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Research Article

Feasibility study of concentration of chemical and physical parameters in excavated water coal mining as a cage fishing destination

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Keywords

Cages
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Abstract

A research was carried out on the feasibility of chemical and physical concentrations in coal mine excavation water for use in cage fisheries. This research aims to analyze the concentration conditions of chemical parameters (NH_3, pH, Cu and Fe) and physical parameters (DO, temperature and turbidity) in water originating from coal excavations which are already in the form of lakes. Samples were prepared before analysis by adding concentrated nitric acid. Analysis of Cu and Fe concentrations was carried out using an Atomic Absorption Spectrophotometer (AAS), ammonia using a UV-Vis Spectrophotometer, DO concentrations were analyzed using the titration method, turbidity analysis using a nephelometer, temperature using a thermometer and pH using a pH meter. From the research results, it was found that the physical parameters of lake water from former coal mine excavations were pH, temperature, DO, NH_3 and turbidity is suitable because it has not yet passed the quality standards for designation as a cage for cultivating freshwater fish. The concentration of the heavy metal Cu in coal excavation water has exceeded the quality standards set for cultivating freshwater fish and the metal concentration Fe has not exceeded the quality standards set. Research analysis of the average concentrations of heavy metals in water samples from former coal mining pools, namely Cu (0.166; 0.278; 0.284 mg/L), and Fe (0.020; 0.029; 0.023 mg/kg).

Introduction

East Kalimantan is a region that has quite large and high quality coal wealth. In 2021, the amount of coal in East Kalimantan will reach 294.252.801,68 tonnes (Badan Pusat Statistik, 2021). However, pollution activities are caused by mining, namely the existence of large holes that cannot be closed again causing water pools with very high acid content (Maluyu, 2022).

Former coal mine excavation ponds are artificial ponds formed as a result of activities from former coal mining that have not been rehabilitated (not backfilled). Excavated ponds receive special attention regarding the use of their water and disasters that may occur as a result of their management, because residual toxicity will affect the ecosystem within. Economically, the potential of the pond can be used as a source of raw water or as a place for fish cultivation. Pool water from former coal mines is acidic water which is dangerous for polluting the surrounding environment (Said and Yudo, 2021).

Tin head fish (*Aplocheilus* sp.), tempala (*Betta* sp.), cere (*Gambusia* sp.), seluang (*Rasbora* sp.), selinca (*Belontia* sp.), berenet (*Brevibora* sp.), mata tiga (*Oryzias* sp.), kemuring (*Puntius* sp.), betok (*Anabas* sp.) and swamp sepat (*Trichogaster* sp.) are types of fish that can be cultivated in calm waters, such as ponds or rivers. This fish can live evenin extreme environmental conditions because it is often found living normally in habitats where other types of freshwater fish cannot live (Kurniawan and Mustikasari, 2021).

Many ponds are produced by coal mining in East Kalimantan, especially in Kutai Kartanegara Regency. Some local people use these ponds as cage ponds. Therefore, based on information, observations and observations in the mining area, it is necessary to conduct a study to analyze the condition of chemical-physical parameters, whether based on concentration is still feasible or not suitable for use by the former coal mine excavation as a fishery cage compared to water quality standards according to Government Regulation No. 82 of 2001.

Based on this background, researchers need to examine the feasibility of whether the lake from a former coal mine excavation in Kertabuana Tenggarong Seberang village is suitable for use as a fishery cage in terms of physical parameters (pH, temperature and turbidity) based on Government Regulation no. 82 of 2001 and whether the lake from a former coal mine excavation in Kertabuana Tenggarong Seberang village is suitable for use as a fishery cage in terms of chemical parameters (pH, temperature and turbidity) according to Government Regulation no. 82 of 2001.

Method

This research uses quantitative descriptive methods within facts and characteristics object by systematic practice. The nature of the research object is made systematic, factual and accurate. The research is designed using field observation and followed by testing using laboratory analysis. This research will be carried out at the Analytical, Inorganic and Physical Chemistry Laboratory, FMIPA, Mulawarman University.

