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MATHEMATICAL MODELING REGIME STEADY STATE FOR DOMESTIC WASTEWATER TREATMENT FACULTATIVE STABILIZATION PONDS

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Abstract: This paper presents a model for natural systems used in Wastewater Treatment Plant (WWTP) Sewon Bantul. The model is modeling development, derived from the physical and biochemical phenomena involved in the biological treatment process. The numerical solution of the resulting on 13 simultaneous systems of nonlinear equations by the Quasi_Newton. Data validation is measured by facultative pond at the inlet and outlet of the pond to the concentration of bacteria, algae, zooplankton, organic matter, detritus, organic nitrogen, NH3, organic phosphor, dissolved phosphorus, Dissolved Oxygen (DO), total coliform, faecal coliform and Biochemical Oxygen Demand (BOD). A simulation model is presented to predict performance regime steady state of domestic wastewater treatment facultative stabilization pond. The high degree of significant of at least 10% indicates that the effluent parameters can be reasonably accurately predicted.

Keywords: Domestic wastewater; regime steady state; facultative stabilization ponds

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INTRODUCTION

The problem of a built environment quality on community settlement in almost all major cities in Indonesia is a multi-dimensional problem. Urban developments are characterized by a rapidly increasing number of people living in the urban settlements. The denser an area is, it will be increasingly complex pollution problems primarily is house hold waste or domestic waste. If no appropriate action to address this problem, it will cause serious problems. Uncontrolled domestic waste has caused contamination in almost all rivers in Indonesia, especially Java (Sudharto & Samekto, 2007).

Domestic waste or household waste consists of sewage from bathrooms, toilets and kitchens. Dirt is a complex mixture of substances of mineral and organic materials in many forms, including large particles and small, solid objects, the remnants of the materials in a state of floating in the form of kolloid and half kolloid (Martopo, 1987).

Stabilization Pond is essential for domestic wastewater pollution control which used to improve wastewater quality by relying on natural processes in the processing namely by taking advantage of the presence of bacteria, algae, and zooplankton to reduce organic pollutants contained in wastewater (Kayombo *et al.*, 2002; Beran & Kargi, 2005; Lani Puspita, *et al.*, 2005).

By mathematical modeling a system can describe how environmental carrying capacity at the wastewater treatment unit in degrading organic matter. A system can illustrate the process of degradation in WWTP system and the interaction between the elements as biochemical models. This condition is a dynamic state in which the state of the system changes with time, which is marked from the state is not steady or transition (unsteady state) until steady state or steady (Purwanto, 2005). In this study the focus analysis is steady state.

Common problems and much bother in the process of wastewater treatment is WWTP planned just to treat domestic wastewater or wastewater from households. But in reality WWTP Sewon often receive non-domestic wastewater especially carried by the feces vacuum fleet that sucks wastewater from small industries or home industry that actually their wastewater before being discharged to the WWTP should be processed first. This will bother the wastewater treatment process at the WWTP. The technical requirements for the sludge quality entering WWTP must meet the rate / capacity of sludge (liquid and sediment) at 0.5 liters / person / day and BOD5 of 5000 mg / liter (Operation and Maintenance IPLT Unit, 2012).This will bother the wastewater treatment process at the WWTP. Processing system is made two rows parallel, each are two facultative ponds and one maturation pond and sampling points presented in **Fig. 1**.

The purpose of this research is (a) determine the level of bacteria, algae, zooplankton, COD, detritus, organic nitrogen, NH_3, organic phosphor, dissolved phosphorus, Dissolved Oxygen (DO), total coliform, faecal coliform and Biochemical Oxygen Demand (BOD) at the exit to the stabilization ponds, (b) determine of the pollution parameters, (c) establish and calibrate a mathematical model by use of the pollution parameters in (a) and (b) as model inputs and balance equation of stabilization pond facultative.

