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.

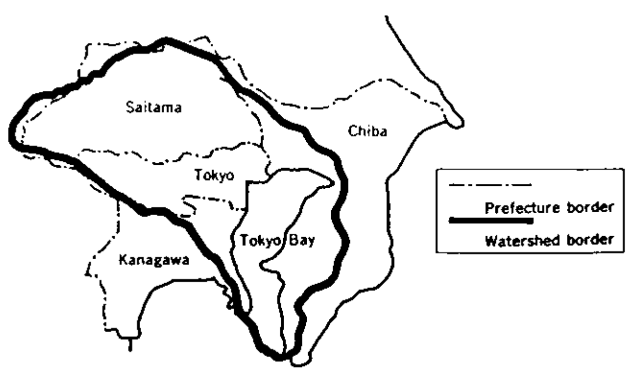

Fig.20-1 Catchment area of Tokyo Bay

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

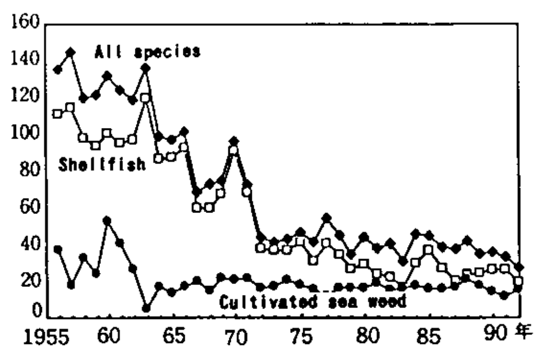

Fig.20-2 Trends in the catch of fish in Tokyo inner Bay

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.

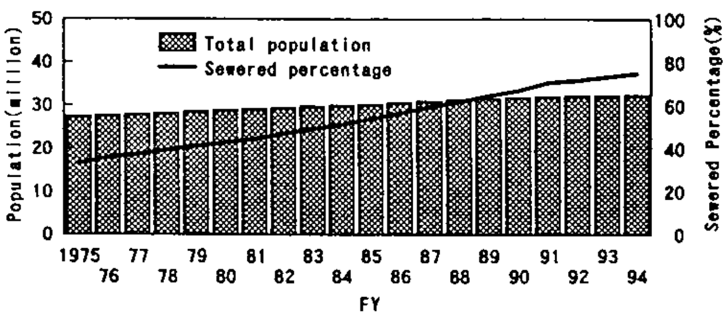

Fig.20-3 Trends in total population and percentage of sewered population in Tokyo Bay basin
(Data:total of one capital and three prefec.)

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.

