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Preliminary Baseline Assessment of Macrozoobenthos Community Structure in Clay-Mining Water Bodies in Tuban, East Java, Indonesia

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ABSTRACT

Macrozoobenthos are widely used as biological indicators because their community structure reflects cumulative habitat and water-quality conditions. However, information on macrozoobenthos assemblages in small artificial water bodies associated with clay-mining landscapes in Indonesia remains limited. This study provides a preliminary baseline assessment of macrozoobenthos and compares observed abundance, species richness, diversity, dominance, and evenness among three clay-mining water bodies—Sugihan, Tobo, and Mliwang—in Tuban, East Java, Indonesia. Field observations were conducted from the second week of July to the second week of August 2022. Macrozoobenthos were collected from littoral and vegetated margins using direct hand collection and scoop-net sweeping, retained through a 0.5-mm sieve, sorted, and provisionally identified based on morphological characteristics. Community structure was descriptively evaluated using the Shannon–Wiener diversity index (H'), Simpson dominance index (D), and Pielou evenness index (J'). A total of 45 individuals representing 13 provisional taxa and 11 families were recorded. Mliwang had the highest observed abundance and richness (21 individuals; 10 taxa), followed by Sugihan (11 individuals; 8 taxa) and Tobo (13 individuals; 6 taxa). H' values were 2.11, 2.02, and 1.61, while D values were 0.14, 0.14, and 0.23, respectively. Pielou evenness ranged from 0.896 to 0.971. These findings indicate spatial differences in assemblage structure; however, the lack of quantitative sampling effort and physicochemical measurements prevents definitive attribution to mining effects or specific environmental drivers. The findings provide an exploratory baseline for standardized, replicated, and environmentally integrated biomonitoring of clay-mining water bodies.

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INTRODUCTION

Macrozoobenthos play important roles in freshwater food webs, organic-matter processing, and sediment-associated nutrient cycling Because many taxa spend most of their life cycle in direct contact with the substrate, their assemblages respond quickly to changes in habitat condition, sediment type, vegetation cover, and water quality. For that reason, macrozoobenthic communities are widely used to diagnose ecological condition in rivers, ponds, wetlands, and other small inland waters

Macrozoobenthos play important roles in freshwater food webs, organic-matter decomposition, and sediment-associated nutrient cycling (Chen et al., 2017; Ciraolo et al., 2025; Darmarini et al., 2024; Xie et al., 2024). Because many macrozoobenthic organisms have relatively limited mobility and spend substantial portions of their life cycles in direct contact with water and sediment, changes in their community structure can reflect cumulative ecological conditions. Consequently, macrozoobenthos have been widely used in the biological assessment of rivers, ponds, wetlands, reservoirs, and other inland water bodies (Brysiewicz et al., 2022; Buschbaum et al., 2024; Sala-Mirete et al., 2025; Tarała et al., 2025).

Mining landscapes deserve particular attention because excavation, land clearing, sediment redistribution, and hydrological alteration can modify the physical structure of aquatic habitats (Adjei et al., 2026; Gerwin et al., 2023; Gray, 2026; Rentier & Cammeraat, 2022; Robles et al., 2026). Mining activities can alter aquatic habitats through excavation, land clearing, sediment redistribution, and hydrological modification (Bănăduc et al., 2024; Goncharov & Shundel, 2026; Haseeba et al., 2025; Pavel et al., 2025).

Small water bodies formed or modified by clay extraction are particularly relevant because they may simultaneously function as post-extraction habitats, irrigation reservoirs, sediment-retention areas, and components of developing greenbelts. Such multifunctional water bodies may support aquatic biodiversity, but their biological communities remain potentially influenced by habitat simplification, sediment accumulation, surrounding land use, and management practices (O'Brien et al., 2021; Oester et al., 2025; Plass-Johnson et al., 2018; Pratiwi et al., 2024; Riera et al., 2025).

