Environmental Management Plan for Air Pollution Abatement

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1. Introduction

Recently, the environmental problems are recognized by many people as the global matters. On the other hand, there are many difficult problems to settle as local environmental pollution problems too, although the past heavy environmental pollution caused by the industry in Japan has been going toward to solve by the administration based on the environmental conservation strategy.

Therefore, standing systematic view points, Japanese administrative activities on the environmental conservation are scrutinizing about the design and enforcement of the environmental management plan on the air pollution problems.

And the technologies for the enforcement of these policies may be useful for the environmental impact assessment institution. Since 1956, the author has been studying on the air pollution in Yokohama – Kawasaki industrial area[1-3] where the pollution was thought to be the heaviest in Japan.

The author has investigated on the measuring method of collection efficiency of dust collector[4], the expression of the specification for dust collector, the analytical method of nitrogen oxides concentration in flue gas[5] and on the emission factors of air pollutants[6-7] etc, at Industrial Research Institute of Kanagawa Prefecture and Kanagawa Prefectural Environmental Center.

And the author was the chief of Air Conservation Department, Environmental Protection Bureau, Kanagawa Prefectural Government in Yokohama, from 1977 to 1980 too. Here, the author represents the environmental management plan for the air pollution abatement through these experiences.

2. The history on the air pollution in Japan

The air pollution will be characterized by the age, area and development of technology. In Japan, the air pollution problems had been occured according to the industrialization since 19th century. After Meiji restoration 1868, modern scientific technologies from Europe and America had been introduced, and industrialization of Japan were promorted very quickly, so the air pollution problems occurred. For example, in 1875, the operation of the cement factory had started at Fukagawa, Tokyo by the Japanese Government, and the cement dust dispersion problem occurred. In 1903, Asano Cement Manufacturing Co. Tokyo factory, that was established by Mr. Souichirou Asano who was famous enterprize manager in this age, taking over the governmental cement factory introduced before, had adopted rotary kiln imported from Allis-Charmers Manufacturing Co. in US, then large scale cement dust dispersion problem occurred and was noticed by many people[9]. This episode was disolved by the adoptation of the electrostatic precipitator that was investigated by Dr. F. G. Cottrell[8], a professor of University of California, for treatment of cement dust[9].

The steel is very important industrial materials and has been used very widely.

The modern steel making industry equipped blast furnace had started in 18th century in Europe. In Japan, first modern blast furnace had been operated at Kamaishi City, Iwate Prefecture in 1858, by Mr. Takatou Oushima.

And this steel making technology had been replaced to the governmental Yawata Steel Mill estabilished at Yawata City in 1901[10]. So, Kamaishi and Yawata cities could not avoid from the air pollution problems due to steel mills.

The seaside reclaimed land construction had been done in Japan very early, to form large scale seaside industrial areas. It is special characteristic for Japanese industry to locate large scale factories in seaside industrial area constructed by the reclaiming works. And four large scale seaside industrial areas, called Keihin, Hanshin, Chukyo and Kita-Kyushyu were constructed until 1900's in Japan. And the air pollution problems occurred due to coal combustion facilities and steel mills located in these

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industrial areas.

During the world war II, Japanese industrial plants got crusing blows, and the atmosphere in Japan became very clear. Japanese people had to work very hard for reconstruction their industry to hold their life after the war.

Because the main energy sources of these reconstructed industries were the coal producted at Japanese coal pits that was contained lot of tar and ash, the air pollution due to black smoke and fly ash exhausted from coal combustion facilities occured and was noticed by many people living around the industrial areas again.

Furthermore, the iron oxide red smoke exhausted from steel making open hearth furnaces, electric furnaces and converter were noticed from many people living around the steel mills.

The fly ash was exhausted from pulverized coal combustion facilities at power plants, and the iron oxide red smoke were exhausted from steel making furnaces adopted purified oxigen blow steel making method investigated in this age[11].

Like these, the air pollution problems are characterized by the main energy sources, main raw materials and new technologies adopted by large scale factories located at industrial area occured these phenomena.

In May 1962, Japanese government established "Soot and Dust Regulation Law" according to the request to hope the abatement of air pollution from many local government and people lived in industrial areas. Before the establishment of this law, governments of Tokyo metropolis, Osaka, Kanagawa and Fukuoka Prefecture established "Abatement Rules for the Environmental Pollution Caused Industry", in 1949, 1950, 1951 and 1955 respectively.

And Dec., 1958, Japanese Government established two laws for the regulation of water pollution, according to the teaching obtained in Urayasu episode that was the troubles on the water pollution occured between the paper mill and union of fisherman in this year.

So Japanese government had the competences due to laws for regulation of environmental pollutant from the factories. After that, these competences has been strongly and widely year by year for environmental conservation.

