Countermeasures Against Water Pollution in Enclosed Coastal Seas in Japan

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Careful attention should be paid to control the water quality of enclosed water bodies such as inner seas, bays, etc., because they have a poor ability to exchange water with the open sea and pollutants are easily accumulated. In Tokyo Bay, which receives many sources of inland pollution, organic pollution is conspicuous and it is reported that many kind of benthos living at the bottom of the inner part of the bay decrease in summer when a thermocline is formed. Anoxia is considered to be closely related with this phenomenon.
In this manuscript, I would like to provide a brief overview of water pollution control measures, taken especially in the enclosed coastal seas in Japan, and the remaining problems to be tackled to protect the water quality of these water bodies.

In the case of some areawide closed water bodies, where there is little exchange of water with the open sea taking place, they may receive a large pollutant load when many pollution sources such as industries, household, etc., are located in their catchment area. In order to improve and preserve the water quality in such closed water bodies, the Areawide Total Pollutant Load Control System was introduced, amending the Water Pollution Control Law, etc., in 1978. The Areawide Total Pollutant Load Control System focused on reducing the total amount of pollutant loads from industrial effluents as well as domestic household effluents, including the loads from prefectures located at the upper reaches of rivers flowing into the designated areawide closed water bodies. Until now, Tokyo Bay, Ise Bay and Seto Inland Sea have been designated by Cabinet Order as designated water bodies and many kinds of required countermeasures have been implemented based on the Plan for Areawide Total Pollutant Load Reduction set up by each prefectural governor. As a result, the total amounts of pollutant load in terms of COD discharged at the interior area of these designated water bodies have been reduced to 373 ton/day in 1988 from 477 ton/day in 1979 in Tokyo Bay, 278 ton/day from 307 ton/day in Ise Bay and 862 ton/day from 1010 ton/day in Seto Inland Sea, respectively (Table 1).

Water Quality

The annual average of COD concentration at the innermost and the most polluted part of Tokyo Bay is around 4.0～4.5 mg/l and at the center it is

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Table 1. The total amount of pollutant load in terms of COD discharged at the interior area of designated water bodies

		1979 (t/day)	1984 (t/day)	1988 (t/day)
Tokyo Bay	Housholds	324	290	255
	Industry	115	83	80
	Others	38	40	38
	Total	477	413	373
Ise Bay	Housholds	151	150	145
	Industry	119	101	99
	Others	37	35	34
	Total	307	286	278
Seto Inland Sea	Housholds	486	443	416
	Industry	429	367	358
	Others	95	89	88
	Total	1,010	899	862

around 2.0 ~ 3.5 mg/l. In Ise Bay it is higher than 4.0 mg/l at the innermost and the most polluted part of the bay and around 2.0 ~ 3.0 mg/l at the center. In the case of Seto Inland Sea comparatively higher concentrations of COD, which usually annually averages 4.0 mg/l or higher, appear at the innermost parts of Osaka Bay, Kojima Bay etc. The seasonal change of COD concentration shows that it is generally higher in summer than during other seasons. Annual change shows that pollution of these water bodies has been slightly improving during the past ten years or so in spite of the population growth and the industrial development during the same period of time (Fig.1 and Fig.2).

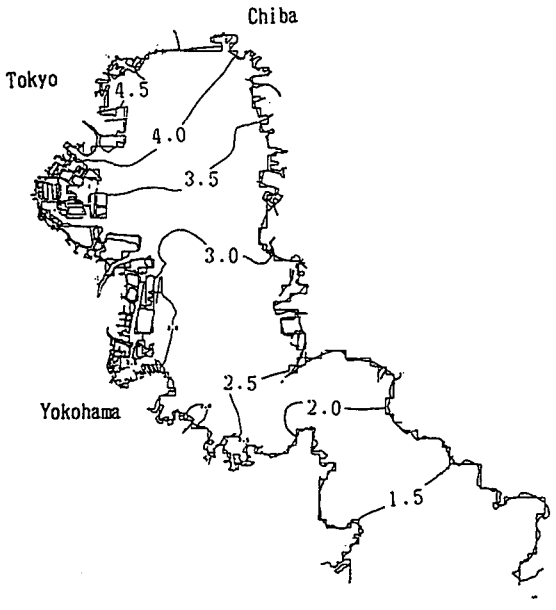

Fig.1. COD concentration in Tokyo Bay during 1978-1980 (mg/l)

