Japan's Experience in Urban Environmental Management

Osaka

A Case Study

Metropolitan
Environmental
Improvement
Program

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MEIP: the Context for the Study

The UNDP-assisted, World Bank-executed Metropolitan Environmental Improvement Program (MEIP) began work in 1990 in five Asian metropolitan areas—Beijing, Bombay, Colombo, Jakarta, and Metro Manila. In 1993, this intercountry program began its second phase and Kathmandu joined as the sixth MEIP city. By 1996, MEIP will enter its third phase — with multi-donor assistance — and launch new programs in additional Asian cities.

MEIP's mission is to assist Asian urban areas tackle their rapidly growing environmental problems. The MEIP approach emphasizes the cross-sectoral nature of these problems and the failure of traditional, sectoral development strategies to adequately address urban environmental deterioration or the linkage between industrial and urban development.

The work program in each city is therefore guided by Steering Committees and technical working groups that reflect the cross-sectoral, interagency nature of urban environmental issues. The policy and technical committees develop Environmental Management Strategies (EMS) for their metropolitan regions; incorporate environmental considerations into the work of economic and planning agencies; contribute to the strengthening of environmental protection institutions; and identify high priority environmental investments.

The MEIP city office serves as secretariat to the Steering Committee and is managed by a local environmental professional, the National Program Coordinator (NPC). The NPC coordinates all MEIP activities and is responsible for developing the environmental network of government, private sector, non-governmental organizations (NGOs), research institutions, and communities. MEIP supports workshops, demonstration projects, and community environmental actions, and links these growing environmental network efforts with government policy and investment initiatives.

A further focus of MEIP is the exchange of experience and sharing of information among MEIP cities. This has been carried out through a series of intercountry workshops that review the city work programs, exchange useful experience, and develop intercountry projects.

MEIP has established the city programs, set in motion a variety of city subprojects, and mobilized the intercountry exchange. MEIP publications are intended to share insights and experiences developed from the MEIP process and its projects. The MEIP city programs work independently, with each other, and with international partners to reverse urban environmental degradation and provide useful and replicable lessons in urban environmental management.

MEIP and Urban Environmental Management Experience in Japan

To assist developing countries strengthening institutional capacity to control pollution and manage environmental resources, learning from countries and cities that have experienced similar problems is a particularly effective tool.

Japan has had a large measure of success in dealing with environmental problems associated with rapid industrialization and urbanization. As a developed country in Asia, its urban environmental management history affords an excellent opportunity to derive lessons and case studies.

This city case study of Osaka is a companion piece and source document for the MEIP national study on Japan. In addition to the city reports on Kitakyushu and Yokohama, MEIP has published a national report entitled, "Japan's Experience in Urban Environmental Management."

The studies undertake a detailed review of Japan's experience in urban environmental protection and clean-up. The focus was to elaborate experiences of particular relevance to MEIP cities, and to other cities in Asia and elsewhere in the developing world.

Some useful conclusions concerning the applicability of Japan's experience for developing countries can be drawn. The studies demonstrate that, while much of the technology and present management practice may not be easily transferable, the way in which Japan tackled pressing environmental problems during the 1960s and 70s is directly relevant to the environmental management challenge facing MEIP cities.

On behalf of the MEIP team, I would like to express appreciation to Shunsuke Aoyama and his colleagues at EX Corporation for their superb efforts in conducting the study. We are especially grateful to the report's principal authors: Shunsuke Aoyoma, Jeremy J. Warford, Kiichiro Sakaguchi, Nahoko Nakazawa, and Hiroshi Naito for their exacting work and careful analysis. Profound thanks are due to Professor Michio Hashimoto, Chairman, and to the other members of the Central Steering Committee, and to Mr. Y. Saito, Chairman, and other members of the Osaka Committee. Finally, we are indebted to the Government of Japan for the support that enabled us to undertake this project and to the unflagging efforts of Kazuhiko Takemoto of the Japan Environment Agency and of Katsunori Suzuki, our colleague at MEIP-World Bank.

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Summary of Environmental Protection Measures in Osaka

In the pre-war period, the western coastal industrial area in Osaka City had been a heavy chemical industrial area which supported national production. Once the area had been burned out due to the Second World War (WW II), it was revitalized again with the post-war economic revitalization and high economic growth. The area has a great number of small- and medium-sized companies. In the pre-war period, air pollution due to soot and smoke became problems. The City of Osaka, with the co-operation of the Osaka prefecture, took measures for soot and smoke control at the beginning of the 1900s. These activities included an increase of pollution awareness on the part of industries and citizens, guidance on improving the coal combustion method, monitoring of dust fall, and research on pollution's influence on economy. The activities provided precious data on air pollution in the post-war period. It took time to identify the cause of land subsidence which was found in 1934 (actually the cause was identified after WW II). The war interrupted these measures, but subsidence monitoring was continued during the war.

Since urban infrastructure such as sewage treatment plants with the activated sludge method and the incineration facilities were well advanced in the pre-war period, water pollution and waste problems were not as serious as air pollution and subsidence. Soot, smoke and dust due to coal, and subsidence due to the excessive pumping of ground water became manifest in the post-war economic revitalization and growth. The "Jane Typhoon" (1950) and the "Second Muroto Typhoon" (1961) made the disadvantage of subsidence clear, and the coastal area suffered significant damage because of flood. Making a priority of the subsidence measures, the City of Osaka ended subsidence in a short period by improving breakwater, increasing the heights of the bridges, regulating the pumping of ground water, and constructing an industrial water supply system including extensions of cooling towers.

Then, the City addressed measures for controlling air pollution, which had become much worse. Luckily, with many technical staff in the public health division and a rich accumulation of monitoring and measurement data on air pollution in the Sanitation Research Institute, it did not take much time to develop the air pollution control system. Especially, research to ascertain the conditions of air pollution had accumulated abundant know-how in both public and private sectors. The measures taken included a broad monitoring network, the improvement of monitoring methods, research on automatic monitoring equipment, and the detection of air pollution by visibility monitoring.

In the latter half of the 1950's, the city responded to the complaints on pollution damage in advance of the national legislation, established self-protection-through-soot-and-smoke organizations by local companies, and held a soot and smoke protection month. These measures originated in the pre-war history of soot and smoke control. Fortunately, the Osaka City Pollution Control Council (established in 1962) included enough scientists who were specialists in public health and labor sanitation as members. These scientists took leadership in systematizing an administrative strategy from the public health point of view.

Considering the special characteristics of Osaka, the council designated the "western coastal industrial area of the city" as the "area for special measures", which is divided into the "area for large factories" and the "area for small- and medium-sized factories". The council advised the City to take different measures at the same time. The action taken for the "area for large factories" called for a "special

measure in the Konohana ward."This measure consisted of organizing the existing large factories in the area into groups based on technical similarities and encouraging them to design a pollution control plan by themselves. This way, the City did not have to use a large number of technical staff for this area. The measure used for the area for small- and medium-sized factories was implemented by the Pollution Special Task Force in NishiYodogawa ward. This measure was aimed at improving many factories in the area in a short period by using many technical staff in the City, since these small industries did not have the capability to undertake their own plan.

Since large companies could use national financial sources to control pollution, the city concentrated on supporting small- and medium-sized companies. The city formed two supporting measures, namely the Osaka City Loan for the Installation of Anti-Pollution Equipment and the Purchase System for Sites of Relocated Pollution Source Facilities, based on inquiries from small- and medium-sized companies. This latter measures resulted in a project which collectively transferred the factories located in the residential area to an industrial site.

The city had accumulated abundant monitoring data through the air pollution monitoring network and precise research data on causes of smoke from factories including facility size, fuel, materials, and the height of the smoke stacks based on the inspection of many factories. Furthermore, using the dispersion coefficient which was obtained by an air tracer experiment, the city calculated the degree of each factory's influence on the pollution by a simulation method, and calculated the reduction rate. Thus, the city could make a persuasive and scientific argument to business owners and technical staff. The influence rate of each factory was the most pervasive factor in solving the problem of industrial air pollution in the city. In areas of high concentrations of pollution, national standards would not be stringent enough. Therefore, it was necessary for the city to set its own targets. The above examples illustrate how the city involved business owners with the implementation of pollution control measures. With respect to automobile exhaust pollution, which is impossible for any one municipality to regulate, the City of Osaka implemented its own campaign, and supported national regulatory measures with the related administrative agencies.

An anti-pollution campaign through the mass media (newspaper and television) started in the 1960s. It raised public awareness on the merits of pollution control by drawing attention to the actual, alarming levels of pollution, promoted new mayors whose primary concern was pollution control in large cities, and facilitated the provision of national pollution related laws. The City of Osaka could promote its pollution countermeasures without having any legal authority over factories because the city received a lot of support from public opinion, which the mass media had helped form.

At first, industries opposed pollution control measures, regarding them as an impediment to industrial development. However, as the conditions of pollution worsened each year, the corporations themselves suffered adverse effects due to pollution, and they belatedly recognized their social responsibilities. Industrial groups, such as the Industrial Pollution Prevention Research Association under the Osaka Industrial Association and the Industrial Pollution Consultation Center under the Osaka Chamber of Commerce and Industry, became active. The Soot and Smoke Control Association was established in each administrative district, and was very effective in controlling pollution. There was also a lot of development in pollution control technology and improvement of equipment by factories. Factories made many proposals to technical staff in administration and provided a great amount of technical information. The good sense and good faith of Osaka factories should be highly respected.

As the "Quiet Town Campaign" indicates, pollution was controlled not by ordinances but by the citizen's self discipline. When pollution reached its worst, the administration designed measures based on scientific proof and obtained support from the mass media and the citizens. At the same time, the companies recognized their social responsibilities and cooperated with the administration. This occurred primarily because Osaka has a 400-year tradition of self-governance by residents.

Reasons for the Success of Pollution Control Measures in the City of Osaka

Japan's administrative structure consists of three levels: central, prefectures, and municipalities. Measures determined by central policy-making are implemented through them. When industrial pollution became prominent, the center and the prefectures had regulatory authority for industrial pollution through laws and prefectural ordinances. Unfortunately, the measures were neither effective nor concrete. Citizens who suffered pollution damage complained only to a local administrative branch under the city office which had no authority to act. The City of Osaka passed the citizens' complaints to the Osaka prefecture and asked for measures. The complaints sometimes bypassed the Osaka prefecture and were sent to a branch of the national agency. However, there was almost no response. The reasons for the success of pollution countermeasures in the City of Osaka under these circumstances include the following points:

1) Ground subsidence has been a critical problem in Osaka since the pre-war period. The public and private sectors cooperatively implemented subsidence prevention ordinances ahead of national measures and established a system to implement measures. Osaka used the approach of public and private cooperation.

2) In the pre-war period, there was a movement to improve air quality on the part of the administration, researchers and business circles; and various data was accumulated. These preparations led to soot and smoke control in the 1950's.

3) The Osaka mayor prioritized removal of industrial pollution as the most important policy in the city, and designed a strategy for pollution control based on available technology in cooperation with scientists and researchers.

4) To implement the strategy, the City of Osaka formed an administrative organization for pollution control whose members consisted mainly of environmental sanitation monitoring staff (pharmacists and veterinarians) and technical staff specializing in civil engineering, architecture, machinery, and electricity, all selected from city agencies. Furthermore, the "Pollution Control Engineer Group" was quickly organized through preferential hiring of graduates who majored in environment and sanitary engineering in universities. Since they already had a technical background, special training was not necessary.

5) The City of Osaka systematized financial support measures, such as the "Osaka City Loan for the Installation of Anti-Pollution Equipment" and the "Purchase System of the Site of Relocated Pollution Source Facilities" for small and medium-sized companies and gave them priority when dispensing financial assistance.

6) With respect to urban waste water, the city set up guidelines for a basic policy and implemented infrastructure beginning from the pre-war period.

7) The following two factors were most important:
   i) the city's proper recognition on the importance of scientific and technological support in the solution of industrial pollution, that was based on a tradition of cooperation with industry;
   ii) firm decisions from the top and the creation of a technical group were key to the success of the measures to control industrial pollution.

8) The reasons for the success of measures to control soot and dust, and SOx in the city were: a) a national fuel policy which demanded conversion from the use of coal to the use of oil, and b) an energy policy which favorably allocated lower sulfur heavy oil to areas with serious levels of air pollution, like Osaka.

9) Since gas was already in use city-wide, it was easy for factories to convert to gaseous fuel.

10) The cooperative attitude of local corporations to pollution control, based on their sense of responsibility towards their local society.

11) The groups of private companies such as the Osaka Industrial Association tried to implement pollution control measures jointly by all of the industry circle members through meetings and discussions, and by providing training and education, etc.

12) The support from mass media that appealed to residents was a very important factor.

Around 1970 in Japan, the problem of pollution worsened due to rapid industrial expansion. Since pollution had an adverse effect upon all parts of society, including residents, corporations, and administrations, solving the problem of pollution became an important national issue. At that time, a large sum of money was invested into controlling pollution and the investment was part of the basis for economic growth. Thereafter, the gain from energy saving balanced the cost of pollution control measures through process change.

Technology Transfer to Developing Countries

Technology transfer in terms of environmental protection includes both administrative measures, and hard technology, such as pollution control equipment. Politics, the administrative system, and economic conditions are diverse in developing countries. Therefore, the pollution countermeasures in developing countries should be selected according to its local applicability.

The following elements in the experience of Osaka are important for developing countries:

1) Use scientific methods. In order to design and execute the measures based on science or technology, staff with a high level of technological expertise should be hired and educated.

2) Establish a cooperative system between public and private sectors. This is one of the major characteristics of the experience of Osaka. The technical staff at the city and district administration levels and the engineers in factories cooperated and enhanced technical standards. This experience indicates the importance of cooperation between public and private sectors.

3) Encourage industry associations to establish waste minimization and pollution control committees and advice functions to provide outreach and training to their members.

4) Focus on hot-spot areas in the city for intensive pollution control measures to achieve desirable results.

5) Establish a financial system that supports corporations which introduce pollution control technology. The City of Osaka created a system which helped small- and medium-sized companies that were short on financial resources. Under that system, a loan was released after technical screening of treatment equipment was conducted.

With respect to pollution control equipment, the applicability of hard-ware technology to developing countries depends on the certain conditions. Without considering these following conditions, technology transfer will fail:

1) Energy supply: The appropriate control equipment depends upon the available energy sources and their reliability. For example, if municipal gas is provided in the cities, its use can greatly improve air quality.

2) Technical Standards: Since equipment needs maintenance, it is necessary to consider the parts production capability and the repair capability of small enterprises. Pollution control equipment which cannot be handled by the technical capability of users should be phased out.

3) Legal system, location conditions, and degree of environmental pollution: These three factors should be considered when determining the most efficient method of removing pollution. It is also necessary to take the local environmental conditions into account.

4) Economic strength of industries: Substantial funds may be needed to maintain the pollution control and the monitoring equipment. Considering the cost, pollution control equipment whose capital and maintenance cost is on par with the economic strength of the firm should be introduced.

5) Educational standards: Due to the difficulty of training engineers up to the necessary educational standards, pollution control equipment should be introduced with consideration given to the difficulty of operation and maintenance.

A prerequisite for effective pollution control measures is to ascertain current conditions. In order to comprehend the characteristics of air pollution, for example, it is necessary to know how it changes in time and space. It is sufficient to have a monitoring system that combines minimum automatic monitoring stations with maximum simple monitoring points selected on a case-by-case basis. Having a monitoring system which needs expensive maintenance costs should be avoided, although some Japanese municipalities use it. Each individual treatment equipment cannot be discussed here. However, many factories in the City of Osaka are using different pollution control facilities, varying in treatment method, treatment efficiency, and facility size. This equipment should be good examples to review when introducing pollution control equipment to developing countries.

The City of Osaka

Introduction

The city of Osaka is the third largest city in Japan. The city is located at the center of the second biggest economic region (Kinki region) which also includes Kobe and Kyoto. Osaka city originated as a hub of land and water transportation and prospered as a commercial center in Japan's medieval period. The city has recently carried out extensive modernization of its infrastructure with the intention of becoming an international city in the 21st Century.

Location, Natural Environment, and Topography

Osaka is situated at 34°N latitude and 135°E longitude, almost in the center of Honshu. The city is about 500 km from Tokyo Metropolitan Region and within three hours of Tokyo by the Tokaido bullet train. The city extends into the Osaka Plain, and its west side faces Osaka Bay. Its land area is about 220 km^2. To the east of the city, mountains loom over the other cities in the Osaka prefecture. The city itself however is almost flat except the Uemachi hill (9 km in length and 2 km in width) which runs through the city and is in general about 3 m above sea level.

The city has always been characterized by the presence of large and small rivers, most of which are artificial ones created by the cut-and-cover method. These rivers and canals facilitated water transportation and contributed to the development of Osaka; indeed, Osaka's nickname is "the city of water." In recent years, however, many of the rivers and canals have been eliminated. The reclaimed lands are now used for roads and parks. Today the city has 23 rivers (canals are excluded). Starting from Biwa Lake (the biggest lake in Japan), the Yodo

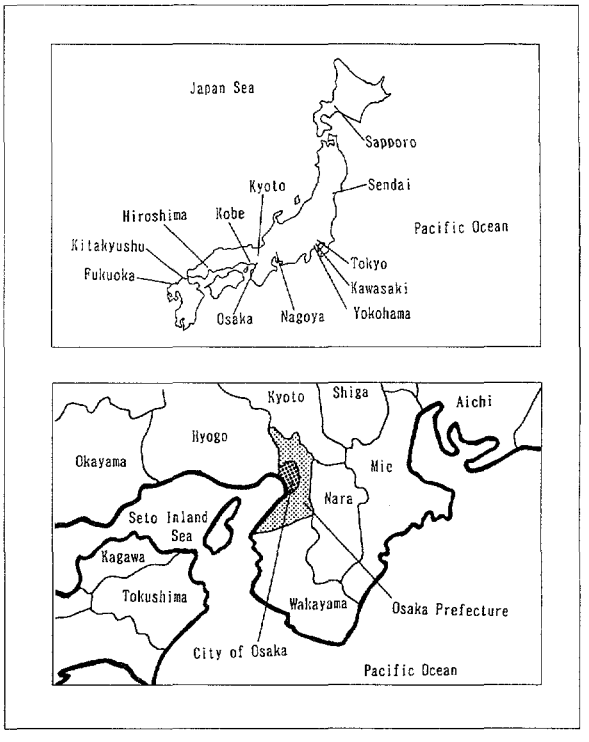


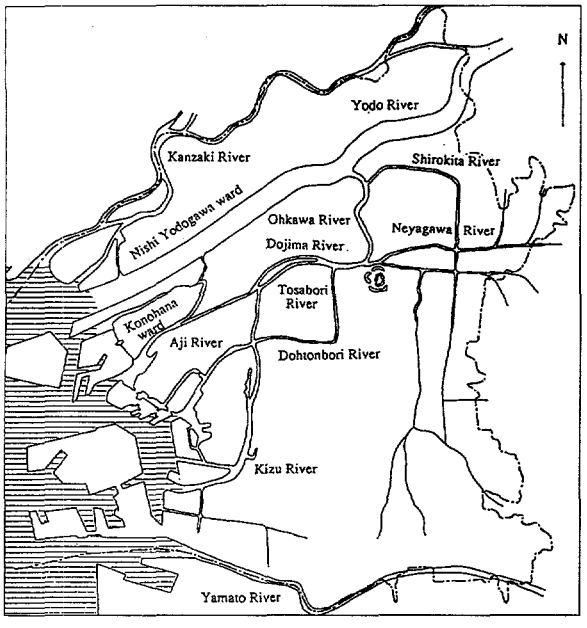
Figure 1-1: Location of Osaka

River—the longest river in Osaka—is full of water. Historically, soil and sand sediment from the Yodo River formed the Osaka Plain, which was once a bay, then a beach, and finally a low marshy district. Since most parts of the city lie on the land of alluvial soft soil, ground subsidence easily occurs due to over-pumping of ground water (See Figure 1-2).

Climate

The city of Osaka is in the mild Setouchi climatic zone. In 1991, for example, average temperature was about 17.1°C (the highest temperature was 37.3°C and the lowest was -2.5°C). More than 1.0 mm precipitation occurred in 108 days. Annual precipitation was 1,433 mm. The area is affected by winds from both land and sea, and natural ventilation in the summer is strong. But a migratory high (anticyclone) in winter creates inversion layer which tends to keep pollutants in the air. In recent years, because of the "heat island" phenomenon, the city has shown an increase in annual average temperature

Figure 1-2: Map of Osaka



and so-called tropical nights with the lowest temperature above 25°C.

Population

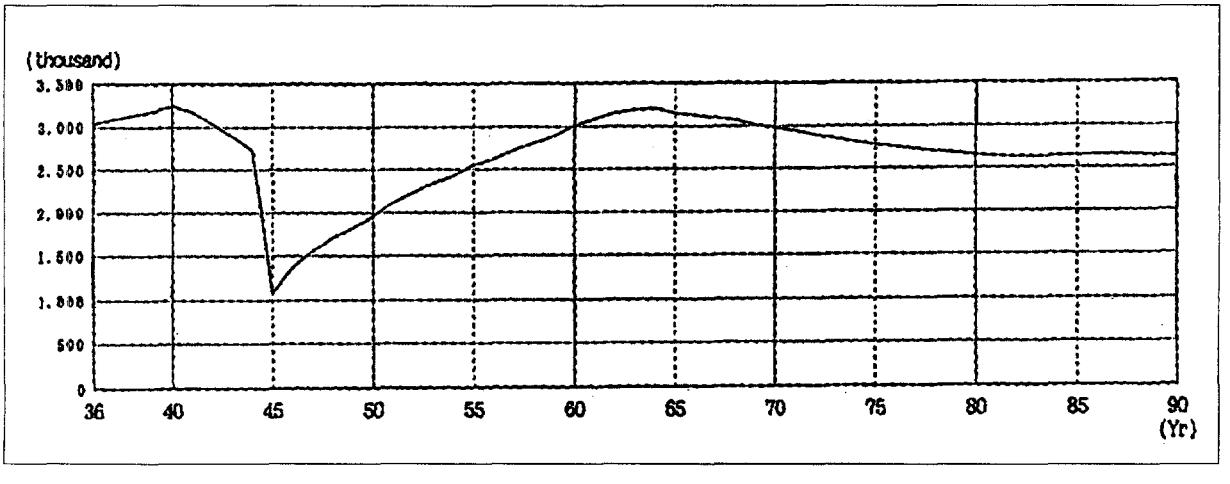
With the expansion of the city area and economic growth, the population of Osaka reached 3.25 million in 1940, which was the largest in its history. After WW II, it decreased to 1.1 million. In the postwar revitalization, it exceeded 3 million in 1960 and reached a peak of 3.16 million in 1965. However, a drastic decline in the city's population as people moved to the suburbs created a so-called sprawl phenomenon. The population of the city decreased to 2.65 million in 1980. Thereafter, the population has continued to decline due to the impact of soaring land prices, though the decline was weaker than before, as more housing and urban infrastructure were supplied (Figure 1-3).

In 1991, the population of the city is 2.64 million; its density was about 12,000 per km^2, which is the second highest after Tokyo. Because the city attracts many workers, the daytime population has steadily increased The daytime population, including 1.48 million from outside the city, reaches 3.8 million—the ratio of daytime to nighttime population is 1.45.

Economy

After the oil crisis in 1973, the Japanese economy entered into a low growth period. Economic growth rate in the Osaka was in fact below the national average during 1975–85. Thereafter, it improved and remained slightly higher than the national average. At the same time, however, employment opportunities decreased, and the unemployment rate in 1990 was 5.5% which was 1.8 times the national average. The gross regional product (GRP) in the

Figure 1-3: Population Growth in Osaka, 1936–90



city was about 19.3 trillion yen in 1989 (5.1% of the national total).

Osaka's industrial structure consists mainly of small- and medium-sized companies. In 1985, small- and medium-sized companies accounted for 99.1% of business establishments and had 76.5% of employees (Table 1-1).

Tertiary industries account for 68% of the city's daytime working population. Secondary industries account for 31.5%, and primary industries only 0.1% of the daytime working population. Tertiary industries continue to expand and secondary industries are decreasing (Figure 1-4).

Commerce (wholesale and retail) is the core of the tertiary industries. Commodity sales in Osaka city in 1991 were 80,167.7 billion yen in total, of which 92.3% derived from the wholesale. Wholesale commodities sales in 1991 accounted for 13% of the national total. The commodities concerned are textiles, chemical products, clothes, daily goods, minerals, metals, and machinery. The manufacturing industry is the core of the secondary industries. Production output in 1991 was 7,917.9 billion yen, mainly in steel, other metals, machinery, chemicals, petroleum, and coal product, and publishing and printing materials .

The city of Osaka is active in trade. Freight shipped from Osaka port in 1990 totaled 9.7 million tons of which 76% is for domestic trade. With respect to international trade, the exports in 1991 were 2,030 billion yen (4.9% of the national total) and imports were 1,660 billion yen (5.2% of the national total). Export items are machinery, textiles, textile products, and chemical products. Import items are textiles and metals, food products, machinery, chemicals, etc.

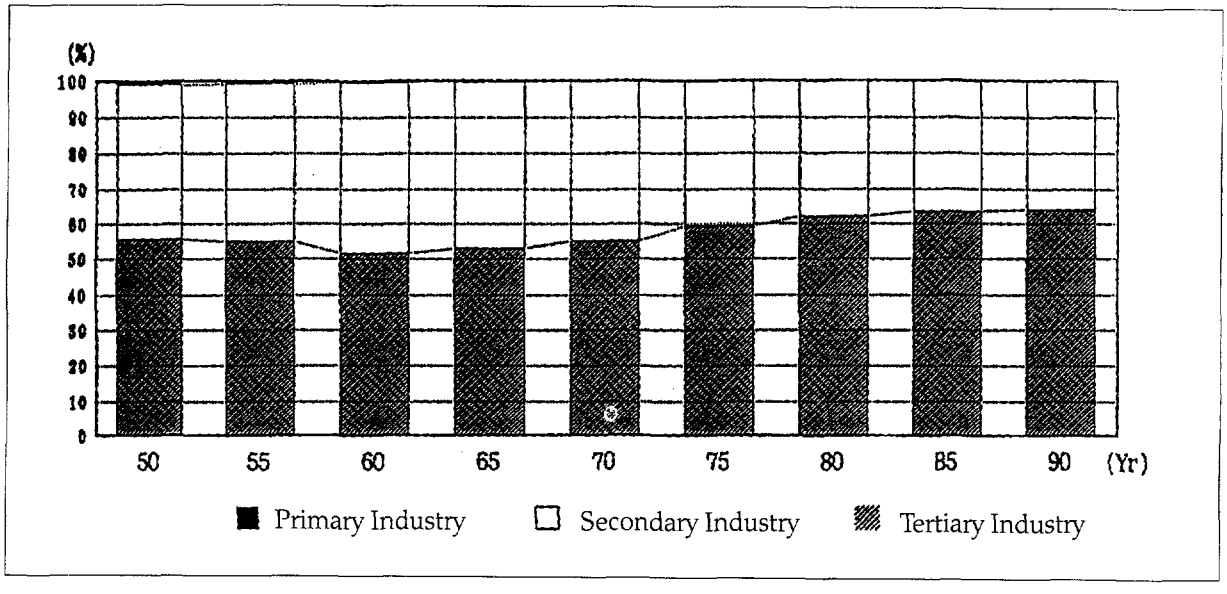
Energy, Water Supply, Sewerage, Wastes

The total energy demand in the city of Osaka has been increasing year by year, and approximately half of this demand is covered by electricity and piped city gas supply. Industry sector is the largest energy consumer, which is followed by transport, commerce, and household. Energy use in offices has also shown a remarkable growth in recent years. Almost all households and business establishments in the city have water. The water supply efficiency ratio, which represents actual amount of water use to the amount of supplied water, has already reached 92.7% in 1990. The diffusion rate of sewerage was 98.8% on drainage catchment area basis or 99.9% on the basis of population provided with wastewater treatment services. With the expansion of economic activities, waste disposal in the city grew

Table 1-1: The Ratio of Small- and Medium-sized Companies

	Number of Establishments			*Number of Employees*		
	Total (a)	*Small and Medium (b)*	*(b)/(a)*	*Total (a)*	*Small and Medium (b)*	*(b)/(a)*
Total	274,098	271,533	99.1	2,364,344	1,809,640	76.5
Manufacturing	44,476	44,358	99.7	482,945	401,925	83.2
Wholesale	38,189	37,616	98.5	494,665	353,472	71.5
Retail, Restaurant	99,924	99,387	99.5	461,027	390,475	84.7
Financier, Insurance	4,128	4,080	98.8	116,658	86,932	74.5
Services	52,818	51,635	97.8	427,110	259,749	60.8
Others	34,563	34,457	99.7	381,940	317,087	83.0

Figure 1-4: Industrial Employment in Osaka, 1950–90



almost five-fold over the 30 years from 1960 to 1991. Eighty-two percent of collected wastes were incinerated in 1991 and the remaining 18% was used for sanitary landfill.

Traffic

The City of Osaka has a well-coordinated transport network. Main forms of transport in the city and suburban areas, and outlying cities are train and bus (42%), walking, bicycles, etc. (40%), and car (18%). Sixty-five percent of commuters use the train or bus, and 37% of workers travel by car. The city is served by JR (Japan Railways), private trains, and subway. The City of Osaka runs the subway, the total length of operating lines exceeding 100 km. Due to a continual increase in traffic volume, the city is proceeding rapidly with additional road construction. By the end of 1991, the city had 11,485 roads (national, prefectural, and municipal roads) totaling 3,803 km in length and 36.88 km^2 area, 96.6% of pavement ratio[1], and 16.7% of road ratio[2].

Land Use

The center of the city is predominantly an office and commercial area, in which residences are also to be found along Midousuji Street. There is also an area devoted exclusively to housing outside of this mixed area. Large heavy chemical industry factories are concentrated in the eastern coastal area. Newly created areas (Techno-port Osaka), including international trade and commercial functions, are underway in the reclaimed land at the south and north offshore ports. Small- and medium-sized factories coexist with residences in the eastern and the northwest areas. The southern part of the city is mainly residential.

History of the City

Up to the Pre-War Period

Old period (6-8th Century) A small bay of Osaka was close to Yamato Imperial Government, and was an important hub of domestic traffic and Chinese trade. In the 7th century, the government moved to Osaka and the Naniwa Palace was built. Until the government moved again to Kyoto at the end of the 8th century, Osaka was the center of Japanese politics and economy.

Medieval period (16–19th Century) The foundation of the present Osaka was laid in the 16th century. Toyotomi Hideyoshi, who brought about national unification in the Civil War period, favored the location of Osaka and built the Osaka castle. Hideyoshi also promoted internal commerce and foreign trade. At that time, many canals were cut for transportation purposes, and the soil was used to reclaim swamps. The downtown area was established on the sedimentary land as the population increased. Waste and rain water from the downtown area was discharged into the rivers through an open drain.

In the peaceful Edo period, Japan's economy flourished and merchants began to become more powerful. Their storage facilities were displayed along canals in Osaka, and Osaka prospered as a center of Japan's commerce, becoming known as "Japan's Kitchen".

From the Meiji Era to the pre-war period Osaka opened its port at the time of the Meiji Restoration of 1868 and along with the ports of Nagasaki, Kobe, and Yokohama increasingly participated in foreign trade. In 1889, Osaka was reorganized as a city, and modernized its water supply and sewerage systems. The city's population was then about 470,000. The capital then moved to Tokyo, which also became the center of Japan's economy. The subsequent decline in financial and distribution activities shook Osaka, but it reconstructed itself with industrial development. In fact, the textile industry in Osaka accounted for 90% of national production by the end of the 19th century; Osaka became a major export center and known as "The Manchester of the East".

The amount of solid waste disposal in Osaka was 300–400 ton/day around the beginning of the 20th Century, and became an increasingly serious problem. The city built its first incinerator in 1903, followed by several more. During the Sino-Japanese and Russo-Japanese Wars and the First World War, Osaka city became one of the major commercial and industrial cities in the East by drastically expanding its metal and chemical industries and increasing exports. Its rivers supplied both abundant sources of water for industrial use, as well as transportation. Air pollution caused by industrial development became severe. At that time, however, smoke and soot were regarded as a symbol of prosperity rather than as pollution. Nevertheless, in the 1920s, soot and smoke countermeasures began to take place. Dust fall measurement started in 1922, and the Osaka mayor founded the "Osaka Smoke and Soot Control Investigation Committee" in 1927. In 1928, the first symptom of land subsidence was observed in the western part of the city. Damage caused by high tides in 1934 was followed by the construction of breakwaters, with more comprehensive actions for subsidence prevention taken after WW II.