For example, althrough in 1962 the concentration of soot, dust and sulfur oxides in the flue gas from the combustion facilities were regulated by "Soot and Dust Regulation Law" only about the factories located at the regulation area prescribed by this law, in 1967 first "Clean Air Law" was established, sulfur oxides exhausted volume was regulated. Furthermore, in this law, the regulation was carried out for the factories located in all over the country, and the regulation for automobile exhaust gas was adopted. As explained before, the administrative compentences became strong and wide, but recently the state of the problems on air pollution have became complicate as follows. Namely, the emissions of air pollutants from regulated facilities decreased by the administrative activities based on the "Clean Air Law", but the emissions from nonregulated sources or regulation difficult one have increased. By these changes about the environmental problems, the administration for the air pollution abatement is obliged to modify its strategy. And the design of the environmental management plan is requested in Japan as one of strategy for the environmental protection.

3. What is environmental management plan

Generally speaking, the population, the desire of persons and the production of industry and agriculture will increase more quickly than the effects of the abatement strategy for the environmental pollution due to these human actions.

And flankly speaking, the enforcement of regulation due to abatement policies hasn't been able to do completely today.

The policies for the environmental conservation on atmosphere were carried out using the technical countermeasures about air pollutants collection, such as dust collector and desulfurization equipments for exhausted gas and heavy oil.

Therefore, we are obliged to consume many energy sources for the operation of these air pollutants collection facilities, and to hold the environmental safety of the collected air pollutants. For example, in 1984, Japanese factories equipped about 1500 desulfurization facilities for the flue gas from these combustion process. And total treatmentable gas capacities of these 1500 desulfurization facilities were about 133.4×10^6 Nm^3/hr, so electric capacities to operate these facilities are calculated as

66.7×10^4 KW.

In 1977, Japan imported 25000×10^4 ton crude oil. And it was estimated that mean sulfur content in this crude oil is about 1.5%, so we can estimate that about 370×10^4 ton sulfur were brought into Japan with imported crude oil.

Japanese people will be obliged to be safety in the environment the lot of sulfur calculated before. But these are very difficult to operate, so we will not be able to continue these collection operating[12).

The author thinks that the environmental pollution have been occured by the inclination of all things and the accumulation of materials as shown present city life, motarization and industrialization.

According to above reasons, we have to rationalize the today's human activities and human life, to conserve the environment.

Furthermore, the author thinks that to solve these subjects are very important and are able to carry out by the design of the environmental management plan.

But practically, Japanese environmental administration do not start the enforcement and design of the environmental management plan explained before, because they have not the information and the technology for these objects.

Therefore, the author explain mainly about the design to decrease of air pollutants exhaust by administrative regulation plans.

4. Environmental monitoring and management plan

The environmental monitoring on the air qualities is the base of the air pollution abatement administration and the design of environmental management plan on the air pollution. The air pollution monitoring started by the measurement of deposited dust used deposit gauge prescribed in BS1747 (1951), atmospheric sulfur dioxide by PbO_2 cylinder method and suspended particulate concentration used filter paper tape type air sampler in Japan from 1940's to 1950's. For example, when reconstruction of industry was carried out in Ube City, Yamaguchi Prefecture using the coal producted at Ube coal pit near this city, the people living in this city noticed and claimed to the deposited dust from the power plants and cement factories etc.

In 1949, the mayor of Ube requested the survey and monitoring about this deposited dust to Dr. Yoshikatsu Nose, an assistant professor of Medical University Yamaguchi Prefecture.

Dr. Nose carried out the monitoring of the deposited dust using deposit gauge in this year at Ube City. After that, he started measurement of atmospheric sulfur dioxide by PbO_2 cylinder method too[13).

In 1954, Dr. Takeo Suzuki, the director of occupational health, National Institute of Public Health, started the measuring of the atmospheric suspended particulate concentration at his laboratory using the filter paper tape type air sampler[14). The author started the air pollution survey and monitoring using deposit gauge and the filter paper tape type air sampler in Yokohama – Kawasaki industrial area since 1956[1-3)

In this age, the air pollution monitoring were carried out in the main industrial area and main cities in Japan. Introducing these, Sapporo is the largest city in Hokkaido located at north Japan. Because the main sources of air pollution were coal combustion for residential heating in long cold season in this city, the deposited soot were measured.

The large scale steel mills located at Kamaishi, Kawasaki, Kobe and Yawata, so in these cities the analysis of iron in deposited dust were carried out.

Industry of Ube was using the coal producted at Ube coal pit contained lot of tar and ash as introduced before, so ash and tar in deposited dust analysis was done. And Tokyo, Kawasaki, Yokohama, Osaka, Amagasaki, Kobe and Yawata were large cities, and large scale industrial area located, so many air pollutant measurings were carried out for air pollution monitoring.

