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HEAVY METAL CONDITION IN KRAMAT KEBO ESTUARY, WEST JAVA, INDONESIA AS HABITAT OF *ORYZIAS JAVANICUS*

KONDISI LOGAM BERAT DI KRAMAT KEBO ESTUARI, JAWA BARAT, INDONESIA SEBAGAI HABITAT DARI OORYZIAS JAVANICUS

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ABSTRACT

Nowadays, contamination monitoring in Indonesia is still focused on traditional method by measurement of chemical and physical parameter. Else, the use of organism, known as bioindicator brings some advantages such as knowing about habitat alteration and relationship between organism and environment. Fish from genus Oryzias had been known in Malaysia and Japan as a sensitive bioindicator. One of species, *O. javanicus*, was found in Kramat Kebo estuary, West Java, Indonesia. This preliminary study aims to determine metal distribution in water and sediment in Kramat kebo estuary, as a habitat of *O. javanicus*. It is also a preliminary study to assess possibility of *O. javanicus* as a bioindicator of heavy metal contamination in coastal area. Sampling was conducted twice in March and September, 2014. The analysis of total metal was done by Atomic Absorbance Spectrophotometry. Results show that metal in water was still below the threshold value by Ministry of Environment. Metal in sediment analyzed by Sediment Quality Guidelines Quetiont (SQG-Q) index shows that all stations presented SQG-Q value between 0.1 and 1, which means that Kramat Kebo estuary is a moderate impacted area. This observation concludes that the existence of *O. javanicus* was related to less polluted of heavy metal in estuary and it suitable for bioindicator of moderate impacted heavy metal area.

Keywords: Bioindicator, heavy metal, Kramat Kebo estuary, *Oryzias javanicus*.

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INTRODUCTION

Heavy metal contamination in aquatic environment has become a global issue, because of their toxicity, broad sources, no eco-friendly properties, and accumulative behaviour. Industrialization and economic development in coastal regions, heavy metals are enter to estuarine and coastal environments through rivers, runoff, and land-based point sources (Khodadoust *et al*., 2012). As a result, aquatic animals are exposed to elevated levels of heavy metals. The levels of metals in upper members of the food web like fish can reach values many times higher than those found in aquatic environments or in sediments (Stancheva *et al*., 2013). Heavy metal concentrations in aquatic ecosystems are usually monitored by measuring their concentrations in water, sediments and associated biota, which generally exist in low levels in water and attain considerable concentration in sediment and biota. Sediments are important sinks for various pollutants like pesticides and heavy metals and also play a significant role in the remobilization of contaminant (Edward *et al*., 2013).

Some metals are necessary for biosphere (e.g. Cu, Zn), but Cd and Pb are needed by living organisms but in limited amount only as micronutrients. Both essential and unessential metals can easily be harmful in the high concentrations (Khodadoust *et al*., 2012). Copper (Cu), zinc (Zn), and iron (Fe) are essential as constituents of the catalytic sites of several enzymes. Other metals, however, such as lead (Pb), mercury (Hg), and cadmium (Cd) may displace or substitute for essential trace metals and interfere with proper functioning of enzymes and associated cofactors (Awheda *et al*., 2015).

Scientists have traditionally conducted chemical assays and directly measured physical parameter of the environment (e.g., ambient temperature, salinity, nutrients, pollutants, available light and gas levels), whereas the use of bioindicator to assess the cumulative impacts of both chemical pollutants and habitat alterations are over time (Holt & Miller, 2011). A bioindicator is an organism (or part of an organism or a community of organisms) that contains information on the quality of the environment (or a part of the environment) (Awheda *et al*., 2015).

