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Water Quality Characteristics of Lhok Geulumpang Estuary, Aceh Jaya

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Abstract
Water quality is a critical factor in determining the ecological condition of estuarine ecosystems, which are highly dynamic due to the interaction between freshwater and seawater. However, information on the water quality characteristics of the Lhok Geulumpang estuary in Aceh Jaya remains limited. This study aimed to analyze water quality parameters in the study area. Field measurements were conducted in October 2025 at a representative station using in situ methods. The observed parameters included temperature, salinity, pH, and dissolved oxygen (DO), with three replicates for each measurement. The collected data were analyzed descriptively and compared with environmental quality standards. The results showed that water temperature ranged from 29.8 to 30.0°C, salinity from 7.24 to 9.39 ppt, pH from 7.61 to 8.31, and DO from 4.3 to 4.9 mg/L. These values indicate that the study area exhibits typical estuarine characteristics, particularly reflected by low salinity due to freshwater influence. The results indicate that the Lhok Geulumpang estuary is in relatively good condition and can support aquatic life. However, the slightly lower DO concentration suggests the need for continuous monitoring to ensure long-term environmental sustainability.

1. Introduction

Coastal and estuarine waters are dynamic ecosystems that play an essential role in supporting aquatic life and maintaining ecological balance. These transitional environments are influenced by the interaction between freshwater and seawater, resulting in unique physicochemical characteristics that determine the distribution and survival of aquatic organisms. Water quality is a key factor in these systems, as it directly affects biological processes such as primary productivity, nutrient cycling, and trophic interactions (Effendi, 2023).

Estuarine environments are particularly sensitive to environmental changes because they serve as receiving bodies for various inputs, including river discharge, surface runoff, and anthropogenic activities. Variations in physicochemical parameters such as temperature, salinity, pH, and dissolved oxygen (DO) can significantly influence the structure and function of aquatic ecosystems. These parameters act as limiting factors that control the growth and distribution of organisms, including plankton, which serve as primary producers and indicators of environmental conditions (Ainalyaqin & Abida, 2024; Widianingsih & Suryono, 2021).

The Lhok Geulumpang estuary in Aceh Jaya represents a coastal area with potential biological resources and ecological importance. This area is influenced by both marine and freshwater inputs, creating a brackish water environment characterized by fluctuating environmental conditions. In addition, the area has been used for fisheries and tourism activities, which may contribute to changes in water

quality over time (Chen et al., 2021; Kurniawan et al., 2022). Such conditions highlight the need for continuous monitoring of environmental parameters to assess ecosystem health.

Despite its ecological importance, scientific information regarding the water quality characteristics of the Lhok Geulumpang estuary remains limited. Previous studies and field observations in this area have primarily focused on general descriptions of environmental conditions or biological components, such as plankton identification, without providing a detailed interpretation of physicochemical parameters as indicators of estuarine dynamics (Cereja et al., 2022; Lin et al., 2024). This lack of focused analysis represents a research gap, particularly in understanding how environmental parameters reflect the estuarine nature and ecological condition of the area. Therefore, this study aims to analyze the water quality characteristics of the Lhok Geulumpang estuary, Aceh Jaya, by evaluating key environmental parameters, including temperature, salinity, pH, and dissolved oxygen (DO), in order to provide baseline information for ecological assessment and sustainable coastal management.

2. Research Method

Time and Place

This study was conducted in October 2025 in the estuarine waters of Lhok Geulumpang, Sawang Village, Setia Bakti District, Aceh Jaya, Indonesia (Figure 1). Field sampling was carried out at a representative station within the estuarine area. Data processing and analysis were conducted at the Aquaculture Environmental Systems Laboratory, Universitas Teuku Umar.

