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# Bioaccumulation of Cadmium (Cd) Heavy Metal on Seaweed (*Gracilaria* sp.) in Traditional Fishpond of Jabon Subdistrict, Sidoarjo District

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**Abstract.** Contamination of poisonous chemical substance is the main problem of every country, one of them is cadmium (Cd). Cd is heavy metal with high mobility from the environment to organisms, especially plants, and will have effect on the food chain. *Gracilaria* sp. is one of the biota capable of accumulating heavy metals through adsorption on the surface of *talus* in the form of cations, anions, or organic compounds. The high Cd content in the environment will lead to the higher amount of Cd accumulated by *Gracilaria* sp. This research aims to learn the bioaccumulation of Cd in seaweed (*Gracilaria* sp.), water, and sediment in Traditional Fishpon of Jabon Subdistrict, Sidoarjo District. This study used observation method, examination of Cd content using Atomic Absorption Spectrophotometry (AAS), and data analysis using the same method. The result of analysis of Cd content in fishpond water with an average of 0.0144 mg/l surpasses the 0.01 mg/l threshold established by Research Regulation Number 82 (2001), Cd content in sediment and *Gracilaria* sp. is <0.0024 mg/kg and is below the 0.2 mg/kg threshold established by BSN (2009).

**Keywords.** Cadmium; *Gracilaria* sp.; bioaccumulation; Jabon Subdistrict Fishpond

## 1. Introduction

Sidoarjo District has potentials in the field of pond fisheries with an approximate area of more than 29.9% of the whole place. It is a quite big potential if it is empowered, so pond cultivation will develop (Ansoriyah et al., 2013). Jabon is one of the subdistricts with a pond area of 4,144.07 Ha with productivity at 1,072.81 Kg/Ha (Yuniar et al., 2010). Fishponds in Jabon Subdistrict is one of those that produce *Gracilaria* sp., one of the seaweed species from rhodophycophyta (red algae) division generating agar with high selling value and is spread in almost all tropical waters (Bold and Wynne, 1978). Fishpond in Jabon Subdistrict utilizes Porong River's estuary as the water source for cultivation. Porong River always deals with pollution contamination, especially of heavy metal. This river is a branch of Brantas River which passes through several districts, such as Kediri District, Jombang District, and Mojokerto District, industrial areas that produces domestic waste disposal (Fitrianto, 2012).

Environmental pollution by heavy metals is an issue that roots from the accumulation of heavy metals gradually in food chain (Sati et al., 2016). Water pollution originates from community activities such as fisheries (capture and cultivation), industry, and tourism, causing pollutant to enter the waters.



One of the heavy metal contamination in waters is cadmium (Cd) (Rumahlatu, 2012). Cadmium is a heavy metal with high toxicity; at a low level it can cause acute and chronic impacts on health and the environment. Cadmium is an element that is non-degradable in nature; once released in the environment, it will remain in circulation. Cadmium can come from nature and industrial waste, such as mining output, smelting, and refining of zinc and copper sulfide ore (Cowi, 2003). It is a toxic heavy metal and is considered non-essential metal for the survival of organisms (Lamai et al., 2005). Cadmium concentration in industrial waste is between 0.01 to 3.2 mg/l (Kulkarni and Kaware, 2013).

Bioaccumulation is a process of extracting chemical substance coming from the environment by living creatures and is marked by an increase in chemical substance concentration in organism's body compared to the concentration of chemical substance in the environment (Puspitasari, 2007). Algae accumulates heavy metal coming from aquatic environment (Lamai et al., 2005). Nasuha et al. (2014) stated that heavy metals enter and are accumulated in the form of cation, anion, or organic compounds through adsorption process on the surface of seaweed's (*Gracilaria* sp.) *talus*. The accumulation of heavy metals by aquatic biota will affect food chain, so it is feared that it will endanger the health when it is consumed by human.

The content of cadmium accumulated in fishpond water and sediment will have impact on the bioaccumulation of cadmium (Cd) on *Gracilaria* sp. at Traditional Fishpond of Jabon Subdistrict, Sidoarjo District. With this basis, it is necessary to conduct a research on the bioaccumulation of cadmium (Cd) heavy metal on seaweed (*Gracilaria* sp.) at Traditional Fishpond of Jabon Subdistrict, Sidoarjo District. This study will provide information on the cadmium bioaccumulation content in *Gracilaria* sp.

## 2. Methodology

This study was conducted from June to July 2018 at several places, namely Traditional Fishpond of Jabon Subdistrict, Sidoarjo District for sampling, and at Research and Industrial Standardization Center (BARISTAND) Surabaya for analysis of cadmium (Cd) heavy metal content.

