Vol. 14, No. 2 (2025): 467 - 472 http://dx.doi.org/10.23960/jtep-l.v14i2.467-472

JURNAL TEKNIK PERTANIAN LAMPUNG

ISSN 2302-559X (print) / 2549-0818 (online)
Journal homepage : https://jurnal.fp.unila.ac.id/index.php/JTP

Gastropod Diversity as a Bioindicator of the Heavy Metal Iron (Fe) Around the East Coast River of Surabaya

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Article History:

Received : 19 July 2024
Revised : 12 September 2024
Accepted : 21 September 2024

Keywords:

Abundance,
Diversity Index,
Gastropods,
Heavy metal iron (Fe),
Surabaya East Coast River.

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ABSTRACT

Surabaya is a large city with a high number of industries and population density, so there is potential for heavy metal iron (Fe) pollution which affects environmental quality and the sustainability of aquatic living creatures. Gastropods are one of the macrofauna that have difficulty moving from place to place, so their presence is a bioindicator of an area with heavy metal Iron (Fe) pollution. Gastropod sampling was carried out using the transect sampling method with sampling locations spread across three locations, namely around the Kebon Agung River, Tambak Oso River and Jagir River. The diversity index was calculated using the Shannon-Wiener diversity index. The concentration of iron (Fe) metal pollutants was analyzed using AAS (Atomic Absoption Spectrophotometer). The relationship between heavy metal Fe accumulation and gastropods was analyzed using the Pearson correlation test. The research results showed that there were 14 types of gastropods with a medium diversity index (H') with values between 1.34-2.03 and an accumulation of the heavy metal iron 35994.7-44986.3 (ppm).

1. INTRODUCTION

The coast is an area that is the boundary between the sea and the land. One of the ecosystems found in the river area to the coast is the mangrove ecosystem or often called mangrove forest. Mangrove forests have a major function in several aspects, both in terms of physical, economic and ecological. The physical function of mangrove forests is to minimize abrasion and prevent sea water intrusion (Salim *et al*., 2016). The ecological function of mangrove forests as a spawning ground, nursery ground, feeding ground and nesting place for various species of fish, birds and other biota. In term of economy, the mangrove vegetation provides local food source and can be developed for ecotourism (Rahim & Baderan, 2019; Kumar *et al*., 2022).

Surabaya is one of the big cities in Indonesia and has a fairly large number of industries. The number of industries on a large and small scale indirectly contributes to waste that is dangerous to survival. Pollution from industry in the form of liquid waste that flows along the river is waste from hazardous and toxic materials originating from heavy metals (Romadhon & Mahmiah, 2017). Metals dissolved in water at certain concentrations and change function to become poisons for life in water, heavy metals are pollutants that are dangerous to living things because heavy metals are elements that cannot be created or destroyed. The heavy metals present will interfere with the lives of living things such as interfering with chemical reactions, inhibiting absorption and essential nutrients.

Related research on gastropods as aquatic bioindicators has been carried out by Ayu *et al*. (2015) on gastropods as bioindicators of chemically polluted waters in the Kreo River, Semarang City, and Sriwahjuningsih *et al*. (2022) on gastropods as bioindicators of water pollution in the Ecotourism Situ Bagendit, Garut Regency. Gastropods are one of

the macrofauna that can function as good bioindicators because they have slow movement properties, can detect heavy metal pollutants in water with the ability to accumulate pollutants in their body tissues (Wulansari & Kuntjoro, 2018). Environmental pressure and changes can affect the number of species and differences in the structure of gastropod communities so that with expertise in responding to water conditions continuously, gastropods can be used as bioindicators of water.

The large number of industries and river basins dominated by residential areas can cause high levels of heavy metal pollution. The high level of pollution will affect environmental conditions and have an impact on the existence of gastropod macrofauna communities. The abundance and diversity of gastropods can be used as bioindicators of heavy metal pollution. Therefore, research is needed on the dynamics of the abundance and diversity of gastropods around the Kebon Agung River, Tambak Oso River and Jagir River which are adjacent to the coast.

2. RESEARCH METHODS

2.1. Research Time and Location

The research was conducted in January to February 2024 around the river flow which is divided into 3 stations, namely Kebon Agung River (Station 1), Tambak Oso River (Station 2) and Jagir River (Station 3). Sample analysis was carried out at the Land Resources Laboratory, Faculty of Agriculture, National Development University "Veteran" East Java. The map of the research location was presented in Figure 1. The research location of each river had 4 sampling points with an interval between points of 250 meters starting from the farthest point from the river mouth, namely point 1 and the innermost point directly adjacent to the mouth, namely point 4.

