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A study of River quality and pollution index in the water around Coal Mining area

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Key words: Water quality, Water quality status, Pollution index, Water quality index, Environmental quality index, Coal mine.

Abstract

This study aims to determine the quality and status of water quality and environmental quality index in river waters around the coal mining area. This study is an observational study with a descriptive design. After the observation, the data were analyzed in the laboratory. The results were then described. The data analysis technique used was descriptive analysis, which compares the results of laboratory tests from each sample that have been calculated based on the value of the water parameter with water quality standards through assessment of environmental quality referring to the criteria for class II water quality standards, water quality status with pollution index method and environmental quality index. The quality of river water around the coal mining area has decreased which is indicated by the water quality parameter that has exceeded the water quality standard of 16.57-25% and still meets the water quality standard of 75-83.33%. The status of the quality of river water around the coal mine using the Pollution Index (PI) method indicates that it has been moderately to heavily polluted. The Environmental Quality Index (EQI) based on the Water Quality Index (WQI) for river waters around the coal mining area in general is of the quite good criteria.

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Introduction

The use and management of natural resources from coal mineral resources in East Kalimantan reach ± 234.7 million tons. Since the beginning of 2014, the coal mining sector has reached 5.2 million hectares (Hamzah and Rosdiana, 2014; Sardjono, *et al.*, 2012; Sardjono, *et al.*, 2014). Mining area consists of exploration IUP covering an area of 2,897,150.85 hectares, Production IUP covering an area of 500,765.85 hectares and exploitation PKP2B (Coal Mining Exploitation Agreement) covering an area of 673,193.76 hectares (Mining and Energy Service of East Kalimantan Province, 2014)

Exploitation of natural resources has raised various problems with the local environment. Soil, water, and air pollutions, floods, landslides, land degradation, limited natural resources and social problems are some of the problems that often occur from time to time. Open pit mining systems that are generally carried out in Indonesia have an impact on changes in the landscape, physical, chemical and biological properties of the soil, and generally cause damage to the earth surface. This impact will automatically disrupt the ecosystem above, including the water system (Marganingrum and Noviardi, 2010).

The existence of coal mining activities, in addition to creating large ponds due to mining excavation, is also estimated to arise pressure on the surrounding aquatic ecosystem due to changes in rock structure followed by changes in the physical and chemical qualities of the surrounding soil and water. Environmental problems in coal mining activities are generally related to Acid Mine Drainage (AMD).

The water is formed as a result of oxidation of certain sulfide minerals contained in rocks by oxygen in the air in aqueous environments (Marganingrum and Noviardi, 2010).

The water quality index in East Kalimantan in 2011-2017 was 50.88 (2011) 51.39 (2012), 48.67 (2013), 54.80 (2014), 77.90 (2015), 79.77 (2016), 57.79 (2017) [10]. This shows a fluctuating value and has not shown significant changes (poor quality trend, rate of increase of 3.81/year). Organic and inorganic pollutants that enter water bodies can cause the quality of the waters to degrade biologically.

The potential of river waters as a source of food and water for the community will be disrupted. The high level of coal mining activity is feared to have an impact on water quality conditions. It is feared that the negative impact will arise in the availability of water supplies that meet the criteria for quality standards for the continuity of life because the process of natural recovery (self recovery) of an ecosystem requires a long and gradual process.

To realize an increase in river water quality management, one of them requires a study and mapping of river water quality to obtain an overview of the quality conditions of the aquatic environment, especially around the coal mining area.

This study aims to determine the quality of water in river waters around the coal mining area and to determine the status of river water quality using the Pollution Index method based on these parameters. It is expected that the results of this study can provide basic information and outputs that can be useful for local governments and the public, especially regarding river water quality around coal mining areas so that it can be used as input in water management in the coal mining area.

Materials and methods

Study Areas

The study was carried out in river waters around the PT XYX coal mining area in Kutai Kartanegara Regency and Samarinda City, East Kalimantan Province.

