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ASSESMENT OF SURFACE WATER QUALITY STATUS IN KRUENG BAROE RIVER PIDIE, USING ENVIRONMENTAL POLLUTION INDEX

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ABSTRACT

The Krueng Baro River is a surface water resource that is widely used by the people of Pidie District for various activities. These various activities have the potential to have a negative impact on the river water itself. Precaution to protect and control water pollution in the Krueng Baro river must be implemented so that water quality standards are maintained. The research aims to assess the water quality status of Krueng Baro River in Pidie District, based on the parameters Odor, Temperature, TSS, DHL, COD, BOD, DO, pH, and Total Coliform. Each Parameter were analysed using Water Quality Index (WQI) and Environmental Pollution Index (PI) to determine the surface water status. The results of data analysis using PI index in 5 different sections showed respectively: Section 1 - IP value of 0.73, Section 2 - IP value of 0.70, Section 3 - IP value of 0.69, Section 4 - IP value of 0.75, and Section 5 - IP value of 1.44. At Section 5, the water quality of the Krueng Baro River is slightly polluted which is caused by the concentration level of BOD exceeding the predetermined quality standards. While using WQI Index, the Krueng Baro River resulting 66 scores, which was in the Moderate category. In conclusion, all parameters measured in Krueng Baroe surface water still met the Government Regulation No.22 Year 2021 Class II, excluded BOD parameter in Section 5.

Keywords: *Surface Water, Krueng Baro River, Water Quality Index, Pollution Index, Government Regulation No.22 Year 2021.*

INTRODUCTION

Water is an essential substance needed by all living beings on Earth. Water resources can be found in various places, one of which is from rivers. However, the availability of water varies from one region to another. Potable water is water that meets the standards of quality and quantity of raw water [1].

A river that has a complex and interconnected environment with a unique characteristic known as a Watershed. According to Law Number 37 of 2012 concerning the Management of the Republic of Indonesia's State Waters, a Watershed is a land area that is an integral part of the river and its tributaries, responsible for collecting, preserving, and draining water from rain to lakes or rivers, seas, with land boundaries acting as topographic dividers, and sea boundaries also extending to water areas influenced by land activities. One of the most important rivers in Pidie District is the Krueng Baro River. This river spans 7 sub-districts, including Tangse, Titeu, Keumala, Delima, Indra Jaya, Mila, Sakti, and Sigli city. Based on [2] Regulation No. 5 of 2014 from Pidie District, regarding the Spatial Planning Plan of Pidie District for the Year 2014-2034, states that the watershed area of the Krueng Baro River span to 483.40 hectares, or around 31.71% of the total Pidie area. The Krueng Baro River serves as the main source of household water needs for the community, as well as a source of irrigation water and water supply for the Tirta Mon Krueng Baro Water Company.

Therefore, this research is conducted to examine the surface water quality of the Krueng Baro River in Pidie District, Indonesia in accordance with the regulation of the Republic of

Indonesia Government Regulation No. 22 Year 2021 [3], concerning the Implementation of Environmental Protection and Management, specifically for Class 2 water designation. This also involves determining the Surface Water Quality Status using the Environmental Pollution Index (PI) and Water Quality Index (WQI) methods, which referred to the Regulation of the Minister of Environment and Forestry of the Republic of Indonesia No. 27 Year 2021 on the Environmental Quality Index [4]. The results should provide information about the water quality status of the Krueng Baro River in the Krueng Baro Watershed and its suitability for public use. Additionally, it can serve as a consideration for the local government of Pidie District to undertakes management and regulation of pollution in the Krueng Baro Watershed.

LITERATURE REVIEW

River Pollution

The aquatic ecosystem is capable of natural purification when water is contaminated, but its capacity is limited. If more urban waste is dumped into rivers without further treatment, this process will not be maximized. Therefore, river pollution will be difficult to address [5]. Water pollution is defined as the presence of pollutants (contaminants) caused by human activities in the human environment, whether physical, biological, or social, which have detrimental effects on human life, both directly and indirectly.

Mismanagement and improper utilization of Watershed Areas by humans can lead to damage of the watershed and have negative impacts on the environment, such as land use conversion for settlements, farming, and deforestation in the upper region. This results in a reduction of ground cover vegetation, leading to increased surface runoff and a decrease in the soil's capacity for infiltration. Human errors in the management and utilization of DAS can trigger damage to the DAS, with adverse environmental effects depending on the type and characteristics of the pollutants. Indicators of river water pollution can be observed through physical, chemical, and biological means [6]. The watershed or surface water pollution tendencies in Indonesia mostly happened as the affect of the low implementation on Government policies on environmental management and protection.

