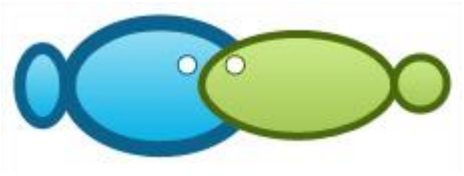

Occurence of *Eristalis* larvae and its association with water quality parameters in West Java mangrove ecosystem, Indonesia

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Abstract. This study investigated the occurence of *Eristalis* larvae and its association with water quality parameters in the mangrove ecosystem of Langensari Village, Blanakan District, Subang Regency, West Java, Indonesia. Water and macrozoobenthos samples were obtained from three locations denoting distinct environmental settings: Station 1 (St-1) near a fish auction site, Station 2 (St-2) adjacent to community ponds, and Station 3 (St-3) near the Blanakan Estuary, Subang Regency, West Java Indonesia. Water quality assessments were carried out to provide a thorough characterization of environmental conditions in Langensari and to investigate the correlation between water quality and macrozoobenthos bioindicator responses. The measures of water quality encompassed temperature, pH, salinity, total suspended solids (TSS), dissolved oxygen (DO), chemical oxygen demand (COD), and biological oxygen demand (BOD). Identification of macrozoobenthos was conducted at the BRIN Marine Research Laboratory using a Leica M205C microscope. The findings indicated spatial variability in water quality across stations. All stations showed elevated COD and BOD levels, suggesting considerable organic contamination. The prevalence of macrozoobenthos was minimal, with only one *Eristalis* larva documented at St-2, and no macrozoobenthos detected at St-1 or St-3. The presence of *Eristalis* larvae may indicate their tolerance to organically enriched environments. Alongside water quality, habitat attributes such as water flow, mangrove presence, temperature, and salinity seemed to affect macrozoobenthos distribution. The data suggest that the distribution of macrozoobenthos in Langensari is indicative of both water quality deterioration and overarching habitat constraints.
Keywords: benthic community, Blanakan estuary, *Eristalis* larvae, organic enrichment, water quality.

Introduction. Macrozoobenthos serve as important indicators of aquatic environmental quality because of their sensitivity to changes in physical, chemical, and biological conditions (Rehitha et al., 2022; Varadinova et al., 2023; Okoro et al., 2024). Variations in pollution levels, water temperature, and dissolved oxygen can markedly affect their prevalence, abundance, and community composition (Brysiewicz et al., 2022; Oyeku et al, 2023; Okoro et al, 2024). The presence or absence of macrozoobenthos offers valuable insights into the biological condition of aquatic habitats, particularly regarding environmental disturbance and pollution. Therefore, water quality assessments combined with macrozoobenthos studies are commonly used to evaluate the ecological status of inland and coastal waters.

Langensari Village, located in the northern coastal region of West Java, is closely associated with mangrove-dependent livelihoods. Based on 2021 village data, approximately 60% of residents depend on pond aquaculture as their primary economic activity, making mangrove habitats essential for local socio-ecological sustainability. Since the 1980s, inhabitants have practiced silvofishery, an aquaculture system that incorporates mangrove vegetation (Hewindati et al., 2022). This method is regarded as environmentally sustainable because pond management does not involve chemical inputs, and prawns and milkfish (*Chanos chanos*) are mainly produced from naturally

occurring food organisms within the ponds. This practice supports ecological balance and reflects local environmental knowledge passed down through generations.

Despite the primarily nature-based management of local ponds, environmental quality in Langensari can be affected by upstream human activities and agricultural practices. Rivers passing through populated areas, pond systems, and downstream channels transport both organic and inorganic contaminants into the estuarine ecosystem (Dey et al., 2023; Singh et al., 2024). These inputs can degrade water quality and alter the suitability of aquatic habitats for benthic organisms. In this context, macrozoobenthos serve as reliable biological indicators for assessing the ecological impacts of pollution. Although macrozoobenthos are widely used as bioindicators in rivers, lakes, and coastal ecosystems, information on their presence in mangrove-associated silvofishery landscapes remains limited, particularly in Indonesia. Previous studies have mainly focused on macrozoobenthos diversity and water quality in natural aquatic ecosystems, while the biological conditions in river systems influenced by traditional silvofishery practices have received little attention. Additionally, environmental stress resulting from reduced water flow and extended dry periods may affect habitat suitability for benthic organisms, but these effects are insufficiently documented in mangrove-associated river systems.

