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A STUDY ON THE CHANGES IN SEAWATER QUALITY DUE TO DUMPING OF TRENCHING MATERIALS

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ABSTRACT

The dumping of trenching materials in offshore areas poses a potential risk to environmental quality and requires proper management to prevent disruption of ecosystem balance. Objective: This study aims to analyze changes in seawater quality, focusing on key parameters such as Total Suspended Solids (TSS), Dissolved Oxygen (DO), Ammonia (NH_3), Orthophosphate (PO_4-P), and Oil and Grease. Method: This study employed a quantitative descriptive research design aimed at assessing marine water quality. Primary data were collected through direct seawater sampling at three observation points in the coastal waters of Tanjung Jumlai, Penajam District, North Penajam Paser Regency. Seawater sampling was conducted using a Horizontal Water Sampler to ensure representative sample collection from each location.The collected samples were subsequently analyzed in a laboratory to determine the concentrations of five key water quality parameters. The results were then compared with baseline conditions and the marine water quality standards as stipulated in Government Regulation of the Republic of Indonesia No. 22 of 2021. Based on the laboratory results, the Marine Water Quality Index (IKAL) was calculated, and the water quality category was determined in accordance with the Minister of Environment and Forestry Regulation No. 27 of 2021.Results: "The analysis results showed an increase in TSS and ammonia levels, while DO slightly decreased after the dumping activity; however, these values remained below the quality standards. In contrast, orthophosphate and oil and grease levels increased beyond the permissible limits. Orthophosphate concentrations ranged from 0.020 to 0.030 mg/L, exceeding the quality standard of 0.015 mg/L, likely due to the release of nutrients contained in the sediments. Oil and grease concentrations reached 1.7 mg/L at all three observation sites, surpassing the standard of 1 mg/L, primarily due to vessel and heavy equipment operations during the dumping process. The rise in phosphorus and oil and grease levels serves as an early indicator of environmental pressure on marine waters and poses a risk of reducing aquatic biodiversity. Therefore, regular environmental quality monitoring is necessary to prevent more severe impacts. Although the Marine Water Quality Index decreased after the dumping activity, it remained within the range of 70–90, classified as 'good'.

Keywords: dumping; marine biodiversity; marine water quality; marine water quality index (MWQI); trenching

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INTRODUCTION

The rising petroleum consumption in Indonesia between 2022 and 2023 underscores the growing urgency for conducting exploration and distribution activities in a safe and efficient manner (China Economic Information Centre, 2023), One of the approaches to support safe and efficient distribution is the utilization of subsea pipeline facilities. An essential phase in the construction of subsea pipeline infrastructure is trenching, a dredging process carried out to attain the necessary depth for pipeline placement (Nanda, 2022). This process produces excavated materials that require appropriate handling to prevent adverse impacts on environmental equilibrium. Nurzahan (2019) an established method of handling such materials is offshore dumping, which is permitted at a minimum distance of 12 nautical miles from the coastline and at depths of no less than 20 meters. This practice may pose environmental risks to marine waters and therefore requires strict control measures to safeguard the continuity of aquatic life and the integrity of marine ecosystems. (Darmawan *et* *all*, 2020). This study aims to analyze the changes in seawater quality caused by the offshore dumping of materials generated from trenching activities.

METHOD

The study was conducted at the offshore dumping site in the waters of Tanjung Jumlai, Saloloang Subdistrict, Penajam District, Penajam Paser Utara Regency, in December 2023. This research employed a quantitative approach using sampling and laboratory analysis methods. Seawater samples were collected from three observation sites (Figure 1) using a Horizontal Water Sampler, following the Indonesian National Standard (SNI) 6964.8:2015 – Water and Wastewater – Part 58: Method for Seawater Sampling. The tested water quality parameters included Total Suspended Solids (TSS), Dissolved Oxygen (DO), Ammonia, Orthophosphate, and Oil and Grease, and the analyses were conducted at the PT Sucofindo Laboratory.