Omuta was industrial city due to Miike coal, so tar and ash analysis in deposited dust were done for environmental monitoring.

Like this, the environmental monitorings were carried out considering about the kind of industries, these main resources and energy sources and human life in monitoring area.

In 1962, Japanese Government established "Smoke and Dust Regulation Law" as explained before, in this law the monitoring of air pollution was provided as the obligation of local government according to 7th articles.

Therefore, the air pollution monitoring system were operated by local authority from 1960's. For example in 1965, Kanagawa Prefecture selected 9 measuring sites in Yokohama – Kawasaki area. And the continous atmospheric sulfur dioxide analysers, the filter paper tape type air samplers and the measuring instruments for wind speed and direction, humidity and temperature were set in each measuring sites.

Furthermore, the data obtained at each measuring sites were transmitted electrically by telemeter system to Kanagawa Prefectural Environmental Center, Yokahama and Kawasaki city hall since 1969[15]. This is one of the typical air pollution monitoring system in this age.

Today, many local authorities are operating the air pollution monitoring systems equipped the continous sulfur dioxide, nitrogen oxides, hydrocarbon, oxidant and carbon monoxide analysers, monitors for suspended particulate and measuring instruments about the weather, telemeter and computer systems.

Fig. 1 shows the distribution of measuring sites in Kanagawa prefectural air pollution monitoring system operating since 1973. In Fig. 1, black circle (●) indicates the measuring sites for environmental air pollution, white triangle (△) shows the measuring sites for air pollution, due to automobile exhaust gas, white square (□) shows the wheather observation sites over this area and white circle (○) shows the measuring sites adopted the portable instrument.

At the each measuring sites, the 8 kinds of air pollutants concentration are measured by the continous air pollutant analysers as introduced before.

And the observation of wind speed, wind direction, humidity and temperature are done by continous weathermeters.

Furthermore, these hourly measuring and observation data are transmitted electrically to Kanagawa Prefectural Air Pollution Monitoring Center located at Yokohama by the telemeter system.

Generally speaking, the air pollutants concentration are

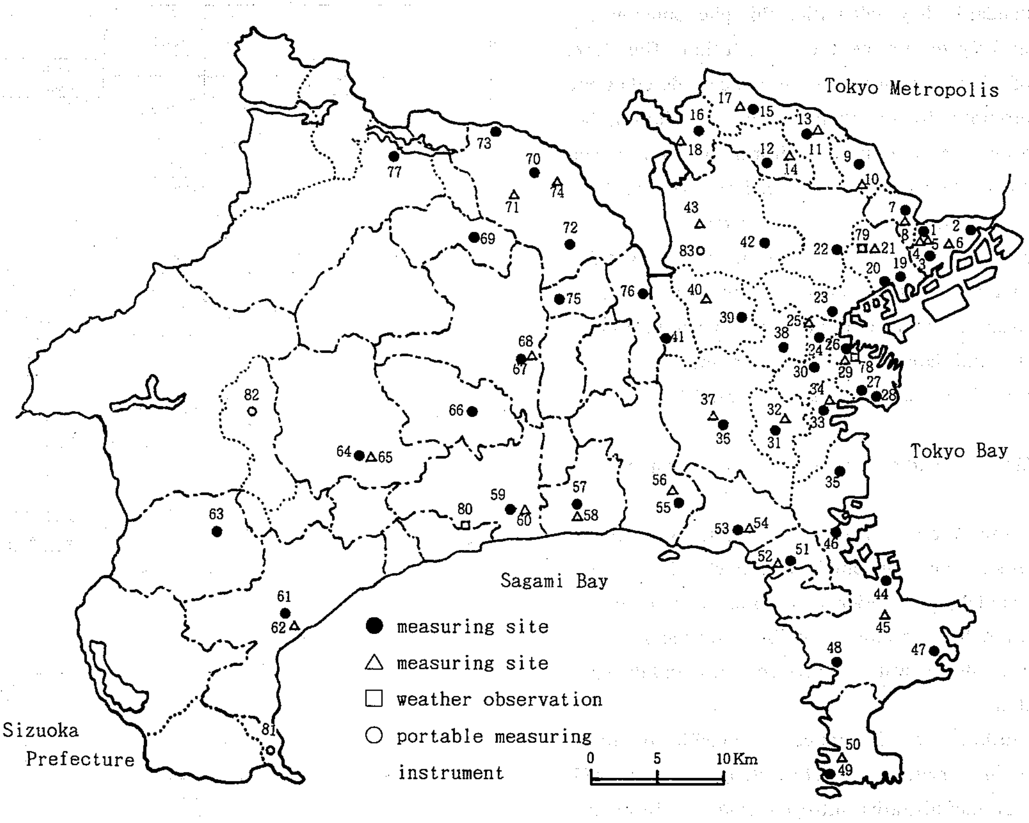

Fig. 1 Distribution of measuring sites in Kanagawa prefectural air pollution monitoring system

varied with the weather conditions, season and human activities. For example, when the wind speed decrease, the concentration of air pollutants becomes higher.

