ASSESSMENT OF CADMIUM (Cd) CONTAMINATION IN MUD CRAB (*Scylla* spp.) AND SEDIMENT FROM SEGARA ANAKAN LAGOON, CILACAP, INDONESIA

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ABSTRACT

The study aimes to examine the accumulation level of selected heavy metal Cd in various of common mud crab (*Scylla* spp.) samples from Segara Anakan Lagoon-Cilacap. Mangrove crab and sediment samples were taken from Segara Anakan (108046'–109005'E; 7034'–7048'S) and were analyzed using *Atomic Absorption Spectrophotometer* (AAS). The Cd extent in *Scylla* spp. varied from 0.084 - 0.273 ppm which still below the European Commission (2006) threshold value (0.5 ppm). On the other hand Cd concentration in sediment for most stations value (0.625 - 1.635 ppm) have exceeded the Interim marine sediment quality guidelines (ISQGs value; 0.7 ppm) except for station 2 and 4. Concerning the sediment, to interpret and assess the contamination status four indices were used, namely Contamination Factor (CF), Enrichment Factor (EF), Pollution Load Index (PLI), and Geoaccumulation Index (*Igeo*). The results show the Segara Anakan sediment value for CF varied 3.125 - 8.175, EF was 50.481, PLI was 5.381 and *Igeo* varied 0.319 - 0.736. The finding result shows the Segara Anakan sediment could be considered as moderately polluted.

***Keywords**: cadmium, contamination, scylla, sediment.*

INTRODUCTION

Contamination is a major form of anthropogenic impact in estuarine systems, acting as a stressor which influences the composition and health of ecological communities. Estuaries are generally believed to contain the highest levels of contamination of any marine environment due to their proximity to human settlements and their position directly downstream of agricultural and industrial activities. Many of these complex estuarine habitats provide a nursery function for ecologically and economically important species. It has been demonstrated that contaminants in these systems could have substantial impacts on larval stadia e.g. fish and that they generally reduce the richness and evenness of marine invertebrate communities (McKinley et al., 2011).

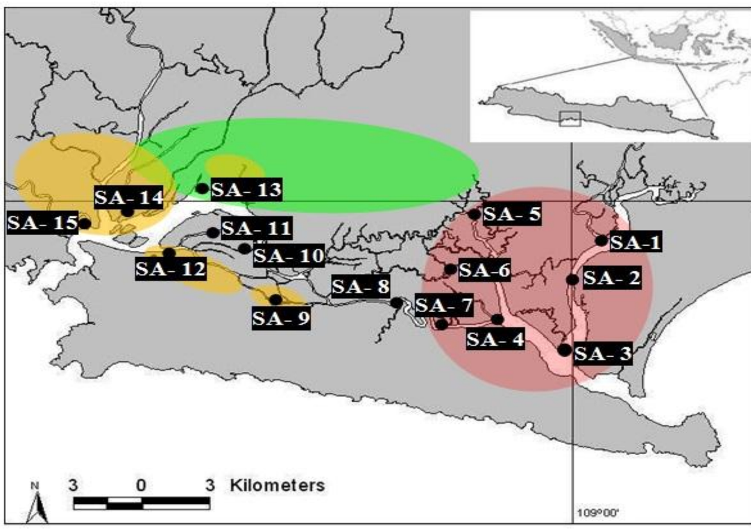
Levels of contaminants in the estuarine environment are increasing as a consequence of anthropogenic activities and resulting diminishing water quality reflects the status of aquatic resources. For this reason, there is an increasing need to develop methods for the identification, estimation, comparative assessment, and management of risk posed by chemical pollutants discharged into the aquatic environment. Therefore, the measuring the biological accumulation of pollutants is essential tools for assessing the quality of the estuarine environment (Vijayavel et al., 2006). With the development of industry and agriculture, numerous heavy metal pollutants have been released into water bodies by various means, resulting in serious water pollution. In polluted waters, exposure of organism to heavy metals leads to interactions between these chemicals and biological systems and causes biochemical disturbances. Mercury (Hg), copper (Cu), cadmium (Cd), and zinc (Zn) are the 4 most common heavy metals (Wang et al., 2013).

