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Conditions of Chemical Parameters of the Anahoni River to Detect Water Quality

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Abstract: This study aims to analyze the water quality of the Anahoni river due to gold mining by covering chemical parameters (pH, DO, BOD, COD, heavy metal mercury (Hg), iron (Fe), copper (Cu), Cadmium (Cd), Arsenic (As)) and cyanide (CN).Metal mercury, iron, copper, cadmium, arsenic, and cyanide were tested at the Proling Bogor Agricultural Institute (IPB) laboratory. Meanwhile, DO, BOD parameters were analyzed at the Maluku Provincial Health Office Laboratory. pH and temperature parameters were carried out measured in situ. The pH value of the waters was obtained in the range of 7.1-10.5. The measured DO concentration has a value that varies in the range of 4.6-10.4 mg/L.The concentration of BOD has a value in the range of 0.5-10 .25 mg/L. COD concentrations have values in the range of 1.7-12.11 mg/L. Hg, Fe, Cu, As, and CN metals were detected in water and sediments.

Keywords: *River, Quality, Water*

I. INTRODUCTION

People's gold mining in Buru Regency is located in several locations, but the most active gold mining activities to date are at the Botak Mountain and Anahoni River locations, Kaiely Village, Kaiely Bay District. This gold mining activity can actually increase the economic level and welfare of the community, especially in rural areas. This economic improvement is mainly in terms of income, employment and opportunities for new activities outside the agricultural and fisheries sectors. But on the other hand, this activity can have a negative impact, namely damage and pollution to the environment, due to the use of various kinds of hazardous chemicals used to extract gold, especially mercury (Hg) and cyanide (CN) (Male et all, 2013).

Mercury or mercury denoted by Hg is a heavy metal which is classified as the most dangerous pollutant, because it is a neutrotoxin, both for organisms and humans (Mukhtosar, 2007).

Cyanide is a chemical compound that contains a CN cyano group, with a carbon atom bonded three to a nitrogen atom (C=N). Cyanide can have a negative impact on humans, including brain damage, disability, and even death (Cahyawati et al, 2015).

The current problem that occurs in gold mining in Buru district, especially on the Anahoni River is the change in the color of the river water which becomes blue. This condition needs to be a concern, because the changing color of river water not only reduces the quality of river water, but this indicates the presence of dangerous chemical compounds used by gold miners on a large scale, which can harm the environment and humans. For this reason, the quality of the waters of the Anahoni River which changes color needs to be investigated with the main indicators of mercury (Hg) and cyanide (CN), as well as other indicators including iron (Fe), copper (Cu), cadmium (Cd), arsenic (As), temperature, color, odor, pH, DO, BOD. So that the water quality is measured using chemical parameters consisting of: pH, Salinity, Nitrate, Ammonia, Phosphate, DO, BOD COD, Hg, iron (Fe), copper (Cu).

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1. pH

pH or degree of acidity is a picture of the amount or activity of hydrogen ions in waters. In general, the pH value describes the level of acidity or alkalinity of a water. Waters with a pH value = 7 are neutral, pH < 7 are said to be acidic, while pH > 7 are said to be alkaline (Effendi, 2003).

2. Nitrate

Nitrate (NO3-N) is the main form of nitrogen in natural waters. Nitrate is one of the most important nutrient compounds in animal and plant protein synthesis. High nitrate concentrations in waters can stimulate the growth and development of aquatic organisms if supported by the availability of nutrients (Effendi, 2003).

3. Phosphate

Phosphate is an important element in water. If the phosphate level is too high, it can cause the waters concerned to experience a eutrophic state resulting in a bloom of one type of phytoplankton that releases toxins (Mustofa, 2015). The high levels of phosphate in the waters are due to the entry of domestic waste (diter general, etc.), industry and agriculture. According to Efendi (2003), sources of phosphate come from natural and anthropogenic waters such as industry and domestic.

4. DO

Dissolved oxygen is the amount of oxygen contained in water and is measured in milligrams per liter. Dissolved oxygen is used as a sign of the degree of contamination of existing waste. The greater the dissolved oxygen, the smaller the degree of contamination.

5. BOD

Biological Oxygen Demands(BOD) or Biological Oxygen Need (KOB) is an empirical analysis that tries to globally approach microbiological processes that actually occur in water. The BOD number is the amount of oxygen needed by bacteria to decompose (oxidize) almost all dissolved organic matter and as suspended organic matter in water. BOD is used as an indicator of pollution in a waters. The BOD value of a high waters indicates that the waters are polluted (Agustira et al, 2013).

6. Hg

Mercury or mercury is translated from the Greek "Hydragyrum" which means liquid silver, symbolized by Hg (Liu et al., 2012). Mercury is an element with atomic number 80, atomic weight 200.5 g (Palar, 2008). The melting point is -34.87 0C, the boiling point is 358.58 0C and it is included in group II B in the periodic elements, has two valences, namely Hg+ is the same as mercury ions and Hg2+ is the same as mercury ions (Liu et al., 2012).

