Metals Content In Edible Gastropod From Blanakan Silvofishery Ponds

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Abstract. Human activities contribute to waste and promote threats to water quality. Heavy metals contamination is one of the threats. High input of heavy metals on ponds will affect organism including gastropods. Mangrove snail (Telescopium telescopium) is one of the non-cultural biotas which is consumed by humans. This research aimed to determine metals content in mangrove snail flesh from Blanakan silvofishery ponds. Samples were conducted from three ponds using a purposive sampling technique in April 2018. Metals content were analyzed using Atomic Absorption Spectrophotometry. The Result showed that the highest Pb and Cu content was in pond 3 at 19.46 mg/kg and 27.52 mg/kg respectively and the highest Zn content was in pond 1 at 21.28 mg/kg. The Bioconcentration Factor (BCF) values ranged 0.05 – 4.57 showed that mangrove snail has a tendency to accumulate heavy metals. The bioconcentration values > 1 at Cu showed that mangrove snail can be used as bioindicator to control Cu pollution, especially in the mangrove ecosystem. One of the efforts to protect public health is to set a maximum limit of metal contamination in food that is suitable for consumption. The maximum limit of metal contamination in food is determined through a decree of the General Director of Drug and Food Control, an institution in Indonesia which is in charge of overseeing the circulation of drugs and food in accordance with the provisions of the legislation. Based on The National Agency of Drug and Food Control No. 03725/B/SK/VII/89, people must be more careful in consuming mangrove snail.

1. Introduction

Environmental pollution is the entry or inclusion of living things, substances, energy and/or other components into the environment by human activities so that their quality and functions drops. Heavy metal is one of the pollutants that is dangerous because it is toxic if exceeds the threshold. Based on its chemical and physical properties, the level or power of heavy metal toxins against aquatic animals can be sorted (from high to low) as follows: mercury (Hg), arsenic (As), cadmium (Cd), lead (Pb), copper (Cu) and zinc (Zn) [1].

Pollutants can be released into the environment as gases, dissolved substances or the particulate form. Ultimately, pollutants reach the aquatic through a variety of pathways, including the atmosphere and the soil. The major point sources of pollution to freshwaters originated from the collection and discharge of domestic wastewaters, industrial wastes or certain agricultural activities, such as animal husbandry.
Most other agricultural activities, such as pesticide spraying or fertilizer application, are considered as diffuse sources [2].

Heavy metals have an influence on human ecology and health. Lead (Pb) is a metal that occurs naturally and found in the earth's crust. Copper (Cu) and Zinc (Zn) are essential elements needed by organisms/ biota but can be toxic if the amount exceeds the threshold. The interaction with certain biomolecules in the body of an organism can increase the lethal effect of the metal [3]. Furthermore, the impact of heavy metals can affect the health of humans who consumed biota.

One of the people livelihoods in Blanakan is fish farming with a sylvofishery concept. This concept is an integrated management effort between mangroves forests combined with ponds. This was considered the most suitable pattern to increase the welfare of the community while the sustainability of mangrove forests is still guaranteed [4].

Molluscs (gastropod) are the most prominent species and play an important ecological role in the mangrove ecosystem. Mangrove snail are gastropods of the potamididae family which was a conspicuous feature of the mangrove associated muds. Their characteristics are high spired, solid shell, smoothly curving outer lip and sharply reflexed anterior siphonal canal [5]. Besides the delicious taste, based on [6] mangrove snail rich in protein (12.16%), less fat (0.38%), and contains alkaloids, steroids, and flavonoids which can be used as an antioxidant. That's why humans like to consume it.

The transformation of heavy metals in the aquatic environment occurs through a process of reduction, methylation, demethylation, and oxidation which is mediated biochemically. The biochemical process is carried out by microorganisms and algae. Methylation of Hg, As, Sn and Pb occur when microorganisms consume organic substances and accidentally come into contact with metal ions. Absorption of heavy metals by fauna and flora can trigger an increase in metal concentrations in the body of the organism; if the excretion phase is slow, this can cause bioaccumulation phenomena. Some metals such as mercury have been shown to experience biomagnification through the food chain [7].

This research aimed to determine the kinds of heavy metals that likely exist in the aquatic environment and penetrate the flesh of an organism. Furthermore, edible biota can actually change the function to be biological indicators (bioindicators).

