# Freshwater Molluscs as Bioindicator of Fe and Mn Contamination in Lematang River, South Sumatera, Indonesia

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**Abstract**. Heavy metal in river come mainly from naturally occurring geochemical materials. However, human activities has enhanced concentration of heavy metal such as coal mine in the case of pollution in Lematang River. The high suspended solid loads in the river can remove most soluble metals from the water and trapped them in the bottom sediment. Freshwater molluscs were collected 3 sampling site, Lahat (ST1) as reference site, and polluted rivers of West Merapi (ST2) and East Merapi (ST2). Freshwater molluscs were analysed for the heavy metal contents in tissue. Relationships of the heavy metal in sediment to the heavy metal content in molluscs was performed using SPSS 24. *Thiara scabra* was the most abundant taxa in sampling area. Concentration of Fe and Mn in sediment has no significant effect on the Fe content in mollusc tissues. Molluscs appeared to more sensitive to higher Mn content. This study did not clearly show molluscs as a bioaccumulator for metal. Nonetheless, *Thiara scabra* were common, abundant, easily sampled and it is a useful choice as bioindicator in Lematang river for future study.

## 1 Introduction

Lematang River located in Lahat, South Sumatera, the river flows through coal mine industry. The branch of Lematang river has been reported to be polluted by coal mine, the concentration of Fe and Mn has been reported exceed permissible concentration in water [1]. The point of source pollution was located in West Merapi, Lahat, which received coal mine effluents from the surrounding areas. Lematang river has been the source for fish and molluscs. It is suspected that the organism from Lematang river, will be contaminated by heavy metal particularly Fe and Mn content. Biomagnification and bioaccumulation of these metal may take place, and molluscs are one of aquatic organisms that effective in bioaccumulation of heavy metal [2].

Molluscs have been considered as bioindicatior and biomonitoring subjects for heavy metal contamination [3,4]. They were found to be strong bioaccumulators for metal accumulation [4]. Some Molluscs which dwelled in the sediment are deposit feeders, tend to accumulate more metals [4]. studying the relationships between the levels of pollutants in the sediments and mollusk can be a valuable tool to evaluate the contamination levels and hazards to the population [5,6].

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In this study, all mollusc species were collected for Fe and Mn content. The objective of this study was to investigate the influence of Fe and Mn content in sediment to freshwater molluscs and to determine the potential of using molluscs as biomonitors for heavy metal pollution in Lematang river.

## 2 Materials and Methods

### 2.1 Study Area and Sampling Sites

The study was conducted on September until December 2017 in Lematang River, South Sumatera, Indonesia. Sampling was conducted every month on September, Oktober, November and December 2018. A total of three sampling site were chosen to specifically study the impacts of the heavy metal (Fe and Mn) point source in Lahat. The three stations is Lahat (ST1), West Merapi (ST2), and East Merapi (ST3) were selected as study areas. In each sampling site, three sites for collecting molluscs samples. Lahat (ST1) was located at the upstream of the point source which will serve as the reference site, another site, ST2, was at the nearest area to the point source and the rest of the sampling sites. ST3 was downstream of the point source. Fig. 1 shows the map of the sampling area of Lematang river.

