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Analysis of Physical and Chemical Properties of Void Water Post Coal Mining Relationship With Aquaculture

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Abstract

Identification of the quality of void water after coal mining needs to be carried out in order to utilize the void as a place for fish farming. Identification of water quality, in the form of physical and chemical water. Physical and chemical parameters can influence the survival of cultivated biota, so research needs to be carried out to identify both physical and chemical water parameters related to aquaculture. The research method involves taking and measuring water samples in both in situ and ex situ settings. Measurements were carried out at three (3) sampling points, sampling four times. The parameters under observation include temperature, TSS (Total Suspended Solids), pH, brightness, dissolved oxygen (O_2), biological oxygen demand (BOD), chemical oxygen demand (COD), nitrate (NO_3), nitrite (NO_2), ammonia (NH3), and hydrogen sulfide (H_2S). A descriptive analysis of water quality is conducted, and the results are compared against the quality standards outlined in the Provincial Regulations of East Kalimantan, specifically, Number 2 of 2011, which pertains to Water Quality Management and Water Pollution Control (APPENDIX V, Class III). The results of the water quality analysis physically show that the temperature is 29.5 –31ºC brightness 135 – 285 Cm, TSS 13.75 – 27.5 mg/L, Chemical pH 7.42 – 7.68, O2 4.26 – 4.84 mg/L, BOD 0.64 – 1.84 mg/ L, COD 2.96 – 5.93 mg/L, NO3 0.026 – 0.049 mg/L, NO2 0.002 – 0.006 mg/L, NH3 0.01 – 0.13 mg/L and H2S 0 – 0.0087 mg/ L. Both the physical and chemical water quality parameters conform to the standards established in the East Kalimantan Province Regional Regulation Number 2 of 2011, which focuses on Water Quality Management and Water Pollution Control. As a result, the post-coal mining void water's condition, in both physical and chemical aspects, remains suitable for aquaculture.

Keywords: Aquaculture, Coal, Void, Water Quality,.

INTRODUCTION

Aquaculture is the practice of breeding and maintaining aquatic life, aiming to increase their population and promote their growth while minimizing mortality. This cultivation can be achieved using various environments, including voids or post-coal mining ponds. Post-coal mining voids can be used for aquaculture with the condition that the quality and quantity of the waters are suitable for the life of aquatic biota, especially fish. Utilizing voids for aquaculture is one way to transform unproductive land into a productive asset. Post-coal mining sensitive voids face specific challenges, particularly related to water quality. The primary concern is acid mine drainage resulting from exposure to sulfate compounds and iron ions, which can significantly impact the aquatic biota that we intend to cultivate. According to Yusmur et al (2019), water conditions characterized by low acidity and high heavy metal content can have a profound effect on fish life.

The life of fish is greatly influenced by water quality. The use of waters as a medium for raising aquatic biota must be suitable for the life of aquatic organisms, especially the aquatic biota that will be cultivated. During the maintenance process, aquatic biota, such as fish, require water conditions that support their health and normal, optimal growth. Maintaining suitable water conditions is crucial to maximize the growth and survival of fish.

Fish rearing in post-coal mining voids uses cages as a rearing medium. Keramba is a traditional place for keeping and cultivating fish. In post-coal mining voids, fish cultivators usually use these voids as land for fish farming with a cage system. The maintenance of fish with the cage system often occurs with problems, including continuous administration of lime, excessive feeding, which will cause problems with the condition of the waters, both physically and chemically. In the end, it affects the continuity of aquatic biota maintained in former coal mining voids. Another impact that occurs is the mass death of cultivated fish due to the accumulation of organic matter at the bottom of the pond or on the surface (Triyanto et al., 2005).

Aquaculture activities in post-coal mining voids require the identification of physical and chemical properties. Farmed fish depend on proper water quality for their well-being and health. The physical and chemical quality parameters include temperature, clarity, Total Suspended Solids (TSS), pH, oxygen (O_2) levels, Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), ammonia, nitrate (NO_3), nitrite, and hydrogen sulfide (H2S) (Local Regulation of East Kalimantan, 2011; Governor's Regulation, 2017). Based on this explanation, research has been conducted in post-coal mining voids to identify the physical and chemical water conditions relevant to aquaculture processes. The aim of the research is to identify physical water quality (temperature, TSS, brightness), chemical (pH, O_2, BOD, COD, NO_3, NO_2, NH_3, H_2S) and to analyze water quality in relation to aquaculture.

