

# On the Controlling Effect of the Planned Management of the Environment in the Kagoshima Bay on the Pollutant Load

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With regard to Kagoshima Bay whose water area is nearly enclosed with the surrounding land, the "Kagoshima Bay Blue Project" was established from the viewpoint of keeping its water quality clean. Prior to planning Phase II of the project, an investigation was made on the extent to which the execution of Phase I of the project had been effective from both aspects of the quantity of pollutant substances and the distribution of water quality. As compared with the figures of the assumed case in which no such project was executed, it is known that the quantity of the pollutant substances discharged has been greatly reduced and also with regard to the level of water quality, the water area where COD exceeds 2 mg/l as well as the same where the content of phosphor exceeds 40  $\mu\text{g/l}$  have decreased.

## 1. Topology and hydrological characteristics of Kagoshima Bay

Kagoshima Bay is located at the central part of the mainland of Kagoshima Prefecture. The population of the bay area is 850,000 and accounts for 46% of the total population of the prefecture. The production activity in the bay area plays the leading role in that of the whole prefecture.

Keeping the water quality of Kagoshima Bay in a favorable condition is the problem common to all the residents of the prefecture.

Kagoshima Bay is a bay formed by a caldera. Its bottom has steep slopes with a large average depth of 117 m (Fig. 1). Besides, it is divided into parts of north and south by the volcano, Sakurajima which continues its vigorous activity at present. The channel between Sakurajima and the city of Kagoshima is narrow with its depth of about 40 m and width of 1.9 km. Its mouth is also narrow with its depth of about 80 m and width of 8.7 km only. On the other hand, the topology of the bottom

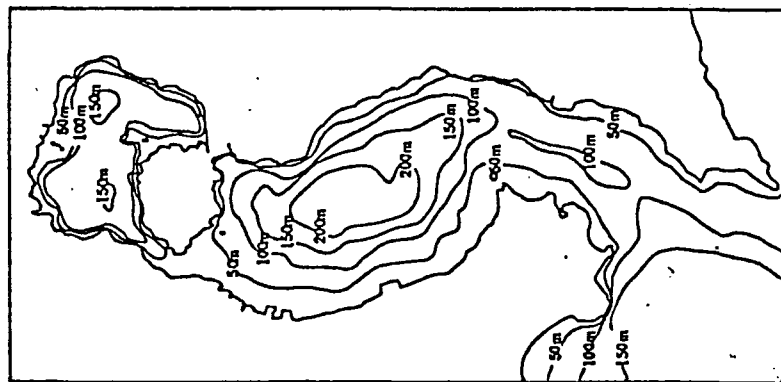


Fig. 1 Topology of the sea bottom of Kagoshima Bay

of Kagoshima Bay presents the shape as if two conical bowls are connected together. Due to these conditions, replacement of sea water of Kagoshima Bay is very slow and if calculated based upon the quantity of sea water that flows in and out at the mouth of the bay and other locations, it is estimated that complete replacement of sea water would take 3 to 6 months.

## 2. Condition of the quality of water in the bay

There are 17<sup>\*</sup> datum points in Kagoshima Bay and the environment standard Category A is set up. Against the environmental standard, in 1987 and 1988, at one or two datum points off the mouths of rivers that flow in through the city of Kagoshima or near the end part of the bay, values exceeding the environmental standard was sometimes observed, but in terms of the water quality, almost constant condition has been kept.

(\*except for points in harbor)

The changes of the annual average values in the surface layer (depth 0.5 m) measured at the datum points 3 and 13 which are the representative datum points of monitoring at the end and middle parts of the bay are shown in Fig. 2. The value of COD since 1985 has remained at around the concentration of 1.6 mg/l at the datum point 3 placed at the center of the end part of the bay and at around 1.3 mg/l at the datum point 13 placed at the center of the middle part of the bay.

With regard to T-P, while it remained at the concentration of 30 - 23  $\mu\text{g/l}$  at the datum point 3 in the end part of the bay in the recent years, it rose up to 30  $\mu\text{g/l}$  in 1989 showing a higher value than ever. On the other hand, its value at the datum point 13 in the middle part of the bay has kept the level of 12 - 15  $\mu\text{g/l}$ .

