Asian Journal of Aquatic Sciences, December 2025. Vol 8, Issue (3) 391-397
e-issn: 2716-4608
p-issn: 2655-366X

ASSESSMENT OF WATER QUALITY BASED ON NITRATE, PHOSPHATE, AND AMMONIA CONCENTRATIONS IN BURUK BAKUL VILLAGE, BENGKALIS, RIAU

Sefni Hendris[1,2*], Dessy Yoswaty[1], Irvina Nurrachmi[1], Nabila Afifah Azuga[1,2], Bella Billiant J Ananta Kambaren[1], Rianti Putri[1], Ardi Gustri Purbata[3]
[1]Department of Marine Science, Faculty of Fisheries and Marine, Universitas Riau, Pekanbaru, 28293 Indonesia
[2]Center for Peatland and Disaster Studies, LPPM Universitas Riau, Pekanbaru, 28293 Indonesia
[3]Department of Fisheries Socio-Economics, Faculty of Fisheries and Marine, Universitas Riau, Pekanbaru, 28293 Indonesia
*sefnihendris@lecturer.unri.ac.id

ABSTRACT

Coastal ecosystems are highly sensitive to nutrient enrichment, particularly from land-based activities and aquaculture effluents, which contribute to water quality degradation. This study evaluated the concentrations of nitrate, ammonia, and phosphate in the coastal waters of Buruk Bakul Village, Bengkalis, Riau Province, Indonesia. Water samples were collected from four representative stations in August 2025: a river estuary, a shrimp pond, a mangrove rehabilitation site, and a natural mangrove forest. The analysis was conducted using spectrophotometric methods in accordance with the Indonesian National Standards (SNI). Results indicated that nitrate concentrations ranged from 0.0822 to 0.1932 mg/L, ammonia from 0.5705 to 1.7338 mg/L, and phosphate from 0.0845 to 0.299 mg/L. All parameters exceeded the seawater quality standards for marine biota established by the Decree of the Minister of Environment No. 51/2004, indicating a significant anthropogenic influence. The river estuary recorded the highest nitrate and phosphate levels, reflecting inputs from land runoff and domestic waste, while ammonia peaked in the shrimp pond due to aquaculture discharge. Nutrient levels in mangrove-associated stations were lower but still above the threshold, indicating that mangrove ecosystems provide some capacity to retain and transform nutrients, although insufficient for full remediation. Elevated nutrient concentrations pose ecological risks, such as eutrophication and algal blooms, which may disrupt biodiversity and fisheries productivity. This study emphasizes the urgency of improving aquaculture waste management, reducing land-derived nutrient loading, and strengthening mangrove conservation and rehabilitation as integrated strategies to sustain coastal ecosystem health in Buruk Bakul and similar regions. These findings provide a baseline for nutrient management and coastal rehabilitation strategies in western Indonesian waters.

Keywords: Water Quality, Buruk Bakul, Coastal Ecosystem

1. INTRODUCTION

Coastal water quality is a key factor in maintaining the sustainability of marine ecosystems and the livelihoods of coastal communities that depend on fishery resources. Chemical parameters such as nitrate, phosphate, and ammonia are often used as indicators of water quality because

Received: 19 October 2025
Accepted: 16 December 2025

they are closely related to primary productivity, fertility, and the balance of aquatic ecosystems[1]. Excessive concentrations of these nutrients can trigger eutrophication, decrease dissolved oxygen levels, and ultimately disrupt the survival of aquatic biota[2]. Nitrate (NO_3^-) is the main form of inorganic nitrogen available to phytoplankton. The increase in nitrate in water generally comes from land runoff, agricultural activities, and domestic inputs[3].

Phosphate (PO_4^{3-}) plays an important role in the metabolism of aquatic organisms, but in excessive amounts, it can become a limiting factor that contributes to algal blooms[4]. Ammonia (NH_3), on the other hand, is toxic at high concentrations and can originate from organic waste or the decomposition of organic matter in the waters[5]. Therefore, monitoring these three parameters is essential to assess fertility status and potential pollution in coastal waters.

