Pollution in Japan - Our Tragic Experiences

— Case Studies of Pollution-Related Damage
at Yokkaichi, Minamata, and the Jinzu River —

July 1991

Study Group for Global Environment and Economics

* The photograph of the cover is Smog emitted from Yokkaichi industrial complex (around 1970)

(by courtesy of Hitotsubashi-Shuppan)

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Foreword

This report offers a rough analysis of the cost-effectiveness of pollution control measures. Needless to say, pollution control measures should not be implemented solely from financial considerations. However, even from a purely financial standpoint, an approach to economic development which includes pollution control is much more fruitful than one which neglects environmental issues. We hope to show this point clearly and concretely through an examination of case studies of pollution in Japan.

Economic development is being pursued hotly these days, especially by the developing nations. Now more than ever Japan needs to strengthen its pollution control measures, and we hope that strategies for future economic development will take into account the tragic experiences and lessons outlined in this report, and initiate a wise course of economic development which takes due consideration of environmental preservation. We hope that this report will be useful for all policymakers who are engaged in making choices about economic development strategies in their countries.

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*Study Group for Global Environment and Economics

* The Study Group for Global Environment and Economics is an autonomous study group composed of interested Environment Agency personnel. This report was written by group members, i.e. General Inspector for Environment, and the staffs of Office of Policy Planning and Research, Planning and Coordination Bureau, with the help of knowledgable sources both inside and outside the Agency. We would like to thank the many people who have helped us with materials and advice. The views expressed in this report do not necessarily reflect those of the Environment Agency; all responsibility for the text rests with the authors.

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SUMMARY

After the Second World War, Japan underwent a period of postwar reconstruction followed by a period of rapid economic growth. This process was undertaken, however, without proper attention to the environment, and the result was serious pollution-related damage. It was only after experiencing this damage that Japan began implementing proper pollution control measures, and today, although we still face serious problems, the environmental situation has improved for most pollutants which had endamaged severely human health and environment.

This curative approach was undesirable, however, not only because it was caused by serious pollution-related damage and the accompanying social discord, but also because it was not economically sound. This report uses case studies of pollution-related damage in Japan to illustrate that the amount of money which would be expended on damages brought about by lack of proper pollution control measures (in Japan this is frequently the amount of money actually paid as damage compensation etc.) is much greater than the cost related to implementing measures that would have prevented such damage from occurring in the first place. We hope that, when decision makers formulate economic development policy, they take into account these examples which demonstrate the importance and economic practicality of pursuing pollution control measures from the initial stages of economic development.

Summary for each Chapter of the report is as follows.

CHAPTER 1: An overview of pollution-related damage and pollution control costs during the process of rapid economic growth in Japan

In this chapter we first explore the reasons for the worsening of pollution during the Japan's period of high economic growth. Some reasons listed are that Japanese growth was fueled by investment in production facilities and the export of manufactured goods, making for the formation of a heavily polluting industrial structure; economic policies favored establishment of an infrastructures for industry; environmental policies were still in a stage of development, and were administered by a number of different government departments as part of their industrial policies. These are factors that exist today in many parts of the world, and there is a possibility that many countries will end up repeating Japan's mistakes.

Next, we discuss the various assumptions on which our analyses in CHAPTER 2 are based. We outline the different types of pollution-related damage that Japan has experienced and explain the difficulties of conducting a monetary assessment of them. In order to simplify the analysis in this report, we use estimates based solely on damage which has actually been compensated financially--the amount of expenditure for compensation related to health damage, reparation amounts, and those for soil restoration projects, etc.--and substitute these figures for the amounts which would probably have been incurred had no pollution control measures been in place. We also outline the various types of pollution control measures, and note that in this report we substitute time series data of actual amounts invested in equipment--the total of equipment investment depreciation costs, interest payments, and running costs--for the cost of pollution control measures in anticipatory manner i.e. those which instituted before damage can occur.

The comparison of damage expenses versus pollution control costs is facilitated by our calculation of one-year expenditures, using methods appropriate to each case. Without pollution control measures, damage would continue indefinitely, and in order to eliminate damage, it is necessary to continue the measures indefinitely. Thus total expenditures for damage and pollution control are impossible to ascertain. This is the reason why we use the amounts of one-year expenditures for the purpose of comparison.

After explaining the assumptions and conventions which inform our analysis, we demonstrate the methods we use in this report by conducting a trial calculation of costs involved in air pollution by sulfur oxide as seen on a nation-wide level, comparing damage expenses incurred when no measures are in place versus the costs of current pollution control measures. From this calculation we can see that the projected damage expenses are on an order of ten times greater than the pollution control costs, and we can be satisfied that current pollution control measures for sulfur oxide are economically viable.

Finally, we note that there were no adverse effects on the macro economy brought about by the implementation of these curative pollution control measures. In fact, these strict pollution control measures may even benefit the economy, as can be seen in the development of technology with low pollution levels and high productivity. This teaches us not to concentrate only on the negative economic aspects of pollution control measures.

CHAPTER 2 Case Studies: Damage vs. Pollution Control Costs

This chapter consists of three case studies: Yokkaichi as an example of air pollution caused by sulfur oxide, the Minamata Bay Area as an example of water pollution caused by organic mercury, and the Jinzu River Basin as an example of soil pollution caused by cadmium.

For each of case studies, we note that ① development was carried out without proper consideration for environmental protection, ② the resulting pollution caused severe health damage, after which ③ corrective measures for pollution control were taken; finally, we calculate and compare the extent of damage with pollution control costs. Assuming no pollution control measures taken, the cost of damage (and in all cases except Yokkaichi, the cost of damage was represented by the real amount paid in compensation for real damages) came to ¥21.0 billion per year for Yokkaichi (all costs in 1989 values), ¥12.6 billion per year for Minamata, and ¥2.5 billion per year for the Jinzu River Basin. These costs were on the order of several times (in the case of Yokkaichi and Jinzu) to about as many as 100 times (in the case of Minamata) the costs for pollution controls that would have prevented this damage (the analysis uses pollution control costs actually incurred). The calculations demonstrate the economic sense of implementing pollution control measures in the early stages of development rather than waiting until damage has already occurred.*

Pollution related health damage, moreover, cannot adequately be assessed by monetary compensation. The cost assessment of damage used in this report does not fully reflect the real extent of damage. We hope that our use of this assessment does not cloud reader's understanding of the extent and misery of the damage caused by pollution, or weaken their commitment to pollution control.

* Figures for damage and costs in this version differ slightly from those submitted to Environment Congress for Asia and Pacific held in Tokyo, July 1991 and G7 Summit held in London, July 1991; The figures are revised based on the newest available deflator for 1989 value, and on a refinement in the method of calculating the operating costs of anti-pollution equipements and interest payment as suggested by several experts. These revised figures, however, do not result in any modification of the conclusion of our analysis.

Damage expenses versus pollution control costs

(unit: million Yen FY1989)

Yokkaichi (air pollution caused by sulfur oxide)

One-year damage expenses	One-year air pollution control costs
Health damage compensation 1,331 Assumed one-year damage expenses for a patient certification rate of 7.27% throughout the Yokkaichi City area 21,007	14,795

Minamata (water pollution caused by organic mercury)

One-year damage expenses	One-year water pollution control costs
12,632 (the detail) Health damage compensation 7,671 Bay pollution damage 4,271 Fishing damage compensation 690	125

Jinzu River Basin (soil pollution through cadmium)

One-year damage expenses	One-year pollution control costs
2,518 (the detail) Health damage compensation 743 Compensation for agricultural damage 1,775 Compensation for crop loss 882 Soil restoration costs 893	603

CHAPTER 3: The implementation of pollution control measures from the initial stages of development

CHAPTER 3 contains supplementary information necessary for an environmentally sensitive approach to development.

The first part provides information about available pollution control technologies that should be used at factories and other sources of pollution. In Japan , pollution control technologies devised to meet a wide range of pollutant reduction needs are currently in use , and it is now possible to pursue proper pollution control from the initial stages of operations. We discuss equipment investment costs for various levels of pollutant reduction, using desulfurization techniques, nitrogen oxide control measures, soot control measures, and water pollution control measures as specific examples.

In the second part, we discuss the role of the local environmental administration bureau. After giving examples of some of the responsibilities the environmental bureau must fulfill in order to prevent pollution from the very beginning stages of development, we list some examples of the costs and the personnel necessary for these tasks in cities of various sizes.

We hope that this material will be useful to economic development policy makers in many countries.

(NOTE)

This report was first conceived by Mr. Aichi, the environmental minister. A group of Agency staffs volunteered to do the research and writing. The report was presented officially to the Environment Congress for Asia and Pacific (ECO-ASIA '91) which was held in July 4 and 5 in Tokyo.

The objective of ECO ASIA'91 was to form a wide range of consensus within the Asia-Pacific region as a preparatory step towards the United Nations Conference on Environment and Development (Earth Summit) to be held next June. Main themes discussed at ECO-ASIA'91 were "New Mechanism for International Cooperation" and "Eco-Industrial Revolution".

Mr. Kato, director-general of the Global Environment Department of the Environment Agency, presented the Study to Group 2 where "Eco-Industrial Revolution" was discussed on July 4. Comments to the report by the participants were favorable.

Furthermore, upon the reporting of Group summary at the Plenary on July 5, Mr. Schmidtheiny, the Chairman of Group 2, stated that "many participants were impressed with the important Study", and "it was hoped that this Study should focus the attention of LDCs on the economic sense of taking action to prevent environmental damage before it occurs".

Chapter 1 An Overview of Pollution-Related Damage And Pollution Control Costs during the Process of Economic Growth in Japan

1. The Relationship between High Economic Growth and Pollution

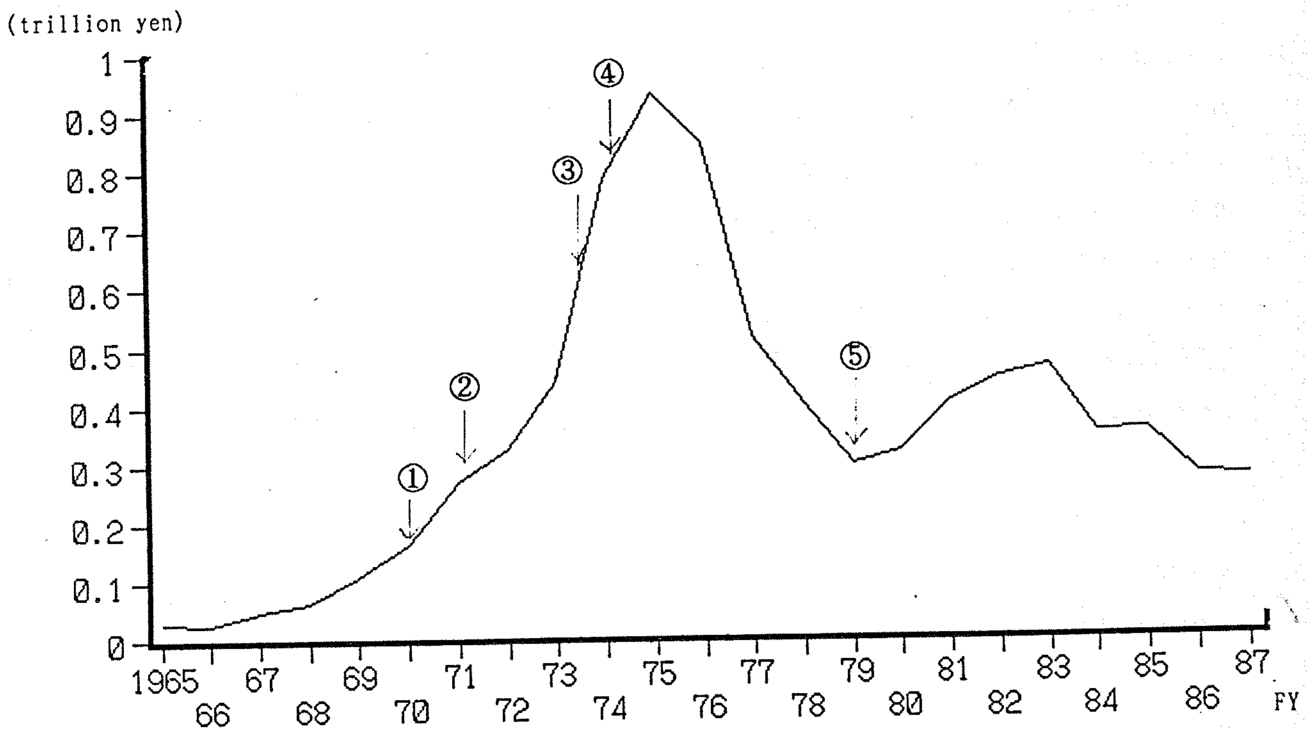
In 1945, the second world war ended with the defeat of Japan. Japanese reconstruction began in a land where the cities had been burned to the ground and the devastated earth had been stripped of its greenery. Expansion of productivity became an overriding priority, and the Japanese people worked night and day to achieve it. As a result, in less than ten years, the economy had recovered to the point where it had been before the war. Then the economy rebounded, with the average real economic growth rate reaching 8.8% during the last five years of the 1950s, holding strong at 9.3% during the first half of the 1960s, then rising to 12.4% during the latter half of the 1960s.

Japan's economic growth was fueled largely by the export of industrial goods and capital investment in production facilities. By multiplier effect, capital investment bred further capital investment and the economic growth rate soared, but during this process the composition of industry became weighted toward the heavy and chemical industries. The amount of pollutants produced per unit of production is higher in the heavy and chemical industries than in any other industry. Consequently, as fast as the GNP growth rate increased, the amount of pollutants produced throughout Japan increased even faster. Furthermore, even in 1965 the percentage of total capital investment that businesses allocated toward pollution control was only 3%--considerably less than it is today.

Complicating the formation of a heavily polluting industrial structure was the relative ineffectiveness of Japanese government policies in controlling the increase in pollution.

Japanese economic policies of the time were aimed at eliminating bottlenecks to high economic growth and stimulating potential economic growth. Public investment was thus much greater in roads, harbors, and other industrial infrastructural requirements than in parks, sewage projects, waste disposal, or other environmental and recreational improvements. One of these economic bottlenecks was the overcrowding already existing in urban areas.

