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Correlation between Concentration of Lead (Pb) and Cadmium (Cd) in Water with Inside Green Mussels Soft Tissues (*Perna viridis*) in Semarang Bay Water

Menur Rumanti[1], Haeruddin[2], dan Ita Widowati[2]
[1]*Postgraduate Program in Coastal Resource Management, FPIK-UNDIP, Central Java*
[2]*Teaching Staff for Coastal Resource Management, FPIK-UNDIP, Central Java*

Abstract

Heavy metal lead (Pb) and cadmium (Cd) are heavy metals which found in marine waters. Those heavy metals are widely industrial and household activities such as in the textile industry, shipbuilding, chemical industry and any others which producing waste. Those waste flows into the sea and affects the quality of the waters and also the sustainability of the biota inside the waters, one of them is green mussels (*Perna viridis*). The method that was used in this research is exploration's method. Sampling was done by purposive sampling method. The sampling locations around the Bedono Village's waters consist of 3 stations and each station has 3 points of area for sampling of water and shellfish. The location around the Tambak Mulyo waters has 5 stations with 3 points of area. The sample was then analyzed with AAS and using SPSS software to see the correlation between the variables. The results of the analysis showed that there were a close correlation between variables in each location with the Significant value <0.05. The highest result of the analysis in Bedono Village in relation to the concentration of cadmium (Cd) in water and shellfish with significant value 0.002, and the closeness of the relationship value between two variables (R) were 0.867. At the location in Tambak Mulyo, the results of analysis between lead (Pb) in water and shellfish obtained the highest value with significant value 0.010, and the closeness of the relationship with value (R) of 0.641. The results of the analysis showed that between variables have close correlation one another.

Keywords: lead (Pb) and cadmium (Cd), *Perna viridis*, and Semarang Bay waters

INTRODUCTION

The cultivation activity of green mussels found around Semarang Bay waters is one of the commodities so it is used by the society around Semarang Bay Water to become livelihoods, and many people depend on this cultivation. Waters around Tambak Mulyo, , North Semarang Distric, Semarang City and surrounding Bedono Village, Sayung Distric, Demak Regency is part of Semarang Bay wich has green mussels cultivation area. Semarang Bay waters close to the Tanjung Mas Port area where there are many industrial activities such as loading commercial vessels and other industrial factory (Sutiyono, 2013). The cultivation activity of the green mussels (*Perna viridis*) in both locations use stepped bamboo, where green mussels will stick to the stepped bamboo until the time of harvested for about 3-4 months. Green mussels that are often found are generally 8 cm in size but green mussels can grow to a maximum length of 16 cm (Gosling, 2004 in Cappenberg, 2008). According to Sagita et al. (2017), a factor that trigger the amount of cultivation of green mussels (*Perna viridis*) due to rapid growth to the size that is ready to be consumption and the availability of the seeds in nature throughout the years. Green mussels (*Perna viridis*) are included in the bivalve class. The foot shape is the widening of the body part which is flat lateral shaped like a small ax and called *pelecypoda*. Green mussels have two thin and symmetrical shells that can be opened and closed its lid with the umbo that curves forward. It has smooth joints with some very small teeth. The shell of the viridis form is oval-shaped with growth lines on the clear outer shell, where in the *Perna viridis* it has a strong bysus to stick (Barnes, 1974 in WWF Indonesia, 2015). The feed process of green mussels using filter feeder system that filters organic and inorganic materials which are found in the water column (Mirawati et al., 2016).

Heavy metals are natural constituents found in waters, generally in low concentrations. Human activities around the waters can increase the concentration of heavy metals. These activities including industrial activities, domestic, etc. Heavy metals which are contained include lead (Pb) and cadmium (Cd). According to research of Van Nguyen (2012) states that domestic, household and industrial production waste disposal contains Pb and Cd metals. Lead source of metals (Pb) are commonly used in chemical factories and coloring pigments, while cadmium is widely used in color pigments in paints, ceramics, plastics, batteries, rubber, soap, fireworks, and textiles. Waste disposal sources that entering a waters and containing metals can enter the body of aquatic biota, one of them is the green mussels (*Perna viridis*). According to research of Putri et al. (2012) in Muara Kamal, Jakarta Bay, the highest heavy metals found in green shells are Pb metal and followed by Cd metal.