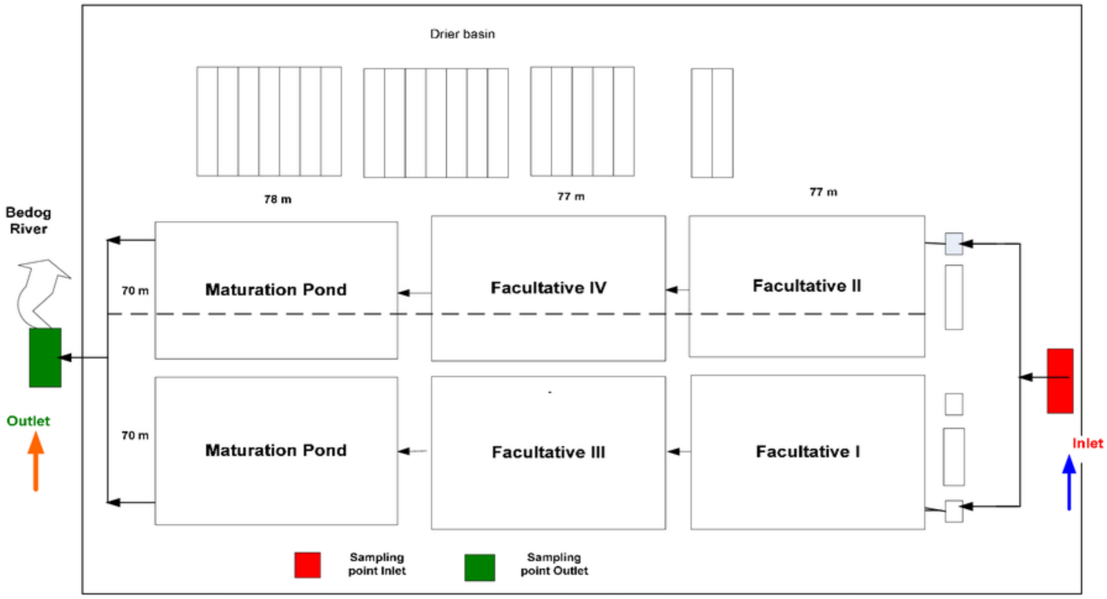

Fig. 1 Layout Inlet and Outlet Stabilization Pond WWTP Sewon and Sampling Point.

Modeling Development

In the stabilization ponds is assumed to occur perfect mixing, so that the concentration of each component part of the pond is considered uniform. This means that each point in pond has the same concentration for each component.Wastewater treatment process at the WWTP unit is illustrated as a biochemical process represented as simultaneous non linear system equations. The pond bed is assumed non-active, so the nitrification process which is on the nitrate and nitrite balance on the process of waste-water treatment is ignored. The waste-water treatment process on WWTP is represented as a completed model consisted of 13-equation systems. This model is using bioogical, chemical, and phisical phenomenon and the interaction between variables influencing on the waste-water treatment system. The model is defined as the growth rate on every species that is biomass bacteria, algae, zooplankton, organic matter, detritus, organic nitrogen, amonia nitrogen (NH_3), organic phospor, soluble phospor, dissolved oxygen, total coliform, faecal coliform, and Biological Oxygen Demand (BOD). The model is an equation system accomodating from different parameter and constants derived from the waste-water treatment phenomenon. The waste-water flow is on the constant condition, so the model with the steady state condondition; with 13 equation defferential systems of zero time derivatives is: concentration value balance of biomass bacteria, algae, zooplankton, organic matter, detritus, organic nitrogen, amonia nitrogen (NH_3), organic phospor, soluble phospor, dissolved oxygen, total coliform, faecal coliform, and Biological Oxygen Demand (BOD).

1. Biomass bacteria (B) of equation system

$$\left(\frac{B_i}{\theta}-\frac{B_e}{\theta}\right)+Y_B\mu_B\frac{OM}{K_{BOM}+OM}\frac{DO}{K_{BDO}+DO}\frac{NH_3}{K_{BNH_3}+NH_3}\frac{SP}{K_{BSP}+SP}\left(1-\frac{B}{\eta_B}\right)B-(K_{BR}+K_{Bd})B=0 \tag{1}$$

2. Algae (A) of equation system

$$\left(\frac{A_i}{\theta}-\frac{A_e}{\theta}\right)+\mu_A f(T)f(pH)f(L)\frac{NH_3}{K_{ANH_3}+NH_3}\frac{SP}{K_{ASP}+SP}\left(1-\frac{A}{\eta_A}\right)A-(K_{AR}+K_{Ad}+S_A)A=0 \tag{2}$$

3. Zooplankton (Z) of equation system

$$\left(\frac{Z_i}{\theta}-\frac{Z_e}{\theta}\right)+\mu_Z f(T)f(pH)\frac{NH_3}{K_{ZNH_3}+NH_3}\frac{SP}{K_{ZSP}+SP}\frac{DO}{K_{ZDO}+DO}\left(1-\frac{Z}{\eta_Z}\right)Z-(K_{ZR}+K_{Zd})Z=0 \tag{3}$$

