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RISK ANALYSIS OF Cr AND Cu HEAVY METALS IN THE CIMANUK WATERSHED

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ABSTRACT

Background: *The Cimanuk River is one of the rivers in the city of Garut. Cimanuk originates in the Mandalagiri Mountains in Garut Regency at an altitude of about 1700 meters above sea level (masl), flows northeast for 180 km, and empties into the Java Sea in Indramayu Regency. Residents along the Cimanuk stream use this river for agricultural and fisheries resources, both traditionally by fishing and netting; additionally, the Cimanuk river has the potential to become a tourist attraction for rafting.The name Cimanuk River comes from a story about a local who went hunting for manuk (birds) and drowned in the Cimanuk River's headwaters.The location of the suction mud is on Mount Mandalagiri, Cikandang Village, Cikajang District, Garut Regency. Because he drowned while hunting for manuk (birds), the river that flows from the quicksand was then named Cimanuk. The headwaters of the Cimanuk River are located on Mount Mandalagiri, in Cikandang Village, Cikajang District. The height is about 1,813 meters above sea level, and it is about 22 km from the capital city of Garut regency to the south. This river flows from Mount Mandalagiri in Garut Regency and empties into the Java Sea on the north coast. This river crosses the districts of Garut, Sumedang, Majalengka, Indramayu, and Cirebon and is the second longest river in West Java. The Cimanuk River is one of the main pillars of water resources in West Java. This river is capable of providing 2.2 billion m3 of water per year. But unfortunately, the Ministry of Environment and Forestry also mentions that the Cimanuk Watershed is the most critical watershed.*

Methods*: Water quality monitoring data for the Cimanuk river in March, June, and October 2021 is sourced from DLHK Province, West Java, 2021, which is then calculated and analyzed using the formula*

Results*: The results showed that from 5 sampling points, the average concentration of the heavy metal Cr was 0.005 mg/L, and the average concentration of the heavy metal Cu was 0.016 mg/L. The intake dose for March 2021 for the heavy metal Cr is at points 1–5 with an intake value of 0.0085 mg/kg/day, and the intake dose for Cu is at points 1–5 with an intake value of 1.559 mg/kg/day. The intake dose for June 2021 for the heavy metal Cr is at point 1 with an intake value of 0.027287671 mg/kg/day, at point 2–5 the intake value is 0.008527397 mg/kg/day, and the Cu intake dose is at point 1–5 with an intake value of 1.559 mg/kg/day. The intake dose for the heavy metal Cr in October 2021 is at point 1 with an intake value of 0.027287671 mg/kg/day, at point 2–5 the intake value is 0.008527397 mg/kg/day, and the Cu intake dose is at point 1–5 with an intake value of 1.559 mg/kg/day. The results of this study indicate that the risk of Cr heavy metal contamination at points 1–5 is 2.833333333. Meanwhile, the risk of Cu heavy metal contamination is 38.975 at points 1-5.*

Conclusion*: Based on the data above, the risk value of the two metals Cu and Cr has a value of 1, so the value of the Cimanuk River watershed is at risk.*

Keywords *: Environmental Health Risk Analysis, River Water*

INTRODUCTION

Water sources are one of the main components needed for a clean water supply system to function. One source of water that is widely used by the community is ground water, which can be extracted by digging

wells. 1 Dug wells are the most commonly used well by the community as a source of drinking water, with a depth of 7–10 m from the ground surface. Drinking water is safe for health if it meets the requirements for glasses, biology, chemistry, and radioactivity. 3 However, due to increasing human activities, development activities, and agricultural waste that uses excess chemical fertilizers, it causes water pollution so that the water quality decreases. The compound most frequently found in groundwater and surface air is nitrate.