Generally, green mussels are aquatic biota which are easier contaminated by heavy metals because of intake that is filter feeder and character which is settled (sessile) (Pratiwi et al., 2017). The entry cycle of heavy metals into the body of the biota starts from the mouth (oral), and then gills and skin enters the circulatory and digestive systems (Jalius et al., 2008). Lead (Pb) enters to the soft tissue through the layers of skin, breathing (gills) and food chains (Mirawati et. al., 2016), on the other hand cadmium (Cd) is carried into the tissue along with food particles, then there is a diffusion process through the gill membrane and carried by the bloodstream (Purba

et.al., 2014). Another way heavy metals enter the body of living organisms is through the food chain. In the process of eating, there will be a transfer of material and energy from the organism that is preyed to its predatory organisms (Permanawati, 2013).

Based on several previous studies heavy metal content was found in several types of mussels, such as green mussels (Purba et al., 2014) (Mirawati et al., 2016), and ceplos mussels (Tielman et al., 2017). The minimum tolerance of aquatic biota to exposure to the contamination of the heavy metals in according to with the Decree of the Minister Republic of Indonesia of Environment Number 51 of 2004 is <0.08 mg / l. Lead and cadmium content is in according to the research of Indriana et al (2011), as a contaminant found in bio indicator body tissues such as mussels, then responds to environmental factors that are toxic. The effects of this contamination are physiological responses to mussels such as the opening of the shells, disturbed tissue growth until death (Gosling, 2004).

RESEARCH METHODS

Research Sites

This research was conducted in December 2018 - January 2019 around Tambak Mulyo waters, Village, North Semarang Distric, Semarang City and around the Bedono Village waters, Sayung District, Demak Regency. The following are the maps of research in figure 1 and 2.

