Heavy metals content (Hg, Cd, Pb, and Cu) in streaked spinefoot *Siganus javus* (Linnaeus, 1766) in Bojonegara Waters, Banten Bay, Indonesia

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Abstract. Anthropogenic activities contribute to heavy metals so that their concentration in the waters increases and causes accumulation, especially in streaked spinefoot. This study aims to estimate the level accumulation of (Hg, Cd, Pb, and Cu) heavy metals contained in streaked spinefoot (*Siganus javus*) meat in Bojonegara waters, Banten Bay, Indonesia. A sampling of 30 to 50 grams of fish meat is carried out every month from August to October 2020 and heavy metals analysis in streaked spinefoot meat was carried out in February 2021 using atomic absorption spectrophotometry (AAS). The (Hg, Cd, and Pb) heavy metals contained in the streaked spinefoot meat were undetected by the AAS, while the content of heavy metal Cu on small fish is 0.348 to 1.530 mg kg^{-1}, and large fish is less than 0.015 mg kg^{-1} to 5.390 mg kg^{-1}. Bioaccumulation Cu metal in small and large streaked spinefoot included low to high accumulation, while it was low for other types of metal. The safe limit for consumption of streaked spinefoot meat for adults (50 kg) is 32.468 kg of meat/week, while for children (15 kg), it is 9.740 kg of meat/week.

1 Introduction

The waters of Banten Bay are located in Serang Regency, Banten Province, Indonesia. One of the waters in Banten Bay, namely Bojonegara waters, has high fishery potential with a relatively shallow depth of 5 to 7 m on average. The freshwater input comes from the Wadas River and the Terate River. Bojonegara waters have undergone modifications in the form of reclamation, *jett*y, port infrastructure, and other coastal structures. The coastal area of Bojonegara has rapidly growing industrial activities such as the vegetable oil industry, steel deli, Java VII steam power plant (PLTU), domestic activities, and capture fisheries which are one of the livelihoods of coastal communities [1]. This activity can produce essential heavy metal waste such as Cu and non-essential materials such as Hg, Cd, Pb, which have toxic and

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hazardous material properties for aquatic biota. This result can lead to pollution of the aquatic environment and a decrease in water quality [2].

Heavy metals have properties that are difficult to degrade, quickly settle in sediments, and can accumulate in aquatic biota [3]. Heavy metals Hg, Cd, Pb, and Cu were selected to be identified because of their high toxicity and accumulative properties. In addition, heavy metals are widely used in industrial activities such as *paper*, textiles, sugar, ship repair and painting, Java VII steam power plant (PLTU), vegetable oil, and steel. The heavy metals waste in the waters will increase. If levels in the water are excessive, it will have a toxic impact on aquatic biota in the food chain [4].

Fish is one of the bioindicators of heavy metal pollution because it is included in the highest trophic level and is bioaccumulative [5]. One of the fish resources with economic value and high nutritional content, namely streaked spinefoot *Siganus javus* (Linnaeus, 1766), is widely consumed by people around the Bay of Banten [6]. Streaked spinefoot belong to the family *Siganidae* and are classified into the demersal fish group that lives near the bottom of the water. Streaked spinefoot can be found in estuaries to coral reefs, including herbivores with a small digestive tract and mouth size, a large and long intestinal surface, and a thick stomach wall [7]. The main food is seagrass, seaweed, algae, or moss, while at the larval level, it eats plankton [8]. Streaked spinefoot are species that live in pairs, are dynamic, tolerant of physical-chemical changes, and have a length of approximately 70 to 190 mm [9].

Heavy metals can absorb fish in two ways, namely the surface of the gills and skin (*water exposure*) and the food channel (*dietary exposure*) [10]. The food chain is one of the pathways that can be achieved by heavy metals able to accumulate on the body of biota. If aquatic biota is continuously exposed to heavy metals, it can accumulate and endanger another biota. Accumulation of heavy metals on the body of biota will interfere with organ function and cause death.

