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ANALYSIS OF HEAVY METAL GEOCHEMISTRY BEHAVIOR ON SOIL IN THE RIVER OF LAKE MATANO AREA, SOUTH SULAWESI

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ABSTRACT

Geologically, the Lake Matano area is an area of laterite deposits, where in these deposits there are heavy metal geochemical elements that can have a negative impact on the environment. This research was conducted in three rivers that surround the area and empties into Lake Matano, with the aim of analyzing the geochemical behavior of heavy metals in soil. The method used includes a literature study and observing the results of previous studies and testing the content of heavy metals with the AAS tool. The results showed the behavior of heavy metals in the soil around Lake Matano in the three rivers where metals that exceeded the critical number were Fe, Mn, Cu, Co, Ni. and which is still below the critical number limit is Cr metal. The presence of heavy metals in the soil at the research site is caused by the results of the disposal of waste from mining activities and anthropogenic activities where the end of the disposal goes directly to the ground so that the heavy metals contained in the disposal will enter the soil and experience contamination in nature so that the existing organic compounds have undergone degradation.

Keywords: heavy metals; geological; geochemistry; laterite nickel; matano lake.

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INTRODUCTION

The presence of heavy metals in waters can arise from various sources, including mining, household waste, rural sewage, and modern waste. Of the four types of waste, the waste that generally contains the most heavy metals is modern waste and mining waste. This is because heavy metal mixtures are often used in industry and extraction or mining processes, both as natural materials, additives and boosters. Meanwhile, in the mining system, during the overburden stripping and mineral extraction methods (Endang Rochyatun et al, 2006). Under reduced conditions, iron can cause damage to rice plants. Damage to iron in rice fields causes low production or even plants do not produce. Rice plants will experience iron damage assuming the iron in the plant exceeds 300 ppm. The component of iron destruction in rice fields is to restrain the intake of supplements caused by not forming roots, because the roots are covered by iron oxide. Harmful iron in paddy fields can reduce rice yields by 52-75%. To determine the level of iron contained in paddy soil requires a really long and broad-minded strategy (Nanda, Budi and Dian, 2019). Geologically, the Lake Matano area is an area of laterite deposits, in which there are heavy metal geochemical elements that can have a negative impact on the environment. So based on this and to support the government's mission in terms of promoting research activities in various fields of science, which can later become a benchmark for conservation efforts for Lake Matano's natural resources, it is deemed necessary to conduct research related to environmental geochemistry in this case heavy metal elements.

Sulawesi Island is located in the focal part of the Indonesian Archipelago, which consists of four lithotectonic belts, specifically the pluto-volcanic curve from south to north of the Sulawesi Island arm, the transformative belt in the middle, stretching from the center to the southeast, the ophiolite belt in the east-southeast, and Banggai-Sula and Metals microcontinent. In the Sorowako region, the boundaries between lateritized zones are very clear. At the top there is top soil consisting of humus and trees. The bottom cover soil layer shows an overburden layer with the principle of formation of Fe, Cr, Mn, and Co. The lower cover layer is found in the Limonite Zone and the Saprolite Zone is located at the bottom of the Limonite Zone while the most reduced zone is bedrock which is new rock that has not gone through the weathering system (Faiz, Sufriadin and Widodo, 2020)

Nickel laterite is one of the abundant mineral resources in Indonesia. Laterite nickel mineral reserves in Indonesia reach 12% of the world's nickel reserves, which are spread over the islands of Sulawesi, Maluku and surrounding small islands. Laterite nickel minerals are grouped into two types, namely saprolite with high nickel content and limonite with low nickel content. The main difference between these two metals is Fe (iron) and Mg (magnesium), saprolite metal has low Fe and high Mg whereas limonite has high Fe and low Mg. Laterite nickel is described by the presence of a rosy earthy colored material containing Ni and Fe. One of the elements that influence the development of laterite nickel deposits is morphology, initial stone, and level of durability. The existence of laterite nickel deposits is generally widely reported in areas, for example in the South Sulawesi Region, in the Sorowako area, East Luwu Regency. Likewise, laterite nickel reserves are also found in Fokal Sulawesi, particularly the Morowali Regional Regulation, Luwuk Banggai Governor Regulation, Focal Sulawesi and Palangga Region, Southeast Sulawesi. (Faiz, Sufriadin and Widodo, 2020)

