

Hydrogeometry And Water Quality Data Analysis For One Dimension Water Quality Modelling Of Lesti River At Malang Regency

by Evy Hendriarianti

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Evy Hendriarianti

Departement of Environmental Engineering , National Institute of Technology, Malang

ABSTRACT

Decreasing of river water quality is one of the main environmental issues for Brantas River. Lesti River is one of the upstream section of Brantas River located on south east side of Malang Regency. Population growth with its attendant economic growth in this region affected environmental quality with the pollution from industrial, agricultural and domestic sources. Water resource managers must increasingly use analytical tools to assist in the formulation of sustainable water management strategies. To get an cohesively water quality management from upstream until downstream, mathematical water quality modelling are needed. Water quality modelling need some data collection such as river hydrogeometry, river water quality and point source of polutant along the river. All collected datas were used to arrange objective model through analysing and scouping data process. Main objective of this research was carried out to know trend of historical of water quality besides hydrogeometry data. These primary and secondary data then analyze. A methode of collecting secondary data is surveyed by a related institution. A Tachimetry methode was used for determining a primary section of a river banks, buoyant plume methode for the river velocity measurement. Standar Methode of 1060 was used for water quality sampling. Those data, then analyze using discriptive statistical and linear regression. For the administration borders, Lesti river area covers Subdistricts of Sumbermanjing Wetan and Turen for the upstream, Subdist of Gedangan and Bantur for the middle and Subdistrict of Pagak for the downstream. Average flow for annual in ten years last range between 11,72 – 77,10 m³/sec with the average is 35,47 m³/sec. A decrease of a water quality occurs interms of physical parameters (TSS) and also that of other chemical parameters, such as DO, BOD, COD, Nitrate and Detergent. From this results, was decided to make those water quality models for Lesti River.

Keywords : water quality, hydrogeometry, Lesti River, scouping for mathematical water quality modelling

INTRODUCTION

The problem of river water quality need an instrument to decide what action will takes. One of the instrument that can predict or simulate water quality changes are called water quality models. Because variability of physical and biochemical phenomena that can be affected water quality condition, it is important to define the objectives of the modeling process. This should involve discussions with stakeholders, regulating agencies, and technical personnel [1].

Brantas river is second biggest river area in Java Island. The area covers 15 (fifteen) regencies and municipalities in East Java Provinsi (Figure 1.) and Lesti river is upstream section of Brantas river.



Figure 1. Map of Brantas River Area
(Source : Bureau of Brantas Rivers District, 2002)

Most of the existing water quality models for Brantas river are in downstream and middle section. With the river management policy called *one river one management* [2], it is important to make water quality model for upstream section. So, water quality management will be more cohesively for all area of Brantas river.

To build one dimension water quality models, detailed site-specific water quality monitoring data is required. Preliminary study must be done for input data preparations such as hidrogeometry of river, water quality of river and pollutant or point source and the location of point sources. Results of those data analysis, give water quality scouping to formulate model objective.

MATERIALS AND METHODS

Water quality modelling is a predictive tool for water quality changes that are effected by changes in the surrounding environment. During the modeling process, modelers and personnel that responsible for the data collection must cooperate and work together with mutual understanding. Water quality model need site specific data to calibrate and verify model prediction [3,4]. Based on this , the flow diagram of activity of this research is arranged and represented on Figure 2 below.