Study Focus

This study focused on the concentration of several physical, inorganic and organic parameters as well as the aquatic microbiology listed on water quality standards. The measurement methods and analysis standards used are presented in Table 1.

Table 1. Parameters and Methods of Analysis of River Water Quality.

No.	Parameters	Methods
Physics Parameters		
1.	Water temperature (insitu)	SNI 06-6989.23-2005
2.	Dissolved residue	Potentiometer (Manual Book)
3.	Suspended residue	SNI 06-6989.3-2004
4.	Color	APHA 21th Ed. 2012 (2120-c)
	Inorganic Chemistry Parameters	
5.	Total hardness	SNI 06-6989.12-2009
6.	pH	SNI 06-6989.11-2004
7.	BOD	APHA 21th Ed. 2012 (5210-B)
8.	COD	SNI 6989.2-2009
9.	DO	SNI 06-6989.14-2004
10.	Total phosphate	SNI 06-6989.31-2005
11.	Nitrate	SNI 06-2480-1991
12.	Cobalt	APHA No. 3111 B, Ed. 2012
13.	Chromium (VI)	SNI 6989.71-2009
14.	Copper	APHA No. 3111 B, Ed. 2012
15.	Lead	APHA No. 3111 B, Ed. 2012
16.	Chloride	SNI 6989.19-2009
17.	Fluoride	APHA No. 4500 F-B, Ed. 2012
18.	Nitrate	SNI 06-6989.9-2004
19.	Free chlorine	Colorimetry
20.	Sulfur (H_2S)	SNI 06-6989.75-2009
Microbiology Parameters		
21.	Fecal coliform	APHA 9221 E.1 2012
Organic Chemistry Parameters		
22.	Oil & fat	SNI 06-6989.10-2004
23.	Detergent	SNI 06-6989.51-2005
24.	Phenol compounds	SNI 06-6989.21-2004

Study Procedure

The type of this study is an observational study with a descriptive design that is observation on river water. After the observation, the data were analyzed in the laboratory. The results were then described. The data analysis technique used was descriptive analysis, which compares the results of laboratory tests from each sample that have been calculated based on the value of water parameters with water quality standards.

Data Analysis

The data were processed and analyzed using the environmental quality assessment based on:

1. Determination of water quality uses water quality standards on water sources based on the class according to the Regional Regulation of East Kalimantan Province No. 02 of 2011 concerning Management of Water Quality and Water Pollution Control. The designation of river water in this study uses Class II Water Quality Standard criteria. Class II designation is based on the designation of rivers included in this area of study. It is not yet clear whether the water quality is included in Class I, II, III or IV Water Quality because it has not been determined by the government through legislation in accordance with Article 9, paragraph 1 letter a, b and c, Government Regulation Number: 82 of 2001. In accordance with Government Regulation Number: 82 of 2001 specifically in Article 55, for water bodies whose designation has not been determined, Class II Water Quality Standard applies.

2. Determination of water quality status (pollution) uses pollution index (PI) method based on Minister of Environment Decree Number 115 of 2003 concerning Guidelines for Determining Status of Water Quality. PI values can be used to determine the value of river water quality for a designation and as a basis in improving water quality in the event of pollution. PI was calculated by using the following equation:

$$PI_j = \sqrt{\frac{(C_i/L_{ij})_M^2 + (C_i/L_{ij})_R^2}{2}}$$

Where, PIj is a Pollution Index for designation (j); Ci is the concentration of water quality parameters (i); Lij is the concentration of water quality parameters listed in the Water Designation Standard (j); $(Ci/Lij)_R$

is the average Ci/Lij value and $(Ci/Lij)_M$ is the maximum Ci/Lij value.

