 E-ISSN: 2303-0720

DOI: https://doi.org/10.21009/JRSKT.112.06

Chemical and Physical Assessment of Water Quality in the Panimbang River Estuary, Pandeglang, Indonesia

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Received: 27 August 2025
Revised: 14 October 2025
Accepted: 17 October 2025
Online: 15 December 2025
Published: 30 December 2025

Jurnal Riset Sains dan Kimia Terapan
p-ISSN: 2302 - 8467
e-ISSN: 2303 – 0720

Abstract

The Panimbang River in Pandeglang, Indonesia, is widely used by residents for daily activities. This study analyzed water quality using physical parameters, including pH, temperature, dissolved oxygen (DO), Total Dissolved Solids (TDS), TSS (Total Suspended Solids), salinity, and alkalinity. Samples were taken around the estuary, which is surrounded by settlements. The results showed a pH of 4.50–6.49, below the standard of 6–9, indicating slightly acidic water. High temperatures, thought to be due to daytime sampling, affect DO. The average DO value was only 2.96 mg/L, well below the minimum threshold of 5 mg/L, indicating poor aeration. The average TDS is above 1000 ppm, indicating pollution from household waste and human activities. The average alkalinity of 384.976 mg/L $CaCO_3$ is within the safe range (30–500 mg/L), so it can stabilize pH. The water quality in the Panimbang River Estuary indicates environmental pressure from anthropogenic activities, resulting in slightly acidic water with low aeration and high solute content. However, adequate alkalinity still helps maintain the water's pH stability. This condition indicates the need for more intensive monitoring and waste management to protect estuarine ecosystems, which are vital to the community and the surrounding environment.

Keywords: alkalinity, dissolved oxygen, pH, total dissolved solid, water quality.

Introduction

The river estuary is the final part of the river's flow that empties into the sea. The problems that arise in this region are usually analyzed through two main parts: the river mouth and the estuary. The mouth of a river is the most terminative point in the estuary that is in direct contact with the ocean, while an estuary refers to the part of the river that is affected by tidal and ebb waves. River estuary

 E-ISSN: 2303-0720

water quality analysis is an important research area in aquatic ecology, particularly regarding anthropogenic impacts and climate change (Asresu et al., 2025). The condition of marine waters is influenced by a variety of factors that alter their physical, chemical, and biological conditions, both from land and from the marine system itself. Among the factors from land, human activities such as settlement development, industry, and mining activities also play a significant role in changing the quality of marine waters (Marigomez, 2023).

Panimbang Estuary is located on the west coast of Banten Province, in the south of the Carita marine tourism area. Estuarine areas with high levels of urbanization tend to be more susceptible to pollution (Sulistyowati et al., 2023). These waters are an important fishing area. Banten Bay is located at the western tip of Java Island and is influenced by the tides of the Sunda Strait and the Java Sea. Hills surround this area with a more expansive coastline than the Carita and Merak areas. The Ciliman River, located in Panimbang, and the Cibungur River, north of Panimbang, are the primary sources of organic matter and sediment that flow into the bay (Helfinalis, 2005). The Ciliman and Cibungur rivers in Pandeglang Regency are key fluvial systems that transport dissolved and suspended materials to coastal waters. Recent studies indicate that the annual sedimentation rate reaches between 2.3 and 3.1 tons/ha/year from both watersheds (Nurhayati et al., 2023).

The rapid population growth has also led to a decline in water quality, with waste from urban and industrial activities as the primary driver of this degradation (Song et al., 2025). In addition, the quality of the water zone and the condition of riparian vegetation also affect the overall water quality in the river ecosystem (Gu et al., 2025). The quality of water in a location has a broad impact on the surrounding environment. Its changes can be analyzed through three main dimensions: physical (temperature, turbidity, dissolved solids), chemical (pH, dissolved oxygen, biochemical oxygen requirements/DO, heavy metal content), and biological (presence of plankton, bacteria, and other biota components). Therefore, comprehensive water quality monitoring requires careful physical and chemical analysis. Some key parameters often measured include temperature, salinity, Total Dissolved Solids (TDS), Total Suspended Solids (TSS), pH, alkalinity, dissolved oxygen (DO), and heavy metal content (Babatunde et al., 2024). Water quality is strongly influenced by water conditions, with BOD values exceeding quality standards (Negara et al., 2024). In this study, the physical parameters measured included temperature, salinity, TDS, and TSS, while the chemical parameters reviewed included pH, alkalinity, and DO.

