JAPAN'S ANTI-POLLUTION MEASURES AND THEIR RESULTS

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INTRODUCTION

THE HIGH growth of the Japanese economy has increased the material wealth of Japanese phenomenally since the end of World War II. However, the rapid economic expansion has also resulted in greater pollution of the environment, such as air pollution, water contamination, and noise pollution, which are representative cases of external diseconomy due to economic development. Few people anticipated that pollution problems would especially become increasingly serious in Japan since 1965. Japan, with a highly dense and concentrated economic society, unmatched in the world, had become the world's most polluted country. This is because the nation underwent rapid expansion of its economic scale without taking adequate measures to prevent pollution.

However, an epochal shift in anti-pollution measures has taken place in the 1970s. In the past several years, Japan has streamlined a comprehensive anti-pollution policy which would have taken scores of years to complete under ordinary social conditions. The anti-pollution policy is aimed at preventing environmental pollution, which is progressing at an accelerative pace, and also providing proper relief to health-hazard victims distressed by environmental disruption. Recently, the streamlining of environmental pollution control measures have led to remarkable improvement in selected cases of pollution, such as air pollution due to sulfur oxides and water contamination by toxic substances.

This paper discusses the progress made so far in Japan's anti-pollution efforts, centering on measures against air pollution, water contamination, and other cases of environmental disruption and relief measures for victims of such pollution. It will then present the achievements of the anti-pollution measures in Japan.

I. PROGRESS IN ANTI-POLLUTION MEASURES

Let us first review the progress made so far in the area of streamlining anti-pollution measures.

It was not until 1955 that environmental pollution became a nationwide and social problem. As problems caused by pollution grew serious, anti-pollution measures increased in number and qualitatively became more and more adequate. The process of development in anti-pollution measures can be divided into three periods.

The first period covers the years from 1955 to 1965 when regional development programs were put into effect in many parts of the country, centering around the Pacific coast of Honshū (the main island). Such industrialization gave rise to various pollution and environmental disruption problems, leading to enactment of laws and regulations for controlling cases of disruption on a case-by-case basis, such as industrial effluents, the pumping up of underground water, and smoke and soot.

The second period runs from 1965 to 1970 when environmental pollution began showing signs of spreading on a nationwide scale. The decaying situation prompted the government to enact the Basic Law for Environmental Pollution Control in 1967. The law was aimed at establishing common principles and objectives for all government ministries and agencies concerned in regard to pollution control and propelling the cleaning of the environment on a comprehensive basis. Until then, the government had lacked a thorough anti-pollution setup with each ministry and agency minding things in each of their own jurisdictions. The basic law cites six areas of pollution as its targets (air pollution, water contamination, noise, vibration, ground subsidence, and offensive odor) and defines responsibilities of businesses, the central and local governments to control such pollution. The law also laid the ground for the establishment of environmental quality standards, drafting of environmental pollution control programs and introduction of relief measures for health-hazard victims as well as enforcement of a number of other specific anti-pollution measures.

The third period is from 1970 till the present. The pollution control policy made epoch-making progress in 1970. At the end of that year, the government amended and streamlined the Basic Law for Environmental Pollution Control and thirteen other anti-pollution laws, thus fundamentally consolidating a statutory framework relating to control of environmental pollution. The consolidation featured tightening in environmental quality standards and regulations. The new set of pertinent laws includes soil contamination and bottom deposits in waters encompassing the scope of environmental pollution in order to cope with newly arising cases of pollution caused by the depositing of sludge and other pollutants.

In 1971, the government established the Environment Agency as its highest unit in the area of environmental protection. The agency is in charge of adjusting responsibilities and jurisdictions concerning environmental protection which were divided among various government ministries and agencies before its creation.

Thus, the streamlining of a fundamental pollution-control setup is about to be completed in Japan against the backdrop of the growing call of its people for restoration of a pollution-free, comfortable-to-live-in environment.

The swift progress in the pollution-control measures may be easily recognized from the phenomenal expansion in the bureaucracy, budget, and private investments in this field.

The scale of the anti-pollution administration setup and its personnel has sharply expanded since the enactment of the Basic Law for Environmental Pollution Control—especially since the law's revision in 1970. For instance, the government set up the Environment Agency for overall execution of its environmental protection administration. Local governments also created special departments or sections which would exclusively engage in monitoring, measurement

TABLE I

NUMBER OF OFFICIALS ENGAGED IN POLLUTION CONTROL

(In persons)

Fiscal Year	Government[a]	Prefectural Governments[b]	Municipalities[c]
1971	501	2,634	3,411
1972	521	4,568	4,519
1973	582	5,284	5,617
1974	670	5,852	6,465
1975	736	6,614	6,892

[a] Government stands for Environment Agency.
[b] Officials engaged in pollution control for prefectural governments.
[c] Officials exclusively engaged in pollution control for municipalities.

TABLE II

ANTI-POLLUTION SPENDINGS BY CENTRAL AND LOCAL GOVERNMENTS

(In billion yen)

Fiscal Year	Environmental Protection Budget by Central Government	Ratio to Total[a] (%)	Loan & Investment Program	Ratio to Total[b] (%)	Spendings by Local Governments	Ratio to Total[c] (%)
1970	82.9	1.2	30.3	0.8	373.5	3.8
1971	111.9	1.4	56.2	1.3	586.6	4.9
1972	169.3	1.4	107.3	1.9	811.3	5.5
1973	273.7	1.8	155.4	2.2	953.7	5.5
1974	342.1	2.0	223.9	2.8	1,196.9	5.2
1975	375.1	1.8	310.6	3.3	1,425.8	6.0
1976	484.5	2.0	385.2	3.6	—	—

[a] Ratio to the general account budget of the central government.
[b] Ratio to total loan and investment program.
[c] Ratio to total expenditures of the local government.

of environmental pollution, and enforcement of anti-pollution regulations. As a result, in 1975 the total number of civil service employees engaged exclusively in pollution control was 6,614 in prefectural governments and 6,892 in municipalities. They rose about 2.5-fold and 2.0-fold, respectively, from the numbers five years earlier (Table I).

