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Physicochemical Conditions of the Cidamar River Estuary in the Rainy Season with Management Implications.

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Abstract
The Cidamar River estuary is one of the major estuarine systems in Cianjur Regency, West Java, and is widely utilized by surrounding communities to support various activities such as agriculture, plantations, livestock farming, and daily domestic uses. This study aimed to analyze the physicochemical characteristics of the waters during the rainy season in the Cidamar River estuary, Cianjur Regency. The research was conducted from January to March 2022, which corresponds to the rainy season period. Water samples were collected from two sampling stations with an approximate distance of 1.5 km between sites. Physicochemical parameters were measured in situ using a Water Quality Recorder (LUTRON WAC-2019SD). The obtained data were analyzed and compared with established water quality standards. The results indicated that all twelve physicochemical parameters exhibited monthly variations. Several parameters, such as dissolved oxygen, were found to comply with the applicable water quality standards. Variations in the measured parameters were influenced by factors including seasonal conditions, sampling time, and anthropogenic activities around the study area. The findings of this study provide baseline information for the environmental management of the Cidamar River estuary to maintain water quality and ensure its sustainable use by local communities.

Keywords: Cidamar, Physicochemical Water Properties, Rainy Season, River Estuary

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Introduction

Government policies related to aquatic environmental management are largely formulated based on the results of water quality monitoring. This process represents a crucial step, as it provides a scientific basis for determining appropriate follow-up actions. Through systematic monitoring, the government seeks to assess whether aquatic environments remain within acceptable environmental standards or have experienced degradation. When pollution occurs, it is often associated with economic activities such as aquaculture and tourism, as well as the input of pollutants transported from terrestrial areas or upstream regions through river flow (Saraswati et al., 2017).

Aquatic environments consist of interconnected physical, biological, and chemical components, each comprising specific parameters. According to Lopez et al. (2018), physical and chemical factors of water bodies significantly influence various aquatic organisms, including periphyton communities, which serve as biological indicators of river water pollution. These communities include groups such as Oscillatoria, Ulothrix, and Gyrasima.

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Physicochemical parameters, including dissolved oxygen (DO), water pH, temperature, concentrations of dissolved ions, total organic matter, and other related indicators, play a critical role in shaping the survival and distribution of aquatic organisms (Pennack, 1970). These parameters are strongly affected by land-use patterns and the intensity of human activities surrounding aquatic systems.

The rainy season represents a period during which water quality parameters often differ markedly from those observed during the dry season. Risuana et al. (2017) reported that the rainy season is characterized by pronounced changes in total suspended solids (TSS). In addition, water temperature is a key parameter distinguishing rainy and dry seasons. Costa et al. (2016) noted that seasonal temperature variations differ across years and subsequently influence aquatic organisms. Consequently, other environmental parameters may also exhibit seasonal variability.

The Cidamar River is one of the rivers located in Cianjur Regency, West Java, and exhibits unique environmental characteristics. Previous studies have indicated that the downstream section of the river is characterized by relatively dense human settlements, the presence of local sand mining activities, and prolonged discontinuity between seawater and freshwater mixing. The interaction between natural factors and anthropogenic pressures makes this river system particularly important for further scientific investigation.

To date, studies specifically addressing the physicochemical characteristics of the Cidamar River estuary during the rainy season remain limited. Previous research by Paujiah et al. (2013) examined the water characteristics of the Cisadea River, which is located near the Cidamar River, and reported that the Cisadea River exhibited distinct characteristics in relation to established water quality standards. Further research by the same author (Paujiah et al., 2019) explored the relationship between aquatic environmental characteristics and resident organisms, revealing a significant association between fish assemblages and the physicochemical conditions of the water. These findings indicate that water quality conditions play an essential role in influencing aquatic biota.

Material and Methods

This study was conducted over a three-month period in 2022, specifically during January, February, and March, which coincided with the rainy season. The timing of sample collection was carefully determined by considering field weather conditions to minimize potential risks, such as flash flooding during the rainy season, thereby ensuring optimal sample acquisition. The research was carried out in the Cidamar River estuary (Figure 1), which served as the primary data source. Sampling locations were selected based on general estuarine characteristics. Each river section with distinct environmental features was represented by a single sampling station, resulting in a total of two sampling points. One sampling station was located in an area influenced by the mixing of seawater and freshwater. The measured variables included a range of physical and chemical water quality parameters, as presented in Table 1.

