**Release of Nutrients from Bottom Sediments in Osaka Bay, Japan in 2015**

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**Abstract.** **Osaka Bay is the most polluted enclosed sea area, in which is located the eastern part of the Seto Inland Sea, Japan. There are four kinds of sources on loadings of nutrients to Osaka Bay, which are land including rivers and industrial effluents beside coast, ocean sea water, release from bottom sediment to sea water, and wet and dry deposition from air. The pollutant loadings inflowing from the land to Osaka Bay have been cut by various policies since 1970’s. The concentrations of nutrients in the inner part of Osaka Bay have showed an obvious decreasing tendency. However, the water quality in offshore sea has not satisfied the environmental standard on nutrients. We investigated the amount of nutrients released from bottom sediments. The core samples were taken at two stations in the inner part of Osaka Bay once a month from February to November, 2015. The core incubation experiment in laboratory was conducted for 24 hours according to Tada et.al. The concentrations of ammonium nitrogen (NH4-N) and phosphate phosphorus (PO4-P) were measured by an automatic analyzer. The flux showed similar range with the values investigated in 1986. The results suggested that the flux of nutrients from bottom sediments in the inner part of Osaka Bay has not decreased during summer season at least since 1985. Therefore, the contribution of release from bottom sediment on the nutrients budget would relatively become larger in inner part of Osaka Bay.**

*Key words: Nutrients, Flux, Bottom sediment, Osaka Bay*

I. INTRODUCTION

Osaka Bay is located the eastern part of the Seto Inland Sea as shown in Fig.1, Japan and is the most polluted enclosed sea area. The catchment area of Osaka Bay is 1,447 km2 and the population is more than 12 million. Yodo River is the largest river in the Seto Inland Sea. There are large heavy industrial areas in reclamation land surrounding in the bay. During the period between 1950’s and 1970’s, serious water pollution had caused in the Seto Inland Sea, because of flowing into industrial and domestic waste water. Especially, Osaka Bay was the most polluted sea area. The water quality in Osaka Bay has been improved according to many policies

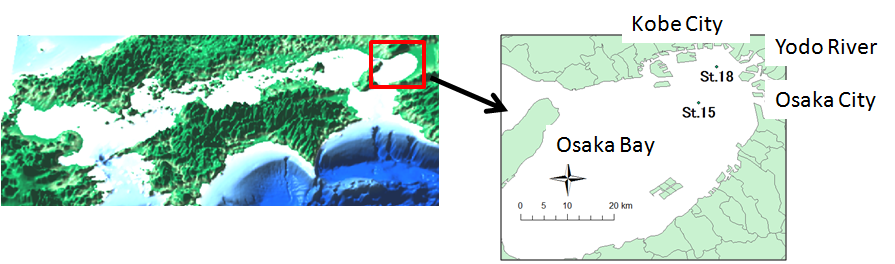


Fig.1 Seto Inland Sea and sampling sites in Osaka Bay

to conserve water environment, which have been conducted based on the Law Concerning Special Measures for Conservation of the Environment of the Seto Inland Sea since 1973. It remains, however, some problems to have to solve, for example anoxic water near bottom and red tide occurrences have been frequently seen in surface layer in the inner part of Osaka Bay, port area, sea area surrounded by reclamation land. On the other hand, oligotrophic condition has been demonstrated in viewpoint of fishery, recently. It is necessary to evaluate the loadings of nutrients in Osaka Bay.

There are four kinds of sources on loadings of nutrients to Osaka Bay, which are land including rivers and industrial effluents beside coast, ocean sea water, release from bottom sediment to sea water, and wet and dry deposition from air. The pollutant loadings inflowing from the land to Osaka Bay have been cut by various policies since 1970’s. The concentrations of nutrients in the inner part of Osaka Bay have shown an obvious decreasing tendency. However, the water quality in offshore sea has not satisfied the environmental standard on nutrients.

II. METHOD

*Sampling sites*

Two sampling sites in the inner part of Osaka Bay are shown in Fig.1. The water depth is 18 m at st.15 and 14 m at st.18. The change of DO saturation in surface and bottom layer is shown in Fig.2. The monthly changes of DO saturation showed similar pattern both sites. The DO saturation in the surface layer changed from about 90 % and about 250 %, and higher values were observed in April and May. On the other hand, the DO saturation in the bottom layer ranged from 4 % to 91 % at st.18 and from 26 % to 100 % at st.15. The minimum value of each site was observed in July.

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Fig.2 Monthly changes of DO saturation at sampling sites in Osaka Bay

*Core Incubation Experiment*

We studied the amount of nutrients released from bottom sediments according to the core incubation experiment in laboratory by Tada et.al[1]. Two sampling sites in the inner part of Osaka Bay are shown in Fig.1. Three core samples at each station were taken by the KK-type core sampler, which is a acryl pipe with 4 centimeters of diameter and 60 cm of length, once a month from February to December, 2015. The core samples were kept in a chilled container on the ship without disturbing layers, immediately and carried at the laboratory for a core incubation experiment.

