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Abstract. This study aims to determine the contamination of ferrous metal (Fe) contained in river water that empties into Lake Matano, Sorowako, South Sulawesi and is associated with remote sensing analysis. From the geochemical review of the heavy metal content of Fe that has been carried out. River water samples were taken at 10 points in three locations on the river and one location in the resident's bore well. Sampling was carried out in the upstream, middle and downstream sections and one at the resident's well as a comparison. Heavy metal concentrations were determined using Atomic Absorption Spectroscopy (AAS). The concentration of heavy metal Fe in the Salonsa River was 1,02 ppm, in the Lawewu River was 0,78 ppm while in the Incoiro River was 0,68 ppm. The concentration of Fe in the bore well in residential areas is 0,88 ppm. This value is still above the water quality standard. Meanwhile, based on the results of remote sensing analysis, the total land opening value is 44,74 km^2. The Salonsa River which has a distribution area of interpretation of the heavy metal element Fe is 783.14 Ha, then for Lawewu River has an interpretation of an area of 1,408.32 Ha and for the Incoiro River, it has an interpretation of an area of 2282.33 Ha. From the results obtained, it can be concluded that the water quality in the three rivers has been polluted by heavy metal Fe

Keywords: *Fe Metal, River Water, Remote Sensing, Sorowako*

INTRODUCTION

Industrial wastewater and many other human activities produce toxic residues and substances, especially heavy metals, which are eventually discharged into rivers and estuaries. Thus, these metals are present in various components of aquatic systems, namely water bodies, suspended matter, bottom sediments, and biota. In rivers and other watercourses, heavy metals occur mostly under two phases: either adsorbed on suspended solids (particulate phase) or dissolved in water bodies (dissolved phase), in continuous exchange during the transport process. Then, to understand and predict the movement and ultimate deposition of heavy metals in shallow water [1]. The presence of heavy metals in waters can be sourced from mining, household activities, agricultural waste and industrial waste. Some heavy metals are toxic, such as As, Co, Se, Cd, Cr, Cu, Fe, Zn and Hg and accumulate in water and aquatic sediments. This condition has an impact on the lives of people who use river water for drinking water, bathing, washing clothes, irrigation for agriculture and fisheries. Especially in the dry season where river water discharge decreases, there is a concentration of pollutant concentrations in the water. The presence of heavy metals in the waters, directly or indirectly endanger the life of organisms and human health. This is related to the properties of heavy metals that are difficult to degrade so that they are easy to accumulate in the aquatic environment and their natural presence is difficult to decompose. Accumulates in organisms including shellfish and fish, thus endangering the health of consumers. Accumulated in sediments, so the concentration is always higher than the concentration of metals in water. [10]. On the other hand, mining of sand and gravel in river basins causes serious damage to watersheds and is a major challenge, especially in developing countries. Mining activities in rivers can damage public property and private assets and aquatic habitats, threaten slope stability and riverbank deformation to negatively impact rivers and their surroundings [9].

Remote sensing is defined as the art of obtaining information about an object, area, or phenomenon through the analysis of data obtained with a device that is not in contact with the object, area, or phenomenon under investigation. Remote sensing is based on the analysis of the interaction between the electromagnetic radiation flux and the object or phenomenon under investigation. Remote sensors are carried to aerial or satellite platforms offering fast and synoptic monitoring capabilities over a wide area. Remote sensors can be used to frequently revisit study areas that provide data to monitor phenomena or processes. In particular, remote sensing is useful for surveying natural resources and monitoring the environment (e.g., urban growth, rainforest deforestation, flood mapping, etc.), especially when rapid and repeated observations are required. The process of obtaining soil information by remote sensing is very complex and requires great knowledge of the interaction between radiation and soil. In this sense, the researcher concludes the three-dimensional nature of the soil by the convergence of two possible forms of evidence 1) direct evidence of soil properties through its spectral characteristics and distribution patterns, and 2) indirect evidence derived from observations of geomorphology, vegetation type and physiological status, and land cover. caused by humans [6].

