Improvement of dissolved oxygen in the water of restricted water area by the spread of bottom water over the surface

Hiroki Shimazu , Atsushi Tanaka , Seiji Kino , Shiro Matsui
Marine Technology Institute Co., Ltd.
2269-53, Seto-machi, Imari-city, Saga 848-0043
Japan
Phone: +81(955)23-2266 ; Fax: +81(955)23-2223
E-Mail: mti@felco.ne.jp

1. Introduction

Many lakes and dams are suffering from organic pollution. During the period of spring and summer the stable density stratification is developed, through which there is no vertical mixing. At the bottom layer cold and poor oxygen content water is laied by the result of resolution of organic matters. On the other hand near the surface green powder, a kind of harmful plankton grows wild extremely. It causes serious problems for the farming water and drinking water. The drastic countermeasure to solve the problem is to reduce the inlet of nourishment from the fields and mountains. But it is quite difficult. Next solution is mixing the bottom water and surface water to in crease the oxygen content in the bottom water. Various equipments are introduced and working, but there are quite few date reported their effectiveness.

The authors were required to examine the reason why the water quality of a dam is poor. They were worrying about the water in foul smelling, cold and black. According to our research there exists the non DO water at the bottom of the dam. Further by numerical simulation the authors have found the best way to eliminate the density stratification is to lift up the bottom water to the water surface and spread it over the surface. Further more the authors have developed the system and installed it at the dam. And the fairly good results have been obtained to improve the water quality.

2. The environment of dam

The purpose of the dam is in irrigation. The drainage facility is located at the bottom. Total volume of the water is 500,000 tons and max. water depth (Pont 1) is abt. 18m. A stream flows into the dam. To understand the environment of the dam, water temperature and water quality were investigated, i.e.

Water temperature, DO, total nitrogen, total phosphorus and COD were measured at the Point 1 ~ 3 in the figure 1.

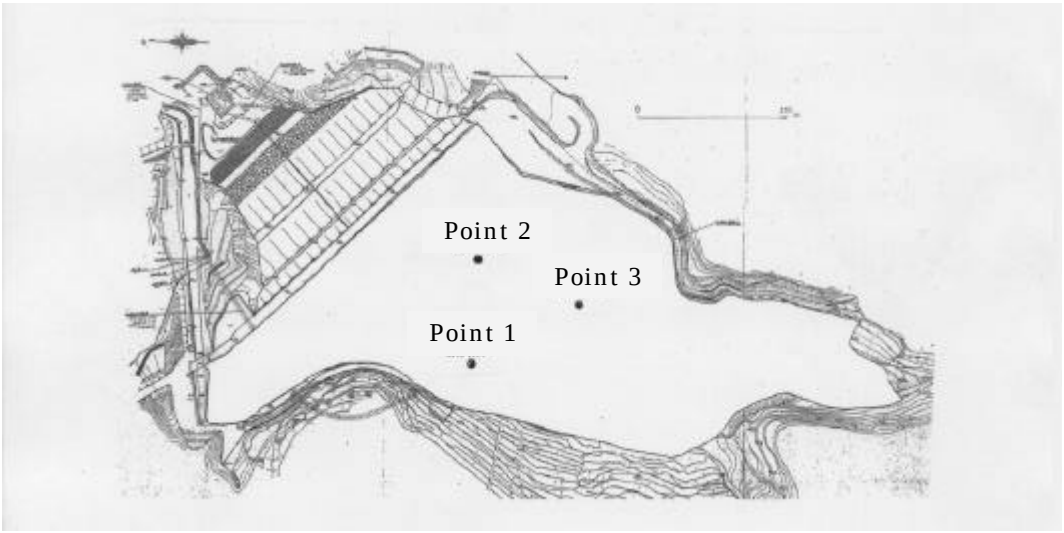


Fig.1 Points investigated

The measurement has been done in September (Sep.5th, 2001). Concerning vertical temperature distribution the temperature stratification has developed all over the dam and the temperature difference between upper and lower layers was more then 10℃ (ref. to Fig2-1, 2-2).

