ISSN 2250-3153

Bioconcentration of Lead (PB) in Milkfish (Chanos Chanos Forsk) Related to the Water Quality in Aquaculture Ponds of Marunda, North Jakarta, Indonesia

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Abstract- Coastal areas of Jakarta are well known for their multiple uses (housings, industries, etc.). In this region, aquaculture ponds are also flourished and receiving not only coastal waters but also from river nearby that contain heavy metals. Lead (Pb) has been recognized as hazardous metal because it can cause health problem. The objectives of this study are to measure the lead (Pb) content in the ponds sediment and C. chanos, to determine bioconcentration factor of C. chanos and its relationship with water quality parameters. Samples of sediments and C. chanos were collected from four (M1-M4) aquaculture ponds located in Marunda, North Jakarta. Lead (Pb) content was analysed by using Atomic Absorption Spectrometry (AAS) Shimadzu 6300. The highest content of lead (Pb) in the sediment (with lowest Pb content in muscles of C. chanos) was found in M2, which is 16.33 µg/g. On the contrary, the lowest content of Pb in sediment (8.93 µg/g) was found in M1 (location with highest Pb concentration in muscles of C.chanos). Based on bioconcentration factor (BCF) calculation, M1 had the highest BCF, as much as 0.558. Pb content in gills of C.chanos always higher compared to muscles. Moreover, the lower dissolved oxygen (6.8 mg/l), pH (7.3), and salinity (16.5‰) were observed in M1. The lower dissolved oxygen in M1 confirmed oxygen consumption by fish. Also, the lower pH accelerated the dissolution/release of metals in sediments, hence it becomes available for fish (C.chanos). Higher salinities ponds have higher bioaccumulated lead (Pb), especially on gills.

***Index Terms*-** Bioconcentration factor (BCF), lead, milkfish, pond, water quality

I. Introduction

The aquaculture enterprise has become one of the major sources of fishes in Indonesia, mainly to fulfill domestic consumption. Likewise, the coastal areas of Jakarta, where the aquaculture practices on *Chanos chanos* expanded along its bay, has suffered from some degree of land use pressures and pollutant discharges such as heavy metals from river and coastal waters nearby.

Though preventive activities have been considered to reduce the input of metals into waterways, rivers, and ponds, however, there are still industries and communities throwing their waste into those waters. As a consequence, accumulation of pollutants mainly heavy metals have been reported [1]. Therefore, it is important through regular monitoring to trace element/heavy metals, in particular lead (Pb).

Lead is a naturally occuring metal found in small amounts in the earth's crust. It can be found in all parts of our environment. Lead (Pb) may be present in hazardous concentrations in food, water, and air. Sources include paint, urban dust, folk remedies, mining, smelting and non-ferrous metal industries. Lead poisoning is the leading environmentally induced illness in children. At greatest risk are children under the age of six because they are undergoing rapid neurological and physical development [6].

Metals concentration in surface sediments of Jakarta Bay, Jakarta, and their spatial distribution have been studied [2]. For example, concentration of Pb during 10 years period varied between 23.3-118.2 mg/kg. According to[4], concentration of Pb in Tiram Rivermouth sediments where Marunda aquaculture ponds located ranged between 40.66 – 59.13 mg/kg. Based on Canadian Standard for contaminated sediments, the ambient value for Pb is 25 mg/kg [4].

According to [6] found that concentration of Pb in Gresik waters, East Java, have exceeded the standard which for Pb is 0.03 mg/kg. On preliminary research, the concentration of Pb in the sediments of ponds close to the sea, human settlement, and industrial areas were 0.049 mg/kg, 0.217 mg/kg and 0.1352 mg/kg, respectively. Concentration of Pb found in *C. chanos* ranged from 0.025- 0.052mg/kg.

A.Bioconcentration

Bioconcentration is the intake of chemical contaminants through an epithelial tissues or gills, and the subsequent concentration of that chemical contaminant within the tissues to a level that exceeds ambient environmental concentrations[7,8]. Thebioconcentration and later, bioaccumulation, are dynamic processes that involve many interconnected variables. For example,the potential of a chemical to bioconcentrate and bioaccumulate, in organisms is dependent upon the properties of the chemical character of hydrophobicity, lipophilicity, and resistance to degradation, environmental factors such as salinity, temperature, concentration of other organic chemicals, and potential redox, biotic factors the mode of feeding, trophic position, lipid concentration, and metabolism, and bioavailability current chemical inputs, transport mechanisms, and degreeof contamination[7,9,10,11,12]. Bioconcentration factors have been reported as arithmetic means for groups of organisms, included fish, bivalves, and shrimp (Office of Environmental Health Hazard Assessment in [13]

Most metal contaminant tend to not be lipid -soluble in the aquatic environment. As a result, metals will more commonly accumulate in non-lipid rich tissues in the gills of fish. However, if the metal is incorporated into a lipophilic organic compound (e.g. methyl mercury compound), the accumulation of the metal is enhanced [14].