RESEARCH METHODS

The tools and materials used in this research include: water samples taken from post-coal mining voids, phenolphthalein indicator, Na_2CO_3 solution, phenate reagent, $MnSO_4$, and chlorox, EDTA solution and Eriochrome Black T (EBT) indicator, phenoldisulfonic solution and NaOH 20 %, NED and Sulfanilamide solution, H2SO4 solution, 0.05 $NK_2Cr_2O_2$ solution, ferroin indicator, and Ferrous Ammonia Sulfate (FAS), MnSO4, NaOH + Kl, H2SO4, amylum, and 0.025N $Na_2S_2O_3$, Aquades, thermometer, DO meter, Secchi disk, pH meter, spectrophotometer, meter, filter paper, oven, Erlenmeyer, analytical balance, tweezers, measuring cup, vacuum pump, measuring pipette, filler pipette, spray bottle, dropper pipette, test tube and glass beaker, plastic and rubber as cover, sample bottle.

Surveys and determining the location of sampling points were carried out at the beginning of the research implementation. The selection of sampling points employed a purposive sampling method, which considered the water sampling points based on the specific conditions at the location, namely the voids left after coal mining, which were intended for aquaculture. The sampling points were designated as follows: at the edge of the cage inlet (sampling point 1), at the edge of the cage outlet (sampling point 2), and at the central location of the cage (sampling point 3), which is in close proximity to the community. Sampling activities were conducted in the morning.

Water sampling at predetermined locations and points using sample bottles for later analysis in the laboratory, especially for water quality parameters that cannot be measured in situ. Sampling was carried out once a week with four (4) sampling times.Sampling and sample measurement were carried out by two methods, both directly on site (in situ) and in the laboratory (ex situ). Several parameters were analyzed in the field (in situ), namely brightness, temperature (T), dissolved oxygen (O_2), pH and carbon dioxide (CO_2), while the parameters measured ex situ were TSS (Total Suspended Solid), BOD (Biological Oxygen Demand), COD (Chemical Oxygen Demand), Ammonia, Nitrate, Nitrite, sulfide acid. Sampling and analysis of water quality parameters was carried out in the morning. Sampling was carried out four (4) times. For the purpose of descriptive water quality analysis, the quality standard used is the Regional Regulation of East Kalimantan (Perda No. 02 of 2011) Concerning Water Quality Management and Water Pollution Control, Appendix V, class III.

RESULTS AND DISCUSSION

The quality of water can be assessed through both physical and chemical parameters. Physical parameters include temperature, brightness, and TSS, while chemical parameters include dissolved oxygen, pH, BOD, COD, nitrate, nitrite, ammonia, hydrogen sulfide.

Temperature

Water temperature is the physical condition of waters that can influence production in aquaculture businesses. The pattern of temperature changes will have an impact on the behavior of the biota that is maintained (cultivated), both the growth and survival rate of the biota (Muarif, 2016). The results of temperature measurements in post-coal mining voids can be seen in Figure 1.

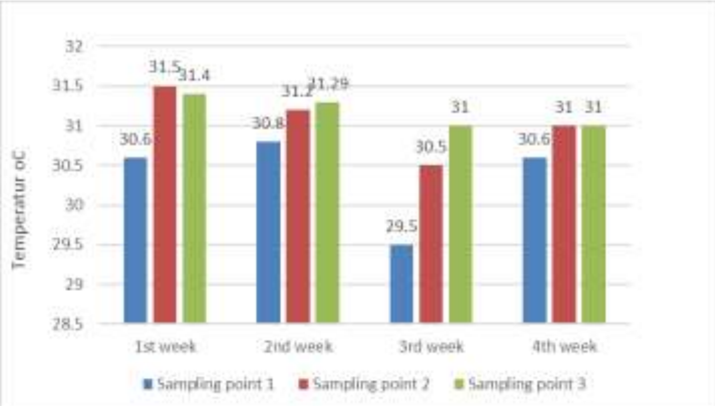

Figure 1. Analysis of temperature measurements (^{o}C) at the sampling location

Figure 1 showed the temperature range at the sampling location was 29.5 ^{o}C – 31.5^{o}C. The highest temperature was 31.5^{o}C at sampling location 2 in 1st week and the lowest temperature at sampling location 1 was 29.5^{o}C in sampling 3rd week. The temperature range at each location and also each week is still within the normal temperature. The range of water temperatures during the study did not show large differences (<30^{o}C). The temperature at the side location is still in accordance with class III water quality standards in Appendix V according to East Kalimantan Regional Regulation No. 02 of 2011. Water temperatures in the range of 25-32 ^{o}C are still suitable for aquaculture (Bolorunduro & Abdullah, 1996). According to Cholik et al., (1986), tropical fish thrive in temperatures ranging from 25 to 32°C, and these temperatures are commonly found in Indonesia. This makes it highly advantageous for fish farming businesses in the region.

