

Quality of Non-Point Source Pollutant Identification using Digital Image and Remote Sensing Image

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Abstract—The integration between technology of remote sensing, information from the data of digital image, and modeling technology for the simulation of water quality will provide easiness during the observation on the quality of water changes on the river surface. For example, Ciliwung River which is contaminated with non-point source pollutant from household wastes, particularly on its downstream. This fact informed that the quality of water in this river is getting worse. The land use for settlements and housing ranges between 62.84% - 81.26% on the downstream of Ciliwung River, give a significant picture in seeing factors that affected the water quality of Ciliwung River.

Keywords—Digital Image, Digitize, Landuse, Non-Point Source Pollutant, Qual2e Simulation

I. INTRODUCTION

THE potency of Ciliwung River is very big and strategic. But its current quality is likely continuing to decline every year. The declining quality of Ciliwung River is caused by the increasing load of pollutant in the river. It also caused by the smaller the flow rate in dry season while in rainy season flooding often occurs [1].

Evaluation of the load carried toward the monitoring results of Ciliwung River using capacity calculating approach, based on its standard quality and in accordance with the allotment of river, that is for the allotment of raw drinking water, with the quality standard of BOD are 10mg/L and the load of river water.

The rivers accept load of pollutant that come from various sources. Big part of the pollutant load is exceeded the permitted threshold so that the entry o pollutant sources cause the declining quality of Ciliwung River. In general, the pollutant sources are classified into three groups; instantional pollutant source, non-instantional pollutant source, and pollutant source from outside Jakarta [1].

a. Instantional Pollutant Source

Instantional pollutant source is the source of different types of activities, either in big scale or in a small scale which is clearly in charge such as, industries, marketing, buildings/offices, hospitals, and so on.

b. Non Instantional Pollutant Source

Another factor which dominates the contribution of pollutant debit in the river, especially Ciliwung River is the wastes from non instantional pollutant source. These wastes derived from household activities or other

activities which clearly not responsible for the waste management (non-point source/NPS) such as, domestic waste (household waste) and agricultural waste, and garbage thrown into the river as well as erosion.

As the description of waste load potential from non instantional pollutant source are as follow [1]:

- Waste debit potential of resident in the area of Ciliwung counted based on the number of organic (BOD/Biological Oxygen Demand) per person is 17.4 grams. The total number of resident in 63villages including Ciliwung is $\pm 1.653.392$ people, then the waste debit potential reaches 28.769.02 kg of BOD per ton in every day.
- The amount of garbage potential calculated based on the assumption that one person produces garbage of 2.5 liter/person/day, the Ciliwung will produce garbage amounted to 620.02 m³ per day. Based on the data, it is shown that waste which is transported by Sanitation Department reaches 85% and based on the data, everyday in Ciliwung will accumulate amount 93.3 m³ wastes which are discharged into the environment, part of them into the river every day. These are not including wastes from the upstream of congenital outside Jakarta.

c. Source Pollutant in the Upstream Outside Jakarta

Ciliwung River flows in some areas of Bogor (the city of Bogor/Bogor District), Depok, and comes to Jakarta which is along the flow has got the load from the residents activities such as, domestic wastes, garbage, agricultural activities, and so on. The philosophy that river as a large basket of landfills is still going on in the riverside communities so that the potential of contamination from the upper outside Jakarta is still potentially visible.

II. THE ANALYSIS OF POLLUTANT ENTERING THE RIVER FROM NON-POINT SOURCE POLLUTANT (NPS)

In accordance with the purpose of the research that is to obtain quantitative description of pollutant entering the river from NPS pollutant source and to predict the possibilities of pollution occur in one point that the data has not yet obtained using spatial analysis of Geographic Information System.

The river can naturally able to rid them from the pollutants that enter the river [1]. However, as other natural resources, the carrying capacity of pollutant is limited. Because of that if the load of pollutant in the river is exceeded the carrying capacity, then water pollution will occur. With the growth of population, industries, agriculture intensification, then the pollution load in Ciliwung flows has increased significantly.

