Accumulation of Lead (Pb) in Blood Clams. *Anadara granosa* L.. Inhabiting Densely Industrial Area in Sidoarjo. East Java. Indonesia

Mohammad Mahmudi[1] and Muhammad Musa[2]

Abstract— Marine Coastal Area Sidoarjo. East Java has long been threatened by pollution originating from industry. One of the most threatening pollutants are heavy metals. Lead (Pb) has been recognized as harmful metals because it can cause health problems. The objective of this research are to measure the lead (Pb) content in the water. sediment and clams. to assess relationships between lead (Pb) in clams and size of clams. to determine a bioaccumulation (BAF) of lead (Pb) in the clams. . Lead content were analyzed using Atomic Absorption Spectrometry (AAS). The results showed that water physicochemical parameters effect on the content of Pb in water with values range from -0.752 between dissolved oxygen and Pb in water to 0.945 between temperature and Pb content in the water. The content of Pb in water ranges from 0.081 to 0.103 ppm, Pb in sediments ranges from 5.447 to 6.357 ppm, and Pb in the small clams ranges from 0.407 to 0.903 ppm, medium clams ranges from 0.737 to 1.253 ppm, and a large clams ranges from 1.237 to 1.787 ppm. The value of bioaccumulation factor of the water (BAF_W) ON SMALL CLAMS WAS 7.13, medium clams WAS 11.46 and LARGE clams WAS 16.23. While the value of bioaccumulation factor OF the sediment (BAF_S) on small clams WAS 0.11 and MEDIUM clams clams WAS 0.18, AND LARGE CLAMS WAS 0.25. This means that clams absorb more Pb from water instead of the sediment due to the clams that are filter feeders absorb more Pb of the plankton as food through the food chain.

Keywords— Lead (Pb). blood clams (*Anadara granosa* L.). Bioaccumulation.

I. INTRODUCTION

SIDOARJO waters is an important area for fishermen around because it has been long used as fishing grounds. but the development of industry in the region caused environmental pollution [1]. An increasing number of industries will always be followed by the addition of the amount of waste. in the form of solids. liquids and gases. Industrial waste primarily sourced from factories of electronics. plastics. paper and others can be harmful to the environment because it is estimated that waste containing heavy metals including lead (Pb) [2].

Heavy metals are derived from natural and anthropogenic such as industrial waste. agricultural waste. transportation. fossil fuel burning. the structure of geochemical and mining activities will be released into aquatic ecosystems [3]–[6]. Most of the heavy metals in the coastal waters leached into the river through the discharge of industrial. urban and agricultural [7]. The toxic effects of metals depending on the nature of the metal. Generally. heavy metals are toxic by forming complexes with organic compounds. The concentration of heavy metals in the water column depends on the physical and chemical factors such as temperature. salinity. pH. dissolved oxygen. conductivity. redox potential. and ionic strength [8]. Heavy metals create serious damage to the system of metabolic. physiological and structural of organisms if high concentrations in the environment. They may have a direct effect on the organism through the accumulation in their bodies or indirectly through the food chain to the next trophic level [9].

Metal distribution process enters natural waters is controlled by a series of physicochemical interaction dynamics and its solubility is mainly controlled by pH. concentration. types of metals. organic ligands. the oxidation state of the mineral components and the redox environment of aquatic systems [10]. Once entered into the aquatic environment through various sources and pathways. metals adsorbed by inorganic and organic particulates and incorporated into the sediments resulting in increased levels of heavy metals in bottom sediments [11]–[12]. Physicochemical parameters play an important role for the determination of water quality. Accumulation of metals into the sediment depends on a number of external environmental factors such as pH. dissolved oxygen. electrical conductivity and surface area available for adsorption caused by variations in the grain size distribution [13]. However. the metal can not always be repaired by the sediment permanently. Some metals are bound into the sediment may remobilize and released back into the water through a variety of environmental conditions such as acidification. redox potential conditions. the level of organic ligands which impose adverse effects on living organisms [12].

The process of absorption heavy metals in the body clams (bivalves) is called bioaccumulation. bioconcentration and biomagnification. This process can occur through absorption by living organisms directly from the surrounding of environmental or through the food chain. Heavy metal uptake by clams through the food chain can arise from the same

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source. and in a natural food chain for heavy metal pollution can be transferred from one trophic level to another trophic level. So. through the food chain. the body of clams will be contaminated by metal compounds. so that over time the concentration of heavy metals in the body will increase [14].