Research on heavy metal content in streaked spinefoot has been carried out by several researchers, such as analyzing lead metal content in Rabbitfish (*Siganus* sp.) From Tanakeke Island, Takalar Regency [11]. Heavy metal levels of Pb in Rabbitfish (*Siganus* sp.), Seagrass, sediment, and water in the coastal area of Bontang City, East Kalimantan [12]. However, research of heavy metal accumulation in streaked spinefoot in the Bojonegara waters has never been carried out, and the database of heavy metal pollution in streaked spinefoot is still relatively low. Therefore, research the bioaccumulation (Hg, Cd, Pb, and Cu) heavy metals of streaked spinefoot *Siganus javus* (Linnaeus, 1766) meat in Bojonegara Waters, Banten Bay needs to be done.

2 Methodology

2.1 Time and location

A Sampling was conducted from August 2020 to October 2020, and laboratory analysis was conducted in February 2021. Streaked spinefoot samples were obtained from Bojonegara waters, Banten Bay (Figure 1). The data was collected three times at intervals of once a month at three observation stations. Heavy metals analysis was conducted at Agricultural Industry Technology Testing Laboratory, IPB University.

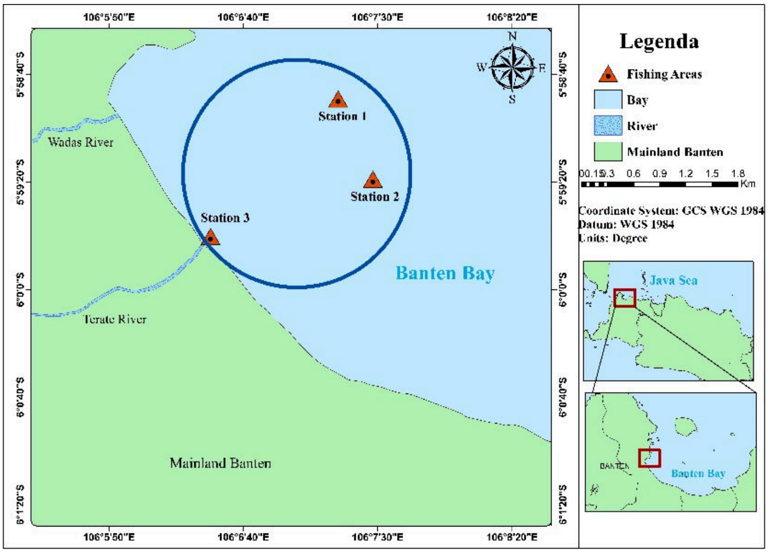

Fig. 1. Map of research location in the Bojonegara, Banten Bay.

2.2 Data collection

Data collection consisted of primary data and secondary data. Primary data used is the (Hg, Cd, Pb, and Cu) heavy metals content in streaked spinefoot meat, while secondary data is the heavy metal content in water and water quality (temperature, transparency, turbidity, depth, salinity, degree of acidity (pH), and *dissolved. oxygen* (DO)). Primary data were obtained from field and laboratory data collection, while secondary data were obtained from colleagues who researched the same location in 2020.

2.2.1 Sampling streaked spinefoot

Streaked spinefoot was carried out using *rampus* net, mesh size 2 inches. The method used is *non-probability sampling* because the opportunities for each population element are not the same, the population cannot be predicted, and the population is not fixed. The sampling technique was used purposive sampling because based on certain considerations such as the presence of streaked spinefoot and the level of pollutants to provide maximum data [13]. Fish samples were taken with three replications based on the month of sampling (August to October 2020). The streaked spinefoot obtained were stored in a *cool box* that contained ice cubes to keep the samples durable. The fish are then grouped into two sizes: small fish (length less than 15 cm long) and large fish (length greater than or equal to 15 cm). Streaked spinefoot meat is taken from the back under the dorsal fin using a surgical instrument as much as 30 to 50 g, then wrapped in aluminum foil, labeled, and stored in the *freezer* so that the sample is not damaged.