Segara Anakan Lagoon is located on the south coast of Java on the border between the provinces of West and Central Java near the port of Cilacap. It is protected from the Indian Ocean by Nusa Kambangan and has two openings to the ocean through the two Plawangan (canal), namely West Plawangan and East Plawangan. Citanduy River, Cimeneng River, and Cibeureum River that empty into the West Plawangan, whereas the various rivers such as Donan River, Sapuregel River, Kembang Kuning River, and Dangal River that empty into the East Plawangan. The rivers that empty into the East Plawangan is an area for transportation and industry in Cilacap, especially in Donan River. Those industries are disposing of waste into the river, potentially harmful to the environment. One kind of pollution that pollute waters indicated in the Segara Anakan Lagoon is Cd, which is probably derived from industrial activities in that area. Moreover, for this reason the lack of proper planning and management leads to a drastic increase in pollutant level in this area.

Mangrove crabs (*Scylla* spp. [also called mud crabs]) are an important component of local economies and mangrove forest food webs throughout the Indo-Pacific. They often exceed 200 mm in carapace width and are commonly harvested as a source of food and income throughout their range (Katherin et al., 2009). Mud crab is one of the important fishery commodities in Southeast Asian countries including in Indonesia especially in Cilacap. Mud crab is a very popular seafood and has a high commercial value. Their feeding behaviour will lead to a higher accumulation of toxic metals in their body which are biomagnified through food chain. Hence, the present research was conducted to examine the accumulation level of selected heavy metal Cd in various of common mud crab (Scylla spp.) sample from Segara Anakan Lagoon-Cilacap.

METHODS

The research method is a combination of field, research, and literature review studies. The sampling technique was used simple random sampling method which selections are drawn from a population in a way that gives every member and every combination of members an equal chance of being selected. (Hadi, 1989). Location of the study sites in the Segara Anakan Lagoon is shown at Fig. 1.



Legend:
Settlements & Industrial Area
Settlements
Agricultural Area

Station	Explanation	Coordinate	
		S	E
SA-1	Port & Industrial Plant Area	07°41'19.3"	109°59'39.2"
SA-2	Industrial Refinery Outlet	07°42'57.0"	108°59'39.7"
SA-3	Sleko Port & Settlements	07°43'39.9"	108°59'35.7"
SA-4	Estuary of Kembangkuning River	07°42'35.6"	108°54'06.1"
SA-5	Estuary of Ujung Alang River	07°42'28.5"	108°52'51.5"
SA-6	Dangal River	07°42'19.8"	108°53'41.0"
SA-7	Kembang Kuning River	07°42'55.9"	108°53'41.0"
SA-8	Nypa Palm Area	07°42'25.7"	108°54'29.8"
SA-9	Ujungalang (Settlements)	07°42'11.6"	108°52'10.5"
SA-10	Klaces I (Mangrove area)	07°40'46.9"	108°50'16.0"
SA-11	Klaces I (Mangrove area)	07°40'42.2"	108°49'43.0"
SA-12	Klaces III (Settlements)	07°40'59.9"	108°49'24.7"
SA-13	Estuary of Cikonde River	07°40'05.90"	108°49'11.50"
SA-14	Karang Anyar (Ujunggagak) (Settlements)	07°40'07.0"	108°48'45.9"
SA-15	Estuary of Citanduy River	07°40'33.1"	108°47'58.8"

Figure 1. Location of the sampling site at Segara Anakan Lagoon, Cilacap (Source: Ardli, 2008).

a) Collection and Preservation of Sediment

Sediment sample was collected from 15 sites from Segara Anakan are shown in Fig. 1. The sample was collected by *Eckman grab* ± 500 g and carried by polythene bag. After collection, in the laboratory some portion of sediment samples was dried in a vacuum oven at 105ºC until constant weight, lightly ground in an agate mortar for homogenization and prepared for analysis of heavy metal of Cd and some portion of samples were prepared for organic concentration test (Total Organic Carbon). (Hutagalung, 1997).

b) Collection and Preservation of Mud Crab (*Scylla* spp.)

