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Surface water quality analysis and monitoring in Aceh Jaya district, Indonesia

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Abstract. Nowadays, changes in the quality of surface water are becoming a serious problem to support clean water for the community. Aceh Jaya district as abundant natural resources that need to be processed and utilized, such as gold mining, agriculture, palm oil mills, and others. These activities can provide economic added value and also decrease the quality of the environment, such as changes in the quality of surface water. Surface water quality analysis has been studied to determine the different ion concentrations in the waters on the river Kr. Teunom and the river Kr. Ligan of Aceh Jaya regency. The results of the analysis of the water quality of the river show were physically the water quality of the river Kr. Teunom and Kr. Ligands are still following quality standards. Based on chemical parameters, the water quality of the river Kr. Teunom and Kr. Ligands, in general, are found in a low level of heavy metals such as Hg, Mn, Pb, As, Cd, and Cr in water. Cyanide levels in all samples of the river water are following the quality standard PPRI No. 82 of 2001 Class I and regulation of the Minister of Health Number: 492/Menkes/Per/IV/2010 concerning drinking water quality requirements. The presence of mercury ions in all river water must be a concern because mercury can accumulate in the tissues of aquatic organisms for a long time.

1. Introduction

Water is one of the essential needs of living things in this world; humans, animals, and plants, all living things need water to survive. Besides, water is a commodity strategic for business, industry, agriculture/irrigation, and food security [1]. Water quality will continue to change from time to time because of community and industrial activities that dispose of pollutants into water bodies. The presence and quality of water have a direct effect on human survival and health. Therefore to ensure the continuity of life and human health, management of water quality at various sources is carried out by efforts to control water pollution and maintain water functions [2]. The water quality is under its designation and ensures that water quality remains in its natural condition and meets water quality standards. To maintain water quality so that it can be used sustainably following the desired water quality level, it is necessary to preserve or control the water quality [3].

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The water quality monitoring is required to be conducted as an effort to manage environmental quality and to obtain monitoring data that can be used to assess water quality conditions. Appropriate management measures can be taken from the water quality assessment. Water quality monitoring is an activity that needs to be carried out continuously. Aceh Jaya regency has natural resources that need to be processed and utilized, such as gold mining, agriculture, palm oil mills. The activities can provide economic added value. The activities can also harm changes/deterioration in environmental quality, such as changes in surface water quality. The artisanal gold mining and processing carried out by a part of the Aceh Jaya community are seen as the basis of environmental damage and pollution. Environmental pollution is mainly associated with gold ore processing activities with an amalgamation process where mercury (Hg) is used as a gold binding media. The tailings produced also contain many other heavy metals which are flowed into reservoirs and water bodies. Among all heavy metal elements, Hg ranks first in terms of its toxic properties, followed by heavy metals including cadmium (Cd), silver (Ag), nickel (Ni), lead (Pb), arsenic (As), chromium (Cr), tin (Sn), and zinc (Zn). The presence of heavy metals is one of the critical indicators used to detect changes in water quality. The heavy metals cannot be destroyed by living organisms and accumulate into the environment to form complex compounds with organic and inorganic materials by adsorption and combination. Water organism that lives in contaminated water can be accumulated the heavy metals in their body tissues. Therefore humans can experience accumulation of heavy metals through the food chain.

Therefore analysis and monitoring of river water quality in Aceh Jaya district is essential to be conducted. The study of surface water quality is expected to provide information about the content of Hg, As, copper (Cu), Cd, Cr, iron (Fe), and Pb levels in water of the Krueng (Kr.) Teunom, Kr. Panga and Kr. Ligan rivers in the Aceh Jaya Regency area and are input for policymakers to take necessary steps in water resources management in Aceh Jaya. Kr. Teunom, Kr. Panga and Kr. Ligan rivers is the primary source of clean water for the surrounding community.

2. Materials and methods

2.1. Equipment and chemicals

The main equipment used is AAS Shimadzu AA-6300 brand for analysis of heavy metal content and Genesys UV-Vis spectrophotometer for analysis of non-metallic compounds. The pH meter is used to analyze water pH. The chemicals used are sulfuric acid, hydrochloric acid, HgCl_2 , $\text{SnCl}_2 \cdot 2\text{H}_2\text{O}$, $\text{Pb}(\text{NO}_3)_2$, As_2O_3 , $\text{K}_2\text{Cr}_2\text{O}_7$, FeCl_3 , NaOH , K_2CrO_4 , $\text{Fe}(\text{NH}_4)_2(\text{SO}_4)_2 \cdot 6\text{H}_2\text{O}$ aquades, acetylene gas, and water. All chemicals used were analytical grade quality.