2.2.2 Sample digestion and heavy metal analysis

Streaked spinefoot meat was crushed by the *Nitric Acid-Perchloric Acid* method, which refers to APHA (2012). Samples were weighed as much as 2 g to 10 g using analytical scales with a tool accuracy of 0,00001 g. Next, the sample was put into a 300 mL Erlenmeyer and placed in the acid chamber. The sample was added with concentrated nitric acid (HNO_3) as much as 5 mL and then homogenized. Next, the sample is boiled at 100 ^oC for 15 minutes on a *hotplate* until the fish sample dissolves. When the solution is light yellow, 2 mL of distilled water is added and cooled at room temperature for 10 minutes. The sample solution was added with perchloric acid ($HClO_4$) 2 mL and then homogenized. This aims to stop the reaction with other compounds so that the sample can dissolve completely. The solution is heated again on the *hot plate* for 15 minutes until a white vapor is formed from perchloric acid ($HClO_4$). If the solution is not clear, keep heating and add 10 mL of concentrated nitric acid (HNO_3) until the digestion process is complete. The digestion stage is declared complete if a white vapor and sediment have been formed. Then, let it cool at room temperature for 15 minutes.

The digestion solution was filtered using filter paper (0.45 μm) to separate the precipitate in the sample solution. Furthermore, distilled water is added until the volume of the solution becomes 100 mL and homogenized. The sample solution was put into a sample bottle, tightly closed, and placed at room temperature. Furthermore, the solution was analyzed using AAS. Values of heavy metals Cd, Pb, and Cu were analyzed using *Flame* (Flame Atomic Absorption Spectrophotometry) and heavy metals Hg using *Cold Vapor Atomic* [14].

Heavy metals (Cd, Pb, and Cu) contained in fish meat were analyzed using an atomic absorption spectrophotometer Shimadzu (AAS) type AA-6880 while Hg metal was detected using Perkin Elmer AAnalist 100. Measurement of Hg metal concentration used a wavelength of 253.7 nm, Cd metal with a wavelength of 228.8 nm, Pb metal with a wavelength of 283.3 nm, and Cu metal with a wavelength of 324.7 nm.

2.3 Data analysis

2.3.1 Descriptive data analysis

Heavy metal content was carried out descriptively by comparing the quality standards for heavy metal content in fish meat with the quality standards of BPOM (2018), SNI (2009), and [17]. Meanwhile, the value of water quality and heavy metals in the water were compared with quality standards according to the Republic of Indonesia Government Regulation Number 22 of 2021 [18] regarding the implementation of environmental protection and management specifically for water quality standards for marine life biota.

2.3.2 Bioconcentration factor (BCF)

The bioconcentration factor is fish's ability to absorb and store pollutants such as heavy metals contained in the environment. The bioconcentration factor value was obtained by dividing the concentration of pollutants in aquatic biota (mg kg^{-1}) by the concentration of pollutants in the water (mg L^{-1}) [19]. Results of the calculation of bioconcentration factor (BCF) can be classified into the accumulation level category based on Esch (1997) [20], namely, low accumulation (BCF value less than 100), medium accumulation (BCF values range from 100 to 1000), and high accumulation (BCF value over than1000).

2.3.3 Maximum Weekly Intake/MWI

The maximum weekly intake value is obtained by multiplying the bodyweight of adults (50 kg) and children (15 kg) [21] by the provisional tolerable weekly intake (PTWI) value so that it can measure the safe limit of consumption for adults and children through the maximum tolerable intake [22]. Provisional tolerable weekly intake issued by the international food institute FAO dan WHO (2004) is Pb of 25, Cu of 3500, Cd of 7, Hg of 1.6 in units of µg kg^{-1} body weight per week.

2.3.4 Limit of tolerance for consumption per week (Maximum Tolerable Intake/MTI)

Maximum Tolerable Intake (MTI**)** can be calculated by dividing the value of maximum weekly intake (mg for a bodyweight of Indonesian adults (50 kg) and children (15 kg) per week) with heavy metals concentration on fish meat (mg kg^{-1}) [22]. So that the maximum tolerance value of fish meat consumption can be obtained for one week.