Several tools were used in this study to collect sample, namely Global Positioning System (GPS), wrapping plastic, label, cool box, water sampler, PVC pipe, water quality tester or thermometer, pH pen, refractometer, and a set of Atomic Absorption Spectrophotometry (AAS) device for heavy metal analysis. Materials used in this study are *Gracilaria* sp., pond water, sediment, and standard material for cadmium solution, concentrated HNO<sub>3</sub> solvent, *aquades*, and acetylene fuel.

Observation method was used in this study. It is a method of data collection using eyes without any supporting tool for such purpose (Nazir, 1999). This method aims to make an observation, description, or image in a systematic, factual, and accurate way on the facts, natures, and relationship among the phenomena being investigated to a number of matters related to cadmium heavy metal bioaccumulation on seaweed.

To determine the sampling station for water, fishpond sediment, and seaweed, a preliminary survey was conducted beforehand to learn the geographic condition and activities around the research environment (Hadi, 2007). Global Positioning System (GPS) was used to determine the geographic coordinate of each sampling station, while the selection of fishpond for each station was done by using the distance from Porong River estuary, the main source of water for seaweed cultivation in that pond.

Sampling of seaweed, pond water and sediments was done using a simple random sample method. A simple random sample is simple random sampling from a population in a way that each member of the population has the same chance to be selected as a sample member (Kusniningrum, 2012).

Seaweed samples were taken based on the number of plants incidentally taken at three points of each station in the pond of Jabon Subdistrict, Sidoarjo District. The collected seaweed samples were then put in a cool box and transported to the laboratory for analysis of heavy metal content.

Water sample was collected using glass bottles at 30 cm below the surface of the water as much as  $\pm 100$  ml and put in a bottle (Zhang, 2007). The bottle containing the water sample was included in the cool box and the transportation process was carried out to the laboratory for analysis of heavy metal content.

Sediment sampling in the ponds can be carried out using PVC pipes by sticking them at 1-5 cm depth (Yustika and Rozuli, 2009), and the amount of sediment taken in each station is 200 grams. The collected sediments were put in a plastic bag, put in a cool box and transported to the laboratory for analysis of heavy metal content. Analysis of cadmium content in seaweed, water and sediment was conducted using the Atomic Absorption Spectrophotometry (AAS) method at BARISTAND Surabaya.

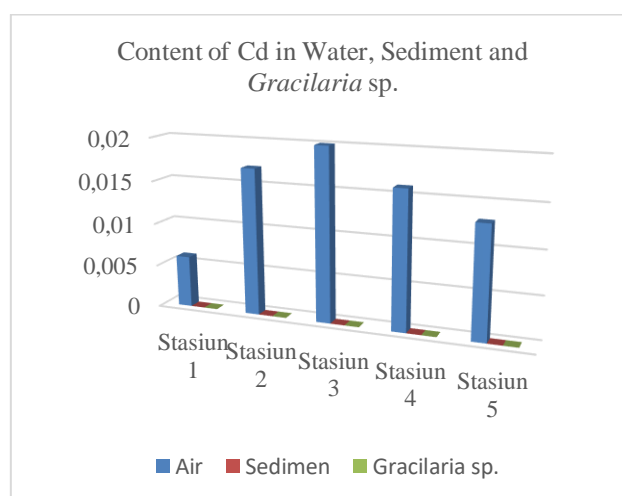
### 3. Results and discussion

The results of the analysis of cadmium content in Traditional Fishpond of Jabon Subdistrict show an average concentration of 0.0144 mg/l and <0.0024 mg/l at the lowest. Complete results of analysis can be seen in Table 1. The highest cadmium content in pond water is found in station 3 at 0.020 mg/l, while in station 1 at 0.006 mg/l, station 2 at 0.017 mg/l, station 4 with 0.016 mg/l, and station 5 with 0.013 mg/l cadmium content. The results of the analysis of cadmium heavy metal content in sediment and seaweed collected from all five stations can be seen in Table 1. The table shows that the concentration of cadmium heavy metal in the sampling spots is all the same <0.0024 mg/kg. This value is still below the 0.01 mg/kg threshold for sediment established in Government Regulation Number 82 (2001) and 0.2 mg/kg threshold for seaweed in accordance with National Standardization Agency (BSN) (2009).

