A NOTE ON DISSOLVED OXYGEN VARIATION IN LAKE YANAKA
谷中湖の貧酸素化について

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1. Study site

Lake Yanaka is part of the Watarase retarding basin. It is the first multi-purpose impoundment lake constructed in alluvial plain in Japan. The lake has a surface area of 4.5 km^2 and an average depth of six meters with seasonal changes of about three meters for flood control. It is divided into three blocks by levees and connected by gaps as depicted in Fig.1. Inflow and outflow are regulated at the pumping station located at the south end of the lake, and the inflow is taken from the Watarase River and the Yata River.

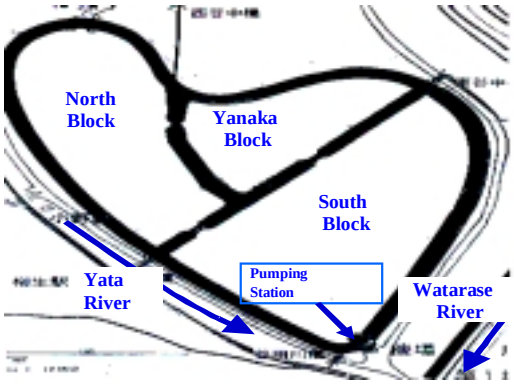

Fig. 1 Lake Yanaka

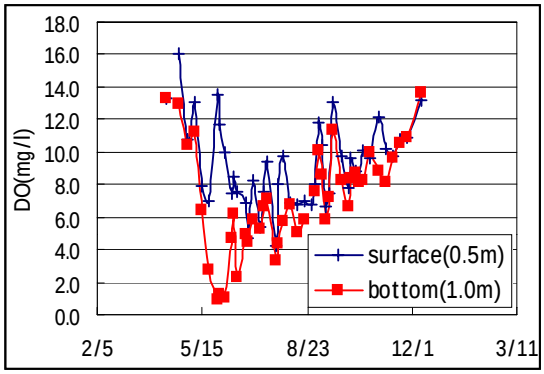

Fig. 2 DO variation in South Block in 1996

In recent years, the eutrophication problem has surfaced up in Lake Yanaka. High inputs of nutrients led to excessive growth of phytoplankton. The concentration of chlorophyll a ranges from 50 µg/l to more than 250 µg/l[1)]. So far, a number of countermeasures have been taken to improve the lake's condition. One of them is to divert the Yata River to the downstream of the lake because the nutrients concentrations are much higher in Yata River as compared with the Watarase River. However, the effectiveness of this diversion project is dependent on the hypolimnetic dissolved oxygen level to some extent. This paper is aimed at shedding some light on the factors affecting the hypolimnetic dissolved oxygen concentrations of the lake.

2. Results and Discussions

Figs.2 shows the periodically measured DO values both near the water surface and lake bottom in the South Blocks for 1996. It can be seen clearly that an anoxic hypolimnion developed in early summer. And similar patterns were also observed in the Yanaka and North Block. Figure 3, 4 show that the near-bottom DO level are correlated with the epilimnetic SS concentrations and hypolimnetic COD concentrations. This may indicate that a significant fraction of organic material from inflow settled into the hypolimnion where

they were decomposed; as a result, the dissolved oxygen in the hypolimnion was consumed.

Next, we examined the hourly-recorded data. The daily average values of near-bottom DO concentration, and the water temperature difference between the surface and bottom layers during May 1996 are plotted in Fig. 5. It can be seen from this figure that as the stratification proceeded, the DO in the hypoliminion was quickly depleted. The correlation coefficient is found to be 0.85. Figure 5 also demonstrates that although the hypolimnetic DO concentrations vary with time, a straight line as drawn in the figure may approximate it (R^2=0.9). Thus, the average hypolimnetic dissolved oxygen depletion rate (HDR) over this period of time can be obtained from the line's inclination as being 0.25 gO_2/m^3d^{-1}.

Figure 6 shows that the hypolimnetic dissolved oxygen concentrations are strongly correlated (r^2=0.93) with the water depth variations from the middle of April to the middle of June in 1996. This may indicate the impact of water level regulation on the dissolved oxygen of the lake.

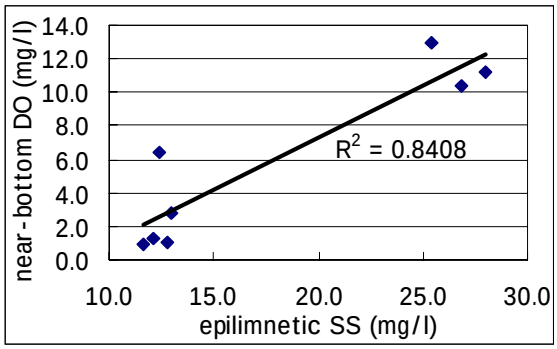

Fig. 3 Relation between DO and SS

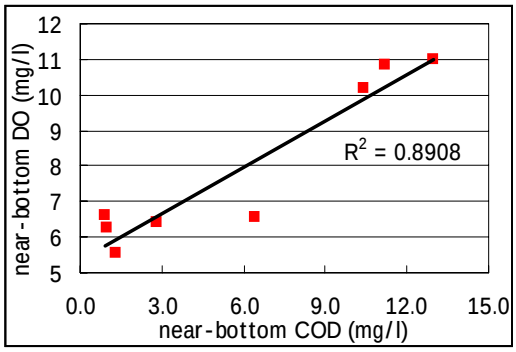

Fig. 4 Relation between DO and COD

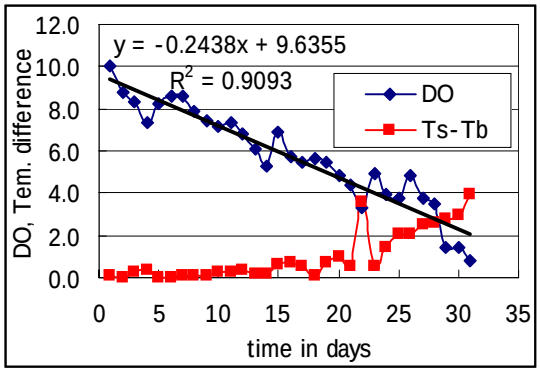

Fig. 5 DO, temperature difference in May 1996

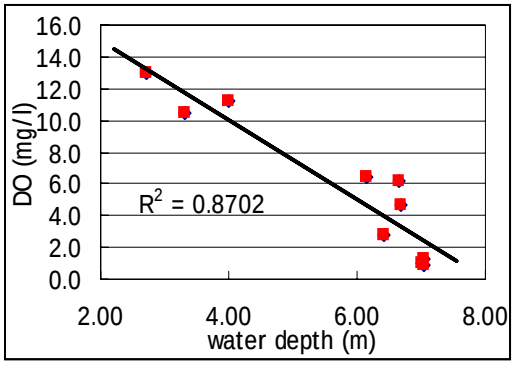

Fig. 6 Dependence of DO on water depth

3. Conclusions

The dissolved oxygen in Lake Yanaka was depleted in the early summer of 1996. The water intake played two roles in the process. Firstly, the inflow carried a large amount of oxidizable material into the lake that caused a reduction of DO. Secondly, it increased the water depth. The deepened lake facilitated the formation of thermal stratification that limited the DO transfer from the epilimnion to hypolimnion.

References

1) Huang, G.W. and Tamai, N.: Limnological studies in Lake Yanaka, Annual J. of Hydraulic Engineering, JSCE, Vol. 44, 1107-1112, 2000.