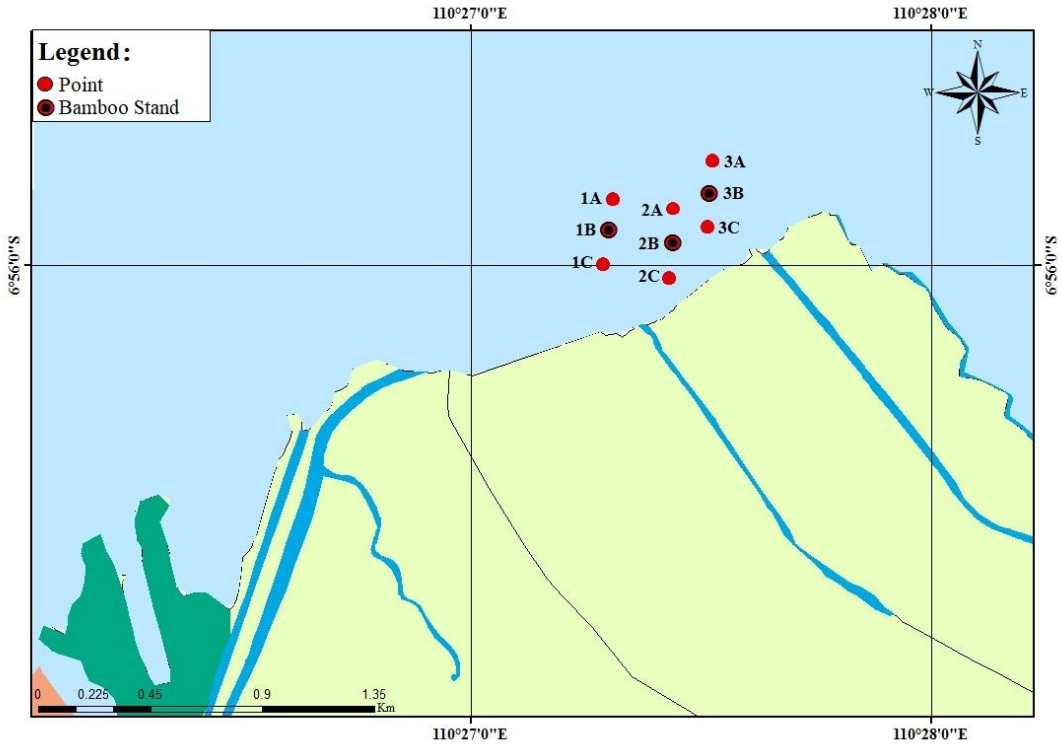

Figure 1. Map of Location in Bedono Village, Sayung Distric, Demak Regency

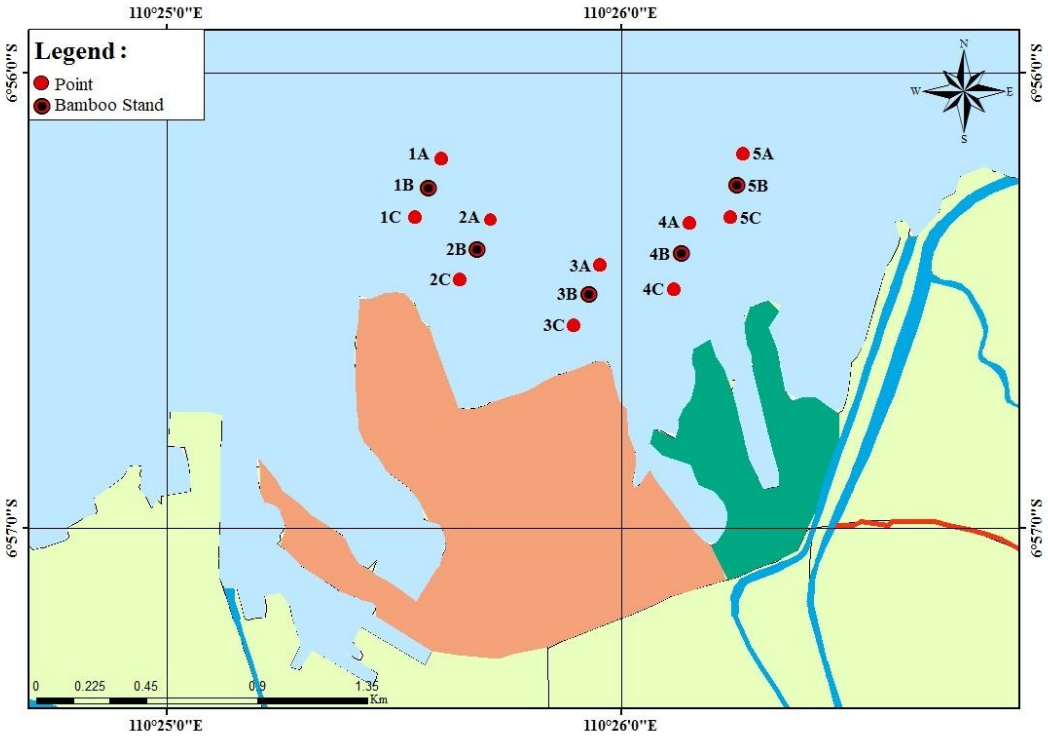

Figure 2. Map of Location in Tambak Mulyo, North Semarang Distric, Semarang City

Sample Determination and Collection

The research method used in this research is an exploratory method. According to Nazir (2015), exploratory research is a method of research conducted with the aim to exploring the phenomena that were targeted in research. The purpose of exploratory research is to explain an object and find out things that affect the occurrence of something.

