

## Article

# Content Analysis of Metals in Fish from Waters that are Closely to Disposal of Industrial Waste

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**Abstract:** This research was conducted to analyze the content of Fe, Cu, Cd, Cr, and Pb in several species of fish taken from three lakes that is closely to disposal of industrial waste in Indonesia. The fish samples were taken from three lakes, namely, Muara Angke, Weda, and Morowali. The samples from Morowali were analyzed in April 2019, those from Weda from November to December 2019, and those from Muara Angke in June 2018. All the samples were then analyzed at the chemistry laboratory of the Department of Chemistry, Faculty of Mathematics and Natural Science, University of Indonesia, and the Integrated Laboratory of IPB. The results showed that all types of fish from Morowali and Weda were no longer safe to consume because they contained Fe, Cu, Cd, and Cr exceeding the threshold of metal contamination. Meanwhile, all types of fish from Muara Angke, except for *ayam-ayam*, are still safe for consumption. The results of this study can be a source of information regarding metal content in fish and fish feed for safe consumption. Several studies have been done to determine the metal pollutants contained by fish. Given the high consumption rate of fish and the hazards of heavy metals on humans' health, such research must be furthered

**Keywords:** metal; fish; water; industry

## 1. Introduction

The presence of heavy metals in the water can accumulate in the bodies of organisms such as fish after being absorbed by the gills. Heavy metals that enter a fish's body cannot be removed from it because of such accumulation. As a result, these heavy metals will continue to exist along the food chain. In addition, this accumulation can ultimately damage the fish's organs, resulting in its death. If the fish is then consumed by humans, this can cause chronic and acute poisoning. For example, the overload of Fe content can cause poisoning (vomiting), intestinal damage, impaired absorption of vitamins and minerals, and homochromia [1]. Se and other heavy metals such as lead can interfere with oxidase production and consequently hamper cell metabolism, affecting growth [2].

Several studies have been done to determine the metal pollutants contained by fish as it is a common meal consumed by humans [3]. Given the high consumption rate of fish and the hazards of heavy metals on humans' health, such research must be furthered. This study aimed to analyze the content of metals in fish that is closely to disposal of industrial waste in Indonesia.

## 2. Materials and Methods

### Study setting



The fish samples were taken from three lakes, namely, Muara Angke, Morowali, and Weda. The first five samples were taken from Morowali in April 2019, namely, the layur, sarong, tracan, taking, and krau fish species. The subsequent fish samples were taken from Weda in November 2019, namely, yellow selar, flying fish, oci, and yellow fish. Meanwhile, at Muara Angke, the fish samples consisted of ayam-ayam, black pomfret, red snapper, kuwe, mackerel, and mackerel tuna.

### Data collecting

The fish samples from Morowali were analyzed in April 2019 at the chemistry laboratory of the Department of Chemistry, Faculty of Mathematics and Natural Science, University of Indonesia; the fish samples from Weda were analyzed from November to December 2019 in the same facility. Meanwhile, the fish samples from Muara Angke were analyzed in June 2018 at the Integrated Laboratory of IPB.

### Instrument and data analysis

The tools used in this study were clear plastic bags, cool boxes, label paper, atomic absorption spectrophotometer cameras, ovens, digital balances, hotplates, filter paper, petri dishes, porcelain mortars, desiccators, analytical scales, and common laboratory glassware. Data obtained from the measurements were analyzed by descriptive comparison with raw data of the National Standardization Agency, which set the limits of metal contaminant weight in fish meals.

### 3. Results and Discussions

The highest Fe content was found in taking (69.60 mg/kg). The highest Cu content was found in sarong (0.18 mg/kg). The highest Cd and Cr content were found in krau (2.30 mg/kg and 8.41 mg/kg, respectively). No amount of lead was contained in all fish samples from Morowali (Table 1).

**Table 1.** Content of Fe, Cu, Cd, Cr, and Pb in Fish Samples from Morowali.

Test Sample	Fe (mg/kg)	Cu (mg/kg)	Cd (mg/kg)	Cr (mg/kg)	Pb (mg/kg)
Layur	25.11	ND (*)	1.93	3.37	ND (*)
Sarong	8.77	0.18	ND (*)	4.42	ND (*)
Tracan	42.25	0.06	ND (*)	5.28	ND (*)
Taking	69.60	ND (*)	ND (*)	7.72	ND (*)
Krau	65.42	ND (*)	2.30	8.41	ND (*)

\* – ND/not detected; Source : primary data processing

The highest Fe content was found in yellow selar (24.15 mg/kg). The highest Cu content was found in yellow selar 3 (0.48 mg/kg). No traces of Cd, Cr, and Pb were contained in all fish samples from Weda (Table 2).

