Lead (Pb) and Cadmium (Cd) Pollution in Karangsong Waters, Indramayu Regency, Indonesia

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Abstract: Heavy metals are hazardous pollutants due to the toxic properties and may affect many aspects of both biology and ecology. The use of heavy metals in industry will cause the waste that will contaminate the aquatic environment. Oil spills from the activities of industrial companies lead to water pollution. Some of the heavy metals contaminating the waters are lead (Pb) and cadmium (Cd). This research aimed to determine the heavy metal content of lead (Pb) and cadmium (Cd) in the waters of Karangsong. Water testing and sampling were conducted at three different stations. Station 1 is located at estuary in Langgen, Singaraja sub-district; Station 2 is located on the beach near the mangrove forest; and Station 3 is located on the Beach near the pier. Heavy metals test was conducted at Chemical-Analytic Laboratory, Basic Science Research Centre, Padjadjaran University. The results showed that the lead (Pb) content in Karangsong waters has exceeded the standard quality threshold with the highest value of 0.517 mg/L, the content of cadmium (Cd) in Karangsong waters also has exceeded the standard quality threshold with the highest value of 0.073 mg/L. Physicochemical test results also showed the presence of heavy metal content in these waters.

Key words: Cadmium • Environment • Heavy Metals • Lead • Pollution

INTRODUCTION

Effort in territorial waters utilization currently shows a high increasing trend in order to support the country's economy and community welfare. Utilization efforts include industrial activities, mining and transportation. In addition, waters are also utilized as a waste disposal area by surrounding industries and local communities. This may have a negative impact toward aquatic environment. One of the negative impacts is water pollution which is marked by the decreasing quality and productivity of waters [1]. The marine environment can be polluted because coastal waters become waste disposal sites (Waste bins) which are relatively cheap and easy from various human activities either from coastal areas or from the open seas. The sources of marine pollution include oil spills, remnants of war ammunition, garbage disposal from land through rivers, marine transport emissions and pesticide discharges from agriculture [2]. However, the main source of pollution is more common in oil spills from oil tankers. Petroleum are transported by petroleum tanker to petroleum refinery.

One of the major polluting factors contained in the waste is heavy metal compounds. Heavy metals are hazardous pollutants due to their toxic properties and may affect many aspects of biology and ecology [3]. Heavy metals are non-biodegradable and are not removed from water as a result of self-purification [2]. The pollution caused by heavy metals is long term and irreversible process [4]. Heavy metal waste disposal into estuary and beach environments gets serious attention from environmentalists due to (a) the toxic properties toward organisms and persistence in aquatic environments; (b) mostly from an increasingly anthropogenic source; (c) limited information on behavior and biotoxicity and (d) accumulation in aquatic organisms [3]. Heavy metals are considered as one of the most serious pollutants in the environment. Heavy metals are involved in various industrial processes, agricultural activities, domestic
Aquatic systems are very sensitive to heavy metal pollutants and the gradual increase in the levels of such metals in an aquatic environment. Heavy metal contamination in aquatic ecosystems is one of the most challenging pollution issues due to the toxicity, abundance, persistence, and subsequent bioaccumulation of heavy metals.

The Indramayu regency is located on the coastline or adjacent to the Java Sea which is very supportive for the development of fishery and marine potentials. Of all the pollutants contaminating the ocean, petroleum-derived pollutants earn great attention internationally, politically and scientifically. Heavy metals have the tendency to accumulate in various organism, especially fish, which in turn may enter into human metabolism through consumption causing serious health hazards. According to Sari et al. heavy metals contained in the waters will be accumulated in marine biota which then, through the food chain, can accumulate in humans eating the marine product.

Leaks in offshore crude oil pipelines from tankers to ground tanks in the process of crude oil distribution resulted in polluted coastal waters. Crude oil spill can contaminate the sea for as far as 55.5 km. Crude oil spill is found in the coastal area of Indramayu Regency, on the beach in four villages within the district of Indramayu, in almost every year. These 4 villages are namely the PabeanUdik, Karangsong, Tambak and Singaraja. The spill is estimated to extend about 7 km along the coastline in the four villages. Lead (Pb) is a very toxic metal which cannot be destroyed and does not break down into other substances. Therefore, when lead is released into the environment it will be a threat to living organisms. Cadmium (Cd) is also a heavy metal which can inhibit lung activity, even lead to lung cancer, nausea, vomiting, diarrhea, cramps, anemia, dermatitis, slow growth, kidney and liver damage and cardiovascular disorders if accumulated over a long period of time and also damage bone (Osteomalacia, osteoporosis) and increase blood pressure. This study aims to determine the effect of heavy metal pollution of Pb and Cd and water quality in Karangsong waters, Indramayu Indonesia.