The sampling technique was done by purposive sampling. According to Sungkawa (2013) purposive sampling is a sampling method which done by prior consideration of the location to be sampled. The sampling station was conducted in 2 locations. Location 1 in Tambak Mulyo, North Semarang Distric. Semarang City by dividing into 5 stations, for taking water for each station divided into 3 area points. The sampling stations in Bedono Village, Sayung Distric, Demak Regency are 3 stations with each station divided into 3 area points. Water sampling was done in the medium column (middle) where the living area of the green mussel (*Perna viridis*). Water sampling beside heavy metals for measurement of supporting water quality were done by measured for temperature parameters, pH, depth, and DO (Dissolved Oxygen). Water sampling is adjusted to SNI 6964.8: 2015 about the Sampling Method of Examples of Seawater Tests with stations and predetermined sampling points. Sampling of green mussels (*Perna viridis*) for each heavy metal parameter in each

station was taken 3 samples with a weight of 200 grams of dry sample. Samples for lead (Pb) and cadmium (Cd) in water and green mussels (*Perna viridis*) were analyzed in the laboratory to determine the concentration of heavy metals contained in water and green mussels soft tissue (*Perna viridis*) using the Atomic Absorption Spectro-photometer (AAS).

Analysis of research data using SPSS with correlation regression test. This correlation regression test is used to determine whether there is a relationship between the heavy metal's concentration found in waters such as lead (Pb) and cadmium (Cd) to the concentrations of lead (Pb) and cadmium (Cd) which contain green mussels soft tissue (Perna viridis). In addition, correlation is done to find out how closely the relationship between variables in this research. The purpose of regression is to know the influence between variables with each other, this analysis in general is to find out the relationship between two variables, where the two variables are independent and dependent variable where the existence of both of them are not influenced by the presence of other variables (X) which are not related (Sungkawa, 2013).

According to Hasan (2010) the value (r), which means that closeness ranges from 0 to 1, where the closer to 1 indicates the correlation between variables is getting stronger, and vice versa when approaching 0, the relationship between variables is less tight or weak. The value (R) obtained showing the closeness correlation between variables is heavy metals in water and green mussels (*Perna viridis*).

RESULT AND DISCUSSION

1. Laboratory Result

Based on the results that was obtained above for lead (Pb) in water around the highest Bedono Village waters is station 1 at point 1 that is equal to 1,159 mg /L, while the concentration of lead (Pb) contained in the mussels for the highest results found at station 3 at point 3 which is 0.772 mg /L. Lead concentration (Pb) between stations 1 point 1 with stations 3, points 3 almost get the equal results . The results of the lowest concentration obtained are at station 2, point 1 for water, while for mussels are also at station 2, points 1. The concentration of lead (Pb) obtained in water is 0.9 mg /L, and in mussels is 0.149 mg /L. Based on the cadmium (Cd) analysis in water and green mussels (*Perna viridis*) using AAS which obtained the highest result on water was a station of 3 points 2 which was 0.553 mg /L, while in mussels with highest result are at the station and the same point with result 0.014 mg /L. The lowest cadmium (Cd) concentration in Bedono Village, Demak Regency was obtained at station 1 (one) point 1 (one) with the results that obtained in water in the amount of 0.014 mg /L, and in mussels at 0 mg /L. The results obtained from the two research locations for measuring lead (Pb) and cadmium (Cd) concentrations in water and green mussels (*Perna viridis*) using AAS can be seen in table 1.

Table 1. The Results of Measuring The Concentration of Lead (Pb) and Cadmium (Cd) in Waters and Green Mussels (*Perna viridis*)

