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by Evy Hendriarianti

RATE OF NITRIFICATION-DENITRIFICATION

BRANTAS RIVER IN THE CITY OF MALANG

Evy Hendriarianti [a,*,†], Email: hendriarianti@yahoo.com

Nieke Karnaningroem [b], Email: nieke@enviro.its.ac.id

[a] Department of Civil and Environmental Engineering, Institut Teknologi Nasional Malang and Institut Teknologi Sepuluh Nopember Surabaya, Indonesia

[b] Department of Civil and Environmental Engineering, Institut Teknologi Sepuluh Nopember Surabaya, Indonesia

* Presenter; † Corresponding author.

Abstract: *One of river deoxygenation process is the nitrication-denitrification due to the existence of dissolved Ammonia (NH_3^+) and Nitrate (NO_3). Nitrification-denitrification in the receiving river of domestic wastewater with organic content and nutrients high, lead to decrease in dissolved oxygen. In the water quality model, rate of nitrification and denitrification are useful in the calibration process. River nitrification-denitrification rates that are currently are inputted to the river water quality models, are still from the old data that is no longer relevant to the current river conditions, especially in Indonesia. These often lead to the length of time for the calibration process in water quality model. In an effort to make model of the optimization DO river and water quality, a study was conducted to determine the rate of denitrification of Brantas river in Malang city using Thomas method and long term analytic method of NH_3 and NO_2. Results of analysis of NH_3 and NO_2 for 30 days showed a tendency to decrease until day 5 where there were no NH_3 and NO_2 anymore after that. Value of rates of Nitrification and Denitrification fluctuated from upstream to downstream in the value range 0.156 to 8.699 for nitrification rate and 0.260 to 1.732 for denitrification rate. The high of the nitrification and denitrification rates showed the high nutrien Nitrogen in the Brantas river in the city of Malang. The high of nutrien-N on the upstream of this complicates the improvement in river water quality downstream. Whereby the nutrient pollutant load in the downstream is greater. The results of calculations by the Thomas method showed difference value of determination R^2 for nitrification (0.3496 to 0.9251) and denitrification rate (0.8987 to 0.9851). With this value, Thomas method was not appropriate to determine the rate of nitrification Brantas river in the city of Malang. But this method was appropriate for determination of denitrification rate.*

Keywords: nitrification-denitrification rate, Brantas river, NO_2, NH3, Thomas Method.

1. Introduction

The existence of ammonia and nitrite compounds in water cause denitrification and denitrification processes. This process requires oxygen, causing a

reduction DO. DO parameters into one river water quality parameters that are important in preserving the river as a water resource. Dissolved oxygen needed by most living things aquatic. In addition, the oxygen needed for other purposes besides fish such as algae respiration and biochemical oxidation processes (Palmer, 2001). The rate of denitrification showed reduced rate of oxygen per day for the denitrification process. Its value depends on the concentration of ammonia in the river. The higher the value on the river that high concentrations of ammonia and nitrate. The rate of oxygen uptake per unit of ammonia of 3.42 MgO/MgN) and the rate of oxygen uptake per unit of nitrite of 1.14 MgO/MgN. In addition it also determined the rate of denitrification (kdn) 0,001 ~ 1 / day and denitrification rate of ammonia-N (kn) 0.05 ~ 0.5 / day (Chapra, 1997).

Denitrification rate value of the river becomes a determinant variable in the calibration process simulation model Nitrogen river. During deoxygenation rate value is determined from literature or previous studies (Palmer, 2001). The calibration process in this way takes in the process of trial and error because of the physical, chemical and biological river is not the same. The calibration process is expected to be faster when using denitrification rate value of the results of research on the location of the same river. Therefore, in an attempt to make the river water quality simulation models and models of dynamics DO Brantas river in the city of Malang, research is needed to determine the rate of nitrification-denitrification. As in determining the rate of carbon deoxygenation, several methods have been used as a method Moment, Least Square, Thomson, Iteration, Fujimoto (Singh, 2014). Besides, the method used O'Connor's (Roquibul Nature, 2006) and Streeter Phelps formula (AP Singh, 2007). From some of these methods, the method regeresi non-linear, least square and Thomas should be the first choice of estimating parameters of BOD (Okay, 2005). So in this study Thomas method is used to determine the value of Nitrification and Denitrification rate.

2. Materials and Methods

Activity determination of the rate of nitrification and denitrification is done by measuring the carbon content of ammonia and nitrite in a long time . With statistical methods , the rate of nitrification and denitrification of the river can be determined from the rate of change in the concentrations of ammonia and nitrite . The series of activities in the research described in below.

a. Determining the location of sampling

Sampling sites on the river upstream from the location determined prior to the point of discharge of the effluent and downstream locations after the point of effluent discharge. Determination of the length of the river segment is based on consideration of the

conditions that affect the water quality of rivers and tributaries such as the location of the discharge point (point source) and security access sampling.