Buruk Bakul Village, located on the coast of Bengkalis Regency, Riau, is influenced by both anthropogenic activities and the natural dynamics of coastal ecosystems. This area is adjacent to mangrove forests and has relatively intensive capture fisheries and aquaculture activities[6]. Previous studies have shown that mangrove ecosystems around Bengkalis play an important role in nutrient cycles, with mangrove sediments storing significant reserves of carbon, nitrogen, and phosphorus. However, land use changes and human activity pressures may alter nutrient distribution, ultimately affecting water quality in region[7].

Several studies in Indonesia show an increasing trend of nutrient concentrations in coastal waters due to human activities. A study in the Malacca Strait revealed that increases in nitrate and phosphate are directly related to shipping activities and waste disposal[8]. In other coastal areas, ammonia levels were found to increase near settlements and aquaculture ponds[9]. This condition underscores the importance of local studies, given that the ecological dynamics and environmental pressures differ across coastal areas[10]. However, research on the influence of community activities on nutrient levels has not yet been conducted at this location.

Based on this background, this study aims to analyze water quality in Buruk Bakul Village based on nitrate, phosphate, and ammonia concentrations. The results of this study are expected to provide scientific information as a basis for sustainable water resource management and support efforts to mitigate potential coastal environmental degradation.

2. RESEARCH METHOD

Time and Place

This study was conducted in the coastal waters of Buruk Bakul Village, Bukit Batu Subdistrict, Bengkalis Regency, Riau, at four observation stations representing coastal environmental conditions. Station 1 was located at the river estuary, Station 2 in the shrimp pond area, Station 3 in the mangrove seedling area, and Station 4 in the relatively natural mangrove forest area. The coordinates of each station were determined and recorded using a Global Positioning System (GPS) device to ensure location consistency during replication. A map showing the positions of each observation station is shown in Figure 1, illustrating the distribution of sampling points in the coastal area of Buruk Bakul.

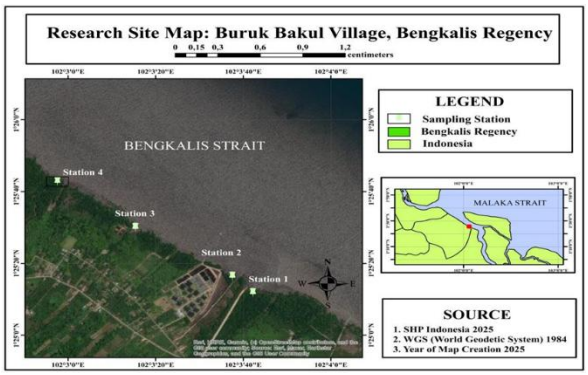

Figure 1. Research location map

In addition to the location map, visual documentation of field conditions at each station was conducted to provide a clear picture of the characteristics of the coastal

ecosystem in Buruk Bakul Village. Figure 2 shows photos of each observation station: Station 1 (river estuary), Station 2 (shrimp pond), Station 3 (mangrove rehabilitation), and Station 4 (mangrove forest). This documentation helps clarify environmental differences between stations that may influence nutrient concentrations in the waters.

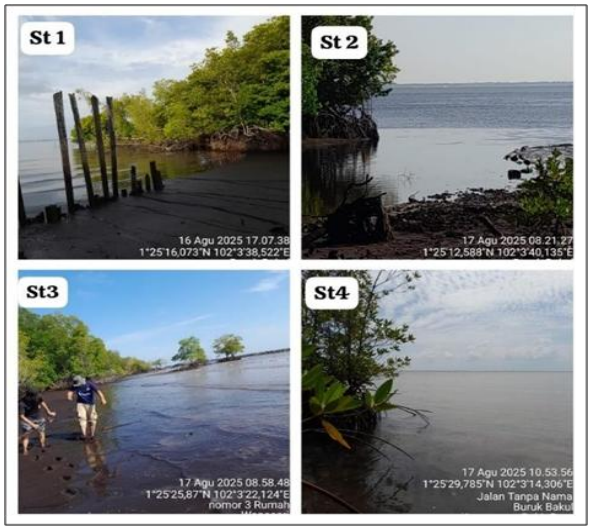

Figure 2. Station 1 (river estuary), Station 2 (shrimp pond), Station 3 (mangrove rehabilitation), Station 4 (mangrove forest)