Heavy metals are usually found in small amounts in normal water, which is below 1 mg/l. When normal disintegration occurs, the concentration of these metals may increase. Many heavy metals, both harmful and basic, are broken down in water and contaminate new water and seawater. Sources of this pollution mostly come from mining, metal refining, and various types of industry, and can also come from agricultural land that uses compost or nuisance enemies that contain metals (Darmono, 2001).

Pollution according to the Keputusan Menteri Negara Kependudukan dan Lingkungan Hidup (1988) is the entry or inclusion of living things, substances, energy, and/or other components into water/air, and/or changes in the composition (composition) of water/air according to activities. human and natural processes, so that the quality of water/air becomes less or can no longer function according to its designation.

Pollution is the entry or inclusion of living things, energy substances, and or other components into the environment, or changes in the environmental order by human activities or by natural processes so that the quality of the environment drops to a certain level which causes the environment to live. become less or unable to function according to its designation. This understanding is in accordance with the definition of internal pollution (Undang-undang Republik Indonesia, 1982; Peraturan Pemerintah Republik Indonesia, 2000; Indrasti N, Ahmad F, 2008; Haines F, Reichman N, 2008).

RESEARCH METHODS

The research location was carried out in the area around Lake Matano and soil sampling was carried out on three rivers, namely the Salonsa River, Lawewu River and Incoiro River which was carried out in November 2020. Research on water quality was carried out at three measurement points, namely in the upstream, middle and downstream areas of the river and one point in the drilled well in 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 (KFA Kamarati et al, 2018; Azizah M et al, 2021; Anwar M et al, 2015). Soil sampling at the location using a tool in the form of a Hand Auger at a depth of 50 - 100 cm is estimated at that depth the samples obtained are not contaminated by organic material. At each station in the left and right areas on the upstream, middle and lower reaches of the Salonsa, Lawewu and Incoiro rivers, four samples of soil were taken with an interval of 10 m, two samples on the left and two samples on the right side of the river. After the soil sample was obtained, documentation and coordinate data were collected. After that, the soil sample was put in a sample bag and immediately put into the laboratory for further geochemical testing. The total samples tested were 34 soil samples representing all observation stations. At this stage, soil and water samples obtained in the field are then subjected to laboratory testing using the AAS method which aims to obtain geochemical data in the form of Fe, Mn, Cu, Cr, Co and Ni elements from soil and water samples at the Soil, Plants, and Plants Laboratory. Fertilizer, Water Agricultural Research and Development Agency (BPTP) South Sulawesi using the SpectrAA 50/55 Atomic Absorption Spectrometer (AAS) (Pataranawat P et al, 2007; Ricksy P et al, 2020; Dino R, Athiyah A, 2019).

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RESULTS AND DISCUSSION

Heavy metals in excess amounts can cause pollution in the soil. Heavy metal elements that have the potential to cause pollution to the environment are; Fe, As, Cd, Pb, Hg, Mn, Ni, Cr, Zn, and Cu, because these elements are more extensively used as well as with a high level of toxicity. Meanwhile, the United State Environment Protection Agency (US EPA) lists heavy metals which are the main dangerous pollutants, namely Sb, Ag, Be, Cd, Cr, Cu, Pb, Hg, Ni, Se, Sr, Ag and Zn. However, there are also heavy metals such as Cr, Cu, Fe, Mn, Mo which are essential micronutrients for plants, but if the amount is too large it will be toxic to plants. The presence of toxins in the soil, especially when the metal has accumulated and has exceeded the critical limit in the soil.