Tools and Materials

Tools used in this research are: pH Meter, Spectrophotometer atomic absorption, UV-Vis spectrophotometer, cuvette, 1500 mL bottle, beaker glass, Erlenmeyer, volume pipette, filter paper, analytical balance, Winkler bottle, burette and stative. The materials used in this research are: water samples, starch indicator, distilled water, potassium bi-iodidate, sulfuric acid, NaI, NaN_3, $MgSO_47H_2OH$, $Na_2S_2O_3.5H_2O$, amoium chloride, phenol, sodium nitrophuside, sodium hypochlorite, hydrochloric acid, sodium hydroxide, nitric acid.

Sampel Preparation

Samples containing iodine were preserved by adding 0.7 mL of H_2SO_4 and 1 mL NaN3in a Winkler bottle to pH 4-8. Then, the samples were stored in a 4°C cooler.

Making of the Solutions

Preparation of MgSO solution by dissolving 22.5 grams of $MgSO_4.7H_2O$ into distilled water and diluted to 1 L. The making of alkali-iodide-azide. Alkali-iodide-azide solution are dissolved separately in ± 100 mL of distilled water, 500 grams of NaOH (or 700 grams of KOH), 135 grams of NaI (or 150 grams of KI) and 10 grams of NaN_3; mixed in a 1 L measuring flask, diluted with distilled water to 1 L and cooled. The making of starch indicator. 0.5% starch indicator (starch) is made by dissolving 5 grams of starch in a measuring flask containing distilled water and diluted to 1 L. This solution then let boiled for 2 minutes until the solution is clear, then cooled and preserved with 1.52 grams of salicylic acid to avoid the forming of molds. The making of 6 N sulfuric acid. 42.5 mL of concentrated sulfuric acid is mixed into distilled water to a volume of 250 mL. Preparation of 0.025 N thiosulfate solution. 6.205 grams of $Na_2S_2O_3.5H_2O$ is weighed in a measuring flask with boiled distilled water. 1.5 mL of 6 N NaOH or 0.4 grams of NaOH was added and diluted to 1 L. Standardization was carried out with potassium bi- iodate solution.

Determination of pH (SNI 06-6989-2004)

Dry the sample with tissue paper, then rinse the electrode with distilled water and dry with tissue. Dip the electrode into the sample for ± 1 minute until the pH-meter shows a steady reading. Note the results of the scale reading or numbers on the display of the pH-Meter.

Temperature Measurement

Temperature measurements are carried out by dipping the thermometer into the water for ± (5-10) seconds, then remove the thermometer from the water, then note down the temperature printed on the tool.

DO Analysis (SNI 06-6989.14-2004)

To the sample that was already in the Winkler bottle, 1 mL of manganese sulfate solution was added with a pipette below the surface of the liquid. Then 1 mL of alkali- iodide-azide solution was added with another pipette. The bottle was closed again carefully to prevent trapping air from the outside, then shaken by turning the bottle upside down several times. Allow the lump to settle for ± 10 minutes. Then 1 mL of H was added $2SO_4$ concentrated, in the solution in the Winkler bottle, then the bottle is immediately closed again. The bottle is shaken carefully so that all the sediment dissolves. Pipette 50 mL, put it in a 150 mL Erlenmeyer flask. Then titrated with 0.025 N thiosulfate solution so that the color changes to light yellow. Then add 4 – 6 drops of starch indicator (a blue color will appear). Titration with thiosulfate is continued, until the blue color disappears and the solution becomes clear.

Ammonia Analysis (SNI 06-6989.30-2005)
Pipette 25 mL of the test sample then place it in a 50 mL erlemeyer; Add 1 mL of phenol working solution and homogenize; Add 1 mL of sodium nitroprusside and homogenize; Add 2.5 mL of oxidizing solution and homogenize; Cover the Erlemeyer with plastic or paraffin film; Leave for 1 hour for color formation; Put it in a cuvette on a spectrometer, read and record the absorption at a wavelength of 640 nm.

Turbidity Analysis
Wash the nephelometer tube with distilled water.Shake the sample and put the sample into the tube on the nephelometer, put on the lid.Let the tool show a stable reading value. Record the observed sample turbidity value.

