Research Article
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Water Quality Analysis of the Sengkaring River for Fish Farming Feasibility in Pekalongan Regency

Fini Afidah, Abdul Qadir Jailani, Muhammad Tri Aji

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Abstract: Rivers serve as essential water sources for freshwater aquaculture, and their quality must meet physical, chemical, and biological standards to ensure environmental sustainability. This study aimed to assess the water quality of the Sengkarang River in Pekalongan Regency, Central Java, Indonesia, determine its suitability for freshwater aquaculture, and identify fish species appropriate for cultivation. The research was conducted from October to November 2021 during the transitional period from dry to rainy season at three sampling sites representing the upstream (Legokalong Village), midstream (Karanganyar Village), and downstream (Karangsari Village) zones. Water samples were collected using purposive sampling and analyzed by the Environmental Agency of Pekalongan City through laboratory testing, descriptive statistics, and a scoring-based suitability assessment. The results showed that temperature (25.3–26.1°C), brightness (38–54 cm), dissolved oxygen (5.2–5.7 mg/L), pH (7.0–7.3), BOD (0.19–1.05 mg/L), COD (20.65–35.92 mg/L), and nitrite (0.026–0.041 mg/L) met the Class III water quality standards based on Government Regulation No. 22 of 2021. Plankton abundance ranged from 47,410 to 75,000 ind/L, indicating fertile and productive waters. With an overall suitability score of 86 (highly suitable category), the Sengkarang River is considered feasible for the cultivation of Nile tilapia (*Oreochromis niloticus*), catfish (*Clarias* sp.), and gourami (*Osphronemus goramy*). These findings highlight the strong potential of the Sengkarang River for sustainable aquaculture development and emphasize the importance of regular environmental monitoring to maintain water quality and ecological balance.

Introduction

Indonesia, an archipelagic nation with more than 17,000 islands, possesses extensive aquatic resources covering approximately 3.25 million km² of water and 2.01 million km² of land (1). The potential area for freshwater aquaculture is estimated at 2.83 million hectares within riverine and lacustrine ecosystems; however, only about 10.7% (302,130 hectares) has been utilized (2). Freshwater aquaculture is a key sub-sector of national fisheries, contributing significantly to food security, economic development, and employment (3, 4). Fish serve as a major source of animal protein after meat, milk, and eggs, playing an essential role in human nutrition and health (5).

Despite its potential, Indonesia's per capita fish consumption remains relatively low, emphasizing the need to enhance public awareness and improve aquaculture productivity (6). Enhancing freshwater aquaculture, therefore, represents a strategic approach to strengthening food security and rural livelihoods by optimizing the use of inland water resources, particularly rivers.

Water is a vital natural resource that supports all forms of life, and its quality determines its suitability for human use and environmental sustainability (7, 8). Rivers are crucial ecosystems that sustain agriculture, industry, and fisheries. In aquaculture, the success of fish production depends heavily on water quality, which affects fish survival, growth, and health (9, 10). River water quality assessments typically include physical (e.g., temperature, turbidity), chemical (e.g., pH, dissolved oxygen, biological oxygen demand, chemical oxygen demand), and biological (e.g., plankton and fish diversity) parameters (11, 12). Variations in these parameters are influenced by human activities such as agriculture, domestic waste discharge, and industrial development, which can alter the ecological balance and degrade aquatic environments (13, 14).

Previous research has shown that land use changes and anthropogenic pressures can lead to river water degradation. A study by Alfionita *et al.* (2019) in Jeneberang Rivers in Indonesia reported that runoff from agricultural land, settlements, and mining has caused excessive accumulation of organic matter and nutrients, triggering significant eutrophication in the river. This eutrophication has resulted in a decline in water quality, which has impacted the sustainability of fish farming in the area (4, 15). These findings underscore the importance of continuous water quality monitoring and environmental management to support sustainable freshwater aquaculture development.

Maintaining good river water quality is essential not only for ecosystem stability but also for unlocking the economic potential of inland aquaculture (16, 17). Rivers that meet water quality standards can serve as reliable sources for freshwater fish farming, providing alternative livelihoods and contributing to local economic growth (18). However, comprehensive data on river water quality remain limited in several regions, particularly in secondary watersheds such as Pemali–Comal.

The Sengkarang River, located predominantly in Pekalongan Regency within the Pemali–Comal watershed, originates in the Pekalongan highlands and flows northward to the Java Sea. Although strategically located near a freshwater aquaculture facility, the river is currently used mainly for irrigation, plantations, and domestic activities. Given its accessibility, community engagement, and the presence of a local freshwater aquaculture center, the Sengkarang River holds significant potential for aquaculture development. Yet, no systematic assessment has been conducted to evaluate its water quality for aquaculture purposes.

Therefore, this study aims to evaluate the water quality of the Sengkarang River based on physical, chemical, and biological parameters, and to determine its suitability for freshwater aquaculture. The outcomes are expected to provide scientific evidence to identify suitable fish species for cultivation, guide sustainable resource management, and support local government planning for aquaculture development in Pekalongan Regency.

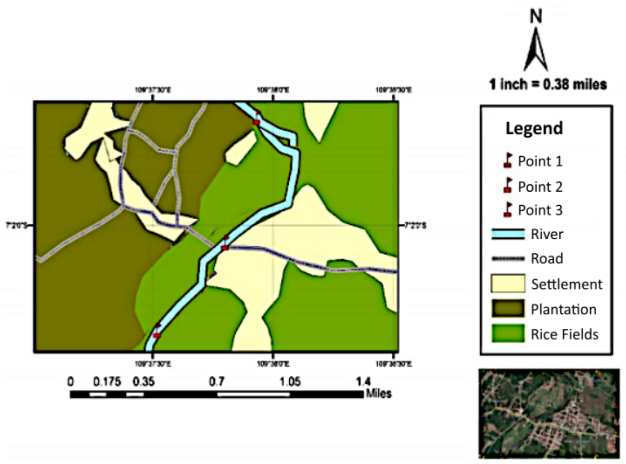

Figure 1. Research location and sampling points at the upstream, middle, and downstream sections of the Sengkarang River.

