Biosurvey of Mercury (Hg), Cadmium (Cd), and Lead (Pb) Contamination in Reclamation Island-Jakarta Bay

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Abstract: Man-made islands allegedly alter the coastline that slowing pollutants retention time. Green mussels (*Perna viridis*) are one of the organisms known to accumulate heavy metals. Biosurvey needs to be conducted to acquire information on heavy metal content in man-made habitat and biota. The aims of this research are to identify the water quality related to heavy metal presence; to measure heavy metal content in green mussels (*Perna viridis*) around the reclaimed island to determine heavy metal level pollution on reclamation island. Sampling was conducted in August 2017 in reclamation islands C and D. Heavy metal measurement values refer to the SNI method 3554-2015. Data of heavy metal content in water, sediment, and green mussels were analyzed with quantitative descriptive method. The results show biological oxygen demands (BOD), and chemical oxygen demands (COD) has exceeded the water quality standard which indicates a high level of pollution. The results of the examination of the heavy metal in seawater show that mercury (Hg), cadmium (Cd), and lead (Pb) are below the tools detection limit (<0.0002; <0.00011; <0.00086 mg/L) and below seawater pollution standard for biota. Concentrations of heavy metals mercury, cadmium, and lead in sediments around the reclaimed islands and Teluk Naga area are below heavy metal pollution standards for sediments. Mercury (Hg) levels below the tools detection limit (<0.0004 mg/L); cadmium (Cd) ranges from 0.02-0.20 mg/L; lead (Pb) ranges from 0.50 to 5.46 mg/L. Heavy metals examination in green mussels indicate that mercury (Hg), cadmium (Cd), and lead (Pb) are below the tools detection limit (<0.001; <0.00011; <0.00086 mg/L) and below the heavy metal pollution standard on bivalves. Generally, water and sediment around the reclaimed islands and natural habitat in August 2017 are not polluted by heavy metals so there is no harm to biota. Heavy metals quality in water, sediment and mussels are below the pollution standard and based on the USEPA system belong to grade A. The heavy metal index on Reclaimed Island is 18 and considered good. Based on the results obtained, it can be concluded that the reclaimed islands C and D in August 2017 were safe from heavy metal mercury, cadmium, and lead pollutions.

1 INTRODUCTION

One of the purposes of island reclamation in DKI Jakarta Provincial Regulation is to comply with land needs with consideration of the ever-increasing population. Modeling research by (Badriana, 2015; Aprilia and P., 2017)states that

- There is current velocity value decrease after reclamation, the current velocity value change occurs in the gap and around reclamation area
- The increase in sediment may potentially appear around the inland/near coastal reclamation area and in inter-island reclamation gap.

Changes in currents around the reclaimed island will decrease the retention time in washing contaminants from the land. This results from sedimentation rates increase around the estuary, eutrophication and contaminants cumulation including heavy metals. Research on heavy metal pollution in Jakarta Bay has been conducted before and indicating heavy metals detected with varying levels (Cordova, 2011; Putri et al., 2012; Permanawati et al., 2013; Suryono, 2006).

Green mussels have a sedentary lifestyle, attached to the substrate using byssus, and filter feeder that allows heavy metals to enter the body (Cordova et al., 2016). Green mussels are able to bind metals and integrate metal concentration in water over time (Dumalagan et al., 2010) so they can be recommended as heavy metal biofilter (Koropitan and Cordova,

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2017). Currently, there is no information about the content of metals in green mussels that live in reclaimed island C and D habitat. Based on these condition biosurvey of heavy metal content on green mussels and their habitats is necessary. Thus the objective of this research was to identify the water quality related to the heavy metal presence and to measure heavy metal content in green mussels (*Perna viridis*) around the reclaimed island.

2 MATERIAL AND METHODS

2.1 Research Location, Time, and Design

The research was conducted from July to December 2017. Sampling station determined purposively based on green mussels presence at the point of biota monitoring attached in Environmental Management Plan and Environmental Monitoring Plan (RKL-RPL) of C and D reclamation islands (A, B, C, and D) and Teluk Naga (figure 1). There are three observation points at each station, positioned by Global Positioning System (GPS). Sampling was conducted in August 2017 and expected to provide an overview of water conditions in the dry season. Descriptive method research was used to determine levels of heavy metals in green mussels. Mussels were collected by hand-sorting techniques (Abdulgani and Aunurohim, 2010).

