International Journal of Science Academic Research
Vol. 07, Issue 10, pp.1626-1628, October 2026
Available online at http://www.scienceijsar.com
ISSN: 2582-6425

Research Article

ANALYSIS OF THE DIVERSITY OF THE NEKTON COMMUNITY IN THE CLAY MINING AREA OF PT SEMEN INDONESIA (PERSERO) Tbk TUBAN FACTORY

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Received 10th August 2026; **Accepted** 05th September 2026; **Published online** 30th October 2026

Abstract

Biodiversity monitoring in mining areas is a key instrument in maintaining ecosystem balance and complying with environmental regulations. This study aims to identify the actual conditions and analyze the dynamics of the necton community in the clay mining area of PT Semen Indonesia (Persero) TbkTuban Factory in the January-June 2022 period compared to data for the 2021 period. Sampling was carried out at three main locations (Sugihan/SUG, Tobo/TOB, and Mliwangan/MLI) using scoop nets and bubu (fish trap). The ecological parameters calculated included the Shannon-Wiener Diversity Index (H'), the Simpson Dominance Index (D'), and the Pielou Equality Index (J). The monitoring results showed that the level of necton diversity at the monitoring site was in the moderate category ($1.00 < H' < 3.00$). There was a significant increase in the number of individuals at Tobo and Mliwang stations from 2021 to 2022. This monitoring confirms the importance of regular biodiversity monitoring as a form of implementation of environmental protection regulations.

Keywords: Necton, Biodiversity, Shannon-Wiener, Mining, Clay, PT Semen Indonesia Tuban Factory.

INTRODUCTION

Mining activities for cement raw materials, such as limestone and clay, have the potential to have an impact on changes in the physical conditions of the environment and the surrounding biological community (Pratiwi *et al.,* 2022; Pratama *et al.,* 2023). To reduce the risk of environmental damage and ensure ecosystem sustainability, biodiversity monitoring activities (flora and fauna) are an obligation based on environmental management laws and standards (Ministry of Environment and Forestry, 2021; Utami *et al.,* 2023). Nekton communities (aquatic organisms that are able to swim actively) function as important bioindicators of the health of flooded and flowing aquatic ecosystems around mining areas (Rahman *et al.,* 2022; Wibowo & Santoso, 2023). Periodic evaluation of the nekton community structure index provides a quantitative picture of the response of aquatic biota to mine operational activities (Hidayat *et al.,* 2024; Setyawan *et al.,* 2021). This biodiversity monitoring activity is based on the laws and regulations of the Republic of Indonesia, including: Law Number 5 of 1990 concerning the Conservation of Biological Natural Resources and Their Ecosystems; Law Number 32 of 2009 concerning Environmental Protection and Management; Government Regulation Number 7 of 1999 concerning Protected Species of Plants and Animals; Regulation of the Minister of State for the Environment Number 06 of 2013 concerning the Company Performance Rating Assessment Program in Environmental Management (PROPER); Tuban Regent Decree No.188.45/3 71/KPTS/414.031/2018 concerning the Granting of Limestone, Clay, and Clay Mining Environmental Permits to PT Semen Indonesia (Persero) Tbk. The purpose of this study is to identify the actual condition of necton community diversity in the clay mining area of PT Semen Indonesia (Persero) TbkTuban Factory; Analyze the diversity, dominance, and evenness index of necton in the 2021 and 2022 monitoring periods; Assess the effectiveness and sustainability of environmental management based on indicators of biodiversity monitoring success.

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METHODS

Observation Time and Location

Surveys, site mapping, sampling, and observations were carried out in the January-June 2022 period. Nekton community observations were focused on monitoring stations in clay mining areas which include:

1. **Sugihan (SUG):** 06°50.954' S / 111°56.898' E (Clay Mine Location)
2. **Tobo (TOB):** 06°49.790' S / 111°53.981' E (Clay Mine Location)
3. **Mliwangan (MLI):** 06°49.447' S / 111°54.243' E (Clay Mine Location)

Sampling Methods

Necton sampling was carried out using scoop nets and fish traps. The species caught were identified in the laboratory to calculate the number of individuals per taxa (ni) and the total number of individuals (N).

