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Bioaccumulation of Lead (Pb) content in three species bivalves in Jakarta Bay, Indonesia

Maman Rumanta*

Universitas Terbuka, Jakarta, Indonesia

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Key words: Bioaccumulation, Lead, Bivalves, Jakarta bay

Abstract

Environmental pollution by heavy metals has become a serious problem in Jakarta Bay. Mobilization of heavy metals as a result of anthropogenic activities has caused the release of heavy metals into the environment, one of which is Pb. Several methods already used to clean up the environment from these kinds of contaminants, but most of them are costly and difficult to get optimum results. In addition heavy metal pollutans in the waters are very stable and tend to be persistent. Recently, bioaccumators is an effective and affordable technological solution used to extract or remove inactive metals and metal pollutants from contaminated soil and water. This technology is environmental friendly and potentially cost effective using bivalves. These study objectives to analyzed the Pb content of three species of Jakarta Bay bivalves. The results showed that Pb content in the Eastern and Western Season bivalve tissue was significantly lowest in *P. viridis* (0,166 ± 0,016µg/g dan 0,161 ± 0,155µg/g) compared the Pb concentration in *A. antiquata* (0,264 ± 0,015µg/g dan 0,247±0,044µg/g), and *M. meretrix* (0,270 ± 0,016µg/g dan 0,240 ± 0,053µg/g). In this study also showed that the concentration of heavy metal Pb in the bivalve shell of *P. viridis* was significantly lower than that of two species (*A. antiquata* and *M. meretrix*). Pb content in the Eastern Season bivalves did not significantly different from that in the Westerrn Season. This is caused by a weather anomaly where the rainy season occurs almos throughout year of 2020. The Pb content in the bivalves shell was significantly higher than in the body tissues. It is because Pb can replace calcium ions in the formation of animal bones or bivalve shells.

***Corresponding Author:** Maman Rumanta ✉ mamanr@ecampus.ut.ac.id

Introduction

Jakarta is the biggest city in Indonesia, with more than 10.64 million inhabitants in 2021 (BPS Jakarta, 2022). The increasing of development rate in all fields in Jakarta city resulted in a positive effect on the society living standard improvement. On the other hand, it gave the negative impact namely the presence of waste production (liquid and soil) which continuously increase (Dhokhiyah and Trihadiningrum, 2012). Muara Angke is a delta in North Jakarta Bay where surrounded by Asin river in the east, Adem River in the west, and Jakarta Bay in the North. Jakarta Bay is an area in the north of Jakarta City which is experiencing quite high heavy metal pollution. Generally pollution in the Jakarta Bay is due to anthropogenic activity and this is common in Indonesia due to certain factors associated with terrestrial run-off and eutrophication (Baum *et al.,* 2015). Most household and industrial wastes with high levels of pollutants are not treated properly but disposed directly into Jakarta Bay (Rees *et al.,* 1999; Baum *et al.,* 2016).

Wulp *et al.* (2016), added that the Jakarta Bay, received a large number of pollutants that are sourced from agricultural activities, industry and domestic waste from the area of Jakarta and surrounding areas. This asserted that the Jakarta Bay is a waters ecosystem which is subjected to high ecological and economic pressures from humans. In addition, the linkage of coastal areas of Jakarta Bay to the mainland area through watersheds (DAS) with 13 watersheds that leads to Jakarta Bay, making the coastal areas of Jakarta Bay as trap sediments, nutrients and pollutants from upstream, which is very effect on biological productivity and water quality of Jakarta Bay waters (Dsikowitzky *et al.,* 2016).

Waste disposal into the environment will cause pollution and role to supply Pb contamination in Jakarta Bay, disturb public health (Rumanta, 2005; Cordova *et al.,* 2012). Rompas (2010), asserted Pb is heavy metal very hazardous not only for waters biota that lives in the area but also for human who consume the biota. Waste containing Pb is commonly comes from industrial waste of paint, battery, car fuel, and pigment (Mukhtasor, 2007 as cited by Selanno *et al.,* 2015). Van der Meij *et al.* (2010), asserted that the local anthropogenic impacts have caused dramatic changes in aquatic ecosystems. The same is added by Bellwood *et al.* (2004) that contaminated waters caused changes in the composition of fauna worldwide. Baum *et al.* (2015), asserted a clear separation of benthic and fish communities between reefs in Jakarta Bay and reefs along the Thousand Islands further north, and Wulp *et al.* (2016), reported that the percentage of heavy metal contaminants already occupy a high gradient around the Jakarta Bay.

