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The Heavy Metal Characteristics (Pb and Cu) in Wideng Crab Tissue from the Gonjol River, Demak

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Authors' contributions

This work was carried out in collaboration between both authors. Author HC designed the research. Authors HC conducted sampling and wrote the first draft of the script. Authors HC and SI wrote protocols, administered the study analysis, and administered the literature search. Both authors read and approved the final manuscript.

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ABSTRACT

Objective and Background: The Gonjol river serves as a lifeline for the communities surrounding Demak's brackish water ponds. Currently, factory waste is poisoning rivers. The purpose of this research was to investigate the levels of heavy metals Pb and Cu in Wideng crab tissue, water, and sediment in the Gonjol river's upper course and estuary.
Methods: This study was place from January to March 2020. Heavy metal concentration was determined using atomic absorption spectroscopy. The linear regression method was used to analyze the data.
Results: Except for Cu in upstream and estuary sediments, the concentration of Pb and Cu in the waters, sediments, and Wideng crab tissue remained below the acceptable limits. Heavy metals Pb and Cu in both sediment and tissue did not reveal a significant association in the upstream and estuary, although there was a correlation between water and tissue. There is no association between silt and water in the upstream and estuary. The river's quality is based on the Decree of the Minister of the Environment of the Republic of Indonesia No.115 of 2003, which places it in category C, which means it has moderate levels of Pb and Cu pollution. While tissue and sediment levels are below the tolerance limit.

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Conclusion: The state of the Gonjol River is a source of concern, particularly the circumstances of Cu and Pb, which allow bioaccumulation in the future, posing a threat to the ecosystem and the communities surrounding it.

Keywords: Correlation; Lead (Pb); and Copper (Cu); gonjol river; wideng crab tissue; characteristics.

1. INTRODUCTION

The Gonjol River is located in the Pandansari area, a Demak coastal area with high ecological and economic value. Because there are still many mangrove plants present, it serves as a source of nutrients, spawning grounds, nurturing areas, and foraging for various marine biota. One of them is the economic usefulness of the pond as a source of irrigation for nearby pond farmers. The river is located near the Jatengland Industrial Park Sayung industrial area [1] Increased waste disposal from industrial activities in the area will degrade environmental quality; in relation to the use of coastal and coastal areas as industrial areas, some industries may pose a threat to coastal and coastal sustainability [2]. At present, the Gonjol river receives significant pollutant discharges from ceramic factories, motor vehicle manufacturers, dyeing and paint factories, and furniture factories, and contains high concentrations of heavy metals such as lead (Pb) and copper (Cu). which is discharged into the channel in the Gonjol river [3]. Disposal of waste into the Gonjol river system will cause an increase in some of the waste entering the aquaculture waterways. The quality of the waters in the area surrounding the estuaries of the Demak, East Flood, and Mangkang rivers have declined due to pollution from the textile, plastic, pharmaceutical, paint, ceramic, fish auction place, car painting industry, and lubricant industry. [4], This results in a significant amount of heavy metal contamination of Pb and Cu [5] [6].Heavy metals such as Pb and Cu can build up and accumulate in crustacean tissues [7].

Wideng crab is a type of crab that plays an important ecological role as a nutrient converter, mineralizer, oxygen distributor, and organic matter decomposer. The presence of heavy metals such as Pb and Cu will have an impact on the lives of Wideng crabs that live in aquaculture areas [8] The Wideng crab is abundant in the study area and is regarded as a pest by the local community. Heavy metals Pb and Cu can have an impact on the life of Wideng crab in water bodies to a certain extent because they are non-selective filter feeders, live permanently (sessile), can live in polluted areas, and can accumulate heavy metals with a concentration factor of 105, allowing heavy metals to accumulate in the body [9]. Pb metal can penetrate cells and accumulate in the tissues of Wideng crab., and it tends to form complex compounds with organic substances found in the body of Wideng crab whereas copper (Cu) is an essential metal that is required by organisms as a coenzyme in the body's metabolic processes in low levels, and its toxic nature only appoints it as a coenzyme in the body's metabolic processes.

The goal of the study was to look at water quality, heavy metal content in water and sediments, and the characteristics of heavy metal correlations, particularly Pb and Cu, between sediment, water, and the Wideng crab in the Gonjol river.

2. METHODS OF RESEARCH

A quantitative approach was used in this exploratory descriptive research [10]. Heavy metal content data in water, sediment, and wideng crab were quantitatively analyzed in the lab, while water quality data such as temperature, pH, salinity, dissolved oxygen content, and brightness were collected during the survey (11).

2.1 The Scope of this Study is as Follows

The purpose of this study is to investigate the levels of heavy metals Pb and Cu in the Gonjol river, Demak in wideng crab, and sediment as their habitat.

2.2 Locations of Sampling

The Gonjol river was sampled at two locations: upstream and estuary. For homogeneous sampling of sediment, water, and Wideng crab at each location, 5 points were taken far apart. Physical parameters of the environment are only measured under the same environmental conditions as when samples are obtained :

Table 1. The locations of the sampling points

Station	Location	Distance from pollutant source	Information
1	Upstream Gonjol River	10 m	The location is close to the source of the pollutant. dense industrial area, route Semarang-Demak outside the city
2	Gonjol River Estuary	6 km	Many mangrove plants are found at the confluence of rivers and sea water, the most common of which are *Avicennia* and *Rhizopora*.

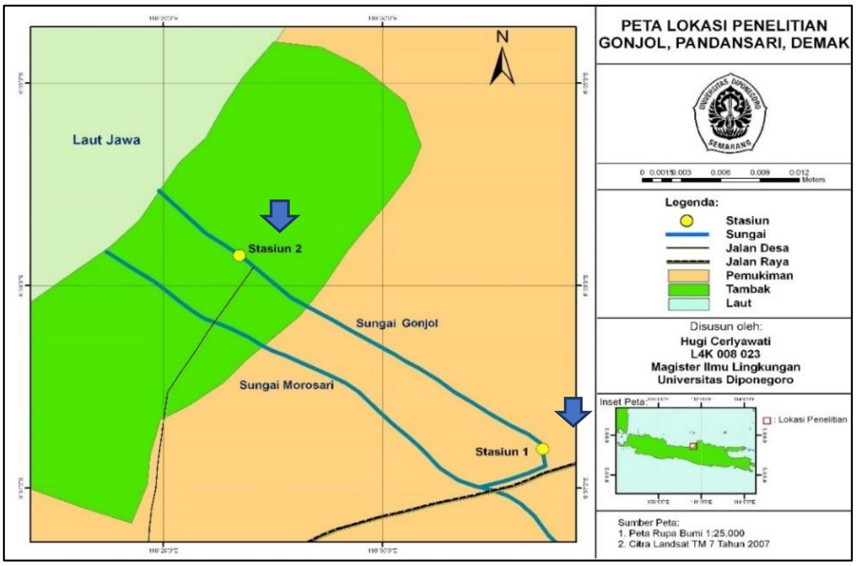

Fig. 1. Research location in Gonjol river, Demak (Station 1 and Station 2)

The condition of the waters surrounding the source of pollution, including topography and slopes, water base (substrate) characteristics, and the direction and pattern of water currents, must all be considered when selecting a sampling location. Research location as follow : (Fig 1).

