

PROBLEMS OF WATER POLLUTION AFTER THE WATER GATE CONSTRUCTION AT THE MOUTH OF THE NAGARA RIVER

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Abstract

From last year, the water gate construction started at the mouth of Nagara River. There are two purposes for the construction of the gate; one is to control the flooding, another is to obtain a water resource. Regarding the former problem, the Water Resources Development Public Corporation, planned to deepen the river bottom in order to expand the area of the river section.

But the deepening of the river bottom would lead the flow of much more seawater into the upper stream than at present. The authorities of the above corporation have emphasized the necessity of gate to eliminate the influence of seawater by possible rice field damage due to saline water which might penetrate through the bank. I will discuss the water pollution problems after the construction of gate at the mouth of river.

KEYWORDS: BOD, Nagara River, nitrogen and phosphorus, phytoplankton growth, water gate

INTRODUCTION

Three big streams, the Kiso, Nagara and Ibi Rivers (Fig. 1), flow into the inner part of Ise Bay, which is a rather big bay locating in the middle of Japan along the Pacific coast. The region of these three rivers is well known for its heavy floods from the ancient times. The idea for water gate construction at the mouth of Nagara River (Fig. 2) took shape in 1959. There have been two purposes for the construction of the gate, one was to control the floods, and another was to obtain a water resource. Regarding the former problem, the Ministry of Construction, later the Water Resources Development Public Corporation, planned to deepen the river bottom in order to expand the area of the river section, instead of building elevated embankments. But the deepening of the river bottom would lead to the flow of much more seawater into the upper stream than at present. The authorities of above corporation, have emphasized the necessity to construct the gate to eliminate the influence of sea water by possible rice field damage due to the saline water which might penetrate through the bank. The



Fig. 2 Location of water gate in Nagara River

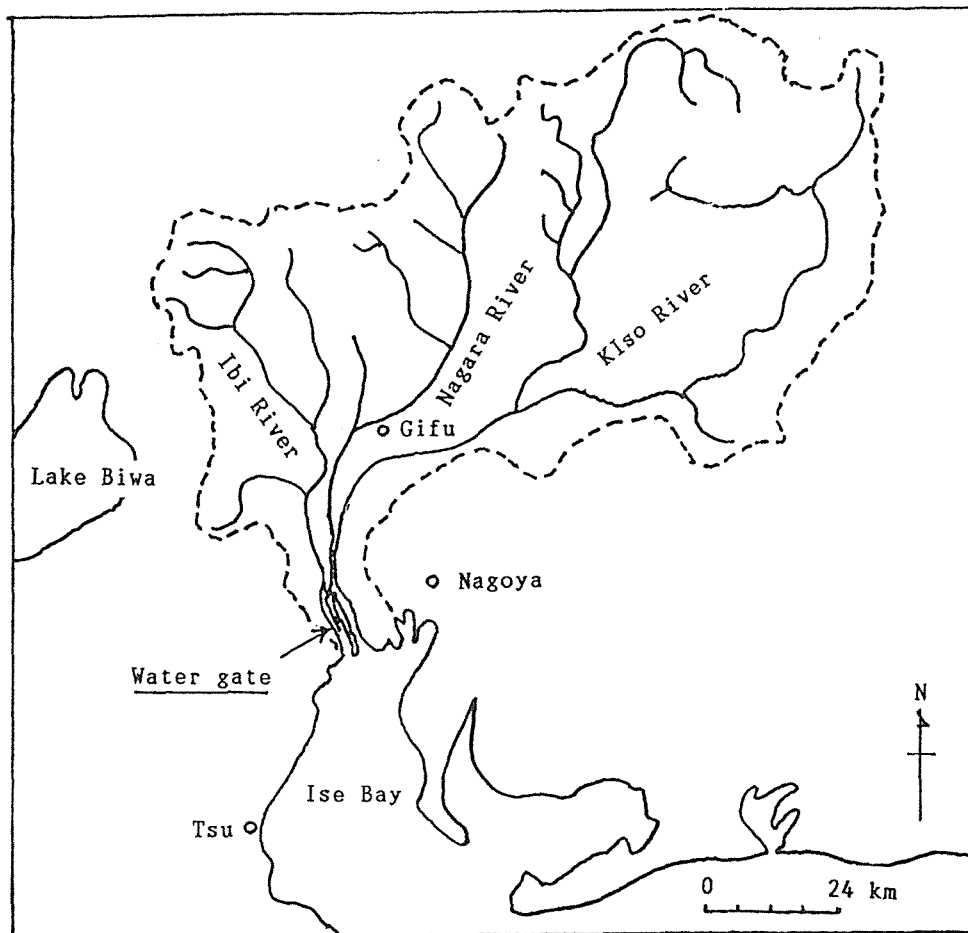


Fig. 1 Location of the Kiso, Nagara and Ibi Rivers

construction of the gate started last year. After the completion of the gate, the downstream area of the river will change to a freshwater stagnating area (something like a reservoir) extending for about 25 km. The freshwater of $22.5 \text{ m}^3/\text{sec}$ will be taken from this reservoir as a new water resource for the prefectures of Aichi, Mie and Nagoya City.

