Accumulation and distribution of heavy metals in *Gerres abbreviatus* (Bleeker 1850) and *Parastromateus niger* (Bloch, 1795) in Kao Bay, North Maluku, Indonesia

R T A Pertiwi¹, K H Iksan¹ and D Ariyanto²
¹Department of Aquatic Resource Management, Khairun University, Indonesia
²Indonesian Mollusk Society, Bogor West Java, Indonesia

Email: renityasasrining@gmail.com

Abstract. Heavy metals have a relationship with fish organs. The aim of this study was to determine the distribution of heavy metals in various organs of *Gerres abbreviatus* and *Parastromateus niger*. The research was conducted in Kao Bay waters from April to September 2019. Samples obtained were prepared at the aquatic science laboratory of Khairun University and were analyzed at the Environmental Productivity Laboratory of IPB University Bogor using the AAS instrument to determine heavy metals concentrations. The result of the heavy metals accumulation in *Gerres abbreviatus* meat was Zn > Cu > Pb > Ni > Hg > Mn > Cd. Meanwhile, the heavy metals accumulation in Roi fish (*Parastromateus niger*) meat was Zn > Mn > Ni > Hg > Pb > Cd > Cu.

1. Introduction

The coastal area of North Halmahera Regency, especially coastal area of Kao Bay, has a high wealth of biological and non-biological resources. The non-biological wealth in the area consists of various types of minerals that have high economic value, especially gold and silver. Huge potential of gold in the area has attracted various parties to exploit resource both legally and illegally. Process of mining and minerals extraction, especially gold, uses various chemicals that are quite damaging to the environment and harmful to human health.

*Gerres abbreviatus* belongs to Family Gerreidae which is found abundantly in coastal lagoons. This fish species feeds on benthic organisms. Distribution of this fish is also found in tropical and subtropical regions [1]. The distribution of food sources among coexisting fish in the same place has been extensively studied [2]. Meanwhile, *P. niger* fish was also found on the Sea Coast of Oman, Iran [3].

Fish exploitation for consumption certainly affects the sustainability of fishery resources. The amount of fish consumption has increased in recent years. This is because fish contain nutrients. The nutritional content includes sources of protein [4], essential minerals, vitamins [5], and unsaturated fatty acids [6].

The level of accumulation of heavy metal concentrations in fish is influenced by various factors depending on the type of metal and fish species [7], their respective tissues [8], water and sediment chemistry [9, 10]. In addition to fish, heavy metals can also be found in various ecosystems, i.e., mangroves [11], seagrasses [12], and coral reefs [13]. In general, heavy metals have an effect on life and have long-term consequences that result in heavy metal poisoning in fish organisms and are
associated with environmental contamination. The aim of this study was to determine the distribution of heavy metals in various fish organs.

2. Materials and methods

2.1 Research location
This research was conducted at Kao Bay waters, North Maluku, Indonesia from April to September 2019. Consideration for selection of research area was because some waste from legal and illegal mining had entered the bay.

![Research location map](image)

**Figure 1.** The research location at Kao Bay waters, Indonesia (铌: Research location)

2.2 Data collection methods
The collected data in this study was primary data from fishermen. Primary data was data obtained from direct observations in the field in the form of fish found in Kao Bay waters. The captured fish samples (10 fish) were prepared in the Aquatic Science Laboratory of Khairun University and then sent to the Environmental Productivity Laboratory of IPB University Bogor for the heavy metal analysis using AAS instrument (Variant SpectrAA-20).

2.3 Data analysis
Data analysis in this study was a quantitative analysis. The first stage was to determine the results of laboratory analysis and then compared them with applicable quality standards for drawing conclusions. Analysis in assessment of heavy metals in fish target organs was performed by comparing the results of the study with the quality standards set by SNI [14]. The design of this research was a descriptive research that aims to explain existing phenomena by using numbers to cover characteristics of individuals or groups.

3. Results

3.1 Distribution of heavy metals in fish organs
Figure 2 shows the size of the fish in this study. *Gerres abbreviatus* was heavier than *Parastromateus niger*. Table 1 shows that the heavy metal content of each target organ of *Gerres abbreviatus*. Heavy metals concentrations in the fish meat ranged from 0.00 to 35.56 mg/kg, gills ranged from 0.02 to 51.83 mg/kg, and liver ranged from 0.02 to 61.31 mg/kg. High content of heavy metals was found in liver with heavy metal Zn dominating in all three fish organs assessed. The order of the heavy metals accumulation in *Gerres abbreviatus* meat was Zn > Cu > Pb > Ni > Hg > Mn > Cd.
Table 1. Concentration of heavy metals in fish tissue caught in Kao Bay waters (mg/kg)