Iron Analysis (SNI 6989.4.2009)
The test sample that has been shaken until homogeneous is placed in 10 mL into a 50 mL volumetric flask, then diluted with distilled water to the tera mark. Optimize the SSA tool according to the tool usage instructions. Measure each working solution that has been made in length wave 248.3 nm. Create a calibration curve to obtain the regression line equation. Continue with measurements of the prepared test samples.

Copper Analysis (SNI 6989.6.2009)
The test sample that has been shaken until homogeneous is placed in 10 mL into a 50 mL volumetric flask, then diluted with distilled water to the tera mark. Optimize the SSA tool according to the instructions for using the tool. Measure each working solution that has been made at a wavelength of 324.8 nm. Create a calibration curve to obtain the regression line equation. Continue with measurements of the prepared test samples.

Results and Discussion

Water samples sourced from 3 locations in hot conditions and rainy conditions. Excavated coal mines in Samarinda Seberang undergo water quality analysis in the laboratory. The chemical parameters analyzed are Ammonia, Fe, Cu and the physical parameters are DO and turbidity. Meanwhile, pH and temperature were analyzed in the field (in situ) when samples of pool water from former coal mine excavations were taken. From 3 locations, water from former coal mining pools was taken at 5 sampling points at each location (Table 1 and Table 2).

Table 1. Water quality parameters and heavy metal concentrations in Ex-mining pools coal (hot condition)

Sample point	pH	Temp	DO (mg/l)	Ammonia (mg/l)	Turbidity (NTU)	Metal concentration (mg/l)*	
						Fe	Cu
1.1	8.1	30	4.72	0.0178	13.53	0.027	0.18
1.2	8.2	30	3.65	0.0186	14.57	0.028	0.16
1.3	8.1	30	4.67	0.0178	13.33	0.029	0.18
1.4	8.3	30	4.50	0.0171	13.24	0.028	0.15
1.5	8.2	30	4.29	0.0193	14.27	0.027	0.15
2.1	8.2	30	4.06	0.0164	11.72	0.030	0.27
2.2	8.2	30	4.17	0.0171	12.56	0.028	0.29
2.3	8.2	30	3.93	0.0164	11.22	0.029	0.28
2.4	8.3	30	4.93	0.0164	11.18	0.029	0.21
2.5	8.3	30	4.69	0.0157	12.87	0.028	0.28
3.1	8.1	30	3.84	0.0164	12.56	0.027	0.30
3.2	8.2	30	4.55	0.0178	11.68	0.028	0.26
3.3	8.2	30	3.98	0.0193	12.34	0.029	0.26
3.4	8.2	30	4.33	0.0171	10.45	0.029	0.27
3.5	8.2	30	3.92	0.0186	12.44	0.030	0.28

Table 2. Water quality parameters and heavy metal concentrations in Ex-mining pools coal (rain conditions)

Sample point	pH	Temp.	DO (mg/l)	Ammonia (mg/l)	Turbidity (NTU)	Metal concentration (mg/l)*	
						Fe	Cu
1.1	8.0	28	5.23	0.0142	15.74	0.022	0.12
1.2	8.0	28	4.75	0.0150	16.76	0.023	0.12
1.3	7.9	27	5.26	0.0135	14.93	0.020	0.18
1.4	8.1	28	5.50	0.0121	14.74	0.022	0.12
1.5	8.0	27	5.23	0.0135	15.27	0.023	0.12
2.1	7.8	27	5.26	0.0135	12.05	0.026	0.20
2.2	7.9	28	5.19	0.0128	13.52	0.030	0.19
2.3	8.0	28	5.02	0.0142	12.45	0.023	0.21
2.4	8.0	27	5.53	0.0135	12.32	0.019	0.18
2.5	7.9	28	5.39	0.0135	13.45	0.020	0.21
3.1	7.8	27	4.84	0.0135	13.71	0.020	0.21
3.2	7.8	28	5.33	0.0142	12.25	0.021	0.20
3.3	7.9	28	5.08	0.0128	13.45	0.020	0.21
3.4	8.0	28	5.83	0.0135	11.45	0.019	0.20
3.5	7.9	28	5.12	0.0186	13.56	0.020	0.19

Determination of pH

The degree of acidity (pH) is a very important parameter for fisheries use. On average, the pH is still a good condition for the life and growth of fish, because the pH value during hot conditions and rainy conditions is still between pH 6.5 to 8.5 (Fig.-1). If the pH is below 6.5 or above 8.5, fish growth will decrease (Tamam and Aji, 2022). The degree of acidity (pH) can affect the heavy metal content in waters, where the solubility of heavy metals will be higher at low pH, thus causing greater heavy metal toxicity.