3 Results

3.1 Content of heavy metals (Hg, Cd, Pb, and Cu) in streaked spinefoot meat

The heavy metals (Hg, Cd, and Pb) in small and large meat of streaked spinefoot in August, September, and October are below the detection limit of AAS (Table 1). Unlike the case with the Cu heavy metal content value, the value varies, namely small fish ranged from 0.348 mg kg^{-1} to 1.530 mg $kg^{-1,}$ and large fish ranged from less than 0.015 mg kg^{-1} to 5.390 mg kg^{-1} (Figure 2). Heavy metals Cu contained on small and large streaked spinefoot does not significantly affect each month. The (Hg, Cd, Pb, and Cu) heavy metals content in every month does not exceed the predetermined quality standard.

Table 1. Heavy metal (Hg, Cd, and Pb) contained in streaked spinefoot meat in Bojonegara waters, Banten Bay.

Month	**Heavy metal content (mg kg^{-1})**	**Small streaked spinefoot (< 15 cm)**	**Large streaked spinefoot (≥ 15 cm)**	**Quality standard**	
				SNI (2009)	**BPOM (2018)**
August, September, and October 2020	Hg	<0.001	<0.001	0.500	0.500
	Cd	<0.005	<0.005	0.100	0.100
	Pb	<0.030	<0.030	0.300	0.200

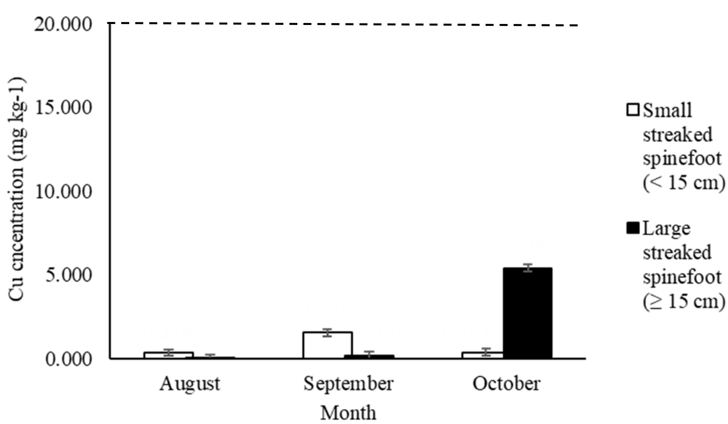

Fig. 2. Heavy metal Cu contained in streaked spinefoot meat in Bojonegara waters, Banten Bay. (‒ ‒ ·) Ditjen POM Depkes RI (1989).

3.2 Bioconcentration factor (BCF)

The bioconcentration factor analysis of Cu metal in small streaked spinefoot experienced fluctuation while large streaked spinefoot experienced an increase every month (Table 2). The bioconcentration factor of Cu in small streaked spinefoot was classified as moderate accumulation (FBK 100 to 1000), while the FBK value of large streaked spinefoot from August to October included low to high accumulation reaching 2695 (FBK greater than 1000). In addition, the level of Hg, Cd, and Pb metal accumulation in small and large streaked spinefoot was classified as low (FBK less than 100).

Table 2. The accumulation rate of heavy metal streaked spinefoot in the waters of Banten Bay.

Month	**Small streaked spinefoot (< 15 cm)**				**Large streaked spinefoot(≥ 15 cm)**			
	Hg	**Cd**	**Pb**	**Cu**	**Hg**	**Cd**	**Pb**	**Cu**
August	5.000	5.000	15.000	174.000	5.000	5.000	15.000	7.500
September	5.000	5.000	15.000	340.000	5.000	5.000	15.000	38.889
October	5.000	5.000	15.000	183.500	5.000	5.000	15.000	2695.000

3.3 Water quality in the Bojonegara waters, Banten Bay

Results of the analysis temperature and transparency parameters from August to October have the lowest average decrease in October, ranging from 32.5 °C to 36 °C while the brightness ranges from 0.85 m to 2.9 m. In October, the highest increase in turbidity and salinity ranged from 1.2 NTU to 3.2 NTU, and salinity ranged from 32 ‰ to 38 ‰. *Dissolve oxygen* and depth fluctuate. The D.O value obtained ranges from 3.3 mg L^{-1} to 6.5 mg L^{-1} and depth ranging from 4 m to 10 m. The pH value is relatively homogeneous, ranging from 7 to 7.9. The temperature, brightness, and turbidity parameters did not follow the quality standard. In contrast, the salinity, D.O, and pH parameters followed the quality standard, but salinity and D.O in August did not follow the quality standard (Table 3).