The results of the Pollution Index calculation were then evaluated based on the pollution index criteria as follows: 0 ≤ Pij ≤ 1.0 (meets the quality standard or good condition), 1.0 < Pij ≤ 5.0 (mildly polluted), 5.0 < PIj ≤ 10 (moderately polluted), PIj > 10 (severely polluted):

1. The environmental quality index was determined with:

- Percentage of fulfillment of water quality (P) is the number of sample points that meet the status of water quality added up and made in percentages by dividing it by the total number of samples. The quality statuses are "Fulfilling", "Mildly Polluted", "Moderately Polluted" and "Severely Polluted".
- Each percentage of fulfillment of water quality was then multiplied by the index values, which are 70 for fulfilling, 50 for mildly polluted, 30 for moderately polluted and 10 for severely polluted. Each index value per water quality was obtained and then added to the water index for EQI.
- The EQI values in 2017 were classified as very good (EQI > 90), good (70 < EQI ≤ 80), quite good (60 < EQI ≤ 70), not good (50 < EQI ≤ 60), very poor (40 ≤ EQI > 50) and alert (30 ≤ EQI > 40)

Result and discussion

Water Quality According to Class II Designation

The status of water quality is the level of water quality conditions that indicate polluted or good conditions in a water source within a certain time by comparing with the water quality standards set. The value of water quality that exceeds the maximum threshold for its designation will be classified as polluted waters. The quality of river water that has undergone changes is the result of water pollution. This is indicated by the decreasing value of water quality to a certain level which causes water to dysfunction according to its designation. River water quality around the coal mine in terms of physical, inorganic chemistry, microbiology and organic chemistry parameters indicates a decline in quality.

This can be seen some water quality parameters that have exceeded the environmental quality standards required in the East Kalimantan Provincial Regulation No. 02 of 2011 concerning Management of Water Quality and Water Pollution Control for class II designation. The results of the field measurement and laboratory analysis on the quality of several physical, inorganic chemistry, microbiology and organic chemistry parameters in the waters surrounding coal mines are presented in Table 2 as follows.

Table 2. Results of Physics-Chemical-Biological Analysis of Water Quality in River Waters around Coal Mining Areas Based on Class II Water Quality Criteria of Regional Regulation of East Kalimantan Province No. 02 of 2011.

No	Parameters	Units	EQS Class II	Results						
				(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Physic									
1.	Temperature	°C	Deviation ±3	28.55	27.30	27.33	27.35	27.10	26.75	29.02
2.	Dissolved residue	mg/liter	1000	150.25	155.00	18.95	165.15	155.30	140.18	129.83
3.	Suspended residue	mg/liter	50	33.00	14.50	40.00	28.00	34.00	53.00	48.75
4.	Color	PtCo	180	27.57	43.50	120.20	55.46	83.35	407.07	107.25
	Inorganic Chemistry									
5.	Total hardness	mg/liter	50	83.22	80.98	23.81	57.48	53.51	43.19	23.10
6.	pH	-	6 - 9	6.95	7.15	6.79	7.07	7.05	6.94	7.05
7.	BOD	mg/liter	3	2.45	0.84	1.44	1.45	1.84	0.74	1.54
8.	COD	mg/liter	25	7.53	10.54	14.43	15.46	21.74	10.61	6.31
9.	*Dissolved Oxygen*	mg/liter	4	6.90	6.81	4.74	5.97	5.61	5.53	3.70
10.	Total phosphate	mg/liter	0.2	0.02	0.02	0.02	0.03	0.05	0.03	0.17
11.	Nitrate	mg/liter	10	0.99	0.46	0.06	0.27	0.19	0.58	0.88
12.	Cobalt	mg/liter	0.2	0.015	<0,02	<0,02	<0,02	<0,02	<0,02	<0,02
13.	Chromium	mg/liter	0.05	0.02	0.03	0.05	<0,01	0.06	0.02	0.01
14.	Copper	mg/liter	0.02	<0,003	<0,003	<0,003	<0,003	<0,003	0.004	0.002
15.	Lead	mg/liter	0.03	0.01	<0,01	<0,01	<0,01	<0,01	<0,01	<0,01
16.	Chloride	mg/liter	600	4.76	4.39	7.15	9.80	10.55	8.36	11.68
17.	Fluoride	mg/liter	1.5	<0,002	0.02	0.03	0.09	0.05	0.15	0.12
18.	Nitrate	mg/liter	0.06	0.003	0.006	0.01	0.006	0.02	0.02	0.007
19.	Free chlorine	mg/liter	0.03	0.20	0.07	0.20	0.68	0.21	0.31	0.34
20.	Sulfur (H_2S)	mg/liter	0.002	0.51	1.22	1.83	1.74	1.05	1.94	0.77