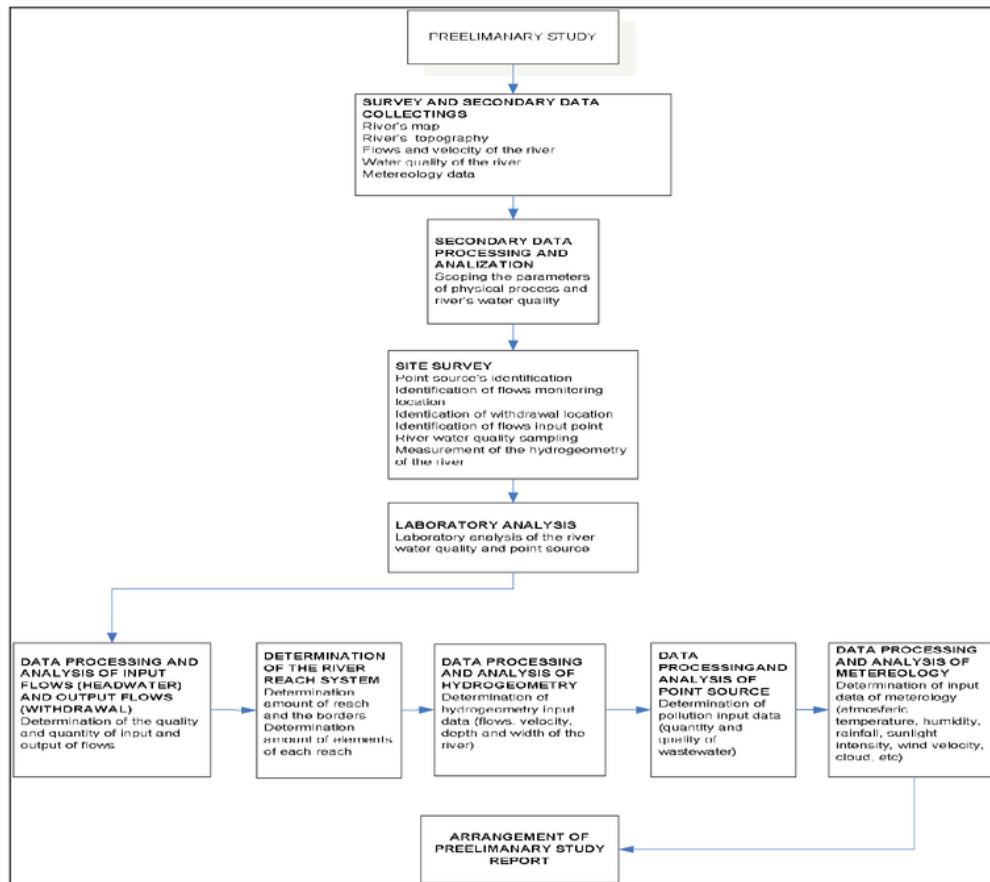


Figure 2. Research Activity Flowchart

Based on Figure 1 above, the activity includes :

1. Site Survey and secondary data collection.

Thus activity aims to get secondary data, such as :

- a. Map of Lesti river and the topography from National Mapping and Surveying Agency at Departement of Geodesy at Malang National Institute of Technology, Water Service General Corporation I, Irrigation Official at Malang Regency.
- b. Hydrogeometri data of river such as flow, velocity, cross-sectional area, depth for the last ten years from Water Service General Corporation I
- c. Water quality data for the last ten years from Water Service General Corporation I.

- d. Metereology datas for the last ten years from Geophysic and Metereology Agency at Karangates.
2. Secondary data processing and Analyzation.
This activity aims to get the discription of physically condition and water quality of the river that urgent to be modelled. Analysis data with discriptive and inferentive analysis result water quality parameter options that being modelled. The result of statistical analyze have been disscused with the related officer of Water Service General Corporation I.
3. Site survey and primary data collecting. This survey aims to :
 - a. Get the discription of the river condition and all related parameters such as upstream location, point-source and withdrawal.
 - b. Determination of sampling point for hydrogeometry and water quality of the river.
 - c. Identification the location of the existing water quality and quantity monitoring by Water Service General Corporation I.
 - d. Measurement of the river's hydrogeometry
 - e. Water quality sampling
The locations of sampling are selected by scoping process of secondary data. Sampling activity includes:
 - Water quality of the rivers and flows
 - Water quality of the point-source and flows
4. Laboratory analyze
This activity have been done at water quality laboratory of Water Service General Corporation I.
5. Data processing and Analyzation
Statistic descriptive analysis is used to get the value of input data in modelling. The input data includes :
 - Hydrogeometry of the rives, input of flows and withdrawals.
 - Water quality of the river
 - Water quality and quantity of the point source
 - Metereology data
 - Reach system of the rivers
6. Arrangement of the Preeliminary study report
This report contain the result of study includes : primary and scndary data analysis, documentation and conclusion for formulation of the modelling object.

RESULTS AND DISCUSSION

General Discription of Lesti River

From Irrigation Official, 2006, Lesti river belonging to Brantas River Flows Area located at Malang Regency. Lesti river is 2nd orde river with 49 km of length and 225,16 Km² of cathment area. Whereas from Bureau of Brantas Rivers District, Lesti river belonging to upstream of Brantas River Flows Area (sub DAS Brantas hulu) includes of three basin block, are Upper Lesti, Genteng and Lower Lesti-Jaruman with totally catchment area as 635 Km². From site survey along Lesti River from Tawangrejeni Bridge until Sengguruh Dam, the point sources comes from branch as sewerage and drainage from domestic facilities. Each branches becomes sampling points to get hydrogeometry data and primary water quality data. The map of Lesti river with the location of sampling is shown on Figure 3 below.

