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Concentrations of Lead, Iron, and Zinc in Blood Mussels in Coastal Waters

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ABSTRAK

Pencemaran lingkungan oleh logam berat adalah masalah lingkungan yang krusial dan menjadi tantangan bagi tercapainya cita-cita pembangunan berkelanjutan. Kerang darah termasuk Benthos dari Filum Moluska Kelas Bivalvia yang memiliki persebaran habitat luas di Indonesia. Pantai sangat rentan terhadap akumulasi sampah rumah tangga, baik dari darat maupun dari laut. Sedangkan telah menjadi bagian penting bagi pertumbuhan ekonomi, industri, dan transportasi di Surabaya. Tujuan penilitian ini adalah untuk mengetahui perbandingan jumlah logam berat Timbal (Pb), Ferrum (Fe), dan Zinc (Zn) pada kerang darah di dua lokasi dengan karakteristik lingkungan yang berbeda serta mengevaluasi kandungan logam berat tersebut masih dalam batas ambang baku pangan. Metode yang digunakan pada penelitian ini adalah penelitian deskriptif dengan metode survei. Analisis data menggunakan uji korelasi dan independent sample t-test. Hasil penelitian menunjukkan bahwa nilai Timbal (Pb) dan Zinc (Zn) lebih tinggi di Teluk Lamong, secara berurutan yaitu sebesar 0.00448±0.0004 dan 0.002±0.0002. Sementara itu, nilai Ferrum (Fe) lebih tinggi di Pantai Kenjeran, yaitu sebesar 0.00284±0.0006. implikasi penelitian ini dapat memberikan gambaran tentang tingkat pencemaran logam berat di ekosistem pesisir, yang penting untuk memantau kesehatan lingkungan perairan. Logam berat seperti timbal, besi, dan seng berpotensi menjadi ancaman bagi keseimbangan ekosistem dan kesehatan manusia, terutama jika kerang yang tercemar dikonsumsi secara langsung..

ABSTRACT

Environmental pollution by heavy metals is a crucial environmental problem and is a challenge to achieving the ideals of sustainable development. Blood cockles include Benthos from the Bivalvia Class Mollusk Phylum which has a wide habitat distribution in Indonesia. Beaches are very vulnerable to the accumulation of household waste, both from land and from the sea. Meanwhile, it has become an important part of economic, industrial and transportation growth in Surabaya. The aim of this research is to determine the comparison of the amounts of the heavy metals Lead (Pb), Ferrum (Fe), and Zinc (Zn) in blood cockles in two locations with different environmental characteristics and to evaluate whether the heavy metal content is still within the standard food threshold limit. The method used in this research is descriptive research with a survey method. Data analysis used correlation tests and independent sample t-tests. The research results show that the values of Lead (Pb) and Zinc (Zn) are higher in Lamong Bay, respectively, namely 0.00448 ± 0.0004 and 0.002 ± 0.0002. Meanwhile, the Ferrum (Fe) value is higher at Kenjeran Beach, namely 0.00284 ± 0.0006. The implications of this research can provide an overview of the level of heavy metal pollution in coastal ecosystems, which is important for monitoring the health of the aquatic environment. Heavy metals such as lead, iron and zinc have the potential to pose a threat to ecosystem balance and human health, especially if contaminated shellfish are consumed directly.

1. INTRODUCTION

The marine environment is very diverse but is threatened by pollutants, especially heavy metals. Rivers carry heavy metals from both natural and man-made sources into the sea. Human activities such as industry and agriculture contribute significantly to heavy metal pollution. Heavy metals are susceptible to bioaccumulation by aquatic organisms, such as algae, plants and small animals, if released into water. Bioaccumulation is the process by which the concentration of metals in an organism's tissues increases over time. As stated previously, heavy metals are defined as a group of metal elements that are potentially very toxic to living organisms, including humans (Biswas et al., 2023; Hasan et al., 2022). Heavy metals in the aquatic environment can cause a long-term reduction in reproductive capacity as well as respiratory and neurological problems for marine animals in that environment. They can also accumulate in the bodies of aquatic animals and be transmitted to humans, which can cause side effects. Bivalves are benthic organisms with a wide global distribution, mostly found in river estuaries or coastal mudflats. They

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function as filter feeders, living in sediments and actively taking food from the seawater and surrounding sedimentary environment. Marine ecosystems often contain heavy metals, especially in sediments. As a result, bivalves accumulate various metals from both sediment and seawater during their feeding process (Qin et al., 2021; Vajargah & F., 2023). Metals that accumulate in benthic organisms have the potential to biomagnify in the food web, posing unpredictable dangers to human health, especially if seafood containing high doses of toxic metals is consumed. Therefore, it is imperative to conduct thorough investigations to critically assess the presence of toxic metals in seafood and the associated health risks to human consumers.