Indonesian Water Quality Categories

Based on [3] Government Regulation No. 22 of 2021 on the Implementation of Environmental Protection and Management, categorizes of water quality divided into four categories:

1. Class one, water intended for use as raw drinking water and/or other purposes that require the same water quality standard.
2. Class two, water intended for water recreation facilities, freshwater fish cultivation, livestock farming, irrigation of gardens, and/or other purposes that require the same water quality standard.
3. Class three, water intended for freshwater fish cultivation, livestock farming, irrigation of livestock farms, and/or other purposes that require the same water quality standard.
4. Class four, water intended for irrigation of gardens and/or other purposes that require the same water quality standard.

Pollution Index (PI)

In order to assess the general condition of surface water in Indonesia, the ministry of environmental established the Decree Number 115 Year 2003 concerning Instructions for

Assessing the Current Condition of Water Quality by using Pollution Index. This index relates to the number of contaminants in surface water, which is a key parameter for a water allotment that expressed as the environmental Pollution Index (PI). Categorize the water quality parameters which relative to pollution content, we required standards quality that can be determined from the Pollution Index. The Index of Pollution assessment relates to a water allotment in part or all of river water bodies. The level of water quality standards determined by the level of the Pollution Index can be utilized as input for relevant stakeholders in assessing a river's water body's degree of purity. [7]

Water Quality Index (WQI)

According to [8], in recent years, the Water Quality Index (WQI) method has been widely used to assess water quality, and its results have been very beneficial for the community and policymakers. [9] Tian et al (2019), mention that the WQI method is a simple mathematical tool that integrates multiple parameters into a single number, to make the results understandable, providing a comprehensive overview of water quality status, and not requiring a significant cost. WQI also serves to describe the overall water quality status from a large amount of water quality data to a simpler form.

METHODS

Materials

The equipment used in this research were camera, type meter, record forms, pen, pH meter, *thermometer*, *Dissolve Oxygen* meter, *Conductometer*, *Hydrobios*, water sampler, PE bottle, dark Duran bottle, cool box, GPS, and rope for sampler. Other materials used were gloves, masked, cool pack H_2SO_4 and water sampling from Krueng Baroe river.

Sampling Area

The water sampling was taken in March 2023, from Krueng Baroe River/Watershed in Pidie District, Indonesia. The fifth Stations were representing each Subdistrict that were passed by the river flows, which are Subdistricts of Tangse, Keumala, Indra Jaya, and Sigli. Water sampling station was chosen from the area that has a long-term effect of environmental changes. All the 5 Stations chosen is having different environmental baselined and condition. The water sampling that was collected, then brought to be analysed at the Laboratories of Environmental in Pidie, Indonesia. The sampling locations were presented in the Figure 1.

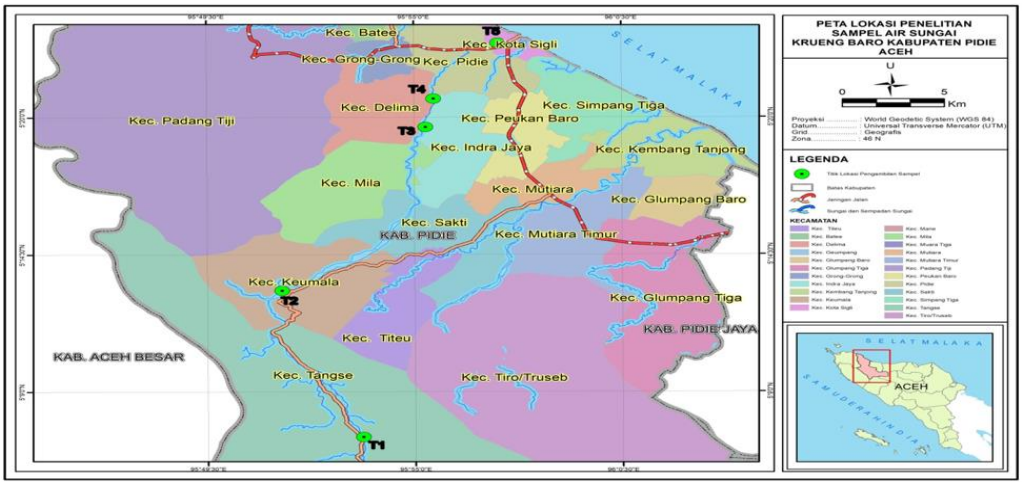

Fig 1. The sampling Stations Points in Krueng Baroe River

All the parameters research that was examined from each Stations were listed on Table 1.