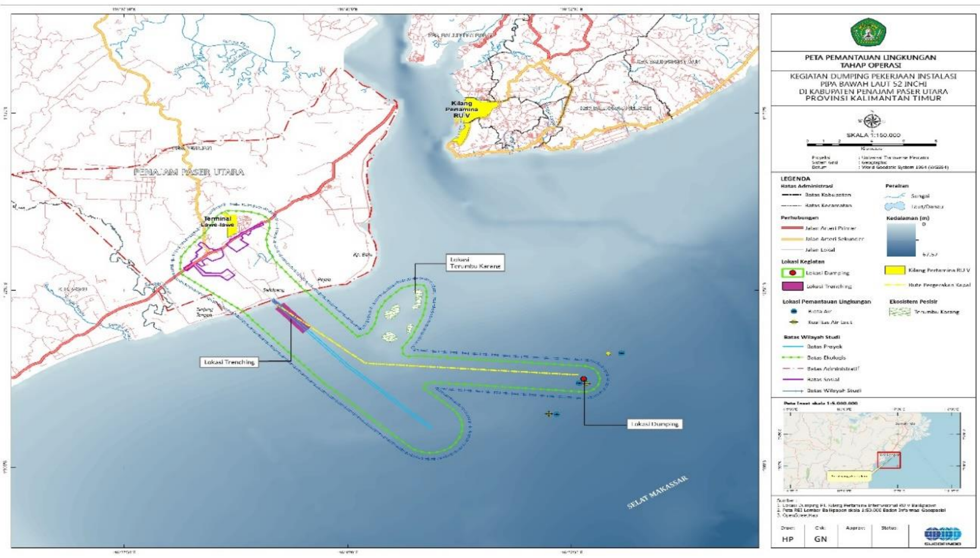

Figure 1. Map of the Study Area

The analysis results will be compared with the marine water quality standards set forth in Government Regulation of the Republic of Indonesia No. 22/2021 concerning the Implementation of Environmental Protection and Management, Annex VIII – Marine Water Quality Standards for Aquatic Biota. Subsequently, the Marine Water Quality Index will be calculated based on Minister of Environment and Forestry Regulation No. 27/2021 concerning the Environmental Quality Index.

RESULT

Table 1.
Seawater Analysis Results

Parameter	Unit	Quality Standard	Location 1		Location 2		Location 3	
			before *dumping*	after *dumping*	before *dumping*	after *dumping*	before *dumping*	after *dumping*
TSS	mg/L	20	2,5	6	2,5	5	2,5	4
DO	mg/L	>5	7,7	7,17	7,8	7,48	7,8	7,62
Ammonia (NH_3)	mg/L	0.3	0,01	0,03	0,01	0,03	0,01	0,03
Ortho Phospate (PO_4-P)	mg/L	0,015	0,010	0,030	0,010	0,020	0,010	0,020
Oil & Grease	mg/L	1	0,001	1,7	0,001	1,7	0,03	1,7

Source: Laboratory Test Certificate issued by PT Sucofindo

Environmental quality refers to the condition that describes the quality of water in a specific location. Seawater quality data were obtained from samples collected directly at three observation sites (Figure 1). The analysis results of the five parameters before and after the dumping activity are presented in Table 1.

Graphs showing the analysis results of each parameter at the three sampling locations before and after the dumping activity are presented in Figures 2 to 6.