As industrial development proceeded and the city expanded, Osaka embarked upon a major program to improve its infrastructure. In the 1920s, the city constructed and expanded streets, sewerage, canals, parks, and cemeteries. In the 1930s, it built the Midousuji Street and Subway Line, along which the city's business area became established. The Midousuji Line remains to this day a major artery of city traffic and has contributed greatly to economic development in Osaka. In 1940, two sewage treatment plants using the activated sludge process were built. A quarter of the costs for sewerage construction was collected from users. At the same time, the biggest central wholesale market in the East was opened and the distribution system was reorganized and modernized. Population in Osaka rapidly increased, from 1.25 million in 1920 to 3.25 million in 1940.

Post-War Reconstruction (1945 to 1955)

During W.W.II, 27% of the city had been burned out and 1.13 million people suffered from 28 air raids. The city was destroyed and its population

dropped to one third of that existing before the war. Immediately after the war, work began to improve urban infrastructure such as roads, parks, transportation systems, and port facilities. With the return of evacuees and repatriates, and resumption of factory operations, Osaka city rapidly regained its population. The "Municipality Law," the basis of local government, was enacted in 1947 under the Japanese Constitution. The authority of the local parliament became much stronger than in the pre-war period and, for the first time, the mayor was directly elected. Nine years later, Osaka, Kyoto, Kobe, Nagoya, and Yokohama became designated cities by cabinet order.

From the High Economic Growth Period to the First Oil Shock (1955–1973)

Osaka's economy kept pace with the generally high economic growth of Japan and the living standards of its citizens continually improved. However, centralization of population and industry in the urban area created air and water pollution, noise, and land subsidence. In 1960, the National Income Doubling Plan[3] was proclaimed. Around that time, smog occurring in winter was thick enough for car drivers to keep their headlights on during the day. The increase in car ownership created a significant noise problem (In 1957, car horn frequency at the intersection of the Umeda Shin-michi was 68 incidents/min.). In response to citizens' request, the city government took actions against pollution by administrative guidance and monitoring before the establishment of pollution-related laws. With respect to land subsidence, the tidal damage in 1950 and 1961 facilitated protection measures. Investigation showed that the high tide was caused by excessive pumping of ground water. Therefore, the City of Osaka constructed an industrial water supply system which was substituted for industrial ground water, and regulated the pumping of ground water by municipal ordinance. Land subsidence then slowed down and rarely occurs now.

Urbanized earlier, Osaka had relatively small green area. In order to improve its environment, the city promoted a tree planting campaign in 1964. In that period, traffic congestion became increasingly serious. In order to counter the situation, the city extended subway lines and constructed freeways. In 1970, the international exhibition was held in Osaka; this encouraged the construction of road, railway, airport, and port facilities, all of which have contributed to Osaka's subsequent progress. The international exhibition attended by 64 million people was memorable to Osaka, and cost 52.4 billion yen. The site of the exhibition subsequently became a cultural park.

From The First Oil Shock to the Present Time

Quality of life The high growth period ended with the first oil crisis. Economic development priorities shifted, with growing concern for the quality of the living environment. The Osaka City Comprehensive Plan, which was released in 1978, declared three slogans of the city development, namely "The City of providing a comfortable living environment to the residents," "The City of supporting various activities at broader scale extending beyond the municipal boundaries," and "The City of creating the new culture." Pedestrian paths and roads tracing the city's historical sites were built. The city built bridges, designed not only for traffic but also to provide views of the city and improve the environment. Social welfare and sports facilities were provided. In parallel with these actions, the city also established the Consumer Protection Ordinance, which required producers to provide information on unit prices and quality of goods. Price monitoring was also introduced.

Development of small- and medium-sized companies Following the oil crisis, small- and medium-sized companies—the majority of the city industries—were hit by recession, the rapid growth of competition from newly industrialized countries,

and appreciation of the yen. Osaka city provided various forms of assistance to companies by increasing loans to avoid bankruptcy, to modernize, encourage use of advanced technology and to support new business. Most of the small- and medium-sized companies in the city were located in the residential-factory areas which implied problems involving such things as housing environments, disaster protection, and the size of factory sites. The city invited and provided loans to small- and medium-sized factories to relocate to more suitable places, where industrial housings and apartments were built. The city also opened a guidance center for small- and medium-sized companies to support their research departments for technological development and managerial improvement.

Osaka, an international city The Osaka city was first exposed to internationalization by the exhibition of 1970. The "Osaka 21st Century Plan," which started in 1983, aimed at further internationalization. The plan is a long-term project (until the 21st century) and includes various elements. Under the "100 year (1989) Osaka Municipality Memorial Project", the city is also establishing facilities in five categories (health, beauty, technology, cultural exchange, and others) appropriate for an international city of the 21st century.

The objective of the "Osaka City Comprehensive Plan for the 21st Century" is to promote international exchange and cooperation, attract international visitors, and provide better information on functions. Osaka also hosted the "International Garden and Greenery Exposition" in 1990. One of the slogans in the exhibition was the "coexistence of nature and humanity." The city invited and officially established the UNEP International Environmental Technology Center in October 1992, which was expected to adopt the above slogan and contribute to global environment issues. Finally, the city will be further internationalized by completion of the Kansai international airport (1994) which will have the first 24-hour operation in Japan.

Endnotes

1. Pavement ratio: ratio of paved roads to total roads area

2. Road ratio: ratio of road area to total city area

3. "National Income Doubling Plan": plan aimed at doubling the national income from 1960 to 1970 but was achieved by 1967

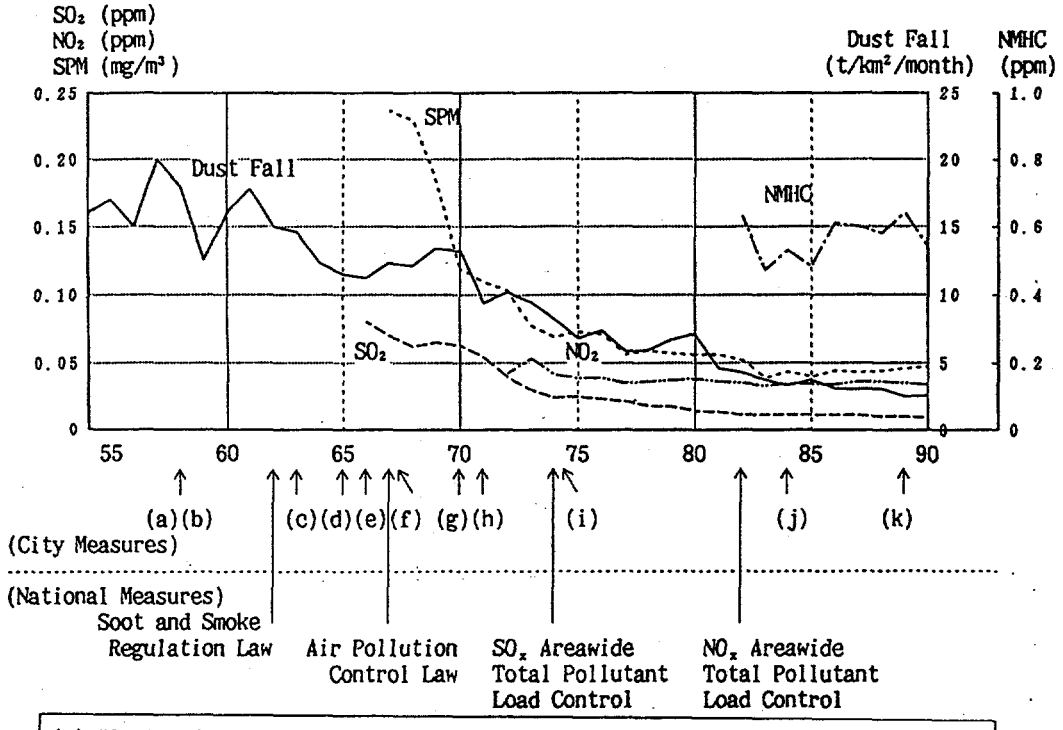
Environmental Pollution in Osaka

This section summarizes the state of environmental pollution in Osaka: air pollution, water pollution, noise, vibration, and night soil.

Air Pollution

Ambient air pollution Figures 2-1 through 2-3 indicate changes in the concentrations of dust fall, SO_2, NO_2, suspended particulate matter (SPM) in ambient air, SOx (by PbO_2 method), and the number of misty or foggy days.

The concentration of dust fall has steadily decreased since observations began in 1954. It has remained almost unchanged since 1981. Also, concentration of insoluble dust fall decreased from the start of 1928 observation to WW II, but increased from then until 1963. However, it decreased during the decade from 1963, and has remained unchanged since the mid-1970s (Figure 2-13).



(a) "Soot and Smoke Control Month" is established.
(b) The Soot and Smoke Control Association is established in Higashi Ward.
(c) Regular Smog Monitoring starts.
(d) City of Osaka establishes its Original Air Pollution Control Standard.
(e) Air Pollution Control Measures are executed in the Coastal area of the Western Osaka.
(f) City of Osaka establishes a Financial Assistance System for Pollution Abatement Equipment Purchase.
(g) Nishi-Yodogawa Ward implements the Emergency Air Pollution Measures.
(h) "Clean Air Plan '71" is formulated.
(i) Air Pollutant Emission Reduction Plan is settled based on "Clean Air Plan '73".
(j) "New Clean Air Plan" is formulated.
(k) Osaka City Automobile Pollution Prevention Program is formulated.

Figure 2-1: Ambient Air Quality: General Environmental Monitoring Stations, 1954–90

Figure 2-2: SOx Environmental Concentration, 1955–90 (by PbO2 Method)

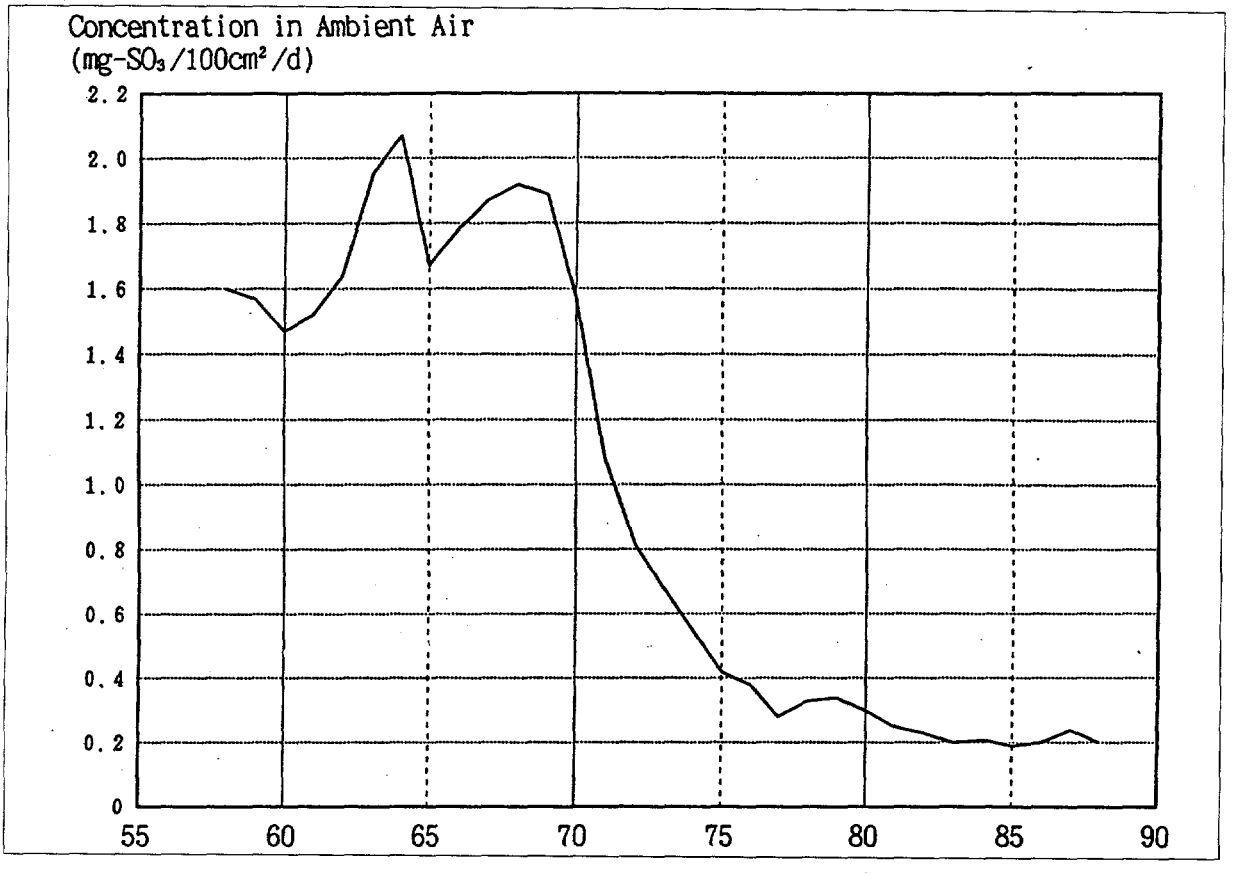
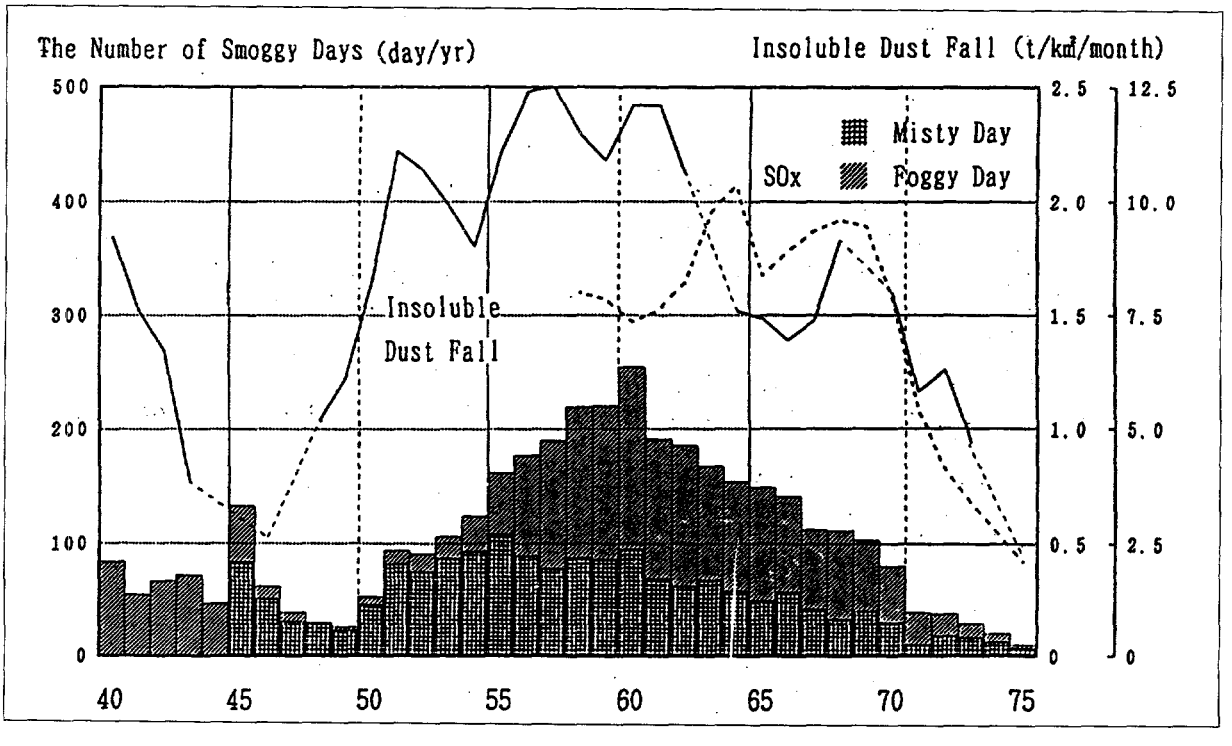


Figure 2-3: The Number of Smoggy Days and Concentration of Insoluble Dust Fall and SOx, 1940–75



Monitoring of SPM concentration started in 1967; it decreased until 1977, and then remained unchanged. The concentration of SO_2 by the PbO_2 monitoring method, started in 1958, decreased since 1969 and remained unchanged in the 1980s. Monitoring by conductometric analysis also started in 1966. SO_2 concentration by this analysis decreased until 1980 and then remained unchanged. Monitoring of NO_2 concentration started in 1972; it increased in 1973, returned to the level of 1972 in 1974, and has remained almost unchanged since the latter half of the 1970s.

The number of smoggy days decreased by the end of the 1950s, but greatly increased in the 1960s, by which time it exceeded the pre-war level. However, misty days decreased from their peak in 1955, and foggy days from 1960, and mist and fog were rarely observed by the mid-1970s.

Road traffic pollution Contained in automobile exhaust, NO_2 and CO are major elements of air pollution. Figure 2-4 shows changes in the concentrations of these substances as measured by automobile exhaust gas monitoring stations.

Monitoring of CO concentration started in 1971. It decreased from its peak of 1972 and has remained unchanged with a slight decrease since 1983. Monitoring of NO_2 concentration also started in 1971. NO_2 remained almost unchanged with a slight increase over several years, but since 1987, it has decreased slightly.

Water Pollution

Rivers Figure 2-5 indicates trends in water quality of rivers in Osaka. Biochemical Oxygen Demand (BOD) monitoring of rivers in Osaka started in 1936, was interrupted by the war, and resumed in 1950. BOD remained almost unchanged in the pre-war period, and was below the pre-war level at the time of resumption. In the post-war period BOD rapidly increased, returned to the pre-war level for several years, and then increased. However, BOD greatly decreased in the 1970s and remained unchanged in the 1980s.

Twenty-four-hour water pollution monitoring was established and Chemical Oxygen Demand (COD) monitoring started in 1971. Figure 2-6 shows

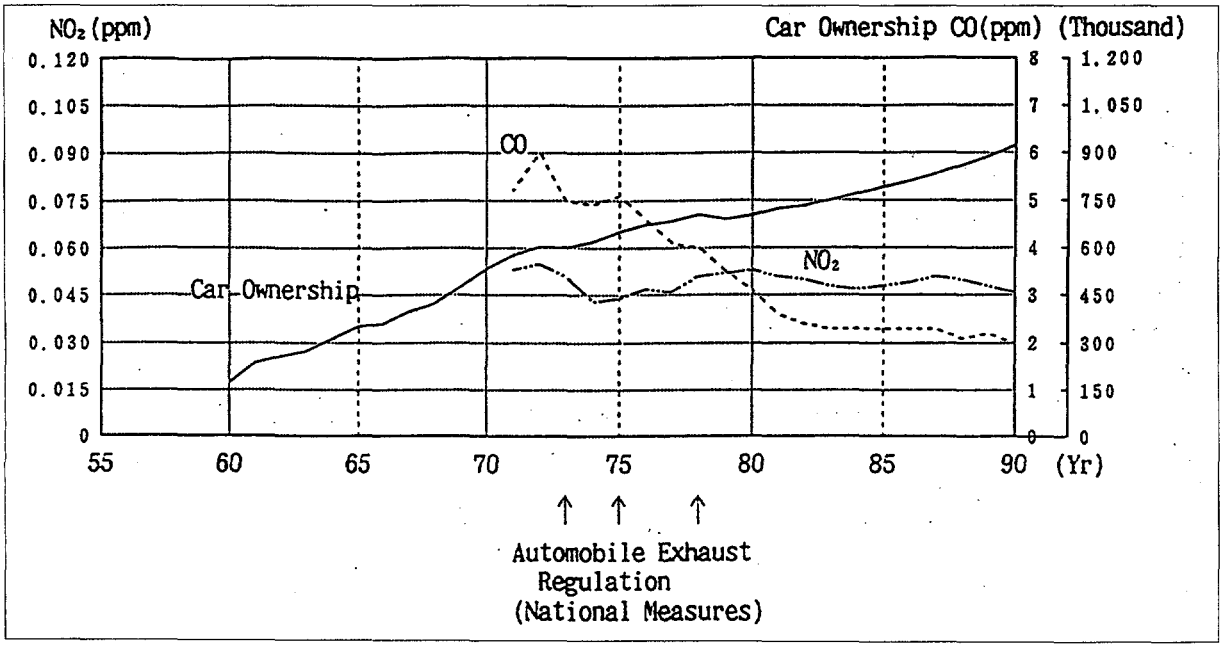
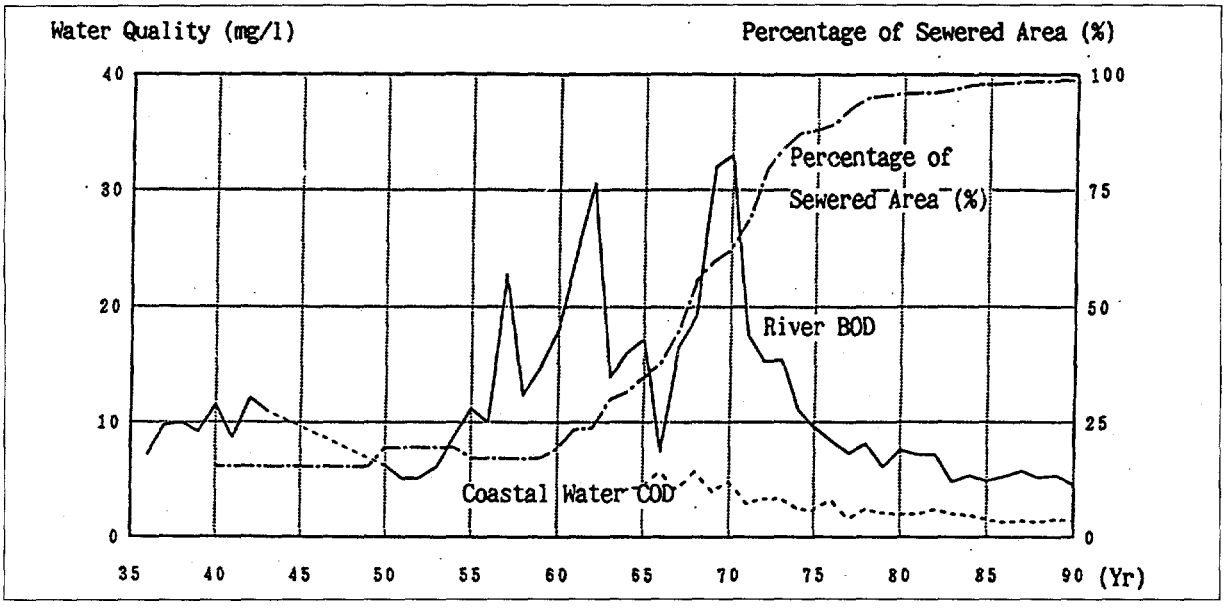


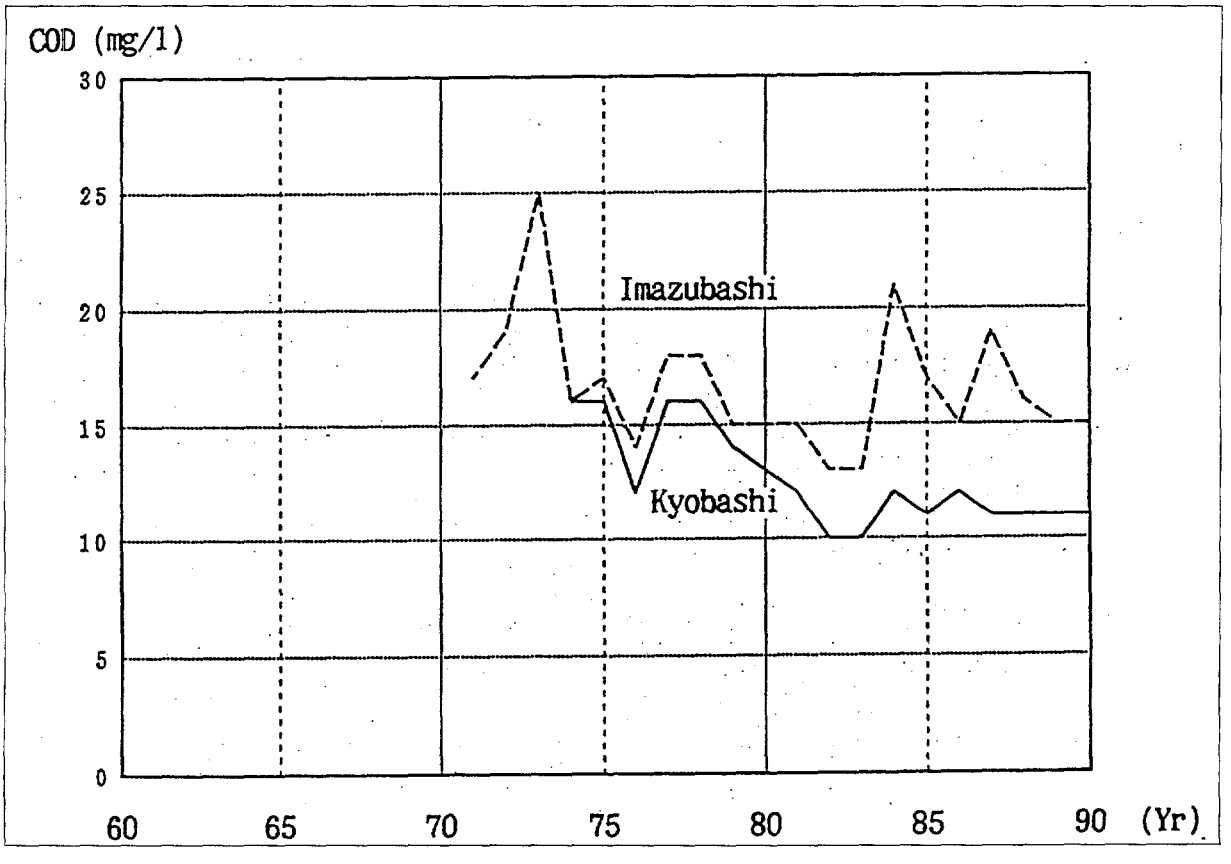
Figure 2-4: Ambient Air Quality Recorded at Automobile Exhaust Monitoring Stations, 1955–90

Figure 2-5: Water Quality in Public Waters and Percentage of Sewered Area by Residences, 1935–90



COD monitored at Imazubashi (the point where the Neya River flows into Osaka City) and Kyobashi (the lowest point on the Neya River). The lower point of the river shows an improvement of water quality and COD at the upper point remained almost unchanged. This is because the access ratio to sewer-

Figure 2-6: Water Quality in River Waters, 1960–90



age in the Osaka city (on the lower part of the river) changed from 68% to almost 100%, while that on the upper part of the river remained about 50%. In recent years, domestic waste water has become a major source of water pollution.

Coastal waters Figure 2-5 shows coastal water quality in terms of COD (measured by the alkali method) in Osaka Bay. COD has tended to decrease over time, remaining unchanged since 1985. Because it is a semi-closed area of water, red tide caused by eutrophication often occurs in the Osaka Bay area.

Noise, Vibration, and Offensive Odors

Figure 2-7 shows the number of complaints about noise, vibration, and offensive odors.

Noise and vibration Complaints about noise increased until 1971, and then slightly decreased or remained on the same level. Recent complaints about noise account for more than half of the total complaints. Factories or business establishments are major sources of noise. Noise is also generated from construction sites, traffic and daily life. In recent years, complaints about noise emanating from Karaoke bars, which operate late at night, have increased. Vibration has much in common with noise in terms of basic characteristics and impact. In many cases, noise and vibration originated from the same source. The number of complaints about vibration is less than that about noise. However, both trends are alike; both complaints reached their peaks in 1971, and then decreased.

Offensive odors Complaints about offensive odors decreased or remained unchanged after they reached their peak around 1971. Service industries and others related to living environment are the source of most recent complaints.

Land Subsidence

Lower ground water levels due to over pumping of ground water has caused subsidence in the city. Figure 2-8 shows changes in the level of ground water

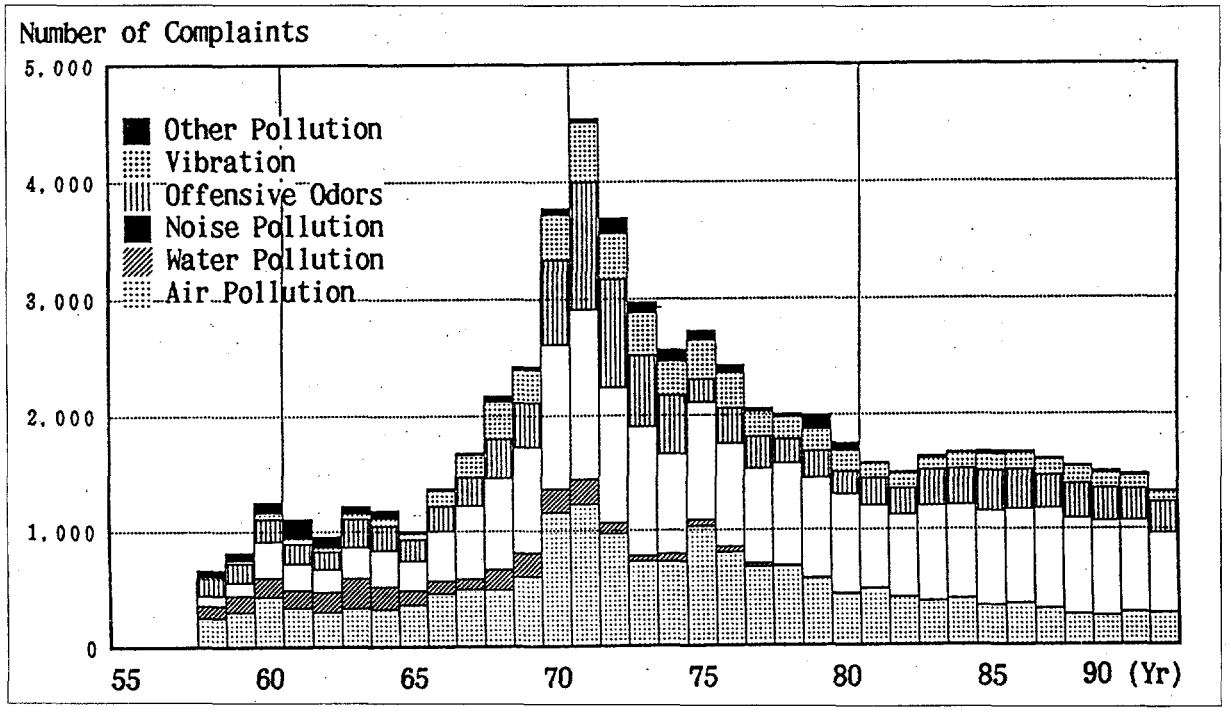


Figure 2-7: Number of Complains for Environmental Pollution, 1955–90

and subsidence. Ground water reached its lowest levels in 1961. Then, the level of ground water was quickly recovered by the effective laws such as "Industrial Water Law (in 1956)", "Law concerning Regulation of Pumping-up of Ground Water for Use in Building (in 1962)," etc. As a result, subsidence stopped and the problem was largely overcome.