Table 1. Characteristics of research parameters examined in each water sampling section

No.	Research Characteristics	Research Parameters
1	Physics	Odor, Temp, DHL, TSS
2	Chemical	BOD, COD, pH, DO
3	Biology	(Numbers of colony) of *Total Coliform*

Source: research data, 2023

Data Analysis

Descriptive analytics method was used to determine the surface water quality status, by employing environmental Pollution Index (PI) dan WQI Index. The PI index was referred to [4], Regulation of the Minister of Environment and Forestry of the Republic of Indonesia No. 27 Year 2021. From [10] Rahmadi et al, (2023), the calculation used to determine the status of river water quality was the Pollution Index (PI) method which is shown as follows:

$$PIj = \sqrt{\left(\frac{(Ci/Lij)^2 M + (Ci/Lij)^2 R)}{2}\right)} \qquad (1)$$

Remark:
PIj = Pollution Index (j)
Ci = concentration of water quality parameter i
Lij = Standart Quality
M = Maximum Value
R = Average Value

Determination of surface water status classifications based on score criteria can be seen in Table 2 as follows:

Table 2. Classification of water quality status based on the pollution index

Score	Criteria
$0.0 \leq PIj \leq 1.0$	Good water quality
$1.0 \leq PIj \leq 5.0$	Moderately polluted
$5.0 \leq PIj \leq 10$	Polluted
$PIj > 10$	Extremely polluted

According to the Minister of Environment and Forestry of the Republic of Indonesia Indonesia No. 27 of 2021, the Pij value each stations was converted to WQI by multiplying the index value Renault with the percentage of quality standards. WQI Qualification river value

could be classified as water quality from "Very Good", "good", "Medium Less", "Not Enough", and "Very Less" categories as given in Table 3.

Table 3. Water quality qualification

No	WQI Skor	Qualification
1.	90 ≤ WQI ≤ 100	Very good
2.	70 ≤ WQI < 90	Good
3.	50 ≤ WQI < 70	Medium Less
4.	25 ≤ WQI < 50	Not enough
5.	0 ≤ WQI < 25	Very less

Source: Minister of Environment and Forestry of the Republic of Indonesia Indonesia No. 27 of 2021

RESULTS AND DISCUSSION

1) Results of Water Quality Analysis

River water sampling has been carried out in the Krueng Baro River, Pidie District, Indonesia, with the aim of measuring physical, chemical and biological parameters. The observation Stations are divided into 5 locations, aimed at representing the character of the upstream, middle and downstream rivers. Analysis of sampling results was carried out at the Environmental Laboratory of the Pidie Regency Environmental Service. The results obtained by measuring data on Krueng Baro River water parameters from the five research Stations were shown in Table 4.

Table 4. Results of water quality analysis from 5 Sections in Krueng Baroe River

No	Type of Parameter	Section T1	Section T2	Section T3	Section T4	Section T5	Units	StandardLimit*)
	Physical Parameters							
1	Odor	No Odor	No Odor	No Odor	No Odor	Odor	-	**No Odor**
2	Temperature	26,4	27,5	27,8	28,2	28,4	^{o}C	**23-30**
3	DHL	200,5	229,2	259,5	264	276	µS/cm	**20 -1500**
4	TSS	19	24	32	38	42	mg/L	**50**
	Chemical Parameters							
5	pH	8,49	7,48	8,18	8,50	8,32	-	**6,0 - 9,0**
6	COD	4,3	3,2	10,7	18,8	16,7	mg/L	**25**
7	BOD_5	2,82	2,50	2,42	2,62	4,51	mg/L	**3**
8	DO	6,64	5,65	6,16	6,14	5,84	mg/L	**4***

	Biology Parameter							
9	Total Coliform	1732,9	1960,8	2092,4	2239,8	2599,4	MPN/100 mL	**5000**

Note: *) Standard limit for Class II Water Classification in Government Regulation No. 22 Year 2021 about Environmental Implementation, Protection and Management

* Standar Limit Value is the minimum value permissible

MPN : Most Probable Number

From Table 4, it can be seen that the four section points has no odor from the water sampler, while on the fifth section there was an odor arising from the water sampling. It was mainly caused by the location of Section 5 nearby the city housing and close to the estuary, where all of the pollution will be drag to the coastline.

