Poll Res. 40 (2) : 593-597 (2021)

ISSN 0257–8050

DETERMINATION OF LEAD AND CADMIUM IN EDIBLE WEDGE CLAM *(DONAX FABA)* COLLECTED FROM NORTH AND SOUTH COASTS OF SUMENEP, EAST JAVA, INDONESIA

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(Received 25 August, 2020; Accepted 7 November, 2020)

ABSTRACT

As a filter feeder species, edible bivalves are prone to heavy metal contamination that can affect the human health. The objectives of this study were to investigate the concentration of Lead (Pb) and Cadmium (Cd) in commercial Donax faba sourced from spatially different coasts and to determine the risk of the selected heavy metals to human health. The spatial differences were represented by the North coast (Gian Beach) and the South coast (Slopeng Beach) of Sumenep Regency, Madura Island, Indonesia. The Pb and Cd concentrations of the clam samples were measured in an Atomic Absorption Spectrometer. The health risk potential from the consumption of *D. faba* clams was calculated by Total Hazard Quotient by determining the Average Consumers (AC) and the High Consumers (HC). Based on the result of independent t-test, significant differences of Pb and Cd concentrations between the North coast and the South coast of Sumenep ($p < 0.05$). The highest concentration of Pb and Cd was found in the South coast, 0.796 ± 0.071 mg/g and 0.057 ± 0.009 mg/g, respectively. The calculation of health risk potential showed no health effect from the consumption of *D. faba* clams for both the AC and the HC, thus safe for human consumption.

KEYWORDS: Heavy Metal, Pollution, *Donax faba*, Spatial Difference, Health Risk

INTRODUCTION

Heavy metal contamination is increasing gradually due to greater anthropogenic activities in the last few decades, especially related to industrial sector. The entrance of heavy metals to the environment has caused various detrimental impacts, from ecosystem decline to human health problems (Putranto *et al.*, 2014; Kim and Choi, 2019). A wide variety of human activities have shown to give a significant impact in increased concentration of heavy metals that exceed the permitted limits, which can cause serious health problems and may lead to chronic toxicity (Ishak *et al.*, 2020). Although heavy metal contamination has occurred from many decades ago, this problem is not yet resolved in the coasts and seas due to increasing human disturbances around these area (Shirani *et al.*, 2020). There are plenty of food sources that are originated from the sea, namely fish and shellfish, which are high in protein, easy to obtain and affordable, especially in an archipelagic country such as Indonesia.

Lead (Pb) and cadmium (Cd) cause substantial heavy metal pollution to the environment. The contamination of Pb in the coastal area can originate from rainwater runoff, poorly treated industrial waste and other waste disposal (Ardiansyah *et al.* 2012; Gallego *et al.*, 2019). A coast that is located not far from these pollution sources tends to have a high potential of Pb contamination. Furthermore, Cd contamination is often related to the combustion of metal ores, fossil fuel, polyvinyl chloride (PVC) and other waste (Rahimzedeh *et al.*, 2017).

In this study, the analysis of heavy metal concentration of Pb and Cd was conducted in Gian Beach located on the southern Sumenep and Slopeng Beach on the northern Sumenep, because these beaches has different types of human activities. Most of the residents that settled not far from Gian Beach (±100 m) carry out many activities in the shoreline of the beach, for instance boat docking, refueling and repairing and also fish nets assembling. Domestic waste is also dumped directly to the beach by pipes as a result of weak waste management in this area. The residents also discard different kinds of plastic litter to the beach. In contrast, Slopeng Beach is an open beach that is located on the northern Sumenep, which has a cleaner environment than Gian Beach, possibly because the location is far from the residential area. However, many tourism activities are observed here, which the activity of tourists visiting this beach may increase the potential of heavy metal pollution in this area. The contrasting conditions of the two beaches make it suitable for studying the relationship of human activities to heavy metal pollution in the coastal areas.

Bivalves are macroorganisms that can be utilized for studying the heavy metal pollution in the coastal areas (Shirani et al., 2020). Many bivalve species can be observed in the coastal area of Indonesia, for example *Donax faba,* which is selected here as the study species*. D. faba* is a seawater mollusk that can be identified from its wedge shells, which belongs to the Donacidae family. This clam lives is found in sandy intertidal zones as an infauna that lives with immersing itself in the substrate. The north and south coasts of Sumenep are known as the habitat of this mollusk.