Watersheds (DAS) are all areas where all the water that falls in the area will flow into a river. The flow of water is not only in the form of surface water that flows in the river channel, but also includes the flow on the slopes of the hills that flow towards the river channel, so that the area is called a watershed. This area is generally limited by topographical boundaries. This limit is not determined based on groundwater because the groundwater level always changes according to the season and level of usage activities. 1 . With the advancement of time and civilization, there will be an increase in human needs, particularly the ever-increasing need for water for human daily activities. Thus, human daily activities greatly affect the use of water, one of which is river water, both of which are used for household, industrial, and agricultural activities, among others. Sources of pollution can also come from piles of garbage in landfills, where runoff water can enter rivers.

Exposure to heavy metal contamination that is present, even in low concentrations in the environment, can be hazardous to human health. Industrial waste is a very dangerous toxicant, especially when it involves heavy metals in the production process. Heavy metals are widely used in industries such as the chemical industry, cement, metal smelting, mining, batteries, paint, and other industries. Contamination by heavy metals is a serious concern because they can contaminate soil and groundwater and spread to the surrounding area through water, wind, and by being accumulated by plants. The dangers of heavy metal Cr Carcinogenicity, immune system disorders, nervous system disorders, kidney disorders and damage, and effects on respiration are among the toxic effects, whereas the dangers of heavy metal Cu cause kidney disorders, liver damage, vomiting, dizziness, anemia, convulsions, and death. If an environment, especially in the water, has been contaminated with heavy metals, the cleaning process will be very difficult to carry out. The characterization of potential hazards that have an effect on human health or environmental hazards is known as risk analysis. The Cimanuk River is the second longest river in West Java with a length of 180 km. Water flows northeast and empties into the Java Sea in Indramayu Regency. The Cimanuk River is also the main support for water resources in West Java. At first, it was based on a book written by a Portuguese explorer named Tome Pires. In his book entitled Suma Oriental, he mentions Cimanuk as Chemano, which was one of the six ports at that time. At Cimanuk Harbor, there are junks or large sailing ships that cannot anchor at the beach but only offshore. The Cimanuk River became the tip of the Sunda kingdom, with a busy trading area.

Cimanuk is also known as Chenano or Chiano, and it separates the Sunda region from Java. The Cimanuk River became the boundary between the two kingdoms, Sunda and Majapahit. Another source says that the origin of the name Cimanuk was taken from the story of a resident who hunted manuk (birds) and drowned in quicksand, which is the headwaters of the Cimanuk River on Mount Mandalagiri.

This watershed is managed by the Ministry of Public Works and Public Housing through the Cimanuk Cisanggarung River Basin Center (BBWS Cimancis). This watershed includes Garut Regency, Sumedang Regency, Majalengka Regency, Indramayu Regency, and Cirebon Regency. This river also divides a number of areas, including the cities of Garut, Jatibarang, and Indramayu. The area of this watershed reaches 3,584 km2, with a total length of the main river reaching 180 km. The headwaters of this river are the Mandalagiri-Puncakgede Mountains in Simpang Village, Cikajang District, Garut Regency. This river flows in the western region of the island of Java, which has a tropical monsoon climate (code: Am according to the Köppen-Geiger climate classification). The average annual temperature is around 25 °C. The warmest month is October, when the average temperature is around 28 °C, and the coldest is

February, at 21 °C. The annual average rainfall is 2465 mm. The wettest month is January, with an average of 461 mm of rainfall, and the driest is September, with an average of 6 mm. Residents along the Cimanuk stream use this river for agricultural and fisheries resources, both traditionally by fishing and netting; additionally, the Cimanuk river has the potential to become a tourist attraction for rafting.

