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Analysis of Water Quality Status in the Polluted Porong River Due to Detergent on the Hematological Performance of Java Barb (*Barbonymus gonionotus*)

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Abstract: The Porong River is one of the rivers that faces high anthropogenic impacts, such as surfactant waste from detergents. The hematology of Javanese carp (*Barbonymus gonionotus*) serves as a sentinel organism that can be used as a biomarker for the waters of the Porong River. The aim of this study is to analyze the water quality status of the Porong River polluted with surfactants using the STORET method, as well as its impact on the hematology of Javanese carp using regression and correlation analysis. The research employed a descriptive survey method. The results of the study indicated that the Porong River was categorized as moderately polluted. The average highest surfactant concentration reached 7.2 mg/L, leading to an increase in TSS to 107.95 mg/L and a decrease in DO to 1.80 mg/L. Surfactants exhibited a negative correlation with erythrocytes (91.2%), hematocrit (47.7%), and hemoglobin (60.6%), indicating that the higher the surfactant concentration, the lower the number of erythrocytes, hematocrit levels, and hemoglobin levels in Javanese carp. Conversely, there was a positive correlation between surfactants and leukocytes (56.7%) and blood glucose (66.7%), suggesting that the higher the surfactant concentration, the higher the number of leukocytes and blood glucose levels in Javanese carp.

Keywords: Hematology; Java barb; Porong river; Surfactant waste; Water quality

Introduction

The Porong River has become a significant environmental concern in recent years, especially in developing countries, due to increased population growth and industrial activities leading to the discharge of untreated wastewater into the river (Tzanakakis et al., 2020). Sungai Porong, located in East Java, Indonesia, is one such river that experiences significant pollutant input, resulting in environmental degradation (Jensen et al., 2023). The East Java Environmental Agency reported that the water quality of Sungai Porong is in a polluted condition. One of the factors contributing to pollutant input in Sungai Porong is domestic waste, including inorganic detergent waste containing active surfactant compounds (Yenni, 2020).

The presence of active anionic surfactant compounds like Linear Alkylbenzene Sulfonate (LAS),

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which have not been adequately degraded, can accumulate in the waters of Sungai Porong (Novitasari et al., 2021; Zakia & Irawanto, 2019). LAS surfactant is commonly used in cleaning and detergent products. The accumulation of undegraded LAS surfactant exposure has negative impacts on aquatic ecosystems, including aquatic organisms such as fish. LAS surfactants can disrupt the cell surface integrity of organisms, damage the protective gill layers of fish, and cause respiratory disturbances and behavioral changes in aquatic organisms (Martins-Costa et al., 2022).

Java barb (*Barbonymus gonionotus*) is one of the aquatic commodities frequently found in Sungai Porong and has a relatively high protein content compared to other freshwater fish. Javanese carp can serve as a bioindicator if it meets specific criteria (Hamza-Chaffai, 2014). Some factors that influence the relevance of Javanese carp as a bioindicator of Sungai Porong water quality include the availability of Javanese carp in Sungai Porong, their response to pollution, and their relevance to human health (Seta et al., 2017).

Significant changes in hematological parameters can indicate health disturbances in fish caused by surfactant exposure (Gouda & Aljaafari, 2021; Gupta & Nigar, 2020). Surfactants dissolved in water and entering the Javanese carp's body through respiration and absorption can affect the circulatory system and vital organs of the fish. This can be reflected in changes in hematological parameters such as a decrease in the number of red blood cells, an increase in the number of white blood cells, changes in hemoglobin levels, and so on. The novelty of this research is analyzing the impact of surfactant pollution on living organisms such as Javanese carp in the Porong River, as well as providing valuable information for environmental monitoring and river ecosystem protection efforts. Changes in the hematological performance of Javanese carp compared to water quality parameters and surfactant concentrations in the Porong River can be a particular concern in assessing pollution levels and their impact on aquatic biota.

The objective of this study is to analyze the water quality status of the Porong River polluted with detergent surfactants using the STORET method and to determine its influence on the hematological performance of Javanese carp using linear regression analysis. Monitoring and analysis of water quality parameters such as pH, dissolved oxygen (DO) concentration, and total suspended solids (TSS) were selected based on the direct impact of surfactant concentrations. Hematological parameters of Javanese carp were observed based on the significant impact of surfactant pollution, including erythrocytes, leukocytes, hematocrit, hemoglobin, and blood glucose.

Method

This study was conducted from December 2022 to February 2023. The selected research location was the Porong River, Sidoarjo Regency. Subsequently, water quality research was conducted on a laboratory scale at the Freshwater Fisheries Laboratory of Sumber Pasir, Brawijaya University. The hematological research on fish was conducted at the Fish Cultivation Laboratory, Fish Disease and Health Division, Brawijaya University.