Figure 3. Field sampling activities at the study site.

Procedures

Sample Collection

Water samples were taken according to SNI 6989.57 procedures using a water sampler at a depth of about 30 cm from the water surface[11]. Water samples were placed in clean 500 mL polyethylene bottles, labeled by station, and stored in a cool box at ±4°C to maintain quality until laboratory analysis (Figure 3).

In addition to chemical parameters, physical parameters were measured in situ. Water temperature was measured using a digital thermometer according to SNI 06-6989.23[12], while pH was measured with a calibrated pH meter in accordance with SNI 06-6989.11[11].

Data Analysis

Analysis of nitrate, ammonia, and phosphate concentrations was carried out using spectrophotometry methods in accordance with APHA standards[13]. Nitrate analysis was performed according to SNI 06-6989.79[14] using the cadmium (Cd) reduction column method, which reduces nitrate to nitrite, which then reacts with sulfanilamide and N-(1-naphthyl) ethylenediamine to produce a pink azo compound measured at 543 nm. Absorbance readings were taken at 543 nm[15].

Ammonia was analyzed based on SNI 06-6989.30[16] using the Nessler method, in which ammonium ions react with Nessler A and Nessler B reagents to form a yellow-brown complex proportional to the ammonia concentration, measured at a wavelength of 425 nm. Absorbance readings were taken at 425 nm[15].

Phosphate was determined using the SNI 06-6989.31[16] method, namely ammonium molybdate spectrophotometry. Phosphate in the sample reacts with ammonium molybdate and potassium antimony tartrate in an acidic environment, forming a phosphomolybdate complex, which is then reduced by ascorbic acid to produce a blue color at 880 nm. Absorbance readings were taken at 880 nm[13].

The measurement results of nitrate, ammonia, and phosphate concentrations from each station were determined using standard calibration curves. The obtained data were then compared with the seawater quality standard for marine biota, as outlined in the Decree of the state minister for the

Environment No. 51 of 2004[17]. The analysis was conducted descriptively, comparing results between stations and relating them to activities in the area. This can be seen in the high nitrate and ammonia concentrations in shrimp ponds, which may be associated with feed waste and metabolic residues, while high phosphate levels in mangrove areas may originate from the decomposition of mangrove leaf litter. With this descriptive approach, water quality conditions in Buruk Bakul Village can be comprehensively understood.

3. RESULT AND DISCUSSION

Water quality measurements were conducted at four stations representing different environmental conditions: the river estuary (Station 1), shrimp pond area (Station 2), mangrove rehabilitation area (Station 3), and natural mangrove forest area (Station 4). The observed chemical parameters included nitrate, ammonia, and phosphate concentrations. The results are presented in Table 1, and the distribution of concentrations among stations is visualized in Figure 1 to clarify comparisons between parameters.

The analysis showed that nitrate concentrations in Buruk Bakul waters ranged from 0.0822 to 0.1932 mg/L (Table 1). The highest value was found at Station 1 (Estuary) with 0.1932 mg/L, while the lowest was at Station 3 (mangrove rehabilitation) with 0.0822 mg/L. Station 2 (Shrimp Pond) recorded 0.1494 mg/L, and Station 4 (mangrove forest) recorded 0.1062 mg/L. All these values exceeded the marine biota quality standard of 0.06 mg/L[17] (Table 2).

