

**STATUS OF HEAVY METAL POLLUTION WITHIN SEDIMENT IN MANGROVE FOREST OF  
SEMARANG CITY AND DEMAK MUNICIPAL COASTAL AREA**

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**ABSTRACT**

Heavy metal pollution in Semarang City and Demak Municipal are increasing as the increase of industrial activity at both location. This research aimed to study the difference of heavy metal concentration in sediment, and to study the level of heavy metal pollution within mangrove area of Semarang City and Demak Municipal coastal areas. This research was conducted through sampling and laboratory analysis. At each location, 3 stations was occupied with 3 sampling points at each stations. Sampling was conducted for sediment within mangrove area at both location, while laboratory analysis was conducted in Laboratory of Analytical Chemistry, Chemistry Major, Faculty of Science and Mathematics Diponegoro University. Heavy metals in sediment observed in this research was Co, Cu, Cr, Pb, Zn, Ni, Fe, Mn and Mg. The result showed that heavy metal concentration in sediment on both location was quiet high. Sequentially, the highest to lowest concentration of heavy metal was  $Fe > Zn > Mn > Mg > Ni > Cu > Cr > Co > Pb$  at Semarang City and  $Fe > Mn > Mg > Zn > Ni > Pb > Cu > Co > Cr$  at Demak Municipal. Heavy metal concentration of sediment for Co, Cu, Cr, Zn and Ni are significantly different between Semarang City and Demak Municipal area. Heavy metal in sediment for Zn, Ni, Fe and Mn at both location had exceeded the recommended limit by ANZECC/ARMCANZ and ISQG.

**Keywords:** *heavy metal, mangrove, pollution state, sediment*

**Introduction**

Heavy metal is such compounds which naturally only available in smal amount in the environment. But, the increase of heavy metal concentration can be a threat to the environment and human being [1]. Heavy metal is capable to accumulate within organisms through food chains, either in plants nor animals [2]. Accumulation of heavy metal in organisms, including human while exceeded the limit of tolerance could cause terrible impact, even could cause death.

[3] mentioned that heavy metal pollution generally came from anthropogenic and industrial activities. Furthermore, agricultural activities also contribute significant heavy metal pollution [4]. Heavy metal containing pollution, either anthropogenic, industrial, nor agricultural activities would enter the water body and carried by river stream, either by surface stream nor groundwater stream [3]. While [4] also mentioned that the accumulation of heavy metal in the soil is exist. The concentration of heavy metal varied based on its sources.

According to [5], heavy metal pollution which had entered the water would be accumulated in the sediment of the river and the sea. The distribution of heavy metal is strongly related to the composition of sediment structure in which sediment with fine grain size tend to bind the heavy metal which had entered the water. Previously, [6] stated that distribution of heavy metal in the water is significantly influenced by the concentration of dissolved sediment. Hence, the extent of heavy metal distribution is also influenced by the concentration of dissolved sediment in the water.

Estuarine is an ecosystem which accumulate heavy metals in large amount [7]. Concentration of sediment carried by the river stream is the main factor causing the accumulation of heavy metal in the estuarine. Hence, as the accumulation rate of sediment in the river stream increase, the concentration of heavy metal in the water body increase as well. Eventhough, there are several ways to lower the concentration of heavy metal pollution such as bioremediation, which is a method utilizing plants to absorb heavy metal compounds from the sediment [8].

Mangrove ecosystem is coastal ecosystem with active inundation either by tide nor by river flow. [9] mentioned that mangrove also have the capability to decrease the concentration of heavy metal in the soil and water. The capability of mangrove as phyto-remediator is supported by its capability to accumulate heavy metals in its parts. The

bioaccumulation capacity of heavy metal in mangrove is varied by mangrove species [10].

The increase of pollutant concentration, especially heavy metal in the coastal area is a threat to surrounding organisms. Although mangrove ecosystem capable to resist the distribution of pollutant to the water, but it doesn't mean that the pollutant is disappeared. Mangrove ecosystem only capable to decrease the concentration of pollutant which had entered the water [11].

The risk of heavy metal contamination in organisms can be evaluated by the concentration of heavy metal in the environment. The higher heavy metal concentration available in the ecosystem, the potential of organisms to be contaminated by heavy metal increase as well. Eventhough, there is such tolerance limit for the environment to maintain its safety to the surrounding organisms. So, in order to evaluate whether the concentration of heavy metal in such area, especially in the coast is safe for surrounding organisms, a research is need to be conducted concerning the existing condition of heavy metal pollution.

Semarang City and Demak Municipal are some region along the northern coast of Central Java which had experienced great ecological stress. The increasing industrial, settlement and agricultural activities had altered the input of pollutant to the coastal area, including heavy metal. The pollution level to the environment increased over years while the condition of mangrove ecosystem had been degraded. Since the lack of information concerning

the pollution, a research need to be conducted to evaluate the condition of heavy metal pollution level in coastal area of Semarang City and Demak Municipal. This research aimed to observe the concentration of heavy metals in the sediment and to evaluate the pollution state of heavy metal in the mangrove ecosystem in Semarang City and Demak Municipal coastal area.

