Omni-Akuatika, 16 (2): 108-115, 2020
ISSN: 1858-3873 print / 2476-9347 online
*Research Article*
journal homepage: http://ojs.omniakuatika.net

# Heavy Metal (Pb, Hg) Extent in Mud Crab (*Scylla serrata*) in Cengkok Coastal Waters, Banten Bay, Indonesia

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*Received 10 June 2020; Accepted 22 December 2020; Available online 31 December 2020*

## ABSTRACT

Banten Bay is located in the north of Java Island and influenced by anthropogenic activities around the bay. Increasing population growth and rapid development of industrial and urban activities around the waters of the Banten Bay can lead to an increased input of pollutants in the form of heavy metal in the water body. This study aims to analyze the Pb and Hg levels that accumulate in mud crab (*Scylla serrata*) in Cengkok coastal waters, Banten Province. Samples of the mud crabs were taken in the waters for six months, from March to August 2019. Analysis of heavy metal concentrations was carried out using the Atomic Absorption Spectrophotometric (AAS) AA 7000 series Shimadzu. Heavy metal (Pb and Hg) in the mud crab in Banten Bay were below the specified quality standard. The bio-concentration factor of the mud crab was low (<100). Results of the calculation of the maximum limit of consumption of the mud crab meat (that accumulates heavy metals in the human body) were 3.5 kg of meat/week for adults and 0.9 kg of meat/week for children.

**Keywords:** *Crustacean, pollution, limit of consumption.*

## ABSTRAK

Teluk Banten terletak di sebelah utara Pulau Jawa dan dipengaruhi oleh aktivitas antropogenik di sekitar teluk. Meningkatnya pertumbuhan penduduk dan pesatnya perkembangan kegiatan industri dan perkotaan di sekitar perairan Teluk Banten dapat mengakibatkan bertambahnya masukan pencemar berupa logam berat di badan air. Penelitian ini bertujuan untuk menganalisis kadar Pb dan Hg yang terakumulasi pada kepiting bakau (*Scylla serrata*) di perairan pesisir Cengkok, Provinsi Banten. Sampel kepiting bakau diambil di perairan selama enam bulan, mulai Maret hingga Agustus 2019. Analisis konsentrasi logam berat dilakukan dengan menggunakan Spektrofotometri Serapan Atom (SSA) AA 7000 seri Shimadzu. Logam berat (Pb dan Hg) pada kepiting bakau di Teluk Banten berada di bawah baku mutu yang ditentukan. Faktor biokonsentrasi kepiting bakau rendah (<100). Hasil perhitungan batas maksimal konsumsi daging kepiting bakau (yang mengakumulasi logam berat dalam tubuh manusia) adalah 3,5 kg daging / minggu untuk dewasa dan 0,9 kg daging / minggu untuk anak-anak.

**Kata kunci:** Krustasea, polusi, ambang batas konsumsi

## 1. Introduction

Banten Bay has relatively shallow waters with substrates such as sandy mud and a coastline of 22 km with an area of ± 150 km$^2$. The bay is located in the north of Java Island and influenced by anthropogenic activities around the bay. Activities around Banten Bay include water transportation, industry, tourism, and aquaculture. Based on the status of the waters, the quality of Banten Bay waters is generally still good and suitable for aquatic organisms (Sugiarti et al., 2016). This result is in accordance with Tobing (2009) and Suwandana et al. (2011) those conducted and concluded that the contents of nutrients and heavy metals in Banten Bay were still low. However, the increase of the population growth and rapid development of industrial and urban

http://dx.doi.org/10.20884/1.oa.2020.16.2.810

activities around the waters of Banten Bay can lead to an increased input of pollutants in the form of heavy metal in the water body.

Heavy metals are sources of pollutants that are harmful to the aquatic environment (Sarjono 2009) as they complex degradation properties, and can easily dissolve in water, or be deposited in sediments. They can also accumulate in the body of marine organisms (Amriani et al., 2011). The heavy metal is toxic and dangerous for the organism. High heavy metal content in the water can cause the death of aquatic biota, while low heavy metal content can cause accumulation in the body of these marine organisms (Monsefrad et al., 2012). Organisms that are in the upper trophic level, such as mud crab (*Scylla* spp), will contain high heavy metals (Darmono 1995).