And if the height of exhausted points at air pollutants emission sources is low, the daily cycle variation of the air pollutants concentration in atmosphere will change with two peak appeared at forenoon and afternoon.

Furthermore, the concentration of air pollutants in cold season are higher than those in hot season effecting atmospheric stability in Japan[1-3].

We can evaluate the measuring results obtained by this system administratively comparing to the environmental standard prescribed in "Fundemental Law for Abatement of Environmental Pollution".

Because the local authority and Environment Agency have to announce officially the air pollution monitoring data and these evaluation results, people notice this announcement.

And if they could know that the air pollutants concentration has increased tendency, and are over the environmental standard, they will notice this phenomenon and request strongly to improve the air pollution. Therefore, the air pollution monitoring systems are considered as one kind of promotor for the abatement of air pollution. So, the operating of air pollution monitoring system is judged as one of execution means on the environmental management plan about the atomospheric conservation.

In Japan, air pollutants dispersion models are used frequently as one means to design the environmental management plan on the air pollution abatements introduced as follows. And data obtained by the monitoring system have been used to design this dispersion model.

5. Modeling and research on technical constants

We have used the model of the air pollutants dispersion for the design of environmental management plan. In this case, the modelling is designed to forecast air pollutant concentration due to atmospheric dispersion theory.

And this modeling system is very complex, and difficult to understand.

So, the author[16] will introduce the modelling on nitrogen oxides in Kanagawa Prefecture designed from 1977 to 1980, as administrative nitrogen oxides emission decreased plan due to "Clean Air Law".

The area of Kanagawa Prefectuer is about 2400 km^2, and the population were about 7 million in 1977. And the distance from east side to west side in this prefecture is about 80 km, the one from north side to south side is about 50 km respectively. And Yokohama – Kawasaki industrial area locate at the east side of this prefecture. So, a lot of air pollutants were exhausted from this side.

At beginning the design of dispersion model, the author and co-researchers divided the area of Kanagawa prefecture into the 1945 regular squares that has 1 km or 2 km bits forming divided meshes. In this case, we set regular squares having 1 km bit near the industrial area. And we calculated the forecasting nitrogen oxides concentration as mean value in year at the center in each regular squares according to Fig. 2 system. At first, we re-

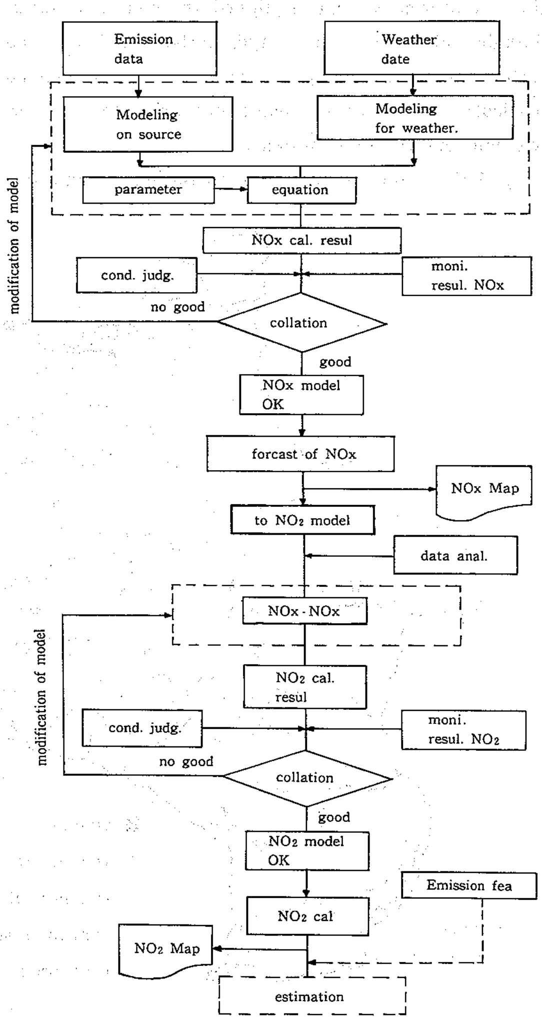

Fig. 2 The calculation system for the NOx dispersion model

searched the emission of nitrogen oxides in each regular squares. In this case, about the stationary emission sources equipped the chimney stack that was higher than 30 m, the emission of nitrogen oxides at each stack were researched, with the hight and position of these chimney stack, namely we developed calculation as the points sources these emissions. And we treated stationary sources equipped chimney stack that was lower than 30 m, as area one and estimated these emission of nitrogen oxides in each regular squares explained before.

