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Heavy metals concentration in water and sediment at Panjang Island, Serang Regency, Banten Province, Indonesia

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Abstract. Coastal waters at Panjang Island are used as berthing area for many ships. Industries that exist in coastal of Serang and Cilegon have bad impact on water quality, especially in Banten bay. Heavy metals from industries and ships scrap are important threats in fisheries activity, because they will accumulate in water and sediment. This research was conducted to determine heavy metals (Hg, Pb, Cu, Cd) content levels in water and sediment at Panjang Island. Sampling activities have been conducted on October 2013 and they have been analyzed by APHA method. Pb, Cd and Cu are over the standard of quality for marine organism, and Hg is still below of standard. In sediment, Cd and Cu are still lower than Jakarta and Banten Bay. Highly levels of heavy metals in water and sediment at Panjang Island indicate that the wastes from industries and ships have an influence to water quality and in long term they may have a negative impact on fisheries production in Panjang Island.
Key Words: fishery, heavy metals, industries, Panjang Island.

Introduction. Panjang Island is located in Banten Bay and it is about 820 ha wide. It has a strategic position, because it is near to Archipelagic Fishing Port (AFP) of Karangantu and Commercial Port of Bojonegara. The intense traffic of ships in Banten Bay has a negative influence to coastal area in Panjang Island. Moreover, many industries that are located in coastal area of Serang City and Cilegon Regency also give threats to water quality and sustainability of fisheries resources along the bay.

Lead, as a heavy metal, is a major toxic pollutant, which commonly interferes with the beneficial usage of wastewater for irrigation and industrial applications. Contamination of sea water by heavy metals is becoming a major problem for aquatic life and human health (Bozkurt 2014). Water area of Karangantu AFP has stained by Pb; its content increased to the west side. Heavy metals concentration which are contained in the water, can be poisonous to organism and they may lead to a decrease in productivity of marine fisheries, marine culture, and biodiversity.

Seaweed culture has become the main livelihood in Panjang Island from 1990 to 2009. Nevertheless, sand mining that developed in 2008 caused a decrease of its productivity and quality. Moreover, declining in water quality and pollution that had caused industrial and ship waste give fearful to sustainability of seaweed culture. The seaweed farmers were griped because their revenue from culture activity was declining. This condition gave effect to the continuity and quality of seaweed in Panjang Island.

Heavy metals become dangerous pollutants because they cannot be degraded and hence they accumulate in the environment, having the potential to contaminate the food chain (Paz-Ferreiro et al 2014) and tend to be contaminants to living organisms as well (Silambarasan et al 2012; Asante et al 2014). Organic and nonorganic materials can react with the heavy metals, forming complex chemical compounds. The highly heavy metals concentration in a certain water area can lead to metals accumulation in body tissues of both wild and cultured organisms. This research aims to explore heavy metals

concentration in coastal area of Panjang Island. The results of this study may become basic information to further seaweed culture evaluation and its development in the area.

Material and Method. This research has been conducted at Panjang Island coastal water in October 2013. The sampling stations consist of five locations that were selected by purposive method based on existing and potential location for seaweed culture area (Figure 1). The water samples for metal analyses were transferred to high-quality plastic (polyethylene) bottles that were pre-washed and spilled with 30% nitric acid as a preservation purpose (Silambarasan et al 2012). The bottles were kept in a cool (4°C) and dark place.

The surface sediment samples were collected from the five stations with grab sampler. They were kept in a refrigerator (~2°C) immediately after collection, before drying and grinding. The sediment samples were dried in an oven at 105°C to constant weight. The sediment material was then grinded and 2.5 g samples were dissolved in 25 cm^3 of 1/1 HNO_3. For investigation of the heavy metals concentration in seawaters, atomic absorption spectrometry (AAS) was used. Lead (Pb), copper (Cu), cadmium (Cd), and mercury (Hg) were analyzed in the sediment by a flameless AAS method, following hot HNO_3 decomposition, according to APHA (2012). Based on Indonesian regulation in Environment Minister's Decision No. 51/2004 about the quality standard of seawater for marine organism, the limits of heavy metals concentration in seawater are: Hg <1 µg L^{-1}; Cd < 0.001 mg L^{-1}; Cu and Pb < 0.008 mg L^{-1}.