2.2. Surface water sample

Water quality testing is carried out in situ and laboratory analysis. Water samples analyzed in the laboratory are store in sample bottles and a refrigerator. The sampling method used is Grab sampling. In this monitoring activity, water samples are taken by using a composite water sampler and grab at each monitoring location point. The location of sampling is determined based on data on surface water conditions that represent the upstream and downstream parts of the activity area, as illustrated in Figure 1.

2.3. Water quality analysis

The parameters of water quality can be seen in Table 1. Analysis of river water quality is carried out using a standard method [4,5]. River water quality standards will use assessment of the quality of the condition of water quality with Government Regulation No. 82 of 2001 and Regulation of the Minister of Health Republic of Indonesia No. 492/MENKES/PER/IV/2010 for drinking water standard quality.

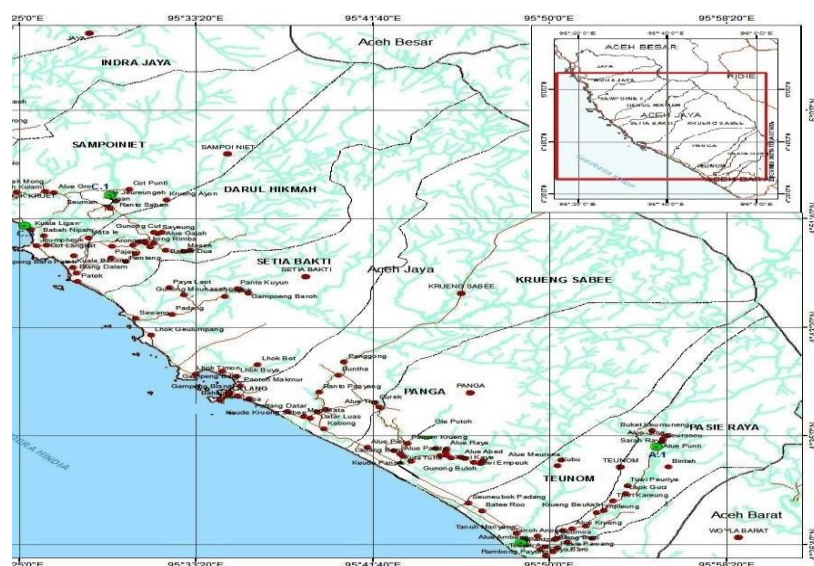


Figure 1. Map of sampling location.

Tabel 1. Parameter and method of Surface water analysis in Aceh Jaya District.

No	Name of Parameter	Unit	Method
Physical			
1	Temperature	°C	Thermometry
2	Total dissolved solids (TDS)	mg/L	Potentiometry
3	Total suspended solids (TSS)	mg/L	Gravimetry
Chemical			
1	pH	-	Potentiometry
2	Nitrate (NO ₃ -N)	mg/L	Spectrophotometry
3	Nitrite (NO ₂ -N)	mg/L	Spectrophotometry
4	Cyanide (CN ⁻)	mg/L	Spectrophotometry
5	BOD	mg/L	Winkler
6	COD	mg/L	Permanganate
7	Iron (Fe)	mg/L	AAS
8	Manganese (Mn)	mg/L	AAS
9	Lead (Pb)	mg/L	AAS
10	Zinc (Zn)	mg/L	AAS
11	Mercury (Hg)	mg/L	AAS
12	Arsen (As)	mg/L	AAS
13	Cadmium (Cd)	mg/L	AAS
14	Chromium (Cr)	mg/L	AAS

3. Results and discussion

3.1. Kr. Teunom river water quality

Water quality monitoring in Aceh Jaya Regency was carried out in September 2018. This month the area of Aceh Jaya Regency was experiencing a moderate and mild rainy season. Rainfall factors will affect the concentration or levels of physical and chemical parameters. The results of measurements of water quality both physical and chemical parameters of the Kr. Teunom water sample can be seen in Table 2. The physical parameters do not directly affect human health, such as temperature, TSS, and TDS. The result indicates that physical water is generally in relatively good condition which is agreed to the class I water quality standard stipulated by PP. No. 82 of 2001 and PerMenKes No.

492/MENKES/PER/IV/2010. The water temperatures are not different at the sampling site show good value for the life of organisms in general and According to optimal temperatures for plankton life range from 20 - 30°C [6].

Table 2. Data on laboratory analysis of river water physical and chemical parameters kr. Teunom Aceh Jaya regency in 2018.