This study took place between January and March 2020, during the transition from the wet to the dry season. At each location, observations and sampling were carried out three times, with each observation repeated three times. The initial sampling was place on January 5, 2010, during the rainy season. The second observation was made on March 1, 2010, when the season had changed to dry, and the third observation was made on March 9, 2010, when the season had changed to dry.

The location was widened by dividing it into four zones. The first and second zones ware separated by 3 meters, while the third and fourth zones are separated by 5 meters from the second zone. In each zone, approximately 15 widengs crab were taken, which were then measured for length, width, height, weight, and sex from the wideng crab.

Water was sampled at the upstream and estuary locations by dividing each into five zones. In each zone, 1 liter of water is collected and analyzed in the laboratory, and sediment samples ware treated similarly by collecting 10 grams of sample. The purpose of the digesting treatment is to eliminate organic matter-related disruptions and transform metals associated with particles into free metal ions that may be measured using AAS (Atomic Absorption Spectrophotometer) [12].

Water quality parameters were measured three times in each zone for each observation. Three observations were made. Data on heavy metal content in water, sediment, and soft tissue of crabs, as well as data on physical and chemical parameters of the waters, were analyzed descriptively, and the STORET (Storage and Retrieval of Water Quality Data System) method was designed to determine good and poor water quality in a reservoir or other water body for a specific water designation. Furthermore, this method can determine which parameters exceeded or did not meet the quality standard requirements. The closed association between the quantities of heavy metals Pb and Cu in water, sediment, and water will be determined using regression and correlation analysis. The following formula is used to compute the correlation coefficient:

$$r = \frac{S_{xy}}{\sqrt{(S_x)^2 (S_y)^2}}$$

$$S_{xy} = \frac{\sum (xi - x)(Yi - y)}{n-1}$$

$$S_x{}^2 = \frac{\sum (Xi - x)^2}{n-1}$$

$$S_y{}^2 = \frac{\sum (Yi - y)^2}{n-1}$$

Information: r = Correlation coefficient, Sxy = Distribution of observation values x and y and Sx^2 = Diversity of x , Sy^2 = Diversity of y values

2.3 Heavy Metal Bioaccumulation Factor Calculation

Bioaccumulation factors can be used to explain an organism's ability to accumulate heavy metals in its body from its environment. The bioaccumulation factor (K_B) is the ratio of metal concentrations in the organism's body to metal concentrations in the surrounding environment [13]. The bioaccumulation factor can be calculated using the equation below.:

$$K_B = \frac{K_1}{K_2}$$

Note: K_B = Bioaccumulation factor, K_1 = Heavy metal content in biota (ppm) and K_2 = Heavy metal content in the water environment (ppm) or in the sediment (mg/kg)

3. RESULTS AND DISCUSSION

Wideng crabs obtained at the study site ranged in length from 10 cm to 21 cm, width from 4 cm - 5 cm, and weight from 35 grams to 72 grams, with the majority being male. The water conditions were rich in nutrients when the Wideng crab (crustácea) was sampled during the spawning (breeding) period [14].

3.1 Heavy Metal Pb and Cu Distribution in Upstream and Estuary Sediments

The analysis of the heavy metal content of lead (Pb) in the sediment in the upstream area, as shown in Table 2, revealed a value in the range of 16 mg/kg – 20 mg/kg, with an average value of 17.8 mg/kg. The values in the estuary range from 12 mg/kg to 17 mg/kg, with an average of 15 mg/kg. Table 2 shows the results of an analysis of heavy metal level of Cu in sediments, with upstream values ranging from 28 mg/kg to 35 mg/kg, with an average value of 30.7 mg/kg. The values in the estuary range from 24 mg/kg to 30 mg/kg, with an average of 26.5 mg/kg.

Table 2. lead (Pb) and Copper (Cu) concentrations in Gonjol river sediments at various locations and conditions (mg/kg dry basis)

Condition	Snippets	Unit	Upstream		Estuary		Information
			Pb	Cu	Pb	Cu	
High tide	1	mg/Kg	17.00	31.00	12.00	27.00	Dry Weather
	2	mg/Kg	17.00	29.00	14.00	30.00	Rainy weather
	3	mg/Kg	16.00	35.00	17.00	26.00	Rainy weather
Low tide	1	mg/Kg	18.00	28.00	15.00	25.00	Dry Weather
	2	mg/Kg	19.00	32.00	16.00	24.00	Rainy weather
	3	mg/Kg	20.00	29.00	16.00	27.00	Rainy weather
Minimum		mg/Kg	16.00	28.00	12.00	24.00	
Average		mg/Kg	17.80	30.70	15.00	26.50	
Maximum		mg/Kg	20.00	35.00	17.00	30.00	
Standard deviation		mg/Kg	1.47	2.58	1.79	2.007	