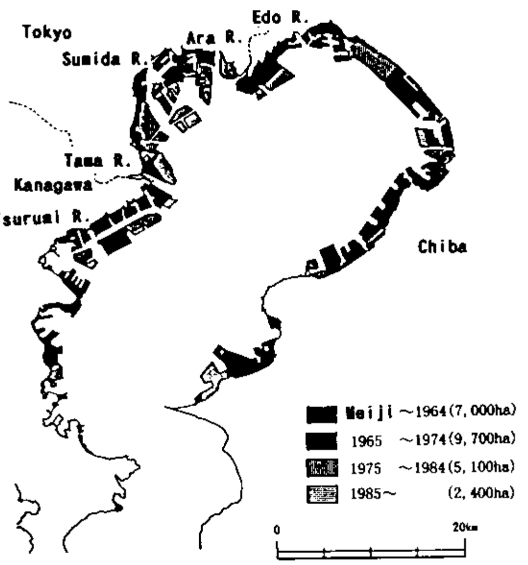

Fig.20-4 Transitions of reclamation along the coast of Tokyo Bay

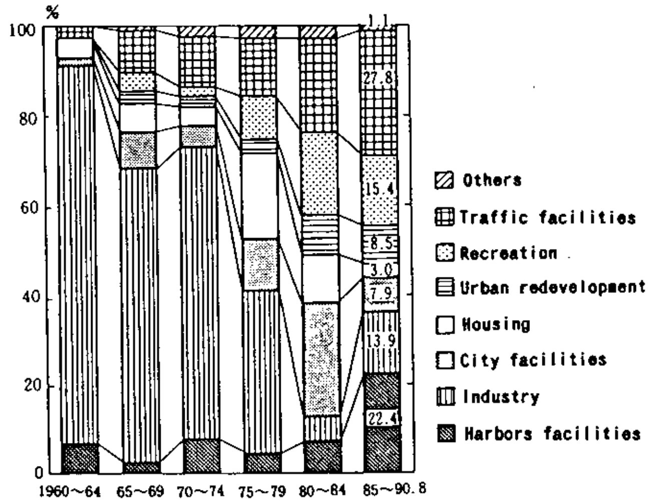

Fig.20-5 Trends in percentages of each usage of the areas for which reclamation have been authorized in Tokyo Bay

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.

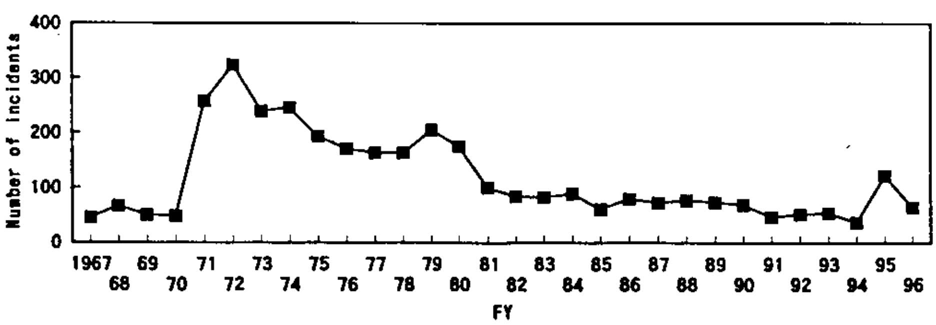

Fig.20-6 Trends in confirmed number of marine pollution incidents caused by oil spills

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

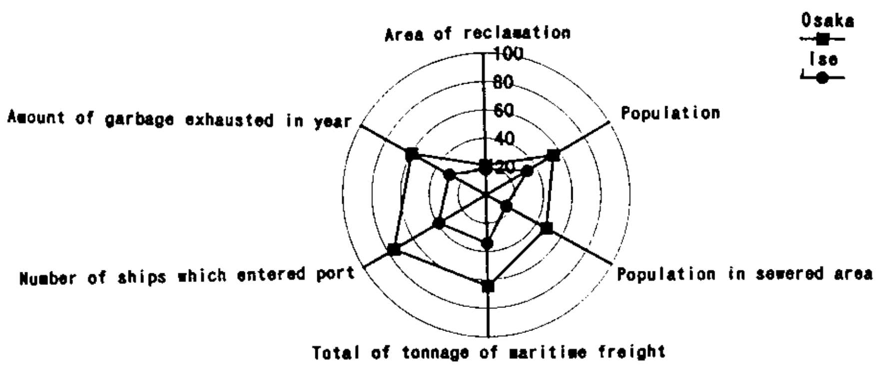

Fig.20-7 Comparison of Tokyo Bay, Osaka bay and Ise Bay

Data in FY 1993 or FY 1994
As for data, Tokyo Bay is calculated as 100%

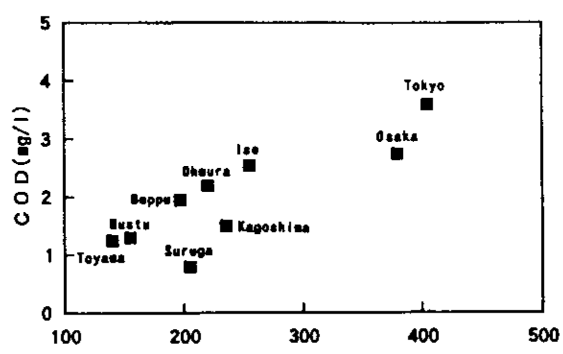

Fig.20-8 Relationship between population densities in the main inner bay basins of Japan and COD of these bays

