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Distribution of physicochemical in the coastal waters of Sembilang National Park, Banyuasin Regency, South Sumatra, Indonesia

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ABSTRACT

Sembilang National Park (SNP) is a large mangrove area and plays an important role in Indonesia, where it has important economic value, especially fisheries resources, a route for protected types of marine biota, and a potential fishing area. Good water quality conditions can optimize the function of the SNP area as an ecosystem for various existing biological resources. The aimed of study was to analyze the relationship between physical and chemical parameters in the inner and outer zones of the mangrove ecosystem. Data was collected directly in situ such as DO, pH, salinity, nitrate, and phosphate. Analysis of the distribution of physical and chemical water data was using Surfer 9 software. Analysis of the relationship between physical and chemical parameters using Principal Component Analysis (PCA). The results showed that the water quality in SNP was still in good condition for biota growth, however, nitrate and phosphate showed high values at 4.32-6.52 mg/land 0.12-0.19 mg/L. Principal Component Analysis (PCA) showed that the estuary zone was characterized by nitrate and phosphate parameters, while the outer estuary zone was characterized by DO, pH, and salinity parameters. The dynamics of the physicochemical parameters of the waters in the SNP area are generally in good condition, except for nitrate and phosphate, which are indicated to cause eutrophication.

Keywords: estuary, fisheries, mangrove ecosystem, Sembilang National Park, waters parameters

INTRODUCTION

Sembilang National Park (SNP) on the Banyuasin Coast is a mangrove conservation area that plays a crucial role in maintaining ecosystem function and services, particularly as a provider of natural resources. SNP is also rich in fishery resources (Agustriani et al., 2020; Fauziyah et al., 2012, 2018, 2022) and has significant economic value (Agustriani et al., 2023). The SNP area also serves as a pathway for protected marine species (Fauziyah & Nurhayati et al., 2019)(Fauziyah & Purwiyanto et al., 2019) and is a potential fishing ground (Rozirwan et al., 2022). SNP has numerous tributaries, both large and small, including the Banyuasin River, Sembilang River, Benawang River, and canals within these rivers (BSNP, 2020). These conditions will affect the aquatic environment through hydrological systems, physicochemical processes, food webs, and biogeochemical cycles (El-Naggar et al., 2019) (Miró et al., 2020).

Aquatic ecology and the distribution of biodiversity are strongly influenced by water quality factors, including temperature, dissolved oxygen, salinity, pH, nitrate, and phosphate. Observations in the Banyuasin region indicate that water quality parameters in Tanjung Api-Api are still within the appropriate range to support aquatic life, both as feeding areas and as habitats for various stages of their life cycles (Rozirwan et al., 2023). However, research (Rozirwan et al., 2022) indicates high nitrate and phosphate levels. Along the Banyuasin coast, there is an extensive mangrove ecosystem, which has a high capacity to absorb and neutralize nutrient pollutants from the surrounding environment (Purwiyanto & Agustriani, 2014). However, high nutrient concentrations can trigger nutrient enrichment. Nutrient concentration is a common metric for coastal ecosystem trophic levels (Balogun et al., 2015). Eutrophication is often accompanied by harmful algal blooms and causes various damages to aquatic life, even under hypoxic conditions in bottom waters, resulting in extreme losses of benthic biodiversity (Ansari & GIll, 2014).

Activities along river flows also determine the dynamics of the distribution of physical and chemical parameters in the water. Human activities and rapid climate variability will drive changes in coastal ecosystems and global economic growth (Cloern et al., 2016). These activities will also impact the Sembilang National Park (SNP) conservation area. Continuous information and monitoring of water conditions are crucial for maintaining the sustainable function of the mangrove ecosystem. The objective of this research was to analyze the distribution of physical and chemical parameters in the Sembilang National Park waters as an effort to monitor environmental quality, and to determine the relationship between physical and chemical parameters in the estuarine and outer estuarine zones of the mangrove ecosystem.

