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Environmental Health Risk Analysis of Mercury (Hg) Heavy Metal Exposure (Study on People Consuming Milkfish Around Konawe Industrial Area)

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ABSTRACT

Introduction: Industrial activities of mining material processing have the potential to cause water pollution. Activities in the Konawe Industrial Estate also require a Steam Power Plant, which has the potential to produce mercury metal (Hg) sourced from coal as raw material. This study aims to analyse the environmental health risks of Hg heavy metal exposure in people who consume milkfish from the Konawe Regency industrial area.

Method: This type of research is quantitative research with Field Research and Laboratory Research methods. The population in this study consisted of 2 subjects, namely people living in the Konawe Industrial Estate area and milkfish specimens. Community samples totaled 97 people and specimen samples were taken at 4 pond locations. Data analysis using Environmental Health Risk Assessment (ERA).

Result: The results of the study obtained the average concentration of mercury heavy metal (Hg) in milkfish was 0.003 mg / kg, the large intake of respondents in consuming milkfish for mercury heavy metal (Hg) was 0.00891 mg / kg / day, and the level of risk of respondents and pollution based on the RQ calculation value was still < 1.

Conclusion: People who consume milkfish from the Konawe Industrial Estate do not have a risk of health problems for now and in the next 30 years. Risk management to prevent the emergence of risks is to maintain the rate of intake and frequency of exposure.

Introduction

Mining material processing industry activities have the potential to cause water pollution in accordance with the Regulation of the State Minister of Environment Number 09 of 2006 concerning Wastewater Quality Standards for Nickel Ore Mining Business and/or Activities. The input of waste into the waters can result in changes in water quality both physically and chemically Deterioration in water quality can be caused by the presence of heavy metals in the sediments and waters of an area. Heavy metals have generally been designated as toxic contaminants due to their stable presence in aquatic environments, easy bioaccumulation in aquatic biota and biomagnification of the food chain.[1]

Basically, all marine life has the ability to accumulate heavy metals.[2] However, heavy metals that accumulate in the body of a biota, including cultivated commodities, will be very dangerous if cultivated products consumed by humans contain heavy metals at unsafe tolerance values.[3] Similarly, milkfish raised in ponds can be exposed directly or indirectly to heavy metals such as Cd, Pb, and Hg.

If the pond waters have been polluted, it is suspected that farmed milkfish are also polluted. This condition is caused by the process of lead bioaccumulation in the body of milkfish through the food chain. Bioaccumulation is an increase in the concentration of a substance through the food chain in the body tissues of aquatic animals. In addition to entering the organism's body through the food chain, heavy metals can also enter through the gills and diffusion through the surface of the skin.[4]

In the process of processing nickel ore, Konawe Industrial Estate also requires a Steam Power Plant with coal as its main fuel. One type of heavy metal contamination of Steam Power Plant that is classified as having a high level of toxicity is mercury (Hg). From the results of an initial survey conducted by researchers at milkfish breeding sites around the Konawe industrial area, it was found that there were 4 villages that passed through the logging area that were still active around the watershed area that passed through the industrial area. Community land around the Konawe Industrial area is used for fisheries or ponds, especially milkfish. The fish is consumed by the surrounding community and may contain heavy metals such as Mercury (Hg) due to the condition of the pond that has been polluted with industrial waste. If fish is consumed continuously and in large quantities it can cause health problems due to the presence of metals. Based on this background, this study aims to analyze the environmental health risks of Hg heavy metal exposure in people who consume milkfish from the Konawe Regency industrial area.

Method

This type of research is quantitative research with Field Research and Laboratory Research methods, where this research is directly carried out in the field or directly on respondents to determine individual characteristics and activity patterns and examination of Hg heavy metal content in milkfish carried out in the laboratory. The population in this study consisted of 2 subjects, namely people living in the Konawe Industrial Estate area who consumed milkfish and milkfish specimen subjects in ponds around the Konawe Industrial Estate. Community samples totalled 97 people and specimen samples were taken at 4 pond locations (Banggina Village, Sama Subur Village, Tani Indah Village, and Tobimeita Village).

The population in this study is all HIV/AIDS patients who live in Kendari City and are undergoing treatment at the VCT Clinic of Kendari City Hospital until 2022, which is 247 people. The number of samples in the study was 151 people, with sampling using Simple Random Sampling. Data collection in the community was carried out by interviews using questionnaires and anthropometric measurements (body weight and height). As for measuring heavy metal concentrations using the Atomic Absorption Spectrophotometer tool. Data analysis using Environmental Health Risk Assessment (ERA).

Result

Table 1 shows that the classification of the intake rate of respondents who consume milkfish (*Chanos chanos Forsskal, 1775*) from ponds around the Konawe industrial area is the highest group with an intake rate of 300-599 grams / day with the number of respondents as many as 60 people (61.86%). While the lowest intake rate was the < group of 300 grams / day with the number of respondents as many as 12 people (12.37%).