Bivalves as benthic animals are able to reflect the increased bioavailability of heavy metals in the environment. Bivalves are widely used in activities as bioindicators and biomonitoring of pollution in the sea. This is because in general bivalves have a wide geographic distribution, large population, relatively stable in locations with heavy contamination, long life, sedentary life, tolerant of environmental changes and pollutants, have a value of bioconcentration factor (BCF) of pollutants which height, and body size make it easier to observe in the field and laboratory (Barka 2012).

Research conducted by Rumanta (2018) reported that nine rivers that empties into Jakarta Bay which were used as research samples were contaminated with heavy metals Pb in concentrations that had exceeded the threshold set by the Minister of Environment, 2004. The highest concentration was in the Ciliwung River which reached 0.117 ± 0.017 µg/ml in West Season. This occurs due to the low awareness of the population and industrial managers in Jakarta on environmental health.

As stated by Maryadi (2009) that currently it is predicted that there are 14 thousand cubic of waste from domestic waste and industrial waste polluting the 2.8 square kilometer bay. In addition Rumanta (2005) stated that the level of Pb and Cd pollution can be determined by examining the levels in marine biota that live in a polluted environment.

Research conducted by Otchere (2003), reported that compared to fish and crustaceans, bivalves have very low enzyme activity for the metabolism of persistent organic pollutants (POPs), so that the concentration of pollutants in bivalves more accurately reflects bioaccumulation. The study of heavy metal bioaccumulation in marine bivalves was mostly studied using the mussel groups, especially the Mytilidae family i.e the blue clam (*M. edulis*) and the green clam (*P. viridis*), the oysters group i.e Crassostrea, and Ostrea, the clams group i.e Corbicularia, and Cerastoderma, as well as the scallops group especially Pecten (Arockia *et al.,* 2012; Torres *et al.,* 2012; Priya *et al.,* 2011; Boateng *et al.,* 2010). This strengthens the reasons for scientists to always research this marine biota and determine the concentration limits of pollutants that are at risk for human consumption. This study objective to analyzed the Pb content of three species of bivalves.

The results of this study will provide an implicit solution to the bivalve species that have great potential to act as bioaccumulatory agents in Jakarta Bay.

Materials and methods

This research was conducted in Jakarta Bay, North Jakarta in two periods based on the division of seasons is Western season (November to March) and Eastern season (April to October) 2020. Pb tests on species bivalves is done using flame AAS in the laboratory of Research Center for Biology, Indonesian Institute of Sciences (LIPI) Bogor.

Analysis of Pb content of Three Species Bivalves

This research was conducted by direct observation technique in Jakarta Bay (In situ Measurement) and laboratory analysis. At the study site, five stations (ST1 to ST5) were selected for data collection based on information from fishermen about the existence of bivalves (Fig. 1).