Concerning the changes in water characteristics above the gate, the authorities (4) insist that there will be no change in water quality even after the construction of gate, because the water will be changed frequently and maintain a condition similar to that of a river having a steady flow though a part of the water is taken for the water supply. They recognize the possibility of increased sedimentation of mud upstream of the gate, caused by the slower flow rate; however, they claim that the mud would be flushed out at the period of the highest water level (about 60 days every year).

I would like to examine this projection of the water characteristics after the gate construction from the standpoint of the organic matter production and matter cycle in the aquatic region.

The first problem is the difference in algal production between the river and the lake. In the river, generally, the periphyton (attached algae) grow on the stone or some other place, while in the lake where there is almost no flow, the phytoplankton (free floating algae) grow in the water. When the river is dammed up, during the period of high flow, the water will maintain a similar condition to that of river. However, how about during the period of water shortage ?

DATA ON WATER FLOW VOLME

To examine this problem, from the data of flowing water volume at Sunomata station of Nagara River from 1979 to 1988 (2), the period when the amount of daily flow did not exceed about $50 \text{ m}^3/\text{sec}$ was listed in Table 1 considering that $22.5 \text{ m}^3/\text{sec}$ of water will be taken for the water supply. If the volume of reservoir (stagnating water) $37,600,000 \text{ m}^3$ is divided by $50 \text{ m}^3/\text{sec}$, it becomes 8.7 days. Here, the winter season was eliminated because in winter, generally from December to February, the flow rate was below $50 \text{ m}^3/\text{sec}$, and often below $30 \text{ m}^3/\text{sec}$, during 50 to 100 days every year.

Table 1 The period when the amount of daily flow did not exceed about $50 \text{ m}^3/\text{sec}$ from 1979 to 1988. The winter season was eliminated.
From the data of Sunomata Station, Nagara River.

Year	Period	Days	Yearly mean flow rate
1979	May 19-June 21	<u>28</u>	123.1 m ³ /sec
1980	no		156.5
1981	no		155.5
1982	June 20-July 8	22	119.4
1983	May 27-June 12	17	145.8
1984	May 19-June 8	21	85.9
	Sep. 16-Nov. 11	<u>57</u>	
1985	Aug. 24-Sep. 6	14	153.4
1986	Aug. 6-Sep. 17	<u>43</u>	95.6
	Sep. 24-Dec. 18	<u>86</u>	
1987	Aug. 28-Sep. 24	<u>28</u>	87.9
	Sep. 29-Oct. 17	<u>28</u>	
1988	Oct. 16-Nov. 23	<u>39</u>	114.4

As seen in this table, there were 11 times when the period of water shortage exceeded 14 days over 10 years, among them 7 times it exceeded 4 weeks. It was longer in the dry year.

CHEMICAL FEATURES OF RIVER WATER (Table 2)

Table 2 Data of BOD, total nitrogen and total phosphorus yearly mean values of Nagara River at Tōkai-ōhashi from 1978 to 1988 (1). The values were shown in mg/L.

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
BOD	1.8	1.9	1.7	1.5	1.4	1.3	1.3	1.2	1.4	1.4	0.9
Total-N	1.3	1.3	1.3	1.6	1.3	1.4	1.4	1.4	1.5	1.4	1.2
Total-P	0.16	0.12	0.12	0.11	0.09	0.08	0.11	0.11	0.15	0.14	0.09

Data of BOD values at Tōkai-ōhashi, which locates near the top of a reservoir (water stagnating area), changed from about 2 to 1 mg/L from 1978 to 1988. It means a decrease of organic matter pollution in the river water. Similar tendencies of BOD decrease were found also at Nannō-ōhashi and Ise-ōhashi. However, there were no appreciable changes in the values of total nitrogen and total phosphorus which are important elements as the source of artificial eutrophication in lakes, from 1978 to 1988. Thus, the

total nitrogen ranged from 1.2 to 1.6 mg/L and total phosphorus from 0.08 to 0.16 mg/L. It is noteworthy that these values are comparable with those in the water in Lake Suwa, which is one of the typical lakes having heavy pollution by eutrophication. Which means that if the water stagnates as in the lakes, in summer the phytoplankton will grow to the level of 100 mg/m³ of chlorophyll-a, which is almost equivalent to the organic matter of 25 mg/L as BOD. But the species of phytoplankton would not be limited to Microcystis, which is the major algae in Lake Suwa in summer.