**Table 2.** Content of Fe, Cu, Cd, Cr, and Pb in Fish Samples in Weda.

Test Sample	Fe (mg/kg)	Cu (mg/kg)	Cd (mg/kg)	Cr (mg/kg)	Pb (mg/kg)
Yellow selar (Weda)	24.15	ND (*)	ND (*)	ND (*)	ND (*)
Yellow selar 2 (Weda)	21.16	0.47	ND (*)	ND (*)	ND (*)
Yellow selar 3 (Weda)	20.54	0.48	ND (*)	ND (*)	ND (*)
Flying fish (Sagen)	7.24	ND (*)	ND (*)	ND (*)	ND (*)
Oci (Sagen)	15.12	0.13	ND (*)	ND (*)	ND (*)
Small yellow selar (Lelilef)	4.00	ND (*)	ND (*)	ND (*)	ND (*)
Large yellow selar (Lelilef)	4.97	ND (*)	ND (*)	ND (*)	ND (*)

\* – ND/not detected; Source : primary data processing

The fish sample containing the highest Cd and Pb content was ayam-ayam (0.0345 mg/kg and 0.428 mg/kg, respectively) (Table 3).

**Table 3.** Content of Cd and Pb in Fish Samples in Muara Angke.

Test Sample	Cd (mg/kg)	Pb (mg/kg)
Ayam-ayam	0.0345	0.428
Black pomfret	0.0210	0.228
Red snapper	ND (*)	0.106
Kuwe	0.0005	0.190
Mackerel	ND (*)	0.206
Mackerel tuna	0.0005	0.142

The heavy metal content in a fish's body is closely related to the disposal of industrial waste in and around the fish's habitat, such as rivers, lakes, and seas [4]. The accumulation of heavy metals in fish is caused by contact between the fish and the aquatic medium containing heavy metals. Such accumulation can occur in several ways, such as in the respiratory and food channels and through the skin [5]. The metals are absorbed into the flesh of the fish by its blood, bound to the blood's proteins, and then distributed to all the body tissues. The highest metal accumulation is usually found in the liver and kidneys. The accumulation of heavy metals in body tissues occurs first in the gills, the liver, and then the meat of the fish. The amount of heavy metals absorbed by and distributed in the fish depends on the form of compounds and concentrations of the pollutants, the activity of the microorganisms, the sediment texture, and the types of fish that live in the neighborhood.

