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Fish diversity and heavy metal accumulation of Pb, Cu and Zn after Mount Sinabung Eruption in Benuken River, North Sumatra, Indonesia

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Abstract. *Pebriani MA, Barus TA, Ilyas S. 2021. Fish diversity and heavy metal accumulation of Pb, Cu and Zn after Mount Sinabung Eruption in Benuken River, North Sumatra, Indonesia. Biodiversitas 23: 187-194.* The Benuken River is a river that has been affected by the volcanic ash eruption of Mount Sinabung, one of the active volcanoes in Indonesia. This study further examines the diversity of fish species and the analysis of their tissues with regard to the heavy metal content of each species in the Benuken River, Berastepu Village, Karo Regency after the eruption of Mount Sinabung using atomic absorption spectroscopy (AAS). The fish and water sampling were carried out in March 2019 with two sampling points using the electrofishing technique. Furthermore, four species were documented, including Spotted barb (*Puntius binotatus*), River loaches (*Homaloptera nebulosa*), Mahseer (*Tor soro*), and Striped snakehead (*Channa striata*). The diversity index of the fish community from two study sites ranged between 0.012<H' <0.023 or was categorized as very low in diversity. Meanwhile, the heavy metals concentrations of Cu, Pb and Zn in the water of Benuken River were below tolerance level based on the Governmental Regulations No. 82 year 2001. The average heavy metal concentrations in fish tissue were also safe for consumption based on the standard quality by FAO/WHO (2004) with 0.0049 ppm, 0.0056 ppm and 0.3852 ppm of Pb, Cu and Zn, respectively.

Keywords: Atomic absorption spectroscopy (AAS), *Channa striata*, heavy metal concentration, lead, zinc

INTRODUCTION

Mount Sinabung is one of the active volcanoes in the Karo Regency Highlands in northern Sumatra, Indonesia, which has erupted since September 2010 and released the first haze of smoke, hot lava and volcanic ash. As a result of this natural event, some villages and habitats are exposed to intense volcanic ash, which contains heavy metals that can harm the environment's health, especially the aquatic environment (Gunawan et al. 2019). Based on this preliminary observation, there are two locations near the eruption sites, namely Site 1 (3º8′14.618″ N, 98º25′19.326″ E) and Site 2 (3º8′14,302″ N, 98º25′18,981″ E) were affected by the volcano eruption ashes. The location is on the Benuken River in Berastepu Village, Simpang Empat District, Karo Regency. The eruption exposed volcanic ashes with a height of 3 to 5 km with gradual earthquakes more than 100 km around the mountain region (Ebo 2010). The previous study reported heavy metals and its concentration in volcanic ashes of Mount Sinabung, which consisted of Fe (37.06 ppm), Mn (0.20 ppm), Zn (1.76 ppm), Pb (0.03 ppm), Cu (0.05 ppm), Al (94.20 ppm) and Na (19.21 ppm) (Tarigan 2014).

Volcanic ashes contain several heavy metals in the form of nanoparticles and masses, which are toxic to living organisms and the environment with an adequate tolerance level (Vigneri et al. 2017). The nanoparticles may be composed of single to multiple toxic elements, including arsenic, mercury, nickel, and lead which with gradual exposure, lead to organ failure and unbalanced physiological conditions of living organisms (Ermolin et al. 2018).

Heavy metals may be divided into essential and non-essential metals for the human body in terms of their bioavailability and function under physiological conditions. Certain metals such as cobalt (Co), copper (Cu), iron (Fe), magnesium (Mg), and zinc (Zn) are needed to function as micro-nutrients to prevent deficiency diseases or syndromes (Tchounwou et al. 2012). Meanwhile, the non-essential metals such as cadmium (Cd), lead (Pb) and mercury (Hg) are regarded as toxic and may pose a health issue to humans as nephrotoxins in the renal cortex (Wilk et al. 2017).