Although numerous studies have evaluated macrozoobenthos in rivers, wetlands, and mining-affected streams, comparatively little attention has been given to small artificial or post-extraction water bodies associated specifically with clay mining in tropical Indonesia. These water bodies differ from natural rivers because they are spatially isolated, have limited hydrological connectivity, and may be subject to different stages of ecological succession and human use. Consequently, information from riverine or large-reservoir ecosystems cannot be directly extrapolated to these small mining-associated habitats.

The Sugihan, Tobo, and Mliwang water bodies in the clay-mining landscape of Tuban represent different habitat contexts and management uses. Sugihan is connected to agricultural and irrigation activities, Tobo is a former clay-mining pond undergoing natural succession, and Mliwang is an irrigation water body surrounded by relatively varied riparian vegetation. Nevertheless, no comparative baseline has been available to describe whether these three water bodies support similar or spatially differentiated macrozoobenthos assemblages. Establishing such a baseline is important for identifying priorities for subsequent standardized biomonitoring and habitat management.

The scientific question addressed in this study was: how do the observed composition, abundance, richness, diversity, dominance, and evenness of macrozoobenthos differ among three clay-mining water bodies with contrasting habitat contexts? The novelty of the study lies in providing an initial comparative ecological account of macrozoobenthos in small, multifunctional clay-mining water bodies in tropical Indonesia—habitats that remain underrepresented in freshwater biomonitoring literature.

Accordingly, this study aimed to describe and compare the observed macrozoobenthos community structure among the Sugihan, Tobo, and Mliwang clay-mining water bodies based on taxonomic composition, abundance, richness, Shannon–Wiener diversity, Simpson dominance, and Pielou evenness. The study was designed as a preliminary baseline biodiversity assessment rather than a causal assessment of mining impacts. Its findings are expected to support the development of more standardized, replicated, and environmentally integrated biomonitoring programs for mining-associated freshwater habitats.

RESEARCH METHODS

This study employed a descriptive quantitative design using macrozoobenthos data collected during the biodiversity monitoring program of PT Semen Indonesia. Field observations and biological sampling were conducted from the second week of July to the second week of August 2022. The expression "July–December 2022" refers to the administrative reporting period of the monitoring program and not to the duration of field sampling. The study covered three freshwater water bodies associated with clay extraction in Tuban, East Java: Sugihan (SUG), Tobo (TOB), and Mliwang (MLI) (Figure 1 and Table 1).