Table 1. Results of Heavy Metal Analysis in Soil

Sample Code	Parameter* (ppm)					
	Fe	Mn	Cu	Cr	Co	Ni
Range of Critical Figures for Metal Content in Soil**	10.000 - 100.000	1000	60 - 125	75 - 100	25 - 50	32 - 100
S1.A1	23.900	16.400	16,36	5,88	200	7.100
S1.A2	20.900	9.300	16,96	7,02	300	7.100
S1.A3	14.800	9.900	12,42	2,35	400	5.100
S1.A4	3.700	12.400	14,84	0,00	300	7.500
S1.B1	46.100	2.600	36,06	50,00	100	11.600
S1.B2	23.000	2.200	64,20	2,35	100	7.400
S1.B3	30.300	3.000	37,57	7,06	200	5.900
S1.B4	29.000	3.100	37,87	17,64	200	3.900
S1.C1	2.300	3.600	16,06	8,82	400	6.500
S1.C2	4.400	3.700	22,41	3,53	200	12.200
S1.C3	4.100	4.700	24,54	11,76	200	7.300
S1.C4	4.300	5.200	22,41	3,53	200	12.200
S2.A1	26.000	5.700	44,55	10,59	200	7.400
S2.A2	21.400	5.700	39,99	10,00	100	7.500
S2.A3	5.000	6.300	43,91	12,35	400	8.000
S2.A4	3.200	6.500	20,60	1,18	300	7.700
S2.B1	29.600	7.500	52,70	14,70	200	8.300
S2.B2	22.000	8.000	49,66	12,34	200	7.500
S2.B3	34.700	8.000	30,30	21,18	100	9.100
S2.B4	24.200	8.700	56,67	0,00	100	8.600
S2.C1	28.100	9.200	44,23	0,00	100	7.500
S2.C2	6.000	10.000	45,76	0,00	100	7.500
S3.A1	39.400	10.500	35,43	25,28	400	5.500
S3.A2	31.500	11.000	59,67	4,70	300	7.300
S3.A3	44.400	11.100	43,00	39,38	200	8.500
S3.A4	72.200	11.400	65,40	19,40	300	9.900

S3.B1	55.000	12.700	66,03	18,82	300	8.400
S3.B2	42.600	12.900	56,67	27,06	300	9.400
S3.B3	45.700	13.500	52,39	2,35	200	9.900
S3.B4	50.400	14.200	52,10	27,64	400	9.400
S3.C1	42.700	14.500	62,68	14,69	200	7.600
S3.C2	59.600	14.400	61,48	54,67	200	8.600
S3.C3	53.000	15.300	63,32	13,53	300	8.000
S3.C4	47.800	15.800	64,55	35,88	200	8.100

*= Source: AAS Analysis of BPTP Prov. South Sulawesi, 2021

**=Source: (Adji, Sunarsih and Hamda, 2008)

Heavy Metal Iron (Fe) In Soil

Based on the results of heavy metal testing using the AAS method for Fe metal in the upstream, middle and downstream areas of the river for soil samples, the average value of Fe heavy metal content at each station is presented in table 2 below.

Table 2. Average Value of Fe Concentration in Soil

Station	Fe concentration (ppm)	Lower Limit of Critical Number (ppm)	Upper Limit of Critical Number (ppm)
S1.A	15.825	10.000	100.000
S1.B	32.100	10.000	100.000
S1.C	3.775	10.000	100.000
S2.A	13.900	10.000	100.000
S2.B	27.625	10.000	100.000
S2.C	17.050	10.000	100.000
S3.A	46.875	10.000	100.000
S3.B	48.425	10.000	100.000
S3.C	50.775	10.000	100.000