Brightness

The brightness of a body of water is influenced by the color of the water, the level of turbidity, the depth of the water and the weather conditions. The results of brightness measurements at the sampling location (post-coal mining voids) can be seen in Figure 2.

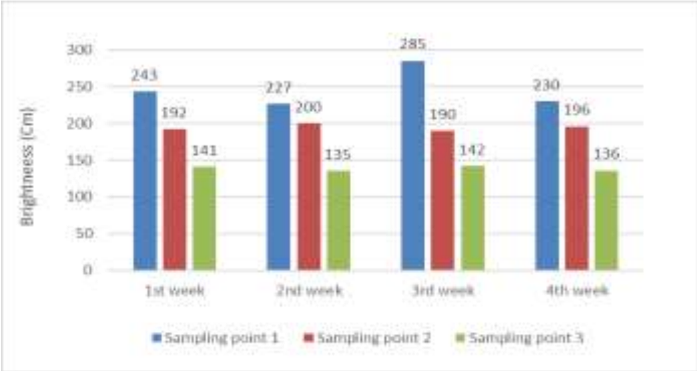

Figure 2. Analysis of brightness measurements (Cm) at the sampling location

Figure 2 displays brightness levels ranging from 135 cm to 285 cm. The highest recorded brightness was observed at sampling location 1 during the third week, while the lowest occurred at sampling location 3 in the second week. The elevated brightness at the former location can be attributed to the measurements being conducted during sunny weather conditions.

The brightness conditions of a body of water for fish that live in freshwater range from 25 – 40 cm (Ahmad & Rahmaningsih, 2018). Brightness is influenced by the color of the water, the darker the color of the water, the more cloudy it will be (Boyd C.E., 1990). Meanwhile, according to Ariawan & Poniran, (2004), brightness of more than 35 cm is classified as not good, there is an assumption that there is a decrease in the amount of plankton, which causes the water to become more transparent. This can affect farmed fish, because plankton in the water is a natural food for farmed fish and wild fish in the post-mining ponds, so that water quality conditions like this can inhibit the growth of fish life.

As per Mujiman (1986) cited in (Saptono & Minggawati, 2012), the brightness level of water that indicates excellent water quality suitable for aquaculture typically falls within the range of 15 to 25 cm. The brightness of a water body is inversely proportional to the abundance of phytoplankton. In simpler terms, high phytoplankton abundance results in low water brightness, and conversely, low phytoplankton abundance leads to high water brightness.

Total Suspended Solid (TSS)

Total Suspended Solids (TSS) are suspended solids consisting of microorganisms, mud, fine sand. The results of measuring total suspended solids at the sampling location (void after coal mining) are seen in Figure 3.

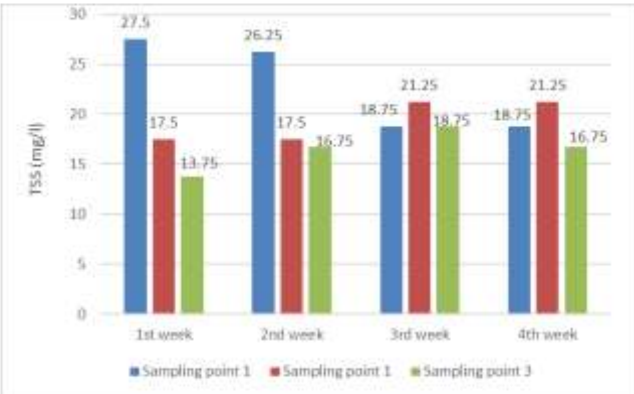

Figure 3. Analysis of TSS (mg/L) at the sampling location

Figure 3 shows the TSS analysis results, which fall within the range of 13.75 – 27.5 mg/L. The highest value is observed at sampling location 1, while the lowest value is at sampling location 3. According to Huda (2009) *in* Agustira et al., (2013), dissolved solids have a negative impact on water quality because they will inhibit the penetration of light in water bodies, and will inhibit the photosynthetic process which affects growth, especially producers. Effendi, (2003) suggests that total suspended solids for businesses in the fisheries sector are in the range of 25 – 80 mg/L). According to the quality standards for East Kalimantan Province Regional Regulations (Perda No. 02 of 2011) Appendix V Class III, the TSS standard is 400 mg/L. Aisyah & Luki, (2012) emphasize that high dissolved solids can negatively affect cultivated fish, including health issues (disease), growth inhibition, change in behavior, and decreased fish reproduction. Fortunately, the TSS value at the sampling location is still suitable for aquaculture.