Water Quality Measurements

The analysis of Porong River water quality with the presence of B. gonionotus fish involves physical parameters (Total Suspended Solids/TSS) and chemical parameters (pH, Dissolved Oxygen/DO). The tools used include pH meters, DO meters, Erlenmeyer flasks, hot plates, cuvettes, spectrophotometers, and porcelain cups. The materials used consist of Lugol's solution, $KMnO_4$, H_2SO_4, sodium oxalate, distilled water, Nessler reagent, phenolphthalein indicator, Na_2CO_3, disulfonic phenol acid, NH_4OH, ammonium molybdate, and $SnCl_2$. The TSS measurement procedure uses the gravimetric method (Ma'arif & Hidayah, 2020).

Surfactant Concentration Analysis

The concentration of detergent surfactants in the river is measured to determine the level of surfactants as a pollutant parameter. Surfactants in detergents can be analyzed using the SNI 06-6989.51:2005 method, which involves testing the concentration of anionic surfactants using a spectrophotometer and methylene blue reagent (Pratamadina & Wikaningrum, 2022).

Hematological Analysis

Fish samples taken include three Javanese carp from each sampling point, with sizes ranging from 10 to 20 cm. The fish samples are categorized based on criteria for healthy fish and those contaminated by detergent surfactants. Javanese carp suspected of being exposed to detergent pollution exhibit clinical symptoms such as slow mouth and operculum movements, sunken eyes, slimy skin, torn fins, and irritation (Bandyopadhyay et al., 2022). Blood sampling from the fish is performed using the Puncturing the Caudal Vessel technique (Yuniastutik, 2019). Hematological analysis includes parameters such as erythrocytes, leukocytes, hematocrit, hemoglobin, and blood glucose.

The formula for calculating the number of erythrocytes is as follows (Yanuhar et al., 2018).

$$RB = \frac{\text{Counted Red Blood Cells xdiluent}}{\text{Volume}} \quad (1)$$

Description:
RB = Red Blood Cell Count

The formula for calculating the number of leukocytes is as follows (Yanuhar et al., 2018).

$$\text{WB} = \text{Counted White Blood Cells} \times 50\ \text{cells/mm}^3 \quad (2)$$

Description:
WB = White Blood Cell Count

Data Analysis

The data obtained from the study is compiled using Microsoft Excel to create graphs. This data is then subjected to multiple linear regression analysis. This analysis is useful for understanding the relationship between detergent surfactant concentrations and water quality parameters specifically TSS, pH, and DO, as well as the relationship between detergent surfactant concentrations and the hematological performance of Javanese carp. The use of linear regression analysis is an easily understandable method that still provides significant insights (Khasanah, 2021). Multiple linear regression offers a robust framework for hypothesis testing and statistical inference (Sutopo & Slamet, 2017). This analysis can help researchers determine the significance of regression coefficients and test hypotheses regarding the influence of independent variables on dependent variables

Result and Discussion

General Condition of Research Locations

Location point 1 is a river stream close to a residential area and is often used as a direct disposal site for household waste by the local residents. Point 1 is near Street of Raya Porong, Sidoarjo Regency. The physical condition of the water at location 1 is grayish in color, turbid, and in some areas, there is foamy water. The foam is visible on the water's surface and is indicated to be a result of surfactant waste from detergents located at point 1.

Location point 2 is situated at Jl. Dukuhsari, Jabon District, Sidoarjo Regency, which is close to areas with resident fishponds, rice fields, and some industries. The physical condition of the water at point 2 appears turbid and is filled with vegetation such as water grass and bamboo. Additionally, some areas of the water also contain foam, although not as much as at location 1. Location point 3 is near the mouth of the Porong River and close to the marine tourism area in Tlocor Village, Jabon District, Sidoarjo Regency. The physical condition of the water at point 3 is turbid, and there is a lot of mud along the riverbanks. At point 3, there are also several pieces of plastic waste stuck along the riverbanks.

Figure 1. Porong river

Analysis of the Water Quality

Governor Regulation of East Java Province No. 6 of 2010 states that the Porong River, based on its water quality classification, is classified as class III within its territorial boundaries. Class III extends from the village of Porong to the estuary, which corresponds to points 1, 2, and 3 in this study. The water quality standards of the river should meet the water quality standards according to the Government Regulation of the Republic of Indonesia No. 22 of 2021 to support the optimal growth and survival of organisms, especially fish.

