Cadmium (Cd) content in mangrove oyster (*Crassostrea sp.*) in tapak coastal water semarang, Indonesia

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Abstract. Tapak area is an estuary of Tapak river where there are many mangrove and oysters (*Crassostrea* sp.) found. The development of industrial estate there has been affect Tapak waters, due to waste contamination containing heavy metals. This in turn will affect the occurrence of heavy metal accumulation in oysters, a cheap fisheries protein source. This research is purposed to identified Cadmium (Cd) content in oysters and water of Tapak coastal waters, Semarang. Sampling was taken through justified random sampling. Laboratory analysis of Cd performed by using Atomic Absorbtion Spectrofotometer (AAS). Data analysis were undertaken using descriptive analysis, numerical indices and statistical analysis. Result showed that Cadmium (Cd) content in oyster in tapak areas were ranged between 0.242 - 0.402 mg/kg, with average 0.340 mg/kg. This value is still below water quality standard regulated by ISO 7287 by 2009 in amount of 1.0 mg/kg. It is concluded that Cadmium (Cd) within the oyster is still low stage, yet there should be carefully consumed, because Cadmium (Cd) was toxic and bioaccumulative heavy metal.

1. Introduction
Oysters *Crassostrea* sp is edible shellfish that mostly live in mangrove waters. People usually catch *Crassostrea* sp for protein source from various places, including around the estuary and coastline water. This molluscs has high potent to accumulate heavy metals compound released from industrial and transportation activities [1,2]

Tapak river which is located on the north coast of Semarang City face about the similar situation. This area is close to the residential and the Wijaya Kusuma Industry Areas.) [2]. The Environment Agency (BLH) of Semarang City stated, there were approximately 14 industries located around Tapak River. These activities produces and disposes of waste containing heavy metals including Cd to the river [3]. The metals can interact to oysters *Crassostrea* sp. through ingestion. Oysters is one of the important public commodities in Tapak. Oysters are belong to Mollusca which are well known as accumulator to heavy metal [4]. Prolong consumption of oysters can trigger accumulation in the human body and endanger human health [2].

The purpose of this studies are to analyze the content of Cd metal in oyster flesh, water and substrate. Besides that, it also to knows the metal accumulation factor in *Crassostrea* sp in Tapak Semarang waters

2. Methods
The study was conducted in August 2017 in the mangrove waters area of Tapak, Tugurejo Village, Tugu District, Semarang City. This research is observational study, using comparative analysis [5]. The sampling
technique was carried out with justified random sampling. The data used in this study was oyster population taken by sampling using a 1 x 1 m² plot size and repeated 3 times. Oyster samples were taken from 3 research stations (Figure 1). Based on the variety habitat their found, oyster sampling was done by taking (gouging it) directly from the hard substrate where it attach. The sample collection was put in the plastic sample and encased within the coolbox.

In the laboratory, the Atomic Absorption Spectroscopy (AAS) method was chosen to determine the Cd on the oyster flesh, water and sediment [6]. Estimation of concentration factor (BF), that proportion of was the heavy metal content in oyster flesh related to heavy metal content in water was also done, as done by [7], namely

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\text{Bioconcentration Factor} = \frac{\text{Cd concentration in oyster flesh}}{\text{Cd concentration in the water}}
\]

The data obtained were processed by descriptive analysis and statistics. Statistical test was run with F test (ANOVA) and further test was followed by LSD to process quantitative data [8]. Descriptive tests were conducted to see the conditions of heavy metal pollution in oyster flesh in Mangrove Waters. The final results of heavy metal values were compared to the quality (value) standards of the Indonesian National Standard (SNI) No.7387 Year. 2009 concerning the maximum limits of heavy metal contamination in food

![Figure 1](image_url)

**Figure 1.** Research Station in Mangrove waters, of Tapak village, Tugu, Semarang

Notes: St A: Coastline water (front estuary), St B: Mid Estuary, St C: Backside estuary (Close to pond area)
3. **Results and discussion**