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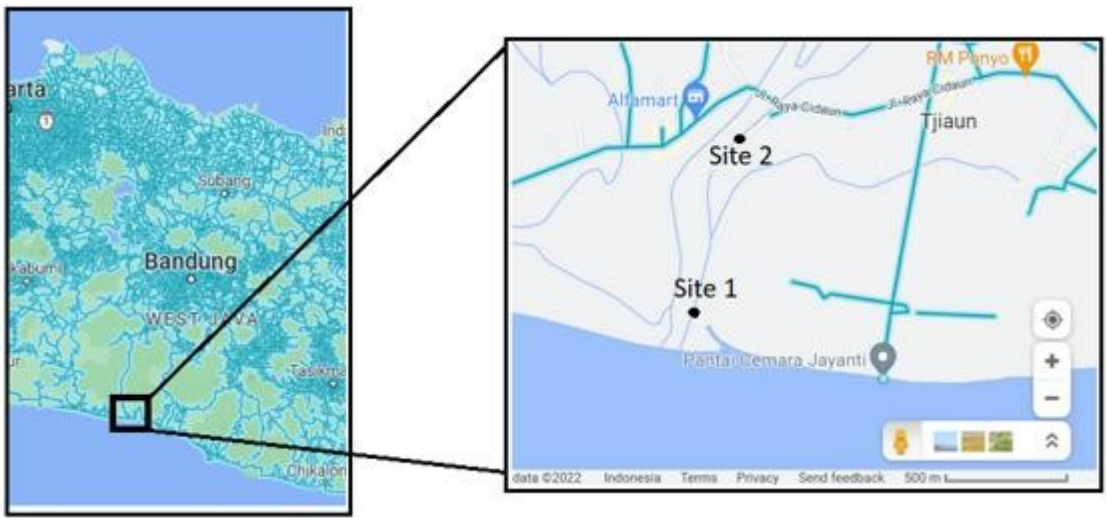

Figure 1. Map of the study area in the Cidamar River, Cianjur Regency, West Java

Table 1. Physicochemical water quality parameters observed at the Cidamar River estuary

Parameters	Unit	Tools	Methods
Physics			
Temperature	°C	Water Quality Recorder LUTRON WAC-2019SD	*Insitu*
Konduktivity	µS/cm	Water Quality Recorder LUTRON WAC-2019SD	*Insitu*
TDS	ppm	Water Quality Recorder LUTRON WAC-2019SD	*Insitu*
Hardness	ppm	Water Quality Recorder LUTRON WAC-2019SD	*Insitu*
Resistance	Ω/ohm	Water Quality Recorder LUTRON WAC-2019SD	*Insitu*
Depth	cm	Meteran	*Insitu*
Current Water	m/s	Current meter	*Insitu*
Chemical			
pH	unit	Water Quality Recorder LUTRON WAC-2019SD	*Insitu*
DO	mg/L	Water Quality Recorder LUTRON WAC-2019SD	*Insitu*
Oxigen (O2)		Water Quality Recorder LUTRON WAC-2019SD	*Insitu*
ORP	mV	Water Quality Recorder LUTRON WAC-2019SD	*Insitu*
Salinity	ppt	Water Quality Recorder LUTRON WAC-2019SD	*Insitu*

Data obtained from in situ measurements were further processed and analyzed to describe the physicochemical conditions of the study area. The analytical results were then compared with established water quality standards for waters intended for consumption, in order to evaluate the suitability of the estuarine environment. This comparison was conducted to identify whether the measured parameters complied with acceptable threshold values or indicated potential environmental concerns. All analyzed data were systematically organized

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through tabulation to facilitate interpretation and comparison among sampling locations and observation periods. The tabulated results were subsequently presented in the form of tables, providing a clear and comprehensive overview of the spatial and temporal variations in physicochemical water quality parameters at the Cidamar River estuary.

Result

The Cidamar River estuary is located in Cidaun District, Cianjur Regency, West Java. The surrounding area of the estuary is characterized by various human activities, including agriculture, plantation activities, and other domestic activities associated with local communities. The environmental conditions around the estuary are illustrated in Figures 2, 3, and 4.