Mud crab (*Scylla* spp.) sample was collected from 15 sites from Segara Anakan as shown in Fig. 1. The sample was collected by *wadong* and *pintur*. Every sites 2 - 4 *wadong,* were set when low tide in June 2014. Samples were collected on the next low tide. *Pintur* was set in every site, samples were collected on next hour. A total of 15 crabs was analyzed based on their weight and size according to carapace width (CW) which varied between 150.5 – 208.5 g and 8.5 – 10.6 cm, respectively. Collected crabs were transferred to the laboratory to record Cd concentration.

c) Sample Extraction and Analysis

Samples preparation for *Scylla* spp.

Wash the shell and take a part of *Scylla* to be measured. Puree in the *blender*. Fill a sample to the *porcelain crucible* and weighed as needed (BSNI, 2011).

Samples preparation for Sediment

Stir the sediment samples to be measured. Take a homogeneous sediment and Puree the sediment sample. Fill a sample to the *porcelain crucible* and weighed as needed (BSNI, 2004).

Destruction process

Fill a 25 g refined sample to the *porcelain crucible,* preheat the sample until dried to forming charcoal, fill sample to the *tanur* and insert to the *furnace*. Set temperature at 250^{o}C. Carefully, raise the temperature every 50^{o}C until 300^{o}C. After that, carefully, raise the temperature every 70^{o}C until 500^{o}C. Preheat sample, made until ashes for 16 hours. Turn off the *tanur* and let it cool in desiccator. Add 5 mL HNO_3 5N, and dried using *hot plate*. Add 5 ml HNO_3 5N to dissolve the solvent. Fill a residue in the *flask measurable*. Wash three times with 5 mL distilled water and mix with residue to the *flask measurable*. Dilute by HNO_3 5N until line mark. Filter solvent by Whatman paper No.40 and discard the first 10 mL. The filtrate of the flask measurable is stored for the next analysis (BSNI, 2011).

The qualitative analysis

Fill a 5 mL sample in the test tube, set pH 6,5 by adding NH_4OH 1N, add 5 mL ditizon solution 0,005% b/v. Mix the sample solution, let layers separate and observe. If the Cd is present, a pink colour will appear (BSNI, 2011).

The quantitative analysis

Determination of the linearity calibration curve add 10 mL of a standard solution of Cd (1000 mg/l) to the 100 mL *flask measurable* by inserting the calibrated pipette/syringe. Add 10 mL HNO_3 5N, add distilled water until line mark (100 mg/L concentration) → Mother liquor (BSNI, 2011).

Fill to the 100 mL *flask measurable* 0, 0.3, 0.5, 0.7, 0.9 mg/L solution of Cd and 1.1 mL of Cd standard mother liquor by inserting the calibrated pipette/syringe, add 10 ml HNO_3 5N and add distilled water until line mark (0, 0.3, 0.5, 0.7, 0.9, 1.1 mg/L each concentration), measuring at a wavelength of 228.8 nm (BSNI, 2011).

Cadmium Analysis by AAS

Fill a 20 mL sample solution of *Scylla* spp. to the nebulyzer sucked by aspirator hose to the atomization and evaporation process. Irradiated sample by cathode at wavelength 228.8 nm and a strong current 10 mA. The results will be captured by the light absorbance detector and will appear on the screen accompanied by the line equation (Hutagalung, 1997).

Calculation of Cd metal concentration in the sample using the formula:

$$\text{Cd Concentration} = \frac{A \times B}{C} \text{ mg/L}$$

Explantation :

A = mg/L readings
B = final volume of extraction (50 mL)
C = initial weigh of sample

d) Assessment of Sediment Contamination

Contamination Factor (CF)

The CF is the ratio obtained by dividing the concentration of each metal in the sediment by the baseline or background value (Hakanson, 1980 *in* Syakti et al., 2014 *in under review*).

$$\text{CF} = \frac{[\text{heavy metal}]}{[\text{background}]}$$

As sugested, the CF values were classified into four groups: CF < 1 indicate low contamination; 1 < CF < 3 is moderate contamination; 3 < CF < 6 is considerable contamination; and CF > 6 is very high contamination.