Table 1. Nitrate, ammonia, and phosphate concentrations were measured at four stations in the waters of Buruk Bakul Village

Station	Nitrate (mg/L)	Ammonia (mg/L)	Phosphate (mg/L)
St 1 (Estuary)	0.1932	0.5705	0.2990
St 2 (Shrimp Pond)	0.1494	1.7338	0.0845
St 3 (Mangrove Rehabilitation)	0.0822	1.6440	0.0928
St 4 (Mangrove Forest)	0.1062	1.7062	0.0933

Table 2. Nitrate concentrations in the waters of Buruk Bakul Village, Bengkalis

Station	Nitrate (mg/L)	Standard (mg/L)[17]	Remarks
St 1 (Estuary)	0.1932	0.06	
St 2 (Shrimp Pond)	0.1494	0.06	Exceeds standard
St 3 (Mangrove Rehabilitation)	0.0822	0.06	
St 4 (Mangrove Forest)	0.1062	0.06	

The relatively high nitrate concentrations at all stations indicate nutrient input from land- based and fishery activities. The highest value at the estuary (Station 1) indicates the strong influence of river runoff, which carries domestic and agricultural waste into coastal waters[18]. At Station 2 (shrimp pond), the nitrate level (0.1494 mg/L) is likely from feed residues and excretion of cultured organisms, supporting findings that intensive aquaculture significantly contributes to nitrate enrichment in coastal waters[19].

Station 3 (mangrove rehabilitation) had lower concentrations (0.0822 mg/L), possibly due to the mangrove vegetation's absorption capacity during development[20]. Meanwhile, Station 4 (mangrove forest) reflected the more stable filtering role of established mangrove ecosystems, resulting in 0.1062 mg/L[21]. Ecologically, nitrate levels exceeding the threshold indicate a risk of eutrophication that, if uncontrolled, could trigger algal blooms, reduce dissolved oxygen, and disrupt marine ecosystems[20].

Ammonia concentrations ranged from 0.5705–1.7338 mg/L (Table 1). The highest

was at Station 2 (shrimp pond) with 1.7338 mg/L, followed by Station 4 (mangrove forest) with 1.7062 mg/L, and Station 3 (mangrove rehabilitation) with 1.644 mg/L. The lowest was at Station 1 (estuary) with 0.5705 mg/L (Table 3). All values exceeded the standard of 0.3 mg/L, indicating high pollutant loads. The highest level in the shrimp pond (Station 2) highlights the contribution of aquaculture activities, particularly uneaten feed, shrimp feces, and organic decomposition[22]. Stations 3 and 4 also showed high values, indicating that mangrove ecosystems function as nutrient sinks but still accumulate ammonia from litter decomposition and land-based inputs[23].

Table 3. Ammonia concentrations in the waters of Buruk Bakul Village, Bengkalis

Station	Ammonia (mg/L)	Standard (mg/L) [17]	Remarks
St 1 (Estuary)	0.5705	0.3	
St 2 (Shrimp Pond)	1.7338	0.3	Exceeds standard
St 3 (Mangrove Rehabilitation)	1.6440	0.3	
St 4 (Mangrove Forest)	1.7062	0.3	

At Station 1, the lower value may be due to river dilution, but still exceeds the standard. Elevated ammonia levels can negatively affect aquatic biota, especially fish and benthic organisms, by increasing toxicity risks and lowering water quality[24].

Phosphate concentrations ranged from 0.0845–0.299 mg/L (Table 1). The highest was at Station 1 (estuary) with 0.299 mg/L, while the lowest was at Station 2 (shrimp pond) with 0.0845 mg/L. Stations 3 and 4 recorded nearly similar values of 0.0928 mg/L and 0.0933 mg/L. Compared to the marine biota standard of 0.015 mg/L, all stations exceeded the threshold[9], as shown in Table 4.

