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Characteristics of Distribution of Heavy Metals in Rivers Around Laterite Nickel Mining Sites in the Tanggetada Area, Kolaka Regency, Southeast Sulawesi Province

Wahyu Ekawati[1], Muhammad Chaerul[1], Ismail Marzuki[2]

[1]Department of Infrastructure dan Environmental Engineering, Fajar University, Makassar, INDONESIA

[2]Chemical Engineering Department, Fajar University, Makassar, INDONESIA

E-mail: muhammad.chaerul@unifa.ac.id

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ABSTRACT

The research location is located in Tanggetada sub-district, Kolaka district, which is an area very close to laterite nickel mining sites. The determination of the research location was deliberately chosen at the nickel mining location, with the consideration that at that location the river was brownish red, and at that location there were many miners who did not carry out according to mining regulations. The method used is observational which is carried out at nickel laterite mining sites. by using a cross sectional approach that is both qualitative and quantitative. Based on the results of the data analysis that has been carried out, it can be explained that the distribution of heavy metal pollution in river water is the largest in the heavy metal Copper (Cu), namely 0.0108 mg/l, which is found at station 3, heavy metal lead (Pb), namely 0.0070 mg/l l found at station 4, heavy metal chromium (Cr) is 0.0038 found at station 6 downstream, heavy metal Cadmium (Cd) is 0.0028 mg/l found at station 3, heavy metal Hexavalent Chromium (Cr6+) is 0.0026 mg/l found at station 2. From the results of the analysis there are no heavy metals that exceed the quality standard (PP No. 82 of 2001). Meanwhile, the river sediment material produced the greatest amount of heavy metal Copper (Cu), namely 0.0229 mg/kg found at station 2, Heavy metal Cadmium (Cd), namely 0.0128 mg/kg found at station 5, Heavy metal Lead (Pb) namely 0.0177 mg /kg is found at station 1 upstream, heavy metal Chromium (Cr) is 0.0118 mg/kg found at station 6 downstream, heavy metal Hexavalent Chromium (Cr6+) is 0.0116 mg/kg found at station 6 downstream. From the results of this analysis there are no heavy metals that exceed the quality standards (USEPA, 2003)

Keywords: heavy metals; mining; nickel laterite; pollution and accidents.

INTRODUCTION

Mining activities, from exploration to the management or refining stage, will always have an impact on the environment, this impact cannot be completely avoided, but the damage can be minimized so that environmental aspects in efforts to support mining activities remain environmentally sound (Arif, Irwandy, 2012). Mineral management is one of the mining industries as an effort to extract valuable minerals from the layers of the earth and is always supported by technological developments and equipment mechanization. Southeast Sulawesi Province is one of the provinces in Indonesia which has a lot of laterite nickel reserves and nickel mines are spread across several districts (Purwantari, N D 2007). One of these areas is Kolaka District, Kolaka Regency, where the effects of the many mines operating in the area have caused the emergence of various kinds of social conflicts such as demonstrations and environmental pollution. Several companies in Kolaka Regency do not have settling ponds in the exploration or exploitation process. In 2013, around 100 hectares of residents' rice fields had been damaged and polluted, so that all the fish seeds died. This is thought to come from heavy metals resulting from nickel mining company tailings in the area. Nickel mining activities that do not pay attention to environmental aspects can cause heavy metal contamination in river and coastal waters, and at high levels can cause pollution, which will have a negative impact on aquatic biota (Darmono, 2001). The mining method that is widely used by companies in the Kolaka area uses the open cast mining method. The mining is done by cutting the side of the hill from the top downwards according to the contour lines, so it can also be called contour mining. The impact of the open-pit mining method is that when it rains, surface water flows will erode the open soil, which becomes polluting material where polluting materials are carried by surface run-off water to lower areas and into water bodies. Therefore, the water becomes cloudy, shallowing in rivers, lakes and sea areas will reduce the level of water clarity (Notohadipawiro, 2000). Any exploitation of these natural resources can have an impact on the environment, both physically and socially (Purwantari N D, 2007). Nickel mining activities cause heavy metal contamination in river and coastal waters, and at high levels can cause pollution, which will have a negative impact on aquatic biota (Muhammad Chaerul, et al., 2015). Taking and depositing certain layers of rock can cause the water to become acidic due to its interaction with the rock. Heavy metals are the main environmental pollutants and most of them are toxic even in low concentrations (Faiz, et al., 2020). The deposition of heavy metals in water occurs due to the presence of hydroxyl and chloride carbonate anions. Heavy metals have the property of easily binding organic matter and settling at the bottom of the waters and uniting with sediment so that the levels of heavy metals in sediment are higher than in water (Hutagalung, 1991). Heavy metals are metallic elements that have a density greater than 5 g/cm3, while metals that weigh less than 5 g are light metals including Ca, Mg, Na, K, etc. Heavy metals are metallic elements with a high molecular weight. In low levels, heavy metals are generally toxic to plants and animals, including humans. Including heavy metals that often pollute habitats are Hg, Cr, Cd, As, and Pb (Am.geol. Inst., 1976). , including Cd, Hg, Pb, Zn, and Ni. The heavy metals Cd, Hg, and Pb are called non-essential metals and at certain levels are toxic metals for living creatures (Subowo et al., 1999). The aim of the research is to analyze the distribution of metal pollution in rivers around nickel laterite mining locations.