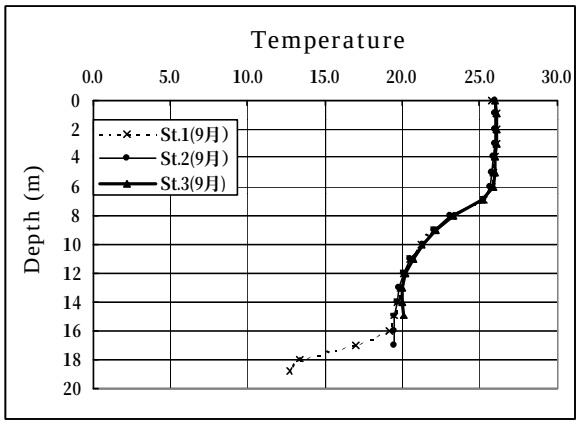


Fig.2-1 Vertical temperature distribution

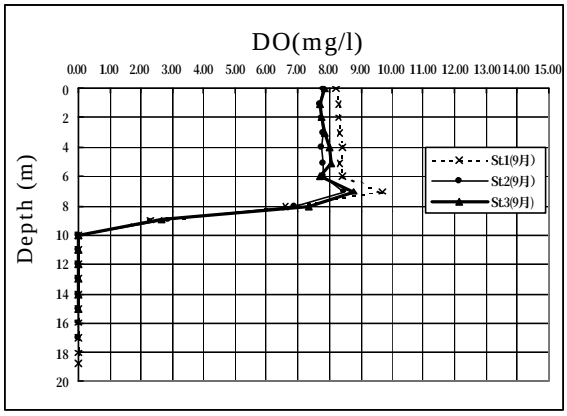


Fig.2-2 Vertical DO distribution

DO was zero below 10m deep.

The water quality is shown in table 1-1,1-2. Near the bottom phosphorus and COD show high values.

Table 1-1 Water Quality in July

Total Nitrogen(mg/l)

	Point 1	Point 2	Point 3
New surface	0.56	0.25	0.14
8m deeps	0.85	0.23	0.20
Near bottoms	0.30	0.25	0.15

Total phosphorus (mg/l)

	Point 1	Point 2	Point 3
New surface	0.02	0.01	0.01
8m deeps	0.06	0.02	0.03
Near bottoms	0.1	0.06	0.02

CODMn(mg/l)

	Point 1	Point 2	Point 3
New surface	3.9	3.7	2.6
8m deeps	3.8	3.9	2.8
Near bottoms	4.6	4.5	2.6

Table 1-2 Water Quality in September

Total Nitrogen(mg/l)

	Point 1	Point 2	Point 3
New surface	1.55	1.54	1.56
8m deeps	1.73	1.67	1.65
Near bottoms	1.47	1.52	1.52

Total phosphorus (mg/l)

	Point 1	Point 2	Point 3
New surface	0.01	0.05	0.01
8m deeps	0.02	0.03	0.01
Near bottoms	0.05	0.03	0.02

CODMn(mg/l)

	Point 1	Point 2	Point 3
New surface	2.5	2.1	2.7
8m deeps	3.8	3.8	3.2
Near bottoms	4.4	2.6	1.9

3. Investigation into the improvement of zero DO condition

The strong sun light in summer prevents the vertical convection and it causes zero DO near bottom. Therefore the authors employed the method of the vertical convection in the dam. There are several methods for this purpose. The authors tried the method to get rid of zero DO condition considering the factors of temperature and flow volume by numerical simulation. The results showed most effective way is to lift up the bottom water to the surface by a pump and hose, and to scatter over the surface. And by the simulation necessary amount of lifting water was determined. The examples of simulated results are shown in Fig.3. The figure shows the temperature of whole dam becomes uniform after 30 days working of the system.