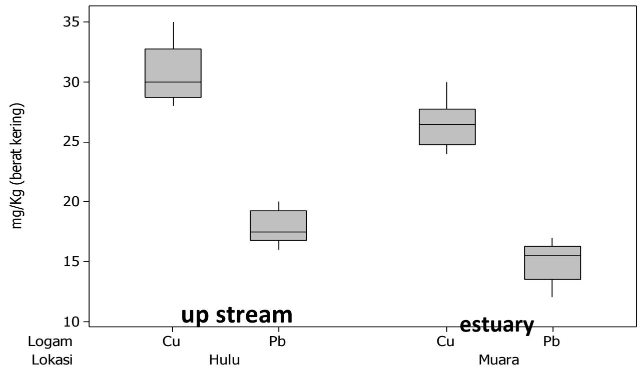

Fig. 2. Heavy metal Pb and Cu box plot in sediment

Pb has the property of accumulating in dissolved organic matter in the water the results of Table 2 show that the average value of Pb level in sediments in the river's estuary is lower than the level of Pb in upstream areas. Because of the mixing of seawater at high tide and fresh water from upstream via the upwelling process, the nature of the accumulation or binding is relatively more vulnerable. This is due to the fact that Pb level in Muara are relatively more stable than in the upstream. Meanwhile, heavy metal levels in the upstream are more variable depending on the mass of water coming from the watershed, as a result, heavy metal leaching of Pb and Cu occurs only when the water mass is present.[15] The greater the distance from the pollutant source, the lower the concentration of heavy metals carried by rivers, some of which have been deposited during the trip to the sea, but because heavy metals are bioaccumulative, they will be quite dangerous if exposed to the environment for an extended period of time [16] During the initial sampling period, modest amounts of both metals were frequent. The meteorological conditions at the time of sampling were likely to had played a role in this. In the initial observation, the season was still summer, therefore the watered discharge in the waters was small. Meanwhile, the second and third samplings take placed during wet weather, which meant that the watered discharge was higher than usual, lowering the risk of heavy metal accumulation in the sediment.

Heavy metal level in sediments are higher, which is due to the nature of heavy metals in water which settle for a period of time and then accumulate at the bottom of the water [17]. The main factor in the distribution of heavy metals into waters originating from river flows is tides in the water [18] The heavy metal content in sediments was found to be much higher than that dissolved in the water column. Because heavy metal elements have a higher density than water, they are likely to precipitate [19] The type of sediment influences the accumulation of heavy metals in the sediment. The sediment in the waters of the river Gonjol Pandansari Demak is a type of mud that appears black. This condition also demonstrates the presence of high levels of heavy metals [20]. Some metals are commonly found in the form of particulates. The formation process begins with the binding of a number of heavy metals in the top layer by suspended particulates from the water column. When the particulates reach a density greater than that of water, gravity will deposit them and they will become part of the surface sediment [21] Metals in solution will be absorbed to some extent by particulate materials. Particulate matter in the water will be deposited and become part of the surface sediment in a subsequent process. Gravity can play a role in the deposition process [22]. Some metals that are bound to sediments and particles that settle back into the water are remobilized and diffuse upward. Metal concentrations in the sediment will be affected by bioturbation [23] Because the effect of bioturbation is the release of metals from the sediment into the water above the sediment surface, fluctuations in heavy metal levels in the sediment are thought to be influenced by the activity of enrichment and metal release in the sediment [24].

3.2 The Distribution of Heavy Metals Pb and Cu in Upstream and Estuarine Water

Rainfall and tides influence the chemical and physical properties of water in rivers and estuaries. As a result, the description of the analysis results differs from the results of the sampling during low and high tide conditions. The findings of the examination of lead (Pb) levels in the river's upstream showed a value in the range of 0.04 mg/L – 0.13 mg/L with an average value of 0.08 mg/L at high tide, and a value in the range of 0.05 mg/L – 0.18 mg/L with an average value of 0.09 mg/L at low tide. The findings of the examination of lead (Pb) levels in the river estuary show a value in the range of 0.05 mg/L – 0.22 mg/L with an average value of 0.12 mg/L during high tide and a value in the range of 0.06 mg/L – 0.32 mg/L with an average value of 0.15 mg/L during low tide.

The findings of the examination of copper (Cu) levels in the river upstream during high tide showed a value in the range of 0.03 mg/L – 0.18 mg/L with an average value of 0.08 mg/L indicating a value in the range of 0.04 mg/L – 0.11 mg/L with an average value of 0.07 mg/L. Copper (Cu) levels in the estuary were measured at high tide and found to be in the range of 0.04 mg/L – 0.31 mg/L, with an average of 0.14 mg/L, while at low tide they were in the range of 0.05 mg/L – 0.42 mg/L, with an average of 0.17 mg/L.

Cu and Pb levels were higher near the river's mouth than in the upper river because the river's was a collection pointed for all garbage generated by home and industrial operations along the river. Pb and cu levels in the watered along the gonjol river were assumed have been caused by industrial operations in industries upstream of the river. These wastes were the product of industrial trash generated by industries along the river. Cu was a member of the essential metal group; low amounts were needed by organisms as coenzymes in metabolic processes, while high levels had harmful effects [25]. Excess cu was very toxic to aquatic biota; concentration of cu dissolved in seawater of 0. 01 ppm could kill aquatic biota. Cu poisoning, which limits the activity of enzymes in respiration and metabolism, including the death of the crustacean (wideng crab) family, was the caused of death. If the cu concentration was in the range of 0. 17 ppm - 100 ppm, the wideng crab (crustacean family) would died within 96 hours [17]. Similarly, molluscs will die if the Cu content is between 0.16 ppm - 0.5 ppm, and fish will die if the Cu content is between 2.5 ppm - 3.0 ppm [26] According to the studied's findings, the highest concentration of heavy metal pb was found in low tide conditions, with an average valued of 0. 32 mg/l, while the lowest concentration was found in high tide situations, with an average valued of 0. 04 mg/l. Cu levels in river watered, on the other handed, was highest at low tide, with an average valued of 0. 042 mg/l, and lowest at high tide, with an average valued of 0. 03 mg/l. because river estuaries were the estuaries for materials carried by the flowed of watered from rivers, it was thought that materials carrying heavy metal trash would congregate at the river estuary and had been mixed and diluted by sea watered before being carried by the current to the sea.

3.3 Heavy Metal Pb and Cu Distribution in the Upper and Estuary of the River

Table 4 shows the results of an analysis of the heavy metal content of Pb in tissue; in the upstream, it ranges from 0.13 mg/kg to 0.27 mg/kg, with an average value of 0.20 mg/kg, while in the estuary, it ranges from 0.04 mg/kg to 0.29 mg/kg, with an average value of 0.17 mg/kg. Table 4 shows the results of an analysis of heavy metal levels of Copper (Cu) in tissues, with upstream values ranging from 0.07 mg/kg to 0.16 mg/kg, with an average value of 0.09 mg/kg. The values in the estuary range from 0.02 mg/kg to 0.13 mg/kg, with an average of 0.06 mg/kg.