Although preventive activities have been considered to reduce the input of metals into waterways. rivers. and ponds. however. there is still the industry and the public throw waste into the water. As a result. the accumulation of pollutants. especially heavy metals have been reported [15]. Therefore. it is important through routine monitoring for trace elements / heavy metals. especially lead (Pb). The objective of this research are to measure the lead (Pb) content in the water. sediment and clams. to assess relationships between lead (Pb) in clams and size of clams. to determine a bioaccumulation (BAF) of lead (Pb) in the clams.

II. Materials and Methods

The study was carried out at heavy polluted cities in Sidoarjo. East Java (Fig. 1). Samplings were done during almost the end of rainy season in March 2014, considering that most industries tended to dump their waste during rainy season. It was commonly understood among industries that waste would be diluted quickly when river is over-flooding. This area are densely occupied for local settlements.

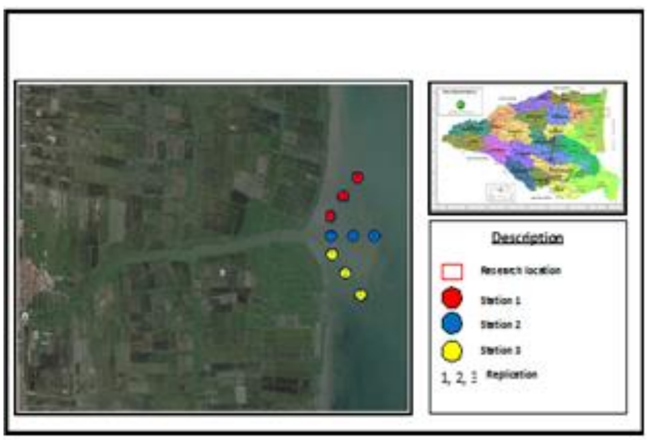

Fig. 1 Map of sampling sites

In-situ water quality parameters were monitored during the study – water temperature. salinity. pH. and Dissolved Oxygen. Water temperature and Dissolved Oxygen were measured using DO-meter (0.1 ºC. and 0.01 mg l-1. respectively). pH was measured using pH-meter (0.01 pH unit). All these water quality may influence the sequestration of released lead and its accumulation into sediment and clams.

Samples for Lead (Pb) heavy metal were collected from coastal water. sediment. . and clams. All the samples were labeled. stored in cool box with ice. and transported directly to the laboratory.

Biota samples of blood clams (*Anadara granosa* L.) were analyzed for Pb's tissue concentrations. The specimens were dissected and dried in an oven to a constant weight for 24 h at 60^oC. The dried tissues (5.0 g) were cold digested with 10.0 ml HNO3 for 24 h. and then heated in a digester at 100^oC for 6 h. Finally. the sample was added with 2-3 ml H_2O_2 [16]. All samples of water. sediments and biota were then analyzed by a Atomic absorption Spectrophotometer. AAS (Varian Spectra AA220).

The exchange factor (CE) water-sediment for each heavy metal was calculated according to [17] as the heavy metal level in water (Cw) divided by the heavy metal level in sediment (C_S): $CE = C_W/C_S$

The concentration of lead in water. sediments and clam tissues compared to measure the rate bio-accumulation.

$$BAF_w = C_t/C_W$$

$$BAF_S = C_t/C_S$$

The Pearson correlation coefficient of variance was used to measure the strength of the linear relationship between two variables on a scale of -1 (perfect inverse correlation) through 0 (no correlation) to 1 (perfect sympatric relationship). In this study, the correlation applied and the physicochemical parameters of water and sediment and heavy metals Data to understand the underlying variability and to assess the relationship between variables. Three sizes small clams (2.5 cm), medium clams (2.6 to 3 cm) and large clams (> 3 cm) was determined. ANOVA was used to evaluate the effect of the accumulation of heavy metals to the three sizes of shells. Then, Duncan's multiple range test done if a significant difference found in ANOVA. Differences were considered significant at $p < 0.05$. Statistical analysis was performed with SPSS 16.

III. Results And Discussion

The Pearson correlation analysis between physicochemical parameters of the water and the content of Pb in water showed that the Pb content in the water was positively correlated to temperature and TSS, and negatively correlated to the dissolved oxygen and salinity (Table 1). This suggests that different physicochemical parameters influencing the concentration of lead in water. The values showed the range from -0.752 between dissolved oxygen and Pb in water to 0.945 between temperature and Pb content in the water.

Negative values showed an inverse relationship that occurs between dissolved oxygen, salinity to content of Pb in water. While the positive correlation occurs between temperature, TSS to Pb content in the water.