No	Name of Parameter	Unit	Result		Standard	
Physical			A1	A2	*	**
1	Temperature	°C	26.4	26.5	Dev 3	Dev 3
2	Total dissolved solids (TDS)	mg/L	87	71	500	1000
3	Total suspended solids (TSS)	mg/L	41	12	-	50
Chemical						
1	pH ^{*)}	-	7.7	7.80	6.5-8.5	6-9
2	Nitrate (NO ₃ -N)	mg/L	0.001	< 0.001	50	10
3	Nitrite (NO ₂ -N)	mg/L	0.004	0.004	3	0.06
4	Cyanide (CN ⁻)	mg/L	0.001	< 0.01	0.07	0.02
5	BOD	mg/L	0.2857	0.7357	2	2
6	COD	mg/L	0.8	2	10	10
7	Iron (Fe)	mg/L	0.221	0.260	0.3	0.3
8	Manganese (Mn)	mg/L	<0.002	<0.002	0.4	1
9	Lead (Pb)	mg/L	<0.001	<0.001	0.01	0.03
10	Mercury (Hg)	mg/L	0.00009	0.00057	0.001	0.001
10	Arsen (As)	mg/L	ND	ND	0.01	0.05
12	Cadmium (Cd)	mg/L	<0.002	<0.002	0.003	0.01
13	Chromium (Cr)	mg/L	<0.002	<0.002	0.05	0.05

ND = very low concentrations and undetected

A1: Teunom River (Upper) River, Alue Jang Village, Kec. Pasie Raya; N: 04° 34" 788'; E: 095° 35" 416'

A2: River Teunom River (Downstream/Muara), Paro Baro Village, Kec. Teunom; N: 04° 34" 788'; E: 095° 55" 416'

* Quality standards in accordance with Minister of Health Regulation Number: 492/Menkes/Per/IV/2010;

** Standard quality according to PPRI No. 82 of 2001 Class I

The test results on TSS values showed relatively low concentrations in the river Kr. Teunom and not yet above the quality standard. This TSS also confirms that there are not many particles suspended in water, the total suspended solids concentration was 12 - 41 mg/L. The water condition of the Kr. Teunom River is very volatile, depending on weather conditions during sampling. Krueng Teunom is one of the relatively large watersheds that originated from Tangse to Pidie District. In rainy season upstream the river will suspend particles to be carried away by rainwater flowing into the river so that it can cause an increase in TSS content in the Kr. Teunom river. The increases in TSS value can be caused by many deforestation factors that cause erosion of the soil that enters the waters through a run-off process. The suspended substances in water consist of various kinds of substances, for example, fine sand, clay, and natural mud, which are inorganic materials or organic materials. Organic materials which are suspended substances consist of various types of compounds such as cellulose, fat, proteins, microorganisms such as bacteria, and algae.

Table 6 also describes the presence of heavy metals in river water Kr. Teunom. Based on the water quality parameters tested shows that river water Kr. Teunom shows that there are very low levels of heavy metals in the water and partially undetectable (ND). Mn, Pb, As, Cd, Cr, and Fe metals are included in the low concentration group, so the Hg metal concentration is very low in the water. The metal mercury concentration is very low both upstream and downstream Kr. Teunom. Based on these Hg levels, the quality of these waters is safe for humans and water organism, still within the range allowed. The presence of metal mercury in water can indirectly indicate the spread of mercury metal has been able to enter the chain of food consumed by the community. Organism water like fish and shells are very vulnerable to contamination by mercury. The mercury is accumulating in the body's

tissues will be chronic and acute so that it can endanger the health of the people who consume it. The measurement results show that the mercury levels in the river are still appropriate to the quality standard according to PP. No. 82 of 2001 that the limitation of maximum mercury content is 0.001 ppm. Whereas the WHO sets a lower maximum limit of 0.0001 ppm for water. The presence of mercury in the Kr. Teunom river flow was thought to have originated from waste from gold processing activities in community settlements adjacent to the Krueng Teunom river or other sources of activity above the river Kr. Teunom located in the Tangse area and related to gold mining and processing activities that use mercury, especially in the amalgamation process.

Table 3. Data on the laboratory analysis of river water physical and chemical parameters Kr. Ligan of Aceh Jaya regency in 2018.

No	Name of Parameter	Unit	Result		Standard	
Physical			C1	C2	*	**
1	Temperature	°C	27.5	27.4	Dev 3	Dev 3
2	Total dissolved solid (TDS)	mg/L	78	78	500	1000
3	Total suspended solid (TSS)	mg/L	8	1	-	50
Chemical						
1	pH ^(*)	-	7.82	7.78	6.5-8.5	6-9
2	Nitrate (NO ₃ -N)	mg/L	3	<0.001	50	10
3	Nitrite (NO ₂ -N)	mg/L	<0.001	<0.001	3	0.06
4	Cyanide (CN ⁻)	mg/L	0.003	<0.001	0.07	0.02
5	BOD	mg/L	0.569	1.056	2	2
6	COD	mg/L	1.6	2.8	10	10
7	Iron (Fe)	mg/L	1.663	0.748	0.3	0.3
8	Manganese (Mn)	mg/L	0.064	<0.002	0.4	1
9	Lead (Pb)	mg/L	<0.001	<0.001	0.01	0.03
10	Mercury (Hg)	mg/L	0.00017	ND	0.001	0.001
10	Arsen (As)	mg/L	ND	ND	0.01	0.05
12	Cadmium (Cd)	mg/L	<0.002	<0.002	0.003	0.01
13	Chromium (Cr)	mg/L	<0.002	<0.002	0.05	0.05