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This prediction is made by taking three parameters assumed as factors that have roles in the occurrence of pollution. These parameters are the number of population, industries, and agriculture.

The following are the sources of pollutant that are potentially affected the decreasing water quality of Ciliwung River.

A. Sources of Household wastes

Limitation of household waste is considered to be polluting the river is the wastewater from washing, toilet, and fasses (MCK).

In addition to household waste that flows from people's houses through the channels, people living in Ciliwung river has a commensurate share of pollution. The way people live in the river usually commensurate offhand dispose of household garbage, water containing foam, and defecating along the rivers. They still do not realize that their lives are like that have a major influence on river pollution. In addition to the lack of awareness of protecting the environment, there are psychological factors that still need to be addressed. Although the government has built several public toilet facilities sufficient, but residents prefer to do the activity, MCK, along the river.

B. Source of Industry Wastes

Industrial waste water pollution is a factor that is more unique Ciliwung River. Its uniqueness is caused by the diversity of processes and products. Because the major factors affecting river water quality parameters of BOD (Biological Oxygen Demand), DO (Dissolved Oxygen), and COD (Chemical Oxygen Demand, hence in this study, only four main parameters of this alone is processed.

Effluent or waste discarded by most of the industries located in the region Ciliwung River, the pollution load will not operate if each industrial waste water treatment plant or WWTP (Wastewater Treatment Plant) with promptly and effectively. The government has been requiring for each potentially polluting industries shall build and operate the WWTP. But the reality proves that not all comply with industry regulations.

C. Sources of Agricultural Wastes

Pollutants generated from the agricultural activities are mainly come from fertilizing and the use of pesticide. Wastes from fertilizer can be measured by the compounds of nitrogen and phosphorus, while for pesticide, the identification of elements that give the pollutant parameter of the use of pesticide have not yet been found [2].

The land use for agricultural which is useful for estimating the debit of pollutant are as follows [2]:

- i. Wetland: the suitable land for rice cultivating is the irrigated land, which is divided into a small individual rice field area.
- ii. Rain fed lowland: the cultivated land for secondary plants such as, cassava, soya beans, and peanuts. Irrigation is done by using the rainwater. But if there is

no rainwater, these lands are flowed with irrigation water.

- iii. Wetland Mixed: The cultivated lands for unspecific plants. These lands are planted with many kinds of vegetables and other food crops simultaneously or in stages.
- iv. Plantation: The area that are planted with plantation crops such as, coffee, tea and chocolate, which are generally located in mountain areas.
- v. Forests: Including wildwoods or artificial forests for timber production (teak, pine)

The agricultural activities in the watershed of Ciliwung consist of wetland only once a year (rain fed lowland), wetland two times a year (wetland), plantation, moor, and forest.

III. SIMULATION ANALYSIS

In the previous section, it has been explained that simulation is performed to obtain quantity data of non-point source pollutant in the estuary area of sub-watershed.

By using the measurement data available and using the facilities available in Qual2e software, we will obtain these quantity data of pollutant.

However, the measurement data that will be used as waste parameter in this research will be adjusted with the major parameter that strongly affected the water quality in a river. They are BOD (Biological Oxygen Demand), DO (Dissolved Oxygen), COD (Chemical Oxygen Demand), and NH4 (Ammonia).

The data need for the simulations are as follow: (Data of measurement result obtained from Geotek LIPI Sangkuriang Bandung, 2002-2003).

- a. Simulation Type : dynamic.
- b. Units : standard metric units.
- c. Number of Reach : 15
- d. Watershed System

From Table 1, it can be seen that the number of reach that can be used in this research is 15, where the upstream and the outlet of each reach is the water quality measurement location. The total length of the river is 124 km with only one headwater. The length of reach element is made short enough, which is 1 km with the purpose is to multiply the location of simulation.