Figure 1 Pollution control equipment investment (FY 1965~1987)



① 14 environmental laws legislated

② Environment Agency established

③ First Oil Crisis

④ Introduction of Areawide Total Pollutant Load Control on SOx

⑤ Second Oil Crisis

1. From MITI <u>Trends of Investment in Pollution Control Equipment by the Private Sector</u>
2. These surveyed are enterprises with a capital over two hundred million yen. Actual investment expenditure
3. The figure for FY 1986 is expectated actual investment, and that of FY 1987 is projected investment.
   Because of the change in accounting method, we could not obtain the latest data on actual expenditure.

New factory development was lured into the countryside, creating great environmental disruption. Harbors were dug, areas of the sea were reclaimed, rivers were tapped for their water. In this way, large scale industrial zones with new and powerful production facilities sprouted up one after the other throughout Japan.

During the latter half of the 1950s a number of pollution control measures were instituted. However, as can be seen from the inclusion of the provision that "protection of the human habitat environment must be sought in harmony with healthy economic development," there was not yet a clear position on pollution control, and it was difficult to institute strict regulations. Also, the actual work of implementing these pollution control regulations was divided amongst a number of different governmental departments, each of which administrated the measures at the same time as they promoted the interests of the industries under their jurisdictions. From the vantagepoint of today, we can say that it was not a system that could allow the flexible administration of stringent anti-pollution measures.

The end result was that very little consideration was given to environmental concerns by either government or the private sector. For that reason, pollution grew more serious as the economy expanded.

2. The Financial Assessment of Pollution-Related Damage and the Relationship between Damage and Pollution Control Costs

As the result of such a small and heavily populated country as Japan undertaking large scale economic activity without proper attention to environmental pollution, serious pollution-related damage has arisen throughout the country.

There are many types of pollution--air pollution, water pollution, etc. The problems arising from these are also many and varied, but they can be divided roughly into 1) illness and other injury to peoples' health caused by the absorption into the body of harmful substances, 2) damage to property--metal corrosion, laundry contamination, drops in land value, increased difficulty in growing crops, decrease in fish catch, etc., 3) disruption of the ecosystem or other damage to the environment, 4) loss of amenities--loss of beaches, spoiling of the scenery, etc.

Japan has suffered every conceivable kind of pollution-related damage. In Section 2, we will examine some representative cases, and compare the expenses incurred by the damage versus the costs of preventive measures.

Before proceeding to that, however, we must examine the criteria with which we will be defining pollution-related damage expenses and pollution control costs. Next we will consider the example of air pollution caused by sulfur oxide, and do a trial calculation of the expenses for damage avoided as well as the costs for pollution control measures. Finally, we will examine the effect that this kind of pollution control expenditure has on the macro economy.

2.1 Expenses Incurred by Pollution-Related Damage

First let us consider how to approach expenses incurred by pollution-related damage.

While some components of the pollution-related damage may easily be assessed financially--damage to assets, for instance--in general, damage caused by pollution does not lend itself to financial assessment. Injury to people's health, for instance, is often irreparable, and is something which can never be fully compensated by financial means. Furthermore, the amount of compensation has to do with people's perception of value of life in each country. When translating pollution-related damage into financial terms it is easy to neglect those parts that are difficult to assess economically, and as a result, the assessed amount tends to be too small.

Research has been done in Japan on financial assessment of such things as the damage from car exhaust fumes and traffic noise, from water pollution in a specific body of water, and from aircraft noise.

This report, however, is not an academic research paper but a specific examination from a purely economic angle of the pros and cons of taking environmental protection into account while pursuing economic development. Therefore, we have not tried to translate damage completely into financial terms. For the purposes of our discussion, we have represented the full financial assessment of expenses incurred by all pollution-related damage by the actual expenditures--for instance, the amounts already paid in compensation or the amounts already paid to clean up polluted fields or water.

As you can see, the amounts cited as damage expenses in this report are clearly nothing more than provisional estimates of amounts paid out to correct some of the damage caused by pollution. The Environment Agency does not view the figures given in this report as a perfect reflection of damage expenses, and we ask the readers to keep this firmly in mind, so as not to form a biased impression of the size of the damage or think it possible to relax pollution control measures.

A time series of damage compensation expenses which have been converted by appropriate means into yearly average compensation amounts has been used for comparisons with pollution control costs.

2.2 Costs Incurred by Pollution Control Measures

By around 1970, at the height of era of high economic growth,pollution had spread drastically and become recognized as a major socioeonomic problem in Japan. From 1970, Japanese public began to question the positive evaluation that high economic growth had had up to then, showing a greater concern with its negative aspects. Regulations also tightened, as the Diet, at the end of the same year, legislated 14 pollution-related laws. Among the legislative changes were the deletion of the provision that protection of the human habitat environment must be sought in harmony with healthy economic development. In 1971, the following year, the Environment Agency was established, thus consolidating authority over pollution regulation.

Actual implementation of pollution control measure benefited greatly from the establishment of a government framework for dealing with pollution.

Pollution control measures can be roughly divided into 1) measures to prevent the production of pollutants in the first place, such as changes in manufacturing methods and changes in raw materials or fuel, 2) measures to prevent pollutants from spreading from their place of origin into the environment, such as the installment of dust collectors and sedimentation ponds, 3) measures to prevent released pollutants from affecting the living conditions of area residents, such as the establishment of green buffer zones, 4) measures in the public sector such as the monitoring of pollutants in the environment and at the source, and the use of that data to establish regulations or propose laws.

The money required to implement these kinds of pollution control measures can be broken down into equipment investment (equipment purchase, including interest payments, and installation costs) and running costs (the personnel, chemical, electrical, and tax costs required to run the equipment).

Data is available, albeit mostly from large companies, on equipment investment costs for item 1. However, there is insufficient data on investment costs for item 2, as well as running costs for both items 1 and 2.

Precise figures are available for the activities covered in items 3 and 4, since these are handled by central and local government bodies; however, these figures are mostly in the area of equipment investment.

In principle, the estimates given for pollution control costs in this report are the sum of depreciation costs for the equipment investment outlined in items 1-4 above and the running costs, and are based on a time series of equipment investment cost data.

Also, general yearly running costs are assumed to be in a proportional relation to equipment investment costs.

As can be seen from the above, the pollution control costs cited in this report are provisional estimates involving bold assumptions, and we ask the readers to keep this in mind.

2.3 Expenses Incurred by Pollution-Related Damage Versus Pollution Control Measures

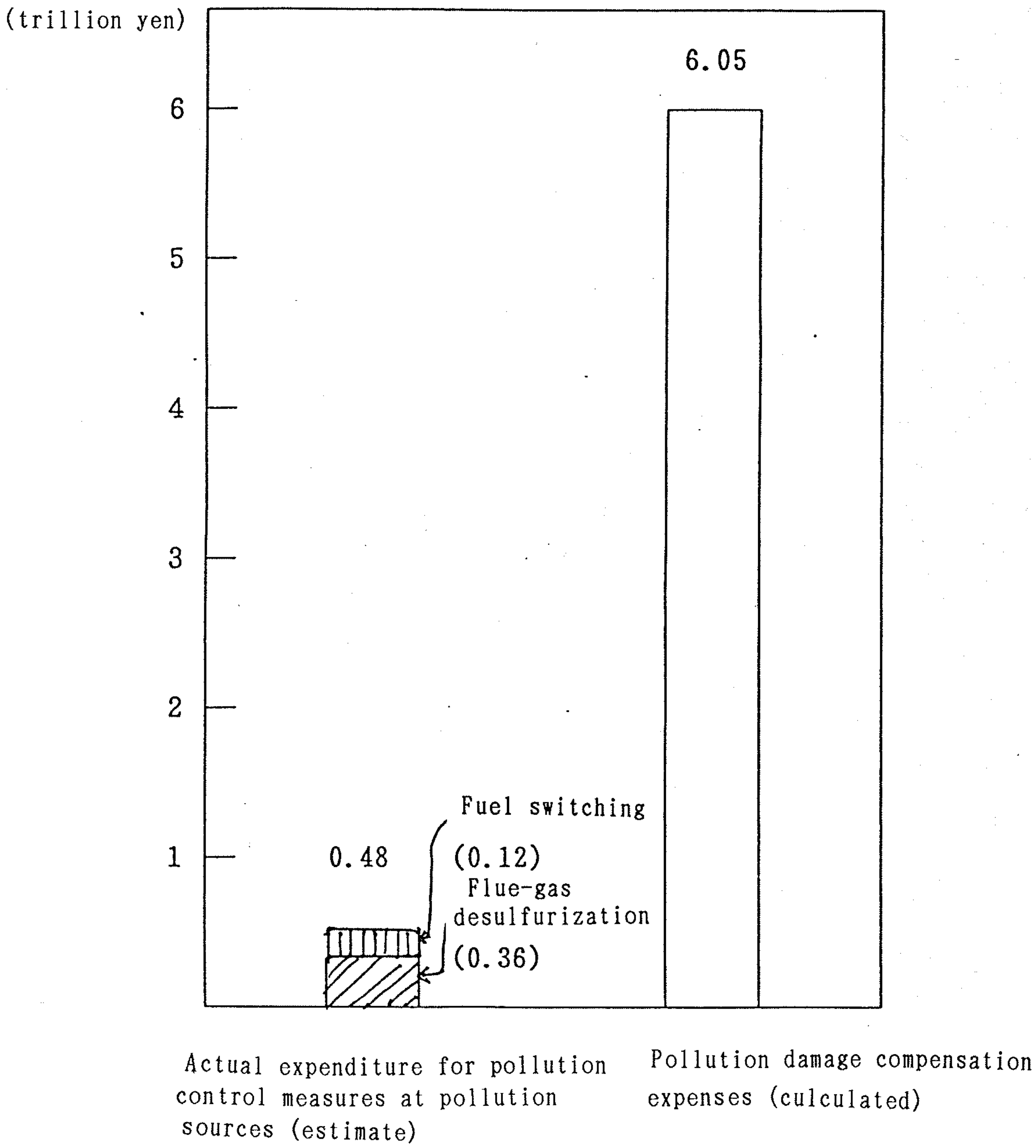
In Chapter 2, we will compare the costs incurred by pollution-related damage versus pollution control measures using concrete examples of air, water, and soil pollution. First, however, as an example of the comparative methods we shall be using in this report, we would like to present a trial calculation of pollution-related costs on a national level.

The following graph shows a comparison for the year 1976 of the costs for sulfur oxide pollution control measures taken at factories and other pollution sources, versus estimates of pollution damage expenses that would have been incurred had no measures been taken at all. (Yoichi Kaya et al. 1982)

It must be emphasized that these calculations are merely provisional estimates involving bold assumptions. However, as you can see, the projected pollution damage expenses that would have been incurred had no preventive measures been in place (approximately ¥6 trillion per year, 1976 values) far exceed the amount which was estimated to have been actually spent on pollution control (approximately ¥480 billion, 1976 values).

Although some may criticize the use of worst-case scenario figures to calculate the certified patient rate, we can still say that an environmentally sensitive approach to economic development is superior even from a purely economic standpoint.

Figure 2 Comparison of the annual costs for sulfur oxide pollution control measures at sources, versus estimates of annual pollution damage expenses that would have been incurred had no measures been taken at all (1976 value).



(Note) From the thesis by Youichi Kaya, presented to the Tokyo meeting of the Club of Rome

Notes on the paper

Pollution control costs are based on published reports from the Environment Agency and other sources, and have been calculated as follows. 1976 was chosen for these trial calculations because of the abundance of data available from this year.

1) The cost of fuel switching was calculated by comparing the actual share occupied by kerosene in the primary energy supply in 1976 versus its share in 1965 before flue gas desulfurization measures started in earnest. The difference was assumed to be the increase in kerosene consumption necessary to accommodate the change in fuel for sulfur oxide control measures. The cost of this increased volume of kerosene was compared with the cost of an amount of heavy oil of equal calorie value, and the difference was defined as the cost for fuel switching.
2) The cost of flue gas desulfurization apparati was reached by multiplying the actual number of flue gas desulfurization apparati by the estimated average yearly depreciation and running costs for one machine.
3) Compensation was calculated by assuming an increase in the concentration of sulfur oxide in the environment proportional to the increase in the primary energy supply volume between 1965 and 1976, and estimating that in this situation 15% of the collected population of the nation's major industrial zones would be certified as suffering from pollution-related illness. The resulting figure was multiplied by the average compensation amount per person in 1976 to arrive at the compensation amount.

We will use the same methods as above in order to compare damage expenses versus pollution control costs for each of the specific local examples given in Section 2, employing estimated average amounts for one year based on actual amounts spent.

The reason for this is that the amounts involved have various payment periods, making it impossible to compare simple totals. It thus becomes necessary to employ a common measure of time in making the comparisons.

Some amounts--compensation for health damage, for example--are paid continuously from the time the person is certified as a pollution-related patient until the person recovers. Other amounts, such as reparations, are paid as a lump sum, and still other amounts, like investment for pollution control, occur occasionally during a long time period. Indiscriminate comparison of the actual totals of these payment amounts over the period that happens to be under consideration would render an invalid result.

A number of different methods were used to obtain the estimated yearly damage expenses and pollution control costs in each case; detailed explanations are given in the notes in Section 2.

This report attempts to compare the amount of money incurred by damage expenses when no pollution control measures are in place versus the amount of money necessary to fund measures which will arrest pollution before damage occurs.

However, it is important to note that the estimated expenditure on damage based on actual amounts spent is not necessarily the same as the amount of money incurred by damage expenses when no pollution control measures are in place.

The fact is that Japan did initiate pollution control measures, albeit after a certain degree of damage had been incurred. Thus the damage expenses actually observed are less than they would have been, had no measures been in place.

Despite this gap, however, the actual damage expenses observed in the cases presented in this report were judged, with the exception of Yokkaichi, to be sufficiently close to the amount of expenditure required when no pollution control measures are in place.