No	Parameters	Units	EQS Class II	Results (1)	(2)	(3)	(4)	(5)	(6)	(7)
	Microbiology									
21.	Fecal coliform	MPN/100 ml	1000	14.00	9.00	80.00	3000	160000	1050	1650
	Organic Chemistry									
22.	Oil & fat	µg/liter	1000	800	500	1050	1000	400	300	400
23.	Detergent	µg/liter	200	19.67	<25	121.87	<25	<25	30.08	37.03
24.	Phenol compounds	µg/liter	1	228.01	198.76	180.33	165.84	62.93	198.64	711.92

Remark: Sampling Location: Busang Jonggon Operation Block (BJO) (1) Kedayan River, (2) Keramba River, (3) Tenggarong River; Gitan Operation Block (GTO) (4) Jambu River, (5) Endau River, (6) Jembayan River and Teluk Dalam Operation Block (TDO) (7) Kutai Baru River.

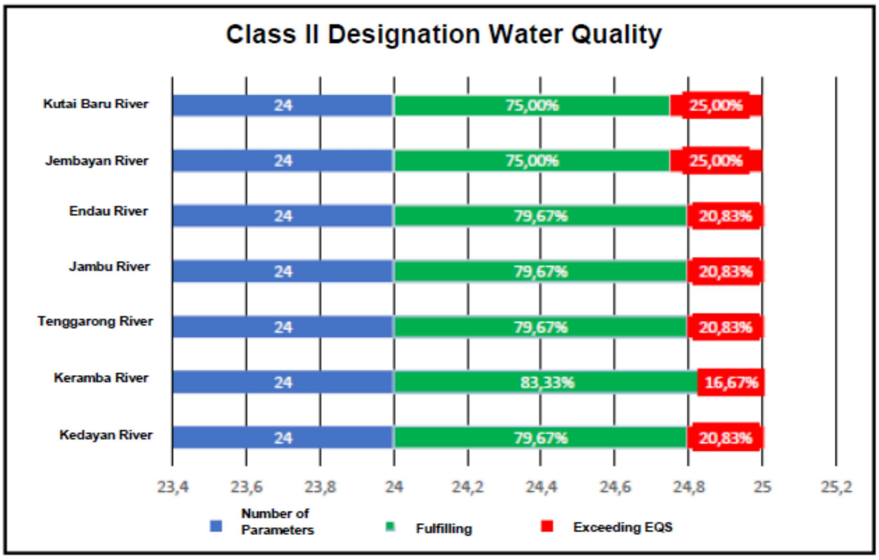

Fig. 1. Water Quality Chart for Class II Designation.

The results of measurements of water quality in river waters around the coal mining area based on the standard criteria for water quality in water sources for a class II designation indicate that:

a. Kedayan River: of 24 parameters, 19 parameters (79.67%) fulfill water quality standards while 5 parameters (20.83%) exceed water quality standards, namely temperature, total hardness, free chlorine, sulfur and phenol compound parameters.
b. Keramba River: of 24 parameters, 20 parameters (83.33%) fulfill water quality standards while 4 parameters (16.67%) exceed water quality standards, namely total hardness, free chlorine, sulfur and phenol compound parameters.
c. Tenggarong River: of 24 parameters, 19 parameters (79.67%) fulfill water quality standards while 5 parameters (20.83%) exceed water quality standards, namely free chlorine, sulfur, oil and fat, detergent and phenol compound parameters.
d. Jambu and Endau Rivers: of 24 parameters, 19 parameters (79.67%) fulfill water quality standards while 5 parameters (20.83%) exceed water quality standards, namely total hardness, free chlorine, sulfur, fecal coliform and phenol compound parameters.
e. Jembayan River: of 24 parameters, 18 parameters (75%) fulfill water quality standards while 6 parameters (25%) exceed water quality standards, namely suspended residue, color, free chlorine, sulfur, fecal coliform and phenol compound parameters.
f. Kutai Baru River: of 24 parameters, 18 parameters (75%) fulfill water quality standards while 6 parameters (25%) exceed water quality standards, namely temperature, DO, free chlorine, sulfur, fecal coliform and phenol compound parameters.

The results of the analysis show the quality of river water that has undergone changes as a result of water pollution. This is indicated by the decreasing value of river water quality to a certain level which causes water to dysfunction according to its class II designation. Parameters that have exceeded the water quality standards are:

A. Temperatures in 2 (two) rivers. Water temperatures play a role in controlling the condition of aquatic ecosystems. Increased temperature causes an increase in decomposition of organic matter by microbes (Effendi, 2003). The increase in temperature can cause stratification or coating of water. The stratification of this water can affect the stirring of water needed in order to spread oxygen so that the coating of water in the base layer does not become anaerobic. Changes in surface temperature can affect physical, chemical and biological processes in these waters (Kusumaningtyas, *et al*., 2014).

B. Suspended residues in 1 (one) river. High TSS parameters indicate high levels of pollution and inhibit the penetration of light into the water resulting in disruption of the photosynthesis process of aquatic biota. In general, TSS consists of mud, fine sand and microorganisms. The high TSS value is thought to be caused by erosion/avalanche of soil carried over to water bodies. Domestic activities that produce domestic waste can add the levels of suspended solids to the river, and decaying plants and animals also affect the levels of Total Suspended Solid (TSS). Organic particles present in the decay process can contribute to the increased concentration of Total Suspended Solid (TSS) [24].

C. Color in 1 (one) river. The increase of the value of color parameters in water can be caused by the presence of organic and inorganic materials due to the presence of plankton, humus, metal ions and other materials (Effendi, 2003). Colors in water can also be caused by the presence of organisms, colored suspended materials and extracts of organic compounds and plants. Colors derived from industrial waste materials may be harmful to health (Unus, 1996).

D. Total hardness in 4 (four) rivers. The high value of hardness is thought to be caused by the presence of CaCO content which is naturally found in the river rock in the location, the formation of limestone and water management with the use of excessive lime. Lime (CaCO) can dissolve in water due to the presence of CO to form carbonate minerals that are soluble in water. The decline of the hardness level of water can be caused by the reduction of Ca^{2+} and Mg^{3+} ions in water. Reduced Ca^{2+} and Mg^{3+} ions in water are thought to occur due to changes in these ions into solids that are insoluble in water and settle in the riverbed as solid $CaCO_3$ and $MgCO_3$. The entry of $Ca(OH)_2$ into the river waters can occur naturally from waste originating from domestic activities (Abidjulu, 2008; Ruliasih. 2011).

D. Dissolved Oxygen/DO in 1 (one) river. Low Dissolved Oxygen (DO) concentration is likely caused by the presence of low river vegetation biota. The main source of oxygen in a waters originates from photosynthesis of organisms that live in these waters, apart from the process of diffusion from free air. The DO content in a waters is closely related to the level of pollution, type of waste and the amount of organic matter in a waters (Salmin, 2005).

E. Free chlorine in 7 (seven) rivers. The high level of free chlorine is thought to be caused by the disposal of chlorine-containing waste into the water, namely the use of pesticides on agricultural land. Chlorine-containing products have the potential to pollute the environment such as the use of organochlorine pesticides, which have a very long rate of degradation in the environment (half-life of 2-4 years) (Hasan, 2006).

