IDENTIFICATION PATTERN OF WATER QUALITY REDUCTION OF BALANGAN RIVER USING INVERSE DISTANCE WEIGHTED METHOD IN BALANGAN REGENCY, SOUTH OF KALIMANTAN, INDONESIA

Novia Lusiana¹, Deni Agus Setyono², Dhara Kusuma Wardhani
¹Study Program of Environmental Engineering, University of Brawijaya
²Urban and Regional Planning Department, Faculty of Engineering, University of Brawijaya,
	Email: novialusiana@ub.ac.id

ABSTRACT

The diversity of activities along the Balangan river causes waste disposal, which contributes to an increase in pollution load in the Balangan river. The purpose of this study is to predict the water quality conditions spatially using IDW method, and to determine the relation among distance and water quality status. In the whole location, the results showed that the pollution load capacity was exceeded, the levels of BOD5, COD, Sulfide, Iron, Manganese and Phosphate were parameters that had exceeded the quality standard. The pattern of water quality decreases in the downstream area, especially at BOD5 and COD levels. While the levels of TSS, Nitrate, Nitrite, Ammoniac, Iron, Manganese, and Detergent showed a temporary pattern of decline and showed an increase again. Phosphate levels showed a temporary increase and then there was a decrease again afterwards. Based on the sampling location the distance between the starting point and end point is 12 km, the prediction of the distribution of water quality using IDW shows that at a distance of 1-6 km shows a stable water quality pattern, a distance of 7-10 has improved water quality and 11-12 has decreased water quality.

Keywords: IDW; pattern; water quality

1. INTRODUCTION

The interrelationship between land use and water quality of upland tributaries which drain forests into higher-order streams with a variety of downstream land use has received less attention (Sidle and Hornbeck, 1991). In addition, there are three distinguished attributes between the temperate and tropical catchments: (1) point source pollution, (2) fertilizer usage, and (3) crop species cultivations (Ometo et al., 2000). Also, land use effects may differ between temperate and tropical river basins because of urban land-use systems with different levels of anthropogenic influences, geology and climate, the impact of agricultural land use, soil properties, and nutrient availability (Dudgeon, 2008). Also, water quality is often degraded by land use. Intensive agriculture increases erosion and sediment load, and leachate of nutrients and other agrochemicals into streams, rivers and groundwater. In fact, agriculture has become the largest source of excess nitrogen and phosphorus to waterways and coastal zones (Foley et al., 2005).

The management of water resources that has been carried out is limiting incoming waste through limiting the number of residents, limiting the quality and quantity of domestic waste entering the river and limiting the waste of institutional activities. In addition, determination of the amount of waste load reduction that must be carried out on waste water that will be discharged into the river is also carried out. Making decisions on the management of polluted sources and managing land use around the river is very important. This is because it will have an impact on the interests of economic activity and its harmony with the preservation of environmental functions. Based on these conditions, the point of reduction in pollution load, type of activity, and the volume of the amount of pollution load must be determined precisely.

The Balangan River in Balangan Regency flows from upstream Meratus to the regency concerning the regency, namely Hulu Sungai Utara Regency. Balangan River has a very important role to support people's lives, both as a source of raw water to be processed into clean water and to meet agricultural needs. In addition, rivers in Balangan Regency have considerable fisheries biological resources. Based on these conditions, to avoid damage and pollution to the Balangan River, research into the capacity of the Balangan River is needed. The purpose of this study is to predict the water quality conditions spatially using IDW method, and to determine the relation among distance
and water quality status. In the whole location, the results showed that the pollution load capacity was exceeded, the levels of BOD5, COD, Sulfide, Iron, Manganese and Phosphate were parameters that had exceeded the quality standard.

2. MATERIAL AND METHOD

Data used are water quality data in dry season with the parameters BOD5, COD, Sulfide, Iron, Manganese, Phosphate, TSS, Nitrate, Nitrite, Ammoniac, and Detergent. The material used is map of the city of Balangan river, map of the land use of Balangan Regency, administrative Map of Balangan Regency, all maps on scale of 1: 25000, the tool used is a Personal Computer equipped with GIS and GPS software for recording regional coordinates. Analysis of pollutant distribution obtained from groundwater quality data processing using IDW interpolation method (Inverse Distance Weighted), to analyze the IDW method the data needed is the sample point in the form point.shp, then filling the database variable Y which will be interpolated, where the variable is water quality parameter values and the next is the research area boundary data. River water quality obtained from laboratory testing is then used to determine the relationship of distance between groundwater sources and pollutant sources of water quality. The results of distance measurements and the results of water quality testing are then inputted into Microsoft Excel to analyze the relationship between the distance of sampling points and the quality of river water.