	Bedono Village, Sayung Distric, Demak Regency				Tambak Mulyo, North Semarang Distric, Semarang City			
Stasion	**Pb water (mg/L)**	**Pb mussel (mg/L)**	**Cd water (mg/L)**	**Cd mussel (mg/L)**	**Pb water (mg/L)**	**Pb mussel (mg/L)**	**Cd water (mg/L)**	**Cd mussel (mg/L)**
	1.159	0.727	0.148	0	1.497	1.003	0.077	0.107
1	0.625	0.235	0.258	0.012	1.412	1.369	0.074	0.164
	0.709	0.157	0.250	0.009	1.471	1.521	0.079	0.033
	0.900	0.149	0.525	0.004	1.484	1.426	0.072	0.133
2	0.919	0.314	0.461	0.007	1.53	0.731	0.081	0.155
	1.057	0.215	0.397	0.003	1.629	0.884	0.088	0.257
	1.105	0.541	0.348	0.013	1.69	1.136	0.073	0.019
3	1.008	0.667	0.553	0.014	1.732	0.974	0.081	0.190
	1.115	0.772	0.512	0.002	1.735	1.253	0.067	0.088
					0.821	0.512	0.081	0.354
4					1.389	1.274	0.051	0.018
					0.784	0.578	0.060	0.062
					0.987	0.539	0.070	0.038
5					1.354	0.783	0.068	0.011
					0.823	0.718	0.077	0.062

Based on the analysis in the waters around Tambak Mulyo, North Semarang District, Semarang City the highest concentration of lead (Pb) in water was 1,690 mg / L, while the result obtained in mussels was 1,136 mg / L. The lowest lead (Pb) concentration result was obtained at station 4, point 1 with concentrations in water in the amount of 0.821 mg / L, and in mussels at 0.512 mg / L. Based on the analysis for cadmium (Cd) found in Tambak Mulyo waters for the highest in water and mussels found at station 2, points 3, for water at 0.088 mg / L, and for mussels at 0.257 mg / L. The result of the analysis for the lowest concentration was at stations 4, points 2 for water at 0.051 mg / L, and for the mussels at 0.018 mg / L. The following are the result of lead (Pb) and cadmium (Cd) concentrations in water and green mussels (*Perna viridis*) can be seen in table 1.

Laboratory analysis using AAS with the highest and lowest concentrations was mostly at the same station and point, where when the metal concentrations in these waters are high, the concentration of heavy metals contained in green mussels soft tissue is directly proportional, but the amount of concentration is erratic. It can occur due to other factors in nature that affect the amount of heavy metal concentration. According to Rumahlatu (2011), the heavy metals content found in waters also contributes to the biota's soft tissue. According to Wardani et al. (2014), the high and

low levels of heavy metals in the body of shellfish are usually influenced by its physiology. The balance of the mussels body function between the rate of uptake and expenditure (rate of excretion) is not suitable in digestion, so absorption is not optimal.

2. Water Quality's Support

Based on the parameter's results of the measurement above for table 2, the average depth parameters are still in good condition for seed and growth of green mussels (*Perna viridis*) because they live and attach to the media in the medium column, while in table 3, the water depth is very good for seed and growth, but when in the process of seeding, the mussels seeds will be attached to a certain depth below the surface. These depth waters can result in the intensity of incoming sunlight for their photosynthesis. Green mussels are usually found below the lowest tide, but the best depth for mussels when in seeding and enlargement eras are 2 m. The seeds of the mussels will be attached to a certain depth below the surface of the water when the highest tide (Erlania and Radiartha, 2011). A depth of water determines the amount of sunlight entering the waters. The deeper, the intensity of the sunlight will decrease. Increasing the depth of the water, the availability of food will be a divider factor for young mussels because they eat phytoplankton. This can cause many mussels growing near the surface (Sari and Ledhyane, 2015).

Table 2. The Quality of The Waters Around Bedono Village, Sayung Distric, Demak Regency

	Average				
Stasion	**Temperature (°C)**	**pH**	**Salinity (ppt)**	**DO mg/L**	**Depht (cm)**
1A	30.3	8	23	6.57	175
1B	31	8	24	6.21	170
1C	29.2	8	21	6.8	150
2A	28.8	8	22	7.8	130
2B	28.3	8	23	7.78	130
2C	30.1	8	22	7.68	140
3A	30	9	20	8.05	140
3B	30	8	21	7.8	160
3C	30.2	8	21	8.04	140

The results of temperature measurement, for the Bedono's Village location range from 29-30 °C, while for the Tambak Mulyo's location ranges from 33-36 °C. The effect of temperature towards the entry of heavy metals into the body of green mussels or other biota is directly proportional, the higher the temperature, it is assumed that the higher the entry of heavy metals into the soft tissue. According to Suwarsito and Esti (2014), temperature has an influence on biotic and abiotic components found in waters. Chemical and biological activities in the waters are affected by the temperature. Temperature also affects towards amount of heavy metal contamination to a body of water, if there is an increase in temperature it can be indicated the process of entering heavy metals into the biota's body increases. Based on the KEP. MEN LH Number 51, 2004 about Sea Water Quality Standards for marine life, a good temperature is in the range of 28-30 °C.