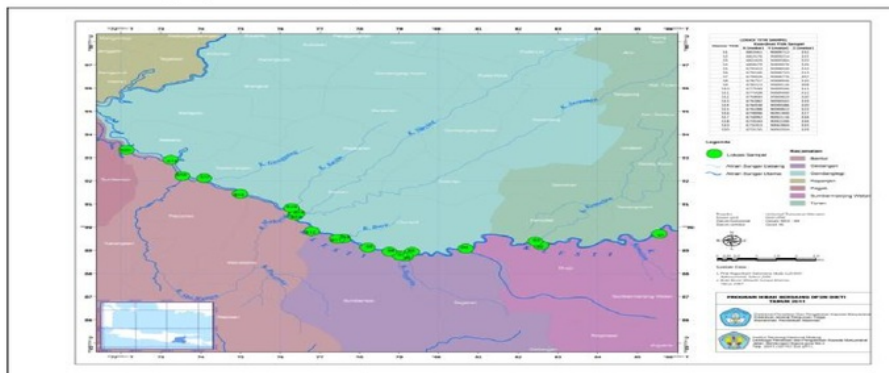


Figure 3. Map of Lesti River and Water Quality Sampling Location

(Source : Topography Map of Indonesia , at Scale 1 : 25.000, National Mapping and Surveying Agency 2006 and Bureau of Brantas Rivers District 2002)

In administration borders, area of Lesti river includes some subdistricts of Malang Regency. There are Sumbermanjing Wetan and Turen at upstream, Gedangan and Bantur at middle and Pagak at downstream. According to the demography data of the area of Lesti Rivers, Subdistrict of Turen have highest of rate of population growth (4,69 %), whereas subdistrict of Pagak is lowest (1,99%). Based on river area management, subdistrict of Turen as a upstream area is main priority for the river conservation efforts. High growth of population have a risk to land conversion. Based on Environmental Status Report of Malang Regency (2010), biggest land use are dry land for dwelling and their facilities (28.318 Ha/42 %) as shown in Fig 4. below.

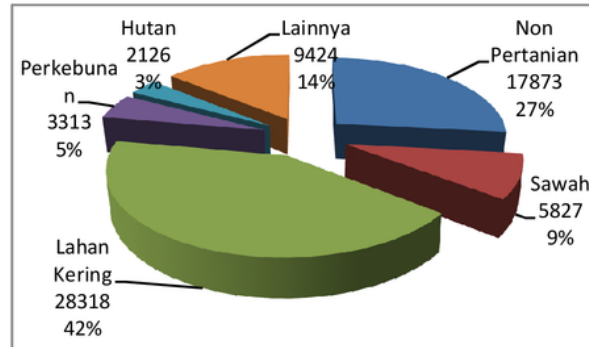


Figure 4. Land Use of Lesti River Area

From this land use discription of Lesti river area, it can be concluded the main point source is from domestic waste. No industries along Lesti River Flows Area. From site survey from Tawangrejeni Bridge until Sengguruh Dam, the point sources comes from branch as sewerage and drainage from domestic facilities. It must be concerned about this point source because there are some household in subdistrict of Lesti river still have no septic tank. Based on Environmental Status Report of Malang Regency (2010), amount of household without septic tank, as shown on Fig. 5 below.

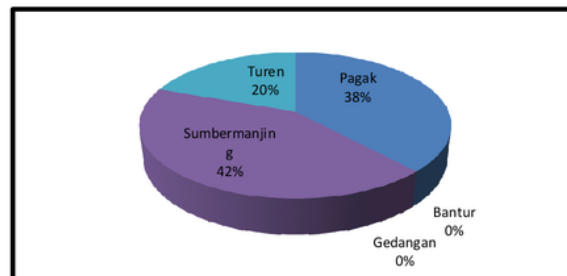


Figure 5. Amount of households without septic tank

From Fig. 5 above, for 5 (five) subdistrict in Lesti river area, households in 3 (three) subdistrict still with no septic tank. Domestic waste disposal directly to water or land without treatment in septic tank cause groundwater and surface water pollution with the high of organic compound of domestic waste.

Hidrogeometry Data

In water quality modelling, transport phenomena have to be modelled first. Most pollutant aquatic are chemical compounds that undergo chemical reaction. Rate of chemical reaction determine fate's chemical then will affect water quality. Three process of mass transport in aquatic environment are advection, dispersion and sedimen transport. Dissolved substances are transported by water movement with entrained in the current and move at the water velocity. Likewise, chemicals that are sorbed to colloidal material or fine suspended solids are essentially entrained in the current, but they may undergo additional transport processes such as sedimentation, deposition or scour and resuspension [4]. So, for transport processes modelling, hidrogeometry data of the river are needed. For temporal characteristic, one dimension model must be steady state. A steady state model can be used to asses the effect of effluent discharge by predicting water quality for the peak, average and minimum flows [5]. Results of secondary data processing of the flows of Lesti River can be seen on this Figure 6. below.