**Table 1.** Results of analysis of cadmium content in water, sediment, and seaweed.

Sampling Spot	Fishpond Water Sample (mg/l)	Sediment Sample (mg/kg)	Seaweed Sample (mg/kg)
Station 1	0.006	<0.0024	<0.0024
Station 2	0.017	<0.0024	<0.0024
Station 3	0.020	<0.0024	<0.0024
Station 4	0.016	<0.0024	<0.0024
Station 5	0.013	<0.0024	<0.0024
Average Cd Concentration ( $\pm$ SD )	0.0144 $\pm$ 0.0053	<0.0024	<0.0024

Results of analysis of cadmium content in pond water in five stations show an average of 0.0144  $\pm$  0.0053 mg/l, above the threshold established by Government Regulation Number 82 of 2001 on quality of water and water pollution control, namely 0.01 mg/l of cadmium content in waters that can be used for fisheries. The highest cadmium content in water is in station 3 with 0.020 mg/l concentration. It was supported by water quality value at 31°C temperature, 25 ppt of salinity, and 8.4 pH. This is consistent with Darmono's (1995) argument saying that heavy metal content will be higher in dry season since metals will be more concentrated. In station 2, 4, and 5, the cadmium content, respectively, is 0.017 mg/l, 0.016 mg/l, and 0.013 mg/l. Cadmium content in station 1 is the lowest at 0.006 mg/l. Such result is thought to be affected by water quality such as salinity, pH, and temperature, which is also in line with Darmono (1995) who claimed that heavy metal content in water can change anytime and depends on the environment and climate. Besides, it is also influenced by water intake coming from more than one source, leading to the uneven concentration in each station. Water intake through station 1 and 2 comes from Tegal Sari River, station 3 and 5 from Gluwo River, and station 4 from Mrutu River. The many sources of water intake lead to the different contents of cadmium in each station. Graph of cadmium content in water, sediment, and *Gracilaria* sp. can be seen in Figure 1.



**Figure 1.** Content of Cd in water, sediment, and *Gracilaria* sp.

The content of cadmium in Sediment is low, namely  $<0.0024$  mg/kg, due to its inability to settle in the sediment as a result of the pH being in an average of 8.4. It was supported by Palar's (2008) argument that heavy metal entering the aquatic environment will face precipitation, depending on the pond water acidity; the lower the acidity, the higher the metals' solubility since pH changes the stability from carbonate form into hydroxide that binds with particles in the water body. The sediment samples from station 1 to station 5 show the same result of  $<0.0024$  mg/kg, still below the 0.01 ppm threshold established by Government Regulation Number 82 (2001) and lower than cadmium content in pond water. Cadmium accumulation in sediment depends on the cadmium's solubility in water and the solid form of cadmium, i.e. its availability in organic and inorganic form (Susanto et al., 2014).

Results of analysis of cadmium content in *Gracilaria* sp. from station 1 to station 5 show the same amount of  $<0.0024$  mg/kg, below the 0.2 mg/kg threshold established by National Standardization Agency (BSN) (2009). It means that there is a cadmium bioaccumulation process in *Gracilaria* sp. at a very low concentration. Factors that affect the low heavy metal concentration in seaweed are biological and environmental factors. The content of cadmium in sediment is low, at  $<0.0024$  mg/kg, which is thought to be affected by normal water quality. Ashar et al. (2014) claimed that metal content in sediment also has impact on the process of cadmium bioaccumulation in seaweed, leading to the low accumulated heavy metal with  $<0.0024$  mg/kg.

*Gracilaria* sp.'s absorption ability depends on the availability of toxic metals in the water (Yulianto et al., 2006). The higher the availability of toxic metals in the water, the higher absorption it is by *Gracilaria* sp. The absorption of heavy metal in high concentration and continuous running will lead to body metabolic disorders and anatomy damage, reducing the absorption as a result of *Gracilaria* sp.'s decreased physiological condition.

#### 4. Conclusion

Based on the results of study conducted in Jabon Subdistrict, Sidoarjo District, the concentration of cadmium (Cd) heavy metal in pond water exceeds the threshold with an average of 0.0144 mg/l, while as for sediment and seaweed (*Gracilaria* sp.), the numbers are below the threshold with  $<0.0024$  mg/kg.

#### 5. References

- [1] Ansoriyah, L., A. Suryono., dan A. Said. 2013. Implementasi Permen Kelautan dan Perikanan Nomor Per.12/Men/2010 tentang Minapolitan dalam Rangka Mengembangkan Kawasan Minapolitan sebagai Pusat Pertumbuhan Ekonomi. J. Admin. Publik. 2 (2) : 230-235.