Blood Clams, *save the country* is a species of shellfish that usually inhabits the intertidal zone and naturally occurs in areas characterized by soft mud and fine sand. In certain locations they are able to inhabit waters as deep as 20 meters; however, they are more frequently observed in coastal and estuarine zones. In addition, blood cockles are able to inhabit estuarine environments and show tolerance to various levels of salinity (Cayabo et al., 2024; Soegianto et al., 2020). Blood cockles are generally consumed as seafood, are a very popular food among the local population and are often identified as a preferred culinary choice in large urban centers in East Java (Indriyasari et al., 2021; Ni'am et al., 2020). Research has been carried out on assessing heavy metal levels in shellfish, including oysters and mussels in Indonesia. Previous research findings revealed that Pb concentrations in Tegillarca granosa in Lamong Bay ranged from 0.017 ± 0.005 ppm to 0.070 ± 0.009 ppm (Wardana et al., 2023). Another study stated that it found heavy metal contamination in *save the country* The concentration of Hg is 0.0009 ppm, cadmium (Cd) 0.62 ppm, and lead (Pb) 1.82 ppm. Other researchers revealed that the concentration of the heavy metal lead (Pb) in *save the country* from Muara Loji, Pekalongan, ranged from 25.65 to 46.25 ppm, and the bioconcentration factor for the heavy metal Pb in blood cockles in water ranged from 41,514 to 366,428. Meanwhile, the safe limit for consuming blood cockles in Pekalongan waters is around 0.032-0.058 kg/week. It was concluded that the heavy metal Pb in water, sediment and blood cockles (*save the country*) in the waters of the Loji River Estuary and its surroundings, Pekalongan City is included in the polluted category because it has exceeded the established quality standard limits. Therefore, determining the concentration of heavy metals in shellfish is very important because of the potential ecological impacts and dangerous impacts on human health if consumed (Kharisma et al., 2023). The novelty of this lies in a deeper understanding of the specific impacts of heavy metals on local marine biota, especially blood cockles which are an important food source for coastal communities. This research also provides the latest data on levels of heavy metal contamination in waters that may not have been revealed before, especially in coastal areas that are vulnerable to industrial activity, agriculture or urbanization. In addition, by using a more sophisticated and up-to-date analytical approach, this research can reveal the bioaccumulation patterns of heavy metals in blood cockles and their impact on human health and the environment. Another novelty is the potential for developing pollution mitigation strategies based on these findings, which could contribute to efforts to preserve the marine environment and public health in coastal areas.

There are striking geographical differences between the south and north coasts of Surabaya. The East Coast of Surabaya is very vulnerable to the accumulation of household waste along the coastline, both from land sources due to human activities and from the sea due to tourism or fishing activities and river discharge. Meanwhile, the source of pollution in the waters of the north coast of Surabaya, Lamong Bay waters, can come from land and ports. The source of land pollution comes from industrial waste which flows into the Lamong River and then empties into the waters of Lamong Bay. The port located in Lamong Bay also has the potential to cause pollution. Pollution from ports includes ship coating paint, remaining fuel or oil, and ship sinking tragedies (Ni'am et al., 2020; Wardana et al., 2023). Investigation of heavy metal concentrations in different environmental characteristics is presented for better understanding. This study aims to compare the concentrations of heavy metals including lead (Pb), Ferrum (Fe), and zinc (Zn) in blood cockles in two locations with different environmental characteristics, namely Lamong Bay and Kenjeran Beach, and examine whether these concentrations can affect the concentration of these heavy metals. These heavy metals meet the food safety standard threshold.