Due to their persistence and their non-biodegradable properties, heavy metals can pose a threat to aquatic ecosystems if they are incorporated into the cell and tissue environment (Peña-Fernández et al. 2014). Fish normally accumulate heavy metals from food, water, and sediments in their environment and are good bioindicators of heavy metal contamination in the aquatic environment (Voegborlo et al. 2012; Zhao et al. 2012). Metals and metalloids from natural and anthropogenic sources are constantly penetrating the aquatic environment, where they pose a serious threat to human and ecological health due to their toxicity, long persistence, bioaccumulation, and biomagnifications in the food chain (Rahman et al. 2013).

There has been no direct evidence or information recently regarding heavy metals polluting the Benuken River, as they were released directly from Mount Sinabung volcanic ashes and may have contaminated local fish species. Therefore, this study examines two objectives: First, the fish diversity in the Benuken River; Second, the occurrence of selected heavy metal elements, Pb, Cu, and Zn in native species inhabiting the river as preliminary environmental monitoring of its ecosystem health. The results can be used as information for the local community regarding the health condition of fish consumption from the river.

MATERIALS AND METHODS

Study area and sampling sites

Field sampling was carried out in March 2019 at Benuken River, Berastepu Village, Simpang Empat District, Karo Regency, North Sumatra, Indonesia, using a purposive method sampling technique. The sampling sites were divided into two sub-sites, Site 1 was located at 3º8′14.618″ N, 98º25′19.326″ E with a length of 500 m and width of 4 m; and Site 2 was located at 3º8′14.302″ N, 98º25′18.981″ E with a length of 350 m and width of 2 m (Figure 1). The substrates at both sampling sites were structured by rocks and sands.

Field sampling

The fish were captured using electrofishing tools by exposing the electrical current in the water bodies for 45 min in each station with an interval of 15 min of electrical exposure following the water current in different spots. The fish were captured manually using a dip net (20 mm) and preserved on ice and transported to the laboratory for processing and analysis. Duplicate specimens were collected for identification using a manual identification book (Kottelat and Whitten 1993). Water samples were taken and measured for the physicochemical conditions (units) the measurements were analyzed in the field and in the laboratory using the National Indonesian Standard (SNI) method, namely temperature (ºC), pH, dissolved oxygen (DO, mg/L), biological oxygen demand (BOD, mg/L), chemical oxygen demand (COD, mg/L), flow rate (m/s), total suspended solids (TSS, mg/L), total dissolved solids (TDS, mg/L), nitrates (mg/L), phosphates (mg/L), turbidity (NTU), Pb (mg/L), Cu (mg/L), and Zn (mg/L).

Specimen processing

The captured fish were dissected to obtain the muscles and immediately frozen and stored at -20ºC prior to experimentation. The samples were dried in an oven at 80ºC for 24 h. One gram of the dried specimens was inserted into a crucible plate and 10 mL of concentrated HNO_3 was added and heated at 180ºC for 3 h. The samples were cooled to room temperature and diluted to the final volume of 25 mL with distilled water. The samples were then filtered using Whatman filter paper with a pore size of 0.45 µm prior to analytical measurement using atomic absorption spectroscopy (AAS) (Yap et al. 2004).

Data analysis

The ecological parameters measured in this study were the Shannon diversity index (H') and evenness (*EH*) to depict fish species richness in the study sites. The water quality was assessed based on assessing the physicochemical conditions of water samples following proposed by the Environmental Protection Agency (USA). The bioconcentration factor (BCF) is described as the ability of an organism to accumulate Pb, Cu and Zn elements from its surroundings using the following formula:

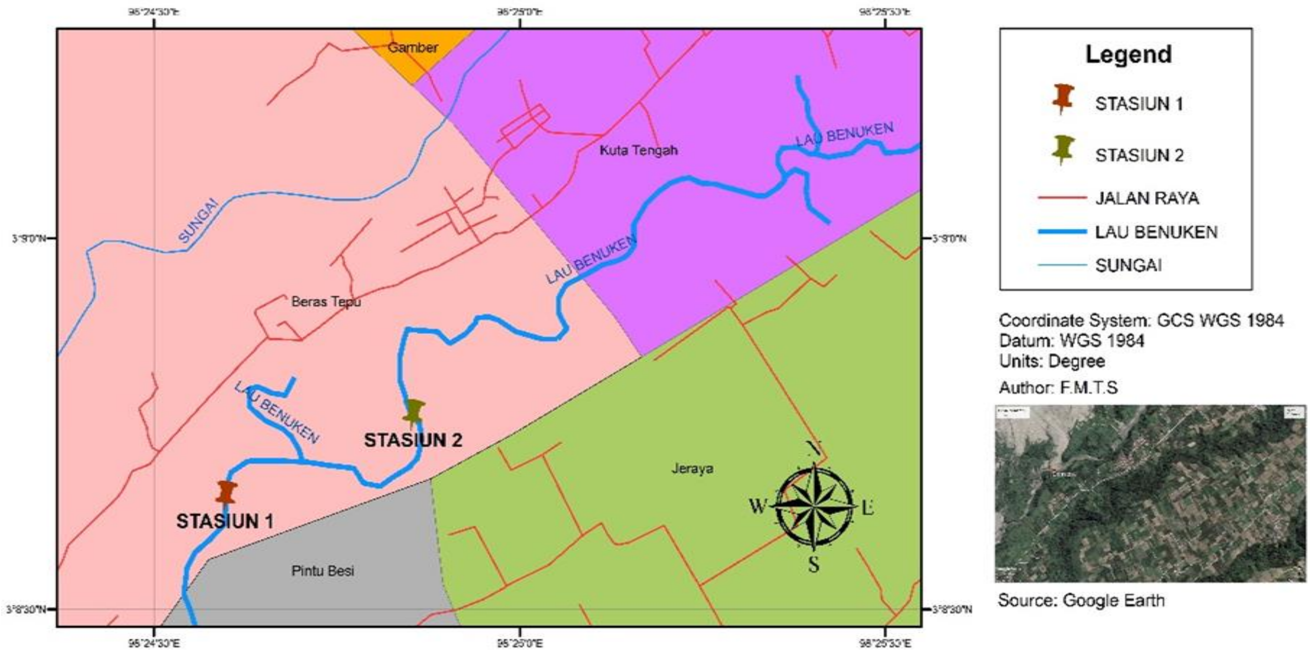

Figure 1. Map of study area showing the sampling sites of fish community at Benuken River, North Sumatra, Indonesia

Shannon - Wiener Diversity Index (H') (Krebs 1985)

$$H' = -\sum pi \ln pi$$

Where, (H') was the Shannon-Wiener diversity index, Pi; was the relative proportion (n/N) of the individual of one particular species found. Furthermore, it entailed dividing (n) number of an individual species by the total number of all species individual numbers (N) found in a particular environment. Finally, (LNPi) was natural logarithm (LN) of the value Pi. Finally, the symbol implied (Σ) summation of the outputs with the final value multiplied by negative one (-1).

Uniformity Index (E_H) (Krebs 1985)

$$E = \frac{H'}{H'\max}$$

H' max = log2 S

Where, H') was the Shannon-Wiener diversity index, (H'max) maximum species diversity index, (S) number of species.

Bioconcentration factor (BCF) (Mellem et al. 2012)

$$Bioconcentration\ factor\ (BCF) = \frac{Heavy\ metal\ concentration\ in\ fish\ (mg/kg)}{Heavy\ metal\ concentration\ in\ water\ (mg/kg)}$$