Methodology

Time and Place of Research

This study was conducted from October to November along the Sengkarang River in Karanganyar Subdistrict, Pekalongan Regency. Water samples were collected from three purposively selected stations representing distinct environmental characteristics. Station 1, located in Legokalong Village (7.0404423°S, 109.626285°E), is an upstream area with minimal anthropogenic disturbance, primarily influenced by agriculture and plantations. Station 2, situated in Karanganyar Village (7.0336961°S, 109.6275372°E), reflects moderate human activity from both settlements and farming. Station 3, located in Karangsari Village (7.0283807°S, 109.6310465°E), represents the downstream section with the highest level of anthropogenic impact (see **Figure 1**). Laboratory analysis of water quality parameters was conducted at the Environmental Agency Laboratory of Pekalongan City.

The selection of three sampling stations was based on their ability to represent the upstream, midstream, and downstream segments of the Sengkarang River, which differ in hydrological and anthropogenic characteristics. This approach aligns with previous river water quality studies that used stratified sampling to capture spatial variation effectively while maintaining methodological efficiency (19). Given that the Sengkarang River's length and flow characteristics are relatively uniform within each segment, three representative points are considered adequate to describe spatial variation along the river. Moreover, this design allows comparison of the effects of land use and human activities on water quality across different zones of the river, which is essential for assessing its suitability for aquaculture development.

The research was carried out during October to November 2021, a transitional period between the dry and wet seasons (pancaroba) in Central Java. This timing captures both hydrological conditions lower flow typical of the dry season and the initial increase in discharge during early rains. Conducting sampling during this transitional phase provides a comprehensive overview of water quality variability, since it reflects fluctuations in temperature, turbidity, and nutrient concentration influenced by rainfall patterns. Therefore, although the study period lasted two months, it effectively represents the actual environmental dynamics of the Sengkarang River and provides valid baseline data for assessing aquaculture feasibility.

Tools and Materials

The tools and materials used in this study included instruments for in-situ and laboratory analyses (**Table 1**). In-situ measurements consisted of a thermometer (°C) for water temperature, a Secchi disk (cm) for transparency, a scaled rope for depth, a pH meter for hydrogen ion concentration, and a DO meter for dissolved oxygen (mg/L). Laboratory analyses were conducted for parameters such as biological oxygen demand (BOD), chemical oxygen demand (COD), nitrite concentration, and plankton abundance.

For plankton sampling, a Plankton Net (mesh size 25 µm) was used to collect samples, which were then preserved in Lugol's solution (1%) and analyzed under a microscope using

Table 1. Tools and materials used in the research.

No	Parameter	Tools	Unit	Description
1.	Temperature	Thermometer	°C	In situ
2.	Brightness	Sechhi disk	Cm	In situ
3.	Depth	Periodic rope	Cm	In situ
4.	Degree of acidity (pH)	pH Meter	pH Unit	In situ
5.	DO (Dissolved oxygen)	DO-Meter	mg/L	In situ
6.	BOD	Lab test	mg/L	Laboratorium
7.	COD	Lab test	mg/L	Laboratorium
8.	Nitrite	Lab test	mg/L	Laboratorium
9.	Plankton	Plankton Net	Cell/L	Laboratorium

the APHA 4500 NO_2 B (2005) method to determine abundance (cells/L) and composition (phytoplankton and zooplankton groups). Other supporting materials included sample bottles, a camera for documentation, and field notebooks.

Research Method

A purposive sampling method was employed in this study to select three representative sampling stations along the Sengkarang River, based on specific environmental characteristics relevant to the research objectives. Water sampling was conducted twice at each station with a one-week interval between collections. The research involved two main stages: in-situ measurement of water quality parameters and laboratory analysis. Field measurements were conducted in the morning and included physical, chemical, and biological parameters such as temperature, transparency, depth, pH, and dissolved oxygen (DO). Laboratory analyses, carried out at the Environmental Agency Laboratory of Pekalongan City, covered biological oxygen demand (BOD), chemical oxygen demand (COD), nitrite concentration, and plankton composition, using water samples collected from each site.Bottom of Form

Method of Data Collection

This study utilized both primary and secondary data. According to Edi Riadi (2016), primary data refers to firsthand information collected directly from its original source. This type of data is considered the most authentic, as it has not undergone any statistical processing. To obtain primary data, researchers must collect it themselves through direct observation or interaction. Primary data were obtained directly through field observations of water quality conditions in the Sengkarang River, a method emphasized by as crucial for acquiring original and specific data tailored to the researcher's objectives (20). Secondary data were obtained indirectly through interviews and relevant literature reviews. This method is considered effective for analyzing existing information to address new research questions, particularly within the context of environmental studies. The integration of these data sources aims to strengthen the findings and provide a more comprehensive understanding in support of the research objectives.

Sampling Work Stages

In-situ Sampling

Water sampling was carried out at three predetermined locations between 09:00 and 10:00 AM. Field measurements included water temperature, recorded using a thermometer submerged until stable readings were obtained; transparency, measured with a Secchi disk lowered until it disappeared from view; and depth, determined using a weighted measuring rope. pH was measured by immersing a pH meter electrode until a stable reading was displayed, while dissolved oxygen (DO) levels were measured using a DO meter with direct digital readout after immersion in the water.