2. Method

2.1. Study Site
The study was conducted in silvofishery ponds at Blanakan village, Subang, West Java. Determination of the coordinates sampling points was carried out using GPS (Global Positioning System). Sampling was carried out at 3 stations: station 1 (S 06O 15’ 47.1’’ E 107O 40’ 08.4’’), station 2 (S 06O 15’ 18.2’’ E 107O 40’ 41.8’’), and station 3 (S 06O 15’ 00.8’’ E 107O 40’ 07.7’’). Station 1 is associated with river estuaries, housing, and rice fields; station 2 is associated with the industry, and; station 3 is associated with river and sea estuaries (figure 1).
2.2. Field Sampling

The tools used in this research are Global Positioning System (GPS), salinometer (refractometer), Marina Cooler 35L, DO meter, pH meter, camera, scoop, bucket, ziplock, sensi gloves, mask. Samples were taken from inlet and outlet positions from each station with 2 (two) repetition. Mangrove snails took by hand with the help of gloves and sediment with scoop, then it was put in ziplock.

2.3. Water Quality Parameter

Temperature is measured using a thermometer, acidity using a pH meter, dissolved oxygen using a DO meter, and salinity using a refractometer.

2.4. Heavy Metal Analysis

The Heavy metal analysis is carried out at the chemical laboratory University of Indonesia using AAS (Atomic Absorption Spectrophotometer) method. Mangrove snail flesh was taken ± 1 gram, then added with HNO3 and HCLO4 concentrated with a ratio of 3: 1. Sediment samples were carried out by taking it to form several location ± 5 gram, then adding HNO3 and HCLO4 concentrated with a ratio of 4:2. Then, the sample was destructed/ heated on Hot Plate for ± 2 hours until the color was clear/ greenish yellow. Next, the sample was filtered and poured into a 10 ml size flask, diluted to the boundary markers. Then, the resulting filtrate was analyzed using the Shimadzu AAS 6300.

2.5. Bioconcentration Factor (BCF)

BCF was calculated to show whether biota could be categorized as accumulators (BCF > 1) using formula as follows [8]:

$$ BCF = \left( \frac{C_{biota}}{C_{sediment}} \right) $$

with BCF = bioconcentration factor; $C_{biota}$ = metal content in biota and; $C_{sediment}$ = metal content in sediment

2.6. Maximum Tolerable Intake (MTI)

The measurement of Maximum Weekly Intake (MWI) using threshold numbers limits issued by the Joint FAO/WHO Expert Committee on Food Additive (JEFCOA), as follows [9]:

$$ MWI (\mu g) = \text{Weight } \times \text{PTWI} $$

With MWI = Maximum Weekly Intake; $\times$ assuming average human weight at 60 kg; $\times$ = Provisional Tolerable Weekly Intake issued by the JECFA Agency (Table 1).
| No | Metals | PTWI (μg.kg\(^{-1}\)) |
|----|--------|---------------------|
| 1  | Pb     | 25                  |
| 2  | Cu     | 3500                |
| 3  | Zn     | 7000                |

After knowing the value of MWI and find out the metal concentration in consumption biota, then maximum tolerable intake (MTI) can be calculated by a formula:

\[
MTI = \frac{MWI}{Ct}
\]  

(3)

With \(MTI\) = Maximum Tolerable Intake (μg for human weight at 60 kg/week); \(Ct\) = Heavy metal concentrations found in mangrove snail flesh (μg.kg⁻¹).

### 3. Result and Discussion

#### 3.1. Water Quality Parameter

Silvofishery which is applied in the Blanakan aquaculture area is a traditional trench pond model with an enhanced pattern. Mangrove bars and ponds are in one stretch and water management is regulated by two sluice gates, namely inlet and outlet (Figure 2). Pond water sources are a mixture of river water and seawater with tidal relief. In meeting water requirements, namely replacing or adding water, the silvofishery pond utilizes the tide time to fill the pond through the inlet. The types of biota that are commonly cultivated are milkfish, black shrimp and tilapia.

![Sampling location](image)

Figure 2. Sampling location
(a) station 1, (b) station 2, (c) station 3

The measurement results of the quality parameters at Blanakan silvofishery ponds (Table 2) showed that waters are still classified as normal or good for aquaculture. The temperature ranged 28.6-33.7 °C, pH 6.5-7.2, salinity ranged 13-26 ‰, and DO ranged 5.8-6.6 mg/l. This is based on the Decree of the Minister of Environment No. 51 of 2004 concerning sea water quality standards for biota.
Table 2. Water quality parameters measurement

|                  | Station 1          | Station 2          | Station 3          | threshold |
|------------------|--------------------|--------------------|--------------------|-----------|
|                  | Inlet   | Outlet  | Inlet   | Outlet  | Inlet   | Outlet  |         |
| Temperature (°C) | 28.6    | 29      | 33.3    | 31.5    | 33.7    | 32      | 28 – 32 |
| Salinity (%)     | 13      | 12      | 26      | 23      | 14      | 14      | s/d 34  |
| Dissolved Oxygen (mg/l) | 6.6 | 5.9      | 5.8      | 6.2      | 5.8      | 6.1      | > 5     |
| pH               | 6.5     | 7.1     | 6.7     | 6.9     | 7.2     | 6.8     | 7-8.5   |

The temperature difference between stations is not too striking, ranging from 28°C - 33°C. The average value of salinity ranges from 12-26 ‰, the fluctuating value is influenced by the tide process. Temperature is one of the parameters that can affect the biological chemistry of biota and the solubility and distribution of heavy metals. Salinity can affect the levels of heavy metals in the waters, increase the toxic power of heavy metals and the level of bioaccumulation of heavy metals [10].

