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MODELLING OF WATER QUALITY IN UPPER CITARUM RIVER

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ABSTRACT

Upper Citarum river water quality management that was conducted by PROKASIH (Clean River Program) was aimed to reduce effluent loads in upper Citarum watershed. However, the river water quality condition in upper Citarum river is not improved yet by dense population and industrial development. Optimizing management strategies is necessary then for improving river water quality. In order to support the river water quality management, a computer model of river water quality has been developed. The model has an important role in optimizing the management policy in such complex water quality system in upper Citarum watershed. The model consists of tree sub-models. Those are runoff-hydrograph by a reformed tank model, estimation of discharge load (COD, BOD_5, T-N, T-P, and NH_3) using loading-factor method, and runoff-pollutegraph by a reformed tank model. The models ware calibrated to the water quality and daily discharge data series of river of upper Citarum (at Nanjung station). The computer models show the run-hydrograph and run-pollutograph models tend to follow the observed data of the river of upper Citarum

Key words: water quality, inflow load, model, hydrograph and pollutegraph

1. INTRODUCTION

Watershed of upper Citarum river which has area of 177100 ha, lies in Bandung old lake. Its watershed includes city of Bandung and regency of Bandung. Upper Citarum river as main river of watershed, passing the city and regency of Bandung then as main supply of Saguling reservoir (used for generation of electric and fisheries). City of Bandung is the capital of West Java Province, and together with regency of Bandung is still in developing. The upper river of Citarum has important potency as water resources for developing the city of Bandung and regency of Bandung.

Rivers have traditionally been used for the disposal of domestic, industrial and non-point sources wastewater. In many cases, this caused undesirable changes to the usefulness and the aquatic flora and fauna. The majority of these changes have been brought about by the discharge of carbonaceous organic and nitrogenous that resulting the decrease of dissolved oxygen (DO), moreover septic condition in the receiving water.

In order to maintain river water quality of upper Citarum, Provincial Government of West Java was decided ambient standard of water quality (i.e. for fisheries). Since 1989, PROKASIH (Clean River Program) was aimed to reduce pollution loads. Although this approach was economically efficient, it provides virtually impossible to administer, because of the difficulties in translating ambient standard in to end of-pipe effluent limit for individual of-pipe effluent limit for individual discharge, waste load allocation. It is proved that the river water quality condition in upper Citarum is not improved yet (Badrudin, 1990; Bukit, 1995 ; Uchida, 1997). Moreover, decrease of water quality in upper Citarum river has been caused fish damage and eutrophication in saguling reservoir (Woo, 1991; Brahmana, 1993) .

One of the factors that contributed to the decrease of water quality in upper Citarum river was that the "translating" technology, water quality modeling, was not yet applied in that river. In this concern, a computer model of river water quality has been developed for upper Citarum river. The model has an important role in optimizing the management policy in such complex water quality system in upper Citarum watershed.

Table 1. Unit loading factor used in modeling.

Source	Q_{eff}	BOD_5	COD	T-N	T-P	NH_3
Domestic	160 l/d/cap	180 mg/l	250 mg/l	50 mg/l	20 mg/l	28 mg/l
Factory :						
Textile	200 m^3/ton	800	1000	80	20	-
Leather	0.42 m^3/ton	800	1000	30	1.5	-
Tea	0.035 m^3/ton	2.2	2.5 mg/l	0.87	0.35	-
Electronic	0.035 m^3/ton	2.2	2.5 mg/l	0.87	0.35	-
Garment	0.035 m^3/ton	2.2	2.5 mg/l	0.87	0.35	-
Land use	**Unit**					
Buildup area	kg/ha/year	187	200	19.7	2.7	-
Forest	kg/ha/year	-	21.5	3.6	0.3	-
Plantation	kg/ha/year	-	15.5	76.0	1.9	-
Dry field	kg/ha/year	-	10.3	76.0	0.68	-
Paddy field	kg/ha/year	-	21.3	49.8	2.02	-