RESEARCH METHODS

The research location is located in Tanggetada sub-district, Kolaka district, which is an area very close to the laterite nickel mining location. Geographically, it is located between 121°31'30"E-121°34'0"E and 04°16'0"S-4°18'30"S (Figure 1). The research location area was chosen deliberately at a nickel mining location, with the consideration that at that location the river is brownish red, and around that location there are many miners who do not comply with mining rules. Based on research material, this research was carried out for 3 months with the scope of activities starting from the preparation stage, data collection, data analysis with activity stages as shown in this implementation schedule table. Research samples were taken from 6 water sample points and 6 sediment sample points which were taken randomly from upstream to downstream of the river.

Research plan

In accordance with the problems and final objectives of this research, this type of study emphasizes observational methods carried out at nickel laterite mining locations, especially in the Kolaka area, using a cross sectional approach that is qualitative and quantitative through several statistical analysis techniques with several research variables. . Variables are characteristics that can be measured either numerically or categorically in general, to measure whether there are differences between groups of variables called independent, dependent and confounders (Sugiyono, 2018). In this study, each variable is grouped as follows:

- Independent Variable: factors that influence the occurrence of river pollution in the nickel laterite mining area, as well as the distribution of heavy metal pollution around rivers in the Kolaka area.
- Dependent Variable: Heavy metal levels (Cd, Pb, Cu, Cr, Cr6+) in sediment material and river water, predicted deposition time of the material contained therein and its distribution pattern

Tools and materials

In accordance with the equipment used in field research is a compass, global positioning system (GPS), camera, stationery. Paralon pipe to take sediment samples in the river. Meanwhile, the equipment needed for laboratory analysis is an Atomic Absorption Spectrophotometer (AAS) to analyze sediment samples.

The materials used in this research are topographic maps at a scale of 1: 20,000 and other thematic maps related to research, filter paper (Micropore filter 0.45 μm), pH meter, temperature. The

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materials used were river sediment samples using plastic samples, river water samples using polytheline bottles which had been sterilized using Aquabides.

Sample

The samples in this study were river water samples. Water samples were taken as much as 1000 mL at each station. Meanwhile, samples of material in the river body (sediment).

Data collection

Sample Data collection in the field using the purposive sampling method. The activity steps carried out in this research, starting from preparing tools and materials, preparing for data collection, to writing writing. This data collection activity consists of field and laboratory research. This activity was carried out to collect all data and information relevant to the objectives of this research. The steps for data collection are as follows:

Determination of sampling points

- Water samples in the river
  Water samples at 6 points, namely input, internal and output
- River sediment samples
  River sediment samples were taken at 6 points randomly from upstream to downstream

Sampling

Sampling was carried out randomly at each station, samples consisted of water samples and sediment samples.

