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Analysis of Nitrate, Nitrite, and Orthophosphate Content in the Waters of Lembar Bay

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ABSTRACT

Lembar Bay is a coastal ecosystem utilized for fisheries, port activities, aquaculture, and human settlements, making it vulnerable to changes in water quality due to natural and anthropogenic nutrient inputs. This study aimed to analyze nitrate, nitrite, and orthophosphate concentrations as indicators of water quality in Lembar Bay, West Lombok, Indonesia. A quantitative descriptive method was employed by collecting seawater samples from five sampling stations representing mangrove, open coastal, port, traditional aquaculture, and residential areas during March 2026. Water samples were analyzed for nitrate, nitrite, and orthophosphate concentrations, while water temperature, salinity, and pH were measured as supporting physicochemical parameters. The results showed that nitrate concentrations ranged from 0.02 to 0.07 mg/L, nitrite from 0.001 to 0.009 mg/L, and orthophosphate from 0.001 to 0.06 mg/L. Nitrate concentrations were relatively high compared with the marine water quality standard for aquatic biota, particularly in the mangrove area, indicating substantial nutrient inputs from organic matter decomposition and terrestrial runoff. In contrast, nitrite concentrations remained low, suggesting that nitrogen transformation processes were functioning efficiently, while orthophosphate concentrations reflected low to moderate trophic conditions that were still capable of supporting primary productivity. Overall, the water quality of Lembar Bay remains suitable for sustaining aquatic organisms. However, the elevated nitrate concentration highlights the need for continuous monitoring and effective nutrient management to prevent eutrophication and maintain the ecological sustainability of the coastal ecosystem.

INTRODUCTION

The waters of Lembar Bay constitute a coastal area located in the southwestern part of Lombok Island, West Nusa Tenggara. This bay is characterized as a semi-enclosed body of water with relatively calm oceanographic conditions, situated directly facing the Lombok Strait—a vital shipping lane (Nugroho *et al*., 2015). Consequently, the area is highly conducive to various activities, including fisheries, port operations, and the utilization of coastal resources.

Local communities utilize the fishery resources of Lembar Bay as a fishing ground for various aquatic organisms. The existing coastal and mangrove ecosystems support benthic organisms, mollusks, fish, and other biological resources that play a role in maintaining the productivity of the waters (Salahuddin *et al*., 2024). The oceanographic characteristics of Lembar Bay influence water mass circulation, nutrient distribution, and the dispersal of aquatic organisms (Sari *et al*., 2022).

As a coastal water area characterized by intensive port operations, capture fisheries, aquaculture, and human settlements, Lembar Bay is susceptible to changes in water quality resulting from the influx of various organic and inorganic substances originating from both land-based sources and marine activities (Nugroho *et al*., 2015). One of the important parameters to consider in water quality management is nutrient concentration, specifically nitrate (NO_3^-), nitrite (NO_2^-), and orthophosphate (PO_4^{3-}). According to Surya *et al*. (2024) these three elements are essential nutrients that play a role in supporting aquatic primary productivity through the growth of phytoplankton and other autotrophic organisms.

Nutrient inputs can originate from various sources, such as land runoff, household activities, port operations, aquaculture, and the decomposition of natural organic matter (Diniariwisan & Rahmadani, 2023). Patty *et al*. (2015) adding that elevated concentrations of nitrate, nitrite, and orthophosphate—exceeding biological requirements—can lead to eutrophication, a condition characterized by excessive nutrient enrichment in aquatic environments. The presence of these chemical compounds in the water has the potential to disrupt ecosystem balance and endanger the survival of marine organisms. Nevertheless, Paundanan & Hikmah (2025) stated that nitrate and nitrite levels are also important components of the inorganic nitrogen required for the metabolism of marine organisms. In short, maintaining the proper balance of nitrate, nitrite, and phosphate levels in the water plays a crucial role.

A study on nitrate, nitrite, and orthophosphate levels in Lembar Bay is essential to gain insight into water quality conditions and the ecosystem's fertility level. The research findings are expected to serve as a valuable source of scientific information for coastal environmental management, fisheries resource conservation, and sustainable coastal development planning in the Lembar Bay area.

