MERCURY CONCENTRATION ON TRADITIONAL GOLD MINING AND ITS ACCUMULATION ON VARIOUS EDIBLE MACROBENTHOS AT LAMPON AREA, BANYUWANGI DISTRICT, EAST JAVA

Aswi A. Rofiqoh
Susintowati
Dan Suwarno Hadisusanto
STIKES Guna Bangsa Yogyakarta
Universitas Gadjah Mada
aswi_ar@mail.ugm.ac.id

ABSTRACT

Traditional gold mining at Lampon Banyuwangi district used mercury amalgamation. Tailings are discharged to waters that caused mercury pollution. Mercury accumulation can be traced in sediments, benthic organisms, and the mining worker. This research aimed to trace mercury bioaccumulation in various edible macrobenthos at Lampon areas as a preliminary study of mercury bioaccumulation on human. The bioindicators used the representatives macrobenthos based on feeding behavior, niches and the mercury contained on edible macrobenthos in the Lampon gold mining area. Mercury content was analyzed by SNI 06-6992.2-2004 with modication at LPPT UGM Yogyakarta. Nine edible macrobenthos species were found in the Lampon gold mining area. The results show different accumulation amount of mercury in specimens based on feeding behavior, niches, and kinds of microbenthos species. Patella intermedia is an edible macrobenthos which has the highest mercury bioaccumulation. It is concentrated in the food chain so predatory edible macrobenthos from polluted location may have the highest mercury bioaccumulation level. Thus, consuming the edible macrobenthos can lead to human mercury exposure.

Keywords*: Mercury, bioaccumulation, edible macrobenthos, feeding behavior*

INTRODUCTION

Lampon was one of the traditional gold mine areas that used amalgamation process at Banyuwangi District. The waste disposed from tailing process would cause mercury pollution to the environment. The waste accumulation cannot reduce in brief time, but it will be far dispersed if it is carried with the spring water up to the estuary. This research traces mercury bioaccumulation in various edible macrobenthos at Lampon areas as a preliminary study of mercury bioaccumulation on human.

Methylmercury (Me-Hg) is highly toxic particularly to the nervous system and the developing brain is thought to be the most sensitive target organ for methylmercury toxicity. Mercury can be accumulated in the body of organisms because water-soluble chemicals bind tightly to specific sites within the body. Bioaccumulation refers to how pollutants enter a food chain. Biomagnification refers to the tendency of pollutants to concentrate as they move from one organism to the next. Bioaccumulation increases in concentration of a pollutant from the environment to the first organism in a food chain. Biomagnification increases in concentration of a pollutant from one link in a food chain to another. Bioindicators are the organisms that are used to detect how some pollutants accumulate in their bodies. Macrobenthos can be used as a bioindicator to traces of mercury (Eisler, 1987; Palar, 2008; Wahyu et al., 2008; Neustadt & Pieczenik, 2007).

The analysis results on mercury dispersion modelling of meteorological parameters showed that wet mercury deposition depends on precipitation, but dry mercury deposition is influenced by various meteorological factors (Lee & Keener, 2008; Bowles et al., 2001) given the fact that mercury accumulation in the body of fish is related with fish's age. The results of observation of Baeyens et al. (2003) show for each of the Belgian coastal zone four species, a weak positive correlation between mercury content and fish length further reveal that the larger the size-range, the higher is the correlation. Taking fish length into account, a statistically significant difference in contamination level was observed for species sampled from the different geographical zones.

The mercury bioaccumulation in aquatic biota significantly correlates with the mercury concentrations in the environmental media. Periphyton had the highest mercury bioaccumulation, subsequently followed by the scraper, the collector filterer, the collector gatherer, the shredder and finally, the predator (Yoga et al., 2009). Some authors suggest that trophic shift occured in response to sediment contaminants, but they were unable to dismiss other factors (such as hypoxia) that may have played a role in benthic trophic structure. No significant relationship between benthic trophic structure and total organic carbon of superficial sediments, and none would be expected unless food were limiting (Gaston et al., 1998).