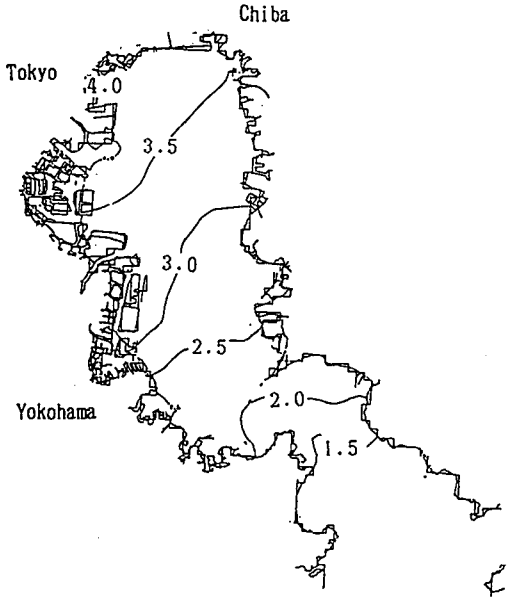

Fig.2. COD concentration in Tokyo Bay during 1986-1988 (mg/l)

However water quality of these designated water bodies is still not good enough and damage caused by red tide or anoxia occur every year. Especially in Tokyo Bay, large scale anoxia is found in the bottom waters in summer season which prevents benthic organisms from existing (Fig.3). In addition anoxia formed at the bottom often moves to the innermost part of Tokyo Bay and may even come up to the surface, killing shallow-dwelling living organisms such as short-necked clams.

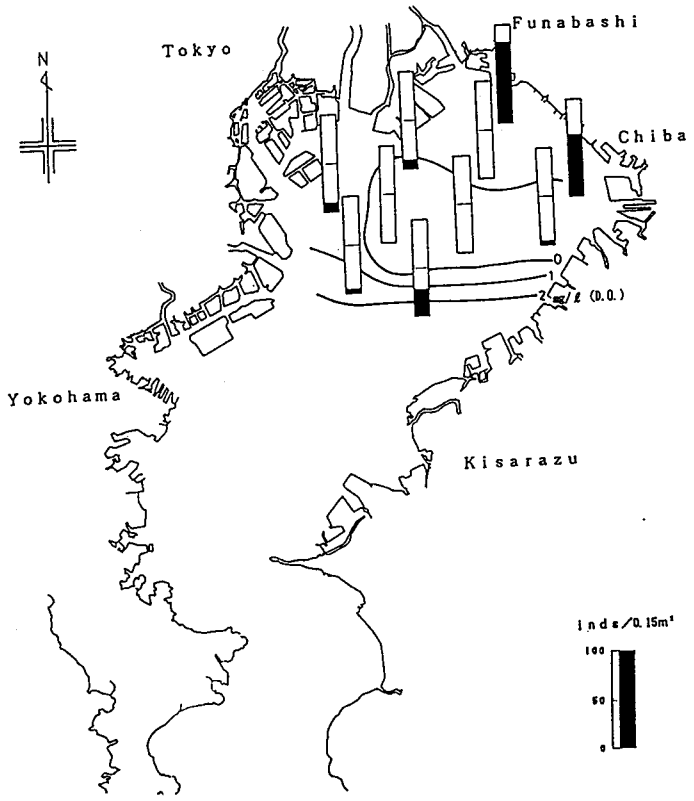

Fig.3. DO concentration of the bottom water and the number of benthic organisms of Tokyo Bay in August, 1989

Table 2. The ratio of COD production with Phyteplankton

	Tokyo Bay	Ise Bay	Mikawa Bay	Osaka Bay
Chlorophyll method	40.6%	34.1%	43.3%	36.0%
Δ COD method				
Average of 4 seasons	50.8%	50.5%	58.8%	43.3%
Average of winter	37.8%	38.5%	49.5%	35.5%
Average of spring	60.4%	55.3%	61.4%	50.1%
Average of summer	62.3%	63.8%	69.4%	53.6%
Average of autumn	40.6%	42.9%	54.5%	32.0%

Causes of Water Pollution

In the past damages to water utilization such as fisheries, irrigation, etc., were caused mainly by industrial waste water, and measures including effluent standards have been implemented mainly to control such industrial effluent. But these days, the situation is becoming different. As a result of the considerable measures taken to improve industrial effluent and the gradual population growth in urban areas, it is becoming difficult to ignore the impact caused by household, domestic waste water. The amount of pollutant loads in terms of COD emitted in 1988 from domestic sources in the interior of the designated water bodies are estimated to represent 68% of all the pollutant load in the case of Tokyo Bay, 52% in Ise Bay, 48% in Seto Inland Sea, respectively.