METHODS

The method employed in this study is quantitative descriptive analysis (Surya *et al*., 2024). This research describes the levels of nitrate, nitrite, and orthophosphate, as well as water quality parameters such as temperature, pH, and salinity, in the waters of Lembar Bay—located within the Lembar and Sekotong Districts of West Lombok Regency. Sampling was conducted in March 2026. Data collection took place at five different stations, namely:

- Station 1 in the mangrove estuary area of Cemara Village, Lembar District
- Station 2 in the Cemara Beach area, directly facing the Lombok Strait
- Station 3 in the area near Lembar Port
- Station 4 in the area near traditional fishponds
- Station 5 in the area near settlements and a rest area, Central Sekotong

This study involved site surveys, the selection of sampling stations, water sample collection, and water sample analysis conducted at the Testing Laboratory of the Lombok Marine Aquaculture Center and the Analytical Chemistry Laboratory. Water samples were collected during clear weather between 09:00 and 12:00 WITA.

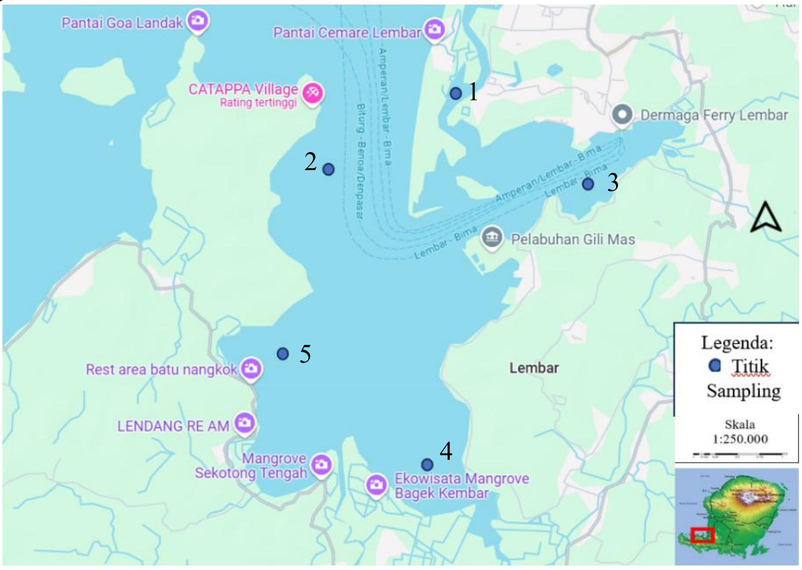

Figure 1. Research Location Map

RESULTS

Nitrate Content

The measured nitrate content in water samples from Lembar Bay is illustrated in the graph in Figure 2.

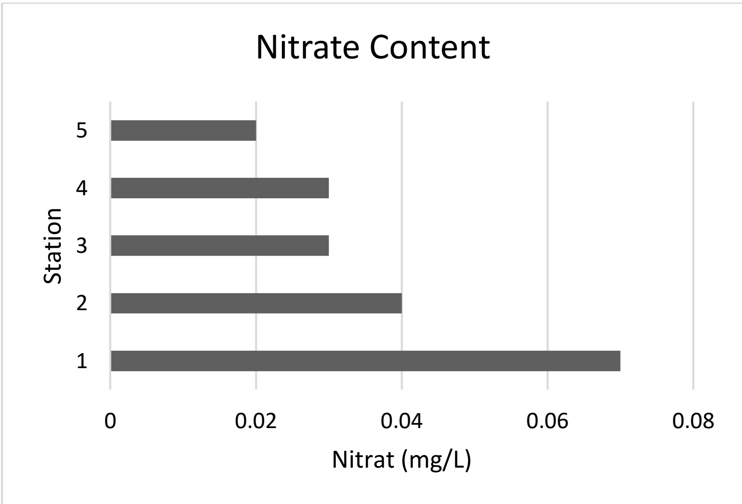

Figure 2. Nitrate Content in Lembar Bay

Nitrite Content

The measured nitrite content in water samples from Lembar Bay shows variable values. The graph is presented in Figure 3.

