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Analysis of Water Quality at The Peak of Spawning Season *Tenualosa ilisha* at The Downstream of Bilah River

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Abstract

Water quality analysis plays an important role in understanding the environmental factors that affect aquatic life, especially during critical periods such as fish spawning. The purpose of this study was to investigate several aspects related to water quality and its impact on hilsa fish species during their life cycle period. The study was conducted in Sungai Bilah over a four-month period in 2023, focusing on three specialized stations to assess water quality during the peak season of hilsa fish spawning. This study uses the descriptive method, with strategic sampling locations determined through interviews with fishermen. This method is crucial for understanding the impact of water quality on fish spawning activities. The results of the water quality analysis showed that each station had an average value of Temperature 26.625 °C, Turbidity 86.033, Total Suspended Solid (TSS) 88.75, Dissolved Oxygen (DO) 6.75, Nitrate 2.50, and Phosphate 0.002. Overall, these results indicate that the water quality in the observation area is in a condition that supports the successful spawning of hilsa fish, with stable temperature and adequate dissolved oxygen levels, while other parameters such as turbidity and TSS remain within acceptable limits.

Keywords: *Hilsa Shad; Spawning Season; Tenualosa ilisha; Water Quality River*

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INTRODUCTION

The fish species *Tenualosa ilisha*, commonly known as hilsa, is an anadromous fish found in a variety of habitats. It naturally matures in seawater, migrates to freshwater rivers for spawning, and then larvae develop in freshwater before migrating to downstream rivers and coastal waters (Das et al. 2022). Studies on the composition of the hilsa microbiome have revealed the diversity of different gut bacteriomes in freshwater, brackish water, and marine habitats, with a shared microbiota among them (Kawser et al. 2024) In addition, research focusing on hilsa larval rearing protocols for captive cultures has highlighted the importance of feeding strategies with formulated foods and plankton to improve growth and survival rates, especially with diets containing 40.5 % crude protein (Chattopadhyay et al. 2022). Moreover, the nutritional value of Hilsa has been emphasized, demonstrating its richness in essential minerals, vitamins, amino acids, and fatty acids that are beneficial to human health (Goswami et al. 2022).

The geographical distribution of *T.ilisha*, commonly known as Hilsa shad, extends from the Arabian Gulf to Southern Vietnam, including countries such as Pakistan, India, Bangladesh, and Burma (Das et al., 2022). This anadromous fish species migrates from seawater to freshwater rivers to spawn, while the juveniles move downstream to the nursery grounds before returning to coastal waters as adults to feed and grow up. Studies have shown that (*T. ilisha*) exhibits distinct genetic populations, with one group found in Peninsular Malaysia and the other in Peninsular Malaysia, Thailand, India, and Bangladesh (Arai et al., 2019). In Indonesia, particularly in Sungai Bilahorth Sumatra Province, Hilsa shad fish were observed to be distributed in groups with negative allometric growth patterns, indicating specific habitat preferences and growth dynamics (Machrizal et al., 2019). The commercial and cultural significance of Hilsa in regions such as West Bengal, India, and Bangladesh underscores the importance of understanding its distribution and behavior for conservation and sustainable fisheries management (Das et al., 2022).

Water quality plays a vital role in the habitat of *T. ilisha*, commonly known as hilsa. Studies have highlighted various parameters that influence water quality in areas where hilsa fish are found. These parameters include water temperature, nitrate, phosphate, dissolved oxygen, pH, transparency, alkalinity, hardness, and CO2 levels (Moniruzzaman et al., 2023). which impacts the plankton community consisting of phytoplankton and zooplankton in the Hilsa sanctuary. In addition, the presence of phytoplankton, especially zooplankton, has been associated with better growth performance of hilsa fingerlings, indicating the importance of plankton in the ecosystem for successful maintenance and conservation of hilsa fish (Das et al., 2022). Furthermore, genomic analysis of *T. ilisha* has identified genes associated with homeostasis processes, including aquatic homeostasis, which provides insights into the adaptation mechanisms of hilsa fish to varying salinity levels during migration (Mohindra et al., 2019). Also correlated with water temperature and salinity levels, emphasizing the importance of maintaining suitable water conditions for reproduction and nursery (Al-Okailee et al., 2022).