METHOD

This research was conducted along the Cimanuk River in Garut Regency, West Java. The data used in this study is secondary data from the Environment and Forestry Office of West Java Province. Water quality monitoring data for the Cimanuk river in March, June, and October 2021, source: DLHK Province of West Java, 2021

No.	Sampling Point	Location
1.	Point 1	Cimanuk in Bayongbong
2.	Point 2	Cimanuk in Sukaregang
3.	Point 3	Cimanuk in Darmaraja
4.	Point 4	Cimanuk in Tomo
5.	Point 5	Cimanuk in Jatibarang

The data analysis technique in this study is divided into an analysis of river water quality with reference to PP No. 82 of 2021, which aims to compare measured heavy metal concentrations with quality standards and perform risk analysis calculations. To find out the amount of risk that is accepted, the amount of intake of heavy metals (Cr and Cu) that is exposed to the human body is calculated first. Contaminant intake can be calculated using the following equation:

$$Ink = \frac{C \times R \times t_E \times f_E \times D_t}{W_b \times t_{avg}}$$

Information :

Ink = Intake, the amount of risk agent that enters (mg/kg-day)

C = Concentration of risk agent (metal in water) (mg/l)

R = Intake rate; 1 liter/day (for children) and 2 liters/day for adults

FE = Annual exposure frequency (day/year)

tE = daily exposure time (hours/day)

Dt = duration of exposure, real time or 30 years projected (years)

Wb = body weight (kg)

TAVG = Average time period (30 Years x 365 Days/Year (Carcinogenic)

Meanwhile, to calculate health risk characteristics, it is expressed as a Risk Quotient (RQ or Risk Level) for non-carcinogenic effects, calculated using the formula:

$$RQ = = \frac{I_{nk}}{RfD}$$

Information :

RQ = Risk Quotient

Ink = Intake (intake) non-carcinogenic

RfD = Reference Dose (for oral exposure).

RESULTS

Heavy Metal Cr

Sampling Point	March	June	October
Point 1	0,005	0,016	0,01
Point 2	0,005	0,005	0,01
Point 3	0,005	0,005	0,01
Point 4	0,005	0,005	0,005
Point 5	0,005	0,005	0,005

Source DLHK Prov. West Java, 2021

Heavy Metal Cu

Sampling Point	March	June	October
Point 1	0,016	0,016	0,016
Point 2	0,016	0,016	0,016
Point 3	0,016	0,016	0,016
Point 4	0,016	0,016	0,016
Point 5	0,016	0,016	0,016

Source DLHK Prov. West Java, 2021

The average concentration of Cr heavy metal is 0.005 mg/L. When compared with the quality standards of class 1 PP No. 82 of 2001 the results of heavy metal concentrations are the same as the quality standard. The average concentration of heavy metal Cu is 0.016 mg/L. when compared with the quality standards of class 1 PP No. 82 of 2001, the concentration of Cu heavy metal was higher than the quality standard.

Estimated intake dose can be calculated according to the equation below:

$$I_{nk} = \frac{C \times R \times t_E \times f_E \times D}{W_b \times t_{avg}}$$

$$= \frac{C \times R \times t_E \times f_E \times D_t}{}$$

$$W_b \, x \, t_{avg}$$

Information :

Ink = Intake, the amount of risk agent that enters (mg/kg/day).

C = concentration of the risk agent (metal in water) (mg/l)

R = Intake rate; 1 liter/day (for children) and 2 liters/day for adults.

FE = Annual exposure frequency (days/year)

tE = daily exposure time (hours/day).

Dt = duration of exposure, real time or 30 years projected (years)

Wb = body weight (kg).

TAVG = Average Time Period, 30 years x 365 days/year (carcinogenic)

The intake dose for the heavy metal Cr is at points 1–8 in segments 4 and 5, with an intake value of 0.00014 mg/kg/day obtained from the calculation results above. The heavy metal Cu intake dose at points 1-8 in segments 4 and 5 with an intake value of 0.000438356 mg/kg/day calculated from the above results.