In addition to the organic compounds flowing into the water bodies from diverse sources, enhanced production by organisms produced directly in the coastal sea bodies is also responsible for the organic pollution of these water bodies in terms of COD. According to past information on the measurement of primary production, the amounts of primary production in enclosed coastal sea bodies are reported to be some ten to hundreds times as much as those measured in ocean. This large amount of primary production is a cause of high COD concentration in summer season and this process has a close relation with eutrophication. This process is sustained by inorganic nutrients, and above all, nitrogen and phosphorus are generally thought to have a close relationship. A result of a field survey conducted in Tokyo Bay by the Environment Agency shows that the amount of primary production is almost nothing in winter and about 3gC/㎡/day in the summer season (Fig.4). Because it is impossible to identify the origin of existing organic compounds as measured by COD in environmental waters, it

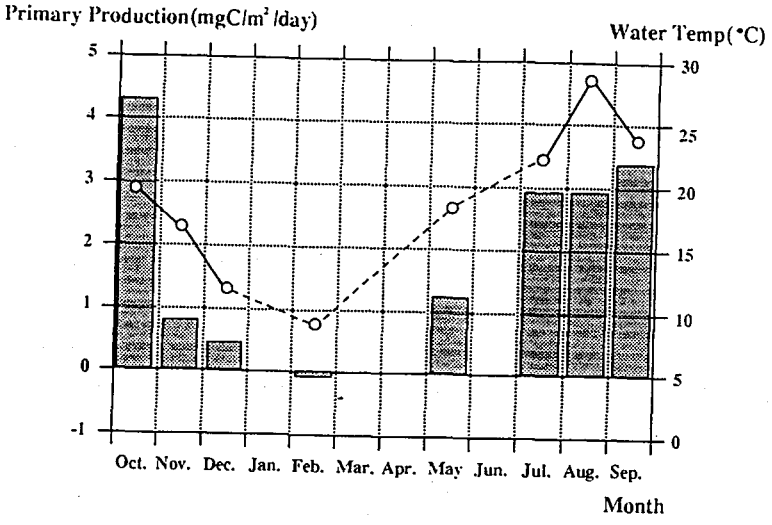

Fig.4. Primary Production of Tokyo Bay

is difficult to estimate the ratio of primary production associated with organic pollution in terms of COD concentration in enclosed water bodies. According to past information the ratio is estimated to be around 40～60% when analysed by means of the Chlorophyll Method, which utilizes the relation between chlorophyll-a concentration and COD concentration, or the △COD Method. Our estimation, also made by means of the Chlorophyll Method and the △COD Method, using the latest results of water quality observations in the designated water bodies, shows almost the same ratio as the past information (Table 2). It means that it is necessary to reduce the amount of organic matter as well as to reduce the amount of nutrients flowing into the enclosed water bodies.

Problems

1.Promotion of measures for domestic effluent control

The amount of pollutant load from industrial sources has been decreasing as a result of implementing stringent effluent controls such as setting up the Areawide Total Pollutant Load Control Standards which established the maximum permissible limits of pollutant load derived from factories or other establishments. However in order to improve the water quality of these designated water bodies, it is necessary to make further efforts to reduce the total amount of pollutant load. In order to realize the additional reduction it is becoming more and more important to promote control measures for other sources, which are presently free from effluent control. Among them, promoting measures for domestic waste water has become a great concern. In view of this situation the Water Pollution Control Law was amended at the last session of the Diet in June, 1990, introducing special provisions to promote comprehensive measures for domestic waste water control. Based on the newly introduced provisions, municipalities are required to take the initiative in improving domestic waste water treatment facilities such as sewage systems, private household waste water treatment systems, etc., and in enlightening residents about measures to reduce the amount of pollutant load in their effluent. Making the most of this new scheme, further promotion of measures to reduce the pollutant load from domestic effluent is expected.

2.Countermeasures for Primary Production

The other major problem is primary production, which has a close relationship with the phenomenon of eutrophication. As mentioned above, in order to improve the water quality in the designated water bodies, it is necessary to take measures to reduce the amount of nutrient load as well as to reduce the amount of COD load. In the case of Seto Inland Sea, although it is favored with good natural conditions, rapid onset of water pollution was anticipated. Thus, in 1978, the Law Concerning Special Measures for Conservation of the Seto Inland Sea was set up, which includes new provisions concerning the prevention of the occurrence of damage from eutrophication. Based on these provisions, guidance has been provided for

the reduction of phosphorus and its compounds since 1980. With regards to Tokyo Bay and Ise Bay, continued efforts have been made by prefectural governors to control eutrophication since 1982 based on the results of information exchange. Taking these efforts into consideration, more effective measures to reduce the amount of nutrients should be introduced.

Enclosed coastal seas have been playing an important role in industrial development or urbanization during the course of high economic growth of Japan. They are shallow enough to provide reclaimed land and offer many good harbors. However we have been apt to make little account of the important roles enclosed coastal seas have. Enclosed coastal seas also act as a space where many kinds of living things are sustained and in addition, especially in recent years, a demand has risen to use the enclosed coastal seas as a precious communion space with nature or water and as a recreation space for large urban areas. Taking these aspects into consideration it will become more and more important to preserve the water quality of these enclosed coastal seas. In order to further develop such measures, in addition to coping with above mentioned problems, sharing information on measures taken in other countries or dissemination of information on the results of studies on pollution mechanisms of these semi-closed coastal seas should be encouraged. International exchanges, bilaterally or internationally, of such information should be further enhanced.