Heavy metal levels of Pb in the body tissue of Wideng (Episesarma sp.) showed the highest results in the upstream with an average value of 0.20 mg/kg, despite the fact that one of the data from the sampling results in the estuary had a value of 0.29 mg/kg. What matters, however, is the sum of three sampling repetitions. The estuary had the lowest value, with an average of 0.07 mg/kg. Meanwhile, Cu metal in wideng body tissue (Episesarma sp.) showed the highest results in the upstream with an average value of 0.16 mg/kg and the lowest value in the estuary with an average of 0.02 mg/kg. These findings suggest that the wideng caught upstream accumulated more Pb and Cu from pollutant sources than those caught in the estuary, where fresh water meets sea water, either directly through predation and digestion or indirectly through metabolism and molting. Because the estuary was relatively more closed and heavily influenced by fresh water, the lower levels of Pb and Cu in the body tissue of the wideng crab caught in the Gonjol River's estuary area were related to the tidal washing system. Heavy metal absorption by aquatic organisms begins with rapid absorption in cell membranes, followed by a rate of uptake that is taken up by diffusion and then bound by proteins, either through food digestion or molting [27] The accumulation of heavy metals Pb and Cu in animal tissues is caused by the biota's life cycle, digestive system, and growth process. The process of taking food can predict the accumulation of heavy metals in crab soft tissues. The food will be forwarded to the digestive tract and undergo a metabolic process after being filtered by the gills. Nutrients that are required will be directly absorbed by the tissues and forwarded to the cell membrane, whereas substances that are not required will be excreted along with the results of digestion and urine. Heavy metals that are bound in food substances are absorbed during the absorption process. Variations in heavy metal levels in soft tissues are thought to be caused by differences in heavy metal levels from the source as well as organism-specific factors such as age, body size, growth rate, feeding rate, and individual ability to accumulate, excrete, and detoxify heavy metals [28].

Table 3. Results of analysis of metal levels of Lead (Pb) and Copper (Cu) in water

Condition	Snippets	Unit	Upstream		Estuary		Information
			Pb	**Cu**	**Pb**	**Cu**	
High tide	1	mg/L	0.13	0.18	0.22	0.31	Dry Weather
	2	mg/L	0.07	0.03	0.09	0.04	Rainy weather
	3	mg/L	0.04	0.03	0.05	0.06	Rainy weather
Minimum		mg/L	**0.04**	**0.03**	**0.05**	**0.04**	
Average		mg/L	**0.08**	**0.08**	**0.12**	**0.14**	
Maximum		mg/L	**0.13**	**0.18**	**0.22**	**0.31**	
Standard deviation		mg/L	0.05	0.09	0.09	0.15	
Low tide	1	mg/L	0.18	0.11	0.32	0.42	Dry Weather
	2	mg/L	0.05	0.04	0.06	0.05	Rainy weather
	3	mg/L	0.05	0.06	0.07	0.05	Rainy weather
Minimum		mg/L	**0.05**	**0.04**	**0.06**	**0.05**	
Average		mg/L	**0.09**	**0.07**	**0.15**	**0.17**	
Maximum		mg/L	**0.18**	**0.11**	**0.32**	**0.42**	
Standard deviation		mg/L	0.08	0.04	0.15	0.21	

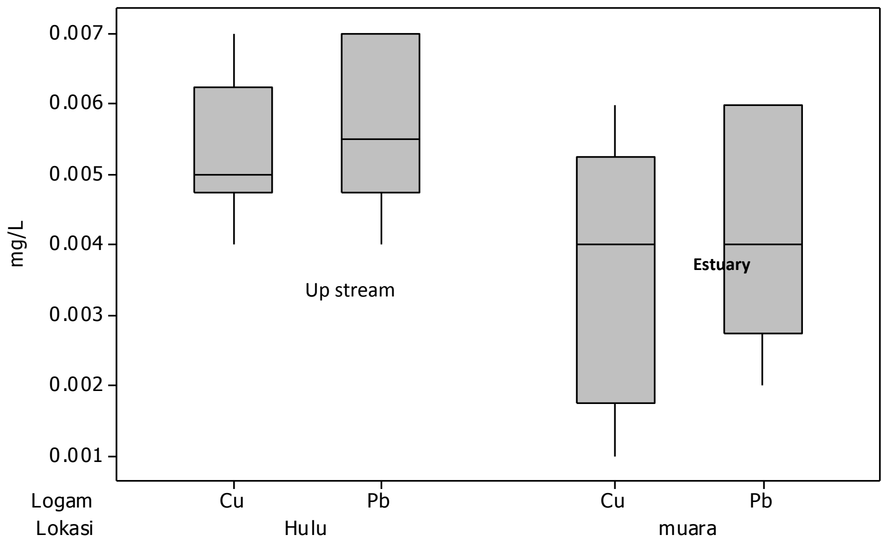

Fig. 3. Concentration of heavy metals dissolved in water in a box plot

Table 4. Results of analysis of metal concentrations of Lead (Pb) and Copper (Cu) in tissue (dry basis)

Condition	Snippets	Unit	Upstream		Estuary	
			Pb	Cu	Pb	Cu
High tide	1	mg/Kg	0.17	0.08	0.09	0.02
	2	mg/Kg	0.27	0.09	0.29	0.07
	3	mg/Kg	0.19	0.07	0.21	0.05
Low tide	1	mg/Kg	0.13	0.11	0.04	0.06
	2	mg/Kg	0.18	0.16	0.29	0.13
	3	mg/Kg	0.27	0.07	0.24	0.06
Minimum		mg/Kg	0.13	0.07	0.04	0.02
Average		mg/Kg	0.20	0.10	0.19	0.07
Maximum		mg/Kg	0.27	0.16	0.29	0.13
Standard deviation		mg/Kg	0.06	0.03	0.11	0.04

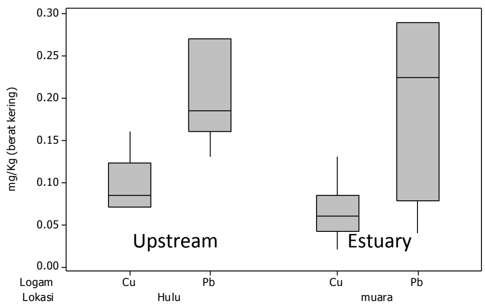

Fig. 4. Box Plot of Heavy Metal Content in Tissue

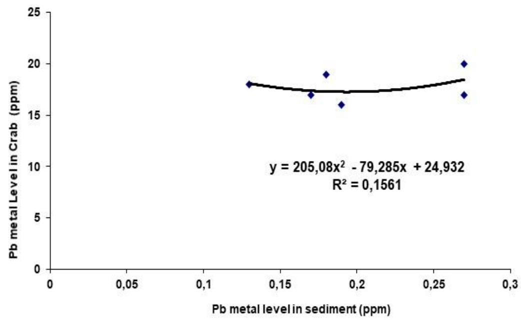

Fig. 5. Pattern of regression relationship between Pb content in sediment and wideng crab tissue (Upstream location)