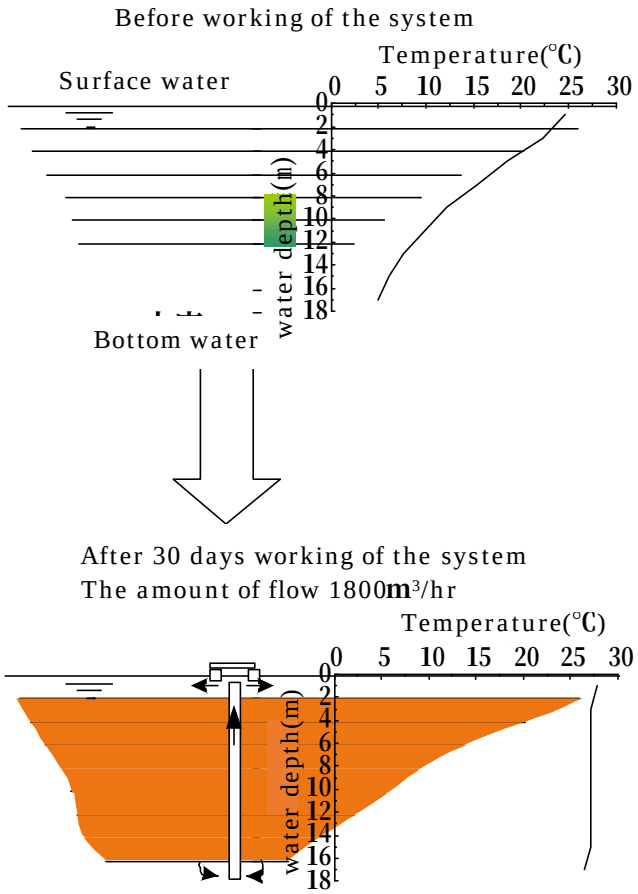
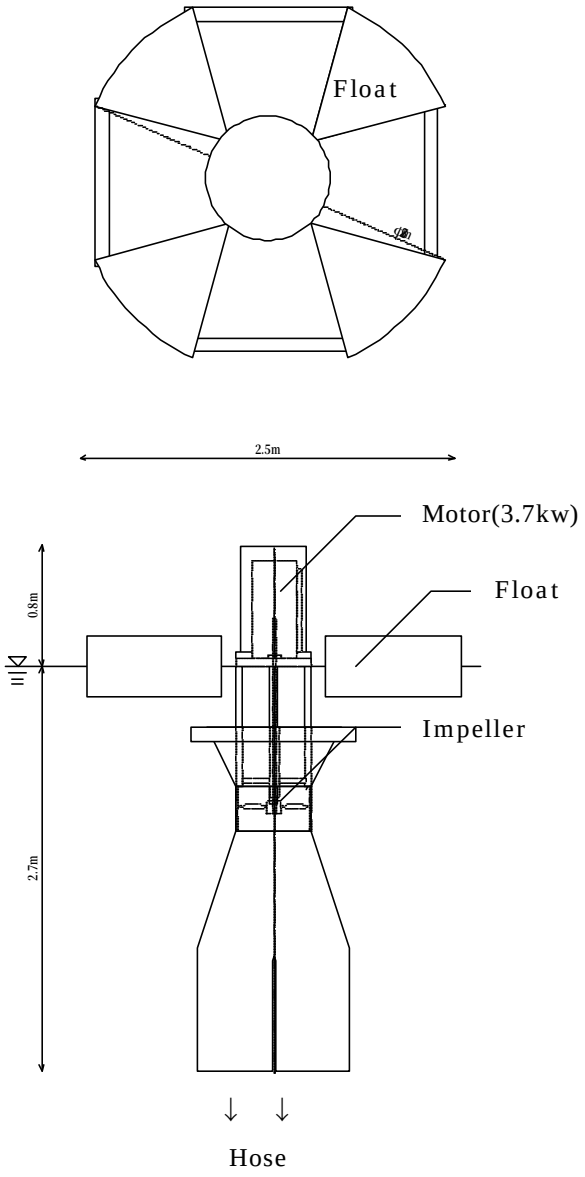


Fig.3 Simulated results of vertical water temperature distribution

4. Bottom water lifting and scattering system

To realize the simulation results investigated in chapter 3 the authors have designed and manufactured the following system. The pump to lift up the bottom water is an impeller pump. The necessary pressure is very small and so impeller pump is effective to lift up the large amount of water. The flexible hose is connected between the bottom of the dam and the system so as to adjust automatically according to water depth.



Flow capacity : 1,800m³/h

Electric Source : abt.2.0kw

Fig.4 Schematic Diagram of the system

5. The effectiveness of the system

The system has been installed at the Point 1, deepest point in the dam. And the operation started on April 27, 2002.

5-1 Water Temperature

Temperature stratification was already seen on April 26, 2002. On May 20, 2002, 1 month later after starting of the operation the stratification has been vanished. Measured date is shown in Fig.5.