Sewerage and Night Soil Treatment

Figures 2-9 presents the areas with access to sewer and the volume of night soil treatment. The area with access to sewer was 15-20% of total city area until 1960, greatly increased in the 1960s and 1970s, and became 96% in 1980. Thereafter, it continued

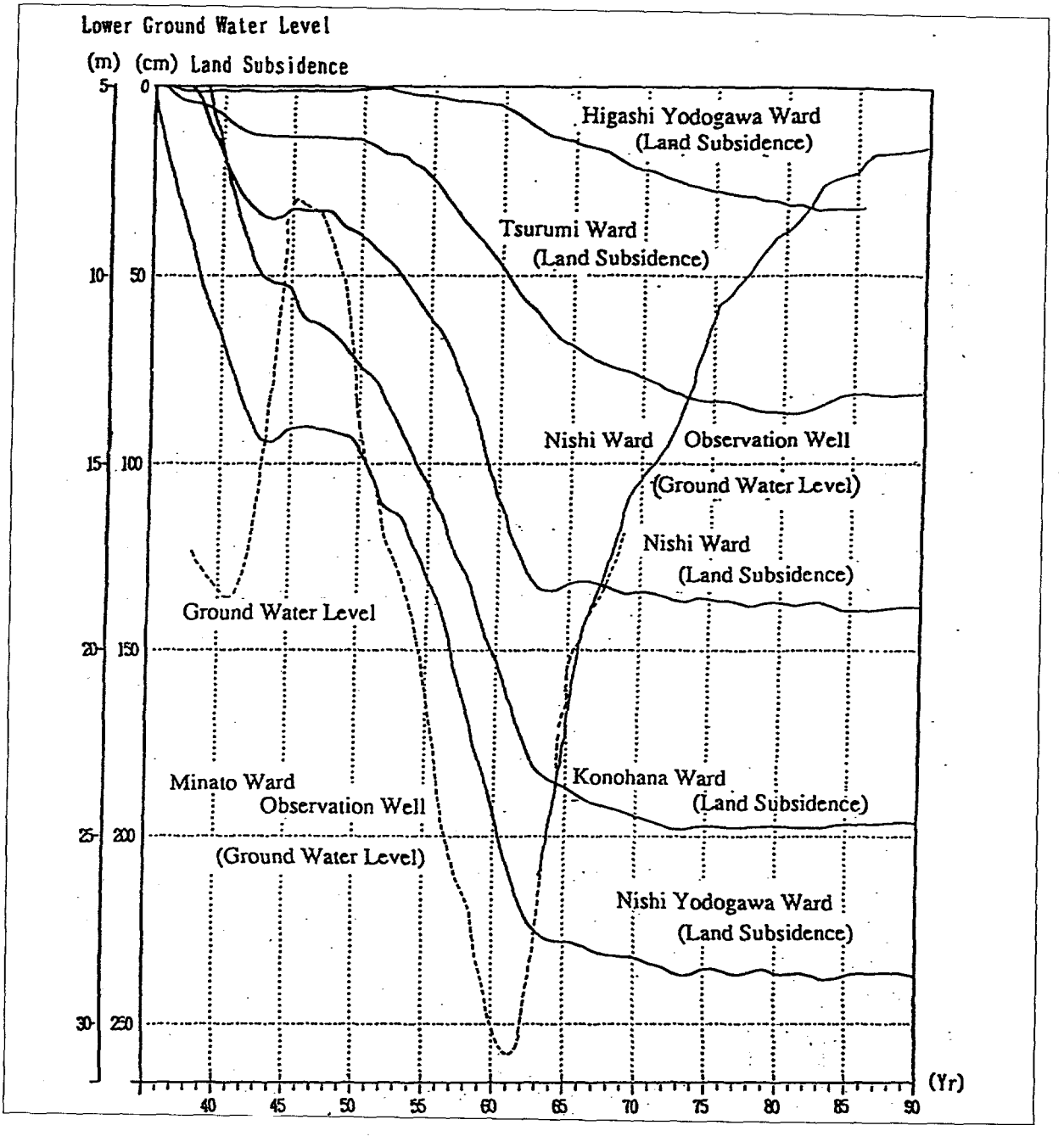


Figure 2-8: Land Subsidence and Ground Water Level in Osaka, 1940–90

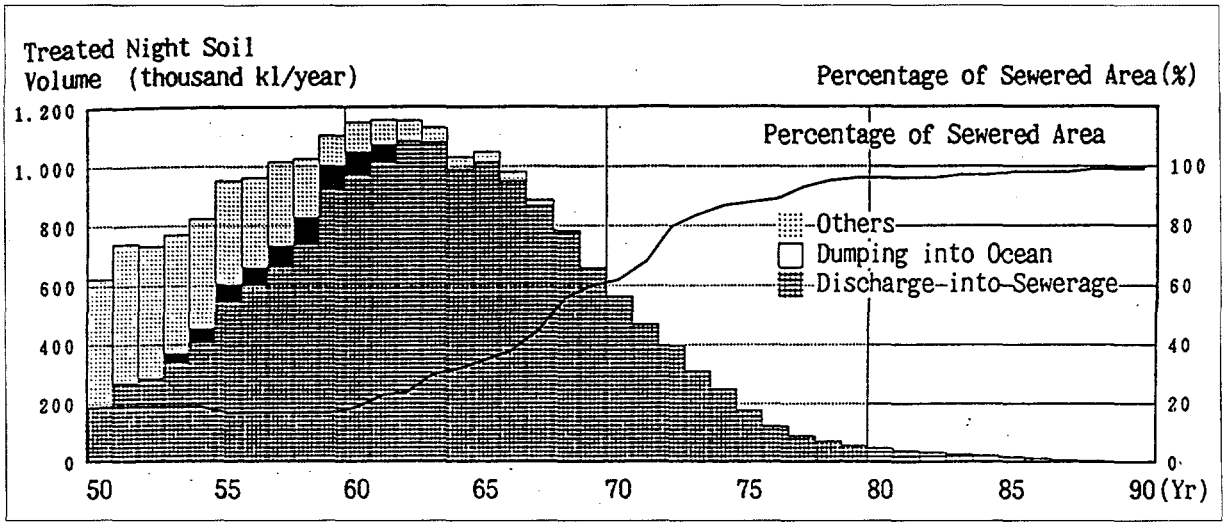


Figure 2-9: Night Soil and Percentage of Sewered Area, 1950–90

to increase slightly with current access at almost 100%. With the expansion of the sewered area, the volume of night soil treatment has greatly decreased, so that today it is almost zero. The amount of waste water discharged into sewerage increased until 1962 and then decreased rapidly.

Solid Waste

Figure 2-10 shows trends in the amount of domestic solid waste disposal. The amount has increased over time, and was about 2.2 million tons in 1990. Detailed research of the amount of industrial waste was conducted every five years, and the interval figures are estimated. Industrial wastes for final disposal are construction wastes, slag, sludge, etc. Slag, metal chips, and wood chips are recycled.

Environmental Protection Measures in Osaka

This section presents a summary of the environmental protection measures instituted in Osaka during different time periods.

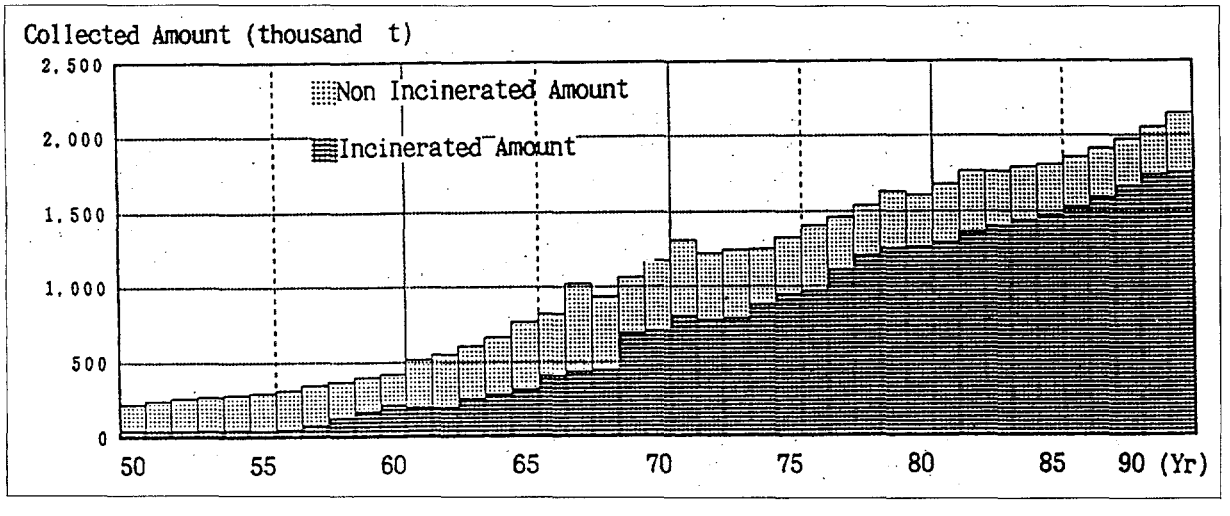


Figure 2-10: Soil Waste Disposal, 1950–90

Prior to the World War II Osaka was originally a hub of land and sea transportation and an economic center during the Edo Period (1603–1869) when it served as an exchange market for goods and materials from all over Japan. However, the transfer of the capital to Tokyo and certain economic policies of the Meiji government were viewed as having an adverse effect on the economic activity in Osaka. Therefore, an industrial policy was implemented in Osaka to boost its economy. As a part of this policy, the Osaka arsenal (1870) and the Osaka mint (1871) were built. Thereafter, Osaka Spinning (1882) which was the first corporation in Japan, was built, and followed by the establishment of a number of other large spinning factories. Osaka Steel, large factories for activities such as sulfuric acid manufacturing (later renamed as Osaka Alkali), and many small- and medium-sized factories were also built. By 1888, Osaka became a modern industrial city concentrating on the spinning industry.

Air pollution Accompanied with the industrial development, air pollution and its damages on residences also increased. In order to control air pollution, the Osaka prefectural ordinance banning factory construction with smoke stacks in the city (current center of the city), was issued in 1889. Furthermore, in 1896 the ordinance was abolished and replaced by a comprehensive "Regulatory Rules for Osaka Manufacturing". Because there was only a small number of factories, air pollution was not widespread at that time—it was only considered locally and not regarded as a social problem.

Thereafter, air pollution increased dramatically due to the increase in coal consumption in factories. The Osaka Prefectural Assembly presented an opinion on soot and smoke control to the governor in 1902. The litigation on rice damage caused by soot and smoke was filed against Osaka Alkali in 1907 and the ensuing widespread public attention increased the awareness of air pollution. These facts indicate that air pollution developed from a mere local problem to a critical social problem in Osaka during this period. As a result, active efforts for soot and smoke control were made to cope with air pollution.

Prominent figures and engineers in politics, business, and bureaucrats of Osaka organized the Society for the Study of Soot and Smoke Control in 1911. The City of Osaka budgeted for soot and smoke control measures in city electric power plants in 1912. However, the outbreak of WW I in 1914 placed the national priority on economic development.

Until the Showa Period began in 1925, only researchers on sanitation and fuels had addressed the soot and smoke problem and published the pollution conditions or solutions to alleviate the pollution. For instance, the Osaka Municipal Hygienic Laboratory (currently, Osaka City Institute of Public Health and Environmental Science) started monitoring dust fall from 1922. According to records, average amount of dust per day was 5 ton/ km^2 .

During the Showa period, air pollution caused by soot and smoke accelerated. The City of Osaka established the "Osaka Investigating Committee for Soot and Smoke Control" in 1927, and conducted research on smoke damage and the regulation on soot and smoke control. In 1928, the committee organized the first Air Cleaning Campaign Week and publicized the necessity for air pollution control and the available technologies for soot and smoke control (an improvement of combustion method) to citizens and business owners. This campaign was very effective in reducing soot and smoke. The committee then submitted a proposal in 1931 to the central government and the Osaka Prefecture to establish the Soot and Smoke Control Regulations as law.

In June of 1932, the "Soot and Smoke Control Regulations" (prefectural ordinance), which in-

cludes emission standards by Ringelmann smoke chart and the limit or ban of use of polluting equipment, was first issued in the nation. This regulation accelerated the soot and smoke control campaign and organized the related research being conducted by various institutions. However, the emphasis on the heavy chemical industry increased, largely in response to the Manchurian Incident (1931) and the ensuing military needs, leading to greater fuel consumption and resulting in worsening soot and smoke problems. In order to promote the soot and smoke control campaign further, the Soot and Smoke Control Association was established in 1936 by business establishments discharging soot and smoke and the sanitation union in each police district. Each association was chaired by the chief of a town marshal. However, the association did not solve the problem thoroughly.

Land Subsidence Osaka, as a matter of procedure, has monitored water levels in the Osaka area every several years since 1885. The monitoring in 1927 and 1928 identified the water levels as increasing and land subsidence became a problem. The severe damages caused by the Muroto Typhoon in 1934 drew citizens' attention to subsidence. In order to grasp the conditions and causes of subsidence, the City of Osaka created a network of water benchmark stations (about 170) in the city from 1934, and started monitoring the changes more thoroughly. The city also started monitoring the level of ground water in wells from 1938 (9 wells). The results of the monitoring stations in the post-war period showed that subsidence had a close connection with the large use of ground water.

Sewage treatment Epidemics of cholera or plague at the end of the 19th Century promoted the construction of water supply and sewerage systems, and the waste disposal measures as public health measures. The modern water supply system with sedimentation and filter tanks was completed in 1895 and the system reduced the ratio of infectious gastrointestinal disease cases to one tenth in the early 1900s. With respect to sewerage, the city had used the so-called "Taiko" sewer (the drainage system with open channels, which was created as a part of town development at the end of the 16th century). Osaka started improving the system in 1894 and commenced on the first full-scale sewer construction in Japan. The sewerage system at that time could only discharge collected waste water into the rivers. Since an English thesis on the activated sludge process was published in 1913, the city started in 1924 to experiment with the first activated sludge treatment in Japan at the Ichioka water plant. The activated sludge treatment plant was completed in 1940 to treat sewage from the center of the city.

The city also adopted the "beneficiary-pays principle" for its sewerage construction in the pre-war period and collected one fourth of the construction costs (although the central government set the principle by responding to the request from Osaka city, the principle does not exist any more). Furthermore, the city asked for national authorization to initiate a user charge system for sewerage, and introduced it in 1940. The system still exists.

Waste disposal Osaka first contracted out its waste disposal works to the fire fighters' organization from the early Meiji period to keep the city clean, and then started its own bidding system operation in 1889. This is because waste was treated as a valuable commodity for its agricultural use. The treatment methods of the early 19th century were agricultural use, coastal reclamation and ocean dumping. However, problems such as an epidemic of contagious diseases, a shortage of appropriate land for reclamation, and waste suspended in the sea, became more evident and incineration became an attractive alternative. In 1903, the city directly operated the waste disposal works and constructed a full-scale incineration plant. Thereafter, new in-

cineration plants were constructed and expanded resulting in a total incineration capacity of 750 ton/day in 1929. (A large amount of night soil was used in agriculture, however, many problems regarding night soil treatment arose after World War II.)

The Period of Pollution Caused by a Rapid Economic Growth and the Years of Groping Pollution Countermeasures (1950s to mid-1960s)

Social, economic, and pollution conditions in the post-war period The economic growth during the post-war reconstruction period and the rapid industrial development around 1950 continued with the development of factories in the western coastal area, centering on the Nishi Yodogawa Ward where the war damage was relatively small. Accompanying this process, subsidence in the pre-war period or industrial pollution such as soot and smoke from factories again became problems. In 1954, there were only 500 pollution control activities (which exclude wastes, sewage, and water supply) among the 200 thousand activities monitored by the environmental sanitation staff at the health centers in Osaka. However, the city had already started responding to the many complaints.

Osaka prefectural government ordinance The second ordinance following the Tokyo Metropolitan Government Ordinance, the "Osaka Prefectural Ordinance for Workplace Pollution Control," was established in August of 1950, and regulated the soot and smoke discharged from the workplace which damages humans, animals, or properties. The ordinance precisely stipulated the targeted workplaces and the pollution criteria. However, the ordinance focused on the actions taken when the governor recognized the necessity of action after the pollution happened. Therefore, the ordinance was not enough to counter general air pollution. As a result the ordinance was totally revised in April of 1954 in order to cope with the increased pollution problems. The revised ordinance first adopted the pre-notification system to new construction, extension, or structural modification of a special facility. However, the emission standards in the revised ordinance was only used at the governor's designation and the ordinance did not impose an observance obligation upon entrepreneurs.

The further revision of the ordinance in 1965, which clearly stipulates an observance obligation of the regulatory standards, strengthened pre-regulatory measures and rationalized the regulatory standards. Also, the revision included the regulatory standards for not only soot and smoke, waste water, and noise but also hazardous gas and vibration. Particularly, since Osaka Prefectural Government transferred the regulatory authority for business establishments and hazardous gas to the City of Osaka, the implementation of factory guidance became smoother.

Pollution countermeasures at the national level Since around 1950, air pollution and water pollution became social problems as industrial activities activated. Pollution countermeasures mainly depended upon the municipal ordinances. The Ministry of Health and Welfare in November of 1955 prepared the "Living Environmental Pollution Control Standards Bill", but the MITI, which promotes industry, and the economic circles (Federation of Economic Organizations — Keidanren) opposed it. In February of 1956, the Kansai Economic Federation officially announced "The Opinion against the Living Environmental Pollution Control Standards Bill", which asserted that the bill would adversely affect the industrial activities by imposing an excessive compensation or contribution for pollution control upon companies.

Frequent pollution incidents demanded that active actions be taken at the national level. The

national government enacted three laws for pollution control, namely, the "Factory Effluents Control Law", the "Water Quality Conservation Law" (1958), and the "Soot and Smoke Regulation Law" (1962). However, since enactment of these laws aimed at not only protecting national health and the living environment but also strengthening industry, they were not sufficient at controlling pollution which got worse.

Pollution countermeasures at the city level This section presents pollution countermeasures at the city level. The city of Osaka started handling pollution complaints, researched air pollution (smog) which was the major pollution problem at that time, and promoted the citizen's anti-pollution campaign based on the pre-war experience and voluntary anti-pollution actions by polluting industries. They also addressed subsidence, noise control by citizens' participation, the provision of sewerage construction and waste disposal.

From public health to pollution countermeasures Since 1955, technological innovation and a structural change in industry were developed with economic policy; the pollution problems became diverse and worse. As an example of air pollution in this period, a meteorological station observed the increase of smoggy days (less than 2 km visibility range) up to more than 50 (see Figure 2-3). This was during the period before the laws were implemented to counter pollution. The City of Osaka dealt with the citizens' complaints or petitions by researching the actual condition of the problems from the environmental sanitation standpoint, and requested the sources to take necessary anti-pollution actions by themselves.

According to the survey of public opinion on soot and smoke by Osaka city in 1956, 43% of citizens suffered to varying degrees as a result of soot and smoke, and 73% of citizens wanted a soot and smoke control ordinance. Further research on urban air pollution problems needed cooperation from many fields, the "Kinki Area Air Pollution Research Committee" which consists of prefectures, universities, research institutes, meteorological stations, related companies, etc. in the Kinki area was established in July of 1956. Eventually, the research results obtained by the committee were very useful in setting the environmental management standards and introducing scientific air pollution measures.

Soot and smoke (smog) countermeasures Most soot and smoke (smog) in this period mainly originated from coal combustion. The conditions from smog, which was caused primarily by heaters in buildings, were so serious that cars had to keep the headlights on in winter. Industrialists recognized the condition as a major urban health problem. In order to counter the situation, the city passed a guidance, developed the management method for proper coal combustion, and requested self control of industrialists. Concretely, the city helped to create the soot and smoke control board in each district (the first board was formed in 1958), and diffused a guidance, technique, and knowledge of combustion through the boards. The "Osaka City Soot and Smoke Control Union" was established in 1960 as a union of the boards, and the members of the union actively exchanged information.

From 1958, the City of Osaka started the soot and smoke control month in wintertime when building heating was most common. In cooperation with the soot and smoke control board, the City of Osaka conducted lecture courses, free diagnostic checks of factories' heat management, soot and smoke monitoring, and various campaign programmes of soot and smoke pollution prevention aiming to increase public awareness and knowledge of air pollution issues.

These campaigns, which were conducted by the local government as well as by the voluntary orga-

nizations of industrialists, were basically not different from those conducted in the pre-war period. The main purpose of the guidance was to develop complete combustion management through the control of soot and smoke produced from coal, but also to rationalize the use of energy by improving heat efficiency. Since the combustion management had merits for corporations, they actively cooperated though the city did not have any legal basis to give guidance. Since the national energy policy at the time began shifting from coal to heavy oil companies faced a renewal of facility and readily accepted shifting to liquid fuel. The city gave guidance on fuel conversion from coal to liquid fuels such as heavy oil, facilitating control of soot and smoke. However, the conversion brought an increase in such new air pollution problems such as sulfur dioxide pollution.

The "Soot and Smoke Regulation Law" established in June of 1962 was fully enacted in September of 1963 and Osaka Prefectural Government had the authority to take measures against factory pollution based on the law. At the same time, the regulatory authority for boilers in business establishments was transferred to the city from Osaka Prefectural Government. The administrative guidance to the factories got smoother with a legal backup. Clause 22 in the Smoke and Soot Regulation Law referred to the "emergency measures", but the law did not set concrete standards for implementation. Thus, the "Guidelines for Emergency Measures on Air Pollution Control" were set based on the discussion among Osaka Prefectural Government, the City of Osaka, the City of Sakai and meteorological stations.

Advance smog information was issued prior to the law's enforcement with the cooperation of the related press organizations and with an initiative in full scale implementation of emergency measures based on the Soot and Smoke Regulation Law, smog reduction was a great success. The smog information was released based on the high probability of smog with consideration of the concentration of sulfur dioxide and climate conditions Broadcasting around 7 am, radios and televisions (NHK and three commercial broadcasting stations) called for restraint in unnecessary and non-urgent combustion and an improvement of the combustion method.

As the smog information was released, the health center requested the facilities to limit the emissions. This became a model of full scale implementation of urgent measures under the Smoke and Soot Regulation Law and was very successful in educating citizens. The reasons for the success were because: 1) Osaka accumulated data in research institutions since the pre-war period, 2) had enough campaign experience for soot and smoke control with the cooperation of companies and citizens, and 3) had enough expertise with the issues in the frontline administrative officers, researchers, and corporate members who had been coping with the soot and smoke pollution.

Table 2-1 shows the frequency of smog information in the winter of 1962 (January, 21 to March, 31).

Research on air pollution To obtain the actual conditions of environmental pollution and its impacts is an extremely important basis for environmental protection measures. The dust fall monitoring system, begun in 1922 (15 monitoring stations in 1960), had to be modified since the later fuel conversion changed air pollutants from soot and smoke to sulfur dioxide.

In 1958, 11 monitoring stations (33 stations in 1959 and later 100 stations) in the city monitored sulfur dioxide with the PbO2 method (See ANNEX 1). Although this method could not measure the volume of sulfur dioxide in the air, or pollution conditions for short periods such as day or hour, it was

Type of alert	Conditions of smog appearance after the release of smog information: Smoggy days	Clear days	Total
Number of smog warning release	15days	10days	25days
Number of no smog \warning issuance	6days	39days	45days
Total	21days	49days	70days
SO2 concentration at the datum point (at 9:00 am)	SO2 concentration (max.)		0.27ppm
	Days of more than 0.20ppm of SO2 concentration		2days
	Days of 0.10-0.19ppm of SO2 concentration		17days
	Average SO2 concentration		0.16ppm

Table 2-1 Number of Smog Information Release in 1962

very simple. Therefore, it played an important role in creating a map of sulfur dioxide concentration and the changes in concentration. Thereafter, the researchers at the Osaka Municipal Hygiene Laboratory utilized a method which measures the volume of sulfur dioxide because a change of concentration and an absolute volume of pollutants are indispensable to promote air pollution countermeasures. Moreover, the researchers and the engineers in Osaka developed automatic continuous monitoring equipment to measure the changeable conditions of pollution. The equipment was on the market by 1962. This equipment was introduced into the area with serious pollution such as Osaka city, and shaped the current monitoring system.

Because air pollution caused smog and poor visibility, the city started observing visibility at 27 fire stations in 1963. It could roughly obtain the conditions and changes in air pollution by conducting surveys at fixed times. Because it was a relatively easy method, it was able to clearly show citizens and industrialists current pollution conditions. It effectively led to a self-reduction of fuel consumption by companies.

It takes more than administrative control and laws to promote air pollution countermeasures by companies. Also, control only by laws (emission standards) cannot catch up with worsening pollution conditions in the serious polluted areas such as Osaka. In order to develop the effective countermeasures, it is indispensable that companies and citizens understand and recognize the seriousness of air pollution and recognize the need of countermeasures. In the city of Osaka, the citizens were informed widely on air pollution monitoring including scientific and advanced measurement methods. Public opinion on pollution control measures was regarded by the city of Osaka as a prime reason to clean the air before the development of laws.

Due to local characteristics and geographical conditions, the Nishi Yodogawa ward in the coastal region of the city experienced serious air pollution and many chronic bronchitis cases were reported. Osaka prefecture, Osaka city health institute, hospitals and universities had conducted a large-scale cooperative research for five years from 1964 and detected a cause-effect relationship between air pollution and the number of bronchitis patients. Based on the research, the city of Osaka established a special task force against pollution and promoted important policies. Other research such as "Economic damages caused by pollution (Economic impacts of air pollution on household, business/commercial, and governmental/public sectors),""Conditions and impacts of air pollution indicated by metal corrosion,"surveys on automobile exhaust gas pollution, and so forth were conducted. The scientific detection of such air pollution was useful to promote the later planned measures.

Land subsidence countermeasures Since more than 120 cm of subsidence occurred in the industrial district of the western coastal area during the

period between 1934 and 1945, a breakwater was built in the coastal area in order to protect Osaka city from high tide. However, the maintenance of breakwater during WWII proved insufficient. The Jane Typhoon in 1950 caused huge water damage with almost 21% of the city area being submerged. Thereafter, Osaka City administration placed a high priority on projects for high tide control. Under the cooperation of the national and Osaka Prefectural governments, the city built breakwaters, piled up soil in some parts, fully provided the water gate for tide protection or the effluent pump, and raised the height of bridges.

In order to regulate the consumption of ground water, which is a cause of subsidence, the city asked the national government to control the use of ground water by law. The "Industrial Water Law" was established in 1956, and the city in 1959 banned any new construction of wells which did not meet the authorized standards in the designated area. Before the application of the regulations on pumping industrial water, the city began constructing the industrial water system in 1951 in order to secure substitute water and started supplying it from 1954. The "Osaka City Subsidence Control Ordinance of 1959" was established in order to prevent subsidence in urban areas. Based upon the Industrial Water Law, the ordinance regulates the pumping of water for air conditioning systems in buildings. However, the conditions of subsidence could not get better until the establishment of the "Law concerning Regulation of Pumping-up of Ground Water for Use in Building" due to the second Muroto Typhoon damages in 1961, or the actual ban of the use of ground water through the amended Industrial Water Law.

Quiet town campaign As the City of Osaka revitalized, noise developed into a problem. Although the loud street advertising announcements, which started in 1950 spread noise all over the town, it was ended by police guidance. Thereafter, an increase in automobiles boosted complaints about traffic noise. The public opinion poll at that time showed that the citizens were in favor of establishment of ordinances to control noise (77.4% in the 1954 poll). In October of 1953, the research on the average level of noise at 68 points (at street level) in the city found that busy streets or traffic centers are the noisiest. The neighborhoods of schools or hospitals showed 68 dB(A) during the day, when it should be quiet.

At that time, the noise control ordinances in some municipal areas were not so effective. Thus, the Osaka city conducted research into noise damages, road conditions, traffic volume, the use of horns, etc. in order to control noise by citizens' movement rather than ordinance. The city developed the "Quiet Town Campaign Promotion Head Office" as a center of citizens' movement at the end of February of 1958 and started a full scale campaign in March. Radio and television were used to promote this campaign in addition to other advertisement tools such as standing signboards, posters, leaflets, and so forth. With the strong backup of the press, results were more successful than expected (the average frequency of horn honking in the city changed from average 27/min. to 1/min.). According to the public opinion poll taken one month after the campaign, more than 90% of the citizens who responded to the poll favored the continuation of the "Quite Town Campaign." As a second step, other measures were promoted to counter noise. Vehicles were required to have fully functioning mufflers and drivers were requested to exhibit better driving manners. Anyone wishing to use the speaker horn on the street had to acquire conditional permission from the police.

The success of the campaign caught the attention of every city, and the campaign spread nationally. The campaign also obtained overseas attention,

and the Mayor of Osaka was presented with an award from the National Noise Abatement Council in the US. The reasons for this success are assumed as follows:

1) Since the noise damage in the city was manifest, its reduction became a base for citizens' movement;

2) Citizens who took actions. The campaign was not forced or enforced, but appealed to drivers through voluntarily guidance in the use of horns and mufflers;

3) Ownership by the peoples living in Osaka; and

4) Cooperation of all the parties concerned in promotion of the campaign.

Development of sewer system The construction works of sewage treatment were resumed in 1957, after the national government decided to subsidize the construction of sewage treatment in order to ban the dumping of night soil into Osaka Bay. Two new plants were constructed, and two old plants were augmented. Although all of these plants were supposed to adopt the activated sludge method, one of them was later switched to the sedimentation method so that it could add a septic tank for the treatment of night soil. The 10-year Program for Public Sewerage Construction of 1960 proposed the construction of twelve new plants and eight of them were designed to employ the sedimentation method. Later on, facilities with activated sludge method were added. This is the current sewage system.

Development of waste management system The incinerators in the city of Osaka underwent great damage during the WWII. The city resumed waste collection in 1946 and used it to fill bomb craters remaining from the war. In 1948, the reassembling of incinerators began and incinerators from the pre-war period that were recovered by 1957 could burn a part of the waste. However, due to the increase of the amount of wastes every year, it became more and more difficult to obtain the land suitable for landfill. Also, as the citizens' complaints about waste pollution increased, greater incineration capacity became an urgent necessity. In June 1958, two existent incinerators began to operate twice a day (morning and evening) to cope with this problem. However, this did not change the situation drastically because of the aging and low efficiency of the incineration facilities. Finally in 1959, the city built an incinerator whose capability was four times greater than that of the older ones. This was the only incinerator with a batch furnace in the entire city.

At that time, soot and smoke were critical problems in the City of Osaka. The construction of an incinerator that did not produce much pollution was needed. Thus, in 1956, the city started considering the introduction of the Swedish "De Roll" furnace, which was new in Europe. However, the city budget in 1956 for the Public Cleansing Bureau was about 1.6 billion yen (the cost of construction for the incinerator in 1959 was 0.2 billion), which was nearly the same as the estimated construction cost of a De Roll furnace. Moreover, because the government subsidy was not provided for the construction of incineration plants at that time, the City of Osaka would have to take all responsibilities for any failure. In fact, many people were worried about the introduction of the De Roll furnace because of the difference in waste types between Switzerland and Osaka city. The Osaka Municipal Hygiene Laboratory analyzed wastes and determined whether wastes in Osaka city could be adequately burned by the De Roll furnace. The introduction of De Roll furnace did not progress despite the favourable decision by the Osaka City Assembly in March 1959. In addition to opposition to the choice of site (no

one wanted an incinerator built in his/her own neighborhood) and technical concerns over insufficient heat value of waste, the main difficulties to overcome were concerns over the legal problems (patent rights, trademark rights, etc.) in introducing new technology and technical knowledge from foreign companies and the price of royalties. Since the estimate of the construction cost increased to a total of 2.2 billion yen, which was far beyond the city's general budget, the city issued the special bond to help finance the project. It took seven years for the city to start construction after the introduction was planned and construction was finally completed in 1965. The completion of the furnace implanted the idea that machine furnaces should be used for waste incineration in all of the major cities in the nation. Afterwards, that same type of incinerator became popular throughout the nation.

Immediately after the war, the demand for night soil in farming regions was strong due to a lack of chemical fertilizers. However, after the development of a chemical fertilizers, night soil became obsolete. All cities had a slight excess of night soil during 1948-49 and an excess of more than 20% around 1950. The excess amounts increased yearly and a night soil problem rapidly unfolded. A part of collected night soil was dumped illegally into the rivers and waterways. To counter that problem, the city set a night soil influent facility in the middle of trunk sewers, and began the operation late in 1949. However, this method also ceased to work due to an increase in surplus night soil. The need for the installation of flush toilets and an increase in the number of sewage treatment plants were urgent. In the meantime, from 1952 to 1960, sewage was dumped into the ocean. Since 1960, an increase in the sewage treatment area and the construction of septic tanks in the sewage treatment plants has decreased the volume of night soil collected and the collected night soil was mostly treated by the sewer system.

The Period of Seriousness of Industrial Pollution, and Stricter Planned and Scientific Administrative Guidance for Pollution Sources (1960s to 1970s)

Socio-economic conditions In the high economic growth period, the total output of products in the City of Osaka was 1,277.7 billion yen in 1960, 1,864.4 billion in 1965, and 3,369.4 billion in 1970. This period emphasized quantity rather than quality of production. Japan's World Exposition 1970 in Osaka symbolized the period's peak. Projects related to the Exposition lavishly provided urban infrastructure such as roads, railways, etc. At the same time, the pollution problems became serious. As for air pollution, problems of SOx replaced those of soot and smoke. The mass media vigorously reported the continued pollution damage, such as the frequent occurrence of the Yokkaichi- asthma in 1960 and the Agano River mercury poisoning in 1964. The reality of pollution boosted the public concern for reducing pollution.

Pollution countermeasures at the national level The increase in pollution proved that legal measures such as the two water-related laws and the Soot and Smoke Regulation Law were not sufficient. Strong public concern over pollution removal prompted the establishment of the "Basic Law for Environmental Pollution Control" in 1967 that defined the range of pollution and gave direction for environmental standards. In 1968, the "Air Pollution Control Law" and the "Noise Regulation Law" were established. In addition, eight similar laws were partially amended and established in the so-called "Pollution Diet" of 1970. The start of the Environment Agency in 1971 strengthened anti-pollution measures at the national level. The environmental standard of sulfur dioxide was first set in 1969 the others were followed to be set successively.