3.4 Metal Content in Wideng Crab Tissue Correlates with Heavy Metals Pb and Cu in Sediment

Based on the regression analysis of the Pb metal content data at the Upstream location, the value of r = 0.395 with the regression equation is $Y = 205.08X^2 + 79.285x – 24,932$, where X is the Pb content in the sediment and Y is the Pb content in the wider network (Figure 4). This means that there is no close relationship between heavy metal Pb found in crabs and those found in sediments upstream. (Fig 4)

Based on the regression analysis of the Pb metal content data at estuary, the value of r = 0.4340 with the regression equation is $Y= - 0.005X^2 – 0.1681X – 1.195$, where X is the Pb content in the sediment and Y is the Pb content in the wideng crab tissue. This means that there is no close relationship between the heavy metal Pb in the sediment and the heavy metal Pb content in

Wideng crab tissue at the estuary site. Estuary river is situated on a heavy metal dump that is directly adjacent to the river. Because of the nature of the Wideng crab, there aren't many of them in the estuary because if the nutrients in the water are depleted, the Wideng crab dies (Fig 6).

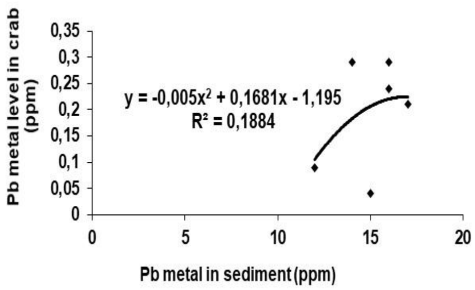

Fig. 6. The pattern of regression relationships between Pb levels in sediments and those in wideng crab tissues (estuary location)

Meanwhile, for Cu metal in the Upstream, the value of r = 0.3912 with the regression equation $Y = -0.0025X^2 + 0.157X - 2.353$, where X and Y are Cu content in sediment and network widening, respectively (Fig 6). This means that there is no direct relationship between the influence of heavy metal Cu in the sediment and heavy metal Cu levels in the Wideng crab tissue. Heavy metal Cu is deposited in crustacean shells because the Wideng Crab requires heavy metal Cu for shell hardening. In this study, tissue from the Wideng crab was taken, and the content of heavy metal Cu was obtained in a small amount compared to heavy metal (Pb).

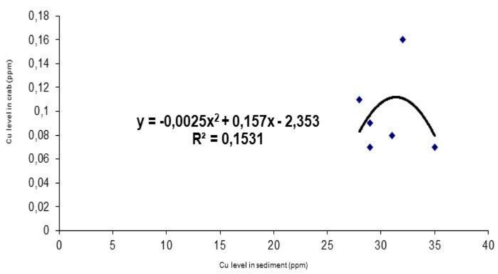

Fig. 7. Pattern of regression relationship between Cu content in sediment and wideng crab tissue (Upstream location)

The correlation test value of Cu metal in estuary to sediments with Wideng has a correlation value of r = 0.8968 with the regression equation $Y = 0.0068X^2 - 0.3736X + 5.1867$, where X and Y are the Cu content of the sediment and the widening tissue, respectively (Fig 8). It means that the heavy metal content of Cu in the sediment is closely related to the heavy metal content of Cu in the Wideng network. The obtained correlation is positive, indicating that if the heavy metal content of the Wideng crab is high, high levels of heavy metal in the sediment will follow.

The results of the analysis revealed that heavy metal Pb levels in sediments in the upstream and estuary affected heavy metal levels in crab tissue more than heavy metal Cu levels in the upstream and estuary due to crabs absorbing more heavy metal Cu for the formation of cuticles/scales in crustaceans.

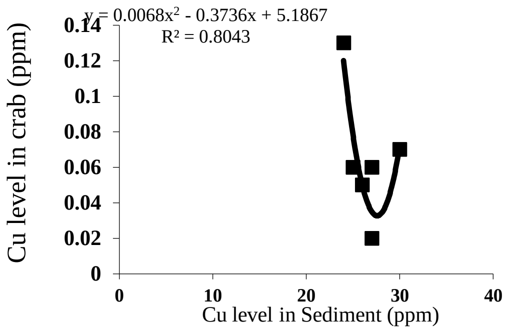

Fig. 8. Pattern of regression relationship between Cu content in sediment and wideng crab tissue (Estuary location)

3.5 Pb and Cu Heavy Metal Rates in Wideng Crab Tissue Correlation with Metals in Water

The correlation test for Pb metal content in upstream waters and wideng crab tissue yielded a value of 0.7338, and the regression equation was $y = -10.576x^2 + 1.6379x + 0.1669$. (Fig 9) where X is the amount of Pb in the water and Y is the amount of Pb in the tissue This means that there is a close relationship between heavy metal levels in the waters and heavy metal levels in the wideng crab tissue in the estuary. The obtained correlation is negative, which means that if the heavy metal content of the Wideng Crab is low, the heavy metal content of the water will be high, and vice versa.

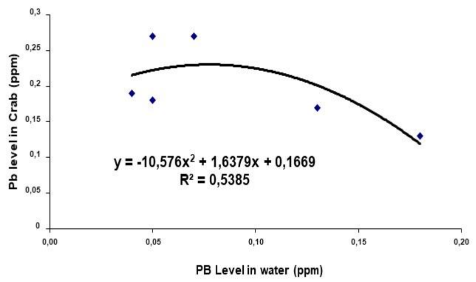

Fig. 9. Pattern of regression relationship between Cu content in sediment and wideng crab tissue (Upstream)

The correlation coefficient for heavy metal Pb in watered to crabs in the estuary area was r = 0. 949, with the equation y = -3. 361x^2 – 2. 0971x + 0. 3654, where x and y were the levels of pb in watered and crab tissue, respectively broadening (Fig 10). The obtained correlation was negative, which means that if the heavy metal content of the Wideng crab was high, the heavy metal content of the watered had been low and vice versa. This indicates that there was a closed relationship between the heavy metal Pb in the watered and the heavy metal Pb content in the wideng tissue. The obtained correlation was negative, which means that if the heavy metal content of the wideng crab was high, the heavy metal content of the watered had been low and vice versa. This implies that there was a closed relationship between the heavy metal Pb in the watered and the heavy metal Pb content in Wideng crab tissue. Because Pb was deposited in considerable numbers in the wideng tissue crab, the heavy metal concentration obtained in the estuary region of the wideng tissue crab was higher. The graph indicates that the amount of heavy metal in the waterways correlates with the amount of heavy metal in the wideng crab tissue