Ecological Data Analysis

The analysis of the structure of the necton community uses three main ecological indices:

1. Indeks Diversity Shannon-Wiener (H'):
$H' = - \sum [(ni / N) \times \ln(ni / N)]$
H' < 1,00 :Low diversity (environmental factors are very influential).
1,00 < H' < 3,00 : Moderate diversity (environmental factors are quite influential).
H' > 3,00 : High diversity (stable environment).

2. Indeks Dominansi Simpson (D'): $D = \sum (ni / N)^2$
A value close to 1.00 indicates the presence of a certain taxa; close to 0.00 indicates no dominance.

3. Indeks Equality Pielou (J): $J = H' / \ln(S)$
A value close to 1.00 indicates an even distribution of the population; close to 0.00 indicates an uneven distribution.

RESULTS AND DISCUSSION

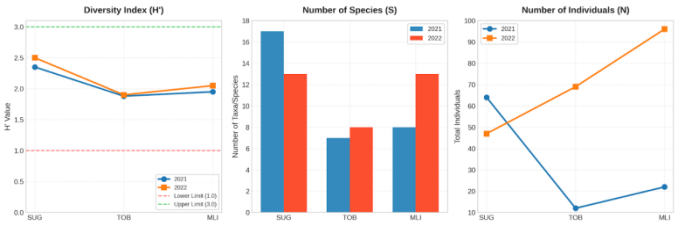


Figure 1. Comparison of Necton Community Monitoring Results (Diversity Index H', Number of Species S, and Number of Individuals N) Period 2021 vs 2022

Analisis Indeks Diversity Shannon-Wiener (H')

Based on ecological monitoring in the 2021 and 2022 periods at three clay mine observation stations (Sugihan/SUG, Tobo/TOB, and Mliwangan/MLI), the Shannon-Wiener Diversity Index (H') value is consistently in the range of 1,880 to 2,500 (Figure 1). Specifically, the H' value at Sugihan Station increased from 2.35 in 2021 to 2.50 in 2022. Meanwhile, Tobo Station recorded a slight increase from 1.88 to 1.90, and Mliwangan Station increased from 1.95 to 2.05.
According to Shannon-Wiener's qualitative criteria, all H' values were in the range of 1.00 < H' < 3.00, indicating that the biodiversity of necton communities in clay mining areas is in the MODERATE category. This condition reflects that although waters are under external pressure from land clearing, excavation, and mine water runoff activities, the physical-chemical conditions of the water (such as sufficiency of dissolved oxygen, neutral pH, and stable temperature) are still within the range of adequate ecological tolerance for the survival of aquatic biota (Rahman *et al.,* 2022; Setyawan *et al.,* 2021).

Dynamics of Species Richness (S) and Their Population Structure

Species richness (S) shows temporal dynamics that vary between observation stations. At Sugihan Station (SUG), there was a decrease in the number of monitored species from 17 taxa (2021) to 13 taxa (2022). The decline in species richness in Sugihan is estimated to be influenced by fluctuations in the intensity of operational activities around water intake and local sedimentation that reduces the availability of aquatic microhabitat substrates (Hidayat *et al.,* 2024). On the other hand, Mliwangan Station (MLI) recorded a significant spike in species wealth, increasing from 8 species in 2021 to 13 species in 2022. Tobo Station (TOB) tends to be stable with the addition of 7 to 8 species. The increase in species richness in Mliwangan and Tobo indicates the success of the natural colonization process by tolerant fish (such as species of the order Perciformes and Cypriniformes) in mine water reservoirs that have stabilized their ecosystems (Wibowo & Santoso, 2023).

