Assessment of heavy metal accumulation in tissues of *keperas* (*Cyclocheilichthys apogon* Val. 1842) in Lake Lau Kawar, North Sumatra

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Abstract. Lake Lau Kawar is one of the exposed areas in North Sumatra by the volcanic ash originating from Mount Sinabung eruption. The lake has been utilized as a tourism site and fish resources for consumption by the local community. *Keperas* (*Cyclocheilichthys apogon* Val. 1842) is one of the native fish commonly caught by the community. The aim of this study was to determine the levels of selected heavy metals such as copper (Cu), lead (Pb), and zinc (Zn) accumulated by *C. apogon* and the ones present in the lake water. The results showed that Zn present in the highest concentration followed by Cu and Pb as similar to the results from bioconcentration factor (BCF). All heavy metals (Cu, Pb, Zn) exhibited their highest concentrations in the gills, while the muscles possessed the lowest concentrations of all metals. Risk assessment based on the national and international standard revealed that the concentration of these metals was relatively low and safe for consumption.

1. Introduction
Mount Sinabung is one of the active volcanoes located at the highland of Karo Regency, North Sumatra. The volcano is categorized in the geological type of *Statovolcano* and dormant since 1600, however it erupted for the first time in 2010, followed by the second eruption in 2013[1]. Based on its activity, the status of mountain has been classified into level IV (caution) with occasional outputs in the form of pyroclastic flow and pyroclastic fall [2]. The eruption has caused a significant loss to the local community who relies heavily on smallholder farm business by reducing the total plantation area for agricultural and horticultural crops [3]. The volcanic ash discharged from the vent also disperse into rural areas and natural habitats while exposing health issue to the ecosystem and living organisms.

Lake Lau Kawar is one of the areas affected by the volcanic eruption which is located 3 km on the north of Mount Sinabung. The lake has been utilized as a recreational area and tourism site governed by the local community with ups and downs during the crisis. In addition, the villagers were known to consume some of the freshwater fishes from the lake to meet their nutritional needs. Based on our observation, *keperas* (*Cyclocheilichthys apogon* Val. 1842) is one of the consumed fish species with little to unknown information on their distribution from the lake and biological aspects. Due to the intense exposure with the volcanic ash, it is likely that the fish species is accumulating toxic compounds from its surroundings [4].
Volcanic ash as a major product of volcanic eruptions may contain hazardous materials in the form of heavy metals. The presence of trace elements such as copper (Cu), lead (Pb), and zinc (Zn) was documented at increased concentration in volcanic soils and sediments [5]. The present study investigated the concentration of selected heavy metals (Cu, Pb, Zn) in the lake water and tissues of *C. apogon* to assess its safety limit based on available standards.

2. Materials and method

2.1. Study period and location
The study was conducted in February 2019 at Lake Lau Kawar, Kuta Gugung Village, Naman Teran District, Karo Regency, North Sumatra. The geographical location of sampling point was located at 3°11'54.1” N, 098°22'26.8” E.

2.2. Fish specimen collection
Specimens of *C. apogon* were randomly caught using a fishing net to obtain a total of 1 g for each tissues (gills, livers, muscles) in heavy metal assessment. The fishes were selected on having the characteristics of 20–30 cm in length and weighing about 110–120 g (Figure 1). The fish specimens were stored in plastic bags under cool condition prior laboratory experimentation. Water samples were also collected in the area to determine the concentration of heavy metals in the lake.

2.3. Specimen processing
The fish organs were dried in an oven at 80°C for 24 h. One gram of the dried materials were reacted with 10 mL of concentrated HNO₃ and heated at 180°C for 3 h. The samples were cooled to room temperature and further diluted using dH₂O until reaching the volume of 25 mL. The crude solutions were filtered using a Whatman filter paper (0.45 µm) and left overnight for further analysis using the A-20 atomic absorption spectroscopy (AAS) [6].