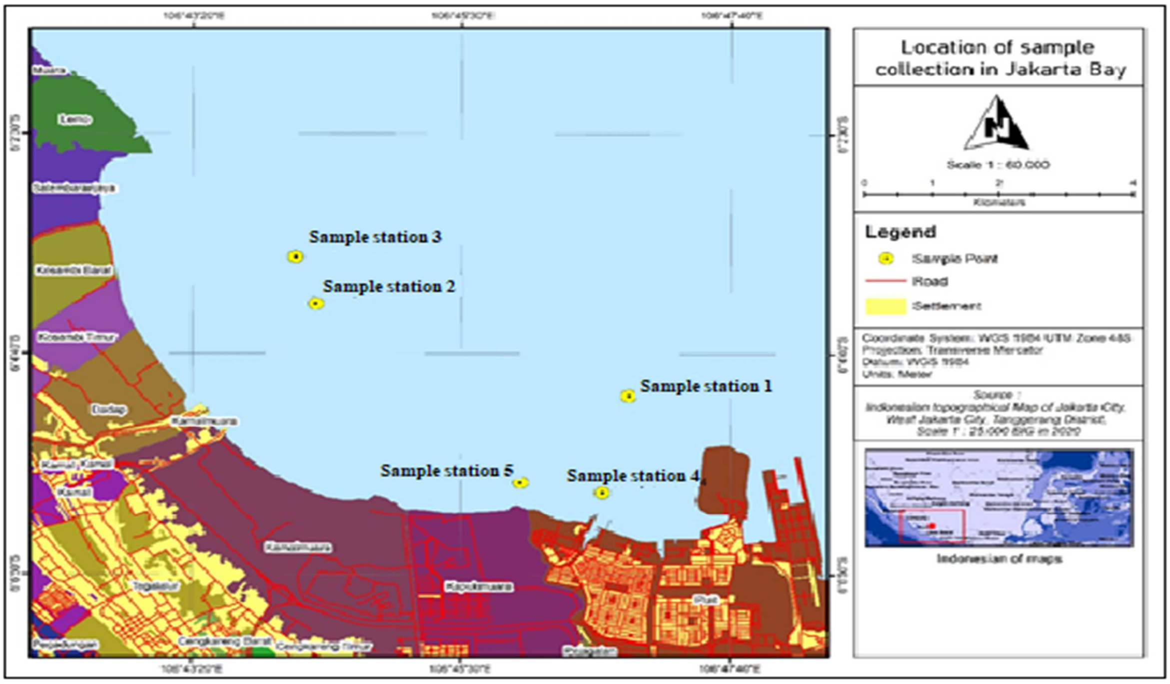

Fig. 1. A map showing the geographic localization of the five sampling sites analyzed in this study.

Tissue samples from three species of bivalves were collected from five observation stations. Each sample was collected in three replications (triplo), dried, then crushed, and weighed. Tissue samples were then ashed using muffle furnace at 435°F and digested using 1 ml of HNO_3 and 0.5 ml of $HClO_3$. These were filtered and made up to volume 25 ml using 25% HNO_3 and analyzed using flame AAS. The research data were analyzed using one way ANOVA to determine difference of Pb concentration at three species bivalves with software of SPSS version 21.

Results and discussion

Accumulation of Pb in Tissue and Shell from Three bivalves Based on laboratory analysis, the concentration of Pb in tissue (Table 1) and bivalve shells (Table 2) was obtained in two different seasons (Western and Eastern seasons). The data in Tables 1 and 2 describe the accumulation of Pb in each bivalve species. The results of this accumulation will answer and give meaning to the effectiveness of Pb accumulation from three species of bivalves. Understanding the heavy metal Pb in the tissue of a species is the key to proving the application of bioaccumulation in that species (Rumanta, 2018; 2019).

Table 1. Accumulation of Pb in the tissue of three species Bivalves in Western and Eastern seasons (µg/g wet weight).

Species Bivalves	Content of Pb (X ± SD)	
	Western season	Eastern season
Anadara antiquata	0,247 ± 0,044 A	0,264 ± 0,015A ns
Perna viridis	0,161 ± 0,155B	0,166 ± 0,016B ns
Meretrix meretrix	0,240 ± 0,053A	0,270 ± 0,016A ns

Note: Oneway Anova: Different capital letters (A, B) in the same column indicate significant differences (p<0.05) in Pb content between shellfish species.

T-test, ns= no significant difference between season in Pb content (p<0.05) each species

Data in Table 1, showed that the Pb concentrations in the tissues of the three species bivalves in the Eastern and Western seasons are not significantly different, but there is a tendency for bivalve heavy metal content in the Eastern seasons to be higher than in the Western seasons. The Pb content in the Eastern and Western Season bivalve tissue was significantly lowest in *P. viridis* (0,166 ± 0,016µg/g dan 0,161 ± 0,155µg/g) compared the Pb concentration in *A. antiquata* (0,264 ± 0,015µg/g dan 0,247±0,044µg/g), and *M. meretrix* (0,270 ± 0,016µg/g dan 0,240 ± 0,053µg/g).

The data showed that Pb content in tissue *P. viridis* was significantly lower than in *A. antiquata* and *M. meretrix*. This is thought to be closely related to the habitus profile of *A. antiquata* and *M. meretrix* which has a way of life by immersing themselves in mud (Novita, 2018; Aprilia dan sudibyo, 2019), whereas *P. viridis* has a habitus profile by sticking to hard substrates, such as wood, bamboo, hard structured mud, nets for cultivation fish, and hulls with using byssus threads (Cappenberg, 2008). The content of heavy metal Pb in bivalve tissue between seasons in this study did not showed a significant difference. This may be due to climatic conditions in 2020, with high rainfall throughout the year, while the dry season is quite short. However, there is a tendency that the heavy metal content of Pb in bivalve soft tissue in the Eastern seasons is higher than in the Western seasons. The results of this study are consistent with research by Rumanta (2005), which reported that the heavy metal content of marine fishery products in the Eastern Season tends to be higher than the Western Season. It is evident that the concentration of Pb increases in the Eastern Season compared to the Western Season.

Table 2. Accumulation of Pb in the shells of Three Bivalves in Western and Eastern seasons (µg/g wet weight).

