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Cadmium, lead and zinc contamination on the oyster *Crassostrea gigas* muscle harvested from the estuary of Lamnyong River, Banda Aceh City, Indonesia

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Abstract. The aim of the present study was to examine the heavy metals lead (Pb), cadmium (Cd), and zinc (Zn) in the oysters (*Crassoscrea* sp.*)* muscle harvested from the estuary of Lamnyong River, Banda Aceh City, Indonesia. The samplings were conducted two times (in May 2013 and March 2014) at four sampling locations. The samples were analyzed for Atomic Absorption Spectrometry (AAS). The study revealed that Pb, Cd and Zn were detected in the oysters. The concentration of Zn increased from 3.778 ppm to 11.567 ppm on May 2013 and March 2014, respectively; the concentration of Pb was undetected to 0.017 ppm on May 2013 and March 2014, respectively; while the concentration of Cd was decreased from 0.152 ppm to 0.015 ppm in the same period. The concentration of Pb was highest in station IV (0.029 ppm), Cd in station I (0.093 ppm), and Zn in stations II and III (8.069 ppm and 8.030, respectively). It was concluded that the concentrations of lead, cadmium and zinc have exceeded the maximum limit for aquatic organism and therefore the oysters from this estuary area were not safe to be consumed.
Key Words: heavy metals, mollusk, domestic disposal, water quality, fertilizer, pesticide.

Introduction. Lamnyong river is situated in the sub district of Syiah Kuala, Banda Aceh, Indonesia. This river has an important role for the local people by providing water resources for domestic needs and livelihoods. Field observations indicate that there is a variety of anthropogenic activities along the river of Lamnyong, for example agriculture, fishing port, traditional market and workshops. These anthropogenic activities are alleged to produce waste that can contaminate and give a negative impact on the aquatic organisms especially on the mollusks settling at the bottom of the river. One of the possible pollutants produced from anthropogenic activities is heavy metals. Heavy metals accumulate in aquatic organisms, especially in a filter feeders organism like oysters and then contaminate humans through the food chain (Amriani et al 2011).

Oysters (*Crassostrea gigas*) are one of the groups of mollusk which have high economic values. These aquatic animals live by attaching themselves to mangrove roots, rocks, dock poles and other objects in waters. Oysters are very susceptible to be contaminated by heavy metals due to their filter feeder habits (Bouilly et al 2006). Accordingly, this study examined three types of heavy metals, namely: lead (Pb), cadmium (Cd) and zinc (Zn) in oysters (*C. gigas*) harvested from the estuary of Lamnyong river. It was presumed that these heavy metals have a higher potential for polluting the Lamnyong river due to the agricultural activities, fisheries and workshops located along the watershed.

Lead and cadmium are non-essential metals; these heavy metals are toxic for human even at low concentration, while zinc is an essential heavy metal needed by living organisms at low concentration, thus is known toxic at high level concentration for animals and humans as well (Darmono 1999). Lead causes anemia, impaired renal function, nervous system, and brain and skin disorders (Palar 2008). Furthermore, cadmium is risky for blood vessel pressure. When cadmium enters the body, it is then most likely to accumulate in the kidneys, liver and partially released through the digestive tract (Mifbakhuddin et al 2010), while zinc will cause health problems, particularly diarrhea at a particular level (Effendi 2003).

Studies on the heavy metal contaminations on the aquatic organisms in Aceh Province, Indonesia, are very crucial because of its rapid growth of population and industries that threaten the environment. However, unfortunately, very limited information on heavy metal contamination of the aquatic organisms is available, except a study by Sarong et al (2013) on cadmium contamination on fish at Keureto river. To date, no study has been conducted on the heavy metal contaminations especially of lead, cadmium and zinc on the oyster tissue harvested from the estuary of Lamnyong river.

Cadmium, lead and zinc are often used as an indicator of heavy metal pollution in waters caused by human activities (Ravanelli et al 1997; Simbolon et al 2014). This study is crucial because most of the oysters traded in the local market come from this area. Hence, the objective of the present study was to examine the lead, cadmium and zinc concentration on the oysters harvested from several locations within the estuary area of Lamnyong river, Banda Aceh, Indonesia.

Material and Method

Site and time. The study was conducted at four sampling sites within the estuary area of Lamnyong river, Banda Aceh, Indonesia. The characteristics of every sampling site are as follow: station I is a tributary of Lamnyong river near Simpang Mesra (95°35'6" E, 5°57'2" N) with residential areas, fish markets and residential sewages; station II is the Lamnyong river watershed close to Krueng Cut bridge (95°35'6" E, 5°57'9" N); station III is situated at Tibang village, which has mangrove green belts and fish pond areas (95°35'0" E, 5°58'7" N); station IV represents an area of the Lamnyong river mouth (Alue Naga) and fishing ports (95°34'8" E, 5°60'5" N) (Figure 1).