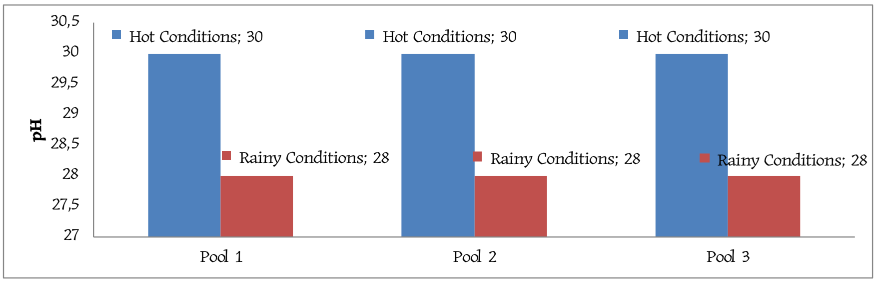

Fig.-1. pH value in hot and rainy conditions

According to PP. R.I. No. 82 of 2001 for cultivating freshwater fish the recommended pH range is 6-9. Based on pH analysis from 3 locations, water sampling ponds in hot and rainy weather from former coal excavations are still very suitable for fish cultivation cages. There is a slight change in pH in hot and rainy conditions, this is natural and is the result of increasing water discharge and volume or the presence of water flow. At the time of sampling, the weather conditions were rainy, so the pH of the water tended to be neutral or alkaline. Meanwhile, when the sample was taken, the weather conditions were hot, the pH of the water was alkaline because there was still a lot of water discharge.

Temperature Measurement

Based on the quality standards of Government Regulation No. 82 of 2001 for Fisheries, the optimal temperature for cultivating freshwater fish is 25°C. The average water temperature measurements sourced from 3 former coal mine excavation locations, both in hot temperatures and rainy conditions, are still in accordance with quality standards so that they are still good for use as fish cage ponds. These temperature conditions have a big influence on the life and growth of aquatic biota. Temperature is a physical parameter that plays a role in controlling the ecological conditions of waters. Changes in temperature generally affect the physical, chemical and biological processes of the water column. Water temperature is also an important factor that can influence the survival of aquatic organisms (Syahrul et al., 2021; Prasasti et al., 2021). Water temperature affects the solubility process of heavy metals that enter the water. In this case, the higher the water temperature, the higher the solubility of heavy metals (Fig.-2).

Water temperature has a very big influence on the process of substance exchange or fish metabolism. Apart from influencing the process of exchanging substances, temperature also influences the levels of oxygen dissolved in water. The higher the temperature of a body of water, the faster the water will become saturated with oxygen (Patty, 2018). Dissolved oxygen or also called Dissolved Oxygen (DO) is needed by all living

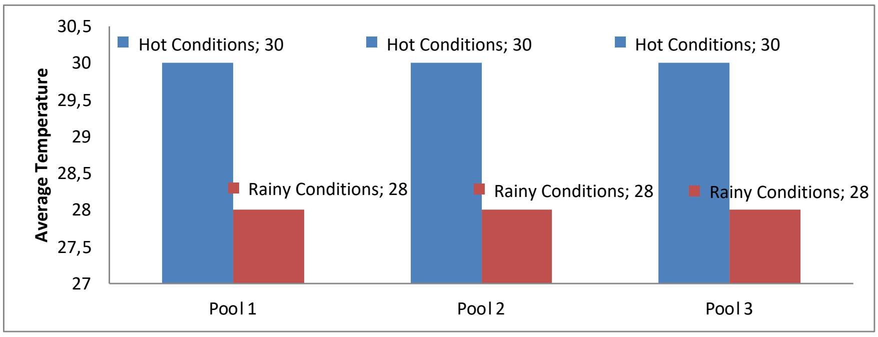

Fig.-2. Temperature values in hot and rainy conditions

creatures on earth for the respiratory process, producing energy through the exchange of substances in the growth and reproduction process. Apart from that, oxygen is also needed for combustion with oxygen in organic plants and aerobic processes in inorganic plants (Yuliantari et al. 2021).