The results of pH parameter measurements in the Bedono's Village location ranged from 8-9 while for the Tambak Mulyo's location ranged from 6-7. The range of pH values is still within the appropriate limits for seeding and growth of green mussels (*Perna viridis*) in the waters, and does not significantly affecting the input of heavy metals. According to Sastrawijaya (2009) in Wardani et al. (2014) stated that ta good acquisition of pH for the growth of green mussels is 6.0-8.6. Changes that occur at pH in waters are generally influenced by waste from human activities, including industrial waste, ship fuel waste, and so on.

The results of salinity parameter measurement at the Bedono Village's location ranged from 21-24 ppt, while in the Tambak Mulyo's location ranged from 28-32 ppt. The difference in the value of salinity can be caused by several factors such as season, fresh water into the ocean, if the input of fresh water is high then the salinity is low. Low salinity measurements are generally caused due to dilution, when higher salinity is generally caused due to evaporation and little fresh water input (Riani et al., 2017). KEP.MEN LH Number 51, 2004 about Sea Water Quality Standards for marine life, good salinity is <34 ‰. According to Mc Guire and Stevely (2009) in Sagita et al. (2017), green mussels can still live in the salinity range between 15-45 ppt.

The results of DO measurements in the Bedono Village's location ranged from 6.1-8.05, while those in the Tambak Mulyo's location ranged from 5.05-7.86. Based on the Decree of the State Minister of Environment No. 51, 2004 about Sea Water Quality Standards for the life of marine biota, good dissolved oxygen is > 5 mg / L. According to Alkassasbeh et al (2009) dissolved oxygen content for organisms found in waters is not recommended at less than 4.0 ppm. Dissolved oxygen is one of the important parameters in analyzing the quality of water, if the value of dissolved oxygen is high then it shows good water quality, otherwise if the value of dissolved oxygen is low then the water quality is not good. Decreasing of DO levels in waters indicates contamination (Eshmat et al., 2014). The results of water quality measurements parameters at the locations around Bedono Village, Demak Regency can be seen in table 2 and at location around Tambak Mulyo, North Semarang Distric, Semarang City can be seen in table 3.

Table 3. The Quality of The Waters Around Tambak Mulyo, North Semarang Distric, Semarang City

	Average				
Stasion	**Temperature (°C)**	**pH**	**Salinity (ppt)**	**DO mg/l**	**Depht (cm)**
1A	33.4	6	30	5.3	335
1B	33.9	7	30	5.05	305
1C	33	7	30	5.12	305
2A	33.3	7	28	5.74	285
2B	33	7	28	5.33	340
2C	33.1	7	30	5.79	340
3A	33.2	7	30	5.09	340
3B	34	7	28	6.08	335
3C	34.2	7	28	6.16	350
4A	34.2	7	30	5.62	350
4B	34.1	6	32	6.28	350
4C	34.2	7	30	7.75	340
5A	34.6	6	29	7.47	180
5B	36.1	6	28	6.26	145
5C	33.4	6	31	7.86	245

3. RESULT OF DATA ANALYSIS

Based on the table above, it shows the relationship of each variable that is connected, it can be seen from the results of Significant which is <0.05. The results of the analysis showed that two highest locations in Bedono's Village were between cadmium (Cd) in water and mussel, which obtained Significant 0.002 which means there is a relationship between both of them, then for the R value in amount of 0.867 which indicates the relationship between both of them are very closely because it close to 1 and > 0.5. The R square value is 0.751 which means that the high concentration of green mussels (*Perna viridis*) in soft tissue is influenced by the concentration of cadmium (Cd) in the waters by 75.1%, while the other 24.9% is

influenced by other factors. The results of data analysis at the two research locations using SPSS software for regression testing can be seen in table 4.