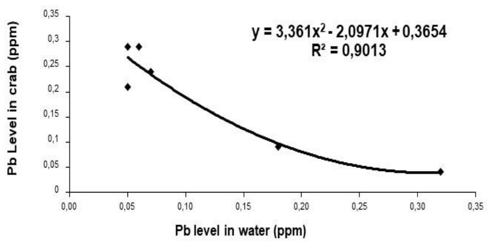

Fig. 10. Pattern of regression relationship between Pb content in sediment and wideng crab tissue (Estuary)

The correlation coefficient of heavy metal Cu concentration in the upstream in water and crabs has a positive value of r = 0.244 with the regression equation y = -2.7975x2 - 0.4827x + 0.0845 where x and y are Cu levels in water and wideng crab tissue, respectively (Fig. 11). This demonstrates that there is no close relationship between water and heavy metal accumulation in wideng crab tissue. As a result, an increase in the accumulation of heavy metals in the water is not followed by an increase in the concentration of heavy metals in the wideng crab tissue.. This is because the heavy metal Cu accumulates in the wideng crab's shell because it is required for the formation of chitin..

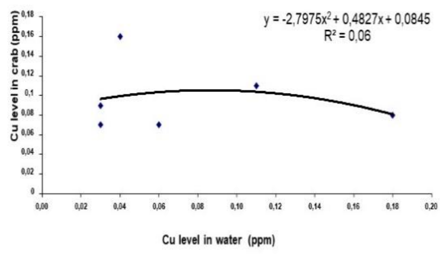

Fig. 11. Pattern of regression relationship between Cu content in sediment and wideng crab tissue (Upstream)

The correlation coefficient of heavy metal Cu in the estuary and the wideng crab tissue is positive (r) = 0.658, with the regression equation y = 1.6176x^2 – 0.8066x + 0.1138, where x and y are Cu levels in water and wideng crab tissue, respectively (Fig. 12). This demonstrates that there is no close relationship between Cu concentration in water and heavy metal accumulation in wideng crab tissue, so an increase in heavy metal accumulation in water does not result in an increase in heavy metal concentration in wideng crab tissue.

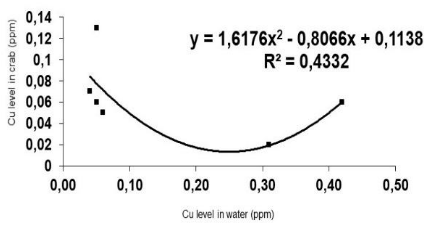

Fig. 12. Pattern of regression relationship between Cu content in sediment and wideng crab tissue (Estuary location)

3.6 Correlation of Pb and Cu Heavy Metal Content in Sediment and Water

The regression analysis results on the two types of heavy metals, namely Pb and Cu, based on the research location, upstream and estuary, are as follows. The correlation coefficient value (r) = 0.7130 was based on the results of the regression analysis of the Pb metal content data at the upstream location of the river, with the regression equation y = 0.0023x2 + 0.8265x – 7.2901 where x is the Pb content in the sediment and y is the Pb content in the water (Fig. 13). The obtained correlation is negative, indicating that if the heavy metal content in the water is high, the heavy metal content in the sediment is relatively low. This means that heavy metal levels in the water are closely related to heavy metal levels in the sediment. The trend graph shows a peak followed by a decrease, which is caused by the influence of tides and conditions in the Upper River where there is no flow for water exchange.

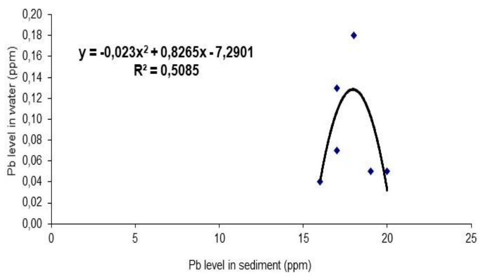

Fig. 13. Pattern of regression relationship between Pb levels water and sediment (Upstream)

The correlation coefficient value (r) = 0.4384 with the regression equation y= -0.0095x² + 0.2513 – 1.4892, where x and y are the levels of Pb in sediment and water, respectively, according to the results of the correlation test value on water with heavy metal sediment Pb in the estuary (Fig 14). This demonstrates that in the estuary, there is no close relationship between water and sediment. As a result, an increase in heavy metal accumulation in the water will not be followed by an increase in heavy metal accumulation in the estuary's sediments. This is due to the fact that the estuary receives a plethora of different sources from the sea and surrounding ponds, making it impossible to estimate how much pollutant affects the estuary.

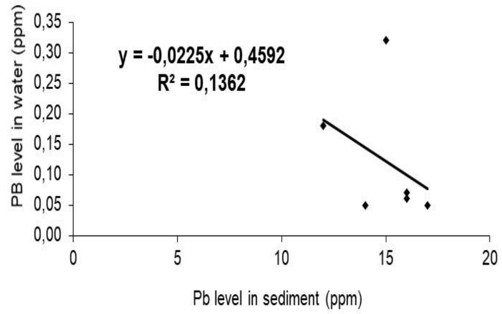

Fig. 14. Pattern of regression relationship between Pb levels in water and sediment (estuary location)

Heavy metal regression analysis of Cu content in water and sediment upstream is positive (r) = 0.3971, as calculated by the regression equation y= -0.0033x² + 0.204x – 3.0277, where cu in water on the Y and Sediment on the X axis (Fig 15). This demonstrates that there is no close relationship between heavy metal accumulation in water and sediment upstream of the river, so that an increase in heavy metal accumulation in water is not followed by an increase in heavy metal concentration in sediment.

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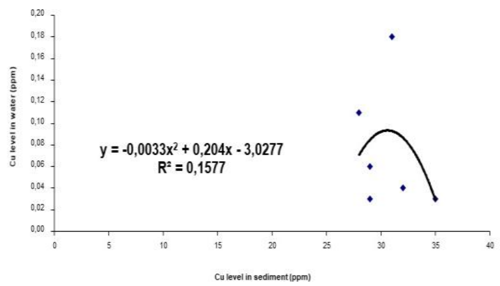

Fig. 15. Pattern of regression relationship between Cu content in water and sediment (Upstream location)

The correlation coefficient between heavy metal concentrations of Cu in river mouths in sediments is (r) = 0.3823, with the regression equation y= -0.0106x2 + 0.5527 – 7.0008 where x and y are Cu levels in sediment and water, respectively (Fig16). This demonstrates that there is no close relationship between heavy metal concentrations in water and in sediment, so that an increase in heavy metal accumulation in water is not followed by an increase in heavy metal concentration in sediment.