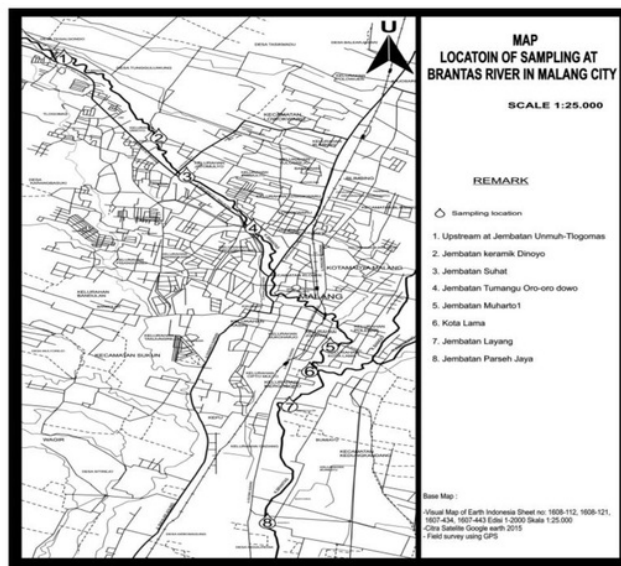Illustration segmentation of the river as in figure 1.

Figure 1.
River Segmentation

b. Sampling of river water conducted by SNI 6989.57 : 2008 Sampling Method of Surface Water .

c. Analysis of NH_3 and NO_2 for 30 (thirty) days with time interval of observation everyday until five (5) days and every 5 days after day 5 for each sample using the Standard Methods (APHA 1971 & 1998).

d. The determination of the rate of nitrification - denitrification using Thomas Method.

3. Results and Discussion

Long Term Analysis of NH_3 and NO_2

NH3 and NO_2 analysis is done by taking a long-term time interval analysis 1 day , 2 days , 3 days , 4 days , 5 days , 10 days , 15 days , 25 days and 30 days . Sampling performed at any monitoring points which have been determined segmentation as in Figure 1 above . The analysis results can be seen in the following table.

Table 1. Long Term Analysis of NH3 and NO$_2$ (Concentration mg/L)

NO	LOCATION	NH3 on day									
		1	2	3	4	5	10	15	20	25	30
1	Kasin Brantas	0,13	0,46	0,40	0,52	0,20	0,00	0,00	0,00	0,00	0,00
2	Jembatan Suhat	0,26	0,53	0,55	0,41	0,28	0,00	0,00	0,00	0,00	0,00
3	Telogo Mas	0,45	0,52	0,24	0,32	0,14	0,00	0,00	0,00	0,00	0,00
4	Jembatan Muharto	0,45	0,67	0,43	0,49	0,23	0,00	0,00	0,00	0,00	0,00
5	Brantas Bangau Amprong	1,14	1,04	0,49	0,08	0,00	0,00	0,00	0,00	0,00	0,00
6	Dinoyo	0,49	0,78	0,51	0,49	0,22	0,00	0,00	0,00	0,00	0,00
7	Jembatan Bumiayu	0,52	0,77	0,03	0,19	0,00	0,00	0,00	0,00	0,00	0,00
8	Bumiayu Mergosono	0,35	0,57	0,69	0,50	1,24	0,00	0,00	0,00	0,00	0,00

NO	LOCATION	NO$_2$ on day									
		1	2	3	4	5	10	15	20	25	30
1	Kasin Brantas	0,257	0,332	0,287	0,239	0,127	0,000	0,000	0,000	0,000	0,000
2	Jembatan Suhat	0,123	0,128	0,102	0,108	0,063	0,000	0,000	0,000	0,000	0,000
3	Telogo Mas	0,102	0,096	0,071	0,058	0,035	0,000	0,000	0,000	0,000	0,000
4	Jembatan Muharto	0,302	0,416	0,534	0,503	0,324	0,000	0,000	0,000	0,000	0,000
5	Brantas Bangau Amprong	0,423	0,533	0,983	0,887	0,744	0,000	0,000	0,000	0,000	0,000
6	Dinoyo	0,122	0,161	0,102	0,107	0,040	0,000	0,000	0,000	0,000	0,000
7	Jembatan Bumiayu	0,217	0,31	0,287	0,284	0,162	0,000	0,000	0,000	0,000	0,000
8	Bumiayu Mergosono	0,244	0,295	0,236	0,304	0,172	0,000	0,000	0,000	0,000	0,000