B.Water Quality of Ponds

Besides heavy metals, surface water quality assessment is commonly considered for an assessment of pollution in aquatic environment settings for example lakes and ponds. Water quality parameters like dissolved oxygen, temperature, pH, and salinity in the ponds provide an indication of the health quality of the associated water and organisms, such as fishes and shrimps. The amount of dissolved oxygen that can be held in water even at saturation is small compared to air, and decrease with increasing temperature. pH of most unpolluted standing waters is between 6 – 9. There is a diurnal as well as seasonal fluctuation of pH in ponds. pH can have direct or indirect effect on fish life, the decreasing pH can increase the solubility of metals in waters. Salinity in estuary usually range from 5-35 ‰. Salinity can influence the heavy metals in the environment by formatting stable chloro complexes in the presence of seawater. Higher salinity will increase the sorption of metals on particulates in seawater[15]. The objectives of this research are to measure the lead (Pb) content in the ponds sediment and *C. chanos*, to determine bioconcentration and its relationship with water quality_parameters.

II. MATERIALS AND METHODS

A.Description of Sampling Area

Jakarta is bordered by 106Figure 3. Lead (Pb) content in muscles and gills of *Chanos chanos* at Marunda Ponds, North Jakarta 03'00" Longitude and 6Figure 3. Lead (Pb) content in muscles and gills of *Chanos chanos* at Marunda Ponds, North Jakarta 10'30" Latitude. Administratively, bordered byBekasi Regency on the East and Tangerang Regency on the West. Marunda's ponds area is located in the coastal areas of the Jakarta Bay closed to Bekasi Regency (Figure 1). Marunda Ponds were used to be mangrove areas and converted into aquaculture ponds, mainly for milkfish (*C. chanos*). Sampling stations consisted of 4 milkfish (C. chanos) ponds (M1, M2, M3, and M4 (Figure 1). In each station, water quality parameters such as dissolved oxygen (DO), pH, salinity, and temperature were measured. Gill nets were used to capture fish (C. chanos). Moreover, samples werelabeledand stored at -40 C until pretreatment and analysis [3].

Figure 1. Sampling Points (M1, M2, M3, M4) at Ponds in Marunda, North Jakarta

B. Heavy Metal Analysis

Fish (*C.chanos*) samples were thoroughly washed with Milli-Q water and after removing the scales, the muscles portion extracted for further processing. Muscle tissue was macerated into 1-2 cm clumps, dried at 70-80ºC, grinded and stored until chemical analysis. Lead (Pb) were analyzed by digesting the homogenized samples in a mixture of nitric, perchloric, and sulfuric acids. After being centrifuged the supernatant was filtered through leur-lock syringe filter paper (45 µm)[16].

Sediment samples were collected using a 3.5 L Ekman grab sampler. The top 2–3 cm of the sediment layer was collected using a plastic spatula, and subsequently placed in the acid-washed plastic-bags and stored at -4º C during transportation to the laboratory. Determination of Pb was carried out using Atomic Absorption Spectrometry (AAS) Shimadzu 6300 at Department of Chemistry, Faculty of Mathematics and Natural Sciences, University of Indonesia. Performance of the instrument was checked by analyzing the reference standard material solutions (Merck NJ, USA); concurrently to check the precision of the instrument. compensate for matrix effects between samples and standards, blank samples were analyzed in each batch. All the samples were analyzed in triplicate. The detection limits for Pb was 0.10 mg/L[16].

C. Bioconcentration Factor

Bioconcentration Factor was measured using formula according to [17]

$$BCF = \frac{\text{Concentration of metals in biota}}{\text{Concentration of metals in water/sediments}}$$

D. Environmental Quality Parameters

Dissolved oxygen,pH, and salinity levels were measured using Jenway pH meter, Lovibond DO meter, and Atago refractosalinometer, respectively [4].