- [2] Ashar, Y. K., E. Naria., dan S. Dharma. 2014. Analisis Kandungan Kadmium (Cd) dalam Udang Windu (*Penaeus monodon*) yang Berada di tambak Sekitar Tempat Pembuangan Akhir (TPA) Sampah Kelurahan Terjun Kota Medan. Universitas Sumattera Utara. Hal 1-10.
- [3] Badan Standardisasi Nasional (BSN). 2009. Batas Maksimum Cemar Logam Berat dalam Pangan. Standar Nasional Indonesia (SNI) 7387: 1-29.
- [4] Bold, H. C. and M. J. Wynne. 1978. Introduction to The Algae: Structure and Reproduction. Prentice-Hall of India Private Limited. New Delhi. pp. 451-565.
- [5] Cowi. 2003. Cadmium Review. Nordic Council of Ministers. 1 (04) : 1-26.
- [6] Darmono. 1995. Logam dalam Sistem Biologi Makhluk Hidup. Penerbit Universitas Indonesia (UI-Press). Jakarta. 140 hal.
- [7] Fitrianto, A. R. 2012. Shrimp Farmers' Innovation in Coping with the Disaster (a Case Study in Sidoarjo Mud Volcano Disaster Toward Shrimp Farmers' Responses). J. Procedia Economic and Finance. 4 (2012) : 168-176.
- [8] Hadi, A. 2007. Prinsip Pengelolaan Pengambilan Sampel Lingkungan. Gramedia Pustaka Utama. Jakarta. 134 hal.
- [9] Kulkarni, S. J. and J. P. Kaware. 2013. A Review on Research for Cadmium Removal from Effluent. International Journal of Engineering Science and Innovative Technology (IJESIT). 2 (4) : 1-5.
- [10] Kusurningrum, R. S. 2012. Perancangan Percobaan. Airlangga University Press. Surabaya. hal 5-6.
- [11] Lamai, C., M. Kruatrachue, P. Pokethitiyook, E. S. Upatham, and V. Soonthornsarathool. 2005. Toxicity and Accumulation of Lead and Cadmium in the Filamentous Green Alga *Cladophora fracta* (O.F. Müller ex Vahl) Kützing: a Laboratory Study. ScienceAsia. 31 : 121-127.
- [12] Nasuha, T., Yuliani., dan N. K. Indah. 2014. Efektivitas *Gracilaria gigas* sebagai Biofilter Logam Berat Timbal (Pb) pada Media Tanam. J. LenteraBio. 3 (1) : 91-96.
- [13] Nazir, M. 1999. Metode Penelitian. Ghalia Indonesia. Jakarta. 62 hal.
- [14] Palar, H. 2008. Pencemaran dan Toksikologi Logam Berat. Rineka Cipta Cetakan ke-4. Jakarta. 152 hal.
- [15] Peraturan Pemerintah. 2001. Pengelolaan Kualitas Air dan Pengendalian Pencemaran Air. Nomor 82. Jakarta. 1-31.
- [16] Puspitasari, R. 2007. Laju Polutan dalam Ekosistem Laut. Oseana. XXXII (2) : 21-28.
- [17] Rumahlatu, D. 2012. Biomonitoring: sebagai Alat Asesmen Kualitas Periran Akibat Logam Berat Kadmium pada Invertebrata Perairan. J. SAINSTIS. 1 (1) : 10-34.
- [18] Sati, M., M. Verma, M. Bora, and J. P. N. Rai. 2016. Potential of Algae in Bioremediation of Heavy Metals: A Review. Bull. Env. Pharmacol. Life Sci. 5 (11) : 86-97.
- [19] Shiva Kiran. R. R., Madhu G. M., Satyanarayan S. V., and Bindya P. 2012. Bioaccumulation of Cadmium in Blue Green Algae *Spirulina (Arthrospira) indica*. J. Bioremed. & Biodegrad. 3 (3) : 1-4.
- [20] Susanto, F., N. V. Hidayati, and A. D. Syakti. 2014. Assessment of Cadmium (Cd) Contamination in Mud Crab (*Scylla* spp.) and Sediment from Segara Anakan Lagoon, Cilacap, Indonesia. Omni-Akuatika. XIII (19) : 60-70.
- [21] Yulianto, B., R. Ario., dan A. Triono. 2006. Daya Serap Rumput Laut (*Gracilaria* sp.) terhadap Logam Berat Tembaga (Cu) sebagai Biofilter. Ilmu Kelautan. 11 (2) : 72-78.

- [22] Yuniar, D. W., T. W. Suharso., dan G. Prayitno. 2010. Arahana Pemanfaatan Ruang Pesisir Terkait Pencemaran Kali Porong. J. Tata Kota dan Daerah. 2 (2) : 1-12.
- [23] Yustika, A. E. Dan A. I. Rozuli. 2009. Studi Implikasi Pengelolaan Irigasi terhadap Akses Air dan Pendapatan Petani. Laporan Hibah Penelitian Strategi Nasional Tahun 2009. Universitas Brawijaya Malang. 10 hal.
- [24] Zhang, C. 2007. Fundamentals of Environmental Sampling and Analysis. Wiley-Interscience A John Wiley & Sons, Inc., Publication. pp. 69-92.