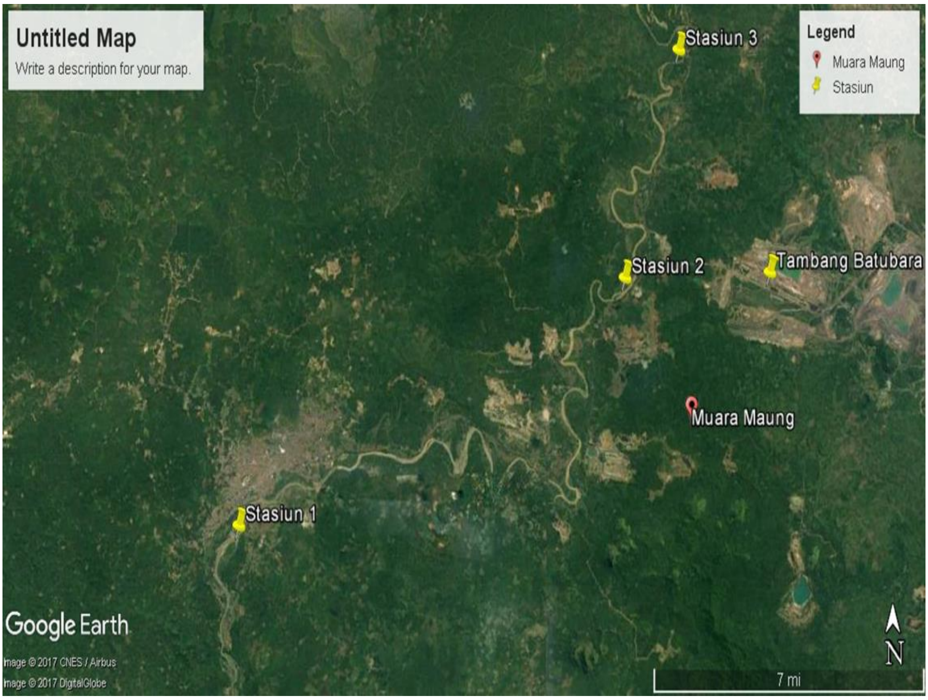


**Fig. 1.** Map of sampling site in Lematang river, Lahat, South Sumatera (Sumber: Google Earth).

### 2.2 Sampling Method

Molluscs were collected in Lematang River. The bottom grab sampler (3.5 liter in volume, and 250 $cm^2$ in sample area) was used for collecting the samples by dragging the grab above the top 20 cm of the bottom sediment. All material sediment collected during each sampling were transported to the laboratory. In the laboratory, each sample was washed with tap water through a sieve (300 µm pore). All mollusc specimens collected were separated according to the sampling site and species identification was transported at the laboratory. Tissues of the molluscs were removed from the shell, washed with deionised water and dried at 70$^o$C for 48 hour. The dried tissues in the powder form were kept in a desiccator for further analysis.

Sediment samples were collected from each sampling station using the bottom grab sampler. The sediment was kept in a 70 % alcohol bottle and later air dried in the laboratory. The dried sediment samples were kept in a desiccator for further analysis. Water samples were collected at the sampling stations using the water sampler. Water samples were kept in bottle for metal analysis.

### 2.3 Heavy Metal Analysis

Dried sediment samples were ground to a size of 60 mesh, weighed to approximately 3 g. The metals; Fe and Mn, in the sediment samples, were analyzed according to the method of Indonesian national standard (SNI). Dried sediment sample are mashed and homogenized. 3 g of homogenized sediment samples, then put it in Erlenmeyer (250 ml) The sediments were digested with 10 ml of concentrated nitric acid and 1 ml of concentrated hydrochloric acid. The digested contents were filtered, diluted to 25 ml in volumetric flasks with distilled water. Heavy metal (Fe and Mn) contents were analyzed using atomic absorbsion spektrophotometr (AAS).

Tissue samples were weighed accurately to approximately 2 g and digested with 6 ml of concentrated nitric acid and 1 ml of 30% hydrogen peroxide. The completely digested samples were filtered and diluted to 25 ml in volumetric flasks with distilled water. The metal contents were analysed using atomic absorbsion spektrophotometr (AAS).

### 2.4 Statistical Analysis

Relationships of heavy metal in sediment to the abundance and Heavy metal content in molluscs was performed using regression analysis in SPSS (Statistical Package for Social Science), Version 24.

## 3 Results and Discussions

### 3.1 The Heavy Metal in Sediment and Molluscs

The sediment were collected for measuring the content of Fe and Mn. The level of Fe and Mn were higher at ST3 (56860 mg $kg^{-1}$ and 321 mg $kg^{-1}$), followed by ST2 (22395 mg kg$^{-1}$ and 201 mg kg$^{-1}$), and the lowest level was found at ST1 as reference site (12977 mg kg$^{-1}$ and 148 mg kg$^{-1}$). heavy metals are easy to bind organic matter and settle in the bottom of the water and unite to sediment, causing the levels of heavy metals in sediment are higher than in water [7].

The concentration of Fe and Mn in water were still in permissible contration, but almost exceed in ST II and ST III, (permissible concentration for iron in water: ≤ 0.3 mg/l and for mangan: ≤ 0.1 mg/l). However, there is no Indonesian standard of heavy metal in sediment.

The highest concentration heavy metal was found in ST3 as downstream than ST2. many factors affect distribution and concentration heavy metal in the river, like different point source of pollution and volume, widespread contamination that is exported downstream from many point sources, natural process, and habitat.

**Table 1.** Fe and Mn content in sampling sites; Sep= September, Okt= October, Nov= November, Dec= December

| **Mean value of Parameter** | **Lokasi** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **ST1** | | | | **ST2** | | | | **ST3** | | | |
| | **Sep** | **Oct** | **Nov** | **Dec** | **Sep** | **Oct** | **Nov** | **Dec** | **Sep** | **Oct** | **Nov** | **Dec** |
| **Fe in Sediment (mg kg$^{-1}$)** | 16650 | 12281 | 12977 | 17764 | 22395 | 20762 | 12992 | 20059 | 56860 | 41508 | 31895 | 35467 |
| **Mn in Sediment (mg kg$^{-1}$)** | 162 | 148 | 154 | 189 | 201 | 180 | 118 | 164 | 321 | 297 | 228 | 272 |

The Fe and Mn content in molluscs were analysed from tissue of mixed mollusc species at each site sampling (due to lack of mollusc tissue samples). The content of Fe was highest at ST2 (6759.64 mg kg$^{-1}$), followed by ST3 (5130.96 mg kg-1) and ST1 (3566.96 mg kg$^{-1}$). The content of Mn was highest at ST3 (1961.32 mg kg$^{-1}$), followed by ST1 (1040.86 mg kg$^{-1}$) and the lowest of Mn was found at ST2 (608.74 mg kg$^{-1}$).