Source : Analysis Result, 2015

Illustration long term NH$_3$ and NO$_2$ value in the chart as follows .
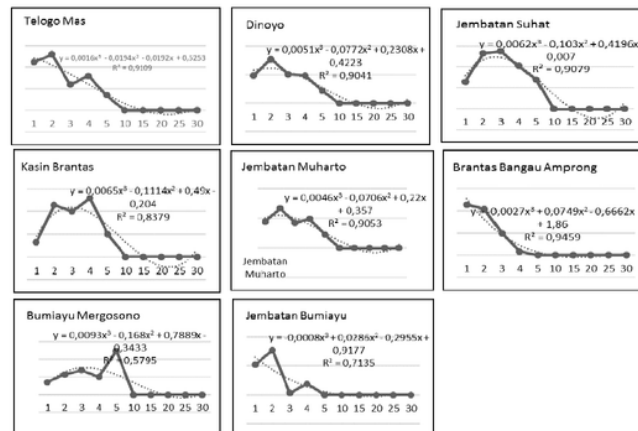
Graph 1. Trend of Long Term NH3 Analysis

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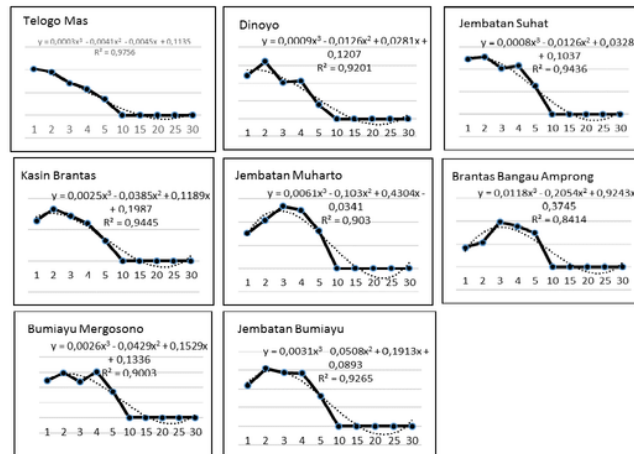
Graph 2. Trend of Long Term NO Analysis

From the graph 1 and graph 2 above, we can be seen that a decline in the value of NH_3 and NO_2 until day 5 time point analysis at all sampling locations. After the analysis time to 5 , there is no more NH_3 and NO_2 in the sample . The existence of NH_3 and NO_2 in the sample shows still need oxygen for bioksidation of N - biodegradable organic compounds .

From the graph 1 , impairment of NH_3 and NO_2 for 10 days had a tendency to order polynomial pattern 3 with the coefficient of determination , R^2 of 0.5795 to 0.9756 . Furthermore, the analysis results NH_3 and NO_2 long term is used to determine the rate of deoxygenation NH_3 and NO_2 (Kn and Kdn) with Thomas method .

Determination value of Nitrification and Denitrification Rate (K_d and K_{dn}) and $NH3_u$ and $NO2_u$ (L_0)

The determination of the value of deoxygenation Carbon and BOD_u with Thomas method using the following formula .

$$(t/y)^{1/3} = 1/(2,3kL_0)^{1/3} + \left[(2,3k)^{2/3}/6L_0^{1/3}\right]t \tag{1}$$

Plot $(t/y)^{1/3}$ with t result slope as $(2,3k)^{2/3}/6L_0^{1/3}$ and intercept as $1/(2,3kL_0)^{1/3}$.

Deoxygenation value, k and BOD_u, L_0 calculated using this following formula.

$$k = 2,61(slope/intercept) \tag{2}$$

$$L_0 = 1/(2,3k.intercept^3) \tag{3}$$

The determination of the value of nitrificaion and denitrificaton rate (Kn and Kdn) and

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NH_{3u} and NO_{2u} by the method of Thomas at each location of monitoring points Brantas river in the city of Malang can be seen in Table 3 below.

Table 3. Value of Rate Nitrificaton and Denitrification

NO.	LOCATION	NITRIFICATION			DENITRIFICATION		
		kn/day	$NH_{3u,}$ mg/L	R^2	kdn/day	$NO_{2u,}$ mg/L	R^2
1	Tlogomas	1,663	0,639	0,9251	1,530	0,134	0,9851
2	Dinoyo	1,357	0,838	0,9104	1,732	0,214	0,8987
3	Jembatan Suhat	0,621	0,492	0,8824	0,991	0,152	0,9679
4	Kasin Brantas	0,412	0,369	0,5292	1,160	0,388	0,9416
5	Jembatan Muharto	1,117	0,685	0,9161	0,503	0,504	0,9111
6	Brantas Bangau Amprong	8,699	2,747	0,853	0,260	0,938	0,8187
7	Bumiayu Mergosono	0,156	1,052	0,3496	0,727	0,324	0,9346
8	Jembatan Bumiayu	3,710	0,704	0,4077	0,759	0,329	0,9332