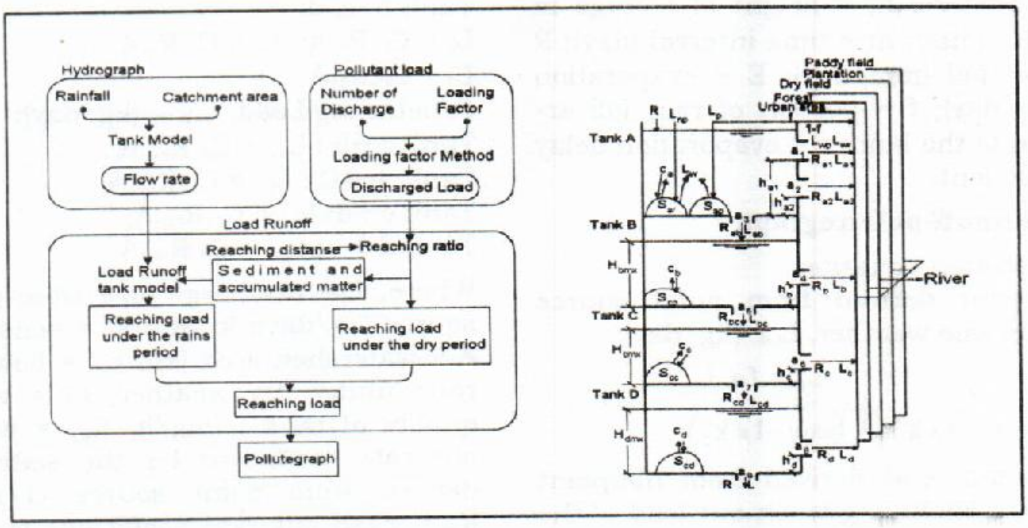

Figure 1. Out line of the tank model for hydrograph and pollutegraph

2. MATERIAL AND METHOD

The model consists of three sub-models as show in Fig.1. Those are, 1) runoff-hydrograph by a reformed tank model 2) estimation of discharge load (COD, BOD_5, T-N, T-P, and NH_3) using loading-factor method 3) runoff-pollutegraph runoff by a reformed tank model. Table 1. Shows the value of unit loading factor used in modeling. Fig.1. Show the out line of the tank model for runof-hydrograph and runoff-pollutegraph simulation.

Fundamental equation for the models can be expressed below,

- **Runoff-hydrograph**

Flow rate from tank a

$H_a = f.R.\Delta t - (1 - s).E.\Delta t$. If $H_a > h_{a1}$,
then $R_{a1} = a_1.(H_a - h_{a1}).\Delta t$,
and $R_{a2} = a_2 (H_a - h_{a2}).\Delta t$,
and then $Ra = R_{a1} + R_{a2}$.
If $h_{a2} < H_a \leq h_{a1}$, then $R_{a1} = 0$
and $R_{a2} = a_2 (H_a - h_{a2}) \Delta t$,
and then $Y_a = R_{a1} + R_{a2}$
If $H_a \leq h_{a2}$, then $R_a = 0$
$R_{ab} = a_3.H_a$ and
$H_a = H_a - R_a.\Delta t - R_{a0}.\Delta t$.

Flow rate from tank b

If $H_b > h_b$, then $R_b = a_4 (H_b - h_b).\Delta t$.
And if $H_b \leq h_b$, then $R_b = 0$.
$R_{bc}=a_5.H_b$ and $H_b=H_b - R_b.\Delta t - R_{b0}.\Delta t$.

Flow rate from tank c

If $H_c > h_c$, then $R_c = a_6 (H_c - h_c).\Delta t$.
And if $H_c < h_c$, then $R_c = 0$
$R_{cd}=a_7.H_c$, and $H_c=H_c - R_c.\Delta t - R_{c0}.\Delta t$.

Flow rate from tank d

If $H_d > h_d$, then $R_d = a_8 (H_d - h_d).\Delta t$.
And if $H_d \leq h_d$, then $R_d = 0$.
$R_{de}=a_9.H_d$ and $H_d=H_d - R_d.\Delta t - R_{d0}.\Delta t$.

Where, H_i = water level of tank i (mm); R_i = flow from tank i (mm/day); R_{ij} = penetration from tank i to tank j (mm/day); $a_1 \sim a_9$ = flow throughout parameters; h_i = height of storage in tank i (mm); Δt = time interval (day); R =rain fall (mm/day); E = evaporation (mm/day); f = portion of rain fall arrived to the land; s = evaporation delay coefficient.

- **Runoff-pollutegraph**

Motion equation:

Flow-out derived from point source under fine weather, L_{po} (kg/day):

$$L_{po} = f \times L_p$$

$$f = \left(\exp(-1 \times k_1 \sqrt{A}\right)\left(\exp(-1 \times k_2\right)$$

Flow-out load derived from nonpoint source (including wash-out load of the sediment derived form point source), $L_{a\sim d}$ (kg/day) :

Tank a:

$$L_a = C_a.R_a.A + K_{wp}.S_{ap}.R_a.A + K_{wr}.S_{ar}.R_a^2.A$$

Tank b, c, d:

$L_b = C_b.R_b.A$; $L_c = C_c.R_c.A$;

$L_d = C_d.R_d.A$

Penetrating Load, $L_{ab\sim de}$ (kg/day):

Tank a→b : $L_{ab} = C_a.R_{ab}.A$;

Tank b→C : $L_{bc} = C_b.R_{bc}.A$

Tank c→d: $L_{cd} = C_c.R_{cd}.A$;

Tank d→ : $L_{de} = C_d.R_{de}.A$

Where, L_p= discharge load from point source (kg/day); k_1 and k_2 = constant; A = watershed area (km^2); f = flow-out ratio under dry weather; C_i = water quality of tank i (mg/l); K_{wp} = wash-out rate coefficient for the sediment derived from point source (1/mm); K_{wr}= wash-out rate coefficient for the sediment derived from nonpoint source (day/mm); S_{ap}= sediment derived from point source (kg/m^2); S_{ar} = sediment derived from nonpoint source (kg/m^2).