7. Iron (Fe)

Iron is a metal with atomic number 26, and has an atomic weight of 55. Iron (Fe) is one of the earth's elements found in various layers of the earth. Iron composes 5-5.6% of the earth's crust and 35% of the earth's mass. Iron (Fe) itself is an essential element needed by living things including humans, where iron (Fe) plays a role in the process of cellular respiration as well as an enzyme cofactor used in reduction and oxidation reactions for the production of energy found in all body cells (Widowati et al. ., 2008).

8. Copper (Cu)

Copper (Cu) is a group IB transition metal which has an atomic number of 29 and an atomic weight of 63.55 g/mol. Copper in metal form has a reddish color, but it is more often found in the form bound to other ions such as sulfate so that it has a different color from pure copper metal. Copper sulfate pentahydrate (CuSO4.5H2O) is a form of Cu compound that is often found (Saputri 2013).

9. Cadmium (Cd)

Cadmium metal (Cd) is a metal with atomic number 48 and atomic mass 112.41. This metal belongs to the transition metals in period V of the periodic table. Cd metal is known as a chalcophile element, so it tends to be found in sulfide deposits (Manahan, 2001). The abundance of Cd in the earth's crust is 0.13 µg/g. In the aquatic environment, Cd is relatively easy to move. Cd enters the aquatic environment mainly from atmospheric deposition and from factory effluents that use this metal in their working processes. In general, Cd is present in water in the form of hydrated ions, chloride salts, complexed with inorganic ligands or forming complexes with organic ligands (Weiner, 2008).

10. Arsenic (As)

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Arsenic (As) is one of the by-products of the processing of non-ferrous metal ores, especially gold, which has toxic properties with damaging environmental impacts (Nurhayati, 2009).

11. Cyanide (CN)

Cyanide is a chemical compound containing a CN cyano group, with a carbon atom bonded three to a nitrogen atom. Cyanide is known as a flammable poison (Slamet, 1994 in Polii and Soya, 2002). According to Sudarmadji et al in Polii and Soya (2002), cyanide has a molecular weight of 27.06, the value inhaled can cause fainting and even death. Cyanide is formed from the reaction between nitrogen (N) and carbon (C) at high temperatures.

II. METHOD

Research Area (Location).

This research was conducted at several points on the Anahoni River, namely in the upstream, middle and estuary areas. Besides that, sampling was also carried out on the Waelata River. There are 10 sampling stations in this study.

Data Types and Sources

This research includes field research andlaboratory research (Laboratory Research). field research (field research), namely: A research conducted systematically by collecting existing data in the field with qualitative methods. While laboratory research (Laboratory Research) is research carried out in a certain place (laboratory.

Sourcethe data from this study are primary data. Primary data is the type and source of research data obtained directly from the first source (not through intermediaries), both individuals and groups. So the data is obtained directly. The primary data in this study are the results of in situ parameter measurements (in the field) as well as the results of measurements (analysis) in the laboratory.

Method of collecting data

The research design stage is the initial stage that must be carried out when conducting research. This is because this stage includes determining research objectives and approaches. The important thing to do in this stage is to determine the sampling and research locations. The next step after the stage is mature, is to start gathering the elements used such as capital, computers, human resources, as well as other equipment needed.

The second stage after the research design is field research. This stage determines the success of the research because it is closely related to the real research objectives. At this stage all research resources, both facilities/tools and research personnel, are synergized to carry out research according to targets that have been previously designed, by synchronizing it with the research methods of each type of sample. At this stage, field parameter measurements were also carried out in situ.

The third stage, namely the data collection method stage is a follow-up from the results of field research, where all the data that has been taken is then collected and classified according to the planned object. The name and numbering of the sample data must be adjusted to the type of each sample.

The fourth stage is the laboratory analysis stage. At this stage all sample data that has been collected is then tested/analyzed in the laboratory. Recommended laboratories are laboratories that have been accredited nationally and internationally.

Data processing

Sample data resulting from laboratory analysis as well as the results of in situ (field) measurements were then processed to obtain conclusions about the quality of the waters in the Anahoni River, Buru Regency due to Unlicensed Gold Mining.

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Analysis Method

The samples that have been collected are then tested/analyzed in the laboratory. For heavy metals mercury (Hg), iron (Fe), copper (Cu), cadmium (Cd), arsenic (As) and cyanide (CN) tests were carried out at the Proling Laboratory of the Bogor Agricultural Institute (IPB). While the DO and BOD parameters were analyzed at the Maluku Provincial Health Office Laboratory. The pH parameter was measured in situ (in the field).

To determine the sediment status of the Anahoni River in several heavy metal samples, the laboratory test results will be compared with several sediment quality standards, namely: Hg (ANZECC/AMRCANZ, 2000), Fe (Winconsin Department of Natural Resources (2003), Cu (SEPA , 2000), Cd (IADC/CEDA, 1997) and As (Pollution Control Department (Thailand) (Mabuat et al, 2017).) The concentration of CN in sediments is not compared to quality standards, considering that sediment quality standards for CN have not been established.

III. RESULTS AND DISCUSSION

Water Chemical Parameters

The chemical parameters measured in this study were found in two types of samples, namely water and sediment samples. In the water sample the parameters measured are:pH, DO, BOD, COD, heavy metals mercury (Hg), iron (Fe), copper (Cu), cadmium (Cd), arsenic (As), cyanide (CN). While in the sediment samples the parameters measured were: heavy metals mercury (Hg), iron (Fe), copper (Cu), cadmium (Cd), arsenic (As), cyanide (CN).