Ex-situ Sampling

Water samples were collected between 09:00 and 10:00 AM from three predetermined locations. Samples were taken from the water column, transferred into tightly sealed and labeled bottles, and stored in a cool box to preserve quality prior to laboratory analysis. The parameters analyzed included Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD), nitrite concentration, and plankton composition, as presented in the **Table 2**.

Table 2. Analytical methods used for water sample measurement.

No	Parameter	Unit	Analysis Method
1.	COD	mg/L	SNI 06-6989.72-2009
2.	BOD	mg/L	SNI 06-6989.72-2009
3.	Nitrite	mg/L	SNI 06-6989.9-2004
4.	Plankton	Cell/L	APHA. 4500 NO2 B, 2005

Data Analysis and Weighting Method

Data analysis in this study employed a descriptive comparative approach to interpret the observed parameters in relation to aquaculture feasibility standards. Instead of focusing on statistical testing, the analysis emphasized comparison between measured water quality data, established regulatory standards, expert opinions, and actual field conditions to determine the level of suitability for freshwater aquaculture. According to Sholahuddin (2010), the scoring and weighting method assigns numerical values to each parameter based on its capacity and contribution to the desired objective (21). In this research, every physical, chemical, and biological parameter was given both a score and a weight that reflected its relative importance in supporting aquaculture productivity.

The scoring criteria were developed by referring to the Indonesian Government Regulation No. 22 of 2021 on water quality standards and FAO (2019) aquaculture water guidelines. Each parameter was evaluated according to its level of compliance with these standards, where “Highly Suitable” (S1) was assigned a score of 5, “Moderately Suitable” (S2) a score of 3, and “Not Suitable” (N) a score of 1. Meanwhile, the weighting process gave each parameter a value ranging from 1 to 7 based on its influence on fish health and growth. For example, parameters such as dissolved oxygen (DO), pH, and temperature received higher weights because they directly affect fish metabolism and survival, while parameters like COD or nitrite were assigned lower weights due to their secondary influence.

The assessment process compared the measured data with both national and international standards to determine suitability levels. After assigning scores and weights to each parameter, a final suitability index was calculated using the formula, Final Value $=\sum(\text{Weight} \times \text{Score})$.

The resulting index values were then compared with the environmental and land-use characteristics of the study area to classify each river segment into one of three categories: Highly Suitable (S1), Moderately Suitable (S2), or Not Suitable (N) for freshwater aquaculture. This comparative–descriptive weighting method provides a holistic framework that integrates quantitative scoring with qualitative assessments based on regulations, expert perspectives, and actual field conditions, ensuring that the evaluation accurately represents both the scientific and practical feasibility of aquaculture development in the Sengkarang River. The determination of class intervals is employed to categorize the suitability of land for aquaculture activities as seen in **Table 3**.

Water quality suitability is classified by dividing the score values into three interval classes. The difference between the highest and lowest scores is calculated and then divided

Table 3. Summary of the maximum and minimum total values for all parameters..

No	Parameter	Highest Value	Lowest Value
1.	Temperature	40	8
2.	Brightness	30	6
3.	Depth	25	5
4.	Dissolved Oxygen	50	10
5.	pH	35	7
6.	COD	15	3
7.	BOD	20	4
8.	Nitrit	5	1
9.	Plankton	10	2
Total		230	46

Table 4. Classification thresholds for aquaculture suitability.

Class	Value	Score	Description
Class I	169-230	5	Highly Suitable
Class II	107-168	3	Moderately Suitable
Class III	45-106	1	Not Suitable

Table 5. Water quality suitability matrix and scoring system for evaluating freshwater fish farming feasibility in river environments.

Parameter	Weight	Level of Conformity			Source
		HS (SI)	MS (S2)	NS (N)	
Temperature	8	28-30	25-28< or >30-32	25< or >32	Hartami, (2008)
Brightness (cm)	6	30-40	20-30	<20	Romadhona, dkk (2016)
Depth	5	80-120	7080	<30	Ghufron dan Kordi (2007)
pH	7	7.0-8.0	6.5-7.0< or >8.0-9.0	6.5< or >9.0	Hartami, (2008)
Do (mg/l)	10	>5	3-5	<3	PP No.22 Th 2021
COD (mg/l)	3	<25	24-25	>26	PP No.22 Th 2021
BOD (mg/l)	4	<3	3-5	>5	Kilawati dan Maimunah (2015)
Nitrit (mg/l)	1	0-0.05	0.05-1	>1	
Plankton	2	0-2.000	2.000-15.000	>15.000	Raymont, (1963)

Note: Each parameter is assigned a weight according to its relative importance and scored based on its conformity with aquaculture standards: Highly Suitable (S1 = 5), Moderately Suitable (S2 = 3), and Not Suitable (N = 1).

$$CI = \frac{\text{Highest Total Value} - \text{Lowest Total Value}}{\text{Number of Classes}}$$

Equation 1 | *CI* = Class interval.

by the number of classes. The **Equation 1** was used to determine the land suitability level. The suitability level for fish farming is based on the class interval calculations, as outlined in **Table 4**.

The water quality suitability for fish farming is determined based on the total score, which is then categorized into three main classes. If the total score falls between 169 and 230, the water is classified as Class I, indicating a very suitable condition that fully supports fish farming without the need for additional intervention. Scores between 107 and 168 place the water in Class II, considered moderately suitable, where aquaculture can still proceed but may require some environmental adjustments. A score range of 45 to 106 categorizes the water into Class III, indicating unsuitable conditions, where the water quality is inadequate for optimal fish farming. This classification serves as a basis for decisions regarding the use of water bodies for aquaculture (see **Table 5**).