Mud crab is a fishery commodity in Banten Bay that has high economic value. It is also an exported commodity often consumed by the community. This organism lives in mud-based intertidal waters (Avianto et al., 2013). Mud crab are benthic organisms that have the habit of immersing themselves in the mud. Their position at the top of the trophic system allows components to enter the crab's body through both physiological and food chain processes. Some of these components are accumulative, for example, lead (Pb) and mercury (Hg) (Irawati et al., 2018).

Study on heavy metal contents was carried out by several researchers, including heavy metal content in water in Banten Bay (Jalius et al., 2008), heavy metal content (Cu, Pb, Zn, Cd, and Cr) in water and sediments in Jakarta Bay (Permanawati et al., 2013), heavy metal in mud clam (*Geloina erosa*) in the East Segara Anakan Lagoon and West of the Donan River (Irawati et al., 2018), and lead (Pb) in fish in the Lamat River (Arkianti et al., 2019). However, a study on heavy metals in mud crab, especially in Banten Bay, is still lacking. Waste that continues to grow due to anthropogenic activities can harm aquatic biota. Mud crab are fishery commodities that have high demands, causing the need for the analysis of their heavy metal contents that have accumulated in tissue due to pressure from the surrounding environment. This study aims to analyze the levels of accumulated Pb and Hg and compared them based on the differences in the size of mud crab (*Scylla Serrata*) in Banten Bay.

## 2. Materials and Methods

### 2.1. Time and Location

This study was conducted from March to August 2019 in Cengkok coastal waters of Banten Bay, Serang Regency, Banten Province. Samples of the mud crabs were taken around river (Stations 1) and estuary (Station 2) (Figure 1).

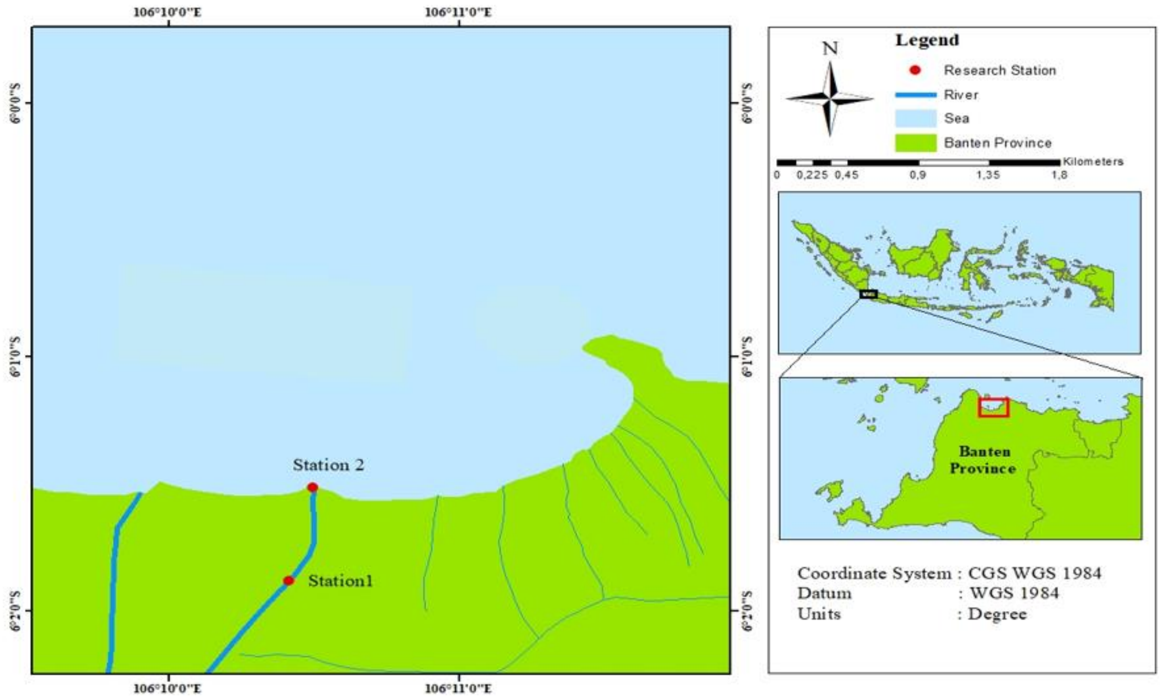


**Figure 1.** Study location in Cengkok Coastal Waters, Banten Bay, Indonesia

2.2. Materials and Equipment

Mud crab samples were collected using trap net and gill net. The materials used in this study were mud crab meat (*Scylla Serrata*), nitric acid ($HNO_3$), perchloric acid ($HClO_4$), and distilled water. The equipment used were gill-net, trap net, cool box, 250 mL water sample bottle, calipers, pipette, thermometer, DO-meter, refractometer, Mercury Vaporizer Unit, aluminum foil, analytical balance, glass equipment (Pyrex), and Atomic Absorption Spectrophotometer (AAS) AA 7000 series Shimadzu.