RESULTS AND DISCUSSION

A total of 119 freshwater fish specimens were collected during this study. The fish community was classified into 2 classes, 2 orders, 3 families and 4 genera, the number of collected specimens are presented in Table 1. Three species were found to inhabit both sampling sites, Spotted barb (*Puntius binotatus*), Mahseer (*Tor soro*), and Striped snakehead (*Channa striata*). This may be due to the substrate characteristics of rocks and sands in which the species lurking near the rocks hide. The structure and arrangement of teeth in the jaw suggest that *Channa striata* has an extendable and stronger lower jaw making the species an effective predator for a number of fish and other aquatic species (Borman et al. 2015). Meanwhile, River loaches (*Homaloptera nebulosa*: Balitoridae) were only found at site 1, possibly due to its shallow water beds and swift currents. Balitoridae family is a group of fish found in shallow waters with moderate to heavy currents and hiding behind rocks (Beamish et al. 2008). According to the research of Rumondang and Mahari (2017), the rivers that flow rapidly around the Asahan River and in the hills, the clear rivers of which are the natural habitat of Batak fish, both of the genus *Neolissochilus* and *Tor*. In particular, the genus *Tor* or locally known as *keureling* (Cyprinidae) is utilized as the basis of a wild fishery and has high potency for the aquaculture industry (Muchlisin 2013).

Table 1. Fish composition and its taxonomy in Benuken River, North Sumatra, Indonesia

Order	Family	Genera	Species	Number of individu	
				Site 1	Site 2
Perciformes	Channidae	*Channa*	*Channa striata*	13	11
Cypriniformes	Cyprinidae	*Homaloptera*	*Homaloptera nebulosa*	11	0
		Tor	*Tor soro*	26	18
		Puntius	*Puntius binotatus*	17	13
Total				67	42

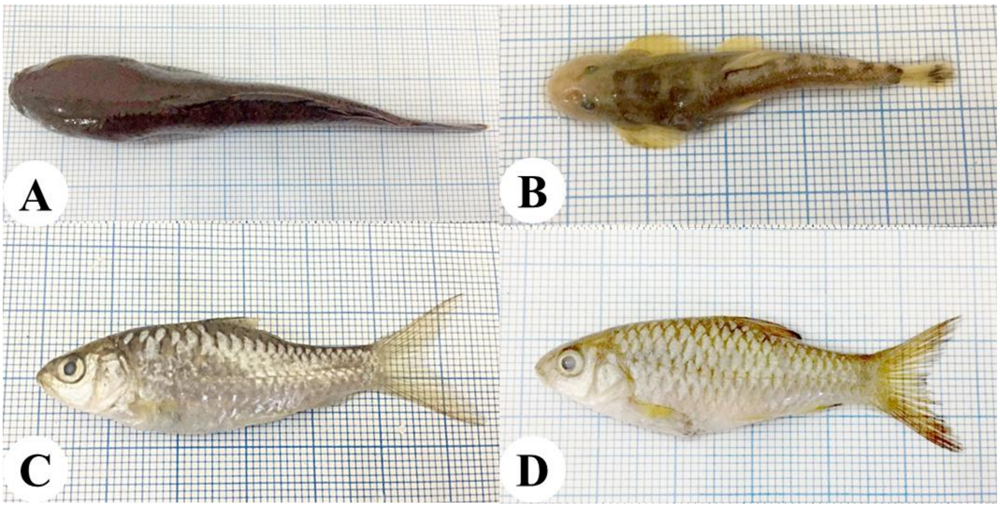

Figure 2. Fish species collected in Benuken River, , North Sumatra, Indonesia (A) *Channa striata*, (B) *Homaloptera nebulosa*, (C) *Tor soro*, (D) *Puntius binotatus*