4. Organic Matter (OM) *mass balance*

$$\left(\frac{OM_i}{\theta}-\frac{OM_e}{\theta}\right)-\mu_B\frac{OM}{K_{BOM}+OM}\frac{DO}{K_{BDO}+DO}\frac{NH_3}{K_{BNH_3}+NH_3}\frac{SP}{K_{BSP}+SP}\left(1-\frac{B}{\eta_B}\right)B=0 \tag{4}$$

5. Detritus (D) of equation system

$$\frac{1}{d}(S_B B+S_A A)+U_r D=0 \tag{5}$$

6. Organic Nitrogen (ON) of equation system

$$\left(\frac{ON_i}{\theta}-\frac{ON_e}{\theta}\right)-\alpha_{ON}ON+T_B BK_{Bd}-T_A A(S_A-K_{Ad})+T_Z ZK_{Zd}=0 \tag{6}$$

7. Ammonia Nitrogen (NH_3) of equation system

$$\begin{aligned}&\left(\frac{NH_{3i}}{\theta}-\frac{NH_{3e}}{\theta}\right)-T_B B\left\{\begin{matrix}Y_B\mu_B\frac{OM}{K_{BOM}+OM}\frac{DO}{K_{BDO}+DO}\frac{NH_3}{K_{BNH_3}+NH_3}\\ \frac{SP}{K_{BSP}+SP}\left(1-\frac{B}{\eta_B}\right)-K_{BR}-K_{Bd}\end{matrix}\right\}\\&-T_A A\left\{\begin{matrix}\mu_A f(T)f(pH)f(L)\frac{NH_3}{K_{ANH_3}+NH_3}\frac{SP}{K_{ASP}+SP}\left(1-\frac{A}{\eta_A}\right)\\ -K_{AR}-K_{Ad}\end{matrix}\right\}\\&-T_Z Z\left\{\begin{matrix}\mu_Z f(T)f(pH)\frac{NH_3}{K_{ZNH_3}+NH_3}\frac{SP}{K_{ZSP}+SP}\frac{DO}{K_{ZDO}+DO}\left(1-\frac{Z}{\eta_Z}\right)\\ -K_{ZR}-K_{Zd}\end{matrix}\right\}\\&+\alpha_{OP}ON+\frac{U_r D}{d}T_A=0\end{aligned} \tag{7}$$

8. *Organic phosphor* (OP) of equation system

$$\left(\frac{OP_i}{\theta}-\frac{OP_e}{\theta}\right)-\alpha_{OP}OP+\psi_B BK_{Bd}-\psi_A A(S_A-K_{Ad})+\psi_Z ZK_{Zd}=0 \tag{8}$$

9. *Soluble Phosphor* (SP) of equation system

$$\begin{aligned}&\left(\frac{SP_i}{\theta}-\frac{SP_e}{\theta}\right)-\psi_B B\left\{\begin{matrix}Y_B\mu_B\frac{OM}{K_{BOM}+OM}\frac{DO}{K_{BDO}+DO}\frac{NH_3}{K_{BNH_3}+NH_3}\\ \frac{SP}{K_{BSP}+SP}\left(1-\frac{B}{\eta_B}\right)-K_{BR}-K_{Bd}\end{matrix}\right\}\\&-\psi_A A\left\{\begin{matrix}\mu_A f(T)f(pH)f(L)\frac{NH_3}{K_{ANH_3}+NH_3}\frac{SP}{K_{ASP}+SP}\\ \left(1-\frac{A}{\eta_A}\right)-K_{AR}-K_{Ad}\end{matrix}\right\}\\&-\psi_Z Z\left\{\begin{matrix}\mu_Z f(T)f(pH)\frac{NH_3}{K_{ZNH_3}+NH_3}\frac{SP}{K_{ZSP}+SP}\frac{DO}{K_{ZDO}+DO}\\ \left(1-\frac{Z}{\eta_Z}\right)-K_{ZR}-K_{Zd}\end{matrix}\right\}+\alpha_{OP}SP\\&+\frac{U_r D}{d}S_A=0\end{aligned} \tag{9}$$

