

Heavy Metal (Pb, Hg) Contained in Blue Swimming Crab (*Portunus pelagicus* Linnaeus, 1758) in Cengkok Coastal Waters, Banten Bay, Indonesia

Nadya Febrianessa¹, Sulistiono^{1*}, Agustinus M Samosir¹, Masashi Yokota²

¹Department of Aquatic Resources Management, Faculty of Fisheries and Marine Sciences, IPB University, Jl. Rasamala, Kampus IPB Darmaga Bogor 16680 Indonesia

²Tokyo University of Marine Sciences and Technology
4-5-7 Kounan, Minato-Ku, Tokyo, Japan
Email: onosulistiono@gmail.com

Abstract

Increasing number of industries and settlements in Banten Bay were subsequently followed by an increase in the amount of waste, whether in the form of solid, liquid or gas that can pollute the environment. One of the toxic pollutants is heavy metal. The entry mechanism of the heavy metal Mercury (Hg) and Lead (Pb) in body of the crab (*Portunus pelagicus*), namely through the process of digestion food. This study was conducted for 6 months, from March to August 2019, and aimed to analyze the heavy metal content levels (Pb and Hg) and the safe consumption level of the blue swimming crab (*Portunus pelagicus*) in the waters. The heavy metal concentration in the meat was measured through the AAS (Atomic Absorption Spectrophotometer) AA 7000 series Shimadzu. The analysis showed that the Pb and Hg contained in the blue swimming crab were still under the quality standards. Also, the bio-concentration factors of the blue swimming crab were low (<100). Water quality data observed as temperature, salinity, TSS, pH, dissolved oxygen, turbidity, and transparency stayed in the range of tolerable limits for the survival of marine organisms. Maximum weekly intake calculation refers to the tolerable limits issued by the Joint FAO/WHO Expert Committee on Food Additives (JECFA). The JECFA recommends calculating the PTWI of each heavy metal if it accumulates in the human body for methyl mercury 1.6 µg.kg bw.week⁻¹ and for lead not exceed 25 µg.kg bw.week⁻¹. The safety consumption level of blue swimming crab from Cengkok Coastal water was 2.3 kg of meat.week⁻¹ (for adults) and 0.6 kg of meat.week⁻¹ (for children).

Keywords: Blue swimming crab, heavy metals, bio-concentration factors

Introduction

Banten Bay is a 10 x 15 km large with shallow (<20m) embayment on the north-west coast of Java, Indonesia. It is located 60 km west of Jakarta along the northern coastline of Java. The Bay has a diameter of about 15 km and a depth of about 12 m. It is characterized by relatively high turbidity (Lestari et al., 2017). The threats from human pressure and changes in the natural conditions in Banten Bay increased over time. These conditions were further aggravated by the increasingly intense economic development, especially industrial activities. Increases in coastal pollutants, largely due to human activity on land, have an impact on seagrass ecosystems, and affect water quality such as increased turbidity. It is estimated that 60% of the seagrass beds have been destroyed which has an impact on the cover and density of seagrass species on Pulau Panjang in Banten City (Sugianti et al., 2018).

The increase in the number of industries and residential areas in Banten Bay is a result of the increase in the amount of waste (ie solid, liquid and gas) that pollute the environment. One of the pollutants requiring special attention is heavy metals that are often used as raw or supporting materials in various industrial activities. The entry of the contaminants, especially into sea waters, can reduce the quality of the waters. Besides, changing water quality, due to heavy metals deposited in the sediments, can also cause the transfer of toxic chemicals from sediments to organisms (Permanawati et al., 2013). This result is alarming since heavy metals are accumulative elements both in sediments and bodies of aquatic organisms. The organisms will be contaminated as a result of the high level of heavy metals in these sea waters (Wahyuningsih et al., 2015).

Various activities taking place in the Banten Bay are thought to have an impact on the biota of the waters. One of the most abundant biotas in the

waters of Banten Bay is the blue swimming crab (*Portunus pelagicus*). The blue swimming crab is a species that has significant economic value among other species such as *P. trituberculatus*, *P. gladiator*, *P. sanguinus*, *P. hastatoides*. Changes in the ecological conditions of Banten Bay due to heavy metals are thought to affect both the biological characteristics and the sustainability of the crab, as they will have an impact on catching activities such as a reduction in the catches and fishermen's income (Prabawa *et al.*, 2014).