**MATERIALS AND METHODS**

**Research Methods:** The research was conducted in April - May 2016 in Karangsong Waters, West Java (Fig. 1) with three different stations (Table 1). Pb and Cd measurement tests were performed at the Chemical-Analytic Laboratory, Padjadjaran University.
Table 1: Sampling Point Locations

<table>
<thead>
<tr>
<th>Station</th>
<th>Coordinate</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>06°19'55.4&quot; S and 108°22'20.1&quot; E</td>
<td>Estuary in Langgen, Singaraja</td>
</tr>
<tr>
<td>2</td>
<td>06°18'08.4&quot; S and 108°22'18.2&quot; E</td>
<td>Beach near Karangsong Mangrove Forest</td>
</tr>
<tr>
<td>3</td>
<td>06°18'17.2&quot; S and 108°22'21.5&quot; E</td>
<td>Pier in Karangsong Beach</td>
</tr>
</tbody>
</table>

The method used in this research is survey method of research methods without special treatment toward the observed variables with the aim to obtain and find useful information factually about the object. Sampling stations were determined by using survey method with purposive sampling technique based on certain purpose and according to various considerations. The obtained samples were analyzed in the laboratory by using Atomic Absorption Spectrophotometry (AAS) [12] to find the heavy metal content.

Station locations were determined based on activities in the waters that can cause pollution, especially Pb and Cd. Three random sampling points were taken on each station. Environmental parameters such as temperature, salinity, clarity and pH were measured by in situ at the sampling site with reference to INS 6989.57-2008 [13]. Seawater sampling was performed simply by inserting seawater from the observed station into a dark bottle and then storing it in a cool box. Pb and Cd testing procedures were referring to INS 6989.8: 2009 [14] and INS 6989.16: 2009 [15].

**RESULTS AND DISCUSSION**

Pb is a toxic metal which cannot be destroyed and does not break down into other substances. Therefore, when lead is released into the environment, it will be a threat to living beings. Cd is a by-product of zinc processing (Zn) which is used to substitute zinc. This element is flexible, resistant to pressure, has a low melting point and can be utilized for mixing other metals such as nickel, silver, copper and iron. Cadmium has a low boiling point and easily concentrated when entering the atmosphere. Water can also be contaminated by sediment and mining waste containing Cd and when mixed with smoke will caused air contamination [16]. Water quality test results (Table 2) of the three observation stations showed high concentrations of Pb and Cd which has exceeded the quality standard. The highest concentration of Pb was found at station 1 (Estuary in Singaraja sub-district near Pertamina oil refinery) by 0.517 mg/L. Pb in three stations has exceeded the standard quality threshold set by Ministry of environment decree of Indonesia, No. 51 year 2004, on the Quality Standard of Sea Water for marine biota by <0.008 mg/L (Fig. 2).

High level of Pb containing in seawater around Indramayu waters is presumably due to the processing and distribution of petroleum activity which are suspected to be the main factor for Pb contamination in Indramayu Sea Waters. According to Rahmadiani and Aunurohim [17] heavy metals contamination and oil spills in the ocean is influenced by wind and currents. Thus, although the distance between station 2 (Near mangrove) and Pertamina's location is quite far away, but the waters in station 2 is highly polluted by Pb and Cd.

The value of Cd contained in water samples obtained from all three stations (Fig. 3) has exceeded the standard quality threshold. The highest content of Cd was found in station 1 (0.073 mg/L), as well as lead (Pb) content found in the station (Fig. 2). The result of Cd concentration from 3 stations were compared with the Quality Standard based on Ministry of environment decree of Indonesia, No. 51 year 2004 on the Standard of Sea Water Quality for Marine Water Biota with maximum content of 0.001 mg/L and the Quality Standard for Marine Tourism is 0.002 mg/L. According to Bigalke et al. [18] Cd is an organic pollutant or mineral which can be accumulated in waters and food. Generally, cadmium contained in the waters will become Cd+2, causing aquatic toxicity. The higher concentration of Cd in the sediments as compared to other estuary can be attributed mainly to the unprecedented industrial development in the surrounding town and cities [19].