10. Dissolved Oxygen (DO) of equation system

$$\left(\frac{DO_i}{\theta}-\frac{DO_e}{\theta}\right)+\frac{K_L(DO_s-DO)}{d}$$
$$-K\alpha_B B\begin{Bmatrix} Y_B\mu_B\dfrac{OM}{K_{BOM}+OM}\dfrac{DO}{K_{BDO}+DO} \\ \dfrac{NH_3}{K_{BNH_3}+NH_3}\dfrac{SP}{K_{BSP}+SP}\left(1-\dfrac{B}{\eta_B}\right)-K_{BR}\end{Bmatrix}$$
$$+\alpha_A A\begin{Bmatrix}\mu_A f(T)f(pH)f(L) \\ \dfrac{NH_3}{K_{ANH_3}+NH_3}\dfrac{SP}{K_{ASP}+SP}\left(1-\dfrac{A}{\eta_A}\right)-K_{AR}\end{Bmatrix}$$
$$-\alpha_Z Z\begin{Bmatrix}\mu_Z f(T)f(pH)\dfrac{NH_3}{K_{ZNH_3}+NH_3}\dfrac{SP}{K_{ZSP}+SP} \\ \dfrac{DO}{K_{ZDO}+DO}\left(1-\dfrac{Z}{\eta_Z}\right)-K_{ZR}\end{Bmatrix}=0 \quad (10)$$

11. Total Coliforms (*TC*) of equation system

$$\left(\frac{TC_i}{\theta}-\frac{TC_e}{\theta}\right)-K_{TC}TC=0 \quad (11)$$

12. FaecalColiforms (*FC*) of equation system

$$\left(\frac{FC_i}{\theta}-\frac{FC_e}{\theta}\right)-K_{FC}FC=0 \quad (12)$$

13. *Biological Oxygen Demand* (BOD)

$$\left(\frac{BOD_i}{\theta}-\frac{BOD_e}{\theta}\right)-kBOD=0 \quad (13)$$

MATERIAL AND METHODS

Quasi-Newton method and program model

Quasi-Newton method is used to accomplish the 13 non linear equation systems which have 44 parameters and constants with Matlab (R2800a). The 44 parameters are previously estimated first using "fmincon" with Matlab program (R2800a) (Won Young Yang *et al.*, 2005). To measure the concentration value on every concentration the first value is required; that is the average value of biomass bacteria (B) = 490 mg/l, algae (A) = 33 total individu, zooplankton (Z) = 1 total individu, organic matter (OM) = 752 mg/l, detritus (D) = 0 mg/ l, organic nitrogen (ON) = 7.0068 mg/l, amonia nitrogen (NH_3) = 2.9130 mg/l, organic phospor (OP) = 0.5924 mg/l, soluble phospor (SP) = 2.3121 mg/l, dissolved oxygen (DO) = 0.9 mg/l, total coliform (TC) = 49.10^5 amount/100 ml, faecal coliform (FC) = 200.10^5 (CFU/100ml) and Biological Oxygen Demand (BOD) = 250 mg/l.

Model Validation

Model validation is conducted to know the appropriateness of the formulated model, to know wheather the model is already represented the field condition with diference deviation between calculated data and the observed data. If the deviation between them is less (in 10% tolerance limit), so the model has been formulated and can be accepted.

Sample and Data Analyses

The sample of waste-water was measured on inlet and outlet pond every two hours at 8:00, 10:00, 12:00, 14:00, and 16:00 in order to get repeated measurement for concentration of biomass bacteria, algae, zooplankton, organic matter, detritus, organic nitrogen, amonia nitrogen (NH_3), organic phospor, soluble phospor, dissolved oxygen, total coliform, faecal coliform, and Biological Oxygen Demand (BOD). The results of the measurement were used in model validation by comparing the calculated data and the observed data. The model that had been formulated and validated with the calculated data and the observed data was analyzed by using the One-Sample Test statistic analysis with 10% trust rate and determination test to show the model was proper with the field condition.

RESULTS AND DISCUSSION

Wastewater Characteristics

Tables 1 and **2** below are the results of the measurement of substance concentration data on the inlet and outlet WWTP Sewon in steady state condition used for the calibration model.

pH

The degree of acidity (pH) is a picture of the amount or activity of hydrogen ions in the water. The results of pH measurements at the inlet are estimated from 7.09–7.35 and at the outlet is estimated from 7.12–7.5. pH conditions both at the inlet and the outlet has pH > 7 it is sais to be alkaline water conditions.

Temperature

In general, the wastewater enter in waters tend to raise the water temperature. The temperature at the inlet is estimated between 27–28ºC and at the outlet is estimated between 28–30.5ºC. With the increase of temperature will increase biological activity.