Alkalinity is one of the most important water quality parameters in aquaculture. It describes the capacity of water to neutralize additional acids without causing a drop in pH. In other words, alkalinity serves as a buffer against changes in acidity. This parameter is expressed in milligrams of calcium carbonate per liter of water (mg $CaCO_3$/L) or as ppm equivalents. The purpose of this study is to determine the quality of water at the mouth of the Panimbang River, Banten, as reflected in the parameters of temperature, pH, DO, Salinity, TSS, and TDS using a multi-parameter analyzer, and alkalinity using the titration method.

Method

Materials and Instrumentation

The materials used include oxalic acid (Merck), methyl orange indicators (Merck), aqueous solutions, water samples, and H_2SO_4 (Merck). The instrumentation in the study includes portable multiparameter analyzers (Hanna), pH meters (Mettler Toledo), burettes, Erlenmeyer flasks, reagent bottles, volume pipettes, and submersible pumps.

Sampling Procedure

Sampling was carried out using a submersible sampling pump equipped with a 30-meter cable, a 30-meter raffia rope, a 12 V DC power supply, and a cork buoy. The sampling location is determined at the mouth of the Panimbang River, with the collection carried out at two points, namely on the right bank and the left bank of the river at the water level. Taking in the middle of the river and at a depth of 1 meter cannot be done due to the extreme location conditions.

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Measurement of Parameters of Temperature, pH, DO, salinity, TSS and TDS

Parameters such as temperature, pH, dissolved oxygen (DO), salinity,TSS, and TDS were measured using a multi-parameter analyzer. Before use, the appliance is first calibrated using a calibration fluid. This tool is prepared by charging the battery and filling the inner filling solution on each electrode The measurement of each sample is carried out three times to confirm consistency and precision before being used to measure the sample. The water sample is put into a sampling container, then the container is locked on a measuring device for the measurement process.

Alkalinity Measurement

The alkalinity was determined by titration with sulfuric acid standardized to sodium carbonate in the laboratory before sampling, yielding H_2SO_4 0.1063 M or 0.2126 N. In the field, 50 mL of water samples were placed in an Erlenmeyer flask, then 2 drops of methyl orange indicator were added. The solution is slowly titrated with H_2SO_4 until the color changes from orange to pink, indicating the titration endpoint. Titration is carried out at least in triplicate. The volume of H_2SO_4 used is recorded and used to calculate the alkalinity expressed in mg/L as $CaCO_3$. The alkalinity of swamp water in the Tanjung Lesung area was determined by acid-base titration. Alkaline samples are titrated with strong acids. Sulfuric acid is the most commonly used acid as a standard solution in alkalinity analysis (Dhoke, 2023). Sulfuric acid is a secondary raw solution with an unknown concentration.

Before use in titration, sulfuric acid is standardized with a primary standard solution, namely 0.05 M sodium carbonate. In determining sulfuric acid concentration by titration, methyl orange is used as an indicator with a pH range of 3.2-4.4. The titration endpoint is indicated by a color change from orange to pink. Sulfuric acid that has been standardized and has a known concentration of 0.1063 M or 0.2126 N is then used to determine the alkalinity or alkalinity content of swamp water.

The titration procedure begins by adding two drops of methyl orange indicator to the sample solution. This indicator helps visualize the endpoint of the reaction, which is observed as a color change from orange to pink. For each test, a sample volume of 10 mL is used to ensure consistency and accuracy throughout the titration process (**Equation 1**).

$$Alkalinity = \frac{mg}{L} = \frac{\text{Vtitration x N } H_2SO_4 \text{ x1000x 50.3}}{v\ sample} \quad (1)$$

Result and Discussion

Water Sampling Location Determination

The water sampling location was chosen at one of the points along the banks of the Panimbang River estuary. The selected point is next to the Ship's Refueling Station. Around the sampling location, residential areas are evident. Based on analysts' observations, the ecosystem around the sampling point is a mangrove forest. A description of the sampling point is shown in **Figure 1** below.

The sampling point location was determined randomly. Points 1, 5, and 4 are located on the left, or adjacent to, the Panimbang River Bridge petrol station, and points 2, 3, and 6 are on the right, directly adjacent to residents' houses. Due to river flow during sampling, the river depth, extreme environmental conditions, and inadequate sampling equipment, it is not possible to sample in the middle of the river mouth or at a specific depth in the middle.