F. Sulfur as H_2S on 7 (seven) rivers. The high sulfur as H_2S in water is thought to be caused by the size of domestic waste and the process of decaying organic matter. The low value of sulfur in water shows that there is still a small amount of household waste containing sulfide which is wasted into the waters. In addition, it is also thought to be caused by the low process of decomposition of organic materials containing sulfur by anaerobic bacteria and as a result of reduction with anaerobic conditions against sulfate by microorganisms (Apriliana, *et al.*, 2014).

G. Fecal coliform on 4 (four) rivers. The high fecal coliform is thought to be caused by domestic activities in this region so that many activities are carried out around the river. The influence of household waste such as feces or other food scraps still dominates as a factor causing pollution of the water environment (Adrianto, 2018).

H. Oil and fat in 1 (one) river. Waste disposal and input of domestic/industrial waste in the river contributes greatly to the content of organic matter, so that the organic matter containing oil and fat increases quite high. The presence of an oil layer on the water surface causes the penetration of sunlight and oxygen into the water to be reduced, making it difficult for decomposing microorganisms to work. The occurrence of the oxidation process by air oxygen to non-saturated fatty acids in fat to form labile peroxide compounds (Hendrawan, 2008).

I. Detergent in 1 (one) river. The high detergent content is due to domestic activities for washing and bathing activities. High concentrations of detergent can interfere with the aquatic life such as fish, shellfish, snails and plankton in river waters. Excessive use of detergent wasted into aquatic environments that endanger aquatic life is caused by high concentrations of detergent waste, containing toxic materials and slow decomposition process (Komarawidjaya, 2004).

J. Phenol compounds in 7 (seven) rivers. High phenol content is thought to be the result of decay of organic matter in the form of leaves and wood, animal feed residues and organic fertilizer residues. Phenol compounds (C_6H_5OH) are compounds with hydroxyl groups (-OH) bound to aromatic hydrocarbons which can be white crystalline solids with a distinctive odor. Phenol compounds are found in industrial waste, one of which is the coal industry (Yudo and Nusa, 2019). The high phenol compound is thought to be caused by the low rate of degradation or decomposition of this compound. In conditions of high temperature and low oxygen solubility in water, and high water pH, the degradation rate of these compounds will also be low. At low pH, the activity of microorganisms will be inhibited. In addition, oxygen cannot dissolve at low water pH, so that it will reduce the supply of oxygen needed by microorganisms to decompose phenol compounds in water (Luvita, 2012).

Status of Water Quality with Pollution Index Method

The status of river water quality shows the level of pollution of a water source in a certain time, compared to the specified water quality standard. The river is said to be polluted if it cannot be used according to its location normally (Mahyudin, *et al.*, 2015). To determine the level of pollution relative to the permitted water quality parameters, the determination of water quality status is used with the pollution index (PI) method. If the pollution index value is smaller than 1.0, then the water sample fulfills the intended quality standard. If it is greater than 1.0, the sample is not fulfilling the quality standard.

Management of water quality on the basis of this pollution index can provide input to decision makers to be able to assess the quality of water bodies for designation and take action to improve quality if there is a decrease in quality due to polluting compounds (Kepmen LH No.115 2003). The results of the analysis of the pollution index values are presented in Table 3 and Fig. 2.

The results of the calculation of the pollution index (PI) above indicate that the river water quality has declined or there are several parameters that have exceeded the quality standard. The results of the PI analysis show that river waters around the coal mine have been moderately to heavily polluted. Kedayan River is categorized as a river with a moderate pollutant quality status (PI 9.29), while Keramba River (PI 10.61), Tenggarong River (PI 11.25), Jambu River (PI 11.18), Endau River (PI 10.43)), Jembayan River (PI 11.26) and Kutai Baru River (PI 10.89) are categorized as rivers with severe pollution status. This reduction in water quality is also related to the presence of land and domestic activities around it.

Table 3. Results of Calculation of Water Quality Status Using Pollution Index Method.