Continuity Equation:

Sediment and wash-out process in tank a:

$$A.\frac{d(C_a.H_a)}{dt} = C_r.R.A - C_a.R_a.A - K_{ai}.C_a.H_a.A + K_{a2}.S_{ar}.A - L_{ab}$$

$$A\frac{dS_{ap\cdot}}{dt} = (1 - F_1).L_p - k_{dp}.S_{ap}.A - K_{wp}.S_{ap}.R_a.A$$

$$A.\frac{dS_{ar}}{dt} = L_{np} - k_{dr}.S_{ar}.A + k_{a1}.C_a.H_a.A - k_{a2}.S_{ar}.A - K_{wr}.S_{ar}.R_a^2.A$$

Penetration, accumulation in soil, desolution process in tank b~d,

$$A.\frac{d(C_b.H_b)}{dt} = L_{ab} - L_b - L_{bc} - k_b.\left\{C_b.H_b - r\frac{(SC_b + SC_{bo})}{SC_{bo}}SC_b.H_{bmx}\right\}.A$$

$$A\frac{d(SC_b.H_{bmx})}{dt} = k_b.\left\{C_b.H_b - r\frac{(SC_b + SC_{bo})}{SC_{bo}}SC_b.H_{bmx}\right\}.A - k_{db}.SC_b.H_{bmx}.A$$

$$A.\frac{d(C_d.H_d)}{dt} = L_{cd} - L_d - L_{de} - k_d.\left\{C_d.H_d - r\frac{(SC_d + SC_{do})}{SC_{do}}SC_d.H_{dmx}\right\}.A$$

$$A\frac{d(SC_d.H_{dmx})}{dt} = k_d.\left\{C_d.H_d - r\frac{(SC_d + SC_{do})}{SC_{do}}SC_d.H_{dmx}\right\}.A - k_{dd}.SC_d.H_{dmx}.A$$

Here, H_{imx}= maximum water level of tank i (mm) ; k_{di} = decreasing rate coefficient in tank i (1/day) ; k_i = adsorption-desorption coefficient in tank i (1/day) ; C_r = rain water quality (mg/l); SC_i = accumulation in soil of tank i (kg/m^2) ; k_{a1} = adsorption rate coefficient in tank a (1/day); k_{a2} = desorption rate coefficient in tank a (1/day) ; $r\frac{(SC_i + SD_{io})}{SC_{io}}$ = adsorption equivalent constant in tank i.

Reaching load and concentration

$$L_{cai} = L_{po} + L_a + L_b + L_c + L_d$$

$$C_{cai} = \frac{L_{cai}}{Q_{cal}}$$

$$Q_{cal} = \sum\{(R_a + R_b + R_c + R_d).A\}\tan k.1 \to 5$$

Where, L_{cai} = total discharge load of parameter i (kg/dy) ; C_{cai} = concentration of parameter i (mg/l) ; Q_{cai} = total discharge (m^3/sec).

Solution of differential equations in the model used Runge-Kutte method, whereas for calculation of the models are programmed in FORTRAN.

Watershed daily rainfall as input of the model is calculated based on daily rainfall data from 11 rainfall stations of telemetry. Those rainfall stations of telemetry are Cicalengka, Paseh, Chinhona, Ciparay, Ujungberung, Bandung, Montaya, Sukawarna, and Saguling dam station (location of the stations in Fig.2). Whereas, available of daily rainfall data is from 1990 to 1998.

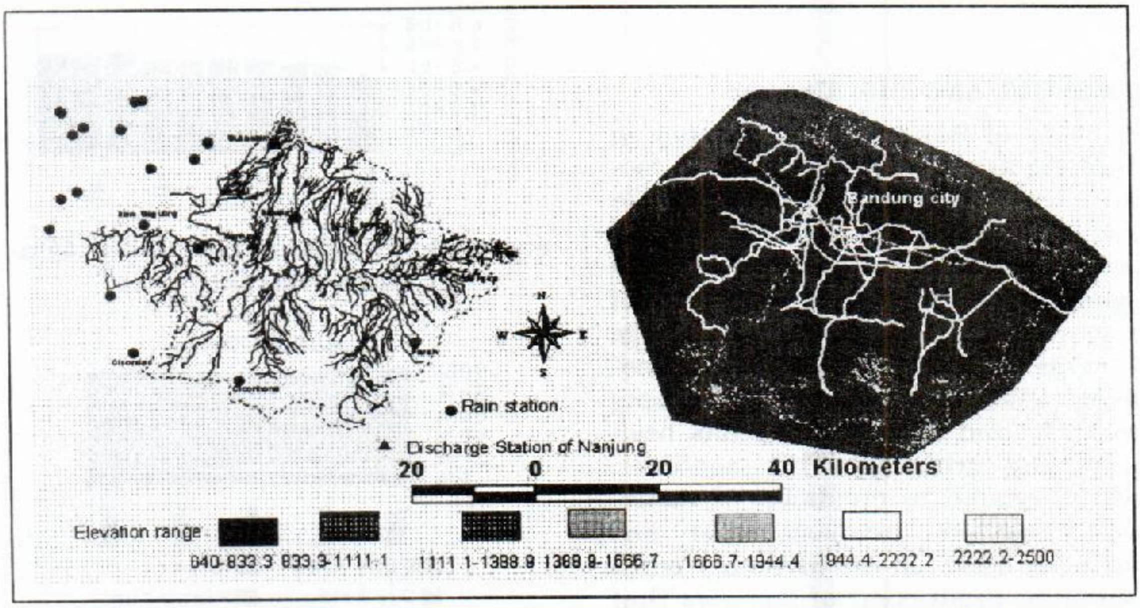

Figure 2. Upper Citarum Watershed

Estimation of pollution load required population, land use and industries production data. Population and industries production data acquired from statistic book of Bandung. Land uses data acquired from statistic book of Bandung, land use map, and interpretation of land satellite image.

