Water Quality Index by Using National Sanitation Foundation-Water Quality Index (NSF-WQI) Method at Krueng Tamiang Aceh

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Abstract

The quality of river water is influenced by two factors, namely nature and human. Natural factors that affect the condition of the river (which can overflow in heavy rain and become turbid), while the factor of human origin (sewage from industry, agriculture and domestic). This study aims at determining the water quality index using National Sanitation Foundation-Water Quality Index (NSF-WQI) based on major water quality parameters including temperature, solids dissolved, turbidity, dissolved oxygen, acidity, biochemical oxygen demand, nitrate, phosphate and fecal coli in Krueng Tamiang. Water quality index at the location 1 (Kaloy village of Tamiang Hulu sub district) is 55.83 (moderate criteria), location 2 (Seumadam Village of Keujruen Muda sub district) is 51.48 (moderate criteria), the location 3 (Kebun Tengah village of Keujruen Muda sub district) is 47, 67 (bad criteria), location 4 (Kuta Lintang Village of Kuala Simpang sub district) is 48.53 (bad criteria), location 5 (Alur Manis village of Rantau Subdistrict) is 47.03 (bad criteria) and location 6 (Pekan Seruway village of Seruway sub district) is 50.86 (moderate criteria). The low value of Water Quality Index at three locations (location 4, 5 and 6) are affected by the low value of the sub-indices for temperature, turbidity, dissolved oxygen, phosphate, and fecal coli. This low value is related to human activities in the region.

Keywords: water quality index; NSF-WQI method; Krueng Tamiang

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INTRODUCTION

The River is one of water's area that has characterized the current flowing from upstream to downstream. The quality of river's water is influenced by two factors of nature and man. Natural factors that affect river conditions is heavy rain which will become an overflow and turbid, while the factor derived from human for example sewage from industry, agriculture, domestic, BOD and fecal coliforms are the main water quality sub-indices that reflect the impact of anthropogenic activities on the water quality of this river system. [1].

Water quality index is defined as a technique that provides a ranking of the composite effect of individual parameters of water quality to the overall water quality [2]. The systems most relevant to it is a system of water quality index (WQI)) is a method that certify the quality of water in a simple way that can respond to changes in the basic characteristics of water. Water quality index based on the WQI was developed by the National Sanitation Foundation (NSF), provides a standard method for comparing the relative quality of various bodies of water [3]. Some researchers use the index of water quality in river water quality assessment [4]. By knowing the water quality into consideration for the management of water resources [5].

Water quality of Krueng Tamiang is using the National Sanitation Foundation Water Quality Index (NSF-WQI). The advantages of this method in general may indicate water quality

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of Krueng Tamiang by observing the parameters measured. NSF-WQI also been widely used in many developed countries to determine the water quality of the river. NSF-WQI was developed since 1970 by Brown, McClelland, Deininger and Tozer with referring on Horton index. Charlotte in Ott-NSF states that WQI has been used by a variety of environmental experts and proven to be a reliable index to describe the quality of the environment [6].

Water Quality Index calculation using NSF-WQI been done after reading sub index values of each parameter by using a functional curve sub index, NSF water quality index value is calculated by multiplying the value sub index with the weight of each parameter. The systems most relevant to it is a system of water quality index (WQI)) that represent the overall water quality parameters in a simple way that can respond to changes in the basic characteristics of water. Therefore, this paper discusses about assessing water quality index in Krueng Tamiang by the National Sanitation Foundation Quality Index (NSF-WQI).). The scoring system is determined based on the parameters of water quality are major temperature, dissolved solids (TDS), turbidity, dissolved oxygen (DO), pH, BOD, NO_3, PO_4, and fecal coli.

RESEARCH METHODS

This research was conducted in the Watershed of Krueng Tamiang **figure 1**. Water sample analysis will be carried out in the Laboratory of Research Institute for Standardization and Industrial Banda Aceh. The analysis had been taken in September 2015. The method used to analyze the samples adapted to the Indonesian National Standard (SNI) Year 1991. Data obtained in the form of quantitative data on physical parameters (temperature, TSS (TDS) and turbidity), chemical parameters (pH, Dissolved Oxygen (DO), biological oxygen demand (BOD), phosphate (PO_4) and nitrate) and microbiological parameters (fecal coli). The data were analyzed water quality status, are then determined by the Water Quality Index (WQI) [7].