3. RESULT AND DISCUSSION

Balangan Regency is located at position 2°01'37'' North Latitude and 02°35'58'' South Latitude, and 114°50' and 115°50' East longitude. The area of Balangan is land area of 130,298 km². In this activity 7 sampling locations were taken (SP-3 Mungkur Ruyan, Sungai Tutupan PS-2, Ninian PS-1, Ninian PS-2, Ninian PS-3 and Ninian PS-4) with 16 water quality parameters). The sampling location can be seen in Figure 1.

3.1. Water Quality of Balangan River

Balangan river water quality based on Governor Regulation No. 5 of 2007 concerning Designation and Standard of River Water Quality has been determined as Class I with designation as Drinking Water. The water quality of the Balangan River can be seen in Figure 2.

TSS levels in all locations showed that they were still below the class I quality standard of 50 mg.L⁻¹. The highest value of TSS levels was at the TK I Ninian location with a value of 14 mg.L⁻¹ and the lowest location was the PS-4 Ninian with a value of <0.0059 mg.L⁻¹. The condition of nitrate levels in Balangan River is still below the water quality class I, which is 10 mg.L⁻¹, so based on nitrate levels between 0.1337 - 0.4339 it is still safe for drinking water. Whereas for nitrite levels also showed the same results, still below the quality standard (0.06 mg.L⁻¹) which is between the values 0.0032 - 0.0103 mg.L⁻¹. According to Davis and Cornwell (1991), in waters that receive runoff from agricultural areas contains a lot of fertilizer, nitrate levels can reach 1000 mg.L⁻¹.

Figure 1. Water sampling location
Rainfall and runoff are the main driving factors that cause N from non-source sources to be released from their catchment areas, while fertilizers cause large amounts of N to enter the environment and agricultural activities accelerate the transformation of N to water bodies (Xia yu et al, 2011).

The BOD5 condition on the Balangan River as a whole has exceeded the bakumutu limit with a maximum limit of 2 mg.L⁻¹, while
the BOD5 level of the Balangan River has an interval of 3.42 - 8.2 mg.L\(^{-1}\) almost close to the standard quality limit for water class IV. The COD levels in Balangan River showed that there were 5 locations that exceeded the standard quality limit (10 mg.L\(^{-1}\)), namely SP-3 Mungkur Ruyan, Sungai Tutupan PS-2, Ninian PS-1, Ninian PS-2 and Ninian I TK. Whereas the Ninian and PS-4 PS-3 locations now have levels that are still below the quality standard but need to be wary of increasing pollution even though it is still below the quality standard but COD levels are close to the quality standard. COD describes the total amount of oxygen needed to chemically oxidize organic matter, both biologically degraded (biodegradable) and those that are difficult to degrade biologically (non-biodegradable) into CO\(_2\) and H\(_2\)O. In the procedure for determining COD, the oxygen consumed is equivalent to the amount of dichromate needed to oxidize water samples (Boyd, 1988).

Sulfide levels in the Balangan River exceeded the standard limit of 0.002 mg.L\(^{-1}\) especially 5 locations, namely the PS-1 Ninian with 0.0823 mg.L\(^{-1}\), PS-2 Ninian levels of 0.0677 mg/L, Ninian I TK with 0.0961 mg.L\(^{-1}\), PS -3 Ninian with levels of 0.1459 mg.L\(^{-1}\)and PS-4 Ninian with levels of 0.1215 mg.L\(^{-1}\). Whereas the SP-3 location of Mungkur Ruyan and PS-2 Sungai Tutupan is still below the quality standard. The biggest contributor to the form of hydrogen sulfide is residential and industrial areas. The high levels of hydrogen sulfide can be tolerated with DO levels of a waters because hydrogen sulfide will be ionized so that its toxic properties are reduced (Boyd, 1982).

The toxicity of ammonia besides the pH and ammonia factors is also influenced by the oxygen content in the water. Water with a low pH value is the dominant one is ammonium (NH4 +). Ammonia levels increase with increasing acidity. Wardoyo (1981), proposed a criterion for tropical waters in ammonia levels not exceeding 1 mg.L\(^{-1}\) because if more than that value could be toxic and endanger aquatic biota. Based on the reference that ammonia levels are not recommended more than 1 mg.L\(^{-1}\), the condition of the Balangan River waters is still relatively safe because the levels are in the range of 0.0553-0.545 mg.L\(^{-1}\).