2.3. Data collection

Data collection was done by taking primary data on the field. Sampling, sample handling, and analysis in the laboratory referred to APHA (2012). Sampling was done through a purposive sampling method, by collecting at 2 stations that are considered representative of each region. Water and sediment samplings were carried out at Station 1 and 2. Water samples were carried out at the surface using a 250 mL polyethylene bottle that had been preserved. Sediment samples were taken using Ekman grab and then put into a plastic bag, labeled per station, and placed into a coolbox.Samples of mud crab were taken about 15 individuals, using trap net and gill net. Crabs were then stored in an ice-coolbox to maintain the condition of the mud crab.

Measurement of water physical and chemical parameters was carried out in-situ and laboratory analysis. In-situ observations and parameter measurements involved temperature, transparency, salinity, pH, and DO. The mud crab was analyzed morphometrically before dissection. Mud crabs were measured for length and weight, and divided them into small and large categories. Length measurements used a ruler with a precision of 0.5 mm, and body weight used an analytical balance with an accuracy of 0.001 gr. Mud crab that have been measured were dissected to collect flesh in the abdomen. A total of 10-15 grams of meat were taken from all mud crab samples was mixed. Then, 30 grams were taken for subsequent analysis.

The extraction process used the wet destruction method, which used 30 grams of mud crab meat and put them into an Erlenmeyer. Ten mL of nitric acid and 2 mL of perchloric acid were added to the mixture, and then allowed to stand for one night. The sample was heated at 100˚C for 1 hour 30 minutes, and the temperature was increased to 130˚C for 1 hour, then 150˚C for 2 hours 30 minutes (until the yellow steam disappeared). Next, the temperature was increased to 170˚C for 1 hour. The extract was filtered in a measuring flask and diluted with distilled water to 50 mL, then shaken.

The analysis of heavy metal concentrations was conducted using Atomic Absorption Spectrophotometric (AAS) by measuring the absorption of a standard solution of 0.6-8 ppm 3 times. Measurements of Pb and Hg ions in mud crab samples were measured using AAS at a wavelength of 283.8 nm and 253.6 nm (Raras et al., 2015). Pb reading used the Flame (Flame Atomic Absorption Spectrophotometer) method, while Hg used the Cold-Vapor (Cold Vapor Atomic Absorption Spectrophotometer) method.

2.4 Data analysis

2.4.1 Descriptive

Descriptive analysis of the heavy metal concentration was carried out to have a picture of the presence and amount of heavy metals in mud crab meat. The results of the analysis were compared with BPOM RI (2018), which is 0.2 mg/kg for Pb metal and 0.5 mg/kg for Hg metal.

2.4.2 Analysis of Heavy Metal Bioaccumula-tion in Biota

The ability to accumulate Pb and Hg in seawater was analyzed using bio-concentration factors (BCF). The analysis of bio-concentration factors was based on the heavy metal contents of biota divided by heavy metals contained in the sea or sediment. The following formula calculated the bio-concentration factors (Wahyuni et al., 2013).

$$\mathrm{CB} = \frac{\mathrm{KB}}{\mathrm{S}}$$

Note:
CB : Bio-concentration factors
KB : Concentration of heavy metals in organism
S : Concentration of heavy metals in water or sediment

2.4.3 Limit of consumption that can be tolerated in one week

According to Azhar et al. (2012), the maximum concentration limit of food concentrations of heavy metals that may be consumed per week (Maximum Weekly Intake) uses threshold figures was published by International Food Organizations and Organizations World Health Organization (WHO) and Joint FAO / WHO Expert Committee on Food Additive (JECFA). This calculation used the formula:

$$\mathrm{MWI\ (mg)} = \mathrm{Body\ Weight\ x\ PTWI}$$

PTWI (Provisional Tolerable Weekly Intake) is the maximum tolerance limit per week issued by the food institutions, namely JECFA Agency and WHO in units of μg / kg body weight. PTWI (Provisional Tolerable Weekly Intake) of several heavy metals is presented in Table 1. After knowing the value of MWI (Maximum Weekly Intake) and the concentration of heavy metals in each consumption biota, it can be calculated the maximum weight in consuming mud crab every week. The following formula calculated the maximum weekly intake.