Water sampling technique

Surface water sampling points in rivers with a discharge of less than 5 m3/sec, water samples are taken at one point in the middle of the river (Efendi, 2003). Water samples were taken on the left, right and middle banks of the river using plastic bottles tied to a piece of wood at a depth of 3-5 meters. The bottle is closed with a cork tied with a string. Put it in water, then pull the lid up so that the bottle is filled with water until it is full, then pull it to the surface. On the left and right sides of the river, samples are taken by placing them directly into the water until it is full. The samples taken are mixed together to be taken to the laboratory for analysis. The water sample container used was a 1 litre HDPE (high-density polyethylene) plastic bottle. At each point, one water sample and one sediment sample were taken combined (composite) based on location, namely at two points on the edges of the right and left parts of the water body and the center of the water body.

Sediment Sampling Technique

The tool used to take sediment samples is a grab (EPA-Ohio, 2001). Sediment samples were taken at the river bank and in the middle of the river. The sample taken is taken from a part that is not touched by the surface of the specimen to avoid metal contamination from the sampling tool. The samples taken are then mixed together and put into a clean sample bottle to be taken to the laboratory for analysis. Based on APHA/AWWA/WEF. Standard Methods 20th end. (2001) for the preservation of sediment samples cooled at 4°C. while the sediment sample container is a clear plastic bag, samples taken are ±100 grams.

Sample Analysis/Testing

The samples that have been taken are analyzed in the laboratory. Metal levels, such as cadmium (Cd), lead (Pb), copper (Cu), chromium (Cr) and hexavalent chromium (Cr6+). From water and sediment samples it was determined using a Hitachi Atomic Absorption Spectrophotometer (SSA) type Z-2000. Test samples that are not directly analyzed are preserved by adding HNO3 until the pH is less than 2. The purpose of adding HNO3 is to dissolve the metal analytes and remove interfering substances contained in the water and wastewater test samples with the help of an electric heater, then measured with SSA. using ethylene gas C2H2 (SNI 06-6989-2004).

Data Analysis

Data analysis for pollution and heavy metal contamination in rivers. By determining the distribution/distribution for each station of heavy metals analyzed in the laboratory Chromium (Cr), Hexavalent Chromium (Cr6+), Cadmium (Cd), Copper (Cu), Lead (Pb), and creating a heavy metal distribution map using ArcGis. By applying statistical and digital (GIS) methods and tools to describe the laterization conditions and distribution of heavy metals more accurately.

RESULTS AND DISCUSSION

Taking river water samples, each sample was taken at one observation station. Determining the sampling location points for observation results was carried out using a purposive sampling method based on the potential for pollution at each sampling location point. Use a Polytheline bottle that has been sterilized with Aquabides. The samples that have been taken are analyzed in the UPTD Health Service laboratory at the regional health laboratory, using Atomic Absorption Spectrophotometry (AAS). Taking river sediment samples, each sample was taken at one observation station. Determining the sampling location points for observation results was carried out using a purposive sampling method based on the potential for contamination at each sampling location point. The samples that had been taken using paralon pipes were then stored in plastic samples, which would then be analyzed in the UPTD Health Service laboratory. area, using Atomic Absorption Spectrophotometry (AAS) (Table 1).