The government's spending on environmental preservation has also increased substantially along with the expansion and streamlining in the pollution-control organization.

As Table II shows, the national budget for environmental protection increased by sixfold in the past six years—from ¥82.9 billion in 1970 to ¥484.5 billion in 1976. The ratio of the environmental preservation spending in the general account budget of the central government also rose from 1.2 per cent in fiscal 1970 to 2.0 per cent in 1976.

Meanwhile, the government's loan and investment budget which earmarked for pollution control likewise jumped twelvefold from ¥30.3 billion in fiscal 1970 to ¥385.2 billion in fiscal 1976, thereby increasing the ratio of such spendings to the total loan and investment program from 0.8 per cent to 3.6 per cent during the same period. Additionally, money spent in the area of pollution control by local governments increased ¥373.5 billion in 1970 to ¥1,425.8 billion in 1975. The 1975 anti-pollution expenditures accounted for as much as 6.0 per cent of the total expenditures by local governments.

These figures show that a sharp increasing amount of money has been spent for pollution-control purposes by both the central and local governments.

Meanwhile, pollution-control investments in the private enterprises have also expanded phenomenally to cope with a tightening in regulations. The share of such investments in total plant and equipment expenditures rose from 2.0 per cent in 1970 to 8.7 per cent in 1975, according to the long-term plan released recently by Environmental Agency [3]. It also shows that the ratio of private pollution-control costs which include operating costs plus opportunity costs and depreciation of pollution abatement capital as compared to the gross national products climbed from 0.2 per cent in 1970 to 1.0 per cent in 1975.

Anti-pollution spendings have increased particularly sharply in the manufacturing, mining, and electricity-gas industries; according to the MITI's investigation of big companies, each capitalized at ¥100 million or more (Table III). As the table shows, pollution-prevention investments by major enterprises in the three industries totaled only ¥29.7 billion in 1965, accounting for a mere 3.1 per cent of the total private plant and equipment expenditures. However, the ratio exceeded 10 per cent in 1973 and further rose to 18.0 per cent in 1975. The increase rate has been so remarkable in recent years that pollution-control spendings have become an important factor in private capital expenditures.

Thermal power generation, chemicals, steel, and petroleum are the top spenders

TABLE III

PRIVATE POLLUTION-CONTROL INVESTMENTS

Fiscal Year	Spendings by Large-Corporations as Manufacturing, Mining & Electricity-Gas[a] (¥ Billion)	Ratio to Total Capital Expenditures (%)	Total Private Anti-Pollution Spendings[b]	
			Ratio to Total Capital Expenditures (%)	Ratio to GNP (%)
1965	29.7	3.1		
1966	26.8	2.9		
1967	46.2	3.5		
1968	62.4	3.7		
1969	106.7	5.0		
1970	188.3	5.3	2.0	0.4
1971	305.7	7.6	—	—
1972	331.1	8.1	3.5	0.6
1973	514.7	10.6	—	—
1974	917.0	15.6	—	—
1975	1,054.6	18.0	8.7	1.2
1976 (plan)	978.8	15.0	—	—

[a] Corporations under jurisdiction of the MITI, each capitalized at ¥100 million or more. (Total number in 1975: 1,430.)

[b] [3].

in industry as far as anti-pollution investments are concerned. In recent years, the pollution prevention spendings by these four industries have been accounting for as much as 65 per cent of their total plant and equipment investments. In 1975, the thermal power industry spent 48 per cent, the biggest for any industry, of its capital expenditures for pollution-control purposes. Other big-spending industries were mining, petroleum, chemicals, pulp-paper, textiles, and petro-chemicals—each of which earmarked more than 20 per cent of its total plant and equipment investments in the pollution-control field.

Of the total private pollution-control investments, 55 per cent went to construction of facilities for preventing air pollution and 19 per cent to facilities for controlling water contamination. Spendings in these two groups of facilities accounted for three-fourths of the total anti-pollution investments.

II. TIGHTENING OF CONTROLS ON EMISSIONS AND EFFLUENT

Pollution-prevention measures are classified into three major areas: (1) control of discharges of pollutants, (2) providing relief to pollution victim, and (3) prevention of possible pollution in advance. Anti-pollution measures with respect to a new regional development project usually start with taking preventive steps, such as conducting environmental impact assessment, which, among other measures, is aimed at checking the possible adverse impact of development projects on the environment in order to attain proper utilization of land and prevent possible environmental disruption. In Japan, however, efforts have had to be made mostly in the areas of control of emissions and effluents and providing relief to pollution victims because of the conditions of environmental pollution which are already grave.

