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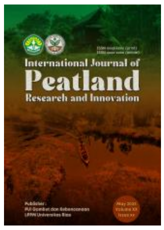

Analysis of Ammonia, Phosphate and Nitrate Levels of Rovers in the Senepis Peat Forest Area, Riau, Indonesia

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ABSTRACT

The Senepis Peat Forest Area in Riau is a tropical ecosystem that plays a crucial role in carbon storage, hydrological regulation, and biodiversity. However, pressures on river water quality in this area have increased due to land use changes. This study aims to analyze the concentrations of key nutrients, including ammonia (NH_3-N), phosphate (PO_4^{3-}), and nitrate (NO_3^-), at various river and water points in the Senepis area during 2017 and 2018. Sampling was conducted at 12 locations, including upstream and downstream points of four main rivers (Senepis, Sinaboi, Nyamuk, and Teluk Dalam), a logging block well, a kampong canal, and rainwater. Laboratory analysis was performed using spectrophotometric methods in accordance with SNI standards for each parameter. The results show that in 2017, phosphate concentrations ranged from 0.301 to 1.263 mg/L, ammonia from 0.030 to 0.534 mg/L, and nitrate from 0.342 to 0.392 mg/L. In 2018, phosphate concentrations decreased (0.0053–0.3292 mg/L), while ammonia (0.0750–0.3468 mg/L) and nitrate (0.1394–0.9668 mg/L) levels increased significantly, particularly in locations close to anthropogenic activities. These findings indicate spatial and temporal dynamics in nutrient levels, which could potentially trigger eutrophication and degrade water ecosystem quality. This data is essential as a basis for water quality management and the sustainable protection of tropical peatland ecosystems.

1. Introduction

Peatlands are one of the most complex and vital ecosystems on a global scale. Their primary roles include large-scale carbon storage, regulation of water balance, and support for

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biodiversity [1]. As part of the tropical wetland system, peatlands also provide essential ecosystem services such as flood control, clean water provision, and nutrient storage [2]. In Indonesia, Riau is one of the provinces with the largest peatland areas, including the Senepis Peat Forest Area in Rokan Hilir, which holds high ecological and economic value.

Rivers flowing through the Senepis Forest, such as the Senepis, Nyamuk, and Sinaboi rivers, function as key components in the hydrological cycle of the region. However, as land use for agriculture, settlement, and industry has increased, pressures on water quality have also escalated [3]. One form of this pressure is the influx of nutrient loads such as ammonia (NH_3-N), phosphate (PO_4^{3-}), and nitrate (NO_3^-) into the water bodies, resulting from surface runoff, soil erosion, domestic waste, and intensive agricultural activities [4].

Ammonia in water is toxic, especially in its non-ionic form (NH_3), which can damage fish respiratory systems and cause physiological stress to aquatic organisms [5]. Phosphate, although an essential nutrient, can promote massive algal growth in excess, leading to reduced ecosystem quality [6]. Nitrate, on the other hand, is a common pollutant derived from agricultural fertilizers and household waste, and when it enters water bodies at high concentrations, it can cause eutrophication and health risks to humans, such as methemoglobinemia in infants [7] [8].

The process of eutrophication caused by nutrient accumulation not only disrupts biodiversity but also reduces the aesthetic value and ecosystem service functions of aquatic systems [9]. Additionally, nutrient enrichment leads to changes in phytoplankton community structure, a decrease in dissolved oxygen, and an increase in aquatic organism mortality [10]. Several studies have shown that eutrophication is one of the most common water quality problems in tropical coastal and river delta regions [11] [12].

The Indonesian government has established water quality threshold values, including ammonia, phosphate, and nitrate concentrations, as outlined in Government Regulation Number 22 of 2021 and previously in the Decree of the Minister of State for the Environment Number 51 of 2004 [13]. These parameters are used as benchmarks for monitoring the quality of seawater and are also relevant for coastal rivers with direct connectivity to the sea, such as in the Senepis region.

Studies on river water quality in peatland forests remain limited, especially those using spatial and temporal approaches to major nutrient parameters. Most previous research has focused more on the physical aspects of peatland soils or the vegetative aspects of ecosystems. Therefore, further research is needed that targets the measurement of water quality from a chemical perspective to provide a more holistic understanding of pollution levels.

