ECOHYDROLOGY
ASIA – PACIFIC
REGION

DYNAMIC MODELING FOR CONTROLLING THE WATER QUALITY OF SITU CIBUNTU EFFLUENT

Tuahta Tarigan and Eko Harsono
R & D Center for Limnology
Indonesian Institute of Sciences
Cibinong 16911, Indonesia

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ABSTRACT

Situ is a very small lake which has function as a water source, flood control, and fishery. Situ Cibuntu situated at Cibinong is one of the numerous small lakes located in Jabotabek. The problem that occur in the situ is euthropication where nutrien enter into water body. Chemical parameters observed are DO, BOD, N-total and P-total, N-organic, ammonia , nitrite and nitrate. Physical parameters are water temperature, depth, discharge and chlorophyll-a. The average discharge is 3.135 m^3/day, water temperature in clear weather is 28.2 ^oC and in rainy weather is 26.6 ^oC. The average DO is 5.67 mg/L, BOD is 16.55 mg/L , N-total 1.95 mg/L and P-total 0.39 mg/L and average chlorophyll-a 0.051 ∝g/L.

Key words: Situ Cibuntu, dynamic modelling, eutrophication

1. INTRODUCTION

Dynamic modeling is an important tool for increasing the knowledge of eutrophication processes in a situ (small and shallow lake). The eutrophication can be defined as the biological reaction of aquatic ecosystems to nutrient (total-N and total-P) enrichment (Straskraba *et al.*, 1999). It can result in alga blooms, decrease in transparency, oxygen deficiency, fish kills and generally a shift phytoplankton, zooplankton and fish species (Jorgensen, 1989). Based on observation, one of the factors efluence of the eutrophication in situ is discharge inflow.

On the other hand water discharges to situ Cibuntu, with biology parameters (total-N, total-P BOD and Chlorophyll-a) can be different too. Discharge indicates the intensity potential for dilution and therefore self purification process can occurred faster. In this study, simulated discharge were evaluated during one year. From the simulation, was selected the ideal discharge entering to lake was determined. The ideal discharge is indicated by parameters of the simulation result in the condition where the situ is still in good or oligotropic condition.

2. DESCRIPTION OF SITU CIBUNTU

Situ Cibuntu has a surface area of 15,834 m^2, average depth is 1.8 m and a total volume of 13545 m^3. It is located 12 km North of Bogor or 46 km south of Jakarta, i.e. between 06^0 29' S latitude, 103^0 51' W longitude, at 119 m above sea level (Fig. 1). The climate of this study is mean annual precipitation 711 mm, air relative humidity 68 – 91 %, and mean annual temperature 25.3 – 26.3 ^{0}C. Inflow entering into situ Cibuntu is from irrigation channel originated from Ciliwung River flowing from Bogor to Jakarta. Situ Cibuntu is utilized as water source, water table controller, flood control, for farming and fishery, whereas land-use at the catchment area is mainly agriculture.

3. MATERIALS AND METHODS

Weekly field sampling were done from middle of September 1999 until December 1999, from samples were taken for the analyses of water quality parameter as well as for chlorophyll-a, total-N and P, BOD and Dissolved Oxygen. However the discharges into situ were measured with weir V-notch 90^0 and water levels