Dynamics of Individual Abundance (N) and Habitat Supporting Capacity

One of the most prominent findings of this monitoring result is the spike in total abundance of individuals (N) at Tobo and Mliwangan Stations in 2022. At Tobo Station, the total number of nectons caught increased dramatically to more than fivefold, from 12 individuals (2021) to 69 individuals (2022). A similar trend occurred at Mliwangan Station, where the abundance of individuals jumped from 22 individuals (2021) to 96 individuals (2022). In contrast, Sugihan Station experienced a decrease in individual abundance from 64 individuals in 2021 to 47 individuals in 2022, in line with the decline in its species wealth. The spike in abundance in Tobo and Mliwangan reflects the increase in carrying capacity of flooded water bodies in mines. The growth of edge aquatic vegetation (such as Typha sp. or watergrass) and the accumulation of natural organic matter have provided abundant spawning grounds and natural feed sources (algae and zooplankton) for fish seeds (Pratama *et al.,* 2023; Setyawan *et al.,* 2021).

Analysis of the Index of Dominance (D') and Evenness of Pielou (J)

Although the abundance of individuals at Tobo and Mliwangan Stations has increased dramatically, the Simpson Dominance Index (D') values across stations have been observed to remain in the low category (D' < 0.50). This indicates that no one species is dominating to the extreme, which can suppress the populations of other species. Accordingly, the Pielou Evenness Index (J) is in the range of 1.00 (J > 0.60), which confirms that the distribution and distribution of populations between species is relatively even. The combination of moderate diversity, low dominance, and high evenness indicates that necton communities are in a state of dynamic equilibrium. These ecological conditions prove that the environmental impact of the Clay mining operational activities are still under control and do not trigger severe structural inequality in aquatic communities (Pratiwi *et al.,* 2022).

Environmental Management Compliance Evaluation and Mitigation Strategy

Monitoring of necton communities as part of periodic biodiversity monitoring has complied with the provisions of environmental protection regulations, as mandated in Government Regulation No. 22 of 2021 and Decree of the Minister of Environment and Forestry No. SK.1021/2021 (PROPER). The results of this study prove the success of the function of the settling pond and mine reservoir of PT Semen Indonesia Tuban Plant in containing sediment levels and neutralizing mine water runoff before flowing into public

waters. To maintain and improve the ecological conditions of mine waters in the future, several strategic mitigation measures are recommended: (1) Enrichment of local aquatic vegetation in the reservoir boundary zone to strengthen the protection function of microhabitats; (2) Routine monitoring of water physico-chemical parameters (turbidity, TSS, pH, and DO) in harmony with biological monitoring; and (3) Implementation of *phytoremediation-based reservoir management to minimize potential pollution due to clay sediment accumulation (Ministry of Environment and Forestry, 2021; Utami *et al.,* 2023).

Conclusion

Based on the results of research and data analysis, it is concluded as follows:

1. The necton community in the clay mining area of PT Semen Indonesia (Persero) TbkTuban Factory is in the category of moderate diversity ($1.00 < H' < 3.00$) with a value range of 1.88 to 2.50.
2. There was a very significant increase in individual abundance (N) in 2022 at Tobo Station (12 to 69 individuals) and Mliwangan Station (22 to 96 individuals), reflecting the restoration of microhabitats and an increase in the environmental support capacity of mined waters.
3. Low dominance values and high species equality indicate that necton communities are in a balanced ecosystem structure without any monopoly competition by specific species.
4. This periodic biological monitoring activity has succeeded in proving the company's operational compliance with environmental protection regulations and the effectiveness of mine water management.

Suggestions

1. Simultaneous monitoring between water physico-chemical parameters (temperature, pH, DO, TSS, turbidity) and aquatic biota sampling to map ecological causality relationships more precisely.
2. Maintain and expand the boundary zone with aquatic vegetation around the pond/mine pond to provide spawning grounds and nursery grounds for aquatic flora and fauna.

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