Nanjung station (Fig.2) is outlet of upper Citarum watershed area. At the station, R&D for Water resource Center, Indonesian Public Work has been monitoring flow discharge and water quality of Citarum River. Monitoring data collected was used for the calibration of the models. Calibration of runoff-hydrograph model used available daily discharge data from 1990 to 1998. Calibration of runoff-pollutegraph model used available water quality data from 1990 to 1995.

3. RESULT AND DISCUSSION

City of Bandung and regency of Bandung are the central of textile factories in Indonesia. About 80% textile production supplied from the region. As shown in fig.3, textile production is higher compared to production of other factories. Fig. 3, shows change of textile production, in the period between 1990 to 1993 has increasing gradually and then in 1997 has been decreasing critically. This condition can be related to condition of monetary crisis in Indonesia that has started in 1997. In the monetary crisis condition, production of factories that used imported raw material, were decreased. In such case, decreasing textile production was caused by import of cottons and synthetic fibers. The same case also in factory of electric products was caused by imported component electric system. Whereas tea and leather productions were relatively constant because raw materials in production process was not imports.

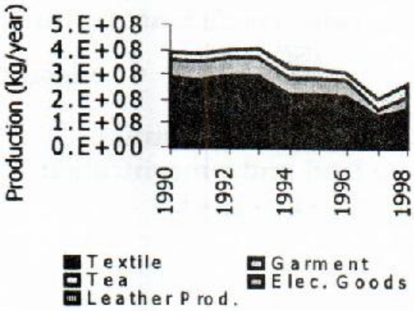

Figure 3. Main factories in Upper Citarum watershed area.

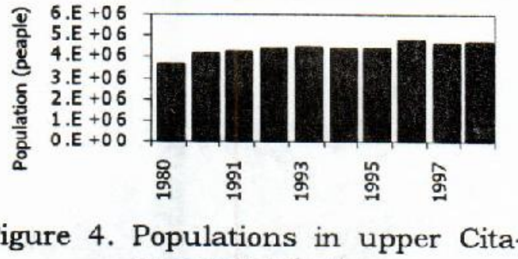

Figure 4. Populations in upper Citarum watershed area.

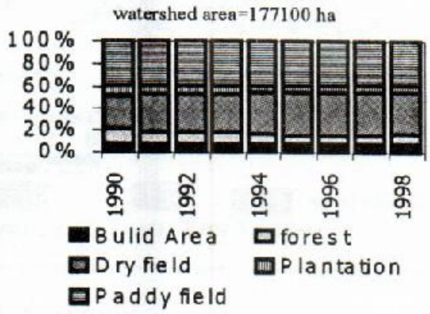

Figure 5. Compositions of Land use in upper Citarum watershed area.

As show in fig. 4, during period 1980 to 2000 population in watershed area of upper citarum river has been increasing gradually. Mean rate of that increase is 1.8% per year. Based on population density mapping (fig.6), those populations have tended to move to the north. The increasing population increased land use for buildup area (fig.5). Then finally, land use of forest area has been decreasing gradually (show in fig.5). In this case, the north location of watershed area of upper Citarum river was initially forest area, then converted to dry field area and finally converted to buildup area.

Through trial and error at sub-model of runoff hydrograph, time step of calculation (Δt) was obtained is 0.11day, and parameters of model are presented in table 2 and table 3. While, simulation runoff hydrograph result is show in fig. 7. Result of run-off-hydrograph simulation was tends to follow the observed data of the river of upper Citarum. Based on calculation using Least Squares (WLS) function, numerical measurement value of the difference between the model-simulated output and the observed data is 5.34.