2. METHOD

This research is quantitative research using survey methods. This research was conducted in Lamong Bay and Kenjeran Beach, Surabaya in December 2022. A total of 30 blood cockle samples were collected (15 from Lamong Bay and 15 from Kenjeran Beach, Surabaya). Samples of blood clams from Lamong Bay were purchased directly from fishermen at the ship loading and unloading terminal in Greges Village, Asemworo, Surabaya. Meanwhile, samples of blood clams from Kenjeran Beach were obtained through a fishing ground or fishing zone, which is a water area that is targeted by fishermen carrying out fishing efforts. After sample collection, surface debris, including mud, barnacles, and other detritus, was

removed using a stainless steel brush. The samples were then stored in an ice box at 4°C and transferred to the laboratory for further processing and analysis. (Dang et al., 2022; Wardana et al., 2023). Analysis of blood cockles was carried out at the Fundamental Chemistry Laboratory, Department of Chemistry, Sepuluh Nopember Institute of Technology.

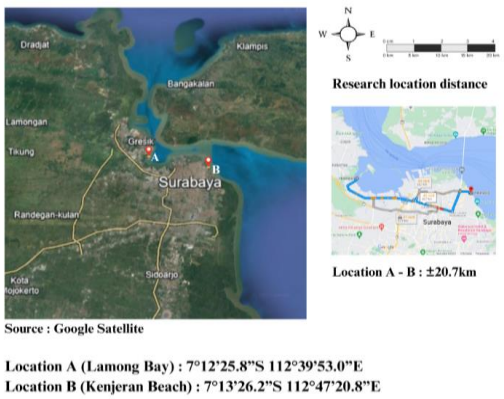

Figure 1. Sampling locations in Surabaya Coastal Waters

This research consists of three stages, namely the sample preparation stage, the implementation stage, and the analysis stage. The sample preparation stage includes preparation of tools, materials and blood cockle samples. Blood clams were separated for each test parameter by five individuals with five repetitions. The blood clams are separated into their tissue and shell, then the blood clam tissue is washed clean and weighed. The blood cockle tissue that had been cleaned and weighed was then separated in an oven at 50°C and left for two days. The dried blood cockle samples were then ground until smooth and weighed. The implementation phase includes preparing standard solutions; solutions were prepared with varying concentrations of 0.01, 0.02, 0.04, 0.08, 0.1, 0.2, and 0.4 (mg/L) by pipetting 0.05; 0.1; 0.2; 0.4; 0.5; 1; and 2 mL of each test solution with a heavy metal concentration of 10 ppm concentration into a 50 mL measuring flask and add distilled water to the mark. Measurement of Metal Content (Pb, Fe, Zn) of Samples with the Thermo Scientific iCE 3300 Atomic Absorption Spectrophotometer (AAS) refers to the Indonesian National Standard Indonesian National Standard 6989.6-2009. The Atomic Absorption Spectrophotometer (AAS) is adjusted and optimized, where the AAS tool is optimized by turning it on and heating for approximately 5 to 10 minutes. After that, the standard sample solution is inserted into the AAS device for analysis. Then the shellfish blood sample solution is added which is ready for analysis. Absorbance is measured with a resonance wavelength that can be used to determine Pb content, namely 283.3 nm, Fe content 248.3 nm, and Zn content 213.9 nm; each sample was repeated five times. The data analysis technique uses descriptive analysis. The results of data analysis used the correlation test and Independent Sample t-test.

3. RESULT AND DISCUSSION

Result

The longest shell has a heavier mesh wet weight, while the shortest shell has a lighter mesh wet weight. This result shows that there is a correlation between the length of the shell and the wet weight of the mesh. The correlation value of shell length and net weight is presented in Figure 2.