Lastly, genetic studies have shown low nucleotide diversity and a single paniculate population of hilsa fish in Bangladeshi waters, highlighting the need to manage hilsa fisheries given its low genetic diversity (Sarker et al., 2021). Research on *T. ilisha*, commonly known as hilsa, has investigated various aspects of this valuable fish species. Studies have explored the reproductive physiology of hilsa, highlighting seasonal gonadal cycles, GSI variations, histological observations, and molecular characterization of estrogen receptors (Roy et al., 2024). In addition, investigations into hilsa allergens have identified potential allergens such as parvalbumin and tropomyosin, revealing habitat-specific variations and interactions with humans (Mou et al., 2024). Furthermore, studies on gut bacterium hilsa have revealed distinct microbial compositions across habitats, suggesting exclusive and potential probiotic properties (Hoque et al., 2023; Kawser et al., 2024). Understanding feeding preferences based on size groups has also been studied, with copepods and diatoms identified as major food sources for juvenile hilsa in the Meghna estuary (Dipty et al., 2024). This study aims to assess the impact of water quality on the reproductive and growth performance of hilsa fish (*T. ilisha*) in the Bilah River, Sumatra, focusing on key parameters such as temperature, turbidity, and nutrient levels. This research also aims to analyze water quality during the peak spawning season of hilsa in the Bilah River, evaluating the influence of water quality parameters on the reproductive process of hilsa. By focusing on this critical spawning period, the study is expected to provide deeper insights into the relationship between water quality and reproductive success, as well as offer recommendations for more effective and sustainable management of the aquatic ecosystem in the region. The findings will provide valuable insights for the conservation and sustainable management of hilsa fisheries in Indonesia.

METHOD

Time and Place

This research was conducted in Sungai Bilah. Measurement of aquatic physicochemical parameters is carried out at high tide and low tide 1 time in 1 month from January to April 2023. The measurement location is divided into three observation points (stations). Station 1 is located in Negri lama whit coordinates 2°30'37.51"N; 100° 9'17.74"E, which is a busy ship traffic area. station 2 is located in Sei mambang with coordinates 2°32'29.03"N; 100° 7'33.03"E (fishing area) and station 3 is located in sijawi jawi with coordinates 2°38'29.113"N; 100° 6'29.43"E (meeting of freshwater and sea) (Figure 1).

Sampling Procedure

Sampling of Bilah river water was carried out at 10.00 A.M. River water samples from each research station that have been taken are put into polypropylene plastic containers with a volume of 5 (five) liters to be analyzed in the Laboratory. The physicochemical parameters of the waters measured in this study can be seen in table 1.

Table 1. Water Quality Parameter Measurement Method

Parameter	Measurement tool	Metode
Temperature	Thermometer	Insitu
Dissolved Oxygen (DO)	DO Meter	Insitu
Total Suspended Solid	Gravimetri	Laboratorium
Turbidity	Spectrophotometer	Laboratorium
Nitrate	Spectrophotometer	Laboratorium
Phosphate	Spectrophotometer	Laboratorium