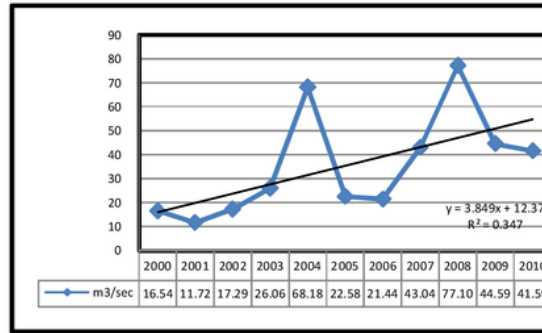


Figure 6. Annual Average Flows of Lesti River (Upstream-Tawangrejeni)

For 2000-2010 years periods there is a linear increase trend of the annual average flows at upstream with R^2 value as 0,347. Annual average flows is 77,10 m³/sec for 2008. Range of annual average flows for the last ten years as 11,72 – 77,10 m³/sec with the average value as 35,47 m³/sec.

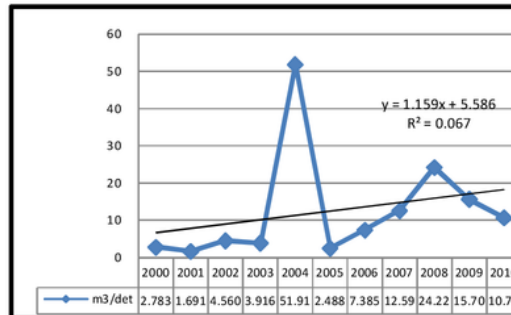


Figure 7. Annual Minimal Flows of Lesti River (Upstream-Tawangrejeni)

For 2000-2010 years periods there is a linear increase trend of the annual minimal flows at upstream with R^2 value as 0,067. Annual minimal flows is 51,9 m³/sec for 2004. Range of annual minimal flows for the last ten years as 2,48 – 51,9 m³/sec with the average value as 12,5 m³/sec.

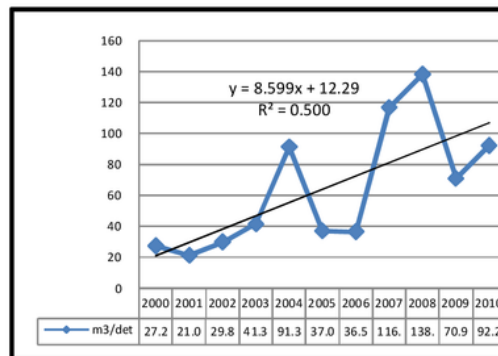


Figure 8. Annual Maximal Flows of Lesti River (Upstream-Tawangrejeni)

For 2000-2010 years periods there is a linear increase trend of the annual maximal flows at upstream with R^2 value as 0,500. Annual maximal flows is 138,3 m³/sec for 2008. Range of annual maximal flows for the last ten years as 21,09 – 138,3 m³/sec with the average value as 63,89 m³/sec.

From the value of R^2 of three kind of annual flows data above, there is increase trend of flows of Lesti river specially for annual maximal flows with highest probability of R^2 (0,500).

The results of cross section of river measurement with Total Station Equipment show variation of width and depth of the river. Figure 9. below, show result of cross section measurement at sampling point one (S1).

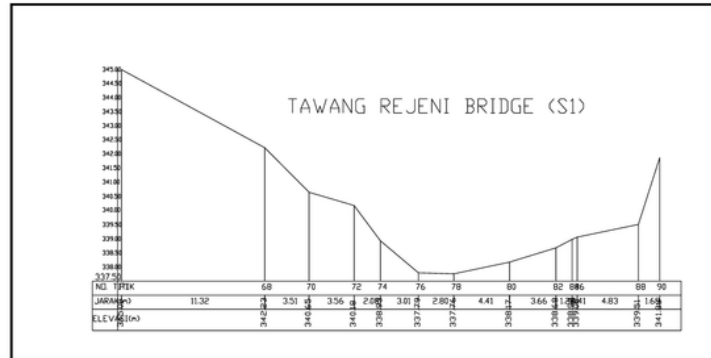


Figure 9. Cross section profile of the river at Sampling Point S1

Next, the result of river velocity measurement show variation value, range between 14.92 – 122.45 m/sec. One of the results of velocity of Lesti’s riverflows measurement manually can be seen at this table below.