MATERIALS AND METHODS

Preparation

This research was conducted in October 2020 in the waters of Sembilang National Park, geographically located at 104°11'-104°57' East Longitude and 01°38'-02°28' South Latitude. Observation stations consisted of 28 stations in mangrove areas such as the Banyuasin River Estuary, Sembilang River Estuary, and Alang Gantang waters (Figure 1). In the Banyuasin River area, there is activity of Tanjung Api-api International Port which borders Sembilang National Park. Sembilang River is a special zone and residential area, while Alang Gantang waters were a mangrove area.

Implementation

Environmental parameters measured included salinity, current velocity, dissolved oxygen, nitrate, and phosphate, all measured in situ. Temperature was measured using a digital thermometer, salinity using a refractometer, current velocity using a current meter, dissolved oxygen using a DO meter (Hannah H198194), and nitrate and phosphate using a spectrophotometer.

Data Analysis

The spatial distribution of physicochemical water in the SNP was analyzed using Surfer 9 software. The relationship between physicochemical parameters was analyzed using Principal Component Analysis (PCA) in XLSTAT 2021 software.

Figure 1. Research location

RESULTS

Water parameters play a crucial role in indicating the condition of coastal ecosystems. Changes in water conditions could significantly impact coastal ecosystem health, including the presence and survival of biota. Research results indicate that water quality in SNP was based on temperature, dissolved oxygen, pH, salinity, nitrate, and phosphate. Water quality values in SNP ranged from 28.50 to 30.72°C (temperature), 4.12 to 8.58 mg/L (dissolved oxygen), 7.05 to 8.34 (pH), 5 to 28 ppt (salinity), 4.32 to 6.52 mg/L (nitrate), and 0.12 to 0.19 mg/L (phosphate) (Table 1). The spatial distribution of water parameters in SNP shows variations between nearshore and offshore waters (Figure 2).

The Temperature Distribution Pattern (Figure 2a) showed that although the range was narrow, the estuary area tends to be cooler and the open sea tends to be warmer, or vice versa depending on the sampling time, but the gradient was not as strong as Salinity or DO. The Distribution Pattern of Salinity (ppt), DO (mg/L), pH (Figure 2b, c and d) shows a clear gradient, with the lowest values being near the coast/estuary (Northwest area) and the highest values being in the open sea (Southeast area). The Distribution Pattern of Nitrate and Phosphate (Figure 2e & f) showed the opposite pattern to Salinity and DO. The highest values were found in the near-coastal area, especially around the mid-northern coordinates, indicating the presence of nutrient input from land (run-off or rivers/estuaries).

Principal Component Analysis (PCA) shows four groups of relationships between physical and chemical parameters of water on four axes with a cumulative eigenvalue of 91.87%. Group 1 consists of DO, salinity, and pH formed on the F1 axis, group 2 consists of nitrate and phosphate formed on the F2 axis, group 3 consists of current velocity formed on the F3 axis, and group 4 consists of temperature formed on the F4 axis. Based on Figure 3, the first group was formed on the positive F1 axis, depicted at stations 7, 9, 11, 12, 15, 17, 19, 28 by showing DO, pH, and salinity parameters. The second group formed on the positive F2 axis was depicted at stations 4, 14, and 21 by showing nitrate and phosphate parameters. Group three was formed on the F3 axis, depicted at stations 1, 2, 10, and 20 by showing current velocity parameters, and group four was formed on the positive F4 axis for temperature parameters but was not depicted at any station.