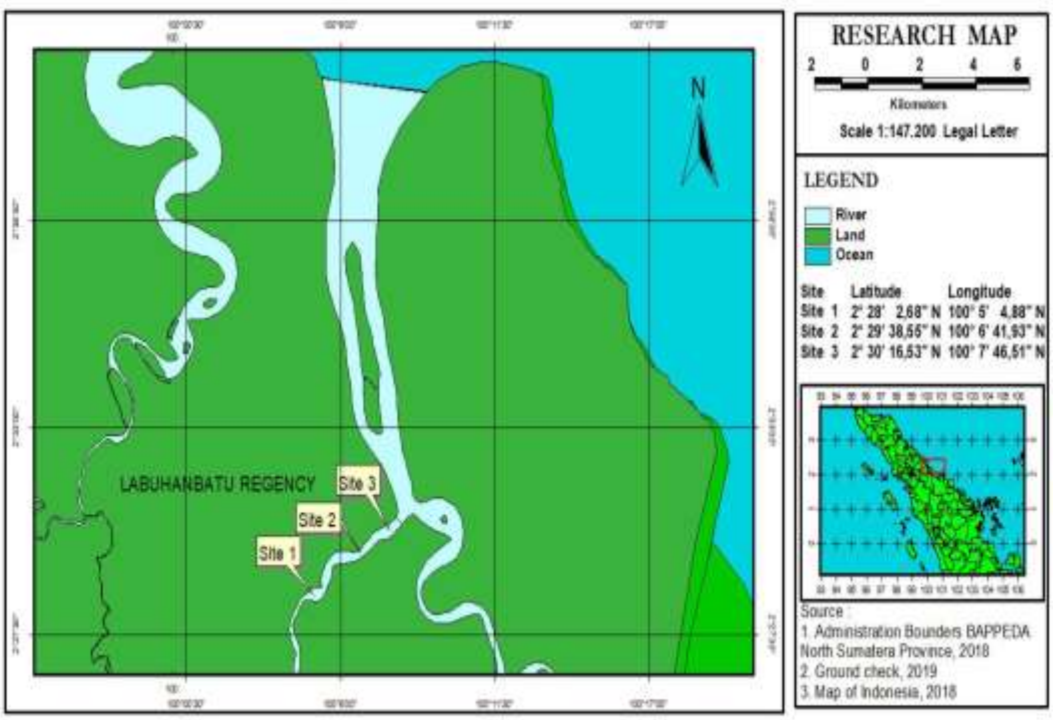

Figure 1. Map of the Research Location

Data analysis

The data on the results of water quality testing which includes physical, chemical and biological parameters is compared to the quality standards that have been set. The river water quality standards refer to Indonesian Government Regulation Number 22 of 2021 concerning implementing Environmental Protection and Management. The data was analyzed descriptively with the help of Microsoft Excel software, and presented in tables and graphs.

RESULTAND DISCUSSION

Water Quality Parameters

Research parameters for water quality analysis include temperature, turbidity, TSS (Total Suspended Sosids), DO (dissolved oxygen), nitrate, and phosphate,The survey results are shown in Table 3.

Temperature

The results of measuring water temperature parameters during the period of January to April are presented in figure 2. This result is the average result of measurements during high and low tide conditions.

Table 3. Results of water quality premeter measurements at each research station

Parameter	Unit	Quality Standart**	Observation Station			Average
			1*	2*	3*	
Temperature	°C	28-32	26.62	26.12	26.12	26.65
Turbidity	NTUs	1000	66.17	71.77	120.15	86.033
TSS	Mg/L	100	79.75	87.00	99.50	88.75
DO	Mg/L	3	7.085	6.850	6.430	6.750
Nitrat	Mg/L	20	2.38	2.48	2.64	2.50
Phosphate	Mg/L	0,2	0.02	0.02	0.02	0.02

Note: (*) average value of each month's measurement; (**)Quality standards based on Government Regulation of the Republic of Indonesia Number 22 of 2021 concerning the implementation of environmental protection and management.

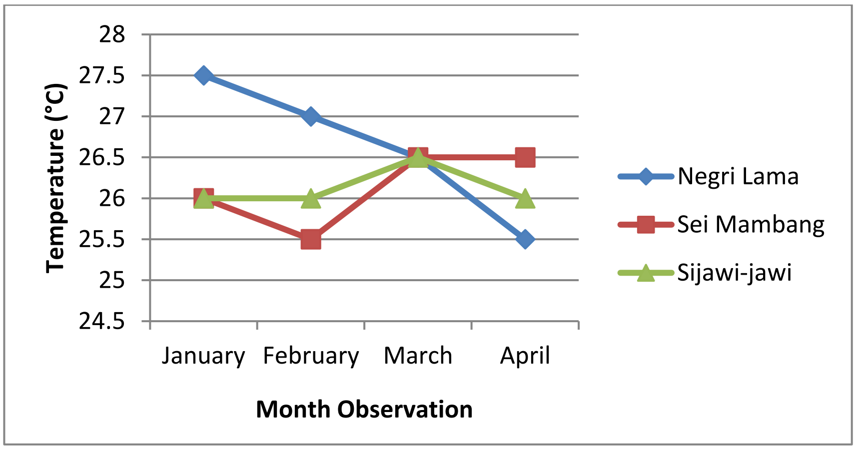

Figure 2. Results of temperature parameter analysis in Sungai Bilah during the Study

The results of the analysis of water temperature measurements during the study showed that the average water temperature of Sungai Bilah was 26.125 - 26.625 °C, with the highest temperature value occurring in March at each research station. This result is not much different from the research obtained by (Harahap, 2022). Measurement of the water temperature of the Barumun River at the location of monitoring point 1 to monitoring point 3 shows that the water temperature ranges from 27 – 28 °C.

