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THE IMPACT OF TRADITIONAL PETROLEUM MINING WASTE ON SURFACE WATER QUALITY IN BOJONEGORO DISTRICT

DAMPAK LIMBAH PENAMBANGAN MINYAK BUMI TRADISIONAL TERHADAP KUALITAS AIR PERMUKAAN DI KABUPATEN BOJONEGORO

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ABSTRACT

Traditional petroleum mining produces liquid and solid waste that pollute the environment. This research aims to determine the impact of conventional petroleum mining waste on surface water quality and calculate the level of surface water pollution. Research was conducted using survey methods and purposive sampling to determine the location and collection points of wastewater and surface water. Petroleum wastewater and surface water samples have been taken using the grab sampling method. The wastewater samples were 3 samples (B1, B2, B3) from oil wells that were operationally active (24 hours/day) and 3 samples (C1, C2, C3) from operationally passive oil wells (12 hours/day). Surface water samples were taken at 6 points, namely control (A0), 0 km (A1), 0.5 km (A2), 1 km (A3), 1.5 km (A4), 2 km (A5). The parameters that have been tested include temperature, TDS, TSS, pH, BOD, COD, DO, fat and oil, ammonia, H_2S, and phenol. The quality of waste and surface water has been determined based on Peraturan Menteri Lingkungan Hidup Number 19 of 2010 and Peraturan Pemerintah Number 22 of 2021. The level of water pollution has been determined by the Pollution Index (IP). The results show that TDS, COD, fat and oil, and NH_3 of the active well waste (B) and COD, as well as fat and oil of the passive well waste (C), exceed quality standards. In addition, surface water TDS, BOD, COD, fatty oils, NH_3, and phenols exceed class III water quality standards. The level of surface water pollution was Light to Moderate Pollution. The farther the sample point from the outlet, the pollution levels decrease.

Keywords: Surface Water, Water Quality, Petroleum Waste

ABSTRAK

Penambangan minyak bumi tradisional merupakan penambangan yang menghasilkan limbah cair dan padat yang dapat menyebabkan terjadinya pencemaran lingkungan. Penelitian ini bertujuan untuk mengetahui dampak limbah penambangan minyak bumi tradisional terhadap kualitas air permukaan, menghitung tingkat pencemaran air permukaan dan mengetahui tingkat pencemaran air permukaan berdasarkan jarak lokasi penambangan minyak bumi. Penelitian dilakukan pada bulan November, menggunakan metode survey dan metode purposive untuk menentukan lokasi dan titik pengambilan air limbah dan air permukaan. Sampel air limbah minyak bumi dan air permukaan diambil menggunakan metode grab sampling. Sampel air limbah terdiri 6 sampel berupa 3 sampel (B1, B2, B3) dari sumur minyak operasional 24 jam / hari dan 3 sampel (C1, C2, C3) dari sumur minyak operasional 3 kali selama 4 jam/hari. Sampel air permukaan diambil 6 titik yaitu A0 sebagai kontrol, 0km (A1), 0,5km (A2), 1km (A3), 1,5km (A4), 2km (A5). Parameter yang diuji meliputi suhu, TDS, TSS, pH, BOD, COD, DO, minyak lemak, amonia, H2S dan fenol. Kualitas limbah dan air permukaan ditentukan berdasarkan Peraturan Menteri Lingkungan Hidup No 19 Tahun 2010 dan Peraturan Pemerintah Nomor 22 Tahun 2021. Tingkat pencemaran air dilakukan mengunakan metode Indeks Pencemaran (IP). Hasil Penelitian menunjukkan TDS, COD, minyak lemak, NH3 limbah sumur aktif (B) dan COD serta minyak dan lemak limbah sumur pasif (C) melebihi baku mutu. Kualitas air permukaan memiliki TDS, BOD, COD, minyak dan lemak, NH3, dan fenol melebihi baku mutu air kelas III. Tingkat pencemaran air permukaan termasuk Cemar Ringan sampai Sedang. Semakin jauh titik sampel dari outlet limbah, tingkat pencemaran mengalami penurunan.

Kata kunci: Air Permukaan, Kualitas Air, Limbah Minyak Bumi

INTRODUCTION

Oil and natural gas are energy sources used for various needs, such as fuel in the industrial sector, power plants, transportation, and household activities. Oil and gas products are widely used to support daily life, leading to an increase in demand for oil and gas products worldwide. This has resulted in growth and expansion in the oil and gas industry from exploration, exploitation, and processing activities in various countries, including Indonesia (Sulistyono, 2015).

Petroleum mining in the Kedewan District of the Bojonegoro Regency is an oil and gas extraction activity that has been conducted using conventional methods and rudimentary equipment. This practice has been shown to have a positive impact on the local economy, as evidenced by an increase in community income at the national level. Furthermore, the presence of petroleum mining has been demonstrated to contribute to an increase in petroleum production. Petroleum mining operations also have deleterious effects on the environment, including the generation of waste in the form of solids, liquids, and gases, which contributes to environmental pollution. This is because the petroleum extraction process utilizes a rudimentary method, thereby rendering the separation of water and oil during production imperfect and resulting in contamination levels that exceed the requisite quality standards (Raharjo, 2016).