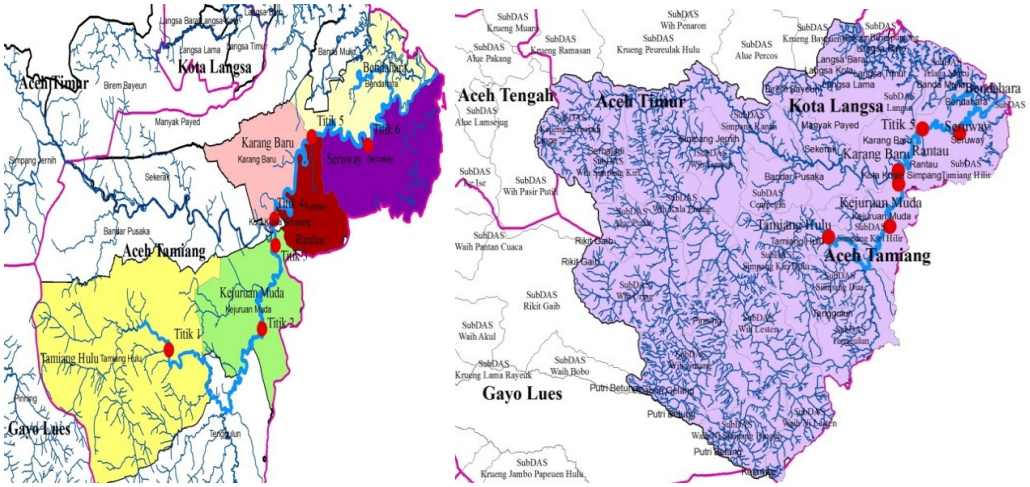

Fig. 1: Map Location Research.

Water quality had been categorized by Horton in 1965 and then in 1970 Brown et al. and developing a common water quality index (WQI) [8]. For calculation of water quality index (WQI), the raw analytical results for the selected water quality variables, having different units of measurements, are transformed into unit-less sub index values [9]. Ii value can be done by transforming each parameter into 0 to 100 scales [10] by using sub-index curves. The sub-index curves may be linear, nonlinear. This index is generally determined by Delphi method, which is based on the weight (Wi) and sub-indices (Ii) of the nine main parameters in water quality that is DO, BOD, E. Coli, pH, temperature, PO_4, nitrates, turbidity, and solids dissolved, which is expressed by the formula [6].

$$WQI = \sum_{i=1}^{n} (wi \times Ii) \quad \text{.....1)}$$

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Information:
W_i = Weight parameter untill i, scale 0-1.0
I_i = Value Sub Index for i^{th}
n = The number of water quality parameters

The weight values of water quality parameters on water quality index system is presented in **Table 1**. The results obtained the calculation of Air Quality Index, and then compared with the water quality criteria according to the National Sanitation Foundation-Water Quality Index (NSF-WQI) in **Table 2**.

Table 1: The weight values of water quality parameters in water quality index system – NSF [7]

um.	Parameters	Weight
1.	Dissolved oxygen (DO)	0,17
2.	Fecal coli	0,15
3.	PH	0,12
4.	BOD	0,10
5.	NO_3	0,10
6.	PO_4	0,10
7.	Temperature	0,10
8.	Turbidity	0,08
9.	Dissolved solids	0,08
	$\sum_{i=1}^{n} wi$	1,00

Table 2: Water quality criteria (NSF-WQI) [7]

Num.	Range WQI	Criteria
1	0,0 – 25	Very bad
2	25,1 – 50	Bad
3	50,1 – 70	Moderate
4	70,1 – 90	Good
5	90,1 – 100	Very good

1. RESULTS AND DISCUSSION

Data from parameter measurements of temperature, pH, turbidity, nitrate, phosphate, DO, BOD, TDS and total coliforms in Krueng Tamiang in several locations: Area 1 at the Village Kaloy District of Tamiang Hulu, area 2 in the village of Seumadam District of Vocational young, area 3 Central Garden District of SMK Desa Muda, area 4 in the village of Kuta latitude District of Kuala Simpang, area 5 in Alur village Rantau Manis Subdistrict and area 6 in the village Peukan Seruway District of Seruway presented in **Table 3**.