DO Analysis

The oxygen content can decrease due to the respiration of organisms in the water and the breakdown of organic material. Cloudy weather and no wind can reduce the oxygen content in the water (Fig.-3).

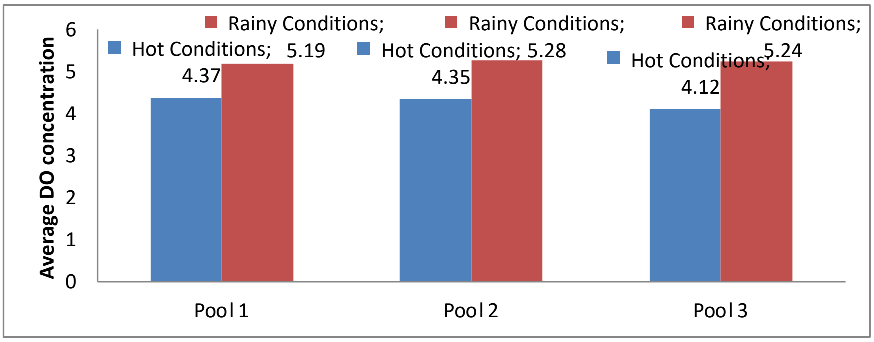

Fig.-3. DO value in hot and rainy conditions

The results of the analysis of the average DO concentration in 3 locations of ex-coal mining cage ponds in hot conditions turned out to be poor when compared with fish cultivation standards because they were still below the average concentration of 5 to 7 ppm. In weather conditions, the average rain in the 3 former coal mining cage ponds is above 5 ppm in accordance with the PP. R.I. No. 82 of 2001 for fish cultivation is classified as good. Waters contain 5 ppm oxygen at a temperature of 20C to 30C is still seen as water that is good enough for fish life (Patty, 2018)

From the measurement results, it was found that the DO value was greater in rainy conditions, this is because oxygen is a gas, so its solubility depends on temperature, if the temperature is low, more oxygen will be dissolved, whereas if the temperature is high the oxygen will be difficult to dissolve so the oxygen will evaporate by hot. Water temperature has a very big influence on the process of substance exchange or fish metabolism. Apart from influencing the process of exchanging substances, temperature also influences the levels of dissolved oxygen in the water. The higher the temperature of a body of water, the faster the water will become saturated with oxygen. The following is the relationship between temperature and the dissolved oxygen content in the water (Mubarak et al., 2010).

Ammonia Analysis

Ammonia (NH_3) is an important parameter in fisheries cultivation, the presence of ammonia is the breakdown of amino acids by various types of aerobic and anaerobic bacteria, the main source of which is food waste and decomposing grass, thus producing nitrate, so the water is said to be polluted. The graph can be seen in Fig.-4.

Analysis of the ammonia concentration of 3 ex-mining cage ponds in hot conditions is still below the threshold, so this condition is still very feasible to make these former coal mining cages into fishing cage ponds. According to PP. R.I. No. 82 of 2001 for cultivating freshwater fish the recommended range of ammonia does not exceed 0.02 mg/L. According to Wahyuningsih and Gitarama (2020) hat dissolved ammonia which is