Figure 2. Agricultural activities surrounding the Cidamar River estuary

Figure 3. Plantation activities surrounding the Cidamar River estuary

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Figure 4. Residential activities surrounding the Cidamar River estuary

Physicochemical Parameter Values of the Cidamar River

The observational data on the physicochemical characteristics of the Cidamar River estuary are presented in Table 2. The results indicate that sampling time influenced the values of the measured water quality parameters. Based on the data shown in the table, the measured parameters exhibited variations across the observation months, indicating noticeable monthly fluctuations. These variations suggest that temporal factors play an important role in influencing the physicochemical parameters measured in the estuarine waters.

Seasonal dynamics during the rainy period may contribute to changes in water input, sediment transport, and dilution processes, which in turn affect water quality parameters. Variations in rainfall intensity and river discharge can modify the concentration of suspended materials and dissolved substances. Therefore, the observed fluctuations reflect the dynamic nature of estuarine environments during the rainy season.

Table 2. Physicochemical characteristics of the Cidamar River estuary

Parameter	January	February	March	Baku Mutu Air (Fisheries)
Physics				
Temperature (^{0}C)	26.1	27.3	34.3	±3 air temperatur (Kulla *et al.,* 2020)
Conductivity (mS)	0.660	0.0612	3.46	-
TDS (ppm)	437	402	226	Max 1000 mg/L (Risuana *et al.,* 2017)
Hardness (ppm)	338	305	166	500 mg CaCO3/L (PERMENKES No. 492, 2010)
Resistance (Ω/ohm)	1.570.000	1631.9	296.66	-
Kedalaman (cm)	14	41,3	15	-

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Current water (m/s)	04.02	1.68	3.49	-
Chemycal				
ORP (oxidation-reduce potential) (mV)	-140	-125	69	~250 mV (Nghi *et al.,* 2018)
pH	8.92	9.26	8.6	Class of II nad III (Abdul Maulud et al. (2021)
DO (mg/L)	13	16,2	7.9	Class of I and II (Abdul Maulud et al. (2021)
O^2	40	38.6	22.2	-
Salt (^{0}/00)	0.03	0.032	0.17	Freshwater (<5 ppm)

Discussion

Anthropogenic activities occurring in the estuarine area, such as plantation operations, agricultural practices, and domestic activities originating from nearby settlements, have the potential to influence the surrounding water bodies. Eddy et al. (2015) reported that plantation and agricultural activities have contributed to the loss of mangrove forests in Indonesia. In relation to aquatic environments, previous studies have demonstrated that anthropogenic pressures can significantly reduce water quality, as indicated by elevated concentrations of heavy metals in water bodies (Syawal et al., 2016). These conditions may alter the physicochemical balance of estuarine waters, including changes in nutrient concentrations and sediment loads. The degradation of mangrove ecosystems further reduces the natural filtering capacity of estuaries, thereby increasing the vulnerability of water bodies to pollution. Consequently, sustained anthropogenic pressure may compromise the ecological function of estuarine systems as transitional zones between terrestrial and marine environments.

Other researchers have also reported that the presence of residential areas adjacent to water bodies, along with extensive agricultural land surrounding river estuaries, leads to increased quantities of waste entering aquatic systems (Fransisca, 2011). Therefore, anthropogenic activities in the vicinity of the Cidamar River estuary are likely to affect water quality, which may subsequently influence the aquatic organisms inhabiting the estuarine environment. Excessive inputs of organic and inorganic waste can increase turbidity and nutrient levels, potentially triggering eutrophication processes. Such conditions may reduce dissolved oxygen availability and disrupt the habitat suitability for sensitive aquatic species. Over time, these impacts can alter species composition and reduce overall biodiversity within the estuarine ecosystem.

The observed fluctuations in each parameter are likely associated with high rainfall intensity during the rainy season, which increases nutrient inputs transported through river runoff. Wang et al. (2019) reported that nitrogen content is the primary factor affecting water quality during the rainy season, whereas phosphorus plays a more dominant role during the dry season. Similarly, Chen et al. (2021) found that river water quality indices during the dry season were lower than those observed during the rainy season, primarily due to factors such as dam construction, land-use patterns, and unstable hydrodynamic conditions. Based on the present findings, it is not yet possible to conclude whether water quality in the Cidamar River estuary during the rainy season is better or worse than during the dry season. Therefore, further studies encompassing both seasonal periods are required to comprehensively assess the water quality dynamics of the Cidamar River estuary.