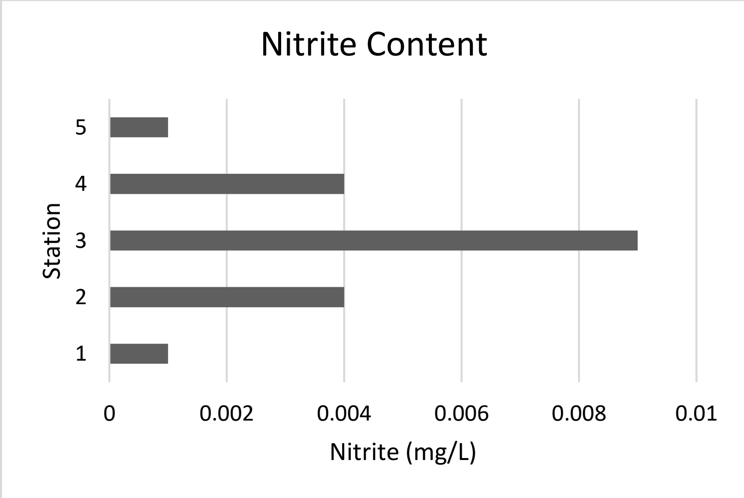

Figure 3. Nitrite Content in Lembar Bay

Orthophosphate Content

The orthophosphate content measured in water samples from Lembar Bay is presented in Figure 4.

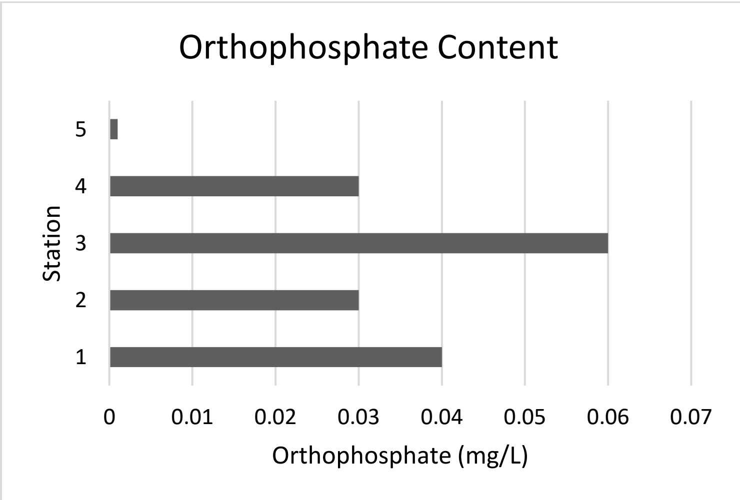

Figure 4. Orthophosphate Content in Lembar Bay

Other Physical Water Parameters

Other physical water parameters measured in this study include temperature, salinity, and pH. The measurement results are presented in Table 1 below.

Table 1. The Average of Water Physics Parameters

Parameters	Station					Quality Standard
	1	2	3	4	5	
Temperature (°C)	28	30	28.6	29.8	32	28-32 (Mudloifah & Purnomo, 2023)
Salinity (ppt)	30	30	35	35	33	30-35 (Diniariwisan & Sumsanto, 2024)
pH	8	7,8	6.7	6.5	6.6	6-8 (Diniariwisan & Sumsanto, 2024)

Based on water quality measurements at five observation stations, parameters such as temperature, salinity, and pH generally remained within the standard ranges that support aquatic life. The stability of these parameters indicates that the aquatic environment continues to provide suitable conditions for the growth of aquatic organisms, including phytoplankton—the primary producers. This relatively good water quality also suggests that, at the time of observation, environmental stress resulting from anthropogenic activities had not yet significantly altered these fundamental water quality parameters (Pratama & Rahmawati, 2025). Nevertheless, the comparatively lower pH values observed at certain stations warrant attention during long-term monitoring, as they could serve as an early indicator of an increasing organic matter load or shifts in biogeochemical processes within the water.