Data values of water quality parameters were analyzed by water quality status that is determined by the Water Quality Index (WQI) [7]. Ii determination based on the calculator according to the NSF-WQI. The results of calculations based on the Air Quality Index WQI calculator NSF presented in **Table 4.**

Tabel 3: Data measurement results of water samples.

Num.	Parameter	Area 1	Area 2	Area 3	Area 4	Area 5	Area 6	Unit
1	pH	7.63	7.23	6.79	6.73	6.71	6.83	
2	Temperature	25.2	24.0	25.8	24.2	26.0	29.4	˚C
3	TDS	49.8	39.1	37.8	37.3	39.6	39.2	mg/l
4	Turbidity	5.67	903.0	841.5	702.5	408.5	455.5	NTU
5	DO	8.11	7.61	7.51	7.61	7.40	7.30	mg/l

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6	BOD	2.94	1.32	4.26	0.71	2.23	0.91	mg/l
7	NO3	1.2	2.1	2.1	1.6	1.6	1.7	mg/l
8	PO4	0.81	0.82	0.80	0.83	0.81	0.80	mg/l
9	E-Coli	40	60	40	215	100	50	Jml/100 ml

The results obtained from the calculation of each Air Quality Index at Krueng Tamiang compared with water quality criteria according to the NSF-WQI. Air Quality Index calculation results at area 1 score a value of 55.83, the area 2 score value is 57.53, area 3 value score is 47.67, the area 4 value score of 48.53, area 5 is scores of 47.03 and index calculation results Water Quality in area 6 have score value of 50.86. All the water quality index values are in the range of 47.03 to 50.86 and status including poor water quality and moderate.

Table 4: Data Calculation Results Air Quality Index 2015

N	Parameter	Wi	Area 1		Area 2		Area 3		Area 4		Area 5		Area 6	
			Li	Wi x Ii	Ii	Wi x Ii	Ii	Wi x Ii	Ii	Wi x Ii	Ii	Wi x Ii	Ii	Wi x Ii
1	pH	0.11	92	10.12	92	10.12	83	9.13	80	8.8	80	8.8	84	9.24
2	Temperature	0.10	15	1.5	17	1.7	15	1.5	16	1.6	14	1.4	11	1.1
3	TDS	0.07	86	6.02	86	6.02	86	6.02	86	6.02	86	6.02	86	6.02
4	Turbidity	0.08	85	6.8	5	0.4	5	0.4	5	0.4	5	0.4	5	0.4
5	DO	0.17	6	1.02	6	1.02	6	1.02	6	1.02	6	1.02	6	1.02
6	BOD	0.11	67	7.37	92	10.12	60	6.6	97	10.67	75	8.25	96	10.56
7	NO3	0.10	96	9.6	95	9.5	95	9.5	95	9.5	95	9.5	95	9.5
8	PO4	0.10	46	4.6	46	4.6	47	4.7	46	4.6	46	4.6	47	4.7
9	Fecal Coli	0.16	55	8.8	50	8	55	8.8	37	5.92	44	7.04	52	8.32
WQI			55.83		51.48		47.67		48.53		47.03		50.86	

Degree of acidity (pH)

Normal water has a pH value ranging between 6.5 - 7.5. Sewage into the water can change the hydrogen ion concentration (pH) in the water becomes more acidic or more alkaline depending on the type of waste and chemical substances contained in them [11]. The pH value in 2015 were highest in one location is 7.63 and the lowest in five locations, namely 6.71. High or low pH is due to the effect of the disposal of industrial wastewater and agricultural wastes into the river Krueng Aceh Tamiang by the surrounding community. This is consistent with the statement [12]. told in their book, mining or agricultural waste water results in a high concentration of hydrogen ions, endangering aquatic life. The high concentration of hydrogen ions, indicate acidic waters and vice versa hidroxil ion concentration (OH) is higher than the concentration of hydrogen ions.