Table 1.
Velocity of riverflows at sampling point S1

| Nr. | Point | Length (m) | Time (sec) | Velocity (m/sec) | Average velocity (m/sec) |
|-----|-------|------------|------------|------------------|--------------------------|
| 1 | S1 | 50 | 0.53 | 94.34 | 62.44 |
| | | | 1.01 | 49.50 | |
| | | | 1.15 | 43.48 | |

Secondary Data of Water Quality

Secondary data of water quality from PJT I for 2000 – 2010 years at Wonokerto bridges’s sampling point (middle area of Lesti river, same location with S14 of the sampling point in Figure 3) includes physical parameters (temperature, turbidity, and TSS), chemical parameters (pH, DO, BOD, COD, Nithrate, Nithrite, NH₃, P_{total}, deterjen) and biological parameter (Total Coli and Fecal Coli). There is declining water quality trend. Most of the chemical parameters tend to increase such as pH, BOD, COD, Nithrate, Detergen. Another data such as DO, Nithrite dan P_{total} tend to decrease.

Trend of water temperature data for 2002 – 2010 years can be seen on this Figure 10 below.

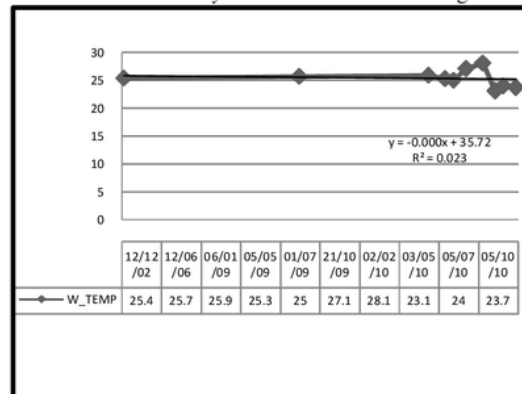


Figure 10. Water Temperature (°C)

According to the graph 7 above, water temperature are relatively stable until in the middle of 2009 years. Then, being fluctuated until the end of 2010 years. Linear regression equation and R² value shows relatively stable trend of water temperature. The fluctuation of temperature having 1,52 °C of deviation standard, still below second grade criteria of water quality standard.

Then, turbidity data of Lesti river that available at PJT I only 2009 and 2010 with the trend shows on the Figure11. below.

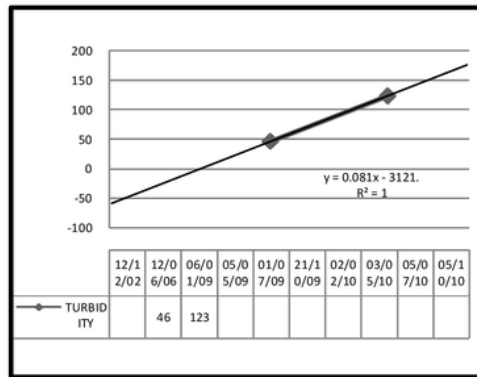


Figure 11. Turbidity (NTU)

For the year of 2009 until 2010, there is turbidity increase significantly. This is shown from R^2 value as 1. Suspended solid data (TSS) for the year 2002 – 2010 can be seen to the Figure 12 below

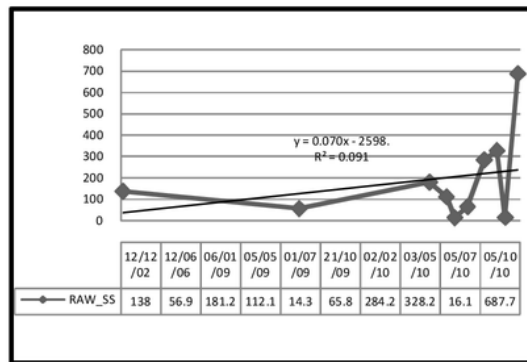


Figure 12. TSS (ppm)

Linear regression equation and low of R^2 value for the year of 2002 until 2010 shows increasing trend of TSS although not significant.

The trend of water acidity data for 2002 – 2010 years can be seen on the Figure 13 below.

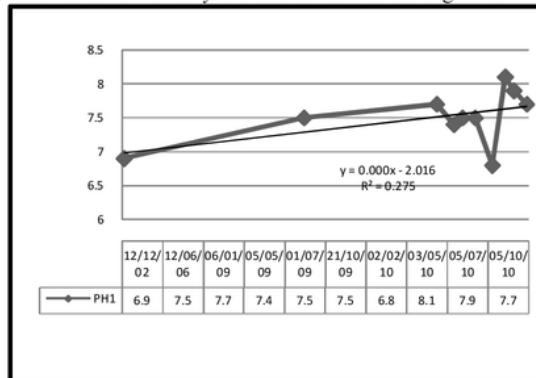


Figure 13. pH

Linear regression equation and low of R^2 value for the year of 2002 until 2010 shows increasing trend of pH although not significant.

Then, dissolved oxygen data for Lesti river that is available at PJT I only for 2002, 2006, 2009 and 2010 with the trend seems like to the Figure 14 below.