DISCUSSION

Nitrate Content

Nitrate (NO_3-N) is the primary form of nitrogen in natural waters. It plays a crucial role in protein synthesis for both animals and plants. High nitrate levels in water bodies can influence the growth and development of aquatic organisms, particularly when other nutrients are sufficiently available (Hamuna *et al*., 2018). The average nitrate concentration measured at each research station in Lembar Bay ranged from 0.02 to 0.07 mg/L. While this level is considered high for marine biota, it remains within an acceptable range for waters designated for recreation or marine tourism. The elevated nitrate levels are likely attributable to nutrient influx resulting from anthropogenic activities (Triawan *et al*., 2023) especially around Lembar Bay. This also refers to the quality standards or specific thresholds stipulated in the environmental regulations under Government Regulation No. 22 of 2021, which set the maximum NO_3-N concentration for marine biota at 0.008 mg/L, while the limit for recreational or marine tourism activities is 0.06 mg/L.

The tendency for high nitrate levels in the waters of Lembar Bay can be influenced by various factors, stemming from both natural processes and human (anthropogenic) activities. According to Nurjumanis *et al*. (2024), nitrate (NO_3-N) is the primary form of nitrogen in natural waters and a vital nutrient for the growth of plants and algae. Nitrate nitrogen is highly water-soluble and stable. Station 1, a mangrove area, exhibited the highest nitrate levels among all the observation stations. This is attributed to several factors, such as the accumulation of leaf litter and significant decomposition processes; furthermore, mangrove ecosystems with muddy sediments are capable of storing substantial nutrient reserves, including nitrates. Nutrient runoff from the land can also contribute to the high nitrate concentrations in the water (Salsabilla *et al.*, 2023).

As a coastal area serving as a hub for port activities, fisheries, aquaculture, and human settlements, Lembar Bay receives significant inputs of organic matter and nutrients. According to Kusumawati *et al*. (2024) domestic waste from residential areas, leftover feed and feces from aquaculture activities, rainwater runoff carrying fertilizers from agricultural land, and the decomposition of dead organisms are the primary sources of nitrogen, which subsequently undergoes mineralization and nitrification processes to become nitrate.

From an ecological perspective, the presence of nitrates in sufficient quantities has a positive impact on aquatic ecosystems. Nitrate is a key nutrient required by phytoplankton for photosynthesis and growth (Paiki & Kalor, 2017). Adequate nitrate availability can enhance aquatic primary productivity, resulting in higher phytoplankton biomass. This condition supports the aquatic food chain, as phytoplankton are primary producers serving as a food source for zooplankton, fish, and other aquatic organisms (Juliasih *et al*., 2017). Thus, a good level of aquatic productivity can enhance fishery resource potential and support both capture fisheries and aquaculture activities.

However, if the nitrate concentration exceeds the needs of aquatic organisms, it can cause various negative impacts on the ecosystem (Malagó *et al*., 2019). Excessively high nitrate levels can trigger eutrophication—an excessive increase in aquatic fertility characterized by the uncontrolled growth of phytoplankton or algae (algal blooms) (Diniariwisan & Rahmadani, 2023, 2024). Algal blooms can cause water to become turbid, thereby reducing sunlight penetration into the water column and disrupting the photosynthesis of other organisms. When algae die and decompose, the process consumes large amounts of dissolved oxygen, potentially leading to hypoxic (oxygen-deficient) or even anoxic (oxygen-depleted) conditions. Consequently, various aquatic organisms—such as fish, shrimp, and benthic biota—may experience stress, be forced to migrate, or suffer mass mortality.

In addition, high nitrate levels can alter the community structure of aquatic organisms and degrade the quality of the coastal environment (Saccon *et al*., 2013). In the long term, this condition has the potential to disrupt the ecosystem balance, reduce fishery productivity, and diminish the economic and ecological value of the Lembar Bay area. Therefore, periodic monitoring of nitrate levels is crucial for assessing water fertility and preventing environmental degradation caused by excessive nutrient accumulation. With proper management, the presence of nitrates can benefit aquatic productivity without negatively impacting the sustainability of the Lembar Bay ecosystem.

Nitrite Content

Nitrite (NO_2^-) concentrations of 0.001–0.009 mg/L in marine waters are generally considered low to normal, indicating that the waters have not yet undergone severe nitrogen pollution. Nitrite is an intermediate compound in the nitrogen cycle, formed during the oxidation of ammonia to nitrate via nitrification. Due to its instability, nitrite is typically found in lower concentrations than nitrate (Surya *et al*., 2024). In marine waters with good water circulation and dissolved oxygen levels, nitrite is rapidly oxidized to nitrate, keeping its concentration low.

