population growth. Population served by on-site small treatment facilities (Joukasou) has increased gradually.

### 5. Water Pollution Control Measures

#### 5.1 Regulatory measures and administrative plans

#### 1) Environmental Quality Standards

According to the Environment Agency Notification No.59 in 1972 based on the provision of the Basic Law for Environmental Pollution Control (1972 Statute No. 132), the northern lake is categorized as AA(1) and the southern lake as AA(3). As for total nitrogen and total phosphorus in terms of eutrophication, both lakes are categorized as Class II (1985 Statute No 24). The standards are shown in **Table 18-1** and **Table 18-2**.

#### 2) Water pollution Control Law and the Shiga Prefectural Environmental Pollution Control Ordinance

Japan Government enacted the Water Pollution Control Law (1971 Statute No. 138) in 1971 in response to the growing threat of water pollution effects on human health and the environment. In Shiga Prefecture, the Shiga Prefectural Environmental Pollution Control Ordinance was already legislated in 1969 and enacted by applying a more stringent prefectural standard to industrial wastewater effluents. In 1973, the ordinance was completely revised to make the regulations stricter.

Furthermore, the **Eutrophication Prevention Ordinance** was legislated in 1979 in order to regulate nitrogen and phosphorus discharges into the lake **(Table 18-3,4)**.

Following this movement, the regulations of nitrogen and phosphorus discharges were

Table 18-1 **The Environmental Quality Standards relating to "health items"**

**(harmful substances)**

| Item | Cd | CN | Org.P | Pb | $Cr^{6+}$ | As | Total Hg | Alkyl Hg | PCB |
|---|---|---|---|---|---|---|---|---|---|
| Standard | 0.01mg/ℓ or less | ND | ND | 0.1mg/ℓ or less | 0.05mg/ℓ or less | 0.05mg/ℓ or less | 0.0005mg/ℓ or less | ND | ND |

Table 18-2 **The Environmental Quality Standards relating to "living environment items"**

**Lakes (natural lakes and artificial lakes having pondage of more than 10 million cubic meters)**

**(a)**

| Item / Category | Purpose of utilization | Standard | | | | | Objective |
|---|---|---|---|---|---|---|---|
| | | pH | COD | SS | DO | Entero bacilli Number of coliform groups | |
| AA | Water supply, Tap water class 1 Fisheries, class 1 | more 6.5 less 8.5 | 1mg/ℓ or less | 1mg/ℓ or less | 7.5mg/ℓ or more | 50MPN/ 100ml or less | Southern lake (3) Northern lake (1) |

(1): Expected to fall under the standard immediately.

(3): Expected to fall under the standard as soon as possible.

**(b)**

| Item / Class | Purpose of use | Standards | |
|---|---|---|---|
| | | Total nitrogen | Total phosphorus |
| II | Tap water Class 1, 2 and 3 (except special cases) Fisheries Class 1 Bathing and those listed in and after III | 0.2mg/ℓ or less | 0.01mg/ℓ or less |

Note: As shown above, Lake Biwa is categorized as Class II. However, the provisional target to be achieved by 1995 is total nitrogen 0.26 mg/ℓ or less for the northern lake and total nitrogen 0.35mg/ℓ or less and total phosphorus 0.015mg/ℓ for the southern lake.

(Source:ref.1)

introduced to the **Water Quality Corruption Prevention Ordinance** in 1985.

### 3) The Shiga Prefectural Ordinance Concerning the Prevention of the Eutrophication of Lake Biwa

The **Eutrophication Prevention Ordinance** was enacted to regulate the discharge of nitrogen and phosphorus in order to prevent the eutrophication of Lake Biwa. This kind of ordinance was enacted in Shiga firstly in Japan.

The features of this ordinance are listed below.

(1) It regulates the concentration of nitrogen and phosphorus discharges from factories and businesses.
(2) It prohibits the sale and use of domestic synthetic detergents that contain phosphorus.

Table 18-3 **Effluent Standards for the discharge from industries and facilities**

**a. substances related to the protection of human health**

| Item | Maximum Permissible Limits | |
|---|---|---|
| | The Water Pollution Control Law | Regulation standard in Shiga Prefecture |
| Cd and its compounds | 0.1 mg/ℓ | 0.01 mg/ℓ |
| Cyanides | 1 mg/ℓ | 0.1 mg/ℓ |
| Organic phosphates | 1 mg/ℓ | ND |
| Pb and its compounds | 1 mg/ℓ | 0.1 mg/ℓ |
| $Cr^{6+}$ compounds | 0.5 mg/ℓ | 0.05 mg/ℓ |
| As and its compounds | 0.5 mg/ℓ | 0.05 mg/ℓ |
| Total Hg | 0.005 mg/ℓ | 0.005 mg/ℓ |
| Alkyl Hg compounds | ND | ND |
| PCB | 0.003 mg/ℓ | 0.003 mg/ℓ |
| Trichloroethylene | 0.3 mg/ℓ | |
| Tetrachloroethylene | 0.1 mg/ℓ | |

(Source:ref.1)

(3) It regulates the suitable application of agricultural fertilizers and water management.
(4) It regulates the improvement of treatment facilities for the disposal of domestic animal waste and the suitable application such as recycling to soil.
(5) It states that household garbage should not be washed down the sink and into public water bodies.

In order to operate this Prefectural Ordinance, the following concrete measures were carried out, e.g. the distribution of domestic water-softeners to hard-water regions, withdrawal of P synthetic detergents from houses, guidance and loaning to factories and businesses for installing N & P treatment plants.

After this Prefectural Ordinance was established, most domestic synthetic detergents became non-phosphoric. At the same time, the Special Measure Law for Preserving Lake Water Quality was enacted in 1984 and the regulations of draining for nitrogen and phosphorus were introduced to the Water Quality Corruption Prevention Ordinance by the Government in 1985.

**4) Plan for Conserving Water Quality of Lake Biwa**

In order to preserve the lake water quality the **Special Measure Law for Conserving Lake Water Quality** was enacted in 1984 (1984 Statute No. 61). This law applies to nine lakes including Lake Biwa. According to this law, a plan for conserving lake water quality pertaining to Lake Biwa was made (first term: 1986—1990, second term: 1991-1995).

In order to pursue this plan synthetically and systematically, included in this plan are the target values of water quality to be achieved in 1990 which was obtained through water quality simulation and working programs for this target such as water quality preserving projects including preparation for well equipped sewerage, measures for draining from factories and domestic sewage and monitoring of water quality (**Fig.18-15**).

**5) Comprehensive Environmental Conservation Plan**

**Table 18-4** **b. Items related to the protection of the living environments**

| Item | Maximum Permissible Limits | |
|---|---|---|
| | The Water Pollution Control Law | Regulation standard in Shiga Prefecture |
| Displacement ($m^3$/day) | 50 or more | 30 or more |
| pH | 5.8~8.6 | 6.0~8.5 |
| BOD | 160mg/ℓ | 20~120 mg/ℓ |
| COD | 160 mg/ℓ | 20~120 mg/ℓ |
| SS | 200 mg/ℓ | 70~150 mg/ℓ |
| T-N | 120 mg/ℓ | 8~80 mg/ℓ |
| T-P | 16 mg/ℓ | 0.5~25 mg/ℓ |
| Mineral oil | 5 mg/ℓ | 5 mg/ℓ |
| Animal and vegetable fat | 30 mg/ℓ | 20 mg/ℓ |
| Phenols | 5 mg/ℓ | 1 mg/ℓ |
| Cu | 3 mg/ℓ | 1 mg/ℓ |
| Zn | 5 mg/ℓ | 1 mg/ℓ |
| Dissolved-Fe | 10 mg/ℓ | 10 mg/ℓ |
| Dissolved-Mn | 10 mg/ℓ | 10 mg/ℓ |
| Cr | 2 mg/ℓ | 0.1 mg/ℓ |
| F | 15 mg/ℓ | 8 mg/ℓ |
| Number of coliform groups | 3,000cells/mℓ | 3,000cells/mℓ |
| B | | 2 mg/ℓ |
| Sb | | 0.05 mg/ℓ |

N.B.1 The figures of regulation standard in Shiga Prefecture lie in "More Stringent Prefectural Standard", "The Environmental Pollution Control Ordinance", or "The Shiga Prefectural Ordinance Concerning the Prevention of the Eutrophication of Lake Biwa".

N.B.2 As far as BOD, COD, SS, T-N and T-P are concerned, the figures of regulation standard in Shiga Prefecture vary according to the industry.

(Source:ref.1)

Besides preserving the water quality of Lake Biwa, in order to promote more overall preservation of the environment in other areas of Shiga Prefecture, the local government is positively taking overall measures for preserving the environment, such as assessing the environment, forming a plan for improving the environment of Shiga Prefecture and enacting an ordinance for preserving scenery as a figure of environment and culture **(Fig.18-16)**.

### i. Environmental impact assessment

In 1981 the Shiga Prefectural Government enforced measures for evaluating the influence of the environment. In other words, before starting large-scale development works such as reclamation of lakes and marshes and building industrial complexes, the local government undertakes research, and forecasts and evaluates the influence of these works on the environment and then opens the outcome to the public to hear their opinion.

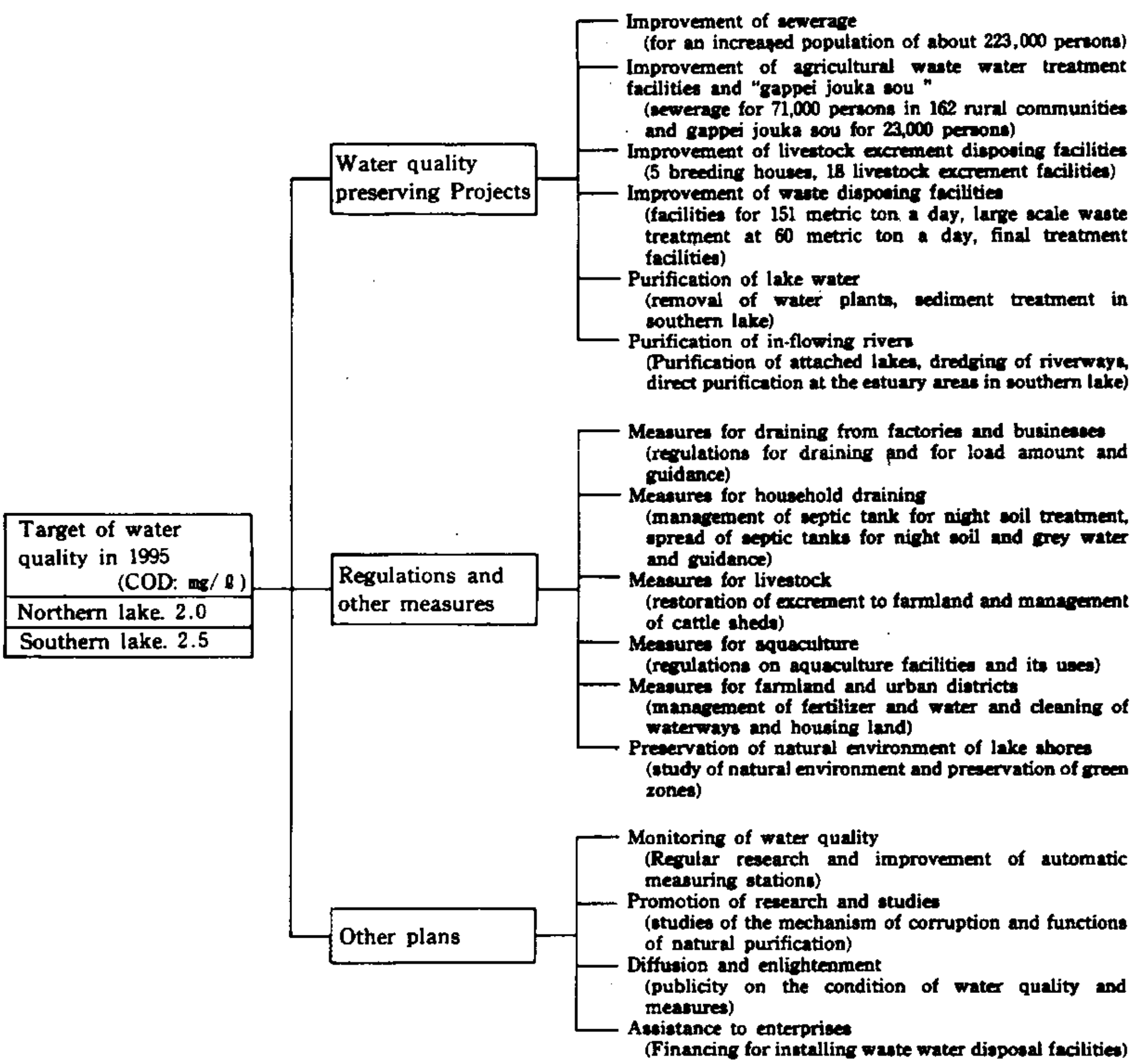
### ii. Residents participation for the improvement of environment

In June 1987, the Shiga Prefectural Government made a plan for improving the environment of Shiga Prefecture as a guideline for a better living environment towards the 21st century.

In this plan overall measures are considered from a wide viewpoint including history and scenery, based on pollution control and preservation of nature. Especially, regarded as important are consideration for preserving the environment in using land and making a better environment by the residents themselves. The plan aims at realizing "a ring (coexistence) of lakes, green and human being"... a figure in which human beings and nature harmonize naturally through the overall measures for preserving the environment and combined efforts

Fig.18-15

**System of the plan for conserving water quality of Lake Biwa**




(Source:ref.1)

for preserving the environment, and for creating a better environment by each and every resident in Shiga Prefecture.

### iii. Establishment of an ordinance for preserving scenery

In order to cope with sudden changes in the social and economic situations in recent years, an ordinance was established in 1984 to preserve the nature and scenery of the local country surrounding Lake Biwa. The outline is as follows:

(1) Promotion of measures for preserving scenery by designating. important areas and districts,
(2) Measures for protecting scenery from high and large buildings,
(3) Promotion of measures for preserving scenery through positive efforts for enhance a better environment for local residents,

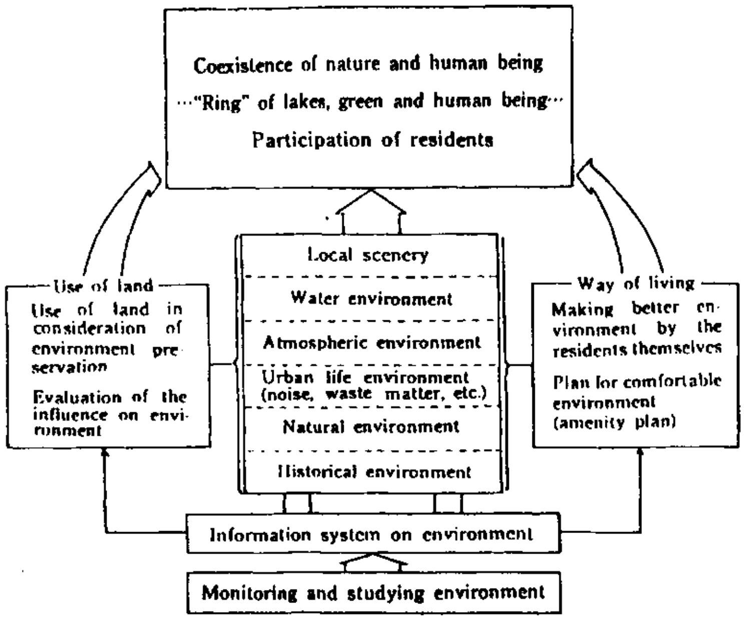



Fig.18-16 Conceptional Drawing of the plan for improving the environment of Shiga Prefecture.

(Source:ref.1)

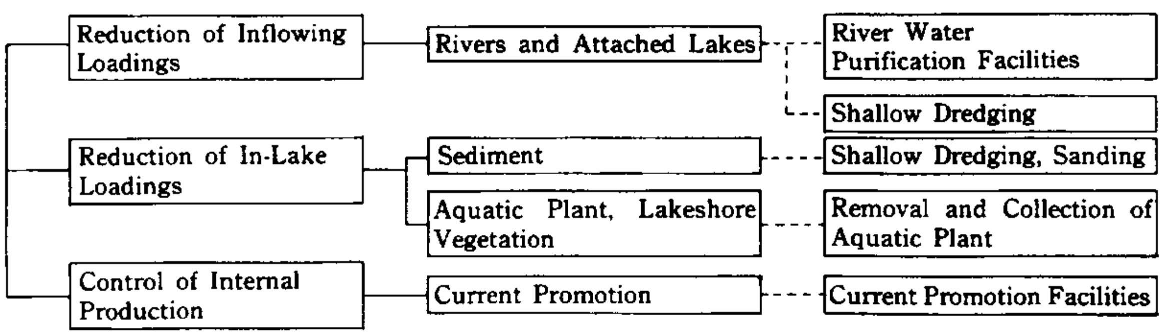



Fig.18-17 Main frame of the Special Project for the Water Quality Improvement of the Southern Lake (1992 - 2001).

(Source:ref.1)

(4) Measures for preserving scenery by making the most of the local characteristics of the cities, towns and villages.

### 6) Special Project for the Water Quality Improvement of the Southern Lake

Recent Southern Lake's water quality is at the critical status into the eutrophication. To prevent the eutrophication, the special project was initiated by using some measures applied in the lake besides the ongoing measures for pollution sources in the catchment area.

During the period from Fiscal 1988 to Fiscal 1991, the detailed survey of the Southern Lake's environments and the pilot project were conducted. The pilot project included pollution loadings reduction measures at estuaries and rivers, utilization of **inner lakes** to decrease the loadings, **removal of sediment** and so on (**Fig.18-17**).

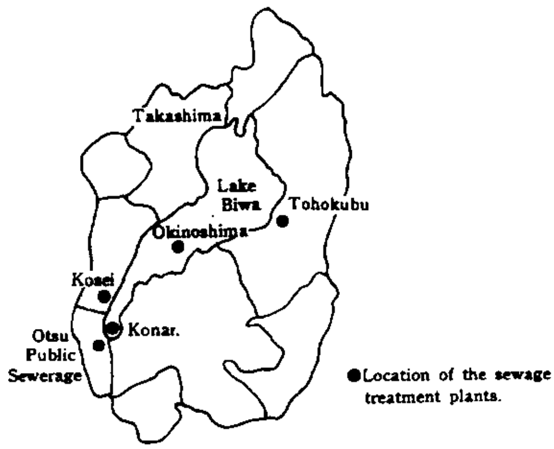



Fig.18-18 Location of the Sewage Treatment Plants and Outline of Sewage Treatment Plan

| Division | Sewerage surrounding Lake Biwa | | | | Otsu Public Sewerage | Okinoshima Special Public Sewerage |
|---|---|---|---|---|---|---|
| | Konan | Tohokubu | Kosei | Takashima | | |
| Pre-estimate treatment area | 25,500ha | 12,700ha | 2,600ha | 2,000ha | 1,338ha | 9ha |
| Pre-estimate Population | 790,000 | 525,000 | 250,000 | 62,000 | 128,000 | 1,010 |
| Pre-estimate water quantity | 1,020,000 m³/day | 505,000 m³/day | 120,000 m³/day | 45,000 m³/day | 95,000 m³/day | 420 m³/day |
| Related cities and towns | 5 cities 14 towns | 2 17 | 1 1 | 5 towns | 1 city | 1 city |

(Source:ref.1)

In March 1992, the Advisory Board for the Project revealed the Report. The Report indicated that eutrophication of the Southern Lake is caused by ( i ) loadings through the inflowing rivers, (ii) high rated release of nutrients from sediment at the stagnated water areas and rolled-up sediment by waves or artificial activities and (iii) release of nutrients from the dead aquatic plants.

### 7) Ordinance Concerning the Prevention of Litter

Litter and rubbish around the lake shore, on roads and footpaths, in parks and gardens, and rivers and streams degrade the beautiful scenery of Shiga and influence the water quality considerably. In order to deal with this problem positively the Prefecture of Shiga Ordinance Concerning the Prevention of Litter was put into effect on 1 July 1992.

## 5.2 Adapting technical measures for improvement of the lake environment

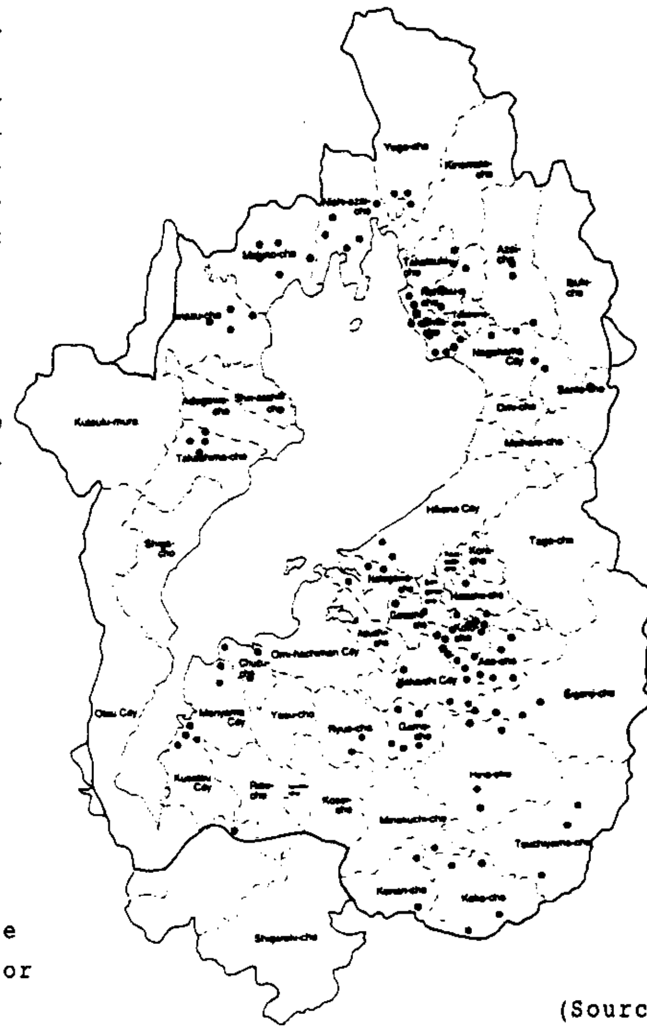
### 1) Construction of large-scale sewerage treatment systems

In order to preserve the water quality of Lake Biwa, construction of wastewater treatment facility is actively promoted. The prefecture is divided into 4 management districts, excluding Otsu City **(Fig.18-18)**. Sewerage systems in southern districts are partly in operation, and nitrogen and phosphorus are removed through extensive sewage treatment.

### 2) Construction of small-scale sewerage treatment systems

In agricultural area with low population densities, small-scale wastewater treatment system is suitable from the viewpoint of construction cost. Approximately 220 facilities are planned for construction **(Fig.18-19)**

This project has been undertaken to improve the facilities treating the waste water discharged from agricultural communities to improve the Lake Biwa water quality and thus the agricultural environment at large.



Targeted districts (Lake Biwa surrounding areas).
● Facilities completed or under construction.
● Completed facilities.
● Under construction.

Fig.18-19
Small-scale sewerage treatment systems for agricultural area

(Source:ref.6)

In residential area where sewerage system is not planned or its service is not expected soon, small sewerage treatment facilities (Gappei Joka-so) for each communities or houses are constructed by the payment of residents or developers. Subsidies from local government for this system is not paid or lower than public sewerage system by local government in general. In shiga Prefecture, however, ordinance for promotion of installment of "gappei joka-so" was enacted in 1996.

Percentage of the population served by small-scale facilities in total population in the prefecture is approximately 11% in 1993. The parentage is rather small comparing to that of large-scale system (27%).

### 3) Human waste treatment facilities

In Shiga Prefecture, population served by septic tank is major (**Fig.18-20**). Therefore, human waste treatment facilities with high performance of removal of pollution load is necessary.

## 6. Environmental improvement by Citizens' Movement

### 6.1 History

Since 1975, resident groups in Shiga Prefecture have developed a concerted action to replace synthetic detergents by soap powder. This movement became an important trigger to enforce the Lake Biwa Eutrophication Prevention Ordinance. At the time of the enforcement of this Ordinance, the ratio for using soap powder increased up to 80 percent. Although the ratio has now dropped down to 40 percent according to the popularization of non-phosphorous detergents, the ratio is still high compared with that of other prefectures (8 percent).

However, this movement by the residents was not limited to using soap powder. The movement was supported by a new sense of value that they live a life which harmonizes the environment surrounding water, sacrificing a little inconvenience and reflecting on their lifestyles. The idea has succeeded up to now. "The campaign for preserving water environment for Lake Biwa by all residents in Shiga Prefecture" which started in 1988 aims at decreasing the corruption load on Lake Biwa to a minimum

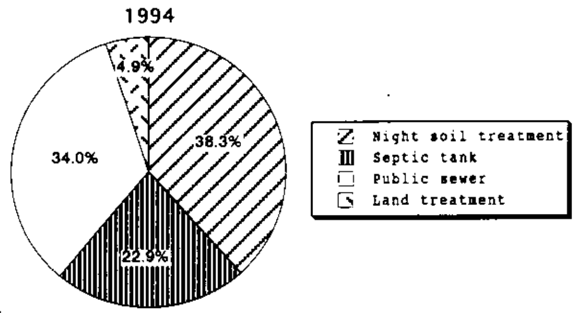



Fig. 18-20 Treatment measures of human waste in Shiga Prefecture in 1994.

Table 18-5 Areas of reed beds and willow stands.

| | Emerged Macrophytes | Willow stands | Total |
|---|---|---|---|
| Northern Lake | 65.4 | 36.8 | 102.2 |
| Southern Lake | 62.0 | 8.7 | 70.7 |
| sub-total of Lake Biwa | 127.4 | 45.5 | 172.9 |
| Nishinoko Lake (an attached lagoon) | 108.8 | 1.9 | 110.7 |
| Other attached lagoons | 88.3 | 11.7 | 100.0 |
| Sub-total of attached lagoons | 197.1 | 13.6 | 210.7 |
| Ado-river delta | 1.8 | 7.5 | 9.3 |
| Grand total | 326.3 | 66.6 | 392.9 |

(Source:ref.9)

Table 18-6 Components and tools of the Reed Beds Conservation Ordinance.

| | | | |
|---|---|---|---|
| * Protection | - Zoning | - Preservation area | - Permission |
| | | - Protected area | - Permission |
| | | - Normal area | - notification |
| * Bring-up | - Restoration | - installation of anti-wave fence | |
| | | - planting | |
| | - Maintenance | - cleaning | |
| | | - mowing | |
| * Utilization | - Investigation and research for utilization of reed | | |
| | - Environmental education and nature observation at reed beds | | |

(Source:ref.9)

with what they can do in daily life.

This object has been achieved in various ways. They include the decrease in load flowing out of household kitchens by fitting very fine strainers, the use of homemade soap made from waste oil used for cooking, and the restoration of broth and leftover soup to soil without letting them flow into the sink.

**6.2 Actions for water-friendly life**

It may be difficult for ordinary citizens to imagine or to know concrete methods for improvement of lake water quality. Therefore, making a leaflet showing the concrete methods being able to do for citizens is important. Some examples are shown below:

a. Treatment of leftover food and cooking waste

# Use fine meshed strainers in your sink.
# Put leftover food and cooking waste back into the soil. It turns into very rich fertilizer. (A composter is good for these processes.)

b. Treatment of oil

# Wash dishes after wiping off oil with paper.
# Do not drain waste oil. If possible use the oil again. Oil used for tempura, for example, should be kept in a cool dark place and can be used over and over again. Oil that needs to be thrown away should be soaked into paper first, or recycled through a collecting service.

c. Maintenance of neighboring river

We Want rivers and streams to be accessible and enjoyed by the whole community. The prefecture makes programs include rehabilitation of fireflies, ayu-fish and carp, construction of windmills and growing flowers.

**6.3 Promotion of environmental education**

**1) Survey of Aquatic Organisms (Bio-monitoring)**

In recent years, the survey of aquatic organisms has been used more and more as a method of monitoring river water quality, in addition to the traditional chemical analysis. The survey evaluates water quality through studying insects, water plants and fishes in aquatic systems such as rivers.

In Shiga the annual survey is conducted every year since its initiation in Fiscal 1984. In 1991, around 1,800 people from 33 organizations took part in the survey on 87 sites of 49 rivers.

Many water insects, with shells from several millimeters to several centimeters in size, can be observed on and under pebbles and in the sand. The types of those creatures vary depending on water quality.

**2) Environment Seminar Boat**

Aiming at a better understanding of Lake Biwa's water quality by direct observation of lake water and the lake shore, the Prefecture of Shiga operates an environment seminar boat.

**3) Open Lecture on the Environment**

The Shiga Prefecture has organized an "Open Lecture on the Environment "since Fiscal 1986. Many experts from various fields are invited as lecturers. The lecture is an opportunity for participants to understand Shiga's environments, think about their daily life in relation to

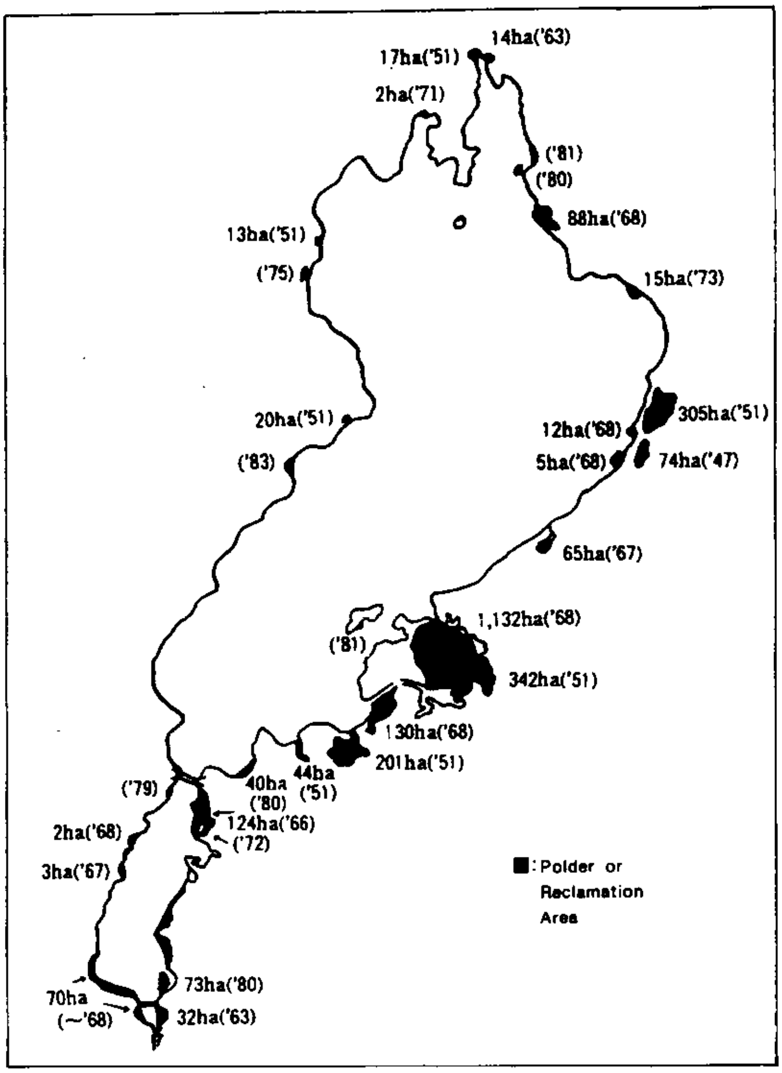



Fig.18-21 **Artificial Change of Lakeshore Line by Polder or Reclamation**

(Source:ref.1)

the environment and to obtain ideas on how to lead an environment-friendly life.

## 7. New Administrative Works for Conservation of the Lake Ecosystem

### 7.1 Ordinance Concerning Conservation of the Reed Beds of Lake Biwa in Shiga Prefecture

### (Reed Beds Conservation Ordinance )

Reed beds at the lakeshore contributes to the shaping of Shiga's local scenery and to the conservation of the lake ecosystem (**Table 18-5**). The conservation of reed beds means not only the protection of Lake Biwa's nature and the lakeshore ecosystem but also the protection of lakeland culture. We must conserve, bring up and utilize the reed beds.

To meet the above objective, the Ordinance Concerning Conservation of the Reed Beds of Lake Biwa in Shiga Prefecture was promulgated on 30 March 1992 and came into effect from 1 July 1992.