This study aims to analyze ammonia, phosphate, and nitrate concentrations in rivers flowing through the Senepis Peat Forest Area, Riau. This research not only provides an overview of nutrient concentrations but also examines their potential impact on local aquatic ecosystems. The data produced can serve as foundational information for developing water quality management strategies and peatland ecosystem conservation policies. Thus, the results of this study are expected to make a significant contribution to ecosystem-based sustainable development.

Furthermore, the findings of this research will provide important input for local and national government agencies in formulating water resource protection policies. Additionally, these findings will enrich the scientific literature on the dynamics of tropical peatland aquatic ecosystems and the potential anthropogenic threats. This research may also serve as a basis for long-term water quality monitoring, particularly in wetland areas sensitive to land use and climate change.

2. Methods

2.1 Time and Location

The sampling was conducted in January of 2017 and 2018. Water samples were collected from each river at two points: upstream (within the concession area) and downstream (at the concession boundary), from a deep well in an active logging block, and from a ditch at Km 11, resulting in 12 water samples for analysis. The sampling locations were as follows: 1) Sungai Sinepis (2 points: upstream (st1) and downstream (st2)), 2) Sungai Sinaboi (2 points: upstream (st3) and downstream (st4)), 3) Sungai Nyamuk (2 points: upstream (st5) and downstream (st6)), 4) Sungai Teluk Dalam (2 points: upstream (st7) and downstream (st8)), 5) Deep well in the active logging block (1 point: st9), 6) Parit Camp Tengah at Km 8 (1 point: st10), and 7) Rainwater (2 conditions: raw (st11) and processed (st12)). The locations of all sampling points are shown in Figure 1.

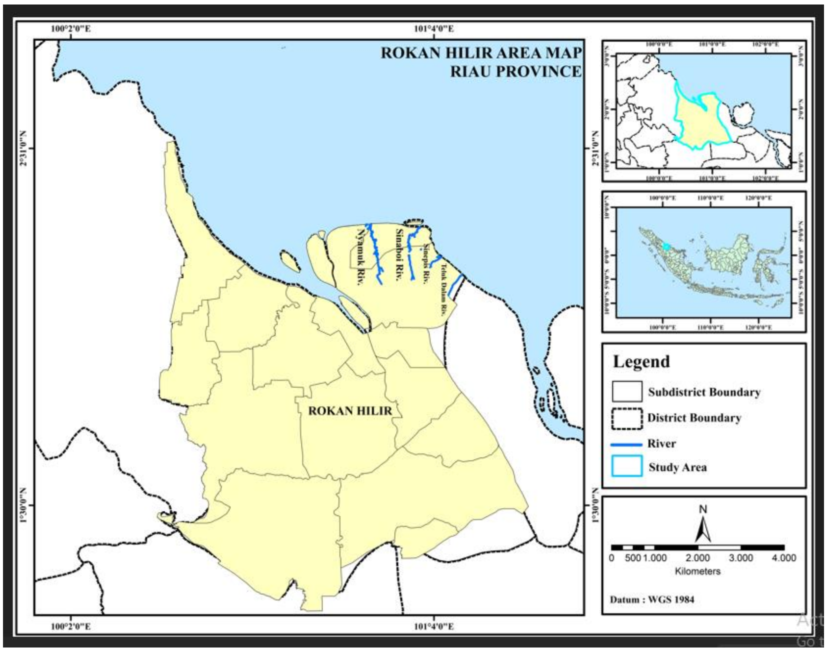

Figure 1. Research location map

2.2 Sample Collection and Handling

All water samples were collected using clean sampling bottles with a capacity of 500 to 1000 mL, which were rinsed beforehand with the respective water samples in the field. After collection, each bottle was labeled with the corresponding station code and year of sampling. The samples were stored in a cool box at approximately ±4°C to prevent degradation of chemical compounds. The time between sampling and laboratory analysis was kept within 24 hours to maintain data integrity. The locations of all sampling points are shown in Figure 1.

Sample handling and preservation followed standard operating procedures to ensure the quality and reliability of analytical results.