Based on the results of the water quality research in Table 1, it can be seen that the concentration of TSS (Total Suspended Solids) in the waters of the Porong River at point 1 has the highest concentration compared to points 2 and 3, with results of 107.95 mg/L (exceeding the standard of 100 mg/L PP No. 22 of 2021) in the first sampling, 29.50 mg/L in the second sampling, and 66.70 mg/L in the third sampling. The high concentration of TSS at point 1 is indicated to be a result of the concentration of surfactants in the water that directly affects TSS. The accumulation of poorly treated surfactants has the potential to increase TSS (Das et al., 2023). The pH concentration of the water obtained from this study ranges from 6.25 to 7.47, indicating that the pH concentration of the Porong River water still meets the water pH quality standard, which ranges from 6 to 9 as stated in PP No. 22 of 2021. The stable pH concentration of river water has important benefits for maintaining ecosystem sustainability and human health (Loi et al., 2022; Xu et al., 2022).

Table 1. Physicochemical Parameters of Water Quality in the Porong River

Parameters	Units	Standard	Site 1			Site 2			Site 3		
			U1	U2	U3	U1	U2	U3	U1	U2	U3
Physics											
TSS	mg/L	100	107.95	29.50	66.70	16.30	15.10	8.50	7.10	7.70	5.00
Chemistry											
pH		6–9	7.32	7.40	7.47	7.29	7.35	7.35	6.90	6.25	6.60
Dissolved Oxygen	mg/L	≥3	1.80	3.85	1.99	3.50	3.75	4.65	6.30	4.40	5.97

The dissolved oxygen (DO) level in the waters of the Porong River in this study shows that point 1 has the lowest DO level compared to points 2 and 3. The DO level at point 1 in the first sampling is 1.80 mg/L (less than the standard of ≥3 mg/L PP No. 22 of 2021), 3.85 in the second sampling, and 1.99 (less than the standard of ≥ 3 mg/L PP No. 22 of 2021) in the third sampling. Low DO levels can increase the vulnerability of organisms to other pollutants (Soegianto, 2019). Organisms exposed to low DO levels are more susceptible to the negative effects of toxic chemical pollutants like surfactants because their immune systems weaken (Marzuki et al., 2022).

Analysis of Surfactant Concentration in the Porong River

The color differences observed in the study of anionic surfactant concentrations in detergents yielded the following results: point 1 has a pale or faint color, point 2 has a pale purple color, and point 3 has a bright blue color. This is due to the increased concentration of detergent, which causes methylene blue to lose its brightness and become paler (Asmare et al., 2022). The reaction between detergent and methylene blue forms a complex that binds detergent molecules with the dye, reducing the intensity of the blue color (Miller et al., 2020).

Based on the color test results, it is indicated that point 1 has a higher surfactant concentration compared to the surfactant concentrations at points 2 and 3. This is supported by the fact that point 1 represents an area near residential areas and is often used as a direct dumping site for household waste by the local residents. The results of the measurement of anionic surfactant concentrations in detergents conducted in the waters of the Porong River over three repeated samplings can be seen in Table 2.

Table 2. Surfactant Concentration in the Porong River

Station	Surfactant Concentration (mg/L)			Average (mg/L)
	Retake 1	Retake 2	Retake 3	
1	7.8	7.2	6.60	7.20
2	4	4.6	4.2	4.27
3	3.6	4.2	3.6	3.80

Based on the results of surfactant concentration calculations in Table 2, it is known that the highest surfactant concentration was found at point 1, with an average surfactant concentration of 7.20 mg/L, point 2 had a concentration of 4.27 mg/L, and point 3 had a concentration of 3.80 mg/L. The high surfactant concentration in the Porong River has exceeded the water quality standards set by Regulation No. 22 of 2021, which has a maximum limit of 0.2 mg/L. This indicates that the excessive use of anionic surfactants in detergents is not balanced by the treatment of wastewater before it is discharged into the river. The significant impact of exceeding these standards will degrade the water quality status of the Porong River (Rusdiyanto et al., 2021). Excessive surfactant concentrations in river waters can have negative effects on the aquatic ecosystem and the organisms living in it (Lestari, 2022). Excess surfactants can reduce the dissolved oxygen levels in the water, and low oxygen levels can disrupt the respiration of aquatic organisms (Wahyono et al., 2021).

Determination of the Water Quality Status of the Porong River

Based on the results in Table 3 regarding the water quality status assessment of the Porong River using the STORET method, a score of -13 was obtained. This represents that the Porong River is moderately polluted with a score ranging from -11 to -30. The parameter that predominantly contributes to the decline in water quality status in the Porong River is the concentration of detergent waste exceeding the maximum limit set by Government Regulation No. 22 of 2021, which is 0.2 mg/L. According to the research by Zakia & Irawanto (2019), the concentration of surfactants in detergents in the Porong River ranged from 0.03 to 0.22 mg/L.

Therefore, it can be concluded that there has been an increase in the concentration of detergent surfactants in the Porong River from approximately 3.57 to 7.58 mg/L in less than 5 years. The increase in population, leading to increased water consumption, puts pressure on biodiversity in ecosystems worldwide (Kılıç, 2020).