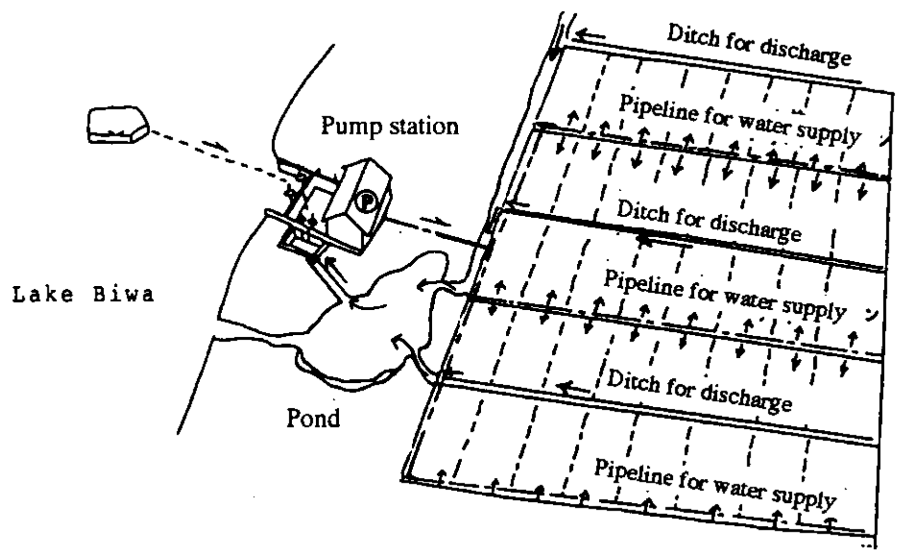



Fig.18-22 Recycling system of agricultural wastewater.

(Source:ref.10)

The Ordinance has three basic tenets: to conserve, nurture and properly utilize reeds (**Table 18-6**). It calls for the close cooperation of citizens, business people and administrators to conserve the reed beds on the lakeshore.

**7.2 Conservation of Inner lakes**

Around Lake Biwa there were many large and small lakes and marshes called "**inner lakes**" including "Dainaka-no-ko" with an area of 1,145 hectares. In the "inner lakes", aquatic plants grow thick forming spectacular sights and the wetland area may have water purification abilities. However, as these lakes were of low depth as shallow as about two meters, most of them were reclaimed after the Second World War to serve for an increased yield of food to cover a food shortage in the periods during and after World War II. Moreover, more than 300 hectares of Lake Biwa were reclaimed to meet the demand for area development and land for public use after the War. **(Fig.18-21)**

Recently section of agriculture administration in Shiga Prefecture is planning effective use of inner lakes for purifying the wastewater from paddy fields, especially in spring season. Discharge of silt from paddy field with rice planting works in spring is a problem in the prefecture. Outlook of measure using inner lakes for improving water quality is shown in **Fig.18-22.**

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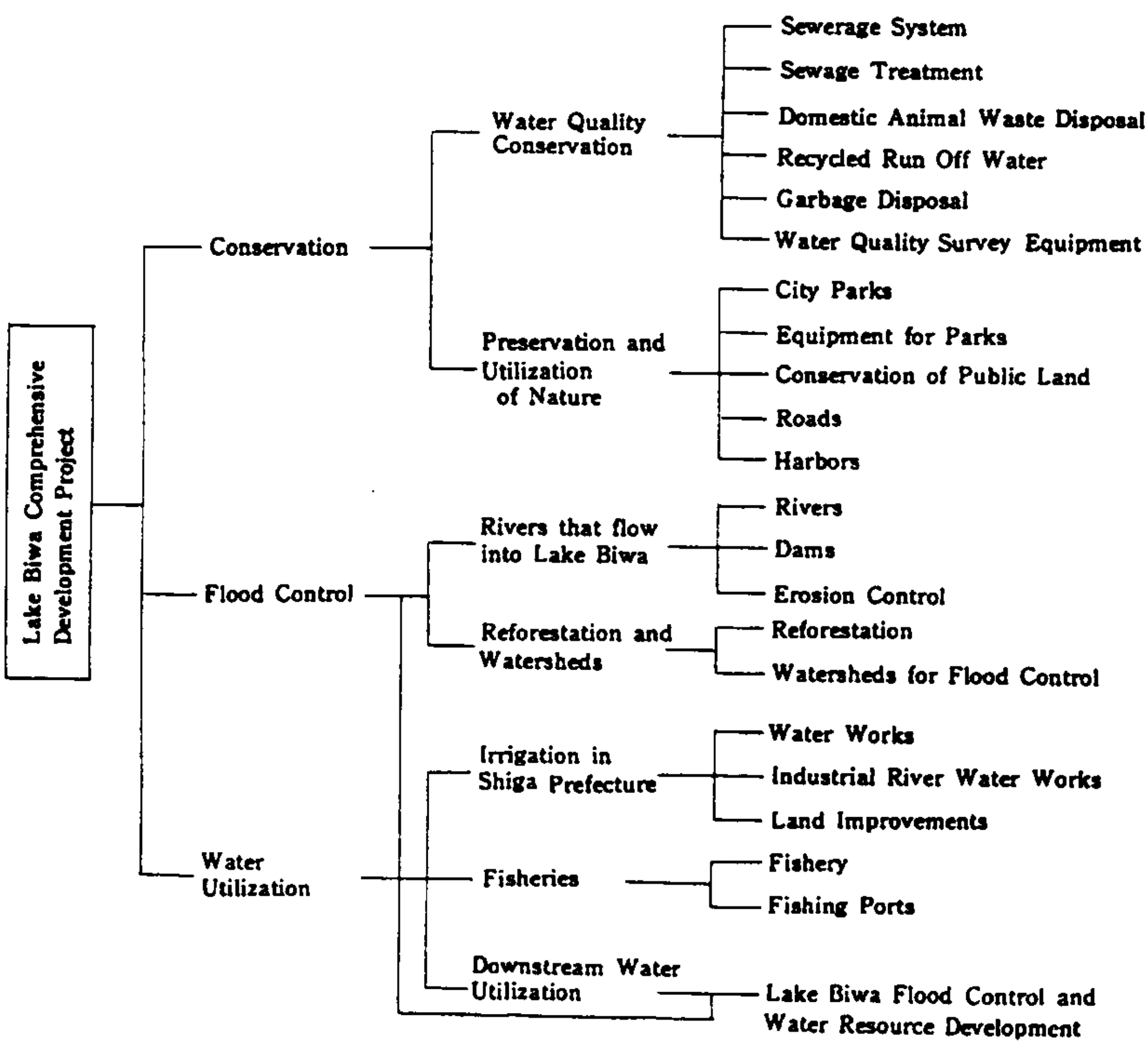
Appendix-1 Outline of Lake Biwa Conprehensive Development Project



## Chapter 19 LAKE KASUMIGAURA

### 1. Outline of Lake Kasumigaura

#### 1.1 Lake Kasumigaura

Lake Kasumigaura is located about 60-90 km northeast of Tokyo (Fig.19-1). It is Japan's second largest natural fresh-water lake, and from ancient times it has bestowed countless benefits on the local inhabitants. In recent years, with the rapid growth of the Japanese economy and in line with policies to promote development within the prefecture, Lake Kasumigaura has come to be viewed as a precious water resource. The lake has become the focus of expectations for it to play a major role in the potential transformation of this flat basin area into a prosperous development region.

Lake Kasumigaura covers an area of approximately 220 square kilometers, and it is comprised of three water regions: Nishiura, Kitaura, and the Hitachi-Tone River (Fig.19-2). While 56 rivers including the Sakura, the Ono, and the Koise, flow into Lake Kasumigaura, the lake discharges into just one river, the Hitachi-Tone, which later joins with the Tone River.

Because Lake Kasumigaura used to be an inland sea, it lies a mere 16 centimeters above sea level, and with an average depth of 4 meters, the lake is extremely shallow in comparison with its size. Moreover, water remains in the lake for as long as about 200 days on average (Table 19-1). Because of all these characteristics, Lake Kasumigaura is unusually vulnerable to pollution. Kasumigaura became a freshwater lake around the year 1638, during the Edo Period (1600-1868).

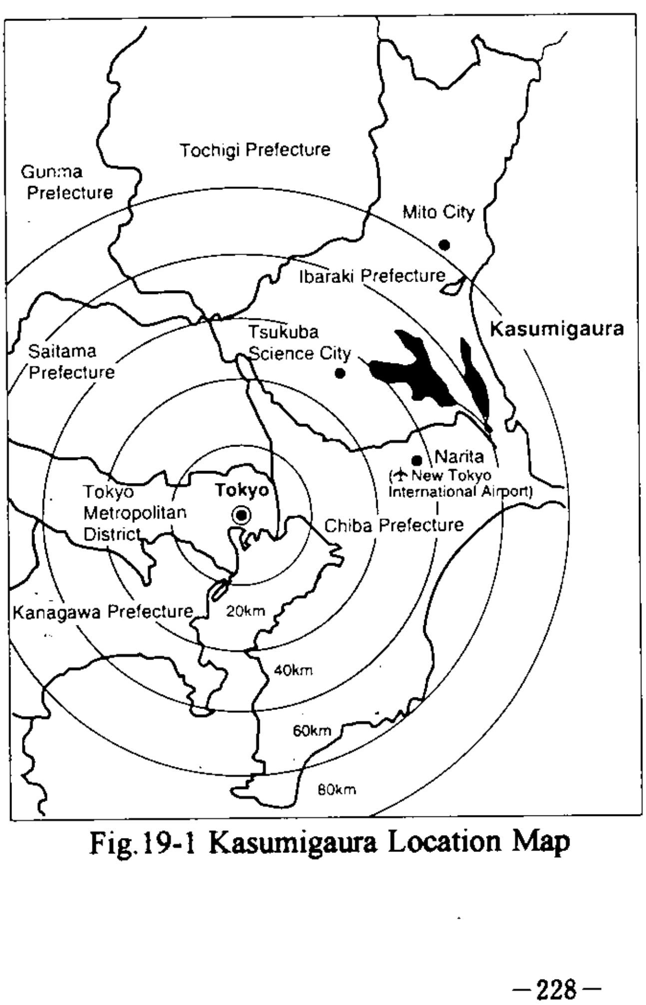


Fig.19-1 Kasumigaura Location Map

Fig.19-2 Region of Lake Kasumigaura

## 1.2 Kasumigaura Basin

The Kasumigaura drainage basin encompasses 45 cities, towns, and villages located in Ibaraki, Chiba, and Tochigi prefectures. The total basin area is approximately 2,200 square kilometers, equivalent to one-third the entire area of Ibaraki Prefecture. At present, about 950,000 people inhabit this basin, and urbanization is expected to progress further in this region. The basin is dominated by agriculture, which accounts for 37.2 percent of the overall land use (Fig.19-3). Urban areas account for 12.4 percent of the land use, and Tsuchiura City, Ishioka City, and Itako Town are among the well-developed areas within the basin. The development of industrial parks in Kashima Town and Kamisu Town and the construction of Tsukuba Science City are changing the characteristics of the regional land use.

Table 19-1 Outline of Lake Kasumigaura

| Category | Item | Unit | Kasumigaura |
|---|---|---|---|
| Lake | Origin | — | Inland Sea-Lake |
| | Maximum Depth | m | 7 |
| | Average Depth | m | 4 - |
| | Area | $km^2$ | 220 |
| | Circumference | km | 252 |
| | Capacity | billion $m^3$ | approx. 9 |
| | Average Water Replacement Period | days | approx. 200 |
| | Height Above Sea Level | m | 0.16 |
| Basin | Area | $km^2$ | 2,157 |
| | Number of Cities, Towns, and Villages | — | 45 |
| | Number of Cities, Towns, and Villages Nearby the Lake | — | 23 |
| | Population | 1,000 persons | 93 |
| | Average Annual Rainfall | mm | 1,350 |
| | Average Annual Discharge | billion $m^2$ | approx. 1.2 |

| Urban Areas | Rice Fields | Other Fields and Orchards | Mountains, Etc. | Lake |
|---|---|---|---|---|
| 12.4 | 21.2 | 16.0 | 40.1 | 10.3 |

*Note:* Figures for fiscal year 1992.

Fig.19-3 Land Use in the Kasumigaura Basin

Table 19-2 Majio Industries in the Kasumigaura Basin

| | |
|---|---|
| Manufacturing | • Industrial Shipments—¥2,407 billion (accounting for approximately one-fifth of the prefectural total, number 9 nationwide) |
| Agriculture | • Rice Cultivation Area—48,000 hectares (accounting for approximately one-half of the prefectural total, number 5 nationwide)<br>• Lotus Root Cultivation Area—1,700 hectares (accounting for virtually all of the prefectural total, number 1 nationwide)<br>• Region for the Provision of Perishable Foods to the Greater Tokyo Metropolitan Area |
| Livestock Industry | • Number of Pigs—330,000 (accounting for approximately 50 percent of the prefectural total, number 3 nationwide)<br>• Number of Beef Cattle—20,000 (accounting for approximately 40 percent of the prefectural total, number 17 nationwide)<br>• Number of Dairy Cattle—30,000 (accounting for approximately 60 percent of the prefectural total, number 8 nationwide)<br>• Number of Chickens for Egg Production—6.17 million (accounting for approximately 60 percent of the prefectural total, number 3 nationwide) |
| Fisheries | • Freshwater Fish Harvest—5,214 tons (accounting for approximately 40 percent of the prefectural total, number 1 nationwide)<br>• Carp Breeding Production—5,471 tons (accounting for virtually all of the prefectural total, number 1 nationwide) |

The Kasumigaura basin is blessed with natural resources, which are being used for the prosperous operation of manufacturing, agriculture, livestock raising, and fisheries (Table 19-2). As for agriculture, the Suigo or lakeside area enjoys an unusually large scale in rice farming. The basin prides itself as the nation's largest production area for lotus root, and the third largest region for pig farming. There has also been a thriving fishing industry in the area for many years. The basin is number one in Japan in both fresh-water fishery catch and carp breeding. Furthermore, becase the Kasumigaura region is located just 60 kilometers from the greater Tokyo metropolitan area, many new production plants are being located here, and factory shipments are increasing.

## 2. The Use and Management of Lake Kasumigaura

### 2.1 Lake Kasumigaura and Human Life

The water resources of Lake Kasumigaura have long been used for diverse purposes. Historically, the abundant varieties of fish that inhabit the lake served as the foundation for the development of the region's fresh-water fishing industry (Fig.19-4). At its peak around 1975, the annual fish harvest from Lake Kasumigaura reached approximately 17,000 tons, but the harvest has been declining ever since. Traditionally, the main varieties were Wakasagi (pond smelt), Shirauo (whitebait), and Shijimi (corbicula). In recent years, the havest of Haze (goby), Ebi (prawn), and Isazaami (shrimp) have been increasing. Since around 1955, carp have also been raised inside fish pens.

The area also has a long history of water transportation. Especially since the mouth of the Tone River was moved to the east in the early Edo period, Lake Kasumigaura was a key route for the transportation of rice and other goods from the northeastern region to the city of Edo (the old name for Tokyo). During the Meiji period (1868-1912), regular steamboat liner services were also widely used.

The waters of Lake Kasumigaura have long been used for agriculture, but the extensive use began from the Taisho period (1912-1926), as pumps and other modern irrigation equipment became widespread. The primary application is rice farming, accounting for 80 percent of the total agricultural use.

The waters were first used for municipal supply (household use) in 1955. The waters have been used for manufacturing since 1965, with the construction of the Kashima Coastal Industrial Region.

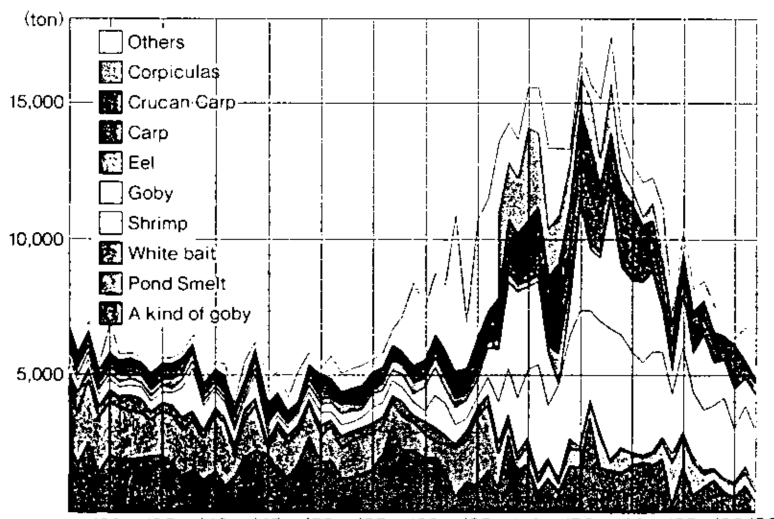



Fig.19-4 Changes in the Total Yield in Lake Kasumigaura

In the past, the lake provided several swimming areas for children including Ukishima, Tennozaki, and Ayumizaki.

## 2.2 Floods and Salt Damage

Moreover, in response to the domestic demand for increased foodstuff production from the Taisho period through to the Showa period (1926-1989), large-scale projects were implemented to open up new arable lands and to reclaim portions of the lake by drainage. As a result, the area of reclaimed land around Lake Kasumigaura reached about 2,700 hectares, expanding the area of fertile agricultural land. Kasumigaura became a key region for the provision of food to the Tokyo metropolitan area.

In this way, Lake Kasumigaura has provided countless blessings to the Japanese people. However, because the lake also functions as the retarding basin for the Tone River, the Kasumigaura basin has been subjects to frequent flood damage during heavy rainfalls and from the backflow of the Tone River. For this reason, diverse efforts have been made to limit this damage including the construction of embankments and the excavation of flood canals. Nevertheless, these flood-prevention works were insufficient. Serious floods occurred in 1938 and again in 1941 (Table 19-3).

Therefore, after the Second World War a radical improvement plan was drawn up and implemented. Efforts to dredge and greatly expand the width of the Hitachi-Tone began to substantially increase the carrying capacity of the river, and the physical interaction between Lake Kasumigaura and the Tone River were greatly improved. However, the intrusion of ocean water led to salt damage, so in May 1963 the Hitachi River Tidegate was constructed at the confluence of the Tone and Hitachi-Tone rivers to prevent flood damage from the back-flow of the Tone and to prevent salt damage during droughts.

## 2.3 Overall Development System for Lake Kasumigaura

These measures proved effective. The region is no longer subject to the type of massive flooding experienced in the past, and since 1975, when "fair current" procedures were instituted whereby the Hitachi River Tidegate is operated to prevent any mixed salt water in the Tone from backflowing into Lake Kasumigaura, there has been no salt damage.

In this way, since the Hitachi River Tidegate came into operation, there have been increasing calls for stopping the "dead" discharge of water (that is the discharge of water not being used for any specific purpose) from Lake Kasumigaura at this tidegate, and for

Table 19-3 Major Floods

| Water Level & Total Rainfall / Date | Water Level | Average Rainfall in the Basin | Reference |
|---|---|---|---|
| June–July 1938 | Y.P. + 3.34 m | 600 mm (7 days) | Typhoon |
| July 1941 | Y.P. + 2.90 m | 315 mm (4 days) | Typhoon #8 |
| Sept. 1947 | Y.P. + 1.96 m | 179 mm (5 days) | Typhoon #9 (Catherine) |
| July 1950 | Y.P. + 2.34 m | 248 mm (10 days) | Typhoon #17 |
| Sept. 1958 | Y.P. + 2.30 m | 246 mm (5 days) | Typhoon #22 Kano River |
| June–July 1961 | Y.P. + 1.96 m | 300 mm (7 days) | Rain Front |
| Sept. 1971 | Y.P. + 1.91 m | 312 mm (9 days) | Typhoon #23 & #25 |
| Aug. 1977 | Y.P. + 1.84 m | 212 mm (7 days) | Rain Front, Tropical Low Pressure |
| Sept. 1982 | Y.P. + 1.80 m | 175 mm (3 days) | Typhoon #18 |
| June–July 1985 | Y.P. + 1.89 m | 115 mm (2 days) | Typhoon #6 |
| Aug. 1986 | Y.P. + 2.05 m | 238 mm (2 days) | Typhoon #10 |
| Sept. 1991 | Y.P. + 2.31 m | 198 mm (2 days) | Typhoon #18 |
| Oct. 1991 | Y.P. + 2.50 m | 279 mm (9 days) | Typhoon #21 |

(Figures for 1961 and earlier measured at the Inoue Water Level Monitoring Station; figures from 1971 and later measured at the Dejima Water Level Monitoring Station).

the efficient use of this "dead" water. The background to these demands includes the opening of the Kashima Coastal Industrial Region in line with the rapid growth of the Japanese economy and regional development policies within Ibaraki Prefecture, the decision to construct Tukuba Science City, and the expansion of the periphery of the greater Tokyo metropolitan area. While supporting the development of the Kasumigaura region, Lake Kasumigaura is also being used to supply the long-term and wide-ranging water needs of the greater Tokyo metropolitan area, which continues to grow. From 1968, a national development project has been conducted at Lake Kasumigaura (Fig.19-5) in accordance with the Water Resources Development Promotion Low, and as part of the Basic Plan for the Development of Water Resources (Tone River Water System).

There are no mountainous areas or large rivers in the region nearby Lake Kasumigaura, and the annual rainfall is relatively small for Japan (1,350 mm versus a national average of 1,780 mm). The subterranean water is limited, and the quality is not very good. On the other hand, Lake Kasumigaura is useful for water regulation because it is located in a downstream lowland, and the lake is also beneficial in that it provides extremely good geographical features to limit the "dead" discharge of water, including the Tone River. Thus, the region increasingly relies upon Lake Kasumigaura for the stable supply of good quality water resources.

The goals of the national development project are to prevent flooding in the basin area through the construction of embankments along the shoreline with a crown height of Y.P.+3.0m (flood-control works), and to utilize the water capacity of 278 million cubic meters that lies between a water level of Y.P. ± 0.0m to Y.P.+1.3m to develop a supply capacity of 42.92 cubic meters per second for irrigation and city water (water-utilization works). The total project costs are ¥286.4 billion, and the project term runs from 1968 through 1995 (Fig.19-6).

2.4 Water Utilization at Kasumigaura

Aside from this national development project, the Kasumigaura Waterworks Project is also designed to secure the water resources at lake Kasumigaura. This project will provide two

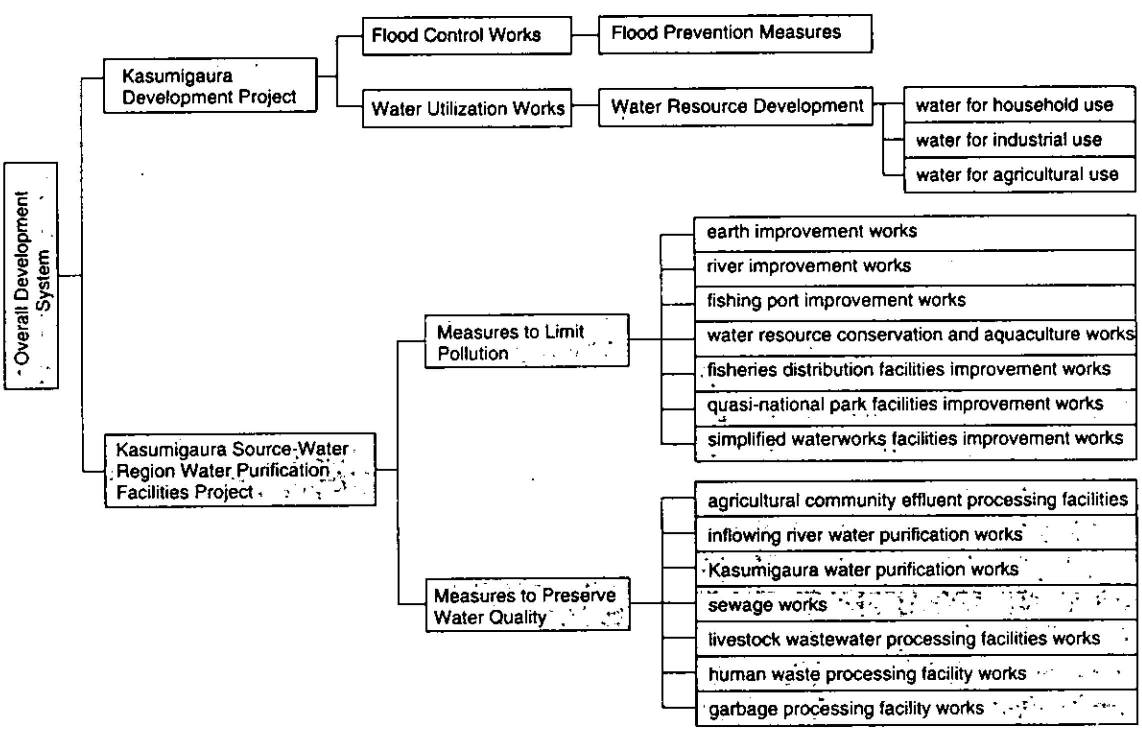
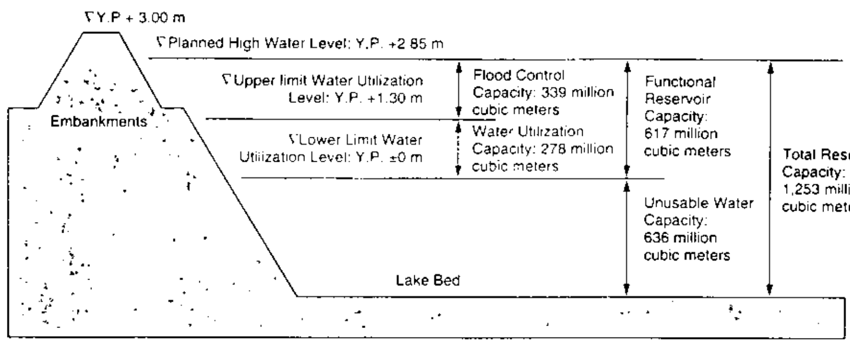



Fig.19-5 Overall Development System for Lake Kasumigaura

underground tunnels to transport 650 million cubic meters of water per year. One of the tunnels will connect the downstream region of the Naka River with Lake Kasumigaura (approximately 42.9 km), and the other will connect the downstream region of the Tone River with the lake(approximately 2.6 km). To improve the water quality of Lake Kasumigaura and the Sakura River (the Naka River water system), and toward the stable supply of water that is already being acquired from the Naka and Tone rivers, the Kasumigaura Waterworks Project will develop 12.7 cubic meters per second of new water supply for urban use from Lake Kasumigaura and the Naka River. The total project costs are projected at ¥190.0 billion, and the project term is from 1976 to the year 2000 (Fig.19-7).

At present, a total of 109.84 cubic meters per second of water is being utilized from Lake Kasumigaura for household, industrial, and agricultural use(Table 19-4). The volume of water usage will continue to grow along with changes in lifestyles, the growth of population




*Note:* Y.P. ±0 m = T.P. (mean tide level of Tokyo Bay) −0.84 m

Fig.19-6 Lake Kasumigaura Capacity Distribution

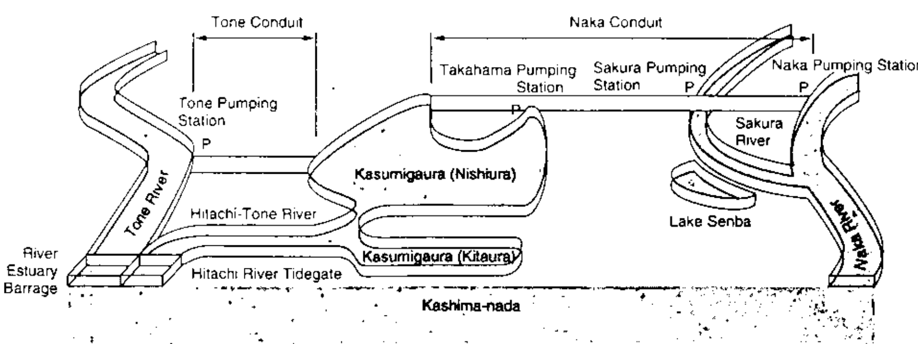



Fig.19-7 Structural Diagram of the Kasumigaura Waterworks Project

Table 19-4 Current Water Use Conditions at Kasumigaura

| Item | Maximum Water Use | Reference |
|---|---|---|
| Agricultural Water | 94.44 | Irrigation area of approximately 50,891 hectares |
| Household Use | 2.98 | Wide-ranging utilization in the eastern and southern parts of the prefecture, Kashima water main, etc. |
| Industrial Use | 11.45 | Kashima Coastal Industrial Region and wide-ranging industrial use in eastern part of the prefecture. |
| Miscellaneous | 0.97 | |
| Total | 109.84 | |

(compiled from data provided by the Ministry of Construction Kasumigaura Works Office) Unit: $m^3$ /sec within the basin, the improvement of agricultural land and industrial parks, and other factors. As a water resource that is highly resistant to drought, Lake Kasumigaura is absolutely indispensable for the further development of Ibaraki Prefecture.

## 3.Water Quality of Lake kasumigaura

### 3.1 Water Quality of Lake Kasumigaura

Originally, Kasumigaura water quality was a COD on the order of 4-5 mg per liter, and the water clarity was not particularly high. Nevertheless, this did not represent an obstacle to the water use. However, from around 1965 as various activities in the Kasumigaura basin began to flourish and water use expanded, the quality of Kasumigaure's water began to change along with growing concern about the water quality (Fig.19-8).

Examining the water quality at Lake Kasumigaura in terms of COD, the level was approximately 6-8 mg per liter from around 1965 through around 1975. In 1978 and 1979, the COD exceeded 10 mg per liter. Thereafter, however, the COD gradually decreased. Following the enforcement of the Ordinance to Prevent Eutrophication, in 1983 the COD level dropped to around 8-9 mg per liter, from 1988 it fell to 7-8 mg per liter, and in 1991 the level was 6.8 mg per liter, falling below 7 mg per liter for the first time in 14 years. Thereafter, the COD level began to increase once again, registering 7.4 mg per liter in 1992, 8.2 mg per liter in 1993, and 8.5 mg per liter in 1994. The present level is about 8-9 mg per liter.

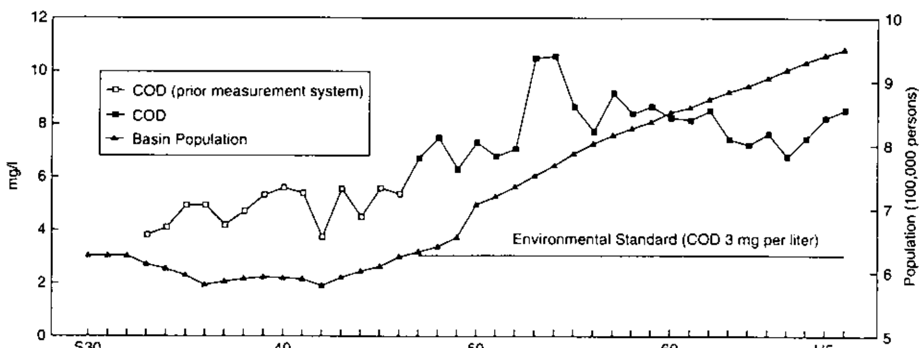


Fig.19-8 Water Quality at Lake Kasumigaura

### 3.2 Damage from Water Utilization

Then, from the early 1970's, algal bloom (a growth of algae near the surface) became conspicuous, and the COD exceeded 6 mg per liter. At the same time, condensation obstructions, filtration stoppages, and other impediments to treatment began to occur at water purification plants using the lake's waters. Water users began to complain of strange odors. Particularly in the summer of 1973, when the areas suffered from unusual drought, there was a major outbreak of algae bloom. In addition to interfering with water purification, the odor from decomposing algae was offensive, and damages were suffered as a large number of cultured carp died from oxygen depletion.

## 4.Measures to Improve Water Quality

### 4.1 Environmental Standards

To prevent this pollution at Lake Kasumigaura, the government set desirable water quality standards as administrative targets in the environmental standards concerning water pollution. Because the waters from Lake Kasumigaure are used as a resource for household water, the lake was classified as a "Class A" lake in 1972, and the rivers that flow into Lake Kasumigaura were designated as "Class A" rivers in 1972 and 1973.

Also in 1985, nitrogen and phosphorus standards were added to the Environmental Standards, and in 1986 Kasumigaura was designated as a "Class 3" lake.

4.2 Local Effluent Standards More Stringent than the National Uniform Standards

To achieve these Environmental Standards, first of all, in accordance with the national Law for Prevention of Water Pollution and the Ibaraki Prefectural Pollution Prevention Ordinance, the regulations governing industrial and business effluent were strengthened. In Ibaraki Prefecture, regulations were passed applying the strictest standards in the nation (the highest effluent standards) to prevent the pollution of Lake Kasumigaura (Table 19-5).

Moreover, in 1975 Kasumigaura was designated as a source-water region under the Special Measures Act for Source-Water Regions, and the Plan for Water Purification Facilities in Kasumigaura's Source-Water Regions was enacted in 1976. Under this plan, various works have been promoted for the preservation of water quality including the improvement of treatment plants for sewage and human waste, the improved processing of livestock waste, and dredging works, etc.

In addition, citizens' movements to improve water quality have included the use of powdered soap and non-phosphate detergent, and a large-scale citizens' plan to clean up Lake Kasumigaura is being implemented.

4.3 Ibaraki Prefectural Ordinance for the Prevention of the Eutrophication

Nevertheless, despite these diverse improvement activities, population growth, expansion of industrial activities, and changes in lifestyle have resulted in a worsening of the water quality at Lake Kasumigaura. In 1978 and 1979, the COD exceeded 10 mg per liter.