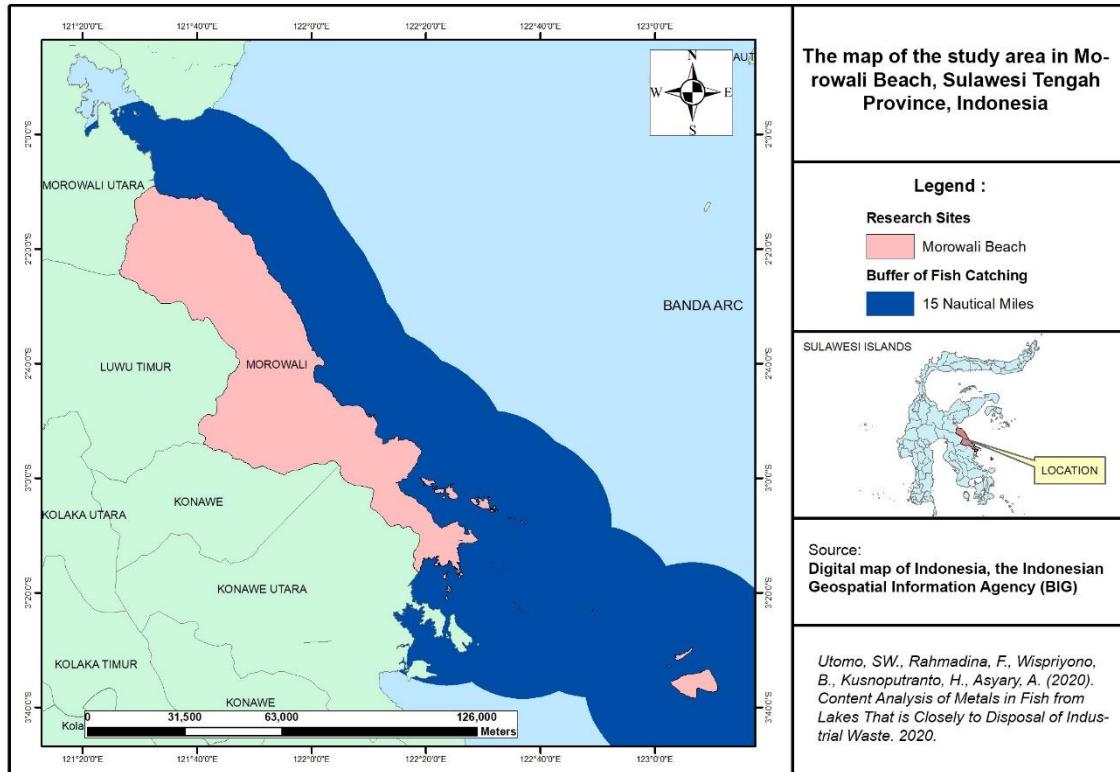
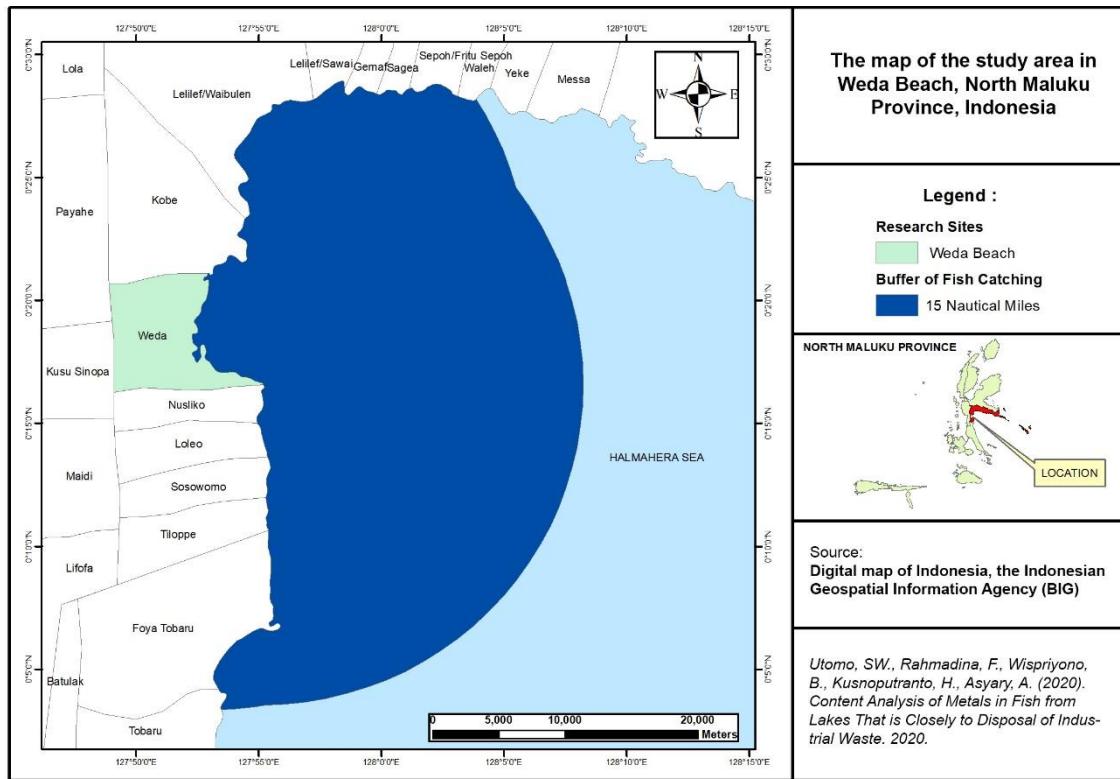
### Metal Content in Morowali Fish