The process of petroleum mining has the potential to generate waste in the form of petroleum sludge (oily sludge) (Karwati, 2009). This sludge has the capacity to contribute to the occurrence of pollution. Petroleum sludge contains hydrocarbon components, which are organic compounds consisting of hydrogen and carbon elements. Examples of hydrocarbon components include benzene, toluene, ethylbenzene, and xylema isomers. In the event that petroleum sludge waste is transported by rainwater and enters surface streams, there is a possibility that water quality in the surrounding area could be adversely impacted (Nugroho, 2006).

The oil and gas production process are a series of complex processes involving activities from upstream to downstream. The process of oil and gas extraction in legacy oil wells has been observed to result in a high water cut value, consequently yielding a substantial volume of produced water. Produced water is defined as water that emerges as a by-product of the oil and gas extraction process and is subsequently carried to the surface. The formation of produced water can occur naturally or as a consequence of water injection used for stimulation purposes or during production recovery. The content encompasses formation water, injection water, and additional chemicals incorporated during the oil and water separation process (Setyaningrum et al., 2020).

The produced water contains a complex mixture of chemical compounds, including hydrocarbons, nitrogen, sulfur, and metals (MacMahon et al., 2018). The primary constituents of produced water that necessitate particular consideration are the salt content, the presence of oil and grease, and the quantity of both organic and inorganic compounds. Oil and grease are the primary constituents of produced water, garnering significant attention in onshore and offshore operations. Conversely, salt content, measured in terms of salinity, conductivity, or TDS, is the predominant concern in onshore operations (Hedar & Budiono, 2018). The characteristics of produced water in the oil and gas industry are unique, depending on the physical composition. Concurrently, disparities in the composition of inorganic and organic chemical compounds are attributable to the geographical location of the industrial facility and the geological formations present in the area. Furthermore, the characteristics and volume of produced water are influenced by the age of the well or reservoir and can change if the oil and gas industry conducts water injection operations, also referred to as water flooding (Hardi et al., 2017).

Petroleum mining operations generate liquid effluents resulting from the execution of production activities. In the production process, the fluid emanating from the well mouth is subsequently directed into a catch basin, otherwise known as an oil catcher basin.This apparatus serves the primary function of separating oil and produced water.The separation process is predicated on the disparity in specific gravity between the two fluids. Water has a greater specific gravity than oil, which results in the oil's dominance at the surface of the liquid. The oil collected on the surface of the liquid is then transferred to a reservoir, while the produced water exits through the bottom. Liquid waste, defined as produced water that has been separated from oil, is the most significant cause of pollution. This is because liquid waste generated from petroleum exploitation and production is discharged directly into surface streams (Hedar & Budiono, 2018).

The presence of petroleum mining waste in surface water has been demonstrated to have deleterious effects on aquatic life and vegetation. These effects are particularly pronounced when the water is utilized for irrigation purposes. Petroleum waste, specifically fatty oil, has been observed to impede the penetration of light into aquatic ecosystems, thereby potentially compromising the viability of aquatic biota. Petroleum waste has been demonstrated to reduce dissolved oxygen levels in water bodies due to the consumption of dissolved oxygen by microorganisms in the process of decomposing organic matter derived from petroleum waste (Nufus H, 2018). In order to regulate activities that have the potential to cause environmental pollution, waste generated from traditional petroleum mining activities must meet the applicable quality standards outlined in Minister of Environment Regulation No. 19 of 2010 concerning Wastewater Quality Standards for Oil and Gas and Geothermal Businesses and Activities. Consequently, it is imperative to undertake research endeavors that seek to ascertain the extent of the impact exerted by petroleum mining operations on the quality of surface water resources.

MATERIALS AND METHODS

This research was conducted in November 2023. Sampling was carried out at the Traditional Petroleum Mining Site, Kedewan District, Bojonegoro Regency, East Java. The geographical location of the study was determined through the implementation of a survey method. The selection of sample points was conducted at the oil and water separation pool or the outlet of the petroleum mining well and at the surface water flow (Dong Rumpit River), which measures 3 km in length and 2-2.5 meters in width. This selection was made using a purposive sampling method, whereby the surface flow with the closest distance to the surface flow (river) and the farthest distance from the petroleum mining site were considered.

The wastewater and surface water sampling method employed in this study was the grab sample method, which involves the direct extraction of samples from the water body under observation. The wastewater and river water samples are obtained by dividing the study area into multiple points that are expected to represent the study population. The sampling points were divided into 12 sample points, consisting of three sample points of petroleum well wastewater (operational 24 hours/day), namely sample points of petroleum well D-18 (B1), petroleum well D-130 (B2), and petroleum well D-30A (B3). The sample points of oil well wastewater (operational <12 hours/day) are the sample points of oil well D-28 (C1), oil well D-30 B (C2), and oil well D-30 C (C3), 1 point upstream of the river that is not affected by petroleum waste pollution (A0), and 5 points downstream of surface water (Dong Rumpit River) that are potentially polluted by petroleum waste. The results of wastewater sampling are averaged based on active and passive oil wells. The surface water sample points are as follows: A1 is a sample point with a distance of 0 km or the closest point to the traditional petroleum mining outlet; A2 is a sample point with a distance of 0.5 km from the petroleum mining site; A3 is a sample point with a distance of 1 km from the petroleum mining site; A4 is a sample point with a distance of 1.5 km; A5 is a sample point with a distance of 2 km and is upstream of the Dong Rumpit River.