### Materials and Method

Data collection of heavy metals was conducted in mangrove ecosystem in Semarang City and Demak Municipal coastal area. Sample collection was conducted from February – April 2010 followed by laboratory analysis. Mangrove sediment was taken as sample involving 3 observation stations at each location with 3 replication at each station. Sample analysis was conducted in Laboratory of Analytical Chemistry, Major of Chemistry, Faculty of Science and Mathematics Diponegoro University. Analysis was conducted to measure the concentration of several heavy metal existed within the mangrove sediment at both location. The heavy metal analyzed in this research was including: Co, Cu, Cr, Pb, Zn, Ni, Fe, Mn and Mg.

Data was analyzed by quantitative method to compare the concentration of heavy metal in mangrove area of Semarang City and Demak Municipal. Data analysis was conducted through ANOVA to calculate the significance of heavy metal concentration difference at both locations. While qualitative analysis was also conducted to evaluate

the concentration of heavy metal in the sediment whether it had exceeded the allowable limit by comparing to the applied legal regulation concerning the standard of heavy metal concentration in the sediment.

### Result and Discussion

The result of data collection on heavy metal showed there were differences on the concentration at both location. Heavy metal with highest concentration was Fe either at Semarang City nor Demak Municipal mangrove area. While among all heavy metal observed in the sediment, heavy metals with lowest concentration was Pb at Semarang City and Cr at Demak Municipal. Orderly, the concentration of heavy metal in the sediment in Semarang City was  $Fe > Zn > Mn > Mg > Ni > Cu > Cr > Co > Pb$ . While in the mangrove area of Demak Municipal, the concentration of heavy metals in the sediment ordered as  $Fe > Mn > Mg > Zn > Ni > Pb > Cu > Co > Cr$ . Detailed of heavy metal concentration in sediment at both location from the laboratory analysis is shown in Table 1.

The analysis result on the heavy metal concentration in mangrove area of Semarang City and Demak Municipal showed some heavy metal had exceeded the recommended limit. Heavy metals such as Zn, Ni, Fe and Mn had exceeded the recommended limit, while Cu, Cr and Pb were still in the allowable concentration. While for Co and Mg there was no recommended concentration limit for sediment quality standard. The analysis result

showed that generally the concentration of heavy metal in mangrove area of Semarang City was higher than in Demak Municipal. Except for Pb, Mn and Mg which were higher in Demak Municipal than in Semarang City.

The statistical analysis of heavy metal at both location showed that there were differences on the concentration of heavy metal in sediment for several heavy metals. Heavy metals which have significant

concentration difference were Co, Cu, Cr, Zn and Ni. While for Pb, Fe, Mn and Mg there were no significant difference between locations. The significant difference of sediment heavy metal concentration at both location indicate that there were significant difference of heavy metal input from upland area.

Table 1. Concentration of Heavy Metal in Sediment (mg/kg)

No.	Heavy Metal	Concentration	Location		Standard (mg/kg)
			Semarang City	Demak Municipal	
1.	Co*	Range	13,295 – 23,448	5,289 – 14,032	N/A
		Average	<b>19,442 ± 4,557</b>	<b>9,621 ± 2,901</b>	
2.	Cu*	Range	20,161 – 40,380	12,042 – 18,578	65 (a)
		Average	<b>28,268 ± 6,086</b>	<b>14,428 ± 1,971</b>	
3.	Cr*	Range	6,176 – 29,938	1,424 – 13,610	80 (a)
		Average	<b>21,622 ± 8,849</b>	<b>7,910 ± 4,442</b>	
4.	Pb	Range	0,000 – 7,982	1,040 – 172,183	50 (a)
		Average	<b>2,498 ± 3,606</b>	<b>24,778 ± 55,418</b>	
5.	Zn*	Range	117,070 – 2.590,238	293,665 – 599,947	200 (a)
		Average	<b>1.439,699 ± 867,473</b>	<b>487,733 ± 100,499</b>	
6.	Ni*	Range	30,410 – 195,141	22,148 – 36,885	21 (a)
		Average	<b>130,296 ± 73,713</b>	<b>29,337 ± 5,010</b>	
7.	Fe	Range	5.275,140 – 55.536,270	14.600,070 – 50.878,650	21.200 (b)
		Average	<b>39.077,647 ± 17.265,882</b>	<b>29.480,925 ± 15.241,122</b>	
8.	Mn	Range	<b>593,880 – 1.995,000</b>	<b>656,268 – 4.152,898</b>	460 (b)
		Average	<b>1.108,717 ± 449,341</b>	<b>1.921,466 ± 1.278,798</b>	
9.	Mg	Range	163,749 – 1.576,737	409,149 – 1.596,248	N/A
		Average	<b>491,457 ± 529,138</b>	<b>916,871 ± 436,529</b>	

Note: asterisk (\*) showed there was significant difference on the heavy metal concentration between observation locations; (a) standard based on ANZECC and ARMCANZ [12]; (b) standard based on ISQG (2002) [13]

Data collection resulted there were significant heavy metal concentration in sediment of mangrove area at Semarang City and Demak Municipal. The

difference of heavy metal concentration was caused by several factors, such as mangrove density, volume of pollutant supply and period of accumulation process. The pollution of heavy

metals had various sources from upland activities such as industrial, agriculture, anthropogenic and even natural atmospheric phenomenon [3][4].