When biomass was considered, filter feeders and filter detritivores were the dominant groups in the estuary, while for the adjacent coastal shelf filter feeders represented 83% of the total biomass. Salinity, depth, and sediment composition were the main factors structuring spatial distribution. Surface-deposit feeders were the most abundant macrobenthos of the upper estuary. Surface deposit feeders also dominated the middle and the lower estuary but the proportion of filter feeders as well as other trophic groups increased with salinity (Gaudêncio & Cabral, 2007).

The Bivalve (macrobenthos) species has contrast feeding niches, which may also affect the Hg accumulation. Methylmercury is produced by methylation of inorganic mercury present in both freshwater and saltwater sediments and accumulates in aquatic food chains in which the top-level predators usually contain the highest concentrations (Eisler, 1987). Methylmercury concentrations increased with trophic level (Bowles et al., 2001). This research traces mercury bioaccumulation at Lampon based on different trophic levels, feeding behavior and niches of macrobenthos.

METHODOLOGY

Lampon estuary was administratively located in Banyuwangi, East Java. This research was conducted from August 2011 to May 2012 and had covered data from dry season to rainy season during that time. Random sampling method was used to collect the samples in this research. The bioindicators used were the representative macrobenthos based on the trophic levels, feeding behavior and niches. Macrobenthos were assigned to the human edible organism and the trophic level (groups) based on feeding behavior and food type preferences in the literature. Macrobenthic taxa were assigned to trophic level based on feeding morphology (in situ), too. The macrobenthos was taken from some niches that every niche with 2 or 3 different species, from each species 2-5 specimens were taken for preparation to mercury analysis. Identified species of the specimen were used to obtain the data and sample picture in literatures at laboratory. The specimens were fixed with 4% formaldehyde before the preparation for mercury analysis. Mercury concentrations were analyzed based on modified SNI 06-6992.2-2004 method and Mercury Analyser at LPPT UGM, Yogyakarta. Environmental parameters recorded (in situ) in this research were: water current, water discharge of estuary, tidal range (maximum tidal rise and drop / receding water maximum), salinity, dissolved oxygen in water and air (DO), water temperature and air temperature, precipitation, and the degree of the water acidity (pH). The environmental parameters were recorded on the three different locations, on mangrove area (site I), mining area (site II), estuary area (site III). The sampling (site) selection has been chosen according to the location and distance to the mining area. The analysis of data on mercury accumulation in the body of specimens and sediments has been done by qualitative and descriptive analysis methods.

Table 1. The values of Environment Factors at Lampon

Environment Parameters	Site I	Site II	Site III
Air Dissolved Oxygen (mg/l)	5.96 ± 0.11	6.92 ± 0.03	6.04 ± 0.05
Water Dissolved Oxygen (mg/l)	6.46 ± 0.04	6.64 ± 0.01	6.22 ± 0.03
Air temperature (^{0}C)	38.44 ± 1.01	34.74 ± 0.29	31.2 ± 0.08
Water temperature (^{0}C)	31.00 ± 0.37	31.08 ± 0.01	28.78 ± 0.74
Sediment Temperature (^{0}C)	37.60 ± 1.86	33.20 ± 0.16	31.9 ± 0.44
Water Salinitas (‰)	25.80± 0.16	29.20 ± 1.24	29.8 ± 0.16
Water pH	8.10 ± 0.11	7.20 ± 0.16	8.88 ± 0.01
Sedimen Acidity	6.28 ± 0.11	6.94 ± 0.01	7.52 ± 0.05

Note: pH=Potential of Hydrogen

RESULTS AND DISCUSSION

The environmental factors of the three sites at Lampon area showed normal temperature and dissolved oxygen condition but the acidity and salinity value were lower than normal value (Table 1). According to the Environment Ministry Department (2004), normal value of environmental factors for marine organisms: 28-32°C of temperature, 7-8.5 of acidity, dissolved oxygen >5 mg/l, water salinity until 34%.