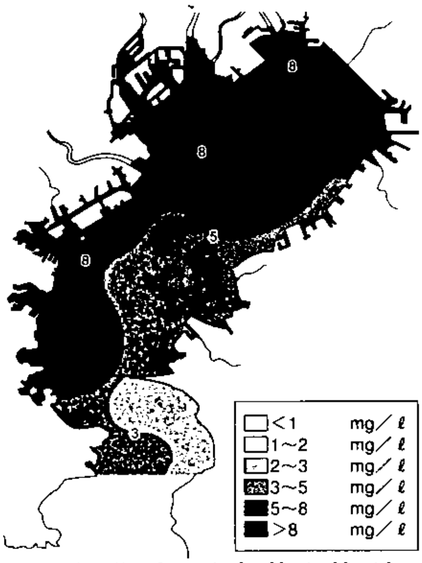

Fig.20-9 Horizontal distribution of COD in upper layer in July (1994)

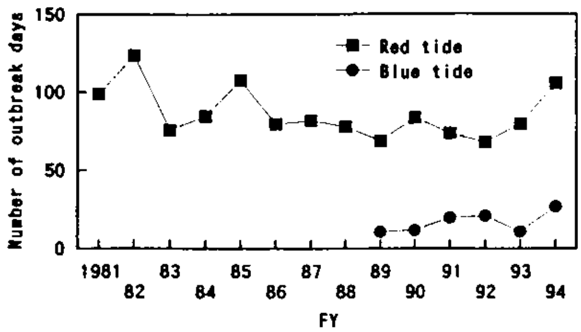

Fig.20-10 Trends in numbers of outbreak days of red tide and blue tide

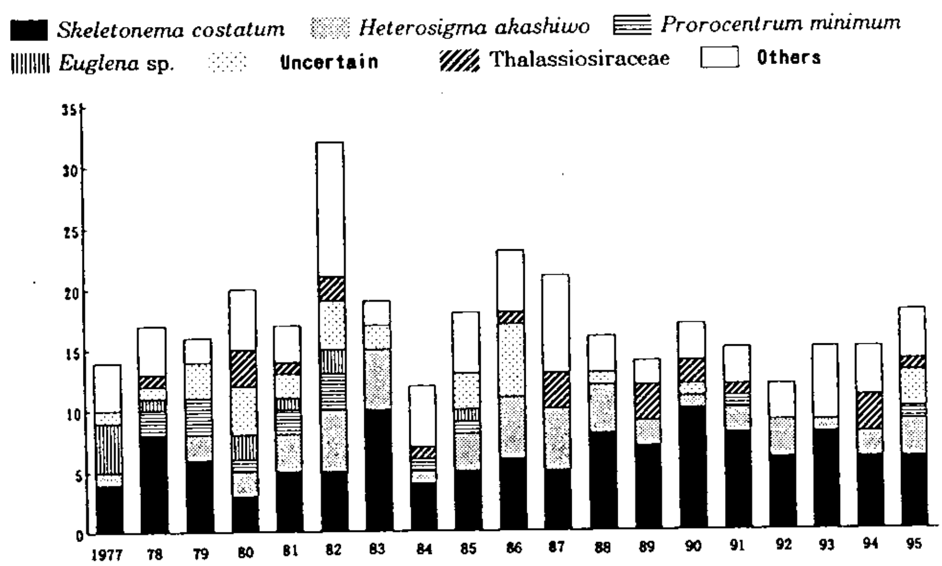

Fig.20-11 Trends in number of occurence of red tide according to dominant phytoplankton

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

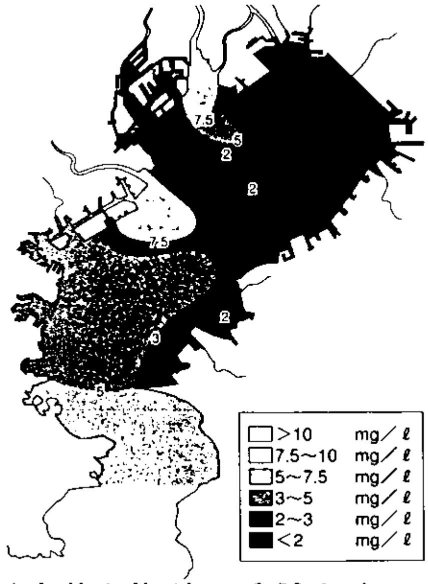

Fig.20-12 Horizontal distribution of DO in lower layer in July (1994)