Under reduced conditions, iron can cause poisoning in rice plants. Iron poisoning in paddy fields causes low production or even plants that do not produce. Rice plants will experience iron poisoning if the iron content in the plant exceeds 300 ppm. The mechanism of iron poisoning in rice fields is the inhibition of nutrient uptake caused by not developing roots because the roots are covered by iron oxide. Iron poisoning in paddy fields can reduce rice yields by 52-75%. To determine the level of iron contained in paddy soil requires a fairly long analytical procedure. To facilitate the analysis process of identifying iron oxide levels in paddy soil, remote sensing methods can be used, namely using data from satellite images, one of which is Landsat 8 OLI/TIRS (Operational Land Imager & Thermal Infrared Sensor) satellite data. One of the uses provided by Landsat 8 is analysis for geological purposes (minerals, mining, oil and gas) so that it can be used for the identification of Fe elements. [8]. This study aims to determine the contamination of ferrous metal (Fe) contained in river water that empties around Lake Matano, Sorowako, South Sulawesi and is associated with remote sensing analysis.

GEOLOGY OF RESEARCH AREA

The geology of the Sorowako area consists of Cretaceous Sedimentary Rock Units consisting of deep-sea limestone and chert. In the western part of the Sorowako area, it is bounded by an ascending fault with a slope to the west. Ultramafic rock units of early Tertiary age, generally consist of peridotite types, some of which are serpentinized to varying degrees and are generally found in the eastern part. In the study area, there is a large fault that causes topographic relief up to 600 meters above sea level and is still actively eroding. This is what causes the lateralization process [1]

The eastern part of Sulawesi is composed of three subduction melange zones that were uplifted in the pre-and post-Miocene. The oldest Mélange is composed of schist oriented towards the southeast with several ultramafic rock bodies that are narrowly distributed with old geomorphic studies. Meanwhile, the post-Miocene age has undergone extensive weathering so that it is sufficient to form laterite deposits [1]

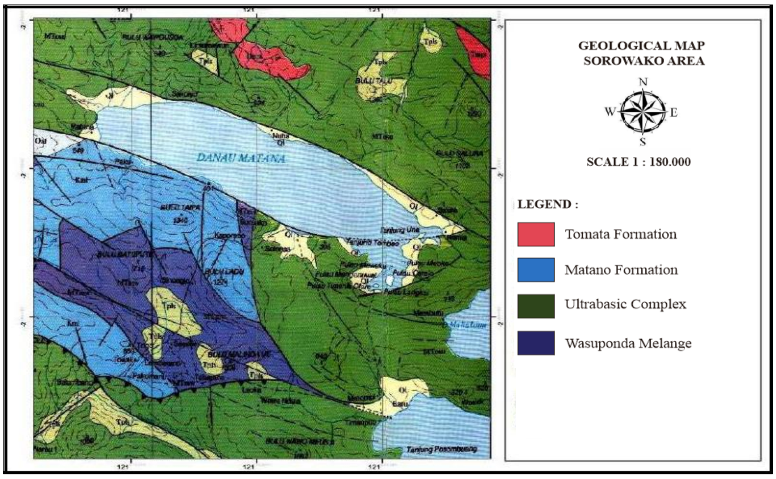

Figure 1. Geological Map of Sorowako Region [1]

MATERIALS AND METHOD

The research location was carried out in the area around Lake Matano and water sampling was carried out on three rivers, namely the Salonsa River, Lawewu River and Incoiro River which was carried out in November 2020. Water quality research was carried out at three measurement points, namely in the upstream, middle and downstream areas of the river and one point in the borehole of the residential area (Figure 2) Determination of the monitoring point as a sampling point for river water using a purposive sampling method based on the convenience of the location points in the river [5]. The following are 10 points for measuring water samples (Table 2):