All core samples were adjusted at the water temperature observed on site under dark condition in simple water bath. The upper water in the core was not replaced. A water sample of 20 ml was taken at upper layer on sediment after slower mixing before sampling at 0, 3 hours, 6 hours, 12 hours and 24 hours. These samples were filtrated by 0.22 m of membrane filter and frozen until analysis. The concentrations of ammonium nitrogen (NH4-N) and phosphate phosphorus (PO4-P) were measured by an automatic analyzer (BLTEC SwAAt ).

The water contents and Ignition Loss (IL) in bottom sediment were measured after the dissolution experiment. The top layer of 1 cm in the core was cut and analyzed according to the experiment manual of bottom sediment by Ministry of Environment, Japan. The result was shown in Fig. 3. The average value of water content was 43 % at St. 15 and 42 % at St.18, and that of IL was 9.8 % and 10.7 %, respectively. The water content was similar value and the monthly change was not observed at both sites. The IL at st. 18 was higher than at st.15 slightly.



Fig.3 Monthly changes of water content and IL at sampling sites in Osaka Bay

III. RESULT & DISCUSSION

The hourly concentration changes of NH4-N and PO4-P are shown in Fig.4 in July, respectively. The initial concentration of NH4-N at st.15 and st.18 was 0.21 mg/L and 0.35 mg/L and the concentration became 0.36 mg/L and 0.76 mg/L, respectively. That of PO4-P at st.15 and st.18 was 0.050 mg/L and 0.080 mg/L and the concentration became 0.053 mg/L and 0.147 mg/L, respectively. The elution of NH4-N was observed through investigation period in both sites. On the other hand, PO4-P was released from June to October at st.15 and from May to October at st.18. NH4-N and PO4-P in each site showed larger concentrations both of 0 and 24 hours in July and August.

The flux was calculated by using the concentrations of 0 hours and 24 hours.

Flux=(Cn-C₀)V/S T)

Where, Cn is concentration of nutrient at n hours (mg/L), C₀ is initial concentration (mg/L),

V is water volume in core pipe (m³), S is cross-section area of core pipe (m²),

T is incubation time (day), value at 24 hours is used as Cn.

Fig.4 Changes of NH4-N and PO4-P in the core incubation experiment

The result is shown in Fig. 5. The flux showed monthly changes at st.15 and st.18. The flux of NH4-N was 4 to 55 (average value is 24) mg/m2/day at st.15 and 8 to118 (average value : 24) mg/m2/day at st.18. The flux of PO4-P was -6 to 8 (average value is 2) mg/m2/day at st.15 and 0.2 to 26 (average value is 8 ) mg/m2/day. The flux of nutrients at st.18 showed larger than that at st.15. The flux of NH4-N increased in May and showed the maximum value in August or September. The flux of PO4-P barely generated until April and increased between May and October. The maximum value showed in August. These results showed that NH4-N was released from bottom sediments in most months through a year. On the other hand, the release of PO4-P is limited in summer season related to decreasing of DO near bottom layer.





Fig.5 Change of Flux of NH4-N and PO4-P at the sites in Osaka Bay

Nakajima et al. measured the flux of nutrients at the same sites by the core incubation method of Tada et al. in May 2012 and 2013, July 2013, and October 2011, 2012 and 2013[ 2, 3, 4]. They got 26 - 89 mg/m2/day of NH4-N and - 6 to 13 mg/m2/day of PO4-P. Their results were similar to this study. Jyo et al[5]. showed 26 to 46 mg/m2/day of NH4-N and 3.2 to 7.4 mg/m2/day of PO4-P in the inner part of Osaka Bay in 1986 by the incubation method, too. It is pointed out that the flux by the core incubation method is different little bit in the case a researcher experimented the perfectly same method. Therefore, the flux by Jyo et al. would be smaller than those of Nakajima and this study.

IV. CONCLUSION

These results suggest that the flux of nutrients from bottom sediment has not decreased in the inner part of Osaka Bay at least since 1985. The loadings of nutrients from land area have decreased and those from ocean would be constant. Therefore, the contribution of release from bottom sediment on the nutrients budget would relatively become larger in inner part of Osaka Bay. We have not investigated bottom sediment in the middle and outer part of Osaka Bay, which occupy more than 80 % at least. As the bottom sediments in these areas include lower concentration of nutrients and organic matter, the flux would smaller than those in inner part of Osaka Bay. Therefore, we cannot estimate the nutrient budget in the whole Osaka Bay. However, this study offered important data to estimate the nutrients budget in inner part of Osaka Bay, which is the most polluted coastal sea area and must improve.

VI. ACKNOWLEDGMENT

We appreciate Mr. Yanagihara and Ms. Nakai for their support on sampling and core incubation experiment.

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