TABLE I
WATERSHED SYSTEMS

REACH NO.	REACH NAME	BEGIN RIVER (km)	END RIVER (km)	HEADWATER
1	CLW-1	124	121	√
2	CLW-2	121	119	
3	CLW-3	119	116	
4	CLW-4	116	112	
5	CLW-7	112	102	
6	CLW-8	102	84	
7	CLW-10	84	64	
8	CLW-12	64	60	
9	CLW-14	60	49	
10	DKJ-1	49	32	
11	DKJ-2	32	26	
12	DKJ-2A	26	15	
13	DKJ-3	15	8	
14	DKJ-29	8	1	
15	DKJ-30	1	0	

- i. The parameter of water quality simulated are:
 - a. BOD (Biochemical Oxygen Demand)
 - b. DO (Dissolved Oxygen)
 - c. COD (Chemical Oxygen Demand)
 - d. NH₄ (Ammonia), and
- ii. Temperature
- iii. Oxygen Measurement Data (Table 2)
- iv. Initial Condition of River Water Quality

In simulation using dynamic type, this data is the initial condition of water quality (when $t=0$) in the downstream (outlet) of each reach. Then, the Qual2e software will perform spatial simulation (when $t=0$) to obtain water quality in other locations along the river based on the data. After that, Qual2e software will perform temporal simulation to obtain water quality for the next time (which is when $t>0$).

In this research, the initial condition of water quality is filled with measurement data of several locations. The water qualities of the other locations are obtained by performing spatial simulation of dynamic type. In Table 2 will be seen the data pollutant of each reach.

TABLE II
NUMBER OF POLLUTANT CONCENTRATION IN THE ESTUARY OF EACH SUB-WATERSHED

No	SubDas _Id	Length (km)	BOD (mg/L)	DO (mg/L)	COD (mg/L)	NH ₄ (mg/L)
1.	P1	113	1.47	5.98	18.76	0.659
2.	P2	111	1.29	5.93	19.19	0.656
3.	P3	109	1.50	6.20	18.54	0.656
4.	P4	107	1.71	6.47	17.89	0.656
5.	P5	106	1.81	6.61	17.56	0.656
6.	P6	102	2.23	7.15	16.26	0.656
7.	P7	81	3.97	5.99	33.19	0.303
8.	P8	74	2.34	3.52	19.52	0.178
9.	P9	54	9.82	5.51	31.59	0.358
10.	P10	16	18.68	0.69	36.03	1.778

(Source :Measured Data from LIPI Bandung)

- P1-P10 : Point of each element of river
 Length : Length of the measured point from the start point of river
 BOD : Biological Oxygen Demand
 DO : Dissolved Oxygen
 COD : Chemical Oxygen Demand
 NH₄ : Ammoniac

After processing the data, then we will get simulation graph depicting the relationship between pollutant concentrations for every parameter along the watershed simulation.

Figure 1 shows the concentration level of pollutant parameter of COD, NH₄, DO, and BOD, along the river simulation. Thus, based on the graph, we can determine the concentration of pollutant in the estuary of each sub-watershed for the same parameters.

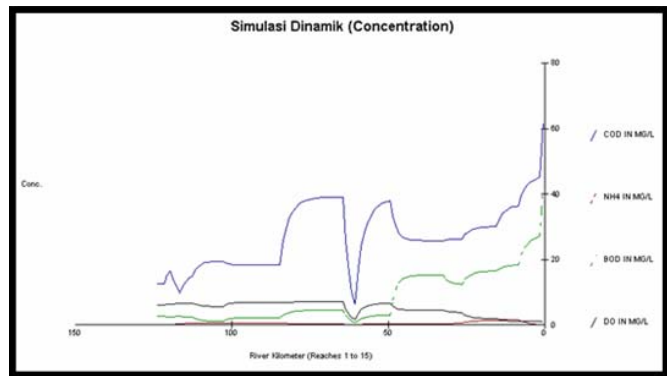


Fig. 1 The result of Pollutant Parameter Simulation along the River Simulation

IV. ANALYSIS OF THE EFFECT OF LAND USE ON THE CONCENTRATION OF POLLUTANT



Fig. 2 Landsat TM 541 Geometric Correction Results

In this research, remote sensing image used was landsat TM satellite image with RoI (Region of Interest) was Ciliwung River downstream. The classification process of landsat TM satellite image was by using maximum likelihood guidance method, in accordance with the diagram below:

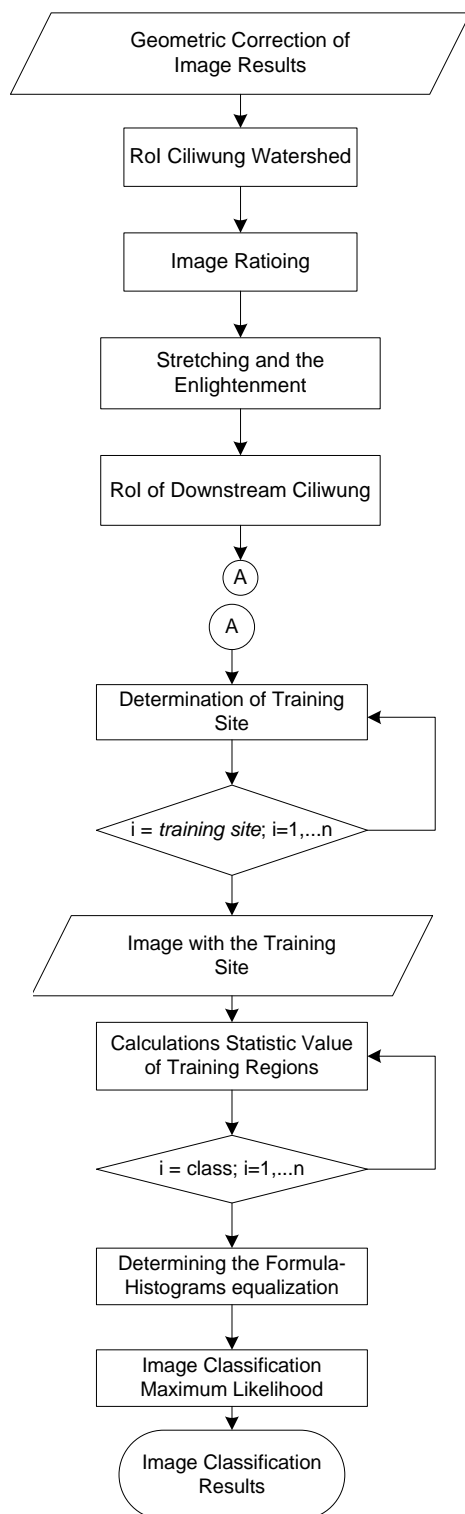


Diagram 1 Classification of Landsat TM Process

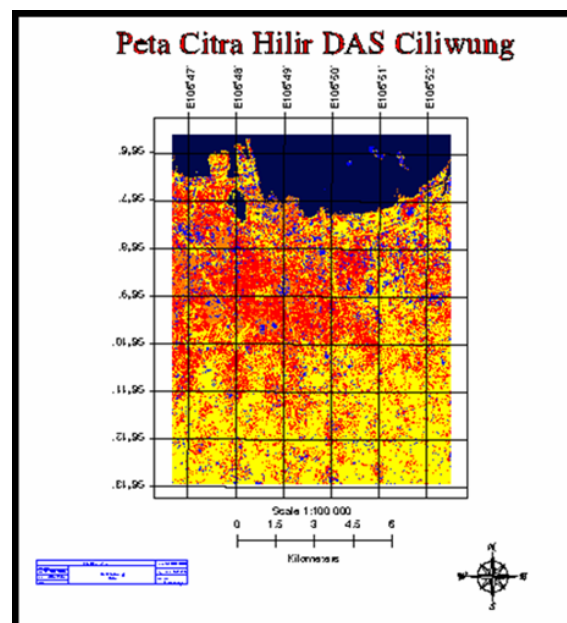


Fig. 3 Image of Landsat TM of Downstream of Ciliwung Watershed Section Classification Results

Where the classification is:

Class	Name	Color
	All	black
1	Greatwaters	0,8,77
2	Emplasmen	yellow
3	Tanahkosong	blue
4	Pemukiman	red
5	Industri	255,128,0

In this research, the effect of land use for each sub-watershed will be analyzed, which in general, is a source of pollutant that potentially affecting the decreasing quality of water in Ciliwung River. The pollutant source is differentiated into three, pollutant source from population wastes, industrial wastes, and agricultural wastes.