Blue swimming crab is an active organism. However, when not moving, the blue swimming crab will stay at the bottom of the water at a depth of 35 meters and live immersed in the sand or muddy coastal areas, mangroves, and rocks (Indriyani, 2006). Adult crabs feed on mollusks, crustaceans, fish, or carcasses at night. Blue swimming crab habitats are sandy, muddy sand beaches, and rocky islands, as they swim near sea level (about 1 m) to a depth of 65 meters (Moosa, 1985). Blue swimming crab is a typical benthic organism. It might also be good indicators reflecting the contamination levels in surface sediment because crabs are known to reside in the surface sediment and feed on benthic prey items living among contaminated sediments. The bioaccumulation of heavy metals in the blue swimming crab is transferred through sediments and seawater (Zao *et al.*, 20012).

Suwandana *et al.* (2011) conducted heavy metal research in the waters of the Banten Bay and Irnawati *et al.*, (2014). It was observed that, in general, the conditions of the Banten Bay waters were reasonably stable (ecosystem) classified as not polluted to moderately polluted. This research is considered crucial because the blue swimming crab

is one of the biotas with high economic value often utilized by the community around Cengklok Coastal waters (Banten Bay). Data regarding the heavy metal contents (Pb and Hg) in the blue swimming crab meat in Cengklok Coastal waters (Banten Bay) is still limited and needs to be updated. Over time, the input of waste continues to grow along with ecological changes in waters. Thus, research related to heavy metals needs to be carried out on an ongoing basis. This research is expected to add information about the status of heavy metal pollution (Pb, Hg) on crab fisheries (*Portunus pelagicus*) and the aquatic environment, to determine the safety level of consumption of crab meat that can be consumed by humans.

Materials and Methods

The research was conducted in Cengklok Coastal waters (Banten Bay) (Figure 1.). Blue swimming crab sampling was carried out monthly from March to August 2019. Blue swimming crab samples, were taken at three different stations.

Crab samples were taken using gill nets and traps. The number of samples taken at each site were 25-35 individuals and divided into two size-groups based on carapace width, namely large (>10 cm), and small (<10 cm). The samples were dissected and organ (meat) was stored in the freezer to maintain the quality before analyzing for heavy metal content. Water sampling was carried out at the surface using a 250 mL polyethylene bottle, sterilized, and then added with nitric acid (HNO₃) as a preservative and stored in a coolbox before analyzing in the laboratory.

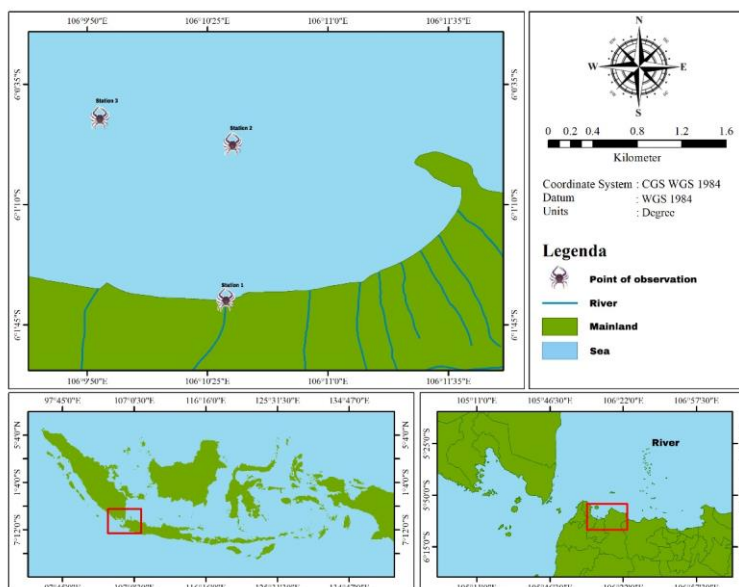


Figure 1. Location of a blue swimming crab sample (*Portunus pelagicus*) in Cengklok Coastal waters and surroundings (Banten Bay)

Sampling, sample handling, and analysis in the laboratory referred to (APHA, 2012). 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 blue swimming crab was analyzed morphometrically before dissection, the crab sample was weighed, and the carapace width measured. Then, the blue swimming crab was dissected to take the meat. The meat was taken from the abdomen. The weight of meat monthly taken from the whole sample was 50-60 grams. The type of destruction carried out in this study was the wet destruction method. Blue swimming crab samples (*P. pelagicus*) were destroyed through the Nitric Acid-Perchloric Acid Digestion method, i.e., samples were oxidized using nitric acid (HNO₃), and perchloric acid (HClO₄) to dissolve metals (Eviati, 2012).