Fish has been widely used as bioindicators for monitoring pollution in aquatic ecosystems (Ismail & Yusof, 2011; Zulkifli *et al*., 2012, Awheda *et al*., 2015), because of highly affected by heavy metals depending on fish age, size and other physiological factors (Awheda *et al*., 2015). Fish could be affected by the elements of water directly through the water enters the gills or indirectly through food in the digestive tract (Sow *et al*., 2012) and being the final consumers in the aquatic food chain that is able to accumulate metals and affect humans through the food (Authman *et al*., 2015). *Oryzias javanicus* (Bleeker, 1854), a species model of true-bony fish, distributed in the freshwater of Japan, Korea and China and in the brackish waters of Peninsula Malaysia, Singapore, Indonesia, Thailand and Western Borneo (Ismail & Yusof, 2011).

Kramat Kebo estuary, located in Naga Bay, Tangerang, West Java Indonesia, which is covering mangrove, fishing area and tambak, is suitable place for the living of Java Medaka (*O. javanicus*) fish. The aim of this study is to determine metal distribution in water and sediment in Kramat Kebo estuary, as a habitat of *O. javanicus*. This is a preliminary study to assess possibility of *O. javanicus* as a bioindicator of heavy metal contamination in coastal area. We would like to analyze whether there are spatial or temporal differences in heavy metal gradients contents in this study area. This fish had known have salinity tolerance so we hypotesized that *O. javanicus* would be found along the river and the habitat of this fish are followed certain pattern according to SQG value.

METHODOLOGY

Site Description

Kramat Kebo estuary is located in the western part of Jakarta Bay, with mangrove covering, and fishing activities (Figure 1). This location covering of mangroves and plants, is a suitable place for the living of Java Medaka. Research was conducted in March and September, 2014. The ecology parameters such as temperature, pH, and salinity of water were measured in situ using SCT YSI and pH meter MetroOhm.

Sampling procedure and analytical method

Sampling point were decided at ten sites from estuarine until river mouth. Because of salinity tolerance of *O. javanicus*, sites were considered salinity gradient and distance from estuarine. Salinity ranges from 21 to 28 ppt. Surface sediment samples from targeted point were collected by using Ponar Grab, stored in a high density polyethylene (HDPE) box and kept cool while in the field. Water were collected by Van Dorn water sampler. One liter of seawater sample was filtered with 0.45 μm celullose nitrate membrane and packed in polyethylene bottle. Acidic destruction and spectrophotometry measurement were used to analyze sediment samples according to USEPA 3050b procedure (USEPA, 1996). HNO_3 (1+1) was added into a gram of dry sediment then the solution was heated for 15 minutes. After the heating, concentrated HNO_3, H_2O_2 30% and concentrated HCl were added by dropper into solution and reheating of solution was

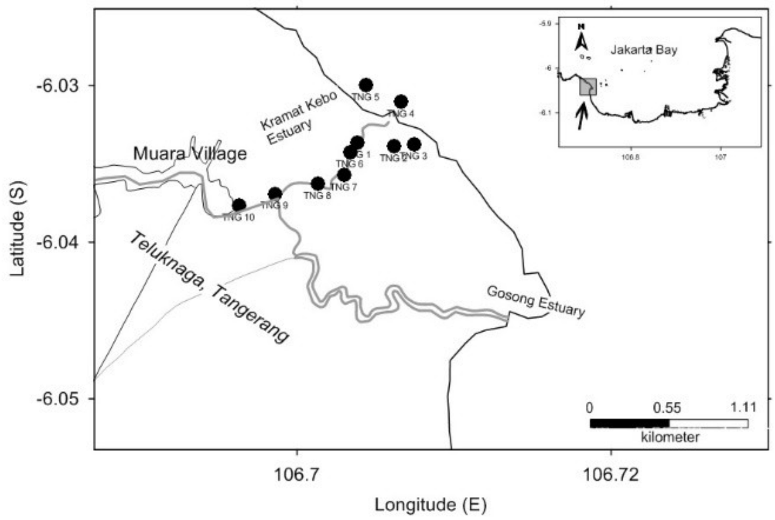

Figure 1. Sampling location in Kramat Kebo estuary, West Java.

performed. Aquadest was added into sample solution to 100 ml in volume. After the destruction processes finished, Cd, Cu, Pb and Zn in sediment were measured using Flame Atomic Absorption Spectrophotometer (FAAS) Varian SpectrAA 20 plus utilizing air-acetylene as ignition gas. All glasswares used in this analysis were prior soaked into HNO_3 (1+1) for 24 hours and were rinsed by destile water.

