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Distribution of heavy metal lead (Pb) on macrozoobenthos in the Karangsong waters area, Indramayu Regency

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ABSTRACT

The study was conducted in July - August 2018 with the aim of analyzing the concentration of lead heavy metals (Pb) in water, sediment and macrozoobenthos in the Karangsong waters area, Indramayu Regency. The research method used is a survey method with purposive sampling technique that is the determination of location based on the existence of certain objectives and in accordance with various considerations, then observed the content of lead metal (Pb) in the Central Laboratory of Padjadjaran University. The research was conducted in situ and exsitu. Parameters of insitu research include temperature, pH and DO carried out in Karangsong waters, Indramayu Regency. Exsitu research parameters include testing of lead metal (Pb) on water, sediment and macrozoobenthos conducted at the Central Laboratory of Padjadjaran University. The results showed that the Pb concentration in the Karangsong waters had exceeded the threshold, which ranged between 1,05 – 1,33 mg/l, while the Pb concentration in sediment was higher than the Pb concentration in water. Lead metal in sediment has not exceeded the threshold. The ability of macrozoobenthos to accumulate lead metal in water and sediment (Bioconcentration Factor / BCF) is included in the low accumulative category because BCF is less than 100.

Keywords: bioconcentration factor, lead (Pb), macrozoobenthos, Karangsong waters area

1. INTRODUCTION

Water pollution is the entry of living things, substances, energy or other components into the water, so the water quality drops to a certain level which causes the water to no longer function according to its designation. Generally, the impact of heavy metals, especially the effects of pollution, causes changes in the structure of the aquatic community, food webs, biota behavior, physiological effects, genetics, and disease resistance (Moriarty 1987).

Karangsong waters located in Indramayu regency received a very large influence from human activities along and upstream of the waters area. Existing activities include activities of household, industry, ponds, ship traffic and mangrove vegetation. The Karangsong waters area is also burdened by the existence of the Fish Auction Place (FAP). The density of human activity that occurs in these waters results in these waters producing waste and causing these waters to become polluted (Utomo et al. 2013).

Pb compounds present in aquatic bodies can be found in the form of divalent ions or tetravalent ions (Pb^{2+}, Pb^{4+}). According Sudarmaji (2006), levels of lead (Pb) which can naturally be found in rocks around 13 mg / kg. Especially for lead (Pb) which is mixed with phosphate rock and is found in a sand stone, the level is greater than 100 mg/kg. Lead (Pb) which is found in the soil of about 5-25 mg/kg and in ground water ranges from 1-60 μg/liter.

Macrozoobenthos can be used as a quality bioindicator in an aquatic area because their life tends to be relatively permanent and always contacted with the waste that enters their habitat so that it is very well used as an environmental bioindicator. The results of research by Lemus and Chung (1999) concerning copper heavy metals, that copper is more toxic in higher temperatures.

Macrozoobenthos is a biological component for monitoring the quality of waters affected by changes in the ecological conditions of these waters. Macrozoobenthos is one of the aquatic organisms that settle at the bottom of the water, which has a relatively slow movement and can live relatively long so that it has the ability to respond to the quality conditions of river waters (Zulkifli and Setiawan 2011).

This research aims to analyze the concentration of lead heavy metals (Pb) in water, sediment and macrozoobenthos in the Karangsong waters, Indramayu Regency. The results of this research are expected to provide information about the concentration of heavy metal lead (Pb) in water, sediment and macrozoobenthos in the waters of Karangsong, Indramayu Regency.

2. MATERIALS AND METHODS

This research was conducted in the waters of Karangsong, Indramayu Regency which will be carried out in July - August 2018 as the location of water sampling, sediment samples and macrozoobenthos samples. Heavy metal analysis was carried out at the Central Laboratory of Padjadjaran University. which will be held in June 2018.

The tools used in sampling test and analysis of research test samples are pH meter, DO meter, thermometer, filter, funnel, sample bottle, plastic tray, plastic clip, camera, AAS, test tube, beaker glass, erlenmeyer, pipette and hot plate. The materials used in this research are water samples, sediment samples, macrozoobenthos, aquades and concentrated nitric acid (HNO_3).