The highest temperature reached and the results of the water temperature analysis. Measurements during the study showed that the average water temperature of Sungai Bilah was 26.125 - 26.625°C, with the highest temperature value occurring in March at each research station. This result is not much different from the research obtained by Harahap (2022) Measurement of the water temperature of the Barumun River at the location of monitoring point 1 to monitoring point 3 shows that the water temperature ranges from 27 - 28 °C. The highest temperature reached monitoring point 3, at 28°C. This temperature condition still follows the Class II water quality criteria according to Government Regulation 82 of 2001, which allows a deviation of 4 °C from the natural temperature. Therefore, the river water quality, based on the temperature parameters, still meets the water quality criteria as per its designation.

Temperature plays an important role in water quality analysis, impacting the accuracy of detection results. Factors influencing temperature in water quality analysis include the need for a temperature-controlled environment for bacteriological analysis (Manfredini, 2022). the utilization of temperature and humidity detection modules to compensate for environmental effects on test results (Lijian et al., 2018). The application of temperature control devices to ensure stable water temperature for accurate detection by water quality detectors (Xiaoping, 2019). and the development of sensors filled with protective materials to prevent interference and accurately measure water temperature (Hyung, 2015).

Turbidity

The results of water turbidity measurements during the period of January – April are presented in Figure 3. The results showed that the average level of turbidity in the Sungai Bilah was 66.17 - 120.15 NTU, with the highest average value occurring in January at each station. In contrast to the turbidity that occurred in the Krueng Aceh river, the highest turbidity occurred in the same sub-watershed, namely the Indrapuri sub-watershed of 20.60 and 40.80 NTU for monitoring in June. The lowest turbidity occurred in the same sub-watershed, namely in Krueng Teureubeh at 2.45 NTU (June) and 3.95 NTU (November). This turbidity is caused by the presence of material entering from rivers that drain into the Krueng Aceh river. These materials can be in the form of organic and inorganic materials, both suspended and dissolved such as mud, fine sand, or organic materials such as plankton and other microorganisms which all flow into the Krueng Aceh river watershed (Patra, 2015).

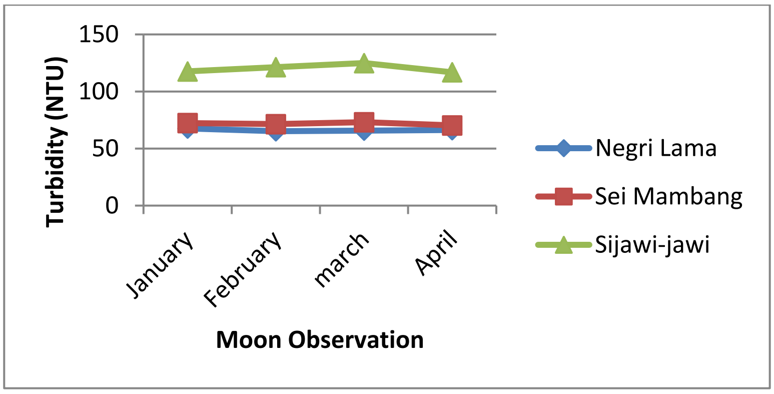

Figure 3. Results of turbidity analysis in Sungai Bilah during the Research

Turbidity in water quality analysis is affected by various factors such as algae concentration, particle size, and solute color, which directly affect turbidity measurements (Zhang et al., 2022). In addition, regional climate factors, human activities, urbanization, and wastewater disposal play an important role in the variation of turbidity in water bodies (Lin et al., 2023). Inorganic turbidity has been identified as a key factor influencing DNA extractability in water quality testing, with high inorganic turbidity leading to reduced DNA extractability and potential bias in molecular diagnostics (Linke et al., 2021). In addition, the correlation between total suspended solids (TSS) and turbidity is essential for assessing water quality, especially in agricultural applications, where turbidity meters can be used to quickly estimate TSS levels (Va et al., 2023).