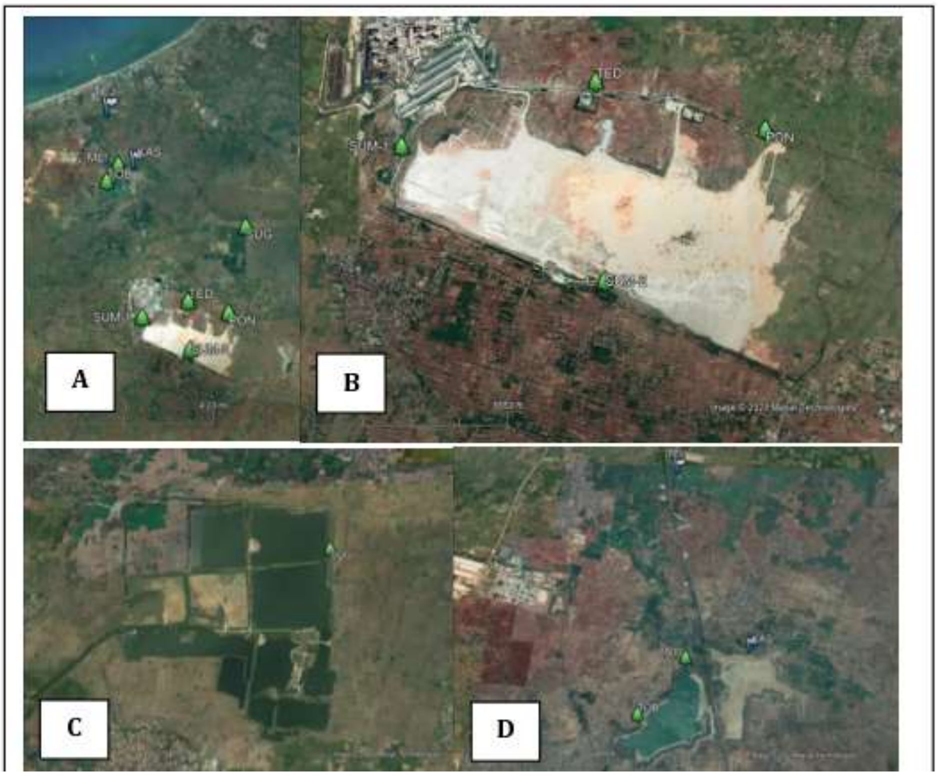

Figure 1. Study area of PT Semen Indonesia, Tuban, showing the broader mining landscape and the clay-mining sampling sites (Sugihan, Tobo, and Mliwang). (A. Overall Area Location; B. Limestone Mining Area Location; C&D Clay Mining Area Location)

Table 1. Coordinates and habitat characteristics of the macrozoobenthos sampling sites

Site code	Latitude (S)	Longitude (E)	Habitat characterization
SUG	06°50.954'	111°56.898'	Embung and community farmland/greenbelt; also used for freshwater fish culture and irrigation of rice fields.
TOB	06°49.790'	111°53.981'	Former clay-mining embung with natural succession and adjacent agricultural greenbelt.
MLI	06°49.447'	111°54.243'	Clay-mining embung used for agricultural irrigation with relatively varied riparian vegetation.

Macrozoobenthos were collected from the littoral margins of each water body using two complementary approaches: direct hand collection of visible organisms and scoop-net sweeping of shallow-water and vegetated marginal habitats. Collected material was washed through graded sieves, with a 0.5-mm sieve used as the smallest mesh to retain macrozoobenthic organisms. The organisms retained by the sieve were sorted from sediment, plant material, and other debris before identification and enumeration.

Because this study was based on an existing monitoring dataset, the available field records did not provide sufficiently detailed information on the number of transects or subsamples, transect length, sampled surface area, scoop-netting duration, sediment volume, or biological replication at each site. Therefore, the values reported in this study represent raw observational counts rather than standardized density estimates. Differences in abundance and richness among sites were consequently interpreted descriptively and should not be considered definitive estimates of ecological differences among the three water bodies. This documentation limitation is explicitly considered when interpreting the results.

To strengthen study-area presentation, the manuscript incorporates the mapped location of the broader mining landscape and the specific clay-mining water bodies used in the monitoring program. The three sites represent man-made or post-extraction embungs embedded within a mining matrix and greenbelt or agricultural surroundings. Sugihan is an embung connected to community farmland and irrigation use; Tobo is a former clay-mining pond undergoing natural succession beside a greenbelt; and Mliwang is an embung used for irrigation, with more varied riparian and shoreline vegetation than the other two sites.

Macrozoobenthos were sampled by direct hand collecting and scoop-net sweeping along the littoral edge of each water body, especially in vegetated margins where benthic organisms and larval forms were expected to occur. Target organisms included insect larvae, crustaceans, small mollusks, and other visible benthic invertebrates. After collection, the sample material was washed through a graded sieve, with 0.5 mm as the smallest mesh used to retain macrozoobenthic organisms. Retained specimens were sorted and provisionally assigned to the lowest practicable taxonomic level based on the morphological information available in the monitoring records. Particular attention was given to shell shape, aperture characteristics, sculpture, coiling pattern, and other visible diagnostic features of mollusks. Nevertheless, voucher specimens, detailed diagnostic photographs, molecular confirmation, and independent taxonomic verification were not available for the present reanalysis. Therefore, records with uncertain habitat compatibility or biogeographic distribution are reported using "cf." and must be considered provisional. These records should not be used as confirmed evidence of species distribution, invasion, or range expansion until the original specimens or high-resolution photographs have been re-examined by an appropriate taxonomic specialist.