Table 6. Average water quality parameters measured at three sampling points in the Sengkarang River.

Parameter	Average		
	Point 1	Point 2	Point 3
Temperature (C)	25.4	25.5	25.9
Brightness (cm)	40	49	52.5
Depth (cm)	114	100.5	135.5
DO (mg/L)	5.45	5.6	5.25
pH	7.1	7.0	7.25
COD (mg/L)	29.04	28.28	28.70
BOD (mg/L)	1.036	0.824	0.409
Nitrit (mg/L)	0.033	0.030	0.027
Plankton (Ind/L)	70,580	58,658	53,008

Results

The Results of Water Quality Measurements

Water quality measurements in the Sengkarang River include primary data covering physical, chemical, and biological parameters, such as temperature, brightness, dissolved oxygen (DO), pH, Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD), nitrite, and plankton. Samples were collected at three designated locations, with two sampling events spaced one week apart. Parameters such as temperature, brightness, depth, DO, and pH were measured directly in the field (in situ), while COD, BOD, nitrite, and plankton were analyzed in the laboratory (ex situ). The Results of these measurements for the physical, chemical, and biological water parameters are summarized in **Table 6**, providing an overview of water quality in the Sengkarang River during the study period.

Discussion

Water quality can be assessed by comparing measured parameters with established standard quality values to determine the level of pollution. This study analyzes water quality based on three main groups of parameters: physical, chemical, and biological. According to Patil (2012), a comprehensive understanding of various physical and chemical parameters such as color, temperature, acidity, hardness, pH, sulfate content, chloride, dissolved oxygen (DO), biological oxygen demand (BOD), chemical oxygen demand (COD), and alkalinity—is essential in evaluating water quality. In addition, the presence of heavy metals such as lead (Pb), chromium (Cr), iron (Fe), and mercury (Hg) requires special attention due to their potential to cause acute or chronic toxicity to aquatic organisms (22). The physical parameters include temperature, brightness, and

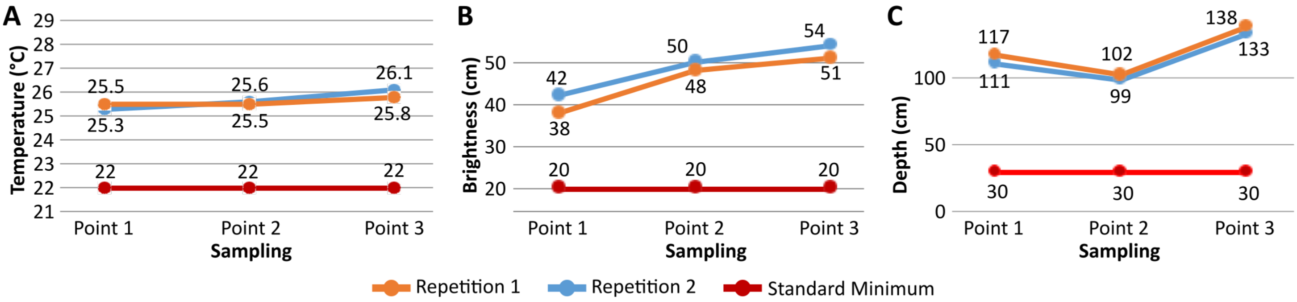

Figure 2. Environmental parameters of the Sengkarang River. (A) Temperature, (B) brightness, and (C) depth of the Sengkarang River.

depth; the chemical parameters consist of dissolved oxygen (DO), pH, COD, BOD, and nitrite; and the biological parameters focus on the type and quantity of plankton (see **Figure 2**).

Physical Parameters

Temperature

Temperature is a critical abiotic factor influencing aquatic metabolism, oxygen solubility, and biological processes. As said by (Ayuniar & Hidayat, 2018) that water temperature is a crucial factor that can affect the survival of organisms in it (23). Measurements at the three sampling points ranged between 25.3°C and 26.1°C, with a difference of about 1°C. Although this variation appears small, it can still indicate microclimatic diversity along the river, influenced by vegetation cover, shading, current velocity, and sunlight exposure. The highest temperature (26.1°C) was recorded at Station 3, which is located downstream and exposed to more sunlight, while the lowest (25.3°C) was observed at the same station during the second sampling period, likely due to early morning measurement conditions.

The temperature of aquatic environments plays a crucial role in supporting aquatic life. In this study, water temperature in the Sengkarang River was measured at three sample points, showing values ranging from 25.3℃ to 26.1℃. The highest temperature, 26.1℃, was recorded at Point 3, Replicate 1, while the lowest temperature of 25.3℃ was observed at the same point during Replicate 2. The relatively lower temperature at Point 1 in Replicate 1 is likely influenced by limited sunlight penetration due to vegetation cover in the upstream areas, high current velocity, and ongoing organic matter decomposition. As stated by K.R. Gunawardena a, M.J. Wells b, T. Kershaw a, Vegetation directly affects the microclimate by reducing surface temperatures and local air temperatures, which in turn affect air temperatures over a wider area (24). Factors such as shading vegetation, aquatic plants, and waste input can cause fluctuations in water temperature. In contrast, the higher temperature at Point 3, Replicate 1, is likely due to increased solar radiation and heat distribution from upstream to downstream through water currents and turbulence.

According to Government Regulation No. 22 of 2021, acceptable temperature variations for Class III waters should not exceed ±3°C from natural conditions. Thus, the observed temperature range remains well within the tolerance limits for common aquaculture species such as Nile tilapia (Oreochromis niloticus), catfish (Clarias sp.), and gourami (Osphronemus goramy), which prefer 25–30°C. Therefore, the temperature differences found in this study do not negatively affect aquaculture feasibility but instead reflect normal environmental fluctuation within the ecosystem.