Pollution Load Index (PLI)

For entire sampling site, PLI has been determined as the nth root of the product of the n CFs:

$$\text{PLI} = (\text{CF1} \times \text{CF2} \times \text{CF3} \times ... \times \text{CFn})^{1/n}$$

This empirical index provides a simple comparative means for assessing the metal contamination status. When PLI > 1, pollution exists, if PLI < 1, there is no metal pollution (Thomlison et al., 1980 *in* Syakti et al., 2014 *in under review*).

Enrichment Factor (EF)

Enrichment factor (EF) is a useful tool for determining the degree of anthropogenic heavy metal pollution (Hakanson, 1980 *in* Syakti et al., 2014 *in under review*). The EF is computed using the relationship below:

$$\mathrm{EF} = \frac{[\text{heavy metal/Fe}]}{[\text{heavy metal/Fe background}]}$$

In this study, iron (Fe) was used as the reference element for geochemical normalisation for the following reason; (i) Fe is associated with fine solid surface; (ii) the geochemistry of iron is similar to that of many trace metals; and (iii) the natural concentration of iron tends to be uniform (Hakanson, 1980 *in* Syakti et al., 2014 *in under review*). Therefore, Fe acts as a normaliser to correct for differences in sediment gain size and mineralogy. EF value were interpreted as suggested by Sakan et al. (2009), where EF < 1 indicates no enrichment; 1 – 3 is minor enrichment; 3 – 5 is moderate enrichment; 5 – 10 is moderately serve enrichment; 10 – 25 is serve enrichment; 25 – 50 is very serve enrichment; and > 50 is extremely serve enrichment.

Geoaccumulation Index (*Igeo*) The geoaccumulation index (*Igeo*) is defined by the following equation:

$$Igeo = \log 2 \frac{[\text{heavy metal}]}{1.5 * [\text{background}]}$$

A factor of 1.5 is the background matrix correction factor due to lithospheric effect. The geoaccumulation index consist of seven classes (Muller, 1981 *in* Syakti et al., 2014 *in under review*). Class (practically unpolluted): *Igeo* ≤ 0; Class 1 (unpolluted to moderately polluted): 0 < *Igeo* < 1; Class 2 (moderately polluted): 1 < *Igeo* < 2; Class 3 (moderately to heavily polluted): 2 < *Igeo* < 3; Class 4 (heavily polluted): 3 < *Igeo* < 4; Class 5 (heavily to extremely polluted): 4 < *Igeo* < 5; Class 6 (extremely polluted): 5 > *Igeo* (Muler, 1979; Bhuiyan et al., 2010 *in* Syakti et al., 2014 *in under review*).

e) Study Site

This research was implemented on June 2014. The mud crab (*Scylla* spp.), sediment, and water samples were collected from Segara Anakan, located in the South-Western part of Central Java (108046’–109005’E; 7034’–7048’S). Water quality was measured by *in-situ* (pH, temperature, salinity, and DO) and *ex-situ* (TOC, COD, and TSS) in Wahana Laboratory, Semarang. The Cd concentration in crab and sediment were measured in Wahana Laboratory, Semarang.

f) Data Analysis

Data Cd concentration in *Scylla* spp. and sediment will be discussed by:

1. Data Cd concentrations in *Scylla* spp. and sediment will be discussed by descriptive with charts to explain the Cd concentration and compared by quality of Cd standard in crab with the European Commission and Interim marine sediment quality guidelines (ISQGs) for sediment (Table 1).

2. Cadmium contamination in the sediment will be assessed by; Contamination Factor (CF), Enrichment Factor (EF), Pollution Load Index (PLI), and Geoaccumulation Index (I_{geo}) to determine the contamination status of sediment in the present study.