The wavelengths were used in AAS to detect heavy metals (Pb and Hg) in blue swimming crab meat with 283, 3 nm, and 253, 7 nm, respectively (SNI, 2009). The analysis of Pb used the Direct Air-Acetylene Flame method, while that of Hg used the Cold Vapor-Atomic Absorption Spectrometry method. Wavelengths used for heavy metal analysis in water samples were (Pb and Hg) were 217.0 nm and 253.7 nm. The principle of AAS work is the amount of energy absorbed proportionally to the concentration of heavy metals in the sample (APHA, 2012).

In the wet destruction process, 30 g of blue swimming crab meat was put into the erlenmeyer, and 10 mL of HNO₃ solution and 2 mL of HClO₄ solution were added. The sample was allowed to stand for one night. The sample was heated at 100°C for 1 h 30 mins, while the temperature was increased to 130°C for 1 h. Next, the temperature was increased again to 150°C for 2 h 30 min. The heating process was carried out until the yellow steam disappeared. If there were still yellow vapors, the heating process would be carried out again. Afterward, the temperature was increased to 170°C for 1 h. The extract was then filtered into a 50 mL volumetric flask, then diluted by adding distilled water and homogenized. Besides, the results of the analysis were compared with the Indonesian National Standard for Limits of Metal Contamination in Food (SNI, 2009).

The analysis of bioconcentration factors was based on the content of heavy metals in biota divided by heavy metals contained in the sea or sediment. The bio-concentration coefficients were calculated using the following formula (Yunasfi *et al.*, 2019). The maximum concentration limit of heavy metal concentration in food that might be consumed weekly (Maximum Weekly Intake) using threshold

figures was published by international food organizations and organizations World Health Organization (WHO) and Joint FAO/WHO Expert Committee on Food Additive (JECFA) (Nuraini *et al.*, 2017). After the determination of the Maximum Weekly Intake value and the value of the concentration of heavy metals, the maximum tolerable intake (MTI) value can be calculated through the following formula, maximum weekly intake (MWI) (mg) divided by concentration of heavy metals in blue swimming crab meat (mg/kg) (Turkmen *et al.*, 2009).

Result and Discussion

Heavy metals are pollutants that can endanger the aquatic environment and contaminate the biota there in. Their toxicity is a significant problem that affects ecology, evolution, nutrition, and the environment. Heavy metals generally have atomic density values greater than 4 g.cm⁻³ or 5 times greater than water density. They enter the environment naturally through human activities. Various sources of heavy metals include soil erosion, natural weathering, industrial waste, urban waste, and pesticides, or insecticides. The heavy metals that are most often contained in waste are Arsenic, Cadmium, Chromium, Copper, Lead, Nickel, and Zinc. All of these heavy metals threaten both human health and the environment (Nagajyoti *et al.*, 2010).

The results of the analysis of the Pb content are presented in Figure 2. Lead (Pb) concentration in blue swimming crab (*P. pelagicus*) meat taken Banten Bay ranged from 0.005-0.071 mg.kg⁻¹. In most of the analysis results, the Pb content in blue swimming crab meat (*P. pelagicus*) was under the AAS device limit, which was <0.005 mg.kg⁻¹. The average Pb content from March to August was still below the SNI 2009 quality standard, which was 0.5 mg.kg⁻¹. Statistical test results showed that the Pb content analyzed in each sampling period based on size differences did not differ significantly (p≥0.05). Lead (Pb) is sourced from industrial activities and vehicle exhaust air pollution. The level of lead solubility is low, and its presence in water is relatively small (Connell and Miller 2006). Based on research conducted by Wahyuningsih *et al.*, (2015) the Pb metal content in *P. pelagicus* caught around Jakarta Bay near Banten Bay in the East and West monsoons is generally not detectable (<0.042 mg.kg⁻¹), this shows an increase in heavy metal content in the blue swimming crab around the bay of banten. In addition, based on the analysis conducted by Hapsari *et al.*, (2017), the heavy metal content of lead in meat (muscle) threadfin bream (*Nemipterus* sp.) in Banten Bay meat (muscle) amounted to 19,098±7.949 mg.kg⁻¹.