SQGs are very useful to screen sediment contamination by comparing sediment contaminant concentration with the corresponding quality guideline. The probable effect level (PEL) was used for the SQG-Q index calculation. Caeiro *et al*. (2005) formulated Sediment Quality Guidelines Quetiont (SQG-Q), ecological risk index as

$$SQG-Q = \frac{\sum_{I=1}^{n} PEL-Qi}{n} \qquad ....1)$$

$$PEL-Qi = \frac{contaminant}{PEL} \qquad ....2)$$

where,

PEL-Qi : Probable Effect Level Quetiont for each contaminant

PEL : Probable Effect Level for each contaminant (Table 1)

Contaminant : Concentration of metal in sediment

n : Number of parameter for calculation

In this calculation, PEL values (Table 1) and actual metal concentration in sediment were filled in equation and the value obtained will vary from 0-1. Caeiro et al. (2005) explained the meaning of the value of SQG-Q (Table 2) and the interpretation would give a clearly statement about Kramat Kebo estuary.

RESULTS AND DISCUSSION

Physicochemical parameter recording showed the range of differences between all sampling sites, with water pH between 7.81 and 8.17 and range of water temperature between 31.4°C and 35.2°C (Table 3). Since, water temperature is not key parameter in tropical region where the temperature variability is very low but aquatic organisms require a particular acceptable temperature range to be optimally healthy.

Table 1. The value of Sediment Quality Guidelines (Caeiro *et al*., 2005)

Metal	Cd	Pb	Zn	Cu
PEL (Probable Effect Level) (mg/kg dry weight)	4.21	112	271	108

Table 2. Interpretation of SQG value (Caeiro *et al*., 2005)

SQG-Q value	Designation of sediment quality
SQG-Q ≤ 0,1	Unimpacted: lowest potential for observing adverse biological Effects
0,1 < SQG-Q ≤ 1	Moderate impact potential for observing adverse biological effects
SQG-Q ≥ 1	Highly impacted potential for observing adverse biological effects

There is a relationship between temperature water parameters that include levels of dissolved oxygen, the types of plants and animals present, and the susceptibility of organisms to parasites, pollution and disease. Water temperature is affected by conditions of weather, availability of shade as well as groundwater inflows and waste effluent from urban and industrial sources. *O. javanicus* individuals are found along the river so this fish can tolerance and adapt in 21-28 ppt. All of parameter shows tolerable range for fish so Kramat Kebo estuary still represents a normal condition of aquatic environment. Anthropogenic activities along the river such as housing, fishery activities have not influence the environment.

Metal concentration in water in each station is varied along the river. Pb, Cd, Cu and Zn in water are still below the threshold level from Ministry of Environment (2004) for aquatic organism. Metal concentration in sediment is also varied among station (Figure 2 and 3). Pb and Cu concentrations are still below the average crustal abundance but Zn and Cd indicate anthropogenic input from surrounding environment. It could be from housing, domestic waste, fertilizer or fishing activities like tambak. Rochyatun *et al*. (2005) reported that the increasing metals content in the river mouth was affected by input volume/runoff of river containing metals. Beside that, Rochyatun *et al*. (2006) observed the impact of riverine runoff in the Cisadane river as long as the fluctuation of metals content on bed sediment by flooding phenomenon. Their research discovered that Cd and Zn increased in two fold of concentration after the flooding, however, Pb and Cu showed no differences between pra and post of the flooding. Urban activities contribute in metals input mostly by fuel combustion, paint weathering, metal furniture corrosion and urban waste disposal (Ciutat *et al*., 2007). Aquaculture area contributes in Cu and Zn input into aquatic ecosystem. Cd and Pb are categorized as non-essential element having toxic effect even in low concentration. In contrast, Cu and Zn were essential elements used in metabolism, however exceeding concentration has toxic potential. Williams *et al*. (2000) and Takarina (2010) also highlighted in previous studies that high heavy metal concentrations (mainly Zn, Pb, Cu, Ni) particularly in Jakarta Bay indicate anthropogenic source from land.