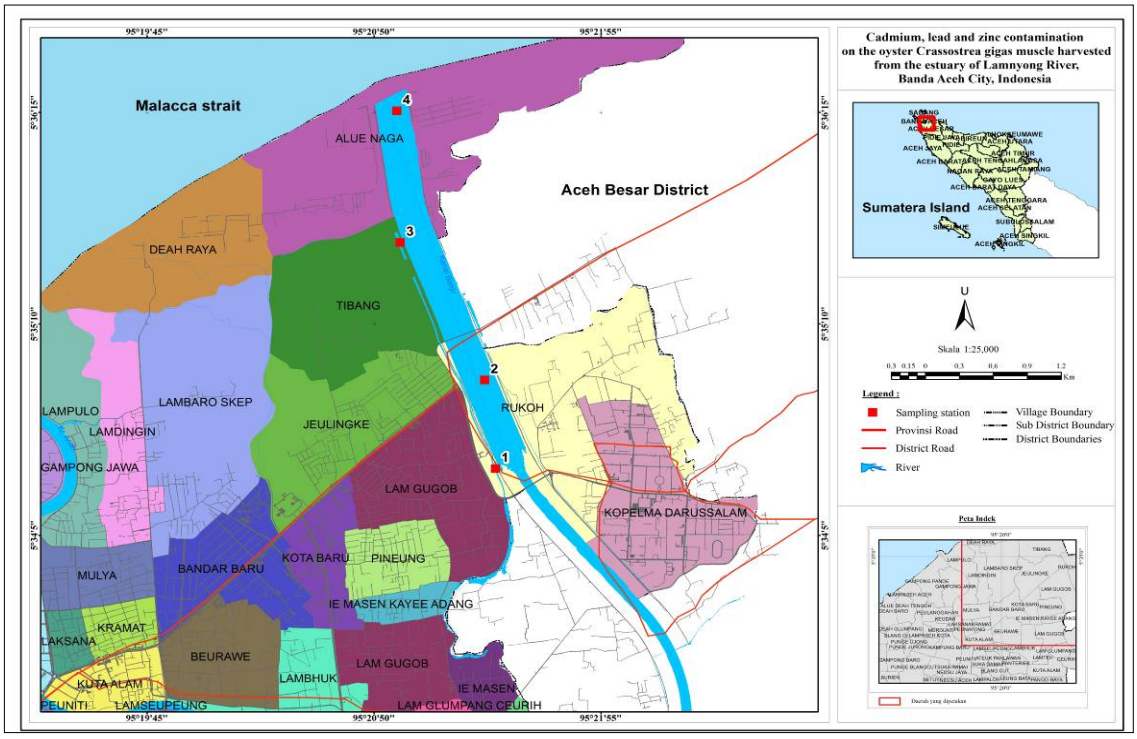

Figure 1. The map of Syiah Kuala sub district, Banda Aceh city, showing sampling sites.

Sampling and sampling preparation. Samplings were done two times, the first one in May 2013 and the second one in March 2014. Three plots were determined randomly at left-right and the center of the river. The plot size was 1m x 1m and only the oysters with size larger than 2 cm were collected at the first sampling in May 2013, and 3 cm minimum oysters were collected at the second sampling in March 2014.

The tissues of oysters were removed from the shell, preserved in the crushed ice (4^oC) and then transported to the laboratory in the Faculty of Sciences, Syiah Kuala University for an analysis of lead, cadmium and zinc. The samples were prepared based on a standard manual for Spectrophotometry analysis proposed by AOAC (1999) and Indonesian National Standard (SNI 06-6989.7). The main physical (temperature, water current and depth) and chemical (pH, dissolved oxygen, salinity) water quality parameters were measured when the oysters were sampled.

Heavy metal analysis. The oyster muscle was used for lead, cadmium and zinc analysis by using a standard procedure of the Atomic Absorption Spectrophotometry (AOAC 1999; Petrovici & Pacioglu 2010; Grd et al 2012).

Results and Discussion. The study revealed that cadmium and zinc were found in May 2013, but lead was not detected in the oyster mussel at that time. However, these heavy metals (cadmium, zinc and lead) were detected in March 2014. The results showed that lead and zinc levels on the oyster muscle increased during the last two years of 2013 and 2014. For example, lead has increased from 0 ppm to 0.019 ppm, while zinc increased from 3.778 ppm to 11.567 pm in respective years, but cadmium decreased from 0.152 ppm in 2013 to 0.015 ppm in 2014 (Table 1). Based on the sampling locations, lead was highest at station IV, cadmium at station I and zinc at stations II and III (Table 2). It indicates that all locations have been polluted by these heavy metals higher than the limit levels.