Brightness

Water clarity reflects the level of transparency in aquatic environments and can be visually measured using a Secchi Disk. This measurement allows estimation of the depth at which assimilation processes may still occur and helps identify clearer versus more turbid water layers. Hamuna *et al*. (2018) noted that low transparency values under normal weather conditions can indicate a high concentration of suspended particles. Additionally, Silalahi *et al*. (2017) suggested that reduced water clarity may result from various factors, such as heavy rainfall or the discharge of industrial waste near the observation area (25).

The measurement of water brightness in the Sengkarang River revealed the lowest value at Site 1, Replicate 2 (38 cm) and the highest at Site 3, Replicate 1 (54 cm). The lower brightness at certain points was likely influenced by sand mining activities near the location, which increased suspended particles in the water. Visual observations indicated that the riverbed was predominantly composed of sand and gravel, and plankton presence also contributed to the variation in water brightness. Fine particles such as microorganisms, silt, sand, detritus, and plankton in the water column can reduce brightness. The higher brightness at Site 3, Replicate 1, indicated relatively clear water, possibly due to lower concentrations of suspended particles, and was observed during clear weather with no rainfall, which facilitated light penetration into the water. Suspended materials, water color, and microorganisms influence water brightness. Organic matter and suspended particles can elevate turbidity, which negatively impacts aquatic organisms' feeding behavior and physiological efficiency.

The brightness difference between stations also reflects local hydrological and anthropogenic influences. Upstream sites tend to have more sediment load from agricultural and sand mining activities, while downstream areas experience sediment settling and clearer water. Brightness values between 30–50 cm are typically suitable for aquaculture (26). The observed range (38–54 cm) suggests that light penetration was sufficient for photosynthesis, supporting plankton growth and maintaining adequate oxygen levels. The positive association between brightness and plankton density observed in this study reinforces the importance of light intensity for sustaining the aquatic food web.

Based on these results, the measured brightness (38–54 cm) is slightly higher than the typical aquaculture optimum (25–40 cm), which suggests favorable transparency and stable primary productivity. The positive relationship between brightness and plankton abundance observed in this study confirms that light penetration enhances photosynthetic activity and, consequently, dissolved oxygen concentration. This balance supports both ecological sustainability and aquaculture feasibility in the Sengkarang River ecosystem.

Depth

Depth is a key physical parameter that is closely related to temperature, dissolved oxygen content, and light penetration. As water depth increases, the intensity of sunlight that can penetrate the water column generally decreases. Sunlight plays an essential role in supporting photosynthesis by phytoplankton and aquatic plants, which rely on light as an energy source. As stated by Purina *et al*. (2018), light and nutrients are crucial elements influencing phytoplankton growth and productivity, making primary productivity in aquatic ecosystems largely reliant on the photosynthetic activity of phytoplankton (27). Water quality is also influenced by depth, as it directly affects the substrate characteristics, including types and nutrient contents. Variations in substrates such as sand, silt, and clay have differing organic content, which impacts the structure and function of aquatic ecosystems.

Depth measurements in the Sengkarang River ranged from 99 to 138 cm, with the shallowest depth recorded at Site 2 (Replicate 1) and the deepest at Site 3 (Replicate 2). The relatively low water level at Site 2 is likely attributed to the dry season conditions in September–October, characterized by reduced rainfall and river discharge. Additional factors such as narrow channel width, rocky substrates, and local topography also contributed to depth variations. Conversely, the greater depth observed at Site 3 is presumed to result from basin-shaped riverbed contours, which facilitate water accumulation. In general, water depth in riverine ecosystems is influenced by hydrological fluctuations, rainfall intensity, land cover, and sediment transport, all of which shape bottom morphology and affect depth variability.

The recorded depth range falls within the optimal limits for aquaculture activities, consistent with previous studies indicating that depths between 75–120 cm are favorable for light penetration and photosynthetic efficiency. As depth increases, light attenuation reduces photosynthetic activity and subsequently dissolved oxygen concentrations, which are critical for aquatic life. Depths greater than one meter are generally favorable for freshwater aquaculture because they allow better vertical mixing and minimize overheating (28). The depth profile of the Sengkarang River, therefore, supports stable ecological conditions for fish farming activities.

Parameter Kimia

Dissolved Oxygen

Dissolved oxygen (DO) concentration in the Sengkarang River ranged between 5.2 and 5.7 mg/L (see **Figure 3**). The highest value was recorded at Station 2, while the lowest was observed at Station 3. These variations may be influenced by differences in water flow, temperature, and organic matter input. The DO level in the Sengkarang River exceeds the minimum requirement for aquaculture activities (3 mg/L) according to Government Regulation No. 22 of 2021.

This indicates that oxygen availability in the river is sufficient for sustaining fish respiration and aerobic microbial activity. The higher DO at Station 2 can be associated with turbulent flow, while the slightly lower value at Station 3 may reflect reduced aeration in slower-moving water. DO levels above 5 mg/L are ideal for species such as gourami and pangasius Syah *et al*, confirming that the river water quality supports aquaculture species (29). Furthermore, the combination of stable temperature and good oxygen levels demonstrates that the Sengkarang River maintains balanced physical–chemical conditions conducive to aquatic life.

Degree of Acidity (pH)

According to Astari (2009), selecting essential parameters in water quality testing is crucial to ensure that water meets the standard of being tasteless, odorless, and colorless. One of these parameters is pH, categorized as an organic chemical indicator. For drinking water, the ideal pH generally ranges between 6 and 7, although some drinking water with a pH of 8 to 9 is known as alkaline water. A pH value above 7 indicates low corrosiveness, while lower pH values tend to increase corrosive potential. Additionally, water with a pH above 7 is more likely to cause scale formation and may be less effective at eliminating bacteria, as bacterial control is typically more efficient under neutral or slightly acidic conditions (30).