The parameters that were assessed included temperature, total dissolved solids (TDS), total suspended solids (TSS), pH, biological oxygen demand (BOD), chemical oxygen demand (COD), dissolved oxygen (DO), presence of fatty oil, ammonia, hydrogen sulfide (H2S), and phenol. The laboratory-based analysis was conducted, and the results of the data analysis of wastewater and surface water quality test results were compared to the applicable quality standards.

RESULTS AND DISCUSSIONS

A. Wastewater Quality Analysis

The value of wastewater quality parameters is used as a reference in surface water quality due to the direct disposal of wastewater into water bodies, which potentially affects the quality of surface water (rivers). Analysis of wastewater quality uses physical and chemical parameters, including temperature, TDS, acidity (pH), COD, fat and oil, H_2S, NH_3, and phenol. The average test of petroleum wastewater quality can be seen in Table 2.

Table 2. Average of Petroleum Wastewater Quality

Sampling Spot	Parameters							
	Temp. (°C)	TDS (mg/L)	pH	COD (mg/L)	Oil & Fat (mg/L)	H_2S (mg/L)	NH_3 (mg/L)	Phenol (mg/L)
Average B Well	34.9	6012	6.2	748.3	86.22	<0.0046	10.2796	0.3280
Average C Well	33.1	2540	6.4	319.9	45.44	<0.0046	2.9905	0.3141
Upper Threshold	40°C	4000	6-9	200	25	0,5	5	2

Several parameters of petroleum wastewater tested exceed the quality standards according to the Peraturan Menteri Lingkungan Hidup No. 19 of 2010. The TDS, COD, fat and oil, and NH_3 parameters in waste B exceed the quality standards. On the other hand, the COD, as well as fat and oil parameters in waste C, exceed the quality standards.

The high TDS value in wastewater comes from substances dissolved in groundwater and rock layers, according to the depth of the oil well. Produced water that comes out of oil wells contains high TDS due to the glauconite minerals contained in the rock formations of the location (i.e., Ledok formation). This glauconite mineral is formed from a shallow marine environment, so that the point of this oil well was previously a sea area that experienced a series of geological processes, which lifted it to the surface of the earth (Saraswati, 2021).

The high COD value in wastewater samples correlates with the levels of oil and fat produced. The higher the levels of fat and oil produced from the petroleum mining process, the higher the COD levels in petroleum wastewater. Oil wells that have higher oil viscosity than water cause COD values to also increase because the oil and fat content in produced water is associated with high BOD and COD values (Gazali et al., 2017).

Both wastewater samples have oil levels exceeding quality standards. This is due to the lack of waste treatment in the oil mining process, causing the levels of fat oil in the waste of the two wastewater samples to still be relatively high. The highest levels of fat oil in the oil wastewater are found in the wastewater sample B. This is because the location of oil well B is in a reservoir dominated by oil with a higher viscosity than water and gas fluids. While the waste C reservoir is dominated by water fluids, the levels of fat oil in wastewater C are smaller than in wastewater B.

The high levels of NH_3 in oil waste are caused by the decomposition process of organic matter in oil waste by bacteria, which can produce ammonia as a by-product. Bacteria involved in the decomposition of organic matter can release nitrogen in the form of ammonia during this process. The low concentration of NH3 was caused by the fact that in the sedimentation pond of waste sample point C, the oil content containing nitrogen in the wastewater was low, resulting in a low NH3 concentration.

B. Surface Water Quality Analysis

Surface water quality analysis in Dong Rumpit River aims to determine the level of surface water pollution due to the disposal of liquid waste from traditional oil mining activities into water bodies without any treatment. The location of surface water intake to determine the quality of surface water in the research area is five sampling points (A1 (0 km), A2 (0.5 km), A3 (1 km), A4 (1.5 km), A5 (2 km)) which covers the entire river body, namely upstream, middle and downstream with a distance of each sample point of 500 m and 1 research location point (A0) as a control which is unpolluted surface water. The parameters used to determine the quality of surface water in Dong Rumpit River are as follows:

1. Temperature

The temperature of the waters plays a role in the life of biota in the waters, namely in the metabolic process. A good temperature for the life of aquatic organisms in tropical areas ranges from 25-32 °C (Rahman et al., 2016). Measurement of the temperature of petroleum wastewater and surface water was carried out by measuring directly in the field when taking water samples using a thermometer. The temperature at various research locations is presented in Figure 1. The test results show that each sample point still has a value below the quality standard according to Government Regulation Number 22 of 2021.

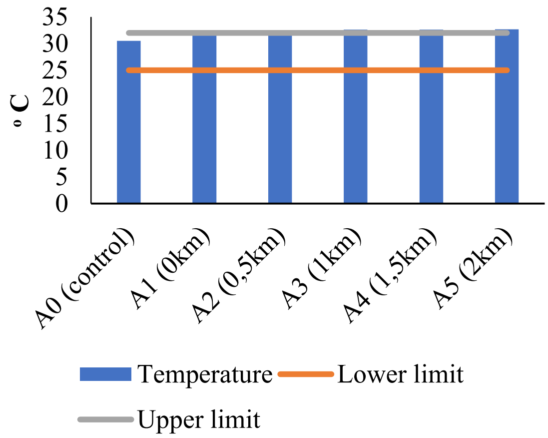

Figure 1. Surface water temperature at various research locations

2. Total Dissolved Solids (TDS)

Total Dissolved Solids (TDS) shows the total amount of solids in the form of organic and inorganic substances dissolved in water. These solids are mineral content, such as iron, chloride, and others. TDS usually consists of organic substances, inorganic salts, and dissolved gases. TDS values at various research locations are presented in Figure 2.