The cause of this water pollution lies in the massive growth of phytoplankton because of the influx of nitrogen, phosphates, and other nutritive salts; that is, in the process known as eutrophication. Therefore, based on a report issued by the prefectural water quality council, in 1981 regulations were enacted to prevent the eutrophication of Lake Kasumigaura. (These represented the second such regulations in all of Japan, following regulations enacted for Lake Biwa). These regulations forbid the use of phosphate and other synthetic household detergents, and place limitations on the levels of nitrogen and phosphorus in industrial effluent (Table 19-6). Ibaraki Prefecture has been ahead of the national government in eutrophication prevention efforts.

4.4 Special Measures Act for the Preservation of Lakes and Marsh Water Quality

From the mid-1980s, water pollution in lakes and marshes became a common national problem, so legal measures were upgraded at the national level. The Special Measures Act for the Preservation of Lakes and Marsh Water Quality was enacted in 1984. This law designated certain lakes and marshes in particular need of pollution countermeasures. Under this law, a Plan for the Preservation of Lakes and Marsh Water Quality was prepared, covering sewage and other works to preserve water quality as well as industrial effluent regulations. In accordance with this plan, the preservation of lake and marsh water quality is moving forward in a systematic and comprehensive manner.

Kasumigaura became a designated lake under the Special Measures Act in 1985, and

## Table 19-5 Uniform and More Stringent Standards for Wastewater

Wastewater standards based on the Water Pollution Control Law and strict standards for Lake Kasumigaura

| Harmful substances items concerning water quality | Water Pollution Control Law uniform wastewater standards (by the Prime Minister's Office) | Ordinance for Prevention of Pollution by the Ibaraki Prefectural Government strict wastewater standards for Lake Kasumigaura | |
|---|---|---|---|
| | | new | conventional |
| cadmium and its compounds | 0.1mg/l | 0.01mg/l | 0.1mg/l |
| cyanogen compounds | 1mg/l | under the detectable level | 1mg/l |
| organic phosphorus compounds | 1mg/l | under the detectable level | 1mg/l |
| lead and its compounds | 0.1mg/l | 0.1mg/l | |
| chrome hexad compounds | 0.5mg/l | 0.05mg/l | 0.5mg/l |
| arsenic and its compounds | 0.1mg/l | 0.05mg/l | |
| mercury and its compounds including alkyl mercury | 0.005mg/l | 0.0005mg/l | 0.005mg/l |
| alkylmercury compounds | under the detectable level. | under the detectable level | under the detectable level |
| PCB | 0.003mg/l | under the detectable level | 0.003mg/l |
| trichloroethylene | 0.3mg/l | | |
| tetrachloroethylene | 0.1mg/l | | |
| dichloromethane | 0.2mg/l | | |
| tetrachlorocarbon | 0.02mg/l | | |
| 1,2-dichloroethane | 0.04mg/l | | |
| 1,1-dichloroethylene | 0.2mg/l | | |
| cis-1,2-dichloroethylene | 0.4mg/l | | |
| 1,1,1-trichloroethane | 3mg/l | | |
| 1,1,2-trichloroethane | 0.06mg/l | | |
| 1,3-dichloropropene | 0.02mg/l | | |
| Thiram | 0.06mg/l | | |
| Simazine | 0.03mg/l | | |
| thiophene carboxylic acid | 0.2mg/l | | |
| benzene | 0.1mg/l | | |
| selenium | 0.1mg/l | | |
| **Conditions and substances affecting living environment** | | | |
| hydrogen-ion concentration (pH) | 5.8-8.6 (5.0-9.0 of seas) | 5.8-8.6 | 5.8-8.6 |
| biochemical oxygen demand (BOD) | 160mg/l (day average 120mg/l) | 15(10)mg/l | 25(20)mg/l |
| chemical oxygen demand (COD) | 160mg/l (day average 120mg/l) | 15(10)mg/l | 25(20)mg/l |
| suspended solids (SS) | 200mg/l (day average 150mg/l) | 20(15)mg/l | 40(30)mg/l |
| extracted n-hexane substances (mineral oil) | 5mg/l | 3mg/l | 3mg/l |
| extracted n-hexane substances (plant and animal fats and oils) | 30mg/l | 5mg/l | 5mg/l |
| phenols | 5mg/l | 0.1mg/l | 1mg/l |
| copper | 3mg/l | 1mg/l | 3mg/l |
| zinc | 5mg/l | 1mg/l | 5mg/l |
| soluble iron | 10mg/l | 1mg/l | 10mg/l |
| soluble manganese | 10mg/l | 1mg/l | 1mg/l |
| chrome | 2mg/l | 0.1mg/l | 1mg/l |
| fluorine | 15mg/l | 0.8mg/l | 8mg/l |
| coliform groups | day average 3,000/cm$^3$ | day average 3,000/cm$^3$ | day average 3,000/cm$^3$ |
| nitrogen content | 120mg/l (day average 60mg/l) | (See next page) | |
| phosphorus content | 16mg/l (day average 8mg/l) | (See next page) | |

Note: These wastewater standards are applied to factories and plants which discharge the following amounts of water:

1. The standards for harmful substances are applied to all factories and plants regardless of the amount of water discharged.
2. The standards for conditions and substances affecting living environment are applied to all existing factories and plants discharging 50m$^3$/day or more (or both harmful substances and 30m$^3$/day or more of wastewater and newly built factories and plants discharging 20m$^3$/day or more.

## Table 19-6 Strict Standards for Nitrogen and Phosphorus in Wastewater

Strict standards for nitrogen and phosphorus in wastewater by the Ordinance to Prevent Eutrophication of Lake Kasumigaura

(unit: mg/l)

| Class | | average amount of water discharged a day | for building new facilities | | for existing facilities | |
|---|---|---|---|---|---|---|
| | | | nitrogen | phosphorus | nitrogen | phosphorus |
| manufacturing industry | food factories | $20m^3$ or more but less than $50m^3$ | 20 | 2 | 25 | 4 |
| | | $50m^3$ or more but less than $500m^3$ | 15 | 1.5 | 20 | 3 |
| | | $500m^3$ or more | 10 | 1 | 15 | 2 |
| | metal factories | $20m^3$ or more but less than $50m^3$ | 20 | 2 | 30 | 3 |
| | | $50m^3$ or more but less than $500m^3$ | 15 | 1 | 20 | 2 |
| | | $500m^3$ or more | 10 | 0.5 | 15 | 1 |
| | other kind of manufacturing industry | $20m^3$ or more but less than $50m^3$ | 12 | 1 | 15 | 1.5 |
| | | $50m^3$ or more but less than $500m^3$ | 10 | 0.5 | 12 | 1.2 |
| | | $500m^3$ or more | 8 | 0.5 | 10 | 1 |
| other industries | livestock farms | $20m^3$ or more but less than $50m^3$ | 25 | 3 | 50 | 5 |
| | | $50m^3$ or more but less than $500m^3$ | 15 | 2 | 40 | 5 |
| | | $500m^3$ or more | 10 | 1 | 30 | 3 |
| | final plants for treating sewage | $20m^3$ or more but less than $100,000m^3$ | 20 | 1 | 20 | 1 |
| | | $100,000m^3$ or more | 15 | 0.5 | 15 | 0.5 |
| | plants for treating human wastes (excluding septic tanks) | $20m^3$ or more | 10 | 1 | 20 | 2 |
| | septic tanks | $20m^3$ or more | 15 | 2 | 20 | 4 |
| | other plants | $20m^3$ or more but less than $50m^3$ | 20 | 3 | 30 | 4 |
| | | $50m^3$ or more but less than $500m^3$ | 15 | 2 | 25 | 4 |
| | | $500m^3$ or more | 10 | 1 | 20 | 3 |

Note: These standards are not meanwhile applied to factories or plants with which only septic tanks are installed.

Ibaraki, Tochigi, and Chiba prefectures prepared a water quality preservation plan in 1987. This plan specified a water quality COD target, and clarified the necessary policies and works to achieve this goal.

4.5 Measures for Maintaining Water Quality

The present water quality preservation plan and basic plan are both based on the third-phase plan of 1997, and all types of measures are being comprehensively pushed forward. The various measures are summarized in Fig.19-9, and the main items are outlined below.

The causes of pollution are summarized in Fig.19-10. Some 42 percent of the pollution may be attributed to household effluent, and the sewage works that serve as the pillar of the countermeasures for this pollution have been improved by both the prefecture and the local municipalities. High-level processing of nitrogen and phosphorus is also being conducted for the water treatment. As of the end of 1995, the population served by the water treatment facilities was 398,300 people, and the coverage ratio was 42 percent.

To address pollution from agricultural water use, an Outline of Guidance in Agricultural Methods has been prepared to prevent the influx of fertilizer runoff from rice paddies and vegetable fields. The primary points of this Outline are appropriate levels of fertilizer use, appropriate water management, and constructive soil buildup.

Similarly, an Outline of Guidance in Stock Raising has been prepared to address the livestock waste issue. The basic premise of this outline is that livestock waste should be returned to the soil, and the outline includes guidance on appropriate handling of animal waste and is designed to promote the stabilization of the livestock business.

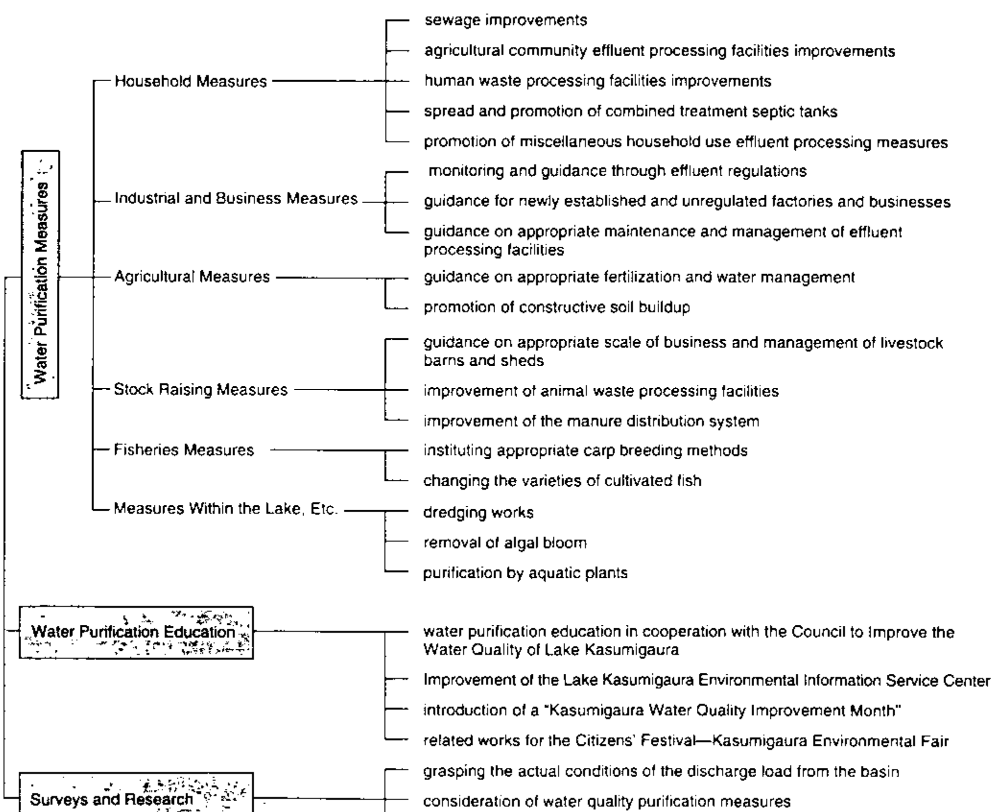



Fig.19-9 Water Purification Policy System

Moreover, an Outline of Guidance in Fish Cultivation was designed to minimize the nitrogen and phosphorus load on the lake from the raising of carp inside fish pens. This outline provides comprehensive guidance on appropriate measures for carp breeding, and on changing the varieties of fish for this type of aqua-culture.

Also, large-scale dredging operations are taking place to remove the accumulated silt on the bed of Lake Kasumigaura (Fig.19-11). Specifically, a target of approximately 7.22 million cubic meters of silt is scheduled to be dredged by the year 2000.

Aquatic plants also play a major role in the purification of the water and the health of the lake's ecosystem. Accordingly, in order to restore the aquatic flora that was reduced by the construction of embankments and the land reclamation works at the lake, (Fig.19-12) efforts are being made to construct natural diversity type shore protection works, floating fields of ditch reeds (*Phragmites communis*), etc.

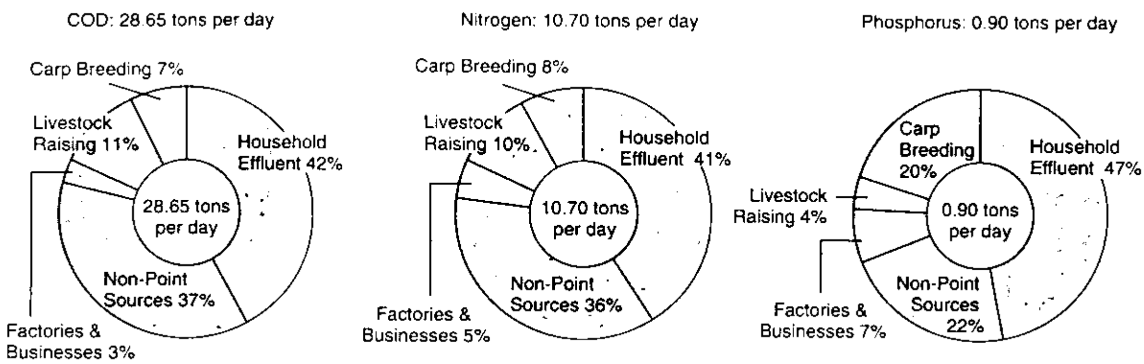



Fig.19-10 COD,Nitrogen, and Phosphorus Influx Load

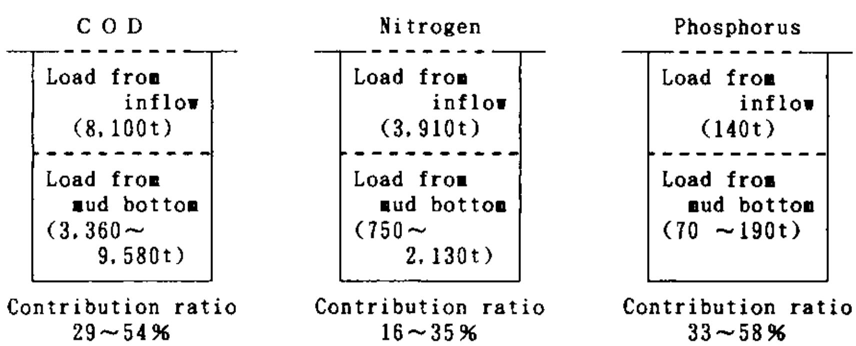



Fig.19-11 Load from Mud Bottom of Lake

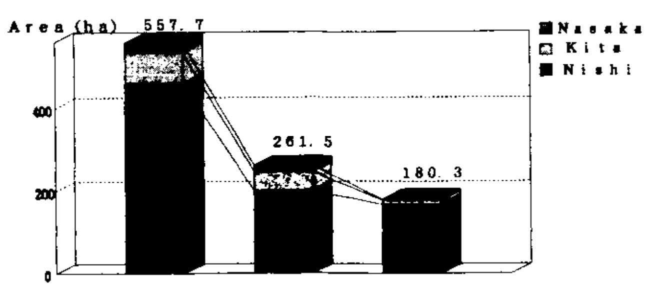



Fig.19-12 Reduction of the Emerging Plant Community

5. Issues for Water Quality Management

As the water quality has been declining since 1991, there are now serious concerns about the future water quality. Nevertheless, the type of rapid pollution seen from 1965 has not occurred, considering the increase in the basin's population, the change in lifestyles, and the development of industrial activities, the fact that the decline in water quality levels has not been more severe may be attributed to the effectiveness of the policies that have been enacted. Of course, the target water quality and water quality levels stated in the water quality preservation plan have not been achieved, and the current water quality levels are not satisfactory. Further efforts to improve the water quality are unquestionably necessary.

It is believed that two of the main reasons for the recent worsening of the water quality are: the varietal shift in the type of phytoplankton growing in the lake from the microcystis, which only appear in the summer season, to the oscillatoria, which bloom throughout the year (Fig.19-13) (Fig.19-14); and the nitrogen and phosphorus loads from the basin have not been decreasing despite the fact that the sewage works, the improvement of combined treatment septic tanks, and the other main works specified in the Plan for the Preservation of Lake and Marsh Water Quality have generally been implemented according to plan.

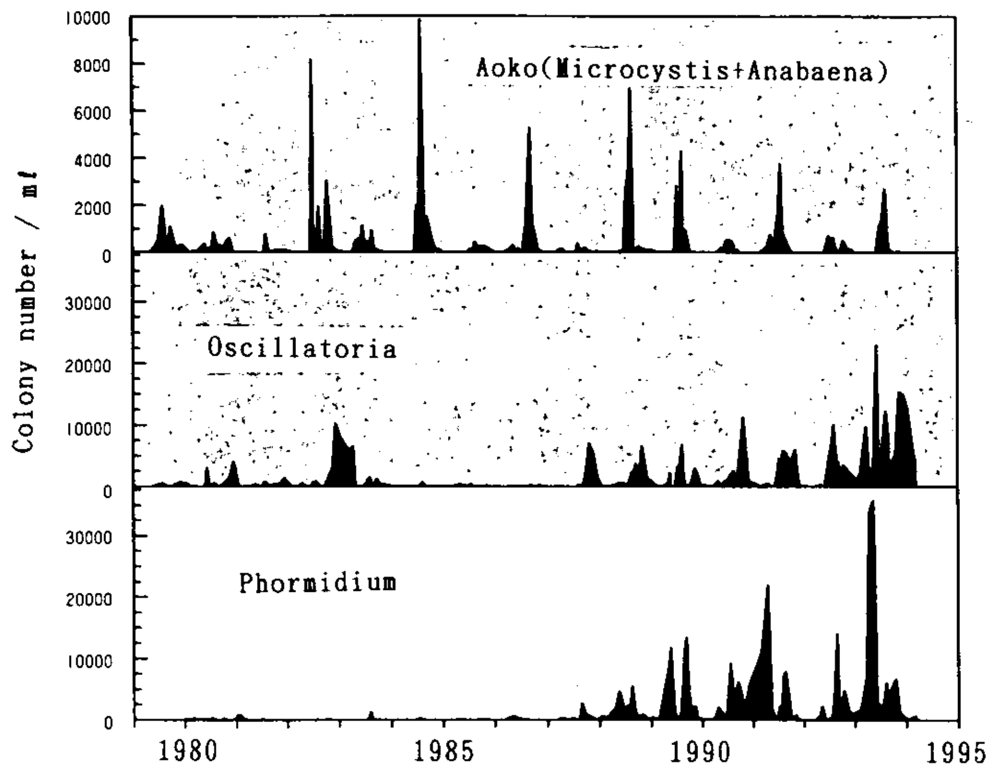


Fig.19-13 Varietal Shift in Type of Phytoplankton

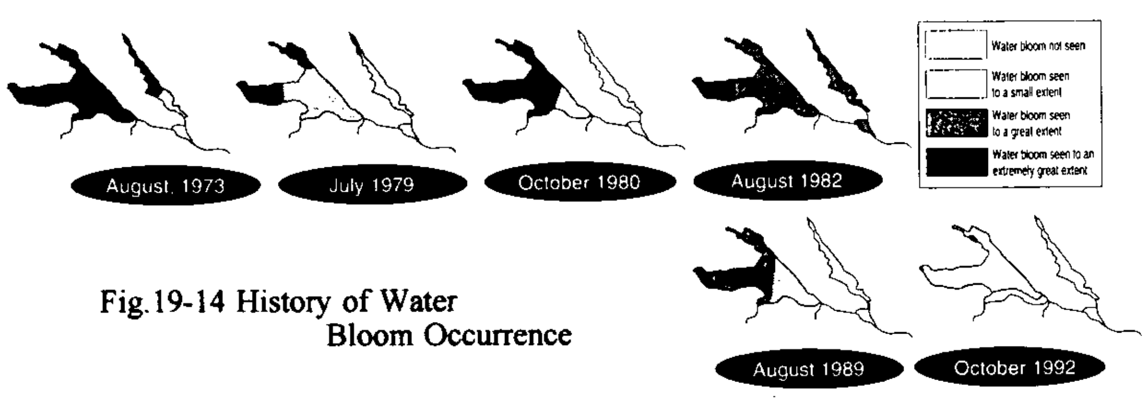


Fig.19-14 History of Water Bloom Occurrence

Therefore, while working to clarify the pollution mechanism including phytoplankton varietal shift and other phenomena, future efforts must include a quantitative and qualitative expansion of the sewage, agricultural community effluent facility, combined treatment septic tank improvement, and dredging works that have been implemented so far.

Moreover, new measures must be introduced and implemented to reduce the load from the household sector, which accounts for the largest share of the pollution factors. These should include promoting the development and spread of high-performance combined treatment septic tanks with a high capacity for the treatment of nitrogen and phosphorus; the transition to a water-conserving, cyclical lifestyle that generates a small environmental load; and the active utilization of gray water and rainwater.

Furthermore, efforts must also be made to address the pollution from non-point sources in urban and agricultural areas, which is the second largest cause of the water pollution following household use. Appropriate measures should include the active utilization of the natural purification functions of fallow rice fields, and other effective measures in line with the local land use.

While striving toward the creation of a good lake environment for fish habitation by actively utilizing the purification properties of aquatic plants, it will also be important to make every effort to improve the lake area environment with hydrophilic functions to contribute to the creation of a healthy ecosystem.

We must also consider new concepts for the management of the lake and the entire Kasumigaura basin including the rationalization of land use, total quantitative regulations taking the environmental capacity into account, and the creation of cyclical regional systems giving consideration to the ecosystem.

As it would be difficult to rapidly devise concrete measures to address many of these issues, it is important to create an institutional environment for the resolution of these problems and toward building a consensus to address these goals.

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## Chapter 20 TOKYO BAY

### 1. Introduction

Tokyo Bay located in the centeral part of Japan is a so-called "enclosed coastal sea". About 26 million people live in the basin of Tokyo Bay, accounting for 22% of Japan's total population of 120 million. The basin includes a capital of Japan, Tokyo Metropolis, where economy and industry are active.

"Edomae" known by "Edomae-Sushi" means the sea in front of Edo (Tokyo) where a lot of fish and shellfishes had been inhabited formerly. Those fresh materials became stuffs of the cooking such as Sushi etc. However, the population concentrated on the metropolitan area after 1955's, and large-scale reclamations and developments in the seaside part were carried out. The change in such a situation resulted in increase in inflow load to Tokyo Bay and in rapid deterioration of the water quality.

The government and the prefectures surrounding Tokyo Bay have made an effort to enforce various countermeasures against water pollution, and the citizens and the enterprises have done away with pollution, also. As a result, the water quality of Tokyo bay has been improved to some degree. But, the water quality in recent years changes in the level-off. This chapter introduces the water pollution countermeasures in Tokyo Bay and refers the eutrophication problem etc.

### 2. Profile of Tokyo Bay

#### 2.1 Present Condition of Tokyo Bay

The shape of Tokyo Bay is long in northeast (length:80km; width:20-30km; area:1,400km$^2$), and the width of the bay entrance is only 6km. The average annual temperature of Tokyo Bay is about 15 ℃. The average annual precipitation of it is about 1,400 mm (one peak of the rainfall in the rainy season of the June-July and the other peak in the typhoon period of September-Octorber). A dry wind from northeast blows in winter, and a wind with high moisture blows from southwest in summer.

In the Tokyo Bay basin (Fig.20-1), there are one capital and three prefectures (Tokyo, Kanagawa pref., and Chiba pref. along the coast of the bay, and Saitama pref. in the inland). There is some big rivers in the north and west coast of the bay. Table 20-1 shows the basin area and the extension distance of big rivers such as Ara R. and Tama R.

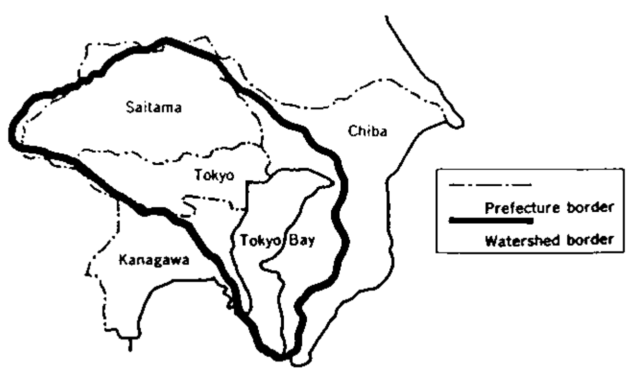


**Fig.20-1 Catchment area of Tokyo Bay**

Table 20-1 Catchment area and extension distance of the big inflow rivers to Tokyo Bay

| River | Catchment area | Extension distance |
|---|---|---|
| Edo | 200 km2 | 54.7 km |
| Naka | 987 | 102.8 |
| Ara | 2940 | 169.0 |
| Sumida | 390 | 23.5 |
| Tama | 1240 | 123.3 |
| Tsurumi | 235 | 43.0 |

Tone R.(catchment area:8588km$^2$) which had flowed in Tokyo Bay was changed to flow directly to the Pacific Ocean aiming at prevention of damage by floods and agricultural development by large-scale public works at the beginning of the Edo era. As a result, it is said that about 30% of the total amount of the inflow of the river water to Tokyo Bay decreased.

The average annual detention period of the seawater in Tokyo Bay is 1.6 months. (maximum:3.5 months during from January to February; minimum:0.8 months during from September to October). The detention period of Tokyo Bay is twice as long as those of Ise Bay and Mikawa Bay .

## 2.2 Fisheries in Tokyo Bay

A small scale fishery was active in Tokyo Bay. But, effluents from factories began to damage it in 1920 and caused a lot of damage to the fishing industry especially after the age of 1950. The fishery environment has gradually deteriorated by the progress of such water pollution. All the fishing rights in the Tokyo Inner Bay was blotted out by the compensation of 33 billion yen in 1962. Afterwards, large scale reclamation for factory use and harbor construction etc. has been conducted along the coast of Tokyo Bay where are the two big industrial zones of Keihin and Keiyo at present. The fishing industry in the bay had a production capability of an annual catch of 120,000 tons about 1970 (Fig.20-2). The amount of catch has decreased gradually and has changed by 40000 tons after 1972. The kinds of shellfish or fish that the amount of catch has decreased were clam, oyster, and shrimp. Asari and breeded seaweed show high ratios in the total amount of catch.

## 2.3 Population and Industry in Tokyo Bay Basin

Table 20-2 shows trends in population and industry in the Tokyo Bay basin. A total population of the capital and the three prefectures in the basin was 32,390,000 people in fiscal 1994, and it

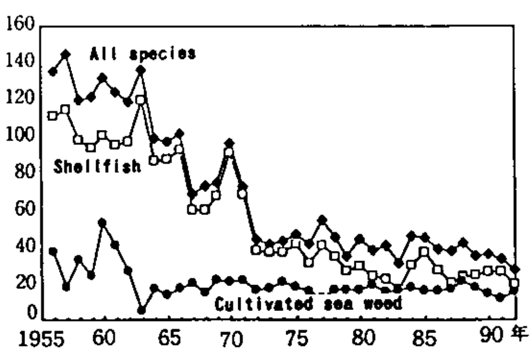


Fig.20-2 Trends in the catch of fish in Tokyo inner Bay

Table 20-2 Trends in population, amount of production, number of livestock, and arable land area in Tokyo Bay

| Fiscal year | | 1975 | 1980 | 1985 | 1990 | 1994 |
|---|---|---|---|---|---|---|
| Population(million) | | 2704 | 2870 | 3027 | 3180 | 3239 |
| Amount of production | Primary industry(trillion) | 0.6 | 0.7 | 0.7 | 0.7 | 0.7 |
| | Secondary industry(trillion) | 17.9 | 27.9 | 35.1 | 49.3 | 46.0 |
| | Tertiary industry(trillion) | 27.2 | 44.8 | 63.8 | 106.0 | 110.8 |
| Number of livestock | Cow (myriad) | 20.0 | 22.6 | 24.2 | 23.9 | 21.3 |
| | Pig (myriad) | 91.6 | 98.9 | 100.7 | 101.8 | 85.3 |
| | Chicken (million) | 18.4 | 20.0 | 22.0 | 19.9 | 19.9 |
| Arable land area (myriad ha) | | 33.0 | 31.1 | 29.9 | 28.5 | 27.0 |

Data:Total of Tokyo Metro.,Kanagawa Pref.,Chiba Pref.,and Saitama Pref.

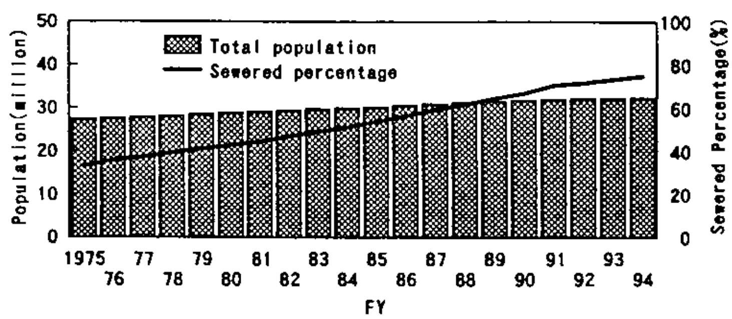


Fig.20-3 Trends in total population and percentage of sewered population in Tokyo Bay basin
(Data:total of one capital and three prefec.)

increased by about 20% over past 19 years. The amount of production of first industry has not changed so much. But, the amount of production of second industry and third industry increased and became 2.6 times and 4.1 times, respectively, in these 19 years. On the other hand, the arable land area has decreased gradually by 18% in these 19 years because of the promotion of making arable land to housing lots etc. Fig.20-3 shows trends in population and percentage of sewered population in the basin. The percentage of sewered population has increased more than the population in these 19 years. Though it was 30% in fiscal 1975, it rose up to 75% by fiscal 1994.

2.4 Decrease in Shallow Area

Reclamation has been conducted along the coast of Tokyo Bay for harbor construction and factory use etc. A total land area of 24,000 ha has been reclaimed along the coast of Tokyo Bay during from the Meiji era to the present time (Fig.20-4). 90% or more of the reclaimed area were shallows. As a result of this, 95% of the coastline of Tokyo Bay is artificial, most of which is in the form of vertical seawall. Only 1.8% of the coastline of Tokyo Bay is a coastline of nature. Trends in composition of reclamed area according to the usage during from 1960 to 1990 is shown in Fig.20-5. The ratios of harbors and recreation usage have increased relatively though the ratio of factory use decreased greatly. The usage of the reclamed area has been diversified gradually.

2.5 Oil Pollution Resulting from Accidents

A large-scale crude oil tanker flowed out the crude oil on July 2, 1997 in Tokyo Bay. But, the amount of the outflow oil was about 1,500 kl of 1/10 of the amount of forecast. The outflow oil was removed mainly by the Maritime Safety Agency, the municipalities, and the fishermen in a short term.

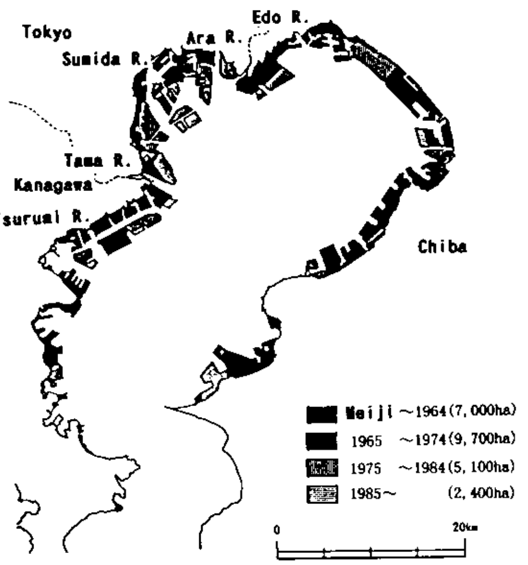


Fig.20-4 Transitions of reclamation along the coast of Tokyo Bay

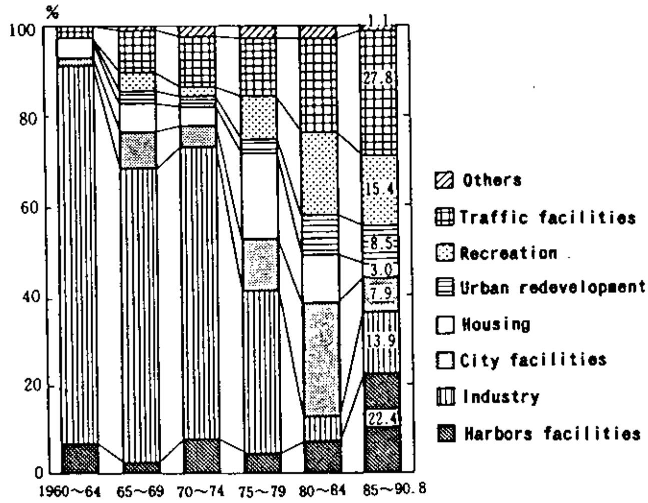


Fig.20-5 Trends in percentages of each usage of the areas for which reclamation have been authorized in Tokyo Bay

For the control countermesure of marine pollution caused by oil spills incident, "Tokyo Bay outflow oil disaster countermeasure conference" started in 1974. The organization now enforces the planning of countermeasure of incident and the training of the maritime disaster prevention.