The density, relative density, and relative frequency of each species of fish collected from the Benuken River are listed in Table 2. The highest density was found in *Tor soro* at both sites, with 1.20-1.73 ind/m^2 and a relative density of 35.72-38.81%. The second dominant, *Puntius binotatus*, had a relative density between 25.37-30.93%. The relative frequencies >25% indicate that the habitat in the Benuken River is suitable for the fish. The relative frequency for *Channa striata*, *Homaloptera nebulosa* and *Puntius binotatus* from both sites were 66.66%, classified as frequent, while *Tor soro* had an absolute presence/ 100% which indicated that the fish collected from Benuken River were the dominant species in their habitat. The uniformity index (*EH*) at the sampling sites ranged from 0.008 to 0.020. The equitability uniformity index of *EH*≤0.4 reflected the low uniformity of a population, which means the fish population in the river was not equally distributed among two sites leading to a certain species becoming dominant. Furthermore, the closer *EH* to zero value (0), the lower the uniformity of a population. The ecological parameter, Shannon's diversity index (H') lies between 0.008 and 0.023, which indicates poor fish diversity in the Benuken River (Figure 3). This result may due to the unequal distribution of fish species in the river. The greater number of fish species and their individuals can reflect the great diversity of an aquatic ecosystem and vice versa (Hossain et al. 2012). Ecologically, it is assumed that high species diversity indicated a better ecosystem balance, while poor diversity indicated that the water is being polluted or stressed by some stressors, for example, natural disasters. The ecological status based on fish assemblage according to environmental variables and anthropogenic pressures showed that total dissolved solids, nitrite, dissolved oxygen, pH, were the primary factors influencing fish distribution (N'Zi et al. 2015). In this study, *Tor soro* is the dominating fish species in the Benuken River. This was supported by the water quality, such as fast current, rocky substrates, optimum temperatures of 20-21.40ºC, and clean waters. The most common fish species are adaptable and can use the potential of existing resources to survive (Desrita et al. 2019). Each species of fish must cope well in the environment in order to live and breed effectively. The higher species diversity and richness at the river may be linked to the river's morphology and hydrology (Mwangi et al. 2012).

The water quality in the Benuken River is presented in Table 2 with the limit value proposed by the Governmental Regulation No. 82 year 2001. Eruption material originating from Mount Sinabung or the volcanic ashes contain toxic materials to the organisms and environment. Sukarman and Suparto (2015) stated that volcanic ashes were the most distributed material, which caused damages to agricultural and aquaculture sites adjacent to Mount Sinabung. Benuken River in Berastepu Village was one of the exposed rivers to the volcanic ashes of Mount Sinabung. The analysis of Pb, Cu, and Zn in water bodies was quantified using AAS, as presented in Table 3.

Based on the results, the heavy metal concentration of Pb, Cu and Zn in the Benuken River after the eruption of Mount Sinabung were measured: Pb in the range of 0.0200-0.0230 mg/L, Cu in the range of 0.0053-0.0081 mg/L, and Zn in the range of 0.1406-0.2844 mg/L. Zinc (Zn) was detected in the highest concentration from both sites, which far exceeded the national standards. Another study reported that the average concentration of Zn was 365 mg·kg^{-1} in the Tianchi volcano, which was higher than those in other volcanoes (Ma et al. 2019). Zhaoyong et al. (2015) also stated that a characteristic of water quality exposed to volcanic eruptions was the presence of zinc as one of the naturally detected heavy metals with that in Tianshan Mountain as Zn>Mn>Cu>Co>Ni>Pb>Cr>As>Hg>Cd.

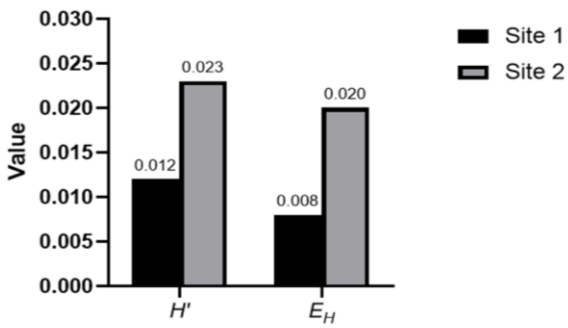

Figure 3. Diversity and equitability index of fish community in Benuken River, North Sumatra, Indonesia

Table 2. Water quality in terms of physicochemical parameters in the Benuken River, North Sumatra, Indonesia