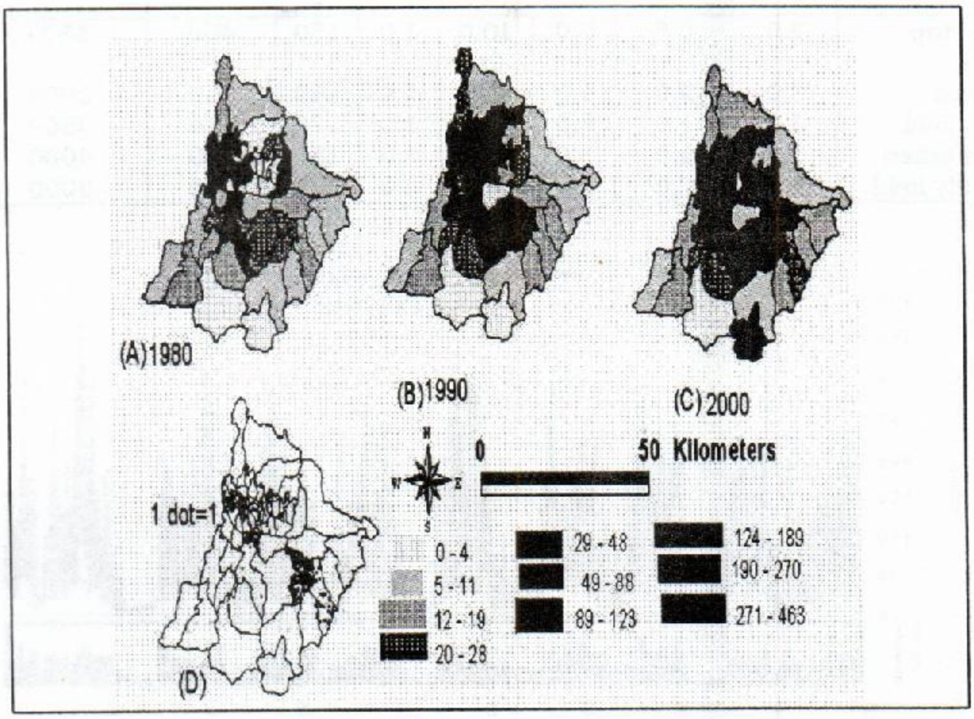

Fig.6. Population densities and textile factories distributions in upper Citarum watershed.

(a)Population density distribution in 1980 (b) population density distribution in 1990 (c) population density distribution in 2000 (d) distribution of textile factories

Table 2. Flow throughout parameters of each land use for runoff-hydrograph model.

Land use	a_1	a_2	a_3	a_4	a_5	a_6	a_7	a_8	a_9
Buildup area	0.85	0.90	0.10000	0.80	0.2000	0.75	0.20000	0.800	0.0000001
Forest	0.70	0.70	0.50000	0.70	0.3500	0.70	0.08600	0.870	0.0000001
Dry field	0.85	0.50	0.39000	0.85	0.2500	0.85	0.05500	0.870	0.0000001
Plantation	0.75	0.80	0.45000	0.80	0.3000	0.85	0.06500	0.800	0.0000001
Paddy field	0.60	0.21	0.00001	0.15	0.0001	0.01	0.00023	0.001	0.000000

Table 3. Height of storage parameters of each land use for runoff-hydrograph model.

Land use	b_1	b_2	b_3	B_4	b_5	H_{bmx}	H_{cmx}	H_{dmx}
Buildup area	2.0	0.5	6.0	10.0	1.0	150	400	3500
Forest	3.0	2.0	9.0	10.0	1.0	160	550	3000
Dry field	3.0	1.0	5.0	10.0	1.0	170	650	3500
Plantation	3.0	1.0	5.0	10.0	1.0	180	700	4000
Paddy field	4.0	2.0	2.0	20.0	2.0	100	800	3000

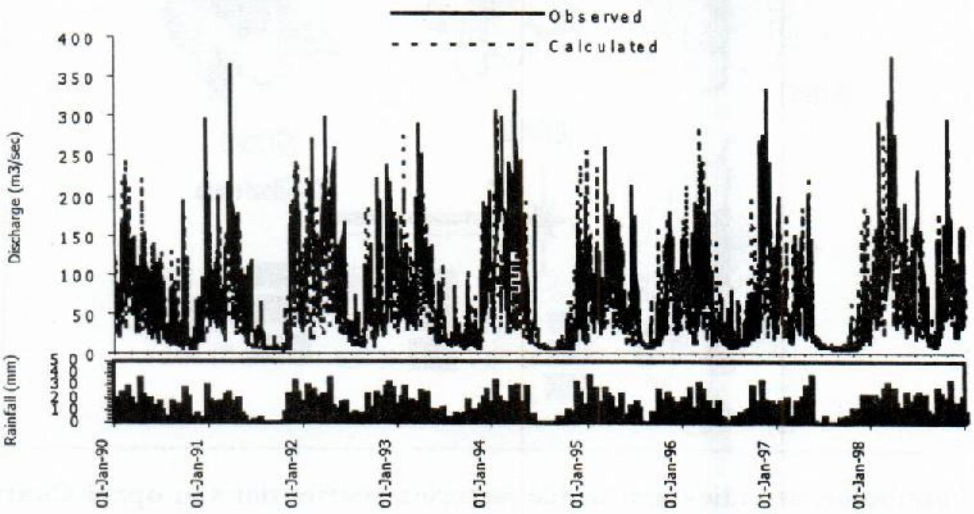

Figure 7. Rainfall, Runoff hydrograf observed and calculated.

Bases on fig. 7, the climate of watershed of upper Citarum river indicates typical tropical type that is divided into two seasons, rainy and dry seasons. In the rainy season, from November to April show 70% of annual precipitation. Precipitation event in rainy season, less than 40 mm was resulted flow discharge of more than 150 m^3/sec in Nanjung station. While flow discharge in dry season, resulted from base flow ad flow discharge of pollution point source (result of calculation is 5m^3/sec), can occur less than 10 m^3/sec. The high fluctuation of runoff hydrograph can be explained relates to fig.5. Forest and plantation, as recharge area in upper Citarum watershed, have percent lower than percent of other land use. Besides, the greater part of upper Citarum watershed have high land slope (showed in fig.2), then the greater part of rainfall will be came direct runoff.

Those phenomena can also be explained by modeling result of runoff hydrograph. The a_1 and a_2 ,as parameter of throughout direct runoff and quick flow respectively, have high value. In other sides, a_3 as parameter that presented value of throughout of infiltration its lower. Besides this, b_1 and b_2 as parameters holding direct runoff are also lower. Then in this condition, the greater part of rainfall will be came direct runoff.