$$\mathrm{MTI} = \frac{\mathrm{MWI}}{\mathrm{Ct}}$$

Note:

MWI : Maximum Weekly Intake (maximum weekly intake (μg) for male and female humans with an average body weight of 60 kg)

Ct : Concentration of heavy metals in mud crab tissue (mg / kg)

## 3. Results and Discussion

### 3.1 The content of lead (Pb) and mercury (Hg) in mud crab (*Scylla serrata*) meat

Heavy metals are sources of pollutants that are harmful to the aquatic environment as they complex degradation properties, and can easily dissolve in water, or be deposited in sediments. They can also accumulate in the body of marine organisms including mud crab. According to Kesuma et al. (2016), crab is a crustacean able to accumulate metals in its body. Mud crab are benthic organisms that have the habit of immersing themselves in the mud. Their position at the top of the trophic system allows components to enter the crab's body through both physiological and food chain processes. According to Kasari et al. (2016), the heavy metals in sediments are higher than those in the water body. This statement was confirmed by Sulistiono et al., (2018) that the heavy metal water column will join other compounds, both organic and inorganic materials, increasing the density. Furthermore, sedimentation will occur quickly.

**Table 1**. Tolerance for maximum consumption value per week

| No | Type of Metals | PTWI (mg/kg Body weight) in one week |
|---|---|---|
| 1 | Pb | 0,025 |
| 2 | Hg | 0,0016 |

The primary source of the lead (Pb) in the environment comes from industrial waste such as the battery industry, the fuel industry, casting and refining, and other chemical industries. The results of the lead content analysis are presented in Figure 2. Figure 2 shows that the Pb contained in mud crab meat taken from Banten Bay ranges from 0-0,053 mg/kg.

The average Pb content from March to August was still below the BPOM RI (2018) quality standard, which was 0.2 mg/kg. Statistical test results shows that the Pb content analyzed in each sampling period does not differ significantly ($p \geq 0.05$).

Mercury is a type of metal that is widely used both in industrial and laboratory activities. The results of the lead content analysis are presented in Figure 3. Figure 3 shows that the Hg contained in mud crab meat taken from Banten Bay ranges from 0-0.039 mg/kg. This value is still below the quality standard set by BPOM RI (2018), which is 0.5 mg/kg. Statistical test results shows that the Pb content analyzed in each sampling period does not differ significantly ($p \geq 0.05$). In general, heavy metal between Pb and Hg fluctuates monthly. The increase of Pb metal in July and August was allegedly due to the beginning of July with increased industrial production, such as oil. According to Santi et al. (2017), Pb was one of the constituent components of petroleum and its processed products. The increase of Hg metal in May allegedly due to increased minning activities and industrial production. Some of the activities around the location were water transportation

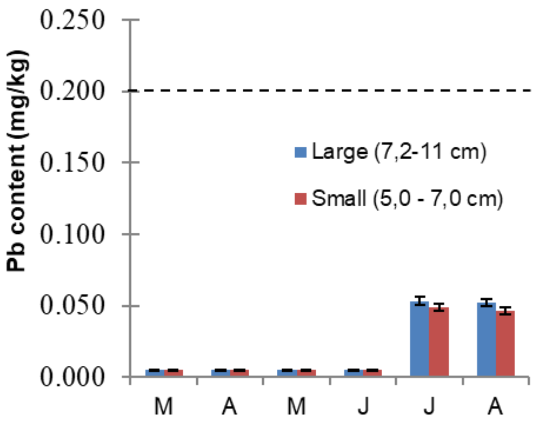


**Figure 2.** Analysis of (Pb) lead metal content in mud crab meat in the Cengkok coastal waters of Banten Bay (M, A, M, J, J, A = March, April, May, June, July and August). (- - -) BPOM (2018)