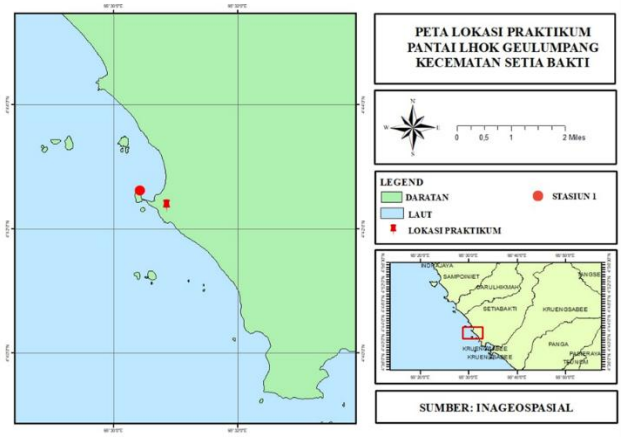

Figure 1. Research Location

Method

This study employed a field survey with a descriptive-quantitative approach. Primary data were collected through in situ measurements of water quality parameters, including temperature, salinity, pH, and dissolved oxygen (DO), using a water quality meter. The measurement procedures followed standard methods for water quality assessment (APHA, 2017). Each parameter was measured three times at the same station to ensure data reliability and representativeness.

Procedures

Water quality parameters were measured directly in the field using a water quality meter. The probe was immersed in the water at a depth of approximately 15–50 cm below the surface. Measurements of temperature, salinity, pH, and dissolved oxygen (DO) were recorded after the readings stabilized. Each parameter was measured in triplicate with time intervals between measurements to minimize error and ensure consistency. In situ measurement is widely used to obtain accurate environmental conditions at the time of sampling (APHA, 2017). The measured values for each parameter were averaged to represent the overall condition of the study area. The mean value was calculated by summing all measurements and dividing by the number of replicates.

Data Analysis

Data analysis was conducted descriptively by comparing the measured water quality parameters with the seawater quality standards established by Government Regulation of the Republic of Indonesia No. 22 of 2021 concerning Environmental Protection and Management. The analyzed parameters included temperature, salinity, pH, and dissolved oxygen (DO). The results were interpreted to assess whether the water quality falls within acceptable ranges for aquatic life. In addition, the analysis considered the estuarine characteristics of the study area, particularly the influence of freshwater-seawater mixing, which may affect parameters such as salinity and pH. Such transitional conditions are common in estuarine ecosystems and play an important role in shaping water-quality dynamics (Effendi, 2023).

3. Result and Discussion

Water Quality

The results of water quality measurements in the estuarine waters of Lhok Geulumpang are presented in Table 1. The observed parameters included temperature, salinity, pH, and dissolved oxygen (DO), which are key indicators in assessing the ecological condition of aquatic environments.

Table 1. Water quality parameters in the Lhok Geulumpang estuary

Parameter	Unit	Range	Mean
Temperature	°C	29.8 – 30.0	29.9
Salinity	ppt	7.24 – 9.39	8.24
pH	-	7.61 – 8.31	7.92
Dissolved Oxygen	mg/L	4.3 – 4.9	4.56

Based on the measurement results, the water quality conditions in the Lhok Geulumpang estuary exhibit characteristics typical of estuarine ecosystems, which are influenced by the interaction between freshwater and seawater. This is particularly reflected in the relatively low salinity values and the variability of physicochemical parameters, which remain within the tolerance range of most aquatic organisms. Estuarine environments are generally characterized by high environmental dynamics due to interactions among hydrological processes, tidal influences, and terrestrial inputs, resulting in more variable conditions than in open marine waters (Chilton et al., 2021; Shen et al., 2022; Gallego-Zerrato et al., 2025).

The temperature values ranged from 29.8 to 30.0°C, with an average of 29.9°C, indicating relatively stable thermal conditions. Temperature is a critical environmental parameter that regulates metabolic activity, enzymatic reactions, and physiological processes in aquatic organisms (Volkoff & Rønnestad, 2020). Stable temperature conditions, as observed in this study, support optimal biological processes, including photosynthesis and respiration. According to Bai'nun et al. (2021), tropical waters typically exhibit a temperature range of 27–32°C, which is suitable for most aquatic organisms. Therefore, the temperature conditions in the study area are not considered a limiting factor for biological activity.