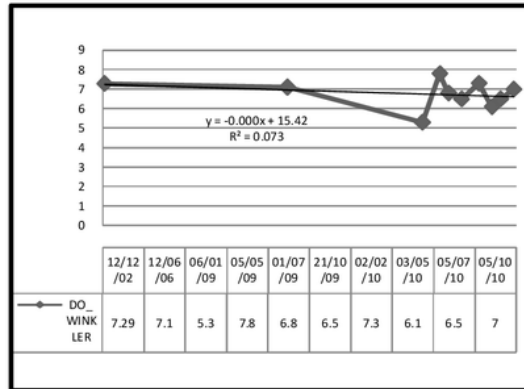


Figure 14. DO For 2002 – 2010 years

Linear regression equation and R^2 value shows relatively declining trend of dissolved oxygen. This condition have to be concerned because water quality depend on dissovded oxygen concentration as source of oxidation and respiration process. Declining of DO shows increasing of respiration and oxidation process because the increasing of organic and anorganic compound. Whereas, this DO value still appropriate with second grade criteria of water quality standard (minimal value as 4 mg/l).

Then, trend of BOD data of Lesti river can be seen on the next Figure 15.

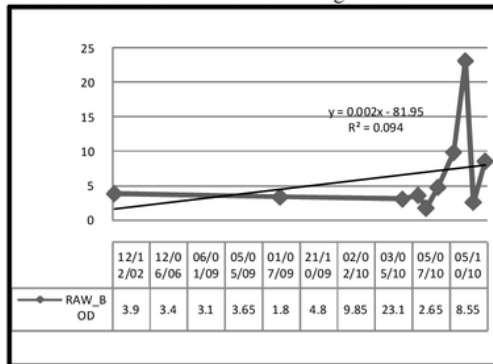


Figure 15. Trend of BOD Concentration (mg/l)

Linear regression equation and R^2 value shows relatively increasing trend of biochemical oxygen demand (BOD). Most of the BOD data with the range of 1,8 – 23,1 mg/l, shows unaappropriate value with second grade criteria of water quality standard (< 3 mg/l).

Trend of chemical oxygen demand (COD) of Lesti river can be seen on the Fig. 16 below..

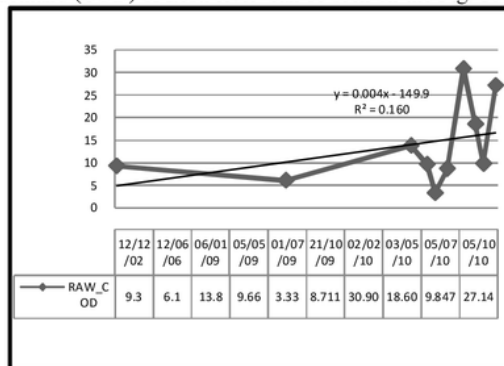


Figure 16. Trend of COD Concentration (mg/l)

Linear regression equation and R^2 value shows relatively increasing trend of COD. Some of the COD data with the range of 6,1 – 30,9 mg/l, shows unaappropriate value with second grade criteria of water quality standard (< 25 mg/l).

Next, trend of nithrate data of Lesti river can be seen on the next Figure 17.

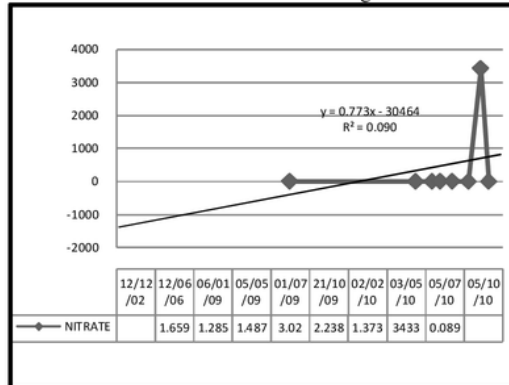


Figure 17. Trend of Nithrate Concentration (mg/l)

Linear regression equation and R^2 value shows relatively increasing trend of Nithrate. Nithrate data shows appropriate value with second grade criteria of water quality standard (< 10 mg/l) except for May 3th 2010 data was written 3344 mg/l that is probably caused by human error.

Next, trend of nithrite data of Lesti river can be seen on the next Fig. 18.

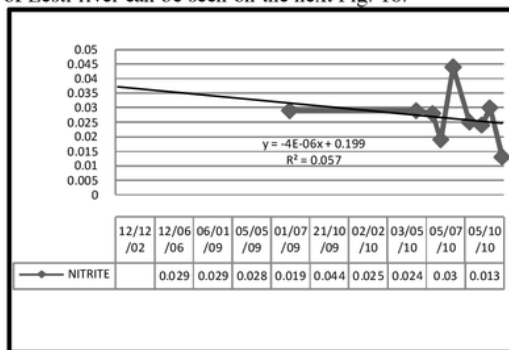


Figure 18. Trend of Nithrite Concentration (mg/l)

Linear regression equation and R^2 value shows relatively declining trend of Nithrite. Nithrite data shows appropriate value with second grade criteria of water quality standard (< 0,06 mg/l).