Measurement of Parameters of Temperature, pH, DO, salinity, TSS, and TDS

The general water quality parameters of the Panimbang River estuary water sample in Pandeglang Regency, Banten, were measured using a Multi Parameter *Analyzer* instrument. The instrument measures pH, temperature, dissolved oxygen (DO), total dissolved solids (TDS), conductivity, and salinity. Before the sample measurement is carried out, the multi-analyzer is calibrated using a standard

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calibration fluid. The results of measuring physical parameters using a multi-parameter analyzer are shown in **Table 1**.

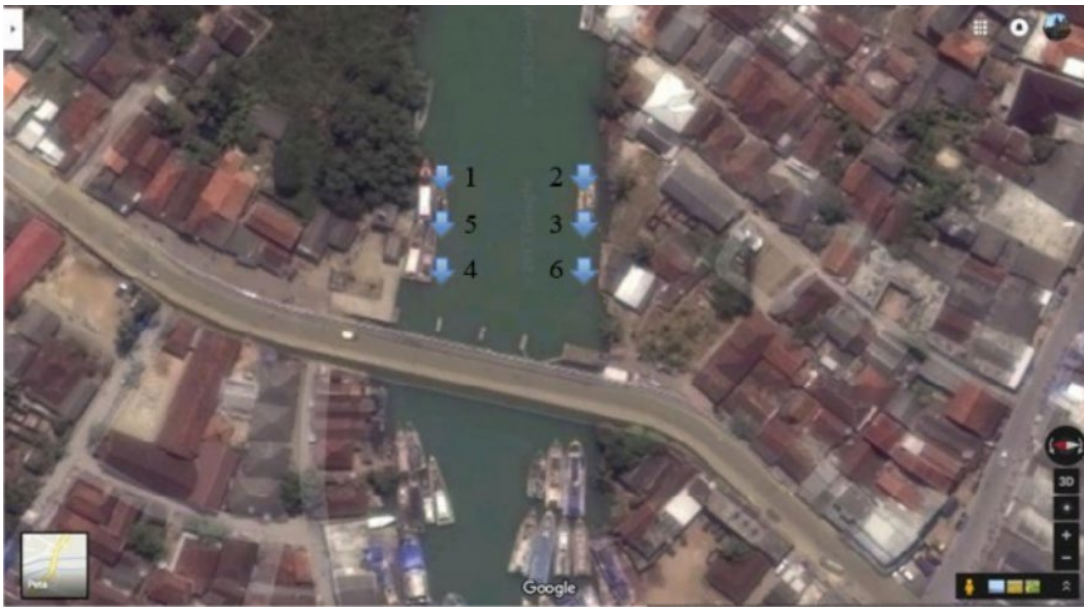

Figure 1. Water Sampling Sites (Around 06º03′06º′South Latitude and 105º36′105º36′East Longitude)

Table 1. Physical Parameter Measurement Results Using Multi Parameter Analyzer Tools

Sample	pH	In-situ temperature (°C)	Ex-situ temperature (°C)	OF (mg/L)	TDS (ppm)	TSS (mΩ/cm)	Salinity (%)
1	4.50	33.0	30.03	3.81	1360	0.0004	1.39
2	5.62	32.0	29.93	3.59	1150	0.0004	1.17
3	5.80	31.0	29.76	3.19	1191	0.0004	1.21
4	6.49	31.5	29.84	2.69	1304	0.0004	1.33
5	6.29	30.5	29.77	2.34	1005	0.0005	1.01
6	6.37	31.0	29.65	2.15	976	0.0005	0.98

The pH value indicates the concentration of hydrogen ions (H^+) in water. The higher the concentration of hydrogen ions, the lower the pH, and these conditions tend to make water more toxic to aquatic organisms (Sun et al., 2025). Based on the measurement, the sample's pH is 4.50–6.49. The water sample is classified as slightly acidic (pH < 7) and is outside the permissible range, in accordance with Government Regulation Number 22 of 2021, which specifies a pH range of 6-9 (Government of the Republic of Indonesia, 2021). The low pH value is suspected to be due to community waste in estuaries, such as plastic, household waste, and ship fuel.

Water temperature is a key factor that affects water quality and the survival of aquatic life. The temperature around the mouth of the Panimbangan River may also be influenced by polluted air conditions, as indicated by high levels of total suspended particulates (Widianti et al., 2025). Temperature plays a role in determining the rate of chemical processes, the level of biological activity, and the physical properties of water bodies. Temperature changes can significantly affect the solubility of oxygen in water, which is vital for aquatic organisms(Chapra & Camacho, 2021). Higher temperatures generally reduce oxygen solubility, leading to hypoxia (oxygen deficiency) and stress that can cause death in fish and other aquatic creatures (Leach et al., 2023).