DIFFERENCE IN PHYSICAL ENVIRONMENT BETWEEN RIVER AND LAKE

Compared with rivers, the characteristics of physical environment of lakes are the low exchange rate of water and the stratification of water temperature in summer. There are many factors influencing the relation between the exchange rate of lake water and the production of phytoplankton. But, generally, from one week to 10 days would be acceptable as enough time for the growth of phytoplankton.

Assuming that the volume of the river where the water will stagnate after the construction of the gate is 37,600,000 m³, the days necessary for river water to pass through that region were calculated as shown in Table 3..

Table 3 The days necessary for river water to pass through the water stagnated region after the gate construction.

Flow rate (m ³ /sec)	200	100	80	60	50	40	30
Days to pass (days)	2.1	4.4	5.4	7.3	8.7	10.9	14.5

And by assuming that the length of water stagnate region is 25 km, the flow velocity was also calculated for the days to pass as seen in Table 4.

Table 4 The flow velocity calculated from Table 3.

Days to pass (days)	3	4	5	6	7	8	9	10	11
Flow velocity (cm/sec)	9.6	7.2	5.7	5.8	4.1	3.6	3.2	3.0	2.6

When the flow velocity of river water decreased to the level of several centimeters per second, it is said that the river cannot easily maintain a steady flow because the influence of wind and other factors becomes much stronger (Okuda, personal communication).

Another problem is that the vertical mixing of water is generally much more stronger in the river than in the lake. But the turbidity of water in the

Nagara River is generally low except in the period of high water level. Therefore, even if the mixing of water takes place during the period of low water level, there is a enough light for the algal photosynthesis down to the bottom of the river. Using high amounts of nitrogen and phosphorus, the phytoplankton will grow extensively. This means an increase of pollution by organic matter in that region. Furthermore, the stratification of water temperature was sometimes observed in summer when the velocity of the stream is very slow. This will give a more favorable condition for the growth of phytoplankton. It was often said that even if the phytoplankton grow during the period of low water level, it will soon be flushed out by the increase of water flowing, however, as I showed above, the period of low water level often continues a rather long time, especially in the year of water shortage.

Though above discussions were mainly directed to the period from spring to autumn, there is also a rather high possibility of algal growth during the period of low water level in winter, based, on enough nutrients, a considerable amount of light and the temperature of 5 ℃ or so. Such an algal bloom was observed in some reservoirs or lakes in winter. For instance, high values of chlorophyll-a were determined in Lake Fukami-ike, in Nagano Prefecture almost every year (5).

SOME OTHER PROBLEMS

1) The possibility of sedimentation of bottom mud containing a large amount of organic matter in the region above the gate is very high. The organic matter will be supplied not only as phytoplankton during the period of low water level, but as the periphyton, the detritus of aquatic macrophyte and the allochthonous substances (i.e., the matters supplied from outside of the river). Nambu (3) suggested the possibility of dissolved oxygen decrease to 2.3 mg/L by the dissolved substance in the region above the gate. The sedimentation of mud containing a high amount of organic matter will accelerate the consumption of dissolved oxygen and the deterioration in water quality. Though the Corporation insist the effect of mud flushing at the period of highest water level, the effects should be examined carefully from the hydrological viewpoint, especially relating to the gate operation.

2) Another fact of the problem is the changes in the water features below the gate. In the downstream, the seawater will be covered with a freshwater layer and stagnate semi permanently even in winter. There will be almost no flow, though the tidal changes in water level will take place. The effect of freshwater flowing down through the gate as the cause of vertical mixing

would be very low except at the highest water level because of a large difference of density between seawater and freshwater. In that region, an anoxic condition will prevail and a large amount of hydrogensulfide will be produced. The influence of this water mass on the benthic organisms as well as on the fish passing through this region should be examined carefully.

3) It is clear that the macrophyte zone along the river will decrease extensively with the construction work, namely by deepening the river bottom and the construction of a so called blanket (the flat plane on the inner banks to eliminate the penetration of water through the bank). The importance of the macrophyte zone for the protection of natural environment in lakes and rivers is well known. Furthermore, the decrease of macrophyte will increase the soluble nutrients, such as nitrogen and phosphorus in river water, and will have some influence so as to increase the phytoplankton growth.

CONCLUSION

To anticipate the changes in aquatic environment by the construction of the water gate in the Nagara River, a series of extensive research was carried out by the group of late Professor Koizumi from 1964 to 1968 with the participation of about 70 scientists. The major part of this research was, however, directed to the changes in fisheries. Furthermore, it is probable that during the more than 20 years since the time of research, there were vast changes in environmental conditions in the river and in the adjacent sea area. On the other hand, significant progress has been made in the techniques of environmental assessment. As pointed out above, there are many environmental problems requiring more extensive research relating to the gate construction. Consequently, I would like to suggest extensive environmental research immediately using new techniques while interrupting the construction work.

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