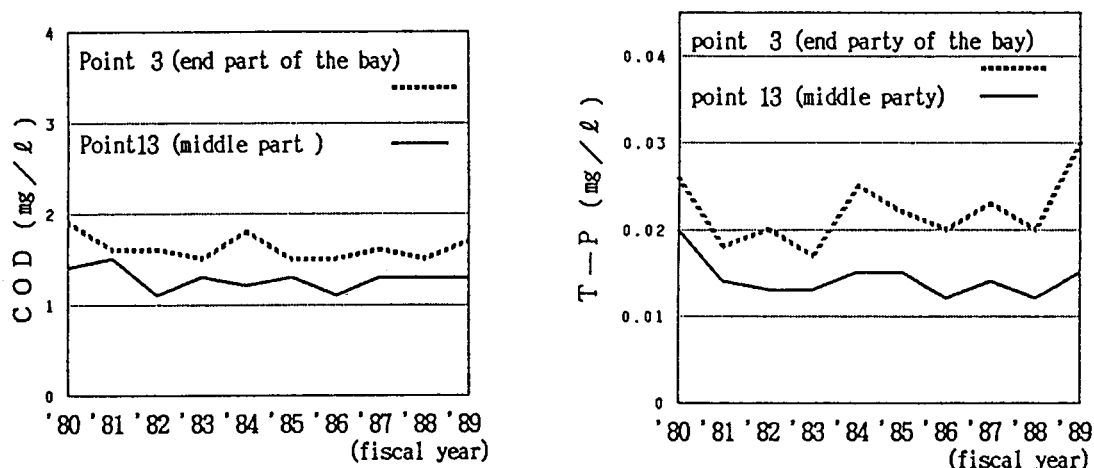


Fig. 2 Time series in water quality of the Kagoshima Bay

## 3. Water quality control in Kagoshima Prefecture

In view of the damage of ¥700,000,000 Kagoshima Prefecture suffered in 1977 due to generation of red tides, it established the "Project for controlling the water quality and environment of Kagoshima Bay (Kagoshima Bay Blue Project)" as preventive means against the progress of eutrophication in May 1979. This project was revised in March 1986 as Phase II of the project.

### (1) Fundamental character of the project

The Kagoshima Bay Blue Project has the character of the "basic plan"

and is not the execution program of any individual undertaking. In other words, it has the nature of the guideline for leading various activities for utilization of environment in the bay area adequately and does not describe any annual programs of individual fields of undertakings in detail.

(2) Target for preservation of environment  
1. Target for preservation of water quality

(i) Water quality

In terms of the items of living environment, the category A of the environmental standard (2.0 mg/l or below for COD) is aimed at. By the way, apart from the environmental standard, from the viewpoint of prevention of eutrophication, 0.030 mg/l or below is aimed at for the phosphor content.

(ii) Allowable limit

In order to achieve and maintain the target values of water quality, the limit value for the quantity of the pollutant substances discharged from the human activities that flow into the bay is established. It is stipulated for each zone of I - IV in the bay area respectively, the limit for the whole bay area is 16.1 tons/day. Besides, it is intended that the useful beaches which are often visited by the citizens of the prefecture for sea bathing, surf riding etc. and the shorelines whose power of water purification is very high will be preserved and controlled in favorable conditions.

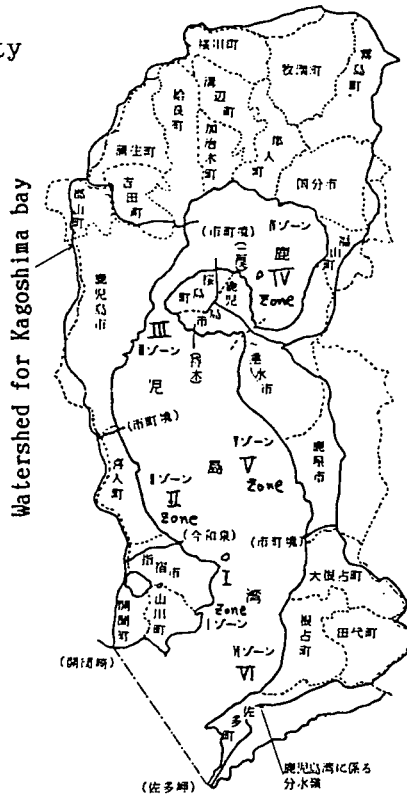


Fig. 3 Zoning of the bay-area

4. Outline of the measures taken for preservation of environment

By establishing the "Promotion center for the project of controlling the water quality and environment of the districts" in the prefectural government as the general headquarter for promotion of the environment control project, the following measures were mainly executed during the period of Phase I of the blue project.