TABEL 1
Correlation coefficients between Pb content and physicochemical parameters in the water

Variables	PbW	T^oC	O_2	Salinity	TSS
PbW	**1**				
T^oC	0,945	**1**			
O2	-0,752	-0,927	**1**		
Salinity	-0,971	-0,996	0,889	**1**	
TSS	0,788	0,543	-0,187	-0,617	**1**

Mobility of heavy metals in the water to the sediment is characterized by the exchange factor (CE) water-sediment. Results for CE analysis are shown in Table 2. The CE-value varies from the 0.0149 ± 0.0002 to 0.0161 ± 0.0014. The value showed that the exchange of Pb from water to sediment low.

TABEL II
EXCHANGE FACTOR OF WATER AND SEDIMENT

Station	Average	SD
1	0.0149	0.0002
2	0.0152	3.0009
3	0.0161	0.0014

Analysis of the content of lead (Pb) in water, sediments and clams are shown in Table 3. The content of Pb in water ranges from 0.081 to 0.103 ppm, Pb in sediments ranges from 5.447 to 6.357 ppm, and Pb in the small clams ranges from 0.407 to 0.903 ppm, medium clams ranges from 0.737 to 1.253 ppm, and a large clams ranges from 1.237 to 1.787 ppm. Pb in the water has exceeded the limits of the sea water quality standard for marine life according to the Decree of the Minister of Environment No. 51 of 2004 [18]. While Pb sediment is below the quality standard [19]. The content of Pb in small and medium-size clams still below the quality standard, while for the content of Pb in large clam have reached the maximum limit of 1.5 ppm standard quality [20].

TABLE III
LEAD (PB) CONTENT IN THE WATER. SEDIMENT AND CLAMS

Station	Pb Content (ppm)				
	Water	Sediment	Small Clams	Medium Clams	Large Clams
1	0.081	5.447	0.407^{a}	0.737^{b}	1.237^{c}
2	0.093	6.127	0.903^{a}	1.253^{b}	1.787^{c}
3	0.103	6.357	0.690^{a}	1.190^{b}	1.453^{c}
Average	0.092	5.977	0.667	1.060	1.492

There is no significant difference ($p > 0.05$) between the research station. Pb content value in clams showed significant differences ($p < 0.05$) between sizes. Lowest The value of Pb content (0.407 to 0.903 ppm) was recorded on small clams and the value of the highest Pb content (1.237 to 1.787 ppm) was achieved in large clams. Clams live and grow longer in contaminated waters will be higher accumulation. Figure 2 also shows that the content of Pb in clams increasing with increasing size. This suggests that the accumulation of heavy metals Pb greater with the larger size of the clams.

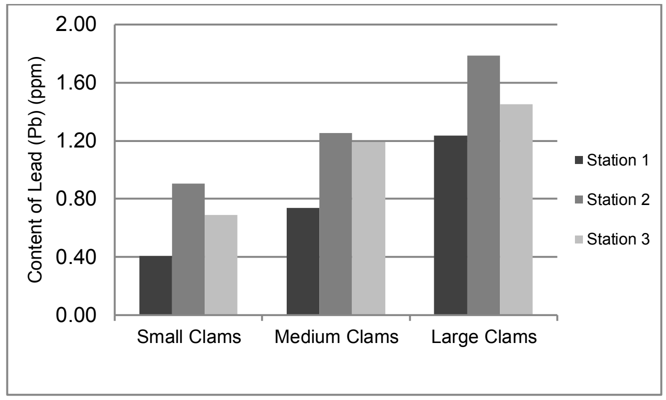

FIG. 2 RELATIONSHIP BETWEEN PB CONTENT AND SIZE OF CLAMS

Based on the calculation of bioaccumulation factor (BAF), that clams accumulate heavy metals Pb derived of the water is greater than the sediments (Table 4). The value of bioaccumulation factor of the water (BAF_W) on small clams was 7.13, medium clams was 11.46 and large clams was 16.23. While the value of bioaccumulation factor of the sediment (BAF_S) on small clams was 0.11 and medium clams clams was 0.18, and large clams was 0.25. This means that clams absorb more Pb from water instead of the sediment due to the clams that are filter feeders absorb more Pb of the plankton as food through the food chain.

TABLE IV
BAF VALUE FROM WATER AND SEDIMENT IN VARIOUS SIZES OF CLAMS

Size of Clams	BAF_W from Water	BAF_S from Sediment
Small Clams	7.13	0.11
Medium Clams	11.46	0.18
Large Clams	16.23	0.25

IV. CONCLUSION

Concentration Pb in the water has exceeded the limits of the sea water quality standard for marine life according to the Decree of the Minister of Environment No. 51 of 2004. However, concentration Pb in the sediment is still below the quality standard. Blood clams, *Anadara granosa* L., able to accumulate Pb by 7 to 16 times the concentrations of Pb were measured in waters. Pb in large clams already reached the limits of the standard quality for feed material of the bivalves.

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