The stationary points sources were almost large scale factories, these number are 844 in Yokohama, Kawasaki and Yokosuka area, and 1017 in other area.

And number of the stationary area sources are 379 in Yokohama, Kawasaki and Yokosuka area, and 316 in other area.

The automobiles were considered as line sources and area one in our model. And we defined the automobile running on 1651 main roads as line sources, and 1721 small roads as area one, and estimated nitrogen oxides emission from each road sources. Furthermore, the vessels equipped 30 – 50 m hight stack were considered as area sources, and one been seaboard as point sources.

And residential combustion sources were considered as area sources and the emissions were estimated in each regular squares. In the design of dispersion model, we had to estimated the emission from surounding area, so we estimated the emissions from Tokyo Metropolis and Chiba Prefecture.

The estimated values of nitrogen oxides emissions in this modelling areas are shown in Table 1.

Table 1. Estimated values of the nitrogen oxides emission in the area designed nitrogen oxide dispersion model

area	kinds of sources		emission of NOx [m_N^3/hr]
Kanagawa pref.	stationary	factry	4045.6(64.0%)
		resident.	103.6(1.6%)
	transfer	automoble	1856.6(29.3%)
		vessel	320.8(5.1%)
	total		6326.5(100.0%)
Tokyo metrop.		factory	913.9
		automobile	1860.8
		aeroplane	71.5
	total		2846.2
Chiba pref.		factory	4321.9
Tokyo bay		vessel	481.6

The hight of pollutant dispersion is very important factor. We adopted Moses & Carson, CONCAWE and Briggs's equation for stationary point sources, and CONCAWE and briggs's equation for stationary area sources to calculate the effective chimney stack hight. And dispersion hight of pollutants from automobiles and residential combustion equipments were estimated as 3 – 5 m, one of the vessels were estimated as 30 – 50 m for area sources and were calculated by CONCAWE and Briggs's equation for the point sources, respectively.

About the weather model, we divided Kanagawa Prefecture to 14 blocks, and using the recent measuring results of weather condition, designed the weather model about each blocks.

And we calculated to forecast yearly mean value of atmospheric nitrogen oxides concentration at 1945 points explained before, using the data about the emissions of nitrogen oxides, hight of dispersion and weather model etc.

In this case, we adopted puff and plume model as dispersion model for the most sources, but adopted JEA equation for line sources of automobile.

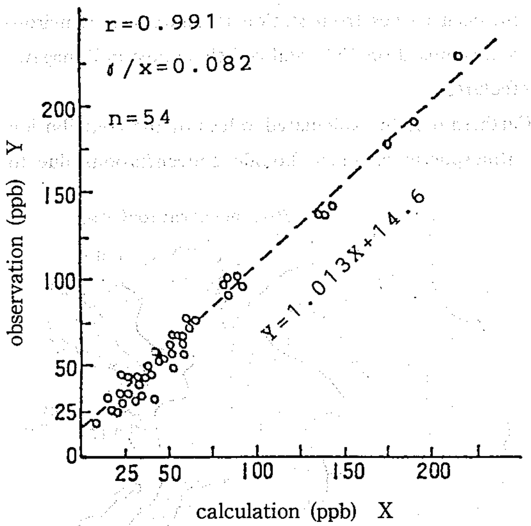

Fig. 3 The collation of NOx model

Fig. 3 and 4 are the collation results about nitrogen oxides model and nitrogen dioxide model, respectively. As shown in both figures, the calculated values in this model are almost equal to the observation ones at 54 air

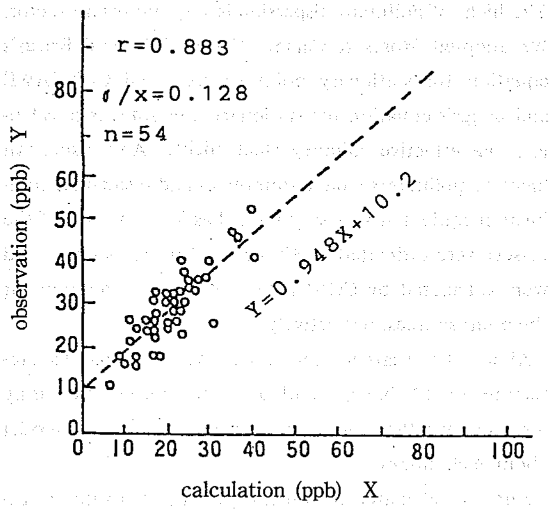

Fig. 4 The collation of NO_2 model

pollution monitoring sites in this area. From these results, we could judge that the modelling of the nitrogen oxides dispersion in Kanagawa Prefecture has completed.

Fig. 5 shows the calculated values of nitrogen dioxide concentration in the case decreasing 30% nitrogen oxides emission from stationary combustion sources.