Revision of Osaka prefectural ordinance The categories of the pollution regulated by laws had

rapidly expanded since the national government established pollution-related laws such as the "Basic Law for Environmental Pollution Control". A large part of the ordinances came to be regulated by laws. With the development of industrialization and urbanization, pollution that the old ordinances did not cover emerged, promoting stricter regulations. In April 1969, the Osaka Prefectural Government asked the "Osaka Prefectural Pollution Control Council" to discuss a revision of the ordinances. According to its result, the Osaka Prefectural Government issued the revised ordinances and enforced them along with new environmental standards and regulations in April 1970.

Pollution Countermeasures at the City Level Air pollution due to dust fall and SOx and water pollution due to factory effluent were serious in this period. In particular, severe air pollution in the western coastal region developed into a significant social problem receiving top priority from the city. The Chuma administration, which pledged to administer pollution countermeasures, took office and rapidly developed pollution countermeasures. This section describes the measures for reducing sulfur dioxide by the scientific method, installing a monitoring system, creating of a corporate support system, and effecting the measures for controlling sewage and industrial wastes.

The planned pollution countermeasures In April 1962, the City of Osaka set up the "Osaka City Pollution Control Council" as an advisory committee for the mayor; it discussed basic policies for pollution control administration and provided the scientific backbone. For example, the city's administration asked the council to set a target for air pollution countermeasures. In December 1965 the council recommended, and set the environmental management standards on air pollution, as the first case and the foremost administrative goals in Japan. The basic direction of the air pollution countermeasures set at that time became the fundamental strategy for air pollution control in the City of Osaka.

Urgent measures to control air pollution in the Nishi Yodogawa ward started in June 1970. They introduced the first air diffusion simulation technique to the Japanese administration and gave scientifically-backed guidance for pollution sources. They later developed into the regulations controlling the total SOx emission and became a starting point for the current air pollution control plan.

24-hour monitoring system of environmental pollution The responses of the Osaka City Pollution Control Council to the management standards for air pollution in 1965 emphasized the need for regular monitoring of air pollution. The Council recommended that the City provide monitoring stations. The City of Osaka immediately started providing a regular monitoring network for air pollution, and built the most basic monitoring system in three years (consisting of a central station, ten monitoring stations, one meteorological station, and a telemeter system for the central station). The construction cost of the system was about 77 million yen which accounted for 0.022% of the three year total of the city's general budget (356.6 billion yen). The distributed income per person in the city was 471 thousand yen in 1967 (4,390 thousand yen in 1989).

Thereafter, the monitoring network was strengthened by increasing the number of monitoring stations along the road. In order to strengthen regulations on the sources of pollution such as factories, a 24-hour measurement of fuel consumption and sulfur dioxide emissions from large factories was initiated in 1974. Furthermore, the 24-hour water quality monitoring system to regulate total effluents started operating from 1979

Support system The installation of pollution control facilities was very costly in the short term, and

required swift implementation to minimize these costs. Therefore, a loan system for companies installing pollution control facilities was started in March of 1967 to aid in providing the necessary financing with lower interest rate. Since 1970, the Japan Environment Corporation has facilitated transfer or grouping of polluting factories.

The development of sewerage This section presents an introduction to the water quality charge system and river cleaning as water pollution countermeasures.

An introduction to the water quality charge system Under the reorganization of the post-war administrative system, the "beneficiary-pays principle" for sewerage construction disappeared. With regards to the charge for using sewers, collection of user charges for flush toilets started in 1951, and adopted the meter-rate system to replace the diminishing charges system to a large user in 1965. However, the system reverted back to the "polluter-pays principle" in 1972. The water quality charge was newly established and meter-rate system changed to gradual increase system.

This collection system based on not only quantity but also quality aimed at inducing a corporate effort towards improving water quality relating to BOD (or COD) and SS (Suspended Solids) roads. Water quality charges are included into water consumption charges. Since this system is a great financial burden on factories, the factories improved water quality by installing a treatment facility, and reduced effluent volume or pollutant load by saving water and recycling the waste water (Figure 2-11).

River cleaning by development of sewerage — Shirokita Canal (currently Shirokita River) The Shirokita Canal is a typical example of a measure for cleaning the city rivers. Under the industrial re-

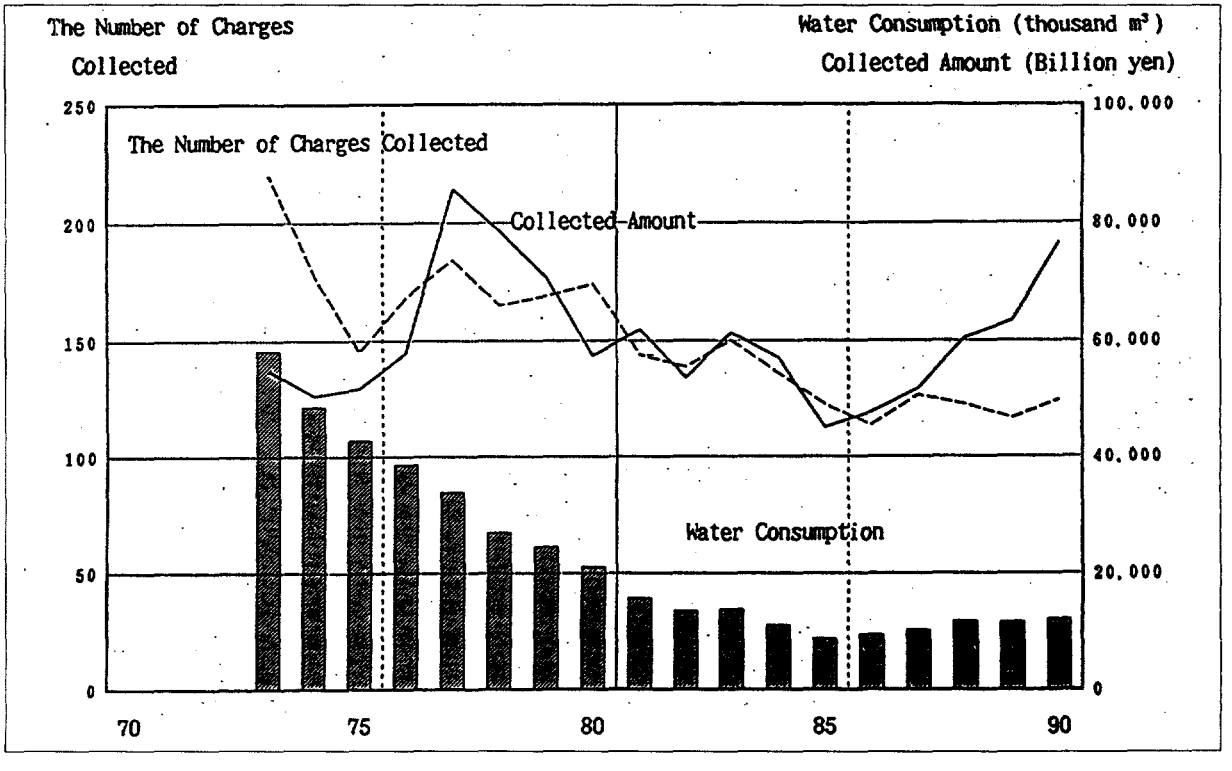


Figure 2-11: The Number and Amount of Water Consumption Charges Collected amd Water Consumption, 1973–90

gions development plan in the northeastern part of the city, the Shirokita Canal was excavated during 1935-40, with a total length of 5,615 m and a width of 40 m. In the post-war period, due to rapid economic development in this canal area, the volume of waste water discharged annually from households and factories into the canal increased, and water pollution annually became worse. Around 1955, the degree of contamination in the canal was the worst and constituted a severe health threat in the city. Therefore, the city of Osaka designed and provided the following clean-up plan in 1965. Implementation was made during 1966–1970.

a) Trunk sewers were installed at both sides of the river banks in order to draw waste water into the sewage treatment plant. For the installation, both sides of the river banks were reclaimed .

b) The environment in the reclaimed land was improved by building a river park.

c) In order to improve water quality, clean water in the river was drawn by operating the water gate of the canal at high tide.

Figure 2-12 shows the result of the clean-up plan implementation. BOD load decreased drastically since 1968 and remained at low level from 1972 onward.

Countermeasures for industrial waste As the pollution regulations accompanying industrial development got stricter, waste originating from waste water/exhaust gas treatment processes also increased. The "Waste Disposal and Public Cleansing Law," a revision of the "Public Cleansing Law," first

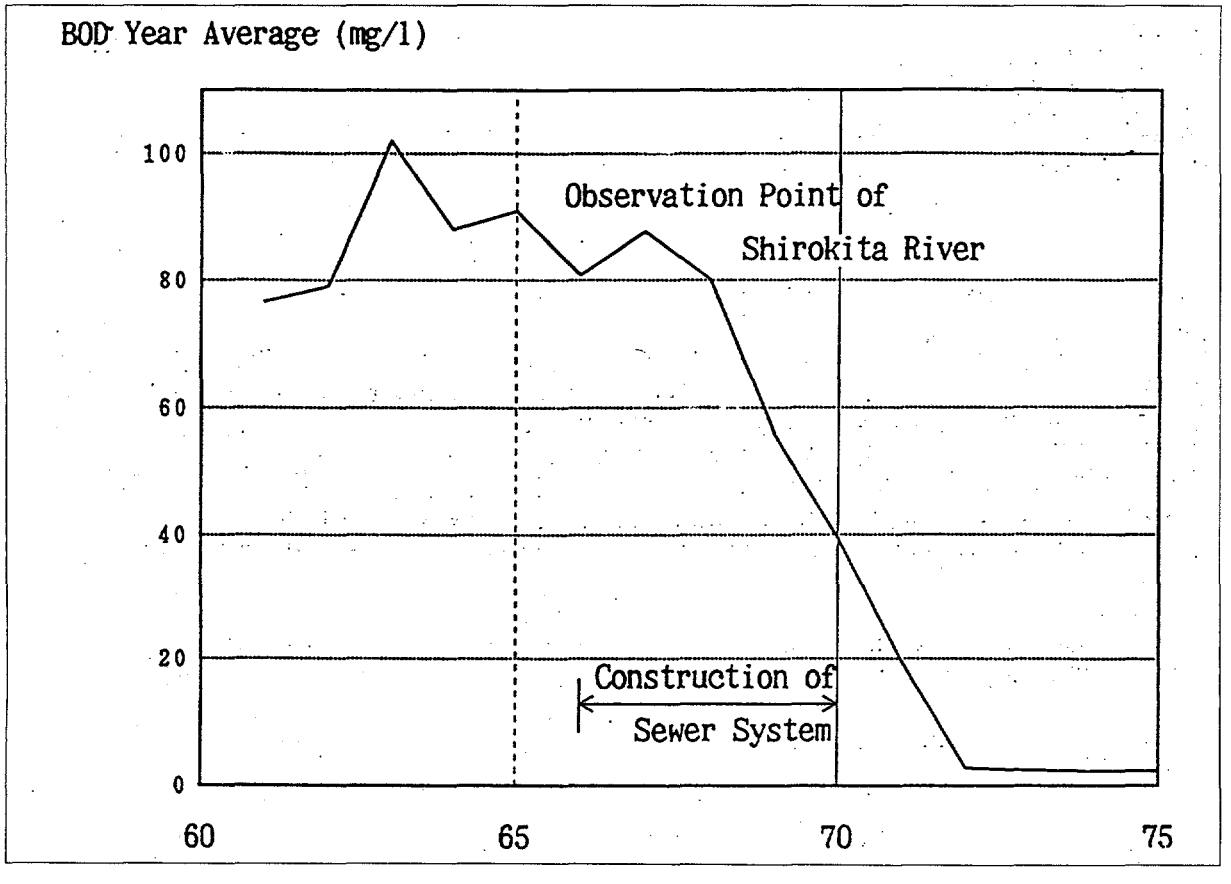


Figure 2-12: Effect of Sewerage Project in Shirokita River

distinguished industrial wastes from general wastes. However, the City of Osaka recognized the importance of industrial waste treatment and conducted joint research on the volume of wastes with the Osaka prefecture in 1968 to collect data for promoting area-wide waste treatment works. According to the city's research on verifying the companies' desires for public sector involvement with industrial waste treatment in the Nishi Yodobashi ward, two-thirds of the companies favored a lump-sum treatment by the city of Osaka. The Waste Disposal and Public Cleansing Law provided that the industrial waste dischargers should be responsible for their waste disposal. However, because of a lack of waste treatment facilities and the existence of many small and medium-sized industries without enough capabilities, the city concluded that the industrial wastes should be treated by the public sector in cooperation with companies, and further examined the forms of public involvement with industrial waste treatment works.

Also, Osaka city did not have sites for the new treatment facilities and consulted with Osaka prefecture about the effective measures. As a result of this effort, the city, along with the Osaka prefecture established the "Osaka Industrial Waste Treatment Corporation." The purpose of this corporation was to provide industrial waste treatment service by public sector involvement while charging an appropriate treatment fee from companies.

From the Period of Industrial Pollution to the Period of Urban Pollution (1980s)

This section presents countermeasures for air pollution by automobiles (typical urban and life-oriented pollution) since the 1960s.

Automobile pollution control (since the 1960's)

Under the municipal leadership With a significant increase in the number of automobiles, CO pollution became a serious problems and full-scale research on air pollution started around 1962. In 1967, the idling adjustment was implemented to control CO. The Osaka prefecture and the city, with the cooperation of the automobile-related groups, established the "Osaka Conference for Automobile Exhaust Gas Control" in 1968 and promoted the campaign to control automobile exhaust gas by an idling adjustment. In 1972, the Environment Agency announced the implementation of the "Guidelines for Permissible Level of Automobile Exhaust," the Japanese counterpart to the US Clean Air Act's amendments of 1970. In 1974, seven large cities including Osaka, formed the "Research Association on Automobile Exhaust Gas for Seven Large Cities," which contributed to promoting exhaust gas regulation.

Integrated measures against automobile pollution (mainly nitrogen dioxide) since the 1980s CO concentration in the city of Osaka decreased yearly. It has met the environmental standard since 1980 in both long-term and short-term assessments. Air pollution caused by nitrogen dioxide emerged and various measures were taken. However, nitrogen dioxide pollution in the urban area did not show a significant improvement. This fact required integrated measures to control automobile traffic and improve roadside environment in the medium- and long-term point of view. In 1980, the City of Osaka focused on mobile source of pollution and conducted studies on quantitative assessment method of environmental improvement impacts of emission reduction or traffic control. The "Osaka Automobile Pollution Prevention Program" was formulated in 1989, setting a reduction target of nitrogen oxide emission from automobiles in order to protect the environment along the main trunk roads in the city. The purpose of the plan is to meet the environmental standards by the year 2000. The four items to implement this measures are: 1) to regulate emission sources, 2) to control traffic volume, 3) to improve roadside environment, and 4) to raise public awareness.

The Relation of the Environment and the Economy in Osaka

With regard to the relation between the economic situation and environmental pollution and its countermeasures in Osaka, we have analyzed the data of air pollution and land subsidence which have been accumulated since the pre-war period.

Economic indicators The "Shipment Values of Manufactured Goods" were used as economic indicators and were converted to the 1985 value by using a pre-war standard wholesale price index to account for deflation.

Environmental indicators For the environmental indicators, we used volume of the insoluble dust fall which has been monitored since 1928 and the land subsidence distance since 1934. Measurement values of dust fall at the Sanitary Institution were adopted. With respect to land subsidence, the monitoring point with the largest distance among many monitoring points was adopted.

The relationship of economic indicators and environmental indicators

The relationship of shipment values of manufactured goods and insoluble dust fall Figure 2-13 shows a change in shipment values of manufactured goods and dust fall. It also shows air pollution countermeasures in the same period. As the nickname "Smoke City" indicates, the City of Osaka in the pre-war period had a serious air pollution problem, but occasionally made efforts to control soot and smoke. The anti-soot and smoke campaign in 1928, as well as recession, successfully reduced dust fall. However, as the economy was restored, dust fall remained unchanged. Accompanied with the economic revitalization in the post-war period, dust fall quickly reached the pre-war level. Around 1955, the shipment values of manufactured goods surpassed that in the pre-war period, and thereafter, had almost increased in a straight line until 1973. Dust fall had remained unchanged until 1963. The national fuel conversion policy from coal to oil beginning in 1955, and the city's soot and smoke control measures since the latter half of 1950 greatly contributed to the control of dust fall. The Soot and

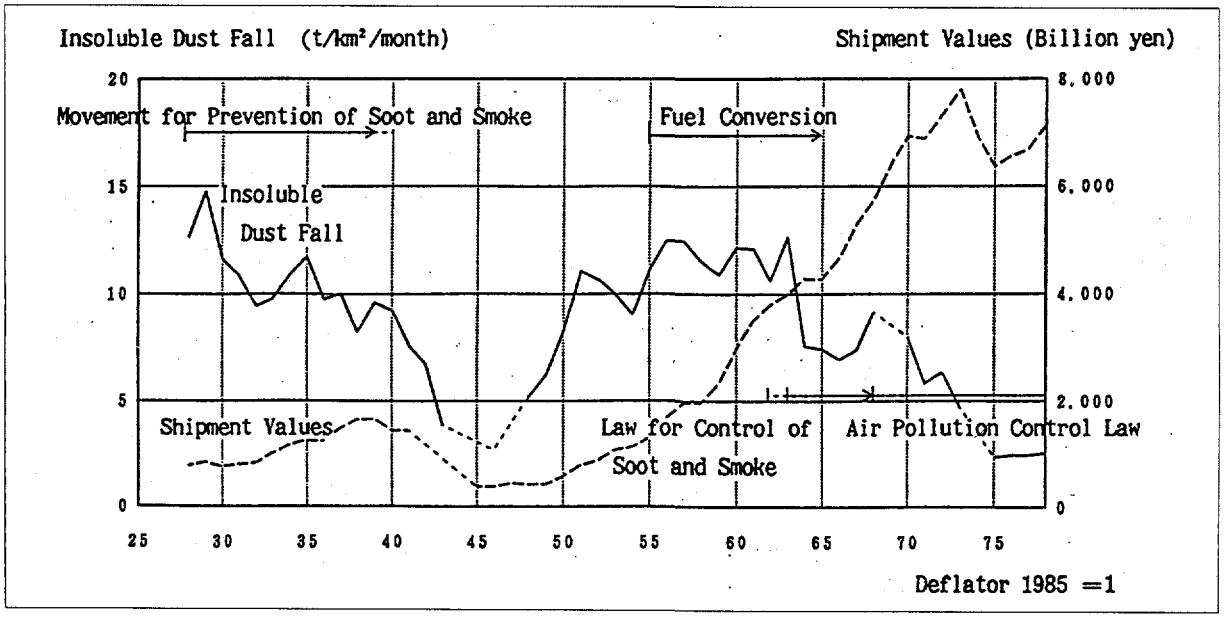


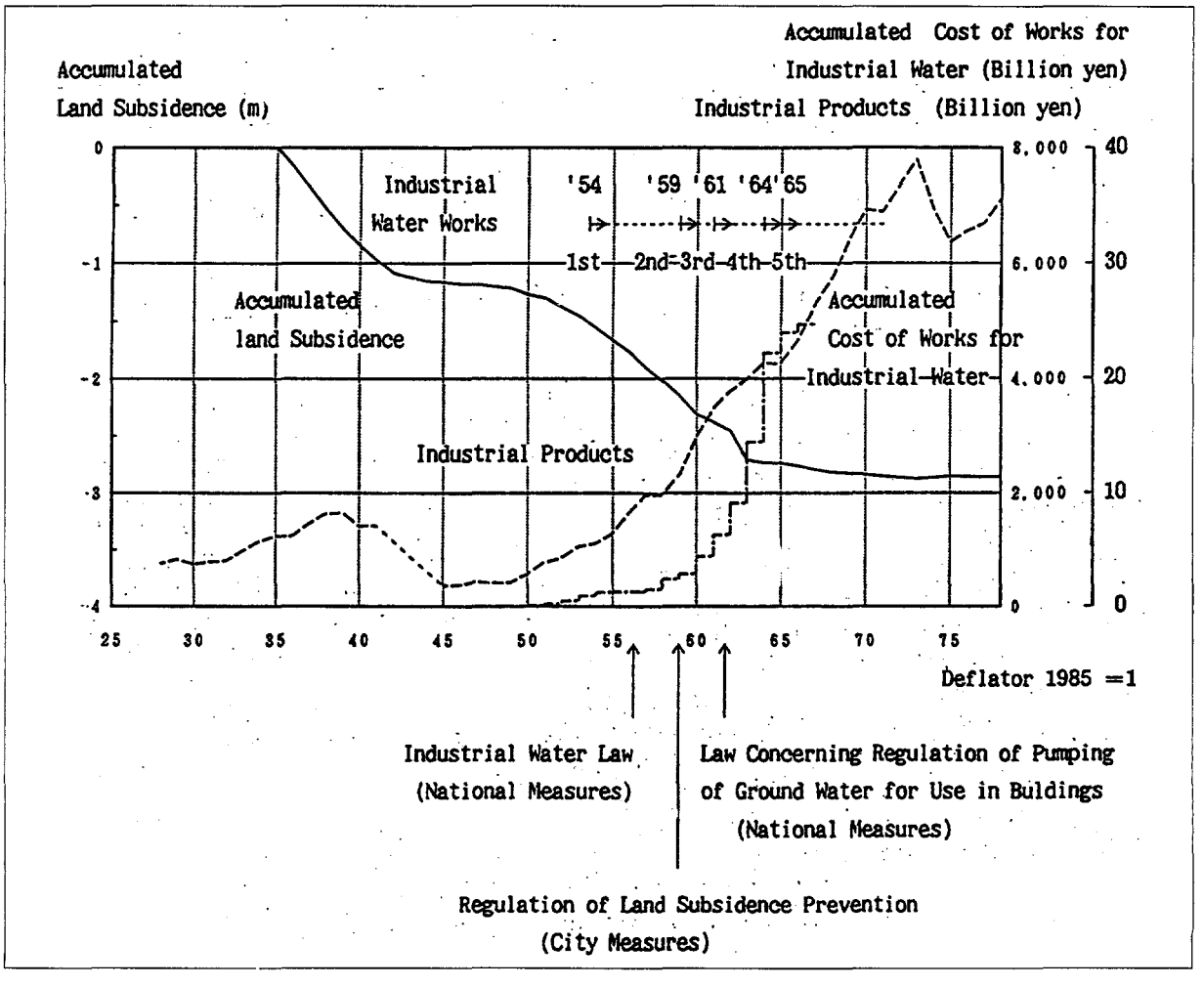
Figure 2-13: Sales of Industrial Products and Insoluble Dust Fall, 1928–78

Smoke Control Regulation Law in 1964 was very effective in reducing dust fall.

The reasons why the degree of air pollution in the City of Osaka in the post-war period did not exceed serious levels of the pre-war period were fuel conversion and soot and smoke control measures. Also, the economic fluctuations affected the emission of soot and smoke. The emission tends to increase when the economy is prosperous.

The relation of shipment values of manufactured goods to land subsidence Figure 2-14 shows a change in shipment values of manufactured goods and accumulated distance of land subsidence. It also shows the costs of the industrial water supply from 1950. The land subsidence identified in the pre-war period increased in accordance with the increase in shipment values of manufactured goods. During WWII and the following five years, land subsidence almost did not occur. With an increase in shipment quantities since 1949, subsidence resumed. Although the subsidence velocity is relatively slower than that in the pre-war period, subsidence increased regardless of any economic fluctuations. Two reasons explain the slow subsidence velocity. One reason is the construction of the industrial water supply. Another reason is the recovery of the level of ground water due to the intermission of the pumping up of ground water.

Figure 2-14: Industrial Products and Accumulated Land Subsidence, 1928–1978



The industrial water supply was provided for the districts with the most severe conditions of land subsidence. After the construction of the industrial water supply system was completed, the pumping of ground water was banned. The construction almost covered all the subsidence areas until 1965, and the subsidence area became very small. The total cost of the industrial water supply development works was 10.65 billion yen at that time and the converted figure to 1985 was 24.7 billion yen.

Organization and Education in Osaka City Environmental Protection

Administrative Organization in Environmental Protection

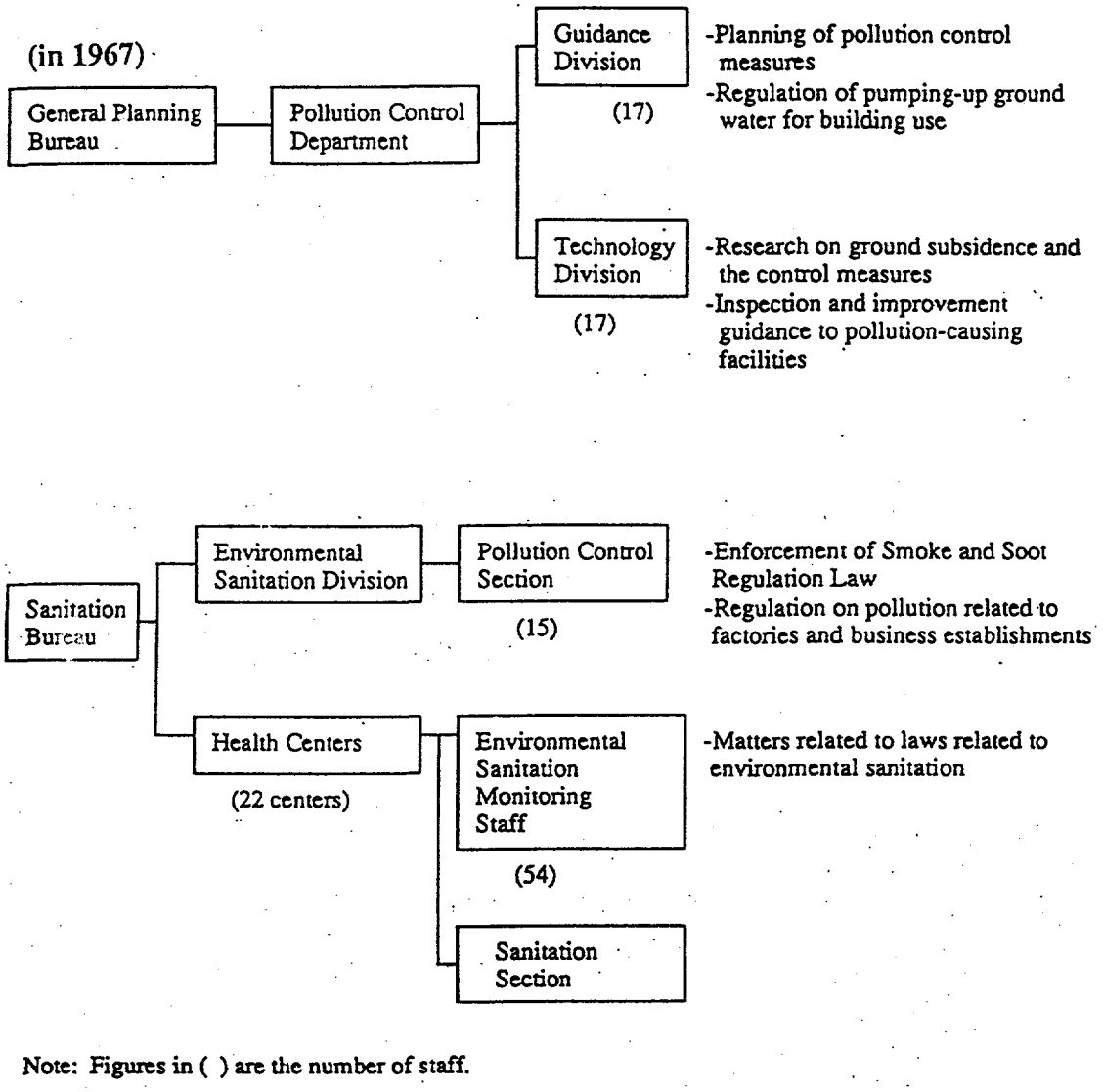
A start of administrative measures Both the Planning Department, which was originally responsible for subsidence, and the Sanitation Department for public health were responsible for pollution countermeasures in the city of Osaka. The research study and the education at the Sanitary Research Institute in the pre-war period played an important role in promoting pollution control measures. With respect to soot and smoke, the Health Section under the Health Department of the Sanitation Bureau first gave combustion guidance in 1937.

Organizational Response In 1958, environmental sanitation monitoring staff at 22 health centers conducted research on fuel consumption at 3295 facilities in the city. In the early stages, the environmental sanitation division of the Sanitation Department, which is usually in charge of public health, also dealt with air pollution problems. However, the full-scale organizational response began in 1966 when the environmental sanitation division was established in the pollution control section, which has a primary responsibility for pollution problems. The Planning Bureau established the Subsidence Prevention Department in February of 1962 in order to systematize subsidence measures. In 1963, this department became the Pollution Control Department of the General Planning Bureau. The General Planning Bureau was responsible for the planning of pollution control by 1968, with an intensification of pollution, the pollution control department had the air pollution management center. The Sanitation Bureau had the local pollution guidance division at the same time. In 1970, the "Special Task Force for Pollution in Nishi-Yodogawa Ward" was organized in order to concentrate on air pollution in the Ward.

The Environmental Department of the Environmental Health Bureau The Environmental Health Bureau was newly established in June of 1971 by combining the Pollution Control Department of the General Planning Bureau and the Sanitation Bureau in order to integrate the administrative structures. The new Environmental Health Bureau included three departments: Management, Health and Environment. Furthermore, the Examination Division was newly organized under the Environmental Department strengthening the administrative structure. The organizations and their functions related to pollution control are shown in Figure 2-15.

Water quality control in the Sewerage Bureau The purpose of water quality control regarding sewerage was to overcome serious pollution conditions of the 1960s. A water quality specialist, who gave guidance to factories discharging effluent into sewerage, was hired in 1963. The staff in charge of water quality control was deployed in June of 1971. Additionally, the Water Research Division (1972) and the Water Quality Institute (1973) were newly es-

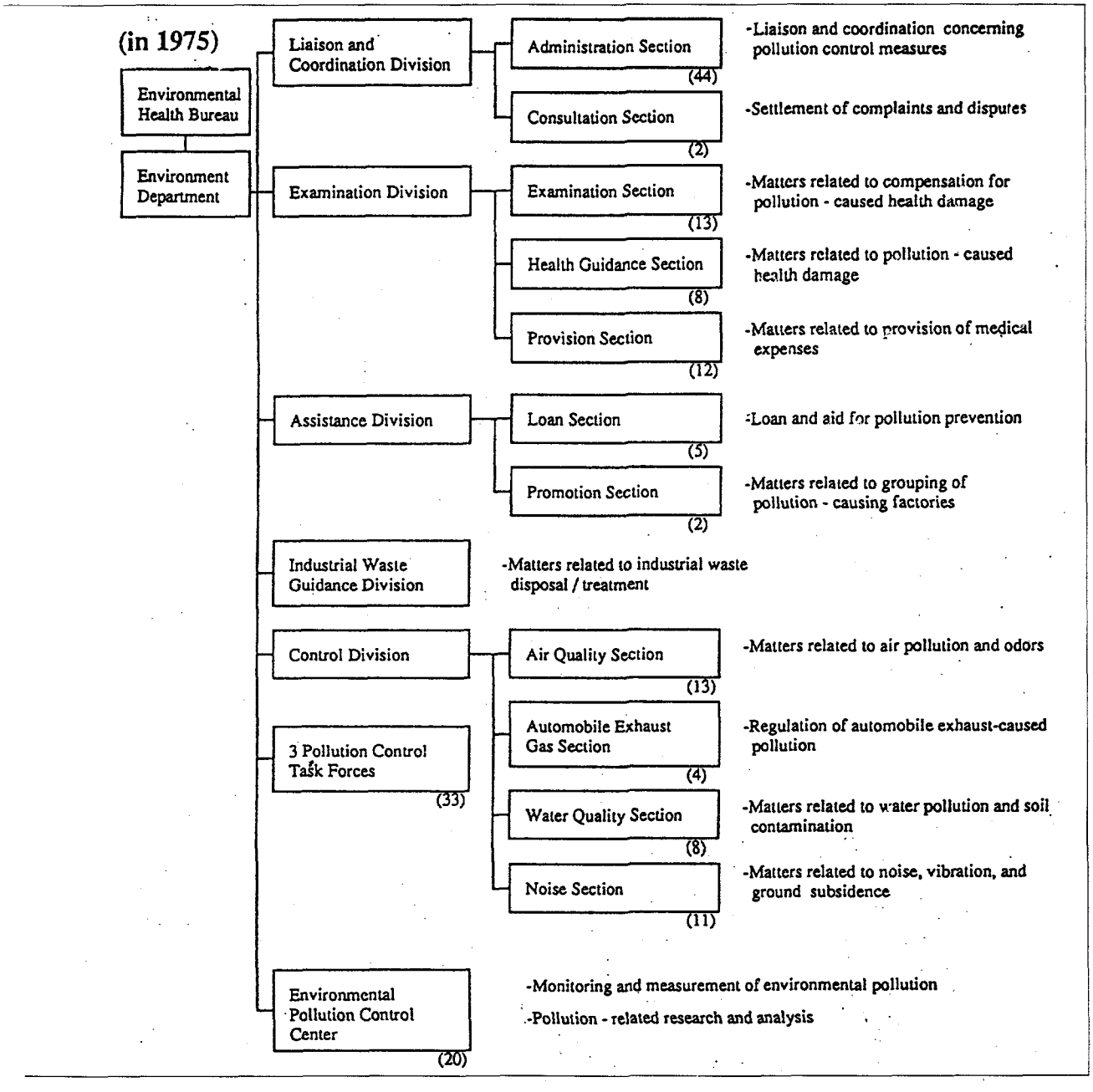
Figure 2-15: Major Organizations and Their Functions Related to Pollution Control in 1967 and 1975



Note: Figures in ( ) are the number of staff.

tablished. Area coverage of the sewerage system including treatment in 1975 exceeded 85% of total city area. Since a large number of factories switched from discharge waste water to sewer, the Sewerage Bureau took the responsibility of implementing water quality control in factories which had been discharging waste water into the public water body. The control of factory effluent that had been regulated by the Water Pollution Control Law was shifted from the Environmental Health Bureau to the Sewerage Bureau in 1975.