Analysis of the Hematological Performance of Javanese carp Erythrocytes and Leukocytes

The analysis of the number of erythrocytes and leukocytes in the blood of tilapia fish can be seen in Figure 2.

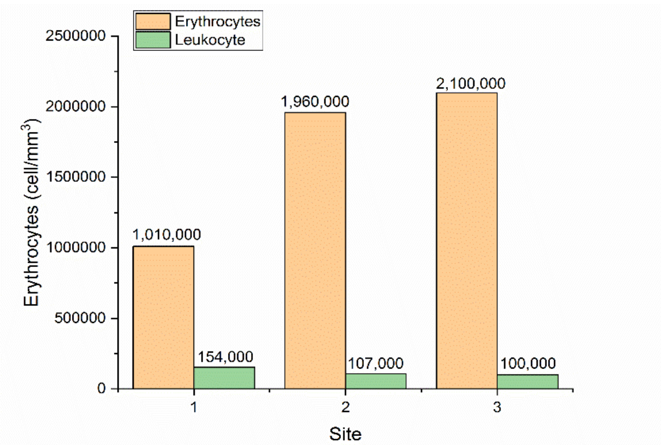

Figure 2. Number of erythrocytes and leukocytes in Java barb

The results in Figure 2 show that the lowest number of erythrocytes was found at point 1, which was 1,010,000 cells/mm^3. This led to an increase in leukocytes in tilapia fish at point 1, reaching 154,000 cells/mm^3. The number of erythrocytes in the blood of tilapia fish at point 2 was 1,960,000 cells/mm^3 with a leukocyte count of 107,000 cells/mm^3. Then, the number of erythrocytes in the blood of tilapia fish at point 3 was 2,100,000 cells/mm^3 with a leukocyte count of 100,000 cells/mm^3. Reviewing the performance of fish blood cells, a good range of erythrocytes for fish to thrive is between 1,050,000 and 3,000,000 cells/mm^3. Meanwhile, a good range of leukocytes for fish survival is between 20,000 and 150,000 cells/mm^3. Therefore, it can be concluded that the number of erythrocytes in tilapia fish at all points is still within the acceptable range for fish survival. However, caution is still needed because the condition of blood cell performance in tilapia fish at point 1 has a high leukocyte count exceeding the normal level for fish.

The decrease in the number of erythrocytes and the increase in the number of leukocytes in the fish's bloodstream are manifestations of how fish naturally create an immune system in response to potential infection or contamination in their habitat (Lubis et al., 2016). This indicates that it occurred because the water quality conditions of the Porong River, which had the highest surfactant content, were found at point 1 with a concentration of 7.2 mg/L in this study. Excessive exposure to surfactants can damage the red blood cell membranes of fish, disrupt erythrocyte integrity and function, resulting in a decrease in the number of erythrocytes in the blood (Kristanti et al., 2021). Additionally, surfactant exposure can also increase the number and activity of leukocytes in fish blood as an immunological response or inflammation within the fish's body in response to surfactant exposure (Giri et al., 2020).

Hematocrit and Hemoglobin

The analysis of hematocrit percentage and hemoglobin levels in the blood of tilapia fish can be seen in Figure 3 and 4, which represents the average hematocrit and hemoglobin at each sampling point with three repetitions.

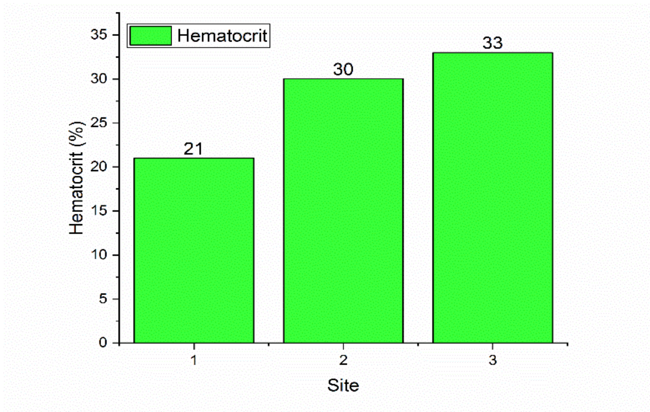

Figure 3. Hematocrit in Java barb

The lowest hematocrit percentage, reaching 21%, was obtained from the blood of fish sampled at point 1, located at the mouth of the Porong River. Point 1 is the sampling point with the highest surfactant concentration, averaging 7.20 mg/L. High surfactant exposure can lead to damage to fish red blood cells, including changes in shape, membrane fragility, and decreased blood flow smoothness. As a result, red blood cells are more prone to rupture and experience damage, leading to a decrease in hematocrit levels in fish blood (Ali et al., 2020).