A. *Setting of Environmental Quality Standards*

In controlling emissions and effluents from each source of pollution, it is essential to set ultimate environmental goals, such as air quality, water quality, and quietness, and gear all anti-pollution measures toward attainment of those goals. Based on Article 9 of the Basic Law for Environmental Pollution Control enacted in 1967, the governments has set environmental quality standards which are considered suitable for protection of human health and preservation of the living environment. The environmental quality standards which the government has formulated so far are as follows:

(1) Environmental quality standards concerning air pollution:
  Sulfur dioxide (set in February 1969; tightened in May 1973)
  Carbon dioxide (February 1970)
  Suspended particulate matter (January 1972)
  Nitrogen dioxide (May 1973)
  Photochemical oxidant (February 1973)

(2) Environmental quality standards concerning water contamination:
  Control of nine substances for protection of human health. They are cadmium, cyanogen, organic phosphorous, lead, hexavalent chromium, arsenic, total mercury, alkyl mercury, and polychlorinated biphenyls

(PCB). (The first eight substances were set in December 1971 with PCB having been added in February 1975.)

Standards for preservation of the living environment, involving biochemical oxygen demand (BOD) or chemical oxygen demand (COD), suspended solid (SS), hydrogen ion concentration pH, dissolved oxygen, and coliform group (set in December 1971).

(3) Environmental quality standards concerning noise:

Concerning noise in general (set in May 1971)
Concerning aircraft noise (December 1973)
Concerning super-express railways noise (July 1975)

Environmental quality standards are established on the basis of scientifically verified concentration of pollutants and its possible adverse effects on human health and the living environment. It must be revised and updated along with the establishment of new theories concerning possible impact of pollution derived from technological advance, discoveries of new pollutants, and progress in measurement techniques.

Regarding sulfur dioxide in the atmosphere, most measurement stations long ago reported that the qualities of the air they checked met the environmental quality standards set in February 1969. However, the number of patients suffering from respiratory diseases, which are considered to have epidemiological connections with air pollution, did not necessarily decrease. This fact led to a tightening of sulfur dioxide standards in May 1973.

As for water quality standards for preservation of the living environment, standards are set as to each purpose of water utilization, such as public water, fisheries, and agriculture. For example, rivers are classified into the following six types—from AA to E—with different quality standards applied to each:

Type AA:

- Nature conservation
- Class A drinking water (which requires filtration and other simple water purification processes)

Type A:

- Class B drinking water (which requires sedimentation, filtration, and other ordinary water purification processes)
- Class A fishery operations (for marine life, such as *yamame* ("trout") and char)
- Bathing

Type B:

- Class C drinking water (which requires highly sophisticated water purification processes involving pretreatment)
- Class B fishery operations (for marine life, such as salmon and *ayu*)

Type C:

- Class C fishery operations (for marine life, such as carp and crucian carp)
- Class A industrial water (which requires ordinary water purification processes by sedimentation)

Type D:

- Class B industrial water (which requires highly sophisticated water purification processes, involving the use of chemical additives)
- Agricultural water

Type E:

- Class C industrial water (which requires special water purification processes)
- Environmental conservation (to a degree at which people do not feel uncomfortable in their daily living)

Environmental quality standards are also set for lakes, marshes, and oceans. Lakes and marshes are divided into three types (from AA to C), while the same is also true for oceans. Just like rivers, environmental quality standards are set for each type of lake, marsh, and ocean according to the purpose of its utilization and consideration of present water qualities.

At present, environmental quality standards are applied to 47 inter-prefectural water areas designated by the government and an additional 336 waters designated by prefectural governments on behalf of the government. Their classification into various categories and controls on each of them will have to be tightened as the nation seeks to attain a cleaner environment.

As mentioned above, environmental quality standards are long-term administrative goals which are aimed at bringing a regional environment to a desirable condition as a whole, so that human health may be protected and the living environment preserved. Thus, in regions where pollution is already serious, efforts must be made to lower the degree of pollution and make legal a set of standards by a specified date.

B. *Countermeasures against Pollution Sources*

When environmental quality standards are set as administrative goals, what plays the leading role in the next stage of pollution control efforts are regulations of pollution sources, based on such laws as the Air Pollution Control Law and the Water Pollution Control Law.

Institutionally, present regulations of pollution sources are incorporated in laws, ordinances of prefectural governments and municipalities, and agreements which are signed between regional inhabitants and industrial companies. Generally speaking, ordinances set tighter standards than laws, while agreements between inhabitants and enterprises are more strict than ordinances. In such laws as the Air Pollution Control Law and the Water Pollution Control Law, the government sets uniform controls on pollution sources for the country as a whole to prevent spread of pollution to large areas. Meanwhile, local governments are authorized to enact ordinances providing for more rigid controls than the government's uniform standards. Such ordinances are aimed at conserving the environment by fully taking into consideration particular natural and social conditions of the regions concerned. All the prefectures in Japan now have anti-pollution ordinances, with many municipalities also following suit. Playing a role supplementary to laws and ordinances are pollution-control agreements settled between local governments and industrial enterprises.

Of all the kinds of regulations, the most important are controls by laws covering the country as a whole, such as the Air Pollution Control Law and the Water Pollution Control Law. Factories and business establishments which violate the government's regulations suffer immediate penalties. They are also subject to facility improvement orders and suspension of business orders on a case-by-case basis.

Controls on major pollutants and how they are implemented will be explained below.

1. *Control of smoke and soot*

In order to control emissions of pollutants of the air from stationary sources, such as factories and business establishments, emission standards and fuel use standards are enforced upon facilities which discharge smoke and soot, while structure, use, and management standards are applied to dust generating facilities. Among the facilities discharging smoke and soot, the primary cause of air pollution are those whose operational scales exceed a certain level and are subject to emission standards of sulfur oxides, soot and dust, nitrogen oxides, and other toxic substances which are emitted mostly by burning of fuels.