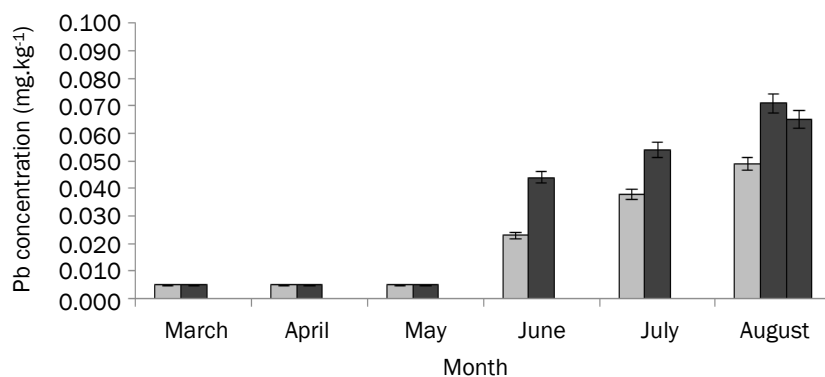


Figure 2. Pb content of blue swimming crab meat (*Portunus pelagicus*) in Cengklok Beach and surroundings (Banten Bay)
Note : □ = small crab; ■ = large crab

The results of the Hg analysis in blue swimming crab meat (*P. pelagicus*) is presented in Figure 3. Mercury (Hg) concentration in the blue swimming crab meat (*P. pelagicus*) was, on average, below the AAS tool limit of <0.002 mg.kg⁻¹. This value did not exceed the quality standard set by SNI 2009, which was 1 mg.kg⁻¹. Statistical test results showed that the mercury content analyzed in each sampling period based on size differences did not differ significantly ($p \geq 0.05$). Mercury is emitted from both anthropogenic and natural sources, primarily as elemental mercury (Hg⁰). Mercury pollution in the water can occur through two channels, namely direct deposition from the atmosphere or liquid waste and through run-off surface water (Fisher *et al.*, 2012).

Water quality data observed (Table 2.), i.e., as temperature, salinity, TSS, pH, dissolved oxygen, turbidity, transparency, were included in the seawater quality standards for biota listed in the Decree of the State Minister for the Environment 51 of 2004 (KLNH, 2004). The results were not significantly different and stayed still in the range of tolerable limits for the survival of marine organisms. Bio-concentration factors described the characteristics of chemicals concentrated in organisms within an environment. Bio-concentration factor values (BCF) are needed to classify and label the level of persistence, bioaccumulation, and evaluate toxicity (PBT), as well as for the chemicals present in the environment (Lombardo *et al.*, 2010). Blue swimming crab bio-concentration factors are presented in Table 3. Bio-concentration is a process in which organisms absorb chemicals from the surrounding environment in the process of respiration through the gills or the surface of the skin. Bio-concentration factors can be influenced by the content of organic matter found at the sampling location (Mackay *et al.*, 2018). The BCF results showed that the average value of the blue swimming crab bio-concentration factor (*P. pelagicus*) is low (<100). According to Amriani (2011), there are 3 categories of BCF values as follows: (1) values

greater than 1000 are included in the group of high accumulative properties, (2) BCF values of 100 to 1000 are called medium accumulative properties and (3) BCF is less than 100 are categorized as low accumulative traits.

JECFA currently recommends calculating the provisional tolerable weekly intake (PTWI) of individual heavy metals instead of the acceptable daily intake (ADI) to compare their pollution levels considering their toxicity accumulated in the human body, heavy metals tolerable weekly intakes for methyl mercury 1.6 µg . kg bw.week⁻¹ and for lead not exceed of 25 µg . kg bw.week⁻¹ (Table 1). (Kim *et al.*, 2012). The maximum concentration of heavy metals in foodstuffs that may be consumed weekly (maximum weekly intake) uses a threshold rate seen from the smallest limit value of the type of heavy metal content. Thus, there is no precipitation of metals in the body that can cause death. MWI needs to pay attention to the tolerable limits issued by the Joint FAO/WHO Expert Committee on Food Additives (JECFA) (Nuraini *et al.*, 2017). The values of allowed blue swimming crab meat consumption (*P. pelagicus*) for a week are presented in Tables 4 and 5. Based on Tables 4 and 5, it can be seen that the lowest consumption limits for adults and children are 2.3 kg of meat.week⁻¹ and 0.6 kg of meat.week⁻¹.

Meanwhile, the highest consumption was 30.6 kg of meat.week⁻¹ for adults and 7.7 kg of meat.week⁻¹ for children. These values were still safe for public use. The maximum concentration limit of heavy metal concentration in food that may be consumed weekly (maximum weekly intake) has the benefit of knowing the limit of consumption of contaminated meat in preventing adverse effects on human health (Hidayah *et al.*, 2014). The maximum consumption value was used as a reference to avoid the harmful effects of heavy metals entering the body (Prastyo *et al.*, 2017).