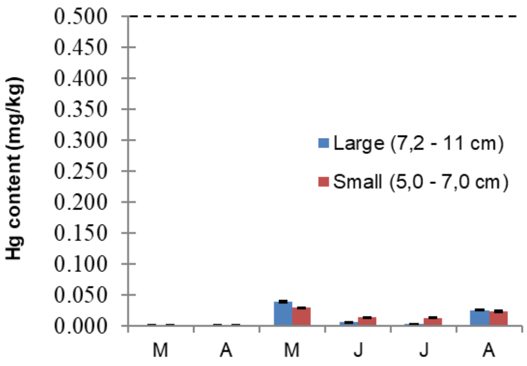


**Figure 3.** Analysis of (Hg) mercury metal content in mud crab meat in the Cengkok coastal waters of Banten Bay (M, A, M, J, J, A = March, April, May, June, July and August). (- - -) BPOM (2018)

activities, port, steel industry, shipbuilding industry, sugar factory, tourism, aquaculture, and fishermen's activities (Putri 2012).

Generally, the heavy metal contents in large mud crab (7, 2 – 11 cm) were higher than those in small mud crab (5,0 – 7,0 cm). Based on the results of the statistical tests, those values are not significantly different. The results of the analysis on mercury (Hg) in June and July showed that the metal content on small mud crab was higher than that of large mud crab. Other researchers reported a negative relationship between the size of the organism and heavy metal accumulation. Rudiyanti (2009) stated small-sized organisms have higher accumulation abilities compared to larger-sized organisms. It was thought that the large-sized organism had better ability to eliminate heavy metals. Besides, decreased metabolic processes will cause a decrease in the ability to accumulate metals so that the concentration of metals in large-sized organisms is lower than small-sized organisms.

### 3.2. Banten Bay waters quality

The water quality status is referred to as the level of water quality that can indicate the condition of polluted or good water at a specific time. Water quality values of certain parameters that exceed the threshold for their designation will be classified as polluted. The following measurements of water quality parameters are presented in Table 2.

### 3.3. Bio-concentration Factors for Mud Crab

Bio-concentration factor measurements are used to determine the ability of mud crab to accumulate Pb and Hg in sediments. Bio-concentration factors for mud crab are presented in Table 3. Based on Table 3, the bio-concentration factor of the mud crab was low (<100), suggesting that the accumulation of Pb and Hg in mud crab is little. Bio-concentration factor measurements are used to determine the ability of mud crab to absorb Pb and Hg heavy metals in sediments (Amriani et al., 2011). The results of the calculation of mud crab bio-

**Table 2**. Water quality of Cengkok coastal waters of Banten Bay

| | Parameter | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Temperature ( $^0$C)** | **Salinity (ppt)** | **DO (mg. L$^{-1}$)** | **pH** | **Turbidity (NTU)** | **Transparency (m)** | **TSS (mg. L$^{-1}$)** |
| March | 28.7 | 0-21 | 4.4-5.2 | 7 | 15-126 | 0.09-0.53 | 52-214 |
| | (28.7±0) | (10.5±14.84) | (4.8±0.57) | (7±0) | (70.5±78.49) | (0.31±0.311) | (133±114.55) |
| April | 28-28.3 | 0-21 | 6-6.9 | 7 | 36-156 | 0.07-0.1 | 84-325 |
| | (28.15±0.21) | (10.5±14.85) | (6.45±0.64) | (7±0) | (96±84.85) | (0.09±0.02) | (204.5±170.41) |
| May | 30.4-31.5 | 0-10 | 4-7.6 | 6.74-7.47 | 67-79 | 0.2-0.3 | 158-182 |
| | (30.95 0.78) | (5±7.01) | (6±2.26) | (7.11±0.52) | (73±8.49) | (0.25±0.07) | (170±16.98) |
| June | 31.3-32,9 | 0-14 | 5,9-6 | 6.9-7.2 | 18-102 | 0.2-0.3 | 18-24 |
| | (32.1 1.13) | (7±9.90) | (5.95±0.07) | (7.05±0.21) | (60±59.40) | (0.25±0.07) | (21±4.24) |
| July | 31.1-32.1 | 26-32 | 5,7-6 | 7 | 29-42 | 0.13-0.3 | 43-196 |
| | (31.6 0.71) | (29±4.24) | (5.85±0.0.21) | (7±0) | (35.5±9.20) | (0.22±0.12) | (119.5±108.19) |
| August | 31.6-31.9 | 15-24 | 4.6-6.4 | 7-8.0 | 30-34 | 0.23-0.26 | 22-72 |
| | (31.75 0.21) | (20±7.07) | (5.5±1.27) | (7.5±0.71) | (32±2.83) | (0.245±0.02) | (47±35.36) |