Mercury in natural aquatic environments has a normal value 0.15 µg/l in the sea water while 0.07 mg/l in the river water. The safety water mercury concentration value which has been recommended by Indonesian government is 0.001 mg/l (Kep.MenLH No. 51 of 2004), whereas Japan and Canada establish the maximum mercury concentration value on edible mollusk at 0,3 ppm. Three different main habitats have been studied on this research, estuarine (site III), rocky shore mining area (site II) and also mangrove area (site I). Mercury concentration on the three sampling locations showed higher value than Indonesian Government's standard value. The high mercury concentration on the sediment showed the presence of pollution at Lampon Mining area. The highest mercury accumulation was shown in the sediment on site II and the rocky shore mining area (figure 1.). According to Susintowati and Suwarno Hadisusanto (2015), the level of mercury in Lampon estuarine new disposal tailing sediment is 65.52 ppm and the old one was 634.52 ppm. This result indicated that mercury accumulation is persisted, because the evidence of mercury in aquatic sediments cannot be easily and immediately eliminated (Eisler, 1987).

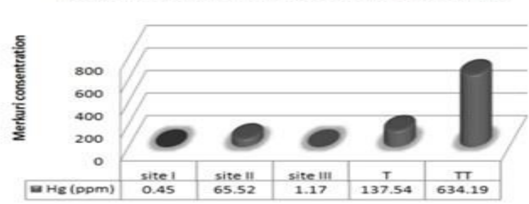

Figure1. Mercury Concentration on Site I, II, III sediments and new disposal (T) and old disposal (TT) tailing waste sediment at Lampon area

Each habitat has its own characteristic. According to each sampling site, the macrobenthos specimens have been sampled and analyzed based on their lifestyle, feeding behavior and edibility. On the rocky mining area (site II), Patella intermedia has the highest abundance. Patella intermedia is an epifauna or solitair herbivour addesive macrobenthos. The high mercury accumulation on this area and the characteristic of Patella intermedia caused bioaccumulation on this organism was highest than the other (figure 2.). This result showed agreement with previous research findings of Gaston et al. (1998) which stated that benthic macrofauna has strong correlation with environmental factors of their habitat (depth, salinity, tidal current velocity, sediment composition) (Gaston et al., 1998; Sivadas et al., 2013).

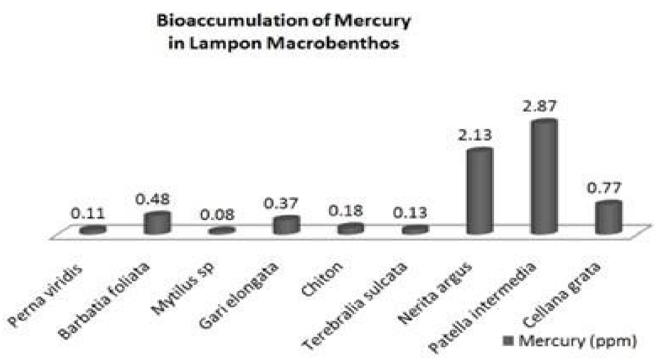

Figure 2. Bioaccumulation of mercury in Lampon Macrobenthos after the amalgamation proccess and the tailing wasting have been enclosed.

Perna viridis, Barbatia foliata, Mytilus sp, and Gari elongata is Bivalvia. In this site (Lampon) the specimens of Perna viridis were found in a small population, it is not in accordance with the research findings of Urian (2009) which declared that Perna viridis has big population (35,000 individu/m2). The small population of Perna viridis that has been found at Lampon area could be caused by the environmental pollution. Barbatia foliata has the same condition with Perna viridis. The colony of Mytilus sp is very solid and tight. Gari elongata is not sessile Bivalvia, they are burrowing in the mud or sediment. In this area, Gari elongata can be found in 5-10 cm in depth of sediment (infauna).