Standard Doses of Cr and Cu Heavy Metals

No	Parameters	RfD RAIS (mg/kg/hari)	PP No. 28 Tahun 2001 (mg/L)	PERMENKES No. 492 Tahun 2010 (mg/L)
1	Cr	0,003	0,05	0,05
2	Cu	0,04	0,02	2

Source : *The Risk Assesment Information System (RAIS)*, PP No. 82 Tahun 2001 dan PERMENKES No. 492 Tahun 2010

Table 1. Overall Results of Cr Dose Response Analysis March 2021

Sampling Point	Concentration (C)	R	Dt	Fe	Wb	Ink (Calculation Result)	Rfd	RQ (Result Calculation/ Risk Quotient)	Categori (Risk/Not)
Point 1	0,005	0,83	30	350	70	0,0085	3,E-03	2,833333333	Risk
Point 2	0,005	0,83	30	350	70	0,0085	3,E-03	2,833333333	Risk
Point 3	0,005	0,83	30	350	70	0,0085	3,E-03	2,833333333	Risk
Point 4	0,005	0,83	30	350	70	0,0085	3,E-03	2,833333333	Risk
Point 5	0,005	0,83	30	350	70	0,0085	3,E-03	2,833333333	Risk

Table 2. Overall Results of June 2021 Cr Dose Response Analysis

Sampling Point	Concentration (C)	R	Dt	Fe	Wb	Ink (Calculation Result)	Rfd	RQ (Result Calculation/ Risk Quotient)	Categori (Risk/Not)
Point 1	0,016	0,83	30	350	70	0,027287671	3,E-03	9,093333333	Risk
Point 2	0,005	0,83	30	350	70	0,008527397	3,E-03	2,84	Risk
Point 3	0,005	0,83	30	350	70	0,008527397	3,E-03	2,84	Risk
Point 4	0,005	0,83	30	350	70	0,008527397	3,E-03	2,84	Risk
Point 5	0,005	0,83	30	350	70	0,008527397	3,E-03	2,84	Risk

Table 3. Overall Results of Cr Dose Response Analysis for October 2021

Sampling Point	Concentration (C)	R	Dt	Fe	Wb	Ink (Calculation Result)	Rfd	RQ (Result Calculation/ Risk Quotient)	Category (Risk/Not)
Point 1	0,01	0,83	30	350	70	0,017	3,E-03	5,666666667	Risk
Point 2	0,01	0,83	30	350	70	0,017	3,E-03	5,666666667	Risk
Point 3	0,01	0,83	30	350	70	0,017	3,E-03	5,666666667	Risk
Point 4	0,005	0,83	30	350	70	0,00852	3,E-03	2,84	Risk
Point 5	0,005	0,83	30	350	70	0,00852	3,E-03	2,84	Risk

Table 4. Overall Results of Cu Dose Response Analysis for March 2021

Sampling Point	Concentration (C)	R	Dt	Fe	Wb	Ink (Calculation Result)	Rfd	RQ (Result Calculation/ Risk Quotient)	Category(Risk/Not)
Point 1	0,016	0,83	30	350	70	1,559	4,E-02	38,975	Risk
Point 2	0,016	0,83	30	350	70	1,559	4,E-02	38,975	Risk
Point 3	0,016	0,83	30	350	70	1,559	4,E-02	38,975	Risk
Point 4	0,016	0,83	30	350	70	1,559	4,E-02	38,975	Risk
Point 5	0,016	0,83	30	350	70	1,559	4,E-02	38,975	Risk

Table 5. Overall results of June 2021 Cu Dose Response Analysis

Sampling Point	Concentration (C)	R	Dt	Fe	Wb	Ink (Calculation Result)	Rfd	RQ (Result Calculation/ Risk Quotient)	Categori (Risk/Not)
Point 1	0,016	0,83	30	350	70	1,559	4,E-02	38,975	Risk
Point 2	0,016	0,83	30	350	70	1,559	4,E-02	38,975	Risk
Point 3	0,016	0,83	30	350	70	1,559	4,E-02	38,975	Risk
Point 4	0,016	0,83	30	350	70	1,559	4,E-02	38,975	Risk
Point 5	0,016	0,83	30	350	70	1,559	4,E-02	38,975	Risk