Strong interrelationships were observed among several physicochemical parameters measured in this study. For instance, physical parameters such as water temperature,

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conductivity, and total dissolved solids (TDS) exhibited close associations. Water temperature is a critical factor in aquatic systems, as it directly influences the physiological processes and survival of aquatic organisms. Temperature has been reported to play a key role in regulating seasonal reproduction in certain fish groups (Taylor, 2019). The results of this study indicate that water temperature values remained within a normal range and were suitable for supporting aquatic life. Monthly variations in temperature may be influenced by seasonal conditions (Gunes, 2022), as well as by sampling time and water depth. In this study, water sampling in January and February was conducted in the morning (07:00 WIB), whereas sampling in March was carried out at midday (11:00 WIB), which may explain the observed temperature differences.

Conductivity and TDS values in aquatic systems are closely related to the concentration of dissolved ions, including Fe^{2+} (Nicola, 2015). In addition, TDS is associated with the presence of suspended and dissolved particles in water bodies (Risuana et al., 2017), where higher TDS values can influence water color and clarity (Rahadi et al., 2020). The results showed that both conductivity and TDS values varied among the sampling months. The lowest conductivity value was recorded in January, while the highest value occurred in March. In contrast, TDS values exhibited an opposite trend, with the lowest value observed in March and the highest in January. This inverse relationship suggests that higher conductivity was associated with lower TDS values in this study. According to the Regulation of the Minister of Health of the Republic of Indonesia No. 416/MENKES/PER/IX/1990 (September 3, 1990), the maximum allowable TDS concentration in water bodies is 1,000 mg/L. Based on this standard, the TDS values measured in the Cidamar River estuary remained within acceptable limits for clean water quality. However, elevated concentrations of total suspended solids in aquatic systems can reduce dissolved oxygen levels due to decreased photosynthetic activity of both micro- and macrophytes (Bilotta & Brazier, 2008).

The chemical parameters measured during the study also showed monthly variability. One example is pH, which exhibited fluctuations throughout the observation period. pH is a critical indicator of water quality status, as aquatic organisms can only survive within specific pH ranges. Furthermore, pH affects the solubility and availability of nutrients required by aquatic organisms (Abdul Maulud et al., 2021). The results indicated that pH values during the rainy season in the Cidamar River estuary ranged from 8.6 to 9.26. These values suggest that the water pH conditions remained suitable for sustaining aquatic life within the estuarine environment.

Management Recommendations Based on Physicochemical Water Parameters

The findings of this study provide an overview of the environmental conditions of the Cidamar River estuary and may serve as baseline data for estuarine management by relevant stakeholders. In addition, the generated data can be utilized as reference information for further studies on aquatic organisms inhabiting the estuary, particularly fish communities as key biological components of the estuarine ecosystem. The results indicate that the physicochemical water quality of the Cidamar River estuary remains within acceptable environmental standards. Based on these findings, it is recommended that estuarine management efforts focus on maintaining current water quality conditions through the implementation of appropriate environmental regulations. Such measures may include controlling and limiting anthropogenic activities around the estuary, especially those related to agriculture, plantations, and domestic waste disposal. Continuous monitoring of physicochemical parameters is also essential to detect early changes in water quality and to support sustainable management of the Cidamar River estuary.

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Conclusion

Human activities surrounding the Cidamar River estuary include plantation, agricultural, and domestic activities associated with local communities. The physicochemical characteristics of the estuarine waters indicate that water quality values remain within acceptable standards for fisheries-related activities. Monthly variations were observed in all measured parameters, suggesting the influence of temporal factors on water quality dynamics. These findings highlight the need for further investigations conducted across different seasons to better understand variations in estuarine water conditions. In addition, future studies should focus on assessing the impacts of anthropogenic activities on water quality in order to identify appropriate environmental management strategies for the Cidamar River estuary in Cianjur Regency, West Java.

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