Figure 1: Sampling Station

2.2 Tools and Materials

Tools used in this research include water sampler model JT-1 made in the USA, sediment sampler, 250 ml and 500 ml polyethylene plastic bottle, Global Positioning System (GPS) Garmin GPSMAP64s, coolbox, plastic clip bag, beaker glass, pipettes, meter, FiveGo pH meter, Atago refractometer made in Japan, turbidimeter, oven, funnel, vernier caliper, adhesive label paper, analytical balance, Mettler Toledo Seven2Go dissolved oxygen (DO) meter, action camera for underwater photo and videography, Fujifilm Finepix s4800 camera, stage sieve, 700 series inductive coupled plasma optical emission spectrometry (ICP-OES) device year 2013 made in Australia. Materials used include green mussels (*Perna viridis*), water samples, sediment samples, distilled water, preservative samples (86% H_2SO_4, 70% HNO_3).

2.3 Sample Storage, Preservation, and Handling

Sampling and handling of the sample refer to Puget Sound Water Quality Action (PSWQA) (PSWQA., 1997) and Standar Nasional Indonesia (SNI) 06-2412-1991 (SNI, 2008). The data taken include the measurement of several physical and chemical parameters of water quality. Measurements were performed either in-situ or ex-situ through laboratory analysis and were done three times at each observation point. In-situ measurements included depth, temperature, pH, salinity and dissolved oxygen (DO). Ek-situ measurements for grain size analysis was done at the Ecology Laboratory of School of Life Science and Technology Institut Teknologi Bandung (SITH ITB) and for Total Suspended Solid (TSS), Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD) and heavy metals samples were sent to Saraswanti Indo Genetech (SIG) Bogor laboratory. Sediment texture was determined based on (K., 1922) by filtering sediment using a stratified filter. The sediment type is determined using Miller's triangle (Miller and White, 1998). TSS, sediment grain and green mussels samples are stored at 4°C. Biological Oxygen Demand (BOD) samples are stored in dark bottles at 4°C. Chemical Oxygen Demand (COD) samples were preserved with H_2SO_4. Water samples are preserved with HNO_3.

3 RESULT AND DISCUSSION

3.1 Heavy Metals in Seawater and Sediment

Analysis result of heavy metals cadmium (Cd), mercury (Hg) and lead (Pb) in the water and sediment of Reclamation Island and Teluk Naga provided in

Table 1. All metals values were below seawater quality standards (Decree Ministry of Environment and Development No. 51, 2004) so they are relatively safe for biota. This result was similar to (Putri et al., 2012) that reported the concentration of mercury, cadmium, and lead in the waters of Muara Kamal is below the standard of seawater so it is suitable for mussels and other biota growth. The concentration of heavy metals in the aquatic ecosystem due to the presence of natural heavy metals and heavy metal waste. The concentrations of heavy metals are higher with the input of waste into the waters and accumulate in the ecosystem. Heavy metals in an aquatic ecosystem experiencing various processes such as precipitation, dilution, dispersion, and absorption by living organisms in aquatic habitat (Warner and Preston, 1974; HP., 1984).

Mercury (Hg) concentrations in sediments around Reclamation Island and Teluk Naga are not hazardous to the environment and living organisms. Mercury (Hg) concentration in the research area probably low that it is undetectable. Cadmium (Cd) concentration in sediments range from 0.07 to 0.15 mg/L. The concentration value was below the standard of IADC (International Association of Drilling Contractors)/CEDA (Central Dredging Association) (1997). Cadmium (Cd) at that concentration has no potential hazard to the living organism. The results of Cd analysis showed higher concentrations in sediment than water column in each research site. This happens due to heavy metals have a tendency to settle because of the large mass. Lead concentrations in sediments range from 2.10 to 4.62 mg/L. The concentration values were below the standard of IADC/CEDA (1997). Presence of Pb metal allegedly due to the concentration of Pb in the waters and the amount of organic and inorganic particles in the waters (CC et al., 2007; Begum et al., 2009; S and MH., 2010).

Metals content in sediment is influenced by several factors, among others; organic matter content, grain size, and mineralogy. High concentrations of heavy metals are generally associated with grain size texture (SE., 2001). Sediment textures on Reclamation Island are mainly sand which may be one of the reasons for the low metal content. Cadmium and lead content in sediment is greater than in seawater but below the pollution standard of sediment. The levels of heavy metal sediment at each station can be said not to endanger marine organisms. It is accord to (Permanawati et al., 2013) which states that heavy metal content (copper (CU), lead (Pb), zinc (Zn), cadmium (Cd), and chromium (Cr)) in water and sediments in Jakarta bay waters below pollution standard.