Table 1. Environmental Quality Standards of Heavy Metal Cadmium (Cd)

Parameter	Type of Sample	Unit	Quality Standards of Cadmium (Cd)				
Cd Concentration	Water	Ppm	Water for protection of aquatic life (Marine water) (CCME, 2006)				*WHO 2011 Guideline Value
			0.12				0.003
	**Sediment	Ppm	ISQGs		PEL		(CCME, 1999)
			0.7		4.2		
	Organism/ Crab	Ppm	**** LD_{50} ♂	♀	***** LC_{50} 96 h	EC, 2006 (wet weigh)	***CAC (wet weigh), Fish and Fishery
			40	60	58.93	0.5€	1.00

* *Source: WHO, Drinking Water Quality for the Period of October 2012 - September 2013.*

*** Source: Interim marine sediment quality guidelines (ISQGs) and Probable effect levels (PELs).*
**** CAC-Codex Alimentarius Commission, FDA- Food and Drug Administration, USA, NHMRC- National Health Medical Council, TPHR- Tasmania Public Health Regulation*
***** Rani et al., 2013.*
****** Sowdeswari et al., 2012.*
€ = *Crustaceans: muscle meat from appendages and abdomen (cephalothorax of crustaceans). In case of crabs and crab-like crustaceans (Brachyura and Anomura) muscle meat from appendages.*

RESULTS AND DISCUSSIONS

Cadmium Concentration

Cadmium concentrations for each sampling site found in Scylla spp. and sediments in this study are shown in Fig. 2 (a). A total of 15 crabs and sediment samples was used in this study, respectively. Segara Anakan Lagoon is an estuary water with mangrove ecosystem. Scylla spp. is one of fishery resources lives in coastal area and in particular in the mangrove area. Scylla spp. depend directly on mangrove areas for survival, by feeding on leaves and litter. The feeding habit of Scylla spp. obviously it could be related to Cd uptake (Shelley and Lovateli, 2011).

Benthic biota *e.g. Scylla* spp. are exposed to pollutants accumulated within the sediments and may transfer potentially toxic concentrations through the food web to organisms in higher trophic levels. Aquatic toxicity testing has determined that many animal species are detrimentally affected at very low concentrations of heavy metals and synthetic organics. Indirect and direct exposure to contaminated sediments may have chronic or acute effects on many species (EPA, 1998).

Cd concentration in *Scylla* spp. in present study was found less than 0.5 ppm (EC, 2006) which varied between 0.084 - 0.273 ppm, could be included category not yet contaminated. Meanwhile, the toxicity study of *Scylla olivacea* revealed that LD_{50} values of male and female by *S. olivacea* were 40 and 60 ppm of crab for 6 days (Rani et al., 2013) and Lc_{50} 96 h 58.93 ppm (Sowdeswari et al., 2012). *Scylla* spp. are able to survive in polluted environments of Cd concentrations because the processes of detoxification must have been developed. Aquatic organisms could take up or accumulate trace metals in their tissues, via the surrounding aquatic environments or diet, based on different metal accumulation patterns. Such low concentrations are due to Cd sequestration may just by feeding behavior of invertebrate organisms (Rani et al., 2013) included Cd concentration of *Scylla* spp. from Segara Anakan, in this case.

In the sedimentary environment, accumulation of Cd is largely dependent on soluble Cd present in pore waters and may also depend upon the chemical forms of solid phases of Cd, since the preponderance of available both organic and inorganic, has a major influence on Cd availability. The Cd is toxic at very low exposure levels and has acute and chronic effects on health and the environment. The Cd is not degradable in nature and will thus, once released to the environment, stay in circulation. New releases added to the already existing deposits of Cd in the environment. They are therefore also more mobile in *e.g.* sediment, generally more bioavailable and tend to accumulate (NCM, 2003).

Determination of problematic levels of sediment contamination has been slowed due to the complex nature of the interactions between particulate matter, contaminant, and biota. The contamination of river and estuarine bottom sediments with adsorbed Cd presents a complex long-term environmental quality and habitat degradation problem. In addition to being pollutant sinks, the sediments become sources of contamination when environmental disturbance, anthropogenic disturbance, or biological activity remobilizes the pollutants (Elder, 1989). Sediments, therefore, act as an important route of exposure for aquatic organisms. Canadian interim sediment quality guidelines (ISQGs) and probable effect levels (PELs) for Cd could be used to evaluate the degree to which adverse biological effects are likely to occur as a result of exposure to Cd in sediments. Cd in aquatic ecosystems tends to accumulate in sediments, acting as a source for benthic biota and possibly for reentering the water column.