2.3 Sample Analysis

The water sample analysis was conducted by the Aquatic Ecology Laboratory and the Food Microbiology Laboratory, Faculty of Fisheries and Marine Sciences, Universitas Riau in Pekanbaru. The river water quality parameters analyzed were:

2.3.1 Phosphate

Phosphate analysis was conducted following the Indonesian National Standard [14] for the determination of phosphate in water using the spectrophotometric method with ammonium molybdate and tin (II) chloride ($SnCl_2$) reagents. A 50 mL water sample was taken, and 2 mL of nitric acid (HNO_3) was added to lower the pH and create optimal acidic conditions. Then, 1 mL of 10% ammonium molybdate solution was added to form a phosphate-molybdate complex. Following this, 1 mL of 0.2% tin (II) chloride ($SnCl_2$) solution was added to reduce the molybdate complex into a stable blue compound. The mixture was left for 10 minutes at room temperature to ensure proper color formation. Afterward, the absorbance of the solution was measured at a wavelength of 880 nm using a spectrophotometer. The absorbance values were compared with a previously prepared calibration curve using phosphate standard solutions to calculate the phosphate concentration in the sample.

2.3.2 Ammonia

Ammonia analysis was carried out according to SNI 06-6989.14-2004 [15], using the Nessler method to determine ammonia in water. This method involves adding Nessler's reagent to form a yellow-colored complex proportional to the ammonia concentration in the sample. A 50 mL water sample was pipetted into a test tube, and 2 mL of 2 N NaOH solution was added to adjust the pH to alkaline. After checking the pH, 2 mL of Nessler's reagent was added to the sample. Nessler's reagent contains potassium iodide (KI) and potassium mercuric iodide (HgI_2), which reacts with ammonia to form a yellow complex. The sample was then left for 10-15 minutes at room temperature to allow maximum color development. The absorbance of the solution was measured using a spectrophotometer at a wavelength of 420 nm. The absorbance was compared with a pre-prepared calibration curve using ammonia standard solutions to determine the ammonia concentration in the sample.

2.3.3 Nitrate

Nitrate analysis was conducted according to SNI 06-6989.31-2004 and SNI 06-6989.33-2004 [16], using the cadmium column reduction method, which converts nitrate (NO_3^-) to nitrite (NO_2^-) under acidic conditions. A 50 mL water sample was mixed with 5 mL of 0.1 N hydrochloric acid (HCl) to lower the pH, and then passed through a column containing cadmium granules for 5 minutes. After the reduction process, the sample was transferred to a test tube and 2 mL of 0.01 M EDTA solution was added to bind the metal ions, followed by 2 mL of 0.2% sulfanilamide solution and 2 mL of 0.1% N-1-naphthyl ethylenediamine solution. The mixture was left for 10 minutes to allow the formation of a red color, which is proportional to the nitrite concentration. The absorbance of the solution was measured at a wavelength of 540 nm using a spectrophotometer and compared with a calibration curve to determine the nitrate concentration in the sample.

2.4 Data Analysis

Data analysis was carried out by calculating the concentrations of phosphate, ammonia, and nitrate based on absorbance values obtained from the spectrophotometer. Each absorbance value from the water samples was inserted into a linear regression equation derived from the calibration curve of each parameter. The calibration curve was constructed by measuring the absorbance of standard solutions at known concentrations, followed by plotting a graph of concentration (X-axis) versus absorbance (Y-axis). The resulting relationship was expressed as a linear regression equation in the form of:

$$Y = aX + b \tag{1}$$

where:

Y = absorbance,
X = concentration of the compound (phosphate, ammonia, or nitrate) in mg/L,
a = slope of the line,
b = intercept on the Y-axis.

3. Results and Discussion

The analysis of water quality in the Senepis Peat Forest area and its surroundings in 2017 and 2018 showed fluctuations in nutrient concentrations—namely phosphate, ammonia, and nitrate—across various types of water bodies. The analytical results are presented below:

Table 1. Results of Water Sample Analysis in 2017

Parameters	St 1	St 2	St 3	St 4	St 5	St 6	St 7	St 8	St 9	St 10	St 11	St12
Posphate (mg/L)	0,799	0,301	1,064	0,412	0,710	0,998	0,821	0,799	1,263	1,086	0,555	0,400
Amoniak (mg/L)	0,170	0,534	0,222	0,131	0,156	0,158	0,096	0,189	0,217	0,286	0,044	0,030
Nitrat (mg/L)	0,379	0,371	0,375	0,383	0,358	0,342	0,350	0,392	0,350	0,371	0,375	0,346