Concerning sulfur oxides, their regulations have been tightened gradually over a long period. The first control of sulfur oxides was laid down in 1962 in the form of regulations of emission concentration at stack outlets. Then, the institution of environmental quality standards led to efforts reducing ground concentration of sulfur oxides below a certain level, rather than controlling stack outlets.

At present, drives to cut down on sulfur oxide emissions are under way on a regional basis by dividing the country into 100 regions and setting a permissible level (K value) for each region according to the region's maximum ground level concentration of sulfur oxides. In heavily polluted regions, stricter permissible levels are imposed on newly constructed smoke and soot emitting facilities.

The method to lower maximum ground concentration of sulfur oxides involves erection of tall smoke stacks in order to disperse the concentration of sulfur oxides at ground level. This control method has proved effective as such. However, realization that the method was liable to spread pollution to a wider area led the authorities to introduce the concept of regulating total mass emission of sulfur oxides.

In regions heavily polluted by sulfur oxide emission, government authorities apply total mass emission controls instead of ground-level concentration rules in order to achieve its environmental quality standards. Under this concept, a total regional permissible level of a sulfur oxide emission is scientifically calculated for a region by taking into consideration the region's meteorological and geographical condition as well as the situation involving sulfur oxides emitting sources. The method of regulate total mass emission was the first of its kind adopted in the world. Its application to actual pollution control was made possible by development of new pollution measurement techniques, including pollution forecast simulation which is designed to estimate quantitatively the possible impact of sulfur oxide emissions at the source on the regional environment.

In addition to the above methods to regulate sulfur oxide emission, the government sets fuel use regulations. In big cities where heating equipment in buildings and other smoke and soot emitting facilities are the primary cause of air pollution in winter, there are regulations setting the permissible level of the sulfur content in fuels used.

Along with the tightening of controls on emissions of sulfur oxides, factories and business establishments have sharply reduced the sulfur content in emissions from their smoke stacks. At present, three major alternatives are available for cutting the sulfur content—(1) low-sulfurization of crude oil, (2) desulfurization of heavy oil, and (3) stack-gas desulfurization. Application of the three methods is as follows.

The average sulfur content of crude oil imported into Japan has been decreasing. It was 1.47 per cent in 1975, compared to 2.02 per cent in 1964. Concerning heavy oil desulfurization, Japan constructed a direct desulfurization plant in 1967 for the first time in the world. Since then, the nation has been installing an increasing number of desulfurization equipment, utilizing both direct and indirect methods. As of the end of 1975, the volume of heavy oil processed by desulfurization plants totaled 1,270,000 barrels a day.

Meanwhile, stack-gas desulfurization plants were put to commercial use sometime around 1975. At present, quite a few stack-gas desulfurization plants, capable of lowering the sulfur content by more than 90 per cent, are now operating in Japan. In 1975, the total volume of flue-gas treated by such desulfurization equipment recorded about 93 million Nm^3/h. In terms of heavy oil desulfurization capacity, the volume is equal to roughly 1 million barrels a day.

TABLE IV
PROGRESS IN SULFUR CONTENT REDUCTION

Fiscal Year	Sulfur Content of Imported Crude Oil (%) (1)	Heavy Oil Desulfurization Facility (BPSD) (2)	Stack-Gas Desulfurization Facility (1,000 Nm^3/h) (3)
1964	2.02	—	—
1965	2.04	—	—
1966	1.99	—	—
1967	1.93	40,000	—
1968	1.82	145,500	—
1969	1.68	292,760	—
1970	1.58	368,760	4,998
1971	1.55	509,260	8,788
1972	1.49	755,260	17,325
1973	1.43	861,500	28,147
1974	1.48	963,500	41,883
1975	1.47	1,270,000	93,142

Sources: (1) Petroleum Association of Japan, *Sekiyu shiryō* [Petroleum data] (Tokyo: 1976); (2) Environment Agency, *Kankyō tōkei yōran* [Environment statistics] (Tokyo: Gyōsei, 1976); (3) [1].

Secondly, regulation of soot and dust emissions is applied according to environmental quality standard which relate to suspended particulate matter.

Originally, soot and dust, together with sulfur oxides, were one of the primary pollutants of the air when fossil fuel was predominantly used. The particle size of soot and dust at that time was usually large. However, the conversion of primary energy resources from coal to petroleum has lowered the emissions of large particle-size soot and dust substantially but increased the amount of soot and dust of extremely fine particle size, instead. As for emission standards of soot and dust, maximum permissible levels are set for the emissions at stack outlets as to different kinds and scales of smoke and soot emitting facilities. While the emission standards are enforced uniformly across the country, there are stricter emission standards for application to newly built smoke and soot generating facilities in heavily polluted regions, as in the case of regulation of sulfur oxides.

Thirdly, nitrogen oxides, together with sulfur oxides, are a representative air pollution substance. They are not only toxic substances themselves but also cause photochemical oxidant. Due to the fact that countermeasures against nitrogen oxides were put into effect as recently as 1973, or about ten years behind controls on sulfur oxides, nitrogen oxides now have replaced sulfur oxides as the chief target of air pollution control measures.

Nitrogen oxides are divided into thermal NO_x and fuel NO_x. Thermal NO_x is generated when nitrogen in the atmosphere is oxidized in the burning of substances. Fuel NO_x, meanwhile, is emitted by oxidization of various nitrogen compounds contained in fuel. While emission sources of both thermal NO_x and fuel NO_x are numerous, fuel burning facilities in factories, such as boilers, industrial furnaces, and nitric acid manufacturing plants, are more numerous than emission sources of sulfur oxides.