The results of heavy metal content mercury (Hg), cadmium (Cd), and lead (Pb) analysis from August to October were below the AAS detection limit, except for lead metal (Cu) ranging of 0.005 mg L^{-1} to 0.008 mg L^{-1}. The Hg, Cd, Pb, and Cu contained in the waters do not exceed the quality standards of PP RI Number 22 of 2021 (Table 3).

3.4 Maximum Tolerable Intake/MTI of streaked spinefoot

The results of the calculation of the safe limit for consumption in Table 7 show that the safe limit for consumption in one week of streaked spinefoot meat for adults (assumed a bodyweight of 50 kg) in Bojonegara waters, Banten Bay, a maximum of 32.468 kg of meat/week while for children (assumed body weight of 15 kg) can consume as much as 9.740 kg of meat/week. This value is taken from the heavy metal Copper which has the *maximum tolerable intake* lowest (MTI) value. Streaked spinefoot meat is still safe for consumption by the people around Banten Bay as long as it does not exceed the predetermined limit.

Table 3. Water quality data in the waters of Banten Bay.

Parameter	Month			Quality standard (PP RI No 22 of 2021)
	August 2020	September 2020	October 2020	
Temperature (°C)	31.5-37.5 (34.50 ± 3.00)	32-36 (33.67 ± 2.08)	32.5-36 (33.87 ± 1.89)	28-30
Transparency (m)	2.65-3.75 (3.38 ± 0.64)	1.75-4.7 (3.23 ± 1.48)	0.85-2.9 (1.72 ± 1.06)	>5
Turbidity (NTU)	1-2.8 (1.73 ± 0.95)	1.1-2.8 (1.80 ± 0.89)	1.2-3.2 (2.17±1.00)	5
Salinity (‰)	29-32 (30.33 ± 1.53)	30-33.5 (31.50 ± 1.80)	32-38 (35.00 ± 3.00)	33-34
Dissolved oxygen (DO)*	3.3-4.4 (4.03 ± 0.64)	4.2-6.5 (5.27 ± 1.16)	3.4-5.6 (4.53 ± 1.10)	>5
pH	7-7 (7.00 ± 0.00)	7-7 (7.00 ± 0.00)	7.1-7.9 (7.60 ± 0.44)	7-8.5
Deph (m)	4-10 (7.00 ± 3.00)	6.5-9.8 (7.60 ± 1.91)	3.5-10 (6.93 ± 3.27)	-
Mercury (Hg)*	<0.0002	<0.0002	<0.0002	0.001
Cadmium (Cd)*	<0.001	<0.001	<0.001	0.001
Lead (Pb)*	<0.002	<0.002	<0.002	0.008
Copper (Cu)*	0.005-0.007 (0.006 ± 0.001)	0.007-0.007 (0.007 ± 0.000)	0.008-0.008 (0.008 ± 0.000)	0.008

*in units (mg L^{-1})

Table 4. Maximum Tolerable Intake of streaked spinefoot per weight of an adult (50 kg) and per weight of children (15 kg).

Size	Maximum Tolerable Intake (kg of meat/week) Adult (50 kg)				Maximum Tolerable Intake (kg of meat/week) Child (15 kg)			
	Hg	Cd	Pb	Cu	Hg	Cd	Pb	Cu
MWI	0.080	0.350	1.250	175.000	0.024	0.105	0.375	52.500
Small streaked spinefoot	80.000	70.000	41.670	114.379	24.000	21.000	12.500	34.314
Large streaked spinefoot	80.000	70.000	41.670	32.468	24.000	21.000	12.500	9.740

4 Discussion

Bojonegara Waters, Banten Bay is one of the fishing areas for local fishers. One of the catches of fishermen in these waters is streaked spinefoot. Streaked spinefoot (*Siganus javus*) are classified into a group of demersal fish that live near the bottom of the water. These fish are found in seagrass beds and coral reefs [6], but streaked spinefoot can be found in estuaries and coral reefs [7]. Based on the catch, the dominant streaked spinefoot were found in the area of station 1 and station 2 (sea waters) and station 3 (Estuary Terate) (Figure 1).