Community structure was evaluated using observed abundance, taxon richness, the Shannon–Wiener diversity index (H'), Simpson dominance index (D), and Pielou evenness index (J'). The indices were calculated as follows:

$$H' = -\Sigma(p_i \ln p_i)$$

$$D = \Sigma p_i^2$$

$$J' = H'/\ln S$$

where p_i is the proportion of individuals belonging to taxon i and S is the number of taxa recorded at a site. Higher H' values indicate greater uncertainty in the taxonomic identity of a randomly selected individual, whereas higher D values indicate greater numerical concentration in a limited number of taxa. J' ranges from 0 to 1, with values approaching 1 indicating a more even distribution of individuals among the recorded taxa (Magurran, 2004; Pielou, 1966). Because fixed categorical thresholds for H' vary among studies and ecosystems, the values were interpreted comparatively among the three sites rather than classified using unsupported terms such as "low," "moderate," or "high" diversity.

No inferential statistical test was conducted because the available dataset did not contain clearly documented biological replicates or standardized measures of sampling effort. Furthermore, water and sediment variables were not quantitatively available. Therefore, habitat characteristics were used only to provide contextual and hypothesis-generating interpretations, not to establish causal relationships between environmental factors and macrozoobenthos assemblages.

RESEARCH RESULT

A total of 45 individuals representing 13 provisional taxa assigned to 11 families were recorded across the three clay-mining water bodies. Gastropod morphotypes constituted most of the assemblage, whereas crustaceans were represented by *Macrobrachium lanchesteri*. Mliwang had the highest raw observational count and taxon richness, with 21 individuals and 10 taxa. Sugihan contained 11 individuals and eight taxa, whereas Tobo contained 13 individuals but only six taxa. These values indicate differences in the observed assemblages; however, because sampling effort was not completely documented, they should not be interpreted as standardized estimates of abundance or richness (see Figure 2 and Table 2).

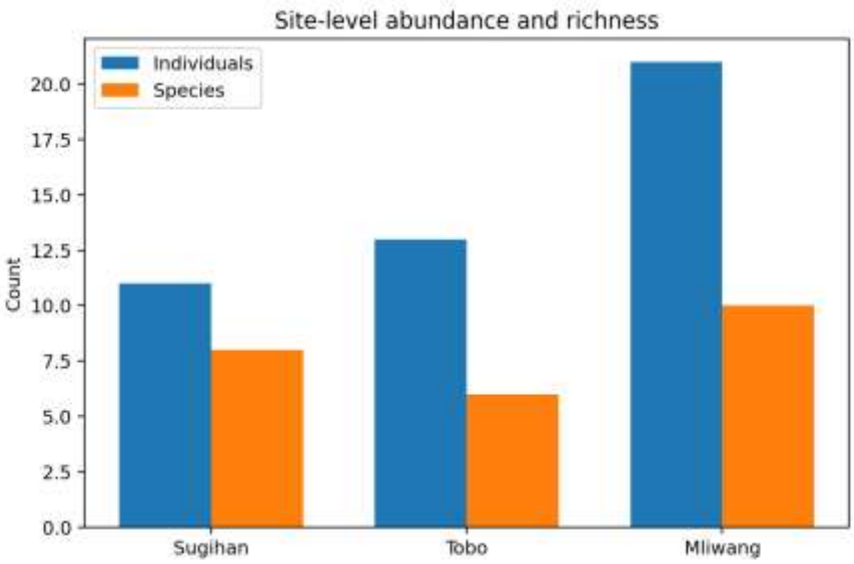

Figure 2. Comparison of total individuals and species richness among Sugihan, Tobo, and Mliwang.

Table 2. Composition and abundance of macrozoobenthos across the three sampling sites

