Analysis of heavy metals in fluvial sediments affected by coal spill waters in Lampuuk Beach, Aceh Province, Indonesia

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Abstract. Coal spill in Lampuuk waters in July 2018 had released some heavy metals into the waters in form of dissolved ions. They were then partially absorbed in the bed and affected the fluvial sediments. The objective of the research was to analyse the heavy metals; Mn, Pb, Cu and Cd content in fluvial sediments affected by coal spill water in Lampuuk, Aceh Province, Indonesia. The fluvial sediments from five stations of Lampuuk beach were collected in December 2018 and analyzed using Atomic Absorption Spectrophotometer (AAS), then resulted that lead (Pb) and manganese (Mn) contained in the samples, ranged from 10.14 to 15.91 and 60.25 to 98.78 mg/Kg, respectively, while copper (Cu) and Cadmium (Cd) were undetected. Based on the regulation of ANZECC (2000), lead content in the sediment was still under the threshold, but manganese was exceeded the threshold.

1. Introduction
Sediment is essential for benthic communities not only because it provides suitable habitats for relevant biological processes but also provides a significant link between biological and chemical processes [1]. A national online news reported that a coal barge spilled 7,000 tonnes of coal just off Lampuuk beach in northern Sumatra in July 30, 2018[2]. The sediments at the beach of Lampuuk has turned black as it’s covered in coal. But, the expanse of coal spilleither in waters or in coastal sediment is still unreported.

Coal is an organic sediment that contains inorganic constituents such as heavy metals[3,4,5,6,] and many different complex organic substances such as Polycyclic Aromatic Hydrocarbons (PAHs), organic sulphur compounds and humic acids [7,8,9,10]. In seepage, the heavy metals are in form of dissolved ions [11]. Coal spill provides those heavy metals dissolved in the water.

Coal spill in Lampuuk waters raised the presumption of heavy metals contamination. Manganese (Mn), lead (Pb) and cadmium (Cd) belonged to the major dissolved metals in waters due to coal spill, but copper (Cu) was belonged to the minor element [8,12]. The contamination of heavy metals in sediment began since metal dissolved in water then precipitated on the sediment [13]. The objective of
the research was to analyse the heavy metals; Mn, Pb, Cu and Cd content in fluvial sediments affected by coal spill water in Lampuuk, Aceh Province, Indonesia.

2. Methods
2.1 Sampling
The study was carried out in December 2018 in Lampuuk beach by collecting the samples of fluvial sediments from five sites of observation and analyzing their heavy metals content. The samples then were analyzed at BARISTAND Laboratory, Banda Aceh using Atomic Absorption Spectrophotometer. The locations of sampling was shown in Figure 1.

![Figure 1. Sites of observation in Lampuuk, Aceh Besar District](image)

2.2 Sediments digestion
Sediment samples were air-dried to a constant weight. A half gram of dried sediment was digested with 7 ml of HNO₃ for 15 minutes. To well dilute the sediment in the digested reagent, samples were put in the microwave for 3 hours. Aquabidest then was added into each mixture to the volume of 100 ml.

2.3 Analytical procedure
The heavy metals, Mn, Pb, Cu and Cd content in sediments were analyzed using Atomic Absorption Spectrophotometer (AAS) in flame mode. Before measuring the analytes, the standard solution for Mn, Pb, Cu, and Cd were separately prepared as calibration curves were required in metals concentration calculation. AAS then was adjusted at wavelenght of 279, 217, 324, and 228 nm for analyzing Mn, Pb, Cu and Cd, respectively. The standard solutions and samples were filled into the test tubes, then were aspirated respectively into the vapour of acetilene [14]. Metals contents then were calculated based on their regretion concentration as provided on AAS by following the formulation below.

\[
\text{Metal content (mg/kg)} = \frac{C_{reg} \times P \times V}{G} \quad (\text{eq.1})
\]
Whereas:

\[ C_{reg} \] = regretion concentration (mg/L)

\[ P \] = dillution factor

\[ G \] = weight of sample (Kg)

\[ V \] = solution volume (L)

3. Results and Discussion

Four heavy metals were analyzed from five sites of fluvial sediments affected by coal spill waters in Lampuuk as shown in Table 1. As comparison, we carried the regulation of ANZECC (2000).

| Sample Unit | metal | 1 (mg/kg) | 2 (mg/kg) | 3 (mg/kg) | 4 (mg/kg) | 5 (mg/kg) |
|-------------|-------|-----------|-----------|-----------|-----------|-----------|
| Sediment    | Mn    | 98,7807   | 71,2034   | 60,2555   | 95,8015   | 78,4307   |
|             | Pb    | 10,4727   | 15,9169   | 15,6351   | 10,3714   | 14,3156   |
|             | Cu    | <0,0008   | <0,0008   | <0,0008   | <0,0008   | <0,0008   |
|             | Cd    | <0,0004*  | <0,0004*  | <0,0004*  | <0,0004*  | <0,0004*  |

Table 1. The heavy metals content in sediment from observation sites

Result showed that the sediment of Lampuuk beach contained of manganese and lead metal. Manganese and lead ranged from 60.25 to 98.78 mg/Kg and 10.37 to 15.91 mg/Kg, respectively (Table 1). The fact can be explained as manganese and lead are the major element of coal [8,12]. Based on the regulation of ANZECC [15], manganese content in the sediment was exceeded the threshold, while lead was still under the threshold. This indicated that the sediment was contaminated by the manganese. A current study also reported that some rivers in Poland were high contaminated by Mn, while Pb, Cu and Cd were obtained at low concentration due to the effect of coal mine waters [16]. Another study in fluvial sediments of coal mining region, Baixo Jacui, Brazil, manganese was also the higher content in those sediments, while copper and lead were found lower [17].

Copper and cadmium were still undetected in samples of Lampuuk fluvial sediment. This result can be explained when copper belongs to the minor element in coal ([8,12]. However, the different dissolved metals have the different velocity of precipitation. In addition, heavy metals were easy bonded to the organic matters[18] while dissolving before precipitating in sediment. This provides the presumption that cadmium was not precipitated yet in the sediment after 5 months of coal spill.

Based on the sites of observation, the distribution of heavy metals contamination in sediment was different. Mn as the major contaminant in those sediments, had the lowest concentration in site 3 despite this site was close to the location of coal spilled off the beach, while it’s values in other sites were higher. Metals content in the fluvial sediments depends on the metals distribution in sediments as affected by coal spill waters and the factors of sediment distribution. Currents and waves are the main factors that determine the direction and the distribution of sediments [19]. From this study we revealed that the fluvial sediments in those sites were transported from site 3 to the north (site 4 and 5) and to the south (site 1 and 2) as shown in Figure 1.
4. Conclusion

Lead (Pb) and manganese (Mn) contained in the samples, ranged from 10.14 to 15.91 and 60.25 to 98.78 mg/Kg, respectively, while copper (Cu) and Cadmium (Cd) were undetected. Based on the regulation of ANZECC [15], lead content in the sediment was still under the threshold, but manganese was exceeded the threshold.

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