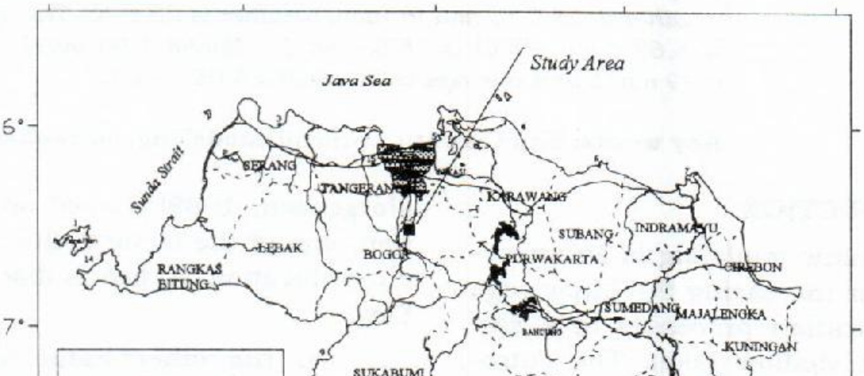


Figure 1. Study area in West Java region

were measured every time with ***absolute pressure logger***. Simulation using dynamics model program Powersim with Runge-Kutta order 4 method (Forrester, 1994) and validation of model to be done before simulation was carried out.

4. STRUCTURE OF MODEL

Structure formation of dynamic model base on finite segment eutrophication for those cases where geometry, advective and dispersive, water temperature and light extinction coefficients vary spatially throughout the water body. These models have been used to calculate ten systems or state variables (show as the square boxes) are modeled including three organic parameters (carbon, nitrogen and phosphorus), four inorganic systems (dissolved oxygen, ammonia nitrogen, nitrite + nitrate nitrogen, and orthophosphate phosphorus) and two biological compartments (phytoplankton and zooplankton). Three nutrients-ammonia, nitrite + nitrate nitrogen and orthophosphate are seen to directly affect the phytoplankton growth rate, in addition to water temperature and solar radiation. Phytoplankton concentrations decrease due to death (D_p) or death rate due (D_z) and to grazing by zooplankton (C_g). Dissolved oxygen is seen to be utilized by organic carbon (BOD), in the nitrification process (K_n) and by algal respiration (R), solar radiation (I) and v_s as settling rate.

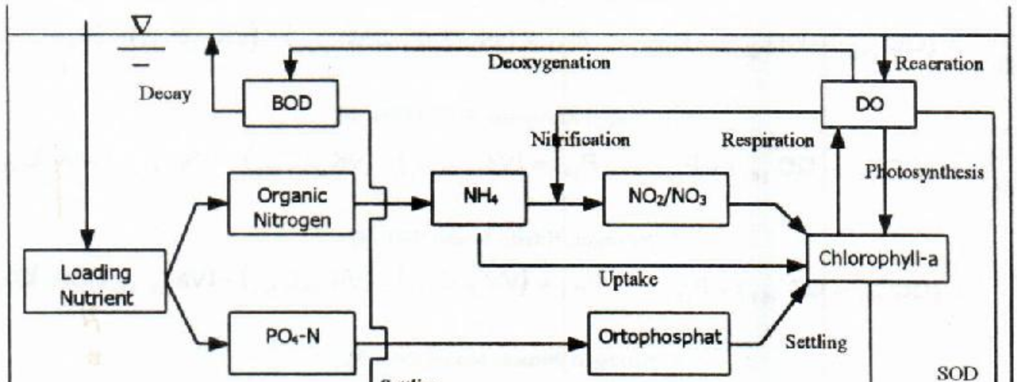


Figure 2. Simplified description of the eutrophication dynamic model (Thomann, 1987)

The differential equations for ten systems the concentration in the segment base on mass balance equation where equation for simplicity is written:

$$V\frac{dC_{(i)}}{dt} = QC_{(i)in} - QC_{(i)} + P_{(i)}$$

Where i= 1 is DO, i = 2 is total-N, i = 3 is organic-N, i = 4 is ammonia, i = 5 is nitrite, i = 6 is nitrate, i = 7 is BOD, i = 8 is total-P, i = 9 is orthophosphate, i = 10 is chlorophyll-a, V is Volume Lake, C is concentration, Q is discharge and P is depletion rate. The final form of the europhication equation model for situ Cibuntu developed as follows:

1. Dissolved Oxygen Model (DO)

$$V\frac{dC_{(t)}}{dt} = (QC_{(1)in} - QC_{(1)}) + P_{(1)}$$

$$P_{(1)} = \left(K_L A(C_{(1)s} - C_{(1)})\right) + \left(p_a VC_{(10)}\right) - \left(VK_d C_{(7)}\right) - V\left[\frac{7.2\left(\frac{C_{(1)}}{0.7 + C_{(1)}}\right)}{H}\right] - V\left(4.57K_{22}C_{(4)}\right) - \left(VRC_{(10)}\right)^2.$$

total-Nitrogen Model (TN)

$$V\frac{dC_{(2)}}{dt} = (QC_{(2)in} - QC_{(2)}) + P_{(2)} \qquad P_{(2)} = \left(C_4 + C_5 + C_6\right) - \left(\upsilon_s AC_{(2)}\right)$$

3. Nitrogen Organic Model (Norg-N)

$$V\frac{dC_{(3)}}{dt} = (QC_{(3)in} - QC_{(3)}) + P_{(3)} \qquad P_{(3)} = \left(ac_3 - c_{10}DAC_{(10)}\right) - \left(VK_{11}C_{(3)}\right) - \left(\upsilon_s AC_{(3)}\right)$$

4. Nitrogen Ammonia Model (NH_4-N)

$$V\frac{dC_{(4)}}{dt} = (QC_{(4)} - QC_{(4)}) + P_{(4)} \qquad P_{(4)} = \left(VK_{11}C_{(3)}\right) - \left(VK_{22}C_{(4)}\right) - \left(Va_{c4-c10}GCA\right)C_{(10)}$$

5. Nitrogen Nitrite Model (NO_2-N)

$$V\frac{dC_{(5)}}{dt} = (QC_{(5)} - QC_{(5)}) + P_{(5)} \qquad P_{(5)} = \left(VK_{22}C_{(4)}\right) - \left(VK_{33}C_{(5)}\right) - \left(Va_{c5-c10}GCA\right)C_{(10)}$$

6. Nitrogen Nitrate Model (NO_3-N)

$$V\frac{dC_{(6)}}{dt} = (QC_{(6)} - QC_{(6)}) + P_{(6)} \qquad P_{(6)} = \left(VK_{33}C_{(6)}\right) - \left(Va_{c6-c10}GCA\right)C_{(10)}$$

7. Oxidation Model (CBOD)

$$V\frac{dC_{(7)}}{dt} = (QC_{(7)} - QC_{(7)}) + P_{(7)}$$

$$P_{(7)} = -\left(VK_d C_{(7)}\right) + V\left(a_{c2-c7}C_{(2)} + a_{c8-c7}C_{(8)} + ac7 - c10DCAC_{(10)}\right) - \left(\upsilon_s AC_{(7)}\right)$$

8. Total- Phosphate Model (TP)

$$V\frac{dC_{(8)}}{dt} = (QC_{(8)} - QC_{(8)}) + P_{(8)} \qquad P_{(8)} = -(Va_{c8-c9}P_{(8)}) - (K_s VP_{(8)})$$

9. Orthophosphate Model (OP)

$$V\frac{dC_{(9)}}{dt} = (QC_{(9)} - QC_{(9)}) + P_{(9)} \qquad P_{(9)} = -(Va_{cp-c8}GCA)C_{(9)}$$

10. Chlorophyll-a Model (CA)

$$V\frac{dC_{(10)}}{dt} = (QC_{(10)} - QC_{(10)}) + P_{(10)} \qquad P_{(10)} = -V(GCA - DCA)C_{(10)}$$