Table 2 based on table 5.5, it was found that the distribution of respondents based on the frequency of exposure was highest in the exposure frequency group of 100-199 days / year with the number of respondents as many as 50 people (51.5%) and the lowest in the exposure group > 300 days / year with the number of respondents as many as 9 people (9.3%).

Table 3 shows that the average value of the concentration of heavy metal Mercury (Hg) in milkfish (*Chanos chanos Forsskal*, *1775*) is 0.003. The analytical method used to measure the metal content is by using Atomic Absorption Spectrophotometry (AAS).

Table 4 shows that the average intake value of milkfish (*Chanos chanos Forsskal*, *1775*) containing heavy metal Mercury (Hg) consumed by respondents is 0.01373 mg / kg / day.

Table 5 shows that the *CoV value* of the variables concentration (C), intake rate (R) and exposure frequency (fE) > 30% which means that the data is not normally distributed so that what is used to calculate intake and RQ is the median value. While the *CoV* value of body weight (Wb) < 30% which means that the data is normally distributed, so the weight value used to calculate intake and RQ is the mean value.

By knowing the value of these variables, it can be calculated the *intake* and risk level (RQ) of the population of people who consume milkfish from ponds around the Konawe Industrial Estate using the equation Louvar & Louvar (1998) as follows:

$$Intake\ (I) = \frac{\mathrm{C\ x\ R\ x\ fE\ x\ Dt}}{\mathrm{Wb\ x\ T_{avg}}}$$

$$Intake\ (I) = \frac{0.0038\,\frac{gr}{kg}\,x\ 400\,\frac{gr}{day}\,x\ 104\,\frac{day}{year}\,x\ 30\ years}{48{,}5876\ kg\ x\ 365\,\frac{day}{year}\,x\ 30\ years}$$

$$Intake\ (I) = 0{,}00891$$

RQ (Hg) = *Intake* / RfD
= 0,00891 / 0.5
= 0,017827425

Based on the results of the calculation of the risk level shows that the RQ value of the heavy metal Mercury (Hg) < 1. So, it can be said that at this time and in the next 30 years the population of people who consume milkfish from ponds around the Konawe Industrial Estate is still categorized as safe and not at risk of the effects of heavy metal content of Mercury (Hg) in Milkfish (*Chanos chanos Forsskal, 1775*).

Table 1.
Distribution of Respondents' Intake Rate in Morosi District, Konawe Regency in 2023

Intake Rate Classification	n	%
> 600 grams/day	25	25,77
300-599 grams/day	60	61,86
< 300 grams/day	12	12,37
Sum	97	100

Table 2.
Distribution of Respondents Based on Frequency of Exposure in Morosi District, Konawe Regency in 2023

Exposure Frequency Classification	n	%
> 300 days/year	9	9,3
200-299 days/year	15	15,5
100-199 days/year	50	51.5
< 100 days/year	23	23.7
Sum	97	100

Table 3.
Mercury (Hg) Heavy Metal Concentration in Milkfish (*Chanos chanos Forsskal, 1775*) from Ponds Around Konawe Industrial Estate in 2023

Coordinates	Location	Hg (mg/kg)
$3,86062^0$ S $122,41438^0$ T	Location 1	0.0013
	Location 1	0.0012
$3,85266^0$ S $122,42141^0$ T	Location 2	0.0037
	Location 2	0.0025
$3,86338^0$ S $122,43884^0$ T	Location 3	0.0051
	Location 3	0.0064
$3,83443^0$ S $122,46612^0$ T	Location 4	0.0038
	Location 4	0.0039
Average		0.003

Table 4.
***Intake* of Mercury (Hg) Heavy Metal Contained in Milkfish Originating from Ponds Around the Konawe Industrial Estate in 2023**

Descriptive	Value
Mean	0,01373
Median	0,01083
SD	0,00976
Min	0,001
Max	0,04872

Table 5.
Variable Data to Calculate Population Intake Consuming Milkfish from Ponds Around Konawe Industrial Area

Descriptive	Heavy Metal Concentration Hg (C)	R (gr/day)	fE (day/year)	Wb (kg)	Dt (Year)	T_{avg} (Day)
Mean	0,0035	432,4742	146,3505	48,5876	30	10950
Median	0.0038	400,00	104,0000	52,0000		
SD	0.00179	164,25990	109,62474	14,26078		
Min	0.00	100,00	52,00	10,00		
Max	0,01	900,00	728,00	77,00		
CoV	51,142	37,981	74,905	29,35		

Discussion

Mercury (Hg) Content in Milkfish

International health organizations, such as the World Health Organization (WHO) and the United States Environmental Protection Agency (EPA), have set maximum limits on safe mercury levels in fish consumed by humans. The limits are based on health risk analysis and consider the long-term effects of mercury exposure on human health, especially in vulnerable groups such as children and pregnant women.[5]