Nitrogen oxide emission standards, instituted in 1973, were tightened in 1975. The tightening was primarily geared to regulate pollution sources where concentration of nitrogen oxides emissions is high. However, the present main controls on nitrogen oxide emissions are being implemented within the scope of commercially available preventive technologies, such as for improvement of fuel burning facilities.

The present emission regulations on nitrogen oxides are also aimed at limited types of emission sources, and the maximum permissible level falls short of accomplishment of the environmental quality standard concerning nitrogen dioxide which were established in 1973. Thus, we need to tighten the emission controls further.

One of our important tasks in the future concerning propelling the reduction of nitrogen oxide emissions is to commercially develop applicable reduction technologies for use at emission sources. Among stack-gas denitrification technologies, those for denitrifying exhaust gases emitted in the burning of light-type fuels, such as liquefied petroleum gas (LPG) and liquefied natural gas (LNG), and of heavy oil in boilers have reached the stage of commercial application. However, technologies to denitrify dirty exhaust gases containing dust and sulfur oxides in roasting and blast furnaces are still at the experimental stage.

Finally, with regard to toxic substances, permissible levels of concentration are set for each, other than nitrogen oxides according to the types of soot and smoke generation facilities. Those toxic substances include cadmium and its compounds, chlorine, hydrogen chloride, fluorine, hydrogen fluoride, and silicon fluoride, and lead and its compounds.

2. *Control of automobile exhaust gas*

Automobile traffic has undergone such a striking development in Japan that it has now become an integral part of daily life. Towards the end of 1974, passenger car ownership was one to each two households and one to each seven persons. The growing role of motor vehicles in transportation is also very impressive. In 1974, automobiles accounted for 50 per cent of total passenger transportation (in men-kilometers) and 35 per cent of total freight transportation (in ton-kilometers).

Meanwhile, expansion of automobile transportation, aggravated air pollution and noise hazard, leading to control of automobile exhaust gas. Presently, passenger car emissions are controlled on the basis of the permissible levels set for average amounts of emissions of major pollutants: carbon dioxide—2.1 g/km; hydrocarbons—0.25 g/km; nitrogen oxides—0.6 g/km (for passenger cars weighing less than one ton) and 0.85 g/km (for those weighing more than one ton).

In the case of carbon dioxide, emission controls for 1975 brought about a 95 per cent reduction in the toxic substance, compared with the exhaust gas of uncontrolled passenger cars produced prior to 1965 (Table V).

As for hydrocarbons, regulations were first imposed on new models produced in September 1970 and tightened thereafter. In 1975, controls achieved a 92 per cent reduction in emissions of hydrocarbons, compared with uncontrolled periods.

Control of nitrogen oxides, the culprit of growing photochemical smog, was

TABLE V
PROGRESS IN PASSENGER CAR EMISSION CONTROLS

(%)

Fiscal Year	Carbon Dioxide	Hydrocarbons	Nitrogen Oxides
Before 1965	100 (uncontrolled)		
1966	60		
1967	60		
1968	60		
1969	50	100 (uncontrolled)	
1970	50	75	
1971	50	75	
1972	50	75	100 (uncontrolled)
1973	45	59 and 48	70
1974	45	48	70
1975	5	8	39
1976	5	8	20–27

Source: [1].

started in April 1973. The regulations of the fiscal year of 1976 were aimed at a 73–80 per cent reduction in their emission from the precontrol level.

Automakers have done research and made development efforts to reduce average emissions of nitrogen oxides to the originally conceived goal of 0.25 g/km. Thus, market introduction of cars which utilize advanced nitrogen oxide emission control technology is planned in 1978.

3. *Control of effluents*

Contamination of public waters is caused mainly by factor effluents and household drainage.

Factory effluents are regulated by the government's uniform effluent concentration standards based on the Water Pollution Control Law. The uniform control standards consist of a two part application. One part concerns toxic substances contained in effluents discharged by all designated factories and industrial establishments. The other is aimed at organic substances, such as BOD, contained in the effluents of factories whose average daily drainage is more than fifty cubic meters. (The number of industries which falls in the second control category was 130 when the control was first applied. The number now is about 560.)

The effluent standard concerning toxic substances is put at a level about ten times higher than the environmental desirable goal by taking the diluting effect of rivers into consideration. However, the standard for alkyl mercury discharges is kept the same with its quality standard (that is, alkyl mercury must not be found in public waters) in consideration of the danger that mercury may accumulate in the human body.

The yardstick of control for organic substances contained in effluents is the quality of household sewage after treatment by the sedimentation process with due attention paid to the diluting effect and self-purification capacity of the water areas involved. However, prefectural governments are authorized to apply more rigid standards on water areas where the uniform regulation is considered inadequate to accomplish the environmental quality standards. An increasing number of prefectural governments have laid down tougher rules on discharges of organic substances accordingly.

To cope with the stiffening in industrial effluent controls, manufacturers have tackled development of new technologies in the fields of waste water treatment and recycling of industrial water.

Household effluents, have increased to such a degree that they account for a major portion of total discharges into public waters in terms of pollution loading amount, particularly in heavily polluted urban areas. This grave situation is making it urgent to step up installation of sewage works across the country. Japan's sewage installation level is still far lower than other industrial countries. Towards the end of 1975, the nation's sewage works met the needs of only 23 per cent of the total population.