As shown Fig. 5, if we succeed to decrease 30% emission of nitrogen oxides from stationary sources, the environmental standard on NO_2 will be held almost in Kanagawa Prefecture.

Furthermore, the calculated values of the contribution of atmospheric nitrogen dioxide concentrations due to

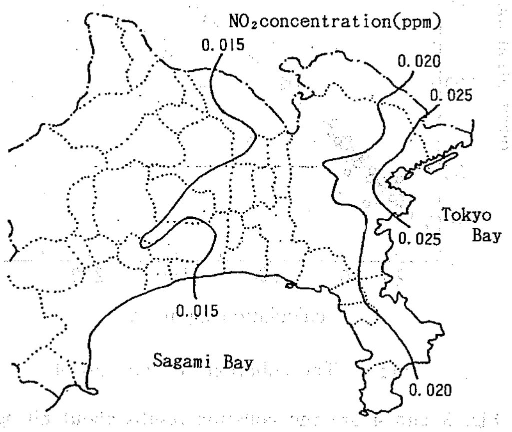

Fig. 5 The calculated values of NO_2 concentration in the case decreasing 30% NOx emission from stationary combustion sources

the each kind of emission sources defined in this dispersion model were discussed[16]. By these results, we can understand that the effect of automobiles are very important.

Designing on the this despersion model, we had to solve many problems.

And the forming the technical constants was one of them. For the design of this model, the technical constant like emission factors, despersion constants, had to be used. The author thinks that these constants varied by the area, age, technology and human activities, so explain these forming process as example our survey on the air pollutant emission factors[6-7].

The air pollutant emission factor has been utilized as very important technical constants, to estimate and characterize the emission rate from the numerous sources that contribute to the community air pollution, and to decide the course of air pollution control policies. The emission factor has been calculated using the emission data from the air pollutants emission sources.

Namely,the emission factor has given as statistical mean value about the ratio of the air pollutant emission to human activity that was the cause of it's emission[6-7].

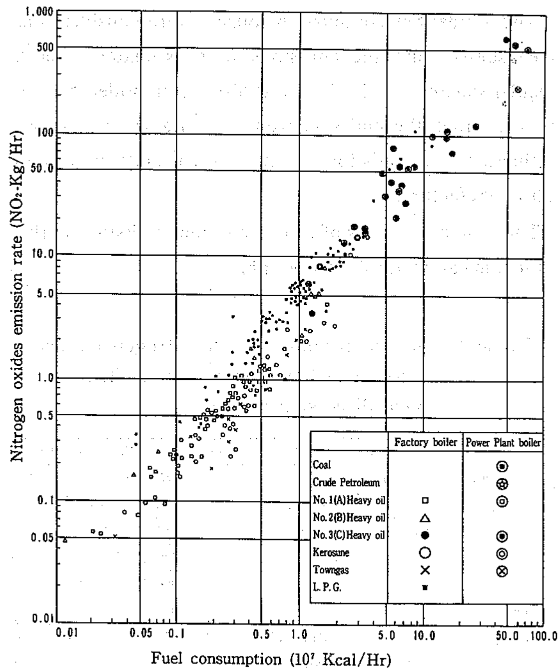

Fig. 6 Relationship between nitrogen oxides emission rate and fuel consumption at the factory boiler and power plant.

Fig. 6 shows the relationship between the emission rate of nitrogen oxides [NO_2-kg/hr] and fuel consumption [10^7 kcal/hr] obtained at the power plants[6-7]. In our surveies, we measured the nitrogen oxides and oxigen concentration in flue gas used chemiluminessence NOx analyzer and magnetic type O_2 analyser, fuel consumption used fuel meter equipped at the power plants.

As shown Fig. 6, the relationship between nitrogen oxides emission rate and fuel consumption at the operating power plants are expressed as the following equation (1)[6-7].

$$E = aQ^b \quad (1)$$

where E; nitrogen oxides emission [NO_2-kg/hr]
Q; fuel consumption [10^7 kcal/hr]
a, b; constant [−]

And if we can consider the operating load of emission sources by equation (2), the nitrogen oxides emission rate are expressed by equation (3)[6-7].

$$R = Q/Q_0 \quad (2)$$

where $$E = a'Q^{b'}R^c \quad (3)$$

R; load of power plant [−]
Q; rating of the power plant [10^7 kcal/hr]
a', b', c; constant [−]

Using the measuring data at the power plants and equation (3), we could obtain Table 2 as the calculated values of the nitrogen oxides emission factors considering the operating load.