Integration of Waste Administration The "Waste Disposal and Public Cleansing Law of 1970" divided wastes into general and industrial wastes, and regu-



lated the entrepreneur's responsibility for treating industrial wastes. The wastes produced from existing treatment facilities of companies were now considered industrial wastes. The Industrial Wastes Guidance Division was established in the Environmental Health Bureau in 1976 to counter industrial wastes. Thereafter, pollution control showed some success through observance of the regulatory standards and an improvement in the entrepreneur's recognition of pollution control. However, many problems required solutions in the whole waste treatment/disposal system. Thus, the industrial waste administration was integrated by moving the Industrial Wastes Guidance Division into the Environmental Works Bureau in 1983.

Table 2-2: Changes in the Number of City Officials in Charge of Pollution Control in Osaka

Pollution Control Bureaus and Divisions	*1969*	*1970*	*1971*	*1972*	*1975*	*1983*
Bureau of Planning						
• Subsidence Prevention Division, (established in 1962 and renamed as the Pollution Control Division in 1963)	38	42				
Sanitation Bureau			95*	111	192	146
• Pollution Control Section, Environmental Sanitation Division (established in 1966 and renamed as the Pollution Control Guidance Division in 1969.)	28	33				
• Nishi-Yodogawa Special Pollution Control Unit	—	13	(13)	(12)	—	—
Sewerage Bureau				17	42	53
• Water Quality Monitoring Division (established in 1972 and renamed in 1979.)						
Environmental Works Bureau						23
• Industrial Waste Management Guidance Division (transferred from Environmental Health Bureau in 1983)						
Total	66	78	95	128	234	222

* Environmental Department of Environmental Health Bureau

Table 2-2 summarizes the changes in the number of city officials in charge of pollution control.

Technical Staff Responsible for Environmental Sanitation At the end of 1958, the environmental sanitation monitoring staff (pharmacist and veterinarian) formed the Association of Environmental Sanitation Monitoring Staff. The group researched pollution problems, aiming at improving administrative capabilities through self-training activity. The City of Osaka deployed the environmental sanitation monitoring staff in charge of public health in 1949, in the middle of the post-war rehabilitation period. At that time, urgent measures were needed since the condition of the living environment was so detrimental. Epidemics of contagious diseases such as typhus broke out. Focusing on facilities such as hair salons, travelers' inns, public baths, and theaters where disease is transmitted to people, laws were established and promulgated for sanitary management. Municipalities started establishing public health focusing on disease prevention.

Pharmacists and veterinarians were appointed to environmental sanitation monitoring staffs because they were familiar with basic public health. They were deployed at the health center in each district to give residents advice. Thereafter, when pollution problems became manifest during high economic growth, a large number of residents' complaints overwhelmed the center. In the City of Osaka, the environmental sanitation monitoring staff took responsibility for these complaints.

Technical Staff in the Environment Division by Type of Work Table 2-3 presents the number of technical workers and their functions in the Environment Division (combination of the former Pollution Guidance Division of the Sanitation Bureau, and the former Pollution Control Division of the General Planning Bureau) by type of occupation.

Role of Public Research Institute in Environmental Protection

Osaka City Institute for Environmental Science (formerly Osaka City Hygiene Research Institute) The Osaka City Institute for Environmental Science was established in 1960 as a hygiene research institute. Since scholars and politicians had a neglectful attitude toward urban sanitary issues at that time in

Table 2-3: The Number and the Functions of the Technical Staff in Environment Division by Occupation in 1966 and 1972

	1966											1972										
Function	*Pharmacist*	*Veterinarian*	*Mechanical Engineer*	*Electrical Engineer*	*Civil Engineer*	*Sanitary Engineer*	*Chemist*	*Architect*	*Meteorologist*	*Mining Engineer*	*TOTAL*	*Pharmacist*	*Veterinarian*	*Mechanical Engineer*	*Electrical Engineer*	*Civil Engineer*	*Sanitary Engineer*	*Chemist*	*Architect*	*Meteorologist*	*Mining Engineer*	*TOTAL*
Monitoring			2	1	1		1		1		**6**	1	2	1	3	3	1	1		1		**11**
Planning-Analysis-Research	2				7			1			**10**	14		7		5	3	2	2			**35**
(Air pollution-Offensiveodor)												4	1	2			2	1				**9**
(Water pollution)	2				2			1			**5**	3		3		2		1				**10**
(Noise-Vibration)												1	1	2					2			**5**
(Industrial waste)												6					1					**8**
(Land subsidence)					5						**5**					3						**3**
Pollution source control-guidance (including the screening of technology subject to loan)	3						1			1	**5**	12		7		1	2	5				**28**
Special Task Force for Pollution in Nishi Yodogawa Ward												7		2								**10**
Research of impacts on human health												2										**2**
Inspection												3						1				**4**
TOTAL	5		2	1	8		2	1	1	1	**21**	32	2	15	3	9	6	9	2	1	1	**80**

Japan, the opening of this institute was unique in the Japan's sanitary administration. Since air pollution at that time in Osaka city was serious, soot and smoke control became an important task for the Institute. Dust-fall monitoring started in 1922 and still continues. The Institute researches sulfurous acid gas, plant damage, UV volume in cities and suburbs, and the degree of pollution damage to clothing. The air pollution control campaign started in 1928 by Osaka prefecture and the City of Osaka cooperated with the Institute through a campaign to monitor the concentration of soot and smoke emitted from factories and by writing an article related to this issue to magazines.

When air pollution got worse in the post-war period, the accumulation of experience and information proved to be very useful, and became a significant factor which allowed Osaka to be the first among Japanese cities to take air pollution control measures. Some measures included the development of monitoring methods on air pollutants and urgent air pollution control in the Nishi Yodogawa ward, which the city's administrative policies successfully improved. Various research on pollution sources or technological guidance on emission control methods played a great role in promoting the control measures.

With respect to other studies, initially the Institute conducted a sanitary examination of river water which is a source of drinking water. However, it started continuous research on water quality in the city rivers in 1937 (still under way) and implemented research on noise and offensive odors in 1930s. The Institute also conducted various research on night soil and waste treatment. It has significantly contributed to the so-called "cleaning administration"

such as control of secondary pollution caused by the final disposal of incineration ash or dust ash, various sludge, and residual soil, and disposal in coastal reclamation sites.

Osaka City Institute for Industry The Osaka City Institute for Industry, established in 1916, is a comprehensive research institute for industrial technology whose purposes are to develop creative technologies appropriate to the needs of local industries and to disseminate these technologies. The Institute has actively contributed to the solution of pollution problems through its own research or joint research with small- and medium-sized companies on such common industrial issues as noise/vibration control technologies and metal-plating related pollution. The research results were publicly disclosed, and the use of patents was opened to small- and medium-sized companies with one tenth of the ordinary price.

Moreover, in order to support small- and medium-sized companies with insufficient capital and technology, the Institute provided on-site technological guidance free of charge. The researchers at the Institute organized a guidance team including university engineers and private consultants. The guidance team made direct inspections of production or processing factories in order to listen to the problems of engineers and staff, pointed out the problems to be improved upon and gave necessary advice on pollution control technology based on comprehensive analysis. Annually, about 90 cases in this project are still examined.

Education, Diffusion and Development in Environmental Protection The task of the environmental sanitation monitoring staff covered a broad range of issues which included rat and insect removal, environmental sanitation of travelers' inns, theaters, and public baths, as well as sanitary inspection in terms of cleaning, sewage treatment, and drinking water. Although each area required special knowledge, the staff could not handle the challenge because they were so occupied with daily work.

In 1958, the "Association of Osaka City Environmental Sanitation Monitoring Staff" was formed as a self-study organization. The purposes of the Association were to promote scientific environmental sanitation administration and to improve the prestige of the staff. The staff obtained skills and knowledge through seminars and training, based on their own real experience. The staff researched the work on special activities and makes presentations of the results, ie, rat and insect removal, business operation regulation and pollution. The Association greatly contributed to the improved quality of the staff and introduced new technology. Particularly, the pollution meeting established a system for handling complaints, researched control technology, conducted research on obtaining actual conditions of pollutants and pollution, and created a technological handbook. These activities greatly contributed to the promotion of pollution control administration in the city. The Association continues, and takes active measures in accordance with changing times.

Training to the other institutions was implemented by the new staff members of the pollution division (which was renamed as environment and consumer protection division) established in the Crime Prevention Department in the Osaka Prefectural Police Headquarters in April of 1974. Furthermore, the city of Osaka annually sends about ten staff members to the National Training Institute for Environmental Pollution Control (established in 1973) for special training. Also, the city itself has training of basic technology in particular fields and makes an effort to improve the quality and capability of the staff.

In this chapter, key measures concerning air pollution, automobile pollution in the 1960s, and land subsidence are presented.

Promotion of the Air Pollution Control Plan Based on the Scientific Method

Environmental Management Standards for Air Pollution

Osaka enjoys mild Setouchi weather, but air pollutants easily accumulate for geographic reasons. Because of the west wind in winter, temperature inversion occurs. Heavy and chemical factories were spread over the western coastal region in the built-up area and played an important role in helping the city gain its appellation, "Smoke City," that persisted up to World War II. After the war, as production in the region increased during the ensuing periods of economic revitalization and rapid economic growth, air pollution in the built-up area in Osaka became serious.

The "Soot and Smoke Control Law" which allows a two-year grace period for emission regulations was established in 1962. The Osaka prefecture had regulatory authority over soot and smoke caused by factories, while the City of Osaka had authority over soot and smoke caused by non-production boilers. Having two authorities made the law ineffective. Controlling soot and smoke from coal combustion became the focus of administrative measures in this period. The City of Osaka provided concrete direction in such forms as comprehensive combustion management that effected the use of full combustion and the conversion of fuel from coal to liquid. Companies in this high economic growth period promoted fuel conversion after giving consideration to economics and production rationalization because they wished to boost their production by renovating the facilities and they faced difficulty in coal ash disposal. The result was that the conversion from coal boilers to heavy oil boilers was swiftly executed in several years. The annual consumption of coal in Osaka city was 1.7 million tons in 1965; it diminished to 1,000 tons per year in 1976. This fuel conversion decreased soot and dust. However, as consumption of heavy oil quickly increased with the expansion of facilities, the impact of sulfur dioxide on the human body caught the attention of the public.

Since soot and dust leave a visible black residue, the objective of the air pollution control measures became cleaning up black smoke. However, since the environmental standard for SO_2 did not exist, determination of the target baseline concentration of SO_2 was critical when the City of Osaka began drafting the measures for controlling air pollution, for getting cooperation from the companies. The health and economic effects of air pollution were not well researched at the time. However, the high incidence of chronic bronchitis and a respiratory ailments of school attendants in Osaka indicated a link to air pollutants.

In order to set the goal of promoting air pollution countermeasures, the City of Osaka consulted the Osaka Pollution Control Councils about "establishment of air pollution control standards," and received its report in 1965. This reply was very advanced and momentous in Japan's pollution control history, and set a precedent for the 1969 cabinet decision on environmental standards regarding sulfur dioxide. The basic recognition in the report is as follows: ideal environmental standards should be identical to the primary stage set by the World Health Organization (WHO) (i.e., at the same or

below the concentration levels and exposure time deemed to have no direct or indirect harmful effects) in regards to the "harmful degree of air pollutant to human body"; however, no industrial city, which is, by nature, highly populated and active in commerce and industry, can be expected to meet these world standards.

Nevertheless, environmental management standards based on findings about the impacts on human body should be set as an administrative target for controlling air pollution. The appropriate level should be set between the primary stage and the secondary stage (a level of concentration and exposure time deemed to have harmful effects on human body and plant life, and adverse effects on the environment) of WHO standards. Concentrations below this level should not cause adverse effects on human health. These standards will be achievable with some effort.

Environmental Management Standards

1)	Sulfurous acid gas* (including sulfuric anhydride)	
	average daily value	0.1 ppm
	daily hour value (once a day)	0.2 ppm
2)	Suspended soot and dust	
	average daily value	0.5 mg/m^3
3)	Dust fall	
	average monthly value	10 ton/km^2

* The maximum concentration level for a short period of time should be set to the limit for the maximum concentration of pollution.

Box 3.1: The Report on Air Pollution Control Standard by Osaka Pollution Control Councils

The "report" suggested concrete measures for providing environmental management standards. The main points contained in the report are as follows:

1) The western coastal industrial region should be designated as the "Special Region for Pollution Control Measures" since it has a massive concentration of pollution sources emitting a large amount of pollutants.
2) Based on the total permitted level of emission, long-term and short-term measures should be planned as part of the "common target between companies and administration."
3) The permissible level of sulfurous acid gas in order to meet current and future environmental management standards should be determined by using the air dispersion simulation method which had been recently developed.
4) Fuel regulations should be enforced to use low-sulfur heavy oil.
5) Dust removal equipment should be installed, and desulfurization equipment should be developed.
6) Pollutants should be diffused by high smoke stacks.
7) Technical advise and a loan subsidy should be given to small- and medium-sized companies in order to obtain anti-pollution technology.
8) A monitoring system for air pollution should be established.
9) A campaign which educates citizens should be developed, and companies should recognize pollution control as their social responsibility.

The above measures were made by systematizing the 1965 strategy and methodology for controlling air pollution in Osaka. The City of Osaka overcame its perilous air pollution problem later mostly because of the foresight of the Osaka Pollution Control Council report. The report makes an interesting preface to Japan's history of pollution control.

Administrative Guidance in Controlling Air Pollution

In the latter half of the 1950s, the measures for controlling air pollution in Osaka began to meet the complaints from residents living around factories. At the time, there were no national laws for regulating air pollution, only Osaka prefectural ordinances. The citizens who suffered from pollution demanded City of Osaka to deal with the problem. Since the city could not ignore the requests, it began to have discussions with individual companies in order to find a solution. This was the origin of administrative guidance. Administrative guidance from the City of Osaka took three forms:

1) The city promoted self-management by the business owners, in such areas as thorough combustion control.

2) The city requested that companies set a pollution control plan with an achievable, concrete target. Companies chose the tools and methods used in controlling pollution. The guidance aimed to make companies recognize the social relevance of pollution control and instill a convention of self-supervision without dependence on laws and regulations. In this way, the companies could introduce their own ideas for improving pollution control more effectively.

Box 3.2: Request for cooperation to achieve goals based on the scientific data

The propositions for meeting environmental management standards, which the Osaka City Pollution Control Council submitted in 1965, suggested that the companies and the administration should establish measures for a common target. Therefore, the city tried to reach a consensus with the companies regarding their common target without regulating the companies, even after the Air Pollution Control Law was established. The reasons are as follows:

1) The city had a long history of a cooperative relationship between the administration and the companies, on education and the awareness of combustion management since the pre-war period.
2) Air pollution in Osaka was serious due to an elevated concentration of pollution sources. The standards set by laws are always behind the aggravation of pollution—their effectiveness was questionable.
3) Although it was possible to strengthen standards through stricter city ordinances, issuing ordinances took time because of the adjustment in authorities and the long decision process of city parliament.
4) Companies could implement their own measures.
5) Individual companies could create measures in accord with local conditions.
6) Creating consensus between companies and administration can cause effective measures to take place immediately.

Box 3.3: The First Blue Sky Plan (Measures for large factories which were announced by the Osaka prefecture in June 1969)

The scientific basis for this administrative guidance plan was the "Comprehensive Research on Industrial Pollution in Osaka and Amagasaki districts (relate to air quality)" conducted by MITI. This research predicted air pollution in 1972 based on data about air pollution sources from 95 large factories in the City of Osaka and its neighboring areas. It identified the concentration of sulfur dioxide from each factory at ground level by using a wind-tunnel test, and summed up to calculate the magnitude of the impact from all factories. With respect to pollution from small and medium-sized factories, the research substituted a diffusion calculation for necessary correction.
The target of reducing pollutants was calculated from "pollutants concentration at ground level" according to the research results (targeting a 20–50% reduction). The research indicated that about 30–40% of the pollution concentration in total will be reduced if the fuel containing less than 1.7% of sulfur is combusted. The First Blue Sky Plan in Osaka was made based on such scientific data. After the announcement of the plan, the Osaka prefecture and Osaka city invited targeted factories to an explanatory meeting and requested their cooperation. Then, the two repeated discussions and rendered administrative guidance to each factory.

Box 3.4: The Second Blue Sky Plan (Measures for heating in buildings which were announced by the Osaka prefecture in October 1969)

The cabinet decided on the "Environmental Standards for sulfur oxides" in February in 1969. Unfortunately, the standards, including those for emissions, in the "Air Pollution Control Law" were not based on scientific and theoretical data. The City of Osaka found that the pollution concentration in the center of the city could not be reduced to meet the environmental standards because of soot and smoke discharged from heaters in non-production facilities, such as most buildings in winter, even though all the targeted facilities met the emission standards in the "Air Pollution Control Law" and the targeted large factories met the standards under the First Blue Sky Plan.

Responding to an inquiry from the mayor of the City of Osaka, the Osaka City Pollution Control Council suggested that the city should effect the following administrative guidance plan (the Second Blue Sky Plan) for non-production facilities (heaters in buildings) in order to meet environmental standards in the city's center:

1) After 1970, fuel used in targeted facilities should contain less than 1.0% sulfur.
2) After 1972, buildings with a large fuel consumption should use fuel with lower sulfur content than the above.
3) Newly constructed buildings should have an air conditioning operation with electricity or gas.

In order to promote the above-mentioned regulations, the Council proposed the following three items:

1) The City of Osaka should fortify its guidance.
2) The City of Osaka should offer loan subsidies for improving facilities.
3) The City of Osaka should request that the central government facilitate the supply of low-sulfur fuel.

Pursuing this recommendation, the City of Osaka developed administrative guidance for buildings located in the center of the city to change their original fuel to heavy oil with lower sulfur content (less than 1% sulfur). The city, with the cooperation of the "Osaka City Soot and Smoke Control Federation," asked building managers to attend explanatory meetings according to ward, type of industry, and size of the facility. Although there was some opposition, the building managers were cooperative overall. Once the managers understood why the conversion to heavy oil with lower sulfur was necessary, they quickly became cooperative. A large number of inquiries regarding heavy oil with lower sulfur rushed into the city office and the health center. The most important reason for the success of the administrative guidance was the "Pollution Control Campaign" that utilized mass media (ie, newspapers and television). That campaign changed the citizens' awareness and provoked business owners into realizing their social responsibility.

3) The City of Osaka and companies made cooperative efforts to control pollution, including measures for small- and medium-sized companies.

Promotion of self-management by administrative guidance Since a large part of the soot and dust problem was due to coal combustion caused by an immature combustion technology and carelessness, a minor improvement ameliorated the situation. At the beginning of winter (when smog frequently occurs), following the pre-war campaign, the City of Osaka developed an education campaign aiming at business owners. During "Soot and Smoke Control Month" in November 1958, the city checked combustion management and gave counsel to companies on discharged soot and smoke. The city also led the way for the establishment of the Soot and Smoke Control Committee, an organization for combustion management, in different areas and formed the first committee in the city in December 1958. The city continued launching the education campaign and expanding the organization. In 1960, the Osaka Federation for Soot and Smoke Control, combining the regional organizations, was established. The Federation published a newsletter, allowing companies to exchange information.

The City of Osaka formed an organization to permit individual companies to control combustion by themselves without regulating all the companies. This was because a large number of companies in the city were small- and medium- sized, so they needed to disseminate combustion management

technology in order to effectively control soot and dust; they sought cooperation among themselves. Additionally, the Osaka Prefectural Industrial Promotion Institute could give technological guidance to companies due to its accumulated experience in controlling air pollution during the pre-war period. The companies managed to reduce citizens' complaints and operational costs by improving the effi-

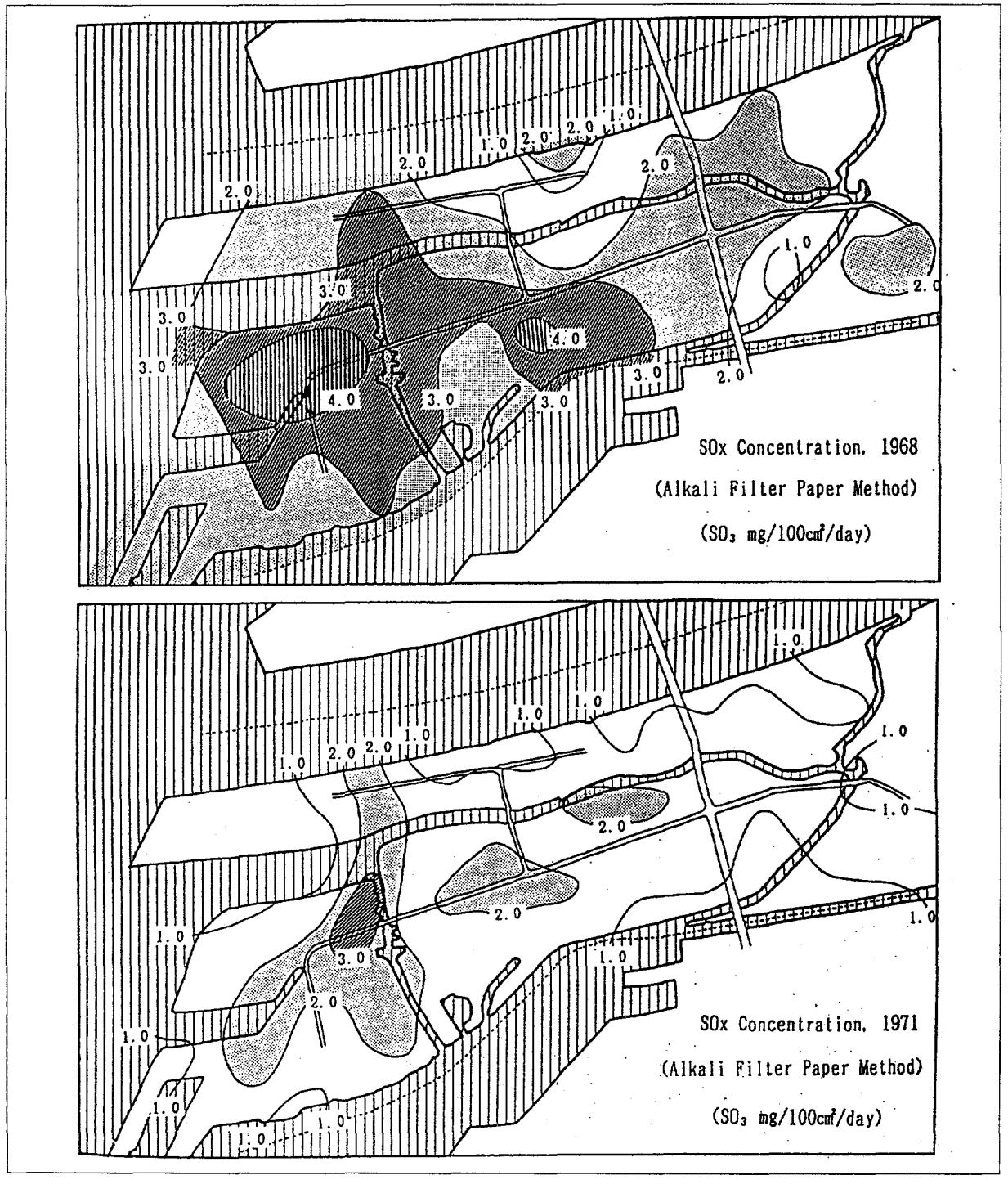


Figure 3.1: SOx Concentration in Konohana Ward Before and After the Measures

ciency of combustion. These were all a part of the reasons for success.

Special Measure in Konohana Ward This section presents the origin of the so-called "Osaka Style," which reduced pollution by letting factories submit their own pollution control plans.

Konohana ward is the core of the western coastal industrial area in the city. In the western part of the ward, there is almost no housing, only large factories which represent the heavy and chemical industries in Japan (one electric power plant, three gas generating factories, steel mill, heavy machine, shipbuilding and chemical factories). This area was rapidly revitalized after the war and contributed greatly to Japan's high economic growth. In contrast, in the eastern part of the ward there are approximately 400 small-sized factories or business establishments which mingle with housing.

The fuel consumption in this ward is recorded (30% of total city consumption in 1963) as the highest in the city. Konohana ward and NishiYodogawa ward are the most important areas in the city for controlling pollution. Figure 3-1 shows the concentration of SOx in Konohana ward in 1968.

At the beginning of 1968, the City of Osaka started its inspection of large factories, which occupy a major area in the western part of Konohana ward, and strongly entreated the business owners to make individual plans for controlling air and water pollution. Since these large factories were major polluters in Konohana ward, the city suggested that the business owners submit a plan, the "Comprehensive Program for Pollution Control," to the mayor. The factories agreed with the idea. Since then, engineers from individual factories and Osaka city have summarized the results of the pollution control measures from studying cases and having discussions for two years. In May of 1970, they submitted the "Comprehensive Pollution Control Program" which covers all forms of pollution, including air, water, noise and vibration. The city approved the program. Table 3-1 shows the major contents of the program.

Afterwards, the city adopted this style of administrative guidance to control pollution. The "Osaka Style" follows:

1) The city investigated the state of pollution and issued the persuasive "Administrative Guidance Plan" based on the scientific data.

2) The city held an explanatory meeting on technology for factories and business establishments to make business owners understand the necessity of preventing air pollution.

3) Presenting the individual factories and business establishments with a concrete target for improvement, the city asked them to individually design and submit the "Air Pollution Control Plan" in compliance with the goal.

4) The city researched methods of reducing pollutants and exchanged this information between the administration and the corporations. This was especially important before control technology was established.

5) The city examined achievability of its target with the aggregated emission data from the "Air Pollution Control Plan."

6) The city approved and requested the corporations to implement the plan.

This style is different from the "Pollution Control Agreement Style," which later became widespread throughout the nation. It became unique to the City of Osaka. Furthermore, the concentration of sulfur dioxide in Konohana ward distinctly improved as the city's guidance extended over low smoke stacks in small- and medium-sized factories.

Table 3-1: Pollution Control Program in Konohana Ward

Measures	*Major Response Actions*
Reduction of SOx emission	Fuels Improvement • Reducing the sulfur content of heavy oil (fuel oil) from 2.5-2.7% to 1.7-1.0-0.1%. Smoke Stack Improvement • Heightening the factories' smoke stacks from 20–25m to 35-105m.
Development of gas treatment facility	Developing gas neutralization facilities (e.g. gas absorption tower). Installation of the wet cyclone for SOx removal. Developing the towers of sulfuric acid removal and absorption.
Dust emission control	Installation of dust removal equipment. Installation of bag filter in electric furnaces. Installation of electrostatic precipitators in melting furnaces.
Water quality control	Installation of wastewater pre-treatment facilities (oil-bearing wasterwater treatment, neutralization, SS removal, etc.)
Noise and vibration control	Installation of noise and vibration proof equipment (noise-proof wall, vibration-proof rubber, relocation of noise and vibration sources)

(Amount of Equipment Investment)

Unit: million yen

Field of investment	*Accumulated investment amount up to March 1970*	*Investment amount between April 1970 and March 1972*	*Total*
Air pollution	1,490	1,876	3,366
Water pollution	892	1,787	2,679
Noise and Vibration	57	87	144
Total	2,439	3,750	6,189

Remark : O&M cost is excluded in the investment amount given above.

Urgent Measures for Controlling Air Pollution in Nishi Yodogawa Ward

Nishi Yodogawa ward, located in the northwestern part of the City of Osaka, is a hub of transportation that links Osaka and Kobe and an area of mingled industry and housing. The western part of the ward joins the Amagasaki Nanbu Industrial Area across the river in the south and the industrial area in Konohana ward across the Shin-Yodo River. These three industrial areas are the part of the "Hanshin Industrial Area" and it forms a concentrated sector of Japan's heavy chemical industrial production. Since Nishi Yodogawa ward has housing that intermingles with small and medium-sized factories, the residents made numerous complaints about pollution, and health problems such as respiratory disease.

Progress to the execution of urgent measures

Responding to the 1965 report on environmental air management standards for air quality by the Osaka City Pollution Control Council, the city designated Nishi Yodogawa ward as a special area for the prevention of air pollution in 1966. The city provided an air pollution monitoring network, inspected factories and business establishments, and researched the damage to health. The substance of the special focus on the ward is as follows:

1) The City of Osaka has conducted minute surveys on pollution to identify the cause-effect relationship between pollution sources and environmental concentrations of pollution substances since 1966. The pollution monitoring network in Nishi Yodogawa ward was the most tight-knit (one monitoring station in every

400m mesh) at that time in Japan. Furthermore, the research on pollution sources covered almost all the factories and business establishments that had smoke stacks or consumed more than 500m^3 of water per month. Because all inspections made by engineers in charge of pollution were summarized, the research method produced very precise data.

2) The "Special Committee for Measures in the Heavily Polluted District" was established under the Osaka City Pollution Control Council. Consisting of the representatives from the local residents, industrial groups, and medical associations, the committee took into account local conditions.

3) With respect to the effect of pollution on the human body, the city, in full cooperation with local self-governed organizations, selected 12.5% of the population living in the ward to conduct a questionnaire survey by the so-called BMRC (British Medical Research Council) method. Regarding the persons who claimed a certain change about their health conditions, detailed questions by doctors and close medical examinations were made and their results were compiled into a report.

4) Air pollution generated by the "Amagasaki Nanbu Industrial Area" in the Hyogo prefecture had a potent influence on NishiYodogawa ward. Thus, in 1968, the City of Osaka asked for administrative cooperation from the city of Amagasaki, and initiated the "Osaka and Amagasaki Cities' Conference on Pollution Administration."The cities held the conference on a regular basis to present technical material on air pollution, explain and adjust their pollution control plans, and design more effective measures.

Based on the above results, Table 3-2 shows heavy oil and coal consumption. Heavy oil consumption accounted for less than 10% and coal consumption less than 1% of the total fuel consumption of the city. Although the percentages were not large, the emission of SOx, a byproduct from raw materials in the sulfuric acid production process or the steel production process using a blast furnace, was distinctly high. Many small- and medium-sized corporations with low smoke stacks were the cause of highly concentrated levels of local pollution.

Further, as Table 3-3 indicates, ten times more fuel was used in the Amagasaki Nanbu Industrial Area in the west than in NishiYodogawa ward. Due

Table 3-2: Fuel Consumption in Nishi Yodogawa Ward (1967)

Fuel type	*Amount of consumption*	*Remarks*	
Heavy oil (Fuel oil)		Oil consumption in energy intensive industries	
A	2,737.8kl	• Steel industry	74,673.7kl (58.3%)
B	65,270.8kl	• Chemical industry	18,683.3kl (13.4%)
C	64,293.2kl		
LSC	6,833.0kl	(Osaka City Total)	
Heavy Oil Total	139,134.8kl	Oil consumption	1,836,131.3kl
Coal	13,506tons	Osaka City Total	1,588,033.5tons

Table 3-3: Fuel Consumption in Amagasaki City (1968)

Fuel type	*Amount of consumption*	*Remarks*	
Heavy oil	1,389,617kl	Consumption for power generation	715,575kl (51.5%)
Coal	1,036,164kl	Consumption for power generation	991,146tons (95.6%)

to the west wind which is peculiar to Osaka, the emitted gas had considerable impact upon Nishi Yodogawa ward. Clearly, these factors exerted a damaging influence on air pollution in Nishi Yodogawa ward.

Besides the impacts on human health, seriousness of air pollution also damaged some business activities such as recruitment. It became obvious that remedial actions were urgently needed to be taken against air pollution.