Trend of NH₃ data of Lesti river can be seen on this next Figure 19.

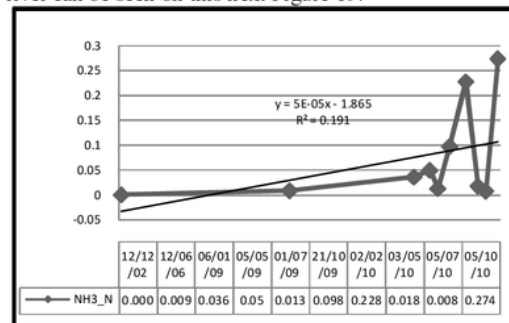


Figure 19. Trend of NH₃ Concentration (mg/l)

Linear regression equation and R^2 value shows relatively increasing trend of NH_3 . This parameter not to be conditional for second grade of water quality criteria, but to be a condition for the first grade ($<0,5$ mg/l).

Trend of P_{total} data of Lesti river can be seen on this next Fig 20.

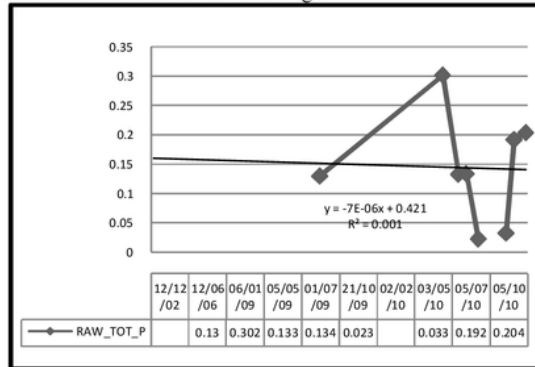


Figure 20. Trend of P_{total} Concentration (mg/l)

Linear regression equation and R^2 value shows relatively declining trend of P_{total} . Some of the data for the year of 2006 - 2010 shows unappropriate value with second grade criteria of water quality standard ($< 0,2$ mg/l). Concentration range of P_{total} as 0,023 – 0,302 mg/l.

Trend of detergent data of Lesti river can be seen on this next Fig. 21.

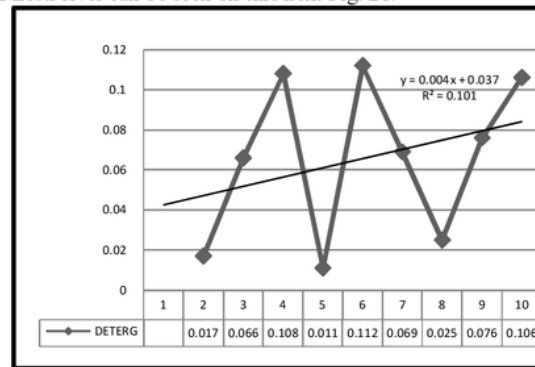


Figure 21. Trend of Detergent Concentration (mg/l)

Linear regression equation and R^2 value shows relatively increasing trend of detergent. Detergent data shows the value below second grade criteria of water quality standard (<200 mg/l).

Biological parameter data that is available at PJT I are Total Coli dan Fecal Coli. Total Coli and Fecal Coli concentration of the Lesti river below conditional concentration for second grade of water quality criteria (<2000 MPN for Fecal Coli and < 5000 MPN for Total Coli). The trend of this data for the 2001 – 2010 years can be seen on the next Fig 22 and Fig. 23.

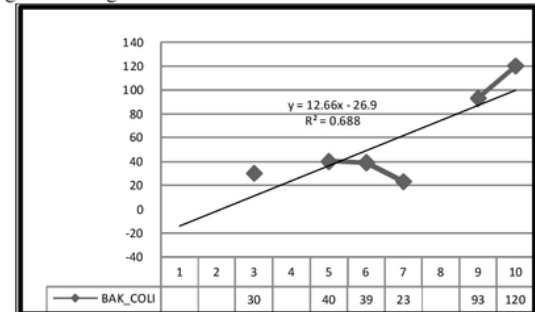


Figure 22. Trend of Total Coli Concentration (MPN)

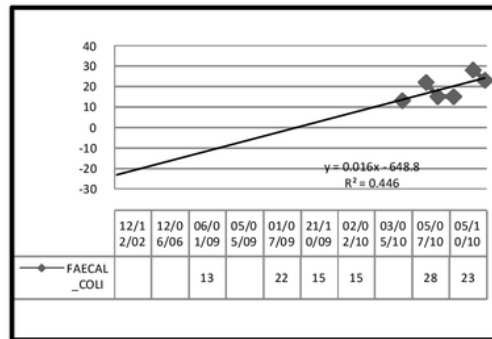


Figure 23. Fecal Coli (MPN)

Linear regression equation and R^2 value shows relatively increasing trend of Total Coli and Fecal Coli.