The main pollution source of oil in the sea area is illegal dumping from ships, outflow by fault, and effluent such as bilge water and oil industrial complexes, besides shipwreck incident of such a tanker. About 340,000 ships entered the ports in Tokyo Bay in fiscal 1990. The number of ships which sailed in the Uraga channel was about 770 per a day. Marine pollution by these ships has happened daily. The number of incident of marine pollution caused by oil spills accounts for about 90% of the total incidents. The number of incidents of oil pollution in Tokyo Bay had been about 50 cases every year until fiscal 1970, though it has increased rapidly in fiscal 1971(Fig.20-6). It was presumed that the reason why the rapid increase occurred in fiscal 1971 is that "the Law relating to the Prevention of Marine Pollution and Maritime Disaster" was established in 1970 and the reinforcement of observing and controlling started to prevent marine pollution. The number of incidents in fiscal 1972 was 324 cases which was the maximum during these periods. It has decreased gradually after fiscal 1973 and has remained around 50 in recent years except in fiscal 1995, accounting for 15% of the number of incidents of Japan.

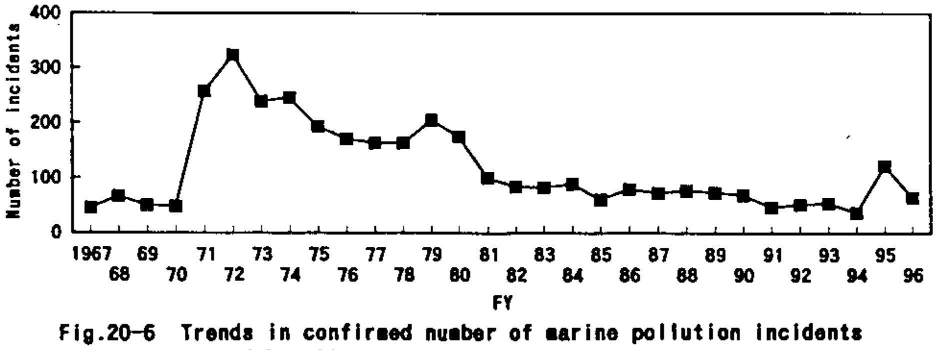


Fig.20-6 Trends in confirmed number of marine pollution incidents caused by oil spills

## 2.6 Present Situation of Japan's Main Enclosed Coastal Seas

Fig.20-7 shows the comparison with Tokyo Bay, Osaka bay, and Ise Bay. The indeces for all items in Tokyo Bay is larger than those in Osaka bay and Ise Bay. Especially, the item with a large index of Tokyo Bay is area of reclamation. The reclamation area of Tokyo Bay accounts for about 50% of the total reclamation area of Japan.

Relationship between population densities in the main inner bay basins of Japan and water qualities (COD) of these bays is shown in Fig.20-8. The concentration of COD of Tokyo Bay is higher than that of the other domestic inner bays. The concentration of COD of Tokyo Bay is 1.5 times as high as that of Osaka bay; these of nitrogen and phosphorus are twice and 1.5 times, respectively. It is thought that the reason why the water quality of Tokyo Bay is worse than that of the other domestic inner bay is the narrow width at the bay entrance in addition to the large amount of the pollution load which flows in the bay.

## 3. Organic Pollution, Occurrence of Red Tide and Blue Tide

The concentration of COD in upper layer in July is high at the head and along the west coast of Tokyo Bay (Fig.20-9). The distributions of the concentrations of nutrients, DO, and chlorophyll-a are similar to that of COD, also. Red tide occurs at high frequency during from May to August in these watersheds. The annual average number of occurrence days of red tide is about 80 (Fig.20-10). The dominant planktons which occurs every year are *Skeletonema costatum* and

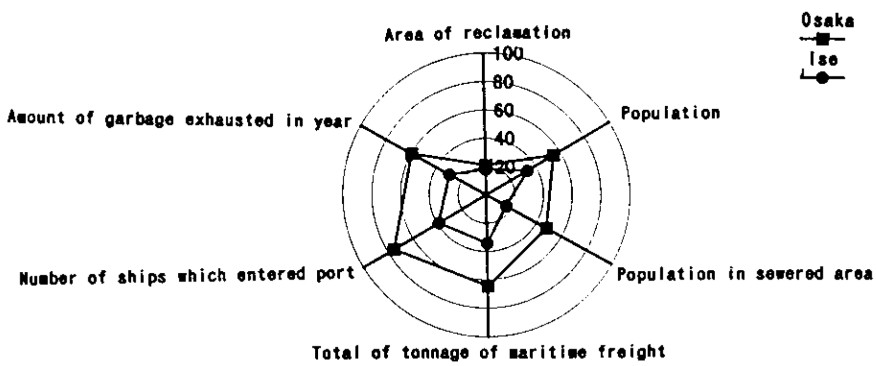


Fig.20-7 Comparison of Tokyo Bay, Osaka bay and Ise Bay

Data in FY 1993 or FY 1994

As for data, Tokyo Bay is calculated as 100%

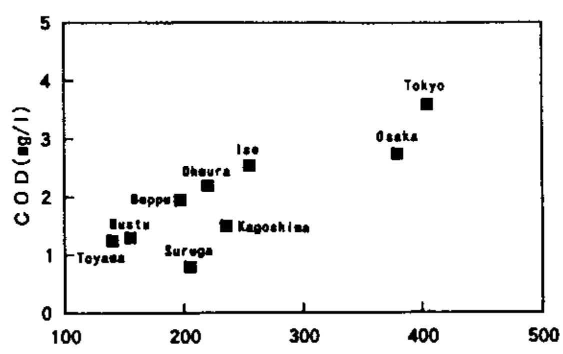


Fig.20-8 Relationship between population densities in the main inner bay basins of Japan and COD of these bays

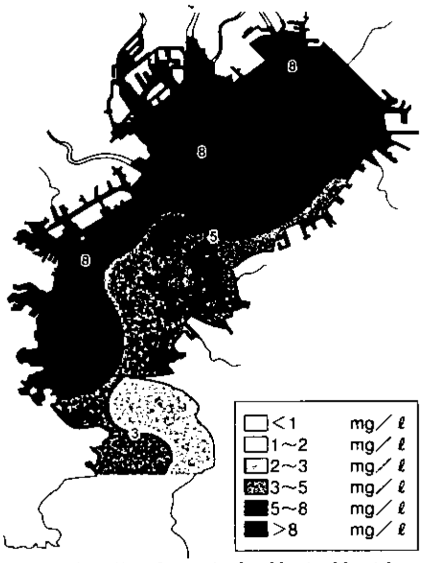


Fig.20-9 Horizontal distribution of COD in upper layer in July (1994)

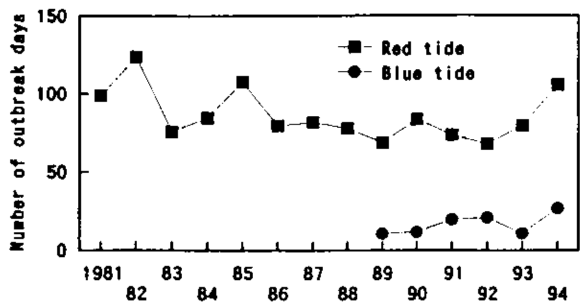


Fig.20-10 Trends in numbers of outbreak days of red tide and blue tide

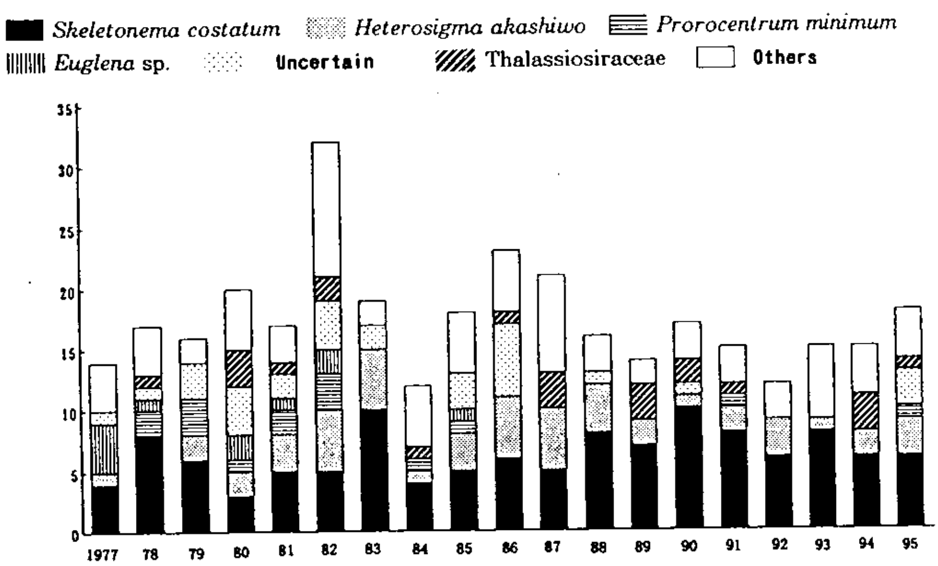


Fig.20-11 Trends in number of occurence of red tide according to dominant phytoplankton

*Heterosigma akashiwo* (Fig.20-11). *Chattonella sp.* of *Raphydophyceae*, which is known as species of the red tide with fishery damage in the Seto Inland sea, was confirmed for the first time in Tokyo Bay in fiscal 1989, and it was observed as one of the five dominant species in fiscal 1994. In fiscal 1995, *Gephyrocapsa oceanica* of *Haptophyceae* occured with a wide range from Tokyo Bay to Sagami Bay where has discolored to earth color.

On the other hand, a portion of phytoplankton deposits on the bottom of the sea just as they are. These organic substances on the bottom of the sea are decomposed by microorganisms, and at this time the consumption of a large quantity of oxgen results in a remarkable decrease in the amount of dissolved oxygen near the bottom of the sea. Such anoxia at the bottom of the sea has been confirmed in Tokyo Bay since 1955's. At the present time, this phenomenan occurs mainly during from the rainy season to autumn at the head of the bay(Fig.20-12), resulting in reduction in the number of benthos and in elution of nutrients such as phosphorus. Especially, at the bottom of the northeast part of the bay where some hollows after dredging exist, it is easy to make the bottom sea water anoxia very much because of strong stagnation of the sea water. When assuming that a strong northeast wind continues for several days under such a condition, the upper layer water

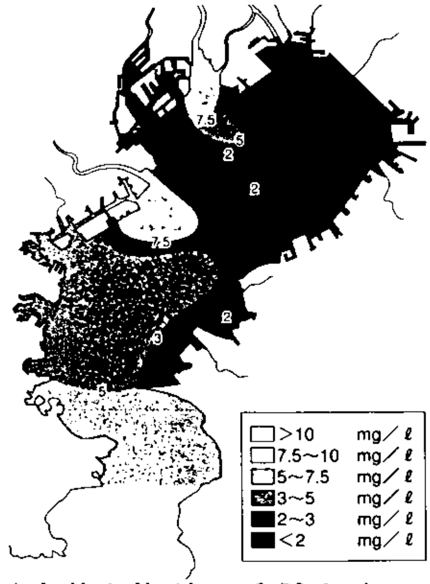


Fig.20-12 Horizontal distribution of DO in lower layer in July (1994)

moves to the offing. On the contrary, the bottom anoxia water containning sulfur compounds rises up and comes in contact with oxidized sea water in the surface layer, resulting in formation of so-called "blue tide". Blue tide occurs mainly in August-September at the northeast part of the bay because of the geographical features and the wind direction of the bay. In recent years, the annual number of occurrence of blue tide in the sea area is about 17days (Fig.20-10). The blue tide with a large scale occured at the offing of Funabashi in August-September in 1994 and resulted in a large amount of damage to the fishing industry of "asari".

## 4. Conservation of Water Environment

### 4.1 Countermeasure of Water Pollution in 1960's

In oder to prevent industrial nuisances which has increased as industry has become active, the municipalities in the Tokyo Bay basin has established pollution control ordinances from 1949 to 1963, respectively. But, a lot of the ordinances provided only for permission procedure of factory installation, and it did not have effluent control system based on quantitative standards. Some of Water pollution problems emerged. For instance, waste water from paper mills on the Edo River in Tokyo lead to severe damage of fisheries in Tokyo Bay and resulted in the first major public dispute over water pollution after World War II. In 1958, the central government promulgated two water quality laws.

One law mandated protection of water quality in public waters and the other regulated factory effluents. However, these two laws were insufficient to respond to increased needs of environmental protection because of their limited areas and less stringent control. Moreover, rapid economic growth and increase in population during the 1960's caused an intensification of water pollution problems in Tokyo Bay. The municipalities in the Tokyo Bay basin have connected large-scale factories with "agreement on pollution control" in the background of the grass-roots movement and made them to admit more stringent effluent standards than these of the law. This chapter introduces an example of countermeasures against industrial pollution on which the citizens, the administration, and the enterprise worked around 1965 at the Negishi coastal industrial zone, Isogo ward, Yokohama City.

#### 4.1.1 Grass-roots Movements

Enterprises have been scheduling factories to be constructed in the industrial zone. The doctors in Isogo ward worried about the inhabitant's health hazard by the factories, and they petitioned the

Mayor for pollution control measures against the factories in May, 1960. The Yokohama City authorities requested the cooperation of pollution control by sending the copy of this request on the companies. As a result, each company agreed with the mayor on this request. But, damages such as noises, stinks, and brown maculas in laundry occurred when the operation of the factories in the industrial zone started in April, 1964, so that a grass-roots movement against such a pollution have occured. At that time, mass communications have been reporting of the miserable appearance of "Yokkaichi Pollution", and the grass-roots movement in oppsition to construction of petrochemical complex in Mishima and Numazu, Shizuoka Pref. had risen greatly.

The inhabitants including doctors and merchants et al. in the region had formed a organization, named "Environmental hygiene conservation conference" extending over 200 committees in June, 1964. The representatives of the conference petitioned the pollution investigation of the industrial zone to the public government offices of the Ministry of International Trade and Industry, the Ministry of Health and Welfare, Ministry of Construction, and Economic Planning Agency. As a result, the Ministryof Health and Welfare announced the statement "Though the Ministry of Health and Welfare takes a proper step in the aspect of environmental hygiene immediately, it is also necessary that the municipality authorities of the region install a special investigation organization and investigate beforehand to the area where occurrences of big pollution in the future is forecast". In the background of the statement, The conference requested necessary countermeasures to the mayor of Yokohama City. Thereafter, this grass-roots movement have played an important role of pollution control countermeasure in Yokohama City.

### 4.1.2 Correspondence of the Administration

According to the request of the conference, Yokohama City authorities enforced a preliminary investigation. On the other hand, "Pollution countermeasure council of Yokohama City " was established by the ordinance in June 1964. And it undertook investigations and discussions on important matters concerning pollution as a mayor's advisory body. The mayor received the reports from the council and advanced the administrations for pollution countermeasures. The council also discussed about the countermeasure against the pollution of the factories in the industrial zone.

The Yokohama City have made an agreement with an electric power company in the zone for the sales contract of land . Contents of the agreement contained an article "When land is diverted for other purpose, an admission of the mayor is necessary". By using this articles, the city authorities was able to conclude companies with an agreement on pollution control. After this, it could make agreements with other big factories in the industrial zone and other regions on pollution control including the contents more stringently than the law. Though the main contents of the agreements contained only countermeasures against air pollution at first, the contents of the water pollution prevention countermeasure were included in it in the first half of 1970's. Afterwards, it has changed into an overall agreement on pollution control by which the entire factory was covered. The effluents water quality standards were included in the agreement after 1973, for example, the standards of both BOD and COD were $10 mg \cdot l^{-1}$ or less.

The staffs of the pollution control bureau of the city played an important role in executing these countermeasures steadily and effectively, who made efforts to understand not only the pollution control laws but also the production processes at factories.

### 4.1.3 Work of Enterprises

When the effluent standards of the control system was based on concentration, reduction in volume of water in factories had an important meaning for lowering the amount of effluent loads. However, a lot of enterprises considered water to be free of charge or cheap except the case of water shortage. From such a point of view, there were a lot of situations in which water was wastefully used in the past. But, the above-mentioned control and guidance by the city authorities have gradually changed the usage of water. Success examples of great reduction in amount of water use is shown as fllowing three cases;

(1) Coke Factory

In "A" coke factory, though a large amount of sea water was used for cooling and washing gas, it was switched to cooled liquid and to absorption liquid, respectively. Consequently, the volume of effluents of 7,000 $m^3$ per day or more was able to be decreased to 600 $m^3$ per day or less.

(2) Laboratory of Chemical Maker

In a big chemical maker's "B" laboratory, chemicals and products used in experiments were classified, and each of them were treated separately. As a result, the amount of effluent decreased from 3,000 $m^3$ per day to 800 $m^3$ per day or less.

(3) Iron and Steel Industry

Iron and steel industry is an industry which uses a large amount of water and exhausts high polluted effluent. Slightly dirty and simply-treated effluents are planed to be reused in other processes of "C" ironwork which had the rough steel productivity of 6,000,000 ton/year. By the multistep use of effluents, the circulation of 96% of the total amount of effluents became possible.

## 4.2 Water Pollution Control Law

### 4.2.1 Prefectural Stringent Effluent Standards

In 1970, the so-called "Environmental Pollution Diet" legislated essential improvements to whole environmental pollution control system, and the Water Pollution Control Law was established. The national effluent standards are uniformly applied in Japan. But, where it is judged that the national effluent standards is insufficient to attain the Environmental Quality Standards in a certain water body, the prefectural governor is authorized to introduce a prefectural stringent effluent standard through a prefectural ordinate. The prefectures in the Tokyo Bay basin have provided for the prefectural stringent effluent standards of such as BOD, COD, and SS etc, respectively (Table 20-3).

The governor is authorized to recommend an improvement of planned facility operation and/or waste water treatment if it is suspected that the effluent of factory or business premise may not comply with the standard. Moreover, a penalty is applied when the violation of the national or prefectual stringent standard is confirmed during its operation.

### 4.2.2 Areawide Total Pollutant Load Control

Efforts must be focused on reducing pollutant loads in the populated and industrialized areas around large enclosed water bodies to improve their water quality. The Water Pollution Control Law was amended in 1978 to implement a system of Areawide Total Pollutant Load Control system for large enclosed water bodies. Tokyo Bay, Ise Bay, and the Seto Inland Sea have been designated as such specified water areas.

The Prime Minister sets every 5 years both the pollutant load reduction target volume in term of COD for each specified water area and the target year by which these targeta are to be met. Following the promulgation of these goals, the relevant prefectural governors determine the pollutant load levels for each prefectural water area and formulate programs to achieve those levels. The first three stages of total pollutant load control applied until the ends of fiscal 1984, 1989, and 1994. The amount of the discharge pollutant load in term of COD which flows into Tokyo Bay has decreased to 40% until fiscal 1994 (Fig.20-13). The amount of discharge pllutant load of domestic origin in term of COD has been reduced to 39%, and that of industrial origin to 49%. An effect of reduction in the amount of the discharge pollutant load was admitted as a result of such stringent effluent regulations etc. According to percentage of the discharge pollutant load according to source in Tokyo Bay in fiscal 1994 (Fig.20-14), these percentages of domestic origin, industrial origin, and others were 69%, 21%, and 10%, respectively. The system is now at the fourth stage with pollutant load reduction target in terms of COD in fiscal 1999. The amount of the pollutant load target in fiscal 1999 is supposed to reduce in 8% for that in fiscal 1994. The control for industries has been strengthened since 1979 and public sewerage systems have expanded

Table 20-3 National effluent standards and prefectural stringent standards (unit:mg/l except pH)

| Items | Natinal effluent standards (Daily average) | Tokyo Metro. "A" area 500m3/day or more | Tokyo Metro. "A" area 500m3/day or below | Tokyo Metro. "B" area 500m3/day or more | Tokyo Metro. "B" area 500m3/day or below | Saitama prefec. 10m3/day or more |
|---|---|---|---|---|---|---|
| pH | 5.8~8.6 | 5.8~8.6(5~9) | | 5.8~8.6(5~9) | | 5.8~8.6(5~9) |
| BOD | 160(120) | 20 | 25 | 20 | 25 | 25(20) |
| COD | 160(120) | - | - | 20 | 25 | 160(120) |
| SS | 200(150) | 40 | 50 | 40 | 50 | 60(50) |
| n-Hexane extracts | | | | | | |
| (mineral oil) | 5 | 5 | 5 | 5 | 5 | 5 |
| (animal fat & vegetable oil) | 30 | 5 | 5 | 10 | 10 | 30 |
| Phenols | 5 | 1 | 1 | 5 | 5 | 5 |
| Cu | 3 | 1 | 1 | 3 | 3 | 3 |
| Zn | 5 | 5 | 5 | 5 | 5 | 5 |
| Notes | | 50m3/day | | | | |

Table 20-3 National effluent standards and prefectural stringent standards (unit:mg/l except pH)
(CONTINUED)

| Items | Natinal effluent standards (Daily average) | Kanagawa prefec. "A" area | Kanagawa prefec. "B" area | Kanagawa prefec. Sea | Chiba prefec. 500m3/day or more | Chiba prefec. 500m3/day or below |
|---|---|---|---|---|---|---|
| pH | 5.8~8.6 | 5.8~8.6 | | | 5.8~8.6(5~9) | |
| BOD | 160(120) | 5(3) | 15(10) | 25(20) | 10 | 20 |
| COD | 160(120) | 5(3) | 15(10) | 25(20) | 10 | 20 |
| SS | 200(150) | 15(5) | 35(20) | 70(40) | 20 | 40 |
| n-Hexane extracts | | | | | | |
| (mineral oil) | 5 | 3 | 3 | - | 2 | 3 |
| (animal fat & vegetable oil) | 30 | 3 | 3 | 5 | 3 | 5 |
| Phenols | 5 | - | 0.005 | 0.5 | 0.5 | 0.5 |
| Cu | 3 | 1 | 1 | 1 | 1 | 1 |
| Zn | 5 | 1 | 1 | 1 | 1 | 1 |
| Notes | | 50m3/day | | | 30m3/day or more | |

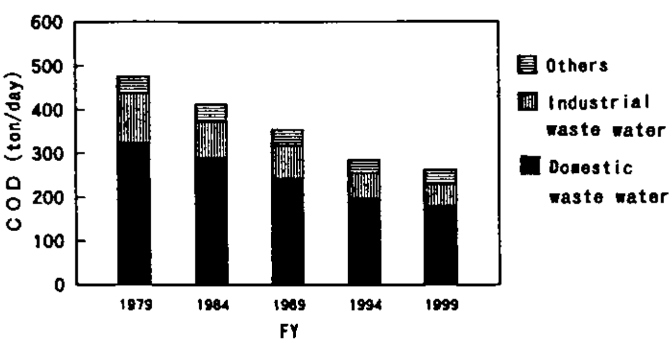


Fig.20-13 Changes in pollutant loads and reduction targets of COD under the Total Pollutant Load Control System

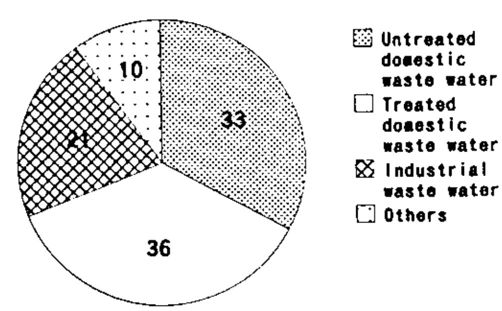


Fig.20-14 Percentage of discharge pollution load according to source in Tokyo Bay (FY 1994)

and introduced sophisticated treatment of their waste water progressively. Smaller factories and business establishments which are not controlled by the Water Pollution Control Law are requested, through administrative guidance, to make voluntary efforts to reduce their pollutant loads.

### 4.2.3 Countermeasures against Eutrophication

(1) Administrative Guidance by Municipalities
For countermeasures against eutrophication of Tokyo Bay, the municipalities in the Tokyo Bay basin have enforced the reduction guidance of discharge nutrient load which flows into Tokyo Bay from the specified factories since 1979. As a result of the first three stages of the reduction guidance (Fig.20-15), the amounts of discharge nitrogen and phosphorus load have been reduced to 23% and 45%, respectively, until fiscal 1994. Such a great reduction in phosphorus was due to popularization of phosphorus-free detergent. The nitrogen and phosphorus load rates of domestic origin in fiscal 1994 are both 62% which are larger than those of industrial origin and others. The guidance is now at the fourth stage with nutrient load reduction target in terms of nitrogen and phosphorus in fiscal 1999.

On the other hand, the pollutant load rates of each type of business have changed with the rise of the percentage of sewered population. According to the investigation results of the municipalities in the Tokyo Bay basin (Fig.20-16), the pollutant load rates of sewage origin were 70% of total phosphorus, 80% of COD and 90% of total nitrogen, respectively, in recent year.

(2) Revision of Water Pollution Control Law
The Environment Agency came to promote countermeasures against eutrophication of enclosed sea areas. The Environmental Quality Standards and uniform national effluent standards for nitrogen and phosphorus were set by revisions of the Environment Basic Law and the Water Pollution Control Law in 1993, and those were effective in the water areas including Tokyo Bay, Ise Bay and Osaka Bay. In addition, the type of water area of the Environmental Water Quality Standards was specified for Tokyo Bay and Osaka Bay in 1995.

5. Water Environment of Tokyo Bay

5.1 Classification of Water Environment and Monitoring System

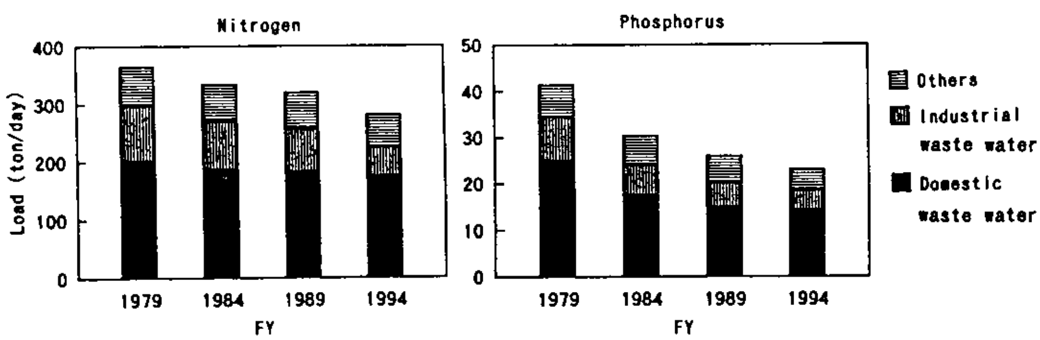


Fig.20-15 Changes in pollutant loads of nitrogen and phosphorus

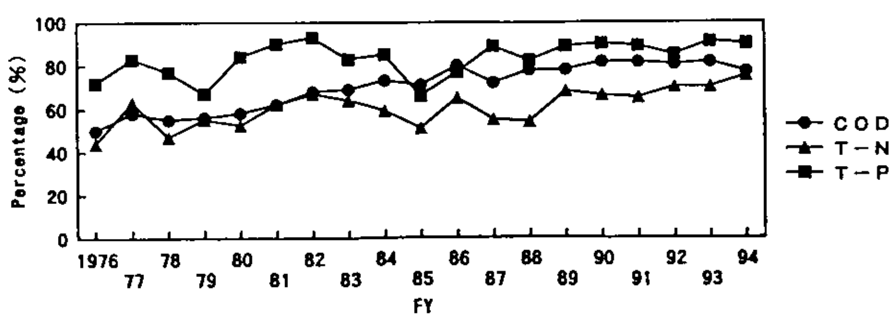


Fig.20-16 Trends in percentage of sewage business load to total loads of factories and other places of business

Though environmental standards relating human health are constant values, those relating human living are classified into some categories to water use and there are different criteria for each category. The criteria for living environmental items such as pH, COD, and DO, etc. are divided into three categories; A, B, and C in the order with small standard values.

Concerning Tokyo Bay, the water area from the bay entrance to the centeral part of the bay is assigned to category A, the water area along the region of high population and factory density is assigned to category C, and the other water area to category B(Fig.20-17).

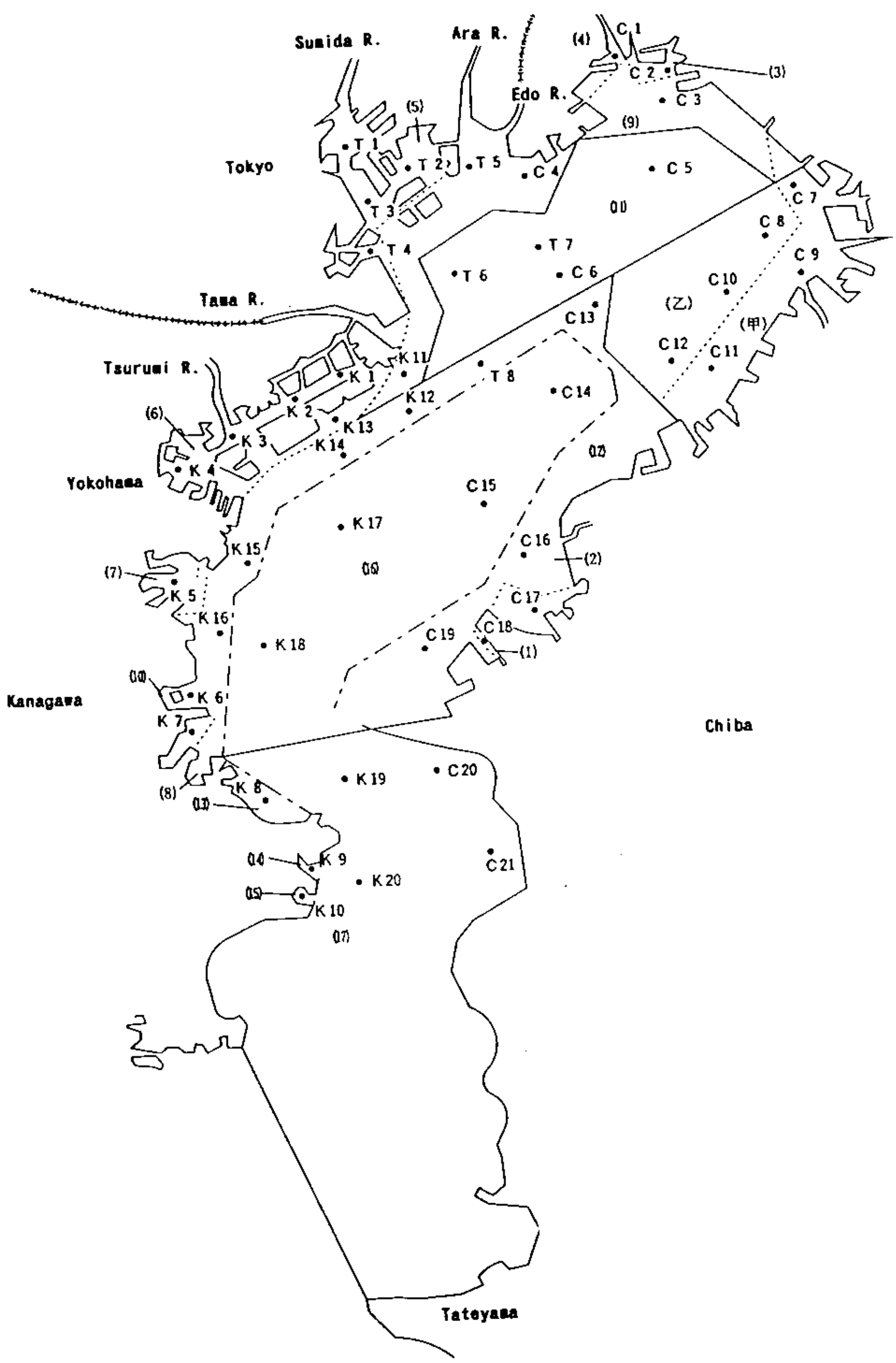


Fig.20-17 Environmental Quality Standard (COD) points and types of specified water area in Tokyo Bay

To evaluate the achievement rate of the environmental water quality standards for each water area, there are two monitoring programs; "surveillance and monitoring system for public water bodies" and "wide area comprehensive water pollution survey". The investigation frequency of the former is once a month, and that of the latter is four times a year, that is once a season.

5.2 Trend in Water Quality

The water pollution of Tokyo Bay is mainly caused by the inflow load from the rivers which flows in Tokyo Bay. The concentrations of COD of the main rivers in fiscal 1973 were about 20mg·l⁻¹ which was the highest value in these 20 years (Fig.20-18). Though it decreased rapidly and reached to 10mg·l-1 or less in fiscal 1977, it has changed in the level-off after the age. The improvement of the water quality was attributed to the reinforcement of the effluent regulation and the promulgation of sewarage system infrastructure etc. after 1970's.