Source: AAS Analysis of BPTP Prov. South Sulawesi, 2021

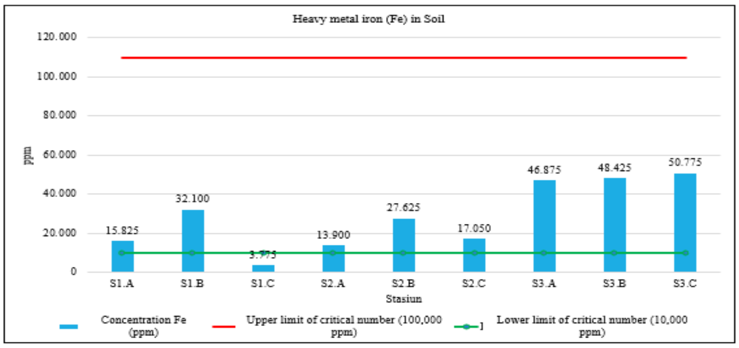

Figure 1. Graph of Comparative Value of Average Fe. Concentration And The Limit Of The Critical Number Of Heavy Metals In Soil

In general, Fe concentrations in the upstream, middle and downstream areas for soil samples were within the critical range, except for S1.C (downstream of the Salonsa River) which did not exceed the lower limit of the critical value. This is because the location is quite far from settlements and is a plantation area with sandy soil conditions. Iron is a traceable component of matter anywhere on the planet, in every geographical layer and in all waterways. Fe is a basic metal whose presence in

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certain quantities is needed by living things, but in abundance it can cause toxic effects. Fe metal occurs normally in the soil, this is due to the large groundwater content of Fe metal.

Heavy Metal Manganese (Mn) In Soil

Based on the results of heavy metal testing using the AAS method for Fe metal in the upstream, middle and downstream areas of the river for soil samples, the average value of Mn heavy metal content at each station is presented in Table 3.

Table 3. Average Value of Mn Concentration in Soil

Station	Mn concentration (ppm)	Lower Limit of Critical Number (ppm)	Upper Limit of Critical Number (ppm)
S1.A	12.000	0	1.000
S1.B	2.725	0	1.000
S1.C	4.300	0	1.000
S2.A	6.050	0	1.000
S2.B	8.050	0	1.000
S2.C	9.600	0	1.000
S3.A	11.000	0	1.000
S3.B	13.325	0	1.000
S3.C	15.000	0	1.000

Sumber: Analisis AAS Laboratorium BPTP Prov. Sulsel, 2021

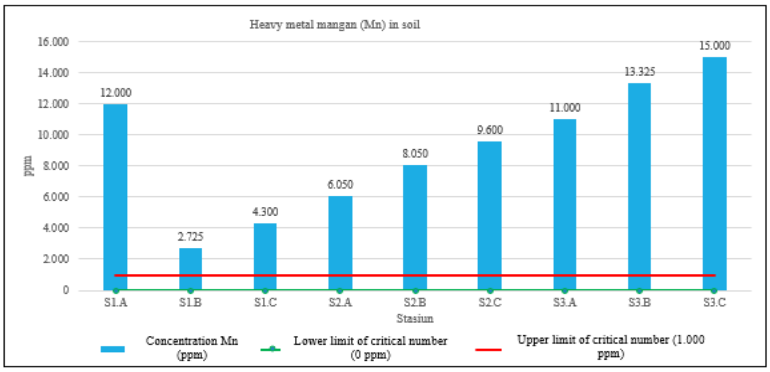

Figure 2. Graph of Comparative Value of Average Concentration of Mn And The Limit Of The Critical Number Of Heavy Metals In Soil

In general, the concentration of Mn in the upstream, middle and downstream areas for all soil samples exceeded the upper limit of the critical number. This is thought to be due to elemental Manganese occurring normally in climates as strong in soil, small particles in water, and residual particles in air. People increase the convergence of manganese in the air with modern exercise, land clearing and through consumption of petroleum products. Manganese from human activities can also saturate surface water, groundwater, and wastewater.