3.1. **Cadmium content (Cd) in Oyster Flesh**

The results showed that value of Cd in oysters ranges from 0.24 to 0.40 mg / kg (Table 1). The Cd value in the waters ranged from 0.015 - 0.016 mg / l. Based on BSN (2009) concerning limit level, Cd value in oyster flesh here is still under the threshold value namely 1.0 mg/kg.

| Cd content (mg/kg) on Oyster flesh (mg/kg) | Station A | Station B | Station C | Threshold value* |
|-------------------------------------------|-----------|-----------|-----------|-----------------|
|                                           | 0.40      | 0.37      | 0.24      | 0.34            | 1.0 mg/kg*      |

Station A: front estuary /coastal water, B: Mid estuary, C: backside estuary (close to pond area)

*SNI nomor 7387 tahun 2009

In general, it can be seen that there is a tendency a decrease in heavy metal concentration from coastline (station A) to backside pond water (station C) (Figure 3). The highest content is measured at station A (coastline water) as much as 0.402 mg/l, while the lowest cadmium content is found at Station C (pond waters) i.e. 0.243 mg / l. whereas station B (middle estuary) is almost the same as station A, (0.378 mg / l). Based on BSN in year 2009 [7], the levels of cadmium heavy metals were still below the standard threshold of 1.0 mg / l.

The high metal content of Cd in oyster flesh at station A is related to the coastline hydro-dynamic with high mud portion. Based on research done by Hidayat & Hariyati [9] in the same location, showed this coastline has highest sludge content compared to other stations. Mud has a high adsorption capacity of heavy metals resulting in high metals accumulation. Rochyatun et al. [10] stated that sediment, i.e. mud has a high heavy metal content compared to sand. In addition, in this location there is also lack of mangroves stand which results in low heavy metal uptake.

![Figure 2. Values of Cd concentration on oyster flesh](image-url)
Open water body here is also affected by water movement (smooth current) which tends to bear sedimentation. Martuti, et al. [2] added that the dynamic movement of water also caused the rise of sediments, which could cause the metal deposited in the sediment layer to rise above the water value.

Meanwhile, the concentration of cadmium in oyster flesh varies between 0.243 - 0.402 mg / kg. The lowest value is measured at station C, which related to the presence of mangrove stands that grow around the area. Mangrove stands are very strong in suppressing the concentration of heavy metals in water [4] including Cd. The denser the mangrove the more mud accumulation. The mud content based on the research of Hidayat and Hariyati [9] in the waters in Station C has high mud amount. Although it has heavy metal content in high sludge, the dense of mangrove plants around the location still can suppress the levels of heavy metals, including Cadmium in the waters. As stated by Martuti et al [2] that based on the interpretation of the Quickbird image regarding land use in Tugu Subdistrict, shown that mangrove vegetation in the Tapak area, Tugurejo is seen abundance in the Tapak River watershed. Kusumastuti et al [12], states that the mangrove root system also holds the sediment and so do heavy metals. Kumar et al [1] and Gautier et al., [13] mentioned that mangrove ecosystems play an important role as a filter and control of pollution. The root system of mangrove are enable of controlling water quality and are participate in sedimentary and particles traps transported by current. Station C waters have relatively slow in currents so the possibility of sediment mixing with the water column is very little. According to Astrini, et al. [14] current velocity in Tapak waters area ranged from 0.13 to 0.26 m / s. Flow is a factor that limits the spread of makrozoobenthos, where the current velocity will affect the type or grain size of substrate of the water [15].

The Cd metal content in oysters at station B is 0.378 mg / l. High level of mud content of this station is believed to cause high levels of Cd. The content of Cd in sediment is higher compared to sea water. This is consistent with the study by Rachmansyah and Taufik [4] which states that the content of heavy metals in sediments is higher compared to their contents in the waters column above. The content of Cd in sediment is higher because the sediment is enable to bind organic and inorganic compounds in high concentration.