Salinity values ranged from 7.24 to 9.39 ppt, with an average of 8.24 ppt, which is significantly lower than typical marine salinity levels (30–35 ppt). This indicates a strong influence of freshwater input, likely originating from river discharge or surface runoff. Such conditions are characteristic of brackish water systems, where the mixing of freshwater and seawater creates a salinity gradient (Kong et al., 2025). According to Patty & Yalindua (2021), salinity is a major environmental factor that determines the distribution and survival of aquatic organisms, particularly in estuarine ecosystems where salinity fluctuates spatially and temporally. The relatively low salinity observed in this study suggests that only euryhaline organisms, which are capable of tolerating salinity variations, can thrive in this environment.

The pH values ranged from 7.61 to 8.31, with an average of 7.92, indicating neutral to slightly alkaline conditions. This range is considered optimal for aquatic life and reflects stable chemical conditions in the water. The pH of aquatic environments is influenced by processes such as

photosynthesis, respiration, and the decomposition of organic matter. According to Putriningtias et al. (2021), the acceptable pH range for marine organisms is 7-8.5, indicating that the observed values fall within the recommended environmental standards. Stable pH conditions suggest that the water body is not experiencing significant chemical stress, such as acidification or pollution (Spyra, 2017).

Dissolved oxygen (DO) concentrations ranged from 4.3 to 4.9 mg/L, with an average of 4.56 mg/L. This value is slightly below the recommended threshold (>5 mg/L) for optimal aquatic life, as set by Government Regulation No. 22 of 2021. Dissolved oxygen plays a crucial role in supporting the respiration and metabolic processes of aquatic organisms, as well as microbial decomposition of organic matter (Rouf et al., 2022; Larance et al., 2025). The relatively low DO values observed in this study may indicate moderate environmental pressure, possibly due to organic matter decomposition, limited water circulation, or biological oxygen demand. Windarto et al. (2024) noted that decreased DO levels are often associated with increased organic load and reduced oxygen diffusion. Although DO levels remain sufficient to support most aquatic organisms, they may pose limitations for species that are highly sensitive to low oxygen levels.

Analysis of Estuarine Water Conditions

Results of water quality measurements indicate that the Lhok Geulumpang estuary exhibits relatively stable environmental conditions while retaining the dynamic nature of estuarine ecosystems. The observed combination of stable temperature, neutral pH, and relatively low salinity suggests a strong influence of freshwater input, which is a defining feature of estuarine environments. The dominance of freshwater influence, as indicated by low salinity values, plays a significant role in shaping the ecological structure of the estuarine system (Zhu et al., 2025). This condition limits the presence of strictly marine species and favors organisms tolerant of salinity fluctuations. Such ecological filtering is a common feature in estuarine environments, where environmental gradients act as selective factors for species distribution (Chistensen et al., 2019)

Although temperature and pH are within optimal ranges and do not indicate environmental stress, the slightly lower dissolved oxygen concentration suggests moderate environmental pressure (Velez et al., 2023). This condition does not necessarily indicate severe pollution but may reflect natural processes such as organic matter decomposition and hydrodynamic limitations. According to Ainalyaqin and Abida (2024), fluctuations in DO are common in estuarine environments due to the influence of tidal dynamics, freshwater inflow, and biological activity.

Furthermore, the interactions among environmental parameters suggest that the aquatic system remains capable of supporting ecological processes, including primary productivity and trophic interactions. However, the relatively low DO levels and strong freshwater influence indicate that the system is sensitive to environmental changes. Any increase in organic input or anthropogenic pressure may further reduce oxygen availability and disrupt ecosystem balance (Bănăduc et al., 2024). Therefore, the water quality of the Lhok Geulumpang estuary can be classified as relatively good, as most parameters fall within acceptable ranges for aquatic life. Nevertheless, the observed conditions also highlight the importance of continuous monitoring to prevent potential environmental degradation. Sustainable management strategies are needed to maintain the ecological function of the estuarine system, particularly in areas experiencing increasing human activities.