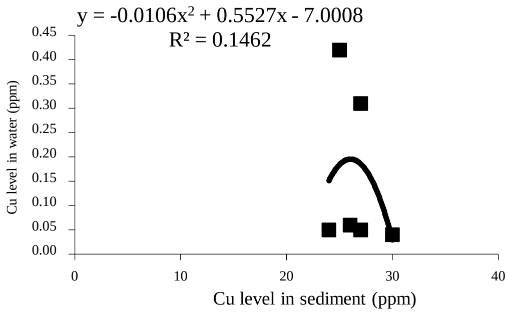

Fig. 16. Regression relationship pattern between Cu content in water and sediment (Estuary location)

The interaction of Pb in the water and in the Wideng crab (estuary location) indicates that the heavy metal Pb has a greater chance of accumulating in the Wideng crab tisue at high tide. This is closely related to the wideng crab's metabolic system and predation. Metabolism occurs when water enters the body through the gills and is used as a source of respiration by taking oxygen. Hemoglobin will bind oxygen and transport it to all body tissues. At the same time, the heavy metal Pb in the media will be carried into the bloodstream and deposited in various body tissues. The same thing happens when the wideng crab hunts for food; the media water enters the digestive tract and is deposited in several body tissues as a result of the process (Hutagalung 1994). Heavy metal concentrations of Pb and Cu in the estuary, both in the sediment and water have effect on the body of wideng crab. Therefore, water containing trace amount of heavy metals may have negative impact on their tissue. Heavy metals present in body tissues are said to enter through food carried by the flow of water and be captured by these biota [29].

3.7 Factors of Concentration and Comparison of Pb and Cu Heavy Metal Levels with Quality Standards

If there are 100 ppm levels of heavy metal Pb in the water, the levels of heavy metal Pb in sediments in the upstream river are around 39 ppm at high tide. Meanwhile, at high tide, wideng crabs can accumulate heavy metal Pb concentrations of up to 88.430 ppm in sediment (Table 5). The accumulation of heavy metal levels of Pb and Cu in bioconcentration conditions at the river's mouth is higher than upstream. This is due to the fact that the bioaccumulation factor of heavy metals in the estuary is higher because the estuary is a confluence of seawater flows and river water, so metal concentrations are higher. The weight settles in the area, and the sediment undergoes bioconcentration. The bioaccumulation factor of heavy metals is greater at high tide than at low tide.

Heavy metal bioaccumulation in aquatic animals is a complex process that is not fully understood [30] Heavy metals can accumulate in aquatic animals' body tissues in four ways: by the flow of water through the gills, the act of eating and drinking, and the skin [31] Metal accumulation in aquatic animals begins with taking (uptake) through the gills, which is then absorbed into all body tissues and stored / trapped inside. Several factors influence the process of 'uptake' of heavy metals and the amount that accumulates. These factors include metabolic rate, size and type, alkalinity, and pH. Furthermore, the demethylation process, temperature, level of contamination, time, source and form of heavy metals, and the organism's life stage all have a significant impact on the uptake process [32]. Aproximately 70% of heavy metals ingested through food are absorbed into the body tissues of aquatic animals, while only 10% are absorbed through the gills [33].

3.8 Water Quality and Heavy Metal Content

According to the findings of the analysis, the levels of heavy metals Pb and Cu in the water in the study area from upstream to the river's mouth, namely the Pandansari River estuary, place the research area in category C, which is moderately polluted by heavy metals Pb and Cu. According to Minister of Environment Decree 115 of 2003, guidelines for determining water quality can use the STORET method or the Index method, so the status of water quality at the Gonjol river estuary is tidal conditions.

Table 5. Heavy Metal Concentration Factors

Sample	W	A	S	FK			W	A	S	FK		
	(ppm)	(ppm)	(ppm)	AW	SW	SA	(ppm)	(ppm)	(ppm)	AW	SW	SA
Upstream (High tide)	0.202	0.080	17.833	0.397	88.430	0.004	0.097	0.080	30.667	0.828	317.241	0.003
Upstream (low tide)		0.093		0.463		0.005		0.070		0.724		0.002
Estuary (High tide)	0.193	0.120	15.000	0.621	77.586	0.008	0.065	0.137	26.500	2.103	407.692	0.005
Estuary (low tide)		0.150		0.776		0.010		0.173		2.667		0.007

Information : W : Wideng Crab, SW : Sediment to Wideng, S : Sediment, FK : Concentration Factor, A : Water, SA : Sediment to Water. AW : Water against Wideng

Table.6 Status of water quality according to the STORET value system at the Gonjol river estuary tidal and low tide conditions and upstream at high tide and low tide conditions

No.	Parameter	Unit	Standard	Measurement Results			Score	Measurement Results			Score
				Max	Min	Avg		Max	Min	Avg	
Physical											
1	Temperature	Celcius	Normal	29.63	29.63	29.63	0,00	29.63	29.63	29.63	**0,00**
2	Brightness	Meter	± 3	0.29	0.27	0.28		0.29	0.27	0.28	
<u>Chemical</u>	Water Temperature										
1	Pb	mg/l	0.03	0.22	0.05	0.12	-10	0.32	0.06	0.15	-10,00
2	Cu	mg/l	0.02	0.31	0.04	0.14	-10	0.42	0.05	0.17	-10,00
3	DO	mg/l	>3	3.18	2.12	3,00	0,00	3.18	2.12	3,00	0.00
4	pH		6,00-8.50	7,00	7,00	7,00	0,00	7,00	7,00	7,00	0.00
5	Salinity	0/00		33	32	32.5	0,00	33	32	32.5	0.00
6	PO_4	mg/l		0.70	0.60	0.65		0.70	0.60	0.65	
7	NO_3	mg/l		5.00	4.00	4.5		5.00	4.00	4.50	
	Total score						-20				-20
No.	Parameter	unit	Standard	Measurement Results			Score	Measurement Results			Score
				Max	Min	Avg		Max	Min	Avg	
Physical											
	Temperature	Celcius	normal ± 3,00	29.63	28.2	28.915	0.00	29.63	28.2	28.915	0.00
	Brightness	Meter		75.33	29.67	52.50		75.33	29.67	52.5	
<u>Chemical</u>											
1	Pb	mg/l	0.03	0.18	0.05	0.09	-10,00	0.18	0.05	0.09	-10
2	Cu	mg/l	0.02	0.11	0.04	0.07	-10,00	0.11	0.04	0.07	-10