No.	Species	Family	SUG	TOB	MLI
1	*Bellamya javanica*	Viviparidae	1	0	2
2	*Batillaria cf. attramentaria (provisional identification)*	Batillaridae	0	0	1
3	*Cochlicella cf. acuta (provisional identification)*	Geomitridae	0	2	5
4	*Lymnaea rubiginosa*	Lymnaeidae	1	0	1
5	*Macrobrachium lanchesteri*	Palaemonidae	2	0	0
6	*Melanoides tuberculata*	Thiaridae	2	4	4
7	*Odostomia cf. scalaris (provisional identification)*	Pyramidellidae	0	1	0
8	*Pila ampullacea*	Ampullariidae	1	1	2
9	*Pomacea canaliculata*	Ampullariidae	2	0	1
10	*Potamopyrgus cf. antipodarum (provisional identification)*	Hydrobiidae	0	1	1
11	*Tarebia granifera*	Thiaridae	1	4	3
12	*Tylomelania cf. neritiformis (provisional identification)*	Pachychilidae	0	0	1
13	*Valvata cristata*	Valvatidae	1	0	0
	Total individuals		**11**	**13**	**21**

Note: Taxa marked with "cf." represent provisional identifications based on the available monitoring records. Because voucher specimens, detailed diagnostic photographs, and molecular verification were unavailable for re-examination, these records should not be interpreted as confirmed distributional or invasive-species records. The total of 13 taxa therefore refers to provisional operational taxonomic units recorded in the original dataset.

Melanoides tuberculata was the most abundant taxon (10 individuals), followed by Tarebia granifera (8), Cochlicella acuta (7), and Pila ampullacea (4). Several taxa occurred only once and were restricted to a single site, including Batillaria attramentaria, Odostomia scalaris, Tylomelania neritiformis, and Valvata cristata. *Melanoides tuberculata* was the most frequently recorded taxon, with 10 individuals, followed by *Tarebia granifera* with eight individuals and the provisional morphotype *Cochlicella* cf. *acuta* with seven individuals. Several provisional taxa were represented by only one individual and recorded at a single site. This pattern demonstrates that the observed composition was not identical among sites. Nevertheless, single-site occurrence cannot be interpreted as evidence of ecological restriction because detectability and standardized sampling effort were not evaluated (see Figure 3 and Table 3).

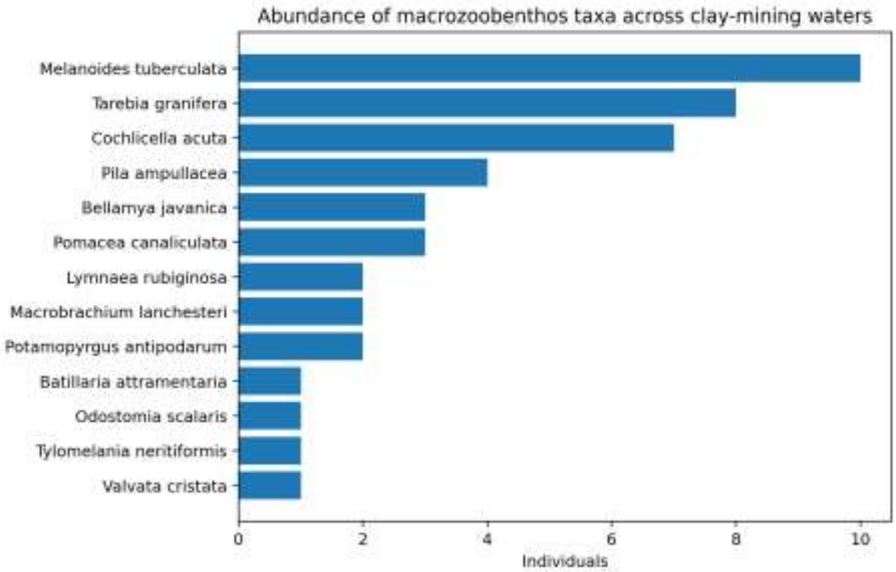

Figure 3. Abundance ranking of macrozoobenthos taxa across the three clay-mining sites.

Table 3. Site-level ecological indices and summary interpretation

Site	Individuals	Species	H'	D	J'	Interpretive note
Sugihan	11	8	2.02	0.14	0.971	Relatively high evenness and low numerical dominance within the present dataset
Tobo	13	6	1.61	0.23	0.896	Lowest observed richness and H', with the greatest numerical dominance
Mliwang	21	10	2.11	0.14	0.916	Highest observed richness and H', with low numerical dominance

Note: The index values are used for descriptive comparison among sites. They are not classified into universal "low," "moderate," or "high" categories because the ecological meaning of such thresholds depends on the ecosystem, sampling design, taxonomic resolution, and reference condition.