In the present study, Cd concentration more than ISQGs standard value are found in all stations except in station SA-2 and SA-4 which concentration 0.625 ppm and 0.685 ppm, respectively. According to ISQGs Segara Anakan Lagoon was contaminated by Cd except in station SA-2 and SA-4.

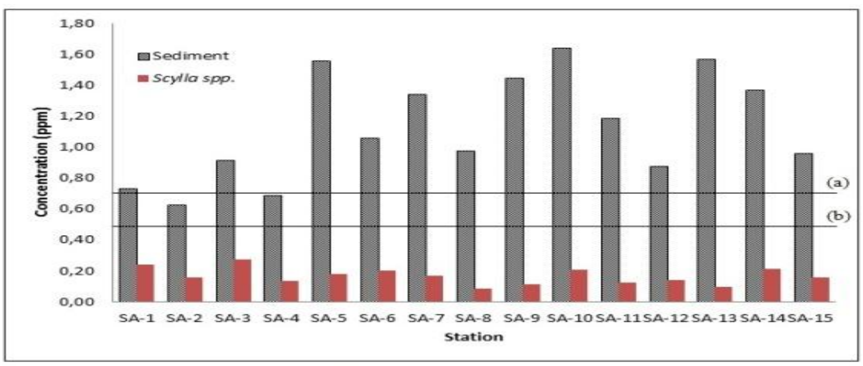
Anthropogenic activities *e.g.* agricultural, could increase Cd uptake in an estuarine ecosystem it is because, rivers and estuaries with agricultural catchments are susceptible to receive substantial quantities of Cd (Monbet, 2004). The farmer usually uses three main macronutrients in agricultural activities namely: nitrogen (N), phosphorus/phosphate (P), and potassium (K) to supply one or more plant nutrients essential to the growth of plants. Phosphate fertilizer is the primary source of Cd accumulation of agricultural runoff. This increase comes primarily from Cd that is present in phosphate fertilizers applied to soils to maintain production (MAF, 2011). Moreover, according to Vijayavel et al. (2006) contaminants of Cd in the estuarine environment are increasing as a consequence of anthropogenic activities such as agricultural activities.

Contamination Factor (CF)

Assessment of Cadmium Contamination Status

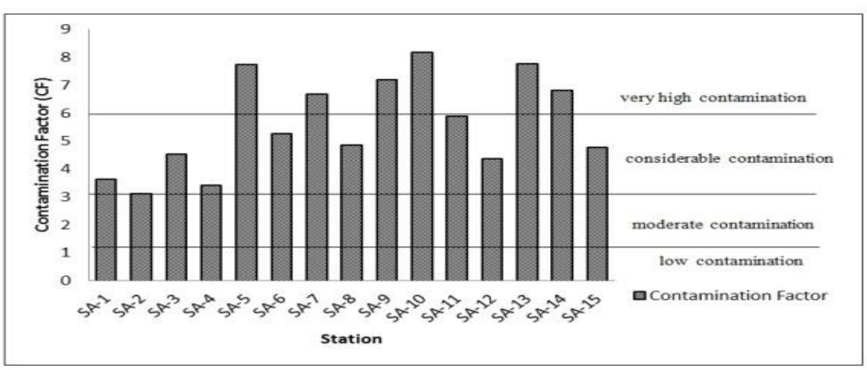
To interpret and assess the contamination status for heavy metals in sediments, four metal assessment indices were discussed using Contamination Factor (CF), Enrichment Factor (EF), Pollution Load Index (PLI) and Geoaccumulation Index (*Igeo*) (Ra et al., 2013).

The contamination factor (CF) is used to determine the contamination status of sediment in the present study. CF values for describing the contamination level are shown in Fig. 2 (b). Contamination factor > 6 (indicate very high contamination) are found in station SA-5; SA-7; SA-9; SA-10; SA-13; and SA-14. Other stations included in the category considerable contamination, that all the station has a CF>3.