No.	Parameter	Unit	Standard	Measurement Results			Score	Measurement Results			Score
3	DO	mg/l	>30,00	3.73	2.38	3.055	0.00	3.73	2.38	3.055	0.00
4	pH		6,00-8.50	7,00	7,00	7,00	0.00	7,00	7,00	7,00	0.00
5	Salinity	0/00		34	32	33	0.00	34,00	32,00	33,00	0.00
6	PO_4	mg/l		0.8	0.5	0.7		0.80	0.50	0.70	
7	NO_3	mg/l		6,00	4,00	5,00		6,00	4,00	5,00	
	Total score						-20				-20

Based on table 6 then the total score is -20, which means that the Gonjol river at station 1 is classified as category C, moderately polluted by heavy metals Pb and Cu. Heavy metals that enter and accumulate in the crab's body can be released through a release mechanism assisted by metabolic processes.

Based on the decree of the Director General of Drug and Food Control no. 03725/B/SK/VII/1989 of 1989 concerning the maximum limit of metal contamination in food for fish and its preparations can be seen in table 7, that the metal content in soft tissue of crabs, for Pb and Cu metals at all stations were low the threshold [34].

According to the FAO, USFDA, and NAS-NRC maximum limit for heavy metal entry into the human body, the metal content in crab soft tissue for Pb and Cu metals was below the consumption threshold, which was 2,00 mg/kg [35] .

The levels of heavy metals in the sediments in the study area for Pb and Cu metals are still below the quality standard threshold at all stations [36].

Table 7. Heavy metal levels of Pb and Cu in Wideng crab soft tissue compared to the decree of the Director General of National Agency of Drug and Food Control of Indonesia

Heavy Metal	Location	Station	Concentration (mg/kg)	Consumption Limit (mg/kg)	Information
Pb	Upstream	1	0.20	2,00	Below the threshold
	Estuary	2	0.17	2,00	Below the threshold
Cu	Upstream	1	0.09	2,00	Below the threshold
	Estuary	2	0.06	2,00	Below the threshold

Table 8. Heavy metal concentration of Pb and Cu in Wideng crab soft tissue compared with maximum limit for heavy metal entry into human body

Heavy metal	Location	Station	Concentration (mg/kg)	Comsumption limit (mg/kg)	Information
Pb	Upstream	1	0.20	0.50	Below the threshold
	Estuary	2	0.17	0.50	Below the threshold
	Upstream	1	0.09	30,00	Below the threshold
Cu	Estuary	2	0.06	30,00	Below the threshold

Table 9. Heavy metal content of Pb and Cu in sediment compared with quality standard value

Heavy Metal	Location	Station	Content at location (mg/kg)	Consumption Limit (mg/kg)	Information
Pb	Upstream	1	17.6	30.24	Below the threshold
	Estuary	2	14.6	30.24	Below the threshold
	Upstream	1	30.3	18.70	Above the threshold
Cu	Estuary	2	26.1	18.70	Above the threshold

4. CONCLUSION

It may be concluded, based on the findings of research into the content of heavy metals Pb and Cu in water, sediment, and wideng crabs in the Gonjol Demak River, that follow :

Pb levels in water in the upstream region varied from 0.04 to 0.13 mg/l at high tide and 0.05 to 0.28 mg/l at low tide. At high tide, 0.05 to 0.22 mg/l, and at low tide, 0.06 to 0.32 mg/l in the estuary area. Pb levels in sediments vary from 16 to 20 mg/kg in the upstream region, and 12 to 17 mg/kg in the estuary. Wideng Crabs in the upstream region have Pb levels ranging from 0.13 to 0.27 mg/kg. Those living near the estuary have levels ranging from 0.04 to 0.29 mg/kg. Cu levels in water in the upstream region varied from 0.03 to 0.18 mg/l at high tide, and 0.04 to 0.11 mg/l at low tide. High tide ranges from 0.04 to 0.31 mg/l in the estuary area, whereas low tide ranges from 0.05 to 0.42 mg/l. Cu content in sediments varies between 28 and 35 mg/kg in the upstream region and 24 to 30 mg/kg in the estuary. Wideng crabs in the upstream area have Cu levels ranging from 0.07 to 0.16 mg/kg, while those in the estuary have Cu levels ranging from 0.02 to 0.13 mg/kg.

According to the Minister of Environment's Decree No. 115 of 2003, the environmental quality of water was categorized as moderately polluted with a score of 20 using the Storet method. Meanwhile, according to NOAA, heavy metal levels in sediments were still below the threshold of 14.6 mg/kg. Meanwhile, Cu's heavy metal concentration was over the 26.1 mg/kg standard. The Pb and Cu concentration in Wideng Crab is still below the quality standard of 0.17 mg/kg set by the FAO, USFDA, and NAS-NRC.

The findings of the correlation analysis revealed that there is a correlation of Pb levels between water and the Wideng Network (r = 0.7338) both in the estuary and upstream, but no correlation of Pb levels between sediment and the Wideng Crab (r = 0.4340). There was a link (r = 0.8968) between Pb levels in water and sediment upstream, but none in the estuary (r = 0.395).

Cu levels in water and wideng network did not exhibit a link (r = 0.3912) either upstream or in the estuary, nor did sediments and wideng network in the upstream, but there was a correlation (r = 0.949) in the estuary. Cu concentration in water and sediment had no connection (r = 0.244 and r = 0.658) both upstream and in the estuary.

The ability of the Wideng crab to bioaccumulate heavy metals can be exploited to reduce heavy metal levels in a body of water. Wideng Crab's propensity to accumulate huge amounts of heavy metals can be utilized as a bioindicator for water quality.

5. DATA AVAILABILITY

All relevant data has been registered with supporting file information. This research will help researchers to uncover critical areas related to The Characteristics of Heavy Metal Correlation Pb and Cu in Wideng Crab tissue in industrial wastewater in Gonjol river, Demak

DISCLAIMER

There are no competing interests stated by the authors. The products employed in this study are routinely and often used in our field of study and country. There is no conflict of interest between the writers and makers of the products because we do not plan to use them as a means of pursuing legal action, but rather to further knowledge. Furthermore, the research was not supported by the production firm, but rather by the writers' own efforts.

CONSENT

The research was carried out in accordance with research standards that apply in the Republic of Indonesia, written consent has been collected and kept by the author

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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