For temperatures, the values from each section getting higher along with the river flows to the estuary. The temperature was range from 26.4 to 28.4 degrees Celsius. But the data didn't exceed the standard from Government, so it is still save for the environment.

The DHL values were varied from 200 to 276 uS/L at section 1 to section 5. Measuring the DHL value is a way to measure the ability of water to transmit electric current. This is influenced by the number of salt ions and metals dissolved in the water. The DHL value tends to increase with the entry of waste, detergent or fertilizer containing ionic salts and metals into the water body and when the river flow slows down. The DHL values still met the standard.

TSS (Total dissolve Solid) is solid material such as sand, mud, soil and heavy metals suspended in water areas due to soil erosion carried into water bodies and is expressed in units of mg/l. Class II of Government Water Quality Standards state that the maximum concentration of TSS in water is 50 mg/l. The TSS value measured from 5 Sections of Krueng Baroe River still meets the standard in range of 19 to 42 mg/L. Section 5 is located in Sigli City with a TSS value of 42 mg/l, close to the maximum limit of 50 mg/l and is the highest observed value. The environmental pattern is densely populated housing close to the river mouth, with sandy riverbanks and minimal vegetation, the river flow is increasingly slow, and domestic waste and rubbish are increasingly found in the Krueng Baro river flow. This is thought to result in the accumulation of suspended solids in the riverbed, making it muddy and contributed to higher TSS value.

The pH of many natural waters ranges from 4-9. The low pH of water is caused by the high sulfuric acid content in the water. On the other hand, the high pH of a body of water can be caused by high levels of lime, sulfur and detergent entering the water. Referring to Class II Water Quality Standards, the permitted pH range is 6 - 9. In general, referring to Class II Water Quality Standards, even though it receives the burden of pollution, the water of the Krueng Baro River is still healthy and suitable for use for various human needs. In addition, the pH was close to normal, making some aquatic biota visible during the research. This shows that the pH of the Krueng Baro River still supports the food chain and living organisms.

The COD parameter is used to see the amount of oxygen needed to break down dissolved organic matter in water through chemical oxidation. This means that the COD value will be inversely proportional to the amount of dissolved oxygen (DO) in a body of water. The COD values in Section 1 only, 4.6 mg/L and it increases at Section 4 into 18.8 mg/L and decreased again in Section 5 into 16.7 mg/L. The highest COD value was measured in Section 4, as there was traditional market nearby the sampling area and mostly the waste was dumped into the

river, that contributed to sparsely degradation of chemical for oxidation of oxygen needed by the organism. The increase in the amount of domestic waste requires more oxygen for the decomposition process compared to the two previous observation section points. This finding was confirmed by [11] in Widodo et al (2019), the high COD concentrations commonly occur in rivers in urban areas that are affected by increased waste disposal of domestic, industrial and livestock activities in the water body.

The BOD5 value is a parameter used to see the amount of oxygen needed by bacteria to break down dissolved organic matter through aerobic metabolism. Class II Water Quality Standards state that the maximum concentration of BOD5 in water is 3 mg/l. The measurement results from the Krueng Baro River obtained an average of 2.9 mg/l. Section 1 to Section 4 obtained values that do not exceed the maximum limit. This result is related to the organic material that enters the river and decomposes having a mass equal to the organic material that is successfully decomposed and dissolved in the current of the Krueng Baro River. Section 5 is the only observation point with measurement values exceeding the maximum limit, because the location of T5 which is at the mouth of the river. The environmental baselined of river estuaries with slow water flows and is influenced by sea tides, resulting in the accumulation of dissolved organic matter and waste from the river upstream.

Dissolved oxygen (DO) is an observation parameter that aims to see the availability of dissolved oxygen in waters. Oxygen plays a role in supporting food webs, food chains, energy cycles and material cycles in water ecosystems [12]. Oxygen is closely related to the ability of macro and micro- organisms in waters to metabolize aerobically and carry out their role in the food chain. Class II of Water Quality Standards state that the minimum DO value for river waters is 4 mg/l. Table 4. and show that the DO measurement results obtained stable values in the range of 5.5-6.6 mg/l and an average value of 6.0 mg/l.