D. faba is suitable as a bioindicator because this species is highly sensitive to the contamination of heavy metals (Nontji, 1993). This is due to its filter feeding behaviour that consume phytoplankton and suspended detritus in the seawater. This marine species is known to accumulate the heavy metals from seawater to their tissues, blood vessels and several vital organs (Rian, 2010).

MATERIALS AND METHODS

Sampling area

This study is conducted from July to September 2020 in two coastal areas. The first site, Gian Beach, is located 38 km south of Sumenep City (7^{0}6'52,73748"S 113,73803 113^{0}44'16,89288"E). The second site, Slopeng Beach, is located 19 km north of Sumenep City (6^{0}53'10,30632"S 113^{0}47'24,65556"E) (Figure 1).

Sample collection

The samples of *D. faba* were taken at the beginning

Fig. 1. Location map of this study

of low tide. Belt transect was used as the sampling technique, according to Setyawan and Winarno (2006) and Suwondo *et al.* (2012). In each site, three horizontally extended subsites were determined. Each subsite had a vertical transect line of 10 m and inside the subsite, ten plots of 1x1 m were determined.

The *Donax* clams were collected in each plot, from the surface to the bottom of substrates until 10 cm depth. The selected *D. faba* for heavy metal analysis had the size range of 15 – 16 mm. The clams were placed in clean polyethylene bags, stored in a cooler box and transported to the laboratory for further analysis.

Sample analysis

The sample analysis was performed in Laboratorium Gizi, Fakultas Kesehatan Masyarakat, Universitas Airlangga. The clams were cleaned thoroughly with tap water prior to sample preparation. For each sample, about 40 g of the clams' tissue was prepared by dry ashing and acid digestion. Then, the samples were analyzed in an Atomic Absorption Spectrometer (AAS) AA 800 (Perkin Elmer, Foster City, CA, USA) for the determination of Pb and Cd concentrations.

Statistical analysis

The significance of the AAS data was analyzed by parametric independent samples t-test using SPSS v.23 (SPSS Inc., Chicago, IL, USA) to investigate the difference of Pb and Cd concentrations in the samples collected from the North and the South coasts of Sumenep.

Human health risk estimation

The calculation of Total Hazard Quotient (THQ) was conducted to estimate the non-carcinogenic risk level due to pollutant exposure caused, which is divided into two groups of consumer, Average Consumers (AC) and High Consumers (HC) (USEPA, 2000). The THQ (Eq. 1) was calculated from the value of the Estimated Daily Intake (EDI) (Eq. 2) with the Oral Reference Dose (ORD).

$$THQ = \frac{EDI}{ORD} \quad .. (1)$$

$$EDI = \frac{M \times C}{BW} \quad .. (2)$$

Note: C = consumption rate (AC = 17,86 and HC = 35,7 g/d. M = metal concentration in the sample (mg/kg ww); BW = average body weight of an adult (60 kg).

In this study, the ORD value used to evaluate the EDI of the Pb and Cd were 1.00 and 3.50 μg/kg/day, respectively. When the THQ is above 1, it is suggested that there is a potential health risk from the consumption of the studied heavy metal-contaminated material (Khan *et al.*, 2008).

RESULTS AND DISCUSSION

Concentration of lead (Pb) and cadmium (Cd) in *DONAX FABA*

The mean Pb concentration was higher in the *D. faba* samples from the South coast of Sumenep (0.796 ± 0.071 mg/g) (Table 1). The Pb concentration was lower in the clam samples from the North coast of Sumenep (0.624 ± 0.056 mg/g), and based on the result of independent samples t-test, there was a significant difference in Pb concentration between the samples from the North and the South coasts ($p < 0.05$).

Moreover, the Pb concentration of these area were higher than the Maximum Level published by FAO/WHO in CODEX STAN193-1995 (0.3 mg/kg). The values were also above than the permitted limit from the Regulation of the Director of National Agency of Drug and Food Control of Republic of Indonesia No. 5 2008 (0.20 mg/kg). This information should be used as an early warning which indicated the waters of Sumenep have been polluted by heavy metals, and is projected to give detrimental effects to tourism and domestic activities in the future.

The exposure of heavy metals, specifically Pb, has found to alter the reproductive cycle of marine bivalve *Tegillarca granosa* (Liu *et al.*, 2014) and to induce oxidative stress in the digestive system of freshwater bivalve *Diplodon chilensis* (Sabatini *et al.*, 2011). Our results was higher than a similar study in Panambur Beach, Mangalore, India, which is located close to industrial area (Singh *et al.*, 2012).