Iron content in waters that get enough aeration is almost never more than 0.3 mg.L\(^{-1}\), iron content in natural waters ranges from 0.05 to 0.2 mg.L\(^{-1}\). In ground water with low oxygen levels, iron content can reach 10-100 mg.L\(^{-1}\). Iron levels> 1.0 mg.L\(^{-1}\) are considered to endanger the life of aquatic organisms. Water intended for drinking water should have an iron content of less than 0.3 mg.L\(^{-1}\) (Effendi, 2003).

Manganese content that exceeds bakumutu is at the PS-2 Ninian location with Manganese content of 0.474 mg.L\(^{-1}\)and the PS-3 Ninian site at 0.1243 mg.L\(^{-1}\). Organic substances (as KMnO4) found in nature can come from plants, oil fibers, and animal fats, alcohol, cellulose, sugar, starch and so on (Sutrisno, 2006).

Phosphate levels in the Balangan River almost exceed the class I quality standard limits with the allowable values being 0.2 mg.L\(^{-1}\). 6 of the 7 sampling locations were identified as having exceeded forfate levels, namely PS-2 Sungai Tutupan with levels of 0.19 mg.L\(^{-1}\), PS-1 Ninian with 0.23 mg.L\(^{-1}\), PS-2 Ninian levels of 0.34 mg.L\(^{-1}\), TK I Now level 0.33 mg.L\(^{-1}\), PS-3 Ninian with levels of 0.21 mg.L\(^{-1}\) and PS-4 Ninian with levels of 0.37 mg.L\(^{-1}\). The level of phosphorus that is permitted for the benefit of drinking water is 0.2 mg.L\(^{-1}\) in the form of phosphate (PO4). Phosphorus levels in the form of phosphate for fisheries purposes should not exceed 1 mg.L\(^{-1}\) (PP No. 82 of 2001 concerning management of water quality and water pollution control). Detergent levels in the Balangan River are still below the quality standard but in some locations it is necessary to control detergent pollution towards Balangan River, especially MCK activities. The location that needs to be monitored and control the utilization of MCK is the PS-1 with detergent content of 65.2 ug.L\(^{-1}\), PS-2 Ninian with levels of 74.7 ug.L\(^{-1}\) and TK I Ninian with levels of 60.9 ug.L\(^{-1}\).

3.2. Water Pollution Index

The status of water quality is the level of water quality conditions that indicate polluted conditions or good conditions in a water source within a certain time by comparing with the specified water quality standard. Location of SP-3 Mungkur Ruyan is classified as mild pollution, the cause of pollution in this location is BOD with excess permissible levels of 5.4 mg.L\(^{-1}\), excess COD levels 5.1 mg.L\(^{-1}\) and iron content 0.2824 mg.L\(^{-1}\). The excess of these three parameters causes an increase from good conditions to mild pollution. The results of the recapitulation of the pollution index and water
quality status of 7 locations in the Balangan River can be seen in Table 1.

<table>
<thead>
<tr>
<th>Location</th>
<th>Pollution Index</th>
<th>Water Quality Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>SP-3</td>
<td>2.6497</td>
<td>low pollution</td>
</tr>
<tr>
<td>MUNGKUR</td>
<td>2.9756</td>
<td>low pollution</td>
</tr>
<tr>
<td>RAYA</td>
<td>29.1950</td>
<td>high pollution</td>
</tr>
<tr>
<td>PS-2 SUNGAI</td>
<td>24.0518</td>
<td>high pollution</td>
</tr>
<tr>
<td>TUTUPAN</td>
<td>34.0986</td>
<td>high pollution</td>
</tr>
<tr>
<td>PS-1 NINIAN</td>
<td>51.7425</td>
<td>high pollution</td>
</tr>
<tr>
<td>PS-3 NINIAN</td>
<td>43.0954</td>
<td>high pollution</td>
</tr>
</tbody>
</table>

The location of the PS-2 Sungai Tutupan is classified as mild pollution with an index of 2.9756, higher than the SP-3 location of Mungkur Ruyan. Pollution at this location is due to excess COD levels of 6.2 mg.L\(^{-1}\), excessive COD levels of 13.4 mg.L\(^{-1}\), excess iron content of 0.918 mg.L\(^{-1}\). If it is seen a greater value, it is very reasonable if the pollutant index at the location is higher than the SP-3 location in Mungkur Ruyan.