The method used in this research is a survey method with purposive sampling technique that is determining the location based on the existence of certain objectives and in accordance with various considerations. Samples were taken from 3 stations, with 3 replications at each station and it was expected that each station could represent the characteristics of the surrounding environment.

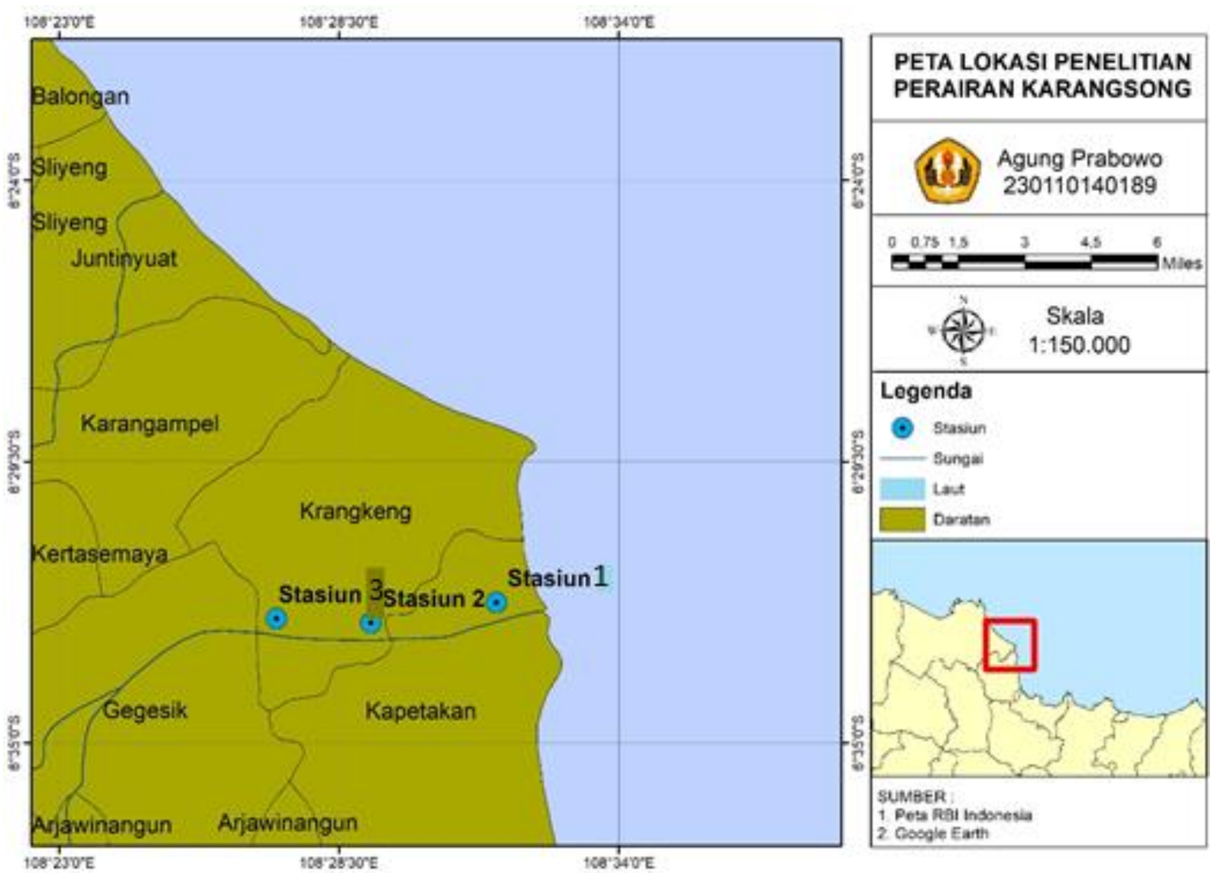

Figure 1. Map of Research Location

Station 1: Located near the sea where places that are likely to be contaminated with lead heavy metals are lower because of the distance away from main source, that is station 1.
Station 2: Located between station 1 and station 3 where a place that is likely to be contaminated with heavy lead heavy metals is due to the general settlement.
Station 3: Located near the harbor and fishing shipyard where places that are likely to be contaminated with lead heavy metals are higher due to the vessel's staining activity.