Based on the results of the surface water TDS test (Dong Rumpit River), the TDS results in samples A1 to A5 were higher than the TDS values in sample A0, which is a location that is not polluted, so the TDS concentration at sample location A0 is still below the quality standard, which is 879 mg/L. The results of the surface water TDS test for samples A1, A2, A3, A4, and A5 exceeded the water quality standard limit for class III of Government Regulation No. 22 of 2021, which is 1000 mg/L.

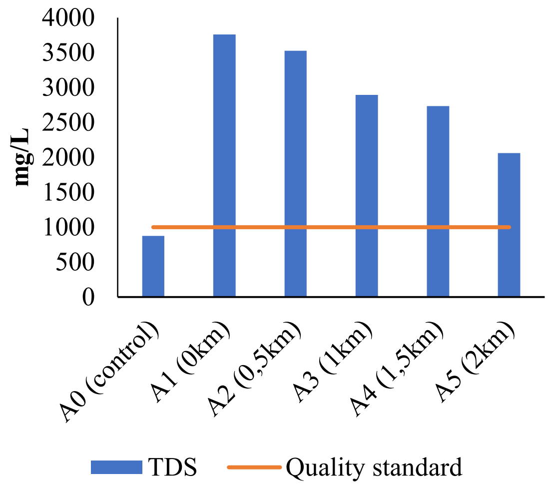

Figure 2. Total dissolved solids in the experiment locations

The highest TDS value was found in sample A1, which was 3759 mg/L. This is because A1 is located in the part of the flow closest to the oil mining outlet location, so that at that location there are still many sodium ions dissolved in the water. High TDS levels are influenced by the presence of ions in the water (Effendi, 2003). The presence of these ions comes from petroleum waste produced from oil exploration without any processing and is directly discharged into water bodies. The dominant ions in petroleum wastewater are sodium and chloride ions. In addition, the high TDS levels are influenced by direct additions from petroleum wastewater which has high hardness so that the more chemical compounds such as hydrocarbons, phenols, benzene and dissolved solids such as calcium, magnesium, carbonate salts, bicarbonate salts, sulfates or other metal ions originating from petroleum mining, the higher the TDS levels in the waters (Permadi et al., 2016). The TDS value of sample points A1 to A5 decreased. The decrease in TDS value in surface water was caused by the Dong Rumpit River having a relatively small water discharge, causing TDS to experience sedimentation, so that the further the sample point is from the petroleum waste outlet location, the lower the TDS value.

3. Total Suspended Solids (TSS)

Total Suspended Solids (TSS) are residues of total solids retained by a filter with a maximum particle size of 2 μm or larger than the size of colloidal particles. TSS consists of mud and fine sand as well as microorganisms, which are mainly caused by soil erosion or soil erosion carried into water bodies. TSS values at various research locations are presented in Figure 3. The results show that each sample point still has a value below the quality standard according to Government Regulation Number 22 of 2021.

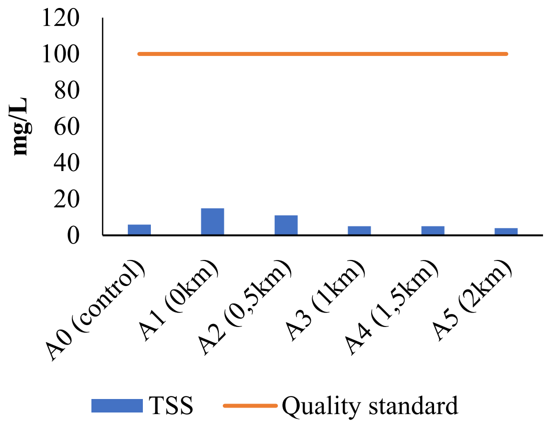

Figure 3. Total suspended solids in the experiment locations

4. pH

The degree of acidity (pH) is a measure of the concentration of hydrogen ions and indicates whether the water is acidic or basic. The pH value is in the interval 1-14. The pH is in an acidic state if the value is 1-6.9, and in a basic state if the pH is 8.1-14. A good pH value for a water body is 7-8, which is in a neutral condition. The pH value of the research location is presented in Figure 4, which shows that each sample point has a value below the quality standard according to Government Regulation Number 22 of 2021.

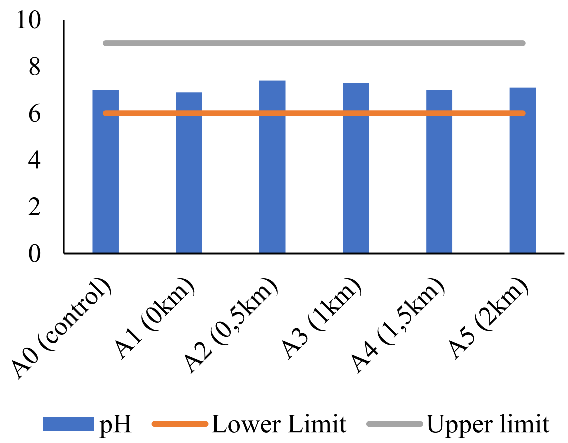

Figure 4. pH in several experiment locations

5. Biological Oxygen Demand (BOD)

Biochemical Oxygen Demand (BOD) is the amount of oxygen needed by microorganisms in the aquatic environment to break down (degrade) organic waste materials in the water into carbon dioxide and water. BOD values at various research locations are presented in Figure 5.