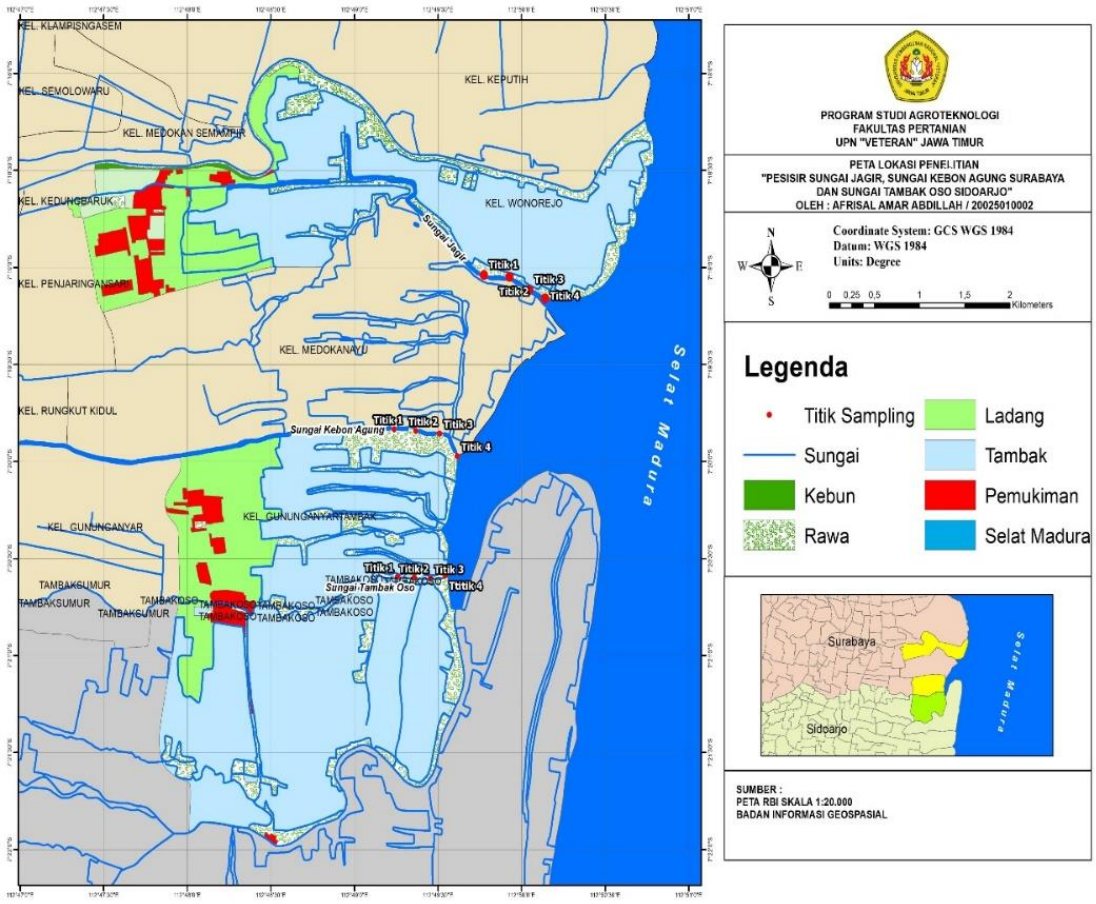

Figure 1. Map of the research locations of the three rivers [sampling points = red dotes]

2.2. Sampling

Determination method sampling points used is method purposive, namely with consideration certain in the process of taking sample (Mahfud *et al*., 2013). Sediment sampling was carried out using a trowel. The sediment samples taken were estimated to be up to 30 cm deep, which was assumed to represent the existing Fe heavy metal pollutants at that depth (Rachmawati *et al*., 2018). The sediment samples obtained were dried in a closed room and continued with laboratory analysis in the form of sediment texture, pH and Fe heavy metals. The sampling of gastropod macrofauna was carried out on a 25m×25cm sampling plots with a depth of 15 cm using the hand sorting method and sorting was carried out based on type.

2.3. Data Analysis

Data on the types and number of gastropods obtained were analyzed by calculating the level of diversity and the level of dominance index.