Water temperature

The temperature is very closely related to the level of rainfall, if the rainfall is high, it will result in water temperature will be low. Moreover, it describes the natural condition of the surrounding mountains [13]. Based on the research that has been conducted in September in area 6 from upstream to downstream along the river waters Tamiang

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found differences in temperature at each location the water sampling (**Table 3**). This is because one of the factors that affect the water temperature in the water is a season (climate) local. Water temperature of Tamiang River is ranging from 24 to 29,4°C and it was considered in good condition. In this study the temperature of the river water in 2015 increase in area 6 and the lowest is happening at 29.4˚C at area 2 is 24,0˚C, high value of the water temperature is suspected because of green space in area 1 on the wane and settlements growing its range. It was instrumental in controlling the temperature conditions of aquatic ecosystems. Temperature is basically important for its effects on certain chemical and biological reaction staking place in water and aquatic organisms [14]. Temperature altered by the change of the sampling time. This can be due to the differences of weather, humidity, and sunlight exposure. If the bright weather affected the temperature, Government Regulation (GR) No. 82/2001 (class II) defines temperature deviation of 3ºC. Hence, the temperatures of water at six areas still meet the national quality standard [17].

Total Dissolved Solids (TDS)

The high TDS parameter values can be identified that watersheds have occurred will result in deforestation and forest / sedimentation in the river [11]. The results of the study can be seen in total dissolved solids in 2015 highest in one location that is 49.8 mg / l and the lowest at area 4 is 37.3 mg/l. The TDS contained in the Krueng Aceh Tamiang River cycle happens differently every year this is due to their indiscriminate disposal of waste water which had been done by the people who live around the river into the river and also due to deforestation around the river.

Turbidity

Turbidity is a description of the optical properties of the water which is determined by the amount of light (light) emitted and absorbed by particles in the water. Turbidity of water in the surrounding mountains or upper part river is denoted a very low compared to the downstream river. Turbidity is derived from suspended materials such as mud, sand, organic and inorganic materials, plankton and other microscopic organisms. The research results show that the turbidity value in 2015 were highest in area 2, namely 903.0 NTU and the lowest occurred in area 1 that is 5.67 NTU. The high turbidity caused by liquid waste of oil. Increasing cloudiness in area 2 is the effect of the disposal of liquid industrial waste into the River Way Tapioca Small Sulan. The increase in turbidity is due to the input of total solids which has organic matter and soil particles that are not immediately precipitate, which comes from the filtering process. The low value of turbidity does not meet the quality standards for drinking water. The quality standards for drinking water turbidity is <5 NTU. The turbidity of the water in the upper part of Tamiang River ranged 5,67-903 NTU. Turbidity of upper part of the river normally quite low was also reported [6]. Highest turbidity was at the area 2, since the dominant sediment of area 2 originates from sandy mud of the river bottom. The area 2 was also often used for washing motorcycle, clothing, and washing muddy agricultural tools by the farmers. High turbidity affects aquatic life [7].

Dissolved oxygen (DO)

Dissolved oxygen (DO) is an important parameter to measure water pollution. Although oxygen (O2) are difficult to dissolve it is needed by all kinds of life on the water. If there is no oxygen there is no life of plants and animals in water such as rivers, lakes and reservoirs (Sutrisno and Eni, 1991). From the results of the study can be seen the

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value of dissolved oxygen (DO) in 2015 were highest in location 1 is 8.11 mg / l and the lowest in six locations, namely 7.30 mg / l.

Biochemical oxygen demand (BOD)

BOD is commonly used to determine the contamination level of organic matter in the wastewater. BOD examination is required to determine the burden of pollution due to waste water and to design biological treatment system. From the results of the study can be seen the value of BOD in 2015 highest in three locations, namely 4.26 mg / l and the lowest occurred in area 4 namely 0.71 mg / l. The decline in the value of BOD due to the presence of domestic waste originating from human activity, who use soap and detergents, organic matter content of the agricultural area.