The H_{bmx}, H_{cmx}, and H_{dmx} are parameters represented capacity of storage of water in tank b,c and d respectively (in soil). The a_4, a_6 and a_8 are parameters as presented throughout of underground flow. The a_5, a_7, a_9 are parameters as presented capacity of percolation. While, b_3, b_4 and b_5 are parameters as presented capacity to hold underground flow. Based on tables 2 and 3, the parameters of a_4, a_6 and a_8 have high value, and parameter b_3, b_4 and b_5 have low value. Whereas, the parameter a_5, a_7 and a_9 have value low, and the value of parameters H_{bmx}, H_{cmx}, and H_{dmx} are relatively low. This condition was presented part of the rainfall that infiltrated to underground will to be empty quickly to base flow. This fact is shown in fig.7, the high of base flow occurs in period of rain, and if period of rain ended, then base flow will decrease dramatically.

Management of water quantity for watershed generally is to decrease fluctuation of discharge hydrograph by increasing the quantity of infiltration water. Based on result of discharge hydrograph modeling, the values of throughout parameter of direct runoff for each land use are high, and values of parameters of indicate infiltration for each land use are low. Then for increasing probability of infiltration can conduct to increased parameters of b_1 and b_2 (as example, to augment of depression storage), so that the probability of water left in underground will be longer.

Result of calculation for inflow loads is shown in fig.8. Result of calibration for parameters of model runoff-pollutegraph can be seen in table 4 to table 7. While result of simulation for runoff-pollutograph can be seen in fig. 9. Result runoff-pollutegraph simulation was indicated to tend to follow the observed data of the river of upper Citarum. Base on calculations used Least Squares (WLS) function, numerical measurement value of the difference between the model-simulated output and the observed are 4.13 for BOD_5, 3.63 for COD, 0.23 for T-N, 0.15 for T-P, and 0.024 for NH_3.

From fig. 8a can be seen, contribution of BOD_5 inflow load from point sources and non-point sources. Industries and population as point sources, contributed to BOD_5 inflow load with decreasing tendency of 98% to 95% during 9 year. Buildup area as non-point source, contributed to BOD_5 inflow load with increasing tendency of 2% to 5% during 9 year. Based on this fact, BOD_5 inflow load from point sources are significant for consideration in this research. Where, population contributed to BOD_5 inflow load with increasing tendency of 48% to 65% during 9 year. Whereas, industries (especially textile industry) contributed to BOD_5 inflow load with decreasing tendency of 47% to 30% during 9 year.

Contributor tendency during 9 year of COD inflow load (fig.8b) are decreasing from 85% to 82% for point sources, and increasing from 15% to 18% for non-point sources. During 9 year of contribution COD inflow load from point sources is increase from 40% to 60% for population, and decrease from 45% to 32% for industries. Whereas, during 9 year of COD inflow load from non-point sources are constant at 12% for paddy field, constant at 1% for sum of plantation and dry field, and increase from 2% to 5% for buildup area. Based on these facts, inflow loads from point source was indicated the greater part of contributor of COD inflow load.

Fig. 8c is shows of inflow load of T-N during 9 years. The contributors inflow load of T-N from population was increased from 45% to 51%, industries ware decreased from 17% to 11%, paddy field was constant at 10%, plantation was constant at 5%, dry field was decreased from 21% to 20%, and buildup area was increased from 2% to 5%. Based on these facts, T-N inflow loads from non-point sources, especially paddy field and dry field, are contributors that must be considered beside contributor from point sources. To be deferent from these, contributors of T-P inflow load from non-point sources are not so significant compared with T-P inflow load from point sources (fig.8d). During 9 year of contribution of T-P inflow load were increased from 75% for population, decreased from 19% to 11% for industries, constant at 3% for paddy field, and increased from 1% to 3% for sum of buildup area and dry field.

Like other inflow loads cases, NH_3 inflow load from population is dominating significantly (fig. 8e). Based on those facts, for water quality improvement in upper Citaum River, inflow loads from industries (especially for textile industry) and populations must appoint mean of consideration.