Sample of River	Pollution Index Value	Status of Water Quality
Kedayan River	9.29	Moderately Polluted
Keramba River	10.61	Severely Polluted
Tenggarong River	11.25	Severely Polluted
Jambu River	11.18	Severely Polluted
Endau River	10.43	Severely Polluted
Jembayan River	11.36	Severely Polluted
Kutai Baru River	10.89	Severely Polluted

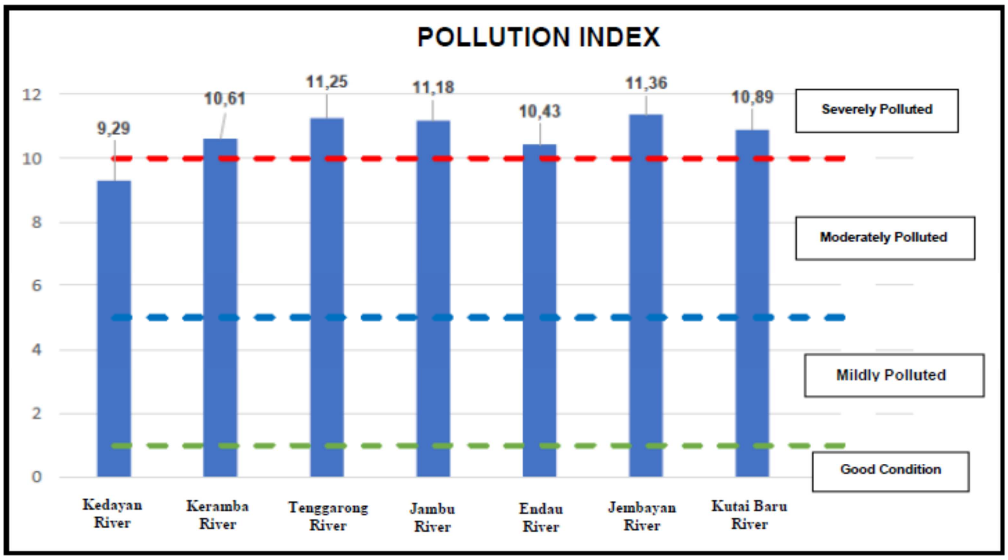

Fig. 2. Chart of Status of Water Quality with Pollution Index Method.

Water Quality Index (WQI)

The Water Quality Index (WQI) and Environmental Quality Index (EQI) provide an initial description or indication that gives a quick conclusion of an environmental condition.

At a certain scope and period, namely the information about environmental conditions as an evaluation of sustainable and environmental development policy. The results of the water quality index calculation are presented in full in Table 4.

Table 4. Results of Calculation of Water Quality Index and Environmental Quality Index.

Location	Water Quality Index (%)	Environmental Quality Index Criteria
Kedayan River	61.67	Quite Good
Keramba River	63.33	Quite Good
Tenggarong River	62.50	Quite Good
Jambu River	61.67	Quite Good
Endau River	60.00	Not Good
Jembayan River	60.83	Quite Good
Kutai Baru River	60.83	Quite Good

EQI refers to WQI values for river waters around the mining area in general which are included in the quite good criteria in Kedayan River (WQI 61.67%), Keramba River (WQI 63.33%), Tenggarong River (WQI 62.50%), Jambu River (WQI 61.67%), Jembayan River (WQI 60.83%) and Kutai Baru River (WQI 60.83) while Endau River (WQI 60.00%) is included in the not good criteria.

This EQI value is higher than that of East Kalimantan Province in 2017 of 57.79%. Despite its quite good criteria, the WQI value obtained approaches the limit of the not good criteria. This shows that environmental management in coal mining areas is under greater pressure from the use of environmental resources compared to efforts to improve environmental quality.