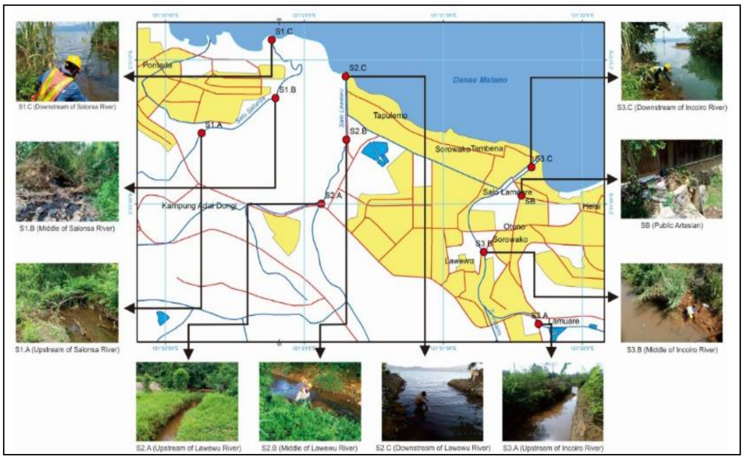

Figure 2. Location of sampling points

Table 1. Description of Location Area

Measuring Point	Location Area	Location Description
S1A	Upstream	It is a forest area and plantation area with cacao plant species, the distance from the residential area is about 100m.
S1B	Middle	It is a plantation area with cacao species and close to rice fields, the distance from residential areas is about 75m.
S1C	Downstream	It is a plantation area with banana species and a cattle ranch area, the distance from the residential area is about 200m
S2A	Upstream	It is a plantation area with corn plants, the distance from the residential area is about 200m.
S2B	Middle	It is a plantation area, the distance from the residential area is about 70m.
S2C	Downstream	It is a pier area, the distance from the residential area is about 50m.
S3A	Upstream	It is a security camp area, the distance from the residential area is about 150m.
S3B	Middle	It is a residential area
S3C	Downstream	It is a residential area
SB	Residential Area	It is a residential area

This research was carried out by identifying iron (Fe) levels using remote sensing methods in the form of processing Landsat 8 satellite image data with a combined ratio algorithm (4+6)/5 channel technique (red channel + shortwave infrared channel / near-infrared). The field survey was carried out by taking water samples in the river body as many as nine points, and one point in borewell water in residential areas. The method used in this study is a survey method with a random sampling process, namely in the upstream, middle and downstream areas of each river. Then the samples were analyzed using geochemical methods in the laboratory with an Atomic Absorption Spectrophotometric (AAS) tool to determine the Fe content in each sample.

RESULTS AND DISCUSSION

Iron is a chemical element that can be found in almost every place on earth, in all geological layers and all water bodies. In general, iron in water can be dissolved as Fe^{2+} (ferrous) or Fe^{3+} (ferry); suspended as colloidal grains (diameter <1 um) or larger, such as Fe_2O_3, FeO, $Fe(OH)_2$, $Fe(OH)_3$ and so on; combined with organic substances or inorganic solids (such as clay). In surface water, it is rare to find Fe levels greater than 1 mg/l, but in groundwater, Fe levels can be much higher. This high concentration of Fe can be felt and can stain fabrics and kitchen utensils. Iron (Fe) exists in soil and rock as ferric oxide (Fe_2O_3) and ferric hydroxide ($Fe(OH)_3$). In water, iron is in the form of ferro bicarbonate ($Fe(HCO_3)_2$), ferro hydroxide ($Fe(OH)_2$), ferrous sulfate ($FeSO_4$) and complex organic iron. Groundwater contains dissolved iron in the form of ferrous ($Fe^{2+)}$. If groundwater is pumped out and in contact with air (oxygen), iron ($Fe^{2+)}$ will be oxidized to ferric hydroxide ($Fe(OH)_3$) [2].