Therefore, these actual figures have been used to represent this amount. In the case of Yokkaichi, since chances the pollution could well have spread and damages could well have been much more severe than they were, we have also used estimates of worst-case scenario damage expenses to compare with pollution control costs.

Similarly, the actual pollution control costs in each case are the costs of corrective measures taken after damage had already arisen, and in many cases these measures proceeded by trial and error. Thus the figures tend to be larger than amounts for pollution control measures that arrest pollution before damage can occur.

However, this report, substitutes actual pollution control costs for the cost of pollution control measures which arrest pollution before damage can occur. Whether these corrective measures were sufficient to prevent pollution is a question that can be addressed elsewhere.

Looking at the specific cases which appear in Section 2, we see that in both Yokkaichi and the Jinzu River, the output of the damage-causing pollutants, sulfur oxide and cadmium respectively, has declined greatly, and their concentration in the environment has decreased. In the case of Minamata, the damage-causing pollutant is no longer being released. Unlike the measures taken to prevent pollution by nitrogen oxide, etc, the control measures for the above cases have already been perfected, and thus we believe the actual pollution control amounts cited in Section 2 provide a good index to costs for measures which arrest pollution before damage can occur.

For the reasons listed above, we must assume that the damage expenses being compared are lower than they should be, and pollution control costs are higher than they should be. However, in the interests of making the economic significance of these pollution control measures clearer, we have felt it safer and more persuasive to proceed with this assumption. (In other words, we are comparing damage expenses which are probably lower and pollution control costs which are probably higher than they should be--see the chart below.)

Damage expenses when no pollution control measures are in effect	>	*Actual damage expenses	vs.	*Actual pollution control costs	>	Pollution control costs (no damage)

Note: The underlined amounts are those which this report is attempting to compare. In actuality, however, the amounts marked with an asterisk * are used to represent the underlined amounts.

2.4 Effects of the Implementation of Pollution Control Measures on the Macro Economy

The worsening of pollution in Japan from mid-sixties prompted the institution of strict pollution control measures, spurred on by the enactment of numerous pollution-related laws by the "Pollution Diet" in 1970 and the establishment of the Environment Agency in 1971. Yet the pursuit of these strict pollution control measures during the 10-year period between 1965 and 1975 had almost no effect on the macro economy.

Investment in pollution control equipment by the private sector during this period totaled ¥5.3 trillion at 1970 values. If we use macro economic models to compare the state of the economy in 1975 with and without this investment, we come up with the results cited below. (from the 1977 White Paper on the Environment)

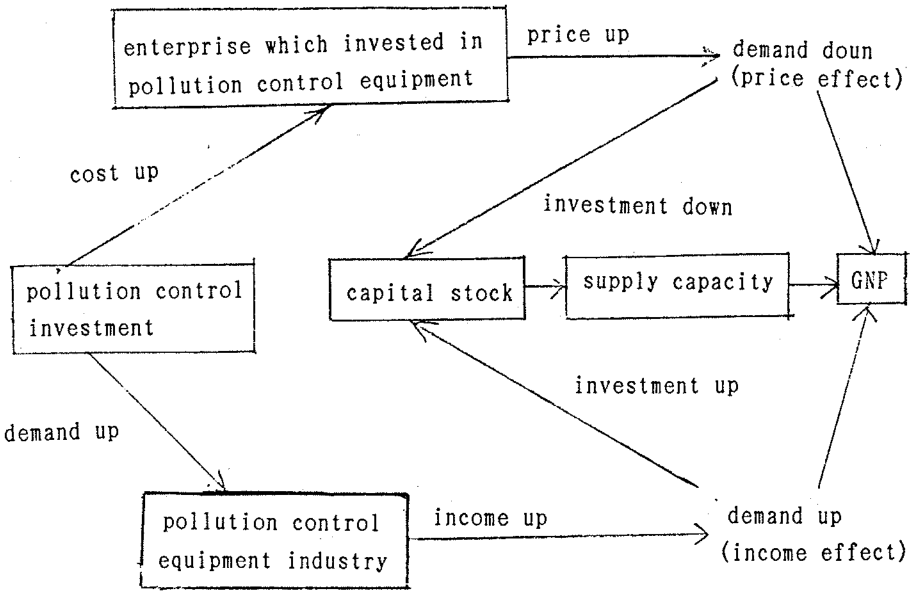
Note, for example, that the real GNP is estimated to be slightly higher when pollution control measures are in effect than when they are not.

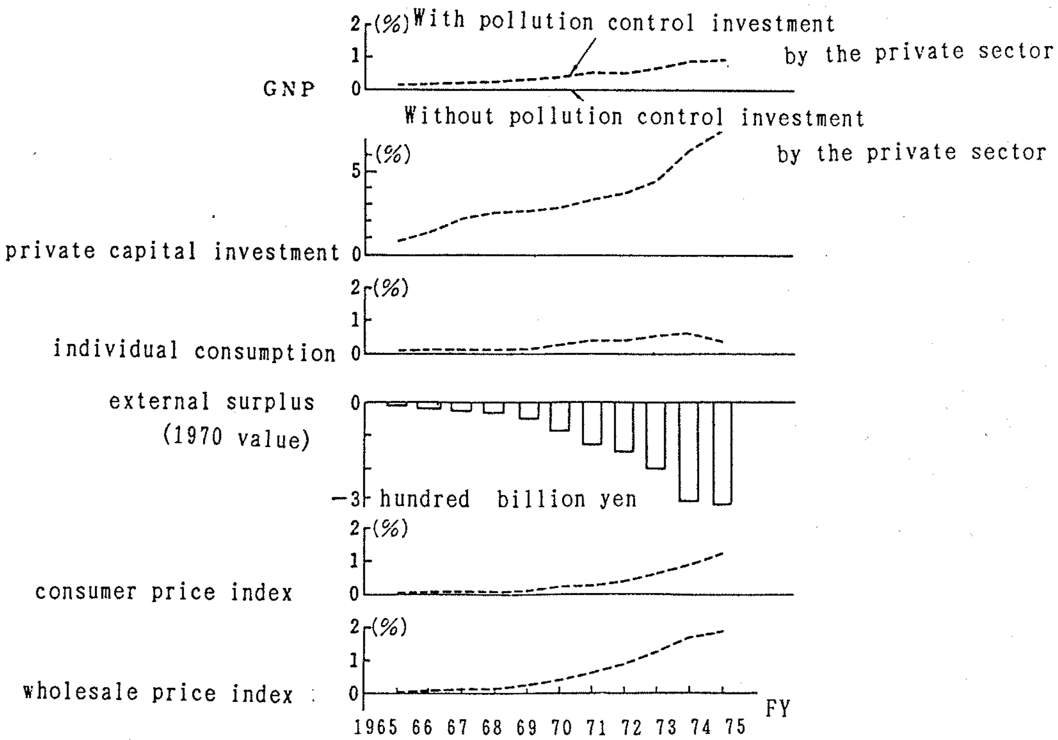
(all figures given in real terms)

GNP	approx. 0.9% increase
individual consumption	approx. 0.4% increase
private capital investment in equipment	approx. 7.4% increase
external surplus	approx. ¥300 billion decrease (1970 values)
consumer price index	approx. 1.2% rise
wholesale price index	approx. 1.7% rise

The reason there were no adverse effects on the macro economy resulting from these strict pollution control measures was that the economic cooling brought about by a rise in prices from pollution control measures was canceled out by the buying effect of an increased demand for pollution prevention-related facilities. In spite of the fact that the measurement of national welfare in terms of GNP has its limits, if we are to make an assessment in terms of GNP, pollution control is itself a kind of investment activity;for example, the market for pollution control equipment in Japan around 1975

Figure 3 Economic impact of pollution control investment by the private sector





1. Source : Quality of the environment in Japan 1977
2. We have simulated macro-economic growth of the Japanese economy between 1965 and 1975 with and without pollution control investment, and presented the difference between the two cases in terms of their ratio and actual GNP.
3. Pollution control investment (source) MITI Investment in Pollution Control Equipment by the Private Sector

exceeded ¥1 trillion and contributed to GNP. Thus, the Japanese experience shows that it is not wise to focus only on the negative aspects of pollution control spending.

Furthermore, the implementation of strict pollution control measures often results in the development of technology which in the long run may prove beneficial to economic activity. For example, decreasing the amount of unburned carbon dust that comes from boilers and such also helps improve boiler heat management and allows a reduction in fuel costs. Thorough sewage treatment measures usually mean thorough control of factory water use and reduced water bills.

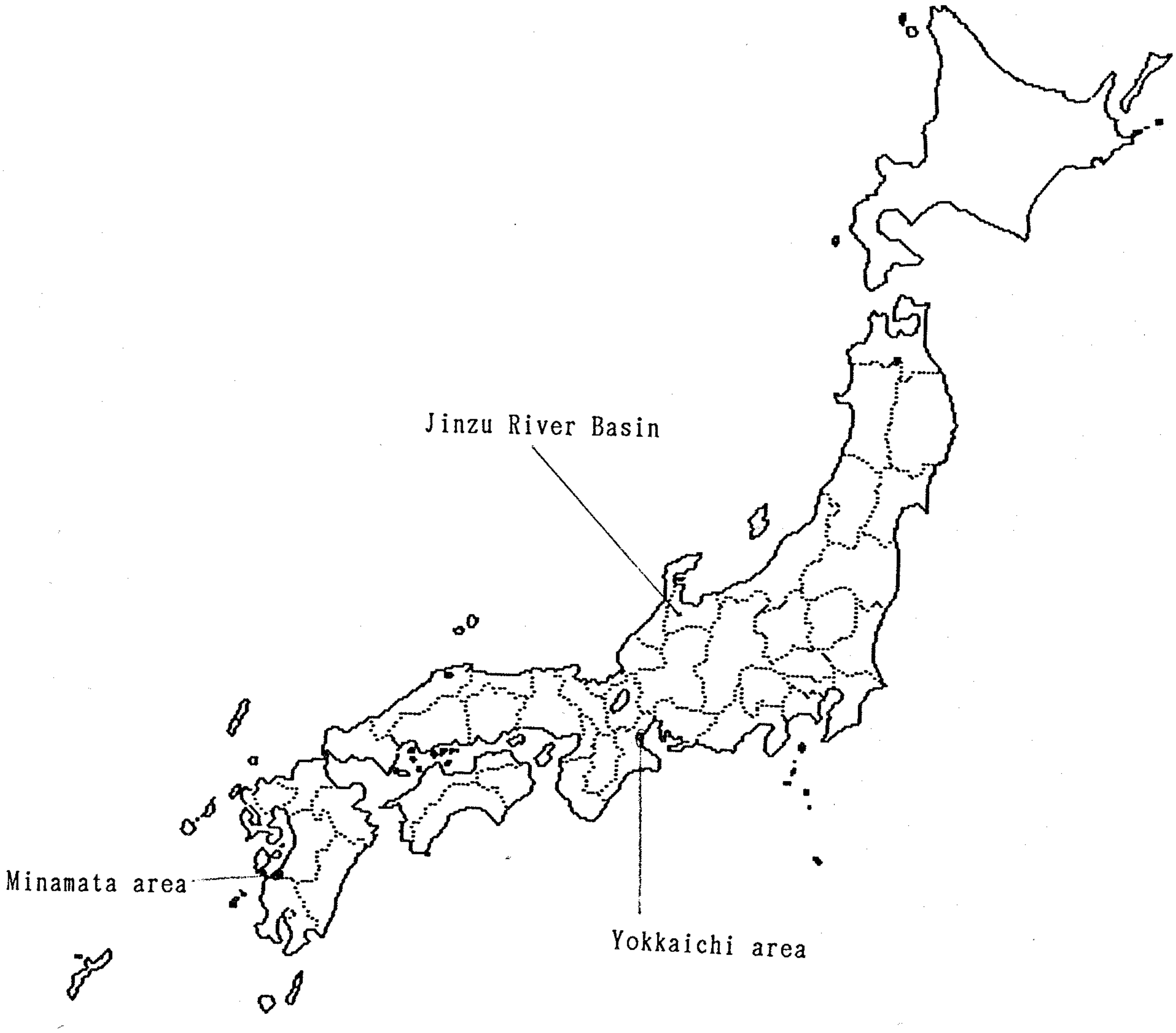
Strict automobile emission regulations imposed in Japan prompted improvements on gasoline-powered automobile engines, leading to the manufacture of clean-running gasoline-powered automobiles with high fuel efficiency. As a result, Japanese automobiles are being exported all over the world.

The low nitrogen oxide-producing NSP kiln and the reduction method of iron manufacture which does not emit CO_2 (under development) are two other examples of economically beneficial technological development brought about by pollution control.

Chapter 2: Case studies: damage versus pollution control

This chapter will compare the pollution-related damage and pollution control costs in Yokkaichi, Minamata, and Jinzu river.

Location of these area is as follows.



1. Yokkaichi (air pollution caused by sulfur oxide)

1.1 Background

During the postwar period of high economic growth, existing industrial zones could no longer provide enough land, water, or transport power to meet industrial demands, in addition living conditions in these zones was deteriorating. In order to continue industrial expansion it became necessary to create new seaside industrial zones.

The location of Yokkaichi City combined large areas of land suitable for factory use with excellent harbor facilities. Because of this, in August of 1955 the government gave businesses the remains of an old navy fuel depot (approx. 660 ha) and the Cabinet granted permission for the construction of a group of petrochemical complexes on the site. In 1956 construction began on a petroleum refinery, and the Number One Complex was completed and began operations in 1959. When the Number Three Complex was completed in 1973, it had a petroleum refining capacity of 505,000 barrels, and an ethylene production capacity of701,000 tons, making it one of the largest in Japan at that time.