Total Suspended Solid (TSS)

The total Suspended solid (TSS) on the Bilah river during January-April shows the average yield in figure 4. The results of TSS analysis on the Bilah River in January-April showed an average of 79.75 – 99.5 Mg/l, with the average value occurring in April at each station. Meanwhile, the results of TSS research analysis by Susiati (2016) In the Tanjung Berani Coastal area, the concentration of TSS is between 0.1 - 42 Mg/l. In contrast to the Krueng Aceh river for monitoring in 2008, the highest TSS occurred in the Krueng Indrapuri sub-watershed at 74 mg/L, and the lowest occurred in the Krueng Ie Alang sub-watershed at 0.002 mg/L. Meanwhile, for 2009 the highest concentration was 93 mg/L, while the lowest TSS concentration was found in the Krueng Teureubeh sub-watershed at 6 mg/L. There was a fluctuation in the TSS value in each measurement due to the difference in material input from the land and flowing from the river Krueng Indrapuri. It can be seen that in the downstream part the TSS value is relatively high due to increased human activity around the area. In addition, the high and low concentration of TSS in the river is also.

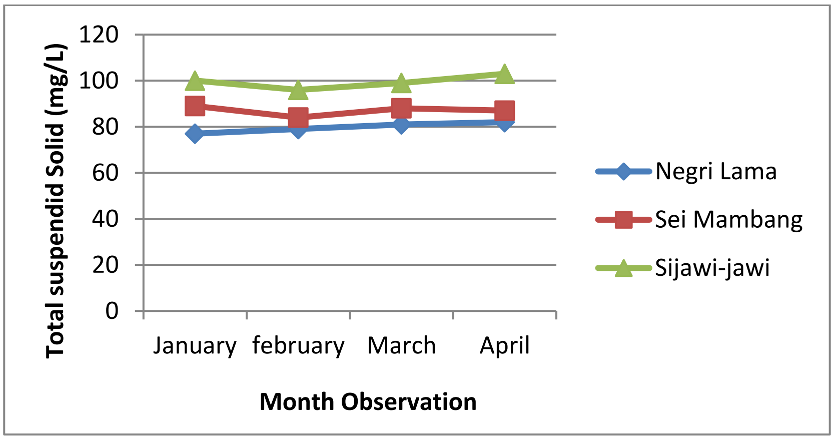

Figure 4. Results of Total Suspended Solid analysis in Sungai Bilah during the Research

Total Suspended Solids (TSS) in water quality analysis are affected by various factors such as the concentration of electrolyte minerals such as sodium, potassium, and calcium, as well as the presence of pollutants such as manganese (Caroline, 2023; Sivakumar, 2023). The optical properties of TSS, turbidity, and electrolyte minerals play an important role in determining water quality, with higher concentrations leading to an increase in absorption coefficients at certain wavelengths (Sivakumar, 2023). Remote sensing methods using satellite imagery have been used to monitor the distribution of TSS in water bodies, revealing

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significant levels of sedimentation and pollution that exceed quality standards, impacting water quality assessments (Hariyanto et al., 2021; Dewi, 2023).

Dissolved Oxygen

The average results of the dissolved oxygen (DO) in the Bilahriver from January to April are shown in figure 5. The results of the Dissolved Oxygen analysis in the Bilahriver showed an average of 7.0-6.4 Mg/l, with the highest DO values occurring in February, March, and April at each research station. The results of init are not much different from those Nursaini & Harahap (2022) The results of the measurement of dissolved oxygen (DO) of Barumun river water at monitoring point 1 sampling of 6.7 mg/l, monitoring point 2 of 5.5 mg/l and monitoring point 3 of 4.9 mg/l. The value of dissolved oxygen concentration in the Barumunriver ranges from 4.9 to 6.7 mg/l. This value is still within the threshold of class II river water quality criteria of 4 mg/l, so river water with a DO parameter value of 4.9 – 6.7 can still be used for recreational facilities (Harahap, 2022).