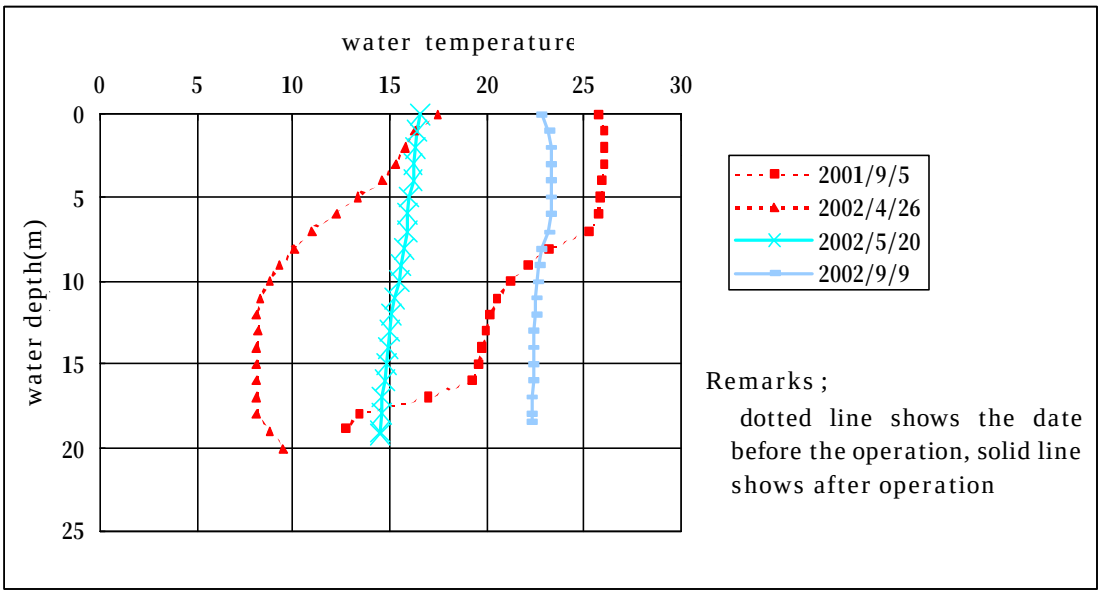


Fig.5 Vertical temperature distribution

5-2 DO

DO value has the same tendency as the temperature.

Fig.6 shows the vertical distribution of DO.

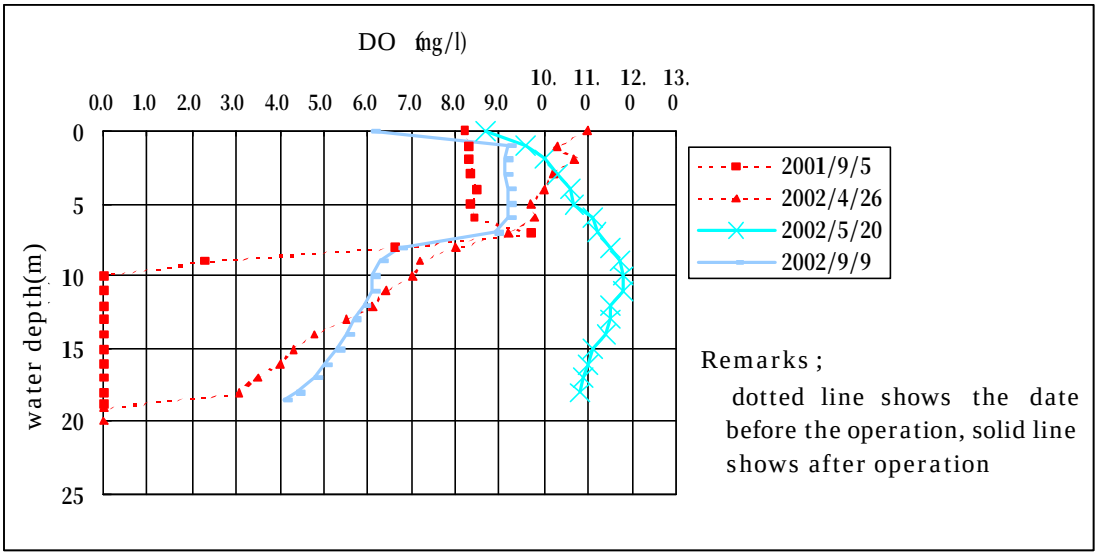


Fig.6 Vertical Distribution of DO

5-3 COD

COD has been improved as well as DO as seen in Fig.7.