Table 1. Tolerance for maximum consumption value per week

Type of Metals	PTWI (mg.kg ⁻¹ body weight) in one week
Pb	0.025
Hg	0.0016

Table 2. Water quality data at Station 1, 2, 3 of Cengkok Coastal Waters of Banten Bay

	Parameter							
	Temperature	Saline	DO (mg.L ⁻¹)	pH	Turbidity (NTU)	Transparency (m)	TSS (mg.L ⁻¹)	
April	28-31.3 (30.3±1.7)	21-34 (28.3±6.7)	3.7-6, (4.7±1.2)	7 (7±0)	0.6-156 (52.5±89.6)	0.1-0.86 (0.6±0.4)	3-325 (110.3±185.9)	
May	31.5-31.8 (31.6±0.2)	10-30 (22±10.6)	4.4-7.6 (6.1±1.6)	7.47-7.77 (7.7±0.2)	5.8-67 (29.6±32.8)	0.3-1.5 (0.9±0.6)	16-182 (72.7±94.7)	
June	32.4-33.1 (32.8±0.4)	14-31 (24±8.9)	5.9-7.3 (6.7±0.7)	7.2-7.3 (7.2±0.1)	4.1-18 (11.2±7)	0.3-1.1 (0.7±0.4)	3-18 (8±8.7)	
July	30.5-32.5 (31.7±1.1)	32-37 (34.7±2.5)	5.7-7.8 (6.7±1.1)	7 (7±0)	1.7-42 (16±22.5)	0.13-2 (1±0.9)	5-196 (68.7±110.3)	
August	30-31.9 (31.1±1)	25-30 (27.3±2.5)	5.2-7.3 (6.3±1.1)	7-8.0 (7.7±0.6)	19-30 (23±6.1)	0.23-1.49 (0.8±0.6)	0.4-72 (26.5±39.5)	

Table 3. Bioconcentration factors of the blue swimming crab (*Portunus pelagicus*) in Banten Bay

Metals/month	Blue swimming crab (large size)		Blue swimming crab (small size)	
	Pb	Hg	Pb	Hg
April	2.50	1	2,50	1
May	0.71	19	0.71	5.50
June	22.00	21	11.50	1
July	27.00	9	19.00	10.50
August	34.25	12.33	24.50	14.50

The strength level of massive metal entry into the tissue is Cd > Hg > Pb > Cu (Darmono, 1995). However, based on the results of the study, the Pb contained in blue swimming crab meat (*Portunus pelagicus*) in Cengkok Coastal waters was higher than Hg, not indicating a linear condition between the strength of entry into the tissue and the content of heavy metals in meat. From the results of observations, both the heavy metal content Pb and Hg were still in the safe category of consumption because they have not exceeded the quality standard set by SNI 7387: 2009, namely for the crustacean category of 0.5 mg.kg⁻¹ (for Pb) and 1 mg.kg⁻¹ (for Hg). Although the results showed that the content of heavy metals in the blue swimming crab meat in Banten Bay had not exceeded the quality standard, this must still be observed.

Seasonal factors and sampling station points can cause the difference in heavy metal content in each month. The waters of Banten Bay are affected by two seasons, namely the west season, which is the rainy season, and the east season which is the dry season. The statistical test results showed that heavy metal contents analyzed in each sampling period in March-August did not show significant differences (p ≥ 0.05). Increased levels of lead (Pb) and mercury (Hg) in June were allegedly due to crab samples taken at station 1 (Figure 1). The small crab

sampling location (Station 1) is located at the mouth of the Cengkok River, which is close to residential and industrial areas. According to Suhartono (2011), lead (Pb) originating from burning motor fuel generally contains tetraethyl additives such as Pb. Meanwhile, according to Riani (2019), mercury (Hg) comes from industrial waste and coal mining. Various activities that take place around Banten Bay include industrial activities (Putri et al., 2012).

Also, an increase in the Pb and Hg contents in the blue swimming crab meat in June, July, and August were allegedly due to the dry season. According to Makarim et al. (2012), in June-August, the waters of Banten Bay experienced a dry season. Various factors influence the difference in the concentration of Pb and Hg in the crab between the dry and rain seasons. According to Younis et al. (2015), seasonal differences influence changes in environmental conditions in water bodies, wherein the rainy season, water sources, and flow rates tend to be higher, resulting in dilution. Differences in heavy metal concentrations by season also occur in research by Nurhayati and Putri (2019) in Cirebon waters, where the concentration of heavy metals in green mussels increased in the dry season. The season also affected the levels of heavy metals, especially lead (Pb), which was strongly correlated.