Table 2: Water Quality Testing Results in KarangsongIndramayu

<table>
<thead>
<tr>
<th>Station</th>
<th>Pb concentration in the water (mg/L)</th>
<th>Cd concentration in the water (mg/L)</th>
<th>Temperature (°C)</th>
<th>Salinity (%)</th>
<th>Clarity (m)</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.517</td>
<td>0.073</td>
<td>32</td>
<td>23</td>
<td>2.32</td>
<td>6.4</td>
</tr>
<tr>
<td>2</td>
<td>0.506</td>
<td>0.072</td>
<td>32</td>
<td>29</td>
<td>2.26</td>
<td>6.5</td>
</tr>
<tr>
<td>3</td>
<td>0.393</td>
<td>0.040</td>
<td>32</td>
<td>27</td>
<td>2.25</td>
<td>6.5</td>
</tr>
</tbody>
</table>
Physical tests conducted were including temperature at the three stations with the same result of 32°C. The obtained temperature is quite high because the observation time was during the day when the temperature is strongly influenced by sun exposure. During the day, the intensity of sun exposure reach its maximum level, making the water temperature to increase. According to Effendi [20] the intensity of sun exposure and calm water surface conditions will increase the absorption rate of heat into the water, making the water temperature becomes maximum. Temperature is one of the parameters that may affect the spread of toxic materials into the aquatic environment, in which the higher the water temperature, the more heavy metal solubility rate [21]. This is caused by the increase in water temperature, which will cause a decrease in dissolved oxygen levels, resulting in anaerobic conditions. At anaerobic or oxygen-depleted conditions, heavy metals such as Pb will be reduced to Pb divalent (Pb²⁺), where Pb divalent is more dangerous than tetravalent Pb (Pb⁴⁺) [22]. Based on the quality standard by Ministry of environment decree of Indonesia, No. 51 year 2004, the safe limit of temperature for marine biota life in the range of standard quality that has been set at 28-30°C. The results of the tests conducted in three stations (Table 2) are above the standard quality, but the intensity of exposure factors may affect the temperature [23].

Other physical test is water clarity which depends on the color and turbidity of the water. The measurement was performed by using Secchi disk. Water clarity level is strongly influenced by weather conditions, measurement time, turbidity and total suspended solids as well as the accuracy level of the person performing the measurements. This measurement should be done during sunny weather [20]. The results of water clarity measurement in three stations showed that water clarity level in all three stations are below the quality standard set by Ministry of environment decree of Indonesia, No. 51 year 2004 (> 5 for coral reef and > 3 for seagrass bed). Low water clarity level in this region is presumably due to contamination of spills oil in the waters.

The results of salinity test conducted from the three observation stations showed that station 1 has a lower salinity level compared to other stations. This difference can be affected by land and sea factors. Azwan et al. [21] stated that estuarine aquatic conditions are affected by land and ocean influences, where high salinity levels occur when the influence of the oceans is more dominant.
than land influences and low salinity levels occur when fresh water enters the estuary through river streams. Station 1 is located in freshwater estuary, close to the mainland.

High salinity level in the waters can disrupt the growth rate of fish. This is because most of the energy owned by the fish is widely used for osmoregulation process. Likewise with low salinity value which can increase the metal toxicity in the waters. Hananingsitas [24] stated that the decrease of salinity level may result in increased toxicity especially for heavy metals and increased metal fraction in the form of divalent cations in waters as well as the increasing disturbance toward physiological factors.

Salinity levels in the three observation stations in the waters of Indramayu Regency (Table 2) are still within safe limits for marine life because it is still within the range of quality standards established by Ministry of environment decree of Indonesia, No. 51 year 2004 (0,5-34 ‰). The obtained pH values in three stations (Table 2) are low but still within tolerable limits. pH value will affect the concentration of heavy metals in the water, in which the solubility of heavy metals will be higher at acidic pH, resulting in greater heavy metal toxicity. According to Palar [22] the higher pH values (Base) will cause the stability turn from carbonate to hydroxide. This hydroxide will easily form a chemical bond with the particles present in the water body. Therefore, the compound between the hydroxide and the particles in the water is created.

CONCLUSIONS

Based on the results of physicochemical and heavy metals test, it can be concluded that: the concentration of Pb and Cd located at three different stations are highly exceeding the quality standard threshold. The highest concentration of Pb was 0.517 mg/L while the highest concentration of Cd was 0.073 mg/L. Physical test results showed a high level of temperature (32°C), the average value of pH in the waters of Indramayu Regency is still within the quality standard set by Ministry of environment decree of Indonesia No. 51 Year 2004 by 6.5 - 8, average clarity of 2.27 which is below the quality standard. Chemical parameters such as salinity and pH showed that the waters still within the standard quality threshold set by the government with an average salinity level of 26.3 ‰ and an average pH of 6.5.

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REFERENCES