Table 4. Phosphate concentrations in the waters of Buruk Bakul Village, Bengkalis

Station	Phosphate (mg/L)	Standard (mg/L) [17]	Remarks
St 1 (Estuary)	0.5705	0.3	
St 2 (Shrimp Pond)	1.7338	0.3	Exceeds standard
St 3 (Mangrove rehabilitation)	1.6440	0.3	
St 4 (Mangrove Forest)	1.7062	0.3	

The high concentration at the estuary (Station 1) indicates runoff inputs from domestic and agricultural activities. Phosphate commonly originates from detergents, fertilizers, and organic waste transported by rivers[25]. The lower value at Station 2 can be explained by the dominance of nitrogen inputs in aquaculture systems, causing phosphate to settle quickly. The nearly equal values at Stations 3 and 4 reflect the role of mangrove vegetation in retaining and absorbing phosphate, although not sufficient to reduce it below the standard[24]. Excess phosphate, combined with nitrate and ammonia, may accelerate eutrophication and promote algal blooms, thereby degrading water quality and disrupting ecosystem balance[26].

4. CONCLUSION

The concentrations of nitrate (0.0822–0.1932 mg/L), ammonia (0.5705–1.7338 mg/L), and phosphate (0.0845–0.299 mg/L) in the waters of Buruk Bakul Village exceeded the marine biota standards set by the Minister of Environment Decree No. 51/2004. The estuary had the highest nitrate and phosphate levels, while the shrimp pond recorded the highest ammonia concentration, highlighting the significant influence of land-based and aquaculture activities. The results of the study indicate that mangrove ecosystems contribute to nutrient retention, but their role is not yet sufficient to reduce concentrations below permissible limits.

ACKNOWLEDGEMENTS

The DIPA of Universitas Riau funded this research through the *Riset Peningkatan Kapasitas Dosen Muda (RIPEKDOM)* scheme for the 2025 fiscal year under Contract Number: 29163/UN19.5.1.3/AL.04/2025.

REFERENCES

1. Schlesinger, W.H., Bernhardt, E.S. *Biogeochemistry: An Analysis of Global Change*. 4th edn. Academic Press, 2020.
2. Howarth, R., Swaney, D., Billen, G., Garnier, J., Hong, B., Humborg, C., Johnes, P., Mörth, C.M., Marino, R. Nutrient Pollution of Aquatic Ecosystems: Causes, Consequences, and Controls. *Science of the Total Environment*, 2021; 755: 142–155.
3. Cai, W., Hu, X., Huang, W., Murrell, M.C., Lehrter, J.C., Lohrenz, S.E., Chakraborty, S. Carbon dioxide dynamics and fluxes in coastal waters influenced by riverine input. *Nature Reviews Earth & Environment*, 2020; 1: 440–456.
4. Wang, Y., Yu, Z., Song, X., Yuan, Y. Distribution and Ecological Risk Assessment of Nutrients in Coastal Waters. *Marine Pollution Bulletin*, 2021; 16B5: 112095.
5. Zhang, J., Liu, S. Nutrient Dynamics and Biogeochemical Processes in Estuarine and Coastal Ecosystems. *Estuarine, Coastal and Shelf Science*, 2022; 265: 107753.
6. Alongi, D.M. Carbon Balance in Tropical Mangrove Forests. *Science of the Total Environment*, 2020; 740: 140123.
7. Pratiwi, A., Supriyadi, S., Wulandari, T. Coastal Ecosystem Management based on Water Quality Assessment. *Ocean & Coastal Management*, 2022; 227: 106279.
8. Li, D., He, J., Chen, Q. Assessment of Coastal Water Quality using Ecological Indicators. *Ecological Indicators*, 2020; 113: 106224.
9. Lestari, F., Nurhayati, S. Water Quality Assessment and Pollution Index Analysis in Coastal Waters. *Environmental Monitoring and Assessment*, 2021; 193: 144.
10. Rahman, A., Fitriani, D., Suryono, C.A. Heavy Metal Contamination and Ecological Risk Assessment in Marine Environments. *Marine Pollution Bulletin*, 2021; 172: 112844.
11. [BSN] Badan Standardisasi Nasional. *Air dan Air Limbah—Bagian 57: Metoda Pengambilan Contoh Air Permukaan* (SNI 6989.57:2008). Badan Standardisasi Nasional, 2008.
12. [BSN] Badan Standardisasi Nasional. *Air dan Air Limbah—Bagian 23: Metode Pengukuran Minyak dan Lemak* (SNI 06-6989.23-2005). Badan Standardisasi Nasional, 2005.
13. [APHA] American Public Health Association, American Water Works Association, & Water Environment Federation. *Standard Methods for the Examination of Water and Wastewater* (23rd ed.). American Public Health Association, 2017.
14. [BSN] Badan Standardisasi Nasional. *Air dan Air Limbah—Bagian 79: Metode Pengujian Deterjen (MBAS)* (SNI 06-6989.79-2011). Badan Standardisasi Nasional, 2011.
15. [BSN] Badan Standardisasi Nasional. *Air dan Air Limbah—Bagian 30: Cara Uji Amonia dengan Spektrofotometer* (SNI 06-6989.30-2005). Badan Standardisasi Nasional, 2005.
16. [BSN] Badan Standardisasi Nasional. *Air dan Air Limbah—Bagian 31: Cara Uji Nitrat dengan Spektrofotometer* (SNI 06-6989.31-2005). Badan Standardisasi Nasional, 2005.
17. [KLH] Kementerian Lingkungan Hidup. Keputusan Menteri Negara Lingkungan Hidup No. 51Tahun 2004. KLH. Jakarta, 2004.
18. Pratiwi, A., Supriyadi, S., Wulandari, T. Sustainable Development of Marine Ecotourism in Small Islands: A Case Study of Gili Bawean Island, Indonesia. *Ocean & Coastal Management*, 2022; 227: 106279.