This study aimed to determine the occurence and spatial distribution of *Eristalis* larvae and to examine their associations with physicochemical water quality parameters in a silvofishery-dominated mangrove river system in Langensari, West Java, Indonesia. The results are expected to support environmental monitoring and provide scientific data to inform the management of local aquatic ecosystems.

Material and Method

Study area. The study was conducted in August 2024 in Langensari Village, Blanakan District, Subang Regency, West Java, Indonesia (Figure 1). Water and macrozoobenthos samples were obtained from three observation stations representing diverse environmental conditions and possible contamination sources. The first station (St-1) was installed at the wastewater discharge near the fish auction location (6°16’38.35”S, 107°40’46.42”E). Station 2 (St-2) was situated on a river channel near community ponds (6° 15’ 4.68” S, 107° 41’ 1.23” E). St-3 was located near the Langensari estuary (6°14’34.25”S, 107°40’53.55”E).

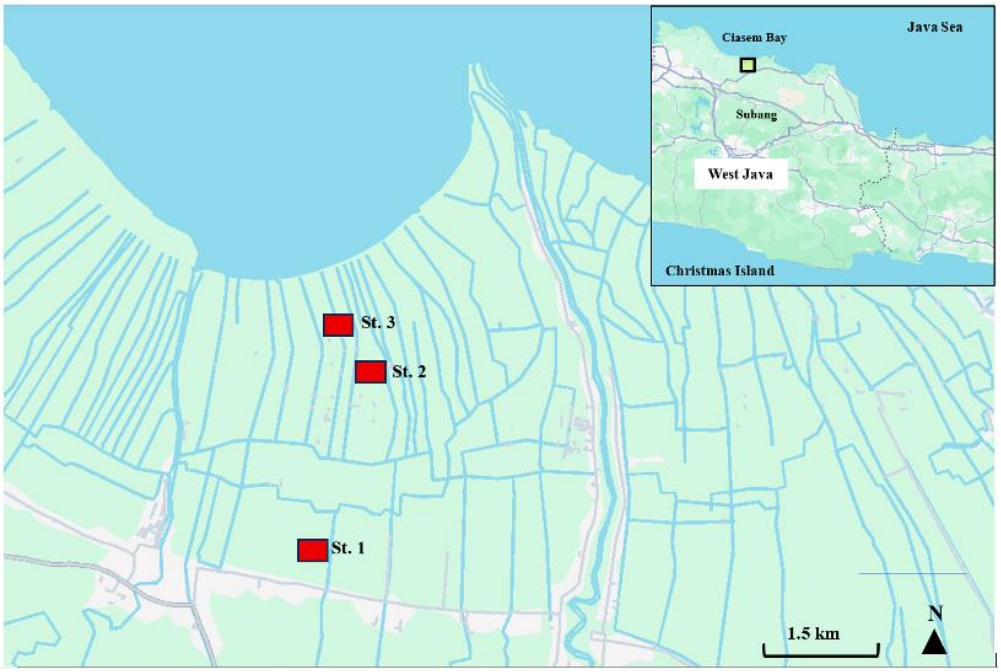

Figure 1. Sampling locations at the three observation stations in Langensari Village, Blanakan District, Subang Regency, West Java, Indonesia.

St-1 was located in a residential neighbourhood that also accommodates fish auction operations for the local fishing population. St-2 was a riverine portion that transected the aquaculture landscape, whereas St-3 showed downstream conditions similar to those near the estuary. At each station, there were different potential sources of environmental stress. These included household garbage, pesticide residues, and rubbish from the fish auction activity at St-1. Pesticide and herbicide inputs from adjacent land usage were probable sources at St-2. At St-3, pollutants transferred from upstream locations may have accumulated before entering the estuary.