Table 2. Result of Heavy Metal Fe in Sample Water Analysis

Station	Coordinate		Quality Standard of Heavy Metal Fe [a]	Fe Concentration [b]
	Latitude	Longitude	ppm	ppm
S1.A	2,52090	121,34383	0,30	1,14
S1.B	2,51887	121,34827	0,30	1,08
S1.C	2,51549	121,34804	0,30	0,85
S2.A	2,52500	121,35102	0,30	0,83
S2.B	2,52128	121,35252	0,30	1,05
S2.C	2,51761	121,35247	0,30	0,47
S3.A	2,53196	121,36405	0,30	0,49
S3.B	2,52779	121,36077	0,30	0,37
S3.C	2,52288	121,36362	0,30	1,19
SB	2,52452	121,36302	0,30	0,88

Source: [a)] Regulation of the Minister of Health of the Republic of Indonesia No.492/MENKES/PER/IV/2010; [b)] Soil Testing Laboratory of South Sulawesi Agricultural Technology Research Center

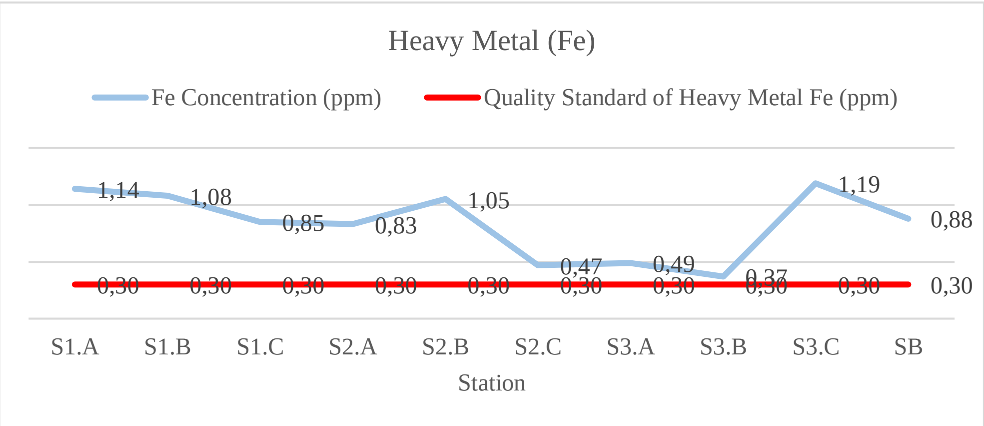

Figure 3. Graph of Iron (Fe) Heavy Metal Concentration on water quality standards

Based on the graph above (Figure 2), it can be analyzed that the highest Fe content of S3.C is in the Incoiro River with a value of 1,19 ppm. Based on the results of the analysis, this is because the rocks that make up the riverbed are ultramafic rocks that contain a lot of Fe metal-bearing minerals. The increase in the value of the heavy metal content of Fe in river water can also be caused by human activities on land, especially in the research location, most of the land has been used as a dense residential location, where there are also several workshops and the river passes through the hospital area. While the lowest level is at point S3.B in the Incoiro River with a value of 0,37 ppm. This is influenced by waterways which generally have undergone a process of concreting and the lack of human activity. From the measurement results, Fe levels have increased at T2 A - T2 B this is because T2 how many coal mining areas are predicted to affect river water quality. The increase in Fe levels in T2 is still within normal limits because, for conventional drinking water treatment, Fe levels are 5 mg/l (Permenkes, 2010) [5].

Remote Sensing Analysis

Based on research conducted [8] states that the value of the channel ratio for iron in the research area ranges from 0 - 3.94217 on Landsat 8 images on April 17, 2017, and 0 - 4.07152 on Landsat 8 images. May 5, 2017. In general, this ratio shows a low value for vegetation, and high for open land and settlements. This is because this ratio is sensitive to the iron element present on the surface, both from open land and settlements (such as house roofs). The results of the regression analysis and the correlation between laboratory measurements of iron content and the value of the pixel ratio (4+6)/5 obtained the regression $y = 0.201x + 0.9081$ with $R^2 = 0.7229$ (Figure 1-3). Regression and correlation analysis was performed with the x-axis being the value of iron content measured in the laboratory using the oxalic acid extraction method and the y-axis being the pixel value of the channel ratio for iron.