1.2 Pollution and pollution-related health damage

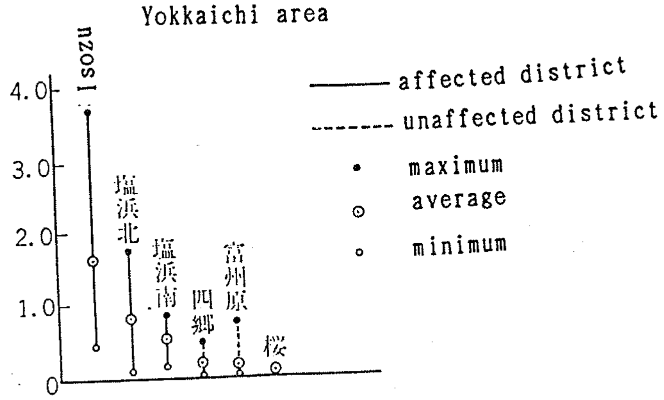
Soon after the start of plant operations, area residents began to suffer from asthma and other complaints. This became a widespread problem, and in October 1960, Yokkaichi City formed a Committee on Pollution Control to measure the severity of air pollution and conduct surveys on the health of area residents. Air pollution around Yokkaichi City continued to worsen, however, and with the Number One Complex being followed by the opening of the Number Two Complex in 1962-1964, the situation became extremely bad.

According to measurements taken between November 1963 and October 1964, the average concentration of sulfur dioxide in the Isozu district was eight times that of unaffected districts, with 3% of the average one-hour measurements exceeding 0.5ppm, and at times even exceeding 1ppm--ten times the current environmental standard of 0.1 ppm.

From August of 1962, patients thought to be suffering from pollution-related health problems were examined free of charge at the Mie University Hospital, and from May 1965, patients certified by the Yokkaichi

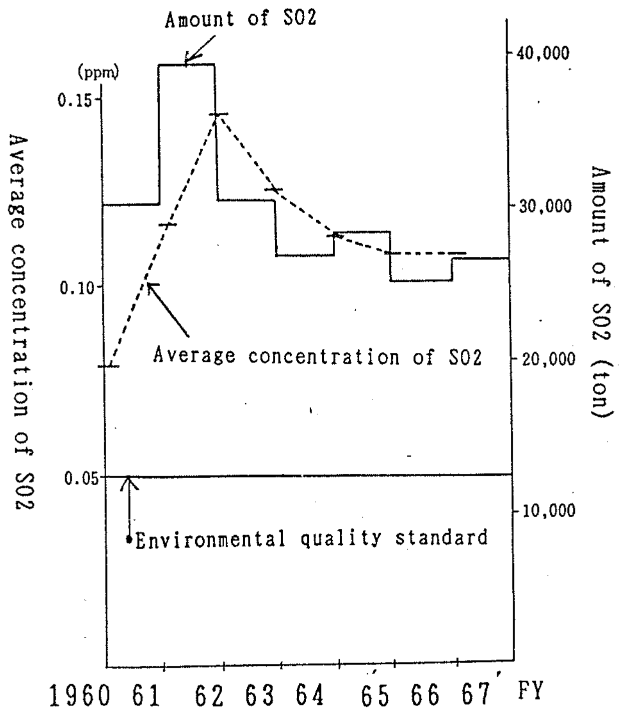
Figure 4 Average concentration of SOx in affected districts and in unaffected districts
(between November 1962 and October 1964)

Yokkaichi area



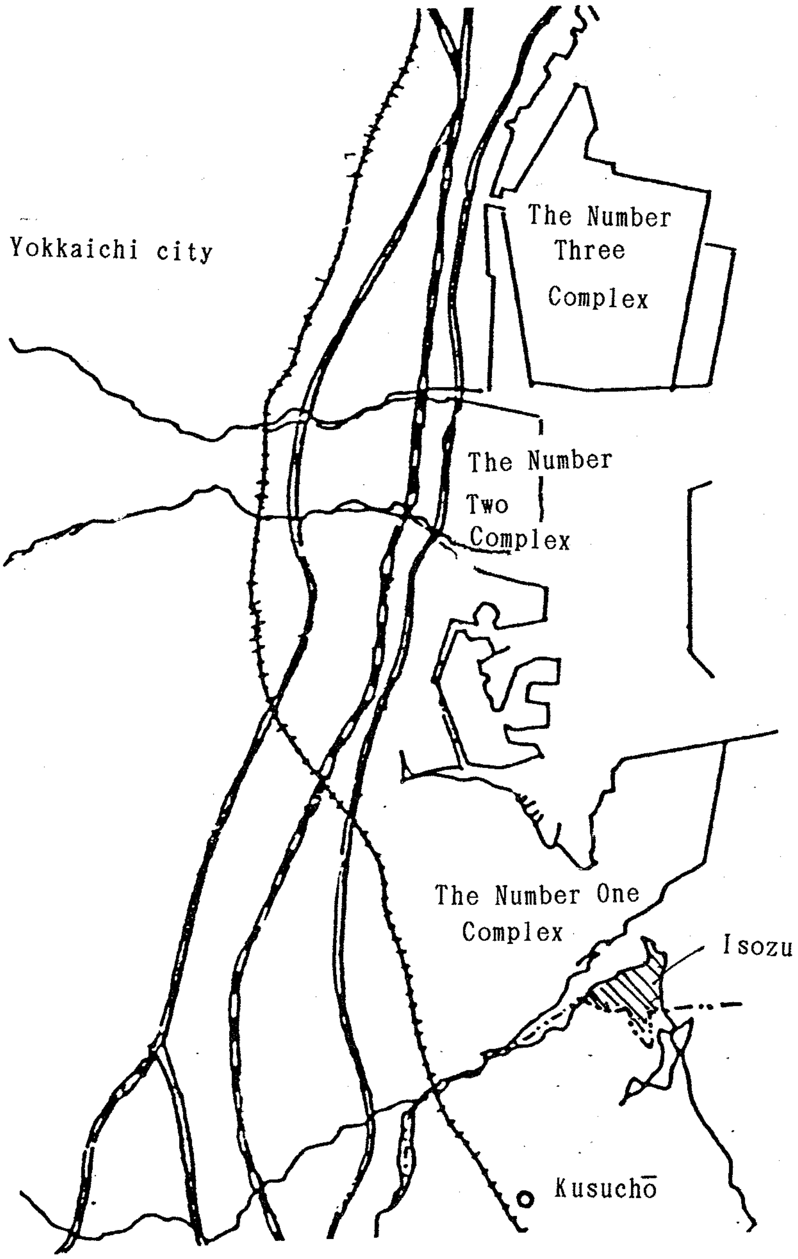
1. From Quality of the Environment in Japan 1969
2. Sakura (unaffected district): monitoring data for the period between August 1964 and January 1965
3. Monitored with lead dioxide method. Correction is needed to compare with present monitoring data.

Figure 5 Average concentration and emission of S02 in the Isozu district from November to April



1. From Yokkaichi pollution litigation ruling
2. We corrected the measurement with lead dioxide method

Figure 6 Yokkaichi area



Medical Review Board were entitled to have all medical expenses paid by the city. Meanwhile, the tragic circumstances of the patients were brought home to the public with the suicide of certified patients due to financial and other hardships and the death of a junior high school girl and other young patients from pollution-related illness.

In September of 1967, the residents of the Isozu area filed a damage suit against six companies of the industrial complex. The suit ended in July of 1972 with the Tsu district court, Yokkaichi branch handing down a decision in favor of the plaintiffs which found all the defendant companies guilty of illegal actions.

From 1970, medical costs for the patients had been supported by private donations from industry and by central as well as local government funds under the Law Concerning Special Measures for the Relief of Pollution-related Patients. However, with the decision of 1972 placing responsibility for pollution damage firmly on the polluting companies, the public became aware of the need for a system which could provide patients with support for living expenses as well as medical expenses. Thus 1974 saw the implementation of the Pollution-related Health Damage Compensation Law, a law which directed that polluting companies bear victims' medical expenses and pay compensation for lost income.

Yokkaichi qualified to receive aid, and the number of patients certified in the Yokkaichi area(Yokkaichi City and adjacent Kusu City) under this law reached a peak of 1,231 in 1975.

1.3 Pollution control measures

In 1962 the government passed the Soot and Dust Regulation Law. In order to designate Yokkaichi, in which there were already patients who were believed to be suffering from pollution-related illness, as a regulated area, the government dispatched a special commission to study air pollution in the region.

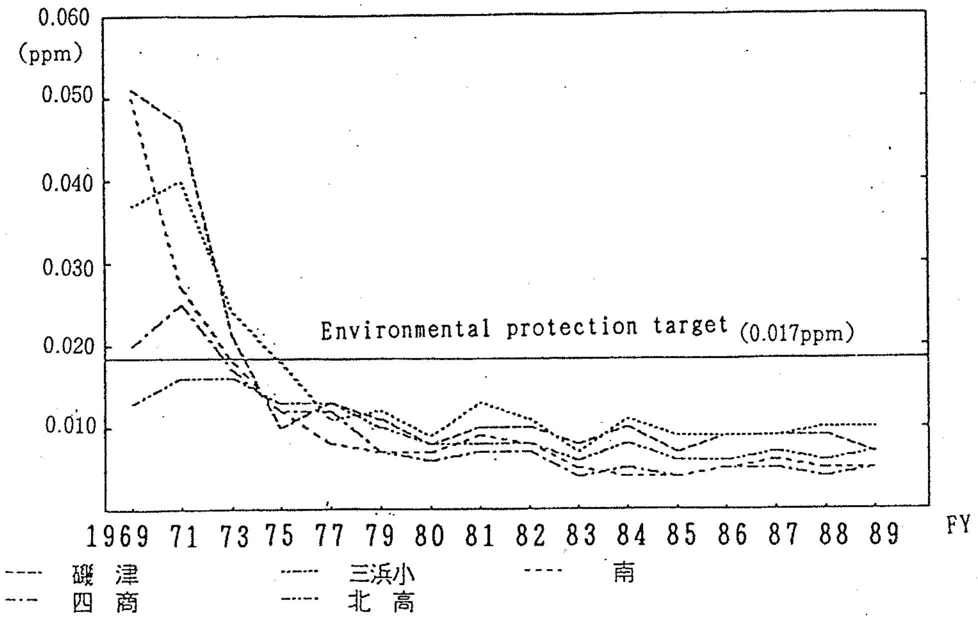
The commission made a number of recommendations, including the designation of Yokkaichi as a regulated area, the promotion of emission dispersion, the restructuring of Yokkaichi City by separating factory areas from residential areas, thorough health checks for area residents, and the institution of a network to monitor air pollution. On the basis of these recommendations, from May of 1964 Yokkaichi City became a regulated area, and reforms such as the translocation of housing, the institution of buffer zones, and the establishment of a monitoring network were put into effect. However, the high smoke stacks installed to promote dispersion of air pollutants merely caused the pollution to spread over a larger area.

The most pressing need was supply low sulfur heavy oil and development a flue gas desulfurization apparatus. In January of 1969, Daikyo Petroleum, one of the companies in the industrial zone at that time, perfected and subsequently expanded an apparatus for making heavy oil with a sulfur content of 1.7% from crude oil with a sulfur content of 3% (manufacturing capability of 2660 tons per day, 56% of the amount consumed by the Yokkaichi complex). Using the opportunity presented by the institution of environmental standards for SO2 in February of 1969, the prefecture called on companies stationed there to use the low-sulfur heavy oil. This and such measures as the strengthening of emission standards stipulated by law and the establishment of pollution monitoring systems caused pollution control to begin in earnest.

December of 1970 saw the institution of the Regional Environmental Pollution Control Program, a program which laid down comprehensive guidelines for sulfur oxide control measures based on projected factory operations and fuel use in the year 1975. In 1972, Mie enacted a prefectural ordinance to regulate each factory's production of sulfur oxide in order to place a cap on the total emission in the area for the first time in Japan. In March 1973, an emission source telemetry system to continuously monitor combustion in 16 major plants was introduced. In February 1976, Area-Wide Total Pollutant Load Reduction Plan and Area-Wide Total Pollutant Load Control Standards stipulated by the Air Pollution Control Law were introduced and by the end of FY 1976, the level of SO2 in Yokkaichi had reached conformity with the Ambient Air Quality Standard for SOx.

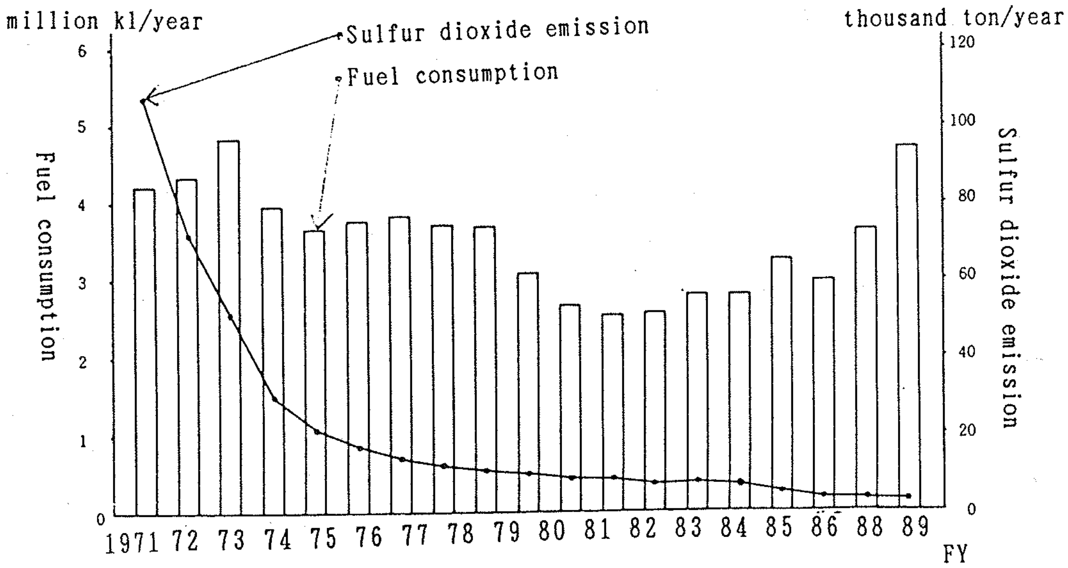
As can be seen from the graph on the next page, although the amount of fuel used today is more than the amount used fifteen or more years ago, the amount of sulfur oxide released into the atmosphere is less than one tenth of what it was.