Nutrient Level

In the nitrogen waste in the form of organic and ammonia. Stage by stage organic is degraded into ammonia and in the condition aerob becomes nitrite and nitrate (Mahida, 1993). The results of measurements of nitrate in the inlet is estimated from 0.02 mg/l–9.04 mg/l and in the outlets is estimated from 0.09 mg/l–0.33 mg/l, while the nitrite on the inlet is estimated between

Table 1. The results of the measurement of substance concentration data on the inlet WWTP Sewon

Effluent Characteristic	Units	Hours				
		8:00	10:00	12:00	14:00	16:00
pH		7.09	7.19	7.19	7.19	7.35
Temperature	°C	27.8	27.5	27.0	28.0	28.0
DO	mg/l	0.9	1.5	0.8	1.7	1.8
BOD	mg/l	250	165	200	155	130
COD	mg/l	752	346	700	364	368
Nitrat	mg/l	9.04	0.04	0.43	0.09	0.02
Nitrit	mg/l	0.1044	0.0821	0.6232	0.1051	0.0223
NH_4N	mg/l	6.9915	8.9407	6.1038	9.0660	10.1800
Pospat	mg/l	2.7160	3.9085	3.5675	4.7680	5.0935
Phytoplankton	Total individu	29	16	22	25	23
Zooplankton	Total individu	2	1	4	5	4
Total Coliform	Total/100 ml	94.10^4	24.10^6	79.10^6	49.10^6	24.10^5
Faecal Coliform	CFU/ml	13.10^5	26.10^6	37.10^6	22.10^7	28.10^6

Table 2. The results of the measurement of substance concentration data on the outlet WWTP Sewon

Effluent Characteristic	Dimensions	Hours				
		8:00	10:00	12:00	14:00	16:00
pH	-	7.12	7.28	7.14	7.18	7.5
Temperature	°C	28.8	28.0	29.5	30.5	30.0
DO	mg/l	4.2	3.4	4.2	4.2	4.3
BOD	mg/l	16	20	18	19.5	19
COD	mg/l	68	72	70	64	76
Nitrat	mg/l	0.18	0.33	0.20	0.18	0.09
Nitrit	mg/l	0.0067	0.1515	0.0821	0.0186	0.0169
NH_4N	mg/l	6.0687	2.4868	4.6408	5.0284	6.4055
Pospat	mg/l	0.6035	1.0360	1.6425	1.5385	3.3005
Phytoplankton	Total individu	33	29	26	25	25
Zooplakton	Total individu	3	1	5	5	6
Total Coliform	Total/100 ml	49.10^5	32.10^6	34.10^6	42.10^6	49.10^6
Faecal Coliform	CFU/ml	2.10^7	66.10^5	27.10^5	72.10^5	26.10^5

0.0067 mg/l–0.1515 mg/l. For ammonia at the inlet is estimated from 6.1038 mg/l–10.1800 mg/l and at the outlet is estimated from 2.4868 mg/l–6.4055 mg/l. Phosphates are found in wastewater in the form of orthophosphates which is the largest source used by phytoplankton and will be absorbed quickly at concentrations less than 1 mg/l (Reynolds, 1993).

The resuls of measurements at the inlet is estimated from 2.7160 mg/l–5.0935 mg/l and at outlet is estimated from 0.6035 mg/l–3.3005 mg/l. Phosphoric content at outlet increasingly decline because in addition to organic matter that has been greatly reduced so that production of phosphate is also used aas a nutrient by photosynthetic microorganisms for growth and development.

Dissolved Oxygen (DO)

The results of the measurements of dissolved oxygen at inlet is estimated from 0.8 mg/l–1.18 mg/l and at outlet is estimated from 3.4 mg/l–4.4 mg/l. Dissolved oxygen is an important measure of water quality, waste freshness aerobic state waters. Other factors affecting the value of the levels of dissolved oxygen in natural water is turbulence in surface water, especially the surface of open water, the atmospheric pressure and the percentage of oxygen in the surrounding air (Mahida, 1993).

Biochemical Oxygen Demand (BOD)

BOD_5 is the amount of oxygen in the water that are intended by aerobic bacteria to neutralize or stabilize the organic material in the water through the decomposition of biological oxygen within 5 days of incubation of temperatures of 20ºC. The results of measurements at the inlet are estimated from 130 mg/l–250 mg/l and at outlet are estimated between 16 mg/l–29 mg/l. If organic waste is released into the water more and more, the value of BOD is increasing and will result in decreased dissolved oxygen content in the water, resulting in a deficiency of oxygen.