Table 3. Water Quality Status of the Porong River According to the STORET Value System

Parameter	Unit	Class III Water Quality Standard	Measurement Results			Total Score
			Maximum	Minimum	Average	
Physics						
TSS	mg/L	100	107.95	5.00	29.32	-1
Chemistry						
pH		6–9	7.47	6.25	7.10	0
DO	mg/L	3	6.30	1.80	4.02	-2
Detergent	mg/L	0.2	7.80	3.60	5.09	-10
Moderate pollution						-13

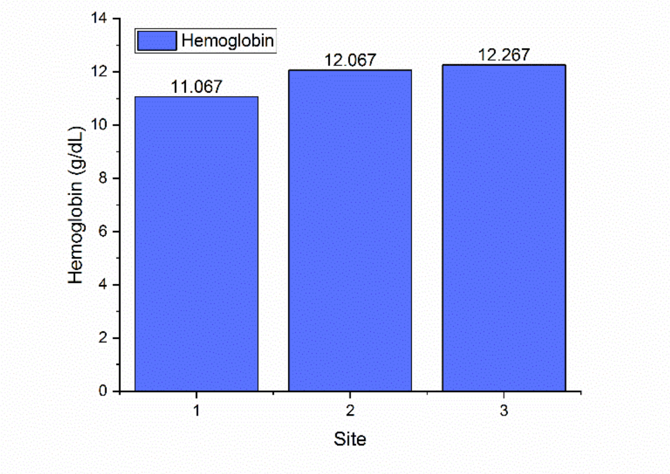

Figure 4. Hemoglobin in Java barb

The low hematocrit level is caused by a low number of red blood cells and hemoglobin, indicating that tilapia fish at point 1 are experiencing anemia due to hematocrit levels of only 21%, below the normal condition for fish, which should have a hematocrit level of about 30%-50%. Severe anemia can lead to growth retardation, general weakness, or even fish mortality (Bijaksana & Fitriliyani, 2023).

Consistent with the decrease in hematocrit in tilapia fish above, the lowest hemoglobin level in this study was 11.07 g/dL and was also obtained from the blood of tilapia fish sampled at point 1. This can be an indicator of low protein levels, vitamin deficiency in fish, or the presence of infections in the fish's body (Yanuhar et al., 2018).

Blood Glucose

The analysis of blood glucose levels in Java carp can be seen in Figure 5.

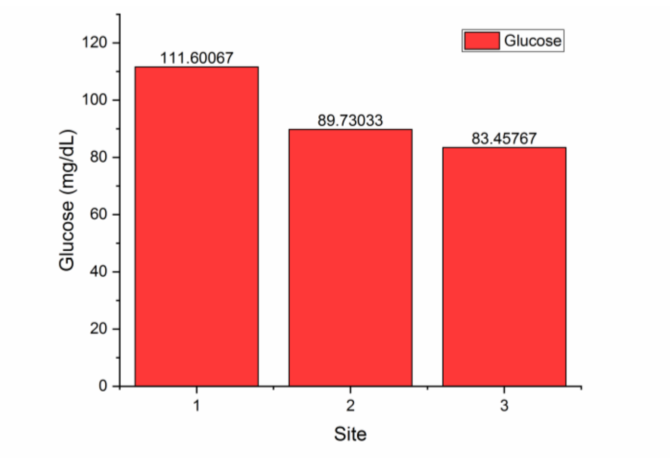

Figure 5. Blood glucose in Java barb

Analysis of blood glucose levels in tilapia fish in Figure 5 showed that the highest blood glucose level was found at point 1, measuring 112 mg/dL, while the blood glucose level in tilapia fish at point 2 was 90 mg/dL, and at point 3, it was 83 mg/dL. The concentration of glucose in fish blood is influenced by various factors, including metabolism, nutrition, and environmental conditions. The increase in blood glucose in tilapia fish in this study is indicated by the stimulation of catecholamine hormones that occur in the catabolism of glycogen reserves in the liver and muscles, leading to the inhibition of insulin hormone release (Hertika et al., 2021).

Looking further into normal blood glucose levels in freshwater fish such as tilapia, it typically ranges from 50-150 mg/dL (Sula et al., 2020). Therefore, it can be said that the blood glucose levels of tilapia fish at points 1, 2, and 3 are still within the normal range for fish. However, caution is still needed because the blood glucose performance of tilapia fish at point 1 has the highest level and is approaching the normal limit for freshwater fish blood glucose.

Regression Analysis of Surfactant Concentration on Water Quality

Simple linear regression analysis of surfactant concentration on water quality parameters in the Porong River, consisting of TSS, pH, and DO, can be seen from the significance results in Table 4.