1. pH

The results of measuring the pH of the waters are shown in Table 1 below:

Table 1. Water pH Measurement Results

Location Sampling	Station Observation	Sample Code	TDS (mg/L)	Quality standards	
Upper Anahoni River (mining site)	St. 1	AIAD	7,1	6 – 9*	6 – 9**
	St. 2	AIIBD	10.5		
Middle of the Anahoni River (mining site)	St. 3	AIIICD	8,9		
	St. 4	AIVDD	8,6		
The mouth of the Anahoni River	St. 5	AVED	9,6		
	St. 6	AVFD	9,6		
	St. 7	AVIIGD	9,4		
	St. 8	AVIIIHD	9,5		
Waelata River	St. 9	WIAD	9,4		
	St. 10	WIIBD	9		

Information: * = Class III water quality standards based on PP R1 No. 22 of 2021 tconcerning the Implementation of Environmental Protection and Management.
** = Ministry of Environment Decree No. 202 of 2004 concerning Wastewater Quality Standards for Gold and or Copper Ore Mining Businesses and or Activities.

The pH value of the waters measured at the research station based on Table 4.4 ranges from 7.1 to 10.5. This value indicates that the measured pH has passed and has not passed the quality standards based on Class III water

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quality standards according to PP R1 No. 22 of 2021 concerning Implementation of Protection and quality standards based on Minister of Environment Decree No. 202 of 2004 concerning Wastewater Quality Standards for Gold and or Copper Ore Mining Businesses and or Activities.

Based onTable 1. The pH of the waters at all research stations is not much different. This condition is caused because all research stations are connected to the people's gold mining in Anahoni, so this indicates that there are contaminants from these activities that have entered the waters. Waters that have a low pH value are usually due to the high acid content in these waters, otherwise a waters can have a high pH value due to the high lime content in these waters (Maniagasi et al, 2013).

2. Nitrate

The results of measurements of water nitrate are shown in Table 2 below:

Table 2. Results of Water Nitrate Measurements

Location Sampling	Station Observation	Sample Code	Nitrate (mg/l)	Quality standards
Upper Anahoni River (mining site)	St. 1	AIAD	0.26	20 mg/L *
	St. 2	AIIBD	0.19	
Middle of the Anahoni River (mining site)	St. 3	AIIICD	0.21	
	St. 4	AIVDD	0.04	
The mouth of the Anahoni River	St. 5	AVED	0.02	
	St. 6	AVFD	0.01	
	St. 7	AVIIGD	0.01	
	St. 8	AVIIIHD	0.01	
Waelata River	St. 9	WIAD	0.01	
	St. 10	WIIBD	0.02	

Information: * = Class III water quality standard based on Government Regulation No. 82 of 2001 concerning Water Quality Management and Water Pollution Control

Based on Table 2, the highest nitrate content is dominated in the upper reaches of the Anahoni River and the lowest is dominated in the estuary area. This condition is due to the fact that the upstream area receives organic waste input from the mainland through the activities of artisanal gold miners. Rahman, et al (2016) explained that low nitrate concentrations in waters are due to a denitrification process where nitrate through nitrite will produce free nitrogen which eventually returns to ammonia. The main sources of nitrogen in water are domestic sewage, industrial wastewater, animal waste (livestock, birds, mammals and fish), agriculture and vehicle emissions. The low concentration of nitrate in the Anahoni River indicates that the river is receiving less pollution loads containing nitrogen.

3. Phosphate

The results of measurements of water nitrate are shown in Table 3 below:

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Table 3. Results of Water Phosphate Measurements

Location Sampling	Station Observation	Sample Code	Phosphate (mg/l)	Quality standards
Upper Anahoni River (mining site)	St. 1	AIAD	2.96	1 mg/L *
	St. 2	AIIBD	3,8	
Middle of the Anahoni River (mining site)	St. 3	AIIICD	0.0	
	St. 4	AIVDD	0.22	
The mouth of the Anahoni River	St. 5	AVED	2.67	
	St. 6	AVFD	0.48	
	St. 7	AVIIGD	0.35	
	St. 8	AVIIHD	0.91	
Waelata River	St. 9	WIAD	0.28	
	St. 10	WIIBD	0.32	

Information: * = Class III water quality standards based on PP R1 No. 22 of 2021 tconcerning the Implementation of Environmental Protection and Management.

Based on Table 3, the highest phosphate content is dominated by the Anahoni River. This shows that the river receives more pollution loads compared to the Waelata River. Phosphate contributors to the waters of the Anahoni River are the community's domestic waste. According to the WHO & European Commission (2002) in Patty et al (2015), phosphorus enrichment mainly comes from household and industrial waste, including phosphorus-based detergents.