Parameter	Unit	Limit*)	Site 1			Site 2		
			Min	Max	X̄	Min	Max	X̄
Temperature	ºC	Deviation 3	20	20	20	20.2	22.6	21.4
TSS	mg/L	50	1	1	1	1	1	1
Conductivity	m/s	-	150.5	161.2	155.7	160.3	162.3	162.3
Turbidity	NTU	-	9.0	10.6	9.80	16.10	16.32	16.21
TDS	mg/L	1000	112.45	112.45	112.45	133.53	133.53	113.53
Velocity	m/s	-	1.5	1.5	1.5	1.3	1.5	1.4
BOD	mg/L	3	0.92	0.92	0.94	1.03	1.05	1.04
pH	-	6-9	8.41	8.47	8.44	7.22	8.32	7.77
DO	mg/L	>4	7.79	7.81	7.8	7.63	7.65	7.64
COD	mg/L	25	7.6	7.6	7.6	15.2	15.2	15.2
PO_4^{3-}	mg/L	0.2	0.063	0.063	0.063	0.102	0.102	0.102
NO_{3-}	mg/L	10	1.5	1.5	1.5	1.7	1.7	1.7

Note: *) Governmental Regulations No. 82 year 2001

Table 3. Heavy metal concentration (mg/L) in water samples of Benuken River, Berastepu Village post-eruption of Mount Sinabung, North Sumatra, Indonesia

Parameter	Site 1	Site 2	Limit*)
Lead (Pb)	0.0200 ± 0.00792	0.0230 ± 0.001414	0.03
Copper (Cu)	0.0053 ± 0.000141	0.0081 ± 0.000707	0.02
Zinc (Zn)	0.1406 ± 0.000707	0.2844 ± 0.002828	0.05

Note: *) Governmental Regulations No. 82 year 2001

Fish can be used as biological indicators to monitor levels of heavy metal exposure. Aquatic organisms are generally exposed to mixtures of metals. A considerable body of data shows that certain metals affect the accumulation of other metals in fish. The interaction between metals are related to their competitive uptake from the environment and different allocation in fish tissues. Interactions among metals may be different, representing additive, synergistic or antagonistic, therefore, the effects of their various mixtures on fish survival may also vary (Svecevičius et al. 2014). The heavy metal content of Pb, Cu and Zn in fish meat obtained in the Benuken River in Berastepu Village after the eruption of Mount Sinabung are presented in Table 4, which also compared to the quality standards by FAO/WHO (2004). The result from the analysis of heavy metals in fish tissue, *Channa striata* showed a significantly higher tendency for the accumulation of all metals in their body, including lead (Pb) of 0.0093 mg/kg, copper (Cu) of 0.0077 mg/kg and zinc (Zn) of 0.8180 mg/kg. The concentration of heavy metals in different tissue/organs of fishes is directly influenced by contamination in the aquatic environment, its uptake, regulation and elimination inside the fish body (Yang et al. 2016). In general, all heavy metals were detected higher at site 2, showing the most exposed environment to the volcanic ashes of Mount Sinabung as the downstream region. The heavy metal concentration in fish species harboring a former mining excavation site and reported the lead (Pb) concentration of 0.068 ppm in the meat of common bream (*Abramis brama*), 0.075 ppm in white bream (*Blicca bjoerkna*), which were below the standard quality (Stanek et al. 2015). The highest copper (Cu) concentration was observed in the *Catla catla* with 11.05 ± 2.65 µg/g in its tissue, while the lowest concentration was found in *Catla reba* with 0.58 ± 0.09 µg/g in its tissue (Maurya et al. 2019). Zinc (Zn) is an essential metal known to play important roles in the human metabolic pathway and its shortage can cause appetite loss, retarded growth, skin changes and dysfunction of the immune system (Ayanda et al. 2019). Furthermore, it is known that Zn, due to its function as a cofactor in metabolic enzymes that are essential for growth, occurs more frequently in an organism than Cu and Pb (Wang and Shi 2001). Hence, the concentration of heavy metals in fish tissues is still suitable and follows the standard quality for human consumption.