Along with regulations of both industrial and household effluents, dredging work has been under way to remove sludge and other bottom deposits in heavily contaminated water areas. For pollutants which have the tendency to collect, such as mercury and PCB, in particular, provisional removal standards were imposed in 1973. This has led to the undertaking of dredging and reclamation jobs in many parts of the country on a gradual basis.

III. RELIEF FOR POLLUTION-RELATED PATIENTS

The worsening of environmental pollution has led to breakouts of a number of pollution-caused diseases, such as Minamata mercury poisoning disease and respiratory illnesses, creating a big social problem. This confronted the government with the urgent need to make a detailed survey and provide necessary relief to the victims.

The government enacted in 1969 the Law concerning Special Measures for the Relief of the Pollution-related Patients (Relief Law for short), which aimed at playing a supplementary role to social security. The law is for providing relief measures on the administrative level, regardless of the polluter's civil liability. The main thrust of the law is in helping pollution-related patients receive relief as soon as possible without going through time-consuming civil proceedings. Civil law provisions ensure the victims of demanding compensations from the polluter, but it is very difficult to prove the cause-effect relationship between a pollution case, its alleged health hazards and the polluter's intentional faults. Even if the existence of the cause-effect relationship and the polluter's responsibilities are proved, a civil case takes a considerable period of time to solve to the disadvantage of the pollution-related patients.

Despite improvements it incorporated, the Relief Law left much to be desired for relief of the victims. For example, the law restricted the scope of benefits to be paid to the victims. (It did not assure compensations to the victims' lost profits.) It was also extremely difficult under the law for pollution-related patients to accuse the polluter of responsibilities for illegal acts.

From 1971 to 1973, relief provided to pollution victims made epoch-making progress in the decisions of the so-called "four major cases of lawsuits on pollution" involving "*itai-itai* disease" (1971), "Niigata Minamata disease" (1971), "Yokkaichi asthma" (1972), and "Kumamoto Minamata disease" (1973). Progress was made in two areas. First, the decisions on the four major trials eased responsibilities for the victims to prove the polluter's violation of law. And it became possible to prove the cause-effect relationship between a pollution case and its possible health hazards with epidemiological judgment. Second, the decisions made it clear that industries which are highly liable to cause pollution have the duty to make efforts to predict the danger of pollution and prevent actual occurrence of pollution.

In the course of the above-mentioned series of judiciary verdicts on pollution cases, it was legally determined in 1972 that companies causing pollution of the air and water have compensation liability without fault concerning health hazards due to such pollution. As a follow-up, the pollution-related health hazards compensation system was established in 1973 in order to institutionally help the victims obtain due compensations from the polluters. The system requires the polluter to pay a wide range of compensations to the victims, covering not only medical bills but also compensation for the handicapped and the bereaved families.

Table VI shows the increase in the number of patients and districts covered by the pollution-related health hazards compensation system. Concerning air pollution-related diseases, such as chronic bronchitis, there were thirty-seven designated districts at the end of 1975 and the combined population of these districts came to 12 million. Out of this population, designated victims of pollution numbered 34,190, of which 60 per cent comprised of infants and children under nine years of age and elderly people above sixty years of age.

TABLE VI
NUMBERS OF DESIGNATED POLLUTION-RELATED VICTIMS AND DESIGNATED DISTRICTS

Fiscal Year	Designated Victims (Persons)			Designated Districts		
	Strange Diseases (A)	Air Pollution-caused Diseases (B)	Total	(A)	(B)	Total
1969	203	962	1,165	5	3	8
1971	211	3,219	3,430	5	4	9
1972	312	6,376	6,688	5	6	11
1973	728	8,737	9,465	6	10	16
1974	1,184	13,574	14,758	6	12	18
1975	1,325	19,281	20,606	7	23	30
1976	1,550	34,190	35,740	7	37	44

Notes: 1. Designated districts are totals of designating authorities of prefecture, city, and ward.
2. Combined population of designated districts concerning air pollution-caused diseases was about 12 million at the end of the fiscal year of 1975.

Meanwhile, seven districts were designated at the end of 1975 with regard to strange diseases, such as "Minamata disease," "*itai-itai* disease," and "chronic arsenic poisoning," with 1,550 people listed as designated patients. The designated patients consisted of 1,414 Minamata disease victims, 62 *itai-itai* disease patients, and 104 suffering from chronic arsenic poisoning.

As to who bears the burden of compensation payments, the present system adopts the "polluter pays principle" (PPP). It provides that the business enterprise which discharges or has discharged pollution agents must pay compensations to the victims. The "PPP," first espoused by OECD, now has international recognition and is aimed at internalizing external diseconomies brought about by utilization of environmental resources. The principle essentially requires the polluter to bear the financial burden which is necessary only for prevention purposes. However, the principle has been applied more extensively in Japan, where various systems concerning pollution relief victims are moving in the direction of requiring the polluter to pay not only the preventive cost but also compensation to the victims and money necessary for restoration of disrupted environmental resources.

IV. IMPROVEMENT IN THE STATE OF POLLUTION

Owing to the progress in efforts to combat environmental pollution, which centers around the tightening of emission controls, some notable reductions have been made in air pollution and water contamination. The following is an overview of the present state of pollution and the progress made in reduction of air pollution and water contamination.

A. *Air Pollution*

1. *Sulfur oxides*

Sulfur oxides, which are one of the primary air pollution agents, are usually generated by the burning of fossil fuel. Thus, the deterioration in air pollution caused by emissions of sulfur oxides was closely linked to the sharp increase in petroleum consumption which accompanied the rapid growth of the economy. As Table VII shows, generation of sulfur oxides, in terms of sulfur dioxide, increased steeply from about 1.6 million tons in 1960 to about 5.9 million tons in 1970. However, this generation levelled off in 1972 (5.6 million tons) and 1974 (5.8 million tons). The slowdown in economic activity is one factor due to the levelling-off. But a bigger cause is the major reduction in the average sulfur content of Japan's imports of crude oil.