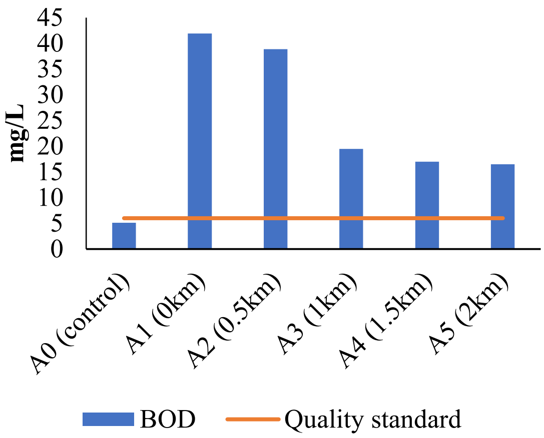

Figure 5. BOD in several experiment locations

Based on the results of the study on surface water quality (Dong Rumpit River), the BOD value at sample points A1, A2, A3, A4, A5 exceeded the quality standard compared to sample point A0 which was still within the class III water quality standard in Government Regulation No. 22 of 2021, namely 6 mg/L. The highest surface water BOD value was found in samples A1 and A2, namely 41.9 mg/L and 38.9 mg/L. Sample Point A0 has a low BOD value and is still within the quality standard.

The high BOD levels in the waters are due to the high organic matter content at points A1 and A2 because locations A1 and A2 are the closest locations to the petroleum waste outlet compared to sample points A3, A4, and A5. The BOD value will increase with increasing organic matter in the waters. Conversely, the lower the amount of organic matter in the waters, the lower the BOD value (Hatta, 2014). The high BOD content in river water can be influenced by the small number of microorganisms. The number and activity of microorganisms have a significant effect on BOD values (Koda et al., 2017). When the number of microorganisms is small, the biochemical breakdown process does not occur, or the intensity of biochemical breakdown is insignificant. In natural conditions, this effect is due to a number of toxic components (such as heavy metals) that negatively impact the enzyme activity of microorganisms (Koda et al., 2017).

The lowest BOD value for surface water is at sample point A5, which is 16.5 mg/L. The low BOD value at sample point A5 is due to the increasingly low organic compound content because sample point A5 is downstream of the river. This is also reinforced by the low value of fatty oil as a source of pollution at sample point A5, which is relatively small.

6. Chemical Oxygen Demand (COD)

Chemical Oxygen Demand (COD) is the amount of oxygen needed for chemical oxidation of organic matter for substances that can be degraded or those that are difficult to degrade. The COD value itself is influenced by the amount of waste in the form of organic and inorganic substances contained in the water. The higher the COD value in a body of water, the more waste (organic and inorganic substances) in the water, which can indicate that it is increasingly polluted. The COD value of the research location is presented in Figure 6.

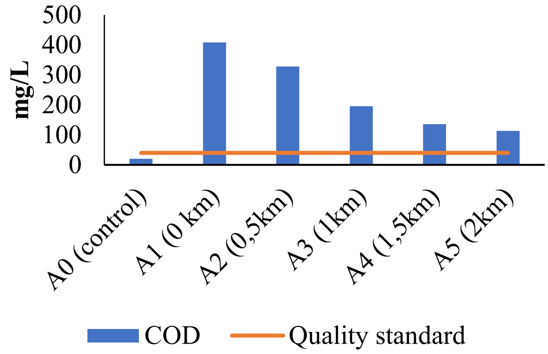

Figure 6. COD in several experiment locations

Based on the research results, the COD value at sample points A1, A2, A3, A4, and A5 exceeded the quality standard compared to sample point A0 which was still within the class III water quality standard in Government Regulation No. 22 of 2021, which was 40 mg/L. High surface water COD values were found in samples A1 and A2, namely 408.3 mg/L and 328.3 mg/L. Sample points A1 and A2 are the closest locations to the petroleum waste disposal outlet compared to sample points A3, A4, and A5, so the levels of pollutants at this location are still relatively high. Petroleum waste that is disposed of in surface water does not go through a processing process, making it difficult to decompose biologically so it must be decomposed chemically and causes high COD levels. The COD value is an indication of biodegradable and non-biodegradable organic pollutants so that the addition of biodegradable organic pollutants (BOD) also affects changes in the COD value so that ideally if there is an increase in the BOD value, there will be an increase in the COD value (Ardhani, 2014).

The lowest COD value of surface water is found in sample A5, which is 113.3 mg/L. The distance of sampling can affect the difference in COD values, where each sample point is 500 meters away so that the source of pollution has a different value at each sample point and in Dong Rumpit River water is a small river that has a relatively small discharge and has a winding river morphology so that the COD content at the oil waste outlet location is not easily carried downstream.

7. Dissolved Oxygen (DO)

Dissolved Oxygen (DO) is the amount of oxygen dissolved in a certain volume of water at a certain temperature and pressure. DO in water is very much needed to support the life of organisms in it (Saksena et al., 2008). The DO value indicates the amount of oxygen (O2) available in a body of water. The higher the DO value in water, the better the water quality. Conversely, if the DO value is low, it can be seen that the water has been polluted. DO values at various research locations are presented in Figure 7.