4. Conclusion

The results of this study indicate that the estuarine waters of Lhok Geulumpang, Aceh Jaya, exhibit relatively stable environmental conditions. The measured parameters, including temperature, salinity, and pH, fall within ranges suitable for aquatic life, reflecting a supportive environment for biological processes. The low salinity values confirm the strong influence of freshwater input, indicating that the study area is a brackish-water ecosystem with typical estuarine characteristics. Meanwhile, the dissolved oxygen (DO) concentration was slightly below the recommended threshold, suggesting moderate environmental pressure that may be associated with organic matter decomposition or limited water

circulation. Overall, the water quality of the Lhok Geulumpang estuary is relatively good, though the observed DO levels highlight the need for continuous monitoring. Sustainable management is necessary to maintain ecological stability and prevent potential environmental degradation in the future.

References

[APHA] American Public Health Association. (2017). *Standard Methods for the Examination of Water and Wastewater* (23rd ed.). Washington, D.C.: APHA.

Ainalyaqin, M.I., & Abida, I.W. (2024). Korelasi Kandugan Oksigen Terlarut dan pH terhadap Keanekaragaman Plankton di Sungai Kalidami Kota Surabaya. *Environmenal Pollution Journal,* 4(1): 859-904.

Bai'nun, N.H., Riyanti, I., Mulyani, Y., & Zallesa, S. (2021). Keanekaragaman Makrozobentos sebagai Indikator Kondisi Perairan di Ekosistem Mangrove Pulau Pari, Kepulauan Seribu. *Journal of Fisheries and Marine Research*, 5(2): 227-238.

Bănăduc, D., Curtean-Bănăduc, A., Barinova, S., Lozano, V. L., Afanasyev, S., Leite, T., Branco, P., Gomez Isaza, D. F., Geist, J., Tegos, A., Simić, S. B., Olosutean, H., & Cianfanglione, K. (2024). Multi-Interacting Natural and Anthropogenic Stressors on Freshwater Ecosystems: Their Current Status and Future Prospects for 21st Century. *Water*, *16*(11), 1483.

Cereja, R., Chainho, P., Brotas, V., Cruz, J.P.C., Sent, G., Rodrigues, M., Carvalho, F., Cabral, S., & Brito, A.C. (2022). Spatial Variability of Physicochemical Parameters and Phytoplankton at the Tagus Estuary (Portugal). *Sustainability*, *14*(20): 13324.

Chen, P., Zhao, Y., Zuo, D., & Kong, X. (2021). Tourism, Water Pollution, and Waterway Landscape Changes in a Traditional Village in the Huizhou Region, China. *Land*, *10*(8): 795

Chilton, D., Hamilton, D.P., Nagelkerken, I., Cook, P., Hipsey, M.R., Reid, R., Sheaves, M., Waltham, N.J., & Brookes, J. (2021) Environmental Flow Requirements of Estuaries: Providing Resilience to Current and Future Climate and Direct Anthropogenic Changes. *Front. Environ. Sci*. 9:764218.

Christensen, E.A.F., Stieglitz, J.D., Grosell, M., & Steffensen, J.F. (2019). Intra-Specific Difference in the Effect of Salinity on Physiological Performance in European Perch (*Perca fluviatilis*) and Its Ecological Importance for Fish in Estuaries. *Biology*, *8*(4): 89.

Desmawati, I., Ameivia, A., & Ardayanti, L.B. (2020). Studi Pendahuluan Kelimpahan Plankton di Perairan Darat Surabaya dan Malang. *Rekayasa,* 13(1): 61-66.

Effendi, H. (2023). *Pengelolaan Kualitas Air untuk Budidaya Perairan dan Lingkungan*. IPB University.

Gallego-Zerrato, J.J., Cuellar, A., & Giraldo, A. (2025). Ichthyoplankton Composition and Environmental Drivers in the Sanquianga Tapaje Estuarine System, Eastern Tropical Pacific. *Diversity*, *17*(9):649.

Kong, L., Chu, H., Hou, G., Zeng, J., Zhao, L., Han, X., Li, Y., Zhou, F., Yin, M., & Zhang, X. (2025) Characteristics and Mechanisms of Sea (Salt) Water Intrusion in Laizhou City, Shandong Province, China. *Front. Mar. Sci*., 12:1578175.