3.2. The Cadmium (Cd) Bio-accumulation in Oyster (Crassotrea sp.)

The occurrence of heavy metal accumulation on oysters can be seen from Table 2 which shows an increase in the level of Cd heavy metals base in the waters <0.1, while in the body of the oyster it increases to 0.242 - 0.402 mg / l. This shows that even the smallest levels of heavy metals in the body of water can cause heavy metal accumulation (higher) in the body of the oyster. From the data presented (Table 2), the highest level of accumulation occurs at station A. Such a high value is consistently related to the mud and mangrove factors. Mangrove and sediment components have a large capacity to accumulate heavy metals. However, the ability to hold heavy metals depends on the age of the stand and biomass production [17]. According to Afiati [18], the content of heavy metals in sediment is high because it might result from binding of several components of compounds, such as organic particles, ZnO2, MnO2, and clay. In addition, physical chemistry of waters, especially salinity also affects the level of accumulation. It is known that the salinity value at station A is higher than that of other stations, namely 30%, the increase in salinity levels in a waters is directly proportional to the increase in the level of Cd accumulation in biota in these waters. As stated by Metian et. al. (2008) in Machrek-Ajmi et.al [23] for Cd metal, the accumulation of metals in the biota becomes higher when it is in high salinity.
Tabel 2. Bioakmulasi Cd di kawasan Mangrove Tapak

| Station | Concentration of Cd (mg/l) in Water | Oyster flesh |
|---------|-----------------------------------|--------------|
| A       | 0.015                             | 0.402        |
| B       | 0.016                             | 0.378        |
| C       | 0.016                             | 0.242        |

Notes: Station A: front estuary /coastal water, B: Mid estuary, C: backside estuary (close to pond area)

3.3. Bioconcentration Factor (BCF)

Based on the graph (Figure 2), it can be seen that there is a trend shows a decrease in the value of bioconcentration factors with a range of 15.12-26.8. Thus, the accumulative properties of Cd for oysters at the study site are included in low accumulative properties. These results differed considerably from the results of Martuti’s et al., research [2], conducted on milkfish meat where the bioconcentration factor (BCF) of cadmium milkfish meat in the Tapak Semarang pond was 2.25. This value, however, still qualified as in low accumulative properties. The value of the concentration factor can be determined by the type of heavy metal itself, the metal content in the study location and the ability of each organism to accumulate metal. In addition, metals that have a high concentration factor index indicate that the metal is more easily accumulated [20]

Figure 3. Bioconcentration factor of Cd in different station

4. Conclusion

The heavy metal content of cadmium (Cd) in water in Tapak is already exceeds the threshold set in the Minister of Environment Decree No. 51 of 2004 [23] concerning the quality standards of sea water for marine biota. Bioaccumulation of heavy metal cadmium (Cd) in Oyster flesh from the Tapak Semarang mangrove area is still far below the threshold regulated by SNI 7287: 2009 in 2009. Oyster Bioconcentration Factor (BCF) is still in the low accumulative category. Since it was categorized as toxic contamination of cadmium, therefore the consumption of the fish product here should be carefull.

5. Suggestion

The suggestion of this study is that the need to do to other heavy metal compound, to get a more complete picture about the contamination of heavy metals in the Mangrove Waters of Tapak. In addition, research needs to be carried out from upstream (river) to downstream, so that it can accurately predict the source of
metal pollution. It is also preferable to take oysters for consumption and culture to be selected in the waters around Tambak. The community should be more careful in consuming excessive consumption of oysters, considering the waste contamination in the Tapak area is not only from cadmium, but there are other compound of heavy metals and the heavy metal properties that can accumulate in the body which run will cause disease. Finally it is necessary to conduct a purification study on the potential of these natural resources so that they are healthy to eat.

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