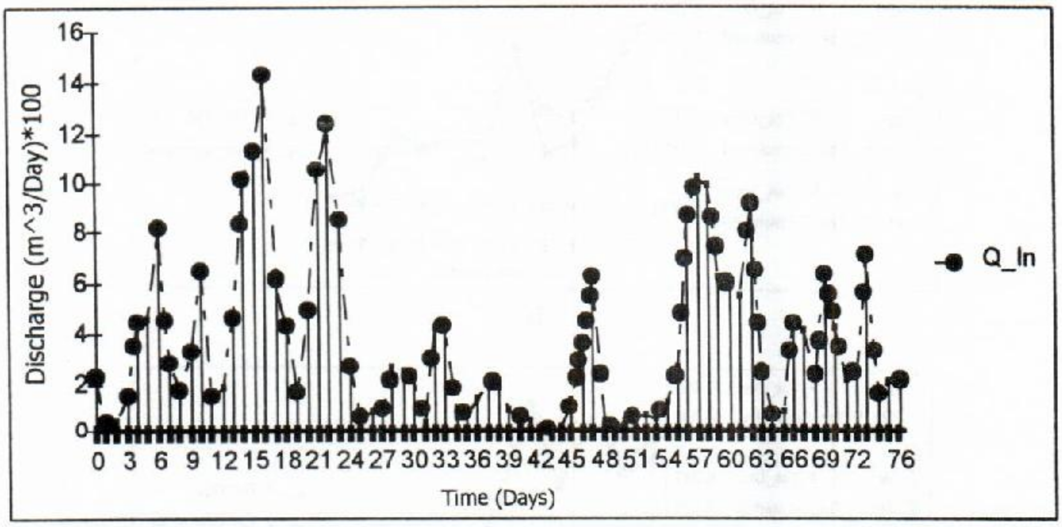
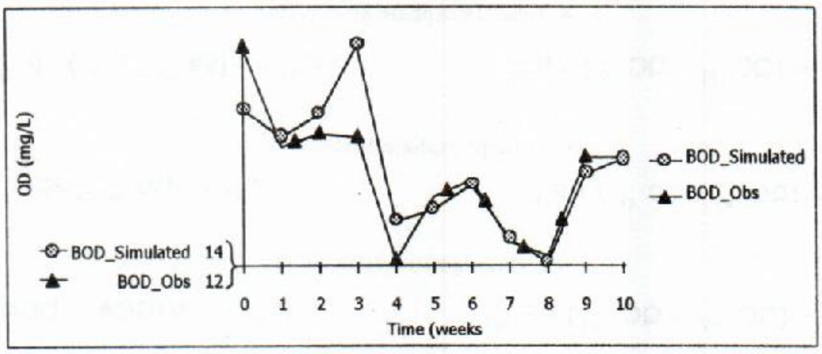


Figure 3. Monitoring of discharge entering of the situ Cibuntu during **76 days**

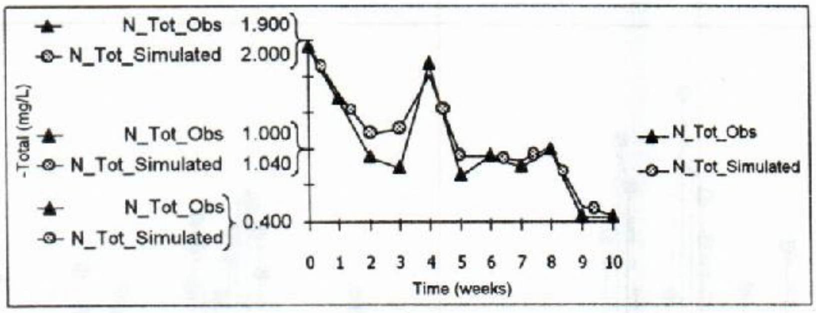
Simulation model function to predict water quality parameters as result of N, P and organic carbon loading limited by external condition of lake ecosystem, which is unchanged. The use of simulation model is limited only for rainy season and is not applicable for dry season because of difference of weather (rain, wind and humidity).