The pH of the Sengkarang River ranged from 7.0 to 7.3, indicating neutral to slightly alkaline conditions. Such conditions are ideal for most freshwater organisms. Variations in pH may be influenced by photosynthetic activity, which reduces CO_2 concentrations during daylight h, and by the buffering capacity of bicarbonates in the water.

The pH range aligns with the preferred conditions for freshwater fish (6.5–8.0) and supports enzymatic and metabolic activity (31). The stability of pH values across stations also suggests minimal pollution input and healthy self-regulation of the aquatic system.

COD (Chemical Oxygen Demand)

According to Sami (2012), Chemical Oxygen Demand (COD) refers to the amount of oxygen, measured in ppm or mg/l, required to chemically break down organic compounds under specific conditions. COD testing is used to determine the concentration of organic materials in wastewater that can be oxidized using acidic solutions containing dichromate. A higher COD value indicates a greater presence of organic pollutants, which may lead to a reduction in dissolved oxygen levels. Meanwhile, Simanjuntak (2007) explains that Dissolved Oxygen (DO) refers to the amount of oxygen present in water, typically measured in ppm, and serves as an important indicator of raw water pollution. Oxygen is essential for aquatic organisms, not only for respiration but also for the microbial breakdown of organic substances into inorganic compounds. DO is introduced into water through air diffusion and photosynthesis by chlorophyll-containing organisms. High DO levels indicate better water quality and low pollution, while low DO levels suggest increased contamination, which may also reduce the efficiency of coagulants, as they must first react with pollutants before binding suspended colloidal particles (32).

In the Sengkarang River, COD values ranged from 20.65 mg/L to 35.92 mg/L, with the highest recorded at station 2 during the second sampling. This elevated value is likely associated with agricultural runoff containing fertilizers and domestic waste from nearby settlements. Conversely, the lowest COD was observed at the same station during the first

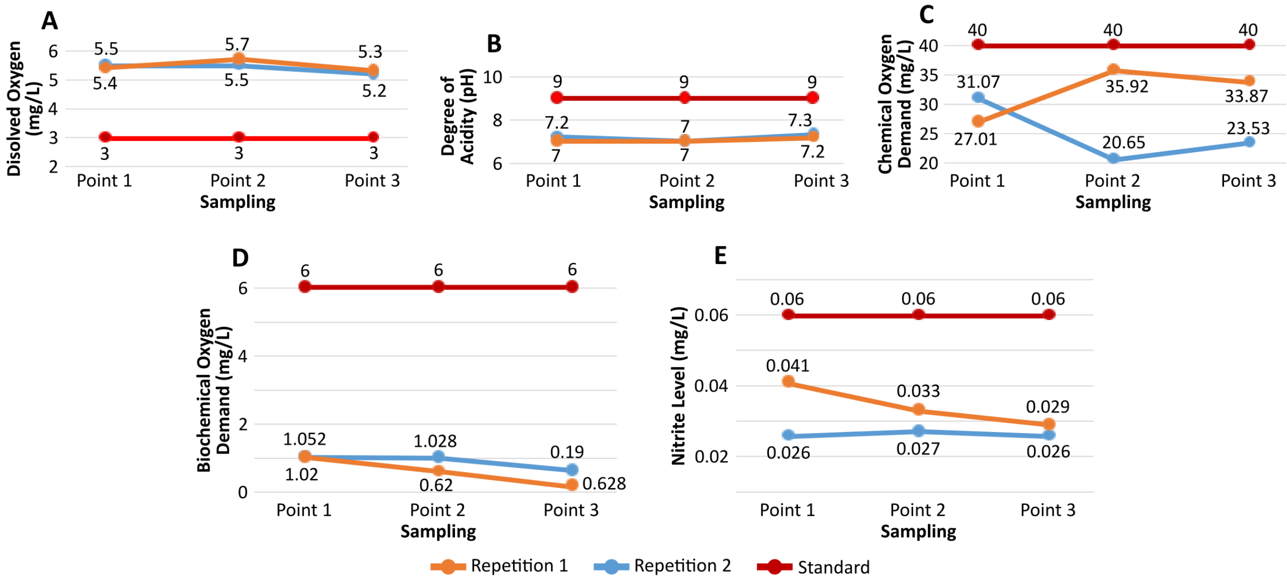

Figure 3. Water quality parameters of the Sengkarang River. (A) Dissolved oxygen, (B) degree of acidity (pH), (C) chemical oxygen demand, (D) biochemical oxygen demand, and (E) nitrite level of the Sengkarang River.

sampling, presumably due to minimal household waste input at the time. Spatial variations in COD concentrations were observed across sampling sites, influenced by differences in river width and flow velocity. Site 1, with the widest cross-section and slowest current, showed moderate COD levels, while site 2 exhibited higher values due to narrower width and stronger currents. Site 3, with intermediate characteristics, showed an increase in COD likely due to slower flow and reduced oxygenation. In addition to hydrodynamic factors, dissolved oxygen plays a crucial role in the degradation of organic matter, affecting COD levels. The measured COD values remain within the permissible limit of 40 mg/L for class III waters, as stipulated in Government Regulation No. 22/2021, and are therefore suitable for aquaculture purposes.