| No | Species               | Tissue | Hg    | Pb    | Cd    | Cu    | Mn    | Zn    | Ni   |
|----|-----------------------|--------|-------|-------|-------|-------|-------|-------|------|
| 1  | Gerres abbreviatus    | Meat   | 0.021 | 0.56  | 0.00  | 0.73  | 0.13  | 35.56 | 0.45 |
|    |                       | Gill   | 0.023 | 2.53  | 0.02  | 0.58  | 1.06  | 51.83 | 0.67 |
|    |                       | Liver  | 0.028 | 2.85  | 0.02  | 1.45  | 0.23  | 61.31 | 0.61 |
| 2  | Parastromateus sp.    | Meat   | 0.004 | 1.19  | 0.00  | 0.00  | 0.33  | 35.68 | 0.02 |
|    | (Bloch, 1795)         | Gill   | 0.004 | 1.99  | 0.01  | 0.47  | 0.15  | 49.94 | 0.80 |
|    |                       | Liver  | 0.61  | 2.89  | 0.03  | 0.99  | 0.60  | 89.86 | 0.61 |
|    | Standart              |        | 0.5*  | 0.3*  | 0.1*  | 0.3*  | 5*    | 100** | 80***|

3.2 Heavy metal accumulation limit

The application of RfD was also to protect consumers' risks from acute health effects. The calculation of the daily consumption limit of fish caught in Kao Bay is presented in Table 2.

Table 2. Calculation of Fish Consumption Limit

| Fish            | Hg     | Pb     | Cd     | Cu     | Mn     | Zn     | Ni     | Cr_{lim}(kg/day) |
|-----------------|--------|--------|--------|--------|--------|--------|--------|-----------------|
| RfD (mg/kg)     | 0.001* | 0.00016* | 0.001* | 0.0371* | 0.14** | 0.91*** | 0.002**** |                 |
| BW (kg)         | 70     | 70     | 70     | 70     | 70     | 70     |        |                 |
| Gerres abbreviatus | 3.33  | 0.02  | -      | 3.55   | 75.38  | 1.79   | 3.11   |                 |
| Parastromateus niger | 10    | 0.28  | -      | -      | 22.27  | 3.39   | 4.51   |                 |

* US EPA (2000), ** IRIS (2005), *** IRIS (2002), **** IRIS (1995), BW = body weight

Based on the calculation, the maximum daily consumption of fish containing heavy metals in Kao Bay varied widely (Table 2). The maximum value limit was determined by selecting the smallest value. The reasoning for this selection was based on facts that consumed heavy metals continuously even at smallest amount will accumulate in human organs and tend to be toxic to human body.

4. Discussion

Table 1 shows that heavy metal content of each target organ of Parastromateus niger fish in meat ranged from 0.00-35.68 mg/kg, gills ranged from 0.004-49.94 mg/kg and liver ranged from 0.03-89.98 mg/kg. The order of the heavy metals accumulation in Parastromateus sp. meat was Zn > Pb > Mn > Ni > Hg > Cd > Cu. Based on the limit of chemical contamination in fish food, heavy metal Pb in fish meat of Parastromateus sp. had exceeded the quality standard that has been set (Table 2). Table 6
shows that the highest heavy metal content in all types of fish was found of Zn in meat, gills, and liver. Based on the amount of heavy metal content, the detected heavy metal Zn was greater than other heavy metals because this metal element is an essential metal that is needed by fish for metabolic regulations. The low concentrations of Pb, Cr, Cu and Cd in fish muscle from Meiliang Bay, Taihu Lake [15]. High levels of Pb and Cu were found in liver and gills of two fish Cyprinus carpio and Pelteobagrus fluvidraco from Meiliang Bay, Taihu Lake. Furthermore, metal accumulation in fish was caused by various factors, e.g., ecological needs, swimming patterns, metabolic activity, and the environment [16]. Fish organs containing concentrations of lead, copper, nickel, and cadmium were also found by [17]. Adaptation capability of Gerreidae fish to salinity variability of the coastal environment enables them to take advantage of available resources and reduces interspecific competition. Furthermore, the presence of fish in a waters is strongly influenced by the amount and quality of food, as well as the condition of the oceanographic parameters of the waters. Furthermore, it is stated that fish that do not have high adaptability will tend to respond to changes in oceanographic parameters by migrating to other areas, so that it will affect the distribution and abundance of fish in a waters. Gerreidae fish were found in estuaries [18].

Due to the accumulation of heavy metals Hg, Pb, Cd, Cu, Mn, Zn, and Ni in fish caught in Kao Bay, it is necessary to know the limits of fish consumption to prevent negative effects on human health who consume them. In calculating the daily consumption of fish (Cr_{lim}) contaminated with heavy metals, the parameters used according to the US EPA (Environmental Protection Agency) are RfD (reference dose), Cm (measured concentration of heavy metals in fish), and body weight of people commonly used is 70 kg. Cr_{lim} is a calculation of the maximum daily lifetime consumption in kilograms of fish which is not expected to cause adverse effects for humans who consume it. The use of RfD in calculating consumption limits is due to the fact that the concentrations of contaminants required to produce chronic health effects are generally much lower than those that cause acute effects [19].

5. Conclusion
The heavy metal contents were found in two fish species examined. Although they were consumed in small amounts, in the long run heavy metal would accumulate in human body and would have a negative chronic impact. The order of heavy metal toxicity to humans starting with the most toxic is Hg, Cd, Ni, Pb, Cr, Sn and Zn, respectively.

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