Temperature parameters are measured 2 times for each sample. From the data obtained, it can be seen that the ex-situ temperature measurements show a decrease in temperature for each sample. The decrease is suspected to be due to the sample's silence for about 2 hours prior to ex-situ measurements. The high sample temperature (based on in-situ measurements) is suspected to be influenced by the sampling time, which was conducted at noon. Temperature is a vital water quality parameter because it is directly related to other parameters. The higher the water temperature, the less the water's ability

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to support biological activity will decrease. The increase in water temperature also reduces the DO value. A 1°C temperature rise in tropical estuaries can lower dissolved oxygen (DO) by up to 2.3 mg/L and accelerate the decomposition of organic matter by up to 15%(Varsh et al., 2025). In the measurements, no direct correlation between temperature and DO is observed. This is suspected to be due to the placement of a non-static sampler pump, which is not static due to a reasonably strong estuary current.

The amount of dissolved oxygen (DO) determines the level of aeration of the observed water body. The higher the DO value, the better the water body's aeration and its ability to support biological activity (Widarti et al., 2024). Based on the water quality standard in Government Regulation No. 22 of 2021, the DO parameter must be> 3 for the class III water category. Based on the measurements, the DO values of the six samples ranged from 2.15 to 3.81 ppm, with an average DO of 2.96 ppm. This indicates that the mouthwater of the Panimbang River does not meet these parameters. The low DO value may be influenced by high pollution from various types of waste dumped into the mouth of the Panimbang River. A decrease in dissolved oxygen is very dangerous because it can cause stress in organisms, impaired growth, or death (Enviroliteracy Team, 2025). The low DO value is also influenced by the high COD (chemical oxygen demand), which results from high levels of organic pollution in the water, such as household and industrial waste (Du et al., 2024).

The salinity parameter measurements performed on the sample provide a value comparable to the TDS value. The quality standard of the TDS physics parameter is 1000 mg/L (Stephen et al., 2023). The results of the 6-sample calculation showed that the TDS concentration at the mouth of the Panumbang River was relatively high. An increase in TDS is usually caused by human activities around the river, such as bathing and washing. The content of chemicals in detergents and soaps (such as surfactants, phosphates, salts, and other organic compounds) contributes to the hardness of the water, which in turn increases the level of dissolved particles and causes TDS values to be high (Arinal et al., 2025). Another factor that can affect TDS values and salinity is the presence of sediment, which is generally collected from the bottom of the estuary and carried into the sample. This is possible due to the sampler pump's instability caused by the relatively strong estuary current. In addition to coming from inorganic sediments and sediments, TDS values can also come from organic materials. These organic materials can be sourced from community kitchen waste or the remains of decomposed organisms. The contribution of organic materials to the TDS value can be seen in the TSS value, which remains constant as the TDS increases. The electrical conductivity (TSS) in water is greatly influenced by the amount of free inorganic ions dissolved in water. There should be a direct relationship between the amount of sediment and inorganic deposits on the TSS value. The TSS value, which tends to be constant, indicates that there is no significant difference in the number of dissolved inorganic ions in the sample.

Alkalinity Measurement

Alkalinity describes the amount of alkalinity contained in water, or the capacity of water to neutralize additional acids without causing a decrease in pH value. Functionally, alkalinity acts as a buffer, providing a natural defense against water acidification. This parameter is essential to prevent drastic pH fluctuations, which can disrupt the balance of aquatic ecosystems. Alkalinity in water is mainly derived from ions such as carbonate (CO_3^{2-}), bicarbonate (HCO_3^-), hydroxide (OH^-), as well as borate (BO_3^{3-}) and phosphate (PO_4^{3-}).

At an alkalinity level of ≥20 mg/L, water has a strong capacity to hold carbon dioxide (CO_2), thereby increasing the availability of CO_2 for photosynthesis. In phytoplankton-rich aquatic ecosystems, the absorption of CO_2 by these organisms reduces the concentration of carbonic acid (H_2CO_3), thereby increasing pH. In addition, phytoplankton and other aquatic plants can use bicarbonate ions (HCO_3^-) as a carbon source for photosynthesis, releasing carbonate ions (CO_3^{2-}) as a by product (**Equation 2-5**). This process also supports the chemical stability of water (Cole, 2002).