However, the decrease rate of the concentration of COD of Tokyo Bay is smaller than that of the rivers (Fig.20-19). The trend in the concentration of COD of Tokyo Bay after the age of 1986 corresponds to chlorophyll-a. In addition to the inflow load from the rivers, those organisms of phytoplankton origin which is produced in the bay heightens the concentration of COD in Tokyo Bay.

The concentrations of nutrients indicated a little high value in the first half of 1970's, and those decreased afterwards(Fig. 20-20). But in recent years, those changes in the level-off. It is thought that the decrease in the concentration of nutrients in the latter half of 1970's is the results of the improvement of sewerage system, the reduction guidance of nutrients, and the popularization of phosphorus-free detergent, etc.

5.3. Environmental Quality Standards and Present Status of Water Quality in Tokyo Bay

Fig.20-21 shows trends in achievement rates of the Environmental Quality Standards in term of COD in Tokyo Bay. The Environmental Quality Standard's achievement rate of water area of category C fluctuated below 100% from 1981 to 1985, and it is maintained by almost 100% in

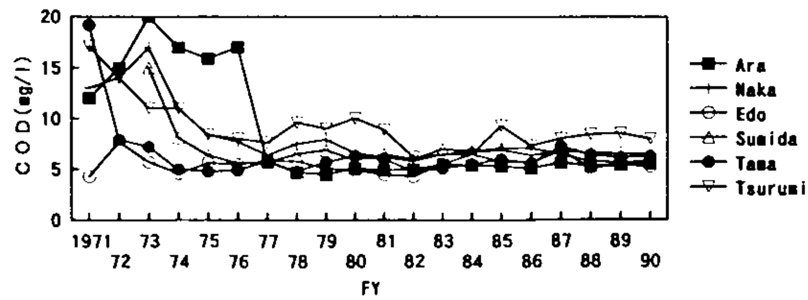


Fig.20-18 Trends in water quality (COD) of rivers which flows in Tokyo Bay

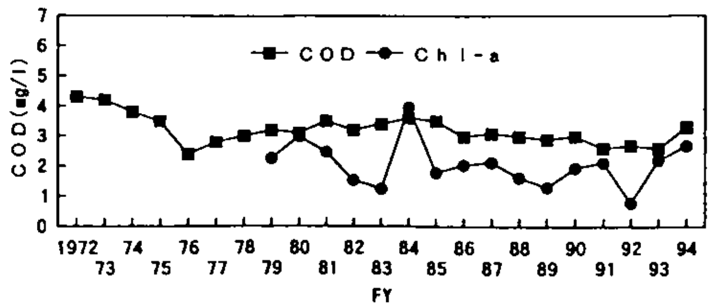


Fig.20-19 Trends in water quality (COD and chlorophyl-a) in Tokyo Bay

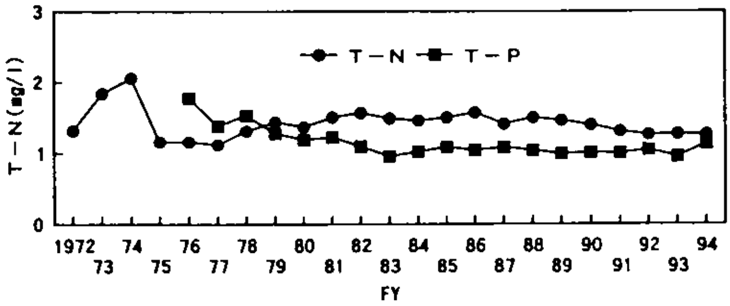


Fig.20-20 Trends in water quality (T-N and T-P) in Tokyo Bay

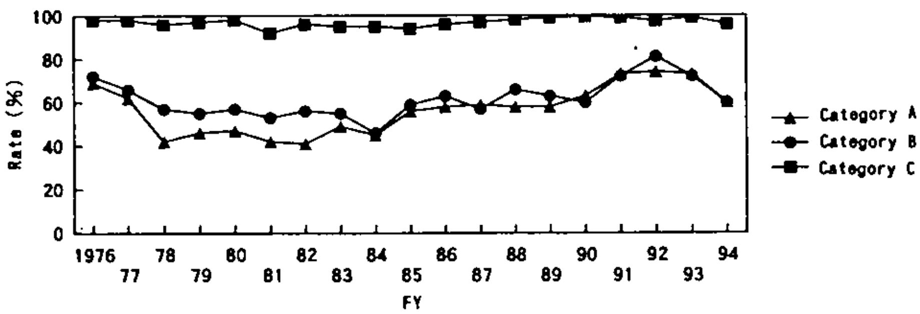


Fig.20-21 Trends in achievement rates of Environmental Quality Standards (COD) in Tokyo Bay

recent years. Those of category A and B showed about 50% during from 1977 to 1984. Afterwards, it gradually has risen and reached to about 70% maintaining by the value after 1991.

The Environmental Water Quality Standards and the average value of items related living environment in fiscal 1995 according to the categories is shown in Table 20-4. The average values in terms of pH of all categories complied with the Environmental Standards. But, those of COD of category A and B in upper layer and DO of category A in lower layer did not comply with the Environmental Standards. These facts are mainly due to the occurrence of red tide in upper layer and the anoxia in lower layer.

Table 20-4 Environmental quality standards and the measured values concerning the living environmental items

| Items | Environmental quality standard | | Average values in FY 1995 | |
|---|---|---|---|---|
| | Type | Standard values | Upper layer | lower layer |
| pH | A | 7.8-8.3 | 8.2 | 8.1 |
| | B | 7.8-8.3 | 8.2 | 8.0 |
| | C | 7.0-8.3 | 8.1 | 8.0 |
| COD | A | 2 mg/l or less | 2.7 mg/l | 1.5 mg/l |
| | B | 3 mg/l or less | 3.6 mg/l | 2.3 mg/l |
| | C | 8 mg/l or less | 3.9 mg/l | 2.5 mg/l |
| DO | A | 7.5 mg/l or more | 8.3 mg/l | 6.4 mg/l |
| | B | 5 mg/l or more | 8.7 mg/l | 6.0 mg/l |
| | C | 2 mg/l or more | 8.3 mg/l | 5.7 mg/l |

On the other hand, the mesurement values of health items such as cadmium and dichlorometane did not exceed the Environmental Standards in all points in recent years. Table 20-5 shows the Environmental Standards, the measurement values in fiscal 1995, and the tentative target values in fiscal 1999 concerning total nitrogen and total phosphorus.

Though the average values of some water areas in category IV in fiscal 1995 achieved the Environmental Standards, those in category II and III exceeded the Environmental Standards in both terms of total nitrogen and total phosphorus. As for the tentative targets, the average values in term of total nitrogen fell below the tentative targets in all water areas. But, those of total phosphorus exceeded the tentative targets by two water areas of three. Therefore, it is necessary to reduce the amount of pollutant load of phosphorus as compared with that of nitrogen for the present.

6. Problems in Future

The water quality of Tokyo Bay has been considerably improved as a result of effluent control and guidance based on the laws and the ordinances besides the effort by the citizens, the administration, and the enterprise. However, the improved tendency to the water quality of Tokyo Bay was not admitted in recent years. Especially, the red tide has been occurring at the head of the bay around summer every year. Moreover, oxygen in the bottom layer is considerably consumed by the decomposition of some of these organic substances which deposit on the bottom of the sea, where organisms can hardly be inhabited.

Based on the result by which the content ratio of stable isotope C13 in organism is examined, most of the bottom mud organisms and the suspended particle organisms in the sea water of the bay except the mouths of rivers presumed to be of sea area origin. It is pointed out that these organisms mainly cause anoxia at the bottom layer of the bay. In order to improve such a current situation, highly developed processing facilities of COD and nutrients in the sewerage system will be needed with further reduction guidance of the pollution load and promotion of the sufficient sewerage system.

**Table 20-5 Environmental standards, measured values, and tentative targets concerning total nitrogen and total phosphorus**

| Items | Water areas | Environmental quality standard | | FY 1995 | FY 1999 |
|---|---|---|---|---|---|
| | | Type | Standard values (mg/l or less) | Average values (mg/l) | Tentative targets (mg/l) |
| Total nitrogen | Chiba port | IV | 1 | 1.07 | 1.1 |
| | Tokyo Bay (A) | IV | 1 | 0.93 | - |
| | Tokyo Bay (B) | IV | 1 | 1.27 | 1.4 |
| | Tokyo Bay (C) | IV | 1 | 0.71 | - |
| | Tokyo Bay (D) | III | 0.6 | 0.89 | 0.97 |
| | Tokyo Bay (E) | II | 0.3 | 0.43 | 0.62 |
| Total phosphorus | Chiba port | IV | 0.09 | 0.085 | - |
| | Tokyo Bay (A) | IV | 0.09 | 0.065 | - |
| | Tokyo Bay (B) | IV | 0.09 | 0.096 | 0.095 |
| | Tokyo Bay (C) | IV | 0.09 | 0.059 | - |
| | Tokyo Bay (D) | III | 0.05 | 0.071 | 0.067 |
| | Tokyo Bay (E) | II | 0.03 | 0.035 | 0.044 |

Moreover, it is pointed out that if reclaimation would not be conducted along almost the coastof Tokyo Bay where shallows lie, neither anoxia nor blue tide would still happen because of the purification of pollutant by microorganism. It is necessary to examine the contribution to the water quality purification by artificial beach at which the purification ability of sea water is inferior to that at natural beach. There are a lot of problems to recover the water environment of Tokyo Bay. It is thought that our obligations to the next generation is the steady enforcement of a versatile measure bringing to "Sea in front of Edo".

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## Chapter 21 SUMIDA RIVER

# Symbol of Edo and Tokyo Which Revived at the Olympic Games…

1 Introduction

Sumidagawa River is the typical one that flows in the center of Tokyo from an old time, and which have appeared in poems, songs and literature mostly. In days of old, it was a down stream part of the Arakawa River. A bypass was made to prevent the damage of the large flood, which leaned a lesson for the typhoon in 1912. Now, a down stream from Iwabuti sluice gate (23.5km of length) is called Sumidagawa River. The width of Sumidagawa River is about 100m in upper part, while it is about 150m in a downstream. The depth of Sumidagawa River is 4-6m near Ryougokubasi bridge. The area of Sumidagawa River basin is 331.9 km3, including its branches. Sumidagawa basin is the main part of the capital where 4,318,000 peoples (40% of the whole population in Tokyo) live. Singasigawa River, Syakujiigawa River, Kandagawa River, etc. flow into Sumidagawa River . A great portion of Sumidagawa River is tidal area and drainage of four sewerage treatment plants has influenced river water greatly and water of Sumidagawa River is exchanged for water of Arakawa river. For this reason the

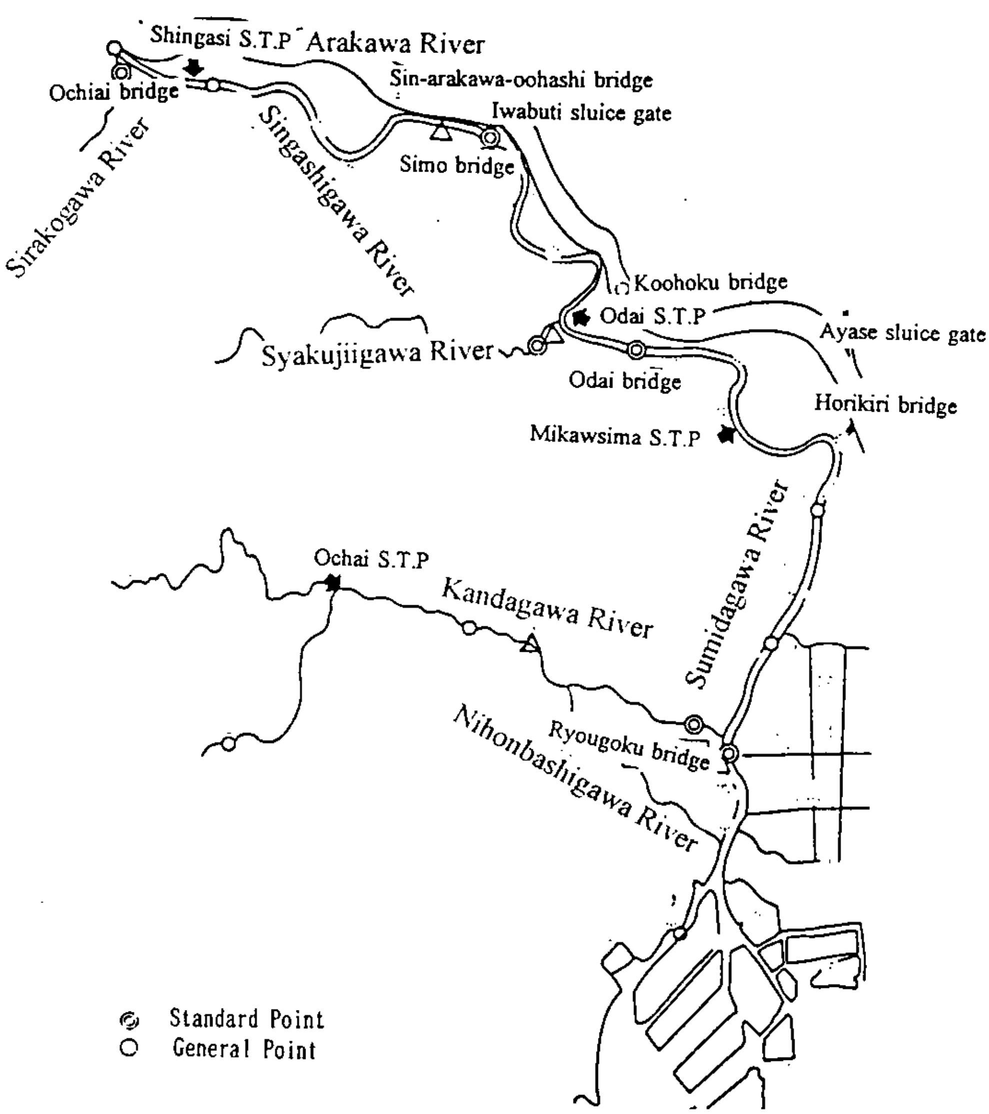


Fig.21-1 Location and components of Sumidagawa River Watershed

flow of Sumidagawa river is completely complicated. The hydraulic gradient of the river is small about in 1/10,000 and winds along greatly area. It takes 3-4 days to flow from Iwabuti sluice gate to the mouth of the river, since it tend to stagnate in response to the influence by low and high tide.

Once, in Sumidagawa River, people enjoyed swimming, or the regatta , and ate Japanese Icefish and corbiculae and had scene of peace and quietude that Pon-pon ship were going up and down. In Showa, times became good by special war demand and city development was promoted and the conditions in which river exists got worse. According to the investigation report which the Tokyo Metropolitan Health Experiment Station performed in 1940, chemistry factories and dyeing factories began to increase at the upstream part of Sumidagawa River , so that BOD indicated 10 PPM at the Senjyuoohasi bridge point, while it was 5 PPM at Ryougokubasi bridge (all was examined by sewerage examination method of those days).

Outbreak of war, and end of the war. Japanese economy recovered from damage of second world war, and industrial recovery was accelerated with special industrial demand by the Korean War. It was around 1952 that Japanese economy recovered from war damage and population and economy returned to the level of prewar days mostly. From these days, water pollution of the Sumidagawa River begins to be became unable to survive. The fish, Colbiculae, Sand worms, and Itome became to live, the right of fishery were lost in 1962. On after the year in which Japanese economy exceeds a level prewar days and began new growth , Sumidagawa River which is the symbol of Tokyo deteriorated to the dirty river that produced offensive odors. The river died. The toxic gas corroded the metal products and metal parts at

Fig.21-2 Water Pollution at Asakusa bridge

the riverside home, shop and factory etc. and that made changed color the Buddhist altar fittings and image of Buddha at the Temple Sensouji. And which injured the inhabitant's health, the cough and nausea had became chronic sick. The cause of pollution at Sumidagawa River was the inflow from the non-seaward area, majority of basin. Specially, the factory sewage from the Singashi riverside area, in which crowded about 1,000 large and small factories had exerted specially influence. According to the damage became serious, Tokyo Human Right Protect Commitiee had appealed hard the improvement conditions to the relational institutions, and the water pollution at Sumidagawa River had became seriously the social problems. In 1961,Ryougoku Fireworks Convention and Soukei Regatta, that was sociable Sumidagawa River Features had unavoidable canceled.

2. Transition of Social and Natural Conditions of Sumidagawa River

2.1 Transition of water quality of Sumidagawa River

According to the change of water quality after 1959 as shown in Fig. 16-3, water quality became bad remarkably from around 1955. Sumidagawa River was heavily in 1962-3 polluted so that BOD was 63 PPM at Odaibasi bridge . After 1964-5, it improves quickly about 20 PPM of water quality. It becomes after that cleaner and after 1985 were set to 10 PPM or less. However, almost all water quality is not improved after that.

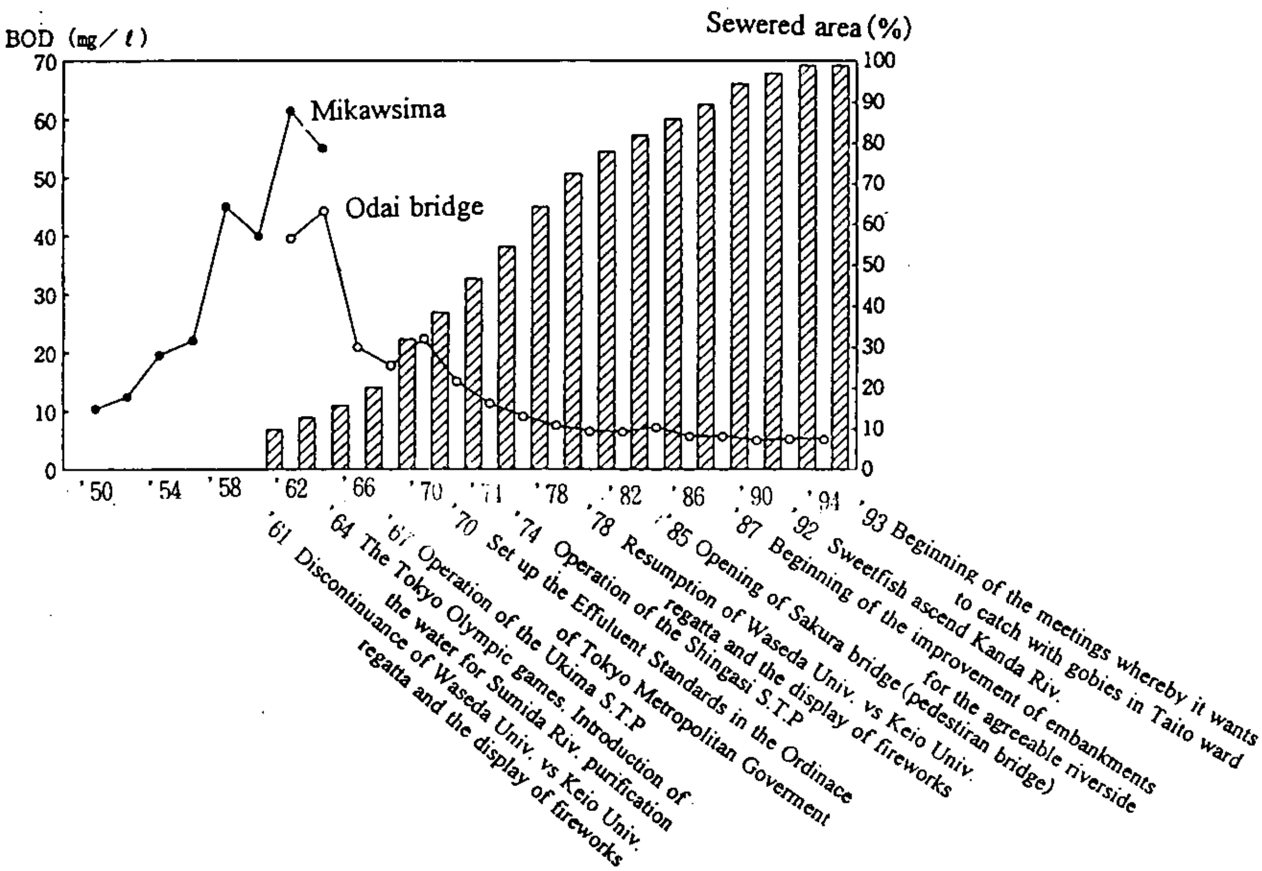


Fig.21-3 Change of water quality of Sumida Riv. and sewered area

2.2 Transition of Cause of Sumidagawa River Water Pollution

According to Economic Planning Agency data, the BOD load discharged to Sumidagawa River was 195 ton per day around 1960 .As for the items, 32% was discharged from household and 68% from factories (among those 53% large-scale factories ). So large-scale factories had much BOD load. And the drainage volume was almost double upper river flow rate in those days. Then in 1995 when 35 years passed from the investigation of Economic Planning Agency , the drainage discharged into Sumidagawa River is mostly from sewerage facilities have spread in the most part of Sumidagawa River basin. Therefore, almost all discharge water to Although household wastewater drains to Sumidagawa River a little, it ceases to drain from factories to the river. The BOD load in 1995 was 15.7t/d. It is below 10% of that around 1960.

3 Match to the Improvement (before 1969)

3.1 Regulation of Factory Effluent

After the war, industrial activity recovered rapidly and complaints about smoke, industrial activity. Such a problem over a very wide area began to advance. In response, in August 1949, Tokyo Metropolitan Government enacted "Industrial Pollution Prevention Ordinance" which is the first pollution regulation ordinance, by local government in Japan. It establishes that a developer needs to get the governor's approval before building or extending his factory. It would be dependent on an administrative guidance. It was unable to define the effluent standard and structural standard.

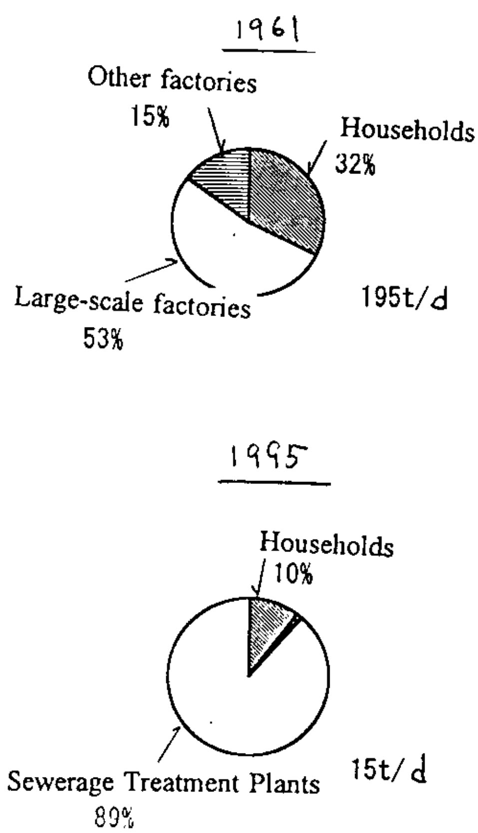


Fig.21-4 BOD load into Sumida Riv.

According to the industry development, the water pollution, of river began to have been conspicuous from around 1952-53 years. The antipathy of fishermen increased suddenly to the factory which was passing drainage. At last, in June1958, about 1000 fishermen crowd to Honsyuu Seishi Edogawa paper mill factory, and a violent crash occurred. Since the Semi Chemical Pulp Production equipment which began to operate in March discharged effluent into Tokyo Bay via Edo River and it annihilated fish, shellfish, etc. that incident broke out. It was the incident against which it protested that a company resumed discharge while it had not agreed (fishermen's groups had required that effluent purified to a company frequently). This incident gave a big shock to not only Tokyo Metropolitan Government but National Government. National Government proclaimed " the Public Water Zone Conservation Law ( abbreviation PWZCL )" and "Industrial Effluent Control Law" by state in December,1958.

Then specified water area and its water quality standard of Edo River were designed in 1962. However, it was 1964 when specification and water quality standard of Sumidagawa River were designed since it took much time in the procedure of a specified water area system. It passed 6 years since PWZCL was established. As mentioned above, various factories had large rate in pollution source into Sumidagawa River. Then, National Government considered the system which differs from the case where the water quality standard of Edo River or Tamagawa river is defined, about the water quality standard of Sumidagawa River. That is, although it set up a standard uniformly to all types of industry in principle, it took the following conditions into consideration further, the public sewerage system stage, planed area, the existing factory or the new factory. This is called system of urban type river. It was specified as Arakawa River basin Kou(it is Sumidagawa River basin) in 1964. A water quality standard was also set up. As a desirable goal, it considered revival of extraction of Japanese icefish in Sumidagawa River. However, the water pollution of Sumidagawa River of those days and concept of PWZCL which harmonizes industrial activity with the environmental preservation were taken into consideration. Since it judged that early realization of desirable goal was difficult, it will be decided that water of Sumidagawa River does not generate a bad smell at least. At the last moment, as water quality of the minimum level, BOD decided on 10 PPM or less, and DO decided on 1 PPM or more.

Tokyo Metropolitan Environmental Pollution Ordinance and a smoke prevention ordinance (enacted from a law before) overlapped a law. A pollution phenomenon is expanded quantitatively and diversified. Therefore, July,1969, Tokyo Metropolitan Government collects these ordinances, and enacted Tokyo Metropolitan Environmental Pollution Ordinance. Moreover, each division and a city get the section take charge of, office work is expanded, and an administrative net spread.

### 3.2 Construction of Joint Wastewater Treatment Plant for Only Industrial Effluent (Ukima Treatment Plant)

Although it traced back a time, it determined holding of an Olympic Games Tokyo convention in 1959. Main concepts of the enterprise relevant to Tokyo Olympic Games considered as the holding city (probably, it will attract attention in the world) were a environmental protection and institution maintenance suitably and wonderfully. However, Sumidagawa River which is the symbol of Tokyo became lifeless river. The greatest point of the measures for Sumidagawa River purification which started in 1962 was construction of Ukima Treatment Plant which collected and processed the industrial effluent located along with Singasigawa River. Since most factories located along with Singasigawa River were minor, Tokyo Metropolitan Government built Treatment Plant for only industrial effluents. That is, in order to carry out waste water treatment for every factory, there are restrictions of management, narrow space, etc. and the direction which treated together was considered that the effect of waste water treatment can expect immediately.

Construction of Ukima Treatment Plant started from February 1964. Ukima Treatment Plant collected and treated effluents (210,000m3/day) of 730 factories and household effluents (80,000m3/day) which were located in 1,087ha in alignment with Singasigawa River. The target of the treated water quality was BOD 120 PPM which was the effluent standard of Sumidagawa River. The treatment water of Ukima Treatment Plant was sent to Singasi sewerage treatment plant. It was further treated to the effluent standard of sewerage treatment plant (BOD 20 PPM) by Singasi sewerage treatment plant. April 1966 Ukima Treatment Plant began treatment with a part of institution. And it also started charge collection of treatment expense. Since it decided that it collected from the factory which drained more than 1000,000m3/day, it only collected charge from about 15 factories.

However, the system was a new system without a similar example. Therefore it received criticism which is not few. When the effluent from various factories was mixed, problems were included in the system of waste water treatments (technical level of those days). For example, since it was disadvantageous to the whole treatment, chemical treatment was stopped soon. Furthermore the investigation result that Activated Sludge Process has not treated the heavy metal contained in industrial effluents was also announced. Ukima Treatment Plant was one urgent measure trial to the last. Social requests changed about treatment of industrial effluents. Effluent regulation was also strengthened. Therefore Ukima Treatment Plant was abolished. However, in each factory instruction, it mentioned the result not obtained. And it is estimated that it brought noteworthy results to water-quality purification of Singasigawa River and down-stream Sumidagawa River.

3.3 Introduction of Water for Purification

It was the unusual water shortage called "Tokyo desert" in 1964. The rate of restriction water supply became 50%. Since Tokyo Olympic Games was due to be held soon, it needed to secure water-service resources. Therefore it was constructing the institution for leading river water of Tonegawa River to Arakawa River hurriedly. It will be used also for the thing with which the surplus of introduced water diluted polluted Sumidagawa River and which it also purified. The amount of use was provisionally set to a maximum of 23.4 m3/s. Use conditions were as follows. (1) It divides into Singasigawa River at the time of ninety-five days discharge of Arakawa River, and it introduced into Sumidagawa River further. It has purified Sumidagawa River. (2) When surplus water is in Tonegawa River and a margin was in the

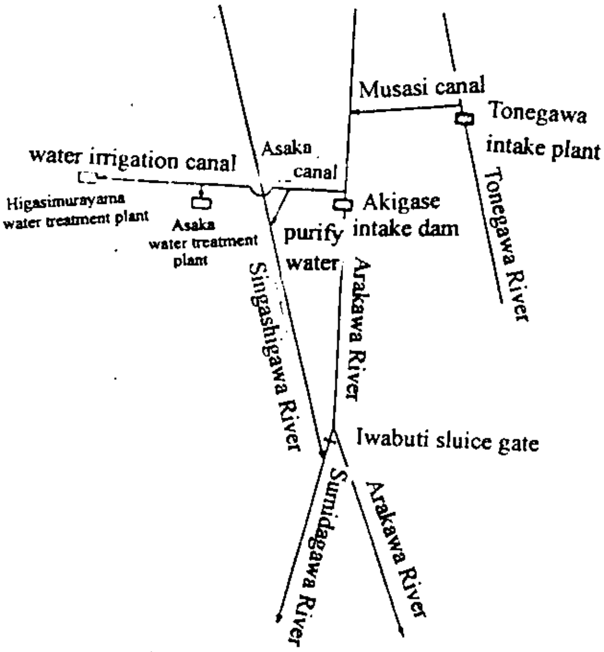


Fig.21-5 Water system fir cleaning up Sumidagawa River

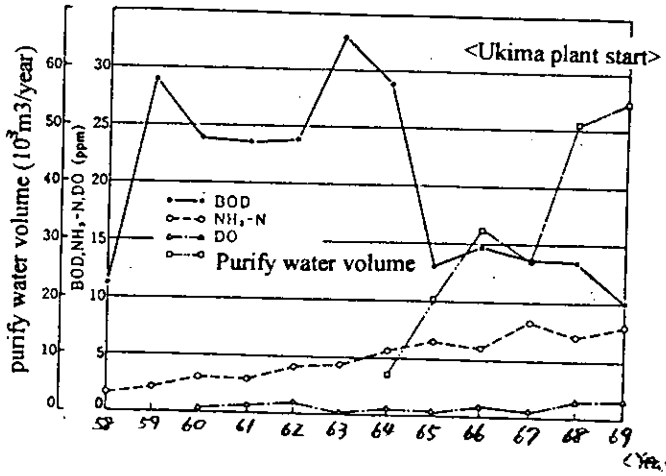


Fig.21-6 Change of Sumidagawa River quality(Ryougoku bridge) And Flow rate fir river cleaning up

capacity of the connection waterway between Tonegawa River and Arakawa River (Musasi waterway), it was that which introduces the surplus of introductory water from Tonegawa River to Arakawa River into Singasigawa River.

The price of the construction expense of a purification waterway was 2,750,000,000 yen. National Government paid 10%. The prediction and the actual result about the effect of the measure against purification are shown at figure 16-6. Also by Ryougokubasi bridge located in the lower stream of a river of Sumidagawa River, water quality has been improved greatly these days. It tried introduction of water in September and October, 1964.May, 1965 or later, when a margin is in the river flux of Arakawa River, it has always introduced water for purification into Singasigawa River. Therefore, it cannot necessarily secure fixed flux continuously. The result introduced into Singasigawa River in 1994 fiscal year as water for purification was as follows. The maximum flux is 21 m3/ s. Flux was 4.5 m3/s above the half of the days of the fiscal year. Incidentally, 4.5 m3/s (about 400,000 m3/d) is equivalent to the amount of effluents of Ochiai Treatment Plant (Kandagawa River basin).

3.4 Public Sewerage System Construction

In 1959 Tokyo Metropolitan Government improved ten-year extension sewerage system plan. It will spread sewerage works powerfully. The plan was large revision which increased project cost from 36.6billion yen to 65 billion yen and which planned to have raised severed rate (area) from 28% to 42% at 1966 ends of the year. Furthermore Tokyo Metropolitan Government decided upon Program for Sewerage Construction newly in January,1961. Furthermore since purchase of the land by which road construction was planned was settled temporarily these days, it invested capital in spread of sewerage system intensively. Thus, as a result of promoting spread of sewerage works powerfully at the time of the Olympic Games, Sewerage rate (against area) became 26% 1964. In the inner side of Japan Railway ltd. Yamanote Line, spread of sewerage works was completed mostly. Odai Treatment Plant started sewer treatment in 1962. Otiai Treatment Plant also attracted in March,1964.Consequently, in the ward area, it began to treat sewage by five Treatment Plants with Mikawasima Treatment Plant, Sunamati Treatment Center, and Sibaura Treatment Center.

3.5 Monitoring, Regulation, and Instruction

(1) Actual regulation instruction to factories

Since water resources accessed our country comparatively easily, it did not have idea in the device which uses water rationally. Rather, the thought of flushing impurity with water is deep-rooted. After almost all factories thinned their effluents, it had discharged.