Table 1. Water parameter values in TNS

Parameters	Minimum	Maksimum	Averages	Std. Deviation	Quality Standards *)
Temperature (°C)	27.05	32.13	28.79	0.46	28-32
pH	6.10	8.80	7.04	0.39	7-8.5
Dissolved Oxygen (mg/L)	2.71	7.21	4.81	1.39	> 5
Salinity (‰)	3.70	28.50	19.36	4.57	< 34
Current Velocity (m/s)	0.06	0.36	0.20	0.15	0.015
Nitrate (mg/L)	6.52	6.52	5.61	0.64	0.06
Phosphate (mg/L)	0.12	0.19	0.16	0.02	0.015

Note: *Government Regulation of the Republic of Indonesia No. 22 of 2021

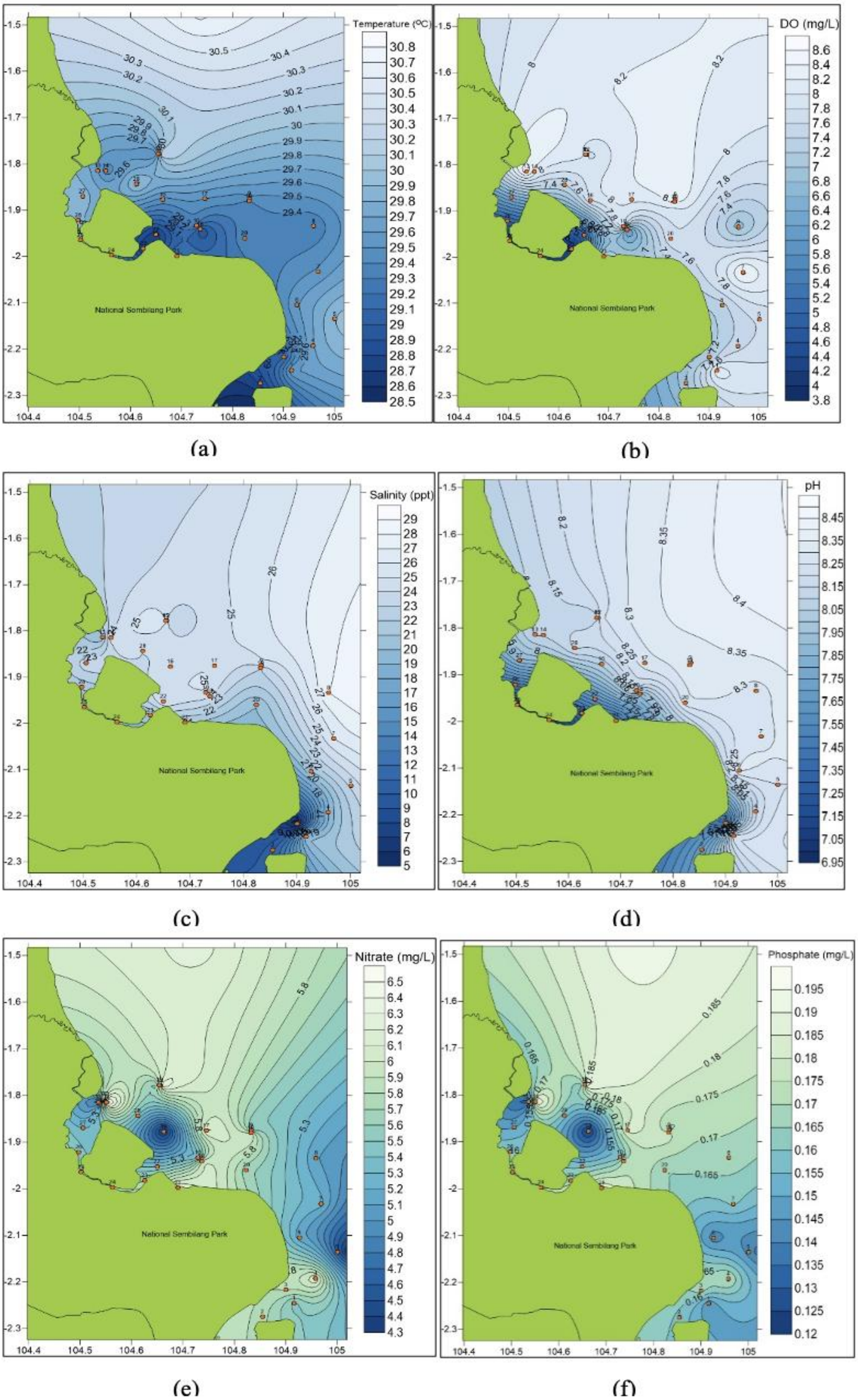

Figure 2. Distribution of water parameters in SNP: Temperature (a), Dissolved Oxygen (b), Salinity (c), pH (d), Nitrate (e), Phosphate (f)