The highest concentration of lead (Pb), copper (Cu), and Zinc (Zn) were all detected in *Channa striata* at site 2 at a concentration of 0.5821, 0.0077, and 0.8180 mg/kg, respectively. In general, all heavy metals were detected higher at site 2, suggesting that the area surrounding the volcanic axis of Mount Sinabung is most exposed downstream. Other studies also reported the average lead (Pb) concentration in *Puntius ticto* as much as 3.0±0.09 (µg g^{-1} BW) (Ahmed et al. 2016), while in another area, the species accumulated as much as a heavy metal concentration of 0.94-3.3 (µg g^{-1} BW) (Arantes et al. 2016), and 0.53±0.49 in Yangtze River, China (µg g^{-1} BW) (Yi and Zhang 2012). In addition, it is known that Zn, due to its function as a cofactor in metabolic enzymes that are essential for growth, can be present in an organism more frequently than Cu and Pb. Hence, the concentration of heavy metals in fish tissues is still suitable and follows the standard quality for human consumption.

BCF was measured to quantify the ability of each fish species to accumulate heavy metals from their surroundings into their tissues or bodies (Table 5). The BCF value of fish species in Benuken River was considered to be a low accumulator, with the value found to be higher in site 2 than site 1. Despite the different characteristics among fish species, the fish immunological condition may also play roles in heavy metals absorption capacity. If the species was vulnerable or sensitive to the polluted environment, it would have to decide between surviving till death or relocating itself to a safer environment. The bioconcentration factor is a measure of how the concentrations of a toxin in an organism exceed the concentrations of that toxin in the environment (Crookes and Brooke 2011). This terminology is often used specifically in reference to aquatic environments and organisms. Subsequently, BCF can be used to express bioconcentration levels in a numeric way. The BCF can be calculated as the ratio of a toxin concentration in an organism and the levels in the surrounding environment. The higher the ratio, the more intense the bioconcentration of toxins, in this case, the higher the metals in fish, the higher the BCF value, the higher the organism accumulates heavy metals. BCF was used to quantify the metal concentrations in fish organs/tissues relative to the concentration in a river (Javed and Usmani 2013). The bioaccumulation of heavy metals by fish occurs when there are extremely high concentrations of metals in the environment, primarily via the gills during ion exchange and then by ingestion of food or sedimentary particles through diet (Kuppu et al. 2018).

Among the fish species in the Benuken River, *Channa striata* showed the highest BCF, which indicates its high adaptability and tolerance to extreme and polluted environments. Among the aquatic fauna, *Channa striata* is the most susceptible fish species toward heavy metal contamination than any other aquatic fauna. It is well known that the species are good indicators of chemical pollution and as a result, they have long been used to monitor metal pollution in the river and marine environment. The heavy metal concentration was 3.29-7.69 mg/kg BW in the muscle of *Channa striata*, while in the liver, the concentration was 3.52-8.09 mg/kg BW.

Table 4. Heavy metal concentration (Mean ± SD) (mg/kg) in tissues from each fish species in Benuken River, North Sumatra, Indonesia

Species/heavy metal	Site		
	Site 1	Site 2	Limit*)
Pb			
Puntius binotatus	0.0032 ± 0.000283	0.0047 ± 0.000141	
Homaloptera nebulosa	0.0030 ± 0.000283	-	0.03
Tor soro	0.0033 ± 0.000707	0.0090 ± 0.000707	
Channa striata	0.0047 ± 0.000141	0.5821 ± 0.009192	
Cu			
Puntius binotatus	0.0060 ± 0.001414	0.0068 ± 0.002121	0.02
Homaloptera nebulosa	0.0042 ± 0.000707	-	
Tor soro	0.0058 ± 0.000707	0.0073 ± 0.000707	
Channa striata	0.0074 ± 0.000283	0.0077 ± 0.00297	
Zn			
Puntius binotatus	0.3971 ± 0.000707	0.4475 ± 0.002121	100.0
Homaloptera nebulosa	0.2170 ± 0.004243	-	
Tor soro	0.3074 ± 0.007071	0.3180 ± 0.000566	
Channa striata	0.5821 ± 0.009192	0.8180 ± 0.001414	

Note: *) FAO/WHO (2004)