Table 4. Regression of Surfactant Concentration with Water Quality

Water Quality Parameters	Significance (sig. < 0.5)	Coefficient of Determination (R^2)	Regression Coefficient (x)
TSS	0.003	0.741	18.495
pH	0.003	0.296	0.222
DO	0.011	0.623	-0.741

Based on Table 4, it is known that the significance value of surfactant on TSS is 0.003, on pH is 0.003, and on DO is 0.001. This represents the results that surfactant concentration (X) affects all three water quality parameters (Y), such as TSS, pH, and DO in the Porong River. The extent of the surfactant's influence on water quality can be seen from the coefficient of determination (R^2), which indicates that the influence of surfactant on TSS is 74.1%, on pH is 29.6%, and on DO is 62.3%. Furthermore, the positive or negative results of the regression coefficients represent a 1% increase in surfactant concentration affecting an increase or decrease in water quality in the Porong River. The calculated regression coefficient results indicate that a 1% increase in surfactant concentration can increase TSS levels by 18.495, increase water pH by 0.022, and decrease DO by 0.741 in the Porong River. The regression coefficients for surfactant and water quality show that there is a positive correlation between surfactant and TSS, a positive correlation between surfactant and pH, and a negative correlation between surfactant and DO.

The positive correlation between surfactant and TSS means that the higher the surfactant concentration in the Porong River, the higher the detected TSS levels. This can occur because surfactants help emulsify solid particles suspended in water, thereby increasing the TSS levels (Hernandez, 2020). The positive correlation between surfactant and pH means that the higher the surfactant concentration in the Porong River, the higher the pH levels detected. Surfactants tend to increase water pH because surfactants are generally alkaline (Wahyudi, 2022).

The negative correlation between surfactant and DO means that the higher the surfactant concentration in the Porong River, the lower the DO levels detected. This can happen because surfactants can form a layer on the water's surface that hinders the absorption of oxygen from the air (Martins-Costa et al., 2022). Decreasing DO in river water can have adverse effects on aquatic organisms, especially fish and other aquatic life. These organisms require dissolved oxygen in water for respiration. If the DO concentration decreases significantly, organisms can experience oxygen stress or even death. Monitoring TSS, pH, dissolved oxygen, and other water parameters regularly is necessary to assess water conditions and identify potential issues related to the presence of surfactants.

Pearson Correlation Analysis of Surfactant Concentration on Water Quality

Pearson correlation analysis of surfactant concentration on water quality parameters, including TSS, pH, and DO, can be observed from the significance results in Figure 6. Based on Figure 6, it is known that the significance value of surfactant on TSS is 0.003, on pH is 0.003, and on DO is 0.011. This indicates that surfactant concentration has an influence on water quality parameters in the Porong River. The Pearson correlation results between surfactant and the water quality of the Porong River show a positive correlation for TSS, a positive correlation for pH, and a negative correlation for DO. The correlation of surfactant concentration with TSS (r = 0.861) and pH (r = 0.857) indicates a perfect correlation with r values ranging from 0.81 to 1.00. Additionally, the correlation between surfactant concentration and DO (r = 0.789) shows a strong correlation with r values ranging from 0.61 to 0.80. The perfect correlation between surfactant and TSS suggests a perfect influence, with an r value of 0.861. Thus, the higher the surfactant concentration in the Porong River, the higher the detected TSS levels. Agglomeration effects caused by surfactants can lead to solid particles that were once dispersed becoming larger and heavier, leading to sedimentation. High TSS levels can make the water appear turbid and affect light penetration into the water, thereby influencing the quality of the aquatic ecosystem (Goldsmith et al., 2021).

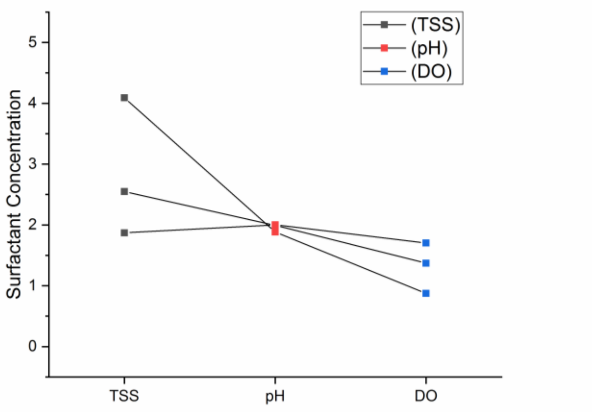

Figure 6. Regression model of surfactant concentration with water quality

The perfect correlation between surfactant and pH suggests a perfect influence, with an r value of 0.857. This means that the higher the surfactant concentration, the higher the pH levels detected. For example, quaternary ammonium, which is often used in cleaning and disinfectant products, can raise water pH levels. If wastewater containing quaternary ammonium is released into water, it can react with water and release ammonium ions (NH^{4+}) into the water. Ammonium ions can react with water to form hydroxide ions (OH^{-}) in a process called hydrolysis (Pati & Arnold, 2020). Hydroxide ions are alkaline and can increase water pH.