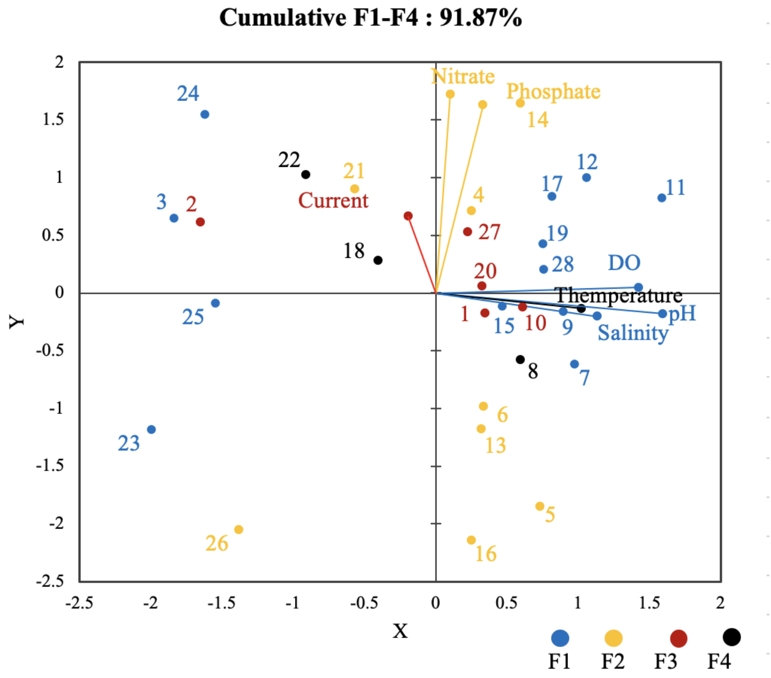

Figure 3. Relationship between physical and chemical parameters

DISCUSSION

Water quality in Sembilang National Park (SNP) is generally below seawater quality standards. However, nitrate and phosphate levels have exceeded the quality standards for marine biota stipulated in Government Regulation of the Republic of Indonesia Number 22 of 2021 concerning the Implementation of Environmental Protection and Management (Table 1). Temperature distribution in TNS does not show significant differences (Figure 2). The average temperature in SNP waters ranges from 28.5 to 30.7 °C, with varying temperature differences between waters close to land and the wider waters. Temperatures in estuaries are generally lower, increasing towards the wider waters. This can be explained by several factors, including rainfall and the intensity of sunlight reaching the water surface (Maniagasi et al., 2013). Water temperature is also influenced primarily by climatic conditions, the atmosphere, and sunlight entering the sea due to several factors such as spatial, temporal, and current dynamics (Supangat et al., 2015). Estuarine waters are lower because the intensity of light entering the water is absorbed by trees and land. Meanwhile, there are no barriers in the waters leading to the sea, so the intensity of light entering the water directly reflects the high temperature distribution. Sea surface temperatures in coastal waters generally range between 20 and 32 °C (Lønborg et al., 2021). Temperatures at the study site are within the typical temperature range for tropical Indonesia (Al Diana et al., 2020).

Oxygen plays a role in the decomposition of organic matter in water, sediment, and biological and chemical processes. Low DO levels are generally found in inner estuary areas. This is due to nighttime sampling conditions. In addition to sampling conditions, other factors also play a role, such as turbidity and the distribution of organic matter from domestic waste. Low DO levels can be caused by organic matter originating from domestic waste, including from residential areas (Sugianti & Astuti, 2018). In estuary areas, several residential areas also contribute to low DO levels in the water. Decreasing DO in rivers impacts biological processes and reduces benthic organism populations (Bu et al., 2021). However, in other waters, values remain within good water quality standards. Based on the quality standards of the Republic of Indonesia Government Regulation Number 22 of 2021, a value considered good for marine biota is >5 mg/L. The pH distribution in the SNP indicates that pH values remain within water quality standards, with a predominantly alkaline pH ranging from 7.05 to 8.34. High pH values were found in waters leading to the sea, while areas closer to land had lower pH values. This may be due to factors such as mangrove vegetation throughout the study area. Mangroves can lower water pH by retaining organic matter from litter and the mangroves themselves. The pH value in mangrove areas can be lower due to the high organic matter content (Simanjuntak, 2022).