**Table 3.** Bioconcentration factors of mud crab (*Scylla serrata*) in Banten Bay

| | Large Mud Crab (7.2 – 11.0 cm) | | Small Mud Crab (5.0 – 7.0 cm) | |
|---|---|---|---|---|
| | **Pb** | **Hg** | **Pb** | **Hg** |
| April | 1.02 | 0.40 | 1.02 | 0.40 |
| May | 0.08 | 7.90 | 0.08 | 5.90 |
| June | 0.00 | 0.00 | 0.00 | 0.00 |
| July | 0.11 | 0.15 | 0.10 | 0.68 |
| August | 0.01 | 1.30 | 0.01 | 1.20 |

**Table 4.** Safe limits on consumption of mud crab meat (*Scylla serrata*) weighting of adults (60 kg) and children (15 years)

| Consumer | Size | Safety level (kg meat/week) | |
|---|---|---|---|
| | | **Pb** | **Hg** |
| Adult | Large | 28.01 | 8.89 |
| | Small | 30.71 | 3.53 |
| Child | Large | 7.02 | 2.22 |
| | Small | 7.67 | 0.88 |

concentration factors on heavy metals, Pb and Hg, were low (<100). However, the calculation results showed a tendency for mud crab to accumulate higher Pb compared to Hg. According to Priatna et al. (2016), the contact between mud crab and medium containing heavy metals such as sediment causes heavy metal accumulation in mud crab. Movement of heavy metals or accumulation can be through various ways, including respiration, skin, and food chain (Darmono 1995). Distribution of heavy metals in the body through the absorption of metals by the blood. That will then lead the metals to bind to blood proteins. Blood protein will be distributed throughout the body tissue, and the accumulation occurs (Cahyani et al., 2016).

3.4. Safe Consumption Limit (Safety level)

The safe limit for consumption is the maximum weight for consuming the organism every week. The determination of the safe limit for consumption can be seen from the smallest limit value of the type of heavy metal content so that there is no deposition of metals in the body that can cause death. The consumption values of mud crab that are weekly allowed are presented in Table 4. Based on Table 4, the safe limit for consumption of mud crab meat for adults and children is 3.534 kg of meat/week and 0.883 kg of meat/week, respectively. Generally, the body of biota can eliminate heavy metals through the process of excretion, but its ability is limited. Thus, if heavy metal accumulation continues to occur, the concentration of heavy metals in the organism's body will be higher than the level of heavy metals in the environment (Riani et al., 2017). The maximum consumption limit value is a reference to avoid the adverse effects of heavy metals entering the body (Prastyo et al., 2017). The determination of the daily maximum limit is carried out through the selection of the smallest value. The presence of foodstuffs, even though they contain small amounts of heavy metals but if continuously consumed, will be dangerous, so that the selection of the daily limit should be based on the lowest value (Hidayah et al., 2014). The maximum weight limit of mud crab meat with the smallest value that can be tolerated within one week (Maximum Tolerable Index / MTI) for adults (60kg) in Pb was 213.4 kg/week and 3.5 kg/week for Hg. For children (15 kg), the Pb was 53.3 kg/week and 0.9 kg/week for Hg. The calculation result of the average maximum consumption limit of mud crab meat that accumulates heavy metal showed that the level of tolerance to heavy metals absorbed in the human body was 3,5 kg of meat/week for adults and 0.9 kg of meat/week for children.

## 4. Conclusion

In general, heavy metal between Pb and Hg fluctuated monthly. Heavy metal (Pb and Hg) in mud crab (*Scylla Serrata*) in Banten Bay have Pb and Hg contents that were below the specified quality standard. The bioconcentration factor of the mud crab was low (<100). The results of the calculation of the maximum limit of consumption of the mud crab meat (that accumulated heavy metals in the human body) were 3.5 kg of meat/week for adults and 0.9 kg of meat/week for children. The safe consumption limit value calculated in this study was quite high, and it can be stated that mud crab meat from the waters of Banten Bay was still safe for consumption as long as it does not exceed the set limits.

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