ND = very low concentration and undetectable

C1: River Kr. Ligan (upstream), N: 04° 53' 443"; E: 095° 29' 349"

C2: River Kr. Ligan (downstream / estuary), N: 04° 51,090'; E: 095° 25,303'

* Quality standards in accordance with the Regulation of the Minister of Health Number: 492/Menkes/Per/IV/2010;

** Quality standards according to PPRI No. 82 of 2001 Class I

The presence of iron content in water is due to originating from dissolved iron metal from the soil by water from the upstream of Krueng Teunom river. Iron levels were found to range from 0.221 to 0.260 ppm. According to PerMenKes No. 492/MENKES/PER/IV/2010, iron is one of the chemical parameters that are not directly related to health and includes less toxic heavy metals. In biological systems such as animals, humans, and plants, these metals are essential, less stable, and slowly turn into ferrous (Fe II) or ferric (Fe III). The content of Fe in an animal's body varies greatly depending on health status, nutrition, age, gender, and species. Iron can be dangerous to humans at higher levels. Iron metal poisoning can irritate the stomach and intestines, and they can cause tissue damage and organ dysfunction. Iron poisoning can also cause liver disease [7].

Therefore the results of the measurement of CN levels in Kr. Teunom waters based on location showed CN concentrations in water at concentrations between <0.001 and 0.001 ppm. This data shows that CN distribution patterns are relatively low. This CN level is still following normal CN levels in Class I surface water sources where the threshold value is 0.02 ppm. Based on these CN levels, the quality of these waters is still safe for humans and water organism. The BOD value of water samples Kr. Teunom has a range of 0.2857 to 0.7357 mg/L. Therefore COD content is obtained in a range of 0.8 - 2 mg/L. The low content of BOD and COD due to the lack of dissolved and suspended organic or inorganic particles as indicated TSS value.

3.2. Kr. Ligan river water quality

In connection with community activities that are increasing in the Sampoiniet District area, especially around and along the river Kr. Ligan that are thought to have an impact on environmental pollution then analysis the quality of water for the river Kr. Ligan are essential. Water quality testing is also intended to find out how the concentration of components of organic and inorganic compounds, especially heavy metals contained in water. The main heavy metals analyzed were Hg, As, Cu, Zn, Cr, Fe, Cd, Mn and Pb. Whereas other critical inorganic parameters are CN. The waters of Kr. Ligan river water is greatly influenced by dissolved and carried material or into the water body from community activities and other activities around the river that produce and dispose of waste into the river.

Table 3. shows the results of the analysis of Kr. Ligan water quality, both physically and chemically. Physically the water quality of the river Kr. Ligan are still following quality standards. TSS and TDS values are relatively low in all Kr Ligan river samples, which is below the class I water quality standard stipulated by PP. No. 82 of 2001. Based on Table 3. the results of the analysis of chemical parameters of heavy metals indicate the presence of metal Hg, Cu, Zn, Cr, Fe, Cd and Mn in water. Especially the concentration of metal mercury has been in low level detected in the river Kr. Ligan.

The presence of CN compounds in the waters of Kr. Ligan is still below the quality standard. Based on location, the concentration of CN in water is at a concentration of <0.01ppm. This CN level is still following normal CN levels in Class I surface water sources where the threshold value is 0.02 ppm. Based on these CN levels, the quality of these waters is still safe for humans and water organism. Test results for water samples Kr. Ligan that have been carried out also show that the BOD and COD values are relatively low. The low value of BOD and COD is thought to be due to the lack of dissolved and suspended organic particles as indicated by the low TSS value of the river water.

4. Conclusions

This present study has described the results of the analysis of the water quality of the river show that physically the water quality of the river Kr. Teunom and Kr. Ligan are still following quality standards. Based on chemical parameters, the water quality of the river Kr. Teunom and Kr. Ligan, in general, are found in a low level of heavy metals such as Hg, Mn, Pb, As, Cd, and Cr in water. Cyanide levels in all samples of river water are still below the quality standard following PPRI No. 82 of 2001 Class I concerning water for designation as drinking water quality raw material and Regulation of the Minister of Health Number: 492/Menkes/Per/IV/2010 concerning drinking water quality requirements. However, the presence of mercury ions in all river water must be a concern because mercury can accumulate in the tissues of aquatic organisms for a long time.

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