Figure 7　Annual average sulfur dioxide concentration in Yokkaichi city (FY 1969～1989)



1. From Environmental Protection in Yokkaichi city 1990
2. Annual average in representative monitoring stations in Yokkaichi city
3. Environmental protection target (0.017ppm) was annual average target established by Mie prefecture. (Nearly equivalant to the Ambient Air Quality Standard by the Environmental Agency)

Figure 8　Fuel consumption and sulfur dioxide emission in the Yokkaichi area (FY 1971～1989)



(Note)　From the Quality of the Environment in Mie 1990

1.4 Damage expenses versus pollution control costs

In this way, the problem of air pollution in Yokkaichi was finally overcome. Although we realize that the loss of life and health can never be compensated by financial means, we have attempted to compare damage expenses and pollution control costs, as follows.

1.4.1 Damage Expenses

For damage expenses we have used the average single-year compensation amounts since the implementation of the Pollution-Related Health Damage Compensation Law in FY 1974 which provided for the payment of medical expenses and compensation for such things as loss of income.
They amounted to ¥1.331 billion per year (1989 value)

1.4.2 Pollution Control Costs

Pollution control costs were calculated by totaling the yearly average corporate investment costs for pollution control facilities, interpreted through average depreciation costs, since implementation of the Regional Environmental Pollution Control Program in 1971; plus operating costs and interest payment which we estimated to be fixed proportions of the annual investment, as well as expenses borne by the public sector for such measures as monitoring systems including operating costs and environmental improvements such as green buffer zones. Their total, which we define as air pollution control costs, amount to ¥14.795 billion per year (1989 value)

1.4.3 Assessment

As a result, we see that ¥14.795 billion (1989 values) is spent yearly on " air pollution control measures" in Yokkaichi. With sufficient pollution control investment of this magnitude, the industrial complex since then has not had problems with regard to pollution. Damage expenses, which resulted from the lack of sufficient pollution control measures at early stages, amounted to ¥1.331 billion (1989 values).

In order to calculate how much money would have been incurred by damage expenses had no proper measures been in place, we have hypothesized a patient certification rate(percentage of certified patients among the total population)for all of Yokkaichi equaling that of the worst-hit Isozu district in 1975, although is reality worst consequence was avoided by corrective pollution control measures. In this hypothetical case, the "projected one-year damage expenses" would amount to ¥21.007 billion (1989 values), an amount greatly in excess of the air pollution control costs. Therefore, we can say that providing sufficient investment to prevent health damage is a logical choice in terms of monetary cost-effectiveness as well.

(Notes:)

1) "One-year damage expenses" were calculated as follows. Damage compensation amounts paid in Yokkaichi area(Yokkaichi City and Kusu City)over the 16 years between the implementation of the Pollution-related Health Damage Compensation Law in FY 1974 and FY 1989, were converted into FY 1989 values, totaled, and divided by 16. To this was added the portion of the reparations awarded by the 1972 court decision (¥88 million) that would be received yearly, when it is converted into FY 1989 values and arranged as payments of principal and interest (7%) made in equal installments over a 30-year period.

2) "One-year air pollution control costs" is the sum of costs to the private sector (¥14.6 billion) and to the local government.

Private sector costs were calculated as follows. Yearly investments for equipment for the 19 years between FY 1971, when the implementation of the Regional Environmental Pollution Control Program prompted pollution control measures to begin in earnest, and FY 1989, were converted into FY 1989 values, totaled, and divided by 19. In addition, operating costs and interest payment, which was estimated to be 80% and 28% of the annual investment respectively, were included (operating costs and interest payment were assumed to be 20% and 7% of cumulative capital stock for any single year which was estimated to be 4 times the annual flow investment considering the fact that pollution control devices are gradually renewed or modified).

Costs to local governments were calculated as follows. Yearly purchase and installment costs of pollution monitoring devices for the 19 years between FY 1971 and FY 1989, were converted into FY 1989 values, totaled, and divided by 19. Additional operating costs which was estimated to be 32% of the annual investment were included (operating costs were assumed to be 8% of cumulative capital stock which was estimated to be 4 times the annual flow investment). To this was added the amount of expenses generated yearly by the establishment of green buffer zones, etc. during the period FY 1971-1973, when expenses are converted into FY 1989 values, totaled, and arranged as payments of principal and interest (7%) made in equal installments over a 30-year period.

3) "Projected one-year damage expenses" for a patient certification rate of 7.27% throughout the Yokkaichi City area were calculated using patient certification rates from FY 1975, the fiscal year that patient certification rates and population figures were identified for all the districts. The calculation assumes a patient certification rate for the entire Yokkaichi city area equal to that of the Isozu district, the district with the highest rate. Compensation amount was determined by multiplying the average compensation amount received per person in FY 1975 in Yokkaichi by 7.27% of the Yokkaichi city population of 279,342 (in FY 1991).

2. Minamata (health damage caused by organic mercury)

2.1 Background

In 1908, a manufacturer of nitrogenous fertilizers, now called Chisso Corporation, located itself in Minamata City. At that time, Minamata was a small scenic town of 12,000, producing wood products and oranges. Numbers of fishermen made their living in the Shiranui Sea between Minamata City and Amakusa Islands.

This, Minamata's first factory, transformed the political and economic character of the town. As the Chisso corporation expanded its Minamata operations, the city developed economically and socially, so that by 1956 the population had grown to 50,000. The Chisso corporation had by that time become one of the largest chemical manufacturers in Japan.

By the 1920s, compensation for fishing damage due to the effluent from the Minamata factory was already an issue.

2.2 Pollution and Pollution-Related Health Damage

2.2.1 Pollution

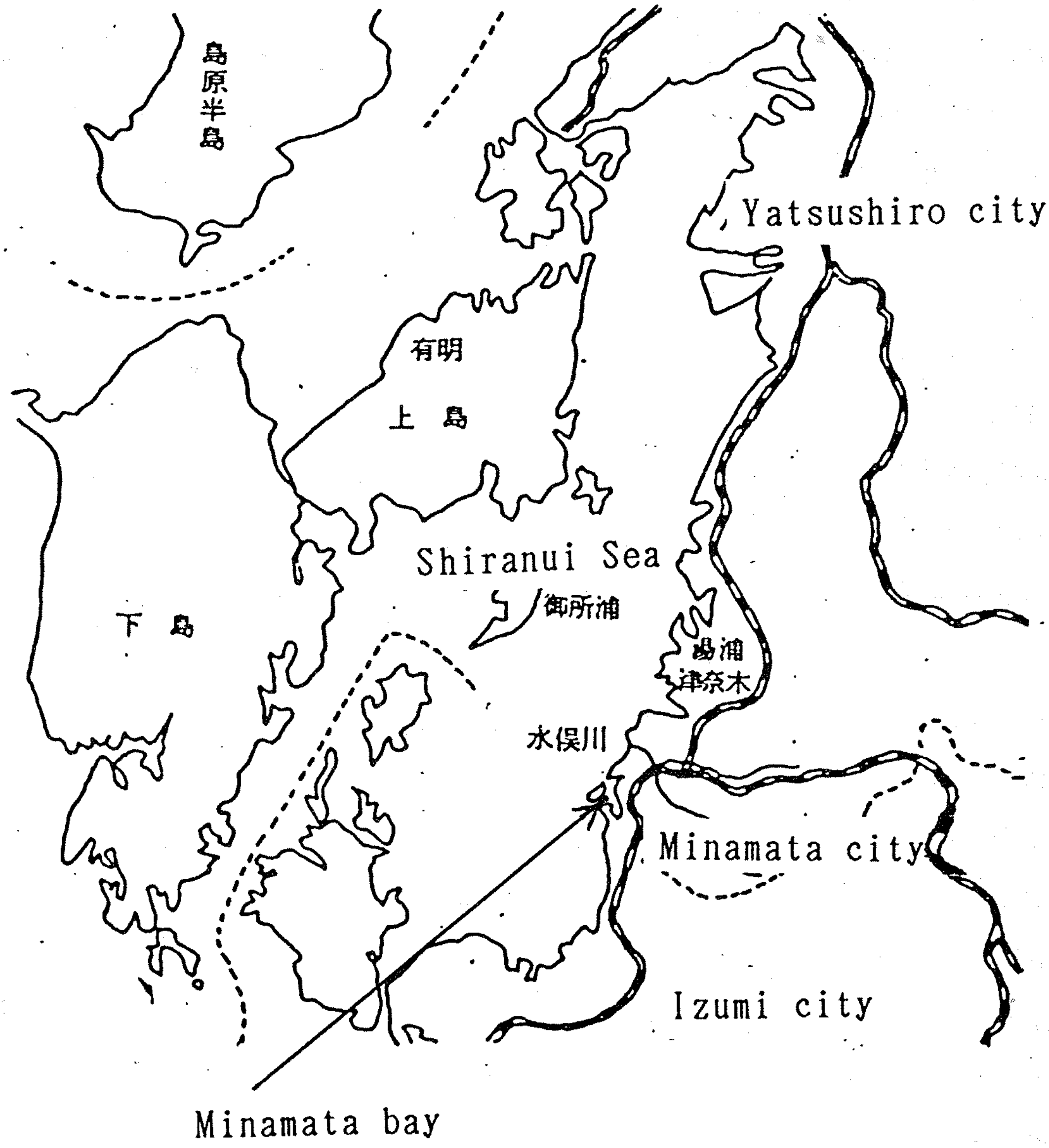
Minamata disease is a neurological affliction caused by the ingestion of seafood with high concentrations of a methyl mercury compound. The Chisso factory discharged this compound, a by-product of the acetaldehyde manufacturing process, into the Minamata Bay Area of Kumamoto Prefecture.

The appearance of Minamata disease has been traced to May 1956 reports of patients with symptoms of a brain-related ailment, but later investigations confirmed that such patients first appeared around 1953.

Immediately after the reports of patients, Minamata City Commission to Control the Strange Disease was established. Kumamoto prefecture requested the Kumamoto University to investigate the disease. In November of that year, the Ministry of Health and Welfare commissioned a study group on the disease. It was, however, extremely difficult to elucidate the cause of the disease.

In 1957, Kumamoto Prefecture set up Kumamoto Prefecture Commission to

Figure 9 Shiranui Sea



Control the Strange Disease and implemented measures to aid the patients and to deal with fishing damage. In 1959, the National Government used reserve fund to finance the investigation of the cause of the Disease and to treat the patients. In 1959, the Food Sanitation Study Commission advised the Minister of Health and Welfare that Minamata Disease is a toxic disease of the central nervous system caused by an organic mercury compound that is transmitted through seafood. However, it was 1962 that Professor Irukayama's group detected methyl mercury from the residue of production process of Chisso's Minamata plant. The government announced its opinion that the cause of Minamata disease was the methylmercury compound in the factory's effluent, conclusively determining the causal mechanism of the Disease, in September 1968, 12 years after the first recorded appearance of Minamata patients.

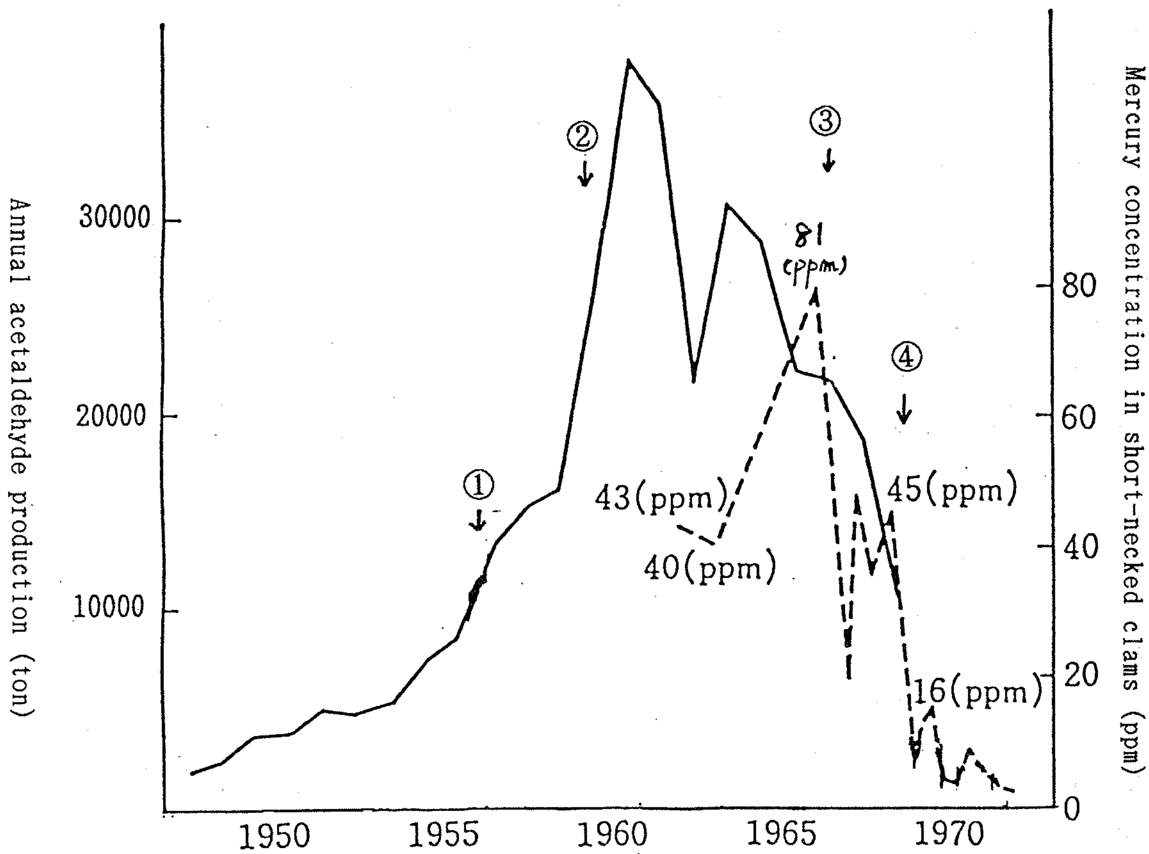
In 1959, while the cause of the disease was still under investigation, the discharge of mercury into the bay reached a peak. By 1966 the factory had implemented a system which in principle stopped the discharge of mercury-containing effluent by completely recycling it within the plant. But factors that might result in the discharge of methyl-mercury was finally eradicated in 1968, when the company ceased the production of acetaldehyde altogether. When acetaldehyde production reached a high of 36,000 tons in 1959 and 45,000 tons in 1960, the factory discharged 11 tons and 5 tons of mercury per year respectively(annual consumption was 150 tons in 1959 and 110 tons in 1960). The mercury seeped into the environment and accumulated in aquatic life. In 1966, the concentration of mercury in clams, for instance, was 80 ppm (total mercury; went down to 4 ppm in 1971).