Table 1. Description of river water and river sediment sampling

Sampling Station	Location Area	Description
ST 1	Upstream	This is a laterite nickel mining area, the distance from the settlement is around 700 meters
ST 2	Upstream	This is a silica sand mining area, the distance from the settlement is around 300 meters
ST 3	Middle of the river	This is a rice field area
ST 4	Middle of the River	This is a laterite nickel mining area
ST 5	Upstream	It is a residential area and rice fields
ST 6	Upstream	It is an area of rice fields and residential areas

Distribusi Logam Berat Pada Air Sungai

Rivers are an important source of water for life, various benefits from rivers include as a source of drinking water, a source of irrigation, a means of transportation, apart from that river water is needed in industrial activities, agriculture, fisheries, and so on. The many benefits of river water for humans certainly do not cover the fact that rivers are also natural resources that are vulnerable to pollution. Heavy metals are one of the most common types of environmental pollutants found in waters. These heavy metals can also have a negative impact on humans who use the water and the organisms in the river. The presence of heavy metal content in organisms indicates that there is a source of heavy metal originating from nature or from human activities (Kamarati, Marlon and M, 2018). Pollution in rivers can also be caused by the presence of metals that make up rocks or soil in the river area and in the river itself, both toxic and essential. Heavy metals in river water were observed using metal parameters (mg/L), namely: Chromium (Cr), Chromium VI (Cr6+), Cadmium (Cd), Copper (Cu), Lead (Pb). Apart from that, river water quality standards and water quality standards to support aquatic life are provided in the following table (Table 2):

Table 2. River water quality standards divided by PP group. NO. 82 of 2001

River Water Quality Standards Standard Quality Chromium (Cr)			
Class I	Class II	Class III	Class IV
0.05	0.05	0.05	0.05
Standard Quality Hexavalent Chromium (Cr6+)			
Class I	Class II	Class III	Class IV
0.05	0.05	0.05	0.05

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Standard Quality Cadmium (Cd)			
Class I	Class II	Class III	Class IV
0.01	0.01	0.01	0.01
Standard Quality Copper (Cu)			
Class I	Class II	Class III	Class IV
0.02	0.02	0.02	0.2
Standard Quality Lead (Pb)			
Class I	Class s II	Class s III	Class s IV
0.03	0.03	0.03	1

From the observation results, descriptive statistics were obtained for the heavy metal content of river water, as follows (Table 3):

Table 3. Primary River Water Data Processing Results, 2023

Statistics	**Chromium (Cr)**	**Hexavalent Chromium (Cr6+))**	**Cadmium (Cd)**	**Copper (Cu)**	**Lead (Pb)**
Minimum	0.0020	0.0016	0.0016	0.0017	0.0029
Maximum	0.0038	0.0026	0.0028	0.0108	0.0070
Mean	0.0027	0.0020	0.0023	0.0071	0.0048
Standard Deviation	0.0006	0.0004	0.0005	0.0032	0.0013
Skewness	1.1946	0.7232	-0.4551	-0.8237	0.4080
Kurtosis	1.8043	0.0581	-1.7936	1.1972	1.5208

In this table, it can be explained that the contents:

- Chromium (Cr) (Figure 4) in river water produces 0.0020 to 0.0038 with a mean and standard deviation value of 0.0027 and 0.004 respectively. Thus, the presence of chromium in classes I, II, III and IV means that from measuring the Cr6+ metal, this water can be used for agricultural irrigation needs with chromium content in accordance with quality standards.
- Chromium (Cr6+) (Figure 3) in river water is produced at 0.0016 to 0.0026 with a mean value of 0.0020 with a standard deviation value of 0.0004. Thus, the presence of Hexavalent Chromium (Cr6+) in river water can be concluded as belonging to Class I, II, III and IV, in which case the measurement of Chromium metal in this water can still be used. In the research area, river water is used for irrigation of rice fields and livestock.
- Cadmium (Cd) (Figure 5) in river water is produced at 0.0016 to 0.0028 with a mean and standard deviation value of 0.0023 and 0.005 respectively. Thus, the presence of chromium in river water is still in accordance with Class I, II, III and IV quality standards, in this case the measurement of cadmium metal is in accordance with quality standards. This river water can be used as irrigation for rice fields and livestock needs.
- Copper (Cu) (Figure 6) in river water produces 0.0017 to 0.0108 with mean and deviation values of 0.0071 and 0.0032 respectively. The presence of copper elements in river water concluded that it was still classified as below Class I, II, III and IV quality standards and could be used for water irrigation and for livestock.
- Lead (Pb) (Figure 2) in river water is produced at 0.0029 to 0.0070 with a mean and deviation value of 0.0048 and 0.0013 respectively. With the results of this analysis, it was concluded that the presence of Lead (Pb) in river water was still below the Class I, II, III and IV quality standards. In this case, river water can be used for agricultural and livestock irrigation.