As it already stated, it took time in State setting up the water quality standard of Sumidagawa River, as for the time of PWZCL. In the meantime, Tokyo Metropolitan Government created the instruction standards of a waste water treatment uniquely. It had begun large-scale establishments instruction as a starter by it. Especially about metal product manufacture business (plating business), Bureau of Environmental Protection, Bureau of Sewerage, and Bureau of Public Health have a liaison committee, and it tried hard so that it might not become scattering instruction. Bureau of Environmental Protection created and guided the structure standard about the waste-water-treatment institution from plating business.

The personnel of those days are telling as follows. "Those days, there were no reference book and instruction document to waste-water-treatment institution. There were not personnel who did instruction experience, at all. Therefore, we investigated the water quality and the flux for every process together with the person in charge of the factory. In order to treat a effluent stable efficiently, we investigated the effluent from which process has influenced bad. Consequently, it was able to make BOD concentration of a effluent low as a result by recovery and reuse of solvent or materials. In plating, we proposed installing a recovery tub at a washing process, and changing the flush method into the multi-stage cascade flush method in the plating company. Consequently, effluent concentration became low. And the quantity of water which it used for washing decreased. The company, it was thankful to us".

Although direct penalty regulation was incorporated by Water Pollution Control Law, Tokyo Metropolitan Government guided an improvement by the means of notice and warning based on the analysis result of the effluent which it sampled when the personnel were the inspection. Moreover, we assemble the enterprise person and held schools. They were because it helps understanding of the principle of a waste water treatment, the waste-water-treatment method, and maintenance management and it puts practice into practice. Furthermore, the person who does not improve enough emits an improvement command and performed sanction of having released nomination to society simultaneously. Occasionally, we guide a middle-scale factory intensively and made it improve first. It made the improved institution take and inspect big factories after that. And we also adopted the method of making make learn and improve from the factory of a scale smaller than they (in order breaking their stubborn attitude not to accept our improvement policy simply).

(3)Instruction of the waste water treatment of a housing complex. A large-scale housing complex came to be built by Tokyo area one after another from around 1960. These housing complexes were the upper-layers buildings from the request of a sudden rise of a land price, nonflammable housing, the increase in efficiency, etc. of a residence. As for a rest room, a flush system began to be adopted. The population density was 300-600 per 1ha. The population scale was mainly about 2,000 from 20,000 persons. Population density (per ha) was larger than an average of 158 persons and a maximum of 285 (that time) in the ward area. The population was equivalent to the population of the towns and villages of Tokyo area. If such a large-scale high-density set residence appears in the country zone which is not perfect not to mention sewerage works even as for the construction of a effluent wastes. When a human waste and a other kinds of liquid waste are discharged there, water quality about there will deteriorate remarkably by them. In therefore, the district considered that sewerage works does not spread soon. Therefore, we taught the chief mourner who builds a set residence, after Showa 38, in the district considered that sewerage works probably will not spread soon so that it might install community plant based on the structure standard which Tokyo Metropolitan Government made uniquely. The structure standard as the system which it purifies after uniting a human waste and a other kinds of liquid waste. The purification capability was the same as the water quality treated by public sewerage system Treatment Plant almost. By 1970, installation of community plant became the scale which can purify about 500,000 persons' sewage a total, including a plan.

### 3.6 Dredging

After the war, earth and sand had flowed and deposited from the upstream each river in the city of Tokyo. Wreckage, such as the building destroyed by war, was thrown away into river. Dust was also so. Industrial effluents and sewage flowed in further. Therefore rivers were polluted remarkably. 1957 , sludge accumulates on the bottom of Sumidagawa River, and it floated as scum or the bad smell of hydrogen sulfide came to occur. It was the necessity on a flood control. It also came to cause trouble again to operation of a ship. Then Tokyo Metropolitan Government added measure against river pollution to a river enterprise newly. Water pollution control and the improvement in water quality will be aimed at. Since it obtained national subsidies as a river water-pollution measure enterprise in the 1958 fiscal year, it started dredging, such as Sumidagawa River. Based on the river dredging emergency 5-year plan in the Showa 34 fiscal year, and the Long Term Planning for the Tokyo Metropolis which started from the 1961 fiscal year, the dredging enterprise was performed further. It carried out the dredging of all the rivers 3 times for 10 years till the 1967 fiscal year. The total of the amount of dredging was shown in figure 21-7 It is understood that a dredging was intensively carried out in three terms at the first. The amount of dredging was about 6000,000

• . Then, in the Tokyo Environmental Pollution Control Plan, It gives priority to deposited dirty mud of the remarkable river of water pollution, it starts a dredging, and it expected purification of river water quality. Every year, a part of Sumidagawa River is put on the list which should give priority to a dredging. It is carrying out the dredging (it also appointing a zone one by one every year now) of the Sumidagawa River. The amount of dredging is 70,000 - 90,000 m3. And, these costs have exceeded 200,000,000 yen every year in recent years.

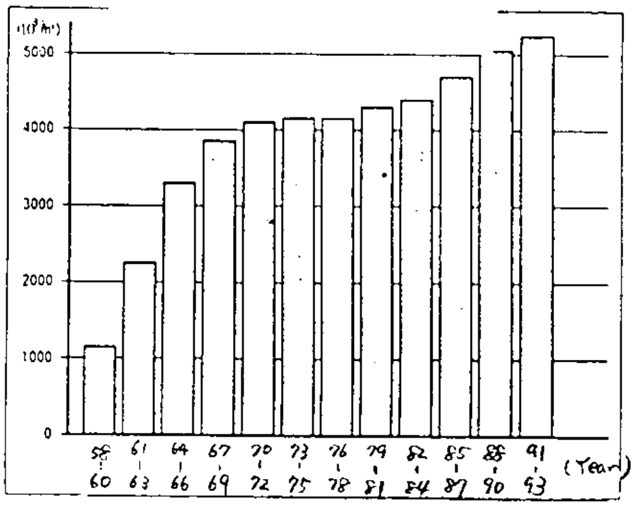


Fig. 21-7 Dreged up sludge from Sumida Riv. (cumulutive)

3.7 Relocation of Factories

(1) Relocation of large-scale factories

In order to restrict new extension of a large-scale factory, a university, etc. considered to be the important factor of the increase of population in an established city area. The Law about Restriction of the Industry in the established city area of a metropolitan area etc.(The Law of Restriction for Industry Development) was enacted in March, 1959 . The new extension of the factory where work area is larger than the area restricted by the law became impossible in the restriction area. The Law of Restriction for Industry Development, and The Cabinet Order of PWZCL and Industrial Effluent Control Law proclaimed by making the time the same. There were also companies which transferred from a metropolitan area or relocated the production section out of a capital in the company which aims at an enterprise expansion and new deployment of factories.

Transition of the number of factories in Sumidagawa basin area in the 1955s is shown in figure 21-8. The population of Tokyo Metropolis continued increasing in spite of he Law of Restriction for Industry Development enforcement. Population in Sumidagawa River basin and the factories located in the area, it has changed from the second half of the 1955s to leveling off or reduction first in the 1965s.

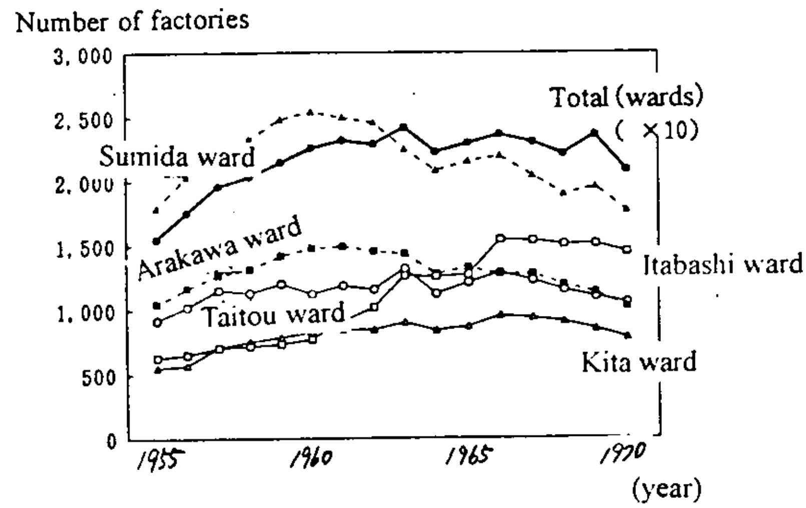


Fig.. 21－8
Change of the number of factoties of Sumida Riv. watershed (more than 10 emplyees)

(2) Support, relocation and collectivization for the environmental protection to the factory of a minor scale

In the city of Tokyo, about 80,000 factories were in 1968. That these factories were intermingled with dwellings had caused complaints and petitions of residents. For these solutions, those cause persons install environmental-protection equipment, and public hazard must be made not to generate them. Relocation itself hardly contributes to production. Considerable expense is required for relocation. Therefore, especially relocation has large economical burdens for minor enterprises. As for Tokyo Metropolitan Government, minor enterprises have promoted the constructions of the measure against a environmental protection. Tokyo Metropolitan Government facilitated the provision of financial aid , such as capital for facility improvement, capital for factory relocation , recommendation to financial institutions and subsidizing interest payments. Prevention of public hazard was difficult for pollution-causing factory, such as casting factories and " the bowel and bone of fishes" factories (it carries out heating cooking of the internal organs and the bone of fish, and it extracts oil etc.), very technically. Therefore, effective measure was dividing the area of residences and factories, i.e., group relocation was carried out to the place suitable for the factory working. In order to promote factory relocation, Tokyo Metropolitan Government purchased their former sites. It purchased the relocation former sites of 57 companies 62 factories, and about 700,000 m2 by 1969 fiscal year. In the land which it purchased, it built 7899 residences, 27 parks, seven playing space, etc.

## 4 Match of Improvement ( Later 1970)

### 4.1 Setup and Reinforcement of Environmental Quality Standards (EQSs)

The Basic Law of Environmental Pollution was enacted in 1970. Based on it, it specified E category of Sumidagawa River. In this way, EQSs of Living Environment became less than BOD 10ppm by cabinet-meeting determination. In order to attain the standard, promoting spread's of sewerage system much more and dredging were needed. The water quality of Sumidagawa River has improved and a social request changed. The EQSs of Sumidagawa River was ranked with D category (BOD8ppm) in 1975 .

### 4.2 Reinforcement of Effluent Regulation

The two old water pollution control laws were abolished, and The Water Pollution Control Law was enacted in December, Showa 45. Nationwide coverage of standard of enforcement standards was provided. In the law, it set the effluent uniform standards from establishments such as BOD120ppm (day average) in the whole country. And power was delegated to prefecture governor regulation to authorize stricter if necessary to achieve environmental quality standards. Since the Law was enforced, a capital revised Tokyo Metropolitan Environmental Pollution Control Ordinance which it was preceding enforcing in January, Showa 47. The effluent standard of establishments with many effluents ( it prepares newly ) set up severe value, such as BOD 20ppm ( it considered as limit of effluent treatment of those days). Then, the effluent standards was revised in Showa 53. Even when it was existing, BOD is set to a maximum of 20 PPM, and established sewerage treatment plant also came to correspond to this.

Moreover, although regulation of direct penal regulations was defined, since Tokyo performs the fine administrative guidance to the violation enterprise place which had the beginning near the half, and it raised efficiency application was few. One time of those days, on the other hand, the Metropolitan Police Department often performed criminal accusation without warning.

### 4.3 Reinforcement of monitoring system

For prevention of water pollution, while strengthening regulation of generation sources in one side, it always needs to monitor river water quality continuously. It needs to be useful also to early detection of unusual water quality (for example, accidents of which fish died by the effluent containing toxic substances) while using for judging effect of the measure for water-pollution prevention. Tokyo Metropolitan Government is investigating the water quality with the duty which it defined by Article 16 in Water Pollution Control Law. In addition to this, it prepares monitoring stations in rivers from 1972, it transmits water quality in telemeter, and it always monitors intensively in the control center. When it became late after 1965, the accidents of fish dying by outflow of cyanide from factories occurred frequently. Therefore, it installed cyanide meter to 120 factories by initiative of the Ministry of International Trade and Industry among 607 factories which were using cyanide. State and Tokyo Metropolitan Government paid expense equally. It gave priority to and installed the factories which discharge effluents to the river used as the source of waterworks. There were unsolved problems on measurement. For example, as for the measurement by cyanide meter, chloride existence caused with error. Installation of meter had a big meaning of having carried out self-management, in effluent water quality.

4.4 Spread of Sewerage Works, and improvement in treatment technology

By spread of sewerage works, the industrial-effluent and households wastewater which discharge to Sumidagawa River directly was also exhausted. BOD has already attained EQSs and has been improved with about BOD 2-4 PPM by Ryougokubasi bridge on a lower stream of the river. Transition of the amount of BOD loads from Showa 51 is shown in figure 21-9. It is because that excellent sewage treatment technology introduced and maintenance management technology improved by sewerage treatment plant that the amount of loads is not increasing so much although sewerage works spreads. Now, most effluents are sewerage treatment plants in the river basin, and it came to occupy 60% of river flux. Therefore, it came to depend on the treated water quality for the water quality of river greatly. Moreover, DO becomes low especially in summer and is set to 5 PPM or less (the lowest DO that fish can survive is called).Thus, nevertheless, DO is not recovered [ to which BOD of Sumidagawa River fell ] so much, A cause is in the above-mentioned smallness of that ammonia oxidizes to nitric acid, and the purification capability of Sumidagawa River. The tidal river like Sumidagawa River is a gentle stream. Since a retention time is long while the oxygen supply from the atmosphere is small, consumption of DO becomes large and, as a result, DO tends to become low. River basin is anxious also about water pollution by to prevent polluted first flush of 23 Discharge Pump Stations from flowing into the receiving water in the early stage of rainfall.

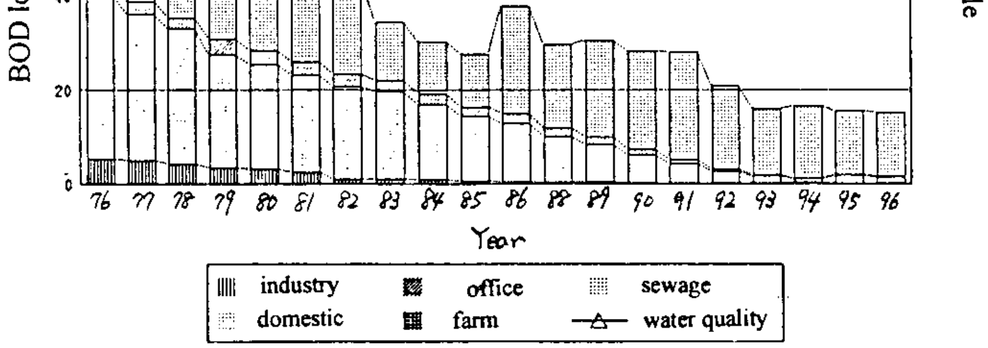


Fig.21-9 Change of BOD load into Sumidagawa River and its water Quarity

4.5 The example according to Principle of PPP

There is example of dredging where the pollution person undertook a burden. The following thing became clear by 'Check Investigation, such as the national mercury contamination', in 1973. The mercury manufacture factory in the upper part right bank in corner Sumidagawa River, discharged sludge containing inorganic mercury to corner Sumidagawa River in the manufacture process of sodium hydroxide by the 1955 mercury electrolytic method. Because of it, the mercury concentration in bottom deposit of a river exceed 25 PPM which is a removal standard, it is detected, and there were the highest value 180 and 8400 m3 of an average of 66 PPM mud a total. The enterprise puts investigation and examination on the responsibility of an enterprise under the administrative guidance of Tokyo according to the principle (Principle of PPP) of the pollution person burden of public hazard, and it carried out dredging, supervising by applying for 6 month from December,1975. It send high concentration pollution soil to Hokkaido and it is processed, and after placing the polluted mud temporizing, others are confined into the concrete wall prepared in site underground after medicine processing, and became Harappa (free open space) of a public lot behind. This company also has the location restricting methods, such as industry, and the trend of drainage regulation, and it transferred it to the industrial complex of Kashima and Ichihara ignited by these incidents.

4.6 Improvement Works for creating an Agreeable Riverside Environment

In Sumidagawa River, tankers, the cargo boats and the water-buses of about 200 boats have gone back and forth on one. The riverside terrace which people brought close to the water's edge was also extended considerably (14.6km of cumulating , the end of the Heisei 6 fiscal year). The transparency has become about 40 cm, a little muddy, and, by the way, as for the water surface which it sees to 1m of views, a sewerage smell is felt. According to the latest living-thing investigation, both the number of the kinds and the number of individuals are few. Recently carp and crucial carp were collected by at Odaibasi bridge, and Sardinella zunasi, sea basses etc at Ryougokubasi bridge. At Sakurabasi bridge (It being down-stream from Odaibasi bridge) Gobies fishing convention was started from Heisei 6. By Kandagawa River which is branch of Sumidagawa River, natural sweetish had gone back also 1994. We conjectured which passed through near Ryougokubasi bridge of Sumidagawa River. However, it only passed these fish. It has not recovered Sumidagawa River which fish can live. As these causes, we have considered river structure besides the problem of the water quality (DO and NH4-N are included) which it mentioned above. Even when it becomes familiarization with water terrace, mostly, since concrete and sheet piles are continuing all of the water's-edge, so the aquatic plants is absent. Therefore habitation of water student living things is difficult. tideland transitionally made in the Sirahigebasi bridge upstream on the terrace under construction ,There was a newspaper report that Little Egret was coming. There, the small fish which Little Egret eats was breeding.

5 Postscript

Population and operating central functions concentrate extremely and the rivers which became serious illness have revived as the symbol of Tokyo by effort of people at the time of the Olympic Games. Although Sumidagawa River did not necessarily drink the river water directly, it was what which moistens the heart and the body of people's, who live from the ancient times of Edo there, is important. Now, it is returning for our hand. In order to cancel uneasiness which faces a calamity, it improved the Super Embankments and Sirahige disaster-prevention district. As it stated until now, it recovered water quality. By building familiarization with water terrace, it enabled to approach the water surface. It began effort that it is regaining prosperity in water-buses, houseboats, fireworks conventions, etc. and it will call backing things. We attempt to revive ferry boat.

In the Sitamachi , peoples and administration will try hard so that Sumidagawa River may revive friendly and freshly.

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# Chapter 22 WATER ENVIRONMENT CONSERVATION PLANNING OF NAGANO REFECTURE

1.Topography of the Prefecture

As shown in Fig. 1-1, Nagano Prefecture is located in the central part of Honshu Island, extending approximately 120km from east to west, 210km from south to north, with total area of 13,585 sq. km., being the forth largest prefecture after Hokkaido, Iwate and Fukushima.

The topography consists of a mountain area, so-called "Roof of Japan", with 16 peaks rising over 3,000m height, a level of Nagano Basin, Saku-Ueda Basin, Matsumoto Basin and others basins surrounded by the mountain area, and intermediate area connecting the mountain and the level. The major rivers are Chikuma and Sai Rivers which flow northward to the Japan Sea Japan, (two rivers connect into Chikuma River, changing the name to Shinano River after entering Niigata Prefecture), Tenryu River and Kiso River which flow southward into the Pacific Ocean and other rivers. Their drift is shown in Fig. 1-2. These rivers are multi-purposely used for drinking water, industrial water and agricultural water in not only Nagano Prefecture, but also in the downstream prefectures, as used in the Aichi irrigation etc. The level is characterized by river terrace, as in Tenryu and other rivers, slope of which plays a role of "green belt".

The climate in the whole prefecture is inland climate with considerable annual and daily ranges of temperature difference. The northern part and the southern part are influenced by climate of Japan Sea and the Pacific Ocean respectively, which, together with geographical and topological features of the each region, causes a most diversified characteristics of climate. In particular, the difference of climate is presented by the snow depth in the winter season. As for the amount of precipitation, in the eastern part, Ueda-Saku Basin, and the northern part, Nagano Basin, of the prefecture the precipitation amounts to around 1,000mm a year, one of the smallest in Japan, while on the other hand, in the western and southern parts of the prefecture there are Mt. Ontake with annual precipitation of over 3,000mm and Nagiso Town with over 2,000mm rainfall and other areas (Fig. 1-3).

Forest accounts for about 80% of the territory of the prefecture, presenting a diversified ecological system due to complicated topography and geography, as well as variety of the climatic conditions.

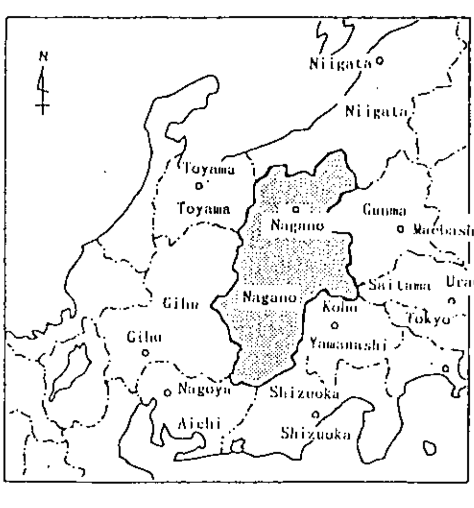



Fig. 1-1 Location of Nagano Prefecture

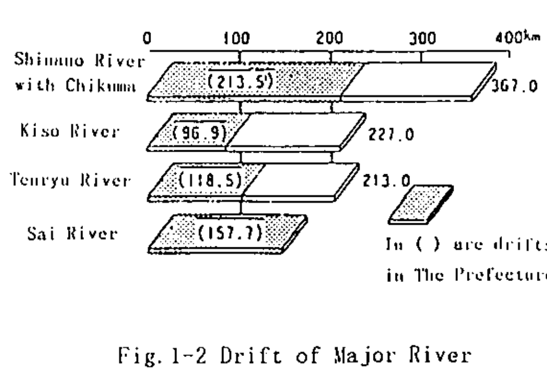



Fig. 1-2 Drift of Major River

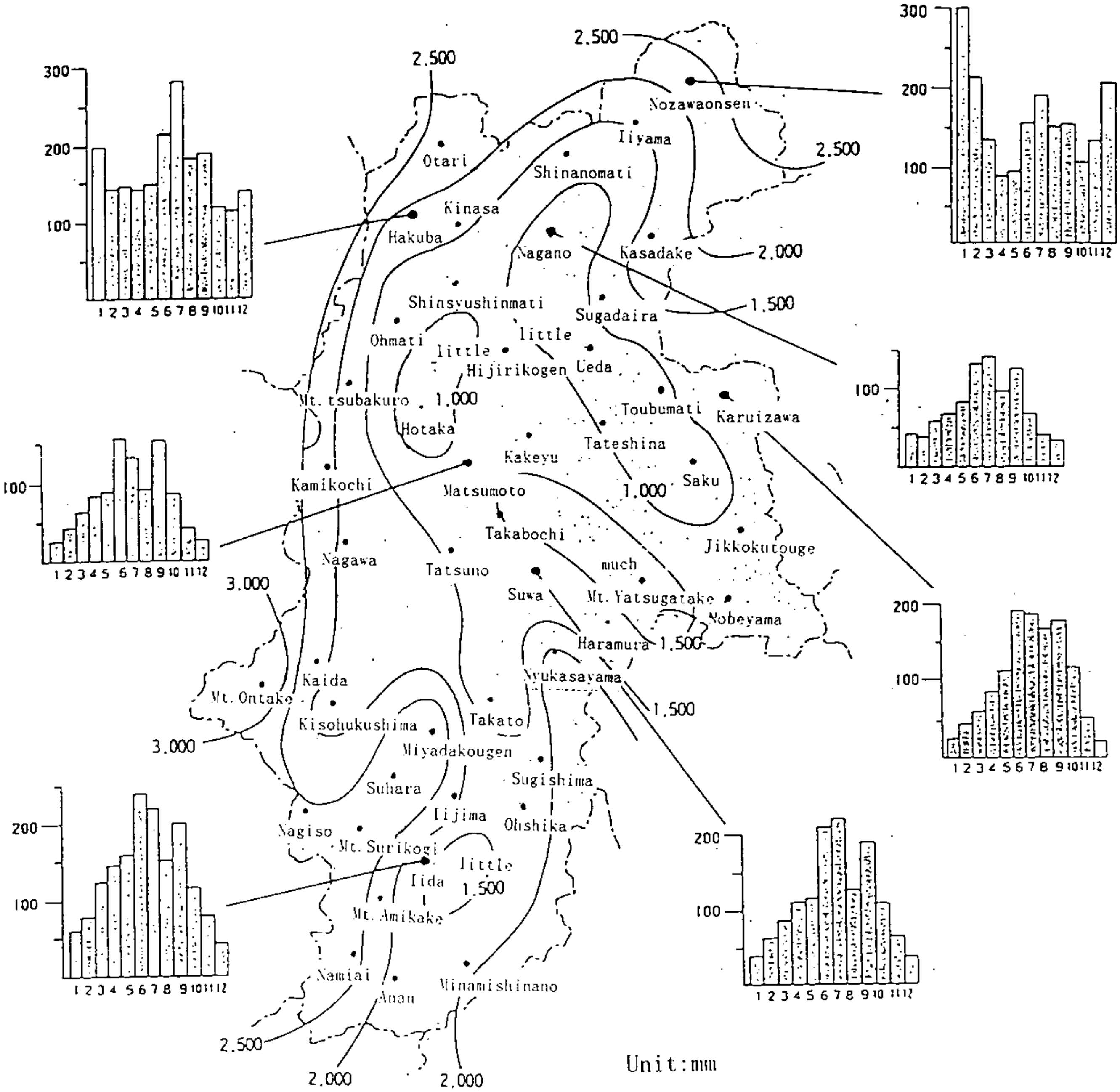



Fig. 1-3 Amount of Precipitation

2. Water Quality

2.1 Results of Water Quality Measurement

(1) Water Quality of Public Water Area

For conservation of public water area, such as rivers and lakes, water quality measurement is conducted under water quality measurement program according to Water Pollution Control Law by the Ministry of Construction, Nagano Prefecture, and Nagano and Matsumoto Cities designated by the Law.

In major rivers and lakes for which typical designation of environmental quality standard for water pollution is established, 24 items related to human health protection (health items) and 15 items related to living environment (environment items) are measured.

As for health items, environmental quality standard is continuously satisfied in all items, except for arsenic of natural origin, such as hot spring, which content exceeds at 2 measured sites.

Environmental quality standard attainment rates for biochemical oxygen demand (BOD:river) and chemical oxygen demand (COD:lake) are given in Fig. 2-1 which says the rates are remaining on the same level or worsening for the last several years, and especially in lakes the rates are on a low level. Fig.2-2 shows the situation of each river and lake in 1996. In Chikuma River and Sai River water quality are worsened at the points affected by urban area with concentrated location of factories and housings. In Tenryu River water quality worsens in upstream affected by Suwa Lake, but the quality is improved as much as downstream by self-purification ability and dilution by clean tributary streams. Among lakes, Suwa Lake, where eutrophication process, such as Microcystis, is taking place, shows the worst situation in the prefecture from the time of typical designation in 1971.

About 70 of medium and small rivers for which type designation is not made are subject to measurement, as they affect on water quality of major rivers and lakes. Approximately 70% of medium and small rivers show under 5mg/l of BOD. Some number of rivers, mainly urban rivers, show over 10mg/l, but water quality is being improved thanks to sewerage system construction and increased consciousness on domestic sewage.

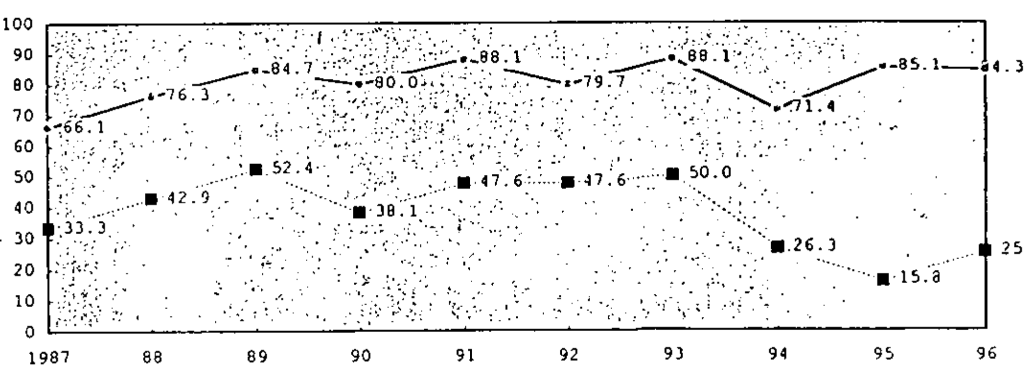



Fig. 2-1 Dynamics of Environmental Quality Standard Attainmnet Rates in Major Rivers and Lakes

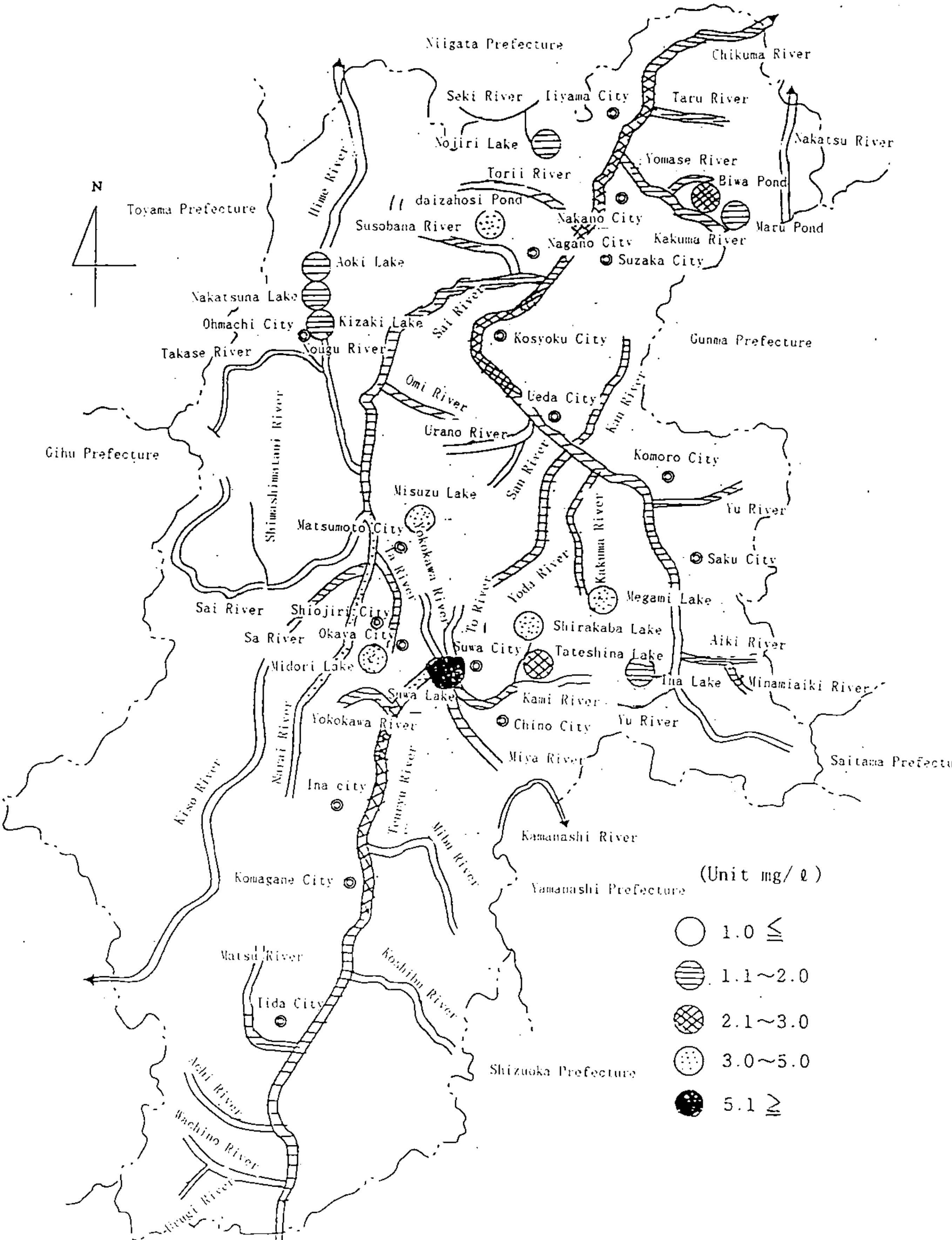



Fig. 2-2 Result of Water Quality Measurement (1996)

(2) Groundwater

For checking pollution of groundwater an overall survey and regular monitoring of polluted sites are conducted. The overall survey is conducted in about 80-100 wells with measurement of environment quality standard items and surveillance-requiring items (chloroform, nitrate nitrogen, nitrite nitrogen) in areas, excluding mountain area, divided into 191 meshes every year from 1989. Up to 1996 in 124 wells has been revealed contamination, including trichloroethylene in 26 wells, tetrachloroethylene in 29 wells, 1,1,1-trichloroethane in 2 wells, nitrate nitrogen and nitrite nitrogen in 72 wells (wells repeated). However, no remarkable excess of standard has been shown in the polluted wells, and the results of regular monitoring for organochlorine compounds indicate a trend of improvement with 12 wells having over-standard measurement continuously from 1986.