Nitrate (NO_3)

Nitrate is a stable form which compounds and derives its existence from the waste, fertilizers, animal and human feces and so forth. From the research results can be seen that the value of nitrate (NO) in 2015 were highest in locations 2 and 3 locations of 2.1 mg / l and the lowest occurred in locations 1 at 1.2 mg / l. Low to high levels of nitrate because it is influenced by a small number of human activity nearby. The main sources of river water pollution come from domestic sewage, animal waste, agricultural waste, soil erosion and runoff from settlements [15]. In addition, high nitrate levels in Krueng Tamiang still ≤10 mg / l, so that the nitrate in all areas meet quality standards. The level of nitrate can be influenced by the presence or sediment runoff from agricultural fertilizers or domestic waste. The high value of nitrate occurs at area 2 and 3 caused by excess use of agricultural fertilizers in palm oil that goes into the water body Tamiang river.

Phosphate (PO_4)

Phosphate comes from detergents in liquid waste and pesticides also insecticides from agricultural lands. Each phosphate compound is present in dissolved form, suspended or bound in the cells of organisms in water [16]. (Peavy, 1986). From the research results can be seen the value of phosphate (PO_4) in 2015 at all locations do not differ much. The highest values occur in four locations namely 0.83 mg / l and the lowest at 3 locations and location 6 is 0.80 mg/l. high phosphate values caused by domestic waste water flowing from settlements along the river downstream Tamiang. Phosphate can be sourced from waste water population and industries that use detergents containing phosphates, such as industrial washing, industrial metals, the waste water of the population (feces) and food waste being dumped directly into waterways.

Fecal Coli (E. Coli)

Coliform bacteria is an important parameter microbiological quality of drinking water. Coliform bacteria group consisting of Escherichia coli, Enterobacter aerogenes, Citrobacter fruendii, and other bacteria. Although this type of bacteria does not cause a particular disease directly, its presence in drinking water indicates a low level of sanitation. Therefore, drinking water must be free of any type of coliform. The higher level of coliform bacteria contamination, the higher the risk of the presence of other pathogenic bacteria that normally lives in the human and animal waste. Results can be seen from the research that the value of Fecal Coli (E. Coli) in 2015 were highest in four locations namely 215 JLM / 100 ml and the low one in the location 1 and location 3: 40 JLM / 100 ml. the high value of Fecal Coli (E. Coli) caused by domestic sewage

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effluent that can be either domestic water, the solid form of garbage dumped into the river, washing water and effluent bathroom stool.

Water Quality Index (WQI)

Sometimes, currently still emphasize only on the measurement of parameters of physical, chemical and biological so that the status of water resources cannot be defined as something that represents the entire parameter. Based on the results of water quality parameters measured can be specified water quality index. Then, from the Air Quality Index obtained by calculating the number of each of the Air Quality Index at that area, which is compared to water quality criteria according to the National Sanitation Foundation-Water. Water quality index at area 1, namely 55.83 in the criteria of being, is 51.48 area 2 in the middle criteria, namely 47.67 area 3 in bad criteria, is 48.53 area 4 in the criteria poor, area 5 , namely 47.03 the bad and the location criteria 6 namely 50.86 in the criteria moderate. The low value of Air Quality Index at three locations, areas 4 and 5 locations affected by the low value of the sub-indices for parameters water temperature, turbidity, DO, phosphates and fecal coli.

2. CONCLUSION

The results showed that the water quality in Krueng Tamiang showed that the Air Quality Index at a specific location using the method of the National Sanitation Foundation-Water Quality Index (NSF-WQI) on water quality index at one location, namely 55.83 in the criteria of being better than the location 2, namely 51.48 in the criteria of being, is 47.67 3 locations in the criteria bad to worse from 4 locations namely 48.53 in bad criteria, is 47.03 5 locations in the criteria poor worse than six locations, namely 50.86 in criteria being. The low value of Air Quality Index at three locations, locations 4 and 5 locations affected by the low value of the sub-indices for parameters water temperature, turbidity, DO, phosphates and fecal coli.

Suggestions which can be submitted based on the findings in this study are suggested to the public, before using the water from three springs as drinking water it is better boiled, or adding a disinfectant such as chlorine to kill bacteria pathogens in the water for drinking water

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