4. DO

The results of the water DO measurements are shown in Table 4 below:

Table 4. Water DO Measurement Results

Location Sampling	Station Observation	Sample Code	DO (mg/l)	Quality standards
Upper Anahoni River (mining site)	St. 1	AIAD	4,6	> 3 mg/L *
	St. 2	AIIBD	5,9	
Middle of the Anahoni River (mining site)	St. 3	AIIICD	6,7	
	St. 4	AIVDD	5,6	
The mouth of the Anahoni River	St. 5	AVED	10.5	
	St. 6	AVFD	7,1	
	St. 7	AVIIGD	8,6	
	St. 8	AVIIIHD	6,8	
Waelata River	St. 9	WIAD	8,4	
	St. 10	WIIBD	6.0	

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Information: * = Class III water quality standards based on PP R1 No. 22 of 2021 tconcerning the Implementation of Environmental Protection and Management.

Table 4 shows that the lowest DO content is at station 1, station 2, station 3 and station 4, of which these four stations are located in the upper and middle reaches of the Anahoni River which have high meas mining activities, where these activities can provide input of organic matter so it takes a lot of oxygen content to decompose the organic matter.

5. BOD

The results of waters BOD measurements are shown in Table 4 below:

Table 5. Results of Water BOD Measurements

Location Sampling	Station Observation	Sample Code	BOD (mg/L)	Quality standards
Upper Anahoni River (mining site)	St. 1	AIAD	9.75	6 mg/L *
	St. 2	AIIBD	3,6	
Middle of the Anahoni River (mining site)	St. 3	AIIICD	1.75	
	St. 4	AIVDD	10.25	
The mouth of the Anahoni River	St. 5	AVED	1,2	
	St. 6	AVFD	1.5	
	St. 7	AVIIGD	1.75	
	St. 8	AVIIIHD	2,5	
Waelata River	St. 9	WIAD	0.5	
	St. 10	WIIBD	8,5	

Information: * = Class III water quality standards based on PP R1 No. 22 of 2021 tconcerning the Implementation of Environmental Protection and Management.

Table 5 shows that the measured BOD concentrations have varying values at each study station with a range between 0.5 – 10.25 mg/L. This BOD value when compared with the BOD quality standard based on PP R1 No. 22 of 2021 concerning the Implementation of Environmental Protection and Management for class III water, where the BOD threshold value is 6 mg/L, it can be concluded that some BOD content has not passed the quality standard and has not passed the quality standard (St. 1, St 4th and St 9th).

6. COD

The results of water COD measurements are shown in Table 6 below:

Table 6. Results of Water COD Measurements

Location Sampling	Station Observation	Sample Code	COD (mg/ L)	Quali ty stand ards
Upper Anahoni	St. 1	AIAD	11.33	
	St. 2	AIIBD	5,4	

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River (mining site)				40 mg/L *
Middle of the Anahoni River (mining site)	St. 3	AIIICD	3,2	
	St. 4	AIVDD	12,11	
The mouth of the Anahoni River	St. 5	AVED	2,4	
	St. 6	AVFD	3,2	
	St. 7	AVIIG D	2.61	
	St. 8	AVIIIH D	4,9	
Waelata River	St. 9	WIAD	1,7	
	St. 10	WIIBD	11,7	

Information: * = Class III water quality standards based on PP R1 No. 22 of 2021 tconcerning the Implementation of Environmental Protection and Management.

The results of the COD analysis in the waters listed in Table 6 show that the measured COD concentrations had varying values at each study station with a range between 1.7 – 12.11 mg/L. This COD value when compared with the COD quality standard based on PP R1 No. 22 of 2021 concerning the Implementation of Environmental Protection and Management for class III water, where the COD threshold value is 40 mg/L, it can be concluded that the COD content in all research stations has not passed the quality standard.

7. Mercury (Hg)

The results of Hg measurements in water and sediment are shown in Table 7 below:

Table 7. Measurement Results of Heavy Metal Hg (Mercury) in Water and Sediments

Location Sampling	Station Observation	Sample Code	Hg concentration	
			Water (mg/L)	Sediment (mg/kg)
Upper Anahoni River (mining site)	St. 1	AIAL	0.0018	0.060
	St. 2	AIIBL	0.0007	0.064
Middle of the Anahoni River (mining site)	St. 3	AIIICL	0.0023	0.058
	St. 4	AIVDL	0.0069	0.209
The mouth of the Anahoni River	St. 5	AVEL	0.0008	0.091
	St. 6	AVIFL	0.0005	0.055
	St. 7	AVIIGL	0.0003	0.058
	St. 8	AVIIIHL	0.0003	0.053
Waelata River estuary	St. 9	WIAL	0.0005	0.055
	St. 10	WIIBL	0.0008	0.076
Quality standards			0.002*	1.0*

Information: * = Class III water quality standards based on PP R1 No. 22 of 2021 tconcerning the Implementation of Environmental Protection and Management.
** = Quality standard basedANZECC/AMRCANZ (2000).

Table 7 shows that Hg metal was detected in water and sediment at all research stations. In water, Hg has a concentration between 0.0003 - 0.0069 mg/L. This concentration when compared with quality standards based on Class III water based on PP R1 No. 22 of 2021 concerning the Implementation of Environmental Protection and Management, where the maximum limit for Hg in water is 0.002 mg/L, there are several research stations that have passed the quality standard, namely station 3 (0.0023 mg/L) and station 4 (0 .0069 mg/L). The results of this study are in line with the results of research conducted in collaboration with the Buru district government and Iqra Buru University in 2021, where the concentration of Hg in water in the Anahoni and Waelata rivers is 0.0009 - 0.0017 mg/L.