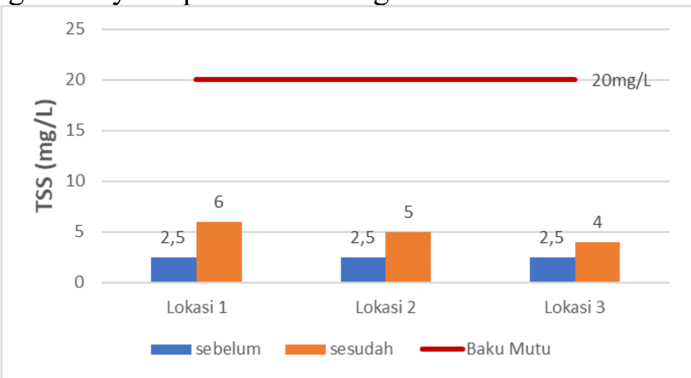

Figure 2. TSS Parameter Test Results

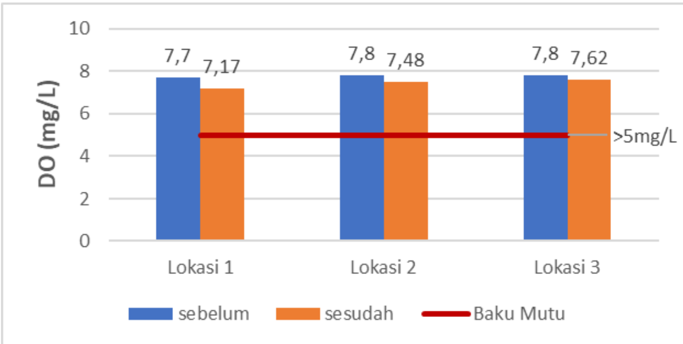

Figure 3. DO Parameter Test Results

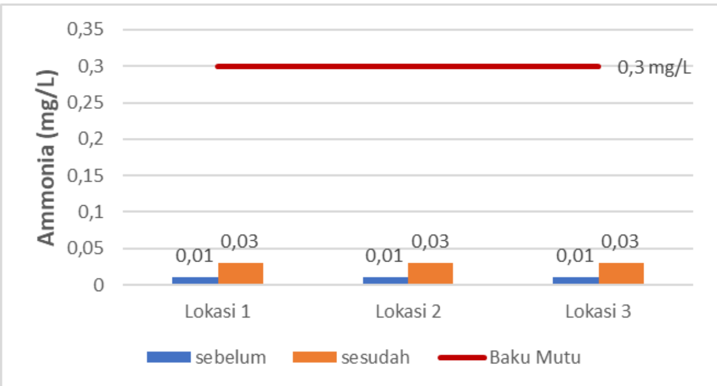

Figure 4. Ammonia Parameter Test Results

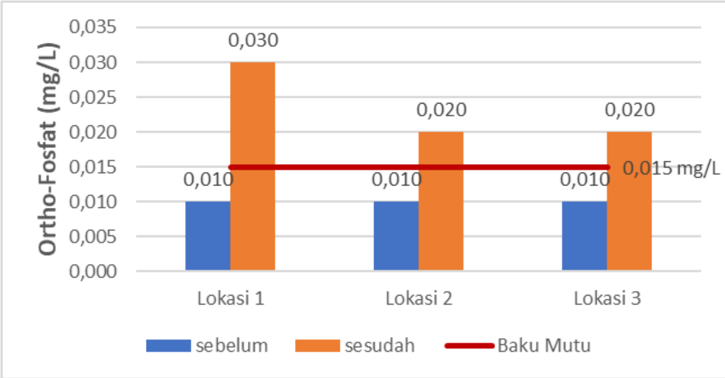

Figure 5. Orthophosphate (PO_4-P) Test Results

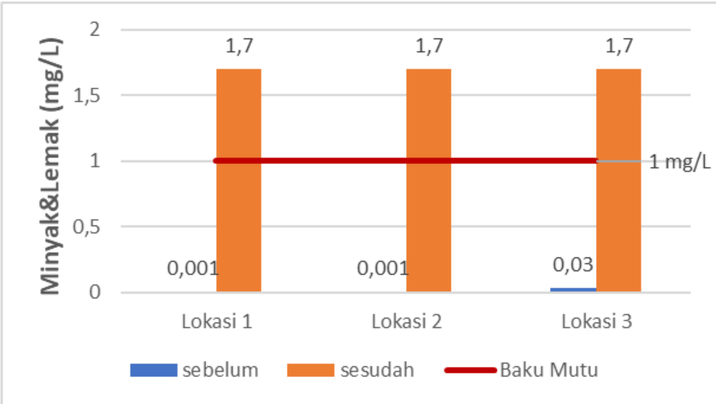

Figure 6. Oil and Grease Test Results

Based on the analysis of the five parameters, the Marine Water Quality Index (IKAL) was calculated. The results of the calculation, following the Minister of Environment and Forestry Regulation No. 27 of 2021, are presented in Figure 7.