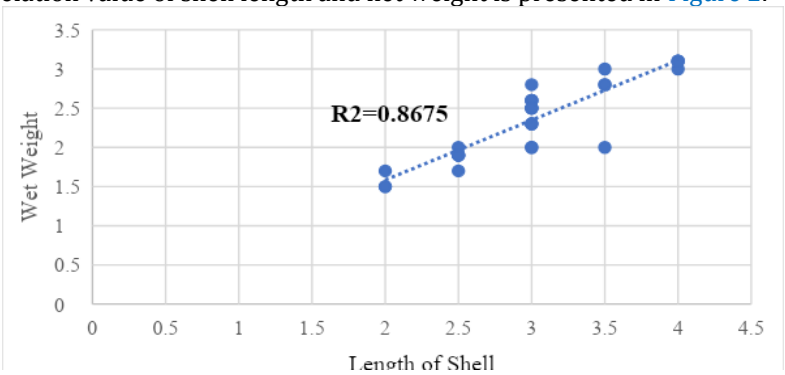

Figure 2. Correlation of Shell Length and Blood Mussel Wet Weight

The R2 value is 0.8675 and the r value is 0.9314. The value is close to 1, meaning that shell length and wet weight are correlated. The correlation value is said to be moderate to strong if the correlation coefficient value is more than equal to 0.8, then it can be said to be a very strong correlation. The correlation coefficient is a measure used to determine the relationship between variables. The correlation coefficient value is between -1<0<1 where r = 1 is a perfect negative correlation, meaning that the relationship between variable x (shell length) and variable y (wet weight of shellfish) is very weak, and if r = 1 is a perfect positive correlation, it means the relationship between variable x and variable y is very strong. If the coefficient value shows 0, then there is no relationship between the two variables. The results of heavy metal analysis in blood cockles are presented in Table 1.

Table 1. Results of heavy metal analysis in blood cockles

Location	Repetitive	Heavy Metals (ppm)±SD			Quality standards (ppm)
		matter	Fe	Zn	
Lamong Bay	1	0,0044±0,0004	0,0026±0,0002	0,002±0,0002	1
	2	0,0051±0,0004	0,0029±0,0002	0,002±0,0002	
	3	0,0041±0,0004	0,0028±0,0002	0,002±0,0002	
	4	0,004±0,0004	0,0026±0,0002	0,0019±0,0002	
	5	0,0048±0,0004	0,0031±0,0002	0,0025±0,0002	
Kenjeran Beach	1	0±0	0,0038±00,0006	0,0008±0,0001	
	2	0±0	0,003±0,0006	0,0006±0,0001	
	3	0±0	0,0028±0,0006	0,0006±0,0001	
	4	0±0	0,0026±0,0006	0,0004±0,0001	
	5	0±0	0,002±0,0006	0,0004±0,0001	

The research results revealed that Lamong Bay had the highest average content of the heavy metal lead (Pb), namely 0.00448 ± 0.0004. Kenjeran shows the highest average heavy metal iron (Fe) content of 0.00284 ± 0.0006. Apart from that, Lamong Bay has the highest average content of the heavy metal zinc (Zn), namely 0.002 ± 0.0002 (Table 1).

Discussion

Benthic animals are very important in ecological monitoring and conservation because they can demonstrate complex interactions between adaptation strategies and environmental factors that influence ecosystem stability and function (Sarwono, 2020; Zi et al., 2024). Adaptability causes the structure of benthic animals to vary from one community to another. The structure of benthic animals differs from one community to another. The difference in shell color at the two locations is thought to be due to the influence of different water conditions. This suspicion was strengthened because the color of the shell faded after cleaning, so the two samples had the same color. However, which environmental factors influence these color differences is still unknown. The difference in color between the two locations is thought to influence the color of the shells. Lamong Bay has cleaner water color compared to Kenjeran Beach which has muddier water color. Water quality is determined by its physical, chemical and biological composition. Its chemical composition includes heavy metals, pesticides, detergents and petroleum. Physical Composition such as turbidity, color, and temperature. Pigments and plankton are biological structures (Sharma et al., 2020; Sudjana, 2019). Increasing the temperature in the water causes the water to become cloudy with oxygen more quickly than at a lower water temperature (Daroini & Apri, 2020; Safitri & R., 2016).

The amount of tissue weight influences the fatness index value of the shellfish. Previous research findings suggest that the fatness index of mussels is related to the growth of mussels; The greater the tissue weight, the greater the obesity index value. The greater the obesity index value. Variations in tissue weight are closely related to shellfish growth, where the products of shellfish tissue are muscle and gonad weight (Ramadhani et al., 2020). Previous research shows that the heavy metal Pb is widely used in industrial processes and marine transportation through ship discharges (Kusuma et al., 2022; Taufiqurrahman & Kaisupy, 2020; Wardana et al., 2023). Teluk Lamong is a logistics and warehousing port located in the northern area of the city of Surabaya. The source of pollution in the waters of Lamong Bay can be caused by the discharge of industrial waste which flows into the Lamong River and then ends up in the waters of Lamong Bay in the form of ship coating paint, remaining fuel or oil, and pollution from the waters of Lamong Bay. harbor. Oil and pollution from other ports. Analytical challenges such as sample