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In sediments, Hg has a concentration between 0.055 - 0.209 mg/kg. This concentration when compared with quality standards based onANZECC/AMRCANZ (2000), where the maximum limit of Hg in sediments is 1.0 mg/kg, the concentration of Hg in sediments at all research stations has not passed the quality standard. In addition, when compared to the concentration of Hg in water and sediment, it can be seen that sediment has a higher concentration of Hg than water at all research stations. The low concentration of Hg in water is due to the fact that Hg in waters precipitates in sediments.

If seen based on Table 7 the concentration of mercury in water and sediment at all research stations is not much different. This condition is caused because all research stations are connected to the people's gold mining in Anahoni, so that mercury is spread over all research stations. In addition, Hg contamination at the Anahoni and Waelata river locations indicates that processing of gold material does not only occur directly at mining locations, but processing using Hg can occur in various areas, especially in areas close to mining areas.

8. Iron (Fe)

The results of Fe measurements in water and sediment are shown in Table 8 below:

Table 8. Measurement Results of Heavy Metal Iron (Fe) in Water and Sediments

Location Sampling	Station Observation	Sample Code	Fe concentration	
			Water (mg/L)	Sediment (mg/kg)
Upper Anahoni River (mining site)	St. 1	AIAL	0.300	10.30
	St. 2	AIIBL	6,341	66.05
Middle of the Anahoni River (mining site)	St. 3	AIIICL	6,295	60,74
	St. 4	AIVDL	4,345	32.58
The mouth of the Anahoni River	St. 5	AVEL	1,200	42.71
	St. 6	AVIFL	0.917	6,14
	St. 7	AVIIGL	0.801	52,69
	St. 8	AVIIIHL	0.713	26,14
Waelata River estuary	St. 9	WIAL	0.922	30,40
	St. 10	WIIBL	5,645	41,62
Quality standards			0.3*	20**

Information: * = Class I water quality standards based on PP R1 No. 22 of 2021 tconcerning the Implementation of Environmental Protection and Management.
** = *Winconsin Department of Natural Resources*(2003).

Table 8 shows that Fe metal was detected in water and sediment at all research stations. In water, Fe has a concentration between 0.300 - 6.341 mg/L. This concentration when compared with the Class I water quality standards based on PP R1 No. 22 of 2021 concerning the Implementation of Environmental Protection and Management, where the maximum limit of Fe in water is 0.3 mg/L, only at station 1 where the concentration of Fe (0.3 mg/L) has not passed the quality standard, while at the research station others have passed the quality standard.

In sediments, Fe metal has concentrations between 6.14 - 66.05 mg/kg. This concentration when compared with the quality standard based on Winconsin Department of Natural Resources (2003) in Muraya et al (2018), where the maximum limit of Fe in sediment is 20 mg/kg, only at station 1 the concentration of Fe (10.30 mg/kg) and station 2 (6.14 mg/kg) have not passed the quality standard, while the other research stations have passed the quality standard.

When compared to the concentration of Fe in water and sediment, it can be seen that sediment has a much higher concentration of Fe than water at all research stations. This finding is in line with research by Muraya et al (2018) who analyzedThe content of heavy metal iron (Fe) in water in Trimulyo Waters, Semarang, where the content of heavy metal Fe in sediments shows a higher level of content compared to the content of heavy metals in the water column. If seen from Table 8, Fe is spread over all research stations with high concentrations. This shows that not only the Anahoni River, but the Waelata River also receives metal pollution.

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9. Copper (Cu)

The results of Cu heavy metal measurements in water and sediment are shown in Table 9 below:

Table 9 Measurement Results of Heavy Metal Copper (Cu) in Water and Sediments

Location Sampling	Station Observation	Sample Code	Cu concentration	
			Water (mg/L)	Sediment (mg/kg)
Upper Anahoni River (mining site)	St. 1	AIAL	0.015	8,73
	St. 2	AIIBL	0.023	3.96
Middle of the Anahoni River (mining site)	St. 3	AIIICL	0.019	3,44
	St. 4	AIVDL	0.016	4.78
The mouth of the Anahoni River	St. 5	AVEL	0.019	10.30
	St. 6	AVIFL	0.017	12.88
	St. 7	AVIIGL	0.019	6,32
	St. 8	AVIIIHL	0.025	6,74
Waelata River estuary	St. 9	WIAL	0.031	12.68
	St. 10	WIIBL	0.014	8.30
Quality standards			0.02*	15**

Description of Quality Standards:

* = Class III water quality standards based on PP R1 No. 22 of 2021 tconcerning the Implementation of Environmental Protection and Management.

** = SEPA, 2000.

Table 9 shows that Cu metal was detected in water and sediment at all research stations. In water, Cu has a concentration between 0.014 - 0.031 mg/L. This concentration when compared with the Class III water quality standards based on PP R1 No. 22 of 2021 concerning the Implementation of Environmental Protection and Management, where the maximum limit for Cu in water is 0.02 mg/L, only at station 2 (0.023 mg/L), station 8 (0.025 mg/L) and station 9 (0.031 mg/L) which has a Cu concentration that has passed the quality standard, while the other research stations have not passed the quality standard.