III. RESULTS AND DISCUSSIONS

Based on analysis of lead (Pb) content in sediments, it showed that M1 had the lowest content of lead (Pb) with value of

8.9281 (µg/g) and the highest content found in M2 with value of 16.3270 (µg/g) Figure 2. Most of these concentrations were still below the Canadian Standards for Contaminated Sediments which for Pb is 25 (µg/g). However, concentrations of Pb in muscles of *C.chanos* ranged from the lowest 1.4473 (µg/g) at M4 until the highest 4,9836 (µg/g) at M1. In addition, concentration of Pb in gills raged from the lowest 3.3543 (ug/g) at M2 until the highest values 5.6834 (µg/g) at M4 (Figure 3). Most of those concentrations were above the standard for food safety. Based on Directorate General of the Medicine and Food Monitoring Centre, Number 03275/B/SK/VII/89, the maximum level of Pb allowed in food/seafood is 2.0 µg/g dry weight. Average concentration of Pb in *C.chanos* (2.9474 µg/g) at Marunda ponds, Jakarta, was higher than in *C.chanos* (0.04 µg/g) at Gresik Ponds, East Java, Indonesia.

Based on bioconcentration factor (BCF) calculation, M1 had the highest BCF, as much as 0.558, followed by M3 (0.2281), M2 (0.1342), and M4 (0.1153) (Figure 4). Pb content in gills of *C.chanos* always higher compared to the muscles (Figure 3). This is because most metal contaminants tend not to be lipid-soluble in the aquatic environment. As a result, metals will more commonly accumulate in non-lipid rich tissues (e.g., the gills of fish) [13]

Figure 5, 6, and 7showed values of DO, pH, and salinity among ponds (M1-M4), respectively. The lowest dissolved oxygen: 6.8 mg/l, pH: 7.3, and salinity: 16.5‰ were observed in M1. Pond located in M1 (inland) has the lowest oxygen content compared to other ponds. This lowest dissolved oxygen confirmed oxygen consumption by fish. In contrast, pond located in M4 (seaward direction) has a higher oxygen content and salinity. Increasing values of DO, pH and salinity in ponds close to coastal area because of the input of seawater (rich in oxygen and salt content) into ponds.

Decreasing metals in the seaward direction is due to the release of metals from sediments introduced into marine environment. Besides that, it is because of mixing process between river and seawater.

Also, the lower pH accelerated the dissolution/release of metals in sediments [23], hence it becomes available for fish(*C.chanos*), and then accumulated in the tissues.[13]reported that increased salinity enhances bioconcentration and bioaccumulation rates of metals by decreasing its solubility in water and subsequently increasing its lipophilicity. Therefore, it can be assumed that areas with higher salinities within will have higher bioaccumulation potential than areas with lower salinities. In this research, Pb values in seaward direction (sampling point M3 and M4 that have higher salinity) were higher in gills compared to muscles of *C.chanos*. In fish, gills are considered to be the dominant site for contaminant uptake because of their anatomical and/or physiological properties that maximize absorption efficiency from water [24,25].

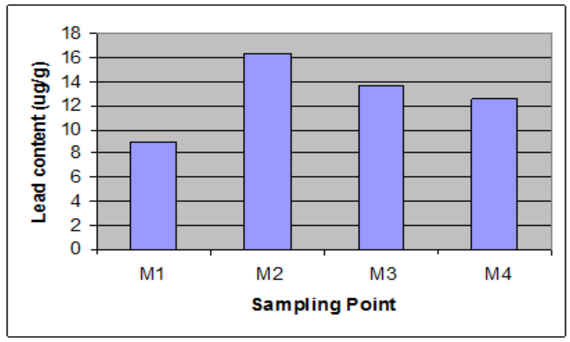

Figure 2. Lead (Pb) content in sediment of Marunda Ponds, North Jakarta

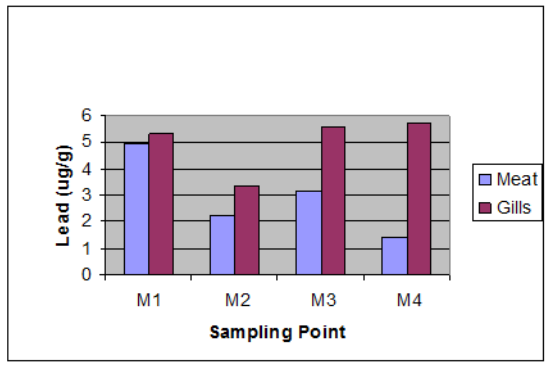

Figure 3. Lead (Pb) content in muscles and gills of Chanos chanos at Marunda Ponds, North Jakarta

Table 1. Bioconcentration Factor of *C.chanos*muscles in Marunda Ponds, North of Jakarta

No	Sampling Point	Pb in muscles (µg/g)	Pb in Sediment (µg/g)	Bioconcentration Factor (BCF)
1	M1	4.9836	8.9281	0.56
2	M2	2.1918	16.3270	0.13
3	M3	3.1669	13.5886	0.23
4	M4	1.4473	12.5479	0.11