According to [14], types and concentration of heavy metal in sediment and water was strongly influenced by kinds of activities in the upland area. Each heavy metal had enriching factors which are defined by kinds and intensity of the existing activities. [15] mentioned that the increasing agricultural activities and atmospheric phenomenon could cause to the increasing heavy metal concentration in sediment.

Basically, heavy metal is an important component for livelihood of the organisms, either plants nor animals. But, the requirement of heavy metal by living organisms are in a very small amount [16]. Heavy metals in the environment basically released in small amounts. But, the increasing human activities such as anthropogenic, agricultural and industrial had impacted the alteration on the heavy metal concentration significantly. This resulted negative impact for organisms. High heavy metal concentration in Semarang City and Demak Municipal were also supported by the existence of industrial, anthropogenic and intensive agricultural activities which cause to upland sediment and lime erosion. The indication had been occurred in Jakarta gulf which had high heavy metal concentration [17].

Data analysis result and inference of sediment quality standard showed that several heavy metal in the sediment of mangrove area at Semarang City and Demak Municipal had exceeded the

recommended limit. These heavy metal were including Zn, Ni, Fe and Mn. The high heavy metal concentration in the sediment increase the risk of accumulation on the benthic organisms and aquatic organisms.

The concentration of heavy metal in the sediment was a threat over heavy metal toxicity to organisms, especially benthic organisms. [18] stated that concentration of heavy metal in the sediment was supported by environment condition such as organic matter compound, concentration of mud and clay and the condition of soil redox at certain range which could increase its bioavailability in benthic organisms. It means that in certain condition heavy metal concentration within organism could increase. The research conducted by [19] also showed the occurrence of heavy metal accumulation in fishes and clams. Based on the research, the concentration of heavy metal in clams were relatively higher than in fishes.

Organisms which had been contaminated by heavy metals, while consumed by human could cause toxicity effect. The research by [20] showed the concentration of heavy metal in several fish species had indicated the increasing threat on human health shown by THQ (Target Hazard Quotient) value more than 1. Heavy metal toxicity on human could be caused by vegetables, fruits or fishes which were contaminated by heavy metals since the utilization of polluted water [21][22].

[23] stated that all kind of heavy metals could cause toxicity risk to human. But, each heavy metals would have different toxicity effect to human body.

Generally, toxicity of heavy metal in human resulted the decrease of organ functions. While [24] mentioned that the effect caused by heavy metal on human can be in the form of neurotoxicity, genotoxicity or carcinogenic. It showed that the negative effect of heavy metal toxicity on human has large scope, hence it should be avoided.

To avoid the extend of heavy metal toxicity on human, such effort had been conducted to formulate solutions of the problems. Several methods recommended including mechanical, chemical and biological [25]. [26] for example, had researched the mechanical method through soilmilling. While [11] studied the effort concerning phytoremediation of heavy metal, which utilized certain plant species to lessen the concentration of heavy metal in the environment. [27] showed the remediation method of heavy metal utilizing chemical compound by binding heavy metals with such bounding compound. Utilization of microbes in the remediation of heavy metal had also been discussed by [28].

[29] had studied the effort of remediation effectivity of heavy metals by combining phytoremediation technique and mircobial supplementary to increase the binding capability of plants over heavy metals. [30] also recommended remediation technique by soil maturation, where mixed mud should be regenerated to soil in upland area. The purpose of this process is to limit the availability of clay which has high capability on heavy metal binding and limit its potential to get drought to the water. But, of all the mentioned

method, the most effective method to avoid the heavy metal pollution was by avoiding the pollution to occur by waste management efforts especially wastes with liquid heavy metal compound [31].

### Conclusion

The concentration of heavy metal in the sediment of mangrove area at Semarang City and Demak Municipal was considered as high. Generally, the concentration of heavy metal in mangrove area of Semarang City was higher than in Demak Municipal. The concentration of heavy metal in the sediment in Semarang City and Demak Municipal which had significant difference were Co, Cu, Cr, Zn and Ni. Several heavy metals in the sediment had exceeded the recommended limit defined by ANZECC/ARMCANZ and ISQG for sediment standard including Zn, Ni, Fe and Mn.

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