In sediments, Cu metal has concentrations between 3.44 - 12.88 mg/kg. This concentration is compared with the quality standard based on SEPA (2000), where the maximum limit of Cu in sediment is 15 mg/kg, so the concentration of Cu in sediments at all research stations has not passed the quality standard.

When compared to Cu concentrations in water and sediment, it can be seen that sediment has a much higher concentration of Cu than water in all study stations. HThis is due to the nature of heavy metals in the water column which precipitate for a certain period of time, and then accumulate in the bottom of the sedimentary waters.

Based on Table 9 it can also be seen that Cu concentrations were spread out at all research stations with low concentrations. This shows that the river in the Anahoni mining area, although not yet polluted with Cu metal, has been detected in the waters.

10. Cadmium (Cd)

The results of measurements of the heavy metal Cadmium (Cd) in water and sediment are shown in Table 10 below:

Table 10. Measurement Results of Heavy Metal Cadmium (Cd) in Water and Sediments

Location Sampling	Station Observation	Sample Code	Cd concentration	
			Water (mg/L)	sediment (mg/kg)
Upper Anahoni River (mining site)	St. 1	AIAL	<0.002	1.24

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	St. 2	AIIBL	<0.002	1.54
Middle of the Anahoni River (mining site)	St. 3	AIIICL	0.002	<0.40
	St. 4	AIVDL	0.002	0.96
The mouth of the Anahoni River	St. 5	AVEL	<0.002	1.06
	St. 6	AVIFL	<0.002	0.81
	St. 7	AVIIGL	<0.002	0.83
	St. 8	AVIIIHL	<0.002	1.05
Waelata River estuary	St. 9	WIAL	<0.002	1.51
	St. 10	WIIBL	<0.002	1.63
Quality standards			0.01*	0.8** = target level 2** = level limit 7.5** = test level 12** = intervention level 30** = danger level

Description of Quality Standards:

* = Class III water quality standards based on PP R1 No. 22 of 2021 tconcerning the Implementation of Environmental Protection and Management.

** = IADC/CEDA (1997).

Table 10 shows that Cd metal in water was only detected at station 3 (0.002 mg/L) and station 3 (0.002 mg/L). This concentration when compared with the Class III water quality standards based on PP R1 No. 22 of 2021 concerning the Implementation of Environmental Protection and Management, where the maximum limit for Cd in water is 0.01 mg/L, the Cd concentration at all research stations is still below the quality standard.

In sediments, only station 3 (<0.40 mg/kg) was not detected (Below detection limit). Sediment concentrations at other stations when compared with sediment quality standards based on IADC/CEDA (1997), are at the limit level, namely Cd concentrations between 0.8 – 2 mg/kg. This value is a limit that can still be tolerated for human health and aquatic ecosystems. Based on this, it can be categorized that the quality of the sediment in the waters of the Anahoni River, although not polluted, is already contaminated by the heavy metal Cd.

If we compare the concentration of Cd in water and sediment, it can be seen that the sediment has a much higher concentration of Cd compared to water in all study stations. HThis is due to the nature of heavy metals in the water column which precipitate for a certain period of time, and then accumulate in the bottom of the sedimentary waters.

Table 10 shows that the concentration of Cd in water and sediment at all research stations has almost the same concentration value. Although there are many stations where Cd is not detected in water, the high concentration in sediments indicates that this metal can move in the water column and increase its concentration in water.

11. Arsenic (As)

The results of measurements of the heavy metal Arsenic (As) in water and sediment are shown in Table 11 below:

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Table 11. Measurement Results of Heavy Metal Arsenic (As) in Water and Sediments

Location Sampling	Station Observation	Sample Code	As concentration	
			Water (mg/L)	Sediment (mg/kg)
Upper Anahoni River (mining site)	St. 1	AIAL	0.0028	0.070
	St. 2	AIIBL	0.0034	0.099
Middle of the Anahoni River (mining site)	St. 3	AIIICL	0.0026	0.060
	St. 4	AIVDL	0.0025	0.077
The mouth of the Anahoni River	St. 5	AVEL	0.0030	0.094
	St. 6	AVIFL	0.0030	0.090
	St. 7	AVIIGL	0.0024	0.095
	St. 8	AVIIIHL	0.0016	0.095
Waelata River estuary	St. 9	WIAL	0.0027	0.081
	St. 10	WIIBL	0.0034	0.105
Quality standards			0.05*	3.9**

Information: * = Class III water quality standards based on PP R1 No. 22 of 2021 tconcerning the Implementation of Environmental Protection and Management.
** = Pollution Control Department (Thailand) (Mabuat et al, 2017).

Table 11 shows that as was detected in water at all research stations, but this concentration had not passed the as quality standard in Class III water based on PP R1 No. 22 of 2021 concerning the Implementation of Environmental Protection and Management, where the maximum limit of As in water is 0.05 mg/L. This also happened in sediments, where metal as was detected in all research stations, but this concentration had not passed the quality standard for as in sediments based on the Pollution Control Department (Thailand) of 3.9 mg/kg (Mabuat et al, 2017). Based on this, it can be categorized that the quality of water and sediment in the waters of the Anahoni River has not been polluted by arsenic, but these waters have been contaminated by the heavy metal arsenic.