There are several changes in salinity distribution in SNP waters. These changes are influenced by several factors, namely different sampling locations, namely in estuarine waters and marine waters. Salinity distribution is usually low towards estuarine waters, this may be caused by estuarine waters that still contain a mixture of seawater and river water. According to (Sembiring et al., 2012), the farther the waters from land, the higher the salinity. Furthermore, mangrove species are uniquely adapted to tolerate dynamic and physiologically stressful tidal environments, facing extreme conditions such as anoxic and liquid sediments, repeated tidal inundation, high salinity, and limited time for rooting and tree formation (Polidoro et al., 2010).

The distribution of phosphate in SNP waters ranges from 0.12-0.19 mg/L, with the phosphate category in these waters exceeding the water quality standard threshold value based on Government Regulation of the Republic of Indonesia Number 22 of 2021, which is 0.015 mg/L. Phosphate concentrations in water can be influenced by several factors, one of which is nutrient input from sediment or land carried by river flow. Nutrients entering the water also contribute to phosphate concentrations in the water. Furthermore, excess nutrients in the water can cause eutrophication (Adyasari et al., 2021), which can harm aquatic biota. One important trophic level affected by marine environmental pollution is phytoplankton, known as microscopic primary producers and the base of aquatic food webs (D'Costa et al., 2017). The presence of excessive phosphate can increase the production of microbes and phytoplankton (Sahoo et al., 2016) and is an important nutrient in photosynthesis and other metabolic processes in plants (Ibrahim, 2018). The distribution of nitrate in SNP nitrate waters ranges from 4.12 to 6.52 mg/L. The high and low concentrations of nitrate distribution in waters can be influenced by several factors, such as freshwater input (rivers), input from land, and various activities in upstream waters, including plantations and agriculture. According to (Oyatola et al., 2021), high nitrate levels of 3.20-6.98 mg/L are caused by the influx of nitrogen-rich floodwaters arising from nitrogen-containing fertilizers, household waste, municipal waste, animal waste used in agricultural fields, and naturally from atmospheric deposition and ammonia oxidation. High nitrate concentrations in waters can also be caused by the influx of domestic waste.

The main processes driving estuarine ecosystems are hydrodynamics (e.g., water circulation, mixing, and flushing), salinity regulation, sediment dynamics (e.g., sediment transport, deposition, and erosion), nutrient cycling and trophic transfer, and hydrological connectivity (e.g., longitudinal and lateral water exchange) (Chilton et al., 2021). Important indicators of ecosystem health depend on the concentration of physical and chemical parameters. Based on PCA analysis, it appears that DO, pH, and salinity characterize the outer zone of the estuary, while the outer zone is characterized by nitrate and phosphate. Based on the distribution of physical and chemical parameters, the waters in the SNP exhibit high organic nutrient values (nitrate and phosphate). This condition is influenced by human activities along the river flow, which produce organic material carried by the river flow. Continuous monitoring efforts are needed to maintain ecosystem health in conservation areas.

CONCLUSSION

Sembilang National Park (SNP) is unique and provides ecosystem functions and services. A healthy ecosystem is expected to support regional conservation. The dynamics of the physicochemical parameters of the waters in the SNP area are generally in good condition, except for nitrate and phosphate, which are indicated to cause eutrophication. PCA analysis shows that the physicochemical parameters of the waters in the estuary zone are influenced by nitrate and phosphate, while those outside the estuary are influenced by DO, salinity, and pH.

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