Table 3. Data on catchment area and percentage of potential Fe content

Station	River Name	Area (km^2)	Percentage of Potential Fe content (%)
S1	River Salonsa	07,83	17,50
S2	River Lawewu	13,87	31,01
S3	River Incoiro	23,04	51,49

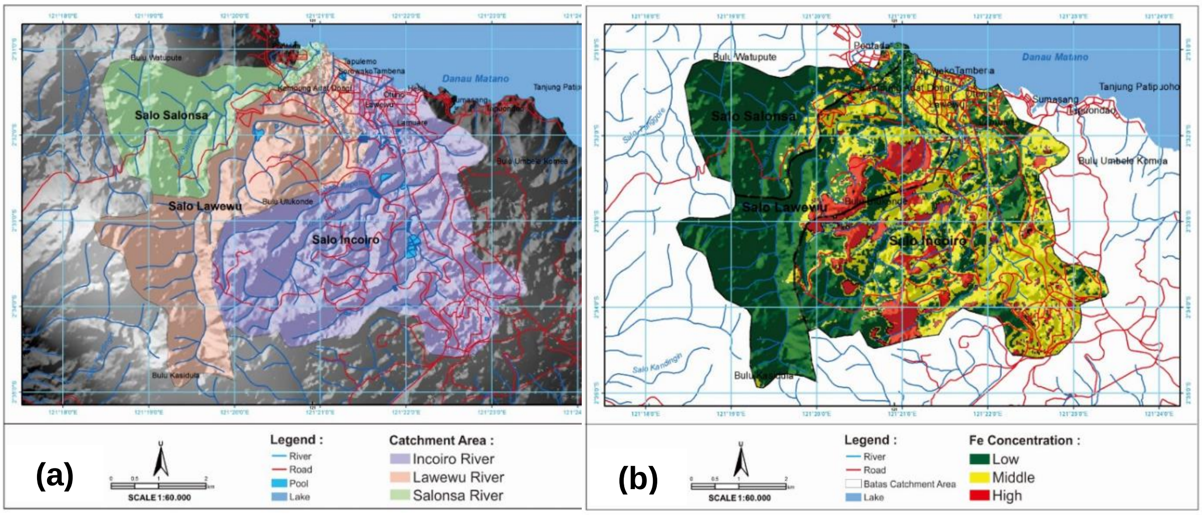

Figure 3. (a) Catchment Area Map (b) Fe Metal Interpretation Map

Based on Table 3, the results of the identification of the element Iron (Fe) using the catchment area analysis and the ratio algorithm technique, the results obtained in three river bodies, namely the Salonsa River which has a catchment area of 7.83 km^2 and a potential Fe content of 17.50%, in the River Lawewu has a catchment area of 13.87km^2 and a potential Fe content of 31.01%, the Incoiro River has a catchment area of 23.04km^2 and a potential Fe content of 51.49%.

Table 4. Data on the Distribution of Interpretation of Heavy Metal Elements Fe (Ha)

Catchment Area	Area of Interpretation of Heavy Metal Elements Fe (Ha)			
	Low	Middle	High	Grand Total
Incoiro River	768,84	1206,25	307,24	2282,33
Lawewu River	957,04	306,54	144,74	1408,32
Salonsa River	716,79	66,11	0,24	783,14
Grand Total	2442,67	1578,90	452,22	4473,79