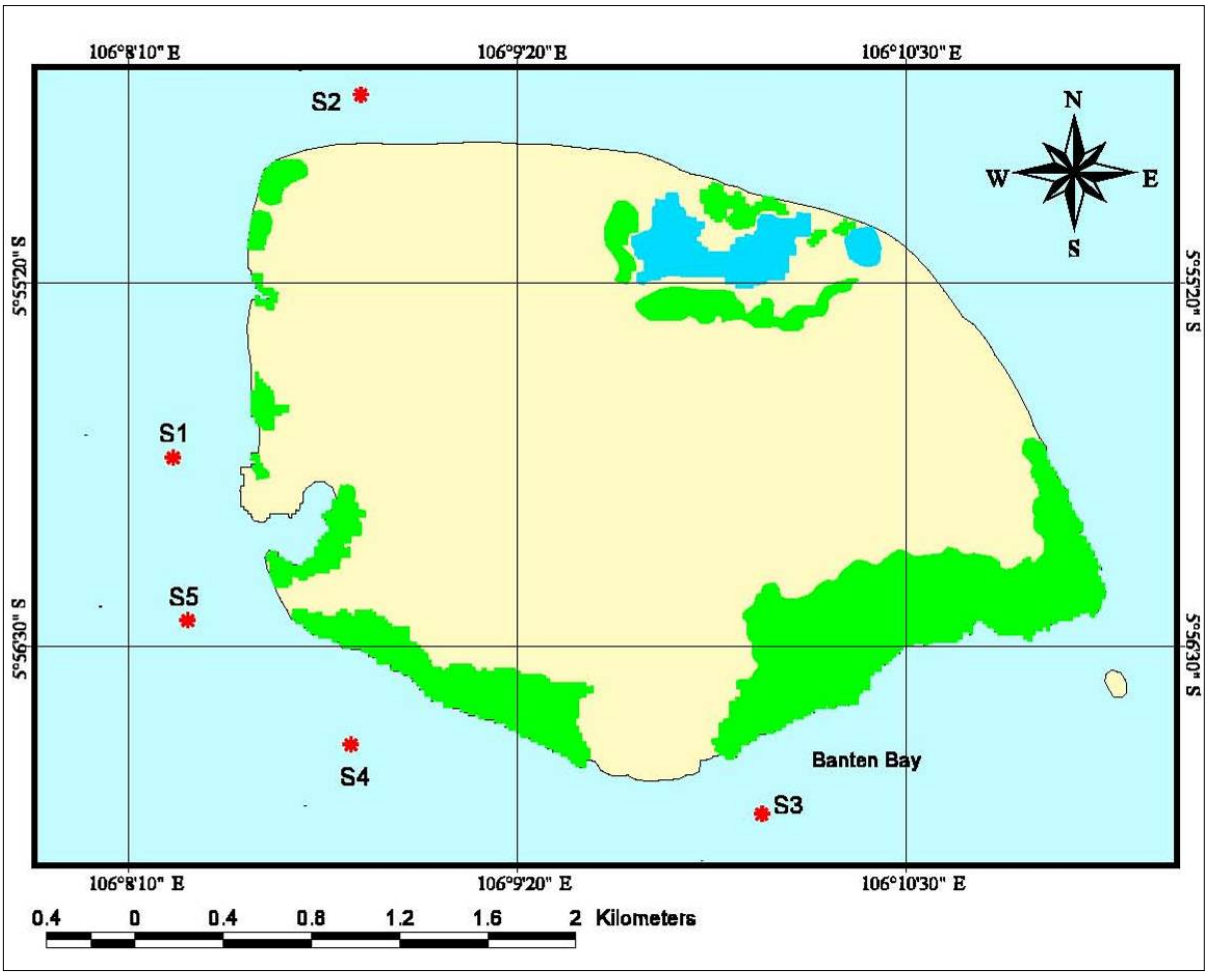

Figure 1. Station map of seawater and sediment sampling (original).

Results. The Hg concentration of the surface waters varied between 0.090 and 0.222 mg L^{-1}; the values show significant difference between station 1 and 5. The highest value of Hg was found at station 5, which is close to berthing ship area. Cd and Cu contents varied between 0.017 to 0.018 mg L^{-1} and 0.013 to 0.015 mg L^{-1} respectively. There are

no significant differences between stations. Pb content varied between 0.057 and 0.074 mg L^{-1}, the highest value being found at station 1. The high level of Pb content is associated with shipyard activities located at the west side of Panjang Island (Table 1).

Table 1

Heavy metals concentration in waters of Panjang Island

Heavy metals	*Unit*	*Station*					*Mean ± SD*	*Limits**
		1	*2*	*3*	*4*	*5*		
Mercury	mg L^{-1}	0.090	0.099	0.135	0.180	0.222	0.1590 ± 0.0535	1.000
Cadmium	mg L^{-1}	0.017	0.018	0.017	0.017	0.017	0.0170 ± 0.0004	0.001
Copper	mg L^{-1}	0.015	0.013	0.015	0.014	0.014	0.0140 ± 0.0008	0.008
Lead	mg L^{-1}	0.074	0.070	0.066	0.064	0.057	0.0660 ± 0.0064	0.008

Annotation: *Limits of seawater for marine organism (Indonesian Regulation in Environment Minister's Decision No. 51/2004).