The mercury content in milkfish can be affected by the conditions of the waters in which they live. Waters contaminated by industrial waste or other human activities have a higher potential to contain mercury. Larger and older milkfish tend to have higher mercury content because they have accumulated mercury over longer time spans and eat more prey in the food chain.[6]

Konawe Industrial Estate is an industrial area that focuses on nickel ore processing. The nickel industry is often associated with the use and disposal of mercury in the production process. Waste and emissions produced by the nickel industry can pollute the surrounding environment, including waters used for milkfish ponds. Mercury pollution in the environment can occur through air emissions and liquid or solid waste disposal systems from nickel plants. The mercury can then enter the pond waters through the sedimentation process or water flow.

Milkfish farmed in ponds around nickel industrial areas can experience mercury accumulation through the bioaccumulation process. Through the food chain, milkfish eat other organisms contaminated with mercury or eat prey that has accumulated mercury. This leads to an increase in the concentration of mercury in the tissues of milkfish over time.

Intake of Mercury Heavy Metal (Hg)

Intakes in environmental health risk analysis studies refer to the number of harmful substances or materials that enter the human body through various exposure pathways, such as food consumption, inhaled air, and direct contact with skin. *Intakes* are important parameters used to evaluate the level of exposure and health risks associated with hazardous substances in the environment.[7]

After conducting research and calculations on the variables and *intakes* of respondents who consume milkfish from ponds around the Konawe Industrial Estate, the average intake of respondents for the heavy metal Mercury (Hg) was 0.00891 mg/kg/day.

Intakes may also vary depending on individual factors, such as age, sex, eating habits, duration of exposure, and health conditions. Therefore, in the analysis of environmental health risks, differences in the characteristics of exposed populations must also be taken into account in order to obtain a more accurate picture of the health risks associated with the intake of such hazardous substances.

In conclusion, intake represents the amounts of harmful substances that enter the human body through various exposure pathways in environmental health risk analysis studies. Measurement and evaluation of hazardous substance intakes is an important component in evaluating health risks associated with environmental exposures.

Risk Level of Public Health Disorders

RQ or Risk Quotient in environmental health risk analysis studies is the ratio between the estimated exposure to a hazardous substance and the acceptable risk threshold. RQ is used as a tool to compare exposure levels against predetermined risk thresholds in environmental health risk analyses.[8]

Risk Quotient (RQ) of mercury (Hg) heavy metal exposure in people who consume milkfish from ponds around the Konawe Industrial Estate is obtained using intake values and compared with RfD values.

In accordance with the results of the risk level (RQ) calculation, it was obtained that people who consume milkfish from ponds around the Konawe Industrial Estate < 1 for the next 30 years. This is due to the low intake rate and frequency of exposure. This means that people who consume milkfish are still in the safe category for the next 30 years provided that the concentration of heavy metal mercury (Hg), intake rate and frequency of exposure do not change for the next 30 years and heavy metal exposure only comes from milkfish and not from other sources.

Risk Management

In accordance with the results of the risk level (RQ) calculation, it was obtained that people who consume milkfish from ponds around the Konawe Industrial Estate < 1 for the next 30 years. This is due to the low intake rate and frequency of exposure. This means that people who consume milkfish are still in the safe category for the next 30 years provided that the concentration of heavy metal mercury (Hg), intake rate and frequency of exposure do not change for the next 30 years and heavy metal exposure only comes from milkfish and not from other sources (Hg).

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The Food and Drug Administration of the Republic of Indonesia and USEPA have set the maximum standard / value of fish consumption with mercury (Hg) does not exceed, 0.5 mg / kg. If the metal content in milkfish is contained in shellfish with concentrations exceeding the predetermined value, it will have a negative impact on the health of the people who consume it.[10]

Conclusion

Based on the results of research conducted on "Environmental Health Risk Analysis of Mercury (Hg) Heavy Metal Exposure (Study on People Consuming Milkfish Around Konawe Industrial Area)" obtained the following conclusions:

1. The average intake rate of respondents was 400 grams / day. The average frequency of exposure for all heavy metal parameters was 104 days/year with exposure duration for a prediction of 30 years.
2. The average value of mercury (Hg) heavy metal concentration in milkfish is 0.003 mg/kg.
3. The average intake or intake of respondents in consuming milkfish for heavy metal mercury (Hg) amounted to 0.00891 mg / kg / day.
4. The risk level of respondents and pollution based on the RQ calculation value is still < 1, which means that people who consume milkfish from the Konawe Industrial Estate do not have a risk of health problems for now and in the next 30 years.
5. Risk management to prevent the emergence of risks is to maintain the rate of intake and frequency of exposure.

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