Nitrification and Denitrification rate fluctuates from upstream to downstream with a range of values (0.156 to 8.699) /day for Nitrification rate and (0.260 to 0.9251) /day for Denitrification rate. Nitrification rate research on Ravi river in Pakistan where receives domestic wastewater from the WWTP showed nitrification rate of 0.22 / day (Haider, 2010]. Nitrification rate approached the rate of deoxygenation of carbon with a value of 0.1-0.5 / day for large rivers and in and rising to 1.0 / day for the smaller river (Thomann, 1987).
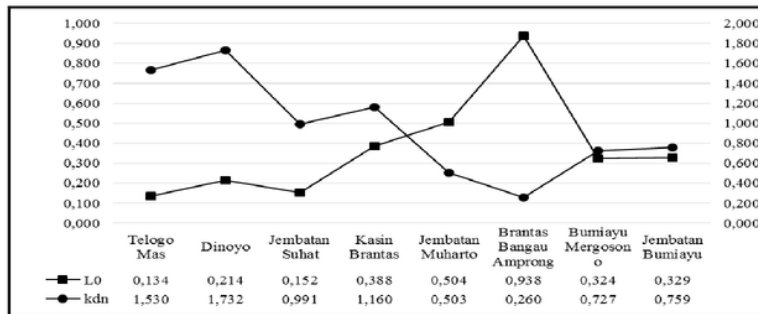
$NH_{3}u$ values are in the range of values from 0.369 to 2.747 mg/L . While $NO_{2}u$ values ranged from 0.134 to 0.938 mg/L. Fluctuations in the rate of Nitrification and ultimate Ammonia can be seen in Figure 6 below.
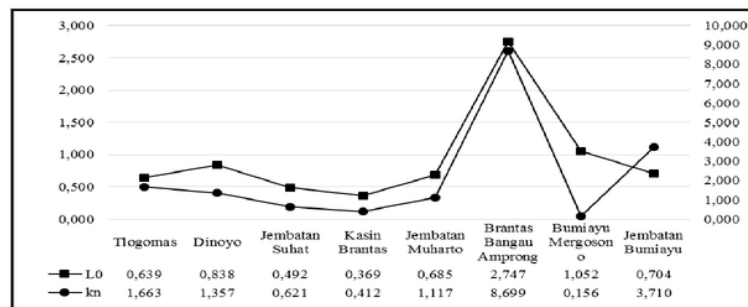
Graph 5. Fluctuation of kn and L_0 (NH_3) Value

To fluctuations in the rate of Denitrification and utimate Nitrite can be seen in graph 6 below.

	Telogo Mas	Dinoyo	Jembatan Suhat	Kasin Brantas	Jembatan Muharto	Brantas Bangau Amprong	Bumiayu Mergosono	Jembatan Bumiayu
L0	0,134	0,214	0,152	0,388	0,504	0,938	0,324	0,329
kdn	1,530	1,732	0,991	1,160	0,503	0,260	0,727	0,759

Graph 6. Fluctuation of kdn and L_0 (NO_2) Value

Nitrification rate variation is controlled by a combination of several factors, including the concentration of nutrient, microorganisms nitrifier and the concentration of dissolved oxygen (Strauss 2002; Dai 2008 ; Hsiao , 2014). This explains the Figure 6 where the rate Nitrification tendency follow the tendency of Ammonia concentration. Coefficient of determination, R^2 of Thomas method for Nitrification rate lower than (0.3496 to 0.9251) than the rate of Denitrification (0.8187 to 0.9851). This showed that Thomas method is more suitable for use in determining the denitrification rate than the rate of nitrification in Brantas river at Malang city. The calculation of the rate of nitrification can use other methods likes Least Square method and Non Linear Regression (Okay , 2005) .

4. Conclusions

1. Decreasing concentration of NH_3 and NO_2 occur within five (5) days in order polynomial tendency pattern 3 with the coefficient of determination, R^2 of 0.5795 to 0.9756 .
2. The rate of Nitrification and Denitrification fluctuate from upstream to downstream with a range of values (0.156 to 8.699)/day for Nitrification rate and (0.260 to 0.9251)/day for Denitrification rate.
3. Value NH4u are in the range of values from 0.369 to 2.747 mg/L. While NO2u values ranged from 0.134 to 0.938 mg/L.
4. The coefficient of determination, R^2 with Thomas method in determining the value kn of 0.3496 to 0.9251. As for determining the value of KDN higher R2 values with a range of values from 0.8187 to 0.9851.

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5. The high coefficient of determination for rate of Denitrification than Nitrification shows that Thomas method is suitable for determination of denitrification rate than nitrification in Brantas river in the city of Malang.

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