Water quality analysis. Water quality parameters were measured in situ once at each station during a single sampling event. Temperature (°C), pH, and salinity (ppt) were measured in situ, whereas total suspended solids (TSS), dissolved oxygen (DO), chemical oxygen demand (COD), and biochemical oxygen demand (BOD) were analyzed in the laboratory. These metrics were chosen to describe the physicochemical state of water and to help understand macrozoobenthos occurrence between stations. The results of the water quality were compared with the norms set forth in Government Regulation No. 82 of 2001 on Water Quality Management and Water Pollution Control.

Macrozoobenthos sampling and identification. Macrozoobenthos samples were collected from the muddy substrate at each station, with three sampling replicates at a depth of 20-30 cm. The samples were then identified at the Marine Research Laboratory of the National Research and Innovation Agency (BRIN). Identification was performed on a Leica M205 C microscope at 7.8× magnification. Macrozoobenthos identification was based on observable morphological features of the collected specimens.

Results. This research was conducted in August 2024 in Langensari Village, Blanakan Regency, Subang, West Java to evaluate water quality and distribution of macrozoobenthos as bioindicators of environmental conditions in the area.

Water quality characteristics. Water quality data for the three observation stations are presented in Table 1.

Table 1

Water quality characteristics at the three observation stations

Observation stations	*Temperature (ºC)*	*pH*	*Salinity (‰)*	*TSS (mg L^{-1})*	*DO (mg L^{-1})*	*COD (mg L^{-1})*	*BOD (mg L^{-1})*
Station 1	30.0	7.8	10.0	45.6	2.9	523	162
Station 2	28.0	8.6	20.0	52.0	7.3	4,222	1,135
Station 3	33.2	8.5	30.0	52.8	5.9	3,848	1,009

Water quality standards refer to Government Regulation No. 82 of 2001 concerning Water Quality Management and Water Pollution Control.

The three stations generally showed diverse physicochemical conditions. The maximum temperature was recorded at St-3 (33.2°C), followed by St-1 (30.0°C), and the minimum temperature was recorded at St-2 (28.0°C). The pH readings at all the locations were slightly alkaline, ranging from 7.8 to 8.6. Salinity increased gradually from St-1 (10‰) to St-3 (30‰), indicating a stronger marine effect at the estuary station. TSS readings were reasonably low at all stations, ranging from 45.6 to 52.8 mg L^{-1}, and did not exceed the threshold value referenced in the paper. However, DO, COD, and BOD showed significant variability, reflecting differences in habitat quality and pollution pressure among sites.

Macrozoobenthos occurence. The macrozoobenthos data are presented in Table 2. Langensari macrozoobenthos diversity was extremely low. Only one taxon was detected and only at St-2. This species was identified in the text as a larva of the genus *Eristalis* (family Syrphidae, order Diptera), with an average biomass of 0.2236 g (Figure 2). Macrozoobenthos was not seen at St-1 and St-3.

Table 2

Mean biomass of macrozoobenthic taxa at the three sampling stations

Taxon/Group	*Station 1*	*Station 2*	*Station 3*
Polychaeta	–	–	–
Crustacea	–	–	–
Mollusca	–	–	–
Echinodermata	–	–	–
Eristalis larva	–	0.2236	–

Average biomass (g).

Figure 2. Macrozoobenthic larvae of the genus *Eristalis* found at St-2. The specimen belongs to the family Syrphidae and order Diptera and is characterized by a posterior respiratory siphon.

Discussion. The river system under study is classified as Class IV water under the water quality criteria in Government Regulation No. 82 of 2001, used for agriculture and other applications, except for potable water. However, the measured COD and BOD levels indicate a high degree of organic contamination.