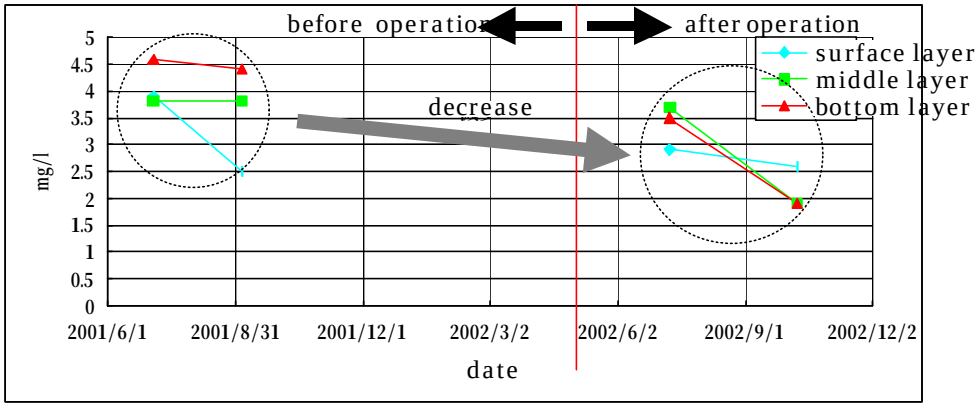


Fig.7 Change of COD in the dam

5-4 Total Nitrogen

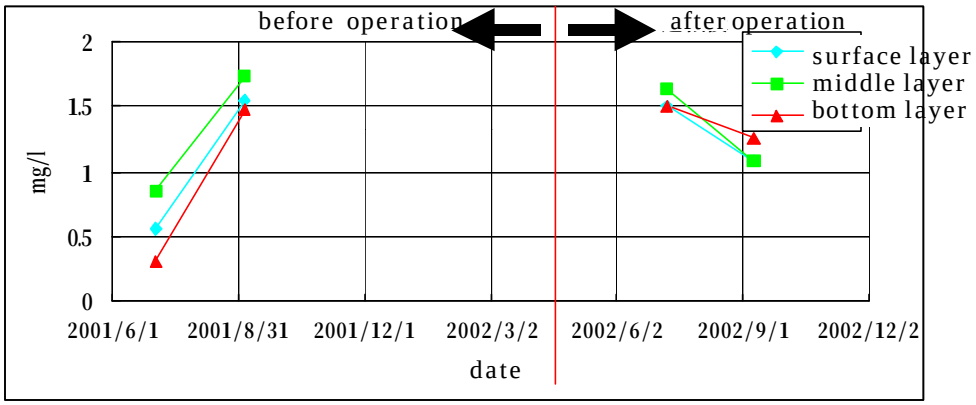


Fig.8 Change of Total Nitrogen in the dam

5-5 Total Phosphorus

In the case of zero DO at the bottom phosphorus liquates out from the bottom mud.

The liquation of phosphorus can be restrained by improving DO condition.

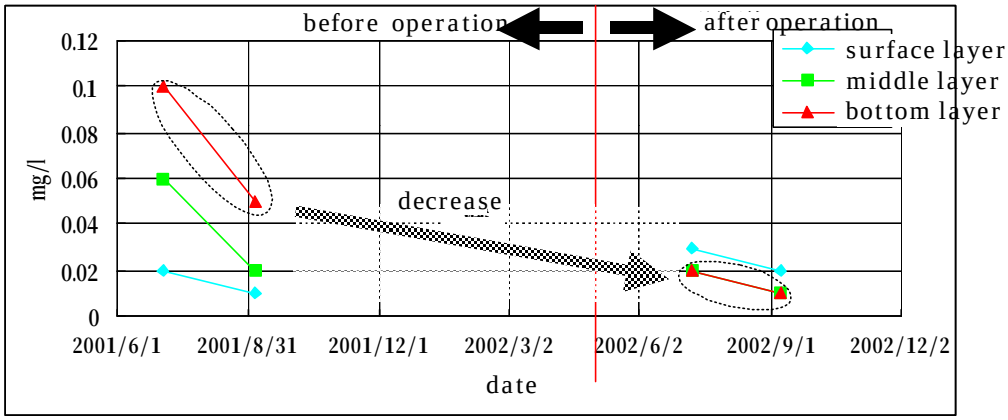


Fig.9

6. Conclusion

By using simple method the problem of zero DO condition is completely solved. As the advantage of this method following two points are emphasized:

(1) The estimation of the effectiveness is possible by numerical simulation.
Generally speaking in almost of such kind of system the estimation of the effectiveness is quite difficult before installation.

(2) As the pump system impeller pum is adopted. From the energy saving point of view the system efficiency is quite high.