Other principal items of measures are:

- o Promotion of the measures against miscellaneous waste water from households (establishment of the general principles for promotion of the measures against miscellaneous waste water from households in the Kagoshima Bay area)
- o Adequate return of the excretion of livestock to farm land etc. (establishment of the general principles of the guidance for prevention of environmental pollution due to operation of the livestock industry)

- o Rectification of the feeding method for cultivated fish etc. (establishment of the guidance for the cultivation of fish in the prefecture)
- o Stricter regulation for factory waste etc. (Enforcement of additional restriction on the standard of discharged water)
- o Construction and extension of the public sewerage system
- o Enhancement of pollution consciousness (Support to activity of public relations and practice) and so forth.

5. Change of the quantity of pollutant substances and its prediction

(1) Change of the pollution load discharged

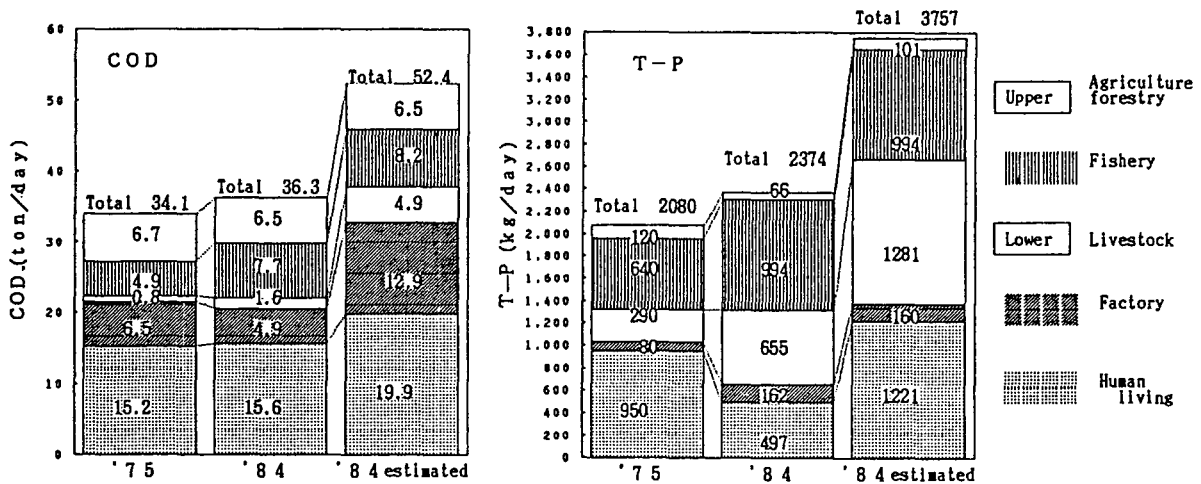


Fig. 4 The pollution load discharged and its estimated

With regard to the quantity of pollutant substances (discharged pollutant load) in the bay area, the conditions in 1975 which was the base period for Phase I of the Blue Project of Kagoshima Bay and in 1984 which is the base period for Phase II of the Blue Project are shown in Fig. 4.

By the way, with regard to the conditions in 1984, the predicted values of the pollutant load on the assumption that the measures for preservation of environment remained the same as those taken as of 1975 are presented in the same diagrams.

With regard to the value of COD, the proportions of the pollutant substances discharged classified by the sources in which they are generated, the human living system is the highest at 43%, then the fishery system (cultivation in the sea area and inland waters) and the agriculture and forestry system follow next at around 20% each. The stock industry system is the lowest at 4%, because return of excretion of livestock to farm land has made good progress. Increase of the quantity of the pollutant substances during 9 years from 1975 to 1984 was about 2 tons/day (6%) or 34.1 tons/day to 36.3 tons/day. If examined by the sources of generation, in the livestock industry system and the fishery system, the load increased, in the human living system and the agriculture system, it remained almost the same as that in 1975 with little increase and in the factory system, it rather decreased by about 25%.