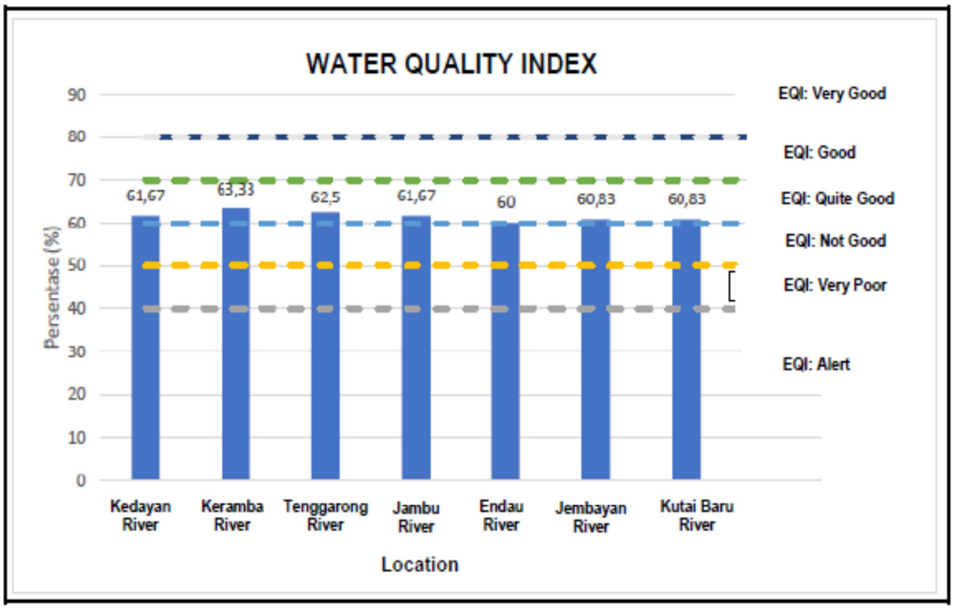

Fig. 3. Chart of Environmental Quality Index Criteria.

For this reason, it is necessary to improve water quality management performance so that water quality does not exceed the required quality standards. The management performance that has been carried out by coal mining companies to maintain water quality includes optimizing wastewater treatment in settling ponds, especially those closest to public channels, and following up with the provision of Al_2SO_4 (alum) and lime ($CaCO_3$) before the water is removed from public water. The use of excessive lime not according to dosage will react with metals or cations with a valence of two such as Fe, Sr., Mn, Ca and Mg, thus increasing the total hardness in river water. The high free chlorine and sulfur, in addition to increasing organic matter in the river, also need to pay attention to the dosage of the use of chemical fertilizers and pesticides in soil and plant repair activities. Policy priorities that need to be carried out to prevent water pollution and decrease water quality so that river water can be utilized in accordance with its designation continuously are as follows: inventory and identification of water pollutant sources, waste management, determining the capacity of pollution loads, maintaining local protection zones, monitoring waste water disposal, monitoring river water quality and community participation in efforts to control water pollution.

Conclusion

1. The river water quality around coal mines has decreased as indicated by the data that 16.57-25% of water quality parameters have exceeded water quality standards and 75-83.33% parameters still fulfill water quality standards based on East Kalimantan Provincial Regulation No. 02 of 2011 about Water Quality Management and Water Pollution Control for class II designation.
2. The status of water quality in river waters around the coal mine using the Pollution Index (PI) method indicates that it has been moderately to heavily polluted, namely the Kedayan River with moderate pollution quality status (PI 9.29), while Keramba River (PI 10.61), Tenggarong River (PI 11.25), Jambu River (PI 11.18), Endau River (PI 10.43), Jembayan River (PI 11.26) and Kutai Baru River (PI 10.89) with severe pollution quality status
3. EQI refers to WQI values for river waters around the mining area in general which are included in the quite good criteria in Kedayan River (WQI 61.67%), Keramba River (WQI 63.33%), Tenggarong River (WQI 62.50%), Jambu River (WQI 61.67%), Jembayan River (WQI 60.83%) and Kutai Baru River (WQI 60.83) while Endau River (WQI 60.00%) is included in the not good criteria.

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