The pollution index at the PS-1 Ninian location of 29.19 was classified as heavily polluted. The cause of contamination at this location is the level of sulfide with excessive levels of 0.0803 mg.L\(^{-1}\) which results in the pollutant index value is a very small divider value, namely the quality standard for levels of sulfide is 0.002 mg.L\(^{-1}\). In addition to other sulfide parameters that cause pollution at this location are BOD5 levels with a difference of 1.43 mg.L\(^{-1}\), COD levels with more levels are 1.41 mg.L\(^{-1}\) and phosphate levels of 0.03 mg.L\(^{-1}\).

The PS-2 Ninian pollution location is in the category of heavy pollution with a polluting index of 24.05. Parameters that cause heavy pollution are sulfide levels with excessive levels of 0.0657 mg.L\(^{-1}\), then BOD levels with a value of 4.82 mg.L\(^{-1}\), COD levels of more than 0.39 mg.L\(^{-1}\), iron content of 0.0691 mg.L\(^{-1}\), manganese content with overage of 0.3740 mg.L\(^{-1}\) and phosphate levels of 0.14 mg.L\(^{-1}\). The Ninian TK-1 location is also subject to heavy pollution with a higher pollution index value than the PS-2 Ninian and the PS-1 Ninian, which is 34.09. The parameters that contributed to this contamination were BOD5 levels with more levels of 3.42 mg.L\(^{-1}\), COD with higher levels of 0.77 mg.L\(^{-1}\), more sulfide levels of 0.0657 mg.L\(^{-1}\), iron content of 0.415 mg.L\(^{-1}\), and more phosphate levels equal to 0.13 mg.L\(^{-1}\).

The more levels of pollutants that enter the waters, the level of pollution also increases. The location of the PS-3 is now the most polluted location of the seven locations that are the study locations, this location has pollution with heavy contamination with a pollution index of 51.74. The most contributing parameter is still the same as the previous location, which is the sulfide content with an excess of 0.1439 mg.L\(^{-1}\). Other parameters that contribute next are BOD with more levels of 1.92 mg.L\(^{-1}\), iron content of 0.1942 mg.L\(^{-1}\), more manganese content of 0.0243 mg.L\(^{-1}\) and phosphate levels of 0.01 mg.L\(^{-1}\). The current PS-4 location is categorized as heavy pollution with an index value of 43.09. Parameters that contribute to pollution in these locations are sulfur content with a higher level of 0.1195 mg.L\(^{-1}\), then the BOD parameter with a higher content of 1.42 mg.L\(^{-1}\), iron overweight of 0.4938 mg.L\(^{-1}\) and phosphate content with an excess of 0.17 mg.L\(^{-1}\).

3.3. Prediction Pattern of Water Pollution Distribution of Balangan River

The IDW method assumes that each input point has a local effect which decreases with distance. The IDW method is generally influenced by inverse distance obtained from mathematical equations. This power value in IDW interpolation determines the effect of closer points to produce a more detailed surface. The effect will be smaller with increasing distance where the resulting surface is less detailed and looks smoother, if the power value is enlarged it means that the output value of the cell becomes more localized and has a lower average value. A decrease in the value of power will provide an output with a larger average, because it will give effect to a wider area. If the power value is reduced, a finer surface is produced (Pasaribu, 2012).

Self purification on water is the natural ability of the river to be able to melt, reduce and eliminate pollutants, dirt or waste that enters the river (Mehrjadi, et al, 2006). One of the decomposition capacities depends on several factors, one of which is water discharge (Fadly, 2008). The projection of the pattern of decreasing water quality in the Balangan River can be seen in Figure 3.
Based on the projection results using IDW shows that the BOD5 levels getting downstream are smaller due to additional discharge at the SP-3 river point Mungkur Ruyan, distribution of the distribution of BOD5 levels in segment 3 of the Balangan River is in the interval 3,441 - 7,984 mg.L⁻¹. The distribution of COD in the Balangan River shows that the pattern of increasingly downstream COD levels shows a decreasing value with an interval value of 8,384 - 22,859 mg.L⁻¹. TSS levels showed a slightly different pattern from BOD and COD where there was a significant increase at the TK I Ninian point with TSS levels up to 13,938 mg.L⁻¹, while the TSS level interval was at the minimum limit of 0.06 mg.L⁻¹ and a maximum of 13,938 mg.L⁻¹.