Since 1964, SOx concentration measured at the air pollution monitoring station had occasionally exceeded 0.2 ppm as its monthly average, which indicates how severe the air pollution was. (Measurements were taken only during winter until 1968, and throughout the year after 1968.) The concentration level of sulfur dioxide improved thanks to the Soot and Smoke Regulation Law in 1963, the Air Pollution Control Law in 1968, and stricter regulations in 1970. However, according to the results at the monitoring station located in the center of Nishi Yodogawa ward (Table 3-4), annual average SOx concentration is 0.083 ppm, which was the highest concentration level among the city's monitoring stations, as opposed to 0.05 ppm of the environmental standard set in February 1969 (0.064 ppm was the city' overall average). As the very first smog alert was announced in December 1970, air pollution was a very serious problem.

Estimating the Degree of Emission Influence on Air Pollution and Guidance for Reducing Emissions In order to create a map of the concentrations of pollutants utilizing the atmospheric diffu-

Table 3-4: Comparison of Actual SOx Concentration with Environment Standards (1969)

Environmental standard value	*Hourly average value of less than 0.2ppm shall be achieved in more than 99% of the annual total hours.*	*Daily average value of less than 0.05ppm shall be achieved in more than 70% of the annual total days.*	*Hourly average value of less than 0.1ppm shall be achieved in more than 88% of the annual total hours.*	*Annual average value shall not exceed 0.05 ppm.*
Nishiydogawa ward	95.7%	24.9%	75.3%	0.083ppm
Osaka city average	97.4%	44.3%	84.3%	0.064ppm

Source : Monitoring Station at Yodo Junior High School.in Nishi Yodogawa ward

Box 3.5: Urgent Measures for Controlling Air Pollution

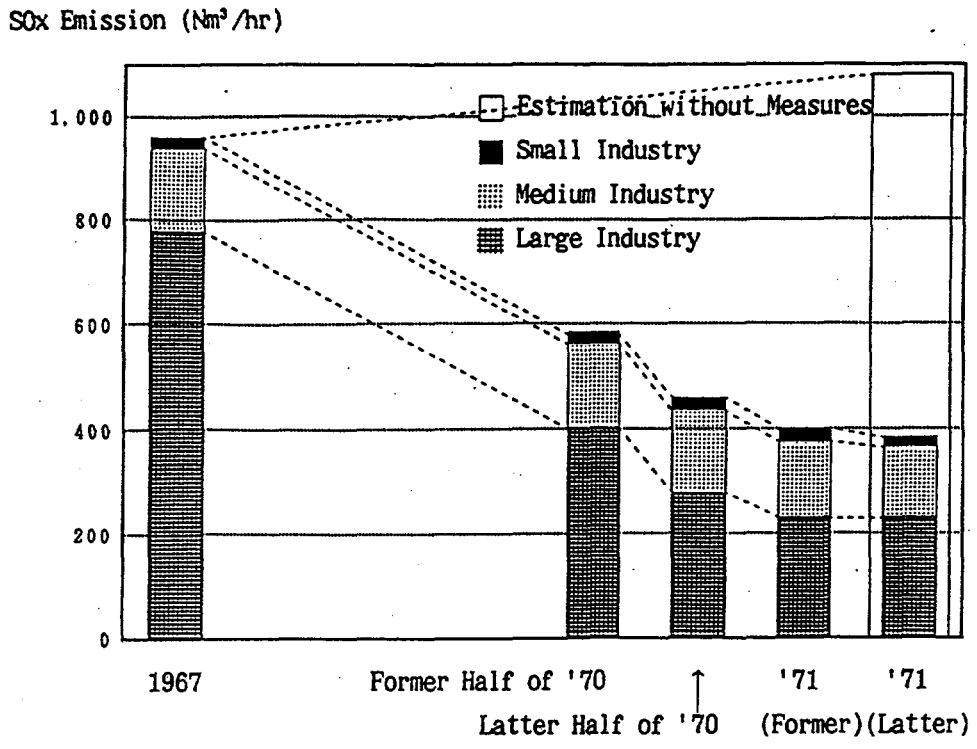
In December 1969, the central government designated Nishi Yodogawa ward as the region targeted by the "Law concerning Special Measures for the Relief of the Pollution-related Patients". Rating Nishi Yodogawa ward as the most important area for measures to control air pollution, the City of Osaka designed an action plan.

The "urgent measures for air pollution in Nishi Yodogawa ward" announced in June 1970 had two major components. One is about pollution sources, and the other is about environmental development. The former measure strived to reduce the concentration of sulfur dioxide in Nishi Yodogawa ward to the yearly average dictated by the environmental standard at that time (i.e., below 0.05 ppm) in about two years. The latter measure aimed at facilitating the implementation of tree planting and sewerage system by reclaiming contaminated rivers, installing air cleaners in schools, and expanding parks. The project was allocated a total of 12.5 billion yen.

When the cabinet decided on the environmental standards (Figure 3-2), they expected cities, especially highly polluted ones like Tokyo or Osaka, to take ten years to meet those standards. But, with regards to the sources of pollution, an aggressive "implementation plan for administrative guidance" was devised. This ambitious plan tried to meet the environmental standards within two years, a fifth of the norm.

Furthermore, the "urgent measure for air pollution in Nishi Yodogawa ward" formulated in 1970 was a "comprehensive pollution control plan" which integrated the measures regarding sources of pollution with the "creation of [a] living environment." This measure became a prototype for the "Local Pollution Control Plan in Osaka," which was based on the "Basic Law for Environmental Pollution Control" of 1972.

Figure 3-2: SOx Reduction Plan in Nishi Yodogawa Ward)



Box 3.6: Organization of the Special Task Force for Pollution in Nishi Yodogawa Ward

Considering the high level of concentrated air pollution in Nishi Yodogawa ward, the precarious situation of health in the ward (ie, damage to the respiratory organs) and the approximately 230 factories with smoke stacks, the city arranged for its engineers to engage in pollution control vigorously in Nishi Yodogawa ward and organized the "Special Task Force for Pollution in Nishi Yodogawa ward." The Task Force was composed of three groups of 13 staff members who specialized in detailed research on pollution sources and offered technical guidance for pollution control, beginning in July 1970. A separate analysis group of three staff members was organized to support the Task Force in Nishi Yodogawa ward. This analysis group examined the cause-effect relationship between the "concentration of air pollution in Nishi Yodogawa ward" and the data of the amount of air pollutant emissions from each factory obtained from the on-the-spot inspections by the Special Task Force. The group sent the findings to the Task Force to serve as a guideline for its activity. This was an important factor in the success of the urgent measures.

sion simulation method, it is necessary to identify the dispersion co-efficient, volume, and the conditions of pollutant emissions from pollution sources. In fact, it is not easy to determine the factors contributing to the atmospheric diffusion in the case of the coastal region in Osaka because it has relatively low height sources of smoke. Also, it is very difficult to minutely identify the assorted emission condition for each pollution source. To estimate the concentration of SOx in the ward the City of Osaka used air dispersion coefficient based on an air tracer experiment supported by the Ministry of Health and Welfare in Nishi Yodogawa

ward, and the emission conditions of pollutants based on data collected by Special Task Force for Pollution from 189 factories/business establishments (206 smoke sources in all) that discharged SOx and 67 factories (295 smoke sources in all) that participated in the Pollution Control Agreement in the City of Amagasaki (situated next to Nishi Yodogawa ward). Figure 3-3 shows the results. The concentration map is almost identical to the actual figures at the technical level in that time.

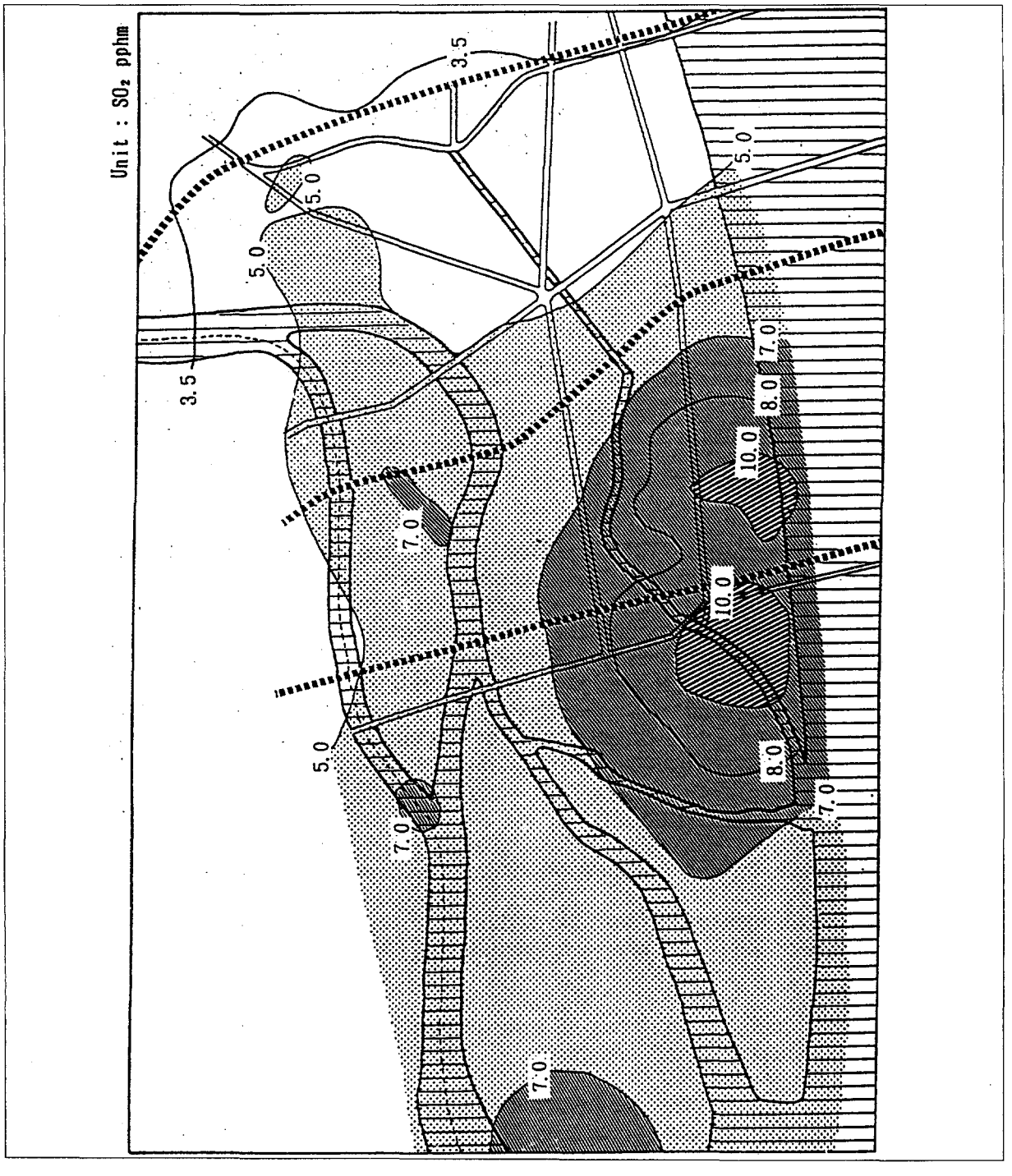


Figure 3-3: Results of Simulation of Air Pollution in Nishi Yodogawa Ward

Based on the above figure, the rate of SOx effected from various sources in NishiYodogawa ward was estimated. With respect to the areas with high concentrations of pollution, the results were: 14% due to large pollution sources, 26% due to medium pollution sources, 28% due to small pollution sources, and 32% due to the impacts from neighboring cities. The City of Osaka calculated the "reduction rate for each corporation" based on the estimated results about the effecting rate from each factory/business establishment in Nishi Yodogawa ward. Furthermore, in October 1971, the city provided each corporation with the reduction rate as a target in the "Pollution Control Plan" and requested individual corporations to draft a "Pollution Control Plan." Then, the city judged the submitted "Pollution Control Plans" from a technological standpoint (Table 3-5).

After November of 1971, the Task Force requested each corporation to carry out the "Pollution Control Plan" and examined the effectiveness of newly-installed pollution control equipment and measures taken by checking the effectiveness of treatment equipment and by measuring the state of local pollution.

The simulation method not only estimates the concentration in limited observation points, but also approximate the overall pollution concentration map, as well as gives guidelines for the precise reduction in the pollution contribution rate of each pollution source. Consequently, it is currently used in designing air pollution control measures. It was an epoch-making event that the city could introduce the method at that time.

Measures for SOx reduction Measures for SOx reduction are summarized as follows. The city:

1) requested a conversion from the original fuel to heavy oil with a lower sulfur content or to kerosene and, if it was possible, to LPG or city gas (measures for fuel);

2) requested changing importers in order to purchase iron ore with a lower sulfur content (measures for raw materials);

Table 3-5: Annual SOx Emission Reduction Program (1971)

Location	*Scale of industry*	*No. of factory*	*Objectives of programmes*	*Date of implementation*
Nishi Yodogawa ward	Large industry	4	• Reducing the emission by 47.3% on average, compared with the 1970's emission. • Promoting the use of low-sulfur (less than 1.0% of sulfur content) fuels and materials. • Installation of stack gas desulfurization equipment in sintering furnace	The programme came into effect in Nov. 1, 1971.
	Small/medium sized industry	151	• Reducing the emission by 51% on average, compared with the 1970's emission. • Promoting the use of low-sulfur (less than 1.0% of sulfur content) fuels	
	Total	155	• Reducing the emission by 49.7% on average, compared with the 1970's emission.	
Amagasaki city	All factories		• Reducing the ground concentration by 60% of the value of September 1970.	

Total amount of SOx emission (Nm^3/hour)			*Rate of reduction of the 1970 emission level*
1967	1970	Target of SOx emission after Nov. 1971.	
961.1	712.6	358.3	49.7%

3) gave directions for installing treatment facilities such as desulfurization equipment and dust-collecting equipment and for improving the process to reduce pollutant emission, and for using high smoke stacks to replace old smoke stacks.

On the other hand, the factories made efforts to respond to the City's request by introducing new treatment technologies which had never been applied before in Japan. These were dust-collecting equipment for electric furnaces in steel factories, the equipment which desulfurizes the emissions from the boiler using alkaline liquids while neutralizing effluents in leather factories, and a fusion furnace for metal with city gas.

When the city first introduced this pollution prevention equipment, the "Osaka City Loans for the Installation of Anti-Pollution Equipment," which supports small- and medium-sized companies for controlling pollution, was actively used. This factory-by-factory guidance was introduced by the engineers of the "Special Task Force." The Task Force monitored pollution and examined and studied various plans with engineers at the factories. With the cooperation of both parties, individual plans for pollution control were designed. Cooperation was attained because the factory managers or engineers understood the importance of using pollution control measures to respond to the mass media's campaign against pollution. Also, active support came from the "Nishi Yodogawa Industrial Association," which consists of factory owners. Efforts were made to change its members' attitudes towards using pollution control measures. Consequently, only a few cases had trouble with the Task Force and its factory inspection.

Results The major target of the "Urgent Measures for Air Pollution in Nishi Yodogawa Ward" was to meet the environmental standards of SO2 (0.05 ppm) in two years. When the standard was established, it was considered to be achieved in ten years in the cities with serious air pollution such as Tokyo and Osaka. However, as already described, City of Osaka made an ambitious plan to meet the standard in two years. The measure was designed in 1969 when the environmental concentration was 0.083 ppm. It was then implemented in 1970 and 1971. The result was that in 1972 the environmental concentration dropped to 0.042 ppm. Figure 3-4 indicates the change in SOx concentration. The Special Task Force achieved its purpose in 1973 and was disbanded. The city reorganized the "Pollution Regulatory Force" which supervises three local sections: the "eastern," "central," and "western" parts.

Total Evaluation The major factors which led the "Urgent Measures for Air Pollution Control in Nishi Yodogawa ward" to success in two years are as follows:

1) much of the data on the pollution emission sources was accumulated through detailed factory inspections for several years before the plan was designed.

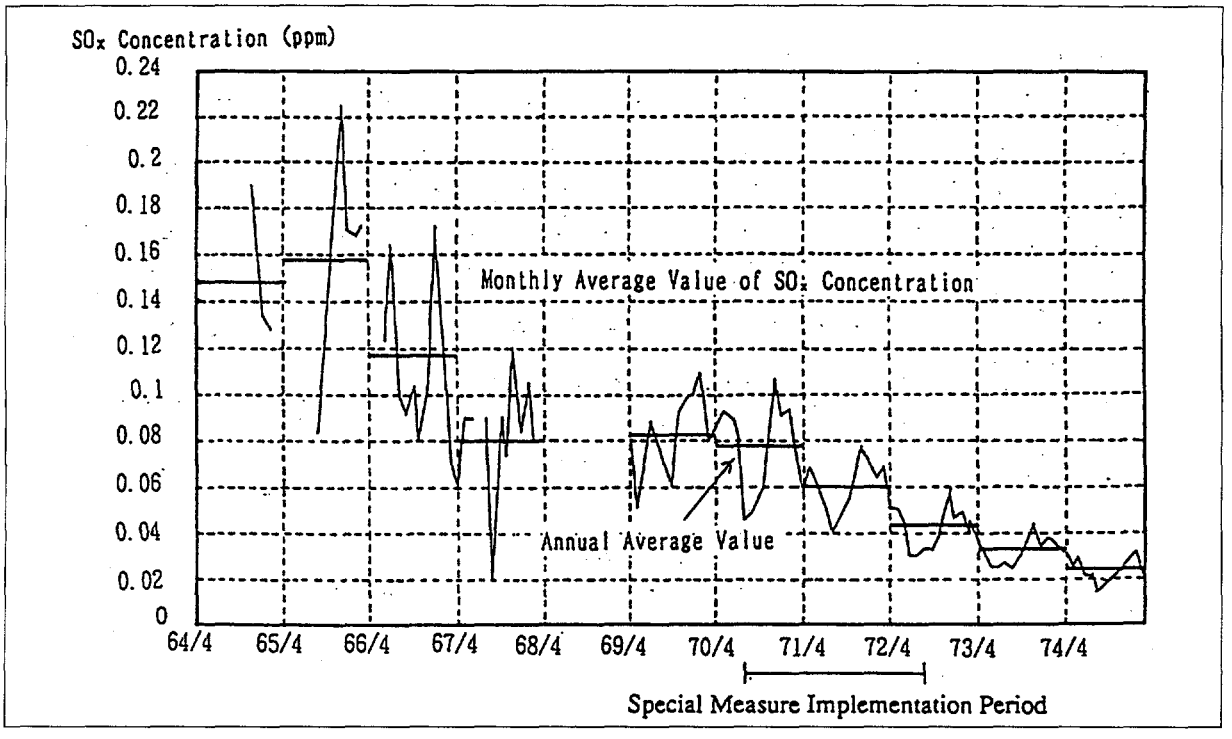
2) there was precise and detailed monitoring data due to a monitoring network that was partitioned into several monitoring points for greater accuracy;

3) as the result of an air tracer experiment, which was undertaken with the cooperation of the Ministry of Health and Welfare and the Osaka Prefectural Government, the simulation method of atmospheric diffusion for the contribution of respective from pollution sources was established;

4) this method became a tool for obtaining scientific proof of SOx reduction by factories;

5) the "Anti-Pollution Campaign" through mass media changed the attitude of apprehensive residents and companies and became a societal demand;

Figure 3-4: SOx Concentrarion in Nishi Yodogawa Ward, 1964–75



6) corporations were very cooperative with the "Special Task Force for Pollution Control." Although the city did not have enough regulatory authority over factories at the time, it could implement administrative guidance through case studies or comprehensive dialogues about technology with factory engineers, without any trouble;

7) at this stage, the city residents' sentiments were clearly in favor of pollution control, fostered by the residents' anti-pollution campaign using local self-governed organizations;

8) the "Osaka City Loans for the Installation of Anti-Pollution Equipment" secured 30 million yen per year as a special loan limit for Nishi Yodogawa ward only;

9) the "Purchase System of the Sites of the Relocated Pollution Factories" prioritized the fund allocation to the factories that had no choice but to relocate;

10) the city exempted soot-and-smoke-treatment facilities from the property tax;

11) pollution control technology was underdeveloped at this stage. Thus, many factories in Nishi Yodogawa ward were used as testing grounds. Engineers from the City of Osaka, factories and equipment manufacturers through cooperation continued to develop new technologies through trial and error. Many of these new technologies were widely introduced throughout the country;

12) focusing on the advancement of pollution control measures, the City of Osaka prioritized the implementation of anti-pollution measures in its budget allocation as well as in manpower development; and

13) the regulatory standards were strengthened with the cooperation of the prefectural and the central governments. In addition, successful implementation of the MITI's anti-pollution measures of decreasing sulfur content of fuels also helped the achievement of city level standards.

Support System for Pollution Control Measures

Osaka City Loans for the Installation of Anti-Pollution Equipment

The loan system for ground subsidence prevention The loans for ground subsidence prevention were one of the first pollution control measures taken in the City of Osaka. In order to avoid pumping an enormous amount of ground water, which was the main reason of ground subsidence, the City of Osaka provided an industrial water supply system and regulated the pumping of ground water. However, in regards to pumping ground water for air conditioned buildings in the city since use of an alternative water source was not economical, it was necessary to install a cooling tower to recycle water. Because it required additional investment to the building owners, the City of Osaka created a system that mediated loans between the owners and banks, and subsidized a half of its interest. Subsidy applications were accepted from 1961 to 1964. This system dispensed 2.5 billion yen total for the loans with 300 million yen spent in subsidizing interest and contributed to stopping ground subsidence.

Research on the needs for pollution control support system In 1965, local health centers in the eastern part of the City of Osaka, especially in Joto ward where residences and factories mingled, received more complaints about pollution than they could handle. The complaints were about air pollution, water pollution, noise, vibrations, and offensive odors. Since the polluting factories in the area were small- and medium-sized and had very limited capacity in pollution control technologies, unsolved pollution problems were increasing one after another. In order to overcome this situation, public and private sectors jointly conducted a series of surveys on pollution-related complaints, the factory managers' attitude toward pollution control, conditions of pollution control technology development, and people's expectations to the administrative body regarding anti-pollution measures. Based on the results of these surveys, the City of Osaka created a plan to establish the following support systems:

1) establishment of the "Osaka City Loans for the Installation of Anti-Pollution Equipment" for small- and medium-sized companies;

2) establishment of the "Purchase System of the Sites of the Relocated Polluting Factories";

3) an exemption of the city property tax for pollution control facilities;

4) influence on the central government to set the shorter period of durability of pollution control facilities.

Osaka City Loans for the Installation of Anti-Pollution Equipment Based on the results of the above-mentioned surveys and the plan of establishing support systems, the city of Osaka first enforced the "Osaka City Ordinance concerning the establishment of the anti-pollution equipment fund" in 1967. In principle, the companies that caused pollution bore the costs of pollution control. Installation of pollution control facilities is a burden on companies in the short term. In this regard, this ordi-

nance supported the small- and medium-sized companies of low financial capacity in installing the pollution control equipment and taking measures by mediating the loans from banks.

At the same time, the City of Osaka subsidized loan recipients a certain proportion of the loans' interest in order to give small- and medium-sized companies easy access to loans. The number of companies that used the loan greatly increased. Twenty-four loans (worth 87 million yen) were given in 1967 and 88 loans (worth 270.67 million yen) were given in 1968. This loan subsidy system has continued to work advantageously up to the present (1993), with an improvement made to the content. By the end of 1991, 2,351 loans (worth about 19.1 billion yen) were granted.

Upon financing, the City of Osaka, the Credit Security Association and the bank conclude the following contract:

- the total amount of loan consists of one part the City of Osaka to more than two parts the bank.
- with regard to the loan based on the contract, the credit security of the Association is attached.
- as the subrogation of the Association's credit security, the City of Osaka provides subsidy to the Association, etc.

The purposes and the contents of the pollution control measures are examined by the city, security and surety are examined by the Association. The final decision of loan is done by the loan examination committee consisting of the city of Osaka, the Association and the banks. The repayment rate from 1967 to 1993 is 95.9%.

Large corporations could apply for loans from the Japan Environmental Corporation and the Japan Development Bank.

Exemption from the property tax and shortening of the facilities' durable period As the companies increased their investment in pollution control facilities, the companies' demand for the exemption from the property tax and shortening of the facilities' depreciation (durable) period was increasingly expressed to the Osaka City Government. The City of Osaka instituted the property tax exemption in order to facilitate the companies' installation of pollution control equipment. In 1966, the city decided that soot and smoke treatment facilities should be exempted from paying property tax[4]. Then, the city increased the types of facilities that qualified for exemption as pollution-related laws and ordinances were established. Furthermore, since many companies required to depreciate the pollution control equipment in shorter term, the City of Osaka repeatedly asked the central government to shorten the durable period of pollution control facilities. This request was finally accepted.

Purchase System of the Site of Relocated Pollution Source Facilities

Background In 1966, the City of Osaka started the purchase system for the old factory sites utilizing an urban development fund in order to implement a total redevelopment plan that would improve downtown Osaka. In 1967, the City of Osaka designed the "Osaka City Comprehensive Plan," in which the City aimed at separating housing from factories, and used the above-mentioned "urban development fund" in order to relocate factories which caused pollution. However, the purchase system was limited to large sites extending more than 10,000 m^2. One of its disadvantages was that it could not be applied to small- and medium-sized companies which were often the troublemakers. Some factories that had serious disputes with residents over the pollution surrounding the housing possessed small sites and no space for installing pollution control facilities. Before the establishment of the Air Pollution Control Law, laws and ordinances

gave neither the nation, prefectures nor the cities any authority to stop operations of the polluting companies. Taking advantage of that lack, some companies continued to operate, asserting that they had a right to run their business. This created an impassioned dispute over pollution. In order to resolve that dispute, the administration requested factories to relocate and purchased their old sites for establishing a relocation fund. This solution was also effective in terminating the business owners' intention of building factories at small sites in residential areas.

Purchase System of the Site of Relocated Pollution Source Facilities In 1968, the city inspected and identified city-wide the factories that should be relocated in order to solve pollution problems and established the purchase system in 1969. Seventy-two factories, covering 192,780 m^2, were relocated under this system by the end of 1991. The "Sales System for the Old Contaminated Sites of Factories," designed by the City of Osaka, became a model for the "Industrial Relocation Promotion Law" designed by MITI in 1972. The results of the city's identification of the factories led to the installation of the Osaka branch of the Industrial Relocation and Coal Mining Area Development Corporation, which was formed based on the "Industrial Relocation Promotion Law." After the Osaka branch was established under the guidance of the Corporation, large factories that were located in the relocation promotion area designated by the Law were able to smoothly relocate to the designated industrial park. Therefore, the disputes over pollution decreased yearly and the difficult situation was settled. Land purchased in this way is sometimes converted into parks or other open public space, thus improving the urban environment. The major items of the purchase system addressed by the law were: 1) the loan for the purchase of old sites of factories; 2) the loan for the relocation fund; and 3) the subsidy for promoting factory relocation.

Promotion of Automobile Pollution Control Measures

Carbon Monoxide Control Measures

Due to increased vehicular traffic, carbon monoxide (CO) emission from automobiles became one of the most serious air pollution problems. The city started a full-scale investigation of pollution in 1962. It concluded that air pollution caused by exhaust gas in Osaka was concentrated in fixed points (ie, traffic congestion along trunk roads and major crossings). Between 1966 and 1968 the research on CO explored indicated that the average concentration per hour (over an 8 hour period) at major crossings was 2-29 ppm. This indicated extremely serious pollution conditions. Cognizant of the importance of air pollution caused by exhaust gas, the central government started to regulate new cars' CO emission in September 1966. In December 1967, the central government instructed the automobile industry circle to inspect the exhaust gas of the cars in use. In order to effectively regulate exhaust gas emission of automobiles, and especially to carry out proper guidance of exhaust gas inspection, the City of Osaka contracted a study on the exhaust gas control by adjusting the engine's idling. The study was conducted in Paris with the cooperation of universities and automobile makers. Based on the results of this study, the Osaka City Pollution Control Council recommended in 1967 that the City authorize requirements for the adjustment of the engine's idling for CO emission control. The City first implemented this measure in official business cars to study its implementation and the possibility of developing a campaign. Since the city obtained favorable results, this measure was expanded to private cars.

The Osaka Prefectural Government and the City of Osaka established the "Osaka Automobile Ex-

haust Control Measures Promotion Committee" in cooperation with the relevant automobile industry circles in 1968, and started a campaign to control automobile exhaust through the adjustment of the engine's idling. Furthermore, to institute this regulation, street guidance of controlling automobile exhaust were simultaneously implemented with the cooperation of the Osaka Prefectural Police Headquarters. In 1966, the City of Osaka conducted the first questionnaire survey on the actual state of pollution with the residents who lived around the major crossings. In 1967 the city conducted a study on driving patterns in the city in order to obtain basic data necessary for controlling automobile exhaust.

Beginning with the campaign of adjusting the idling of automobile engine (See ANNEX 3), steady efforts of the Osaka Automobile Exhaust Measures Promotion Committee finally strengthened the legal implementation of regulations to control exhaust gas and helped reduce the concentration of CO year after year. After 1980, the concentration of CO in Osaka met environmental standards in both long-term and short-term assessments. Since the 1970's, the focus of exhaust-related problems has shifted to NO_2.

Regulation of automobile exhaust by municipal leadership

In 1972, regulations based on the "Guidelines for the Permissible Level of Automobile Exhaust" (the Japanese counterpart of the 1970 Amendments in the US Clean Air Act) and aimed at regulating CO, hydrocarbon, and NO by 1976 were announced by the Environment Agency. However, in 1974, regulation of NO became difficult because of technological difficulties. Recognizing that the automobile pollution control was the most important issue concerning urban pollution, a meeting took place with the mayors of seven large cities, including Tokyo, Yokohama, Kawasaki, Nagoya, Kyoto, and Kobe. It resulted in the "Announcement of Promoting Automobile Exhaust Control" and the formation of the "Investigating Commission for the Regulation of Automobile Exhaust in Seven Large Cities." The commission performed various activities, including researching the automobile makers' reactions to regulations and the state of and prospects for technological development in the auto industry. It also arranged for a televised public hearing on prospective exhaust treatment technology in the auto industry. Due to the cooperation of the mass media, this hearing initiated great national concern. Bolstered by this national concern, in 1978 automobile exhaust regulations were completely executed according to the original guidelines.

The group of seven cities then proceeded to form the "Automobile Technology Evaluation Committee" in 1975, which researched the composition of the exhaust produced by domestic automobiles and conducted an evaluation of the technology involved in introducing a low-pollution car. Moreover, the "Study Group on the Regulation of Area-wide Total Emission" was established and it scientifically researched the emission volume of pollutants such as nitrogen oxides in order to ascertain the required amount of reduction in traffic volume. These activities, from the point of view of the municipalities facilitated the implementation of measures directed at countering automobile pollution in Japan.

Comprehensive measures against automobile pollution

Environmental standards on sulfur dioxide and carbon monoxide were met. However, with respect to nitrogen dioxide, the countermeasures for stationary sources of pollution progressed but the pollution of nitrogen dioxide in the urban area did not improve. It was necessary to take comprehensive measures, including taking control of the demands

of traffic, and making a provision to improve the road conditions as a medium- and long-term prospect. In 1979, the Promotion Committee declared that the nitrogen oxides countermeasures were important, and put forth four items: 1) self-control in driving automobiles; 2) formulation of a safe and orderly flow of traffic that practiced moving at the proper speed; 3) enforcing regular check of cars and raising people's awareness of black diesel smoke control; and 4) popularization of electric automobiles.

Also, the City of Osaka formed the "Roadside Environment Research Committee" to conduct the research on emission reduction measures, traffic control methods, and the methodology of a quantitative analysis on the environmental effects of these response measures for their promotion. Moreover, the "Osaka City Automobile Pollution Control Plan" was formulated in 1990. The plan set a reduction target of nitrogen oxides emitted from automobiles in order to meet environmental standard of NO2 at the surroundings of major trunk roads in the city in the year 2000. Four major components of the plan were: 1) response measures concerning the sources of pollution, 2) traffic volume reduction measures, 3) roadside anti-pollution measures, and 4) anti-pollution campaigns. In addition, the City of Osaka set up a loan/subsidy system for purchasing low-pollution cars, such as electric and gasoline cars, which discharge less nitrogen oxides than diesel ones.

Land Subsidence Preventive Measures

Although land subsidence can be halted, the subsided land cannot be recovered, and a huge amount of costs is required to stop subsidence. Therefore, preventive measures are of the most importance against land subsidence. As chapter one indicated, a large part of the city has a soft alluvial soil layer that has been accumulating for around 10 thousand years. Since the alluvial soil layer is 35m thick and is not enough solidified in coastal areas, land subsidence occurs easily. Thus, subsidence in the city caused problems in the former half of the 1900s. In the post-war period, the City of Osaka became a model of full-scale pollution prevention activity, manifesting in acts such as the implementation of regulations by ordinance and public and private requests for legislation to prevent subsidence.