Chemical Oxygen Demand (COD)

COD indicates the amount of oxygen needed for chemical decomposition. COD measurements have significance or special when BOD can not be determined. The results of measurements at the inlet is estimated from 346 mg/l–752 mg/l and at outlet between 48 mg/l–72 mg/l. COD usually produce oxygen demand values higher than BOD test because materials stable against biological reactions to biological reactions and microorganisms can oxidized in the COD test (Fardiaz, 1992).

Phytoplankton dan Zooplankton

The research results show that the alga is one type of phytoplankton, at WWTP Sewon found as many as 8 species / species at the inlet and 15 species / species at the outlet.

Diversity and number of organisms in the plankton communities in freshwater bodies is a function of the large number of available organic materials (Patterson., 1996).

To see the quality of wastewater in the presence of plankton is one component of waters that is almost always present in any body of water. The group is divided between phytoplankton and zooplankton. Phytoplankton are primary producers that sustain aquatic life, oxygen is the main producer and has chlorophyl for photosynthesis, while the zooplankton play an important role in transferring energy from primary producers are phytoplankton (algae).

Bacteria

Research results at inlet for total coliform is estimated between 94.10^4–79.10^6 (total/100 ml), whereas at outlet is estimated between 49.10^5–49.10^6 (total/100 ml). For the measurement of faecal coliform at inlet is estimated between 13.10^5–37.10^7 (total CFU ml), whereas at outlet is estimated from 26.10^5–2.10^7 (total CFU ml). These bacteria are needed to describe the organic material in the wastewater, the amount bacteria should be enough to decompose organic matter.

Kinetic Coefficients

Kinetic coefficients of optimization results include kinetic constant of bacterial respiration ($K_{BR} = 0.035$ mg L^{-1}), and a constant detritus mass kinetics temperature 20°C ($K_{Bd} = 0.035$ day^{-1}) day^{-1} the value is realtively close with reseracher (Metcalf and Eddy, 1979; Frizt *et al.*, 1979). At the kinetic constant temperature 20°C ($K_{20^oC} = 0.0015$ day^{-1}) much lower than those obtained (Fritz *et al.*, 1979) of 0.05 day-^{1}, the difference is due to differences in temperature and algal respiration kinetic constant ($K_{AR} = 0.003$ day^{-1}), ($K_{Ad} = 0.001$ day^{-1}) is realtively close the value with reseracher (Baca and Arnett, 1976) and the kinetic constant of zooplankton respiration ($K_{ZR} = 0.003$ day^{-1}) is the same with researcher (Bowie *et al.*, 1985) and zooplankton detritus mass kinetics constants at 20°C ($K_{Zd} = 0.0001$ day^{-1}), is higher than reseracher (Bowie, *et al.*, 1985) namely ($K_{Zd} = 0.0001$ day^{-1}) this is due to the difference in temperature. At the kinetic parameter the rate of change of DO concentration were affected by the air-water transfer coefficient ($K_L = 0.8566$ m day^{-1}) and the kinetic constant at T (day^{-1}) for $K = 0.0005$ is much smaller than those obtained by (Fisher *et al.*, 1979) with $K = 500$, this is due to differences in substrate conditions, the degradation rate and temperature (Kayombo *et al.*, 2003).

At the kinetics parameter $\alpha_{ON} = 0.2$ day^{-1} is oxygen consumption at organic metamolisme nitrogen is higher than that obtained (Moreno-Grau, 1983) of 0.01 day^{-1}, the difference is due to differences in the concentration of total nitrogen. For the kinetic parameter (Y_B) = 0.09 is the rate of bacterial products and dead and (μ_B) = 0.01 day^{-1} is a special bacterial growth in this study are much lower than those obtained by (Metcalf & Eddy, 1979), this is caused by the different concentrations of substrate available. High substrate concentration will cause becomes high rate of bacterial growth. Semi-saturation constants of bacteria to organic material is amount to ($K_{BOM} = 50$ mg L^{-1}), and for dissolved oxygen ($K_{BDO} = 0.1$ mg L^{-1}) the value is much smaller than that obtained (Frizt *et al.*, 1979) amounted to K_{BDO} = 1 mg L^{-1}, it indicates the degree of organic pollution is higher. At the semi-saturation constants of organic nitrogen ($K_{BON} = 0.01$ mg L^{-1}), organic phosphorus ($K_{BOP} = 0.01$ mg L^{-1}), the maximum population of bacterial cells ($\eta_B = 0.95$ mg L^{-1}).