Distribution of Heavy Metals in River Sediment

Sediment is a product of the disintegration and decomposition of rocks, disintegration includes all processes in which rocks that have been damaged become small grains without changes in chemical substance. Sedimentation is the process of deposition of rock material that is transported by water or wind. The water carries the material to rivers, lakes and to the sea. If the strength of the transport energy is reduced, the material is deposited at the bottom of the waters. Sediment not only reflects the quality of surface water, but also provides important information regarding the transport and fate of pollutants that enter a body of water. The metal content in sediment plays an important role in detecting the source of pollutant materials in the water system. Physical adsorption occurs when heavy metals are absorbed by particulate matter directly from the water column. Biological and chemical adsorption is a more complex process because it is controlled by many factors such as pH and oxidation. Heavy metals that settle in sediment are influenced by several parameters including pH, temperature and oxygen content. An increase in the pH and temperature of sea water will reduce the solubility of metals in water so that they will precipitate to form mud. Heavy metals that settle together with suspended solids will affect the quality of sediment at the bottom of the waters. The level of heavy metal pollution in river sediments was observed using metal parameters (mg/L), namely: Chromium (Cr), Chromium VI (Cr6+), Cadmium (Cd), Copper (Cu), Lead (Pb). Besides that, the following sediment quality standards are given:

Table 4. Sediment material quality standards

Us Environmental Protection Agency Quality Standards On River Sediments

Sediment Qulity Standart	**Elements**				
	Cr	**Cr6+**	**Cd**	**Cu**	**Pb**
Non-Polluted	<43	<43	<0.99	<0.025	<0.04
Modertely Polluted	43-76	43-76	0.99-3	0.025-0.05	0.04-0.06
Heavy Polluted	>76	>76	>3	>0.05	>0.06

From the observation results, descriptive statistics of heavy metal content for sediment in rivers are obtained as follows:

Table 5. Results of Primary Data Processing for Sedimentary Material in Rivers, 2023

Statistics	**Chromium (Cr)**	**Hexavalent Chromium (Cr6+))**	**Cadmium (Cd)**	**Copper(Cu)**	**Lead (Pb)**
Minimum	0.0053	0.0016	0.0016	0.0063	0.0029
Maximum	0.0118	0.0026	0.0028	0.0170	0.0070
Mean	0.0080	0.0020	0.0023	0.0096	0.0048
Standard Deviation	0.0026	0.0004	0.0005	0.0040	0.0013
Skewness	0.7671	0.7232	-0.4551	1.5240	0.4080
Kurtosis	-1.2566	0.0581	-1.7936	2.3428	1.5208

In this table, it can be explained that the content:

- Chromium (Cr) in river sediments was produced at 0.0053 to 0.0118 with a mean value of 0.0080 and a standard deviation of 0.0026. Thus, the presence of Chromium in River Sediment is concluded to be Non-Polluted.

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- Hexavalent Chromium (Cr6+) in River Sediment was obtained at 0.0016 to 0.0026 with a mean of 0.0020 and a standard deviation of 0.0004. Thus, the presence of Hexavalent Chromium in River Sediment is concluded to be Non-Polluted.
- Cadmium (Cd) in River Sediment was obtained at 0.0016 to 0.0028 with a mean and standard deviation of 0.0023 and 0.0005 respectively. Thus, the presence of Cadmium (Cd) in River Sediment is concluded to be Non-Polluted.
- Copper (Cu) in river sediments was obtained at 0.0063 to 0.0170 with a mean and standard deviation value of 0.0096 respectively. The presence of Copper (Cu) in River Sediment is concluded to be Non-Polluted.
- Lead (Pb) in River Sediment was obtained at 0.0029 to 0.0070 with a mean value of 0.0048 and a deviation value of 0.0048. Thus, the presence of Lead in River Sediment is concluded to be Non-Polluted.