19. Li, D., He, J., Chen, Q. Spatial and Temporal Variations of Water Quality in a Highly Urbanized River Network (the Pearl River Delta, China). *Ecological Indicators*, 2020; 113: 106224.
20. Yulma, Y., Salim, G., Sampe, Y. Analisis Bahan Organik Nitrogen (N) dan Fosfor (P) pada Sedimen di Kawasan Konservasi Mangrove dan Bekantan (KKMB) Kota Tarakan. *Jurnal Borneo Saintek*, 2018; 1(2): 75–82
21. Zainuri, M., Pranowo, W.S., Suryono, C.A. Geospatial Modeling of Nitrate Distribution as an Indicator of Aquatic Fertility in Mangrove Waters. *Jurnal Kelautan Tropis*, 2024; 27(3): 345–356
22. Zhang, T.-X., Li, M.-R., Liu, C., Wang, S.-P., Yan, Z.-G. A Review of the Toxic Effects of Ammonia on Invertebrates in Aquatic Environments: A Focus on Bivalves and Crustaceans. *Environmental Pollution*, 2023; 336:122374
23. Parry, M.J., Zainuri, M., Indrayanti, E., Lukman, A.A., Jihadi, M.S. Sebaran Nitrat dan Ammonium di Wilayah Mangrove Mojo, Kabupaten Pemalang. *Indonesian Journal of Oceanography*, 2025; 7(3): 145–156
24. Adyasari, D., Oehler, T., Afiati, N., Jennerjahn, T.C. Mangrove Forests as Nutrient Filters in Indonesian Estuaries. *Estuarine, Coastal and Shelf Science*, 2019; 230: 106446
25. Withers, P.J.A., Jarvie, H.P., Doody, D.G., Silgram, M., MacDonald, G.K. Dissolved Phosphorus Emissions to Water from Agriculture and their Mitigation Options. *Science of the Total Environment*, 2018; 622–623
26. Akinnawo, S.O. Eutrophication: Causes, Consequences, and Control Measures. *Environmental Challenges*, 2023; 11: 100767