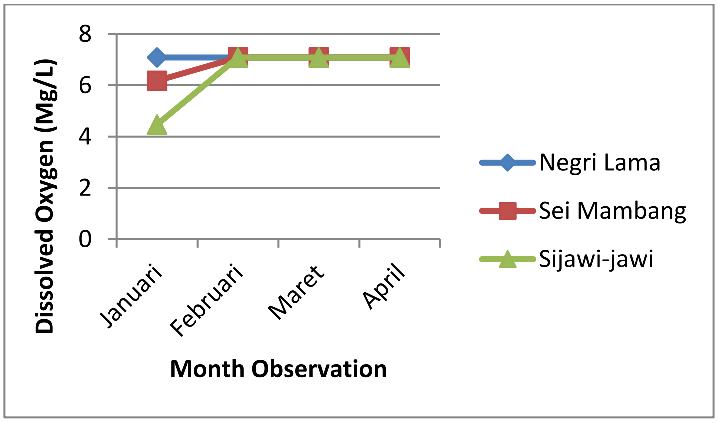

Figure 5. Results of Dissolved Oxygen analysis in Sungai Bilah during the Research

Factors affecting Dissolved Oxygen (DO) levels in water quality analysis include the rate of addition of pollutants along rivers, the contribution of organic matter, the rate of bacterial growth, and environmental conditions. Analytical and numerical models show that the level of pollutant addition and the term pollution source exponentially inversely affect the concentration of DO (Manitcharoen et al., 2020). Bacterial growth rates, organic matter repartitioning, and physical factors such as reoxygenation due to navigation and wind significantly impact DO simulations, especially during low-flow seasons (Hasanyar, 2022). In addition, key variables that affect surface water quality, such as BOD (Biochemical Oxygen Demand , $N\text{-}NH^{4+}$, TN (Total Nitrogen), TOC (Total Organic Carbon), Cl^-, TSS, $SO4^{2-}$, Fe, and coliform, play an important role in determining DO levels in water bodies (Giao, 2022).

Nitrate

The results of the analysis of nitrite deposits in the Bilahriver during the period of January – April are presented in Figure 6. This result is the average result of measurements during high and low tide conditions. The results of the analysis of nitrite deposits in the Bilahriver showed an average of 2.3 - 2.6 Mg/l with the highest nitrite value in March at each station. In the research (Harahap, 2022). The analysis of nitrite content (NO_2-N) in Barumun river water showed that the nitrite concentration at monitoring point 1 was 0.037 mg/l, monitoring point 2 was 0.040 mg/l, and monitoring point 3 was 0.047 mg/l. The value of the Barumun River nitrite concentration ranges from 0.037 – 0.047 mg/l, this value is still within the threshold of class II river water quality criteria of 0.06 mg/l, so that river water with a nitrate parameter value of 0.037 – 0.047 mg/l, can still be used for recreational facilities (Harahap, 2022).

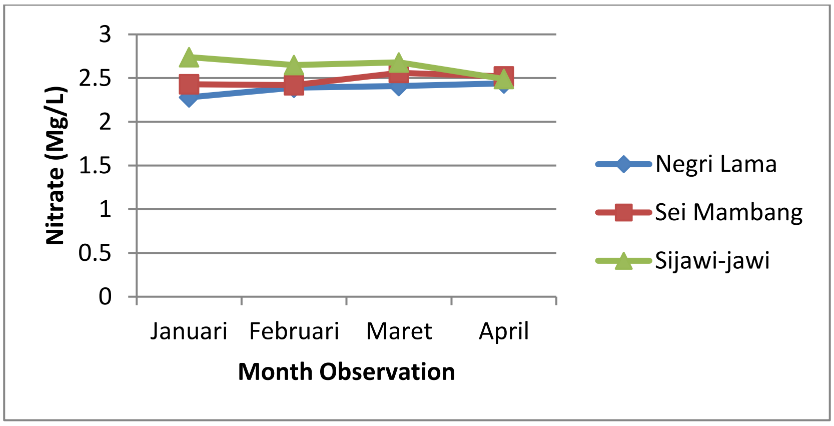

Figure 6. Results of nitrate analysis in Sungai Bilah during the Research

Factor, an anthropogenic activity such as agriculture, can significantly affect nitrate levels in water bodies, affecting water quality analysis (Villegas et al., 2023). Nitrate contamination from sources such as agricultural runoff poses environmental and public health risks, requiring accurate monitoring methods (Ingles et al., 2021). Innovative technologies such as portable nitrate sensors that use smartphone cameras and spectroscopy techniques offer efficient and cost-effective solutions for nitrate detection in water samples (Ingles et al., 2021). Real-time monitoring with in-situ sensors provides valuable data for understanding nitrate dynamics in watersheds, emphasizing the importance of analyzing nitrate levels in conjunction with other water quality variables for effective management and decision-making (Kermorvant et al. 2023).