Table 4. Correlation Regression Tests

	Bedono Village, Sayung Distric, Demak Regency		**Tambak Mulyo, North Semarang Distric, Semarang City**	
	Lead (Pb) in water and *Perna viridis*	**Cadmium (Cd) in water and *Perna viridis***	**Lead (Pb) in water and *Perna viridis***	**Cadmium (Cd) in water and *Perna viridis***
R	.711[a]	.867[a]	.641[a]	.626[a]
R Square	.505	.751	.411	.391
Sig.	.032[b]	.002	.010[b]	.013

Based on the analysis results above for Tambak Mulyo location which has the highest value and there is a relationship between both of the variables are lead (Pb) in water and green mussels (*Perna viridis*) is Significant 0,010 <0.05. The R value that obtained is equal to 0.641 which indicates the correlation between the squares is very tight because it is close from 1 and > 0.5. The R square value that obtained is 0.639 which means that the high concentration of lead (Pb) in green mussels (Perna viridis) is influenced by the concentration of lead (Pb) in the waters by 41.1%, while 58.9% is influenced by other factors.

The results of the analysis show that the high and low concentrations of heavy metals in water and green mussels (*Perna viridis*) are caused by other factors. Natural factor is the factor that influences the amount of heavy metal concentrations contained in particular lead (Pb) and cadmium (Cd) which are not easily predicted. According to Rumahlatu (2011), because the nature of sea water which is influenced by waves and flows, the concentration varies greatly, one of them can also depend on the season. In the rainy season when rainfall is high, many heavy metals such as lead (Pb) and cadmium (Cd) in the form of dissolved or sediment are carried from land to sea through the river flow.

The large concentration of heavy metals such as lead (Pb) and cadmium (Cd) can also be caused by the food chain and filter feeder's characteristic of green mussels (*Perna viridis*). According to Pratiwi et al (2017), the concentration of heavy metals in the water is directly proportional to the increase in the concentration of heavy metals in the soft tissue of green mussels (*Perna viridis*) through its food chain causing toxicity and carcinogenic characteristic. The gill tissue of the green mussel is very important because the heavy metals that accumulate in the gill tissue can reduce the ability of reciprocation and filtration. The ability to absorb food will decrease and cause death. The entry of contaminants into the body of the mussels is generally through 3 ways; consist of the food chain, gills and skin diffusion. (Suprapto et al., 2017).

CONCLUSIONS AND RECOMMENDATION

Conclusions

The conclusions for the results of the research on the correlation between concentration of lead (Pb) and Cadmium (Cd) in water with inside green mussels soft tissues (Perna viridis) in Semarang Bay Water are as follows:

1. Bedono Village, Sayung District, Demak Regency and at Tambak Mulyo, North Semarang District, Semarang City showed that there was a relationship between lead (Pb) and cadmium (Cd) concentration in waters and in soft tissues of green mussels (*Perna viridis*). There is a correlation where the concentration of heavy metals could be found in the waters affects the high and low concentrations of heavy metals that found in soft tissues of green mussels (*Perna viridis*).
2. Analysis using a correlation regression test with the highest results in the Bedono's Village location is the relationship between cadmium (Cd) in water and green mussels (*Perna viridis*) gets the Significant value 0.002 <0.05, and the correlation closeness of value R is 0.867. In Tambyo Mulyo's location, South Semarang district, the results of the analysis between lead (Pb) in water and mussels obtained the highest value with Significant value 0.010, and the closeness of the correlation with the value R) in amount of 0.641.

Suggestions

Suggestions given for the next research are the need for deeper research about the effect of other heavy metals which enter into waters from industrial and domestic waste, and the need for more concrete actions and further handling about this phenomenon.

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