The ecological indices showed that Mliwang had the highest H' value (2.11), followed by Sugihan (2.02) and Tobo (1.61). Simpson dominance was similar in Mliwang and Sugihan (D =

0.14) but higher in Tobo (D = 0.23), reflecting a greater numerical concentration of individuals in a limited number of taxa at Tobo. Sugihan had the highest evenness (J' = 0.971), followed by Mliwang (J' = 0.916) and Tobo (J' = 0.896). Thus, Mliwang supported the broadest observed taxonomic representation, whereas Sugihan showed the most even distribution of individuals among the recorded taxa. These comparisons apply only to the present observational dataset. Overall, all three sites supported multiple macrozoobenthos taxa, but the magnitude and distribution of the calculated indices differed among sites.

The report also helps explain these differences ecologically. Sugihan is closely linked to rice-field irrigation and community use; Tobo is a former excavation embung undergoing natural succession; and Mliwang is an irrigation embung with more heterogeneous riparian structure. Across all three sites, muddy bottom substrate, accumulated litter, and marginal vegetation likely created suitable habitat for grazer gastropods and other detritus-associated benthic fauna.

DISCUSSION

Community Composition and Taxonomic Considerations

The strong representation of freshwater gastropods is ecologically meaningful. The most abundant taxa—*Melanoides tuberculata, Tarebia granifera, Cochlicella acuta, Pila ampullacea, and Bellamya javanica*—are associated with shallow littoral environments where biofilm, algae, fine sediment, and organic debris are available (Gümüş et al., 2022; Jitkaew et al., 2023; Machuca-Sepúlveda et al., 2024; Nunes et al., 2024). Their predominance suggests that the clay-mining water bodies provide stable muddy substrate and food resources, but also that the community may be structured by disturbance-tolerant taxa rather than by a wider mixture of sensitive forms (Akamagwuna et al., 2022; Buczyńska et al., 2018; Jorissen et al., 2022; Newsome & Falagán, 2021; St-Pierre et al., 2026).

Nevertheless, the ecological interpretation of several taxa requires caution. The records originally assigned to *Batillaria attramentaria, Cochlicella acuta, Odostomia scalaris, Potamopyrgus antipodarum,* and *Tylomelania neritiformis* have potential habitat or biogeographic inconsistencies because the corresponding taxa may be associated with marine, brackish, terrestrial, invasive, or geographically restricted environments. Consequently, these records should be regarded as provisional identifications pending re-examination of voucher specimens, diagnostic morphological characters, or high-resolution photographs. Their occurrence in the dataset should not yet be interpreted as confirmed evidence of species distribution, biological invasion, or geographic range expansion. Future surveys should preserve voucher specimens and involve taxonomic specialists or molecular identification when morphological confirmation remains inconclusive.

The dominance of gastropods may reflect their ability to exploit fine sediment, periphyton, detritus, and organic material in shallow littoral habitats. However, the predominance of particular gastropod taxa cannot independently establish whether a water body is in good or degraded ecological condition. A reliable ecological-status assessment requires the integration of taxonomic composition with pollution-tolerance information, functional feeding groups, standardized sampling effort, and quantitative environmental measurements.

Spatial Variation Among Sites

Mliwang consistently showed the most favorable community profile in the present dataset because it combined the highest abundance, the greatest species richness, and the highest diversity while maintaining low dominance. This pattern is consistent with a more heterogeneous habitat mosaic and a more even allocation of microhabitats along the shoreline (Bishop et al., 2022; Clemente & Thomsen, 2025; Firth et al., 2026; Gomes et al., 2024; Lupton et al., 2026; Sueiro et al., 2011; Wei et al., 2025).