Pre-war Period

The first leveling of the city was conducted in 1885. Since then, every two or ten years, national surveys have been conducted. It was the 1928 survey that first discovered that the northwestern coastal industrial area in the city had subsidence. The City of Osaka officially recognized it in 1933, and began leveling in the entire city. This survey has continued up to the present without interruption, even during the war. There are two methods of ground subsidence observation; one is the standard survey to observe the change of surface level, and the other is monitoring of wells of different depths to check the ground water level and to measure the difference between the top point of the well and the ground due to land contraction. The worst period of subsidence occurred during 1935–40. Subsidence almost stopped in 1943 and 1944. However, within a decade, some areas sank 100 cm. The chief actions taken during the pre-war period were continuous monitoring, research on the possible cause, and construction of a breakwater.

In the Post-war Period

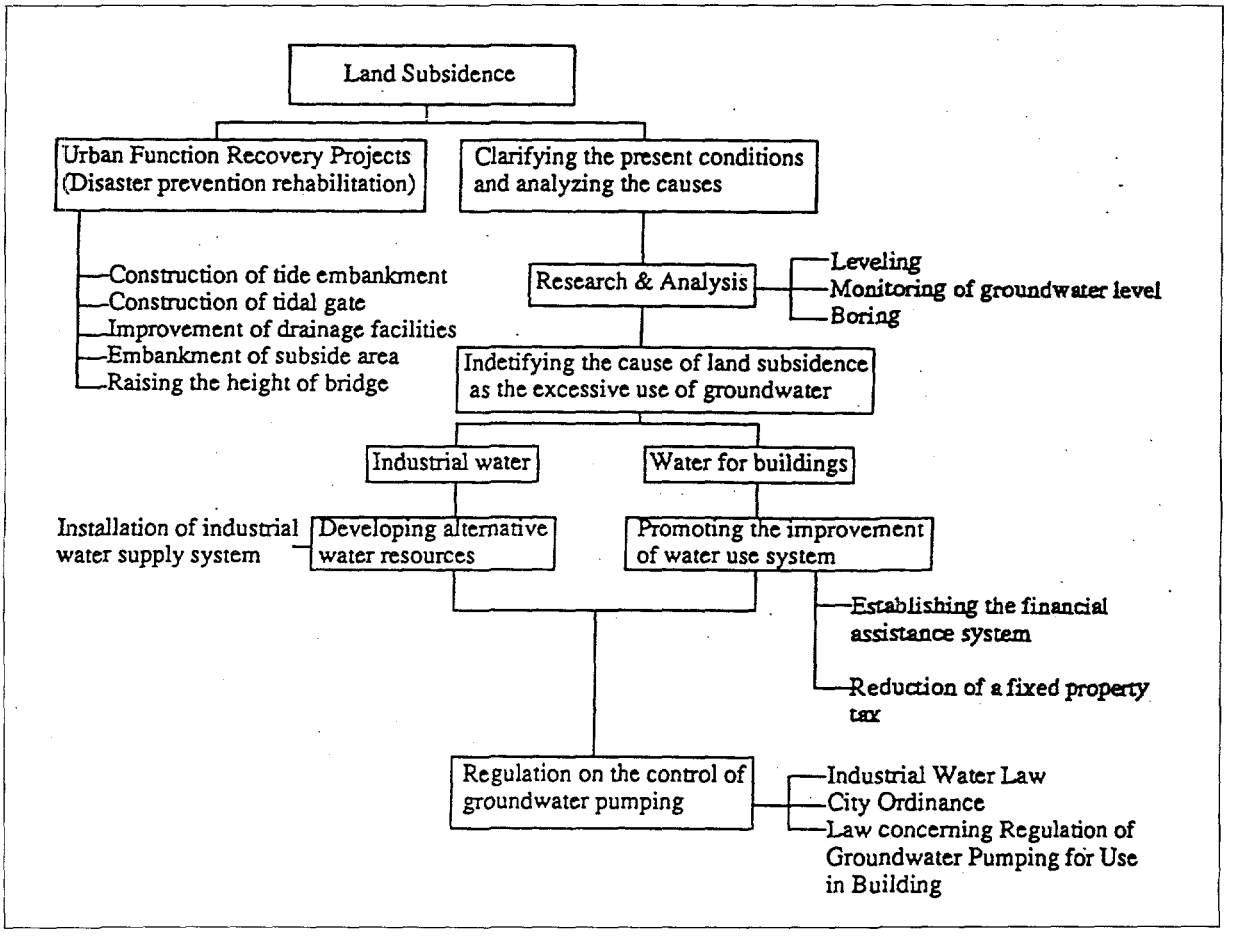
After the war, subsidence ceased, and the ground water level increased because industrial activities stopped. As soon as those activities resumed, so did subsidence. Thus, the correlation between subsid-

ence and the pumping of ground water (strictly speaking, between subsidence and the ground water level) became clear (Figure 2-9 in Chapter 2) and as a result, measures for subsidence prevention fully started. This demonstrates the importance of obtaining environmental information when designing pollution control measures.

The measures taken to counter subsidence are as follows: 1) protection for areas where high tide due to subsidence causes damage including the construction of a breakwater, the provision of a drainage facility, and raising of bridges; 2) the monitoring of subsidence; and 3) preventive measures (Figure 3-5). The measures in 1) were urgently needed to protect the citizens' lives and properties. However, insufficient action taken in 3) would create additional burdens for 1). Therefore, the measures taken in 3) were very important.

After the "Jane Typhoon" in 1950 caused massive damage, the City of Osaka and the Osaka Prefectural Government spent a large sum of money effecting strong measures for controlling floods caused by high tide in order to protect Osaka from water damage. The measures taken encompassed the construction of a breakwater (124 km), the development of tidal sluice, raising of bridges, and the embankment of coastal port area. In order to grasp the mechanism of subsidence, geographical research using deep boring, as well as the standard survey, was conducted. In 1951, the City also started constructing an industrial water supply system, an alternative to pumping ground water. The first offi-

Figure 3-5: Structure of Response Actions Against Land Subsidence



cial regulation for subsidence prevention was the "Osaka Prefectural Ordinance for Civil Engineering Regulation." However, this regulation was not applied because it did not have a provision regarding an alternative water supply.

Subsidence due to the over-pumping of ground water and the deteriorating quality of the ground water (saltwater intrusion) became a serious problem in industrial areas in Tokyo. MITI started a national subsidy for industrial water supply works in June of 1956, and it established the "Industrial Water Law" to promote rational use of ground water in industrial areas. Based on that law, the City of Osaka restricted construction of new wells from 1959 onwards.

Around this time, subsidence existed not only in industrial areas but also in the city center. This was caused by the large amount of water pumped for air conditioners in buildings during the summer. The installation of a cooling tower was chosen as an appropriate measure. Since the cooling tower could replace the use of ground water, in 1959 the City of Osaka established the "Osaka City Ordinance for Ground Subsidence Prevention," the first of its kind in the nation, and regulated the pumping of water for building use. The loan and the subsidy for this facility conversion project was allocated in December 1961.

Since the ordinance only regulated new wells, the pumping of ground water by old wells still continued, and the volume of the water pumped did not decrease. High tide caused by the second Muroto Typhoon in September of 1961 flooded about one-third of the city. In October 1961, the Osaka City Council made a request to draft the city ordinance concerning the total ban on the pumping of ground water. In November, the "Osaka Council for the Comprehensive Countermeasures Against Ground Subsidence" was established by the Osaka Prefectural Government, the City of Osaka, and the Osaka business circles. The Council actively developed activities for national legislation that banned the pumping of ground water. The City of Osaka prepared for the ban by setting up a new subsidence prevention division under the Planning Bureau and an Industrial Water Division under the Waterworks Bureau.

At first, the national government was reluctant to adopt the strict regulations on the pumping of ground water, claiming that they were a serious restriction on national rights, but it later recognized the necessity of new counter-subsidence measures. In 1962, a "partial amendment of the Industrial Water Law" and the "Law concerning Regulation of Pumping up of Ground Water for Use in Building" were instituted. As a result of applying very strict technical standards to the pumping of ground water (the vent of a water-pump machine for a well was less than 21 cm^2; the strainer was installed more than 600 m deep in the western area and 500 m deep in the eastern area), use of ground water was in fact nearly impossible. Since these laws covered both new and old wells, the regulations on the pumping of water progressed a lot. By the December of 1968, ground water was no longer used with a few exceptions. The city's ordinance was abolished by enactment of the "Law concerning Regulation of Pumping up of Ground Water for Use in Building".

During this period, the city implemented a more complete leveling survey for ground subsidence monitoring and created a monitoring network with the cooperation of the national government and municipalities in its neighborhood. In 1963, the city researched the strata of 1,000m depth by boring machine and increased the number of wells to monitor subsidence and the ground water level.

Land sank rapidly and the factories submerged in the coastal water were abandoned. Due to the

shock generated by this incident, an incentive was created for promoting subsidence countermeasures with the firm cooperation of the public and private sectors. Despite the restriction of private rights the city ordinance aimed to regulate the rights to ground water pumping in order to protect the welfare of the public by preventing subsidence. Further, to request stricter regulatory measures by the national government, private and public sectors joined to form a strong pressure group and introduced financial support measures for corporations. These measures became the foundation for the supporting measures for corporations and for more stringent regulations when full-scale counter-pollution measures were implemented. A pattern of pollution control measures undertaken by the cooperation between private and public sectors was formed.

Chapter Four: Environmental Protection Measures in the Private Sector

This chapter focuses on the environmental protection measures carried out by the private sector in Osaka. Four examples are presented: private corporations; measures for the environment and for energy and resource conservation in medium-sized steel maker; sand blast dust treatment measures in small factories; and joint treatment facilities for waste water of steel acid washing.

Private Corporations

The Osaka Industrial Association

The Osaka Industrial Association, which consists of corporate manufacturing managers, was established in 1914 at a time when Japan underwent rapid industrial conversion from light industry to heavy and chemical industries. Its purposes were to advance the common interests of the manufacturers, such as technological innovation through the members' activities; to promote the local economy; and to encourage progress in industry. (In the entire nation, there are only five industrial groups which have same objectives and activities as this. All of the groups are located in the Kinki Region.) Since then, using various committees and study groups, the Osaka Industrial Association has developed a range of serviceable activities such as mutual education, provision of information, and occasional policy suggestions stemming from research and discussions.

In 1965, industrial and urban pollution became a major social problem, and local residents stridently demanded that the corporations should take proper pollution control measures. The Osaka Industrial Association established the "Pollution Prevention Committee" believing that pollution countermeasures should be implemented not only by individual corporations but also jointly by all of the industry circle members. The committee gave speeches and held meetings discussing problems and possible control measures for industrial pollution, and conducted a corporate management symposium on industrial pollution based on administrative data and in cooperation with academia. Also, by sending missions to the US and Europe, the committee thoroughly researched the current countermeasures for industrial pollution with the cooperation of the other business groups in Kansai region.

In 1969, at the "Corporate Management Symposium on Industrial Pollution," in which the major corporate managers in the Kansai region participated, participants affirmed their attitude towards industrial pollution raising the following major:

1) It is natural that corporations should avoid causing pollution since the overall purpose of economic activities is to improve the life of the people. Therefore, pollution control should not be considered an external pressure, but a management requirement.

2) Pollution control is a corporate responsibility to the local society.

3) The regulations in pollution-related laws are basic rules, and corporations are obligated to follow them. Although pollution control requires a large sum of money, the costs of pollution control should be considered an important element in management, just like the costs for labor, finance, materials, and technology. Further, not only local factories but also management itself has to take responsibility for pollution control. Pollution problems should be actively discussed by national government, municipalities, corporations, and residents at the same table. The corporations have to recognize that they, too, are part of society.

Such attitudes by the management caused great response from every field and generated a large movement to solve pollution problems in the City of Osaka. Considering the importance of an active exchange of information among corporations in promoting an effective pollution control program, the Pollution Control Committee conducted a study to ascertain what pollution countermeasures were taking place in factories in 1971. The following are the points of the result of the research:

1) the actual conditions of complaints about factories and their responses;

2) the current and foreseeable future problems in pollution management: a lack of active technological guidance and support for funding, the need for administrative unification, a demand for regulatory guidance from a long-term standpoint, and the need for favorable measures in finance and taxes;

3) the influence of expenditures for pollution control (although corporations increased their production sales, and cut their expenditure as a countermeasure, 34% of them reported a decrease in profit);

4) the factors which make it difficult to solve pollution problems (lack of fund, undeveloped pollution control technology, lack of sites for pollution control facilities, inadequate city planning, etc.).

In order to learn and carry out effective and suitable pollution control technology promoting pollution control measures, corporate staff in the pollution control division established a study group in 1968. The study group focused on the current and the anticipated future problems in pollution-related laws, litigation cases dealing with pollution, pollution economics, the pollution control works undertaken by the Japan Environmental Corporation, and the utilization of computers in pollution control.

Furthermore, acknowledging that pollution removal is one of the requirements of corporate management and that the development of human resources is very important in promoting the measures systematically in the long run, the Osaka Bureau of International Trade and Industry, the Osaka prefecture, and the City of Osaka supported establishing the "Kansai Pollution Prevention Study Center" in 1971. They also started an educational training program for the entire corporate staff from the management down to the local workers. This center offered five courses whose contents are given in Table 4-1. The lecturers were drawn from related government agencies, research institutes, academia, experts in various industries, labor leaders, and editorial writers for newspapers. The lectures were given for four years, between 1971 and 1974, and a total of 1300 people participated; the lectures were quite successful. Thereafter, the "Law for the Establishment of Organization for Pollution Control in Specified Factories" was established in 1972. This law required certain special factories to employ a specialist for pollution control beginning in 1972. Also, the center modified its curriculum and started providing a course for pollution control managers who have national licenses; since the provision of the laws in the early 1970's, pollution control regulations has been gradually strengthened. At the same time, there existed a trend among industries that they should put forth opinions to the administration, and do what was necessary to improve the environment. The Osaka Industrial Association held an administrative meeting with the Osaka prefecture. Then, a similar meeting was held with the City of Osaka and the central government. The meetings are still being conducted to the present day. Such meetings made for better understanding between the industries and the administration and created a firm relationship between them. This

played a very important role in promoting the improvement of the local environment.

The Osaka Industrial Association actively made an effort to control pollution earlier than other economic groups. It launched beneficial activities such as research on pollution control technology, education about pollution countermeasures, and the creation of basic dialogue between and cooperation among government, academia, and industries, in conjunction with the economic groups in Osaka. The Osaka Industrial Association continues to do such activities even now. The companies have consistently tried to solve pollution problems by focusing on the local area. This background became the foundation for improving the environment in Osaka.

The Osaka Chamber of Commerce and Industry

The Osaka Chamber of Commerce and Industry, established in 1878, consists of all commercial and industrial workers, which covers everything from individual retailers to large corporations in the city, regardless of the size and type of the business. The original purpose of the association was to promote the development of the local economy and society. In 1970, as social awareness of pollution gradually spread, pollution control measures became an urgent issue for all companies. The Osaka Chamber of Commerce and Industry had a contract with MITI, and set up an "Industrial Pollution Consultation Office." The goals of this consultation works were to give guidance regarding pollution control technology, funding, and relevant laws to companies that were interested in preventing industrial pollution; to prevent member companies from causing pollution; and to increase the recognition of pollution control in order to protect the environment. In order to achieve these goals, the office provided a window consultation, a local technological consultation, classes and consultation meetings on pollution-related laws, and other works in public relations. Table 4-2 shows the content of the works (The Consultation Office was closed in March of 1990 after it achieved its goals).

Table 4-1: Training Courses in Kansai Industrial Pollution Control Center

Management Executive Course (entrepreneur, company manager)
- Acquiring overall knowledge on pollution issues.
- Cultivating the basic philosophy of management executives to deal with pollution issues.
- Training pollution control supervisors.

(Total training hours : 30 hours)

Labor Union Executive Course
- Acquiring overall knowledge on pollution issues.
- Cultivating the basic philosophy of labor unions to deal with pollution issues.
- Studies on pollution abatement measures.

(Total training hours : 30 hours)

Pollution Control Manager Course
- Acquiring the knowledge of pollution abatement technologies and measures.
- Training the pollution control chief managers.

(Total training hours : 92 hours)

Pollution Control Technology Expert Course
- Acquiring the knowledge of pollution abatement technologies.
- Training the promoters of pollution abatement technology.
- Training R&D staff on pollution abatement technology.

(Total training hours : 180 hours)

Judicial Affairs Course
- Acquiring knowledge of pollution legislation.
- Research on laws and judicial precedents.

(Total training hours : 45 hours)

Table 4-2: Outline of the Office of Industrial Pollution Consultation in Osaka Chamber of Commerce and Industry

1. Regular guidance
   The 4 expert counselors were appointed to provide the consulting services concerning pollution prevention technologies, pollution laws and regulations, financial assistance and tax incentive systems, and so forth.

Number of counseling cases by type (July 197–March 1971)

	Air Pollution	*Water Pollution*	*Noise*	*Vibration*	*Offensive Odor*	*Wastes*	*Others*	*Total*
Tech.	30	72	35	16	—	5	4	162
Law	11	12	9	7	—	2	18	59
Financial	7	13	13	10	—	—	11	54
Tax	6	1	1	1	—	—	2	11
Relocation	2	3	10	6	—	—	3	24
Others	9	20	7	9	1	5	41	92
Total	65	121	75	49	1	12	79	402

2. Expert counselors
   The expert counselors have enough knowledge and experience of pollution control measures. The counselors were appointed from the institutes which were fully independent from the government or any other administrative body. The counseling services were carried with full attention to the specific conditions of those who asked for the counseling on pollution control measures.
3. On-site technical consultation
   For the enterprises which need technical consultation of pollution control measures on site, pollution research and analysis services were provided by the counselors.
4. Training course
   In order to deepen the understanding of pollution issues, as well as to propagate the counseling system to the private companies, various training courses were held for manufacturing and other potential polluting industries by inviting pollution experts from governmental or administrative bodies.

As pollution control management standards became stricter with each stipulation of new pollution-related laws, it was necessary for companies to implement pollution control measures, such as monitoring of corporations. Although it was easy for large companies to implement those measures with their own funding and technological capability, it was not as easy for small- and medium-sized companies to provide the necessary materials for monitoring and hiring highly skilled engineers. It is still difficult in terms of human resources, finances, and technology for small and medium-sized companies to improve their facilities and streamline the processes. In order to overcome these difficulties, the establishment of neutral, official institutions, whose major works were the monitoring and analysis of pollution in contract with small and medium-sized companies; technological consultation and guidance; and R & D of pollution control technology were needed. After the Osaka Chamber of Commerce and Industry repeatedly talked with economic groups such as the Osaka International Trade and Industry Bureau, the Osaka Prefectural Government, the City of Osaka, and the Osaka Industrial Association, the **"Kansai Industrial Pollution Prevention Center" was established in 1972.** Starting in October of 1972 with the monitoring and analysis of water and air, the monitoring and analysis of different items increased yearly. The number of items was 160,138 in 1977. This was 24 times the number (6,673) in 1972, and 8.2 times the number (19,035) in 1973. Such activities, fostered by the Osaka Chamber of Commerce and Industry, helped small and medium-sized companies that lacked sources of funding and technology and greatly contributed to the advancement of pollution countermeasures on the part of small- and medium-sized companies.

The Pollution Control Association

As Chapter Two indicated, due to the intensification of soot and smoke problems caused by coal combustion, the City of Osaka suggested to organize the "Soot and Smoke Control Association" at ward level, which would consist of factories and building-related groups, when it consulted with business people in each district health center during the "Soot and Smoke Control Month" of November 1958. This proposal was based on the principle that fuel users' self-awareness and enthusiasm are indispensable to clean the air. The "Soot and Smoke Control Association" was first established in December of 1958 in the Higashi ward, where the pollution by soot and smoke emission from heating boilers in buildings was very serious due to the concentration of office buildings. The prospectus of the establishment stated as follows:

1) With rapid commercial and industrial development and an increase in population, smog coated the city sky, and air pollution and its impacts on buildings became very serious.

2) This phenomenon not only damaged the scenery in the city, but also caused critical problems for the citizens' health.

3) Air pollution control in the city was an issue which should be solved by cooperation between the employers and employees of combustion facilities and the citizens.

4) The purposes of the Association were to contribute to the public welfare through proper monitoring of air pollution, analysis of the effects of pollution upon the human body from the public health standpoint, economic research on fuel consumption, and implementation of combustion management and soot and smoke control measures.

Thereafter, each district continued to have a "Soot and Smoke Control Association." In 1960, the "Federation for the City of Osaka's Soot and Smoke Control Association" was established with all district associations and pollution control spread throughout the city. The number of members began with only 27 companies in 1958, but it increased to 1,733 in 1966 and to 2,726 in 1982. The major activities of the "Pollution Control Association" included pollution monitoring by its members or by engineers belonging to the Osaka Prefectural Industrial Promotion Group in close cooperation with local health center; consultation for projects or cruise guidance on soot and smoke control; combustion management; lectures/field trips/meetings on pollution control; publication of the association newspaper "Kemuri" ("Smoke"); and the giving of awards to facilities and staff that distinctly contributed to controlling pollution. The "Kemuri" reports not only administrative information such as laws, ordinances, regulations, or administrative measures, but also presents articles on combustion management technology, pollution control technology, pollution control measures in each facility, the latest equipment for pollution control, and an analysis of the status of the business establishment on pollution control. It has contributed greatly to the improvement of the technology in its members, and to an overall increase in awareness of pollution control.

Reasons for the Success of Pollution Control Measures in the City of Osaka

Japan's administrative structure consists of three levels: central, prefectures, and municipalities and measures determined by central policy-making are implemented through them. When industrial pollution became prominent, the center and the prefectures had regulatory authority for industrial pollution through laws and prefectural ordinances. Unfortunately, the measures were neither effective nor concrete. Citizens who suffered pollution damage complained only to a local administrative branch under the city office which had no authority to act. The City of Osaka passed the citizens' complaints to the Osaka prefecture, and asked for measures. The complaints sometimes bypassed the Osaka prefecture and were sent to a branch of the national agency. However, there was almost no response. **There are several reasons for the success of pollution countermeasures in the City of Osaka under these circumstances:**

1) Ground subsidence has been a critical problem in Osaka since the pre-war period. The public and private sectors cooperatively implemented subsidence prevention ordinances ahead of national measures, and established a system to implement measures. Osaka used the approach of public and private cooperation.

2) In the pre-war period, there was a movement to improve air quality on the part of the administration, researchers and business circles, and various data was accumulated. These preparations led to soot and smoke control in the 1950s.

3) The Osaka mayor prioritized removal of industrial pollution as the most important policy in the city and designed a strategy for pollution control based on available technology in cooperation with scientists and researchers.

4) To implement the strategy, the City of Osaka formed an administrative organization for pollution control whose members consisted mainly of environmental sanitation monitoring staff (pharmacists and veterinarians) and technical staff specializing in civil engineering, architecture, machinery, and electricity, all selected from city agencies. Furthermore, the "Pollution Control Engineer Group" was quickly organized through preferential hiring of university graduates with environment and sanitary engineering majors. Since they already had a technical background, special training was not necessary.

5) The City of Osaka systematized financial support measures, such as the "Osaka City Loan for the Installation of Anti-Pollution Equipment" and the "Purchase System of the Site of Relocated Pollution Source Facilities" for small- and medium-sized companies and gave them priority when dispensing financial assistance.

6) With respect to urban waste water, the city set up guidelines for a basic policy and implemented infrastructure beginning from the pre-war period.

7) The following two factors were most important:
   i) the city's proper recognition on the importance of scientific and technological support in the solution of industrial pollution;
   ii) firm commitment of the top management and the creation of a reliable technical group were key to the success of the measures to control industrial pollution.

8) The reasons for the success of measures to control soot and dust and SOx in the city were a national fuel policy which demanded conversion from the use of coal to the use of oil, and an energy policy which favorably allocated lower sulfur heavy oil to areas with serious levels of air pollution, like Osaka.

9) Since gas was already in use city-wide, it was easy for factories to convert to gaseous fuel.

10) The cooperative attitude of local corporations to pollution control, based on their sense of responsibility towards their local society.

11) The groups of private companies such as the Osaka Industrial Association tried to implement pollution control measures jointly by all of the industry circle members through meetings and discussions, and by providing training and education, etc.

12) The support from mass media that appealed to residents was a very important factor.

Around 1970 in Japan, the problem of pollution worsened due to rapid industrial expansion. Since pollution had an adverse effect upon all parts of society, including residents, corporations, and administrations, solving the problem of pollution became an important national issue. At that time, a large sum of money was invested into controlling pollution, and the investment was part of the basis for economic growth. Thereafter, the gain from energy saving balanced the cost of pollution control measures through process change.

Technology Transfer to Developing Countries

Technology transfer in terms of environmental protection includes both administrative measures, and hard technology, such as pollution control equipment. Politics, the administrative system, and economic conditions are diverse in developing countries. Therefore, the pollution countermeasures in developing countries should be selected according to its local applicability.

The following elements in the experience of Osaka are important for developing countries:

1) Use scientific methods. In order to design and execute the measures based on science and technology, staff with a high level of technological expertise should be educated and hired.

2) Establish a cooperative system between public and private sectors. This is one of the major characteristics of the experience of Osaka. The technical staff in the city administration at the city and district levels and the engineers in factories cooperated, and enhanced technical standards.

3) Encourage industry associations to establish waste minimization and pollution control committees and advice functions to provide outreach and training to their members.

4) Focus on hot-spot areas in the city for intensive pollution control measures to achieve desirable results.

5) Establish a financial system that supports corporations which introduce pollution control technology. The City of Osaka created a system which helped small- and medium-sized companies that were short on financial resources. Under that system, a loan was released after technical screening of treatment equipment was conducted.

With respect to pollution control equipment, the applicability of hard-ware technology to developing countries depends on the certain conditions. Without considering these following conditions, technology transfer will fail:

1) **Energy supply:** The appropriate control equipment depends upon the available energy sources and their reliability. For example, if mu-

nicipal gas is provided in the cities, its use can greatly improve air quality.

2) **Technical Capability:** Since equipment needs maintenance, it is necessary to consider the parts production capability and the repair capability of small enterprises. Pollution control equipment which cannot be handled by the technical capability of users should be phased out.

3) **The legal system, location conditions, and degree of environmental pollution:** These three factors should be considered when determining the most efficient method of removing pollution. It is also necessary to take the local environmental conditions into account.

4) **Economic strength of industries:** Substantial funds are needed to maintain the pollution control and the monitoring equipment. Adequate pollution control equipment should be selected, taking into account the capital, operational and maintenance costs, and financial capability of the firm to pay for them.

5) **Educational standards:** Training requirements for engineers differ significantly, depending on their educational level. Pollution control equipment which needs high technical expertise for maintenance should not be selected unless highly educated engineers can be hired.

A prerequisite for effective pollution control measures is to ascertain current conditions. In order to comprehend the characteristics of air pollution, for example, it is necessary to know how it dilutes in time and space. It is sufficient to have a monitoring system that combines minimum automatic monitoring stations with maximum simple monitoring points selected on a case-by-case basis. Having a monitoring system which needs expensive maintenance costs should be avoided, although some Japanese municipalities use it. Each individual treatment equipment cannot be discussed here. However, many factories in the City of Osaka are using different pollution control facilities, varying in treatment method, treatment efficiency, and facility size. This equipment should be good reference when introducing pollution control equipment to developing countries.

ANNEX 1: Osaka Industrial Association

The Osaka Industrial Association was founded in 1914. The Association started with a foundation mainly consisting of the industrial executives but, in the course of time, it has become necessary for the industrial and economic growth in the Kansai Region to strengthen extensive tie-up and cooperation with various sorts of industries, not merely limited to the manufacturing division. As a consequence, all the divisions of industries and economy such as construction, finance, insurance, services have come to join the Association. The total number of member companies in 1992 was around 1200, consisting of 670 steel, metal machinery, electric, chemical companies; 190 for construction; 170 for commercial; 140 for finance, insurance, services, and 30 for public utilities and other organizations.

The characteristics of activities of the Association are that it performs the practical actions, based on the spirit of its foundation, for the mutual enlightenment and interest among members and for the industrial and economic development in the Region.

In addition to these activities, it has increasingly been called upon to strengthen the international relationship and contribution for instance, intercourse with overseas industrial and economic missions and Osaka Consulate General. The core of such activities as above is the standing committee. At present, the Association has eight standing and two acting committees. The standing committees are on Industrial Policy, Management Development, Judicial Affairs, Financial Affairs, Industrial Technology, Environmental Problem, Social and Cultural, and International Community Relations. The acting committees exclusively deal with the study of problems common to the above eight committees and their solution, and, at present it has two acting committees, namely, Global Environmental Problems and Industrial Design Committees.

Several study meetings are held for the mutual enlightenment of members and management improvement of member companies. University researchers and persons of academic experience are invited to lecture and discuss points focused on the theme together with members.

As described above, the Osaka Industrial Association has a long history of activities, among them are monthly Regular Luncheon Meetings, Monthly Breakfast Meetings and Incentive Tours to Industrial Areas held once or twice a year. The Monthly Breakfast Meeting is a social gathering between Osaka-based governmental organizations, local governmental heads and officers of the Association. The Regular Luncheon Meeting includes visits to well-managed plants and public facilities. Incentive Tours to Industrial Areas survey the industrial and economic conditions in areas other than Osaka and intercourse with governmental and business people in these areas.

The Association has been putting much emphasis on the cultivation of technical human resources. The Association established the Advanced Technical Training Institute of Osaka in 1959 with support from Osaka Prefectural Government to cultivate technical human resources of corporations. Training and education of technical trainee are conducted at this Institute cooperated by Osaka University, Osaka Prefectural University and others. Yearly, about 500 trainees receive training and so far some 20,000 have graduated in total who are now active at many corporations.

The Association took up the issue of pollution in 1967, taking the initiative over other various economic organizations. In the same year, the Industrial Policy Committee invited some lecturers from Osaka Prefectural Government and universities to hold lecture meetings, through which the Commit-

tee was active in enlightening membership companies about the pollution problem. Subsequently, in 1968, the Committee for the Industrial Pollution Preventive Measures Study was founded and governmental specialists in pollution, researchers at universities and research laboratories were invited to exchange discussions on the environmental countermeasures.

In 1970, the Pollution Prevention Committee separated from the Industrial Policy Committee and is exclusively engaged with the issue of pollution. The Pollution Prevention Committee is active in propelling the prevention of industrial pollution and henceforth contributing to industrial development compatible with the society.

In order to carry out these specific goals, the Association established Kansai Pollution Prevention Study Center in 1971, under the joint work with Kansai Productivity Headquarters and Osaka Training Center of High Technology, with cooperation by such governmental organizations as Osaka Bureau of International Trade and Industry, Osaka Prefectural Government, Osaka Municipal Government, together with Osaka Chamber of Commerce and Industry, Kansai Economic Federation, Kansai Committee for Economic Development and Kansai Employer's Association.

It is fundamentally necessary to cultivate corporate personnel to carry on the pollution prevention. Based on such recognition, the Study Center set up the training course targeted for employees ranging from executive management to manager, plant engineer, foreman at work site. The training for these personnel was conducted over four years, during which period about 1300 personnel from Kansai's corporations received the training. During the period of the training, not only specialists from governmental offices, researchers from universities and laboratories, but also, corporate executives, labor union staff and press editorial writers served as lecturers.

The fundamental concept of the Association on the pollution prevention is, "To do what must be done,""To say what must be said." In 1969, the industrial and economic bodies of Kansai dispatched to Europe and America "Kansai Mission of Industrial Pollution Issues" composed of the top-management class of the Kansai business world. Those participating in this tour learned through the European-American tour that, the social climate highly respecting human life and health is deeply rooted region to region and corporations execute feasible anti-pollution measures while evaluating its economic effect.

Both authorities and industry understood the need to frankly discuss concrete countermeasures together, thus, "The Talkfest for Administrative Policies" was set up together by Osaka Prefectural Government and Osaka Industrial Association. The Talkfest was scheduled to be held every year; subsequently, emphasis has been placed on driving the regional pollution prevention forward under the government-industry cooperation. Such Talkfest is held also between the Association and Osaka City Government. This Talkfest stabilized in Osaka not apparent in other regions. It is highly rated as a model to advance the regional environmental protection measures through dialogues and coordination between concerned authorities and industries.

In order to expand its range of activities regarding environmental issues, the Environment Development Committee in 1977 set up the Special Committee for Environmental Development composed of clerical managers under the Pollution Prevention Committee. A proactive approach to global environmental problems has been taken up as a central task for the committee, and has continued to collect related information and research. (The Acting Committee for Global Environmental Problems—a direct spin-off of these efforts— first met in 1991.)