The total coliform parameter is used to see the extent of contamination by bacteria in a water body/river. The total coliform bacteria were the object of observation. The presence of total coliform bacterial colonies in river water is directly proportional to the level of river water pollution. Table 4. shows the results of calculating total coliform bacterial colonies from the Krueng Baro River water sampling point ranging from 1700-2500 NPM/100 ml. Referring to Minister of Environment Regulation No. 22 of 2021 Class II, the maximum limit for total coliforms in river water is 5000 NPM/100 ml.

2) Krueng Baroe River Status Based on Environmental PI and WQI Index.

Assessment on the surface water status using PI index has been done by some researchers, e.i [7], [8], [10], and [11]. The pollution index (PI) can be calculated after all observation parameters have been analysed. The analysis value that has been obtained is then calculated using the IP formula and the results are compared with the quality standard value. IP quality standards range from 0 - 10.0. The calculation results show that at Section 1, Section 2, Section 3, Section 4, had the IP value less <1, which means the water quality status is in good condition, while at Section 5 the IP value analysis results was more >1, which indicates the water quality is slightly polluted. Complete information on correlation between PI to Water Quality status is attached in Table 5 and Table 6.

Table 5. Correlation of Pollution Index value into Water Quality Status of Krueng Baroe River

No	Sections	PI Values	Water Quality Status

1	Section 1	0,73	Good
2	Section 2	0,70	Good
3	Section 3	0,69	Good
4	Section 4	0,75	Good
5	Section 5	1,44	Slightly Polluted

Source: Data analysis, 2023

From Table 5, the results of the calculation show that the PI value of the Krueng Baro River from each observation point is relatively the same, namely Good Condition status. This is because the PI value is in the range $0.0 < PIj \leq 1.0$ at Section 1, 2, 3, and 4. The difference in water quality status is at Section 5 with an IP value of 1.44 which is included in the status Slightly Polluted. Slightly polluted status occurs because the BOD parameters from Section 5 exceed the specified quality standards. This is thought to be related to the accumulation of dissolved organic matter.

The WQI index combines the results of several parameters into a certain scale and then makes it into a single number using a certain calculation method so that it can be seen whether the water quality is good or bad [12]. The results of WQI calculations on the Krueng Baro River are shown in Table 6.

Table 6. Transformation of PI Index into WQI values

Water Quality Status	Number of Section that fulfilled the standard	Percentage	Weight of Index Values	Index Values Per Water Quality Assessed	Category
Fulfilled the standard	4	80%	70	56	
Slightly Polluted	1	20%	50	10	
Total	**5**			***WQI = 66**	***Medium Less**

Source: *Minister of Environment and Forestry Regulation of the Republic of Indonesia No. 27 of 2021

Table 6. shows that the results of each Section that meet the quality standards are 4 Sections, (80%) which are called the Percentage of Water Quality that Fulfilled the Standard

from the number of observation points with an Index Value Weight of 70 points based on the Minister of Environment and Forestry Regulation of the Republic of Indonesia No. 27 of 2021. Then, the Water Quality that Fulfilled the Standard, Presentation value of Water parameter is multiplied by the Index Value Weight to get the Index Value Per Water Quality, which is 56 points. Othe Section that didn't match the Fulfilled Standard were counted as 20 percents, or having the index values per water quality of 10. The multification of both values gave 66 points of Water Quality Index, which included in category of Medium Less. From literature [13] it can be said that the WQI data must be combined with a two-dimensional, longitudinal/vertical, hydrodynamic model to study water quality, and it is best suited for relatively long and narrow water bodies, such as rivers, lakes, reservoirs, estuaries, as well as entire river. Krueng Baroe river has a wide, narrow, and a long span flowing currents that suitable for observing the water surface status. The status of river was collected to prevent it from further pollution happened.

CONCLUSION

The surface water status of Krueng Baro River in Pidie, Indonesia still meets the standard of water quality requirements according to Water Quality Class II Government Regulation Number 22 of 2021. The measurement results at Section 1, 2, 3 and 4 were classified in Good Condition. Slightly Polluted was detected at Section 5, which was caused by BOD parameters exceeding predetermined quality standards.

The Pollution Index (PI) from five observation Sections shows that the Krueng Baro River water is still in Good Condition. Meanwhile, the Water Quality Index (WQI) value shows Krueng Baro river was in the medium less category with a value of 66 points.

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