Nitrate levels showed different distribution where there was not significant gain at the present PS 1 point, PS-2 Sungai Tutupan, PS-2 Ninian, TK 1 Ninian. However, there was a decrease in the current PS-3 and again increased in the Ninian PS-4 and SP-3 Mungkur Ruyan, the distribution value of Nitrate content was 0.136 - 0.424 mg.L⁻¹. The pattern of the spread of Nitrite levels also showed the same pattern with increasing Nitrite levels from the Ninian PS-1 and PS-2 Sungai Tutupan and a decline in the PS-2 Ninian and TK I Ninian then decreased in the PS-3 Ninian to SP-3 Mungkur Ruyan Nitrite levels are estimated to be 0.002 - 0.01 mg.L⁻¹.
Ammoniac levels also showed the same pattern with the pattern of increase in the PS-1 Ninian until the PS-2 Ninian and then decreased in the TK-1 Ninian and experienced an increase again, Ammoniac content values ranged from 0.055 - 0.533 mg.L\(^{-1}\). Iron content also shows the same pattern with values ranging between 0.285 - 1.174 mg.L\(^{-1}\). Manganese content also shows the same thing. There is an increase in the PS-2 Ninian. Then, downward to the downstream, the value of manganese content ranges from 0.024 - 0.473 mg.L\(^{-1}\). Detergent levels also experienced the same pattern with an increase in the current PS-2 with an interval of detergent levels of 0.2 - 74,641 mg.L\(^{-1}\).

Sulfide levels showed increasingly downstream distribution, especially in the TK-I Ninian, PS-3 Ninian, PS-4 Ninian and SP 3 Mungkur Ruyan with intervals of sulfide values of 0.016 - 0.146 mg.L\(^{-1}\). Sulfate levels show a pattern that is increasingly downstream, decreasing with levels ranging from 3.2 - 123.122 mg.L\(^{-1}\). Lead Level did not show a significant spread pattern, Lead level at the present PS-1 Ninian, PS-2 Sungai Tutupan, PS 2 Ninian, TK1 Ninian, PS-3 Ninian, PS 4 Ninian almost had the same level, only SP-3 Mungkur Ruyan has the highest levels, Lead levels in the Balangan River are between 0.006 - 0.011 mg.L\(^{-1}\). Oil and fat levels also decrease to downstream with values ranging from 0.65 - 5 mg.L\(^{-1}\). Phosphate levels indicate that the more downstream the levels increase from the Ninian PS-1 to the PS-4 Ninian, while the SP-3 Mungkur Ruyan increases, the value of phosphate levels ranges from 0.11 - 0.365 mg.L\(^{-1}\). The level of hospital also shows the same pattern, an increase in line with the downstream direction with an interval of values of 0.025 - 0.306 mg.L\(^{-1}\).

### 3.4. Relation among Distance and Water Quality in Balangan River

The relationship between the distance and the decrease in water quality can be seen in Figure 4.
The relationship between distance and water quality is very close, this is related to the effect of mixing liquid waste with river water. The distance of pollutant sources to river water also affects pollution patterns in water quality. The analysis of the relationship of distance and water quality in the Balangan River shows that at a distance of 1-6 km for several parameters (Nitrate, Nitrite, Sulfide, Ammonia, Lead, Iron, Manganese, Phosphate, Iron, Manganese, Phosphate and Phospit) show a stable pattern or the same value, while at a distance of 7-10 km has increased (highest level) and the distance of 11-12 km has decreased.

Whereas the levels of detergent and sulfate show different forms which at a distance of 1-5 km tend to increase, at a distance of 6 km to the highest level and a distance of 7-12 decreases. This shows that the highest pollution occurs at a distance of 6-10 km or at the TK-1 Ninian and PS-4 Ninian points.

4. CONCLUSION

1. Balangan River in Segment III has experienced pollution by showing several parameters that already have levels that exceed the standard quality limit.

2. Based on the results of water sampling, it was found that the water quality in SP-3 Mungkur Ruyan decreased to the water class IV, at the PS-2 point the Tutupan River decreased to class IV, PS-1 Ninian point decreased class III water quality, PS point -2 Now there is a decrease in class IV water quality, the Ninian I TK point has decreased water quality to class IV, the Ninian PS-3 point has decreased water quality to class III and the Ninian PS-4 point has decreased class III water quality.

3. In the whole location, the results showed that the pollution load capacity was exceeded, the type of parameters received by the river and exceeding its capacity were BOD5, COD, Sulfide, Iron, Manganese and Phosphate.

4. Based on the IDW method, the decreasing pattern in the downstream area includes BOD5 and COD levels. While the levels of TSS, Nitrate, Nitrite, Ammoniac, Iron, Manganese, and Detergent showed a temporary pattern of decline and showed an increase again. Phosphate and Phospitative levels showed a temporary increase and then there was a decrease again afterwards.

5. REFERENCES


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