(3) Upper Stream Rivers

Upper stream river surveillance is conducted in upstream rivers with drinking water supply source and presenting possibility of water pollution caused by large-scale development such as waste disposal and golf course. Measurements being made in about 50 rivers for items for which water quality control target (see 5.4) is established; metallic compounds, volatile organochlorine compounds, pesticide and others. As of today, no water pollution suspiciously connected with the development has not been revealed.

2.2 Factories and Business Establishments

Specified factories and business establishment for which a registration under Water Pollution Control Law is required are shown in Fig. 2-3. As of the end of March, 1997, 11,565 registrations have been made, the most of which falls on hotels ; 6,793 (68.7%). The number of specific establishments for which effluent standard shall be applied is 2,291.

5 categories of business not controlled by Water Pollution Control Law such as auto-repair works are required to be registered by Pollution Control Ordinance. 302 establishments are subject to registration as of March, 1997. In October, 1997 restaurants and others of not-specified establishment scale under Water Pollution Control Law newly became specified establishments due to revision of Ordinance.

In our prefecture effluent from factories and business establishments is controlled according to more stringent effluent standard established in 1972 based upon Water Pollution Control Law. However, an overall review of more stringent standard has been made for BOD(COD) and SS, as needed to work out new measures against factory and business effluent under the circumstances that 1) environment standard attainment rate remains on the same level, 2) construction of sewerage system will be completed in whole Nagano Prefecture by 2020 as countermeasure for household effluent under a long-term prefectural planning. Newly established more stringent standard is characterized by 1) prefecture-wide unification of standard which varied depending upon water area and business category, 2) more stringent standard values based upon the up-to-date level of wastewater treatment technology, 3) wider application of standard, covering small-scale establishment which were not controlled, in consideration of the extended sewerage system. New standard shown in Tab. 2-1 has been effective as from October, 1997.

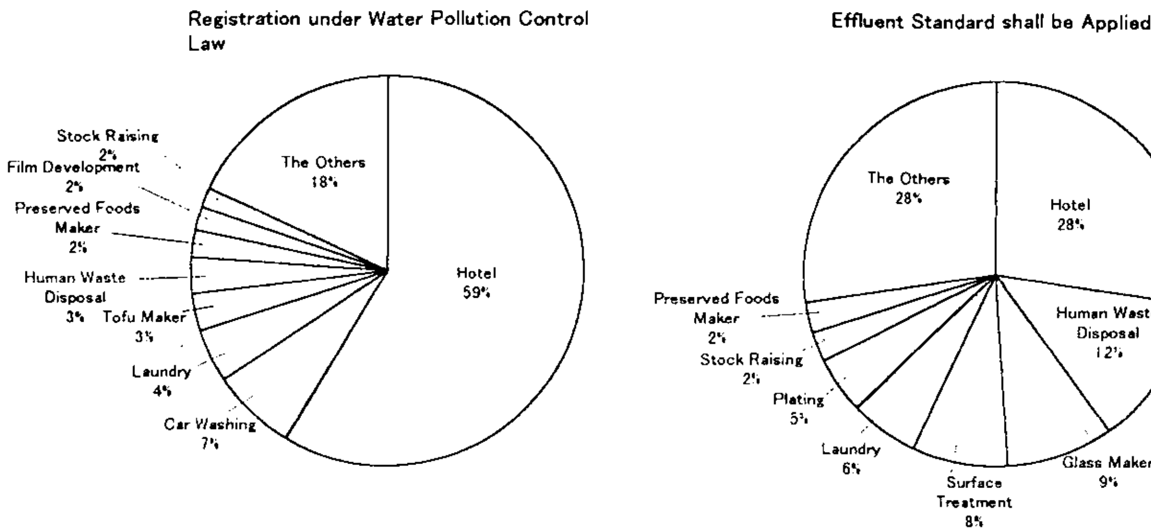



Fig. 2-3 Specified Factories and Business Establishment under Water Pollution Control Law (March, 1997)

Tab. 2-1 Stringent Effluent Standrad for BOD (COD) and SS

<table>
<tr><th colspan="3" rowspan="3">Division</th><th colspan="4">Item and Allowable Limit</th></tr>
<tr><th colspan="2">BOD (COD) (mg/l)</th><th colspan="2">SS (mg/l)</th></tr>
<tr><th>Max.</th><th>Day Average</th><th>Max.</th><th>Day Average</th></tr>
<tr><td rowspan="2">Industries other than shown below</td><td rowspan="2">Effluent</td><td>10 cu. m. - 50 cu. m.</td><td>60</td><td>40</td><td>90</td><td>60</td></tr>
<tr><td>Over 50 cu. m.</td><td>30</td><td>20</td><td>50</td><td>30</td></tr>
<tr><td>Gelatine Producer<br>Janpanese Sake Producer</td><td>Effluent</td><td>Over 10 cu. m.</td><td>60</td><td>40</td><td>90</td><td>60</td></tr>
<tr><td rowspan="3">Live-stock Industry/Agriculture (with over 250 sq. m. horse house and over 500 sq. m. cowhouse)</td><td rowspan="3">Effluent</td><td>Under 10 cu. m</td><td>160</td><td>120</td><td>200</td><td>150</td></tr>
<tr><td>10 - 500 cu. m.</td><td>160</td><td>120</td><td>85</td><td>70</td></tr>
<tr><td>Over 500 cu. m.</td><td>30</td><td>20</td><td>50</td><td>30</td></tr>
</table>

2.3 Household Effluent

According to 1994 research pollution factors of rivers and lakes in the prefecture included household-related (44%), factory and business-related (27%), and agriculture-related and others (29%). The household effluent presents the largest pollution factor. For this reason, maintenance of sewerage system, rural community sewerage, community plant, combined type Johkaso or private sewage treatment system (further, sewerage and other systems) is needed and planned consolidation is being realized based upon "Sewerage and other systems Consolidation Concept Area Map" worked out in consideration of topographical and regional specific conditions.

As shown in Fig. 2-4, the percentage of sewered population is 52.1% as of March, 1997, enabling every second population to use the sewerage and other systems. Middle-term comprehensive planning of Nagano Prefecture has a target to lift the percentage of sewered population up to 66% by March, 2001.

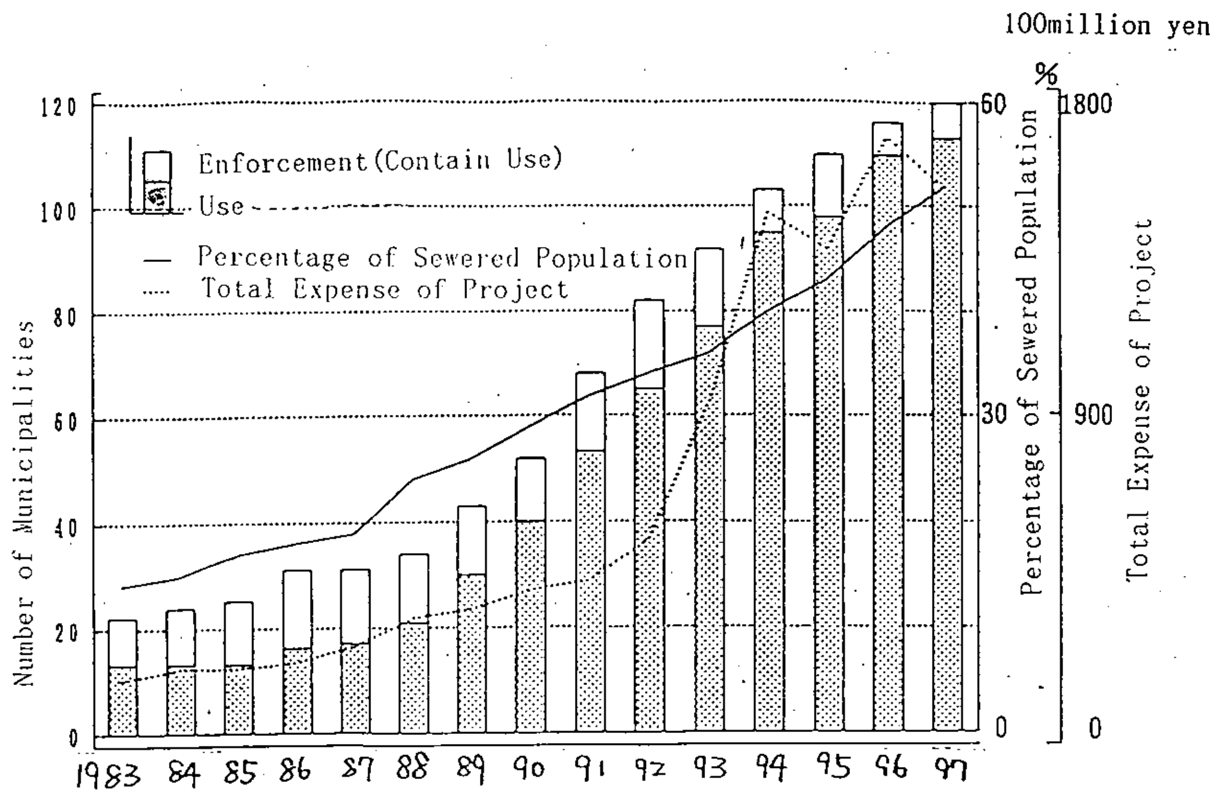



Fig. 2-4 Percentage of Sewered Population

3. Present Situation of the Waterside Consolidation

There are 8 water systems with 740 rivers of first category, total length of which is as long as 5,121.1km. In addition to natural conditions such as steep topography and fragile geology, change of land utilization of catchment area; urbanization for the recent years, form of agriculture, forest type, intensive land utilization, consolidation of waterway; lead to lowering of water retaining capacity, penetration capacity and flood control capacity originally available for catchment area and flood control safety is jeopardized, flood disaster are frequent. For this reason, river and lake banks are being protected and river protection rate is 32.7% in 1996.

While flood control measures give remarkable results in respect of protecting human life and property from flood disaster, concrete rivers eventually isolate rivers from people. Thus from mid 80's people began to pursue not only material , but also mental richness, which has led to insistence on creation of "comfortable environment", deeming waterside as playing spot or place of mental cure.

On such background, river improvement incorporate conservation or consolidation according to 3-zone zoning shown in Tab. 3-1 to create more desirable river environment with well-concorded conservation and utilization, taking actual situation of utilization into account.

Furthermore, "creation of multi-nature type river" is being realized with construction of light-sloped banks and water park, and attention to local fauna and flora. 72.2km of such river was completed in 1996 (Tab. 3-2). An artificial beach and trial to re-vive a reed field on Suwa Lake are typical examples in our prefecture.

For well nature-coordinated landscape Landscape Ordinance of Nagano Prefecture was established in 1992 to serve conservation and creation of natural landscape.

From old times people has been tightly connected with water in our prefecture, where up to today a specific food culture "zazamushi" and traditional culture of festival "misogi" or a purification ceremony continue to exist. Trade with ship transport, using rivers, also played an important role in the past.

However, the relationship between people and waterside has weakened because of change of life style, water pollution and flood control measures. At present, the relationship is being reviewed through introduction of class lessons using canoe or observation of aquatic organism, triggered by rising environmental consciousness of the last years.

Tab. 3-1 Zonig of River

| Division | Description |
|---|---|
| Natural Zone | Space which is supposed to be used as a place for contact with the nature as it is, with conservation of specific natural river environment and landscape, without, in principle, artificial modification exept for flood control and water utilization purpose |
| Nature Utilization Zone | Space which is supposed to be used as a place of a walk and nature-oriented recreation, taking an advantage of specific river environment and improving sub-natural environment such as natural observation area, wild grass square and urban agricultural land |
| Consolidated Zone | Space which is supposed to be consolidated as a place of various kinds of recreation and sport activities or demonstration of river channel fire works, with utilization of high water channel and banks and consolidation of multi-purpose squares, parks, sport squares, stair type bank protection, sloped bank protection etc. |

Tab. 3-2 Results of Constructed Multi-natural Type Rivers (km)

| | 1994 | 1995 | 1996 |
|---|---|---|---|
| Extend Distance | 54.0 | 62.1 | 72.0 |

## 4. Water Environment Conservation Ordinance of Nagano Prefecture

### 4.1 History of Establishment of the Ordinance

Recently, with socio-economical changes, e.g. progressing urbanization, intensification of industrial structures, a problem of water pollution by household effluent and contamination of drinking water supply source by ground water polluted by new chemicals is emerging in our prefecture. Deep concern is expressed by prefectural population to conservation of catchmment area - waterside and forest - .

To cope with such a change of situation around water environment, together with repletion and strengthening of ongoing conservation measures, such as water quality surveillance, "Water Environment Conservation Conference" was organized in 1990 from national authorities with rich knowledge of water environment to study a matter of development of a comprehensive planning for organic promotion of systematic measures, newly incorporating waterside consolidation and catchment conservation.

On the other hand, as a number of construction of waste disposals and golf courses were planned, some cities and towns in the country, located in the upstream water supply source area, with concern of drinking water supply source contamination, established their ordinance preventing water supply area from various sorts of development. Our prefecture due to geographic condition - near location to the metropolitan area - has been selected for a lot of resort facilities construction. For example, there were 47 golf courses in 1987. Further, with establishment of so-called "Resort Law" aimed to improve recreation facilities by private sector, from 1987 till 1990, in the period called "Bubble Epoch", 11 golf courses were newly constructed, as shown in Tab. 4-1. In such situation of continuous construction of resort facilities like golf courses a fear of contamination of drinking water supply source was rising among the prefectural population.

In 1990 Prefectural Coordination Meeting for Establishment of Water Supply Source Protection Ordinance of Nagano, with more than 120,000 signatures, made a direct claim for establishment of "Ordinance on prohibition of golf course development in water supply source and other areas" to the effect that any development of golf courses, waste disposals and resort facilities should be prohibited in the water supply source and supply source areas in the prefecture to conserve drinking water supply source. The prefectural government, after detail examination of contents of ordinance draft, submitted the draft to the prefectural assembly with negative opinion that it is difficult to specify the water concentration area and thus to forecast areas to be prohibited, as well as wide area prohibition might seriously affect life of population and industrial activities.

Finally the assembly rejected the draft in December, 1990, but after that the movement for establishment of ordinance was continued by Social Democratic Party of Japan and the Lawyers Association of Nagano Prefecture, and the public opinion in the prefecture resulted in an active campaign.

In these circumstances, the above-mentioned Water Environment Conservation Conference has concluded that it is necessary to establish an ordinance in any form to make the comprehensive planning for water environment conservation more effective, in response to which "Water Environment Conservation Ordinance of Nagano Prefecture" was established in March,1992.

As an ordinance aimed at conservation of "water environment", comprehensively covering water and its environment, such as water quality, waterside and catchment area, the ordinance is the first one in the whole country.

Tab. 4-1 Number of Golf Course Newly Constructed in the period of "Bubble Epoch" (1987 - 1990)

| | 1987 | 1988 | 1989 | 1990 | 1997 |
|---|---|---|---|---|---|
| Newly Constructed Golf Courses | 3 | 0 | 6 | 2 | 2 |
| Accumulation | 50 | 50 | 56 | 58 | 67 |

## 4.2 Outline of the Ordinance

Water Environmental Conservation Ordinance of Nagano Prefecture

- Chapter 1 General (Clause 1 - 6)
- Chapter 2 Comprehensive Water Environment Conservation Planning (Clause 7)
- Chapter 3 Water Conservation and Others (Clause 8 - 10)
- Chapter 4 Drinking-water Supply Source Conservation Areas (Clause 11 - 14)
- Chapter 5 Water Environment Conservation Commission of Nagano Prefecture (Clause 15 - 21)
- Chapter 6 Micsellanious (Clause 22, 23)
- Chapter 7 Sanction (Clause 24, 25)

Fig. 4-1 System of Water Environmental Conservation Ordinance of Nagano Prefecture

System of Water Environment Conservation Ordinance of Nagano Prefecture is shown in Fig. 4-1.

In Chapter 1, Clause 1 declares the purpose of ordinance; to promote comprehensive measures of water environment conservation through clarification of the obligations of the prefecture, the cities, towns and villages, and population and enterprises in respect of water environment conservation, as well as working out of necessary issues on development of comprehensive water environment conservation planning and designation of water quality surveillance areas and water supply source conservation areas, and thus to ensure healthy and cultural life of the population. In Clause 3 through 5 the obligations of the prefecture, the cities, towns and villages, and population are specified.

Chapter 2 provides the establishment of "Comprehensive planning for water environment conservation" which shall specify items concerning policy and measures for water environment conservation. (See 5. "Comprehensive planning for water environment conservation" ).

In Chapter 3, in view of the fact that golf courses and waste disposals are sited even in the upstream water supply source areas, necessary water quality surveillance is provided for conservation of supply source water quality depending upon local land utilization situation. Based upon this provision, Nagano Prefecture conducts, separately from regular surveillance by Water Pollution Control Law, water quality surveillance and measurement of upstream areas, having set out the points and measurement items.

Chapter 4 provides that the Governor, upon the application by the mayor of the subject city or town or village, has a right to designate the area specially requiring conservation of drinking water supply source as drinking water supply source conservation area. Besides this, the Governor can, upon the application by the mayor for designation of a area, belonging to the area of other mayor and after consultation with related mayor, designate as drinking water supply source conservation area.

It is provided that any who plans to construct golf course, to install final waste disposal, or to transform the land over 1ha according to Executive Regulations to Water Environment Conservation Ordinance of Nagano Prefecture, shall consult in advance with the Governor to obtain his consent. The Governor shall, at the consultation, make hearing from the mayors of the related communities and Water Environment Conservation Commission, and can attach conditions to the extent needed for drinking water supply source conservation (Clause 12).

Clause 13 provides that the Governor can order to suspend the act or to restore the status quo when preliminary consultation has not been made or attached conditions are violated. Clause 14 further provides the Governor's right to be reported of execution status of approved act, or to inspect on the site in respect of consulted acts.

Clause 24 of Chapter 7 sets forth the penalty provision for violations of Clauses 12 through 14 , so that protection of drinking water supply source is secured for drinking water supply source conservation area.

Chapter 5 provides the institution of Water Environment Conservation Commission for research and deliberation of the important issues concerning water environment conservation.

Clause 22 of Chapter 6 provides that the Governor appoints Water Environment Conservation Promoter for effective promotion of water environment conservation.

At present 150 promoters are appointed and, in contact with the communities, are conducting campaigns for higher water environment conservation consciousness, as well as patrolling and observing the river catchment area.

## 5. Water Environment Conservation Comprehensive Planning

### 5.1 Purpose of Planning

Recently, with socio-economical changes, as concern about water pollution in the upstream area and problems of contamination of ground water by new chemicals, and further, eutrophication of lakes by household effluent are emerging, prefectural population are being more conscious to conservation of catchment area - waterside and forest - .

To cope with such change of situation around water environment, the prefectural government worked out Water Environment Conservation Comprehensive Planning in July, 1992, based upon Water Environment Conservation Ordinance of Nagano Prefecture established in March, 1992.

This planning , together with River Environment Management Master Plan and Regional Forest Plan and others, is aimed to comprehensively promote measures of water environment conservation for ensuring high quality of water and rich catchment area creation hereafter.

### 5.2 Nature of Planning

The nature of Water Environment Conservation Comprehensive Planning is 1) to show basic direction of water environment conservation to be followed by our prefecture, 2) to show comprehensive measures for integrated covering water and its environment, such as water quality, waterside, catchment area, and creation of healthy, comfortable and rich water environment, and 3) to show method of water environment conservation, based upon coordination and cooperation of citizens, enterprises and the prefecture, utilizing each regional features of the prefecture.

### 5.3 Structure of Planning

Structure of the planning consists of "water environment targeted by Nagano Prefecture" and "comprehensive measures for achievement of the target" , as shown in Fig. 5-1.

"Water environment targeted by Nagano Prefecture" consists of "idea of water environment conservation" - basic concept of water environment conservation, "policy of water environment conservation" - core of measures, and "target of water environment conservation" - target of planning.

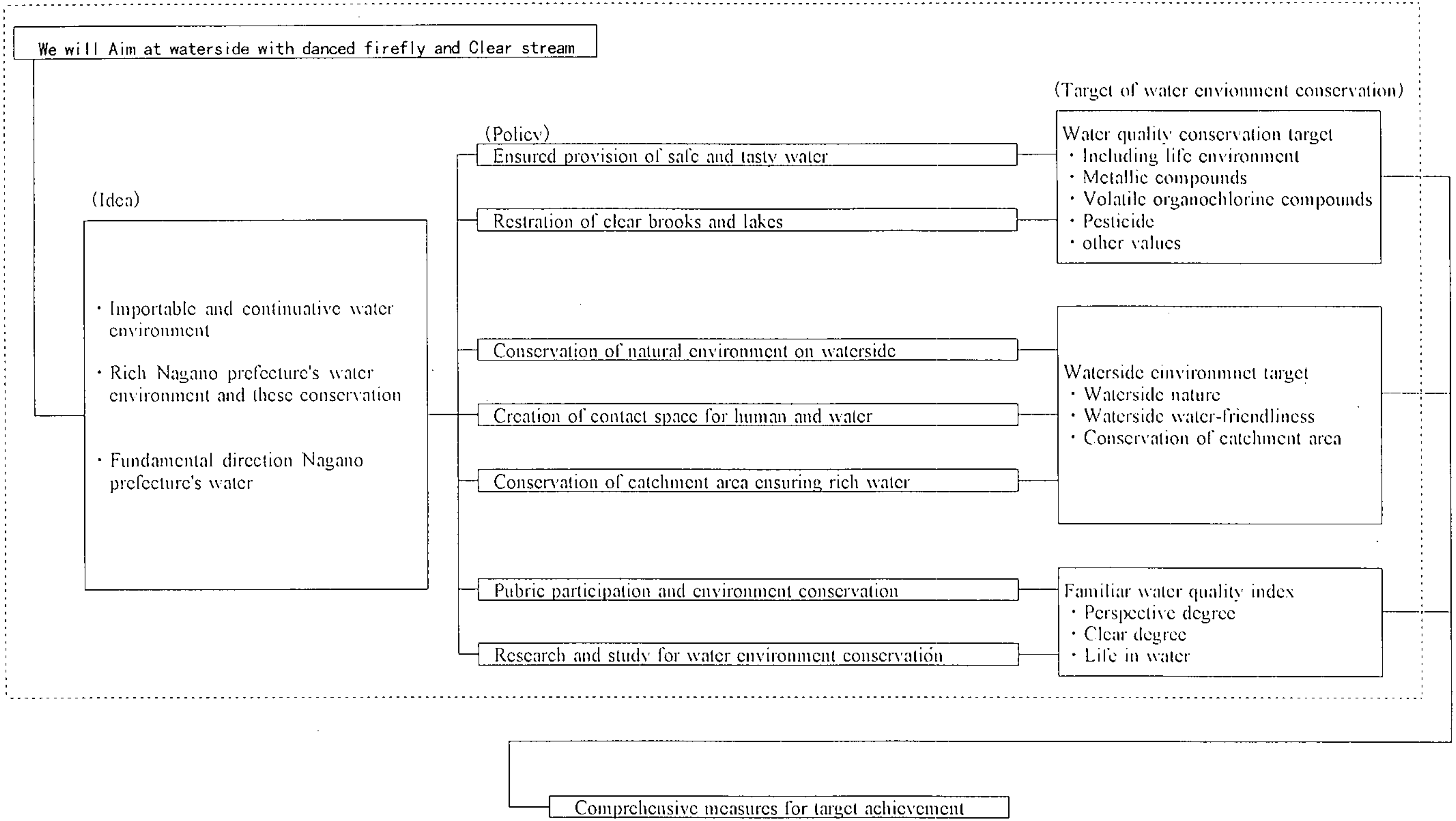



Fig5-1 Strucuture of Nagano prefecture's water environment conservation comprehensive planning

## 5.4 Outline of Planning

### (1) Water Environment Conservation Policy

"Policy of water environment conservation" which is core of measures consists of the following 7 policies:

- ensured provision of safe and tasty water
  (conservation of water quality of water supply source, such as water surveillance in upstream area )
- restoration of clean brooks and lakes
  (promotion of countermeasures for contamination sources such as household effluent)
- conservation of natural environment on waterside
  (protection and rearing of various fauna and flora, conservation and creation of waterside landscape)
- creation of contact space for human and water
  (improvement of water-friendly waterside, promotion of making "mother-land" rivers)
- conservation of catchment area ensuring rich water
  (conservation of forest and others ensuring water)
- public participation and environmental education
  (developmental education of citizens on water environment conservation, promotion of voluntary activities)
- research and study for water environment conservation
  (research and study on water environment conservation of river and lake, on consolidation of comfortable waterside environment)

### (2) Target of Water Environment Conservation

In promotion of the planning, target of water environment conservation consists of water quality conservation target and waterside environment target.

- Water quality conservation target
  Water quality conservation target sets forth target values for 77 items, including life environment, metallic compounds, volatile organochlorine compounds, pesticide and other values. These values are determined to achieve drinkable level of water quality, such as environmental quality standard and drinking water quality standard.
  As for pesticide, Nagano Prefecture's own target value is also set forth.
  Apart from concrete target values, as simple criteria for water quality surveillance and practical activities of water environment conservation conducted by community citizens, "near-at-hand" indexes are also set forth to raise citizens' consciousness of water environment conservation.
- Waterside environment target
  Waterside environment target for waterside nature, waterside water-friendliness and conservation of catchment area sets forth prefectural common target and local target based upon regional features and present state (Tab. 5-1).

(3) Comprehensive Measures for Target Achievement

"Comprehensive Measures for Target Achievement" systematizes the measures by each of 7 policies of water environment conservation, as shown in Fig. 5-1, to make clear present state and problem of each measure and shows contents of measures to be taken hereafter.

5.5 Promotion of Measures

The progress of measures is checked every year for water environment projects. The measures are promoted at water environment conservation meeting consisting of related sections (offices) which conduct such projects to further improve water environment conservation measures and achieve the target.

Tab. 5-1 Example of Local Waterside Environment Target (Suwa Region)

| | | (1) Nature of Waterside | (2) Water-friendliness of Waterside | (3) Conservation of Catchment Area |
|---|---|---|---|---|
| 3. Suwa | 1. Suwa | - to consider coordination of waterside of Suwa Lake's upper stream and landscape of mt. Yatsugatake<br>- to consider conservation of marsh plant community of mt. Yatsugatake, p. Kirigamine and Takabotch Height as well as bioenvironment of the rare amphibian, living there<br>- consider bioenvironment of dragonflies and others, peculiar to p. Kirigamine and Tateshina Heights | - to endeavor to conserve nature rich waterside of rivers flowing at the foot of mt. Yatsugatake and used as famous resort as well as to improve water-friendly facilities for its utilization | - to endeavor to maintain storage , filtration and other facilities for outflow control in catchment areas<br>- to maintain forest, mainly red pine and larch, and diversify trees for higher water supply source preservation function<br>- to consider well organized water circulation in urban areas<br>- to consider surrounding natural conditions in water resource development as dam construction |
| | 2. Suwa Lake | - to endeavor to restore and create lake side for revival of Suwa Lake in the mid 60's as its prototype scene<br>- to maintain and create lake shore plant community suitable for spawning and growth of fish<br>- to maintain waterside with attention to bioenvironment of migratory birds such as swan and wild duck<br>- to aim at "swimmable Suwa Lake" by means of water quality purification in colaborationn with citizens | - to maintain waterfriendly facilities such as "welcome beach" utilizing lake water surface, lake shore<br>- to maintain a walk way utilizing waterside space<br>- to endeavor to maintain facilities supporting recreation activities such as fireworks and boat sailing at lake surface and lake shore | |
| | 3. Kamanasi River | - to consider bioenvironment of a char, bullhead and other fish<br>- to consider bioenvironment of firefly widely living in the level land | | |

- Ensured Supply of Safe and Tasty Water
  - Water Quality Surveillance of River, Lake and Ground water
    - Exercise of Regular Surveillance of Water Quality
    - Measures for Water Quality Control of Drinking-water and Other Water
  - Prevention of Pollution by Chemicals and others.
    - Measures on Factories and Business Establishment which use Harmful Chemicals
    - Measures on Organochlorine Compounds
    - Measures on Pollution by New Chemicals
    - Measures on Chemical Discharge Accident
  - Prevention of Pollution by Pesticide and others.
    - Measures on Pesticide
    - Measure on Nitrate Nitrogen and Nitrite Nitrogen
  - Prevention of Pollution by Waste
    - Measures on Final Industrial Waste Disposal
    - Measures on Final General Waste Disposal

- Restoration of Clean Brooks and Lakes
  - Promotion of Countermeasure for Household Effluent
    - Maintenance of Sewerage System
    - Maintenance of Rural Community Sewerage
    - Maintenance of Night Soil Treatment Facility
    - Measures on Private Sewage Treatment Tanks
    - Measures on Miscellaneous Household Effluent
  - Measures on Industrial Effluent
    - Measures on Factories and Business Establishment
    - Measures on Livestock Industry
    - Measures on Fisheries and Aquaculture
    - Measure on agriculture
    - Measures on Construction Works
  - Measures for Purification of Rivers and Lakes
    - Measures for Sediment Removal of Rivers and Lakes
    - Direct Purification of Rivers and Lakes
    - Measures on Scrapped Mines
  - Promotion of Comprehensive Measures Concerning River and Lake
    - Promotion of Comprehensive Measures Concerning River and Lake

- Natural Environment Conservation on Waterside
  - Management of Waterside
    - Designation and Management of Natural Parks and Others
    - Designation and Management of Scenic Zones
    - Management through Designation of River Zones
  - Protection and Rearing of Fauna and Flora on Waterside
    - Protection and Rearing of Fauna and Flora
    - Maintenance of Existing Facilities
  - Conservation and Creation of waterside Landscape
    - Reconstruction Coordinated with Landscape
    - Measures on Architectures Coordinated with Landscape
  - Increasing and Utilization of Fishery Resource
    - Increasing of Fishery Resource by stocking and other means
    - Active Usage of Fishing Ground

- Creation of Contact Space for Human and Water
  - Maintenance of Water-friendly Facilities
    - Reconstruction with consideration of Water-friendliness
    - Maintenance of water-friendly Parks
    - Creation of Water and Green Promenades
    - Maintenance of Waterside Environment in Rural area
  - Creation of Waterside Accorded with Town and Area Creation
    - Promotion of "Mother-land" Rivers Creation
    - Promotion of "Romantic" Towns
    - Promotion of Basical City Improvement with Consideration of Rich Waterside

- Conservation of Catchment Area Ensuring Rich Water
  - Coordination of Development and Conservation
    - Regulation by Development Law and Acts
    - Implementation of Environmental Impact Assessment
  - Conservation and Maintenance of Forest
    - Improvement of Water Preservation Function of Forest
    - Maintenance of Flood Control Facilities
  - Promotion of Measures on Flood and Debris Flow
    - Maintenance of Rivers, Dams and Debris Control Facilities
    - Measures on Flood Outflow Control
  - Maintenance and Conservation of Agricultural Land
    - Conservation of Water Preservation Function of Agricultural land
  - Securing of Water Resource
    - Development of Water Resource
    - Ensuring of Maintained Water Flowrate
    - Conservation and Preservation of Ground Water
    - Effective Water Utilization

- Public Participation and Environmental Education
  - Development of Consciousness of Water Environment Conservation
    - Promotion of Education
    - Presentation of Environmental Information
    - Coping with Global Environmental Issues
  - Promotion of Water Environment Conservation with Public Participation
    - Promotion of Practical Activities
    - Support and Assistance to Organizations
    - Repletion of Various Funds
  - Promotion of Environmental Education in Schools and Community
    - Promotion of Environmental Education in Schools
    - Promotion of Environmental Education in Community
    - Repletion of Environment Education Facilities

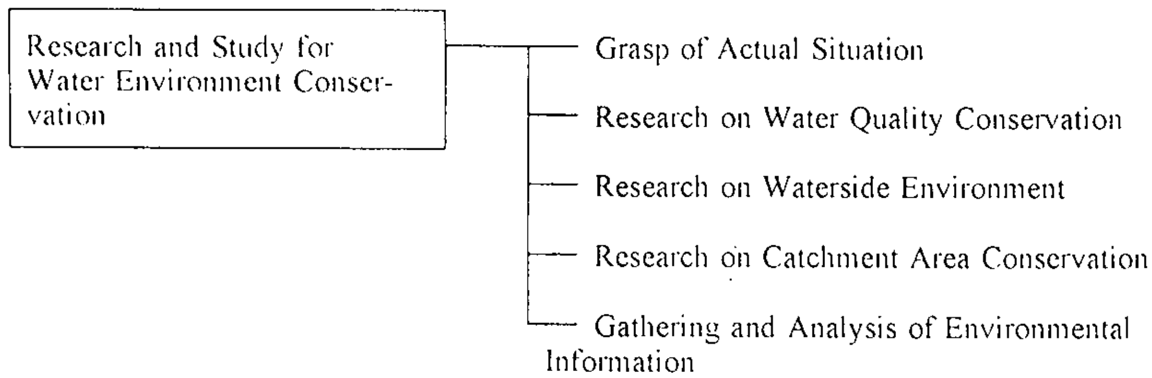



Fig. 5-2 System of Measures for Water Environment Conservation

## 6. Conservation of Drinking water Supply Source

### 6.1 Outline of System

In recent years an increasing attention is being paid by citizens of our prefecture to protection of drinking-water supply source from resort and other development in the upstream areas. To cope with the problem, of Water Environment Conservation Ordinance of Nagano Prefecture provides that the Governor designates areas required for conservation of drinking water supply source as "drinking water supply source conservation area" upon application or request of the mayors of the communities ("application and others") and obligates enterprises to enter preliminary consultation with the Governor in respect of the projects connected with golf course construction, location of final waste disposal, land transformation over 1ha and quarrying.