3.2. Metals Content and Bioconcentration factor in Mangrove Snail Flesh

According to The Food and Agriculture Organization of The United Nations (FAO), mangrove snails can be found in abundant quantities in aquaculture areas and close to the river mouth bordering mangrove forests. Mangrove snails like open land, lots of suns, large enough water, rich in organic matter and sandy mud substrate. Mangrove snails have the following classifications:

Phylum: Mollusca
Class: Gastropods
Order: Neotaenioglossa
Family: Potamididae
Genus: Telescopium
Species: Telescopium telescopium

*Telescopium telescopium* is one of the mangrove associated fauna which is present at Blanakan Sylvofishery ponds and exploited for consumption. In this research, heavy metals content is measured from the sample of size 8.5-9.5 cm with body weight at 41.5-43.3 gram (figure 3).

According to the FAO, heavy metals enter the water environment from natural and anthropogenic sources. Entry may be as a result of direct disposal to freshwater and marine ecosystems or through indirect routes such as deposition of dry and wet land runoff. Anthropogenic sources include: 1) mining waste; 2) industrial waste; 3) household and urban rainwater waste flows; 4) washing metal from
waste and solid waste is disposed; 5) metal inputs from rural areas, for example, metals contained in pesticides; 6) atmospheric sources, such as burning fossil fuels, burning waste and industrial emissions; 7) petroleum industry activities. Examples of sources that have the potential to produce heavy metals in the environment are presented in Table 3. Subang has several industrial areas including Cikaum, Pabuaran, Cipeundeuy, Kalijati, Purwadadi, Cipunagara, and Cibogo.

Table 3. Industrial and agricultural sources that have the potential to contribute metals in the environment

| Source                                           | Metal produced                          |
|--------------------------------------------------|-----------------------------------------|
| Batteries and other electricity                  | Cd, Hg, Pb, Zn, Mn, Ni                 |
| Paints and pigments                              | Ti, Cd, Hg, Pb, Zn, Mn, Sn, Cr, Al, As, Cu, Fe |
| Alloys and solders                               | Cd, As, Pb, Zn, Mn, Sn, Ni, Cu         |
| Pesticides (herbicides, preservatives)           | As, Hg, Pb, Cu, Sn, Zn, Mn             |
| Catalyst                                         | Ni, Hg, Pb, Cu, Sn                     |
| Glass                                            | As, Sn, Mn                              |
| Fertilizer                                       | Cd, Hg, Pb, Al, As, Cr, Cu, Mn, Ni, Zn |
| Plastic                                          | Cd, Sn, Pb                              |
| Dental and cosmetics                             | Sn, Hg                                  |
| Textile                                          | Cr, Fe, Al                              |
| Oil refinery                                     | Ni, V, Pb, Fe, Mn, Zn                  |
| Fuel                                             | Ni, Hg, Cu, Fe, Mn, Pb, Cd             |

http://www.fao.org

Based on The National Agency of Drug and Food Control No. 03725/B/SK/VII/89 [11], the maximum limit of metal contamination in fish and their processed products is 2 mg/kg for Pb, 20 mg/kg for Cu and 100 mg/kg for Zn. The Result showed that most of the Pb value exceeds the quality standard, ranged 1.07-19.46 mg/kg (Table 4). The highest Pb content was in inlet station 3 because inlet is the entry point for pollutants and Pb was non-essential metal in the organism body. The lowest Pb content was in inlet station 2 because this station has a lot of mangrove trees which can help to absorb the metals.

Cu content in mangrove snail ranged 12.46-27.52 mg/kg. The highest Cu content was in outlet station 3 because mangrove snail was deposit feeder and using extensible snout for swallowing mud and detritus from the surface of silt during low tide. The lowest Cu content was in inlet station 1 because Cu was essential metal. According to [12], Cu was used by a mollusk as blood proteins to bring O2 such as hemoglobin function. Zn content at research sites still below the quality standard ranged 7.93-21.28 mg/kg. This value indicates that no harmful effects for the content of Zn in mangrove snail.