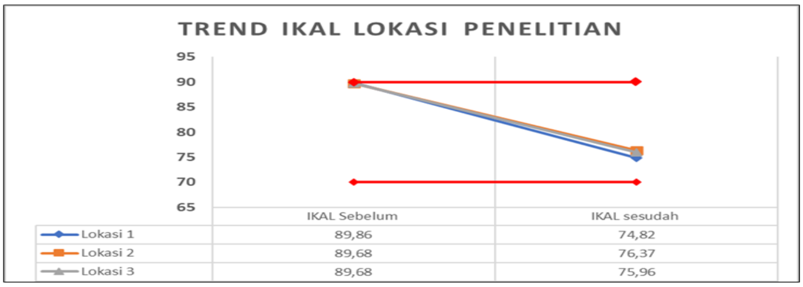

Figure 7. Trend of Marine Water Quality Index (MWQI)

The analysis results indicated an increase in TSS and ammonia concentrations, as well as a decrease in DO levels after the dumping activity at all three observation sites. However, these values remained within the quality standards stipulated in Government Regulation of the Republic of Indonesia No. 22/2021. In contrast, orthophosphate and oil and grease concentrations increased post-dumping and exceeded the established quality standards. The Marine Water Quality Index (MWQI) of the Tanjung Jumlai waters declined following the dumping activity but remained within the range of 70–90, which falls under the "Good" category. This indicates that the water conditions are still capable of optimally supporting marine life

DISCUSSION

Total Suspended Solids (TSS) consist of fine silt, sand, and microscopic organisms, typically originating from soil erosion and surface runoff entering water bodies (Effendi, 2003). TSS content can affect water turbidity and the penetration of sunlight, which is essential for phytoplankton and aquatic plants during the photosynthesis process.The TSS analysis results from the three observation sites are presented in Figure 2. TSS concentrations at the three observation sites increased after the dumping activity, ranging from 4 to 6 mg/L, and remained below the quality standard. These values indicate that the waters of Tanjung Jumlai remained relatively clear and contained minimal suspended particles after the dumping activity.Dissolved Oxygen (DO) refers to the amount of oxygen present in water. Oxygen is essential for all aquatic organisms to support respiration and metabolism, which are necessary for growth and reproduction.The DO analysis results are presented in Figure 3. Dissolved oxygen concentrations at the three observation sites ranged from 7.17 to 7.62 mg/L, meeting the quality standard (>5 mg/L). According to Subarujanti (2005) as cited in Kadim et al. (2017), the ideal oxygen content in water ranges from 3 to 7 mg/L. DO levels in a water body are closely related to pollution levels, types of waste, and the amount of organic matter present (Salmin, 2005). Based on the DO parameter analysis, the post-dumping water quality in Tanjung Jumlai remains good and capable of supporting aquatic life.

Ammonia is formed from the decomposition of nitrogen-containing organic matter by microbial activity and may also originate from industrial and domestic waste discharges (Effendi, 2003). High concentrations of ammonia can create toxic conditions in aquatic environments, disrupt ecosystem balance, and degrade habitat quality for aquatic organisms (Boyd, 1990). The post-dumping ammonia concentrations at the three observation sites were found to be 0.03 mg/L, which is below the quality standard (0.3 mg/L). The results of the analysis are presented in Figure 4. Ammonia concentrations below the quality standard indicate no significant contamination from domestic or organic waste sources (Effendi, 2003) and reflect the presence of a stable ecosystem capable of managing nutrient loads effectively (Boyd, 1990). Ammonia toxicity in marine waters is also influenced by pH levels. High concentrations of ammonia may not be immediately toxic under normal pH conditions (Wahyuningsih, 2021). Therefore, further research is needed on the richness and diversity of marine biota to better assess the actual toxicity levels of ammonia and/or other pollutants Phosphate is one of the essential nutrient compounds, present in both organic and inorganic dissolved forms. It is chemically unstable due to its susceptibility to erosion, weathering, and dilution (Affan, 2010). Phosphate plays a crucial role in determining phytoplankton abundance (Kadim et al., 2017). The orthophosphate analysis results from the observation sites are presented in Figure 5.