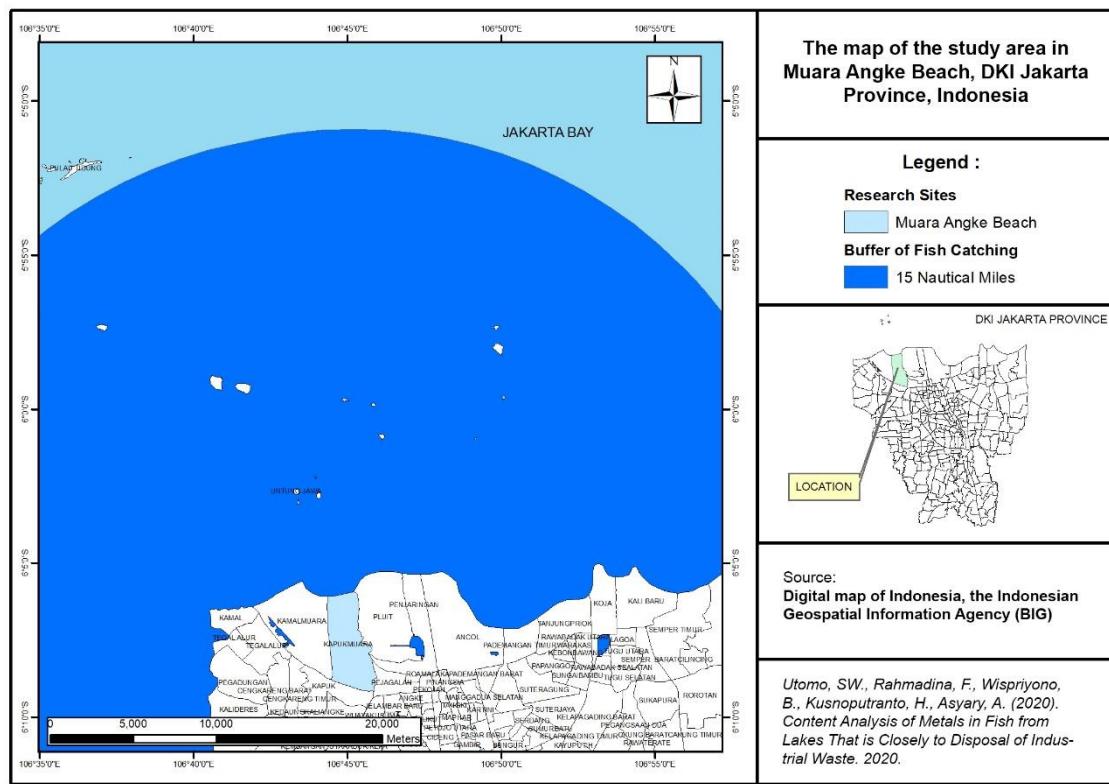
The metal content in the fish samples from Morowali, from the highest to the lowest levels, were as follows: Fe, Cr, Cd, Cu, and Pb. When compared with data from the National Standardization Agency (2009) regarding Fe contamination in food, all the fish samples from Morowali exceeded the limit, which is 1 mg/kg. The Cr content in the fish samples was compared with data from the Director General of POM Decree No. 03725/B/SK/89 concerning Cr contamination in food; all the fish samples exceeded the threshold, which is 2.5 mg/kg [6].

The Cd content in layur and krau exceeded the limit of Cd contamination in food, which is 0.2 mg/kg [6]. The Cu content in sarong exceeded the threshold of Cu allowed in food, which is 0.02 mg/kg. The Pb content in all the Morowali fish samples was still below the threshold, which is 0.3 mg/kg [6]. To sum, the fish samples from Morowali that exceeded the threshold of metal contamination are no longer safe for consumption.

### Metal Content in Weda Fish

The fish samples derived from Weda only contained Fe and Cu. When compared with data from the National Standardization Agency (2009) regarding the limit of Fe contamination in food, all the fish samples from Morowali exceeded the limit, which is 1 mg/kg. The Cu content in the fish samples was also compared with data from the National Standardization Agency (2009) regarding the limit of Cu contamination in food. The yellow selar (2 and 3) and oci exceeded the specified threshold, which is 0.02 mg/kg. Meanwhile, the results of the analysis did not show the presence of Cr, Cd, and Pb in all the fish samples from Weda. To sum, the fish samples from Weda that exceeded the threshold of metal contamination are no longer safe for consumption.