Fishing activities, industry, and highly developed human activities cause pollution in Bojonegara waters. The wastes suspected of contaminating the waters are heavy metals mercury (Hg), cadmium (Cd), lead (Pb), and copper (Cu). They have toxic properties and, for a long time, can settle in the aquatic environment. In addition, heavy metals have the characteristics of bioaccumulation and persistence [24].

The AAS undetected the Hg, Cd, Pb metals contained of small and large streaked spinefoot meat, except for heavy metal Cu, which has varying values. Accumulation of Hg, Cd, Pb metals in streaked spinefoot meat is very low and is below the quality standard according to BPOM (2018) [15] and SNI (2009) [16]. Low levels of heavy metals in water cause heavy metals that enter the body of biota will also be lower [25]. Heavy metal accumulation in biota will still occur if exposed for a long time, even though the levels are low in the water. Heavy metal content in meat was lower than in other organs such as the liver, kidneys, and gills [26].

Streaked spinefoot can excrete heavy metals contained in their bodies through metabolic processes. Liver and kidney organs can eliminate toxicants in the fish body through various enzymatic reactions [27]. The low levels of Hg, Cd, and Pb of streaked spinefoot meat are thought to be due to the ability in optimal metabolic processes, low input of industrial waste and domestic activities, as well as heavy metals found in waters scattered freely in various locations due to currents. The level of heavy metals bioaccumulation in aquatic organisms depends on the presence of metal concentrations in water and the ability to metabolize metals [28]. In addition, it can be influenced by tides, currents, and waves in the sea cause heavy metals to move freely, resulting in a dilution process [29]. The input of heavy metal pollutant sources that flow through rivers to the sea comes from the accumulation of land waste with the proportion of waste input between 80 and 85% [30].

Sources of Hg, Cd, and Pb metals in Bojonegara waters are thought to come from the vegetable oil, sugar, steel deli industries, and the Java VII steam power plant (PLTU). The pollutant input of mercury (Hg) (non-essential metal) can come from anthropogenic activities, deposition from atmosphere, and industrial wastewater from surface runoff [31]. Sources of metal contaminants cadmium (Cd) (non-essential metal), are widely used in the battery, electroplating, plastic stabilizer, and pigment industries. Cadmium in agriculture is usually used in pesticides and fertilizers [31]. Pollutant (Pb) (non-essential metal) is generally produced from anthropogenic activities such as agricultural waste originating from the application of inorganic pesticides and fertilizers, domestic waste, industrial and ship oil spills, and the use of ship fuel [32].

Heavy metal copper (Cu) is an essential heavy metal that, in small amounts, is still needed by the body for physiological and metabolic processes. Cu metal will be very toxic if the concentration is high in the body of biota [32]. Copper (Cu) in fish bodies can be found in gills, kidneys, hematopoietic tissue, mechanoreceptors, and chemoreceptors. Naturally, Cu metal enters the waters due to erosion events and from the air carried by rain, while from human activities, it comes from industrial and domestic activities [33]. Cu metal waste can come from ballast water discharge activities on ships and ship paint as anti-rust [34]. In addition, the metal content of Cu is thought to come from PLTU activities using coal and from ship transportation activities in Bojonegara waters.