TABLE VII

GENERATION AND EMISSION OF SULFUR OXIDES

(In terms of SO_2, in 1,000 tons)

Fiscal Year	Generation	Emissions	Removal Rate (%)
1960	1,600	1,600	0
1970	5,900	5,300	10
1972	5,600	4,300	22
1974	5,800	3,500	40

Source: [2].

Sulfur oxides emitted into the environment, increased from 1.6 million tons in 1960 to 5.3 million tons in 1970. Then, they decreased to 4.3 million tons in 1972 and further declined to 3.5 million tons in 1974. This was because various preventive measures, such as heavy oil desulfurization and flue-gas desulfurization, made it possible to keep emissions of sulfur oxides lower than the generated amounts. Owing to the progress in desulfurization technologies, the sulfur oxide removal rate, which was nothing in 1960, rose to 10 per cent in 1970, to 22 per cent in 1972, and further to 40 per cent in 1974.

The headway made in reducing sulfur oxide emissions is also evident due to the fact that the average concentration of sulfur dioxide in the atmosphere which is measured at 15 measuring stations and is located in as many typical air-pollution districts, peaked at 0.059 ppm in 1967 and then gradually decreased year after year to reach 0.021 ppm in 1975 (Table IX). According to the latest data available, of the nation's total of 1,238 air-pollution measuring stations, 972, or 80 per cent, registered sulfur dioxide concentrations which met the government-set air quality standards.

2. *Nitrogen oxides*

Pollution by nitrogen oxide emissions continued to get worse for some time, but have begun showing signs of improvement in recent years, though slightly.

The amount of nitrogen oxides which were generated, recorded 700,000 tons in 1960 in terms of nitrogen dioxide. After an increase in pollution sources (such as factories and automobiles) boosted it to 1.9 million tons in 1970, the generated amount levelled off at 2.1 million tons in 1972 and 2.2 million tons in 1974.

Meanwhile, emissions of nitrogen oxides had remained the same with the generated amounts until 1972 because countermeasures against them were not enforced until 1973. In 1974, the nation succeeded in a 6 per cent reduction in nitrogen oxide emissions (to 2 million tons) due to improvement in fuel burning methods used in factories and enforcement of tighter auto emission regulations.

The progress made in the efforts to combat nitrogen oxide emissions also is underlined by the data gathered from six measuring stations which have continued to measure nitrogen oxide emissions in the air since 1968. According to the data,

TABLE VIII
GENERATION AND EMISSIONS OF NITROGEN OXIDES
(In terms of NO_2, in 1,000 tons)

Fiscal Year	Generation	Emissions	Removal Rate (%)
1960	700	700	0
1970	1,900	1,900	0
1972	2,100	2,100	0
1974	2,200	2,000	6

Source: [2].

TABLE IX
TRENDS IN CONCENTRATION OF MAJOR AIR POLLUTANTS

Fiscal Year	Sulfur Dioxide (ppm)	Nitrogen Dioxide (ppm)	Carbon Monoxide (ppm)	Oxidant (Number of Alerts Issued)
1966	0.057			
1967	0.059			
1968	0.055	0.022	4.9	
1969	0.050	0.023	3.5	
1970	0.043	0.028	2.3	7
1971	0.037	0.026	2.4	98
1972	0.031	0.029	1.8	176
1973	0.030	0.034	1.8	328
1974	0.024	0.033	1.7	288
1975	0.021	0.030	1.4	266
	15 measuring stations	6 stations	2 stations	

Source: [1].
Note: Concentration levels are annual averages recorded at measuring stations based on continuous available data.

the average concentration of nitrogen dioxide in the air, which had exhibited a long-term increasing trend levelled off in 1974 and 1975 at 0.033 ppm and 0.030 ppm, respectively (Table IX).

However, only 54 measuring stations, or 8 per cent with a total of 666, recorded nitrogen dioxide concentration levels satisfying the environmental quality standards for nitrogen dioxide. Thus, additional efforts must be made for improvement of pollution by nitrogen oxides.

3. *Air pollution by other substances*

As for soot and dust, 22 out of a total of 139 measuring stations recorded levels of suspended particulate matter in the atmosphere which satisfied environmental quality standards in 1975. This indicated the need to tighten regulations. On the other hand, dust falls have been generally showing signs of improvement, thanks to the enforcement of controls.

Concentration of carbon monoxide in the atmosphere must be measured at the roadside where traffic is very busy because automobiles are the primary source of carbon monoxide emissions. As Table IX shows, pollution by carbon monoxide has been decreasing in recent years largely due to the imposition of controls on automobile exhaust gas. Especially in 1975, all of the 99 measuring stations recorded carbon monoxide concentration levels which met its environmental quality standard.

Finally, photochemical oxidant is a secondary pollutant which is produced by the photochemical reactions of such primary air pollutants as nitrogen dioxide and hydrocarbons. Its generation has much to do with weather conditions. As Table IX indicates, the number of oxidant alerts issued had been on the rise until 1973 but decreased in 1974 and 1975 consecutively.

B. *Water Contamination*

The percentage of water samples satisfying environmental quality standards concerning toxic substances increased from 98.6 per cent in 1970 to 99.80 per cent in 1975, testifying to the steady improvement in the water quality (Table X).