3.2 Heavy Metals in Green Mussels

Table 1 shows the concentration of heavy metals mercury (Hg), cadmium (Cd), and lead (Pb) in the green mussels are not detected and below heavy metal pollution standards for bivalves according to Badan Standarisasi Nasional (BSN) 7387 (SNI, 2009). Mercury, cadmium, and lead contained in water and sediments have not exceeded the specified standard threshold. This shows that heavy metal concentration does not pollute the environment even though Jakarta bay has the potential to be highly polluted. Bioaccumulation of heavy metals in green mussels can occur because heavy metal enters into the body of the living organism easily and quickly (de Astudillo L. R. et al., 2005). But this research did not show the accumulation of mercury (Hg), cadmium (Cd), and lead (Pb) on the green mussels. This is probably due to low of mercury (Hg), cadmium (Cd), and lead (Pb) content in water and sediment. Heavy metal accumulation in aquatic organism according to (SE., 2001) are influenced by many factors, among others:

- The concentration of heavy metals in water
- The concentration of heavy metals in sediment
- Acidity of the water and sediment
- Chemical oxygen demand (COD) level in water
- Sulfur content in water and sediment
- Types of aquatic organism
- Organism age and body weight and
- Organism life phases (eggs, larvae)

If concentrations of heavy metals in water are high then there is a tendency for heavy metals concentrations to be high in sediments, and the accumulation of heavy metals in the demersal organism occur (K. et al., 2004; IDL and SM., 1996).

- Seawater Standard Quality for Marine Biota, standard criterion set by Indonesia Government Decree Ministry of Environment and Development (DMED) No. 51/2004. Tool detection limit for mercury (Hg) 0.0002 mg/L; cadmium (Cd) 0.00011 mg/L; lead (Pb) 0.00086 mg/L.
- Sediments pollution standard in Indonesia has not been established. IADC (International Association of Drilling Contractors)/ CEDA (Central Dredging Association) (1997) has been used as standard. Tool detection limit for mercury (Hg) 0.0004 mg/L.

Table 1: Water quality and heavy metal content in water, sediment and green mussels.

No.	Parameter	A	B	C	D	TN	Standard Quality
Water							
Physical							
1	Bright(m)	0,9	1,8	1,4	0,9	1,7	Coral: >5; mangrove: -; seagrass: >3; natural >0,5
2	Turbidity (NTU)	10,5*	7,0*	4,5	8,3*	5,5*	<5
3	Total suspended solid (mg/L)	9,3	7,3	8,3	13,0	3,6	20
4	Waste	-	-	3	5	-	Nihil
5	Temperature (0C)	28,9	28,7	29,0	29,1	30,2	Natural (20-30)
Chemical							
	pH	8,4	8,6	8,6	8,9*	8,6	7-8,5
1	Salinity (%)	29,3*	30,0	30,1	30,2	30,8	Natural (30-40)
2	Disolved oxygen (mg/L)	3,89*	4,70*	4,67*	4,55*	5,16	>5
3	COD (mg/L)	70,0*	85,1*	71,2*	79,6*	81,7*	20
4	BOD (mg/L)	265,3*	474,8*	373,8*	593,2*	418,2*	20
5	Mercury (mg/L)	nd**	nd**	nd**	nd**	nd**	0.001
6	Cadmium (mg/L)	nd**	nd**	nd**	nd**	nd**	0.001
7	Lead (mg/L)	nd**	nd**	nd**	nd**	nd**	0.008
Sediment							
1	Mercury (mg/L)	nd**	nd**	nd**	nd**	nd**	0.03
2	Cadmium (mg/L)	0.14	0.07	0.08	0.15	0.09	0.8
3	Lead (mg/L)	3.19	2.29	2.1	4.62	2.5	85
Green mussels							
1	Mercury (mg/l)	nd**	nd**	nd**	nd**	nd**	1
2	Cadmium (mg/l)	nd**	nd**	nd**	nd**	nd**	1
3	Lead (mg/l)	nd**	nd**	nd**	nd**	nd**	1.5