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.				Saitama prefec.
		"A" area		"B" area		
		500m3/day or more	500m3/day or below	500m3/day or more	500m3/day or below	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.			Chiba prefec.	
		"A" area	"B" area	Sea	500m3/day or more	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	

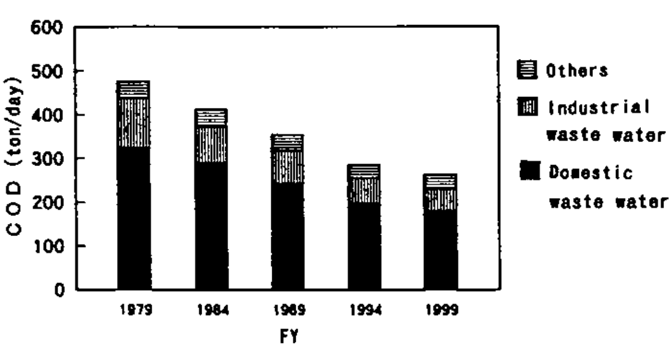

Fig.20-13 Changes in pollutant loads and reduction targets of COD under the Total Pollutant Load Control System

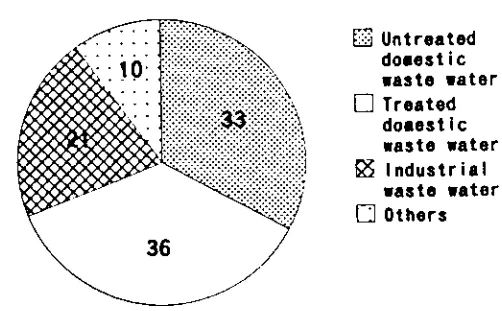

Fig.20-14 Percentage of discharge pollution load according to source in Tokyo Bay (FY 1994)

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

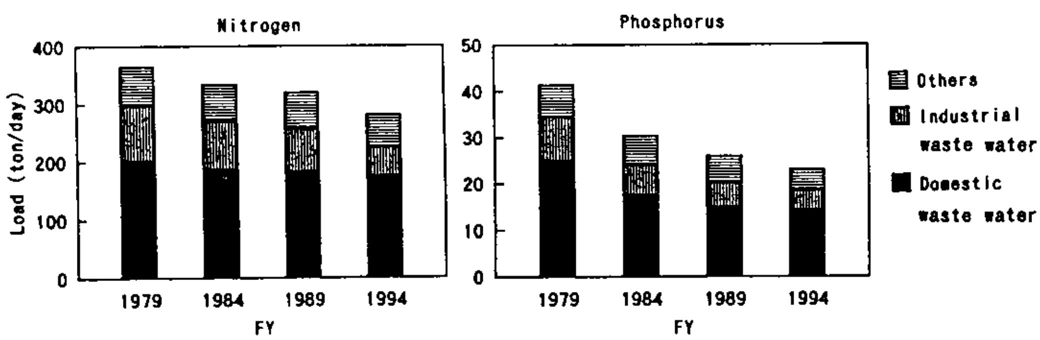

Fig.20-15 Changes in pollutant loads of nitrogen and phosphorus

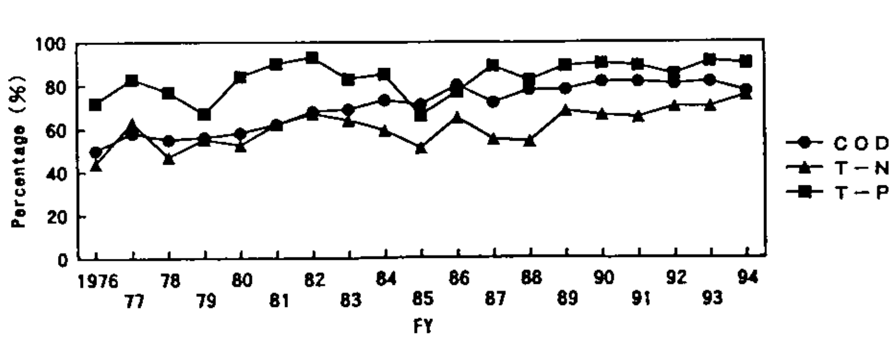

Fig.20-16 Trends in percentage of sewage business load to total loads of factories and other places of business

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).