Species Bivalves	Content of Pb (X ± SD)	
	Western season	Eastern season
Anadara antiquata	4,128±0,565A	4,380± 0,249A ns
Perna viridis	2,428 ±0,566B	2,674 ± 0,726B ns
Meretrix meretrix	3,209 ± 0,897A	3,578 ± 0,255A ns

Note: Oneway Anova Different capital letters (A, B) in the same column indicate significant differences (p<0.05) in Pb content between shellfish species.

T-test, ns= no significant difference between season in Pb content (p<0.05) each species

Data in Table 2 showed that the Pb concentration in the bivalves shell was much higher than the Pb concentration in the tissue. The concentration of Pb in the Eastern and Western seasons did not differ significantly, but there was a tendency that the heavy metal concentration in shells in the Eastern seasons was higher than in the Western seasons. The concentration of heavy metal Pb in *P. viridis* was significantly lower than that of other bivalve species. Based on Table 1, showed that the Pb content in the soft tissue of all bivalves is still below the threshold set by SNI (2009) and CCFAC (1999) of 1.5 µg/g for Pb, although it is still above the threshold for heavy metal content in processed food determined by the Head of BPOM Regulation No. 5 of 2018 (0.2 mg/kg for Pb).

This is still quite encouraging because the research results of the last few years Wahyuningsih *et al.*, (2015); the levels of Pb in Jakarta Bay are below the threshold allowed by SNI (2009) and Head of BPOM Regulation No. 5 of 2018. This may occur as the structuring and improvement improve rivers that cross the city of Jakarta, since the Reformation in 1998.

Table 3. Comparison of accumulation of Pb in the tissue and shells of Three Bivalves in Western and East seasons (µg/g wet weight).

Species Bivalves	The Pb Conten in Western Seasson ($\overline{X} \pm SD$)		The Pb content in Easter Seasson ($\overline{X} \pm SD$)	
	Tissue	Shell	Tissue	Shell
Anadara antiquata	0,247 ± 0,044 A	4,128 ± 0,565B	0,264 ± 0,015A	4,380± 0,249B
Perna viridis	0,161 ± 0,155A	2,428 ± 0,566B	0,166 ± 0,016A	2,674 ± 0,726B
Meretrix meretrix	0,240 ± 0,053A	3,209 ± 0,897B	0,270 ± 0,016A	3,578 ± 0,255B

Note: One way Anova: Different capital letters (A, B) in the same line indicate significant differences ($p<0.05$) in Pb content

The data in Table 3 shows that the Pb content in the shells of all bivalves at West monsoon and east monsoon were significantly higher than in the tissues. This happens because Pb can replace calcium ions in the formation of bones or bivalve shells that require calcium (Rumanta, 2005).

Then Crenshaw (1980) stated that shell composition is controlled by the metabolic activity of the outer mantle epithelium; it should then be assumed that the integration of elements into shells during their synthesis by the mantle would occur in simple proportion to the amounts of the contaminants in the soft parts. Therefore, contamination gradients produced by the shells and the soft parts would be expected to agree substantially. It must be understood that shells are extremely difficult to work with, e.g. insufficient cleaning will cause the inclusion of metals in components other than the shell and too vigorous cleaning may strip metals from the shell surface (Phillips, 1980).

Afianti (2005) stated that not least amongst the problems associated with the use of shells as indicator materials is the difficulty experienced in analysis; such as lead in the shell of this clam which acts differently compared with other elements. Such data do not lend confidence to a suggestion of using shells of *A. granosa* as indicators of trace metals abundance in marine or estuarine environments.

Conclusions

We asserted that the Pb content in the Eastern and Western Season bivalve tissue was significantly lowest in *P. viridis* (0,166 ± 0,016µg/g and 0,161 ± 0,155µg/g) compared the Pb concentration in *A. antiquata* (0,264 ± 0,015µg/g dan 0,247±0,044µg/g), and *M. meretrix* (0,270 ± 0,016µg/g dan 0,240 ± 0,053µg/g). The results of the present study showed that the concentration of heavy metal Pb in the bivalve shell of *P. viridis* was significantly lower than that of two species i.e *A. antiquata* and *M. meretrix*. Pb content in the Eastern Season bivalves did not significantly different from that in the Westerrn Season. This is caused by a weather anomaly where the rainy season occurs almos throughout year of 2020. The Pb content in the bivalve shell was significantly higher than in the body tissues. It is because Pb can replace calcium ions in the formation of animal bones or bivalve shells.

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Conflict of interest

The author declares that there is no conflict of interest.

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