Table 2. Results of Water Sample Analysis in 2015

Parameters	St 1	St 2	St 3	St 4	St 5	St 6	St 7	St 8	St 9	St 10	St 11	St12
Posphate (mg/L)	0.0963	0.2347	0.2032	0.1541	0.3292	0.2592	0.1926	0.1839	0.0628	0.1966	0.0070	0.0053
Amoniak (mg/L)	0.2417	0.2833	0.3250	0.2625	0.3468	0.2208	0.2833	0.3250	0.2000	0.2833	0.1583	0.0750
Nitrat (mg/L)	0.8872	0.5155	0.6137	0.2743	0.9668	0.2611	0.7611	0.8298	0.4801	0.9004	0.2279	0.1394

3.1 Phosphate

From the figure 2, phosphate concentrations in 2017 were observed to be relatively high, with the highest value recorded at the RKT Canal 2016, reaching 1.263 mg/L, while the lowest value was found at the Senepis River Delta with 0.301 mg/L. In 2018, a drastic decrease was observed, with the highest concentration only reaching 0.3292 mg/L (Sinaboi River Upper) and the lowest at 0.0053 mg/L in mature rainwater. This decline is suspected to be influenced by reduced runoff of fertilizers and organic materials from the land, an increase in the riparian vegetation's ability to absorb phosphates, and the sedimentation of phosphate particles to the water bottom [5] [17]. High phosphate content can accelerate eutrophication, stimulate excessive algal growth, and ultimately reduce dissolved oxygen levels, which adversely affects aquatic organisms [18] [19].

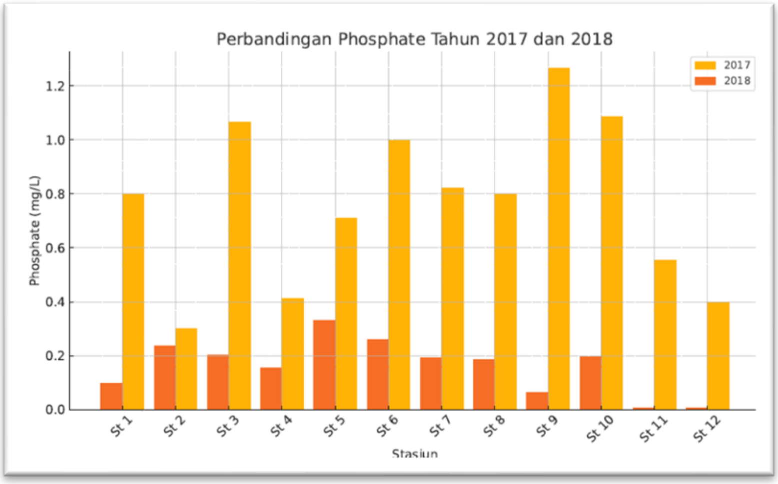

Figure 2. Phosphate Concentrations in 2017 and 2018

3.2 Ammonia

From the figure above, ammonia concentrations showed an increase at several locations. For example, in the Nyamuk River Upper, ammonia levels increased from 0.222 mg/L in 2017 to 0.325 mg/L in 2018. Ammonia originates from the decomposition of nitrogen-rich organic materials such as domestic waste, fecal matter, and livestock or aquaculture feed residues. Although most ammonia values in 2018 were still within the safe threshold for marine waters (<0.3 mg/L according to KepMenLH No. 51/2004), some locations, such as the Nyamuk River Upper and Teluk Dalam Delta, slightly exceeded this limit. Free ammonia (NH_3) is toxic to fish and other aquatic organisms, especially at high temperatures and alkaline pH levels [20] [21].