5. RESULTS

Result of monitoring of discharge inflow into situ Cibuntu was conducted during 76 days can be seen in fig. 3 and the range of discharge monitoring its from 500 m^3/day to 14000 m^3/day. Water quality of the situ Cibuntu was monitored together with discharge at 3 stations (i.e. Inflow, middle and outflow of the situ).



a



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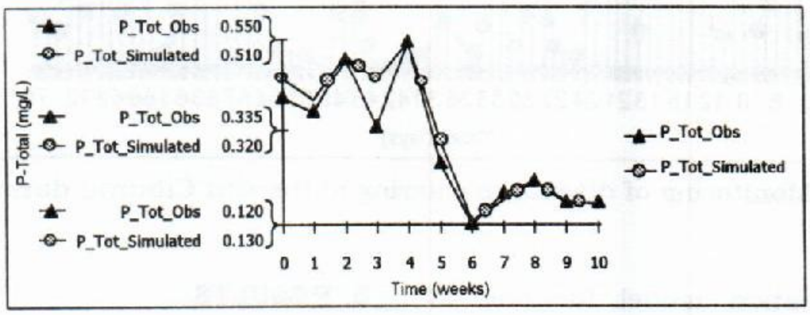

c

Figure 4. Observed and simulated BOD, N-tot and P-tot of the situ Cibuntu during 76 days

Result of the water quality monitoring, together with simulation result can be seen in figure 4.

Figure 4, shows the observed (result of monitoring) with simulated of water qualities have range 16 – 35 mg/L for BOD (fig. 4 a), 0.41 – 1.90

mg/L for N-total (fig.4 b), and 0.09 – 0.57 mg/L for P-total (fig. 4 c). Through trail and error, the result of simulation have tend follow the of observed. Base on the criteria of tropic status USEPA in Thomann (1987), the situ Cibuntu during observed was conducted still in oligotropic condition.

The climate of situ Cibuntu indicates typical tropical type that divided into two seasons its rainy and dry. In the rainy season, the mean inflow of discharge in to situ cibuntu its 14000 m^3/day. Whereas in the dry season, the mean inflow of discharge in to situ cibuntu its 500 m^3/day.