ANNEX 2: Lead Peroxide Method (PbO_2 Method)

The lead peroxide method is developed in Britain as a simple measuring method using the reaction of SO_2 and SO_3 with lead peroxide PbO_2 to form lead sulfate, $PbSO_4$. Although this method cannot measure the absolute concentration of SO_2 and is also low accuracy, it is a simplified manual analytical method to be convenient in use. It has a wide scope of applications, for example, such as to investigate the state of SO_2 dispersion around a thermal power plant.

The paste of PbO_2 is applied to cotton cloth, which is then wound around a porous porcelain cylinder. Provided with a proper shelter from rain, the cylinder is left outdoors for a period of time, eg, one month. SO2 reacts with PbO_2 which obtained when a sulfuric acid ion is determined by gravimetric method using barium ion.

$$SO_2 + PbO_2 \longrightarrow PbSO_4$$

$$SO_3 \text{ mg/day/100 cm}^2 PbO_2$$

$$= (w1 - w2)\frac{80}{233} \cdot \frac{100}{a} \cdot \frac{1}{n} = \frac{34.3(w1 - w2)}{a.\,n}$$

wherein,

W1: Quantity (mg) of $BaSO_4$ obtained form PbO_2 cylinder being left in the air.

W2: Quantity (mg) of $BaSO_4$ obtained by blank test.

a: Area (cm^2) applied with PbO_2

n: Number of days for which PbO_2 cylinder was left outdoors.

What must be taken into consideration when using this method is that it is conspicuously influenced by wind velocity, humidity and temperature. An increase in the wind velocity increases the amount of contact with lead dioxide, and as the humidity becomes higher, the rate of sampling is said to increase by 0.4%. Therefore, if the numeric values obtained from this method are thought to be the absolute indication of air pollution, there will be a significant risk of misunderstanding the real state. In fact, the result obtained from this method shows that in summer when the temperature and the humidity are high, the values of the measurement are higher than in winter, and that the results are often quite opposite to the seasonal changes of the concentration of sulfuric acids in the air measured with pararosaniline method. This method was originally devised in order to obtain a coefficient showing the activation of sulfur dioxide which will injure buildings in the atmosphere, and it may be proper to think that this is an experimental method of getting the coefficient obtained from the combination between the activation of the atmosphere polluted with sulfur oxides under the overall conditions of sulfur oxides, the velocity of wind, humidity, and temperature and the activation of lead dioxide itself under those conditions. These things are what should be especially kept in mind in the case of a comparison among the numeric values obtained from this method.

And as the quality of lead dioxide produces a great deal of effect on the values of measurement, it is necessary to use lead dioxide of a certain level of quality.

The total cost of the equipment and analysis was about 10 thousand yen in 1990.

ANNEX 3: Campaign for Idling Adjustment

Background

Around 1967, air pollution caused by automobile exhaust gas, especially CO, became a serious problem with the rapid increase in the number of cars. The City of Osaka considered the importance of CO control measures as it conducted environmental measurement at major intersections, surveys of the impacts on human body and public opinions since 1962.

National government started guidance of CO control to new-model cars in September 1966 and new cars made after September 1967. However, to the existing cars in use, there was no applicable measures to be taken.

In April 1967, Osaka City Pollution Administration Liaison Council proposed the idling adjustment campaign as a tentative plan for automobile exhaust gas control measures.

Process of implementation

- *April, 1967:* Proposal of the campaign came from the idling adjustment already implemented successfully in Paris to reduce CO emission in idling.

- Various surveys conducted by the City of Osaka before the implementation
  - establishing patterns of cars in Osaka
  - research on idling adjustment methods with universities
  - feasibility study on development of the campaign (questionnaires sent to car repair shops)

- Establishment of "Osaka Style" idling adjustment after remodeling Paris Style. By adjusting effectively screws of idling adjustment and throttle adjustment in carburetor and decreasing the fuel flux without damage to the running capacity, CO concentration can be reduced to less than 3%.

- *December 1967 through March 1968:* Implementation of idling adjustment to 2,000 official cars belong to Osaka city and prefecture.

- *March 1968:* Establishment of "Osaka Automobile Exhaust Gas Control Promotion Committee" as a nucleus of the campaign promotion as citizen's movement. (The members of the committee are 20 groups such as Osaka prefecture, city, Osaka Prefectural Public Headquarters, Osaka Transportation Bureau, Osaka Chamber of Commerce and Industry, Osaka Prefectural Trucking Association, Osaka Automobile Dealers Federation, etc.)

- *May 1968–*: Development of the campaign
  - Committee members took the lead in adjusting the idling of their cars.
  - Public relations (TV, radio, newspaper, posters, etc.) to the citizens.
  - Appeal to repair shops and gas stations for adjustment at the time of regular check-up and repair, and put "idling adjusted" stickers on the cars.
  - Appeal car dealers to do adjustment at the sale of new cars and put stickers on the cars.

The number of adjusted-idle cars (up to February 1969)

Organizations implemented adjustment	
Repair shops	45,000
Car delars	136,000
Prefecture. city and other cities	2,420
Kansai Electric Power Co.	530
Gas stations	1,260
Total	185,210

- *August 1970:* As a result of this campaign, the control for cars in use by law was started. (CO concentration 5.5%)

- Thoroughgoing campaign through street investigation of cars in use the car with high CO concentration over CO standards were advised and noticed to do adjustment and improvement.

The result of the street investigation

Year	Total number of cars	CO concentrarion		
		less than 5.5%	5.6–8.9%.	more than 9%
1970	5,974	49%	37%	14%
1971	4,452	66%	27%	7%

Effects of the campaign

- More than half of adjustment, CO concentration reduced to less than 5%.
- Following this campaign, the other cities developed the similar campaigns, which led to the enactment of a law for regulation of cars in use.

Environmental and Energy Saving Measures in Medium-Sized Steel Industries

This example presents environmental and energy-saving measures in a medium-sized integrated steel factory. This integrated steel factory, established in 1919, has blast and converter furnaces, a non-stop steel casting machine, and a rolling mill, and it is located in the southern part of the western coastal industrial area of the city. Currently, the capital it generates is 12.9 billion yen. Its employees number 2,000 and the area taken by the factory site is 0.74 million m^2. It produces 2.2 million tons of crude steel with an annual sales profit of 150 billion yen. This factory is one of bigger factories in the city.

Basic Policies of Environmental Protection Measures

The basic policies of environmental protection measures in the factory are: to meet the regulatory standards of laws and ordinances; to take responsibility, as a steel manufacturer located in a large city, through active cooperation with environmental measures in Osaka Prefecture and the City of Osaka; and to contribute to the improvement of the environment in the local society. The result of these environmental protection measures from productive standpoint is, generally, an increase in cost. However, the measures for reducing pollutants by strengthening management in areas like energy saving, resource saving, and facility protection decrease the costs. Therefore, the basic idea behind implementing environmental protection measures is weighing the balance of the costs.

Environmental Protection Measures

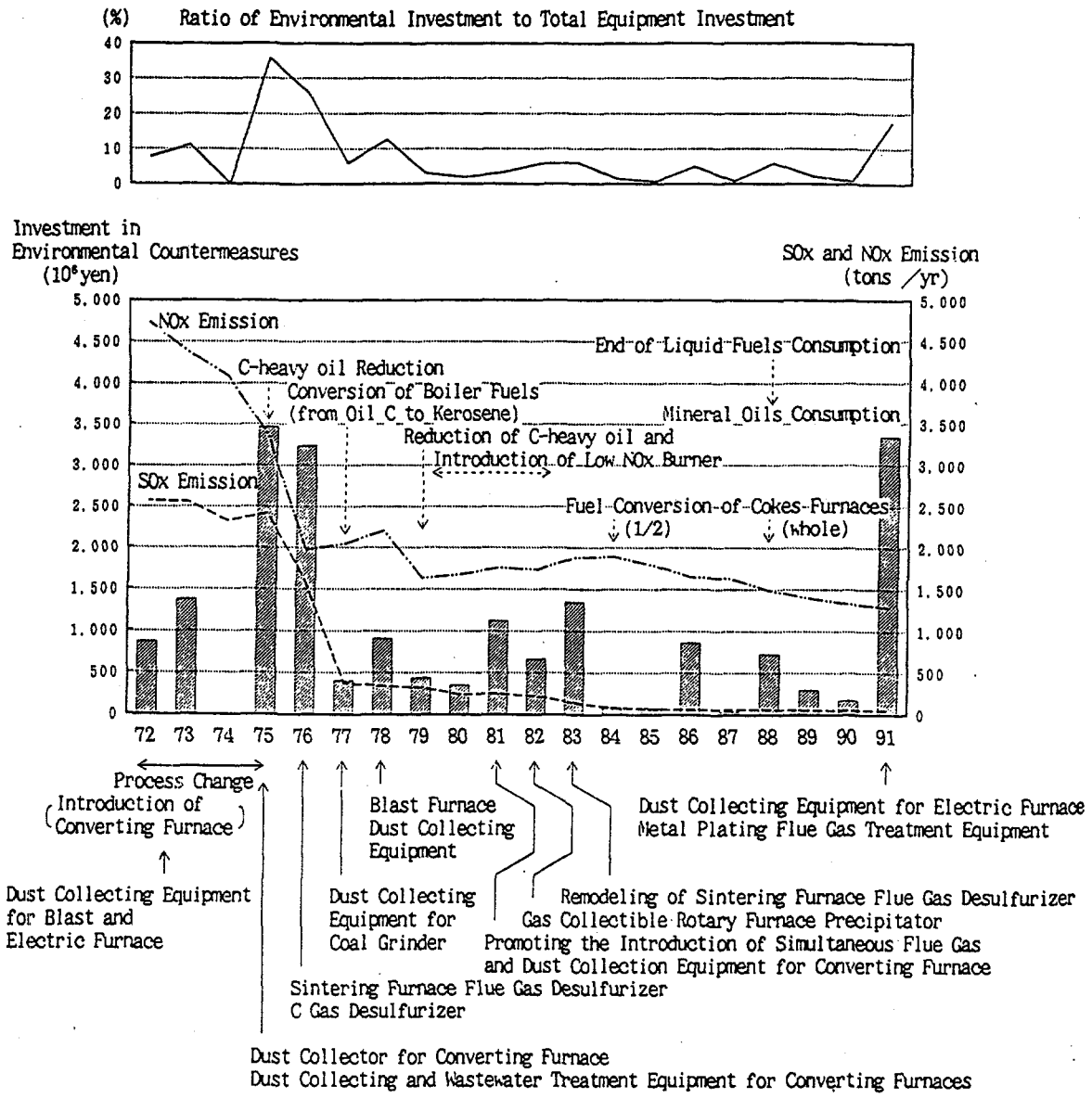
Steel production uses a large amount of materials and a variety of processes. In each process, a large amount of fuel and water is used, and consequently, a large amount of exhaust gas, waste water and other wastes are discharged. Thus, to solve this pollution problem, pollution control equipment is installed, the production process is improved to reduce pollution, and clean energy is introduced in accordance with the process. Exhaust gas and wastes, which still contain usable resources, are recycled. Recycling waste water reduces the amount of waste water and greatly reduces the load of pollutants. Furthermore, each process introduces completely new equipment to protect the environment, and cleans both the interior and the exterior of the factory.

Investment in environmental measures Figure 4-1 shows the investment in environmental measures and SOx and NOx emission. The sum of the money invested in environmental measures such as air pollution control, waste water treatment, and facilities for the environment approaches approximately 20 billion yen in the past 20 years. Under Figure 4-1, investments as air pollution countermeasures, such as installation of major gas treatment equipment and process improvement, are described. Although there is no description given for some years, investment mainly went to waste water treatment equipment or tree planting. The figure indicates measures such as fuel conversion and adoption of NOx decreasing burners, which reduces SOx and NOx emission. This figure displays the ratio of investment in environmental measures to that in total facilities. This investment in environmental protection, which accounts for more than 25% of total facility investments between 1975 and 1976, led to the installation of desulfurization equipment. The result was that SOx emission reduced considerably. The operation cost of environmental protection facilities was 3,360 million yen per year (actual base in 1991), of which 50% is spent on electricity.

Air pollution control SOx measures are:

i) a large reduction of C-heavy oil accompanied by the conversion from open-hearth furnaces to converters;

Figure A-4-1: Investment in Environmental Countermeasures of SOx and NOx



ii) installations of stack gas desulfurization equipment in a sintering furnace, and use of desulfurization equipment in a coke oven; and

iii) reduction of liquid fuel consumption by using secondary gases efficiently (ie, blast gas, coke oven gas, and converter gas).

Represented in i) is a modification of the process with an increase in energy efficiency, and iii) is an energy saving measure in factories. Such measures resulted in a 98% reduction of SOx emission, from 2,571 ton/yr in 1972 to 51 ton/yr in 1991. The reasons for implementing the measures were as follows:

a) the necessity of emission reduction due to stricter regulations in both laws and ordinances (stricter K-value in regulatory concentration, and the introduction of total emission regulation);

b) the necessity of SOx emission reduction to decrease the levy of emission charge by the polluting corporations under the "Pollution-Related Health Damage Compensation Law";

c) the design and implementation of the reduction plan as a response to the request of cooperation in the execution of administrative guidance plan formulated by the City of Osaka and Osaka Prefectural Government.

NOx measures are:

i) change of the process
ii) conversion from heavy oil to good quality fuel
iii) improvement of combustion methods
iv) adoption of lower NOx materials

Measures i) and ii) were effective in reducing NOx, just as the SOx measures were. Their outcome was that 73% of NOx emission was reduced from 4,731 ton/yr. in 1972 to 1,291 ton/yr in 1991. The company is currently considering further reduction in response to the city's request. Fuel conversion with the use of a by-product gas is an energy-saving device .

Figure 4-2 shows fuel consumption. Although the consumption of heavy oil and coal-tar accounted

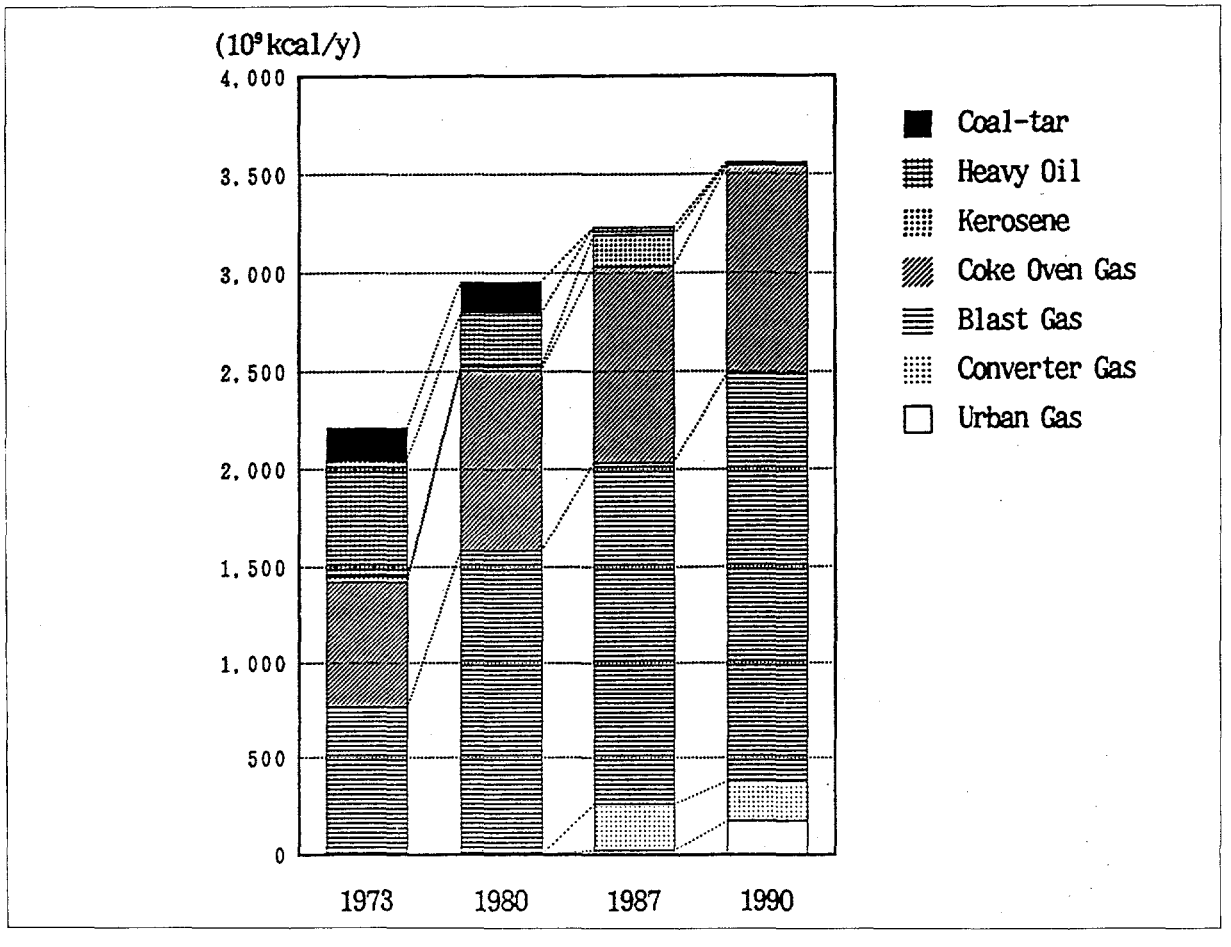


Figure A-4-2: Fuel Consumption by Type of Fuel

for one-third of the total consumption in 1973, it accounted for about only 15% in 1980, half the original volume. Heavy oil was converted to kerosene in 1980, and by 1990, liquid fuel was hardly ever used. As measures for controlling particulate matter, exhaust gas treatment facilities for production facilities such as blast furnaces, coke ovens, converters, and sintering furnaces, and dust-collecting equipment were installed in factories. Dust prevention measures such as material yards or conveyors were implemented. As for future measures, an improvement in dust-collecting equipment, leakage protection, an amelioration of the sprinkler equipment, and maintenance are scheduled.

Waste water The waste water generated through the process (except for the indirect cooling water) from blast furnaces, coke ovens, non-stop foundry facilities, plating facilities, and wet dust-collecting equipment is 125 thousand tons per day. All waste water is collected, and treated through processes such as coagulating sedimentation, the activated sludge method, rapid filtration, cooling, and pH neutralization. Ninety-seven percent of the waste water is recycled, and the remaining three percent is discharged into rivers.

Industrial wastes The volume of industrial wastes in 1991 was about 270 thousand ton/yr., of which 90% was slag from the converter and electrical furnace. About 50% of the slag is disposed by landfill, and the rest is effectively used for construction or cement materials. Dust ash and sludge are used for steel and cement materials. Secondary products from the desulfurization equipment are effectively used for sulfuric acid materials or fertilizer. The annual expenditure for industrial waste treatment is approximately 510 million yen (1991).

The internal organization for pollution control As an internal organization for pollution control, the Environmental Management Division was installed as a supervisory section under the Environmental and Energy Bureau. Based on the "Law for Establishment of Organization for Pollution Control Organization in Specified Factories," the company established a self-management system by appointing a managing director as the supervisor of pollution control, main managers, and each factory manager as a pollution control manager. Furthermore, in order to increase the employees' awareness of pollution control and to implement comprehensive pollution control, the company regularly scheduled seminars or meetings to report the actual conditions and problems of pollution control in each factory, gave training in how to behave in case of accidents, patrolled the factory, and utilized informative placards/posters.

Saving Energy

Since the latter half of the 1970s, the company has actively promoted the replacement from open-hearth furnaces to converters for use in the processing; the recycling of gas from blast furnaces, converters, and coke oven (currently 99% of the gas is being recycled); the recycling of waste heat; non-stop foundries; an increase in adiabatic strength; the installation of combined electric facilities; de-petroleum; and complete combustion management. These measures save energy as well as reduce air pollution. As Figure 4-3 indicates, energy consumption per ton of crude steel has declined by 33% since 1973.

The reasons for actively promoting energy-saving measures were a need to reduce the production costs, the soaring price of crude oil and the difficulty in obtaining oil due to two oil shocks, and the stricter SOx and NOx regulations.

Overall Evaluation

The factory greatly reduced pollutants through drastic investment in new pollution control equipment in the 1970s. Thereafter, it continued to reduce pol-

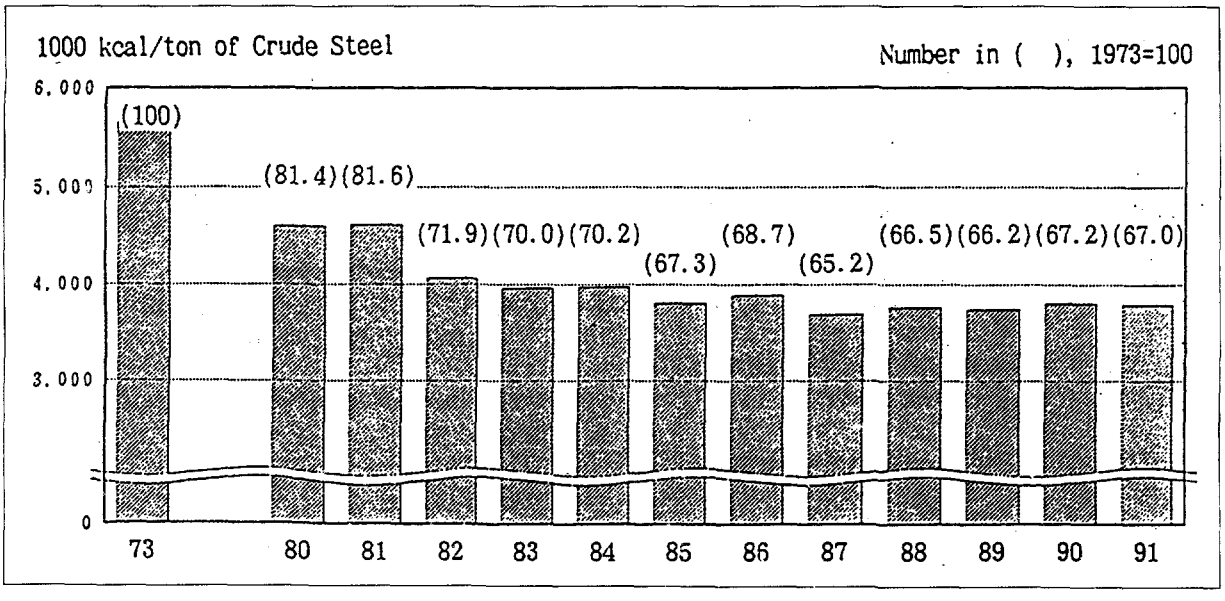


Figure A-4-3: Trend of Energy Consumption per unit Production of Crude Oil, 1973–91

lutants through a combination of the environmental protection measures and the resource-and-energy-saving measures.

Sand Blast Dust Measure

Small- and medium-sized companies introduced counter-pollution facilities by using the loan system for pollution control facilities in the City of Osaka. The city operated that system flexibly in order to respond to the companies' diligent action.

The company to be presented here is a small- and medium-sized company with 30 million yen of capital and 60 employees in 1970. It's operation is metal surface treatment such as sand blasting, grid blasting, metallicon, coating, and buffing. The sales were about 220 million yen as of September 1972.

Historical Background

Since 1960, the company has researched and implemented the introduction of a water washing method for dust control, but the removal rate has not been favorable. The enactment of the Air Pollution Control Law strengthened the emission standards (0.5 mg/m^3) in 1971. The company did not receive any direct complaints from the local residents, but it thought that a rapid introduction of effective facilities was necessary to prepare for even stricter regulations, since the City of Osaka had implemented urgent measures for air pollution control in Nishi Yodogawa ward.

Summary of Measures

The company implemented comprehensive pollution control measures such as the installation of complete dust-collecting equipment for sand blast dust (bag filter: effective rate 99.95%), silencers for secondary pollution control, and dust mixer equipment (waste measure: adding water to dust ash).

The Structure of Decision-Making

The company was profitable at that time, but it did not sufficiently implement pollution control measures. Consideration was given to transferring the factory in order to avoid disturbing its neighbors. However, the company finally concluded that the measures should be taken at the present location

without any relocation of factories to minimize the new equipment investment, as well as to secure the present employees. One factor in realizing this conclusion was the company's cooperation with treatment equipment makers in active technological development. Another factor is that the companies were able to obtain financial support from the City of Osaka for installing pollution control facilities.

Content of Financial Support

At first, companies could only use the loan system in the City of Osaka one time. However, the City of Osaka changed the system considering this company's enthusiastic actions to install pollution control equipment, so that the company were able to use it in 1970 and 1971.

Interest rate:	8.4% /yr. The City of Osaka subsidized 5% of the interest payment.
Loan from the City:	30 million yen
Self Loan:	20 million yen

Moreover, as preferential tax treatment, 78% of the original loan, which consisted of 50% special repayment in the initial year, and 28% general repayment (7-year loan period, and 28% in the initial year), was accepted as repayment. Therefore, the company could undertake heavy investment in pollution control facilities.

Merits and Weaknesses

1) The company could push itself toward business without worrying about pollution.

2) The installation of bag filters created a noise problem. Thus, the company needed to spend extra installing new silencer equipment.

3) Later on, the owner of the company said that the 50 million yen investment in pollution control for a company whose capital was 30 million yen was a gamble, and that it took a lot of courage to invest.

Total Evaluation

During the high economic growth period, the company could, using comprehensive dust-collecting equipment, develop without complaints from local residents. Furthermore, since pollution was a social problem, the company's active role in countering pollution was highly lauded, and the company received more jobs from major manufacturers.

Sales	220 million yen (September 1972)
Up 30%:	270-280 million yen (March 1973)

At that time, loans from the City of Osaka were limited to 10 million yen per a company and were given only once. This company became a good example for others to follow. Later, the limit of the loan was modified to 20 million yen, and the loan system was strengthened.

Joint Treatment for Waste Water Used for Washing off Steel Acid

This example shows that pollution-causing companies contributed to pollution control by installing joint treatment facilities under administrative guidance.

Content

Twenty-one zinc plating companies in the Osaka prefecture established the Osaka Treatment Center for Waste Acid in March 1968. Shortly after, a joint treatment facility for sulfuric acid was constructed in September of 1969 with the participation of com-

panies connected to polished stick steel, steel pipes, and wire rods, which discharge waste acid. The center treated collectively the sulfuric acid waste water discharged from its 99 members, and partially recycled it. This way, the industry could drastically reduce the costs of pollution control.

Summary of Joint Treatment Center

Number of members:	99 companies and 5 cooperative unions
Area of site:	2,123 m^2
Construction costs:	318.8 million yen
Loan:	80% from the Osaka prefecture and Small and Medium-sized Companies Promotion Corporation, 20% from the Environmental Pollution Control Service Corporation (currently known as the Japan Environment Corporation)
Treatment capacityof waste sulfuric acid:	7,000 ton/month
Refined sulfuric acid (50% sulfuric acid):	1,750 ton/month
Recovered ferrous sulfate heptahydrate:	1,582 ton/month
Number of employees:	15

Historical Background

It is imperative for steel processing makers to remove rust from steel. Around 1960, rust was usually washed off by sulfuric acid. Since the waste water is strongly acidic, without treatment its discharge will contaminate water and damage sewers and agricultural products. In this time period, waste acid around Osaka prefecture increased yearly, and amounted to more than 13 thousand ton/month. Also, complaints to the Osaka prefecture about waste acid increased. Some small- and medium-sized companies which lacked treatment facilities went out of business.

In 1963, the Osaka prefecture offered guidance to these business establishments, stipulating that factory waste water should be regulated by stricter ordinances, and introduced the final waste water treatment facility. Recognizing that the treatment of acid water was urgent and instrumental in the future continuation of corporate activities, the industries started researching a treatment method. In 1965, the Osaka prefecture gave the zinc plating industry (the Kansai branch of the Japan Melting Zinc Association) guidelines on the joint treatment method of recycled waste acid. Examining the method and its economy of treatment, the industry decided to carry it out with the support of the Osaka prefecture and Osaka city. In fall of 1965, the industry asked the Osaka prefecture for support in establishing the joint treatment facility. In response, the Osaka prefecture announced the construction plan of a joint treatment plant. In March of 1968, the "Cooperative Union, Osaka Waste Acid Treatment Center" started with its task of promoting the construction of the treatment plant.

The industry rented 2000 m^2 of the site from the City of Osaka, obtained a loan of 318 million yen for construction costs from the Japan Environment Cooperation, and the Small and Medium-sized Company Promotion Fund, and conferred the sum of 20 million yen, jointly contributed by the members, to the operational costs. Then, it constructed a waste acid renewable treatment plant whose capacity is 7 thousand tons/month. The construction of the plant was completed in September 1969, and it began operation in October.

Structure of Decision-Making

- The companies understood that they could not discharge waste acid without treatment. Also, they judged that the construction of a joint treat-

ment plant forced them to borrow the money and site from the public organizations, and to obtain support from the Osaka prefecture and city, and to have technical advantages. Furthermore, there was a strong leader to actualize the project in the business circle in this period.

- The treatment adopted the recycling method rather than the neutralizing method. The neutralizing method is inexpensive in terms of construction costs, but it requires a large amount of sludge disposal. On the other hand, the recycling method is expensive. However, the administration and the corporations decided to adopt this method after considering recycling and reuse of resources, and the marketability of the secondary products (i.e. iron sulfate) of recycling.

- Since the businesses were small- and medium-sized, those companies could use loans from the Small- and Medium-sized Company Promotion Fund. Furthermore, they also had the possibility of using the Environmental Pollution Control Service Corporation.

- To reduce the costs, not only the melting zinc plating industry participated, but also the establishments for polishing stick steel, steel pipes, and wire rods. Also, waste acid discharged from a large factory, which was located next to the prospective construction site, could be secured.

- The Osaka Prefectural Government and the City of Osaka supported the joint treatment plant because the plant effectively promoted the pollution control measures of small- and medium-sized companies.

- The industry could secure the market for recovered iron sulfate under the guidance of the Osaka Prefectural Government and the City of Osaka.

Content of Treatment Works

1) Waste sulfuric acid discharged from member factories was carried by truck tanks to the plant (waste sulfuric acid contains 5% sulfuric acid and 13% iron sulfate).

2) Collected waste sulfuric acid was recycled as 50% sulfuric acid, ferrous sulfate heptahydrate through vacuum concentrator and vacuum crystallizer.

3) Recycled sulfuric acid (1/3 of the discharge) was taken back to the companies that discharged it, and iron sulfur was sold.

4) The treatment fee and repayment plan are as follows (1969):

   - Treatment fee: 1,400 yen/ton (700 yen for the treatment works, and 700 yen for the facility, repayment of debt)
   - Loan from the Japan Environment Corporation: 4 years for redemption
   - Small- and Medium-sized Companies Promotion Fund: 15 years for redemption

5) To secure the quality of the secondary substance, the plant regulated the type of steel and the method of washing by the Rules for Waste Acid Treatment, and prevented different substances from being mixed into the waste acid.

Merits and Weaknesses

Merits

1) The joint treatment method was more advantageous than an individual treatment plant in terms of site, funding, technology, and sludge treatment after the neutralizing treatment (99 companies greatly reduced their running costs per company by recycling secondary substances in the larger facility).

2) The costs of waste acid treatment is 1400 yen/ton for the treatment fee, and 1100 yen/ton for the truck tank. The company, which generates 100 tons of waste water per month, could control pollution for the cost of 250 thousand yen. The company saved labor and electricity costs by having a joint treatment plant.

3) Eighty percent of the construction costs came from the Small- and Medium-Sized Promotion Corporation, and 20% came from the Japan Environment Corporation. The completed facility was received as a mortgage.

4) The recycled sulfuric acid was purchased, to some extent, by sending-in companies. Ferrous sulfate heptahydrate (recovered substances) were sold as a coagulant for sewage treatment. In this manner, the company could save in treatment costs (these substances were sold as materials for steel-oxidized paint, ferrous materials, magnetic materials, and printing ink).

Weaknesses

1) In 1972, the sulfuric acid market was stagnant due to over-investment in facilities by the chemical industry. The price of 98% sulfuric acid dropped from 12 thousand yen to 8 or 9 thousand yen.

2) When the plant was first constructed, there was no other plant like it. However, treatment companies and large factories introduced similar treatment facilities, and the volume of waste acid decreased.

3) In the future, if the volume of domestic secondary steel products decreases due to industrialization in developing countries, a decrease in waste acid would be necessary. Therefore, reexamination of merits of joint treatment is expected.

4) Since the waste acid recycling equipment operated under harsh conditions, there were some cases where the companies could not meet the legal repayment period. Thus, the costs of repayment will be increased.

Total Evaluation

The establishment of the center helped solve most of the sulfuric acid pollution problem in the Osaka prefecture. Creating a treatment center in cooperation with industries at an early stage was very significant.

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