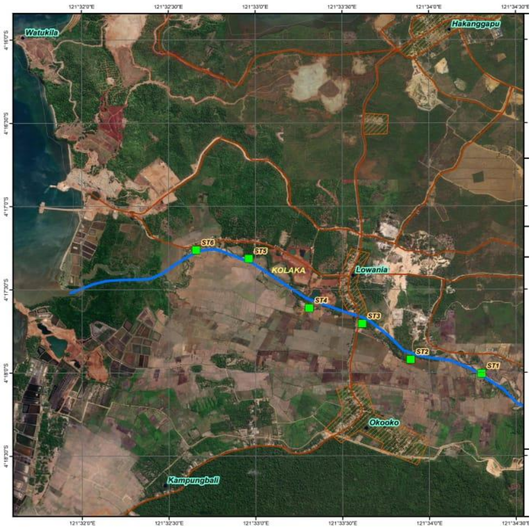

Figure 1. Map of Sampling Points

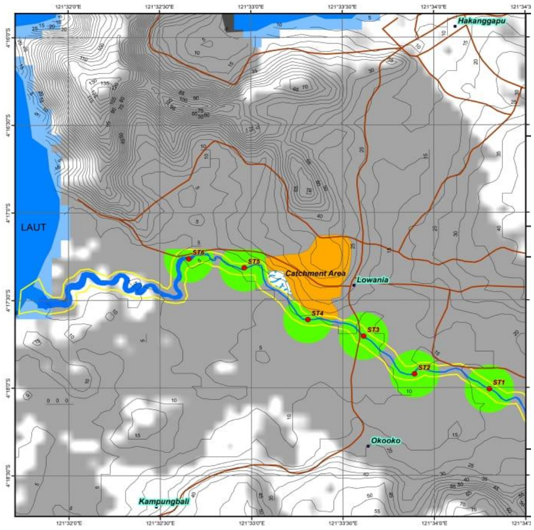

Figure 2. Distribution map of the heavy metal Pb in river water

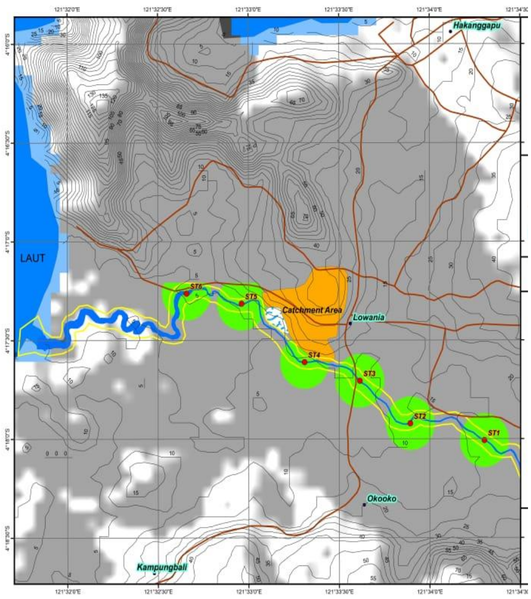

Figure 3. Distribution Map of the Heavy Metal Cr6+ in River Water

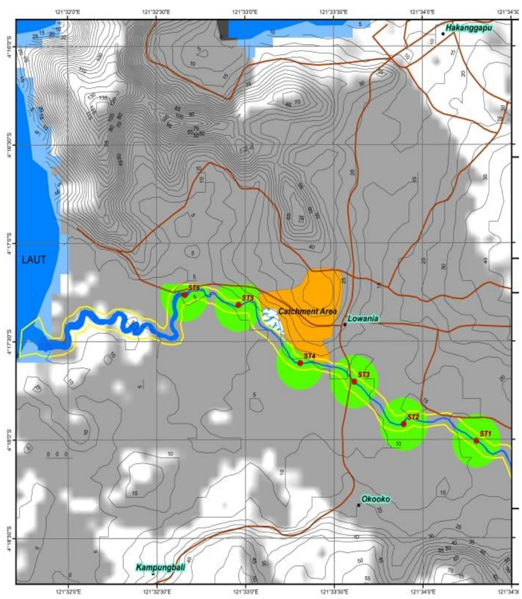

Figure 4. Distribution map of the heavy metal Cr in river water

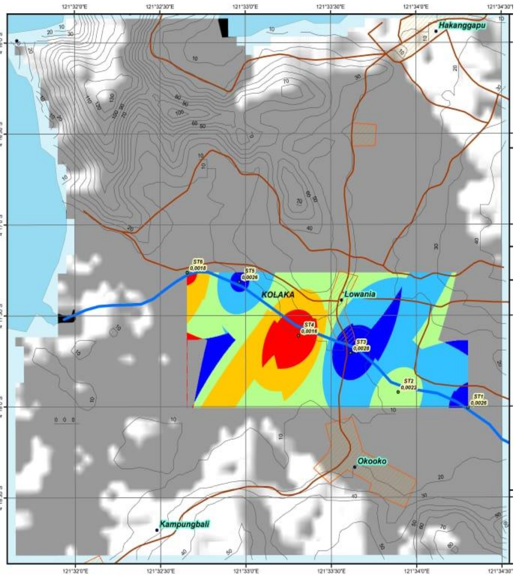

Figure 5. Distribution map of the heavy metal Cd in river water

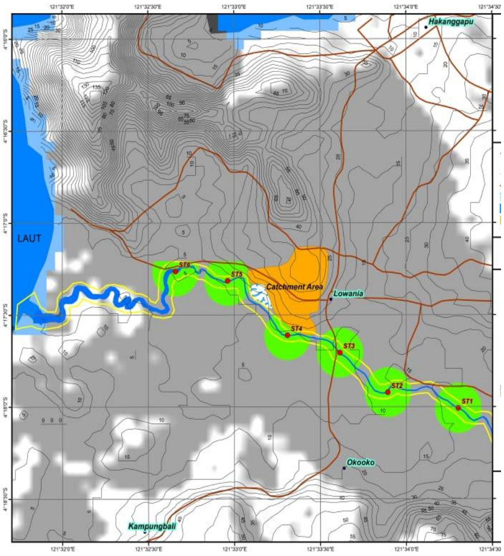

Figure 6. Distribution map of the heavy metal Cu in river water

CONCLUSION

Based on the results of data analysis carried out in this research, it can be concluded that the distribution of heavy metal pollution in river water is greatest in the heavy metal Copper (Cu), namely 0.0108 mg/l, which is found at station 3, the heavy metal lead (Pb) is 0.0070 mg/l found at station 4, the heavy metal chromium (Cr) which is 0.0038 found at station 6 downstream of the river, the heavy metal Cadmium (Cd) which is 0.0028 mg/l found at station 3, the heavy metal Hexavalent Chromium (Cr6+) which is 0.0026 mg /l is found at station 2. From the results of the analysis there are no heavy metals that exceed the quality standards (PP No. 82 of 2001). Meanwhile, in river sediment material, the largest production of the heavy metal Copper (Cu), namely 0.0229 mg/kg, is found at station 2, the heavy metal Cadmium (Cd), namely 0.0128 mg/kg, is found at station 5, the heavy metal Lead (Pb) is 0.0177 mg. /kg found at station 1 upstream of the river, the heavy metal Chromium (Cr), namely 0.0118 mg/kg, found at station 6 downstream, the heavy metal Hexavalent Chromium (Cr6+) namely 0.0116 mg/kg found at station 6 downstream. From the results of this analysis there were no heavy metals that exceeded quality standards (USEPA, 2003)

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