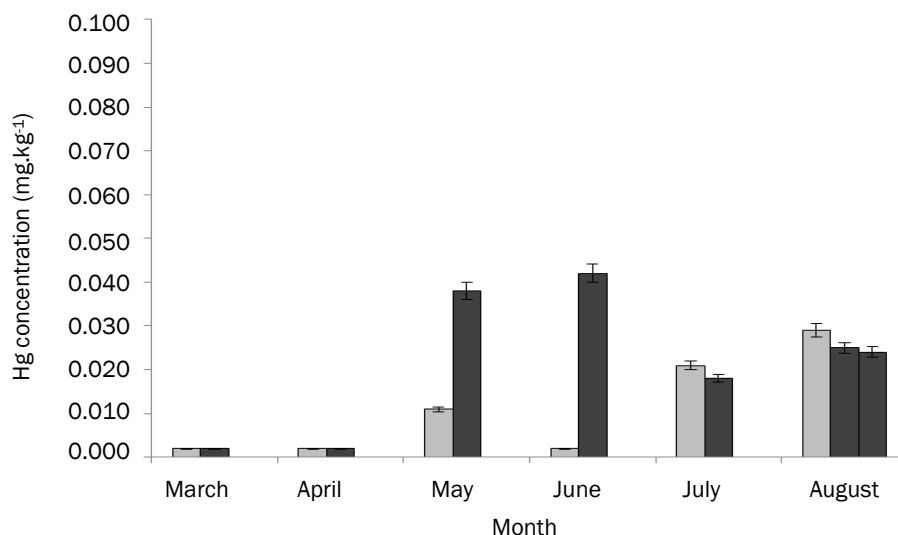


Figure 3. Hg content of blue swimming crab meat (*Portunus pelagicus*) in Cengkok Beach and surroundings (Banten Bay)
 Note : □ = small crab; ■ = large crab

Table 4. Safe limits for consumption of blue swimming crab meat (*Portunus pelagicus*) per weight of adult (60 kg)

Size	Safety level consumption per week (kg meat.week ⁻¹)	
	Pb	Hg
Maximum weekly intake	1.5	0.096
Large	21.13	2.29
Small	30.61	3.31

Table 5. Safe limit for consumption of blue swimming crab meat (*Portunus pelagicus*) per weight of children (15 kg)

Size	Safety level consumption per week (kg meat.week ⁻¹)	
	Pb	Hg
Maximum weekly intake	0.375	0.024
Large	5.28	0.57
Small	7.65	0.83

The heavy metal content in large size blue swimming crabs if averaged was higher than small size crabs. However, a statistical test related to the analysis of heavy metal content based on the treatment of size differences revealed no significant differences ($p \geq 0.05$). This is presumably because the size of biota is identical to the life of the biota, so the prolonged exposure to metals received by biota that have an older age will accumulate more heavy metals (a positive correlation between crab size and the ability to accumulate heavy metals). The strength of metal accumulation by biota will increase as the biota experiences growth (Sari et al., 2017).

Conclusion

The Pb content in crab meat (*Portunus pelagicus*) taken from the waters of the Bay of Banten has a range of 0.005–0.071 mg.kg⁻¹ and the Hg content of crab meat (*P. pelagicus*) ranges from

0.002–0.042 mg.kg⁻¹. The lead (Pb) and mercury (Hg) contents in Banten Bay blue swimming crab meat were mostly under the SNI quality standard (2009). Based on the results of observations of water quality parameters, the condition of Banten Bay waters is still within the quality standard range that has been stipulated by the Minister of Environment Decree No. 51 of 2004 to support marine biota that live in mangroves. The content of heavy metals in the blue swimming crab meat in each sampling period based on size differences had no significant effect. The bio-concentration factor of the blue swimming crab was low (<100). Blue swimming crab meat (*P. pelagicus*) was taken from the Cengkok Coastal Waters of Banten Bay, can be consumed as long as it does not exceed the safety level. The safety level of blue swimming crab consumption from Cengkok Coastal and surrounding area is 2.3 kg of meat.week⁻¹ (for adults) and 0.6 kg of meat.week⁻¹ (for children).

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