Rainfall and Climate Data

This data include humidity, wind speed, sunlight, air temperature, and etc. Lesti river located on river area of Brantas river on East Java provinsi with highest air temperature in November of 35,6°C and the lowest as 18,1°C in July, the humidity about 32 - 98 percent. Month with frequently cloudy happen on Pebruary and December. Average length time of sunlight radiation is on Pebruary as 52 percent, whereas in December as 46,1 percent. Highest air pressure reach on 1.012,4 milibar that happen on September and lowest value happen on February as 1.009,2 milibar. Highest value of wind speed as 7,4 knot on July with east direction and the lowest value as 4,3 knot on March with east direction too.

Climate condition is dominated by tropical climate. On normal condition, wet season were happen in 6 (sixth) month periods from November until April and dry season were happen on May until October. Whereas rainfall data were significantly variation.

Rainfall data was got from 3 (three) monitoring station with the location at Sitiarjo, Bantur and Wagir that represent upstream, middle and downstream of Lesti river. The kind of rainfall data are amount of rain for a month, amount of day with rain for a month and highest rainfall for a month. Result of amount of rain data processing for 2001 – 2010 year from the monitoring stations can be seen on Fig 24 and Fig. 25 below.

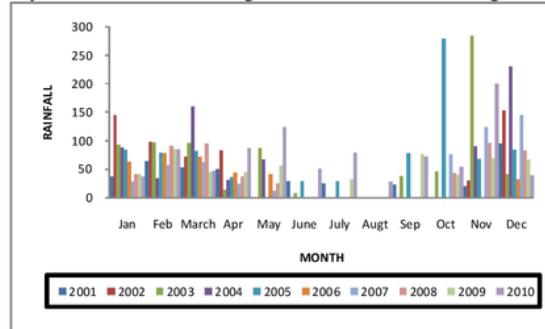


Figure 24. Amount of day with rain for a month (HH) at Bantur station

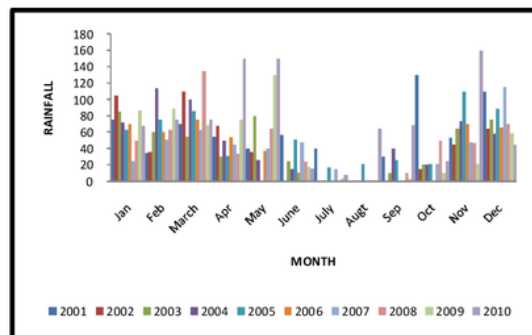


Figure 25. Amount of day with rain for a month (HH) at Wagir Station

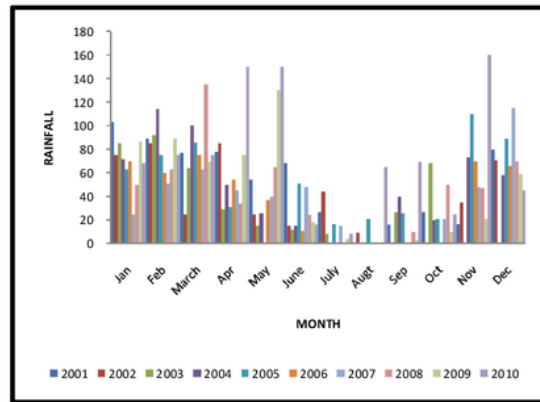


Figure 26. Amount of day with rain for a month (HH) at Sifiarjo station

From the graph above, we can see that wet season start from November and ends on June.

CONCLUSION

1. Lesti river is 2nd orde river with 49 km of length and 225,16 Km² of cathment area. Whereas from Bureau of Brantas Rivers District, Lesti river belonging to upstream of Brantas River Flows Area (sub DAS Brantas hulu) includes of three basin block, are Upper Lesti, Genteng and Lower Lesti-Jaruman with totally catchment area as 635 Km².
2. Along 2000-2010 years, at the upstream was occured linear increasing trend of annual averave flows, annual minimal flows and annual maximal flows.
3. Result of speed flow of the river are in the range of 14,94 -122,45 m/sec with the average value as 41,55 m/sec.
4. Water quality decline from physically parameter (TSS) and most of the chemical parameters such as DO, BOD, COD, Nithrate, Detergent.

ACKNOWLEDGEMENT

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