Observations of Cu metal on streaked spinefoot meat in August, September, and October were higher than other heavy metals. The Cu metal contained on small streaked spinefoot meat fluctuates every month, the highest in September at 1.530 mg L^{-1} and the lowest in August at 0.348 mg L^{-1}. In contrast to the large streaked spinefoot meat, the highest monthly increase was in October, reaching 5.390, while the lowest in August was under AAS detection of less than 0.015 mg L^{-1}. The content of heavy metal Cu per month is still below the quality standard according to the Directorate General Ministry of Health, Republic of Indonesia (1989) of 20 mg L^{-1}. The content of heavy metals Cu in small and large streaked spinefoot does not significantly affect each month. It can be said that streaked spinefoot have bioaccumulation of heavy metal Cu. Biota can accumulate heavy metals in the body, because toxicants are easily bound and dissolve in fat (lipid-soluble) and then be absorbed by body parts to accumulate in certain tissues [27].

The content of Cu metal in the flesh of small streaked spinefoot in August and September has a higher content than that of large streaked spinefoot. It is suspected that before the small streaked spinefoot were found in the Bojonegara waters, they came from waters contaminated with heavy metals. The fishing location was on the ship transportation route so that it was easy to accumulate heavy metal Cu. Small streaked spinefoot can accumulate more Cu heavy metals than large streaked spinefoot. This result is because large streaked spinefoot have more ability to eliminate heavy metals than small streaked spinefoot. The main sources of heavy metal pollution in waters are industrial activities and ship transportation [35].

This study is in line with that conducted by Noviani (2020) [36] in Banten Bay waters that small mangrove crabs have a high level of accumulation of heavy metals because large organism have a good ability to eliminate heavy metals from their bodies. In addition, the ability to accumulate heavy metals in organisms will be lower due to decreased metabolic processes. The value heavy metals concentration in large organisms is lower than in small organisms. The value of heavy metals concentration on large fish is lower because dilution occurs during the growth process so that the heavy metals accumulation decreases with increasing size [37].

In October, the Cu metal contained on large-sized streaked spinefoot meat has a higher concentration than that of small-sized streaked spinefoot. It is suspected that the biota size is identical to the biota life. The heavy metals exposed to the body of large and old streaked spinefoot for a relatively long time causes a higer accumulation of Cu metals. In addition, the input of Cu metal in October is predicted to be higher than in August and September. Heavy metal toxicity is affected by the exposure time, fish species, the way the toxicant enters the body, the nature, form, and concentration of the toxicant [38]. Fish will accumulate if the rate of heavy metal elimination in their body is lower than the rate of heavy metal intake [39].

The concentration of Cu metal is relatively high every month because it accumulates in tissues and meat. In the long term, the heavy metal content increases. Environmental conditions and seasons can affect the heavy metals content in water and biota [40]. Streaked spinefoot is easy to accumulate heavy metals because it is thought to come from waters with poor environmental conditions. It is suspected that the dominant streaked spinefoot areas are located at station 1 and station 2 (sea waters), and station 3 (Estuary Terate) (Figure 1) is an area close to PLTU Jawa VII and as a ship transportation route. The heavy metal content from August to October is the dry season so that the heavy metals concentration is higher and is referred to as concentrated metal.

The value of the bioconcentration factor is used to determine the level of bioaccumulation and evaluate the chemical's toxicity in the environment [41]. The bioconcentration factor (BCF) of heavy metal Cu in small streaked spinefoot fluctuated while large streaked spinefoot increased every month. The bioconcentration factor (BCF) of Cu metal in small streaked spinefoot is on average classified into moderate accumulation (BCF 100 to 1000). In contrast to the FBK value of large streaked spinefoot from August to October, the accumulation was low to high reaching 2695 (BCF greater than 1000). In addition, the level of accumulation of Hg, Cd, and Pb metals each month remains the same, large and small streaked spinefoot are included in the low accumulation (BCF less than 100). The low concentration of Hg, Cd, and Pb metals in streaked spinefoot meat cause the heavy metals concentration in water to be very low, so the calculation is assumed to use the detection limit of the tool. The presence of Hg, Cd, Pb needs to be watched out for even though it is low in accumulation because these heavy metals are accumulative in the body of organisms or humans.

