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Biological indicators of aquatic health: Evaluating water quality in Krueng Baru River

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ABSTRACT

The purpose of this study was to determine the quality of water contained in the Krueng Baru River area, South Aceh Regency, and to determine the effect of iron metal (Fe) pollution on the structure of snail shells found in the Krueng Baru River area, South Aceh Regency. This research was conducted on February 20/March 2021. Research sampling in the Krueng Baru River, South Aceh Regency. Ferrous heavy metals (Fe) were analyzed at the Chemistry Laboratory and Biological Laboratory of Syiah Kuala University. The research site contained research samples of suction snails (*Cerithidea obtusa*). The sampling technique uses a purposive sampling technique. The data processing method used in the research is the descriptive method. Based on the results of research that have been done, Fe heavy metal levels in water and biological indicators of *Cerithidea obtusa* at station I 1,264 ppm, station III 2,323 ppm, and most obtained at station II with an average amount of Fe levels reaching 2,592 ppm. Based on the results of the analysis, in terms of the biological indicators of the sucker *Cerithidea obtusa*, it shows that there are differences in water quality at Station I, Station II and Station III. Conclusions based on the results of research on water quality in the Krueng Baru River show the content of heavy metal compounds (Fe) in the river, which means the area is polluted with Fe.

Conflict of interest: The authors declare no conflicts of interest.

Introduction

Rivers as flowing open water ecosystems certainly have an important role for society in the economy and regional development, including as a source of drinking water, fish cultivation, and agricultural irrigation. Rivers receive input from outside from upstream to downstream. This input is from industrial and domestic waste, sometimes from natural disasters. This impacts aquatic biota and reduces river water quality[1].

River waters are waters that are widely used for domestic and industrial activities and daily human activities. This is because the river is flowing water and easy to reach[2]. The river itself is open-flowing water (lotic) that takes input from all waste from various human activities around residential, agricultural, and industrial areas[3]. The decline in water quality is caused by uncontrolled waste disposal from development activities along the river, so it is not under the carrying capacity of the river[4]. Rivers are used as waste dumps for various human activities, causing rapid silting of rivers and degrading river water quality[1]. River water is the lowest position in the Earth's landscape. Therefore, river conditions cannot be separated from watershed conditions[5].

The water quality of water bodies and water potential, especially biological indicators, can be monitored continuously and are easy indicators to monitor the occurrence indication of pollution. In addition to physical and chemical indicators, the presence of aquatic organisms is also an indicator of water pollution[1]. The various human activities can reduce water quality and then cause water pollution. Water pollution can be measured using various methods, both physically, chemically, and biologically. Biological water quality measurement methods generally use sensitive biota as parameters in measuring the amount of pollution. The more sensitive species are found in an area, the less pollution occurs[6].

Various analyses, such as physical and chemical water analysis and biological analysis can detect deterioration in water quality. Using physical and chemical analysis in lotic water conditions with dynamic sources of nutrients, such as rivers, is less effective because the resulting values can deviate due to changes. Determination of water quality using biological analysis using organisms as indicators can provide a better reaction to monitor water quality because of the existence of organisms that are sedentary and continuously exposed to pollutants. The input of waste into the river will result in changes in physical, chemical, and biological factors in the waters. This change can affect the presence of essential materials in the waters so that it can disturb the aquatic environment and aquatic biota[7].

Heavy metal pollution to the environment is a process that is closely related to the use of these metals by humans. At the beginning of its use, it was not yet known the effect of pollution on the environment. The oxidation process in metals that cause rusting is a sign of pollution[8]. The presence of heavy metals in waters is very dangerous directly to aquatic biota. This relates to the properties of heavy metals that are difficult to degrade, so they accumulate in the aquatic environment and their presence is naturally difficult to remove. Heavy metals can accumulate in aquatic biota such as shellfish, and fish as well as in sediments[9]. According to Nursidika et al.[10] industrial liquid waste discharged into water bodies (waters), usually contains heavy metals such as Cr, Cd, Hg, and Pb.

Water quality analysis based on the environmental pollution index in rivers in the Aceh region shows good conditions[11], but the research does not cover the Krueng Baru river basin. The community believes that the water quality of the Krueng Baru River is starting to decline due to pollution from the asphalt processing plant. This research aims to describe the water quality of the Krueng Baru River based on biological indicators.

Method

This type of research uses the quadratic transect method with area sampling techniques by placing it in three types of habitats, namely area A, which is dominated by Suction snails (*Cerithidea obtusa*) in the upper reaches of the river; area B is dominated by *Cerithidea obtusa* in the middle of the river to be researched; and area C downstream. With the following procedure, drawn at each station, a transect line parallel to the river line along 10 m is drawn, then placed sequentially three squares with a size of 1 x 2 m with a distance between squares of 5 m. Determining the area of river water sampling stations is carried out by estimating the geographic distribution of pollutants in river watersheds that represent various activities. This is following Lacorte's which states that determining the sample area by considering geographic distribution can guarantee a comprehensive understanding of the distribution of substances in river systems[12].