*value higher than pollution standard, ** nd=not detected

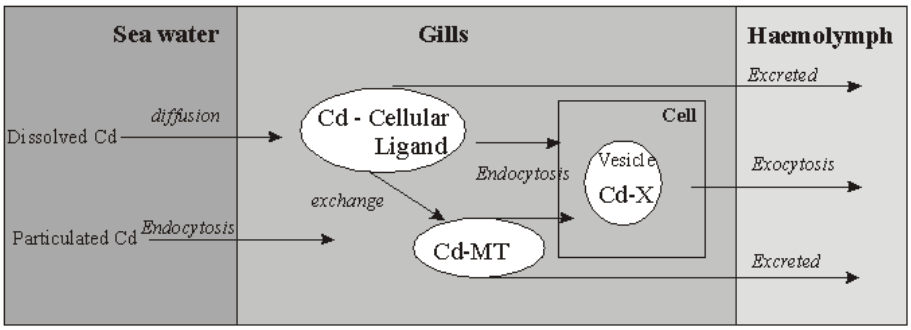

Figure 2: Mechanism of accumulation and detoxification of heavy metals by bivalves (Soto et al., 2003)

- Green mussels pollution standard based on Standar Nasional Indonesia (SNI) 7387: 2009 [17] as the maximum limit of heavy metal contamination in food. Tool detection limit for mercury (Hg) 0.009 mg/L; cadmiun (Cd) 0.00011 mg/L; lead (Pb) 0.00086 mg/L.

The heavy metals entering cells through the lipid layer of the membrane by endocytosis, through a pumping and organic chelating system. Non-essential metals that enter the cells will compete with essential metal to bind to ligands. Binding mechanism of metal and proteins generally damages sulfide bonds (N. et al., 2004). Metals binding to biomolecules then will accumulate in hepatopancreas or be detoxify. The mechanism of accumulation and detoxification of heavy metals in bivalve can be seen in Figure 2. Heavy metals modify existing enzyme processes by interfering with and replace calcium (Ca) ions that affect oxidation. In this research-heavy metal mercury (Hg), cadmium (Cd), and lead (Pb) of green mussels samples are inert within the acceptable limit for green mussels and other predators. This can be observed from the absence of heavy metals accumulation in mussels indicating that cadmium (Cd) and lead (Pb) in sediments that enter mussels body has been detoxified.

3.3 Heavy Metal Pollution Level on Reclamation Island

Pollution level of heavy metal on water, sediments, and biota are determining using STORET method (US-EPA/United States Environmental Protection Agency) based on scores (Decree of the Minister of Environment (DMED) no. 115/2003 about Guidelines for Determining Status of Water Quality) (DMED No.115, 2003). Results show that heavy metal mercury, cadmium, and lead in water, sediments, and green mussels around reclamation island are below standard quality so that it is included in class A. This is probably due to the intensity of waste disposal consist of low heavy metals.

Although in this research there was no heavy metal pollution, it does not indicate the condition around the reclaimed island is good. Physical and chemical analysis of water shows that turbidity, Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), and dissolved oxygen (DO) parameters do not comply with water quality standards in Decree Ministry of Environment and Development No. 51/2004. Biological Oxygen Demand (BOD) concentrations in water range from 265,3 to 593,2 mg/L, it is much higher than the standard quality which is 20 mg/L. Chemical Oxygen Demand (COD) concentrations in water range from 70,0 to 85,1 mg/L that higher than the standard quality which is 20 mg/L. dissolved oxygen (DO) concentrations in water range from 3,89 to 5,16 mg/L that below than the standard quality which is 5 mg/L except for Teluk Naga station. These parameters illustrated the high pollution around the reclaimed island.

4 CONCLUSIONS

Based on the results it can be concluded that :

- Mercury (Hg), cadmium (Cd) and lead (Pb) content in the water below the water quality standard for biota. Mercury (Hg), cadmium (Cd) and lead (Pb) content in sediments below the standard set by IADC/CEDA. The content of heavy metal in water and sediment of reclamation islands are safe for biota. High Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) content showed high organic pollution around reclaimed islands C and D
- There is no accumulation of heavy metal mercury (Hg), cadmium (Cd) and lead (Pb) occur in green mussels.
- Heavy metal pollution level in the water, sediment, and green mussel organs based on the STORET (US-EPA) method included in class A which is classified as not contaminated by heavy metals mercury (Hg), cadmium (Cd), and lead (Pb). Mercury (Hg), cadmium (Cd), and lead (Pb) quality index in reclamation island C and D amounts to 18 so that it is classified as good.

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