Heavy Metal Copper (Cu) In Soil

Based on the results of heavy metal testing using the AAS method for Cu metal in the upstream, middle and downstream areas of the river for soil samples, the average value of Cu heavy metal content at each station is presented in Table 4.

Table 4. Average Cu Concentration Value in Soil

Station	Cu concentration (ppm)	Lower Limit of Critical Number (ppm)	Upper Limit of Critical Number (ppm)
S1.A	15,15	60	125

S1.B	43,93	60	125
S1.C	21,36	60	125
S2.A	37,26	60	125
S2.B	47,33	60	125
S2.C	45,00	60	125
S3.A	50,88	60	125
S3.B	56,80	60	125
S3.C	63,01	60	125

Source: AAS Analysis of BPTP Prov. South Sulawesi, 2021

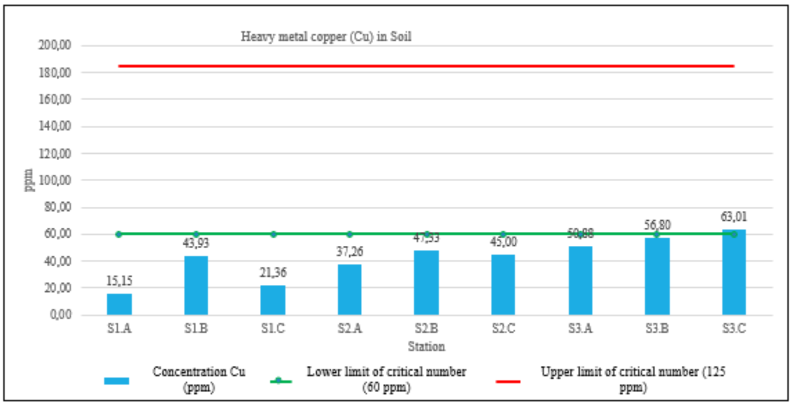

Figure 3. Graph of Comparative Value of Average Cu. Concentration And The Limit Of The Critical Number Of Heavy Metals In Soil

In general, the concentration of Cu in the upstream, middle and downstream areas for soil samples did not exceed the lower limit of the critical number, except for S3.C (downstream of the Incoiro River) which was in the critical range. The presence of Cu in the environment can accumulate in waters or settle in sediments. Cu is a heavy metal commonly used in metal amalgams, link assembly, pottery production, and pesticides. Cu is very dangerous and highly bioaccumulative. The solubility of Cu is very low in liquid but it is effectively adsorbed on the particles which are broken down in water. It can be produced by domestic waste containing Cu due to inspection in the environment near waterways and roads.

Heavy Metal Chromium (Cr) In Soil

Based on the results of heavy metal testing using the AAS method for Cr metal in the upstream, middle and downstream areas of the river for soil samples, the average value of Cr heavy metal content at each station is presented in Table 5.

Table 5. Average Value of Cr Concentration in Soil

Station	Cr concentration (ppm)	Lower Limit of Critical Number (ppm)	Upper Limit of Critical Number (ppm)
S1.A	3,81	75	100
S1.B	19,26	75	100
S1.C	6,91	75	100
S2.A	8,53	75	100
S2.B	12,06	75	100
S2.C	0,00	75	100
S3.A	22,19	75	100
S3.B	18,97	75	100
S3.C	29,69	75	100

Source: AAS Analysis of BPTP Prov. South Sulawesi, 2021

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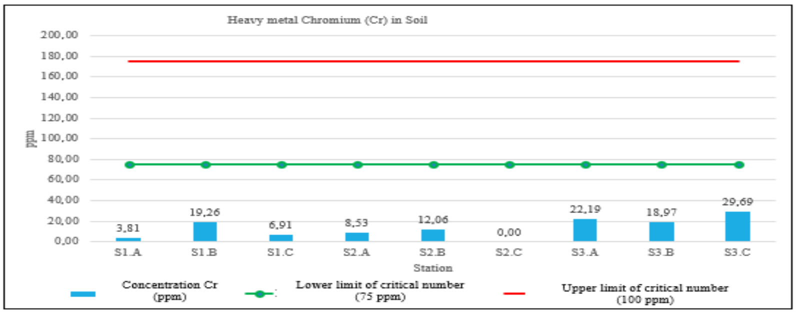