2.2.2 Damage

2.2.2.1 Damage to Health

Minamata Disease produces sensory and physical coordination damage by afflicting the nervous system. When the Disease occurred in 1950s, there were tragic cases where many seriously afflicted patients died after body convulsion

Figure 10 Acetaldehyde production and mercury concentration in short-necked clam



① Official discovery of Minamata Disease

② Food sanitation study commission report

③ System for complete recycling of waste water completed

④ Acetaldehyde production ceased

1. Acetaldehyde production: (source) Evidence presented to Minamata Disease criminal trial
2. Mercury concentration in short-necked clams (Koiji Island) : (source) Japan public sanitation journal (19(1): 27, 1972), IRUKAYAMA et al.

and where babies were born with damage to the brain and physical coordination. The time it took to determine the cause of the disease and to create a framework for compensation delayed the construction of a system for compensation for health damage.

In 1959, Chisso signed a contract for compensation to the injured parties. Since the cause of the disease had not yet been conclusively determined, the contract did not hold Chisso responsible for the damage, and thus exacted only a small indemnity from the company.

After the government announced its opinion on the cause of Minamata disease in 1968, the Minamata victims resumed moves towards obtaining a larger indemnity, and in June 1969 brought a suit against the company claiming compensation for damages.

In December of the same year, certified patients in the Minamata area were declared eligible for coverage of medical and other expenses under the Law Concerning Special Measures for the Relief of the Pollution-Related Patients.

In March 1973, the Kumamoto district court confirmed a court decision that the Chisso corporation be held responsible for compensation for damages. Furthermore, in July, the Chisso corporation and a group representing the Minamata patients signed a compensation agreement requiring Chisso to pay compensation for damages directly to people legally certified to have Minamata disease. In 1974, patients with Minamata disease became eligible for the Pollution-Related Health Damage Compensation Law, introduced that year with the court decision on the Yokkaichi pollution case.

As of end of March 1991, there are currently 2,248 people who are certified patients of Minamata disease by the above-mentioned framework (of whom 1,004 have died); Chisso up to this period has paid about ¥ 9.08 billion in compensation, and current annual payment is in the order of ¥ 3 billion per year. In addition to certified victims of Minamata disease, there are about 2,000 people claiming to have Minamata disease and suing for compensation. More than 35 years after the discovery of the disease, compensation issue has not been completely resolved.

2.2.2.2 Pollution from the Minamata Bay Floor

In 1968 the company ceased production of acetaldehyde and the discharge of any new mercury into the bay, but mercury had already accumulated in the aquatic life and the floor of the bay.

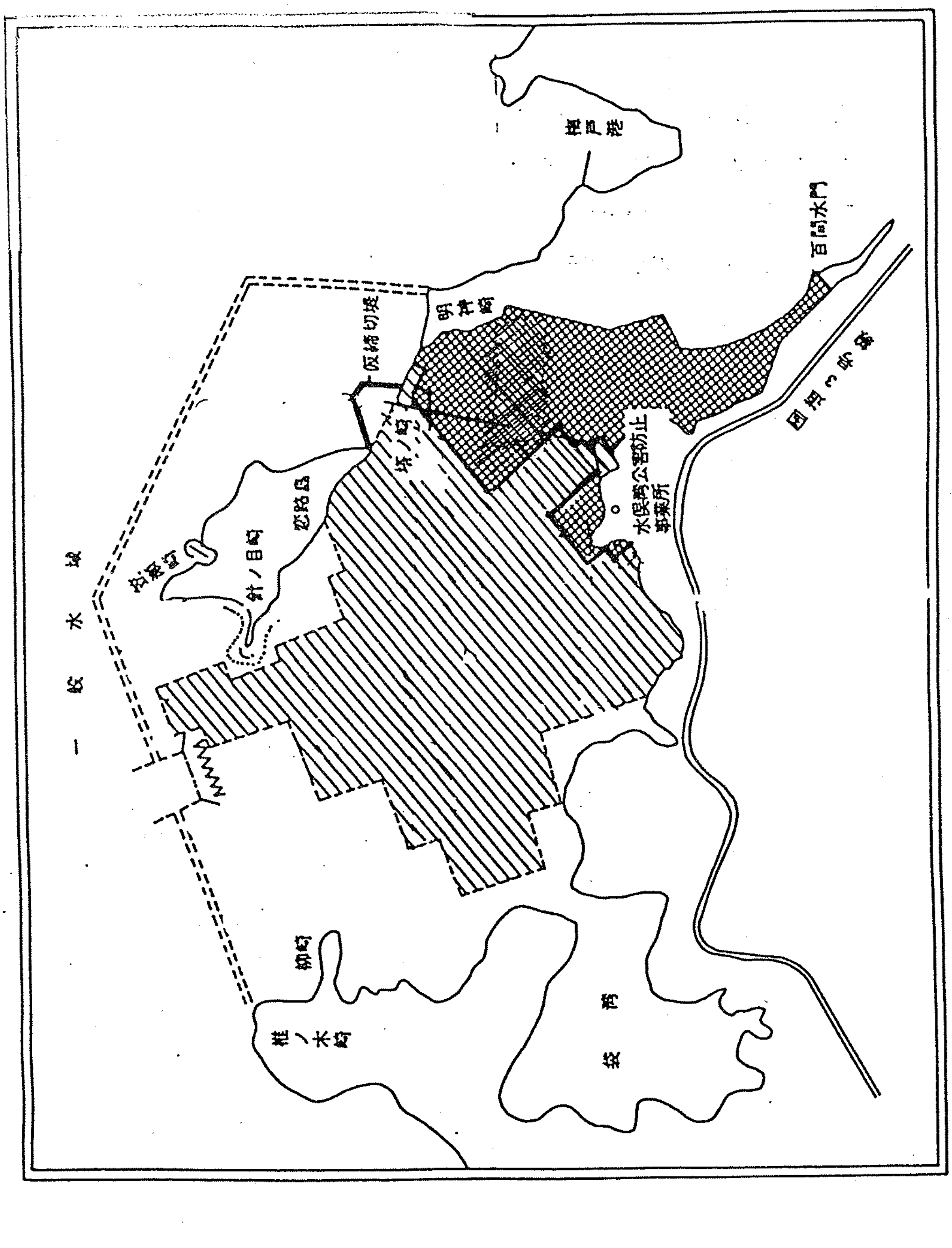
In 1973, the Environment Agency set temporary removed standards for mercury in the bay floor, and in 1974 created a temporary guideline index for the treatment and disposal of mercury-contaminated sediment of the bay floor areas, according to which the removal of polluted sediment, which was thought to be contaminating the fish, was implemented. Following a study by Kumamoto Prefecture at Minamata Bay, ¥48.5 billion were spent from fiscal 1974 to fiscal 1989 in order to treat 1.5 million cubic meters of bay floor with a mercury concentration exceeding 25 ppm, by dredging and reclaiming 1.5 million cubic meters, and developing of 58 ha of reclaimed land. (The Cost was born by the national government, Kumamoto Prefecture and Chisso corporation). After the completion of the dredging, the average concentration of total mercury in the bottom sediment is 4.65 ppm.

2.2.2.3 Damage to the Fishing Industry

Fish caught in Minamata Bay used to be plenty to support those living on its shores. A marked decrease in the quantity of fish caught was the first indication, however, of the destructive effect on the fishing industry of the Chisso factory effluent. During the Taisho Period (1912-1926) Chisso was already paying indemnities to the fishing industry. In 1959, after the appearance of Minamata disease, the company paid ¥140 million in compensation, and ¥3.93 billion from 1973-1974; but the company also ruined many lives by destroying abundant marine resources and robbing fishermen of their livelihoods.

Even now, a portion of the fish in the bay contains mercury exceeding the Temporary Regulatory Standard for Mercury set by the Ministry of Health and Welfare, and Kumamoto Prefecture is conducting a study.

Figure 11 Outline of sludge disposal work



Dredged land

Reclaimed land

Net

Sonar

2.3 Pollution Control

In the 1950s, Chisso began instituting pollution controls by collecting mercury in sedimentation tanks and installing other equipment to treat waste water. In 1966 the factory adopted a method for completely recycling waste water within the plant. There are no accurate records of how much was paid, but including the periphery equipment the improvements are estimated to have cost about Y400 million at the time. Furthermore, in 1968, the factory stopped producing acetaldehyde.

2.4 Pollution Related Damage vs Pollution Control Costs

The lengthy investigation into the cause of Minamata disease delayed the timely prevention of the spread of damage. What follows is a comparison between the extent of damage in which pollution control was not effected, and pollution control costs.

2.4.1 Extent of Damage without Pollution Controls

A financial assessment of the damage caused by Minamata disease consists of three parts: health related damage, damage from the polluted bay bottom, and damage to the fishing industry. What follows is a calculation of the average yearly payments for damage by Minamata disease if the spillage of mercury had continued without any pollution control.

If we define health compensation (1) as the sum of the average yearly indemnity after FY 1974, a year after the 1973 compensation agreement between Chisso and the patients' association, the ¥1.184 billion Chisso was forced to pay after the 1973 trial, arranged as payments of principle and interest (7%) in equal yearly installments over a thirty year period; and FY 1973 payment of ¥11.15 billion which was paid to the existing patients as a lump-sum compensation equivalent to the amount set by the compensation agreement, then total health damage costs come to ¥7.671 billion yearly (at 1989 values).

Then, if we define bay pollution damage (2) as the average yearly cost of the sludge dredging projects, then total bay pollution costs reach ¥4.271 billion per year (at 1989 values).

Finally, if we define fishing industry compensation (3) as the indemnity to the fishing industry arranged as payments of principle and interest (7%) in equal yearly installments over a thirty year period, the total damage to the fishing industry costs ¥690 million yearly (at 1989 values).

The total yearly cost of damages (4) would thus be ¥12.632 billion (1989 value).

2.4.2 Pollution Control Costs

Pollution control costs were calculated by totalling the yearly average corporate investment in pollution control equipment, which was interpreted as average depreciation costs since 1955, plus additional operating costs and interest payment which was assumed to be fixed proportions of the annual investment. Their total amounted to ¥125 million (FY 1989 value).

2.4.3 Assessment

The comparison of yearly payments for pollution damage of ¥12.632 billion (1989 value) and that for pollution control of ¥125 million (1989 value) makes it very clear that pollution control undertaken at the early stages would have been good policy in terms of monetary cost-effectiveness.

Regardless of why it took so long to elucidate the causes of Minamata disease, there is no way to reclaim the lives, health, and environment lost during that time.

the March 1973 court decision (¥1.184 billion) that would be received yearly, and FY 1973 payment of ¥11.15 billion which was paid to existing patients as a lump-sum compensation equivalent to the amount set by the compensation agreement, when these amounts are converted into FY 1988 values and arranged as payments of principal and interest (7%) made in equal installments over a 30-year period.

2) "Bay pollution damage" was calculated as follows. Yearly expenses for the sludge processing project during the 16 years between FY 1974 and FY 1989 were converted into FY 1989 values, totaled, and arranged as payments of principal and interest (7%) made in equal installments over a 30-year period.

3) "Fishing industry compensation" was calculated as follows. The three lump-sum compensation amounts paid in 1959, 1973, and 1974, were converted into 1989 values, totaled, and arranged as yearly payments of principal and interest (7%) made in equal installments over a 30-year period.

4) "Water pollution control costs for one year" was calculated as follows. The amount that the Chisso Corporation invested in order to perfect a completely closed in-plant recycling system from 1955 to 1966 (including peripheral equipment, using figures currently available) was converted into FY 1989 values, totaled, and divided by 12. In addition, operating costs and interest payment, which was estimated to be 80% and 28% of the annual investment respectively, were included (operating costs and interest payment were assumed to be 20% and 7% of cumulative capital stock for any single year which was estimated to be 4 times the annual flow investment considering the fact that pollution control devices are gradually renewed or modified). We did not include the pollution control investment prior to 1954 because we were not able to obtain pre-1954 deflators and because the investment in this period was small.

3. Jinzu River Basin (soil pollution through cadmium)

3.1 Background

Records of gold production in the vicinity of the Kamioka mine, located on the upper stream of the Jinzu river, date back to 720, but it was first made into a working mine in 1589. In 1887 operations were modernized, making Kamioka Mining Station a leader in the smelting of lead and zinc and the production of sulfuric acid. Zinc and lead production steadily expanded, especially under the system of increased production instituted by the wartime management by the military.