Kurniawan, F., Adrianto, L., Bengen, D.G., & Prasetyo, L.B. (2022). Hypothetical effects assessment of tourism on coastal water quality in the Marine Tourism Park of the Gili Matra Islands, Indonesia. *Environment, Development and Sustainability*, 1–27.

Larance, S., Wang, J., Delavar, M.A., & Fahs, M. (2025). Assessing Water Temperature and Dissolved Oxygen and Their Potential Effects on Aquatic Ecosystem Using a SARIMA Model. *Environments*, *12*(1): 25.

Lin, X., Li, K., Zhao, H., Gao, Y., Zhang, Z., Wang, L., Wang, X., Sanganyado, E., Zheng, Z., Gutang, Q., Liu, S., Li, P., Yan, X., Chen, Z., Lin, J., & Liu, W. (2024). Seasonal Changes of Plankton Community and Its Influencing Factors in Subtropical Coastal Marine Areas Revealed by eDNA-Based Network Analysis. *Front. Mar. Sci.* 11:1416359.

Patty, S.I., & Yalindua, Y.F.Y (2021). Analisis Kualitas Perairan Bolaang Mongondow, Sulawesi Utara Berdasarkan Parameter Fisika-Kimia Air Laut. *Jurnal Kelautan Tropis,* 24(1): 113-122.

Putriningtias, A., Bahri, S., Faisal, T.M., Harahap, A. (2021). Kualitas Perairan di Daerah Pesisir Pantai Ujung Perling, Kota Langsa, Aceh. *Journal of Aquatic Resources and Fisheries Management,* 2(2): 95-99.

Rouf, M.A., Islam, M.J., Roknuzzaman, M., Siddique, M.N., & Golder, M.R. (2022). Vertical Profile of Dissolved Oxygen and Associated Water Variables in the Pasur-Rupsha estuary of Bangladesh. *Heliyon*, *8*(10): e10935.

Shen, X., Detenbeck, N., & You, M. (2022). Spatial and Temporal Variations of Estuarine Stratification and Flushing Time Across the Continental U.S. *Estuarine, Coastal and Shelf Science*, *279*: 1–19.

Spyra A. (2017). Acidic, Neutral and Alkaline Forest Ponds as a Landscape Element Affecting the Biodiversity of Freshwater Snails. *Die Naturwissenschaften*, *104*(9-10): 73.

Velez, K.E.C., Leighton, R.E., Decho, A.W., Pinckney, J.L., & Norman, R.S. (2023). Modeling pH and Temperature Effects as Climatic Hazards in V*ibrio vulnificus* and *Vibrio parahaemolyticus* Planktonic Growth and Biofilm Formation. *GeoHealth*, *7*(4): e2022GH000769.

Volkoff, H., & Rønnestad, I. (2020). Effects of Temperature on Feeding and Digestive Processes in Fish. *Temperature (Austin, Tex.)*, *7*(4): 307–320.

Widianingsih, W., & Suryono, S. (2021). Struktur Komunitas Fitoplankton dan Parameter Kualitas Air di Perairan Paciran, Lamongan. *Journal of Marine Research,* 10(4), 493-500.

Winarsih, L., Susanto, D., & Duya, N. (2024). Efektifitas Larutan Pengawet pada Sampel Plankton pada Pemeriksaan di Laboratorium. *Indonesian Journal of Laboratory*, 1(3): 226-236.

Windarto, F., Natalie, D.C., Rummapuk, Jane, M., Mamuja., Royke, M, Rampengan., Joshian, N.W., Schaduw, Hermanto, W, K., Manengkey (2024). Kajian Kualitas Air di Kawasan Malalayang Beach Walk. *Jurnal Ilmiah Platax,* 12 (1).

Zhu, Q., Min, L., Zhang, W., Ji, S., & Chi, Y. (2025). The Evolution of Sediment Microorganisms During the Transition from Freshwater to Seawater and Their Dependence on Water Quality. *Water*, *17*(12): 1831.