BOD (Biochemical Oxygen Demand)

According to Santoso (2018), Biological Oxygen Demand (BOD) refers to the amount of oxygen required by microorganisms, primarily bacteria, to break down organic matter in water through aerobic processes. As stated by Pour *et al*. (2014), this decomposition process indicates that microorganisms gain energy through oxidation while consuming organic materials present in aquatic environments. Determining BOD levels is useful for assessing the pollution load in water bodies resulting from domestic or industrial wastewater, and it also serves as a reference for designing biological treatment systems in polluted waters (33).

In the Sengkarang River, BOD measurements ranged from 0.19 mg/L to 1.052 mg/L, with the highest value observed at point 1 (replicate 1) and the lowest at point 3 (replicate 2). The elevated BOD at point 1 was linked to agricultural runoff and domestic wastewater input, while the lower BOD at point 3 reflected reduced anthropogenic activities and minimal organic input. This spatial pattern indicates the presence of a natural self-purification process along the river's course, particularly effective under low pollution loads.

Factors such as water flow dynamics, temperature, light penetration, and biological activity were likely contributors to BOD variation. Faster flows and clearer waters may have enhanced oxygen availability, while cooler temperatures supported oxygen solubility. Despite these variations, all recorded BOD values remained below the 6 mg/L threshold established by Indonesian water quality standards for aquaculture (Government Regulation No. 22/2021, Class III), indicating that the river's water quality is suitable for fish farming activities.

Nitrite (NO2)

Nitrite (NO_2) is an intermediate form of oxidized nitrogen oxidation state +3, typically present in aquatic environments such as rivers, drainage channels, and wastewater treatment systems (34). Although usually found at low concentrations, nitrite is considered toxic due to its ability to react with hemoglobin to form methemoglobin, impairing oxygen transport in the blood.

In the Sengkarang River, nitrite levels ranged from 0.026 mg/L (lowest at point 1, replicate 1) to 0.041 mg/L (highest at point 1, replicate 2).

All recorded nitrite concentrations in the Sengkarang River (0.026–0.041 mg/L) were below the threshold of 0.6 mg/L as stipulated by Government Regulation No. 22 of 2021 for Class III waters (designated for aquaculture purposes). These values also fall within the acceptable range of 0.01–0.05 mg-NO_2/L and remain below the tolerance limit set by the Ministry of Environment (KLH, 2004), which is <0.08 mg-NO_2/L. Therefore, the nitrite concentrations in the river comply with established environmental water quality standards and indicate the river's suitability to support aquaculture activities.

Biological Parameters

Aquatic environments with high fertility levels are generally considered to be in good condition. The quality of a water body can be assessed by evaluating its fertility, with plankton serving as a key biological indicator. Plankton play an essential ecological role as primary producers in the food chain and act as bioindicators for assessing aquatic

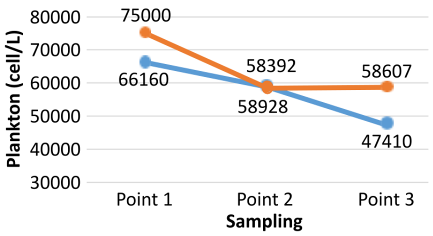

Figure 4. Variation in plankton abundance across the upstream, middle, and downstream sections of the Sengkarang River.

productivity (35). These microscopic organisms drift within the water column, carried by the current. Plankton are broadly categorized into two groups: phytoplankton (plant-like organisms) and zooplankton (animal-like organisms).

Plankton abundance in the Sengkarang River ranged from 47,410 to 75,000 individuals per liter, with the highest count at Station 1 and the lowest at Station 3. Plankton density reflects nutrient availability and light penetration. The higher plankton abundance upstream may result from nutrient inflow from agricultural areas, while the lower count downstream could be due to dilution and sediment deposition.

According to Landner (1978), waters with plankton density above 15,000 ind/L are classified as eutrophic, indicating high fertility. Based on this classification, the Sengkarang River can be categorized as fertile and productive. The relationship between brightness and plankton abundance in this study confirms that adequate light penetration enhances photosynthesis, which contributes to dissolved oxygen production and food availability for aquatic organisms. Recent studies Neun *et al* (2022) have also emphasized that plankton distribution strongly correlates with brightness and nutrient input, supporting this finding (36).

The high plankton productivity benefits aquaculture by providing a natural food source for filter-feeding species such as tilapia and gourami. However, overabundance may increase nocturnal respiration, potentially reducing oxygen levels. Hence, balanced nutrient management remains crucial to maintaining a sustainable aquatic environment**.**

Table 7. Calculation of water quality suitability index for freshwater aquaculture at three sampling points in the Sengkarang River.

Location	Parameter	Average	Weight	Score	Ni (Weight × Score)	Total Score	Suitability Class	Description
Point 1	Temperature (°C)	25.4	8	3	24	206	Class I	Highly Suitable
	Brightness (cm)	40	6	5	30			
	Depth (cm)	114	5	5	25			
	DO (mg/L)	5.45	10	5	50			
	pH	7.1	7	5	35			
	COD (mg/L)	29.04	3	5	15			
	BOD (mg/L)	1.036	4	5	20			
	Nitrite (mg/L)	0.033	1	5	5			
	Plankton (Ind/L)	70,580	2	1	2			
Point 2	Temperature (°C)	25.5	8	3	24	206	Class I	Highly Suitable
	Brightness (cm)	49	6	5	30			
	Depth (cm)	100.5	5	5	25			
	DO (mg/L)	5.6	10	5	50			
	pH	7.0	7	5	35			
	COD (mg/L)	28.28	3	5	15			
	BOD (mg/L)	0.824	4	5	20			
	Nitrite (mg/L)	0.030	1	5	5			
	Plankton (Ind/L)	58,658	2	1	2			
Point 3	Temperature (°C)	25.9	8	3	24	206	Class I	Highly Suitable
	Brightness (cm)	52.5	6	5	30			
	Depth (cm)	135.5	5	5	25			
	DO (mg/L)	5.25	10	5	50			
	pH	7.25	7	5	35			
	COD (mg/L)	28.70	3	5	15			
	BOD (mg/L)	0.409	4	5	20			
	Nitrite (mg/L)	0.027	1	5	5			
	Plankton (Ind/L)	53,008	2	1	2			

Water Quality Scoring

An integrated assessment of the Sengkarang River's water quality in Karanganyar District, Pekalongan Regency was conducted based on physical, chemical, and biological parameters, including temperature, transparency, pH, dissolved oxygen (DO), biological oxygen demand (BOD), chemical oxygen demand (COD), nitrite concentration, and plankton abundance. Following individual analysis of each parameter, a suitability evaluation was performed using a scoring method (**Table 7**).