3.2 Pollution and Pollution-Related Health Damage

3.2.1 Pollution

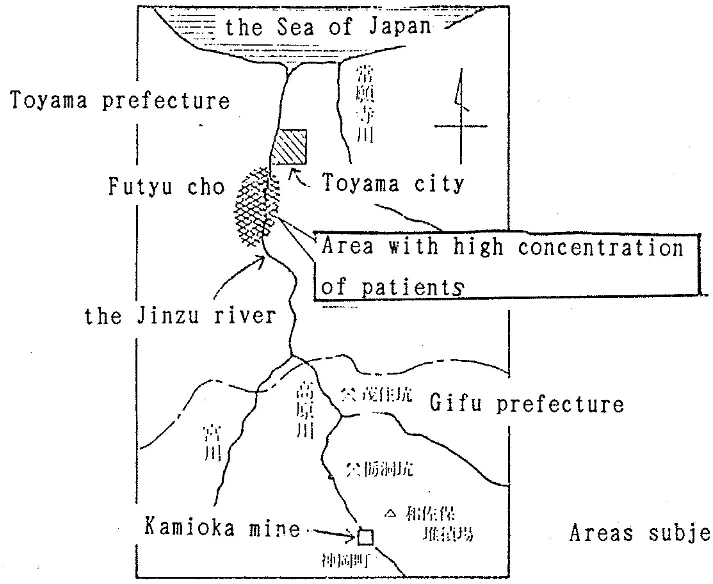
The Kamioka mine once ranked among the world's best. Over an extended period of time, however, the Kamioka Mining Station had been discharging large amounts of waste water into the Takahara river in the upper streams of the Jinzu. This effluent and seepage from accumulated slag contained cadmium and other heavy metals, which polluted the paddy field soil, river sediment and river water. Damage to the agriculture in the Jinzu river basin dates back to the Taisho period (1912-1926), when a strange disease, which was recognized as a kind of endemic disease, was observed in the area.

Farmer in the Jinzu river basin protested and demanded the installation of wastewater treatment facility and compensation for crop damage, and in 1932 the company built sedimentation facilities. This equipment seemed to alleviate agricultural damage, but higher wartime production increased slag and effluent, and agricultural damage persisted.

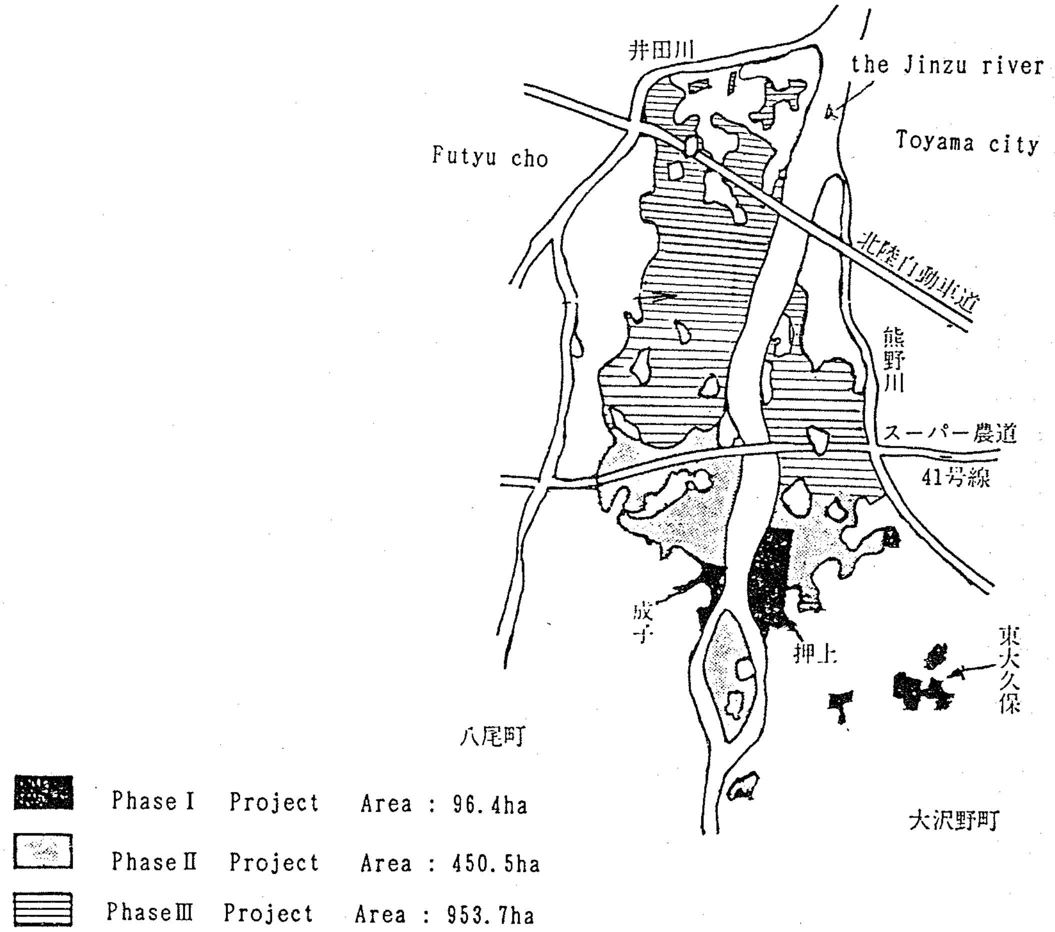
A 1971-1976 study of areas designated for pollution control under the Agricultural Land Soil Pollution Prevention Law showed that the concentration of cadmium in untreated soil reached 4.85 ppm, with an average of 1.12 ppm (compared to a concentration of cadmium in unpolluted areas); the highest concentration in unpolished rice was recorded at 4.23 ppm, with an average of 0.99 ppm.

Figure 12 Areas affected by Itai-itai disease and areas subject to soil restoration project

Itai-itai disease and Kamioka mine



Areas subject to soil restoration project (1500.6ha)



3.3.2 Damage

3.3.2.1 Pollution-Related Health Damage

A strange disease primarily affecting women appeared in the Jinzu river basin area. This disease was characterized by extreme pain in the entire body, and those severely afflicted incurred broken bones just by moving their limbs. The disease was named "itai-itai," or "it hurts it hurts," after the victims' screams of unbearable pain.

Itai-itai disease was first studied in earnest in the 1950s, and in 1959 the cause of the disease was first announced as chronic cadmium poisoning. Then, Toyama Prefecture initiated measures for pollution control and began a careful investigation into the causes of the disease in 1961; the Ministry of Health and Welfare and the Ministry of Education began research into the causes of the disease in 1963.

The Ministry of Health and Welfare summed up the results of these investigations in 1968, expressing its official view that "Itai- itai disease is characterized by kidney damage and loss of strength of the bones caused by chronic cadmium poisoning, and co-factors including reduced levels of calcium due to past pregnancies, nursing, changes in endocrine secretions, aging and diet.""And further, the only possible source of the cadmium was the effluent of the Mitsui Mining and Smelting Co located on the upper streams of the Jinzu river.

Victims of Itai-itai disease began receiving prefectural medical relief in January 1968, and national government subsidies in April of this year, and in February 1970 were supplied with medical and other expenses under the Law Concerning Special Measures for the Relief of Pollution-related Patients.

In 1972 the Nagoya High Court concluded that cadmium, whose major source was the effluent from the Kamioka Mine, was the principle cause of Itai-itai disease, and placed the company at fault. The Kamioka mine was to pay compensation for damages to the plaintiff, the Association for Measures for Itai itai Disease, and at the same time signed a pollution control agreement. Further, the company signed an agreement the following year (1973) pertaining to the treatment of the patients, and later paid compensation according to that agreement. In 1974, Itai-itai patients became eligible for the Pollution Related Health Damage Compensation Law, introduced that year with the court decision on the Yokkaichi pollution case. As of end of March 1991 there are 129 certified patients of Itai-itai disease (of whom 116 have died).

3.2.2.2 Agricultural Damage

a) Compensation for Crop Loss

Since 1890, the Mitsui Mining and Smelting Company had been paying indemnities for agricultural damage. After the 1972 court decision, the company was required to bear responsibility for past and future agricultural damage to the region afflicted by Itai-itai disease, and since has been paying yearly reparations for damages to the farmers for contaminated rice and depletion of cultivatable soil.

b) Measures for the Restoration of Farm Lands

In 1971, after the enactment of the Agricultural Land Soil Pollution Prevention Law in December of the previous year, Toyama Prefecture began investigations into soil restoration. From 1974 to 1977 the prefecture designated four target areas comprising 1,500 ha of rice-producing agricultural land in the Jinzu river basin with cadmium concentrations over 1 ppm, and settled on a plan for soil restoration. In 1979 the prefecture began work on the soil. (National government, Toyama prefecture and Mitsui Mining and Smelting Company bears the expense for this undertaking.)

It is expected that by 1992 restoration work for 36% of the planned area, or 547 ha, will be completed.

Soil restoration reduces the concentration of cadmium in the soil to 0.14 ppm, and in unpolished rice to 0.11 (as measured in the restored section of the phase 2 district)

3.3 Measures to Prevent Pollution

In response to arguments made by injured parties--the agriculture group and the fisheries group--the company now discharges effluent in which cadmium concentration is far below the national and prefectural standards for effluent and smoke (for example the effluent standard for cadmium is 0.01 ppm). It treats the effluent and smoke from the mine pits and factory, and covers contaminated soil with sand and new soil to be planted as stipulated under the Special Law for Mining, Pollution Control in Metal Mining Industries, etc. of 1973. The water quality in Jinzu river also meets the ambient water quality standard for cadmium with a large margin to spare (the ambient standard is 0.01 ppm, and the concentration in the river water is 0.005 ppm).

3.4 Pollution Related Damage vs Pollution Control Costs

Although current pollution control for effluent and smoke now allows satisfactory operation of the plant, and no new agricultural or health damage will be wrought on the Jinzu River basin, the area remains affected--there are still victims of Itai-itai disease, as well as agricultural damage, and soil restoration projects are currently under way. The following is a comparison of pollution control costs with the damage that would have been incurred without pollution control.

3.4.1 Extent of Damage without Pollution Controls

We can financially assess the damage to the Jinzu River basin by calculating the average yearly cost of health damage and agricultural damage assuming that environmental controls were not instituted and cadmium-containing effluent continued to be released into the environment.

If we define health damage costs as the average yearly indemnities required by the agreement for compensation between Mitsui Mining and Smelting and the patients' association in FY 1973, added to the compensation decided on in the 1972 court ruling (arranged as payments of principle and interest (7%) in equal yearly installments over a thirty year period), the total compensation reaches a yearly ¥743 million (FY 1989 values).

We add the compensation for agricultural damage, which includes compensation for crop loss (¥882 million annually, at FY 1989 values) and soil restoration costs (two projects planned for a 15 year period, costing ¥893 million yearly, at FY 1989 values) to the cost for health damage--this comes to a total of ¥1.775 billion at FY 1989 values.

The cost for the Stage 3 soil restoration project should doubtless also be included, but has not because the plans are still pending. Thus we use only the yearly costs of the first two projects in this calculation.

The total cost of damages is ¥2.518 billion annually (FY 1989 values).

3.4.2 Pollution Control Costs

After pollution control investment reached a significant level as a result of the Special Law for Mining, Pollution in Metal Mining Industries, etc., which went into effect in FY 1973, pollution control costs were ¥603 million per year in FY 1989 values.

3.4.3 Assessment

The cost of damages (¥2.518 billion, FY 1989 value) clearly exceeds pollution control costs (¥603 million). We can therefore conclude that it is rational in terms of monetary cost-effectiveness to implement pollution control in the early stages to prevent damages incurred by pollution.

totaled, and divided by 17 (compensation payments). To this was added the portion of the reparations made by Mitsui Mining and Smelting Co. after the 1972 court decision (¥2.358 billion) that would be received when the amount is converted into FY 1989 values and arranged as yearly payments of principal and interest (7%) made in equal installments over a 30-year period.

2) "Compensation for crop loss" was calculated as follows. Yearly amounts paid over the 17 years between FY 1973 and FY 1989, were converted into FY 1989 values, totaled, and divided by 17.

3) "Costs for soil restoration" were calculated as follows. Actual expenditures for the stage one district were converted into FY 1989 values and added to the projected expenditures for the stage two district, and divided by 15 (duration of stage 1 - stage 2 projects). The soil restoration project was planned for execution in three consecutive stages. Currently the project is in stage two. The land area covered by the project is 96.4 ha for the stage one district, 450.5 ha for the stage two district, and 953.7 ha for the stage three district, so there is still a large area left to treat.

4) "Pollution control costs" are calculated as follows. The mining pollution control investments including running costs made yearly by the Kamioka Mining Co. (previously the Mitsui Mining and Smelting Co., Kamioka Mining Station) over the 16-year period between the FY 1973 implementation of the Special Law for Mining, Pollution Control in Metal Mining, etc., and FY 1988, were converted into FY 1989 values, totaled, and divided by 16. In addition, interest payment, which was estimated to be 28% of the annual investment, was included (interest payment was assumed to be 7% of cumulative capital stock for any single year which was estimated to be 4 times the annual flow investment).

Chapter 3 The Implementation of Pollution Control Measures from the Initial Stage of Development

In each of the case studies presented--Yokkaichi, Minamata, and the Jinzu River--we have compared expenses incurred by pollution-related damage (for Yokkaichi these were the estimated worst-case scenario expenses) with pollution control costs, and in each case it has been clear that it is much more advantageous to pursue pollution control measures from an early stage than to apply them after damage has already occurred.

Let us now take a look at the kinds of measures which should be implemented.

1. Pollution Control at the Source

Stopping pollution damage before it occurs is the key to environmentally sensitive development. In order to achieve this, it is important to exert strict control over the release of pollutants from the source.

The technologies Japan has developed to facilitate pollution control at the source vary with circumstances at the source and the required reductions or costs. They range from combustion management, use of non-polluting fuel, improvements in the manufacturing process, etc.--all measures aimed at reducing the amount of pollutants produced--to dust collectors, techniques for extracting pollutants from gas emissions such as flue gas desulfurization and flue gas denitration, and techniques for gas dispersion such as the institution of higher chimneys.

1.1 Optimizing Combustion Efficiency

Of the measures listed above, the first to implement is the optimization of combustion efficiency. This technique, whereby the concentration of residual oxygen is measured and the fuel-air ratio is optimized, is relatively inexpensive and quite effective. By improving combustion efficiency, the amount of fuel and thus the amount of pollutants released can be reduced significantly, controlling the amount of nitrogen oxide and soot produced.

This operation, however, requires staff with a basic knowledge of combustion technology; thus it becomes of primary importance to train competent technicians who can manage the technologies involved.