2.4. Data analysis
Data were analyzed descriptively for each parameter. Bioconcentration factor (BCF) is described as the ability of an organism to accumulate elements (Cu, Pb, Zn) from its surroundings using the following formula [7]:

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

3. Results and discussion
Copper (Cu) and zinc (Zn) are essential heavy metals for maintaining the physiology and metabolism of an organism. Meanwhile, lead (Pb) is a non-essential heavy metal which is carcinogenic and highly toxic for cellular metabolism. The determination of these heavy metals is important due to the human
consumption on *C. apogon* inhabiting an area exposed to the volcanic ash of Mount Sinabung. The average concentration of Cu, Pb and Zn in the tissues of *C. apogon* and lake water is presented in Table 1. Based on the results, the concentration of Zn was detected as the highest element in *C. apogon* (0.2439±0.1606 mg/kg), followed by Cu (0.01±0.0071 mg/kg), and Pb (0.0064±0.0018 mg/kg). The average concentration of selected heavy metals in the lake was 0.068, 0.0244 and 0.0970 mg/L for Cu, Pb and Zn, respectively.

The levels of Cu (<0.02 mg/kg), Pb (<0.3 mg/kg), and Zn (<100 mg/kg) in *C. apogon* tissues were still under in the permissible limit by the Indonesian National Standard [8] and FAO/WHO [9], thus considered as safe for consumption. Moreover, the levels of Pb (<0.03 mg/L) and Cu (<0.02 mg/L) in the lake water were also within the tolerance limit by the Governmental Regulation No. 82 year 2001 with an exception to Zn level (>0.05 mg/L). The fate of high amount of Zn in lakes was mostly derived from the deposition of the atmosphere similar to Pb input into the ecosystem [10]. In addition, a recent study reported that the concentration of Zn in the volcanic ash of Mount Sinabung was fairly high (109.35 ppm) while other elements including Pb and Cu were not even detected or in trace amounts [11]. It is most likely that the lake water was contaminated by Zn rather than Pb and Cu from the eruption of Mount Sinabung. The bioconcentration factor (BCF) of Zn was determined as the highest (2.51), followed by Pb (0.26), and Cu (0.15). The BCF value reflects the bioaccumulation of an element as the result of uptake and retention of elements by the organism under complex process. The intake of elements was heavily determined by the environmental conditions while the retention process was more dependent on biological process [12]. Hence, the higher BCF value for Zn displayed its selective importance for tissue and cellular metabolism of *C. apogon* in the habitat.

### Table 1. Heavy metal concentration in *C. apogon* (*N* = 12) and freshwater samples (*N* = 6)

| Heavy Metal | C. apogon (mg/kg) | Freshwater (mg/L) |
|-------------|-------------------|-------------------|
|             | Min. | Max. | Mean | S.D | Min. | Max. | Mean | S.D |
| Cu          | 0.0087 | 0.0116 | 0.0100 | 0.0071 | 0.0083 | 0.0068 | 0.013 |
| Pb          | 0.0055 | 0.0072 | 0.0064 | 0.0018 | 0.0288 | 0.0244 | 0.0043 |
| Zn          | 0.0203 | 0.3016 | 0.2439 | 0.1606 | 0.1039 | 0.0970 | 0.0064 |

![Figure 2. Bioconcentration (BCF) analysis of different heavy metal accumulated in *C. apogon*](image-url)
Figure 3. Heavy metal (Cu, Pb, Zn) concentration in various organs of *C. apogon*
The trend of heavy metal bioaccumulation was consistent in which *C. apogon* tend to accumulate more Cu, Pb and Zn in gills rather than other organs (livers, muscles). Our finding was also similar with the study of fishes in the Red Sea, Egypt [13]. In general, the distribution and accumulation of heavy metals in muscles is usually the lowest among target organs. The reason was due to the indirect contact of heavy metals in water with the muscle tissue. Gills are the main site of metal ion exchange characterized by having a large surface area to facilitate efficient diffusion of heavy metals from water [14]. Gills are also the thinnest epithelium in fish tissue which facilitate metal ions more readily than other tissues [15]. However, other factors such as intrinsic factors (species, age, feeding habits), heavy metal concentration and extrinsic factors (water temperature, pH, salinity) may also contribute to the bioaccumulation capability of a fish [16]. Further investigation is needed to observe the physical change of each organ as being exposed to the high Zn in the lake.

4. Conclusion
The levels of Cu, Pb and Zn in the water of Lake Lau Kawar were still within the tolerance limit for human consumption based on the national and international standards. The target organ for bioaccumulation was gills, followed by livers and muscles. A high Zn level was documented from the *C. apogon* tissues and lake waters as also being supported from a study of volcanic ash of Mount Sinabung.

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