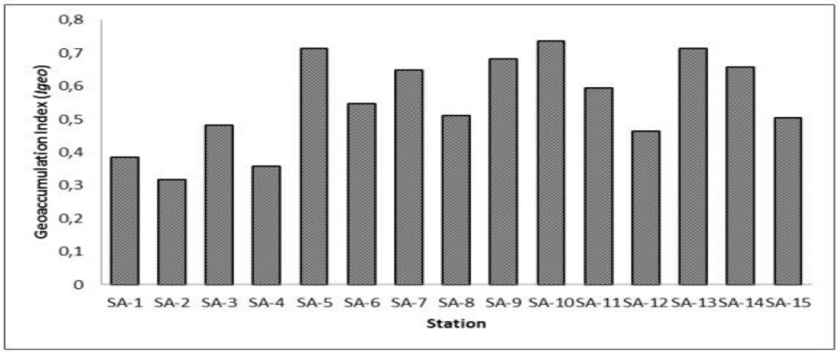


Note: (a) ISQGs standard value (0.7 ppm) for sediment; (b) European Commission standard value (0.5 ppm) for *Scylla* spp..

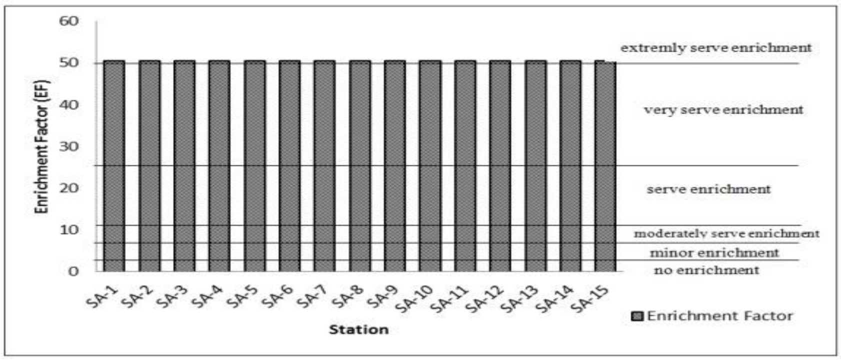
a)



(b)



(c)



(d)

Figure 2. a) Cadmium concentration in *Scylla* spp. and sediment; b) Contamination Factor (CF); c) Enrichment Factor (EF); and d) Geoaccumulation Index (I*geo*).

The station with contamination of Cd levels, are close to the agricultural areas. Those areas, in addition to direct inputs of Cd, phosphate fertilization could indirectly affect Cd accumulation in crops through its effects on soil chemistry then becomes runoff from agricultural drainage water to the water body. Therefore, the management of phosphate fertilizer application, both in the short and long term, could influence the potential accumulation of Cd (Grant, 2011). Accordingly, the contamination status of Cd in sediment based the calculated results of CF values, included category considerable contamination to very high contamination.

Enrichment Factor (EF)

Environmental pollution by heavy metals is due to the many activities whereas in the soil system, pollution by heavy metals is mainly due to both natural processes such as weathering of minerals and anthropogenic activities related to industry, agriculture, burning of fossil fuels, vehicular emission, mining and metallurgical processes and their waste disposal. In the study of environmental contamination, a common approach to estimate how much the soil is impacted (naturally or anthropogenically) with heavy metal is to evaluate the Enrichment Factor (EF) for metal concentrations above uncontaminated background or reference levels (Likuku et al., 2013). The results of the calculation of the EF values were 50.481 in this study (Fig. 2 (c)) shows the enrichment of Cd has occurred very serve enrichment to almost extremely serve enrichment at all locations in the Segara Anakan Lagoon.

EF value calculation results are not accordance with the high concentration of Cd in the study. This phenomenon indicates the source of Cd in Segara Anakan Lagoon derived from anthropogenic sources more than natural sources. The Cd exposures in areas of the Segara Anakan Lagoon are most likely related to human activities, such as industrial, runoff agriculture, and atmospheric deposition which is a compiler of anthropogenic sediment that found in those locations although a direct link could not be established by the available data. According to Sutherland (2000) in keeping with the higher the value of EF so that the contribution of anthropogenic sources also increased. The overall enrichment of sediments at the site, based on the EF values indicate that sediments were indicate very serve enrichment.