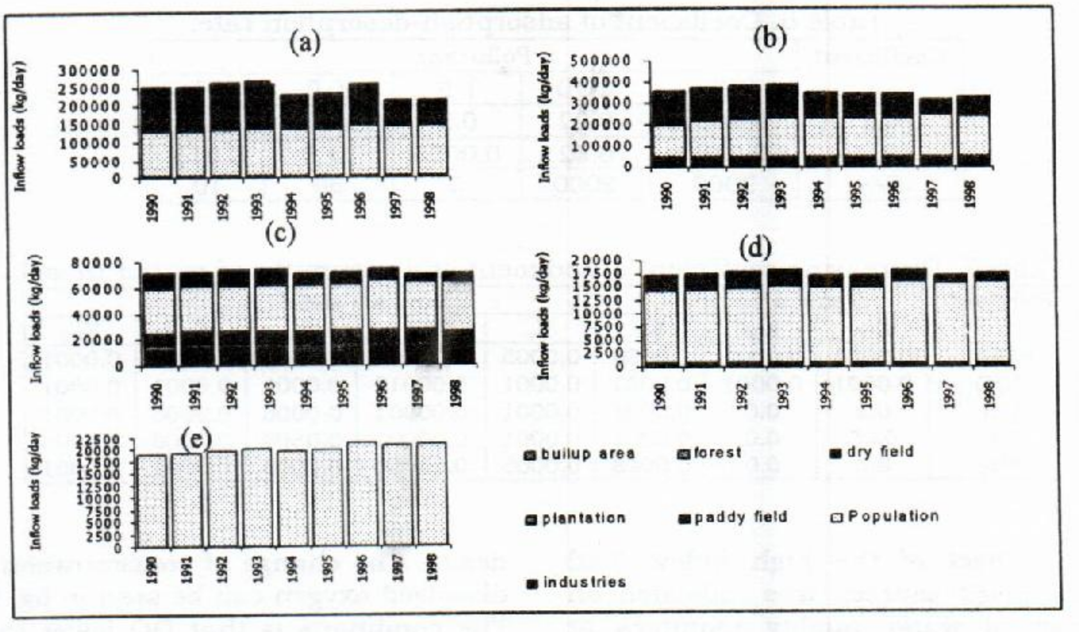

Figure 8. Inflow loads from upper Citarum watershed.
(a) inflow loads of BOD_5 ,(b) inflow loads of COD, (c) inflow loads of T-N,
(b) (d) inflow loads of T-P, (e) inflow loads of NH_3

Table 4. Coefficient of flow-out ratio and wash-out from sediment in buildup area.

Coefficient	Pollutant				
	BOD_5	COD	T-N	T-P	NH_3
k_1	0.15	0.16	0.18	0.01	0.10
k_2	0.40	0.48	0.10	0.01	0.35
K_{WP}	0.00002	0.00005	0.00005	0.00005	0.002

Table 5. Coefficient of wash-out from sediment (K_{WR}).

Pollutant	Land use				
	Buildup area	Forest	Dry field	Plantation	Paddy field
BOD_5	0.0009	-	-	-	-
COD	0.0015	0.0013	0.0030	0.0020	0.0011
T-N	0.0001	0.0001	0.0004	0.0004	0.0004
T-P	0.0001	0.0001	0.0004	0.0003	0.0002
NH_3	0.0008	-	-	-	-

Table 6. Coefficient of adsorption-desorption rate.

Coefficient	Pollutant				
	BOD_5	COD	T-N	T-P	NH_3
K_{a1}	0.3000	0.02	0.2	14.0	0.03
K_{a2}	0.0180	0.02	0.0005	11.0	0.018
S_{CO}	2000	2000	3	50	10

Table 7. Decreasing coefficient of sediment and accumulated matter in soil.

Pollutant	Tank a		Tank a,b and d					
	K_{DR}	K_{DP}	K_b	K_c	K_D	K_{DB}	K_{DC}	K_{DD}
BOD_5	0.0001	0.0001	0.0008	0.0005	0.00010	0.0000	0.0001	0.0001
COD	0.0001	0.0001	0.0001	0.0001	0.00010	0.0001	0.0001	0.0001
T-N	0.2	0.0	0.0001	0.0001	0.00001	0.0006	0.0005	0.0001
T-P	0.05	0.0	0.0001	0.0001	0.00001	0.0600	0.0005	0.0005
NH_3	0.0	0.0	0.0008	0.0005	0.00050	0.0000	0.0001	0.0001

Impact of the high inflow load from point sources was indicated on result of water quality monitors at Nanjung station (fig. 9). Concentrations of BOD_5, COD and NH_3 was exceeded the ambient water quality standard. Based on fitting between time of water quality sampling and daily flow discharge data at Nanjung station, pollution of BOD_5, COD and NH_3 was occurred at flow discharge equal or lower than $10m^3/sec$. From 57 time points of water quality sampling (fig.9), was occurred 9 times of BOD_5 pollution, 8 times of COD pollution and 23 times of NH_3 pollution. The other hand, probability of pollution occurrence 15.8% for BOD_5, 14% for COD and 40.4% for NH_3.

The concentration of BOD_5 and COD in water body of upper Citarum River, that exceeded ambient water quality standard was oxidized. So that, concentration of dissolved oxygen (DO) in water body of upper Citarum River was decreased lower than ambient water quality standard that desire. The change of concentration of dissolved oxygen can be seen in fig. 9f. The conditions is that DO lower then 2mg/l will be limiting growth and process of nitrification bacteria for oxidation of NH_3 to NO_2 and NO_3 (Grady, 1980). The situations that cause the probability of pollution of occurred for NH_3 higher than BOD_5 and COD. This process was successfully modeled by coefficients of flow-out ratio of NH_3 lower than BOD_5 and COD, and K_{WP} value of NH_3 higher than K_{WP} values of BOD_5 and COD (table. 4). Whereas, decreasing coefficient of NH_3 its 0 and 0.0001 for BOD_5 and COD. And if show coefficients model generally (table 4~7), the height of concentrations BOD_5, COD, and NH_3 not caused by contribution of base flow and runoff-rainfall, but caused by contribution of runoff in fine weather. These condition also in the T-N and T-P, though the inflow load T-N from non-point source significantly.