Table 5. Bioconcentration factor (BCF) of fish species in Benuken River, North Sumatra, Indonesia

Species	#1 Conc. (mg/L)		#2 Conc. (mg/kg)		BCF	
	Site 1	Site 2	Site 1	Site 2	Site 1	Site 2
Lead (Pb)						
Puntius binotatus	0.0200	0.2300	0.0032	0.0073	0.160	0.317
Homaloptera nebulosa	0.0200	0.0230	0.0030	-	0.150	-
Tor soro	0.0200	0.0230	0.0033	0.0090	0.165	0.391
Channa striata	0.0200	0.0230	0.0047	0.0093	0.235	0.404
Copper (Cu)						
Puntius binotatus	0.0053	0.0081	0.0060	0.0068	1.132	0.839
Homaloptera nebulosa	0.0053	0.0081	0.0042	-	0.792	-
Tor soro	0.0053	0.0081	0.0058	0.0073	1.094	0.901
Channa striata	0.0053	0.0081	0.0074	0.0077	1.396	0.950
Zinc (Zn)						
Puntius binotatus	0.1406	0.2844	0.3971	0.4475	2.824	1.573
Homaloptera nebulosa	0.1406	0.2844	0.2170	-	1.543	-
Tor soro	0.1406	0.2844	0.3074	0.3180	2.186	1.118
Channa striata	0.1406	0.2844	0.5821	0.8180	4.140	2.876

According to WHO, the present results indicated that the concentration levels was higher than the permissible limits set for human consumption by various regulatory agencies and therefore indicated possible health risks associated with the consumption of these fish (Krishna et al. 2021). However, at higher concentrations, Zn produced adverse effects in fish by structural damages, which affects the growth, improvement and survival of fish. Zinc accumulates in the gills of fish and this designates a depressing effect on tissue respiration leading to hypoxia which results in death. Zinc pollution also tempts changes in ventilator and heart physiology (Afshan et al. 2014). The order of bioaccumulation of these metals might be a result of the fact that different metals tend to accumulate differently in the tissues of different species of fish. All metals that are concentrated in different parts of the fish's body can accumulate in the human body if it is digested gradually. In Bangladesh, water sources are getting more polluted day by day, hence these heavy metals from polluted water bodies are getting more concentrated in those fish living in those areas (Shovon et al. 2017). However it may also be noteworthy that the fish species collected in the Benuken River was considerably smaller in size as a limitation in our study. Further investigation may be improved by selecting a consistent body size of fish samples or focusing on one species with a greater population size to solve this issue.

In conclusion, the fish diversity in the Benuken River was extremely low, while the heavy metal concentrations in the water of the Benuken River after the eruption of Mount Sinabung were Pb: 0.0200-0.0230 mg/L, Cu: 0.0053-0.0081 mg/L and Zn: 0.1406-0.2844 mg/L. The Pb and Cu concentration meet the quality standard by the Government Regulation of Indonesia No. 82 year 2001, while Zn concentration exceeds the quality standard of 0.05 mg/L. The heavy metal concentrations of Pb, Cu, and Zn on fish tissue are different as follows: *Puntius binotatus* contains Pb ranged from 0.0032-0.0047 mg/kg, Cuo f

0.0060-0.0069 mg/kg, and Zn of 0.3971-0, 4475 mg/kg. *Homaloptera nebulosa* contaminated Pb with 0.0030 mg/kg, Cu of 0.0042 mg/kg, and Zn of 0.2170 mg/kg. Meanwhile, the concentration of Pb, Cu, and Zn on *Tor soro* are 0.0033-0.0090 mg/kg, 0.0058-0.0073 mg/kg and 0.3074-0.3180 mg/kg, respectively. *Channa striata* also has Pb with 0.0047-0.5821 mg/kg, Cu of 0.0074-0.0077 mg/kg and Zn of 0.5821-0.8180 mg/kg. All fish accumulated a considerable concentration of heavy metals but below the quality standard according to FAO/WHO 2004, which is therefore categorized as suitable for human consumption.

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