The low nitrite content indicates that the processes of organic matter decomposition and nitrogen transformation in the water are proceeding normally. This condition also demonstrates that the water body retains the capacity for natural self-purification, thereby minimizing the accumulation of toxic nitrogen compounds (Paundanan & Hikmah, 2025). In other words, waters with a nitrite content of 0.001–0.009 mg/L can generally be categorized as having relatively good nitrogen quality, especially when supported by other water quality parameters that also fall within normal ranges.

In terms of impact, the presence of nitrite at low concentrations has a relatively minor effect on aquatic organisms. Nitrite is part of the nitrogen cycle and plays a role in supplying nutrients to the ecosystem. Low nitrite concentrations indicate that the nitrogen conversion process is proceeding effectively, thereby supporting natural aquatic productivity (Rejito, 2019). Furthermore, this condition indicates that the oxygen content in the water is likely still sufficient to support the activity of nitrifying bacteria, which convert nitrite into nitrate.

Orthophosphate Content

Orthophosphate (PO_4^{3-}) concentrations in marine waters ranging from 0.001 to 0.06 mg/L generally indicate conditions of low to moderate fertility. Orthophosphate is the form of dissolved inorganic phosphorus most readily utilized by phytoplankton, macroalgae, and aquatic plants to support growth and metabolic processes (Aziz *et al*., 2014). In marine ecosystems, phosphorus often acts as a limiting nutrient; consequently, its presence is a key determinant of the primary productivity of a body of water.

In the 0.001–0.02 mg/L range, waters can be categorized as having low to normal fertility (oligotrophic). This condition is typically found in relatively pristine marine waters with limited nutrient input. Meanwhile, orthophosphate levels in the 0.02–0.06 mg/L range indicate waters with moderate fertility (mesotrophic), capable of supporting phytoplankton growth and higher biological productivity (Diniariwisan *et al*., 2018). These values remain within a reasonable range for coastal waters receiving nutrient inputs from land, rivers, and surrounding human activities.

The presence of orthophosphate in marine waters can originate from various natural and anthropogenic sources (Kusumawati *et al*., 2024). Naturally, orthophosphate is produced through the weathering of phosphorus-bearing rocks, the decomposition of dead organisms, the excretion of aquatic biota, and the release of phosphate from bottom sediments (Aziz *et al*., 2014). In coastal areas such as Lembar Bay, orthophosphate levels can also be influenced by water mass mixing processes—specifically sediment resuspension caused by currents, waves, or vessel activity—which release phosphate from the sediment into the water column.

Meanwhile, anthropogenic sources of orthophosphate include domestic wastewater, household detergents, agricultural fertilizer runoff, aquaculture activities, industrial waste, and port operations (Muliari *et al*., 2024). The influx of phosphorus-rich organic matter into aquatic environments increases orthophosphate availability following decomposition by microorganisms. In coastal waters subject to high levels of human activity, elevated orthophosphate levels often serve as an indicator of anthropogenic pressure on the aquatic environment.

Based on the range of 0.001–0.06 mg/L, orthophosphate levels in the waters of Lembar Bay are categorized as low to moderate and generally remain conducive to aquatic ecosystem productivity. These values indicate sufficient phosphorus availability to support the growth of aquatic biota—particularly phytoplankton—yet periodic monitoring is necessary to ensure that increased phosphorus input from human activities does not lead to eutrophication and a decline in water quality.

CONCLUSION

Research results indicate that nutrient levels in the waters of Lembar Bay range from 0.02–0.07 mg/L for nitrate, 0.001–0.009 mg/L for nitrite, and 0.001–0.06 mg/L for orthophosphate. Nitrite and orthophosphate concentrations reflect waters of relatively good quality with low to moderate fertility levels capable of supporting primary productivity. Meanwhile, nitrate levels are considered relatively high relative to marine biota quality standards, indicating the influence of nutrient inputs from both anthropogenic activities and natural processes, particularly in mangrove areas. Although overall water quality remains suitable for supporting aquatic organisms, the high nitrate levels highlight the need for sustainable monitoring and management of nutrient inputs to prevent eutrophication and to safeguard the environmental quality and ecosystem sustainability of Lembar Bay.

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