Table 2. Calculated values of nitrogen oxides emission factors considering operation load in power plant (Heavy oil No. 3 firing)

Fuel consumption rating Q_0 [10^7 kcal/hr]	Emission factor [NO_2-kg/10^8 kcal]			
	load 0.4	load 0.6	load 0.8	load 1.0
10	49.1	57.3	64.1	69.8
30	49.7	58.1	64.9	70.7
50	50.0	58.5	65.3	71.2
70	50.2	58.7	65.6	71.5
90	50.3	58.9	65.8	71.7
100	50.4	58.9	65.9	71.8

Table 3. Calculation results of emission factors from stationary combustion plants

Combustion plants		Fuel	Emission factor (kg/10^8 Kcal) *a)			
			NO_x *b,**)	HC *c,**)	CO **)	Parti.**)
Heat and power generation	Power plant boiler	No.3-heavy oil	63.5 B	37.1 C	78.9 C	4.7 C
		No.1-heavy oil	50.7 D			
		Crude petroleum	56.5 D	89.0 D	3.3 D	
		L.N.G.	38.9 D			
		Coal	128.0 D			
		Pulp mill waste water	5.4 D			
	Factory boiler	No.3-heavy oil	56.6 B	0.11 D	7.5 C	12.2 B
		No.2-heavy oil	40.5 C	1.12 D		5.9 C
		No.1-heavy oil	25.2 A	0.43 D	7.1 C	6.4 C
		Kerosene	20.7 B	0.08 D	3.5 C	5.6 D
		Gas oil	18.7 D			
		Town gas	24.0 C		3.7 C	
		L.P.G.	32.4 C	0.09 D	17.3 D	
		L.N.G.	57.6 D			
	Diesel engine	No.1-heavy oil	437.0 C	12.9 D	61.1 C	
	Gas turbine	No.2-heavy oil	96.4 D	44.0 D	479 D	
Ceramic industry	Glass melting furnace	No.3-heavy oil	251.0 C	0.25 C	32.5 C	48.1 D
		No.2-heavy oil	257.0 C			
		No.1-heavy oil	121.0 C			2.4 D
		Gas oil	223.0 D			1.9 D
		Town gas	134.0 D			
	Glass annealing furnace	No.3-heavy oil	45.1 D	2.0 D	74.2 D	
	Cement Kiln Dry		127.0 C	4.64 D	83.2 C	9473 D
	Cement Kiln Wet	No.3-heavy oil	162.0 D	1.63 D	12.2 D	11782 D
	Cement Kiln Lepol		212.0 D	1.42 D	246 D	14414 D
	Cement materials dryer	No.3-heavy oil	34.1 D	7.48 D		68014 D
		Kerosene	26.3 D			
		Coal	32.3 D		39.4 D	55385 D
	brick kiln	No.3-heavy oil	60.0 C	13.2 D	222.0 C	13.5 D
		No.1-heavy oil	227.0 D		49.2 D	
		Kerosene	97.5 D		36.1 D	21.8 D
	Porcolin kiln	No.2-heavy oil	130.0 D	26.0 D	74.7 D	9.3 D
		No.1-heavy oil	18.2 D	3.8 D		
		Gas oil	36.3 D	2.2 D	10.8 D	5.2 D
Iron and steel industry	Iron ore pelleting furnace	No.3-heavy oil	47.5 D			
	Coke oven	B.F.G.	73.1 D		159 D	
		C.O.G.	140.0 C	59.8 D	115 D	
	Blast furnace stove	B.F.G.	1.5 D			1.0 D
	Steel heating furnace for hot working	No.3-heavy oil	55.8 C	0.5 D	11.7 D	7.7 C
		No.2-heavy oil	56.4 D			
		No.1-heavy oil	37.4 C	0.5 D	31.3 D	3.1 D
		Kerosene	17.4 C	0.9 D		
		Gas oil	42.8 D			0.5 D
		L.P.G.	30.6 D		18.8 D	1.5 D
		L.N.G.	14.8 D			
		C.O.G.	38.7 D	0.3 D		
		No.3-heavy oil	76.1 D		72.9 D	
		No.1-heavy oil	23.2 C	22.2 D		4.0 D
			Emission factor (kg/Ton-charge) *a)			
Incinerator	Municipal incinerator	Garbage	1.05C	0.06 D	5.29D	3.59D
		Paper, wood, plastic	0.48D			
	Industrial waste incinerator	Waste oil	3.50D		5.93D	1.68D
		The others	13.2 C			

*a) expressed as uncontrolled plants, *b) expressed as NO_2, *c) expressed as CH_4, **) ranking scale of emission factor

And as the definition introduced before, we could calculate the emission factors from the ratio of the air pollutants emissions and the level of human activities at the same kind of air pollutants emission sources. Table 3 shows the example of the air pollutant emission factors at the stationary combustion sources, according to this definition using the data obtained in our survey in 1973 – 1976 that was developed as the project of Environment Agency, Japanese Government.