Degree of Acidity (pH)

The degree of acidity of water or pH of water is the activity of hydrogen ions in a solution which is expressed as the concentration of hydrogen ions. The degree of acidity of water can provide an overview of the balance of acids and bases which is absolutely determined by the concentration of hydrogen ions (H+) in the water. The degree of acidity is very important in determining the use-value of waters for the life of organisms, and the acidity of the water is also affected by photosynthetic activity, the presence of anionic cations (Siburian et al., 2017).

Analysis of the degree of acidity at the sampling location (post-coal mining voids) is shown in Figure 4.

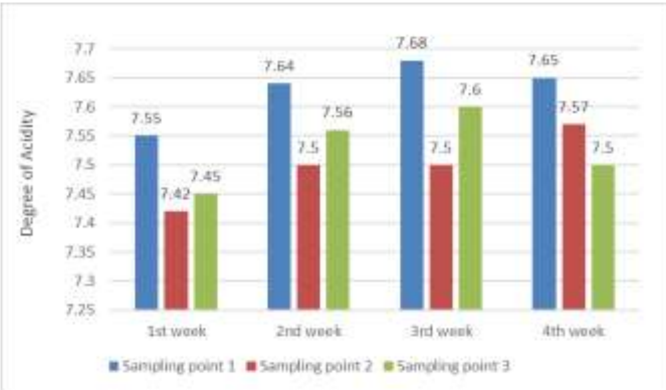

Figure 4. Analysis of the degree of acidity (pH) of water at the sampling location

The results of the acidity degree analysis in Figure 4 indicate a pH range of 7.42 –7.68, with the highest pH value recorded at sampling location 1 and the lowest at sampling location 2. Cholik *et al*. (1986) stated that the pH of pond water is in the range of 6.5 -9.0, whereas according to (Huet, 1971) a good pH range for aquaculture businesses is a pH between 7.0 - 8.0. BM standard (quality standard) Regional Regulation of East Kalimantan Province Number 2 of 2011 Attachment. V Class III is pH 6-9. The pH range at all sampling points includes conditions that are still suitable for aquaculture (cultivation). A pH value in the range of 4.0 - 6.5 can hinder fish growth, whereas a pH value below 4 or exceeding 11 is considered an extremely acidic or alkaline condition that can be lethal to organisms (Swingle, 1968, as cited in Arinardi, 1997).

Dissolved Oksigen (DO)

Dissolved oxygen (DO) is very important in the process of breathing organisms that live in waters. It also affects the process of metabolism or exchange of substances that will produce energy for breeding and growth. Dissolved oxygen will affect the process of oxidation of organic and inorganic materials (Salmin, 2005).

The results of the analysis of oxygen content in the waters at the sampling location (post-coal mining voids) are shown in Figure 5.

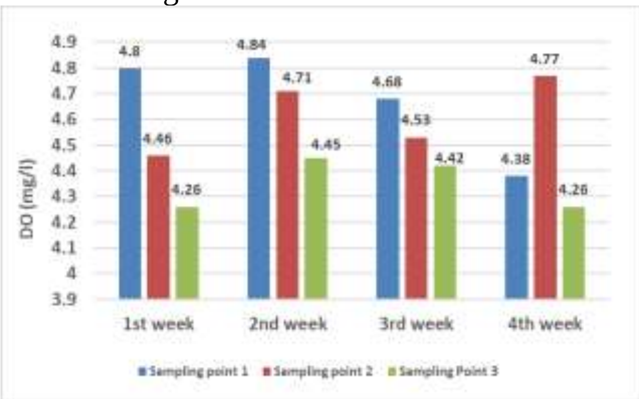

Figure 5. Dissolved oxygen analysis (mg/L) at the sampling location

Figure 5 showed that the oxygen (O_2) concentration in waters was 4.26 – 4.84 mg/L, the highest oxygen is at sampling location 1 and the lowest is at sampling location 3. According to Barus (2001) *in* Pratiwi et al., (2015), The range of dissolved oxygen that is good for plankton growth is >3 mg/L. According to Wardhana, (1995), a dissolved oxygen value of at least 2 mg/L can support the normal life of organisms in waters. The ideal dissolved oxygen value is not less than 1.7 mg/L for 8 hours and the saturation value is 70% (Huet, 1971). East Kalimantan Regional Regulation BM Standard Number 2 of 2011 Appendix V Class III is 3 mg/L.