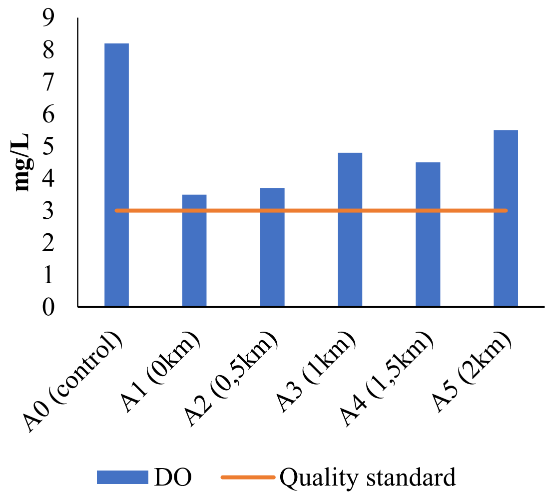

Figure 7. DO in several experiment locations

Based on the research results, the DO value at sample point A0 has a high value compared to sample points A1, A2, A3, A4, A5. However, the overall sample value exceeds the quality standard in Government Regulation No. 22 of 2021, which is 3 mg/L. The higher the DO value indicates that there is more oxygen in the water, so the condition of the water is also better. Sample point A0 has the highest DO value compared to other sample point locations because A0 is a location that is not polluted so that there is no organic material sourced from oil exploration activities and causing oxygen levels at that location to be high.

The DO values at sample points A1 and A2 have low values, namely 3.5 mg/L and 3.7 mg/L. This is because the river is highly polluted by oil waste carried by produced water, and the condition of the river flow is not so fast because locations A1 and A2 are the locations closest to the oil waste outlet compared to locations A3, A4, and A5. The percentage of dissolved oxygen in the waters is influenced by water temperature, water salinity, altitude, and plankton (in hot air, dissolved oxygen will decrease). Low DO levels can be caused by the addition of organic pollutant loads due to waste disposal that exceeds the water's ability to self-purify, and also the presence of chemicals that are oxidized by oxygen (Wibowo, 2013).

The DO values at sample points A3, A4, and A5 increased compared to sample points A1 and A2. This shows that at sample points A3, A4, and A5 the self-purification process has run optimally. The longer the distance, the better the river's self-purification ability, which is indicated by the increasing DO value in the water, provided that there is no input of pollutant loads from outside (Hendrasari & Cahyarani, 2010). According to Salmin, (2005) oxygen plays an important role as an indicator of water quality because dissolved oxygen plays a role in the oxidation and reduction processes of organic and inorganic materials. The higher the DO levels in the water, the better the condition of the water.

8. Oil and Fat

Oil and fat are floating on the surface of the water because oil and fat cannot dissolve in water. Oily liquid waste that is discharged into the water environment will float on the surface of the water. The concentration of oil and fat at various research locations is presented in Figure 8.

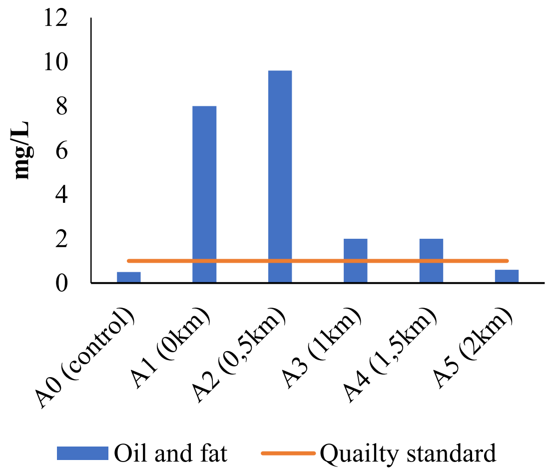

Figure 8. Oil and fat content in several experiment location

Based on the research results, the fatty oil values at points A1, A2, A3, A4, A5 are higher and exceed the quality standards compared to the fatty oil value of A0 which is still within the water quality standards of class III Government Regulation No. 22 of 2021, which is 1 mg/L. The fatty oil value at sample point A0 is still within the quality standards, this is because sample point A0 is a location that is not affected by pollution so that the fatty oil content at that location is relatively small and still within the quality standards because there are no petroleum mining activities as a source of pollution.

The highest fatty oil values are at points A2 and A1, namely 9.6 mg/L and 8 mg/L. This is because, at the A2 sampling point, there are many tree branches and rocks, which trap the oil carried by the water flow, causing the fatty oil levels at the sample point location to be high. Sample point A1 is the closest location to the petroleum waste outlet, resulting in high fatty oil levels at this point.

The fatty oil values at sample points A3, A4, and A5 decreased, and the lowest was at sample point A5. The decrease in the levels of fat oil in the water is influenced by the morphology of the winding river, allowing the levels of fat oil at point A5 to have a small value because it is further away from the location of the petroleum waste outlet. Oil has a lower specific gravity than water, so the presence of oil in the river is on the surface of the water. The relatively small water discharge in the Dong Rumpit River causes a lot of oil to stick to the river walls.

The real impact of the presence of oil and fat on the water surface is the obstruction of sunlight penetration, which means reducing the rate of photosynthesis in the water. Covering the water surface by oil reduces the input of free oxygen from the air into the water. Some oil and fat emulsions will experience degradation through spontaneous photooxidation and oxidation by microorganisms. The decomposition of oil and fat in conditions of lack of oxygen will cause incomplete decomposition, resulting in a rancid odor (Hendrawan, 2008).