The concentration of heavy metal lead (Pb) measured is the concentration of lead metal (Pb) in water, the concentration of lead metal (Pb) in the sediment and the concentration of lead metal (Pb) on macrozoobenthos. According to Connel and Miller (2006) bioconcentration factors are calculated using the formula below:

$$CB = \frac{KB}{KW}$$

The ability of macrozoobenthos in accumulating lead (Pb) metal in water and also sediment can be known by using BCF (Bioconcentration Factor) or bioconcentration factors. The relationship between heavy metal lead (Pb) concentration in water and sediment with macrozoobenthos was analyzed using multiple regression and correlation. The correlation formula can be calculated using the following formula:

$$r = \frac{n\sum xy - (\sum x)(\sum y)}{\sqrt{\{n\sum x^2 - (\sum x)^2\}\{n\sum y^2 - (\sum y)^2\}}}$$

The analysis was carried out in the form of comparative descriptive analysis. Data obtained from both water quality, concentration of heavy metals in water, sediment and macrozoobenthos are presented in tables and graphs which will then be compared in the form of measurement results at each station observed.

3. RESULTS

Temperature

The observation result of temperature from the 3 research stations in Karangsong waters, Indramayu Regency (Figure 2) show the value that is not so far at each station and every replication. The observed temperature of the 3 stations ranged from 29,2 – 33,8 °C. The lowest temperature from observations in Karangsong waters, Indramayu Regency was at station 2 repeat 1 at 29,2 °C and the highest temperature was at station 1 repeat 3 at 33,8 °C. Temperature can affect the level of heavy metal toxicity in water, the increase in temperature will cause an increase in the toxicity of heavy metals in the waters.

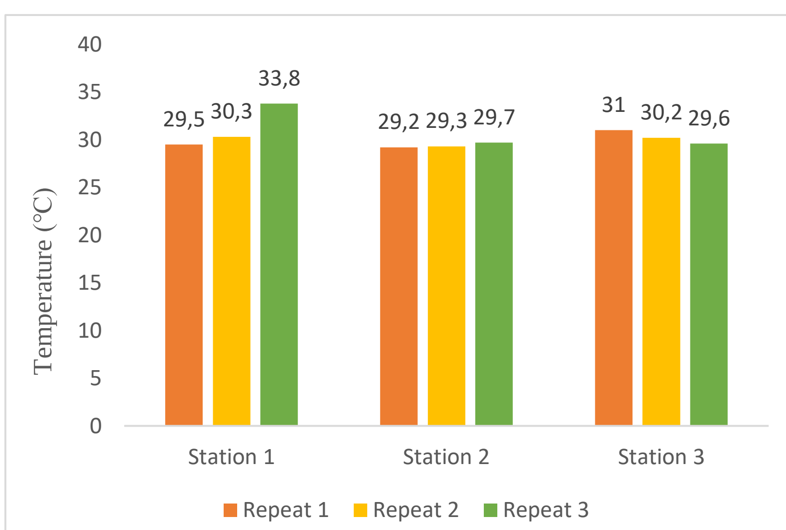

Figure 2. Value of Temperature at Each Station

The difference in temperature values obtained at each observation station is caused by the time of temperature measurement that is not carried out at one time or not simultaneously, because the temperature is influenced by the intensity of sunlight entering the waters. Temperature measurements are carried out at noon at 11.00 WIB. Saenab (2013) says that temperatures that are good for macrozoobenthos life usually range from 28-31 °C, but there are several types of macrozoobenthos that can tolerate higher temperatures.

Acidity (pH)

The observation result of the acidity level (pH) of the 3 research stations in Karangsong waters, Indramayu Regency (Figure 3) shows the varying values at each station and each replication. The degree of acidity (pH) observed from 3 stations ranged from 6,16 to 8,31. The lowest degree of acidity (pH) from observations in Karangsong waters, Indramayu Regency was at Station 3 repeat 2 at 6,16 and the highest pH was at Station 2 repeat 2 at 8,31.