***Biochemical Oxygen Demand* (BOD)**

The amount of dissolved oxygen needed by organisms is usually called BOD (Biochemical Oxygen Demand) which is used to decompose organic matter in waters. The results of BOD measurements in the waters at the sampling location (void after coal mining) are seen in Figure 6.

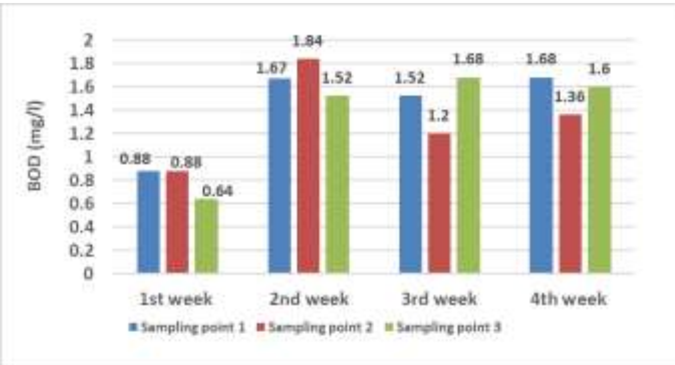

Figure 6. BOD analysis (mg/L) at the sampling location

Figure 6 shows that the BOD concentration ranged from 0.64 to 1.84 mg/L, with the highest BOD recorded at sampling point 2 and the lowest at sampling point 3. The BOD values ranging from 0.64 to 1.84 mg/L indicate low levels of oxidized organic matter and cleaner waters with minimal organic waste. Effendi (2003) states that waters with a BOD value exceeding 10 mg/L are considered to have been polluted. Waters that have a BOD content of 0-10 mg/L are waters with a low level of pollution and are categorized as adequate or good waters (Salmin, 2005). In general, the BOD content at the sampling location is still suitable for aquaculture. BM Standard Regional Regulation of East Kalimantan Province Number 2 of 2011 Attachment. V, Class III, namely 6 mg/L.

Chemical Oxygen Demand **(COD)**

Chemical oxygen demand (COD) is the amount of oxygen needed to decompose organic matter present in water, both biologically degraded and difficult or not biologically degraded. The results of COD analysis at the sampling location (coal mining pool/void) are presented in Figure 7.

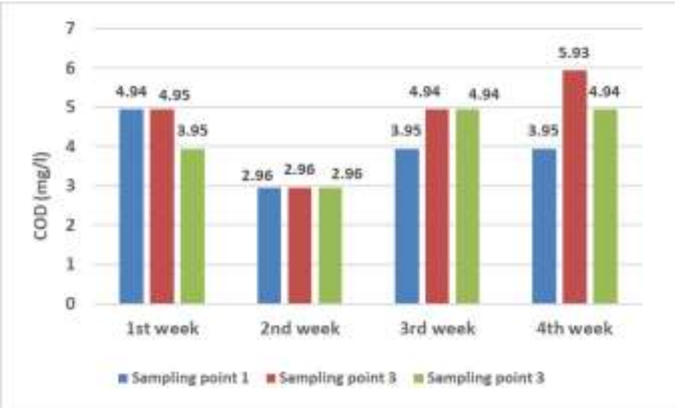

Figure 7. COD analysis (mg/l) at the sampling location

Figure 7 shows that the COD value falls within the range of 2.96 to 5.93 mg/L, with the highest content recorded is in sampling location 2 and the lowest content is in sampling location 1,2,3 during the second week. The COD value is still in the proper category for aquaculture. Quality Standard Regional Regulation of East Kalimantan Province Number 2 of 2011 Attachment. V Class III COD value of 50 mg/L. Effendi (2003) stated that a COD value of more than 200 mg/L was categorized as polluted.