The character of niche and eating behavior of macrobenthos at Lampon showed the correlation between the biotic and abiotic factor to the mercury accumulation on macrobenthos. Perna viridis, Barbatia foliata and Mytilus sp shared the same feeding behavior and trophic level, they lived as a surface filter feeder and deposit feeder but their ability to accumulate mercury was different. The average mercury accumulation value of Perna viridis was 0.11 ppm (the highest accumulation of 0.18 ppm), Barbatia foliata 0.48 ppm (the highest accumulation of 0.83 ppm), Mytilus sp 0.07 ppm (the highest accumulation of 0.08 ppm). The lifestyle of Gari elongata as in fauna that bury themselves in the mud sediment enhances the accumulation of mercury on their bodies.

The mercury accumulation on herbivorous macrobenthos was also observed in this study. Chiton, Pattela intermedia and Cellanagrata (Patteloids) are herbivorous Gastropods. They consumed the algae and fitoplankton in the estuary area. The results showed that mercury accumulation of Chiton, Patella intermedia, Cellana grata were 0.18 ppm, 2.9 ppm 0.77 ppm, respectively. Herbivorous benthos (Gastropoda) has the higher mercury accumulation value than filter feeder organism (Bivalvia), the high and wide mobility of Gastropods could be the reason of high mercury accumulation on their bodies.

Table 2. The lifestyle and the characters of feeding behavior and niche of macrobenthos at Lampon

Species	Function	Lifestyle	Feeding Behavior	Niche
Perna viridis	edible	sessile in not massive colony	filter feeder	epifauna
Barbatia foliata	edible	sessile in not massive colony	filter feeder	epifauna
Mytilus sp	edible	sessile in massive colony	filter feeder	epifauna
Gari elongata	edible	infauna/free colony	filter feeder	infauna
Chiton	edible	epifauna/solitair addesive at the holes of rocks	herbivore	epifauna
Terebralia sulcata	edible	epifauna/solitair	detrivore	epifauna
Nerita argus	edible	epifauna/free colony	detrivore	epifauna
Patella intermedia	edible	epifauna/solitair addesive at the rocks	herbivore	epifauna
Cellana grata	edible	epifauna/solitair addesive at the rocks	herbivore	epifauna

Note: The characters of lifestyle are actually based on the observation at this place, the function is based on interview with the most people that were fishing the kind of species during the research sampling

The major source of mercury biomagnification on human is caused by fish and marine product. The riverine in Lampon area often takes the macrobenthos as their diet. The included seafood, particularly fish, in the human diet has been emphasized with regard to its lower levels of saturated fat, cholesterol, and caloric intake compared with meat, poultry, and dairy products. This consumption has had a positive economic impact on commercial fishing industries but the investigation of the presence of environmental contaminants in fish and other seafood is needed. This research result showed that mercury accumulation has been found in all of the edible specimen in the Lampon area. Perna viridis and Barbatia foliata have a small amount of mercury concentration in their bodies, but both of them are the most favorite shellfish in the Lampon area. Aquatic food chains are capable of accumulating certain environmental contaminants up to toxic concentrations (bioamagnification).

The highest mercury content was found on Pattela intermedia. Although Pattela intermedia was not edible by human, the high mercury accumulation value on it has gradual effect to humans. Pattela intermedia indirectly has a role as a food source for human. Pattela intermedia is consumed by another marine organisms such as a crab, which is consumed by human. The mercury concentration of Pattela intermedia will be accumulated in the human body because of the biomagnification. This condition also happened on Cellana grata and Nerita Argus.

All the data showed the ability of mercury bioaccumulation based on several specimens' trophic levels, feeding behavior and niche. Benthic filter feeders and sessile but not in massive colonies will accumulate mercury more dense than massive. Non-sessile benthos accumulates higher than the sessile. Filter feeder with a massive colony was lower than solitary herbivores. Niches affect the ability to accumulate mercury in the same trophic levels or even in the same feeding behavior. All of the macrobenthos at Lampon area are edible and has the potencies to cause biomagnification on human body.

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