The strong correlation between surfactant and DO indicates a strong influence, although not perfect, with an r value of -0.789. This means that the higher the surfactant concentration, the lower the DO levels detected. Surfactant waste containing organic matter can lead to eutrophication, which occurs when there is an increase in nutrient concentrations in water. These nutrients can come from organic matter in surfactant waste. Increased nutrients trigger excessive algae growth or algal blooms. When the algae die and decompose, decomposing bacteria consume oxygen in the process, reducing DO availability in the water (Zalfiatri et al., 2023). Decreased DO in river water can have adverse effects on aquatic organisms, especially fish and other aquatic life, which require dissolved oxygen in water for respiration (Malik et al., 2020; Qadri & Faiq, 2020). If DO concentrations significantly decrease, organisms can experience oxygen stress or even die. Regular monitoring of TSS, pH, dissolved oxygen, and other water parameters is essential to assess water conditions and identify potential issues related to the presence of surfactants.

Regression Analysis of Surfactant Concentration with Hematological Performance

Simple linear regression analysis of surfactant concentration with the hematological performance of Java barb fish in the Porong River, consisting of erythrocytes, leukocytes, hematocrit, hemoglobin, and blood glucose, can be observed from the significance results in Table 5.

Table 5. Regression Analysis of Surfactant Concentration with Hematological Performance

Hematological Parameters	Significance (sig. < 0.5)	Coefficient of Determination (R^2)	Regression Coefficient (x)
Erythrocytes	< 0.001	0.912	-303406.276
Leukocytes	0.019	0.508	15445.912
Hematocrit	0.040	0.511	-0.032
Hemoglobin	0.014	0.647	-0.326
Blood glucose	0.007	0.736	7.027

The significance value of surfactant concentration on erythrocytes is less than 0.001, leukocytes is 0.019, hematocrit is 0.040, hemoglobin is 0.014, and blood glucose is 0.007. This represents the results that surfactant concentration (X) affects the five hematological parameters (Y) of Java barb fish, including erythrocytes, leukocytes, hematocrit, hemoglobin, and blood glucose in the Porong River. The extent of surfactant influence on hematological performance can be observed from the coefficient of determination (R^2), which indicates that surfactant affects erythrocytes in Java barb fish by 91.2%, leukocytes by 56.7%, hematocrit by 47.7%, hemoglobin by 60.6%, and blood glucose by 66.7%. Furthermore, the positive or negative results of the regression coefficients represent that a 1% increase in surfactant concentration affects the increase or decrease in water quality in the Porong River. The calculated regression coefficients show that a 1% increase in surfactant concentration can decrease erythrocyte count by 303,406.276, increase leukocyte count by 15,445.912, decrease hematocrit by 0.032, decrease hemoglobin by 0.326, and increase blood glucose by 7.027 in Java barb fish.

The negative coefficients for erythrocytes, hematocrit, and hemoglobin in Java barb fish mean that the higher the surfactant concentration in the Porong River, the lower the detected erythrocyte count, hematocrit level, and hemoglobin level in Java barb fish. Surfactant waste can have toxic or irritative properties that can damage the erythrocytes of fish. The decrease in erythrocyte count, hematocrit, and hemoglobin can disrupt the fish's ability to transport and obtain sufficient oxygen, leading to oxygen stress, physical weakness, and even death in fish (Ahmed et al., 2020; Dagoudo et al., 2021; Sadiqa et al., 2024; Xu et al., 2021).

The positive coefficients for leukocytes and blood glucose in Java barb fish mean that the higher the surfactant concentration in the Porong River, the higher the detected leukocyte count and blood glucose level in Java barb fish. Prolonged exposure to excessive surfactant waste can lead to decreased water quality and fish health. When fish face infection and stress conditions due to surfactant waste exposure, their immune system responds by increasing leukocyte production and blood glucose levels (Mishra et al., 2024; Samuel & Musa, 2024). An excessive increase in leukocyte count and blood glucose may indicate disturbances in the fish's immune system, metabolic disorders, and organ damage.

Pearson Correlation Analysis of Surfactant Concentration on the Hematological Performance

Pearson correlation analysis of surfactant concentration on the hematological performance of Java barb fish in the Porong River, including erythrocytes, leukocytes, hematocrit, hemoglobin, and blood glucose, can be observed in Figure 7.

