

HEALTH RISKS OF EXPOSURE TO CADMIUM IN TILA FISH IN THE COMMUNITY OF KERTA BUANA VILLAGE, KUTAI KARTANEGARA DISTRICT

Reni Suhelmi, Hansen, Ramadhani Putri Nurislam

Environmental Health Undergraduate Study Program, Muhammadiyah University of East Kalimantan
Jl. Ir. H. Juanda No. 15 Sidodadi Samarinda City, East Kalimantan 75124
E-mail: rs663@umkt.ac.id

Article Info

Article history:

Received May 10, 2023

Revised May 11, 2023

Accepted July 01, 2023

Keywords:

Health Risk

Cadmium

Tilapia Fish

Ex-Mining

ABSTRACT

Health Risks of Exposure to Cadmium in Tila Fish in The Community of Kerta Buana Village, Kutai Kartanegara District. The presence of heavy metal cadmium in ex-mining ponds results from coal excavation and refining activities. Ex-mining ponds are used by the community for fishing and fish farming, the community uses ex-mining ponds. Communities often consume fish without fully understanding its quality and the potential health risks it poses. As a result, it is necessary to conduct community research on environmental health risk analysis (EHRA) as a first step to estimating or predicting health risks. The research was conducted for one month, from June to July 2022. Data collection was carried out using questionnaires, food models, and anthropometric measurements. Fish samples were collected from five different locations in ex-mining ponds, while human samples were taken from 20 respondents. The analysis of cadmium concentration in fish was done using the Atomic Absorption Spectrophotometry (AAS) method. The study's results showed that the highest number of samples was about 0.0006 mg/kg of cadmium, while all of the respondents had a risk level value (RQ) of less than 1. This indicates that none of the respondents faced any health risks. It is recommended that people know and pay more attention to the types and sources of fish produced.

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INTRODUCTION

The issue of environmental pollution has become quite serious in various countries, including Indonesia, as evidenced by the emergence of various unique phenomena such as air pollution and river pollution. This phenomenon is caused by various human activities, such as transportation and industry. One well-known branch of industry is the coal mining industry, especially East Kalimantan, which increased by 294 million tons in 2021. ⁽¹⁾

Increased coal production has a positive impact, particularly in the economic sector, as evidenced by significant regional income profits. However, this activity leaves a large pool (ex-mining pond) as the end result of the mining process, which contains acid mine drainage (AAT). Acid mine drainage (AAT), or in foreign terms, acid mine drainage (AMD), is pollution on the surface of waters resulting from mining operations with low pH content and high metal solubility. Acid mine drainage contains heavy metals, which are toxic and have the potential to disrupt habitat environmental quality ⁽²⁾ and impact human health ⁽³⁾.

Cadmium is one of the heavy metals produced by mining operations. Studies in India report high concentrations of heavy metal cadmium in surface water around coal mining ⁽⁴⁾. The appearance of water from former mining pools is not dangerous for the surrounding community. This ex-mining pool water has even been used as an economic field through the construction of fish cages.

Fish that live and are raised in excavated coal mine ponds are very susceptible to heavy metal contamination. This is because fish are in the hierarchy of the food chain, which can directly absorb (digest) heavy metals from water and indirectly biomagnify through the food chain. ⁽⁵⁾. Previous research evidence also shows that fish contain heavy metals when they live in ex-mining ponds, and other studies show 0.10 mg/kg cadmium in fish ⁽⁷⁾. The emergence of the issue of heavy metals in fish needs to be followed up considering that fish is a source of protein for the human body and is a popular food ingredient among the public, with the national fish consumption figure (AKI) reaching 56.39 kg/person per year in 2020 ⁽⁸⁾.

Consumption of fish containing heavy metals poses chronic health risks to humans. The health effects of cadmium include an increased risk of cancer, lung disease, and heart disease ⁽⁹⁾. Previous research reported that cadmium was found at a concentration of 0.06 µg/L in the blood and 0.072 µg/L in the urine of children in Germany⁽¹⁰⁾. Another study explains that the highest concentration of cadmium is found in populations living around industrial areas, with an average concentration of cadmium found in human blood of 0.43 µg/L ⁽¹¹⁾. The heavy metal cadmium can enter the human body through inhalation and consumption of foods such as fish. For this reason, it is necessary to carry out an environmental health risk analysis (ARKL) to predict the level or characteristics of health risks in people exposed to cadmium.