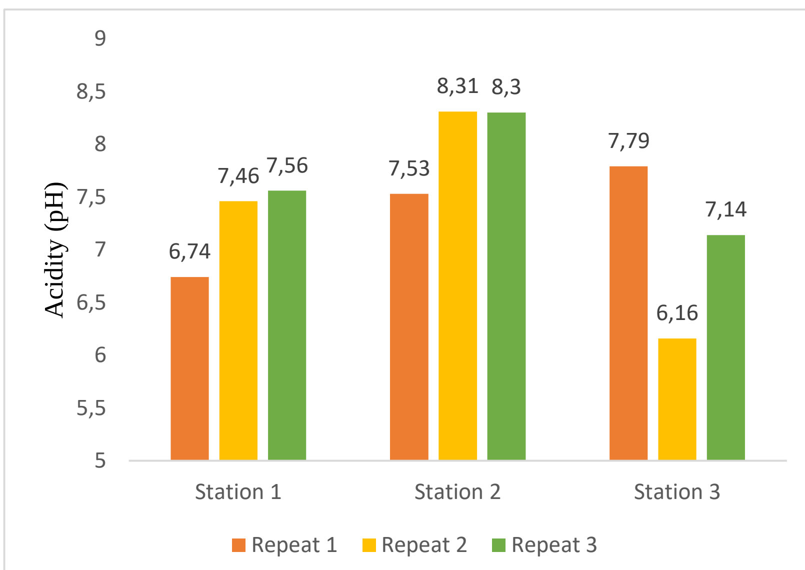

Figure 3. Value of Acidity at Each Station

Generally, the pH in Karangsong waters, Indramayu Regency is still relatively normal because it is still in the range close to neutral pH and supports the activity of aquatic organisms in the waters. Metal complexes will begin to form under alkaline conditions, these complexes will settle to the bottom of the waters (Novotony and Olem 1994). pH values <5 and> 9 create conditions that are not beneficial for most aquatic organisms, especially macrozoobenthos (Hynes 1978). The degree of acidity (pH) of the research location that tends to base allows the heavy metals in the water to settle to the bottom of the water.

Dissolved Oxygen (DO)

The observation results of dissolved oxygen (DO) from all 3 research stations in Karangsong waters, Indramayu District (Figure 4) showed varying and far enough changes in values at each station and every replication. Dissolved oxygen (DO) observed from 3 stations ranged from 4,4 to 5,6 mg/l. The lowest dissolved oxygen levels (DO) were at station 1 repeat 3 at 4,4 mg/l and the highest was at station 3 repeat 1 at 5,6 mg/l.

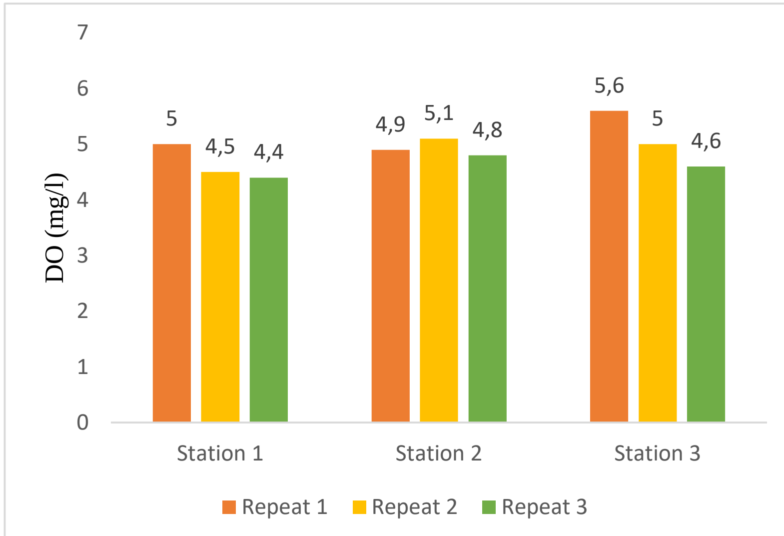

Figure 4. Value of Dissolved Oxygen at Each Station

Dissolved oxygen levels less than 4 mg/l can have adverse effects on the aquatic organisms therein (Effendi 2003). Sample measurements are carried out on the morning before noon with fairly calm water conditions so that the intensity of sunlight in the waters takes place optimally. The contamination of a waters based on dissolved oxygen value according to Ardi (2002) can be classified as follows: non-polluted waters have dissolved oxygen values ≥6,5 mg / l, medium polluted waters have dissolved oxygen values ranging from 4,5 to 6,5 mg / l and heavily polluted waters have dissolved oxygen values <2,0 mg/l.