Table 6. Overall Results of Cu Dose Response Analysis for October 2021

Sampling Point	Concentration (C)	R	Dt	Fe	Wb	Ink (Calculation Result)	Rfd	RQ (Result Calculation/ Risk Quotient)	Categori (Risk/Not)
Point 1	0,016	0,83	30	350	70	1,559	4,E-02	38,975	Risk
Point 2	0,016	0,83	30	350	70	1,559	4,E-02	38,975	Risk
Point 3	0,016	0,83	30	350	70	1,559	4,E-02	38,975	Risk
Point 4	0,016	0,83	30	350	70	1,559	4,E-02	38,975	Risk
Point 5	0,016	0,83	30	350	70	1,559	4,E-02	38,975	Risk

The results showed that from 5 sampling points, the average concentration of the heavy metal Cr was 0.005 mg/L, and the average concentration of the heavy metal Cu was 0.016 mg/L. The intake dose for March 2021 for the heavy metal Cr is at points 1–5 with an intake value of 0.0085 mg/kg/day, and the intake dose for Cu is at points 1–5 with an intake value of 1.559 mg/kg/day. The intake dose for June 2021 for the heavy metal Cr is at point 1 with an intake value of 0.027287671 mg/kg/day, at point 2–5 the intake value is 0.008527397 mg/kg/day, and the Cu intake dose is at point 1–5 with an intake value of 1.559 mg/kg/day. The intake dose for the heavy metal Cr in October 2021 is at point 1 with an intake value of 0.027287671 mg/kg/day, at point 2–5 the intake value is 0.008527397 mg/kg/day, and the Cu intake dose is at point 1–5 with an intake value of 1.559 mg/kg/day. The results of this study indicate that the risk of Cr heavy metal contamination at points 1–5 is 2.833333333. Meanwhile, the risk of Cu heavy metal contamination is 38.975 at points 1-5.

DISCUSSION

Based on the Regulation of the Minister of Health of the Republic of Indonesia, Number 32 of 2017, concerning environmental health quality standards and water health requirements for sanitary hygiene purposes, swimming pools, solus per aqua, and public baths, the permissible levels of nitrate in water for sanitary hygiene purposes or daily needs is 10 mg/L. 15 Meanwhile, according to Minister of Health Regulation Number 492/MENKES/PER/IV/2010 concerning drinking water quality requirements, the maximum limit for nitrate content is 50 mg/L. This watershed includes several districts, namely Garut, Majalengka, Sumedang, Indramayu, and finally Cirebon. According to research conducted on the Cimanuk River, Garut Regency is very risky. Based on the results of water quality tests that have been carried out, the water in the Cimanuk River is also categorized as bad. This happens because:

1. Carrying high levels of dissolved solids as an indication of soil erosion in the watershed

2. The content of COD and BOD exceeds the required quality standards.

3. The content of phosphate (PO4) and chloride (Cl) exceeds the required quality standards, possibly due to agricultural and plantation waste.

Almost the entire river flow is polluted with excessive levels of sulfate (SO4), sulfide (H2S), iron (Fe), manganese (Mn), and zinc (Zn).

CONCLUSIONS AND RECOMMENDATIONS

Based on the study's findings, it is possible to conclude that the average concentrations of the heavy metals Cr and Cu are lower than the quality standard of class 1 PP No. 82 of 2001. The risk of heavy metal Cr and Cu contamination is 1, which means that the Cimanuk watershed is at risk. Suggestions for the regional government of Indramayu Regency to always maintain good water quality from rivers in the Bogor Regency area Then, to avoid health problems in the Cimanuk watershed, it is critical to issue a warning about the dangers of heavy metal pollution and other factors that can affect river quality. In addition, the importance of waste management is important so that people do not throw garbage around the river. The community is also expected to be careful when using river water, which contains heavy metals such as Cr and Cu. It is necessary to carry out further research and monitor water quality on a regular basis to obtain the latest information about water conditions.

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