II -490

Partition Effect on the Algal Blooming in a Eutrophic Reservoir

Nimal Priyantha, D. G. Saitama University Student Member
Asaeda, T. Saitama University Member

1. Introduction

The need for simulation of the internal dynamic of a reservoir results from the increased desire to manage the quality of the stored water. River water carries a sufficient amount of nutrients to the epilimnion for the phytoplankton activities, and seems to be responsible for algal blooming during summer time. Thus, if the epilimnion is isolated from the riverine water artificially, a significant reduction of algal blooming can be expected. The simplest way to isolate riverine water from epilimnion is to install a partition across the reservoir as illustrated in Figure 1. Experiments were conducted in the Terauchi Dam reservoir, located in the northern part of the west island of Japan, Kyushu, 33° 25'N in latitude, 130° 43'E in longitude, which is shown in Figure 2 (Saitoh *et al.* 1994). The processes in the lake after installing partitions are modeled. The method of modeling and the results are discussed in this paper.

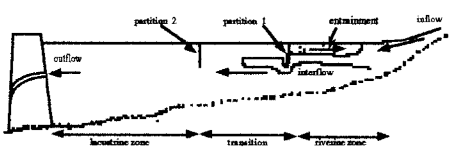

Figure 1. Illustration of effects of partitions

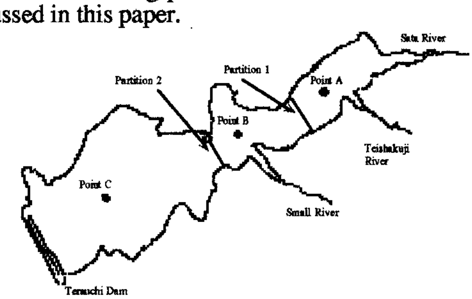

Figure 2. Plan view of Terauchi reservoir (Not in scale)

2. Modeling Procedure

The methods described in 1-D dynamic reservoir simulation model, DYRESM, is used for the prediction of temperature (Imberger *et al.* 1978). However, the model has been changed to apply for three reservoirs simultaneously and then separate models are coupled to account for partition effect and biological processes. DYRESM represents water body as a stack of horizontal layers of finite thickness. Each slab is homogeneous in terms of its state variables and is thus of uniform density. It uses Lagarangian layers that combine, expand, contract, move vertically, and divide in response to the physical processes within the reservoir, and has been applied successfully on a number of different reservoirs (Imberger *et al.* 1978). Each mixing process is represented by a subroutine in the FORTRAN coding of DYRESM. The length of a time step for each process varies. The processes of surface heat transfer and wind mixing (via the integral energy model) are combined in a sub daily loop for which the time step is dictated by the rate of surface heat and momentum transfer, with a minimum time step of 15 minutes. Vertical mixing in the hypolimnion is determined by an eddy diffusion model, with the diffusivity based on the ratio of total energy dissipation to the strength of stratification as given by buoyancy frequency following the model of Weinstock (1981). The time step for diffusion is fixed at one hour. Inflow and outflow are considered to be insensitive to fluctuations on time scales of less than one day. Withdrawals and insertions, therefore occur once per day (Imberger *et al.* 1978). In the new model, after each day, flow under each partition from upstream zone to middle zone and from middles zone to dam zone are calculated by balancing top surface water levels of three parts of the reservoir. Entertainment to the flow under the partition are calculated by using equations described in Jirka *et al.* (1973). Phytoplankton (expressed as chlorophyll-*a*), Equation (1), and phosphorus, Equation (2), are solved by using forth order Runge-Kutta method in the biological model. Vertical diffusion of *Chl-a* and PO_4 are treated similar to the method described above for temperature.

$$\frac{\partial Chla}{\partial t} = (Gpf(PO4)f(I) - kr - km)fp(T)Chla - Kgzfgz(T)Zfgz(Chla)P \qquad (1)$$

$$\frac{\partial PO4}{\partial t} = (-Upf(PO4)f(I) + kr + km)fp(T)Chla + Kgzfgz(T)Zfgz(Chla)P \qquad (2)$$

Where, *Chla* is the chlorophyll-*a* concentration, *PO4* is the dissolved phosphorus, t is the time, G_p is the maximum rate of phytoplankton growth, k_r is the rate coefficient for respiration, k_m is the rate coefficient for mortality, K_{gz} is the rate coefficient for zooplankton grazing, P is the grazing preference factor for specific phytoplankton groups, $f(PO4)$ is equal to $PO4/(PO4+K_p)$, K_p is the half saturation constant for phosphorus uptake, $f(I)$ is equal to $(I_i/I_s)exp(1-I_i/I_s)$, I_s is the saturating light intensity for phytoplankton, I_i is equal to $I(1-exp(-n\ dh)/n\ dh$, I is the incident PAR at the surface of layer i, n is the light extinction coefficient, dh is the layer thickness, $f_p(T)$ and $f_{gz}(T)$ are temperature function of form v^{T-20}, T is the temperature of layer i, v is a process-specific non dimensional temperature multiplier, Z is the zooplankton biomass, U_p is the maximum rate of phosphorus uptake, $f_{gz}(Chla)$ is equal to $Chla/(Chla+K_{pz})$, K_{pz} is the half saturation constant for zooplankton grazing.

3. Results

The hydrodynamic component of the above model is totally calibration free (Imberger *et al.* 1978). The biological model is calibrated by using Terauchi reservoir data over four months from March to June. The measured and simulated chlorophyll-*a* at the top layer of the lake is shown in Figures 3 ,4 and 5. The Chl-*a* concentration at the dam zone of the reservoir is comparatively smaller than middle zone and riverine zone.

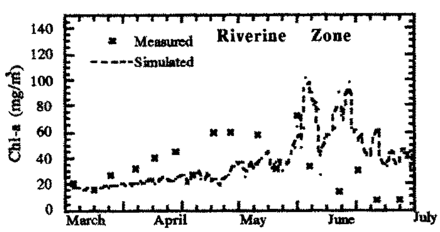

Figure 3. Riverine zone (A) top layer Chl-a.

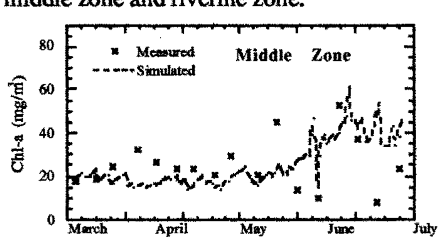

Figure 4. Middle zone (B) top layer Chl-a.

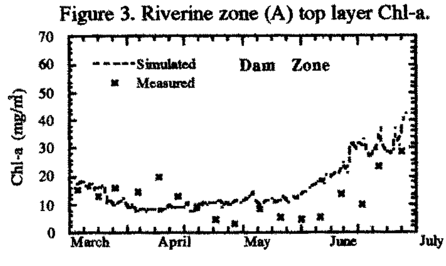

Figure 5. Dam zone (C) top layer Chl-a.

4. References

Imberger, J., Patterson, J. C., Hebbert, R., and Loh, I. (1978). "Dynamics of reservoir of medium size." J Hydr. Div., ASCE.

Jirka, G., Harleman, D. R. F., (1973). "The mechanics of submerged multiport diffusers for bount discharges in shallow water." Report No. 169, Dept. of Civil Eng.,Massachusetts Institute of Technology.

Saitoh, T., and Gotoh, K. (1994) "Water management of Terauchi Reservoir." Water Resources Agency of Japan, p.19(in Japanese).

Weinstock, J. (1981). "Vertical turbulence diffusivity for week or strong stable stratification. "J. Geophysical Res.,86(10),9925-9928.