As for T-P, the situation was considerably different from that of COD. That is, the value of the fishery system showed the highest at 42% due to the influence of leftover of feed and excretion of fish and next came that of the livestock industry at 28%. The value of the human living system came down to 21% and the proportion of the agriculture and forestry system showed the lowest value at 3%. As for the factory system, the value of COD as well as those of T-P occupy the 4th place among the divisions of the systems by origins of generation and the quantity of pollutant substances discharged to the Kagoshima Bay area is small.

(2) Prediction of the conditions of pollution if the measures for preservation of environment was not taken

On the assumption that no progress in the execution of the measures for the preservation of environment were made during the period of the Phase I of the Blue Project, a prediction for the quantity of pollutant substances and the quality of water in the bay was undertaken. In so doing, the condition where "there had been no progress in executing the measures for preservation of environment" is assumed to be that the conditions of discharge of the pollutant substances in the year of 1975 which was the base period of the Phase I of the Blue Project would have continued. Practically, the basic units of the pollution load as of 1975 are applied to the quantities of the social activities.

i. Prediction of the quantity of the pollutant substances (Fig. 4)

As for COD, if the measures taken for preservation of environment remained as they had been in 1975, the quantity of the pollutant substances discharged in the bay area is anticipated to be 52.4 tons/day which is estimated to have reached 1.4 times of the actual quantity 36.3 tons/day of the pollutant substances in 1984.

On the other hand, the values of T-P is anticipated to have reached 1.6 times of the actual quantity of the pollutant substances similarly to the case of COD. It is estimated that with regard to COD, anticipated increase of 54% of the pollutant substances was controlled to 6% increase and as for T-P, anticipated increase of 81% in the quantity of the pollutant substances was controlled to 14% increase respectively.

ii. Measures that made major contributions to the reduction of the pollutant substances

As investigated in (1), it is made clear that the quantity of the pollutant substances discharged in the bay area had been greatly suppressed by the execution of the controlling plan. Here in this section, in order to investigate how and by what sort of measures, these results were achieved, the differences in the quantity of the pollutant substances between 1975 and 1984 are shown in Table 1 for each zone of the bay area.

Table 1 Difference of the pollutant substance

	COD (ton/day)							T-P (kg/day)						
	I	II	III	IV	V	VI	Total	I	II	III	IV	V	VI	Total
Living	0.5	0.3	-3.2	2.1	0.4	0.3	0.4	-26	-4	-356	-62	-13	-7	-463
Factory	-0.7	-0.1	-0.9	0.0	0.0	0.2	-1.5	11	1	40	28	8	4	92
Fishery	0.3	0.0	0.2	1.5	0.6	0.2	2.8	-11	0	42	198	116	10	355
Livestock	0.4	0.1	-0.1	0.1	0.0	0.3	0.8	183	12	-10	39	33	108	365
Agri-Fores	0.0	0.0	0.0	-0.1	-0.1	0.0	-0.2	-15	-7	-11	-17	-4	0	-54
Total	0.5	0.3	-4.0	3.6	0.9	1.0	2.3	142	2	-290	186	140	115	295

(Difference: '84 - '75)

While the increase of COD was 2.3 tons/day for the whole bay area, it is known that, it is, as a matter of fact, largely reduced in the zone III which includes the city of Kagoshima at its central part. On the other hand, it increased in the zone IV at the end part of the bay as much that it would compensate the reduction in the zone III and besides, it is known that the discharge from other zones raised the value.

Most portion of the reduced quantity 4.0 tons/day in the zone III is attributed to the human living system, and next comes the reduction of 0.9 ton/day from the factory system. The reduction of COD from the human living system and the factory system is attributed to the increase of the population whose waste water is treated and the quantity of treated waste water owing to the extension of the area covered by the public sewerage system in Kagoshima City.

In the bay area, there was only one sewerage system that was in operation in Kagoshima City as late as in 1984 and its coverage ratio was 36.0% in 1975 and 58.1% in 1984.

With regard to T-P, the total increase was 295 kg/day and if seen by dividing it into the origins of generation, those from the fishery system and the livestock industry system increased by around 463 kg/day each and those from the human living system and the agriculture and forestry system decreased. This is attributed to the fact that the ratio of the users of synthesized detergent with phosphor had shown a steep fall from 58.1% in 1980 to 0.8% in 1985 according to the questionnaire investigation. With regard to the agriculture and forestry system, it is caused by the decrease of the cultivated farm land and fertilizer applied to it.