Table 2. Bioconcentration Factor of *C.chanos*gillsin Marunda Ponds, North of Jakarta

No	Sampling Point	Pb in gills (µg/g)	Pb in Sediment (µg/g)	Bioconcentration Factor (BCF)
1	M1	5.2991	8.9281	0.59
2	M2	3.3543	16.3270	0.21
3	M3	5.5769	13.5886	0.41
4	M4	5.6834	12.5479	0.45

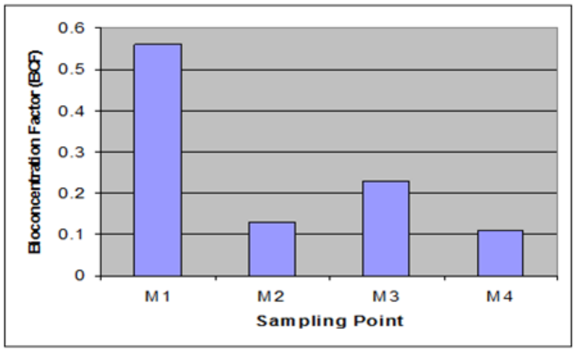

Figure 4. Bioconcentration Factor (BCF) in Chanos chanos at Marunda Ponds, North of Jakarta

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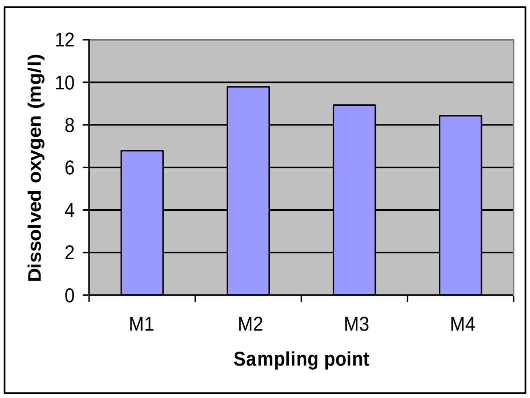

Figure 5. Dissolved Oxygen values at Marunda Ponds, North Jakarta

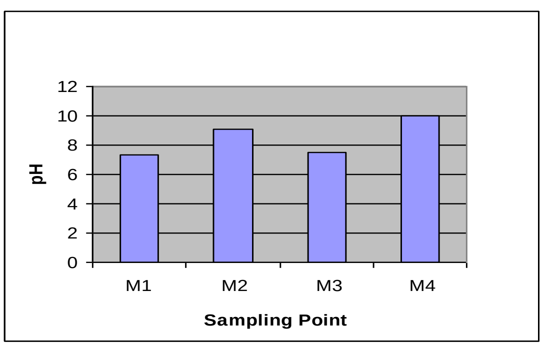

Figure 6. pH values at Marunda Ponds, North Jakarta

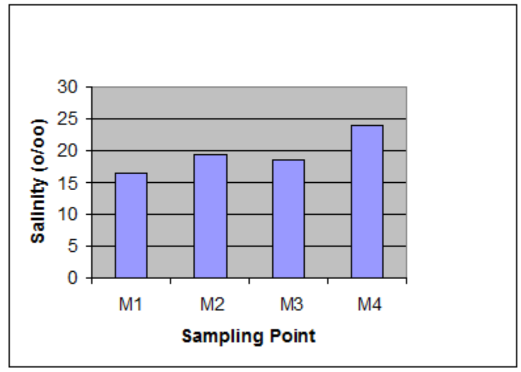

Figure 7. Salinity values at Marunda Ponds, North Jakarta

IV. CONCLUSIONS

Cconcentration of Pb in sediments were still below the Canadian Standard for Contaminated sediments which for Pb is 25 mg/kg. However, concentration of Pb in *C. chanos* were above the ambient concentration according to Directorate General of the Medicine and Food Monitoring Centre, Number 03275/B/SK/VII/89. Eventhough, the bioconcentration factor (BCF) in *C.chanos* still considered low (did not exceed 1.2, a value that confirmed bioaccumulation), the highest BCF found in *C.chanos*muscles and gills at M1 were as much as 0.55 and o.59, respectively.. These means that lead (Pb) was about to be accumulated in fish (muscles/gills). Care for ponds must be taken in order to avoid further contamination.
It is suggested that to have a good quality of fish, organisms should not reared in contaminated ponds because they are not suitable for consumptions.

ACKNOWLEDGEMENTS

This research was funded by DIKTI (Directorate of Higher Education) and DRPM UI (Directorate of Research and Community Services University of Indonesia) through RUUI Scheme. Under contract Noverita Dian Takarina Number: 445AX/H.2.PP/ HKP.05. 00/2012. March, 05 2012.

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