Several components that make up oil are also known to be toxic to animals and humans, depending on their structure and molecular weight. Saturated hydrocarbon components can cause anesthesia and narcosis in various lower animals, and if present in high concentrations can cause death. Aromatic hydrocarbon components such as benzene, toluene and xylene are toxic to humans and other life (Fardiaz, 1992).

9. Sulfide (H_2S)

Sulfide (H2S) is the end product of decomposition under anaerobic conditions, which is an unstable compound and has toxic properties. The H2S values at various research locations are presented in Figure 9. Based on the test results, it shows that each sample point still has a value below the quality standard according to Government Regulation Number 22 of 2021.

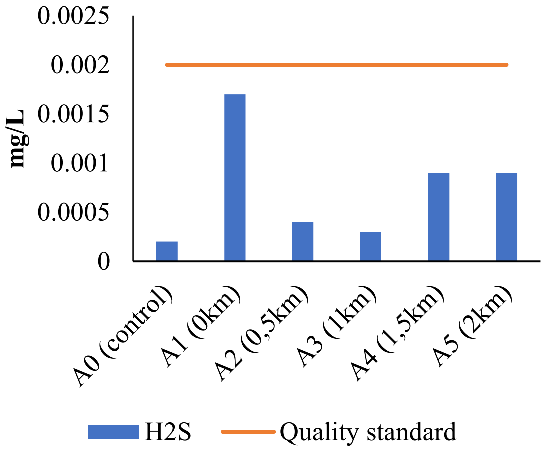

Figure 9. Sulfide (H2S) in several experiment locations

10. Ammonia (NH_3-N)

Ammonia (NH3) is an alkaline compound in the form of a colorless gas and can dissolve in water. In water, ammonia is in two forms, namely non-ionized ammonia and ionized ammonia. The NH3 values at various research locations are presented in Figure 11.

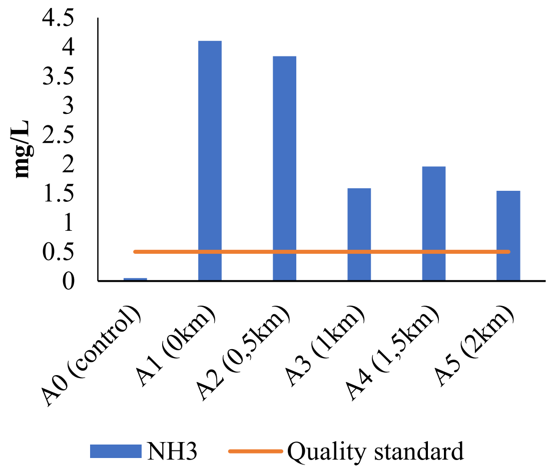

Figure 10. Ammonia in several experiment locations

Based on the research results, the NH3 value in samples A1, A2, A3, A4, A5 exceeded the quality standard compared to sample A0 which was still within the water quality standard class III of Government Regulation No. 22 of 2021, which was 0.5 mg/L. The highest NH3 content in surface water was at sample point A1, which was 4.1046 mg/L. The high ammonia content at sample point A1 was because sample point A1 was closest to the petroleum waste outlet and at this location it had a relatively smaller discharge, causing the petroleum waste to still contain compounds containing ammonia. According to Effendi (2003), unionized free ammonia (NH3) is toxic to aquatic organisms. The toxicity of ammonia to aquatic organisms will increase if there is a decrease in dissolved oxygen levels, pH, and temperature (Effendi, 2003).

The lowest NH3 concentration in surface water was at sample point A5, which was 1.5442 mg/L. The decrease in ammonia concentration is due to the meandering morphology of the Dong Rumpit River, which has implications for changing the river flow from laminar to turbulent, thus helping the self-purification process of water pollutants.

11. Phenol

Phenolic compounds are one of the pollutants that often cause problems in the environment. Phenolic compounds are often found in aquatic environments originating from oil drilling mud, water flows, household waste, and industry. Phenol values at various research locations are presented in figure 11.

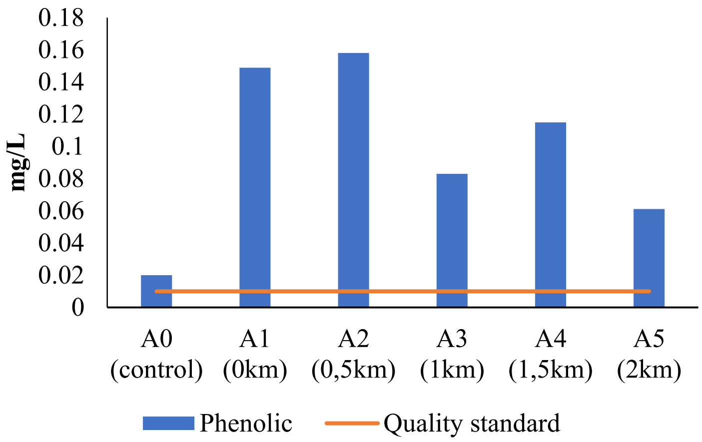

Figure 11. Phenol content in several experiment locations

Based on the research results, the phenol value of samples A0, A1, A2, A3, A4, and A5 exceeds the water quality standard for class III of Government Regulation No. 22 of 2021, which is 0.01 mg/L, but has varying values. A0 is a sample point that is not exposed to petroleum waste, but the location around A0 is agricultural land, so that the phenol value at point A0 exceeds the quality standard due to the influence of agricultural activities around the location. The highest phenol value is at sample point A2, which is 0.1580 mg/L. The high phenol value at sample point A2 is influenced by the relatively small river flow at this location, allowing phenol accumulation at sample point A2. This fairly high phenol concentration is due to the influence of petroleum wastewater, which has characteristics that are difficult to degrade by decomposing organisms. This is also caused by the high temperature in the water body, so that decomposing organisms cannot live or decompose waste materials. The lowest phenol value is at sample point A5, which is 0.0612 mg/L. Sample point A5 is downstream of the river 2 km from the oil waste outlet, allowing phenol levels to accumulate in the middle of the river, causing low phenol values at sample point A5.