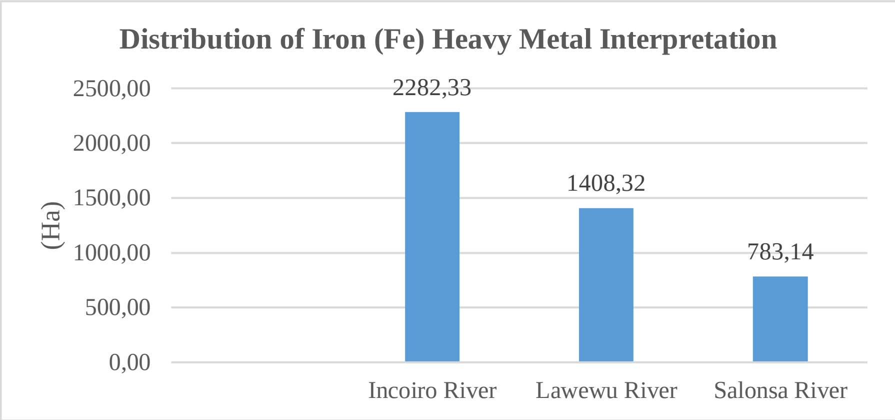

Figure 4. Graph of the Interpretation of Fe Heavy Metal Distribution Area

Based on the graph above, the results of the identification of the element Iron (Fe) using the catchment area analysis and the ratio algorithm technique, the results obtained in three river bodies, namely the Salonsa River which has a distribution area of interpretation of the heavy metal element Fe is 783.14 Ha, then for Lawewu River has an interpretation of an area of 1,408.32 Ha and for the Incoiro River, it has an interpretation of an area of 2282.33 Ha.

The presence of heavy metals in waters is harmful both directly to the life of organisms, and their effects indirectly on human health. This is related to the properties of heavy metals, which are difficult to decompose, so they are easy to accumulate in the aquatic environment and their natural presence is difficult to decompose. Heavy metals are still a metal group with the same criteria as other metals. The difference lies in the effect that is caused when this metal is given or enters the body of a living organism. Although all heavy metals can cause poisoning in living things, some of these heavy metals are still needed in very small amounts. These heavy metals can cause health effects for humans depending on where the heavy metals are bound in the body. The toxic power possessed will work as a barrier to the work of enzymes, so that the body's metabolic processes are interrupted. Furthermore, these heavy metals will act as allergens, mutagens, or carcinogens for humans. The route of entry is through the skin, respiration, and digestion. Each of these heavy metals hurts humans if consumed in large quantities for a long time [4].

Heavy metal Fe that enters the body of biota must pass through the cell membrane which consists of a biomolecular layer formed by lipid molecules with protein molecules scattered throughout the membrane. Heavy metal Fe that enters the body of aquatic biota tends to bind to proteins and lipids in biological tissues. Inside the cell, the metal will form a complex bond with the ligand. Heavy metals can bind to the sulfhydryl groups of proteins so that they will cause damage to related proteins and this overall condition will damage metabolism [7]. Excess iron can cause poisoning where vomiting occurs, intestinal damage, premature ageing to sudden death, irritability, arthritis, birth defects, bleeding gums, cancer, cardiomyopathies, kidney cirrhosis, constipation, diabetes, diarrhoea, dizziness, fatigue, skin discoloration, headache, liver failure, hepatitis, hyperactivity, infection, insomnia, liver pain, mental problems, metallic taste in the mouth, myasthenia gravis, nausea, nevi, restlessness and irritation, Parkinson's, rheumatism, sarcopenia, stomach ulcers, sickle-cell anemia, stubbornness, strabismus, impaired absorption of vitamins and minerals, and hemochromatin [4].

CONCLUSION

Based on the results of geochemical analysis using AAS, the highest value of heavy metal elements FE is 1.19 ppm and the lowest is 0.37 ppm where is by the results of remote sensing interpretation that this area has the widest catchment area of 23.04 Km2. Iron is 51.49% and has an accumulation area of 2,282.33 Ha of heavy metal interpretation.

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