Pollution load index (PLI)

The applications of all these indexes (CF and EF) at present could not provide information on the effects of the combination of pollutants on the estuarine biota. Yet, it could provide the public some understanding about the quality of the estuarine sediment. Tomlinson *et al*., (1980) elaborated that the application of PLI provides a simple way in assessing estuarine sediment quality. It is vital that all the necessary variables for the construction of PLI would be readily available. This is to analyse all variables together which will raise the index value and provide valuable information and advice in the policy and decision makers on the estuarine quality (Praveena et al., 2007).

Pollution index is a powerful tool for processing, analyzing, and conveying raw environmental infomation to decision makers, managers, technicians, and the public (Qingjie et al., 2008). The pollution load index (PLI) was also evaluated to assess the mutual contamination effects of the measured of Cd in this study. The PLI, which basically is a measure of site quality, indicated deterioration due to metal contamination. A PLI < 1 denote perfection; PLI = 1 present that only baseline levels of pollutants are present and PLI > 1 would indicate deterioration of site quality (Likuku et al., 2013). The PLI was 5.381, indicating that the sediments were contaminated with measured metals in this study.

Geoaccumulation Index (I_{geo})

The geoaccumulation index is a quantitative measure of the degree of pollution in aquatic sediments. It consists of seven grades ranging from unpolluted to very extremely polluted (Rabee et al., 2011). Geoaccumulation index (I_{geo}) has been calculated and relative contamination level assessed in the study area. The enrichment of Cd in the study area has been observed to be relatively high. According to the *Muller* scale, the calculated results of I_{geo} (Fig. 2 (d)) indicate, for Cd sediment quality be considered as class 1 (unpolluted to moderately polluted): $0 < I_{geo} < 1$ for all stations. I_{geo} results reveal that the study area is not contaminated with respect to Cd; unpolluted to moderately polluted which value 0.319 until 0.736.

CONCLUSION AND SUGGESTIONS

Conclusion

The conclusion of this study based data on the study present, compare with the reference, and assessment of sediment contamination, are:

1. Cadmium concentration in *Scylla* spp. was which varied between 0.084 - 0.273 ppm, could be included category not yet contaminated. Cd concentration in sediment was found which varied between 0.625 - 1.635 ppm.
2. Contamination status of Cd in *Scylla* spp. could be included category not yet contaminated, its because Cd concentration in *Scylla* spp. < 0.5 ppm (EC, 2006) low concentrations are due to Cd sequestration may just by feeding behavior of *Scylla* spp.. Whereas, according to ISQGs, sediment in the Segara Anakan was contaminated by Cd which values > 0.7 ppm, except in station 2 and 4 which concentration 0.625 ppm and 0.685 ppm, respectively. From Contamination Factor values which varied 3.125 - 8.175, Segara Anakan could be included category considerable contamination to very high contamination. Consequently, the Pollution Load Index was 5.381 indicating that the sediments were contaminated. The overall enrichment of sediments at the site, based on the Enrichment Factor was 50.481 those sediments in the Segara Anakan were indicate very serve enrichment. Meanwhile, I_{geo} results reveal that the study area included the category unpolluted to moderately polluted which value 0.319 until 0.736. Estuaries with agricultural catchments are susceptible to receive substantial quantities of Cd and could increase Cd uptake in estuarine ecosystems.

Suggestion

Mud crabs are typically caught using *pintur, bubu/wadong*, with the latter being the most popular device in Segara Anakan, Cilacap. The correct bait is essential if you want to get good results. Mud Crabs are caught in *pintur* mesh or *wadong* baited with meat or fish, where to place your *Crab Traps* are abundant in a wide range of aquatic habitats, ranging from the upper reaches of estuaries to coastal mud flats and trenches. Most estuarine areas fringed with mangroves and/or mud flats will contain mud crabs. Use *pintur* than *bubu* to get Mud Crab faster. It's because *pintur* could set in the river when low or high tide, we can check it every hour. Whereas, for a *wadong* we must set in mangrove areas when low tide and wait for several times of low tide passes the high tide until low tide again. Accordingly then the wadong could be checked.

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