recognition, non-spectral interference, and spectral interference in measurements by inductively coupled plasma atomic emission, mass spectrometry, and atomic absorption spectroscopy methods; therefore, samples must be mineralized or at least diluted to reduce the amount of accompanying compounds before analysis to remove organic matter (Hosry et al., 2021; Santoso, 2023). In Kenjeran with an average value of 0.00284 ± 0.0006 (Table 1). The heavy metal Fe in water comes from various human activities, such as household or industrial activities Astari et al. (2021). Kenjeran Beach is the estuary of the canals in the city of Surabaya. The Kenjeran Channel is located in the Kenjeran District area and then flows upstream and empties into the Ria Kenjeran Beach area. Industrial areas that are not equipped with adequate wastewater treatment installations (IPAL) will result in industrial liquid waste being directly discharged into rivers or ditches. This causes the water quality around industrial areas to become polluted and threatens the life of aquatic organisms and the surrounding ecosystem. Based on the Geo-accumulation Index and Pollution Load Index, several locations on the coast of Surabaya experience pollution, and metal particulate concentrations are relatively high in several locations, possibly caused by ports, marine tourism and other anthropogenic activities (Habibi et al., 2020; Taufiqurrahman & Kaisupy, 2020). High levels of zinc, a heavy metal, can be found in water due to the presence of copper and zinc in chemical fertilizers and household waste disposal that contain these metals. Zinc can also enter water sources from pipe corrosion and consumer products such as detergents (Brewer & Prasad, 2020; Salem et al., 2020). Zinc (Zn), a heavy metal, has several physiological functions in the human body. These functions include activation and synthesis of growth hormone (GH), maintenance of immunity, antioxidant activity, modulation of taste perception, regulation of reproductive function, and stabilization of cell membranes. The heavy metal content in blood cockles according to quality standards is one ppm(Alam et al., 2020; Astari et al., 2021). This statement is contained in SNI 7378:2009 Maximum Limits for Heavy Metal Contaminants in Food, which was prepared and formulated by Technical Committee 67-02: Additional Materials and Food Pollutants.

The average limits for shellfish consumption are as follows: children weighing 15 kg may consume a maximum of 1 kilogram (± 50 shells) per week, and adults weighing 60 kg may consume a maximum of 4 kilograms (± 200 shells) per week . This research has several important implications. First, the results of this research can provide an overview of the level of heavy metal pollution in coastal ecosystems, which is important for monitoring the health of the aquatic environment(B.P.O.M., 2019, 2022). Heavy metals such as lead, iron and zinc have the potential to pose a threat to ecosystem balance and human health, especially if contaminated shellfish are consumed directly(Indonesia, 2018; Paramitha et al., 2021). Second, the findings of this research can be used by the government and local authorities to formulate stricter environmental management policies and pollution prevention measures, especially in coastal areas which are sources of seafood. Apart from that, this research can also be a reference for further studies regarding the bioaccumulation of heavy metals in other organisms, thus providing a deeper understanding of the long-term risks to marine ecosystems and communities that depend on these aquatic resources. Limitations of this study include the limited coverage of the sample area, which may not fully represent water conditions throughout the coastal area. In addition, seasonal fluctuations and local environmental variations such as ocean currents, temperature, and human activities can also influence research results, but may not have been fully measured in this study. The use of specific analytical methods also has limitations regarding instrument sensitivity or measurement accuracy, which can affect the final results. In addition, this study may not fully explore the long-term impact of heavy metal bioaccumulation on the health of organisms and humans. As a recommendation, further research should cover a wider area and be carried out periodically to obtain a more comprehensive picture of the dynamics of heavy metal pollution in coastal waters. It is also recommended to use more sensitive and specific analytical methods to measure heavy metal concentrations more accurately. In addition, collaboration with human health researchers can provide a broader perspective regarding the impact of consuming blood cockles contaminated with heavy metals. Increasing public awareness about the risks of this pollution as well as implementing stricter environmental management policies is also important to reduce potential negative impacts on public health and the environment.

4. CONCLUSION

The heavy metal Pb found in Lamong Bay is higher than the heavy metal Pb found on Kenjeran Beach with an average of 0.00448. For comparison, the heavy metal Fe found on Kenjeran Beach is higher than the heavy metal Fe found in Lamong Bay, with an average of 0.00280. The levels of the heavy metal Zn found in Lamong Bay are higher than the levels of Zn found on Kenjeran Beach, with an average of 0.002. The standard threshold limit for heavy metal foods is one ppm. This proves that the blood cockles found in Lamong Bay and Kenjeran Beach are still within the food standard limit so they are suitable for

consumption in sufficient quantities. Excessive consumption of blood clam tissue can cause excess heavy metal content in the body.

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