Orthophosphate concentrations at the three observation sites ranged from 0.020 to 0.030 mg/L, exceeding the quality standard of 0.015 mg/L. One of the main causes of increased orthophosphate levels is the release of nutrients contained in sediments (Boynton et al., 1995). Hammuna et al. (2018) also explained that phosphate levels in aquatic environments, reaching up to 1.19 mg/L, can result from natural sources such as erosion, sediments, animal waste, domestic wastewater inflow, decaying organic matter, and naturally occurring phosphate minerals. The influx of sediments containing natural phosphate may increase phosphate concentrations in water through a remobilization process (Pan et al., 2021). Phosphate is considered hazardous in aquatic environments when concentrations exceed 0.050 mg/L, as it can lead to algal blooms and hypoxia, ultimately resulting in the death of aquatic organisms (Smith et al., 1999).Although the orthophosphate concentrations at the three observation sites exceeded the ideal threshold for marine biota conservation, they have not yet reached harmful levels. This condition serves as an early indicator of pollution and warrants regular monitoring to prevent more severe environmental impacts.Oil and grease are hydrophobic fractions (insoluble in water) that tend to float on the surface of water bodies, forming films or emulsions when discharged into aquatic environments.

Based on the analysis results, oil and grease concentrations at the three observation sites reached 1.70 mg/L, exceeding the standard limit of 1 mg/L (Figure 6).The increase in oil and grease concentrations was caused by the operational activities of vessels and heavy equipment used during the dumping process. Elevated levels of oil and grease can lead to ecological impacts, including the formation of a thin film on the water surface that hinders oxygen diffusion, disrupts phytoplankton photosynthesis, and causes physiological stress in marine organisms such as fish and benthic fauna (Sari et al., 2021). A study by Putri et al. (2021) showed that oil and grease concentrations ranging from 0.8 to 2.1 mg/L can result in a decrease in plankton diversity index and an increase in the dominance of pollution-indicator species. Environmental stress potential was observed at all three monitoring sites and requires regular observation.The Marine Water Quality Index (MWQI) is a quantitative approach used to describe the water quality level based on physical and chemical parameters, including TSS, DO, Ammonia, Orthophosphate, and Oil and Grease. The Marine Water Quality Index (MWQI) values at Locations 1, 2, and 3 prior to dumping were 89.86, 89.68, and 89.68, respectively. These values decreased after the dumping activity to 74.82 (Location 1), 76.37 (Location 2), and 75.96 (Location 3).

The trend of MWQI values is presented in Figure 7.
The calculated Marine Water Quality Index (MWQI) values at the three research sites, both before and after the dumping of trenching materials, ranged from 70 to 90. According to the MWQI category table from Minister of Environment and Forestry Regulation No. 27 of 2021, the seawater quality at the study sites falls within the “Good” category.An MWQI value in the "Good" category indicates that the water quality remains capable of optimally supporting marine life, with ecological functions of the aquatic environment not yet significantly disrupted. This reflects a low level of pollution and a high environmental carrying capacity. A "Good" MWQI category is considered suitable for various marine activities such as fisheries, tourism, and conservation (Hidayat et al., 2021).

CONCLUSION

The Marine Water Quality Index (IKAL) decreased after dumping activities but remained in the 70–90 range, classified as “good” under Regulation No. 27/2021. Regular monitoring is essential to maintain marine environmental quality. To ensure the long-term sustainability of the marine ecosystem, it is crucial to implement regular and systematic monitoring of water quality, especially in areas affected by activities such as offshore dumping of trenching materials. Such activities have the potential to alter key water quality parameters and introduce harmful pollutants. Ongoing monitoring allows for the early detection of pollutant concentrations—such as orthophosphate and oil and grease—that may exceed regulatory thresholds and pose risks to marine life.Moreover, continuous assessments are essential for evaluating cumulative impacts, guiding mitigation strategies, and supporting evidence-based decision-making in marine environmental management. These efforts are also critical to preserving ecosystem services and ensuring that marine waters remain viable for fisheries, tourism, and conservation initiatives.

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