Hg concentration in the waters of Panjang Island is still below of the Indonesian standard, but Cd, Cu, and Pb are higher than it. Cd and Cu in each from the 5 stations have no significant differences between them. The first and third stations have highest levels of Cu. In each station, Cd has the highest values after Pb.

The heavy metals in sediment also have high values. Cu has the highest concentration - 24.58 mg kg^{-1} at a first station. Hg has the highest concentration at the second station, with a level of 2.74 mg kg^{-1}. At the same station there is the highest level of Pb - 20.75 mg kg^{-1} (Table 2). Whereas Indonesian government does not have standards for heavy metals contents in sediment, these results can indicate that the coastal area at Panjang Island needs serious attention to manage the wastewater quality from the industries.

Table 2

Heavy metals concentration in sediment of Panjang Island

Parameters	*Unit*	*Station*					*Mean ± SD*
		1	*2*	*3*	*4*	*5*	
Mercury	mg kg^{-1}	2.623	2.735	2.416	2.188	1.001	2.193 ± 6.980
Cadmium	mg kg^{-1}	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100	-
Copper	mg kg^{-1}	24.580	23.340	22.370	23.480	20.300	22.814 ± 1.609
Lead	mg kg^{-1}	15.340	20.750	0.400	< 0.200	11.430	11.980 ± 8.614

Discussions. Heavy metals in water and sediment are generally not harmful to organisms at normal concentrations. They are essential for metabolism, the organisms need them to grow and for chemical process, but they can become dangerous when they are above a critical threshold. They enter natural waters and become part of the water sediment system; their distribution processes are controlled by a dynamic set of physical and chemical interactions (Vuković et al 2012). High levels of metals may have detrimental effects on the marine organisms and may create problems in relation to their suitability as food for humans (Bazzi 2014). The enrichment of trace elements in the water indicates their impact as potentially hazardous to the environment and human health (Vuković et al 2012). However, the increasing levels of heavy metals for a long time can cause fish mortality and genetic mutations in aquatic organisms.

The most numerous sources of heavy metals pollution are industrial activities which discard their waste to the sea without sewage treatment. The progress of industries has led to increased emission of pollutants into ecosystems, as well as shipping and fishing can increase Pb concentration in coastal areas (Bazzi 2014). The highest Pb level was found in the western of Panjang Island (station 1). This area has near distance from coastal of Bojonegara, which has many industries so that it has high chances to be polluted. The chemicals, refined sugar, and shipyard are the main industries activity that are close to Panjang Island. The high content of Pb along the coastal of Dabijiashan Hill because of the moorings of the ships (Wang et al 2012).

The levels of Pb, Cd, and Cu in the water in all stations were higher than the Indonesian standard limits. Pb value reaches 1700% above the limits. Cu and Cd levels were also above the limits with percentages between 63-88% and 713-925% respectively. The amount of Pb concentration in water at 0.1-0.2 ppm will envenom to several fish, because according to Daniszewski (2013) the permissible limit of Pb is 0.1 ppm. Acute toxicity of Pb in invertebrates is reported at concentration of 0.1-10 ppm and in aquatic plants at concentration of 0.1-5.0 ppm.

The heavy metals which are dissolved in seawater and then are absorbed in the sediment become suspended matter in Panjang Island. The limit for Pb content at sediment is 47.82-161.06 ppm (USEPA 2004). Although Pb value is below from the limits, coastal management at the island must concern about the heavy metals effect to water quality and biodiversity. The accumulation of heavy metals is predominant in sediments rather than in seawater. This can be interpreted as sediments act as reservoir for all the contaminants and dead organic matter descending from the ecosystem above (Bazzi 2014). Sources of imbalance heavy metals in seawater are oftenly some anthropogenic activities like mining, ultimate disposal of treated and untreated waste effluents containing toxic metals, as well as metal chelates from industries, which may pollute the seawaters (Silambarasan et al 2012). Major anthropogenic source of heavy metals are reclamation and dredging, sewage discharge, industrial effluents, desalination plants and oil pollution (Naser 2013).

Conlusions. The heavy metals Pb, Cu and Cd levels at Panjang Island water are higher than the limit, except Hg. The highest concentration of Hg has been found at station 5, and of Pb at station 1. Industrial activity, shipyard and ship activity in Banten Bay has a negative impact to water quality, because heavy metals from water and sediment can be poisonous to organism and can lead to a decrease in the productivity in marine fisheries, marine culture, and also in biodiversity. Dissolved heavy metals in water are also accumulating to sediment.

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