Nitrate (NO_3)

Nitrate (NO_3) is a chemical water quality parameter, which is related to the fertility level of a body of water. If the nitrate content exceeds quality standards, eutrophication or nutrient enrichment will occur. High nitrate content can cause plankton to bloom, especially phytoplankton, affecting the survival of biota in the waters. The results of Nitrate (NO_3) measurements at the sampling location (void after coal mining), are seen in Figure 8.

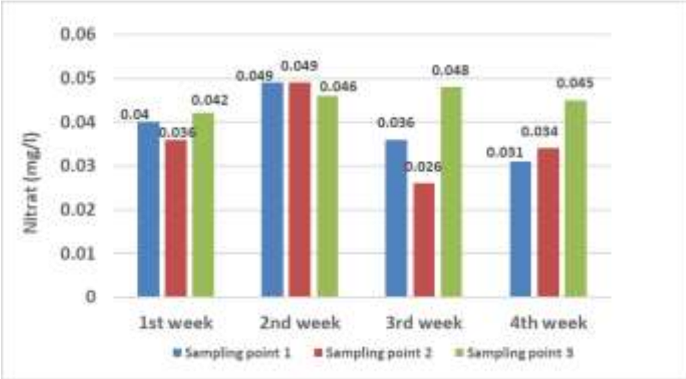

Figure 8. Analysis of nitrate (mg/L) at the sampling location

Figure 8 showed that nitrate ranges from 0.026 to 0.049 mg/L, the highest level observed at sampling points 1 and 2, the lowest at sampling location 2. Sources of nitrate and phosphate nutrients from the waters themselves are through the process of weathering or through the decomposition process of plants and residues. dead organisms (Patty et al., 2015). Nitrate plays a role in the formation of biomass of aquatic organisms. Boyd (1980) stated that a nitrate content of 2 - 5 mg/L is a good category in waters. Quality Standards Regional Regulation of East Kalimantan Province Number 2 of 2011 Attachment. V Class III, NO_3 20 mg/L.

Nitrate is a nutrient needed to help the growth and development of phytoplankton. Nitrates play an important role in the photosynthesis process. Nitrate is used as an indicator to see the condition of a body of water, including the fertility of the water, because nitrate is closely related to the productivity of phytoplankton which are the primary producers in a body of water (Sudjadi & Pancar, 2005).

Nitrite (NO_2)

Nitrite (NO_2) is an oxidized form of nitrogen. Nitrite content is found in small amounts, because it has a less stable nature due to the presence of oxygen. The results of nitrite measurements at the sampling location (voids in coal mining) are shown in Figure 9.

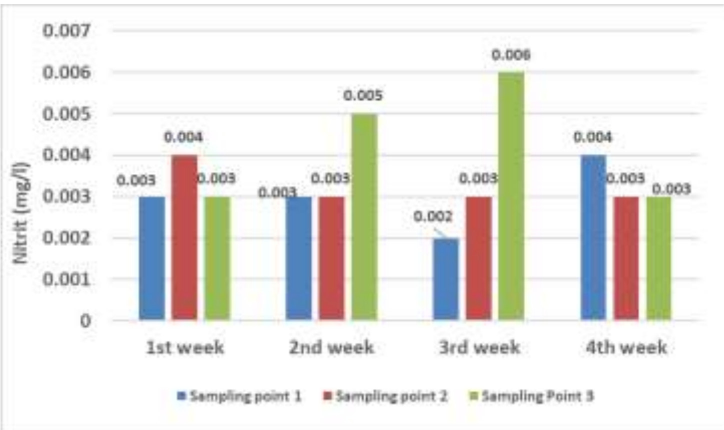

Figure 9. Nitrite analysis (mg/L) at sample locations

Figure 9 showed that the nitrite concentration in the waters is 0.002 – 0.006 mg/L, the highest at sampling location 3 and the lowest at sampling location 1. Putri *et al*. (2019), states that in general natural waters contain 0.001 mg/l of nitrite, not exceeding 0.06 mg/L. Nitrogen compounds are generally the result of metabolism and decomposition of organic materials carried out by bacteria (Boyd, 1990). The nitrite content when compared to East Kalimantan

Province Regional Regulation Number 2 of 2011 Lamp. V Class III is 0.06 mg/L, still suitable for aquaculture.

Ammonia (NH_3)

Aquaculture businesses can be influenced by the presence of ammonia (NH_3). The results of NH_3 measurements at the sampling location (void after coal mining) are shown in Figure 10.