2.3.1. Diversity Index

The diversity of gastropod macrofauna obtained was carried out using the Shannon-Wiener diversity index (Odum, 1971; Fachrul, 2007; Adelina *et al*., 2016), with the following formula;

$$H' = \sum_{i=1}^{s} Pi \ln Pi \quad (1)$$

where H' is Shannon Wiener diversity index, Pi is the ratio of the number of individuals of each species to the total number of individuals. The diversity index was classified three, namely high diversity with $H' > 3.0$, moderate diversity with H' 1.0 to 3.0, and low diversity with $H' < 1$ (Diana *et al*., 2024).

2.3.2. Dominance Index

The calculation of the dominance index uses the Dominance of Simpson formula (Odum, 1971; Sriwahjuningsih *et al*., 2022), as the following:

$$C = \Sigma \left(\frac{ni}{N}\right)^2 \quad (2)$$

where C is dominance index, ni is number of individuals of type i, and N is total number of individuals. The dominance index was categorized into three classes, namely low dominance ($0 < C \leq 0.5$), moderate dominance with ($0.5 < C \leq 0.75$), and high dominance with ($0.75 < C \leq 1.0$) (Diana *et al*., 2024).

3. RESULTS AND DISCUSSION

3.1. Sediment texture

The sediment texture at the three research locations was dominated by the silt fraction, which in percentage units was recorded between 54-76%, but had different texture classes in each river (Table 1). The Kebon Agung River has a silty clay texture which has a rather slippery and adhesive nature (Silitonga *et al*., 2014). The Jagir River has a silty clay texture class, this type of texture has a good level of total soil porosity (Pusparani, 2018). The differences in the types of texture classes in the three rivers are influenced by several factors such as organic matter content which will be absorbed at a high level if the sediment substrate is dominated by clay fractions or has a very fine texture, in addition, the differences in texture classes are also supported by the level of river flow where the magnitude of the river current will easily carry small particles than particles with a fairly large size (Mustafa *et al*., 2022).

Table 1. Results of sediment texture analysis of 3 fractions in three rivers

River	Sand Fraction (%)	Silt Fraction (%)	Clay Fraction (%)	Class
Kebon Agung	3	76	21	Silty Clay
Tambak Oso	3	54	43	Silty Clay
Jagir	2	64	34	Silty Clay Loam

3.2. pH

The degree of acidity or pH is an index of hydrogen ion levels as a characteristic of the balance between acidity and alkalinity of a solution, the pH range is at 0-14 which is divided into 2, namely acidic pH at 0-7 and alkaline pH at 8-14. Based on the results of laboratory analysis that can be seen in Table 2, it was found that the average pH value of each research point in the three rivers decreased as they approached the open sea, which was indicated by the increasing acidity level. The pH value, although increasingly acidic, is still classified as neutral pH or the pH value is still at around 7.

Table 2. Laboratory test results of sediment pH analysis for each distance interval in the three rivers

River	Interval 1	Interval 2	Interval 3	Interval 4	Average
Kebon Agung	7.43	7.51	7.38	7.36	7.42
Tambak Oso	7.25	7.24	7.15	7.22	7.22
Jagir	7.38	7.38	7.32	7.29	7.34
Average	7.35	7.37	7.28	7.29	7.32

3.3. Heavy metal Fe

Heavy metal Fe is one of the one essential heavy metal needed by humans for metabolic purposes if consumed in the right amount. Analysis of Fe heavy metal pollutants in each river flow has different concentrations. Heavy metal pollution that pollutes an area or river flow will be carried to the sea with the sedimentation process where the pollutants are absorbed into the soil or sediment around the river flow. Heavy metal pollutants spread across the three research locations have the lowest to highest values, namely 35994.7 to 44986.8 ppm (Table 3). There are relevant research results from Putri (2013) regarding the iron content in water bodies and river sediments in Surabaya, one of which is located on the Jagir River and has a heavy metal accumulation of Fe of 16944.24 to 29135.6 ppm.