$$2HCO_3^- + \text{phytoplankton} \rightarrow CO_2 \text{ (photosynthesis)} + CO_3^{2-} + H_2O \quad (2)$$

$$CO_3^{2-} + H_2O \rightarrow HCO_3^- + OH^- \text{ (strong base)} \quad (3)$$

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High pH can also be seen as a decrease in hydrogen ions (H^+):

$$CO_3^{2-} + H^+ \rightarrow HCO_3^{2-} \quad (4)$$

or

$$HCO_3^{2-} + H^+ \rightarrow H_2O + CO_2 \quad (5)$$

The release of carbonate ions (CO_3^{2-}) derived from the decomposition of bicarbonate ions (HCO_3^-) by aquatic plants can cause a dramatic increase in pH exceeding 9 values, especially during periods of intensive photosynthesis due to the abundant growth of phytoplankton (algae). This increase in pH can occur in both low-alkalinity waters (20–50 mg/L) and moderate-to-high bicarbonate-alkalinity waters (75–200 mg/L), especially if the water hardness is below 25 mg/L. In soft waters, high bicarbonate alkalinity is often derived from sodium and potassium carbonate compounds, which are more soluble than calcium carbonate ($CaCO_3$) and magnesium carbonate ($MgCO_3$). Causes of permanent hardness. However, when calcium and magnesium ions are present along with an active process of photosynthesis, and the pH rises above 8.3, the resulting carbonate can react to form calcium carbonate ($CaCO_3$), which is the initial form of limestone (limestone) deposits, which slowly accumulate in aquatic ecosystems (Truchot & Forgue, 2020).

The alkalinity of natural waters usually does not exceed 500 mg/L as $CaCO_3$. Waters with too high alkalinity are generally not ideal for aquatic organisms, as they often correlate with high hardness or significant sodium salt content (Zhu et al., 2023). The optimal alkalinity level is 30–500 mg/L $CaCO_3$. Water with calcium carbonate content exceeding 100 ppm is considered alkaline. In comparison, water with a content below 100 ppm is categorized as soft water or has moderate alkalinity. In general, environments that support fish life tend to have alkalinities above 20 ppm, which provides chemical stability and supports important biological processes such as phytoplankton growth and fish health (Tumwesigye et al., 2022).

Table 2. Results of Alkalinity Calculation at the Mouth of the Panimbangan River

Sample	The volume of experiments to-		Average volume (mL)	Alkalinity (ppm)
	1	2		
1	0.5	0.5	0.5	534.689
2	0.2	0.3	0.25	267.344
3	0.3	0.3	0.3	320.813
4	0.4	0.4	0.4	427.751
5	0.4	0.3	0.35	374.282
			Average alkalinity	*384.976*

Tanjung Lesung swamp water for alkalinity analysis was sampled at five locations, at depths of 50-100 cm. From the five sampling points, different alkalinities were obtained, for the alkalinity of swamp water taken from the right edge, namely samples 2 and 3, had an alkalinity of 267.344 mg/L $CaCO_3$ and 320.813 mg/L $CaCO_3$, and the right edge of the swamp, namely samples 1, 4, and 5 had an alkalinity of 534.689 mg/L $CaCO_3$, 427.751 mg/L $CaCO_3$, and 374.282 mg/L $CaCO_3$. It can be seen that the right bank of the swamp is more alkaline. This is due to the many fishing boats on that side, and also a gas filling station. So that the average alkalinity of Tanjung Lesung swamp water is 384.976 mg/L $CaCO_3$. The alkalinity value of Tanjung Lesung swamp waters is in the range between 30-500 mg/L $CaCO_3$, so it can still be said to be safe for the survival of aquatic organisms such as fish.

Conclusion

Based on the experimental results, the water quality in the Panimbang River Estuary exhibits several important characteristics. The water's pH is 4.50 to 6.49, indicating it is slightly acidic and below the standards set by Government Regulation Number 22 of 2021 (pH 6-9). The relatively high water temperature is likely due to sampling during the day. The dissolved oxygen (DO) levels measured ranged from 2.15 to 3.81 ppm, well below the permissible threshold of 5-6 ppm, indicating poor aeration quality. The value of the electrical acidity degree (TSS) tends to be constant, so it shows no

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significant difference in the number of dissolved inorganic ions in the sample. Meanwhile, the water's alkalinity, at an average of 384.976 mg/L $CaCO_3$, remains within the safe range, 30-500 mg/L $CaCO_3$. The water quality in the Panimbang River Estuary indicates environmental pressure from anthropogenic activities, resulting in slightly acidic water with low aeration and high solute content. However, adequate alkalinity still helps maintain the water's pH stability. This condition indicates the need for more intensive monitoring and waste management to protect estuarine ecosystems, which are vital to the community and the surrounding environment.

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