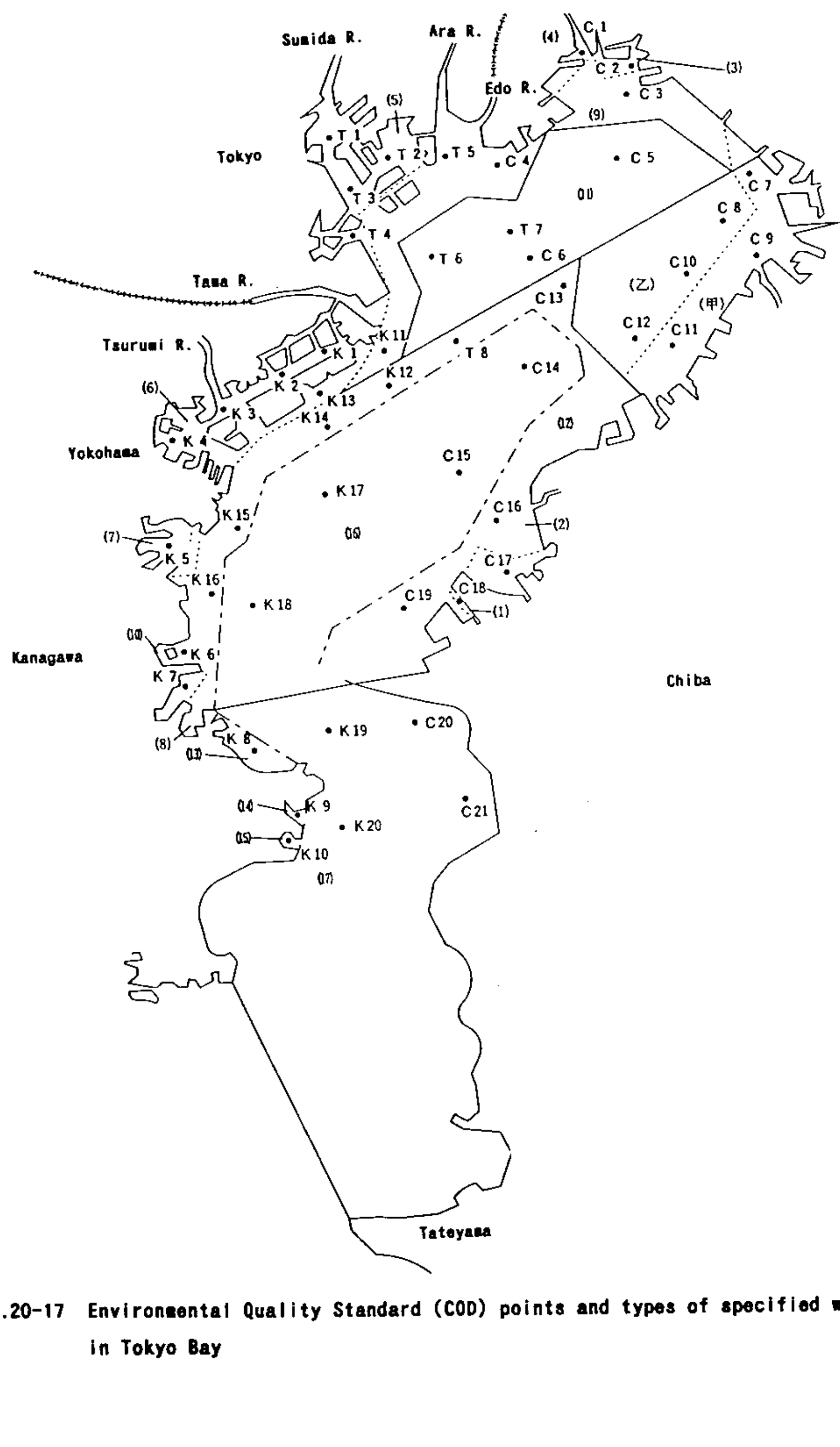

Fig.20-17 Environmental Quality Standard (COD) points and types of specified water area in Tokyo Bay