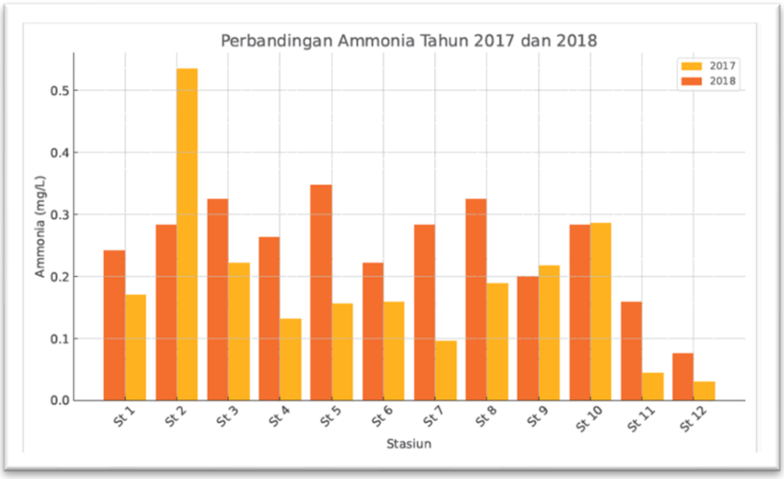

Figure 3. Ammonia in 2017 and 2018

3.3 Nitrate

Meanwhile, the figure 4 shows that nitrate concentrations increased from 2017 to 2018. In 2017, nitrate values were relatively uniform, ranging from 0.342 to 0.392 mg/L. However, in 2018, significant increases occurred at several locations, such as the Senepis River Upper

(0.8872 mg/L), Sinaboi River Upper (0.9668 mg/L), and the Pemda Camp Canal (0.9004 mg/L). This indicates an increase in nitrogen inputs into the water bodies, most likely from nitrogen fertilizers, domestic waste, and the leaching of organic material carried by surface runoff [10]. High nitrate concentrations, in addition to causing eutrophication, can also pose health risks to humans if the water is consumed, such as methemoglobinemia [22] [23].

The comparison of data from the two years shows that water bodies such as canals, lower rivers, and areas of former reclamation tend to have higher nutrient levels compared to raw and processed rainwater, which can serve as a natural water quality control. This indicates that human activities around water bodies, including agriculture, settlement, and peatland water management canals, have a significant impact on the increase in nutrient concentrations in the water.

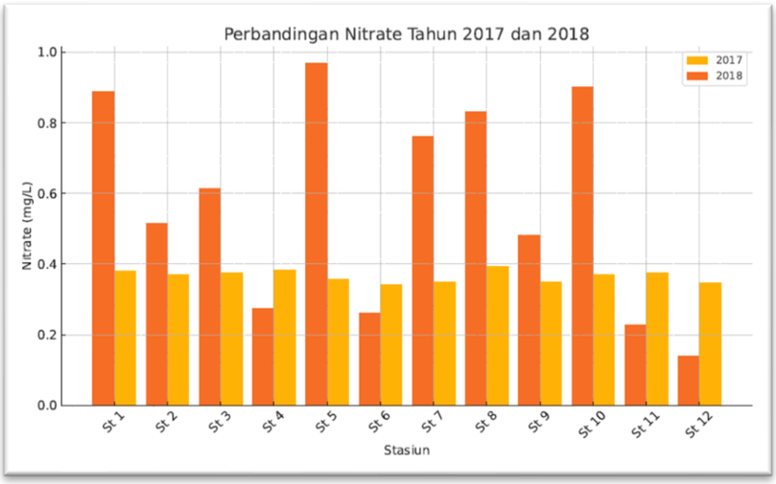

Figure 4. Nitrate in 2017 and 2018

Therefore, sustainable water quality management is essential, through controlling the use of fertilizers and organic materials, maintaining buffer zone vegetation, and implementing environmentally friendly wastewater treatment systems. Routine monitoring and education for local communities are important steps in preventing excessive nutrient pollution in peatland and coastal areas, to maintain healthy and productive aquatic ecosystems [24] [25].

4. Conclusions

This study shows that the concentrations of ammonia, phosphate, and nitrate in the waters of the Senepis Peat Forest area exhibited significant spatial and temporal variations between 2017 and 2018. In 2017, phosphate concentrations tended to be higher compared to 2018, while nitrate concentrations increased in 2018 at almost all sampling points. Ammonia concentrations showed more varied fluctuations, with some points experiencing both increases and decreases that were not uniform.

Nutrient concentration values found at several points exceeded the established water quality standard limits, indicating the potential for nutrient pollution in the area. This leads to the risk of eutrophication, which could negatively impact the quality and functioning of the peatland aquatic ecosystem. These findings highlight the need for more effective management of activities around peatland areas, particularly in controlling nutrient inputs from anthropogenic sources.

The data obtained from this study can serve as a key foundation for long-term monitoring planning, ecological risk assessments, and decision-making in the management of water quality in tropical peatland ecosystems. Further research with a broader temporal scope and a multi-method approach is highly recommended to gain a more comprehensive understanding of pollution dynamics.

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