And the author adopted the nitrogen oxide emission factors shown in Table 3, for the design of the nitrogen oxides dispersion model in Kanagawa Prefecture 1977 – 1980 introduced before[16]. In this design of the model, the author used the nitrogen oxides emission factors from automobiles, vessels and combustion equipments in residential heating obtained in other our projects.

6. The environmental management technology and resources

We have to consider abuout the resources, when we design the environmental management plan for air pollution abatement.

As introduced before, in 1977 it was estimated that about 370×10^4 ton's sulfur were brought into Japan with imported crude oil. Therefore, Japanese people experienced violent air pollution problems due to sulfur dioxide. And the countermeasures adopting the desulfurization equipments to the flue gas from many factories for this air pollution has been done.

Limestone is main resources in Japan. Japanese factories has adopted the limestone – gypsum method[17] for the desulfurization for flue gas.

The chemical processes of limestone – gypsum method are the flue gas scrubing by the milk of lime, blowing the air into the formed $CaSO_3$ solution and oxidation it to $CaSO_4$. The main chemical reactions in this desulfurization processes are shown chemical equation (4) and (5).

$$Ca(OH)_2 + SO_2 = CaSO_3 + H_2O \quad (4)$$

$$2CaSO_3 + O_2 = 2CaSO_4 \quad (5)$$

Formed $CaSO_4$ in equation (5) is crystallized with two molecule crystal water in this desulfurization process.

And formed $CaSO_4\ 2H_2O$ crystals are very stable in the environment. Furthermore, this crystals have two type crystal forms, namely a needle type and plate one. And only plate type $CaSO_4\ 2H_2O$ crystal is useful as the material of plaster and the cement congealment time control mixture.

So, at the oxidation reaction expressed equation (5) in the desulfurization equipment, we have to prepare the chemical condition to form the plate type crystal. And we have used this formed $CaSO_4\ 2H_2O$ crystal for the material of plaster and the cement congealment time control mixture.

$CaSO_4\ 2H_2O$ crystal is called as gypsum. And gypsum is very stable material in the environment. This fact has been told by the Pyramid constructed from gypsum and stone during about 4000 years. So limeston – gypsum method with the oxidation reaction expressed equation (5) is very useful for the environmental protection due to sulfur dioxide pollution in atmosphere. From such technical fact, the author will assert that the resources problems have to be noticed for environmental management. As explained before, for the design of the environmental management plan we need the knowledges not only the state of environment, but also production technologies and resources.

Technology of the saving energy is noticed to conserve the environment.

And the using waste heat from many kinds of the factories is judged useful countermeasure for energy saving and abatement of environmental pollution.

Fig. 7 shows the calculated values of the nitrogen oxides control effects using the waste heat of power plant for area heating in Kanagawa Prefecture by the dispersion model explained before[16]. From Fig. 7, we can judge the effects of using the waste heat to environmental con-

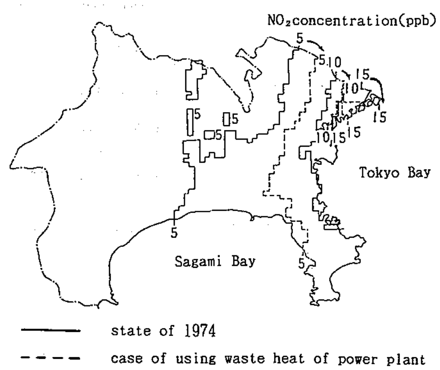

Fig. 7 NOx control effect by using waste heat of power plant for areal heating

servation, and efficient use of the dispersion model.

And the author thinks that carrying out such calculation is first step to design the environmental management plan for air pollution control.

The author described this paper based on the author's lecture on "Environmental Management Plan" to the JICA-counterpart training for study on the Air Quality Management Planning for Samud Prakan Industrial District in Kingdom Thailand, held on 6th Sep. 1989.

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大気環境管理計画について

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環境問題は，最近地球規模の課題として注目されるにいたったが，大気汚染問題を考慮する時，かつての激しかった状況から脱しつつあるとはいえ，地域環境汚染問題についても都市の巨大化や技術革新は新たな課題を生みつつあり，地域環境管理計画の策定と実行が望まれるようになってきた．本報告では，大気汚染問題を視点にその歴史を科学技術の発展を考慮しつつ顧み，実行された対策について触れ，大気環境管理計画の本質と必要性を説いた．そしてその前提になった大気環境モニタリングについて解説し，大気環境管理計画の実行を具体化する大気環境汚染モデルの策定とその実例を紹介してその利用法として地域的大気汚染物質排出量削減計画と廃熱回収の効果を記述した．またこのような大気環境汚染モデルの策定に必要な技術定数として重視される大気汚染物質排出係数につきその算出法を述べてから，大気環境管理と資源問題について硫黄酸化物対策における石灰－石膏法を例示しつつ概説した．