## (2) Prediction of the water quality distribution

Similar to the prediction of the quantity of the pollutant substances, that of the water quality distribution of the Kagoshima Bay in 1984 was undertaken on the assumption that the measures for preservation of environment as of 1975 remained as they were (Fig. 5).

Both for the values of COD and T-P, highly polluted water areas newly appeared owing to the elevation of the concentration levels in the bay as a whole.

While, according to the measurement of COD made in 1984, a water area where the concentration exceeded 2 mg/l was found to have emerged to the south of Kagoshima City, it was anticipated that the water area where the concentration exceeded 2 mg/l would expand in the south of Kagoshima City and such sea areas would have newly emerged at two locations in the end part of the bay.

With regard to T-P, the level of concentration differs from the mouth toward the end of the bay, and according to the result of the measurement in 1984, the water area where the concentration exceeded the target value of preservation of the water quality 30 µg/l was found to be on the north side of the line that connects the southern part of Kagoshima City and Kunugihara, Tarumi City in Osumi peninsula. There were two water areas where the value of T-P exceeds 40 µg/l to the south of Kagoshima City and at the far end of the bay (off the isthmus connecting the mainland and Sakurajima). On the other hand, according to the result of the prediction, it is anticipated that as the water area where the value exceeds the target of the preservation 30 µg/l expanded, the area where the value exceeds 40 µg/l also expanded.

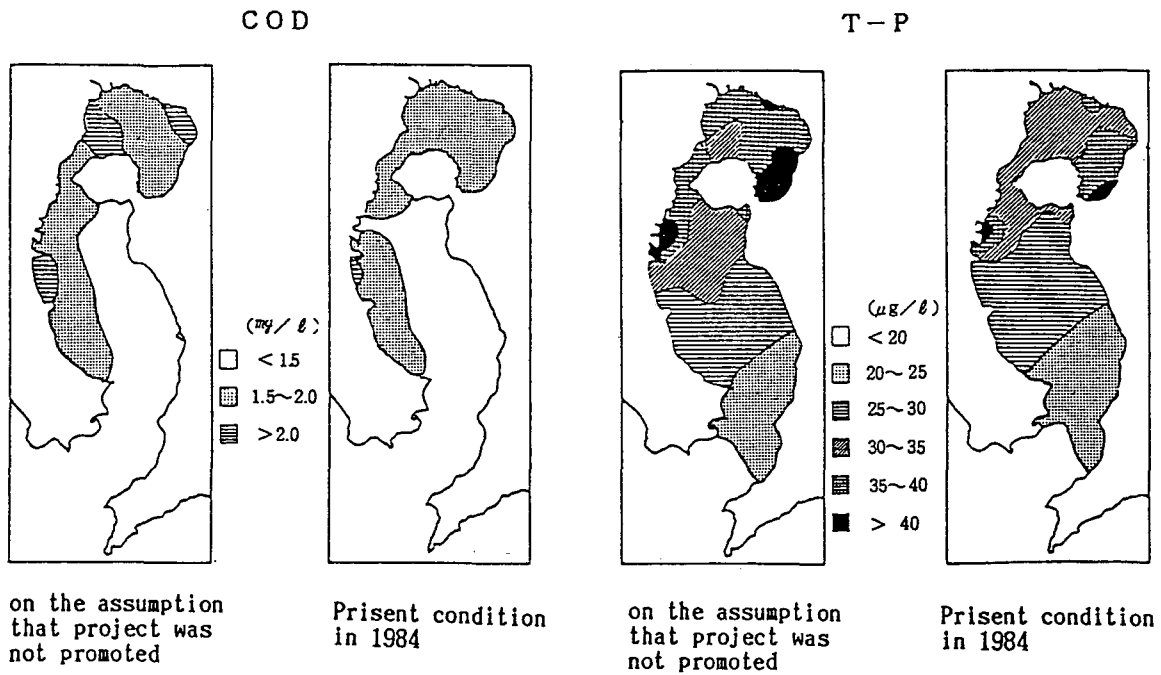


Fig. 5 Present condition and prediction of concentration distribution