Table 4. Metals Content and BCF Value in Mangrove Snail Flesh

| Station | Pb | Mn | Cu | Zn |
|---------|----|----|----|----|
|         | Snail | Sediment | BCF | Snail | Sediment | BCF | Snail | Sediment | BCF |
| 1       | Inlet | 9.11 | 18.96 | 0.48 | 12.46 | 5.70 | 2.19 | 21.28 | 57.94 | 0.37 |
|         | Outlet | 8.80 | 19.47 | 0.45 | 21.96 | 6.28 | 3.5 | 17.09 | 67.80 | 0.25 |
| 2       | Inlet | 1.07 | 19.56 | 0.05 | 21.96 | 6.28 | 3.5 | 17.09 | 67.80 | 0.25 |
|         | Outlet | 1.46 | 17.87 | 0.08 | 19.89 | 6.11 | 3.26 | 9.36 | 61.34 | 0.15 |
| 3       | Inlet | 19.46 | 15.30 | 1.27 | 18.46 | 6.57 | 2.81 | 13.59 | 51.86 | 0.26 |
|         | Outlet | 2.39 | 13.81 | 0.17 | 27.52 | 6.02 | 4.57 | 12.31 | 57.46 | 0.21 |

Station 3 is associated with river and sea estuary as a source of pollutants. River and sea estuaries are the distribution routes of heavy metals into pond waters. Waste produced by households, settlements, rice fields, and industries can be carried away by the flow of water and wind entering the pond waters through rivers and the sea. The tidal process also influences the entry of heavy metals into pond waters.
Biota that lives permanently (sessile) such as mangrove snails have the potentiality to accumulate higher heavy metals than biota that are actively swimming. Gastropods have high adaptability in various habitats, can accumulate heavy metals without experiencing death and act as environmental indicators due to their inhabitation character as a filter feeder and in the sediment (deposit feeder) [13]. The highest Zn value is found in sediments because sediment is a metal repository, heavy metals in the aquatic environment will eventually settle in the sediment.

Bioaccumulation is a process in which chemicals can affect living organisms. Bioaccumulation occurs when an organism absorbs heavy metals in amounts exceeding the threshold. The several processes are by uptake, storage, and elimination. Bioaccumulation is related to increase the concentration of chemicals in biological material of an organism over a period of time and compared with the concentration of these chemicals in the environment. Bioaccumulation occurs when an organism absorbs a toxic compound at a higher level than the release of the compound [14].

The results showed that the Bioconcentration Factor (BCF) values in mangrove snails were Cu > Pb > Zn ranged 0.05-4.57 (Table 3). The highest average BCF value in mangrove snails is found in Cu. Organisms that have BCF values > 1 can be used as bioindicators [15]. The high accumulation of Cu is from household waste and industrial wastes around the Blanakan-Subang aquaculture area. The results showed that mangrove snail has the ability to accumulate metals and could be used as bioindicators, especially Cu at the mangrove ecosystem.

3.3. Consumption Feasibility

Based on The Provisional Tolerable Intake (PTWI) calculation, can be said that mangrove snails from Blanakan silvofishery ponds are still safe and suitable for consumption as long as they do not exceed the established limits (Table 5).

| Table 5. Maximum Weekly Intake (MWI) for individuals weighted 60 kg |
|------------------------|------------------|------------------|
| No | Heavy Metals | MWI (µg) | MWI (mg) |
|---|-------------|--------|---------|
| 1 | Pb | 1500 | 1.5 |
| 2 | Cu | 210000 | 210 |
| 3 | Zn | 420000 | 420 |

If the metals enter the body exceeds the MWI value, it will be toxic. Metals toxicity can cause stomach ache, nausea, vomiting, diarrhea, impaired brain function, impaired growth, liver or kidney dysfunction and reproductive disorders, and can cause and death [8]. Next, the estimation of the risk of consumption of mangrove snail from Blanakan silvofishery ponds will be achieved if the community with 60 kg body weight consumes it as much as 0.08 kg/week for Pb, 7.63 kg/week for Cu and 19.74 kg/week for Zn (Table 6).

| Table 6. Maksimum Tolerable Intake (MTI) for individuals weighted 60 kg |
|------------------------|------------------|------------------|
| Station | MTI (kg) |
|---|--------|
| | Pb | Cu | Zn |
| 1 Inlet | 0.16 | 16.85 | 19.74 |
| Outlet | 0.17 | 9.56 | 24.58 |
| 2 Inlet | 1.40 | 9.56 | 24.58 |
| Outlet | 1.03 | 10.56 | 44.87 |
| 3 Inlet | 0.08 | 11.38 | 30.91 |
| Outlet | 0.63 | 7.63 | 34.12 |
4. Conclusion
Based on metals content and bioconcentration factor, people must be more careful in consuming mangrove snail. In the future, mangrove snail can be used as bioindicator to control environmental pollution, especially Cu in the mangrove ecosystem.

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