Metal concentration in Kramat Kebo estuary is lower than Jakarta Bay, although their locations are

Table 3. Ecological parameters of water in sampling sites of Kramat Kebo estuary

Stations	Salinity	Ammonia	Nitrat	pH	Temp
TNG 1	26	0.15	5.2	7.88	31.4
TNG 2	27	0.15	4.7	7.81	31.7
TNG 3	28	0.09	6.7	7.87	32.5
TNG 4	24	0.05	5.0	8.03	32.7
TNG 5	24	0.06	4.8	8.07	32.3
TNG 6	22	0.15	6.4	7.93	33.1
TNG 7	24	0.06	5.6	7.98	33.0
TNG 8	23	0.09	5.4	7.99	33.6
TNG 9	21	0.07	8.0	8.17	34.4
TNG 10 2	2	0.12	2.8		35.2
Ministry of. Env. (2004)	**until 34**	**0.3**	**8**	**7-8.5**	**28-32**

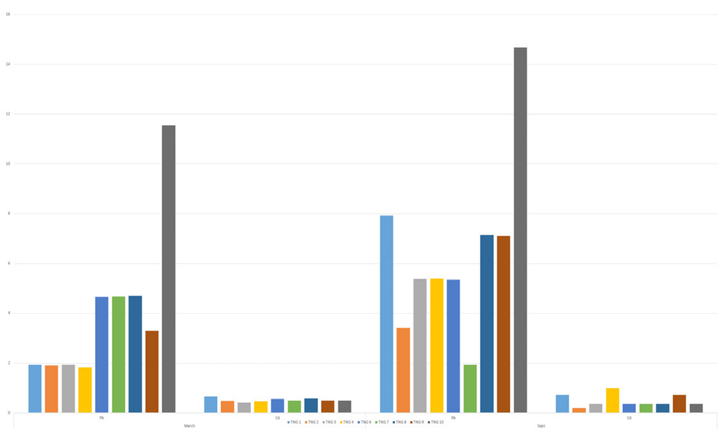

Figure 2. Lead and cadmium concentration in sediment on March and September 2014.

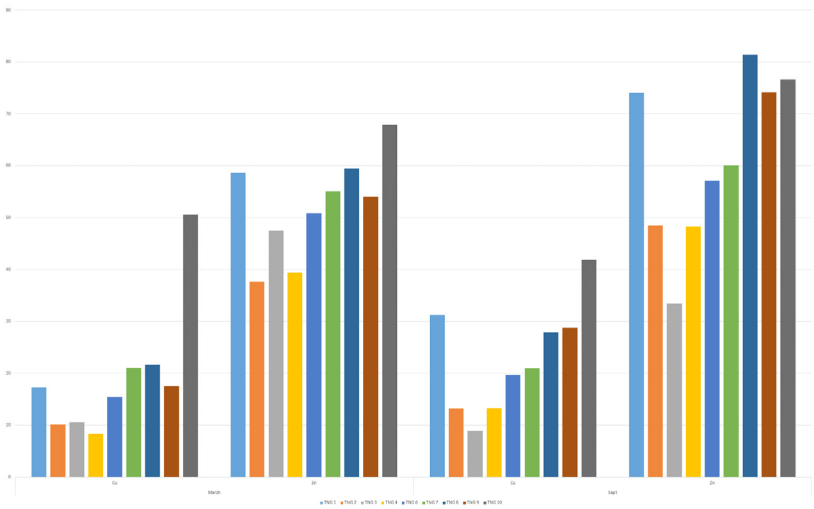

Figure 3. Copper and zinc concentration in sediment on Mach and September 2014.