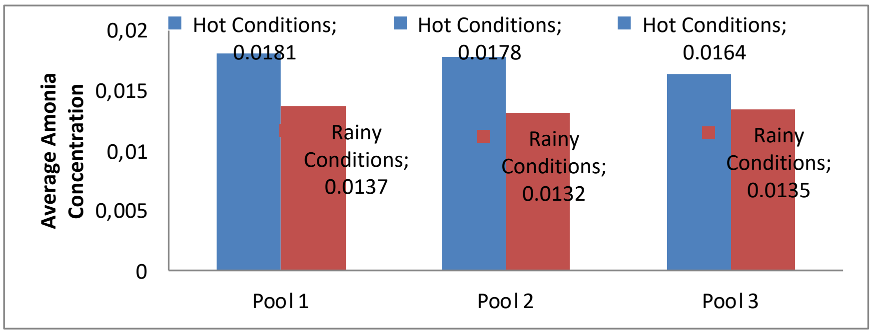

Fig.-4. Ammonia concentration in hot and rainy conditions

good for fish survival is less than I mg/L. Ammonia can affect the growth of fish and other aquatic organism (Wahyuningsih and Gitarama, 2020). That low ammonia levels are good for fish, but ammonia levels of 2 to 7 ppm can kill several types of fish.

Turbidity Analysis

The turbidity of waters is closely related to the total suspended solid (TSS) value because turbidity in waters is caused by the presence of suspended solids. The graph can be seen in (Fig.-5).

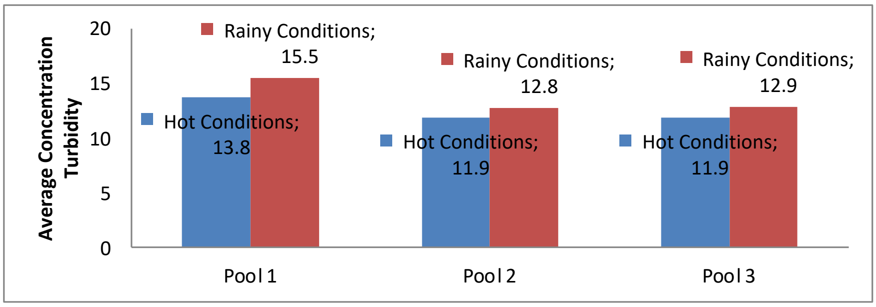

Fig.-5. Turbidity value in hot and rainy conditions

Measurement of the turbidity value of 3 cage ponds from former coal mines in hot conditions and in rainy weather according to PP. R.I. No. 82 of 2001 for cultivating freshwater fish, the recommended range of turbidity values is not to exceed 30 NTU and is recommended to be less than 5 NTU. Turbidity in rainy conditions is higher because when it rains solid particles such as mud mix with water, causing an increase in the turbidity value compared to during hot conditions. The turbidity value is also influenced by the flow of water entering the pond, because the sampling pond is located under a mountain, causing rainwater that falls to flow carrying particles or mud around the pond, causing the pond to experience turbidity.

According to (Sinaga et al. 2020) the influence of strong currents in waters carries and stirs up particles in the water, causing turbidity and having an impact on marine ecosystems and the biota within them, thus reducing the ability of fish and other aquatic organisms to obtain food, reduces photosynthesis of aquatic plants, fish food becomes covered in mud, fish and shellfish gills are covered by sediment and accumulate toxic materials such as metal compounds.

Iron Analysis

The high concentration of Fe in water causes the color of the water to change to brownish yellow after contact with air. This color change event is very common in mining areas and this condition indicates that the acid mine water at the mining activity location is high or what is generally known is that the pH around the mining waters is acidic (Fig.-6).

The average value of the heavy metal Fe concentration at each sample point in the ex-mining cage pondwater at the three locations, both in hot and rainy conditions, still does not exceed the standards set by the PP.R.I. No. 82 of 2001 for freshwater fish cultivation at 0.3 ppm. The concentration of the heavy metal Fe in rainy conditions is lower than in hot conditions, this is due to the reduction process occurring with the addition of rainwater (Hidayah et al., 2019).

The presence of Fe metal in cage ponds from former coal mines most likely comes from acid mine water and coal leaching. According to Azwari (2020) one of the bad impacts is pollution with the causative element