Similar to Pb, the clam samples from the South coast (0.057 ± 0.009 mg/g) was higher than the North coast (0.038 ± 0.006 mg/g) (Table 1). Based on the result of independent samples t-test, there was a significant difference of Cd concentration between two sampling areas ($p < 0.05$). The Cd concentration in the clams of the studied area was above the Maximum Level from FAO/WHO (2 mg/kg) and the National Agency of Drug and Food Control of Republic of Indonesia (0.10 mg/kg).

Cadmium is highly toxic and can be found in many ecosystems, including in the aquatic ecosystem (Maurya and Malik, 2019). As both coasts are utilized for tourism and fisheries sectors, hence the chance of bioaccumulation effect of Cd is predicted to be higher in the future, especially due to high consumption of *D. faba* by the local people as their affordable source of protein.

Physiologically, the exposure of Cd may affect synergistically to the feeding activity, metabolism and ATP synthesis of bivalves as the response of oxidative stress and neurotransmitter disorders (Shi *et al.,* 2019). Although the Cd concentration in the studied area is lower than Pb, previous studies have shown that the impact of Cd pollution is significant and therefore need to be monitored regularly (Zhang *et al.,* 2008). The exposure of Cd in human has shown to alter the function of various organs and organ systems, such as kidney, respiratory system, reproductive system, and skeletal system (Godt *et al.,* 2006; Ruaeny *et al.*, 2015). The pollution of Cd can be dispersed from one area to another by the attachment of this metal to the marine debris, for example on plastic, ceramic, glass and rubber tires, which have increased the contamination of Cd in marine environment to 50 µg/L (Vinarao *et al.,* 2014). Therefore, higher heavy metal pollution on the South coast of Sumenep is predicted not only induced by the human activities in the Madura Island, but also the activities from the adjacent islands and the geographical condition of the South coast that is assumed to have higher residence time than the North coast.

Human health risk assessment

Based on the defined concentration to estimate the health risk potential from Pb and Cd contamination in *D. faba* tissue for safe human consumption, the THQ of both average and high consumers (AC and HC) in this study was below 1, which is considered as the safe consumption level (Table 2). Hence, noncarcinogenic health effect of Pb and Cd from consuming *D. faba* was not observed in this study. However, it should be noted that there might be other heavy metals that have contaminated the edible bivalves in the study area, which is beyond the scope of this study.

CONCLUSION

In this study, there was a significant difference of Pb and Cd contamination between the North coast with the West coast of Sumenep. The highest Pb and Cd concentrations were both observed in the South coast samples, which were 0.796 ± 0.072 mg/g dan 0,057 ± 0,009 mg/g, respectively. The health risk assessment of these heavy metals showed that the *D. faba* clams harvested from the study area are currently safe for human consumption.

ACKNOWLEDGMENTS

The authors is grateful to the Faculty of Science and Technology and the Faculty of Public Health, Universitas Airlangga, Surabaya, East Java who had facilitated and supported this research. The authors also thanked the fishermen in Sumenep who had supported and assisted the sampling activity.

Table 1. Mean ± SD content of lead (Pb) and cadmium (Cd) in *Donax faba* on the North and the South coasts of Sumenep, East Java, Indonesia (N = 36).

Sampling site	North coast		South coast	
1.	Pb (mg/g)	Cd (mg/g)	Pb (mg/g)	Cd (mg/g)
Station 1	0.691 ± 0.025146	0.043 ± 0.007	0.879 ± 0.029614	0.063 ± 0.008737
Station 2	0.606 ± 0.008505	0.039 ± 0.005568	0.776 ± 0.034078	0.057 ± 0.008386
Station 3	0.606 ± 0.02928	0.033 ± 0.004163	0.731 ± 0.03691	0.051 ± 0.008505
Mean ± SD	0.624 ± 0.056305	0.038 ± 0.006483	0.796 ± 0.071739	0.057 ± 0.00888

*Notes: Permissible limit concentration of lead (Pb) = 0.3 mg/kg and cadmium (Cd) = 2 mg/kg (data adapted from CODEX STAN193-1995); lead (Pb) = 0.20 mg/kg and cadmium (Cd) = 0.10 mg/kg (data adapted from the Regulation of the Director of Indonesia National Agency of Drug and Food Control No. 5 2018).

Table 2. Target hazard quotient values of Pb dan Cd for AC and HC consuming the remainder tissues of *Donax faba*

THQ values	North coast		South coast	
1.	Pb	Cd	Pb	Cd
Average consumers (AC)	0.05	0.01	0.07	0.02
High consumers (HC)	0.10	0.02	0.13	0.03

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