Parameters specific algae growth kinetics ($\mu_A = 0.5$ day^{-1}) is same with researchers (Bowie *et al.*, 1985). For the semi-saturation constant of organic nitrogen (K_{AON} = 0.01 mg L^{-1}) has a lower value ($K_{AON} = 0.1$ mg L^{-1}) and organic phosphorus ($K_{AOP} = 0.10007$ mg L^{-1}) is relatively same by researchers (Chen, 1970), it is because it has the same concentration of nutrients. For maximum coefficient of population growth ($\eta_A = 0.95$ day^{-1}) and for a special rate of algae growth at temperature 20°C ($S_A = 0.0488$ day^{-1}) is greater than researchers (Bowie *et al.*, 1985) amount to ($S_A = 0.05$), this difference in the content of the substrate.

Table 3. Physical constants and Environmental Conditions for WWTP Sewon

Parameter	Name	Value	Units	Source
V	Pond Volume	43680	m^3	Determined
θ	Retention time	4.27	Days	determined
T	Temperature	30	^0C	determined
W	Wind speed	7.0	m/s	determined
Is	Saturation intensity of solar radiation	350	$kJ\ m^{-2}\ day^{-1}$	Moreno-Grau et al., 1983
C_L	Light intensity correction factor	0.6		determined
d	Depth	1.5	M	determined

The growth rate of particular zooplankton ($\mu_Z = 0.1\ day^{-1}$) are much lower than the researcher (Jorgnsen, 1976) with ($\mu_Z = 0.7\ day^{-1}$), and this is because of differences in nutrient concentration. At the semi-saturation constant of organic nitrogen ($K_{ZON} = 0.1\ mg\ L^{-1}$) is higher than the researcher (Read and Arnett, 1976) of $0.01\ mg\ L^{-1}$ and for organic phosphor ($K_{ZOP} = 0.01\ mg\ L^{-1}$) is the same. For coefficient of maximum zooplankton population growth ($\eta_Z = 0.95\ mg\ L^{-1}$).

For the specific growth rate of bacteria at a temperature of 20ºC ($S_B = 0.0488\ day^{-1}$) greater obtained (Frizt *et al.*, 1979) that is ($S_B = 0.05\ day^{-1}$) the difference temperature and coefficient of benthic regeneration at temperature 20ºC ($U_r = 0.09\ day^{-1}$). At the parameters ($T_B = 0.00924\ mg\ mg^{-1}$) are the coefficients stoichiometric in bacteria is much smaller than the researcher (Bowie *et al.*, 1985) amounted to $0.124\ mg\ mg^{-1}$, as the concentration substat lower. Similarly to parameter of the algae $T_A = 0.053\ mg\ mg^{-1}$ lower than $T_A = 0.063\ mg\ mg^{-1}$ (Moreno-Grau *et al.*, 1983) and for $T_Z = 0.14\ mg\ mg^{-1}$.

At the coefficient of oxygen consumption on the metabolism of algae $\alpha_A = 1.244\ mg\ mg^{-1}$ magnitude higher than the researcher (Orlob, 1982) with $\alpha_A = 1.0\ mg\ mg^{-1}$, this is because the available amount of oxygen. Similarly to the bacteria $\alpha_B = 1.2\ mg\ mg^{-1}$ to other researchers (Orlob, 1982) $\alpha_B = 2.0\ mg\ mg^{-1}$ whosevalue is much higher and for zooplankton $\alpha_Z = 0.5\ mg\ mg^{-1}$, which are much smaller than the researcher (Moreno-Grau *et al.*, 1983) with ($\alpha_Z = 1.244\ mg\ mg^{-1}$). The rate of degradation of the average $k = 1.85\ day^{-1}$.

Physical Constants and Environmental Conditions

The physical constants and environmental conditions areused during the study are presented in **Table 3** as follows and biochemical constants model is in Appendix A.

Quasi-Newton method and program model

The programe output is the amount of concentration value of non-linear equation simultaneous system the value of nilai *B*, *A*, *Z*, COD, *D*, *ON*, NH_3, *OP*, *SP*, *DO* , *TC*, *FC*, *BOD* successively 0.6487 total/100 ml, 17.455 mg/l, 3.0839 mg/l, 65.281 mg/l, 11.429 mg/l, 2.1131 mg/l, 5.879 mg/l, 1.1608 mg/l, 1.0956 mg/l; 4.9753 mg/l, $4.822.10^7$ jumlah/100 ml, $3.6459.10^6$ CFU/ml and 20.433 mg/l.