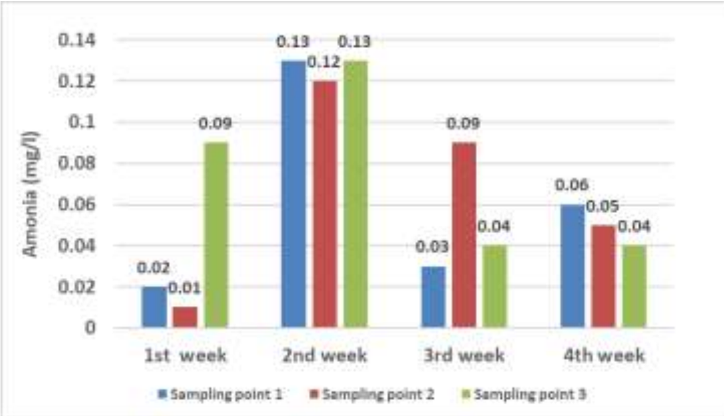

Figure 10. Analysis of ammonia (mg/L) at the sampling location

Figure 10 showed that the ammonia (NH_3) value at the sampling point was 0.01 – 0.13 mg/L, the highest at sampling locations 1 and 3 in the 2nd week and the lowest at the sampling location in the first 2 weeks. NH_3 at concentrations above 1.5 mg/L can be toxic to farmed fish, whereas in extreme conditions the concentration that can be tolerated is only 0.025 mg/L (Wahyuningsih & Gitarama, 2020).

Hidrogen Sulfida (H_2S)

The foul-smelling gas produced from the process of decomposing sulfur compounds from organic matter by anaerobic bacteria is called Hydrogen Sulfide (H_2S). This condition occurs in waters where there is no direct contact with air and the water has no circulation, thereby reducing the ability of water to dissolve oxygen. The results of hydrogen sulfide measurements at the sampling location (voids in coal mining) are shown in Figure 11.

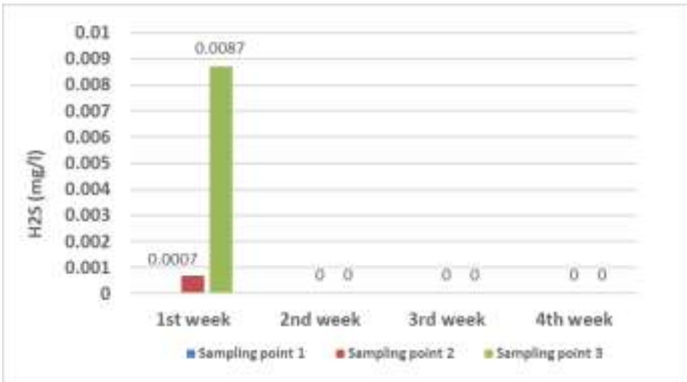

Figure 11. Analysis of H_2S (mg/L) at the sampling location

Figure 11 showed that H_2S at the sampling location is 0 – 0.0087 mg/L, the highest at the first 3 week sampling location 3 and the lowest at the first 2 week sampling location 1, while for the 2nd and 3rd weeks at all sampling points the value is 0. The maximum H_2S content that can be tolerated for aquaculture activities is 0.002 mg/L (class III aquaculture water quality standard, East Kalimantan Regional Regulation No. 02 of 2011). According to (Gusrina, 2008) the range value of H_2S for fish cultivation is <0.1 ppm (0.1 mg/L). This condition indicates that post-coal mining voids contain H_2S which is not dangerous for aquatic biota.

CONCLUSION

The measured water quality parameters in the void including temperature in the range of 29.5 – 31.5 ^oC, brightness 135 – 285 Cm, TSS 13.75 – 27.5 mg/L, Chemical pH 7.42 – 7.68, O_2 4.26 – 4.84 mg/L, BOD 0.64 – 1.84 mg/ L, COD 2.96 – 5.93 mg/L, NO_3 0.026 – 0.049 mg/L, NO_2 0.002 – 0.006 mg/L, NH_3 0.01 – 0.13 mg/L and H_2S 0 – 0.0087 mg/ L. Overall, the water quality in the void areas meets the quality standards established by East Kalimantan Provincial Regulation No. 2 of 2011, which addresses the Management of Water Quality and Control of Water Pollution. Therefore, the post-coal mining void water remains suitable for aquaculture, both in terms of its physical and chemical attributes.

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