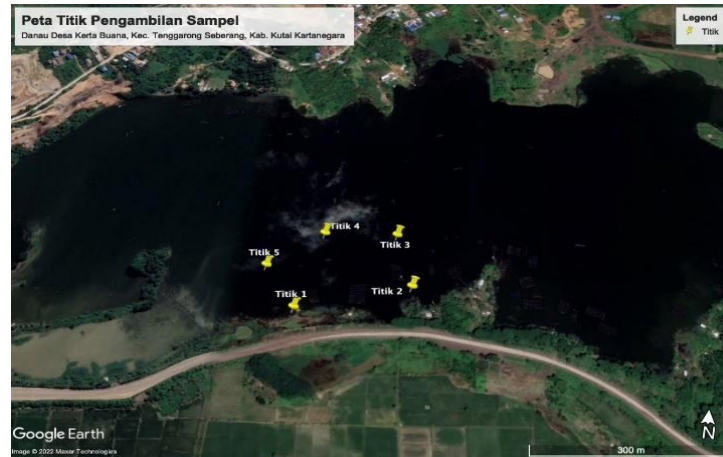
As previously explained, we carried out our follow-up by selecting research locations based on the cases observed in the field. The choice of location was evident by the presence of fish cages in the water from the former mining pool in Kerta Buana Village, Tenggara District, Kutai Kartanegara Regency. Based on initial observations, there are approximately 50 fish cages in the former coal mine excavation pond. The type of fish that is most widely cultivated and consumed by the community is tilapia, and in one harvest, it can produce up to 4 quintals of fish, which will then be sold to the village community. This is also proven by the Fish Production Figures (API) data for tilapia fish, reaching 11,090.55 metric tons in 2020 and ranking 10th nationally ⁽¹²⁾.

The main reason for the need for research is the existence of water from former mining ponds, which are associated with various fish cage activities and are managed and consumed by the surrounding community. This research aims to analyze the presence of heavy metals in tilapia fish from ex-mining pond water and carry out an environmental health risk analysis (ARKL) to predict the health risks experienced by the people of Kerta Buana village.

MATERIALS AND RESEARCH METHODS

The type of research carried out was an analytical observational method using the Environmental Health Risk Analysis (ARKL) approach. The ARKL approach method is used to measure risk factors so that it can predict the magnitude of health risks to humans due to the heavy metal cadmium (Cd), which accumulates in the body of consumed tilapia. This research was conducted in Kerta Buana Village, Tenggara Seberang District, Kutai Kartanegara Regency for one month, from June to July 2022.

This research encompasses both environmental populations and samples, as well as human populations. The environmental population in this study was all tilapia fish from cages in ex-mining ponds, while the environmental samples in this study were 5 tilapia fish taken from 5 different cages. Here are the locations where we sampled the fish:



Source: Google Earth

Figure 1. Map of sampling point locations

Laboratory analysis was carried out to determine the concentration of cadmium in fish. Five fish samples were placed in a cool box and then transported to Mulawarman University's soil science laboratory for digestion. After that, the samples were analyzed using the Atomic Absorption Spectrophotometry (AAS) method at the Samarinda Center for Standardization and Industrial Services (Baristand) laboratory.

Apart from that, interviews were conducted with 20 people in the community who live around the former mining pool. Data were collected using a questionnaire to obtain the respondent's identity and duration of exposure. We obtained consumption rate data from interviews using a food model, and we also collected exposure frequency data via a food frequency questionnaire. The data obtained is then continued in the ARKL calculation process (intake and risk characteristics) through a formula ⁽¹³⁾, following:

a. Intake Value Calculation Formula (Intake)

$$\text{Ink} = \frac{C \times R \times fE \times Dt}{Wb \times tAVG}$$

Information:

Ink (*Intakes*): Total risk agent concentration (mg).

enter the human body with
certain body weight (kg) every day
(mg/kg/day)

C (*Concentration*): Concentration of risk agents in food
(mg/kg)

R (*Rate*): Consumption rate or amount of food
that comes in every day (grams/day)

fE (*Frequency of Exposure*): The duration or number of days it occurred
annual exposure (days/year)

Dt (*Duration Time*): The duration or number of years it occurred
exposure (years)

WB (*Weight of Body*): Respondent's weight (Kg)

tavg (*Time Average*): Average time period for non effects
carcinogenic, 30 years × 365 days/year
= 10,950 days/year

b. Value Calculation Formula *Risk Quotient* (RQ)

$$RQ = \frac{I}{RfD}$$

Information:

I (Intake): Mark *intake* which has been calculated

RfD (Reference Dose): Risk agent reference value on ingestive exposure

RESEARCH RESULTS AND DISCUSSION

Data collection was carried out for 3 months, starting in May and ending in July 2022. The collected data was sorted based on the respondent's identity, the results of the cadmium concentration test, and the results of calculating intake and risk characteristics. The following results are presented in Table 1. A total of 20 community respondents were collected for this research. The following is the respondent identity table:

Table. 1 Distribution of Respondent Characteristics
in the Kerta Buana Village Community

No.	Respondent Characteristics	n	%
1.	Gender		
	Man	11	55
2.	Woman	9	45
	Age		
	14-23	1	5
	24-33	5	25
	34-43	5	25
3.	≥44	9	45
	Level of education		
	Finished elementary school	5	25
	Finished middle school	6	30
	Finished high school	8	40
4.	College	1	5
	Work		
	Private sector employee	6	30
	Self-employed	6	30
	Farmer	1	5
	Housewife	3	15
	Other	4	20

The table above reveals that 11 respondents were male (55%) and 9 were female (45), ranging in age from 14 to 44, with the majority being over 44 years old at 45%. Most of the research respondents had a high school education (40%), and at least 5% of respondents had a college education. Most of the respondents in this study work as private employees and entrepreneurs, with 30% each; 5% work as farmers; 15% work as housewives; and 20% work in other professions.

In addition to gathering data from respondent interviews, gathering environmental data is crucial for calculating ARKL and obtaining concentration values. The heavy metal concentration values in this study were obtained from the results of laboratory tests for the concentration of the heavy metal cadmium in fish, the results of which are explained in the following table:

Table 2. Results of Cadmium Concentrations in Tilapia taken from used water Mining Pool

No.	Pick Up Point	Concentration
1.	Cage 1	0.0000 mg/kg
2.	Cage 2	-0.0010 mg/kg
3.	Cage 3	0.0006 mg/kg
4.	Cage 4	-0.0004 mg/kg
5.	Cage 5	0.0006 mg/kg

According to table 2, the tilapia fish taken from cage 3 and cage 5 had the highest concentration of cadmium, at 0.0006 mg/kg. Tilapia fish from cage 1 had a cadmium concentration of 0.0000 mg/kg; tilapia fish from cage 2 had the smallest cadmium concentration, namely -0.0010 mg/kg; and tilapia fish from cage 4 had a cadmium concentration of -0.0004 mg/kg.

The highest concentration result calculated at 0.0006 mg/kg is used as the concentration value (C), which is then calculated in the ARKL formula. Data from the calculation of intake values and risk characteristics are displayed in Table 3 below:

Table 3. Calculation results of respondents' intake values and risk characteristics (RQ).

No. Resp.	C	R	fE	Dt	Wb	tAVG	Rfd	Ink	RQ	Note.
1.	0.0006	120	260	30	53	10,950	0.01	0.0010	1.0	TB
2.	0.0006	120	260	30	51	10,950	0.01	0.0010	1.0	TB
3.	0.0006	40	208	30	63	10,950	0.01	0.0002	0.2	TB
4.	0.0006	25	260	30	57	10,950	0.01	0.0002	0.2	TB
5.	0.0006	80	52	30	58	10,950	0.01	0.0001	0.1	TB
6.	0.0006	40	260	30	44	10,950	0.01	0.0004	0.4	TB
7.	0.0006	120	260	30	63	10,950	0.01	0.0008	0.8	TB
8.	0.0006	120	52	30	82	10,950	0.01	0.0001	0.1	TB
9.	0.0006	50	260	30	66	10,950	0.01	0.0003	0.3	TB
10.	0.0006	120	156	30	68	10,950	0.01	0.0005	0.5	TB
11.	0.0006	120	208	30	71	10,950	0.01	0.0006	0.6	TB
12.	0.0006	75	208	30	59	10,950	0.01	0.0004	0.4	TB
13.	0.0006	25	104	30	45	10,950	0.01	0.0001	0.1	TB
14.	0.0006	80	52	30	74	10,950	0.01	0.0001	0.1	TB
15.	0.0006	120	52	30	71	10,950	0.01	0.0001	0.1	TB
16.	0.0006	120	260	30	66	10,950	0.01	0.0008	0.8	TB
17.	0.0006	50	52	30	64	10,950	0.01	0.0001	0.1	TB
18.	0.0006	75	260	30	56	10,950	0.01	0.0006	0.6	TB
19.	0.0006	40	52	30	54	10,950	0.01	0.0001	0.1	TB
20.	0.0006	80	260	30	51	10,950	0.01	0.0007	0.7	TB

Information:

C = Concentration (mg/kg)

R = Intake rate (gr/day)

fE = Frequency of exposure (Fe)

Dt = Duration of exposure (years)

Wb = Body weight (Kg)

tavg= Average time period (days)

Rfd = Cadmium dose response

Ink = Intake

RQ = Risk Characteristics

TB = No risk

According to Table 3, of the 20 respondents involved in this research, the average intake value was 0.00586. All of them are not at risk of experiencing health problem This is evident from the RQ value, which is less than 1. However, there are two respondents with an RQ value of 1, which means that the respondent is at high risk of experiencing health problems due to consuming tilapia fish from cage cultivation in former coal mine excavation ponds.