The agricultural parameter of each sub-watershed consists of:

- 1 : Moor, mixed garden, rice field with two times of crops in a year, and rice field with once crop in a year.
- 2 : Mixed garden, plantation, rice field with once crop in a year, and moor.
- 3 : Mixed garden, plantation, rice field with two times of crops in a year, rice field with once crop in a year, and moor.
- 4 : Rice field with two times of crops in a year, rice field with once crop in a year, plantation, and mixed garden.
- 5 : Rice field with two times of crops in a year and plantation.

- 6 : field with two times of crops in a year, mixed garden, plantation, and moor.
- 7 : Moor, mixed garden, and rice field with two times of crops in a year.
- 8 : Mixed garden, moor, rice field with two times of crops in a year, and artificial forest.
- 9 : Rice field with once crop in a year, rice field with two times of crops in a year, moor, and mixed garden.
- 10 : Mixed garden.

While for population parameters are:

- 1-6: Settlement.
- 7-9: Housing and Settlement.
- 10-12: Settlement.

From the description above, it can be seen that for sub-watershed located in the upstream of Ciliwung watershed, the parameter of land use that dominantly affecting the pollutant is the agriculture which is ranges from 44.72%-95.13%, contrasted with the population parameter that ranges from 0.04%-8.26%. While the industrial parameter that dominantly affecting the pollutant is 0%. It can be understood because the land in the upstream of Ciliwung watershed is still dominantly used for agricultural and population. Then, entering the body section and the downstream of Ciliwung watershed, the number of population is increasing, while the land use for agriculture is decreasing caused by the diversion of land use from agricultural use to population and industrial use.

V. ANALYSIS OF POLLUTANT LOAD

A. Analysis of Household Wastes

As mentioned in the previous chapter that the pollutant load caused by household is influenced by the number of population that are in the watershed area. Then, the analysis is conducted by assuming that all population (100%) are in the area/ population parameter. The table below shows the number of population in each sub-watershed.

The potency of wastes load from household activities are as follows:

- a) Potency of household wastes load in the area of Ciliwung watershed calculated based on the number of organic per person per day is 17.4 grams [1]. So, the potency of BOD wastes load per ton can be seen in the table below.
- b) Potency of number of trash calculated based on the assumption that every person produces trash of 2.5 liter/person/day [1], then in Ciliwung watershed of 6.009.84 m³ trash generated per day. Based on the data from environmental impact control agency of Jakarta Province (Bappedalda DKI) shows that the trash which is transported by the Sanitation Department reach 85% and based on the data, then everyday in Ciliwung watershed will accumulate a number of 901.48 m³ trash that are discharge into the environment, including the river, everyday.

By ignoring the assumption of the great potential of each resident in producing BOD pollutant, we can calculate the load of BOD wastes in year 2003 for each point of calculation simulation result that is by calculating the growth rate and BOD measurement data available.

B. Analysis of Industrial Waste

Since the industrial waste theoretically is categorized as point source pollutant source, thus in this research the analysis of load waste caused by industrial parameter will not be done.

C. Analysis of Agricultural Waste

Because there is no definitive data of types of fertilizer used, either the data released by the government of DKI Jakarta, the government of Bogor Regency, or the data released by Bogor Municipality, then the determining toward the type of pollutant occur cannot be done. So, in this research, the analysis of agricultural wastes will not be conducted.

VI. RIVERSIDE ANALYSIS

As described in the previous chapter that the function of riverside is to protect the water quality of the river from pollutant that caused by the inappropriate use of land, both on left side and right side of the watershed.