As a result of the strict monitoring of the quality of effluents and improvement in waste water treatment technologies, most of the environmental quality standards concerning water quality have presently been met as far as toxic substances contained in water are concerned. In particular, total mercury, alkyl mercury, and organic phosphorous were not found in any of the samples taken in the latest checking.

As for such factors as BOD and COD which are necessary for conserving the living environment, Table XI shows that the combined amount of COD generated by both industrial and household effluents increased from 8,000 tons a day in 1960, to 23,000 tons a day in 1970, to 26,000 tons a day in 1972, and to 27,000 tons a day in 1974. Despite the rise in COD, tightened controls on effluents kept the increase in effluent amounts to a modest level—from 8,000 tons a day in 1960 to 11,000 tons a day in 1970. As a matter of fact, the amount of

TABLE X
DEGREE OF ACHIEVEMENT OF WATER QUALITY STANDARD CONCERNING POLLUTION BY TOXIC SUBSTANCES

(%)

Toxic Substances \ Fiscal Year	1970	1971	1972	1973	1974	1975
Cadmium	97.2	99.3	99.66	99.68	99.63	99.69
Cyanogen	98.5	98.8	99.5	99.8	99.94	99.98
Organic phosphorous	99.8	99.8	100.0	100.0	100.0	100.0
Lead	97.3	98.6	99.3	99.45	99.63	99.68
Sexivalent chrome	99.2	99.9	99.93	99.92	99.97	99.98
Arsenic	99.0	99.6	99.71	99.69	99.73	99.76
Total mercury	99.0	99.7	99.96	99.99	100.0	100.0
Alkyl mercury	100.0	100.0	100.0	100.0	100.0	100.0
Total	98.6	99.4	99.7	99.77	99.80	99.80

Source: [1].
Note: Degree of achievement is obtained by dividing the number of samples remaining below the environmental quality standards by the total number of samples taken. The value for total mercury in 1974 represents the number of sample districts staying below the environmental quality standards divided by the total number of sample districts. The total for 1974 excludes total mercury.

TABLE XI
GENERATED AMOUNTS AND EFFLUENTS OF COD

(In 1,000 tons a day)

Fiscal Year	Generated Amounts	Effluents	Removal Rate (%)
1960	8	8	0
1970	23	11	52
1972	26	9	65
1974	27	8	70

Source: [2].

effluents decreased from 9,000 tons in 1972 to 8,000 tons in the fiscal year of 1974. The amount in 1974 was equivalent to that in 1960, or fifteen years earlier. Due to the remarkable decrease in COD effluents, the removal rate of COD, which was zero in 1960, reached a high level of 70 per cent in 1974.

Reflecting a decrease in the amount of COD effluents, as mentioned above, the ratio of the number of water samples satisfying the environmental quality standards concerning BOD and COD (which are key indicators of water contamination by organic substances) increased steadily by 1974. As for water areas which are classified into various types under environmental quality standards (numbering 1,850 rivers, 70 lakes and marshes, and 471 oceans), the accomplished rates of environmental quality standards regarding BOD and COD in 1975 stood at 57.1 per cent for rivers, 38.6 per cent for lakes and marshes, and 72.4 per cent for oceans making it an average of 54.8 per cent.

V. TASKS AHEAD

Having been reviewed in the foregoing, environmental pollution in Japan at one time deteriorated to such an extent that it caused grave health hazards on many people, but it has been improving remarkably in some areas due to the progress in anti-pollution measures, centering on the tightening of controls on emissions and effluents. For example, the nation has succeeded in making notable headways in its battle with air pollution (by sulfur oxides) and water contamination (by toxic substances). Japan, which had been notorious as the most polluted nation in the world until several years ago, is now known as a country which has one of the toughest and most comprehensive sets of pollution-control regulations and most advanced anti-pollution technologies in the world.

However, a number of problems remain to be solved in the way of pollution control and environmental conservation.

First, with a few exceptions, there are still many pollutants that have to be reduced below environmental quality standards in order to protect human health and preserve man's living environment. Further efforts must especially be made in reducing emissions of nitrogen oxides into the atmosphere and bringing down noise pollution caused by automobiles, aircraft, and the super-express railways below environmental quality standards. The water quality also leaves much to be improved in order to provide people with a better living environment. All in all, it is incumbent upon the nation to step up its efforts to restore a cleaner environment.

Second, socioeconomic approaches together with direct assaults on individual pollution sources must also be an integral part of anti-pollution measures. For instance, it is necessary to grasp the environmental pollution problems from such wide-ranging angles as land utilization, the industrial structure, the regional structure, and the traffic systems. The fast deterioration in Japan's environmental conditions in the postwar rapid economic growth process had much to do with such socioeconomic conditions as a high-density economic society characterized by a mixture of industry and residential districts, emphasis on fostering heavy and chemical industries which are highly liable to cause environmental pollution, and heavy population concentration in big cities. From now on, it is desirable that anti-pollution measures will be propelled with due attention paid to these socioeconomic factors.

Prevention of possible pollution in advance is equally important. It is vital, in this connection, to conduct effective environmental impact assessment before regional development is undertaken. Results of such assessment must be incorporated in decision-making and blueprinting of the regional development plan. Environmental impact assessment has been conducted for public work projects but there has not been any such practice as far as regional development is concerned. Thus, it is important to make environmental impact assessment legally obligatory and also establish a system to ensure that the opinions of experts and regional inhabitants are reflected in the assessment process of possible environmental impact.

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