Research tools and materials

Tools used to take samples in the field include plastic bottles, plastic bags, rubber bands, raffia rope to taste, and tweezers. Tools used for sample analysis and snail shell observation include Caliper. Materials for the laboratory analysis of Fe content in the Krueng Baru River water include Aquades, ethanol solution, nitric acid, Na sulfur solution, KCN solution, and BOD. Materials for taking samples in the field include snails, Aquades, and nitric acid (HNO3).

Research sampling

River water samples were taken as much as 500 ml in the Krueng Baru River, namely at a depth of 0 and 100 cm, using plastic bottles at the sampling point. River water samples were taken at three Krueng Baru River stations, namely Station I (Upper), Station II (Middle), and Station III (Downstream). After the sample is taken, it is taken to the Chemistry Laboratory at Syiah Kuala University for analysis. Samples of *Cerithidea obtusa* taken at the location (Fig 1) are then washed thoroughly, put in plastic bags, and ready to be taken to the laboratory.

Fig 1. Cerithedea obtuse ar Krueng Baru river

Time and place of research

This research was conducted on February 20/March 2015. Research sampling in the Krueng Baru River, West Labuhanhaji District, South Aceh Regency. Meanwhile, ferrous heavy metals (Fe) were analyzed at the Chemistry Laboratory of the Biological Laboratory of Universitas Syah Kuala.

Samples of Snails (*Cerithidea obtusa*)

Snails of various sizes were collected, and then their total length and body weight at snails were measured individually using calipers and analytical scales. The length of the *Cerithidea obtusa* measured is the total length (TL), the straight-line distance measured from the umbo to the end of the shell. As for weight, the total weight of the *Cerithidea obtusa* is measured using analytical scales, which is the total weight of the entire *Cerithidea obtusa*.

Work procedure

Samples of *Cerithidea obtusa* taken at the observation site are washed first to remove mud attached to the suction of *Cerithidea obtusa*. After cleaning, the drying stage begins to be stored in the oven with a temperature of 70 – 80. After drying, the snail shell is crushed and mashed to a powder. The powder sample of the suction snail shell is then weighed as much as 2 – 4 grams. After that put in the oven at a temperature of 80 for 2 hours until it becomes white ash. The ash is then chemically destroyed for analysis.

Research design

Before taking data in the field, a survey was first carried out at the research location to determine the presence of the type of *Cerithedea obtusa* found at the research site. The observation site is divided into 3 stations. The observation location consists of Upstream, middle of the river, and downstream of the river. Noticed by the presence of Gastropods in the plot. Each station is made 1 x 2 m and takes *Cerithidea obtusa* on the plot. At each station, 1 plot is made. Every *Cerithidea obtusa* found was immediately taken and photographed and then taken to the laboratory to see the metal (Fe) levels in the shell of the *Cerithidea obtusa*.

Data Processing Method

This research method uses qualitative descriptive methods. The research variable is the heavy metal content of iron (Fe) in the shell of *Cerithidea obtusa* in the Krueng Baru River. Supporting variables are water pH, water clarity, and temperature, at the study site measured in situ.

Data Analysis

The data processing method used in qualitative descriptive research is to determine the ratio of heavy metal pollution (Fe) in the Krueng Baru River. To determine the level of metal pollution in the Krueng Baru River, the data obtained from heavy metal analysis is compared with the normal standard table of concentration of quality standard provisions for heavy metal content in river water.

a. Heavy metal analysis of iron (Fe) Mix 10 grams of pre-cooked material in 40 ml of hot water, add 10% KCN then 25 ml of a 1:2 ammonia solution. Finally, add 0.5 ml of 10 % sulfur Na solution. Make up to 100 ml. Prepare a blank solution using 10 gr of tartar-free fe with a solution in the same way. Calculate the absorption of both solutions with a spectrometer at a wavelength of 430 nm.
b. Analysis of Liquid Samples (River Water) For the analysis of liquid samples using a discrete method of comparison namely with the following procedure: the sample is inserted in a 50 ml glass beaker, plus diluted HNO3 as much as approximately 10 – 15 ml. Then it is heated to boiling, then cooled, after which it is filtered. Then Aquades are added to the boundary mark, shaken until homogeneous, and then analyzed for heavy metal content.

Results and Discussion

Fe heavy metal content in river water, *Cerithidea obtusa* Analysis of Fe metal concentration in river water presented in Table 1, the highest Fe metal concentration is found at station III (Downstream of the River), which is 0.175 ppm. However, when compared with the heavy metal quality standards for river water from Minister of Environment Decree No.51 of 2004 (< 0.008 ppm), it can be said that heavy metal levels in the waters of the Krueng Baru River, South Aceh Regency have exceeded the quality standards that have been set. The highest level of Iron (Fe) metal in *Cerithidea obtusa* was found at Station II (middle of the river) which was 2.592 ppm.