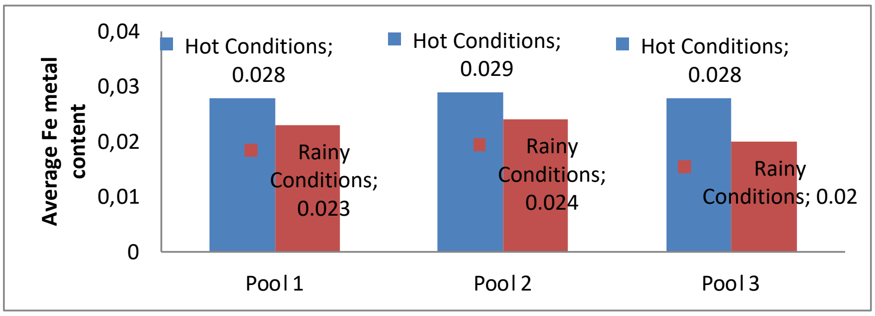

Fig.-6. Fe metal levels in hot and rainy conditions

namely acid mine water (AAT) which contains iron sulfur, such as pyrite (FeS_2) and pyrotite (FeS) which can pollute surface water and water land, disrupting the life of flora and fauna and the health of surrounding communities and is in accordance with the results of research conducted by the Research and Development Center for Mineral and Coal Technology where liquid waste from coal washing generally contains various types of heavy metals including iron (Fe), copper (Cu), lead (Pb) and zinc (Zn). These metals can come from overburden stripping activities and processing processes.

The Research and Development Center for Mineral and Coal Technology where liquid waste comes from coal washing generally contain various types of heavy metals, including iron (Fe), copper (Cu), lead (Pb) and zinc (Zn). These metals can come from overburden stripping activities and processing processes.

Copper Analysis

The content of the heavy metal Cu in waters, apart from its natural presence in these waters, is also inseparable from human activities around coal excavation which results in ponds full of water so that they are shaped like lakes. From Tables 1 and Table 2, a comparative graph of Cu metal content from several sampling location points is made in Fig.-7.

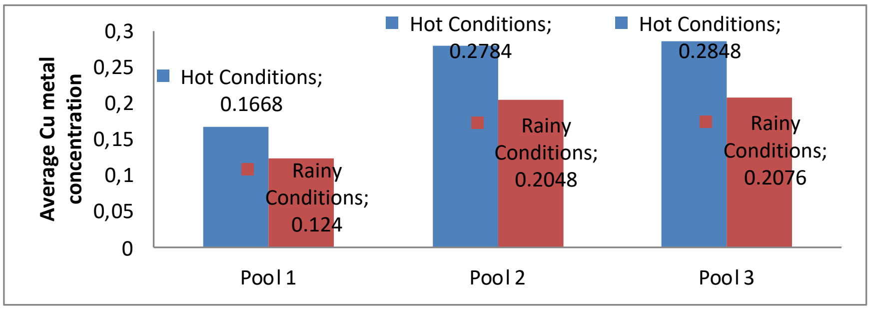

Fig.-7. Cu metal levels in hot and rainy conditions

The average content of the heavy metal Cu in hot conditions and rainy conditions from each location of water sample points from former coal mine excavations has apparently exceeded PP. R.I. No. 82 of 2001 for freshwater fish cultivation at 0.02 ppm. From this concentration provision, the former coal mine excavation in the form of a lake is not suitable for use as a fishery cage. Several factors such as rain, tides, waves and currents. According to (Pratiwi et al. 2019) heavy metals including copper in water can accumulate in the bodies of aquatic organisms such as fish directly through the gills and skin. If aquatic organisms such as fish that contain copper are consumed by humans, the copper will also enter the human body and have an impact on health. The presence of Cu metal content in the water of ex-coal mining pools is likely that the ex-mining pool stillcontains water from coal washing, disposal of used batteries and comes from overburden stripping activities and accumulation of rock fragments.

Conclusion

Based on the physical parameters (pH, temperature and turbidity) of the former coal mine pond water, it can be concluded that the 3 former coal mine ponds are suitable for use for cultivating freshwater fisheries where the above results are still below the minimum limit specified in the PP. R.I. No. 82 of 2001. Based on the chemical parameters (DO, Ammonia, Fe and Cu) of the former coal mine pond water, it can be concluded that the 3 former coal mine ponds are suitable for use for cultivating freshwater fisheries where the results above are still below the minimum limit set in PP. R.I. No. 82 of 2001 with Cu metal content values above the minimum limit set with an average of 0.2 mg/L.

Conflict of Interests

The author (s) declares that there is no conflict of interest in this research and manuscript.

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