The high temperature at St-3 was probably related to its proximity to the ocean and the low mangrove coverage in the area. Less vegetation cover can increase the amount of sun reaching the surface and heat the water column. A similar heat impact may have happened in St-1, where no mangrove vegetation was present in the wastewater outflow segment. On the other hand, the lower temperature at St-2 may indicate slightly better habitat conditions; this station also showed strong chemical evidence for organic pollution. Temperature thresholds over 20°C in mangrove areas are identified as zones undergoing mangrove degradation (Rendana et al., 2023). Comparable studies have also reported temperatures exceeding 25°C in mangrove ecosystems (Inoue et al., 2022; Vorsatz et al., 2022).

The pH values observed in this study ranged from 7.8 to 8.6. This range generally aligns with the optimal pH range for mangrove regions (7.0-8.5; Harifia et al., 2022), except for St-2. The significantly high pH at St-2 might be attributed to stagnant water conditions throughout the test period, with restricted inflow and outflow. Field observations indicated that the sample period was characterized by prolonged dry conditions, which may have reduced water exchange and exacerbated physicochemical concentration.

Station locations were related to salinity patterns, with the highest salinity at St-3, nearest the estuary, and the lowest at St-1, more influenced by inland freshwater conditions. Although within the given standard range, TSS readings should not be regarded in isolation as a measure of excellent environmental condition. However, the co-occurrence of very high COD and BOD values, along with the low DO concentration at St-1, suggests severe organic enrichment and ecological stress. The very low DO value (2.9 mgL^{-1}) at St-1 indicates conditions probably not suitable for the majority of aquatic creatures that are oxygen-constrained. DO readings at St-2 and St-3 were higher than at St-1, but significantly increased COD and BOD values indicated that the systems were still under heavy organic pollution pressure. Overall, these results indicate that water quality in Langensari is influenced by local circumstances and cumulative downstream inputs. Similar studies have identified high COD and BOD levels in Indonesian mangroves (Putra & Hendrasarie, 2022; Soeprobowati et al., 2022), specifically within the Langensari area (Hewindati & Kusumaningrum, 2024). The highest COD and BOD levels

were measured at St-2 and St-3 in this study, indicating substantial organic loading in both the river segment connected to the pond and the downstream estuary region.

Macrozoobenthos as bioindicators of environmental quality. Physical, chemical, and biological features of aquatic habitats greatly control the spread of macrozoobenthos (Rehitha et al., 2022; Varadinova et al., 2023; Okoro et al., 2024). Temperature, salinity, dissolved oxygen, pH, substrate type, and availability of organic matter are known to be important factors determining the presence and abundance of benthic species (Fu'adah et al., 2025; El-Kahawy et al., 2026). Macrozoobenthos are often used as bioindicators of water quality and environmental disturbance because they are typically stationary and tightly attached to the substrate (Hewindati et al., 2022; Himawan & Hewindati, 2022; Teristiandi & Yuliana, 2024). Their appearance may indicate not only current conditions but also the cumulative ecological impacts of pollution over time.

Environmental conditions were not favorable for the survival of macrozoobenthos in St-1. Relatively high temperature, low DO, moderate salinity, and high COD and BOD indicate that this station was subjected to considerable organic stress. The small channel width, lack of mangroves, and low ecological complexity likely significantly restricted habitat appropriateness. In these circumstances, the absence of macrozoobenthos is ecologically reasonable.

At St-2, water temperature was lower, and DO was higher than at the other sites, indicating considerably better physical conditions. However, this station also showed the highest COD and BOD values in the dataset, indicating serious organic pollution. The presence of *Eristalis* larva at St-2 (Figure 2) is particularly remarkable, as larvae of this genus are known to survive in organically enriched (Kamdem & Otomo, 2023), oxygen-deprived environments. They have a posterior respiratory siphon that draws in oxygen, allowing them to live in muck, sewage, decomposing organic matter (Kamdem & Otomo, 2023; Abdulla et al., 2025), and other toxic environments. Therefore, the occurence of *Eristalis* larvae at St-2 indicates localized organic enrichment within the mangrove ecosystem. This finding is also in line with previous research that identified *Eristalis* sp. among macroinvertebrate communities dominated by pollution-tolerant species in contaminated waters (Olomukoro et al., 2022; Agunbiade et al., 2025).