Table 3. Results of analysis of heavy metal pollutants Fe (ppm) in sediments in the three rivers

Location	Interval 1	Interval 2	Interval 3	Interval 4	Average
Kebon Agung River	37442.3	38259.6	39591.9	35994.7	37822.1
Tambak Oso River	44701.9	40077	41567.5	39719.7	41516.5
Jagir River	44986.3	40741.2	40547.7	41328.7	41901.0
Average	42376.8	39692.6	40569.0	39014.4	40413.2

The concentration value of Fe heavy metal in sediment decreased at the outermost sampling location or directly adjacent to the sea, this is likely because the further the sediment sample is from the source of Fe heavy metal pollutants itself and the accumulation that has been carried out by mangrove plants along the Kebon Agung and Tambak Oso rivers. The decrease in Fe pollutants indicated to have been accumulated by mangrove plants is supported by research conducted by Khairuddin *et al*. (2018), that there are several mangrove species such as *Sonneratia alba* and *Ryzophora apiculata* that can absorb heavy metals with the discovery of metal content in the roots and leaves.

3.4. Diversity and dominance of gastropods

The results of the biological analysis in the form of the abundance of gastropods in the three rivers found a total of 3932 individuals divided into 14 types of macrofauna (Table 4). In the three rivers studied, there are several types of macrofauna that have different distribution patterns marked by the absence of macrofauna types in a river, the differences that exist can be supported by physical factors in the form of texture and chemical characteristics in the form of pH and C-organic and the distribution of heavy metal pollutants Fe around the river flow. Based on the calculation of the Shannon-Wiener diversity index, it was found that the three rivers have a moderate category where the calculation value is between 1.34 and 2.03 so that the moderate category can be interpreted that the existing ecological pressure is classified as moderate and in the Simpson dominance calculation, the dominance category is classified as low, namely a dominance value of <0.05 which means that there are no species that extremely dominate other species, environmental conditions are stable, and there is no ecological pressure on the biota at that location. (Supriadi *et al*., 2015).

Table 4. Results of the analysis of diversity and dominance of gastropods in the three rivers

No	Macrofauna	Kebon Agung River	Tambak Oso River	Jagir River	Total
1	*Nucella lamellar*	0	0	172	172
2	*Cerithidae quadrate*	0	180	164	344
3	*Terebralia sulcata*	0	0	200	200
4	*Littoraria melanostoma*	316	184	140	640
5	*Pila ampulacea*	0	0	140	140
6	*Cerithidea cingulata*	0	0	244	244
7	*Olive irisans*	364	260	324	948
8	*Cassidula mustelina*	180	0	0	180
9	*Little box golden cat*	220	0	0	220
10	*Littoral conical*	176	0	0	176
11	*Pythia scarab*	180	0	0	180
12	*Littoral scythe*	124	0	0	124
13	*Nassarius Dorsat*	256	0	0	256
14	*Ellobium aurijudae*	0	108	0	108
	Total (N)	1816	732	1384	3932
	Diversity Index	2.03	1.34	1.9	moderate
	Dominance Index	0.14	0.27	0.16	low

3.5. Correlation of gastropods with Fe heavy metal pollutants

Gastropoda is one of the macrofauna with a soft body but protected by a hard and circular shell. Environmental monitoring and bioindicators of a body of water can use gastropods in waters that are indicated to have heavy metal pollution, this is due to the slow movement of gastropods, habitats located at the bottom of the water and the ability to accumulate chemical compounds in their body tissues (Wulansari & Kuntjoro, 2018). Based on the correlation calculation using IBM SPSS Statistics 22 software, the correlation value is -0.411 which has a moderate relationship (Table 5). The negative correlation can be interpreted that the presence of a high number of gastropod class macrofauna will indicate that the concentration of Fe heavy metals in each river flow has a decreasing value. This is in line with the opinion that the density of gastropods is influenced by several factors such as local environmental factors including human activities, food availability, predation and competition. Environmental pressure and changes can affect the number of species and differences in the structure of gastropod communities. Therefore, gastropods can be said to be bioindicators that have the expertise to respond to water conditions continuously (Sari *et al*., 2020).

Table 5. Correlation of gastropods with Fe heavy metal pollutant values

Relationship	r count	Description
Gastropoda with Fe pollutant	– 0.411	Moderate

4. CONCLUSION

The diversity of gastropods in the Kebon Agung River, Tambak Oso River and Jagir River is included in the moderate category because it has an index value of more than 1 but less than 3 and a low dominance index category of less than 0.5. The relationship between heavy metal pollutants of iron (Fe) in sediment and the number of gastropods has a moderate correlation interpretation and a decrease in heavy metal pollutants has an impact on the increasing number of gastropods.

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