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

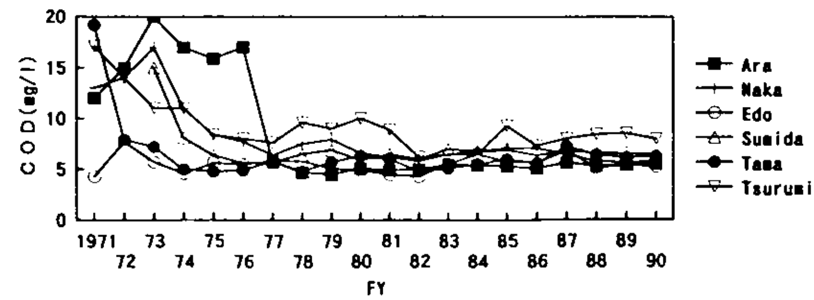

Fig.20-18 Trends in water quality (COD) of rivers which flows in Tokyo Bay

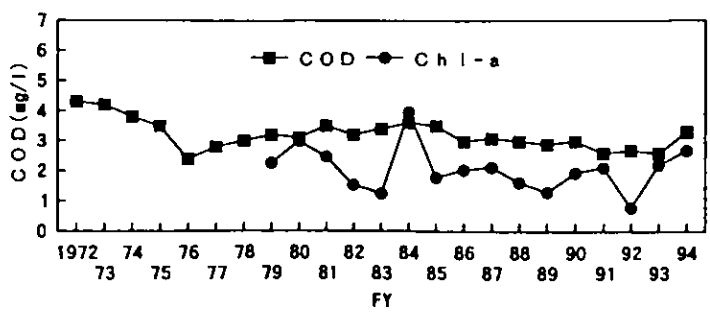

Fig.20-19 Trends in water quality (COD and chlorophyl-a) in Tokyo Bay

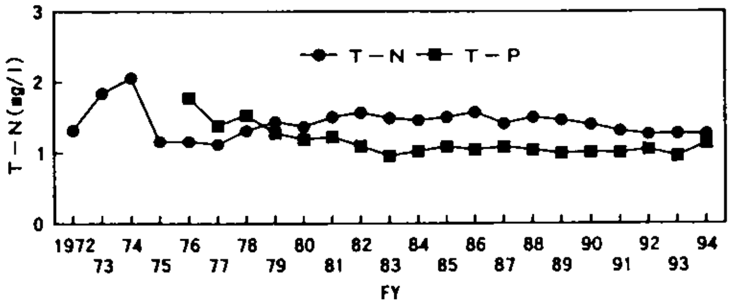

Fig.20-20 Trends in water quality (T-N and T-P) in Tokyo Bay

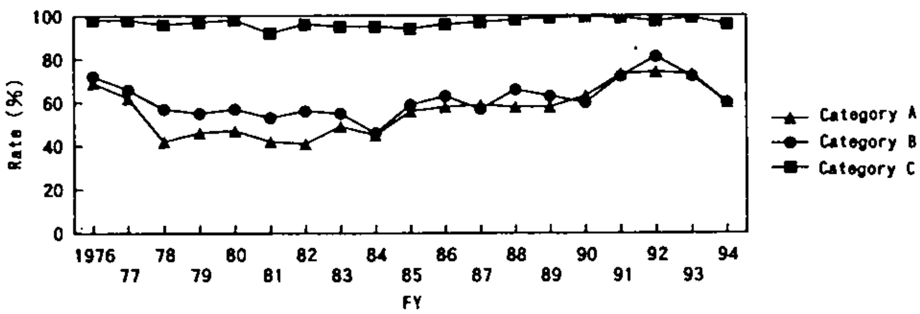

Fig.20-21 Trends in achievement rates of Environmental Quality Standards (COD) in Tokyo Bay

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 Type	Environmental quality standard Standard values (mg/l or less)	FY 1995 Average values (mg/l)	FY 1999 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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