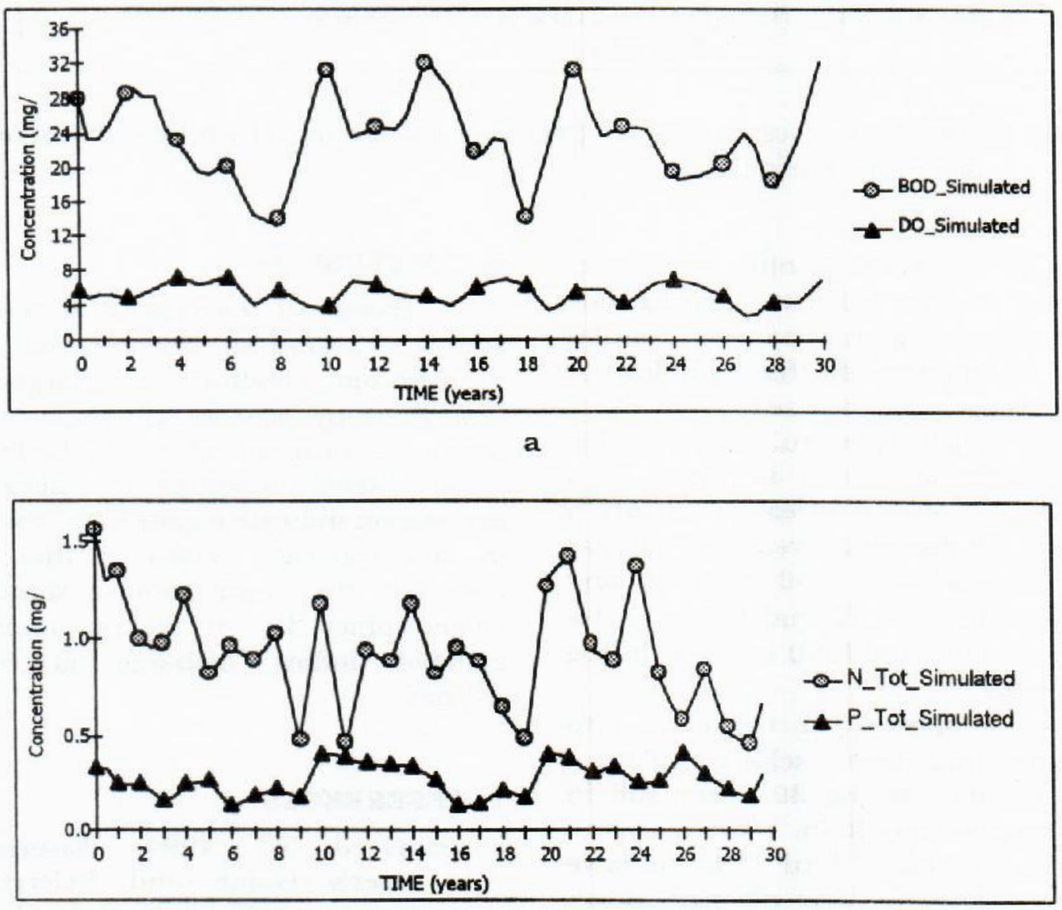

Figure 5. Result of simulated TN, TP with 500 m^3/day discharge during 30 years.

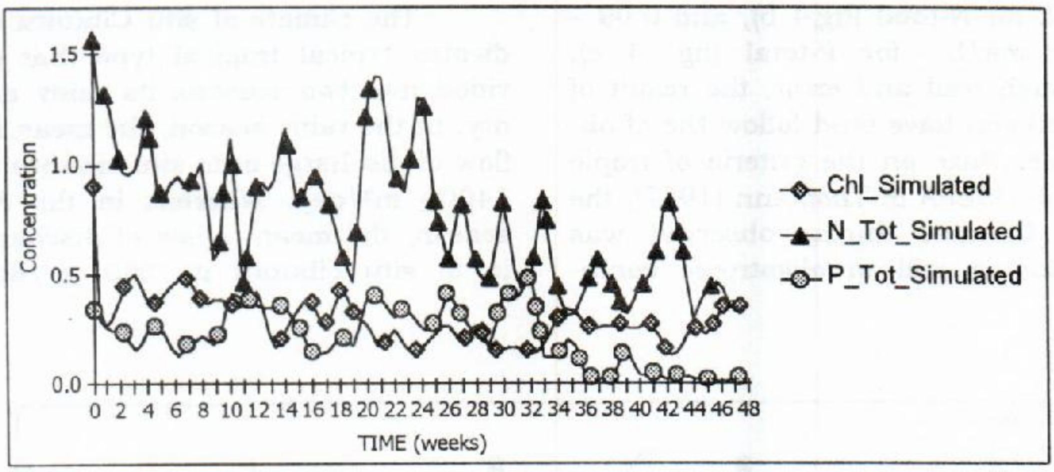

Figure 6. Result of simulated TN, TP (mg/L) and Chl-a (μg/L) with 14000 m^3/day discharge during 1 year

In order to identify the water quality of situ Cibuntu during one year, this research conducted simulation of impacts discharge inflow at rainy season and dry season on water quality of situ Cibuntu. Result of this simulation is shown in figure 5 a (BOD, DO, durind 1 year) figure 5 b (TN, TP during 30 years) of simulation at discharge 500 m^3/day) and figure 6 (for TN, TP and Chlorophyl-a of simulation at 14000 m^3/day during one year).

As showed in figure 5, situ Cibuntu that have discharge inflow of 500 m^3/day during 30 years still in oligotrophic condition. Whereas figure 6 indicate that if situ Cibuntu have inflow 14000 m^3/day during 1 year, nutrient (total-N, P) in this situ will deficit that cause decrease concentration of chlorophyll-a.

6. CONCLUSIONS

Based on the criteria of tropic status, situ Cibuntu observed was still in oligotropic condition. Discharge inflow at rainy season will cause the deficit of nutrient of phytoplankton growth. Result of simulation inflow at dry season indicate oligotrophic status in situ Cibuntu. Based in this, to maintain the tropic status desired (oligotrophic) for 30 years, recommended inflow disharge is 500 m^3/day.

7. REFERENCES

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