**Table 2.** Metal content in Molluscs

| **Stations** | **Mean value of Fe in Molluscs (mg kg$^{-1}$)** | **Mean value of Mn in Molluscs (mg kg$^{-1}$)** |
|---|---|---|
| ST1 | 3566.96 | 1040.86 |
| ST2 | 6759.64 | 608.74 |
| ST3 | 5130.96 | 1961.32 |

Fe and Mn content in sediment has positive relationship to Fe and Mn content in molluscs. Increasing Fe and Mn content in mollusk related to increasing Fe and Mn content in sediment. However, the relationships has no significant effect. The heavy metals, Mn and Fe, are essential metals for benthos and can be toxic at certain concentrations [8]. Fe content was found to be highest in mollusk tissue [8-10]. Many factors determine heavy metals content in organisms, like their habitat, feeding habits and natural metal concentratiom in organisms [11].

**Table 3.** Regression analysis of relationships between Fe and Mn content in sediment and Fe and Mn content in Molluscs

| Variabel | Regression coefficient | P |
|---|---|---|
| Fe content in sediment | 0.868 | 0.419 |
| Mn content in sediment | 0.704 | 0.508 |

## 3.2 The Influence of Heavy Metal on the Mollusc Abundance

Five species of molluscs; *Melanoides tuberculata, Pamacea canaliculata, Tarebia granifera, Thiara scabra,* and *Corbicula fluminea*, were identified from three stations. The lowest abundance was found at nearest site to point source (ST II). *Thiara scabra* and *Melanoides tuberculata* were the most abundant taxa in sampling area. The highest abundance was found in ST3, the molluscs particurally *Thiara scabra* appeared to more tolerant taxa.

**Tabel 4.** Mollusc taxa in sampling area

| Spesies | Density (individu/m$^2$) | | |
|---|---|---|---|
| | ST 1 | ST 2 | ST 3 |
| *Melanoides tuberculata* | 13.3-66.7 | 0 | 0-40.0 |
| *Pamacea canaliculata* | 0-13.3 | 0 | 0 |
| *Tarebia granifera* | 0 | 0-13.3 | 0-13.3 |
| *Thiara scabra* | 0-26.7 | 0-13.3 | 26.7-66.7 |
| *Corbicula fluminea* | 0 | 0 | 0-13.3 |

Regression analysis shows the influence of Fe and Mn in water and sediment on the abundance of molluscs. The abundance of Molluscs showed positive relationship to fluctuation of Fe content in water and sediment, it is indicating that Molluscs appeared to more tolerant taxa to the fluctuations. However, the abundance showed negative relationship to Mn content in water and sediment. It indicate that Molluscs appeared to be more sensitive to higher Mn content in water and sediment.

An ideal biomonitor should fulfil the following criteria: 1. It should be sedentary in order to be representative of the study area; 2. It should be abundant in the study area, easy to identify and sample at all times, and have enough tissue for analysis; 3. It should be tolerant to wide ranges of contaminant concentrations; and 4. It should be a strong accumulator of the relevant contaminants [12].

**Table 5.** Regression analysis of relationships between metal content and the abundance of Molluscs

| Variabel | Regression coefficient | P |
|---|---|---|
| Constanta | | 0.315 |
| Fe content in water (x8) | 0.218 | 0.829 |
| Mn content in water (x9) | -1.459 | 0.155 |
| Fe content in sediment (x10) | 0.891 | 0.380 |
| Mn content in sediment (x11) | -0.173 | 0.864 |

Based on the ideal biomonitoring criteria, the only one mollusc species in this study, satisfied criteria 1, *Thiara scabra* were found throughout the entire study area. The metal concentrations in mollusk species was not clearly determined during the research and it would be the focus of our future work. As at the present evaluation, the molluscs were considered to be a good biomonitor for metals with *Thiara scabra* showing greater potential due to its representative and abundant in the Lematang River.

## 4 Conclusions

*Thiara scabra* was the most abundant taxa in sampling area. Thiara scabra are suitable for used as biomonitors for heavy metals in Lematang river. *Thiara scabra* was common, easily sampled and it is a useful choice as bioindicator in Lematang river for future study. Molluscs appeared to be more tolerant to higher Fe concentration and more to be sensitive to Mn concentration.

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