Model Validation

The testing of the adequacy of the model was done using field data and calculated value by the model. The field data include value for algae, zooplankton, COD, detritus, organic nitrogen, ammonia, organic phosphor, soluble phosphor, DO, total coliform, faecal coliform and BOD. Statistical one sample t-test analysis at 90% confidence level on the observed and calculated value for the determination of model validity gave significant value for A, Z, COD, D, ON, NH_3, OP, SP, DO , TC, FC and BOD were 0.003, 0.099, 0.078, 0.74, 0.01, 0.080, 0.97, 0.006, 0.005, 0.102, 0.070, and 0.069 successively. These validation results show that the model gives a reasonable good approximation of the field data and hence can be used by WWTP Sewon as a tool for evaluation the performance of the WWTP Sewon.

CONCLUSION

Mass balance equation model developed from the biochemical model of stabilization ponds in a steady state where derevative time is zero produce equilibrium value at wastewater effluent to the value of algae, zooplankton, COD, detritus, organic nitrogen, ammonia, organic phosphor, soluble phosphor, DO, total coliform, faecal coliform and BOD. Kinetic coefficients optimization results for the WWTP Sewon include half substrate saturation, half constant, specific growth rate, maximum specific growth rate, specific growth rate species 20ºC, stoichiometric coefficient, oxygen consumption in metabolism coefficient each of substance concentration.

A simulation model is presented to predict performance regime steady state of domestic wastewater treatment facultative stabilization pond. The high degree of significant of at least 10% indicates that the effluent parameters can be reasonably accurately predicted.

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Appendix A. Value of the biochemical constant model

Parameter	Name	Value	Units	Source
K_{BOM}	Half substrate saturation bacteria	50	mg/l	Metcalf and Eddy , 1979
K_{BDO}	DO bacteria half constant	0.1	mg/l	Determined
K_{BON}	Organic Nitrogen bacteria half constant	0.01	mg/l	Frizt *et al.,* 1979
K_{BOP}	Organic Phosphor bacteria half constant	0.01	mg/l	Frizt *et al.,* 1979
K_{AON}	Organic Nitrogen algae half constant	0.1	mg/l	Chen, 1970
K_{AOP}	Organic Phosphor algae half constant	0.1	mg/l	Chen, 1970
K_{ZON}	Organic Nitrogen zooplankton half constant	01	mg/l	Baca and Arnett, 1976
K_{ZOP}	Organic Phosphor zooplankton half constant	0.01	mg/l	Baca and Arnett, 1976
μ_B	Specific growth rate bacteria	0.01	day^{-1}	Metcalf and Eddy , 1979
η_B	Maximum specific growth rate bacteria	0.95	day^{-1}	determined
μ_A	Specific growth rate algae	0.95	day^{-1}	determined
η_A	Maximum specific growth rate algae	0.95	day^{-1}	determined
μ_Z	Specific growth rate zooplankton	0.1	day^{-1}	determined
η_Z	Maximum specific growth rate zooplankton	0.95	day^{-1}	determined
K_{TC}	Maximum specific growth rate total coliform	0.6214	day^{-1}	determined
K_{FC}	Maximum specific growth rate faecal coliform	16.464	day^{-1}	determined
S_A	Specific growth rate algae 20°C	0.0499	day^{-1}	determined
S_B	Specific growth rate bacteria 20°C	0.0488	day^{-1}	determined
U_r	Regeneration rate	0.09	day^{-1}	Frizt *et al.,* 1979
T_B	Bacteria stoichiometric coefficient	0.0092	mg/mg	determined
T_A	Algae stoichiometric coefficient	0.053	mg/mg	determined
T_Z	Zooplankton stoichiometric coefficient	0.14	mg/mg	Moreno-Grau, 1983
α_A	Alga oxygen consumption in metabolism coefficient	1.244	mg/mg	determined
α_B	Bacteria oxygen consumption in metabolism coefficient	1.2	mg/mg	determined
α_Z	Zooplankton oxygen consumption in metabolism coefficient	0.5	mg/mg	determined
α_{ON}	Nitrogen oxygen consumption in metabolism coefficient	0.02	mg/mg	determined
α_{OP}	Phosphor oxygen consumption in metabolism coefficient	0.125	mg/mg	determined

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