Laboratory results showed that the highest heavy metal content was 0.0006 mg/kg; this figure is still a very small figure for the heavy metal content of cadmium in tilapia fish. According to the Samarinda Baristand Laboratory's provisions, the Meter Detection Limit (MDL) value for heavy metal cadmium is 0.0023 mg/kg. The small content of the heavy metal

cadmium in tilapia fish is because the tilapia fish used as samples are small tilapia fish, so the heavy metal has not accumulated in the fish's body.

This aligns with research indicating that large fish exhibit elevated levels of heavy metals, primarily due to their accumulation within their bodies ⁽¹⁴⁾. Apart from its small size, the absence of heavy metal cadmium in tilapia can also be attributed to its rare presence in water and its insoluble nature. This aligns with the previously stated theory, which states that the cadmium content in water is found in small amounts and has the property of being insoluble ⁽¹⁵⁾.

Even though the concentration value is low, this value can be used to calculate the intake value, and the RQ value is a calculation method to determine the risk of health problems in someone who has been exposed to heavy metals for a long time. Researchers calculated intake and RQ values in this study to determine how much health risk was experienced by the 20 respondents. The RfD value, which is the maximum limit value set by the integrated risk information system (IRIS), is needed in calculating the RQ value. The system determines the RfD value to be 0.001 mg/kg.

Based on the calculations that have been performed, all respondents involved in this research have an RQ value ≤ 1 , which means that the respondents are not at risk of experiencing health problems due to the heavy metal cadmium that comes from tilapia fish cultivated in ex-coal mine excavation ponds. However, two respondents, who were husband-and-wife couples, had an RQ value of 1. This was because the two respondents always consumed tilapia fish from ex-coal mine excavation ponds every day and three times a day. As research has shown, people who have a pattern of consuming fish 3–4 times a week have a 10 times greater risk of having heavy metal content in their bodies when compared to people who consume fish only 1–2 times a week. ⁽⁵⁾. Apart from being influenced by consumption patterns, the respondent's body weight also influences the RQ value. A person's weight will affect the risk value, and theoretically, the heavier a person is, the smaller the risk value, or, in other words, the smaller the possibility of a person experiencing health problems due to exposure to pollutants. ⁽¹⁷⁾.

The results of the RQ calculation show that several respondents are in the safe, no-risk category, which indicates that they will not experience health risks if they only consume fish from acid mine water in Kerta Buana village. However, looking at the 2 respondents with an RQ value equal to 1, it can be concluded that these 2 respondents have a high potential risk of experiencing health problems caused by their daily intake of tilapia fish. This aligns with research findings that indicate heavy metals pose a significant risk of health issues due to their relatively high concentration values ⁽¹⁸⁾. In contrast, preliminary studies suggest that cadmium concentrations are high, but the results of RQ measurements show there is no risk of health problems caused by low intake amounts. ⁽¹⁹⁾. According to the International Agency for Research on Cancer (IARC), cadmium is one of the most dangerous metals for human health, with acute symptoms such as coughing, irritation, dizziness, and chest pain, while long-term exposure is carcinogenic. ⁽²⁰⁾.

CONCLUSIONS AND RECOMMENDATIONS

Based on the results of research that has been conducted, the majority of respondents are male, with the largest age range ≥ 44 years. The results of research conducted in the laboratory showed that the highest concentration of the heavy metal cadmium in tilapia fish was found in cages 3 and cages 5, namely 0.0006 mg/kg, but this figure was still very small because it was below the Meter Detection Limit (MDL) value. determined by the Baristand Laboratory, namely 0.0023 mg/kg.

Furthermore, the results of calculations using the ARKL formula for all respondents had an RQ value ≤ 1 , which means that all respondents did not have the risk of experiencing health

problems due to exposure to the heavy metal cadmium from consuming tilapia fish cultivated in former coal mine excavation ponds. However, there were 2 respondents who had an RQ value of 1 who had a high potential for experiencing health problems. Based on pAs a result of the research, it is recommended that it is important to pay attention to the type and source of food that will be consumed as a preventive measure and that further research needs to be carried out by analyzing the levels of heavy metals in people's blood and urine.

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