Content of Lead Heavy Metal (Pb) in Water, Sediment and Macrozoobenthos

The concentration of heavy metal lead (Pb) in water has a value range between 1,05 – 1,33 mg/l. Pb concentrations in sediments ranged from 7,78 to 9,58 mg/kg. Pb concentration in macrozoobenthos ranged from 38,31 to 47,45 mg/kg (Table 1).

Table 1. Pb concentration in Water, Sediment and Macrozoobenthos

Station	Water (mg/l)	Sediment (mg/kg)	Macrozoobenthos (mg/kg)
1	1,13 - 1,31	8,06 - 8,65	41,44 - 47,45
2	1,05 - 1,33	8,04 - 9,10	40,22 - 43,61
3	1,22 - 1,28	7,78 - 9,58	38, 31 - 40,82

The degree of acidity (pH) of water in Karangsong waters, Indramayu Regency generally shows that neutral values tend to be alkaline, with the pH value, lead heavy metals in the waters will settle to the bottom of the water so that the concentration of lead heavy metals in the water will decrease. But in fact the condition of the Karangsong waters, Indramayu Regency has exceeded the threshold of the availability of heavy metal lead in waters according to Minister of Environment Decree No. 51 of 2004 that is equal to 0,008 mg/l (Wahyuni 2013). Generally at higher pH, the stability shifts from carbonate to hydroxide. These hydroxides make it easy to form surface bonds with particles in the water body. Over time the compound that occurs between hydroxide and particles in the water body will settle and form mud (Chon 2010). The factors that cause high content of lead heavy metals in water in Karangsong waters, Indramayu Regency, are due to the many activities of shipbuilding and painting of ships in the area and can also be caused by fuel spills of these vessels.

The quality standards set by the Australian and New Zealand Environment and Conservation Council (ANZECC, 2000) content of heavy metals lead (Pb) in sediment is> 50 mg / kg, so the content of lead heavy metals in each research station is still below the threshold. The content of lead (Pb) in sediment is higher than that of lead in water. This is due to the sedimentation process experienced by lead. The concentration of lead (Pb) in each station has no significant difference. This can be caused by several factors, one of which is the tide so that water can easily carry heavy lead metal thoroughly.

Macrozoobenthos species commonly found in Karangsong waters, Indramayu regency namely Pleurocera sp. This indicates that Pleurocera sp has been contaminated by heavy metals lead (Pb), so it is strongly recommended not to be consumed. At station I with the highest average concentration of lead metal, it was influenced by the size of Pleurocera sp which was found to be larger in size compared to the size of Pleurocera sp found in stations II and III, so that it was indicated that Pleurocera sp's age was longer and metal accumulation the load is much higher. The concentration of heavy metal lead (Pb) in each station has a significant difference. The type of macrozoobenthos tested to determine the concentration value is only 1 species, because one of the factors that influence the accumulation of heavy metals in an aquatic organism is species.

Factors of Pb Bioconcentration in Macrozoobenthos in Water and Sediment

Bioconcentration factor (BCF) can be used to determine the ability of creatures to absorb and store pollutants (Connell and Miller 2006).

Table 2. Bioconcentration Factor (BCF) Pb in Macrozoobenthos in Water

Station	Lead Concentration (Pb)		BCF (mg/kg)
	Macrozoobenthos (mg/kg)	Water (mg/ml)	
1	45,16	1,22	36,9
2	42,34	1,23	34,3
3	39,83	1,25	31,7

The results of the calculation of bioconcentration factor (BCF) on macrozoobenthos with water ranged from 31,7 – 36,9 so it is still classified as low accumulative. This is consistent with the statement of Gosh and Singh (2005) which states that BCF values <100 mg/kg, fall into the category of low accumulative properties.

Table 3. Bioconcentration Factor (BCF) Pb in Macrozoobenthos in Sediment

Station	Lead Concentration (Pb)		BCF
	Macrozoobenthos (mg/kg)	Sediment (mg/kg)	
1	45,16	8,38	5,4
2	42,34	8,64	4,9
3	39,83	8,89	4,5

The results of the calculation of bioconcentration factor (BCF) on macrozoobenthos with sediments ranged from 4,5 to 5,4 so that it was still classified as low accumulative. This is consistent with the statement of Gosh and Singh (2005) which states that BCF values <100 mg/kg, fall into the category of low accumulative properties.