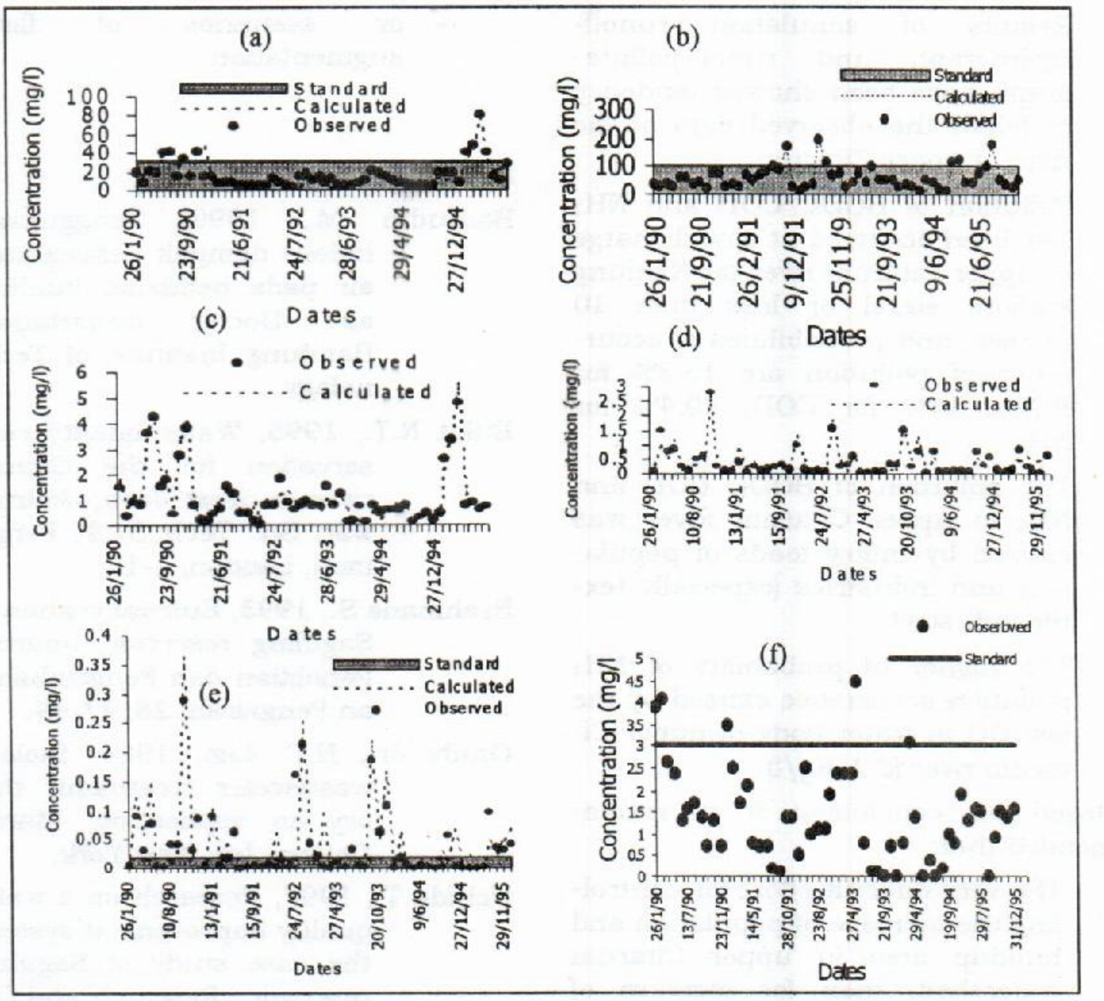

Figure 9. Results of modeling.

(a) Concentration of BOD_5 calculated and observed, (b) Concentration of COD calculated and observed, (c) concentration of T-N calculated and observed, (d) Concentration of T-P calculated and observed, (e) Concentration of NH_3 calculated and observed, (f) DO observed

4. CONCLUSION

The main results obtained in this research are as below,

- The increasing of population of upper Citarum watershed has been effecting conversion of recharge area to buildup area.
- The fluctuation of runoff hydrograph in order for water quality improvement in upper Citarum river its extreme, where higher flow discharge is more than 250 m^3/sec and lower is less than 10 m^3/sec.

- Results of simulation runoff-hydrograph and runoff-pollute-graph have been showed tendency to follow the observed data of the river of upper Citarum.
- Pollution of BOD_5, COD and NH_3 has been occurred at flow dicharge of upper Citarum river (at Nanjung station) equal or less than 10 m^3/sec, and probabilities of occurrence of pollution are 15.8% for BOD_5, 14% for COD, 40.4% for NH_3.
- The pollution of BOD_5, COD and NH_3 in upper Citarum River was caused by inflow loads of population and industries (especially textile industry).
- The higher of probability of NH_3 pollution occurrence caused by the low DO in water body of upper Citarum river (≤ 2 mg/l)

Based on conclusion it is recommended that:

- The very difficult effort for controlling the increase of population and buildup area in upper Citarum watershed, then for increase of base flow and decrease peak runoff hydrograph need to develop depression storage augmentation.
- The model that has been developed, can be used for approach of water quality improvement in upper Citarum river caused inflow loads of carbonaceous organic and nitrogenous, e.i with
  - scenarios of waste load allocation (AWL) for point sources,
  - or scenarios of flow-augmentation.

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