**Figure 1.** The map of the study area: (a) Weda; (b) Morowali; and (c) Muara Angke.

### Metal Content in Muara Angke Fish

When compared with data from the National Standardization Agency (2009) regarding the limit of Pb contamination in food, only the ayam-ayam sample exceeded the threshold, namely, 0.3 mg/kg. No level of Cd content in the samples exceeded the limit of Cd contamination in food. Thus, only the ayam-ayam is not safe for consumption.

The high concentration of Fe in all the samples from Morowali and Weda can be caused by several sources (i.e., apart from the land, human activities that occur on the mainland)—for example, the discharge of domestic sewage containing iron, the water reservoir containing iron, industrial waste deposits, and the corrosion of water pipes containing ferrous metals leading to the ocean. Increasing concentrations of iron can also be caused by the erosion of mineral rocks from pounding waves and wind as well as the corrosion of rusting ships and ports [7].

Fe has an important role in the process of enzymatic oxidation, cytochromes, and respiratory pigments (hemoglobin), but the excess of Fe can lead to poisoning. It can cause vomiting, impaired intestines, premature aging to sudden death, irritability, arthritis, birth defects, bleeding gums, cancer, cirrhosis of the kidneys, constipation, diabetes, diarrhea, dizziness, fatigue, blackish skin, headaches, liver pain and failure, hepatitis, hyperactivity, infections, insomnia, mental health problems, metallic taste in the mouth, rheumatism, cytopenia, the impaired absorption of vitamins and minerals, and homochromia [8].

The high level of Cr contained in fish from Morowali can be caused by activities in the textile (e.g., fabric coloring), paint, leather tanning, metal coating, or battery industries. Cr infestation into the food chain deposited in fish can cause poisoning. Cr is an important nutrient in carbohydrate metabolism, but at higher concentrations, it can be toxic [9]. It has a negative impact on the liver, kidneys, and protoplasm in cells, producing carcinogens (cause cancer), teratogens (inhibit fetal growth), and mutagens [10].

In addition, the presence of Cu in fish from Morowali and Weda can be derived from antifouling, widely used for fishing boats. Antifouling is used to seal the vessel and reduce damage to the boat

by organisms. The existence of fish in poor environmental conditions can also cause the fish to accumulate heavy metals. Such a situation occurs because fishing locations are correlated with industrial waste and the transportation hubs of ships. The shipping industry and transportation are major sources of heavy metal pollution in waters.

Cd contamination in fish from Morowali and Muara Angke indicate the presence of Cd pollutants in these lakes. Cd contamination can be due to waste disposal by industries that use Cd for electric and galvanic coating processes as Cd is noncorrosive. Cd metal poisoning can be characterized by symptoms of back pain for several years and eventually osteomalacia or the softening of bone and spinal fractures.

The content of Pb in all samples from Muara Angke indicates Pb pollution caused by the contamination of fuel ships. Based on the analysis of Pb content in fish samples in Muara Angke, only *ayam-ayam* exceeded the limit of Pb contamination, while the other fish samples are still safe for consumption. However, overexposure to Pb can disrupt the hemopoietic, nervous, kidney, gastrointestinal, cardiovascular, and reproductive systems in the human body.

## 5. Conclusions

In conclusion, all types of fish from Morowali are no longer safe for consumption because they contain traces of Fe, Cu, Cd, and Cr that exceed the thresholds of metal contamination. All types of fish from Weda are no longer safe for consumption as well because they contain levels of Fe and Cu that exceed their respective thresholds. Meanwhile, all types of fish from Muara Angke, except *ayam-ayam*, are safe for consumption.

**Supplementary Materials:** The following are available online at [www.mdpi.com/xxx/s1](http://www.mdpi.com/xxx/s1), Figure S1: title, Table S1: title, Video S1: title.

**Author Contributions:** Conceptualization, SWU, FR, BW, and HK; methodology, SWU; software, AA; validation, SWU and AA; formal analysis, FR; investigation, SWU and FR; resources, SWU; data curation, FR; writing—original draft preparation, SWU and FR; writing—review and editing, all authors; visualization, AA; supervision, BW and HK; project administration, SWU; funding acquisition, SWU. All authors have read and agreed to the published version of the manuscript.

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**Conflicts of Interest:** The authors declare no conflict of interest.

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