Janssen et al. (1997) stated that the greater the bioconcentration factor, the easier the metal is absorbed and accumulated by living tissue from its habitat. Factors that influence the size of the concentration include the type of organism species and the type and level of pollutant content. Generally, the higher the value of bioconcentration factors, the easier it will be for an organism to accumulate heavy metals from its environment.

Regression Analysis

Simple linear regression is a statistical method that serves to test the extent to which a causal relationship between variables. Simple linear regression can determine how much the variable x affects the variable y, where the variable x is the concentration of lead metal in the sediment and the variable y is the concentration of heavy metal lead on macrozoobenthos (Figure 5). The results of a simple linear regression test with a value of $y = -2.6596x + 65.432$, this value indicates that the regression is negative which means that the higher the value of lead heavy metal concentration (Pb) on macrozoobenthos (variable y), the lower the concentration of lead heavy metals in sediment (variable x).

The determination coefficient (R2) of 0,2912 means that 29,12% of heavy metal lead (Pb) concentration in macrozoobenthos is influenced by the concentration of lead metal in sediment, and the remaining 70,88% is influenced by other factors.

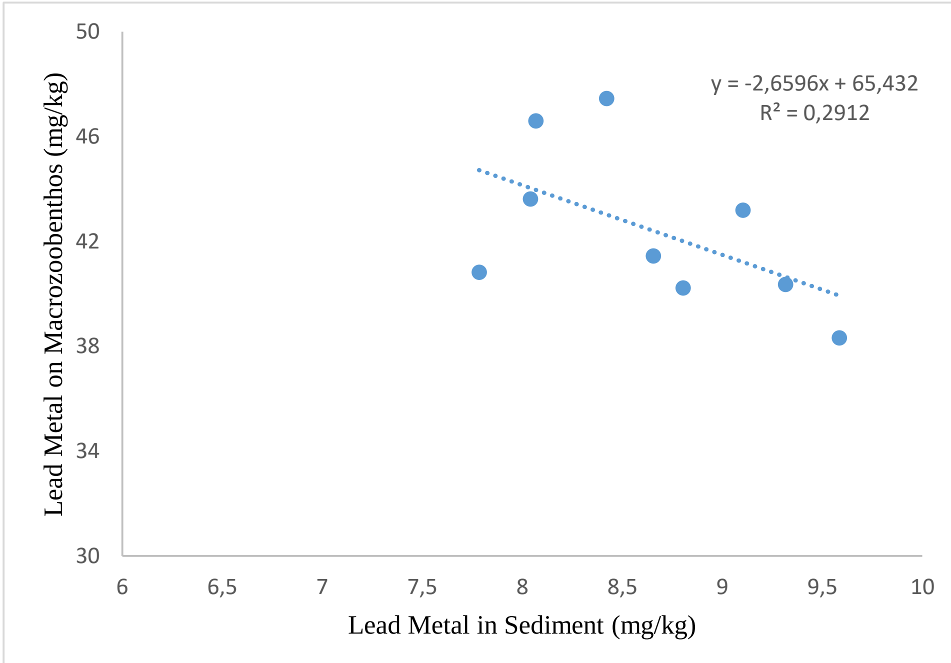

Figure 5. Linear Regression of Pb Concentration on Macrozoobenthos Against Sediments

4. CONCLUSIONS

The average content of heavy metal lead (Pb) in water in each research station has exceeded the quality standards set by the Minister of Environment Decree No. 51 of 2004 which is equal to 0,008 mg/l, with the highest average content of lead found at station III, which is 1,25 mg/l and can be categorized as being medium polluted, the sediment in each research station is still below the where the highest average content of lead is at station III, which is 8,89 mg/kg, the macrozoobenthos in each research station has exceeded the threshold, with the highest average content of lead at station I of 45,16 mg/kg and macrozoobenthic ability to accumulate heavy metal lead (Pb) in water and sediment including low accumulative properties which ranged between 31,7 – 36,9 and 4,5 – 5,4, because the BCF value was <100 mg/kg.

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