When compared to the concentration of as in water and sediment, it can be seen that sediment has a much higher concentration of as compared to water in all study stations. HThis is due to the nature of heavy metals in the water column which precipitate for a certain period of time, and then accumulate in the bottom of the sedimentary waters.

Based on Table 11, it can be seen that as concentrations are spread over all research stations, both in water and sediment with low concentrations. This shows that the river in the Anahoni mining area, although not yet polluted with metal As, has been detected in the waters.

12. Cyanide (CN)

The results of measurements of the heavy metal Arsenic (As) in water and sediment are shown in Table 12 below:

Table 12. Results of Cynide (CN) Measurements in Water and Sediments

Location Sampling	Station Observation	Sample Code	Cyanide Concentration	
			Water (mg/L)	Sediment (mg/kg)
Upper Anahoni River (mining site)	St. 1	AIAL	0.18	0.081
	St. 2	AIIBL	0.032	0.126
Middle of the Anahoni River (mining site)	St. 3	AIIICL	0.092	0.326
	St. 4	AIVDL	0.024	0.099

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The mouth of the Anahoni River	St. 5	AVEL	0.056	0.206
	St. 6	AVIFL	0.081	0.287
	St. 7	AVIIGL	0.092	0.322
	St. 8	AVIIIHL	0.051	0.188
Waelata River estuary	St. 9	WIAL	<0.001	0.009
	St. 10	WIIBL	<0.001	0.012
Quality standards			0.002*	-

Information: * = Class III water quality standards based on PP R1 No. 22 of 2021 tconcerning the Implementation of Environmental Protection and Management.
- = There are no quality standards.

The results of Cyanide (CN) analysis at each research station are shown in Table 12 showing that, cyanide was not detected only at station 9 and station 10 (<0.001 mg/L), while at other stations cyanide was detected in water and its concentration was above the quality standard cyanide in Class III water based on PP R1 No. 22 of 2021 concerning the Implementation of Environmental Protection and Management, namely 0.002 mg/L. The highest concentration of cyanide is found at station 1 which is the closest station to the gold mine in the Anahoni area. In this area, cyanide is also detected with high concentration. Meanwhile, stations 9 and 10, which were not detected by cyandia, were not centers for smallholder gold mining in the Anahoni area.

In sediments, cyanide was detected at all research stations with values ranging from 0.012 - 0.326 mg/kg. The concentration of cyanide in sediments is also higher than its concentration in water. This value differs from water, in which there are stations where cyanide is not detected. No cyanide was detected in the water, but it was detected in the sediment indicating that a lot of cyanide had accumulated in the sediment at the station.

Based on Table 12 it can also be seen that CN concentrations were spread over all research stations with high concentrations (except station 9 and station 10) and reached dangerous levels in the waters. This shows that it is not only the rivers in the Anahoni mining area that have been polluted with CN, but the nearby river (Waelata River) also receives the CN pollution load. CN contamination in these two river locations indicates that processing of gold material does not only occur at the mining location directly, but processing using CN can occur in various areas, especially in areas close to mining areas.

The Average Value of Chemical Parameter Measurements in Water

Water chemical parameters measured in water and sediment samples. On water, consisting ofpH, DO, BOD, COD, heavy metals mercury (Hg), iron (Fe), copper (Cu), cadmium (Cd), arsenic (As), cyanide (CN). The average value of chemical parameter measurements is shown in Table 13.

Table 13. Average Value of Chemical Parameter Measurements in Water

Sample Type	**Chemical Observation Parameters**					
	pH	**Nitrate (mg/L)**	**Phosphate (mg/L)**	**DO (mg/L)**	**BOD (mg/L)**	**COD (mg/L)**
River water	**9,16 *ab**	0.078	**1.99 *a**	7.02	4,13	5,855
Quality standards	6 – 9	20mg/L	1mg/L	>3mg/L	6 mg/l	40mg/L

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Sample Type	Chemical Observation Parameters					
	Hg (mg/L)	**Fe (mg/L)**	**Cu (mg/L)**	**CD (mg/L)**	**US (mg/L)**	**cn (mg/L)**
River water	0.00146	**2.2479*a**	0.0198	<0.002	0.00244	**0.0608*a**
Quality standards	0.002	0.3	0.02	0.01	0.05	0.002

Information:

* = Not according to Quality Standards.
a = Class III water quality standards based on PP R1 No. 22 of 2021 concerning Implementation of Environmental Protection and Management.
b = Ministry of Environment Decree No. 202 of 2004 concerning Wastewater Quality Standards for Gold and or Copper Ore Mining Businesses and or Activities.

Table 13 shows that the average values of pH, phosphate, DO, iron (Fe) and cyanide (CN) in the waters of the Anahoni River have values that have passed Class III water quality standards based on PP R1 No. 22 of 2021 tconcerning the Implementation of Environmental Protection and Management. This shows that the chemical parameters of the water have a quality that is not in accordance with its designation

The average pH value of 9.16 which is classified as alkaline can affect the chemical compounds that are in the water body. The higher the pH parameter value, the higher the alkalinity value, whereas if the pH parameter value is lower then the water is corrosive acid (Effendi, 2003). High pH will cause heavy metals to precipitate (Novotny and Olem, 1994).