Small and large streaked spinefoot have a greater ability to accumulate Cu in the water column so that heavy metals concentration in the fish body is greater than in the living medium. This is because heavy metal Cu has the highest value in the water column, so that it affects the accumulation in the meat of streaked spinefoot. The size of the bioconcentration factor value depends on heavy metal type, exposure time, and aquatic environment condition, and the type of organism [42]. The high accumulation of heavy metals in aquatic biota causes the bioconcentration value to be higher.

The average of Hg, Cd, Pb metals in water was undetected by AAS, excepted for Cu metal from August to October, which had values ranging from 0.005 mg L^{-1} to 0.008 mg L^{-1}. The Average of Hg, Cd, Pb, and Cu metals is still below the quality standard of PP RI No. 22 of 2021 [18]. The low concentration of heavy metals in water is caused by mass transfer of water, both moving in and out of one water to another, thus affecting the distribution and dilution of these waters [29]. The low heavy metals concentration in water affects the accumulation that occurs on aquatic biota. Bojonegara Waters, Banten Bay are still classified as good so that they can support the life of aquatic biota, one of which is streaked spinefoot [43].

The general condition of waters can be described from water quality measurements such as physical and chemical parameters. When compared with the quality standard of PP RI Number 22 of 2021, the temperature parameter is more than the predetermined quality standard, which is 28 °C to 30 °C. According to local fishermen, the high temperature in Bojonegara waters is thought to have come from the heat water waste disposal pipe produced by PLTU Jawa VII. The transparency and turbidity value of the waters does not exceed the quality standard, which is more than 5 m and 5 NTU. The range of salinity and DO values from September to October is following the established quality standard range, which is 33 to 34 and more than 5 mg L^{-1} but in August, it does not meet the quality standard. Every month, the pH parameter is still within the specified quality standard range, which is 7 to 8.5. The water depth parameter value obtained follows its natural state. So it is suspected that the aquatic environment can still be tolerated by streaked spinefoot.

The maximum weekly intake value is obtained by multiplying the bodyweight of adults (50 kg) and children (15 kg) by the provisional tolerable weekly intake (PTWI) value so that it can measure the safe limit of consumption for adults and children through the maximum tolerable intake [40]. The safe limit for consumption calculated in this study is quite high. Adults (50 kg) can consume a maximum of 32.468 kg of fish meat per week, while children (15 kg) can consume 9.740 kg of meat per week. The safe limit for consumption can be taken from the smallest value of the type of heavy metal content because foods containing heavy metals, even at low levels if consumed continuously, will accumulate in the human body, are toxic, and can cause interference with the kidneys, blood circulation system, lungs, and heart [13].

The research that has been done can be used as a consideration in managing to maintain the survival and presence of streaked spinefoot in the Bojonegara waters. Activity monitoring needs to be done and evaluate heavy metal pollution that occurs every year, so that can be used as a guideline in updating the rules every year regarding the disposal of waste such as industrial waste, domestic waste, and agricultural waste that leads to the waters of Banten Bay. In addition, socialization to the public regarding the safe limit for consumption of streaked spinefoot meat for adults (50 kg) is a maximum of 32.468 kg of meat/week, while children (15 kg) can consume as much as 9.740 kg of meat/week needs to be done to avoid disease for the elderly human.

5 Conclusion

The heavy metal content of Hg, Cd, Pb in small and large streaked spinefoot was below the AAS detection limit, while small streaked spinefoot were detected to contain heavy metal Cu ranged 0.348 mg kg^{-1} to 1.530 mg kg^{-1} and large fish ranging of less than 0.015 mg kg^{-1}

to 5.390 mg kg^{-1}. Heavy metals (Hg, Cd, Pb, and Cu) contained in streaked spinefoot as a whole is below the quality standard that has been set. Small-sized streaked spinefoot experienced bioaccumulation of heavy metal Cu including medium accumulation and large-sized streaked spinefoot including low to high accumulation, while heavy metals Hg, Cd, and Pb including low accumulation. The safe limit for consumption of streaked spinefoot meat for adults (50 kg) is a maximum of 32.468 kg of meat/week, while children (15 kg) can consume as much as 9.740 kg of meat/week.

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