Posphate

The results of the analysis of the Poafat river water during the period of January – April are presented in figure 7. This result is the average result of measurements during high and low tide conditions. The results of the analysis of the Bilah River water phosphate showed an average of 0.002 because the study in each station from January to April had the same results. In the research of (Harahap, 2022). the results of the analysis of Phosphate content (PO_4^-P) in Barumun river water showed that the phosphate concentration at monitoring point 1 was 0.094 mg/l, then increased at monitoring point 2 by 0.291 mg/l and decreased the concentration at monitoring point 3 by 0.257 mg/l (Hoque et al., 2023). The value concentration of Phosphate in the Barumun River ranges from 0.094 to 0.291 mg/l, this value is still within the threshold of the class II river water quality criteria of 0.2 mg/l, so river water with a Phosphate parameter value of 0.094 – 0.291 mg/l, can no longer be used for recreational water, freshwater fish farming (Harahap, 2022).

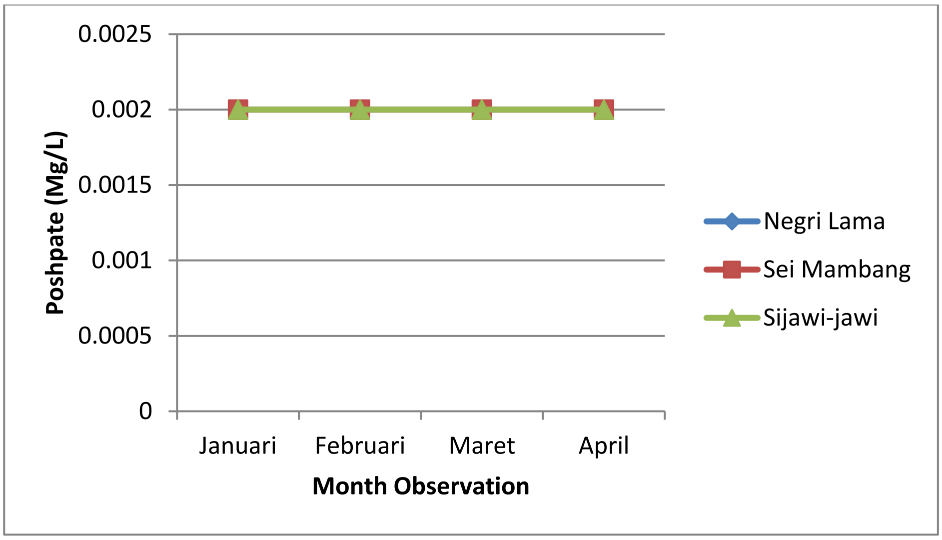

Figure 7. Results of phosphate analysis in Sungai Bilah during the Research

The impact of factor on water quality analysis was not directly discussed in the context of the research provided. However, various studies highlight the importance of utilizing advanced technologies such as satellite imagery, and social media analysis to improve water quality assessments. Remote sensing techniques using satellite imagery offer a scalable and efficient method to monitor water bodies globally, extracting key indicators such as turbidity and chlorophyll-a concentrations. In addition, social media platforms can be leveraged to automatically capture and analyze user-generated content related to water quality issues, aiding in the identification and classification of issues such as color, disease, and taste (Eken, 2023).

CONCLUSION

Based on the results of the study, it was found that all the measured parameters are below the maximum limit of the quality standards set by the government, making this condition safe for all aquatic biota, with a stable temperature ranging from 26.625°C and dissolved oxygen (DO) levels above 5 mg/L, which have proven to be important factors influencing the successful spawning of hilsa fish in the observation area.

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