From the time of establishment of the Ordinance 29 areas have been designated as drinking water supply source conservation area in the prefecture, as shown in Tab.-6-1.

### 6.2 Concept of Area Designation

Areas to be designated as drinking water supply source conservation area are, in principle, selected by the mayors who submit application or request. However, as designation is made in a centralized manner by the prefectural government, basic concept of area designation was required. For this reason, in September, 1992 was published "Concept of Drinking water Supply Source Conservation Area Designation" which is used as reference when the mayors submit application and others.

(1) Surface water (river water, infiltration water, lake water and dam water)
areas where effluent may reach drinking water supply source without sufficient dilution
(Fig. 6-1, 6-2)

(2) Ground water (shallow ground water, deep ground water and spring water)
areas where a separate act may affect drinking water supply source
(Fig. 6-3)

When establishing areas the community which make application and others shall conduct preliminary research on topography, geology, water condition, and others for flexible selection depending upon actual conditions of the subject water supply source.

Tab. 6-1 Status of Designated Areas of Drinking-water Supply Source Conservation (as of November, 1997)

| Wide Area | No. of Regions | No. of Water Supply Sources | Area (ha) | Name of City, Town, Village |
|---|---|---|---|---|
| 7 | 29 | 36 | 2,287 | 22 Names |

1. Concept

(1) In respect of river water, the area is basically established in such zone of the catchment basin of a drinking-water intake point, in which effluent may reach the intake point without sufficient dilution, taking into consideration the intake condition, shape and flow of the river, water quality and other factors, situation in the catchment basin.

(2) The above-mentioned concept is, in principle, applied to infiltration water, too.

2. Establishment of the area

(1) Range

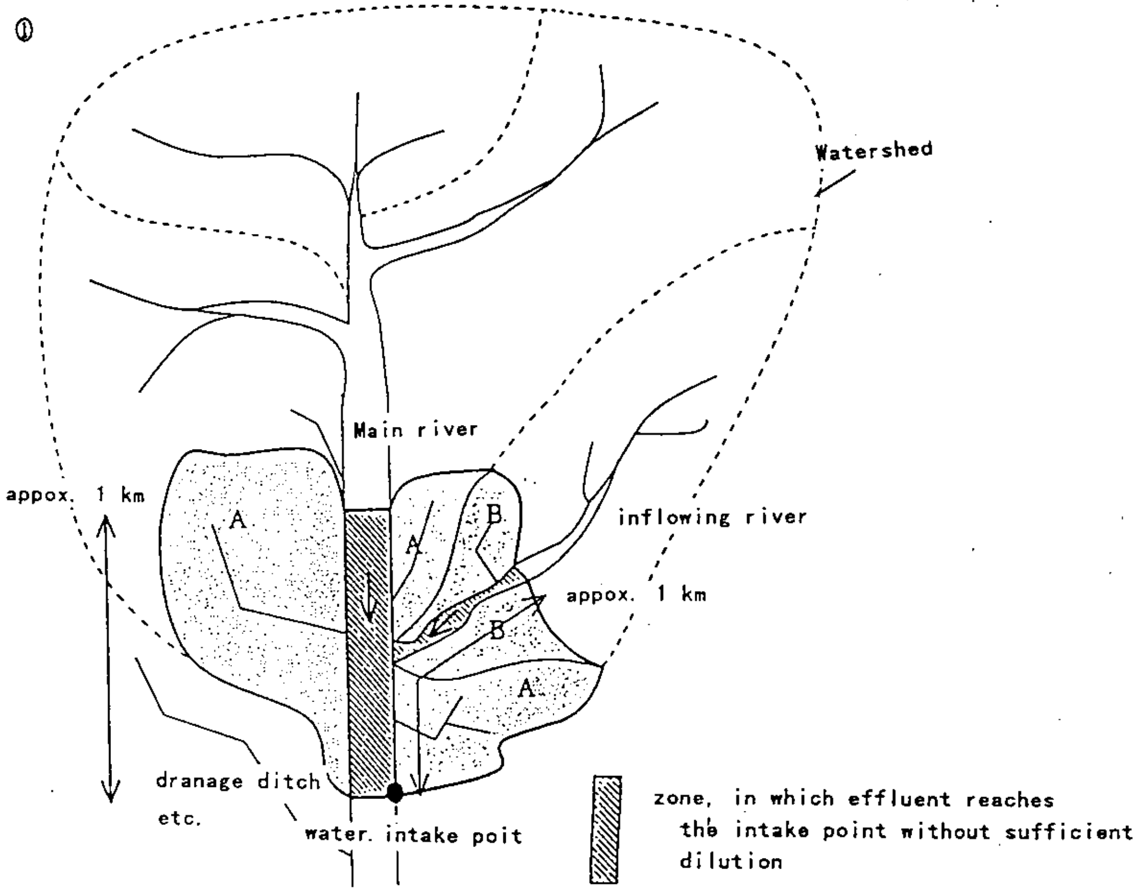
The above "zone, in which effluent may reach the intake point without sufficient dilution" shall be a zone of direct catchment in the range of approximately 1 km upstream from the taking point (including inflowing rivers). However, this provision does not apply to rivers for which sufficient dilution water flowrate is not ensured.

(2) Items to be considered

- water intake condition: intake position, intake quantity
- shape of river: width, depth, slope, form of watercourse,roughness of river
- condition of river flow, water quality: flow status, flow velocity, water quality
- condition of catchment basin: watershed, topography, water system, waterway, geographic structure, vegetation, precipitation, land utilization
- others

Concept of Area Designation (River Water, Infiltration Water)

①

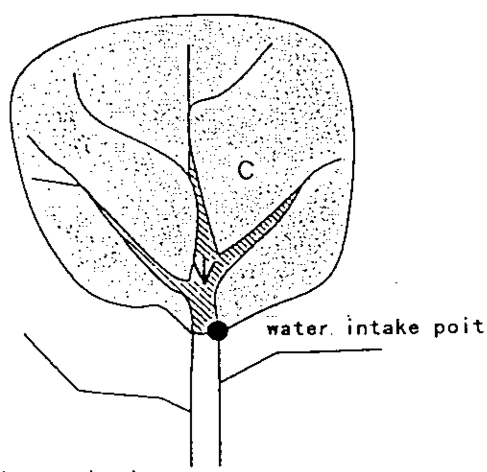



A: Area of direct catchment basin at aproox. 1km upstream of water intake from main river (area of direct inflow of precipitation, effluent etc. to main river)

B: Area of direct catchment basin at aprrox. 1km upstream of water intake from inflowing rivers (area of direct inflow of precipitation, effluent etc. to inflowing rivers)

(Note) The arrow shows dirction of river flow.

② In case of a river without efficient quantity of water for dilution




C: catcment basin

Fig. 6-1 Concept of Area Designation (River Water, Infiltration Water)

1.Concept

The area is basically established in such zone of the catchment basin of a drinking-water intake point on lakes and dams, in which effluent may reach the intake point without sufficient dilution, taking into river of lakes and dams, water quality and other factors, situation in the catchment basin.

2. Establishment of the area

(1) Range

The above "zone, in which effluent may reach the intake point without sufficient dilution" shall mean:

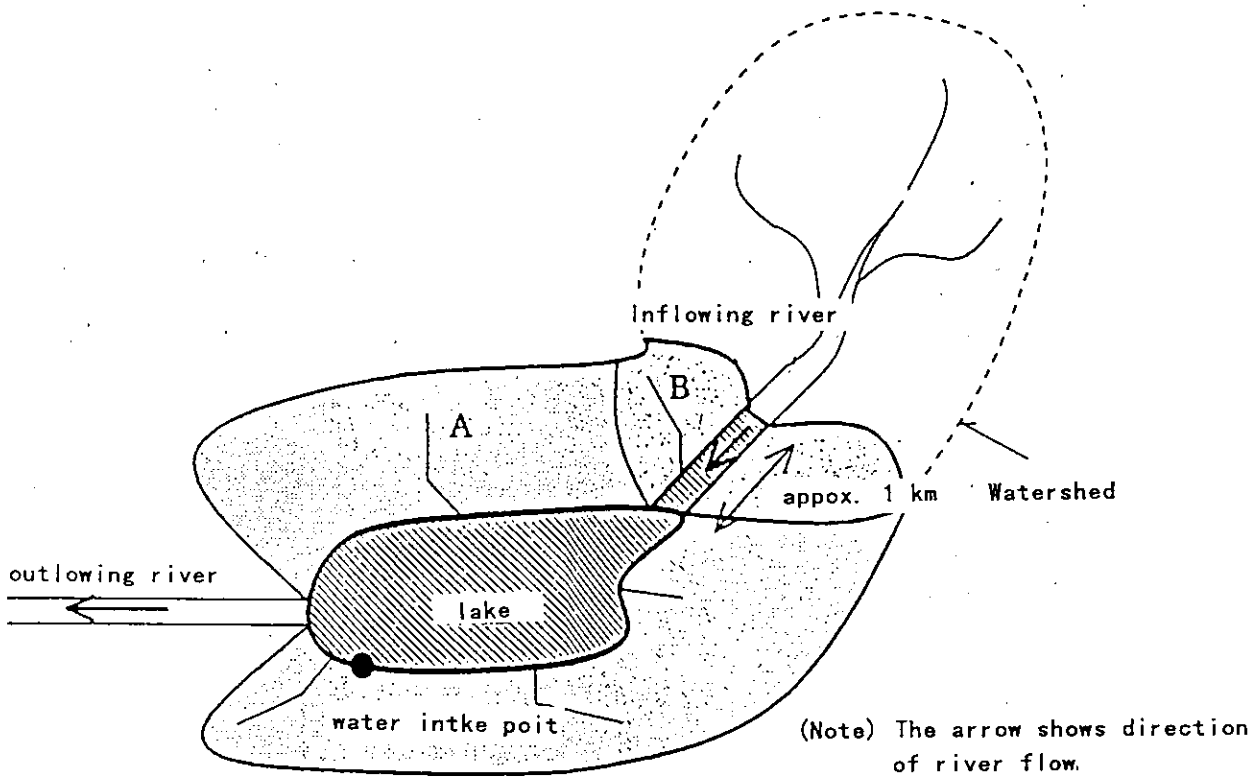
(a) a zone of direct catchment of lakes (dams)

(b) a zone of direct catchment in the range of approximately 1 km upstream from the inflowing point to lakes and dams in respect of inflowing rivers. However, this provision does not apply flowing rivers for which sufficient dilution water flowrate is not ensured.

(2) Items to be considered

- water intake condition : intake position, intake quantity
- shape of lake (dam lake) : area, depth, volume, shape of lake (dam)
- condition of lake (dam),such as water flow, water quality:inflow and outflow rate of water, water flow of lake (dam), water quality
- shape of inflowing rivers : width, depth, slope, shape of watercourse, roughness of rivers
- conditions of inflowing rivers, such as water flow water quality : flow status, flow velocity, water quality
- condition of catchment basin : watershed, topography, water system, waterway geographic structure, vegetation precipitation land utilization
- others

Concept of Area Designation (Lake Water, Dam Water)




A: Area of direct catchment basin on a lake (area of direct inflow of precipitation, effluent etc. to the lake)

B: Area of direct catchment basin at aprrox. 1km upstream of water intake from water inflow to the lake (area of direct inflow of precipitation, effluent etc. to inflowing rivers)

Fig. 6-2 Concept of Area Designation (Lake Water, Dam Water)

1.Concept

The area is basically established in such zone, where a separate action may affect on drinking-water supply source , taking into consideration the intake condition, condition of water take, situation around water source and preservation area, as well as depending upon the condition of separate water source.

2.Establishment of the area

(1) Range

The above "zone, where a separate action may affect on drinking-water supply source" shall be as follows:

a) in respect of shallow ground water, zone within a range of approximately 1 - 2 km from the water intake point, provided that, if there is a considerable watercourse such as an old river waterway, then it shake be in the range of 3 -4 km upstream along the watercourse from the water intake point.

b) in respect of deep ground water, it shall be in a range defined with consideration of preservation area such as watershed, topography, and geological structure.

c) in respect of spring water, the range for shallow or deep ground water shall be applied depending upon condition each water source.

(2) Items to be considered

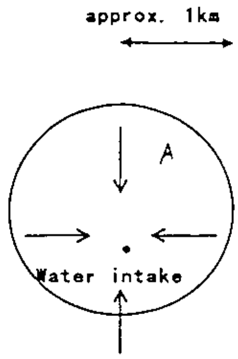
- water intake condition: intake depth, intake quantity, level lowering at water intake
- conditions around water source: characteristics and distribution of water bearing layer, flow direction of ground water
- condition of preservation area: watershed, topography, geographic structure, vegetation, precipitation, land utilization
- others

Concept of Area Designation (Shallow Ground Water, Deep Ground Water Spring Water)

Illustrations:

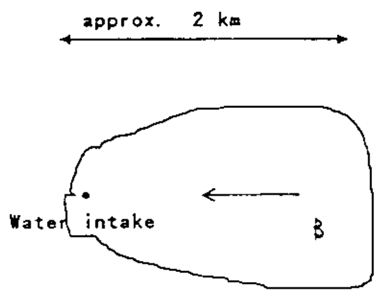
① In case of shallow ground water

a) without ground water



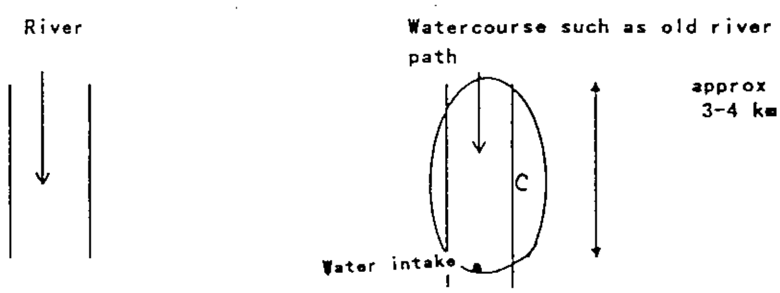

A: zone approx. 1km from water intake point

b) with ground water




B: Area at approx. 2km upstream of water intake.
However, in case of week gound water flow due to, e. g. small ground surface slope, and with large amount of water to be intaken, downstream area of water intake point shall also be taken into account.

② In case of shallow ground water with considerable watercourse




C: Area approx. 3-4 km along the watercourse upstream of the water intake point

(Note) The arrow shows direction of river and ground waterflow

Fig. 6-3 Concept of Area Designation (Shallow Ground Water, Deep Ground Water, Spring Water)

## 7. Conservation of Lake Water

In our prefecture there are many lakes and marshes which form a rich natural environment, as well as are multipurposely used as water supply source. However, in some lakes, as the Suwa Lake, the process of eutrophication is taking place, and in 14 lakes for which environment standards are established the standard attainment rate (COD)is as low as 25.0%, which makes water quality conservation in such lakes very urgent issue. Furthermore, as unique environment of lakes and their surroundings is never met in rivers, the lake conservation is also needed.

The Suwa and Nojiri Lakes designated under Law concerning Special Measures for Conservation of Lake Water Quality (Clean Lake Law) are subject to comprehensive measures of water quality conservation, and similar measures are being taken in respect of the 3 Nishina Lakes ;the Aoki, Nakatsuna and Kizaki Lakes.

The outline is as follows:

### 7.1 Suwa Lake

Suwa Lake is the largest in our prefecture with an area of 13.3 sq. km and catchment area population of 180,000, being a place of historical industrial activities, and thus representing our prefecture. In the past the Suwa region surrounding the lake was famous as the biggest producer of silk, and afterward - for fine mechanics such as watches and cameras, which together with its landscape worn by the lake and mountains around made the region called "Oriental Swiss". People loved the lake, swimming there in summer and skating there in winter.

From the mid 50's, however, with the intensive economic growth of our country the water pollution has been progressing, which has led to increasing eutrophication such as water bloom with abnormally grown phytoplankton - "Microcystis" in the summer period of the year.

The prefectural government, from the commencement of dredging of benthic mud in 1969, has conducted measures such as improvement of sewerage system in the catchment area and strengthening of factory effluent control. After the lake was designated by the Clean Lake Law, the lake water quality conservation planning was established to promote further comprehensive measures of conservation. As a result of this, the percentage of sewered population in the catchment area has reached 81% and water quality shows a trend of improvement, as shown in Fig. 7-1, but environmental quality standard has not yet been ensured, as well as water bloom is continuing taking place. However, in the situation when improvement of water quality in the country's 10 designated lakes is going on in the not-so-good manner, it may be said that the lake enjoys relatively high effect of the taken measures.

The waterside maintenance project which provides the maintenance of the waterside divided into 8 zones is started to improve it taking each specific environment and utilization form into consideration, which, together with water quality conservation, is to realize good water environment conservation.

7.2 Nojiri Lake

Nojiri Lake is located on the northern part of the prefecture, on the border with Niigata Prefecture, having lake area of 4.56 sq. km. Surrounded by Mt. Myukou, Mt. Kurohime and other grand mountains and tablelands, it is a nature-rich lake in the Joushin-etsu National Park. The water quality is relatively good, being used for drinking water supply to Nagano city, some enjoy waterbath in it in summer.

In late June through July, 1988 due to abnormal growth of phytoplankton - Urogrena - the first freshwater red tide in Nojiri Lake occurred. The lake surface was colored in red-drown, offensive odor floated in the air around. This triggered taking measures for water quality conservation, which has led to primary treatment of household effluent, working-out of planning and commencement of sewerage system construction and designation by Clean Lake Law.

At present, in accordance with Law concerning Special Measures for Conservation of Lake Water Quality, are being conducted improvement of the sewerage system as main program, construction of agricultural effluent treatment facilities, planning of the waterside maintenance and other programs. As a feature of nature-rich lake, the weight of pollutant load from natural system is very high, so it is not easy to improve lake water quality, though trial is made for water purification using water plants. The water quality for the last several years shows a constant level by COD and decreasing tendency by T-N and T-P.

7.3 Nishina Sanko Lakes

Nishina Sanko Lakes is located in the western-northern part of the prefecture, being a collective name of Aoki, Nakatsuna and Kizaki Lakes, lying along Fossa Magna which crosses Honshu Isl. from south to north. The collective name was given to the three lakes, because in the past a powerful family Nishina ruled this region. Some call these lakes "mirrors of the north Alps", as the lakes reflect figures of the north Alps, standing on the west of them.

Nature around is rich, having similar environment to Nojiri Lake, the water quality is relatively good in all of the 3 lakes.

About at the same time as Nojiri Lake, in summer of 1988, a freshwater red tide by phytoplankton - Peridinium - occurred in one of the lakes - Kizaki Lake.

Nishina Sanko Lakes have not been designated under Clean Lake Law because of the water utilization purpose, lake area and other reasons. The prefecture established own "Water Quality Conservation Planning for the 3 Nishina Lakes", in accordance with which taking due measures in collaboration with one city and one village consisting the catchment area of the lakes. Coordinated with the concept of "Water Environment Conservation Comprehensive Planning of Nagano Prefecture", this planning takes the rich natural environment into consideration and provides for organization of "Nishna Sanko Lakes Water Quality Conservation Measures Meeting" from public bodies such as communities self-governed organs, fishermen's association, sight-seeing association and others for conducting practical activities in the tight contact with the local community.

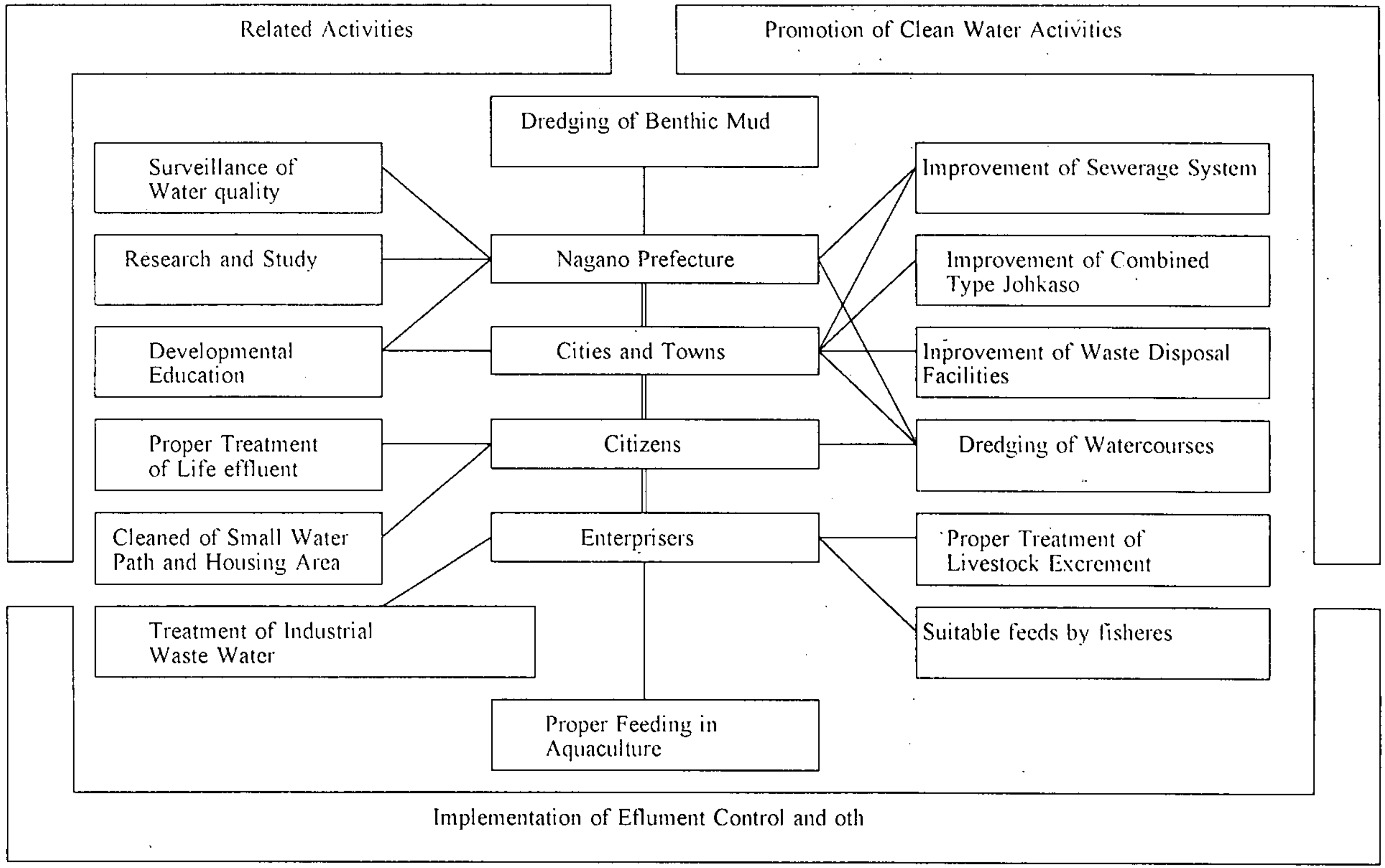



Fig.7-1 Systematic Scheme of Lake Water Quality Conservation Planning (Suwa Lake)

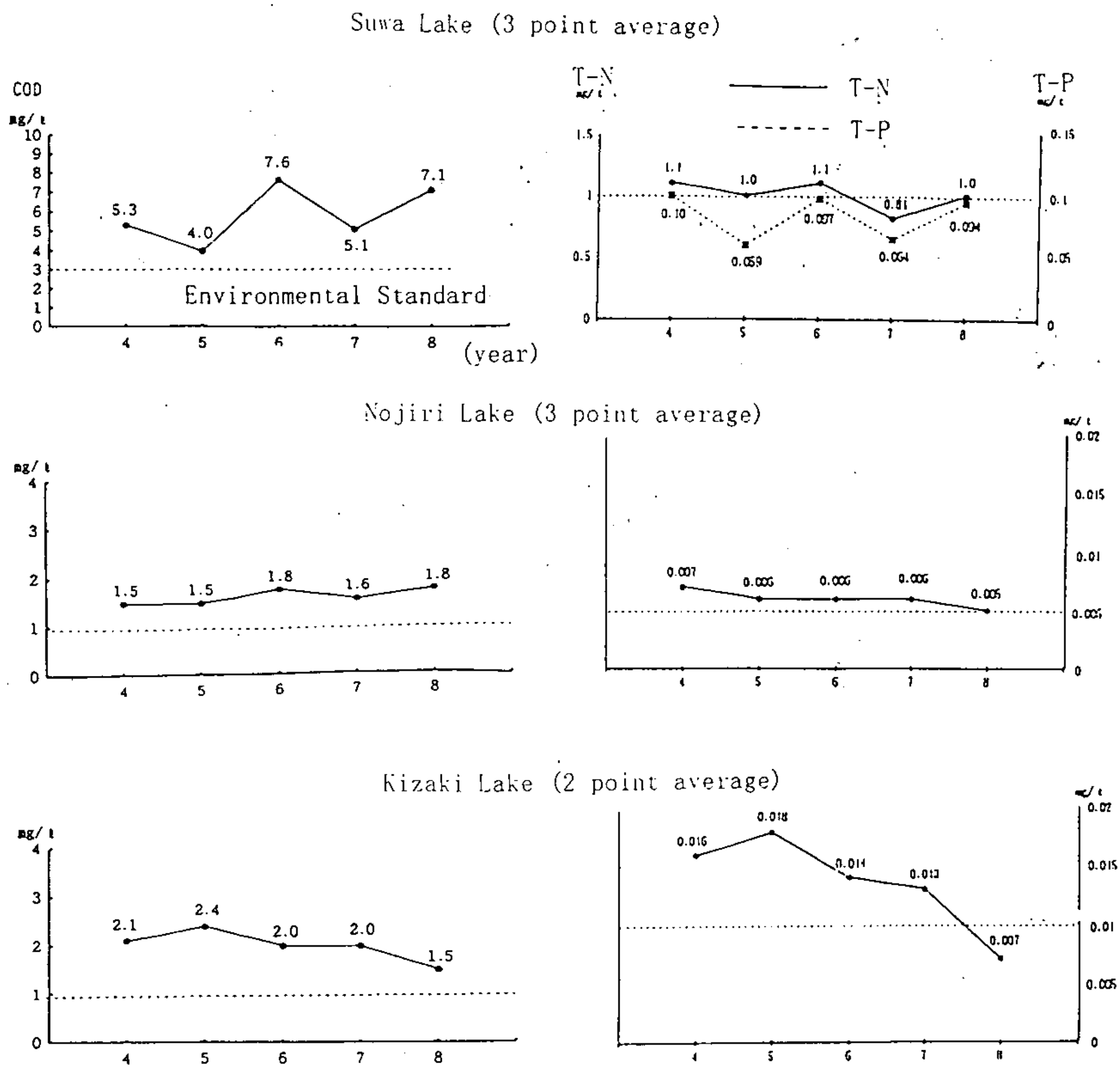



Fig. 7-2 Dynamics of COD, T-N and T-P in Major Lakes

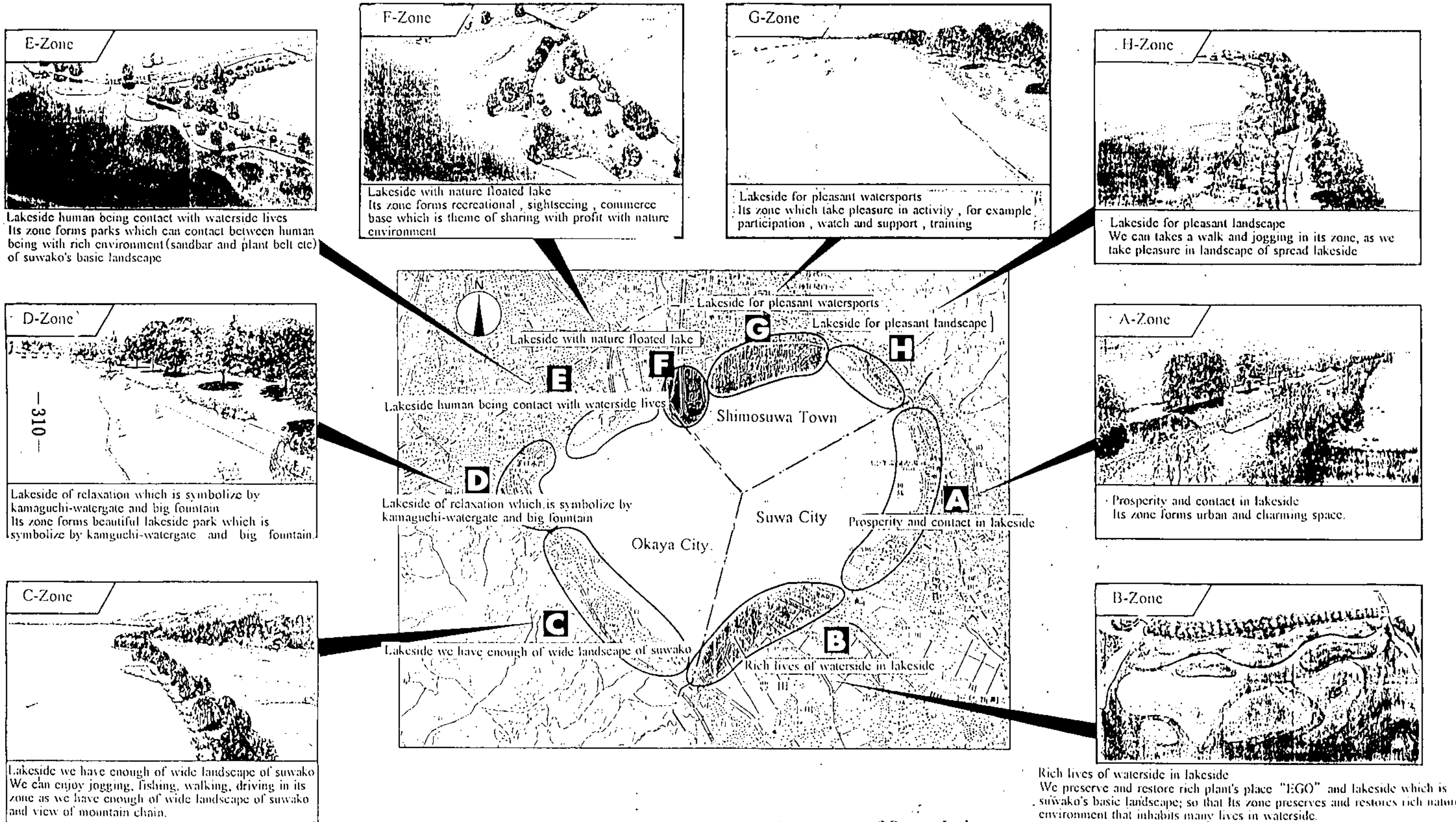



Fig. 7-3 Outline of the Waterside Maintenance of Suwa Lake

## 8. Further Steps of Planning

At present in our prefecture "The Second Water Environment Conservation Comprehensive Planning" and "Lake Water Quality Conservation Planning in Suwa Lake" are being worked out. These plannings, in addition to the ongoing measures, shall provide for 1) measures for preventing pollution by unspecified pollution source in the agricultural land and urban zone, 2) guaranteed good water circulation, 3) water environment conservation activities by citizens' initiative and other measures.

Pollution by unspecified sources imposes considerable pollution load on rivers and lakes, for example, water quality of the road effluent in the beginning of rain shows a COD value of 40 - 60mg/l. Although no effective method has not been established as of today, urgent measures have to be taken, additionally to that being conducted in respect of industrial and household effluent, as sedimentation of pollutants inflows at the time of rain may cause a serious problem.

Further, with increasing urbanization, an original water circulation when precipitation slowly penetrates and springs out is being damaged, which leads to a fear of decrease of ground water, spring water and river flow rate, as well as water quality deterioration resulting from it. Thus urban planning and river maintenance which take penetration factor into consideration. Practice of effective water usage - water saving privately and in business establishments is also important to keep water circulation in a good condition.

Consciousness and action of separate citizen of the prefecture are as well indispensable for water environment conservation. In the recent days observation and study on aquatic organism, clean-up movement and other practical activities are becoming more frequent. But so frequent are the cases of garbage dump into the rivers and, as children, compared with the past, have less chances to be in touch with water, it is needed to widen the possibility of their learning through experience, ensure the relevant facilities and train the instructors. It is desired to spread a method to carry out practical activities in the community with the corresponding action target and self-evaluate before going to the next stage.

Besides the above, it is planned that more comprehensive measures for water environment conservation will be taken, incorporating culture by water, exchange through water and other additional aspects.