Phenolic compounds produced from oil and gas industry activities will be carried to the surface with water, which then find themselves in wastewater after the oil separation process. Phenolic compounds in petroleum are found as natural components together with other organic compounds, such as organic sulfur and nitrogen compounds, and other heteroatom organic compounds. The presence of phenolic compounds in oil and gas waste often also comes from the use of certain chemicals during exploration, production, and refining. Waste containing phenol, if disposed of into the environment, will endanger the lives of living things around it. Phenolic compounds are dangerous because they are carcinogenic and degrade very slowly in sunlight. Phenol is a very toxic organic compound, has a very sharp taste and odor, and can cause skin irritation (Aprilita & Wahyuni, 2018).

C. Surface water pollution level of Dong Rumpit River

The level of water pollution in surface water (Dong Rumpit River) was calculated using the chemical-physical pollution index (IP) method. The IP method is used to determine the level of pollution relative to the permitted water quality parameters. Water quality management based on the Pollution Index (IP) can provide input to decision makers to assess the quality of water bodies for a purpose and take action to improve quality if there is a decrease in quality due to the presence of pollutant compounds.

Table 3. Surface water pollution index of Dong Rumpit River

Sample Code	Pollution Index	Pollution Level
A1	5.410	Medium
A2	5.465	Medium
A3	4.331	Light
A4	4.787	Light
A5	3.493	Light

Based on the results of the Pollution Index (IP) using the class III quality standards of Government Regulation No. 22 of 2021, it shows various results with the focus of the pollution index on the parameters of TDS, BOD, COD, DO, fatty oil, H2S, NH3, and phenol. The parameters of pH, temperature, and TSS are still classified as meeting the quality standards because they have values below 1. This can be seen that the influence of the environment or activities in the surrounding area emphasizes the impact on parameters that exceed the quality standards. The calculation of the Pollution Index (IP) shows that sample points A1 and A2 are included in the Moderate Pollution category, surface water samples A3, A4, A5 are included in the Light Pollution category. The quality status of surface water has decreased downstream. This shows that there has been a decrease in pollution from nearby waters with pollution downstream of surface water. Disposal of petroleum wastewater with high pollutant content into surface water without prior treatment causes water pollution. The highest pollution value is found in surface water sample A2, which is 5.465. The location of surface water sample A2 is located near the petroleum waste outlet with a distance of 0.5 km, causing pollutants to accumulate at that location and supported by a relatively small river discharge, making sample point A2 have a high concentration of pollutants. The surface water sample with the lowest value is in surface water sample A5, which is 3.573. The location of surface water sample A5 is downstream of the river and has the furthest location from the source of pollution, causing the concentration of pollutants at that point to be low because the pollutants have been diluted.

According to Government Regulation No. 82 of 2001, water pollution is the entry or introduction of living things, substances, energy, and/or other components into water and/or changes in the order that cause water to no longer function according to its intended use. In accordance with this statement and the results of the calculation of the level of surface water pollution in the Dong Rumpit River, including Light Pollution to Moderate Pollution, the quality of surface water in the Dong Rumpit River has decreased. Surface water is in accordance with its intended use for freshwater fish farming. Livestock, water for irrigating plants should be included in class III water quality, but its quality has decreased to class IV water quality which can be used to irrigate crops and/or other uses that require the same water quality as the use. The level of water pollution from point A1 to A5 has decreased. This shows that the further the sample point is from the petroleum waste outlet, the lower the level of surface water pollution.

CONCLUSIONS

The conclusions of this study are:

1. The quality of traditional petroleum mining wastewater has active wastewater (B) TDS 6012 mg/L, COD 748.3 mg/L, fatty oil 86.221 mg/L, NH3 10.2796 mg/L and wastewater sample C parameters COD 319.9 mg/L, fatty oil 45.444 mg/L, NH3 2.9905 mg/L exceeding the quality standards for petroleum wastewater according to the Regulation of the Minister of Environment No. 19 of 2010. While the parameters of temperature, pH, H2S (wastewater B and C), phenol, NH3, and TDS (wastewater C) are still within the quality standards for wastewater.
2. The quality of surface water in the Dong Rumpit River has TDS, BOD, COD, fatty oil, NH3, and phenol exceeding the water quality standards for class III, which are intended for freshwater fish farming, livestock, and water for agricultural irrigation according to Government Regulation No. 22 of 2021. The temperature, pH, TSS, H2S, and DO values are still within the water quality standards.
3. The level of surface water pollution in the Dong Rumpit River is included in Moderate Pollution and Light Pollution, according to the Pollution Index. The physical and chemical parameters with the highest pollution value in surface water are in sample A2, namely 5.465 ($5.0 \leq IPJ \leq 10$ = Moderate Pollution).

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