Table 1

Average concentration of lead, cadmium and zinc in the oysters (*Crassostrea gigas*) harvested from the estuary of Lamnyong river, Banda Aceh, Indonesia, in May 2013 and March 2014

Heavy metal	*May 2013*	*March 2014*
Lead (ppm)	0.000	0.019
Cadmium (ppm)	0.152	0.015
Zinc (ppm)	3.778	11.567

Table 2

The average levels and standard deviation (SD) of lead, cadmium and zinc on oyster muscle (*Crassostrea gigas*) from two sampling times in May 2013 and March 2014 according to the sampling sites

Sampling station	*Heavy metals (ppm)*		
	Lead	*Cadmium*	*Zinc*
I	0.004±0.009	0.093±0.059	7.122±1.577
II	0.003±0.006	0.081±0.099	8.069±5.744
III	0.004±0.009	0.074±0.073	8.030±4.877
IV	0.029±0.039	0.086±0.083	7.470±5.099

Heavy metal contaminants often occur in open waters due to industrial activities, agricultural, horticultural and domestic wastes (Rahman et al 2010; Petrescu-Mag et al 2010; Al-Baggou et al 2011; Mohammed et al 2011). Therefore, we speculate that the heavy metals of lead, cadmium and zinc sources mostly came from workshops (vehicles and welding), agricultural activities (pesticide and fertilizer) and household waste disposals located along the Lamnyong river. This is in agreement to Liu et al (2014) that lead is commonly used in paint and canning industries, gildings and pesticides. While

cadmium probably came from domestic disposals and oil spills from fishermen boats (Hidayat & Novita 2012). According to Huamain et al (1999), fertilizers and pesticides contribute significantly to soil fertility but are also major sources of pollution to aquatic organisms. Similarly, Cyrille et al (2012) reported that the source of cadmium mostly comes from industrial and domestic wastes, fertilizers and pesticides used in plantations. According to Amin (2002), the source of zinc in the waters comes from settlement disposals which entered the waters without being treated. Besides domestic pollutants, the intensive agricultural activities were also a potential source of zinc.

The concentration of heavy metals in the waters probably changes by seasons, where the high level would occur during the dry season (i.e. March 2014 was in the dry season in Banda Aceh). Similarly, Fisher et al (2000) reported that the heavy metals concentration on *Crassostrea virginica* muscles in Tampa Bay, Florida was higher during dried seasons because the concentration of heavy metals on the water was higher by inspissation due to the decline of water volume. In addition, Edward (2014) reported that the concentration of heavy metals was higher in the sediment compared to in the waters as recorded in Wawobatu Bay Waters, Southeast of Sulawesi.

In general, the concentration of the heavy metals, in particular lead and cadmium, was higher in Station IV. This location is the mouth of Lamnyong river which connects directly to the sea. A similar finding was reported by Lauenstein et al (2002) that heavy metals accumulation in the oyster (*C. virginica*) occurred highest in an estuary area of a polluted river in the waters of Carolina, USA.

Besides toxic to human, the heavy metals also give a negative impact to aquatic biodiversity. For example, Samman et al (2014) found that there was a strong relationship between mercury concentration and the density of popaco snail (*Telescopium telescopium*) in Kao Bay, North Halmahera, where the density of snail was lower when the concentration of mercury was higher.

According to the Indonesian Government Law No. 82 Year 2011, the limit of cadmium for fisheries purposes is 0.01 ppm, while based on the Indonesian Ministry of Environment Year 2004, the maximum standard of lead, cadmium and zinc on aquatic organisms is 0.008 ppm, 0.001 ppm and 0.05 ppm, respectively. Therefore, the oysters in the estuary of Lamnyong River have been contaminated by the heavy metals of lead, cadmium and zinc in which the concentration of these heavy metals have exceeded the permitted limit. Therefore, the oysters in the estuary of Lamnyong River are not safe for human consumption.

Conclusions. The concentration of lead, cadmium and zinc on the oysters (*Crassostrea gigas*) harvested from the estuary of Lamnyong river increased from May 2013 to March 2014 in which the concentration of these heavy metals has exceeded the maximum limit. Therefore, it is concluded that the oysters from this estuary have been contaminated by lead, cadmium and zinc and are not safe to be consumed by humans.

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