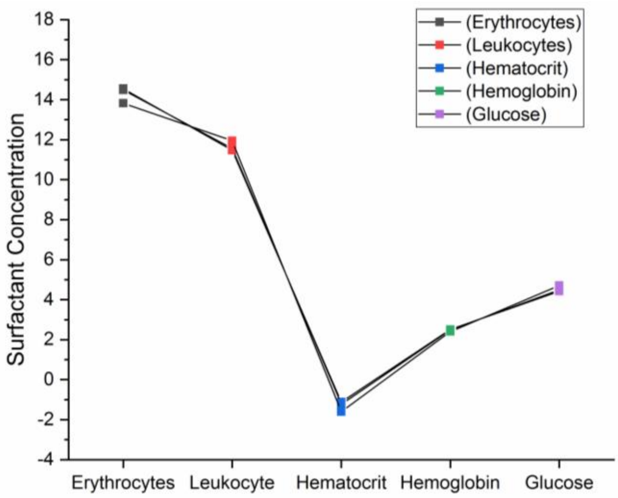

Figure 7. Regression model of surfactant concentration on hematological performance

The significance values for surfactant concentration on erythrocytes are less than 0.001, leukocytes are 0.019, hematocrit is 0.040, hemoglobin is 0.014, and blood glucose is 0.007. This indicates that surfactant concentration affects the five hematological parameters of Java barb fish, namely erythrocytes, leukocytes, hematocrit, hemoglobin, and blood glucose in the Porong River. The Pearson correlation results between surfactant and the hematological parameters of Java barb fish show negative correlation for erythrocytes, positive for leukocytes, negative for hematocrit, negative for hemoglobin, and positive for blood glucose. According to the Pearson correlation values in Table 13, surfactant concentration has a perfect correlation with erythrocytes (r = -0.953) and blood glucose (r = 0.817), with r values ranging from 0.81 to 1.00. Furthermore, the correlation between surfactant concentration and leukocytes (r = 0.753), hematocrit (r = -0.69), and hemoglobin (r = -0.778) shows a strong correlation with r values ranging from 0.61 to 0.80.

The negative correlation between surfactant and erythrocytes, hematocrit, and hemoglobin in Java barb fish indicates that the higher the surfactant concentration in the Porong River, the lower the detected erythrocyte count, hematocrit level, and hemoglobin level in Java barb fish. When fish are exposed to surfactant waste at sufficiently high concentrations or for extended periods, surfactants can enter erythrocytes and cause damage to their structure and function. Erythrocyte damage can lead to various changes in fish blood parameters, including a decrease in erythrocyte count, hematocrit level (the percentage of erythrocyte volume in blood), and hemoglobin level (the protein that carries oxygen in erythrocytes).

The positive correlation between surfactant and leukocytes and blood glucose in Java barb fish means that the higher the surfactant concentration in the Porong River, the higher the detected leukocyte count and blood glucose level in Java barb fish. Prolonged exposure to excessive surfactant waste can lead to a decrease in water quality and fish health. Leukocytes are responsible for fighting pathogens, responding to inflammation, and mobilizing immune responses to combat infections. Cortisol hormone stimulates the release of glucose from the liver into the bloodstream, providing an additional source of energy for fish to respond to stress and survive.

Conclusion

Based on the results of this research, the following conclusions can be drawn that the water quality status of the Porong River is categorized as moderately polluted (-11 to -30) with a score of -13, represented by surfactant concentrations exceeding the maximum water quality standard (Government Regulation No. 22 of 2021), which is 0.2 mg/L. The highest average surfactant concentration was found at point 1, reaching 7.2 mg/L, leading to an increase in Total Suspended Solids (TSS) to 107.95 mg/L, which correlated with a decrease in Dissolved Oxygen (DO) to 1.80 mg/L. Anionic surfactant waste from detergents in the Porong River has a significant impact on the hematological performance of Java barb fish (*Barbonymus gonionotus*) with a significance value of less than 0.05. Surfactants negatively correlate with erythrocytes by 91.2%, hematocrit by 47.7%, and hemoglobin by 60.6%. This means that the higher the surfactant concentration, the lower the erythrocyte count, hematocrit level, and hemoglobin level in Java barb fish. Conversely, there is a positive correlation between surfactants and leukocytes by 56.7% and blood glucose by 66.7%, indicating that higher surfactant concentrations result in higher leukocyte and blood glucose levels in Java barb fish. Furthermore, based on Pearson correlation analysis, perfect correlation is shown in the correlation between surfactant concentration and erythrocytes (r = -0.953) and blood glucose (r = 0.817), while strong correlation is shown in the correlation between surfactant concentration and leukocytes (r = 0.753), hematocrit (r = -0.69), and hemoglobin (r = -0.778). section.

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Conflict of Interest
The authors declare no conflict of interest.

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