The high average value of phosphate (1.199 mg/L) indicates that the waters of the Anahoni River have been polluted with phosphate. Ketchum in Paty et al (2015) defines a phosphate value of 2.8 ug.at/l or equivalent to 0.087 mg/l as the upper limit for water that is not polluted. This can be due to the high diffusion of phosphate from the sediment. Phosphorus compounds bound in sediments can undergo decomposition with the help of bacteria or through abiotic processes to produce dissolved phosphate compounds which can undergo diffusion back into the water column (Paytan and McLaughlin, 2007).

The average value of Fe which exceeds the quality standard indicates that the waters in the Anahoni River have been polluted with these heavy metals. Sources of iron metal (Fe) in waters can come from several sources, namely apart from soil it also comes from human activities that occur on land, namely the discharge of iron-containing household waste, iron water reservoirs, industrial waste deposits and corrosion. from water pipes containing iron metal carried by the river flow. According to Maulidah et al (2015), mining activities can result in land erosion so that the mineral content is also eroded and dissolved in the water. Because of this erosion, the dissolved iron content does not comply with the water quality standards.

The average value of cyanide in water that passes the quality standard indicates that the waters of the Anahoni River have been polluted with cyanide. This pollution is of course related to the gold mining activities of the people who use cyanide as an ingredient to process gold materials. The high concentration indicates that this chemical compound is widely used in gold mining activities. It is also a strong suspicion that the blue water phenomenon that occurred on the Anahoni River in August 2022 is the effect of the high concentration of cyanide used in gold mining. The cyanide reacts with elemental iron. The reaction between cyanide and iron ions, known as pyrite, forms a blue compound. This is in line with the findings of iron (Fe) concentrations detected in the waters of all research stations. Where the concentration of Fe itself is very high and exceeds the quality standard, except at station 1. Cyanide itself can have bad effects on humans, including brain damage, disability, to death (Cahyawati et al, 2015). The level of toxicity of cyanide in water depends on the concentration of cyanide. Gintings in Polii and Sonya (2022), hazardous and toxic materials in certain concentrations if ingested by humans can endanger health and even threaten life.

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For aquatic sediments, the chemical parameters measured were heavy metals mercury (Hg), iron (Fe), copper (Cu), cadmium (Cd), arsenic (As) and cyanide (CN). The average value of these parameter measurements is presented in Table 14.

Table 14. Average value of chemical parameter measurements in sediments

Sample Type	Chemical Observation Parameters					
	Hg (mg/kg)	**Fe (mg/kg)**	**Cu (mg/kg)**	**CD (mg/kg)**	**US (mg/kg)**	**cn (mg/kg)**
River water	0.0779	**36,937 *c**	7,813	1.103	0.0866	0.1656
Quality standards	1.0a	20b	15c	0.8 – 30d	3,9e	-

Quality standard description:

* = Not according to Quality Standards.
[a] = ANZECC/AMRCANZ (2000).
[b] = *Winconsin Department of Natural Resources*(2003).
[c] = SEPA, 2000.
[d] = IADC/CEDA (1997).
[e] = Pollution Control Department (Thailand) (Mabuat et al, 2017).
- =There are no quality standards.

Table 14 shows that, in sediment samples, iron (Fe) has an average concentration value that has passed the quality standard based on SEPA (2000) of 20 mg/kg. this value is in line with the concentration of the metal in water. This shows that the sediment in the Anahoni River has been polluted with ferrous metals. The high concentration of this metal can be caused by people's gold mining activities in the Anahoni area which results in erosion.

For Cd metal, the average concentration values indicate that the metal is still within tolerable limits for human health and aquatic ecosystems. Meanwhile, the parameters for the heavy metals mercury (Hg), copper (Cu) and arsenic (As) although the average concentration values have not passed the quality standard, these concentrations can increase at any time and can exceed the quality standards, especially since the metal concentration values are not much different from quality standards, except for arsenic (As). There may be an increase in the concentration of heavy metals in waterIf the use of these metals increases in private gold mining, both in the processing of gold materials and through community waste activities in the mining area, especially in the Anahoni River Basin area. This increase can make the metal reach dangerous levels, so it needs to be watched out for.

There are no quality standards for cyanide in sediments that can be used as a reference in determining its level or status. Even so, the concentration of cyanide is very high and very dangerous for aquatic ecosystems.

To determine the differences in concentrations of aquatic chemical parameters in water and sediment, especially heavy metal parametersmercury (Hg), iron (Fe), copper (Cu), cadmium (Cd), arsenic (As) and cyanide (CN).

IV. CONCLUSION

Based on the results of the study it can be concluded that: the condition of the quality of the waters of the Anahoni River due to Unlicensed Gold Mining in the Regency based on the parameters most of them still meet the set quality standards, so that they can still be allocated according to their functions. Even so, there are several parameters that are not in accordance with the quality standards which include pH, Phosphate, iron (Fe) (in water and sediment) and cyanide (CN).

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