Table 4. SQG index for each stations

PEL-Qi								SQG-Qi	
Cu		Pb		Cd		Zn			
March	Sept	March	Sept	March	Sept	March	Sept	March	Sept
0.16	0.29	0.02	0.07	0.16	0.17	0.22	0.27	0.14	0.20
0.09	0.12	0.02	0.03	0.11	0.05	0.14	0.18	0.09	0.09
0.10	0.08	0.02	0.05	0.10	0.09	0.18	0.12	0.10	0.09
0.08	0.12	0.02	0.05	0.11	0.24	0.15	0.18	0.09	0.15
0.14	0.18	0.04	0.05	0.14	0.09	0.19	0.21	0.13	0.13
0.19	0.19	0.04	0.02	0.12	0.09	0.20	0.22	0.14	0.13
0.20	0.26	0.04	0.06	0.14	0.09	0.22	0.30	0.15	0.18
0.16	0.27	0.03	0.06	0.12	0.17	0.20	0.27	0.13	0.19
0.47	0.39	0.10	0.13	0.12	0.09	0.25	0.28	0.23	0.22

nearly each other. The fact that in this river, it can be found easily organism like mussels, fish and other. Interpretation of SQG index showed that Kramat Kebo estuary is moderate impact potential for observing adverse biological effects area because 72% show SQG value between 0.1 and 1 (Table 4). In an overall evaluation of indicator criteria performance, SQG-Q evaluates the potential for adverse biological effects more effectively compare than other indices like MSPI (Caeiro *et al*., 2005). This phenomena must be watch out for sustainability organism in this estuary.

Elevated heavy metals concentration due to anthropogenic inputs were shown in Jakarta Bay, Semarang Harbour and Gresik, and relatively unpolluted locations were shown in Arafura Sea,

Table 5. Comparison of total metal concentration in sediments reported in other location

Location	Pb	Cd	Cu	Zn	References
Estuary of Digul and Arafura Sea	3.6-12.4	< 0.1	-	-	Hutagalung & Manik (2002)
Jakarta Bay	5.7-42.9	0.04-0.5	8.6-186.8	51.9-480.5	Arifin *et al*. (2003)
East Kalimantan	4.4-15.2	0.001-0.1	2.02-14.5	15.8-121.2	Rochyatun *et al*. (2003)
Pari Islands,	0.84-6.01	0.03-0.06	13.24-15.93	0.73-17.83	Rochyatun (2003)
Semarang Harbour	10.9-17.3	0.06-0.13	18.3-36.6	0.73-17.83	Lestari (2011)
Gresik	4.29	0.2	85.5	134	Lestari & Budiyanto (2013)
This study (Kramat Kebo estuary)	1.83-11.5	0.41-0.66	8.4-50.5	37.6-67.9	This study (March 2014)
This study (Kramat Kebo estuary)	1.9-15.7	0.19-1.00	8.9-41.9	33.4-81.4	This study (September 2014)

Digul Estuary, Pari Island, and East Kalimantan (Table 5). It is cannot direct compare between Kramat Kebo estuary with other location because data from other location is still focused on total metal concentration, not in SQG index. Beside that, there is no observation about occurrence of *O. javanicus* in previous location.

CONCLUSION

Based on SQG-Q index from metal concentration in sediment, Kramat Kebo estuary is classified into moderate impact potential for observing adverse biological effects. *O. javanicus* proved have a high salinity tolerance and can be found along the river. The existence of *O. javanicus* is related to clean aquatic environment especially for metal and it suitable for a bioindicator of moderate impacted heavy metal.

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