Table 1. Analysis of heavy metal (Fe) concentration in *Cerithedea obtusa* at Krueng Baru River, South Aceh Regency

Station	Concentration Fe (ppm)	
	Water Krueng Baru river	***Cerithedea obtuse***
I	0.102	1.264
II	0.134	2.592
III	0.175	2.323
Average	0.137	2.059

The concentration of Fe heavy metals in *Cerithedea obtusa* at the waters of the Krueng Baru River, South Aceh Regency does exceed the threshold and remains within natural levels for heavy metals. Studies have shown that heavy metal concentrations in snails can vary significantly based on the environment and the specific species of snail[13]. The bioaccumulation of heavy metals in snail tissues can be influenced by factors such as water pollution levels and the type of heavy metal present in the environment[14]. Additionally, the concentration of heavy metals in snails can be affected by the location and the level of environmental pollution in that area[15].

Furthermore, research has indicated that the concentration of heavy metals in snail tissues may not always directly correlate with the levels of heavy metals in the surrounding soil or vegetation, highlighting the complexity of heavy metal bioaccumulation in snails[16]. It has been observed that the concentration of heavy metals in snails can be influenced by various factors such as the type of heavy metal, the snail species, and the level of pollution in the environment[17]. While the concentration of Fe heavy metals in suction snails in the Krueng Baru River may exceed certain thresholds, the levels observed are within natural ranges for heavy metals in snails. The variability in heavy metal concentrations in snails underscores the importance of considering multiple factors when assessing heavy metal pollution in aquatic ecosystems.

Table 2. Accumulation heavy metal (Fe) in shell *Cerithedea obtusa*

Station	Concentration Fe in shell (ppm)
I	12.3
II	19.3
III	12.3

Based on Table 2, the accumulation of Fe heavy metals in the shell Cerithedea obtusa ranges from 12.3 - 19.3 ppm. This result indicates a notable concentration of iron in the shells of Cerithedea obtusa[18]. This accumulation of heavy metals, particularly Fe, in mollusk shells can have implications for human health when these snails are consumed. Iron (Fe) is an essential mineral for the human body, playing a crucial role in various physiological processes. However, excessive intake of iron, especially in the form of heavy metals, can lead to toxicity and adverse health effects[19]. The accumulation of heavy metals, particularly iron, in organisms like Cerithedea obtusa can have implications for human health when these organisms are part of the food chain. In aquatic environments, heavy metals like Fe have also been found to accumulate in organisms such as prawns, fish, and macrophytes[20-22].

Apart from measuring Fe accumulation, water samples from the Krueng Baru River were also measured, and physicochemical measurements were also carried out. The physicochemical analysis carried out includes pH, temperature, salinity, BOD, and Clarity (Table 3).

Table 3. Physicochemical analysis of water Krueng Baru River

Station	Parameters				
	pH	Temperature (ºC)	Salinity (%)	BOD (ppm)	Clarity (m)
I	6.25	27	27.4	6.2	0.2
II	6	28	25.5	5.8	0.19
III	6	28	26.2	6	0.19

Based on Table 3, the highest value for each parameter results were obtained: pH 6.25, temperature 28°C, salinity 28, BOD 6.2 ppm, and clarity 2m. These parameters are crucial indicators of water quality and can provide insights into the environmental conditions of a water body[23]. pH is a measure of the acidity or alkalinity of water, with a value of 6.25 indicating a slightly acidic nature. Temperature, at 28°C, influences various biological and chemical processes in water bodies, affecting the overall ecosystem. Salinity, which stands at 28‰, is a key factor in determining the type of organisms that can thrive in the water. BOD, with a value of 6.2 ppm, is a measure of the amount of dissolved oxygen consumed by microorganisms during the decomposition of organic matter in water, indicating the level of pollution. Lastly, clarity, measured at 2m, reflects the transparency of the water, which can be influenced by suspended particles, algae, or pollutants.

These parameters are often used in water quality assessments and monitoring programs to evaluate the health of aquatic ecosystems. Understanding these measurements can help in assessing the impact of human activities, such as industrial discharges or agricultural runoff, on water bodies. Additionally, variations in these parameters can influence the distribution and abundance of aquatic organisms, making them essential for ecological studies. By analyzing these measurements collectively, researchers and environmentalists can gain a comprehensive understanding of the overall water quality and ecosystem dynamics in a particular area.

Conclusion

Based on the results of research on water quality in the Krueng Baru River, show the content of heavy metal compounds (Fe) in the river and Cerithedea obtusa. The condition pollutant quite worrying, so it is recommended not to consume water or organisms from the Krueng Baru River. It is recommended that research is needed to handle this waste.

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Author contributions

All authors contributed to this article. The conception and design, material preparation, data collection, and analysis were performed by **[Burhanuddin AG]**, **[Elvitriana]**, **[Nurlena Andalia], [Sariakin],** and **[Muhammad Ridhwan]**. The first draft of the manuscript was written by **[Burhanuddin AG]** and **[Nurlena Andalia]**. All authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.