1.2 Use of Non-Polluting Fuel and Improvement of the Combustion and Manufacturing Process

The next measures to be discussed are use of non-polluting fuel and improvements of the combustion and manufacturing process. These measures can be quite expensive if high quality materials or methods are involved, but the methods employed can be chosen according to budget restrictions. As for improvements in the combustion and manufacturing process, the introduction of advanced technology is often accompanied by a reduction in manufacturing costs. Employment of such measures is one large reason that despite the extensive measures Japan has taken to control pollution, as we have seen in the previous sections, this has not proved an obstacle economically, but if anything has been linked to economic development.

1.3 Technologies for Contamination Removal

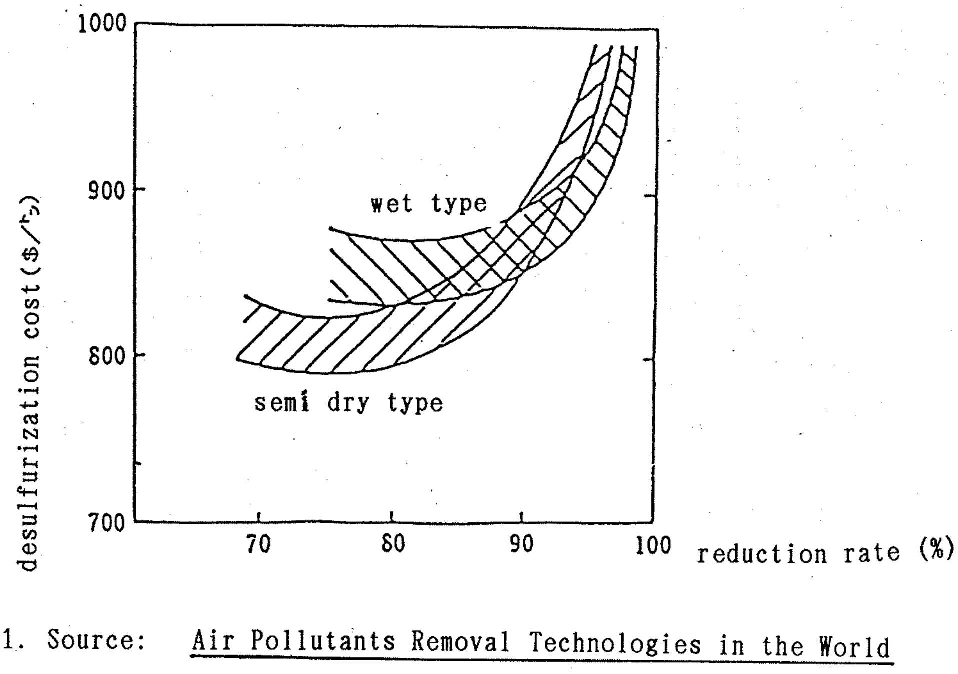
These measures require quite a long period of time to implement, as can be judged from the need to train staff. Furthermore, it may be necessary to reduce the amount of emissions even more, depending on the circumstances.

Situations of rapid large-scale industrial development, for example, require the introduction of suitable methods of pollutant extraction. Highly specialized technicians are needed for the introduction of pollutant removal technologies as well, but there have already been a number of different technologies developed.

1.3.1 Sulfur Oxide

Taking sulfur oxide as an example, there are already technologies which can be employed effectively for wet process flue gas desulfurization. Although this process is quite expensive, it may by possible, depending on the circumstances, to cut costs by employing the technique on perhaps half of the gas emitted. Industries must be inventive in their application of these pollution control measures. And finally, some consideration ought to be given to the employment of a simple desulfurizing apparatus of the type shown in the figure below (although there are not many instances of its use in Japan.)

Figure 13 Cost comparison of desulfurization technologies in the US (estimate)



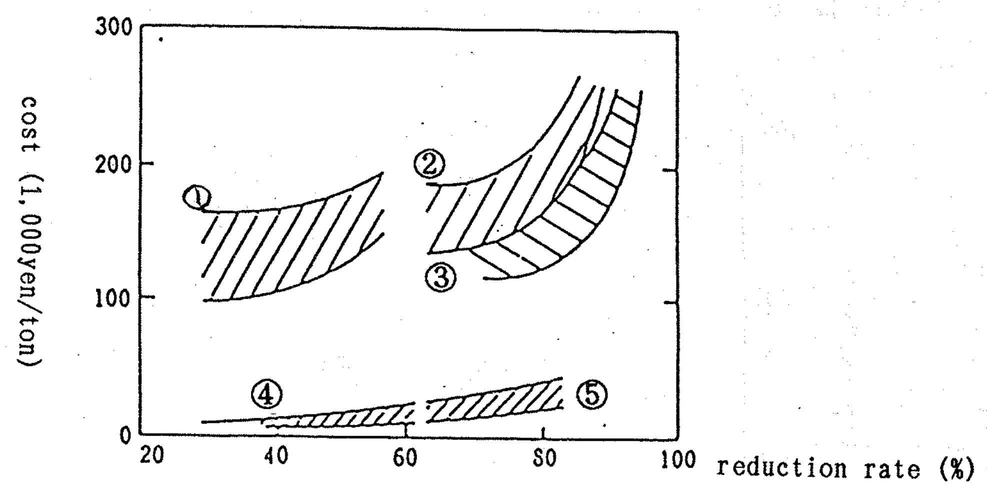
1. Source: Air Pollutants Removal Technologies in the World
   Jyunpei Ando
2. SOx concentration at the entrance is 1,000ppm.

1.3.2 Nitrogen Oxide

The level of nitrogen oxide released can be significantly reduced at relatively low cost through optimization of combustion efficiency. However, large scale industrial development may require the implementation of flue gas denitrification techniques.

The equipment available for flue gas denitrification is limited, but there are other cheaper methods such as the induction of ammonia into the furnance (non-catalytic denitrification) or in-furnace denitrification although these involve some sacrifice of removal efficiency.

Figure 14 Cost comparison of NOx removal technologies



① non-catalytic denitrification
② catalytic denitrification
③ combustion progress + catalytic denitrification
④ combustion progress
⑤ combustion progress + in furnace denitrification

Source: <u>Air Pollutants Removal Technologies in the World</u>
Jyunpei Ando

1.3.3 Soot

As can be seen from the following table, there are many techniques of various costs and cleaning efficiencies for handling soot, and it is important to choose the proper one.

Table 1 Cost comparison of soot and dust removal technologies

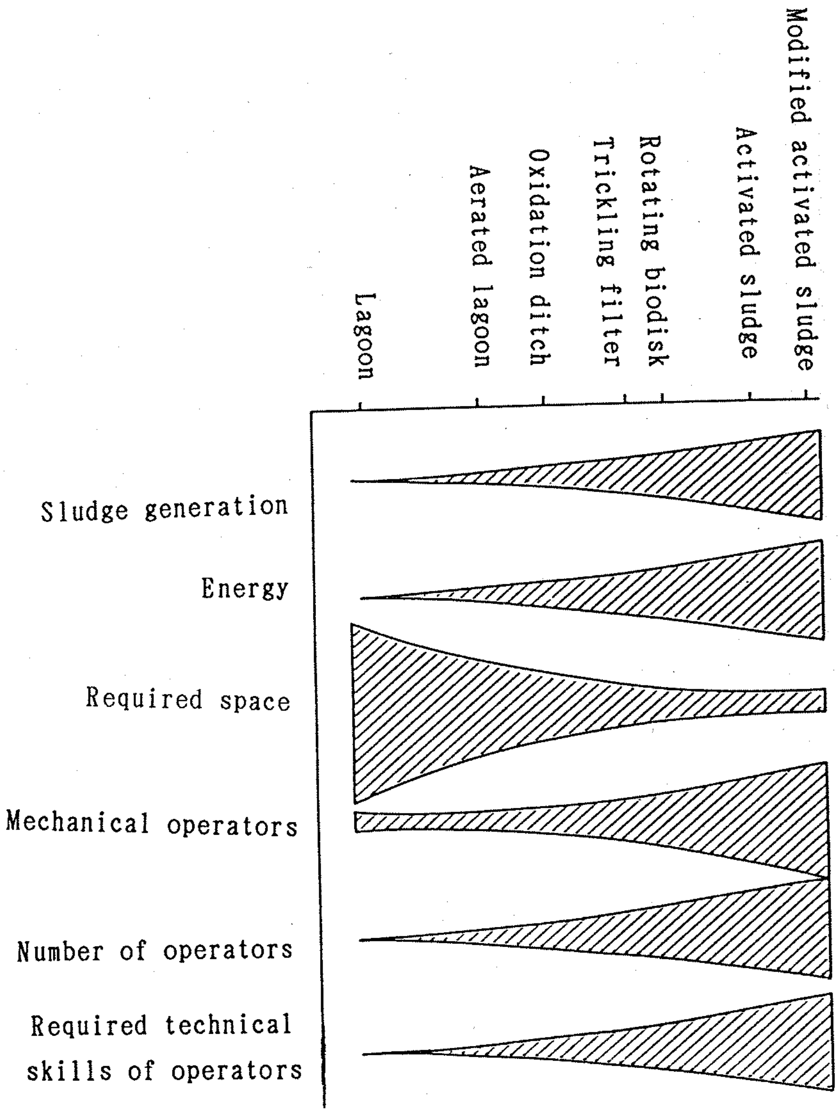
Type of dust collector	Cost		Reduction rate(%)
	Initial cost(1000000yen)	Running cost(yen/h)	
Electric precipitator	130 493	3,800 38,000	80～99.5
Filter dust collector (e.g. Bag filter)	73.6 330	5,800 58,000	92～99.5
Scrubber	213 1574.1	4,100 41,000	80～99.5
Centrifugal precipitator (e.g. multi-cyclone)	61.5 269.1	4,800 48,100	50～96

＊1) Initial cost do not involve cost of land.
＊2) The figures in upper row; the volume of flue gas $10^5 Nm^3/h$,
in lower row; $10^6 Nm^3/h$.
＊3) The efficiency in dust collecting depends on type of dust collector and the character of dust as diameter of dust.
(Electric precipitator and Filter dust collector can collect so far as small size dust but Centrifugal precipitator cannot collect small size dust whose diameter is smaller than 3μ.)

1.3.4 Sewage

The situation is the same for sewage processing technology as for soot: various processing methods exist for treating even specific effluents. The figure below shows comparisons of the characteristics of various processing methods for domestic waste water.

Figure 15 Comparison of key elements classified by effluent treatment technologies



Notes;

1. Source:"Guidebook of Household Wastewater Treatment: Study Group for Environmental Protection Technologies"

2. This figure compares characteristics of representative sewage processing techniques for household waste water.

3. Pollutant reduction rates may vary, even within one technique, depending on the characteristics of the effluent. They may also vary according to the scale of the installation, making it difficult to conduct a simple comparison between them. arranging them as best as possible, in order of what tends to be the lowest to highest processing efficiency, we have: lagoon, aerated lagoon, activated sludge, modified activated sludge.

4. Sewage processing techniques which produce less sludge are generally more advantageous, since the processing and disposal of this sludge costs money. Similarly, equipment running costs are linked with the amount of energy used, so it may be better to employ a technique which uses less energy. It is especially unwise to use a process which requires a lot of electricity in situations where the electrical power supply is unstable.

Some additional considerations are the availability of land, equipment installation costs, and the level of technical ability required of the operating staff. It is important to take all these factors into consideration and choose the method of processing most suited to the circumstances of the area.

As can be seen from the above, during its struggle with environmental pollution Japan has developed pollution control measures that can respond to various technical and cost needs. This allows the selection of equipment appropriate to the particular circumstances of the source and the region, and enables implementation of environmental protection measures from the very first stages of operations. We urge that these measures and equipment be employed from the initial stage of industrial operations, so as to promote an environmentally sensitive type of development.

2. The Role of the Administrative Sector in Pollution Control

The role that the environmental administration bureau must play in preventing pollution before damage occurs and promoting healthy economic development is a big one that includes such tasks as providing guidance concerning proper preventive measures to polluting companies. The Environment Agency is currently cooperating with an international joint project team to formulate pollution control proposals throughout the world. The role of the administrative sector is specifically outlined in these proposals, and we offer it here as a reference.

In general, the major responsibilities of the environmental administration bureau are as follows.
-Monitoring of the environment (constant or periodic monitoring at important sites, mobile monitoring as necessary, gathering specimens for analysis upon return)
-Monitoring of the source of pollution (on-the-spot inspections and site measurements, gathering samples for analysis upon return)
-Research on the relationship between the source and environmental pollution (conducting simulation tests, etc.)
-Combatting environmental pollution and setting goals for the maintenance of a healthy environment
-Formulation of regulatory programs (formulation of alternative proposals for measures and conducting feasibility studies)
-Providing guidance to the pollution source (legislation of laws, educational activities, technological guidance)

-Providing guidance concerning the construction of new facilities (inspection, technological guidance)

The following is a table showing the personnel and cost outlay currently required by the environmental administration sector for the implementation of these tasks in various Japanese cities. It is worth noting that these expenses are quite small compared to the cost of pollution control investment made by businesses. Most important is the training of staff, the procurement of necessary equipment, and the proper conduct of everyday administrative tasks.

Figure 2 Pollution control expenditure compared by city size

City	Population	Annual fuel consumption (kl)	Personnel in local environmental bureaus (of whom engineers)	Pollution control budget (labor cost excluded, million yen)	Annual pollution control investment in the private sector(million yen)
Hachinohe	242,607 (1991.3)	1,478,200 (FY 1989)	16 (9) (1991.3)	32 (FY 1991)	7,352
Yokkaichi	277,991 (1991.3)	3,722,869 (Factory use only)	23 (9) (1991.3)	71 (FY 1991)	8,260
Kitakyushu	1,025,654 (1991.3)	6,515,380 (1989)	51 (44) (1991.5)	329 (1990)	6,271
Yokohama	3,220,350 (1990.10)	10,700,000 (FY 1989)	170 (122) (1991.5)	2,228 (FY 1991)	32,936

Notes:

1. 4 cities were selected from Reginal Pollution Control areas according to city size.

2. Pollution control investment in the private sector is a five-year average of actual expenditure for FY 1985-1989 converted to 1988 value, and includes running costs.
For Kitakyushu, annual average for 1982-1986 was used.