In this research, using digital imaging maps, the size of riverside is adjusted with the order of the river, because the large amount of the river affecting the river potential in the environmental damage on either side. The amount of the riverside are:

Orde 1	=	100m	;	Orde 5	=	6-6.5m
Orde 2	=	50m	;	Orde 6	=	3-3.5m
Orde 3	=	25m	;	Orde 7	=	2m
Orde 4	=	12,5m	;	Orde 8	=	1-2m

In figure 4, it can be seen the relationship between riverside area (long polygon/ yellow river) with RUTR (Spatial General Plan) for the upstream area and the body of Ciliwung watershed, where the use of land along the riverside area is the sources of household load.

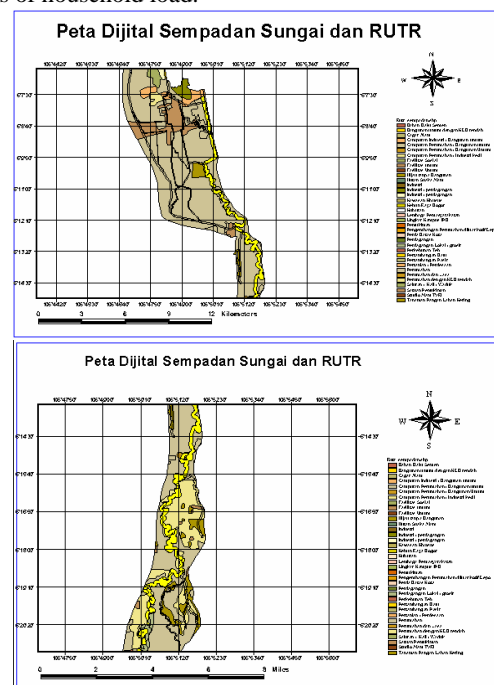


Fig. 4 Digital Map of Riverside and Spatial General Plan

While for the upstream along the riverside area, the use of area for household is not too dominant. The use of area in the upstream of Ciliwung watershed is dominated by agricultural activities (Fig. 5).

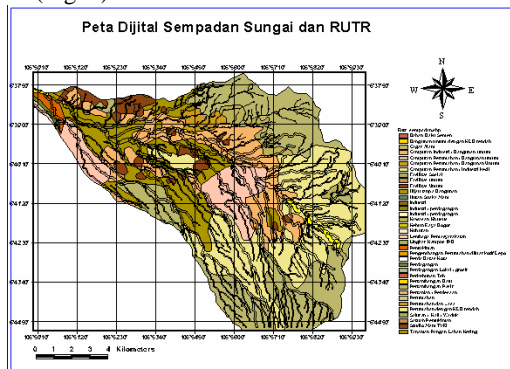


Fig. 5 Digital Map of Riverside and Spatial General Plan in the Upstream

VII. CONCLUSIONS

- 1) Generally, processing digital image and image classification conducted in this research showed relatively good results. However, in the classification process conducted, the overlapping process between digital map and image map while defining training site have not been done yet, so that which technique resulted the better image classification. For further research, other classification techniques need to be done so that the results can be compared with the result from the techniques that have been done.
- 2) If we compare digital map of land use in the upstream of Ciliwung watershed issued by National Agency of Surveys and Mapping Coordination (Bakosurtanal) and Geo-technological of Indonesian Institute of Science (LIPI) Sangkuriang, Bandung (fig. 4), with TM landsat image 30 meters of resolution, taken in 1997 using RoI (Region of Interest) in the upstream of Ciliwung watershed classification results (fig. 3), there is a difference referring.

The difference can be understood with several reasons:

- a. Digital map obtained from filed review results and the data obtained from the qualified authorities (local government of DKI Jakarta, Bogor Regency, and the city of Bogor), while image capturing concrete information on the earth surface. So, the information for classification has its own patterns.
- b. As the example for settlement classification, the information detected by the satellite is the appearance from above. We will also get this information from industrial classification so that image classification for industrial cannot be obtained because it is considered as settlement classification. In contrast with information from digital map because the information depicted by the institutions are in the form of area, so that the classifications of land use shown.

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