Figure 4. Graph of Comparative Value of Average Cr. Concentration And The Limit Of The Critical Number Of Heavy Metals In Soil

In general, the upstream, middle and downstream areas for all soil samples do not exceed the lower limit of the critical number. The following parameters indicate that the soil is still suitable for use. The rise and fall of fixation at different stations can be caused by different soil conditions at each station and the capacity of plants to ingest heavy metals. Soil type affects the response that occurs in heavy metals. Soil with high dirt on vertisol soil compared to entisol soil will grow an absorption surface which can reduce the solvency of heavy metal Cr.

Heavy Metal Cobalt (Co) In Soil

Based on the results of heavy metal testing using the AAS method for Co metal in the upstream, middle and downstream areas of the river for soil samples, the average value of Co heavy metal content at each station is presented in Table 6.

Table 6. Average Value of Co Concentration on Soil

Station	Co concentration (ppm)	Lower Limit of Critical Number (ppm)	Upper Limit of Critical Number (ppm)
S1.A	300	25	50
S1.B	150	25	50
S1.C	250	25	50
S2.A	250	25	50
S2.B	150	25	50
S2.C	100	25	50
S3.A	300	25	50
S3.B	300	25	50
S3.C	225	25	50

Source: AAS Analysis of BPTP Prov. South Sulawesi, 2021

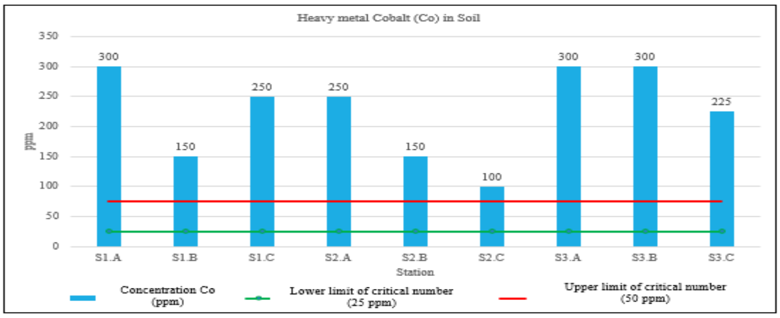

Figure 5. Graph of the comparison value of the average concentration of Co and the critical number of heavy metals in soil

In general, the concentration of Co in the upstream, middle and downstream areas for all soil samples exceeded the upper limit of the critical number. Co. sources foreign metal materials from modern waste, mining activities, family waste and further agricultural activities. Wastewater that contains Co and is used to inundate horticultural land can lead to accumulation of cobalt in plants which will be dangerous assuming it enters a good pecking order.

Nickel (Ni) Heavy Metal In Soil

Based on the results of heavy metal testing using the AAS method for Ni metal in the upstream, middle and downstream areas of the river for soil samples, the average value of Ni heavy metal content at each station is presented in Table 7.