Results showed that all sampling sites (Stations 1, 2, and 3) yielded identical total scores of 206, categorizing them as "highly suitable" for aquaculture activities. This scoring approach, adapted from Krisna Setiaji *et al*. (2018), assigns different weights to each parameter based on empirical data and prior research findings. The reliability of this method is closely linked to the volume and rigor of supporting studies. Overall, the findings indicate that the water quality of the Sengkarang River meets the criteria for sustaining aquaculture operations.

Recommendations for Aquaculture Activities Based on Water Quality in the Sengkarang River

Based on comprehensive measurements of physical, chemical, and biological parameters, the water quality in the Sengkarang River, located in Karanganyar District, Pekalongan Regency, was found to meet the criteria for supporting aquaculture. These findings suggest a significant opportunity for the local community to consider fish farming as an alternative livelihood.

The suitability of specific fish species was evaluated using water quality data from three sampling stations. The measured water temperature ranged from 25.4°C to 25.9°C, dissolved oxygen (DO) from 5.25 to 5.6 mg/L, pH from 7.0 to 7.25, water transparency from 40 to 52.5 cm, and nitrite concentrations from 0.0275 to 0.033 mg/L. Based on these values, common freshwater fish such as Nile tilapia (*Oreochromis niloticus*), catfish (*Clarias sp.*), gourami (*Osphronemus goramy*), and striped catfish (*Pangasius sp.*) were deemed suitable for cultivation. In contrast, koi (*Cyprinus carpio*), which require more stringent water conditions, were found unsuitable for culture in this area.

Tilapia farming is supported by optimal temperatures (25–30°C), pH range (6.5–8.5), and DO levels above 3 mg/L, all of which were met at the study sites. Catfish, known for their tolerance to a wide pH range (5-9) and minimum DO of 3 mg/L, also thrive under these conditions. For gourami, ideal temperatures (24–28°C), pH (6.5-8), DO (3–9 mg/L), and transparency (30–45 cm) were satisfied, although nitrite levels remained below the species' preferred range (>1 mg/L). Similarly, environmental parameters also aligned with the requirements for striped catfish, which prefer temperatures of 22–29°C, pH of 6.5–9.0, transparency above 30 cm, and DO above 3 mg/L.

However, koi cultivation is not recommended, as the measured temperature and transparency values fall short of the species' optimal requirements (27–28°C, >45 cm transparency), and nitrite concentrations slightly exceed the ideal threshold of 0.2 mg/L.

In conclusion, the Sengkarang River demonstrates favorable conditions for the development of sustainable aquaculture, particularly for tilapia, catfish, gourami, and striped catfish. Strategic utilization of these opportunities could revitalize fish farming in Pekalongan and contribute to improving the socio-economic conditions of the local population.

Conclusion

This study evaluated the water quality of the Sengkarang River through physical, chemical, and biological parameters to determine its suitability for aquaculture development. The findings show that temperature (25.3–26.1°C), brightness (38–54 cm), dissolved oxygen (5.2–5.7 mg/L), pH (7.0–7.3), BOD (0.19–1.05 mg/L), COD (20.65–35.92 mg/L), and nitrite (0.026–0.041 mg/L) all meet the Class III water quality standards based on Government Regulation No. 22 of 2021. These results demonstrate that the Sengkarang River maintains good ecological conditions, with stable physicochemical characteristics that support freshwater aquaculture. Plankton abundance (47,410–75,000 ind/L) further indicates fertile waters with adequate natural food availability for fish species such as tilapia, catfish, and gourami.

The integration of physical, chemical, and biological data confirms that the Sengkarang River is suitable for sustainable freshwater aquaculture under current conditions. Minor spatial variations observed in temperature, brightness, and plankton density represent natural environmental dynamics rather than pollution. However, continuous monitoring is necessary to control potential impacts from sand mining and agricultural runoff. Proper management of organic matter and sedimentation is recommended to preserve the river's ecological integrity and long-term aquaculture potential.

Declarations

Author Informations

Fini Afidah

Corresponding Author

Affiliation: Department Aquaculture , Faculty of Agriculture, Tidar University, Magelang, Indonesia.

Contribution: Data Curation, Formal analysis, Visualization, Writing - Original Draft, Writing - Review & Editing.

Abdul Qadir Jailani

Corresponding Author

Affiliation: Department Aquaculture , Faculty of Agriculture, Tidar University, Magelang, Indonesia.

Contribution: Conceptualization, Funding acquisition, Methodology, Project administration, Resources, Supervision, Validation, Writing - Review & Editing.

Muhammad Tri Aji

Corresponding Author

Affiliation: Department Aquaculture , Faculty of Agriculture, Tidar University, Magelang, Indonesia.

Contribution: Conceptualization, Funding acquisition, Methodology, Project administration, Resources, Supervision, Validation, Writing - Review & Editing.

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The authors declare no conflicting interest.

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