At St-3, despite moderate DO levels, no macrozoobenthos was identified. This may be due to the interplay among numerous stressors, especially high temperature, high salinity, and very high COD and BOD. These combined forces may have exceeded the tolerance limits of many benthic species. The non-occurrence of macrozoobenthos at St-3 is probably attributable to the combined effect of physicochemical stress and organic pollution in the vicinity of the estuarine zone. This pattern demonstrates that the studied area was under severe ecological stress, and only highly tolerant organisms could survive under the prevailing environmental circumstances.

Influence of habitat and climate. In addition to pollution, the wider habitat characteristics and climatic circumstances appear to influence the occurrence of macrozoobenthos in Langensari. Large, flowing bodies of water tend to offer more stable biological conditions, such as greater habitat diversity, better oxygenation, and more consistent food availability. By comparison, the fairly narrow water body at St-1 (~60 cm wide) presumably had limited biological potential to host a diversified benthic ecosystem. This conclusion is consistent with studies showing that macrozoobenthos abundance and diversity are often related to water body size and habitat stability.

The paper also notes that the field survey was conducted during a period of extreme dryness. Local knowledge indicated little rainfall for about 4 months prior to sampling. The Indonesian Agency for Meteorology, Climatology, and Geophysics (BMKG) climate data used in the book showed very low rainfall across the larger region in August 2024. Such protracted dry spells probably meant less water was flowing from upstream, restricted river channel flow, and increased heat stress. At St-1, almost no water flow was detected, and at St-2 and St-3, water movement was equally severely limited despite bigger channels. Prolonged dry conditions could have increased pollutant

concentration, reduced habitat quality, and further restricted the permanence of macrozoobenthos by reducing flow.

In such situations, the existence of *Eristalis* larva is quite instructive. This taxon is tolerant of organically enriched, low-quality habitats, and hence its presence supports the idea that the aquatic ecosystems in Langensari were under ecological stress during the time of sampling. The macrozoobenthos results agree with the water quality data and support the use of benthic species as bioindicators of habitat loss.

Conclusions. The results of this study reveal that water quality in Langensari varies across sampling sites and is typically characterized by high levels of organic pollution. High COD and BOD levels resulted in water quality conditions at all stations that were not in compliance with the referenced water quality requirements. The highest levels of organic contamination were found at St-2 and St-3.

The occurrence of macrozoobenthos is quite limited in the whole research area. Exclusively, an *Eristalis* larva was documented, exclusively at St-2, whilst no macrozoobenthos were identified at St-1 or St-3. The distribution pattern of macrozoobenthos in Langensari was limited by a combination of environmental stresses, including organic pollution, high temperatures, salinity, limited water flow, limited habitat size, and limited mangrove cover.

These results show that pollution-tolerant benthic animals, such as *Eristalis* larvae, could be valuable biological indicators of deteriorating aquatic conditions in Langensari. The results further underline the need to integrate biological indicators with physicochemical water quality to improve environmental monitoring in mangrove-associated river systems. Combining water quality assessment with pollution index methodologies, such as the Pollution Index or the STORET method, could be useful for future monitoring to improve environmental interpretation and management recommendations.

Authors Contributions. Conceptualization: SU, YTH, FRZ; Methodology: SU, YTH, FRZ; Formal analysis: SU, YTH; Investigation: SU, YTH, FRZ; Data curation: SU, YTH; Writing-Original draft: SU, YTH, FRZ, RZ, HJ; Writing-review and editing: SU, YTH, FRZ, RZ, HJ.

Conflicts of Interest. The authors declare that there is no conflict of interest.

Data Availability. The data supporting the findings of this study are available from the corresponding author upon reasonable request.

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