Table 7. The Average Value of Ni Concentration in Soil

Station	Ni concentration (ppm)	Lower Limit of Critical Number (ppm)	Upper Limit of Critical Number (ppm)
S1.A	6.700	32	100
S1.B	7.200	32	100
S1.C	9.550	32	100
S2.A	7.650	32	100
S2.B	8.375	32	100
S2.C	7.500	32	100
S3.A	7.800	32	100
S3.B	9.275	32	100
S3.C	8.075	32	100

Source: AAS Analysis of BPTP Prov. South Sulawesi, 2021

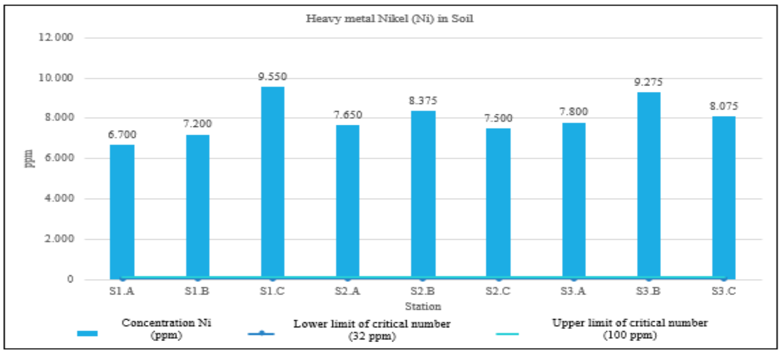

Figure 6. Graph of the comparison of the average concentration of Ni and the critical number of heavy metals in soil

In general, the concentration of Ni in the upstream, middle and downstream areas for soil samples all exceeded the upper limit of the critical number. This of course cannot be separated from the type of bedrock at the research site which is dominated by ultramafic rocks and has undergone a laterization process with several dominant metals, one of which is Ni. Nickel laterite is a buildup that occurs due to a long-lasting substance in ultramafic rocks. Lateritization interactions take place over a long period of time starting when ultramafic rocks are exposed on the world's surface to produce nickel deposits caused by variables of survival rate, geographic design, environment, geography, synthetic reagents, vegetation, and time.

Analysis of Heavy Metal Behavior on Soil

The increasing metal content in the soil, especially contaminated iron (Fe) indicates that the metal has been concentrated in the soil for a long time with the highest average Fe content in the soil around the Lower Incoiro River with a value of 50,775 ppm and the lowest in the soil. which is

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around the Lower Salonsa River with a value of 3,775 ppm. The metal substances in the soil are caused by the soil being eroded for a long time and the heavy metals continue to increase, so that the existing natural mixture has been damaged. The presence of other heavy metal content in the soil at the research site such as chromium (Cr), Iron (Fe), Manganese (Mn), Copper (Cu) Cobalt (Co), Nickel (Ni) in the soil at the study site was caused by the disposal waste from mining and anthropogenic activities whose final disposal is directly disposed of in the sewage so that the heavy metals contained in the waste will be swallowed into the feces and destroy the natural mixture. Furthermore, the metallic substance in the feces increases. Heavy metal content that enters a climate is generally carried by human activities, such as modern waste or mining waste and family waste containing heavy metals. These heavy metals will then be wasted into the ground so that there will be developments with the assumption that the waste is modern or the waste is continuously lowered directly into the ground. Where based on the results of pH measurements carried out on soil samples at three points on four samples consisting of two samples on the left and two samples on the right it is known that the average value is on the Salonsa River pH 6.49 for the Lawewu river pH 6.39 and Incoiro pH 6.85. The effect of this pH on the research location where this condition is still neutral so it has no effect on the metals present in the soil of the study area. The presence of heavy metals in the soil at the study site is caused by the results of the disposal of waste from mining activities and anthropogenic activities where the tip of the disposal goes directly to the dirt so that the heavy metals contained in the waste disposal will enter the dirt and damaged natural mixtures. existing nature has been degraded.

CONCLUSION

The behavior of heavy metals in the soil around Lake Matano in the three rivers where metals exceeding the critical limit are Fe, Mn, Cu, Co, Ni. and which is still below the critical number limit is Cr metal. The presence of heavy metals in the soil at the research site is caused by the results of the disposal of waste from mining activities and anthropogenic activities where the end of the disposal goes directly to the ground so that the heavy metals contained in the disposal will enter the soil and experience contamination in nature so that the existing organic compounds have undergone degradation.

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