Within the available observational dataset, Mliwang recorded 21 individuals distributed among 10 provisional taxa and had the highest Shannon–Wiener diversity value (H' = 2.11). Its low Simpson dominance value (D = 0.14) and relatively high Pielou evenness value (J' = 0.916) indicate that the observed assemblage was not numerically concentrated in only one or two taxa. This combination distinguishes Mliwang from Tobo, although the difference should be understood as a descriptive pattern rather than as a statistically confirmed difference because replicated and standardized sampling units were not documented.

In contrast, Tobo exhibited the clearest sign of habitat filtering: richness was lower, diversity declined, and dominance increased. Even though evenness remained relatively high, the smaller taxonomic pool indicates that fewer taxa were able to occupy the site successfully (Chan et al., 2024; Haase et al., 2023; Li et al., 2025; Schooler et al., 2017; Widmer et al., 2025).

The expression “habitat filtering” is used here as a possible ecological interpretation rather than as a directly tested process. Tobo contained 13 individuals from six provisional taxa, with the lowest H' value (1.61) and the highest D value (0.23). Its J' value of 0.896 indicates that the individuals were still relatively evenly distributed among the taxa that were recorded, but its smaller taxonomic pool suggests a more restricted observed assemblage. Because environmental variables and sampling effort were not quantitatively evaluated, this pattern may reflect habitat conditions, differences in organism detectability, sampling variation, or a combination of these factors.

Sugihan presented a different community pattern. Although its observed abundance and richness were lower than those of Mliwang, Sugihan had the highest Pielou evenness value (J' = 0.971), with H' = 2.02 and D = 0.14. This indicates that individuals were distributed more evenly among the eight provisional taxa recorded at the site. Thus, Mliwang had the broadest observed taxonomic representation, whereas Sugihan showed the most even distribution of individuals within its recorded assemblage.

Potential Environmental Drivers

The site descriptions from the monitoring report strengthen the interpretation of those differences. Sugihan and Mliwang are both multifunctional embungs connected to greenbelt and agricultural landscapes, but Mliwang appears to have more varied riparian cover and shoreline structure. Tobo, by comparison, is described as a former clay-mining pond undergoing natural succession, which may still impose constraints related to sediment quality, bank simplicity, or aquatic-vegetation development. These contextual factors help explain why abundance alone did not translate directly into richer diversity at every site (Bracewell et al., 2018; Gaüzère et al., 2025; Kennedy & Rotjan, 2026; Yee & Juliano, 2007).

The differences among sites may therefore be associated with variation in riparian vegetation, shoreline structure, sediment characteristics, surrounding land use, hydrological function, and the stage of post-mining ecological succession. A more structurally varied shoreline may provide additional microhabitats, food resources, refuges, and attachment surfaces for benthic organisms. Conversely, habitat simplification and the accumulation of fine sediment may restrict the number of taxa able to persist in a water body. These explanations are consistent with the ecological literature cited above, but they remain hypotheses in the context of the present study.

The study did not quantitatively measure water temperature, pH, dissolved oxygen, conductivity, turbidity, total dissolved solids, nitrate, phosphate, water depth, sediment grain size, sediment organic matter, or aquatic-vegetation cover. Accordingly, the observed community differences cannot be causally attributed to any specific physicochemical or habitat variable. The qualitative habitat descriptions are used only to provide ecological context and to generate hypotheses that can be evaluated through subsequent field research.

Interpretation of the Ecological Indices

Overall, the three sites can be interpreted as moderately diverse clay-mining freshwater habitats that still support multiple macrozoobenthos taxa but remain influenced by local environmental pressure. However, because categories for Shannon–Wiener diversity vary among classification systems and ecosystem types, the term "moderately diverse" should be interpreted cautiously. In the present study, H' values are used primarily for comparison among the three sites rather than as universal indicators of low, moderate, or high ecological quality. The values show that Mliwang had the highest calculated diversity, followed by Sugihan and Tobo, but they do not independently establish the ecological-status category of each water body.

The combined interpretation of H', D, and J' provides a more informative description than any single index. Mliwang combined the highest observed richness and H' with low dominance, while Sugihan combined relatively high H' with the greatest evenness. Tobo showed lower richness and H' and greater dominance, although its J' value remained relatively high. These complementary patterns demonstrate that diversity, dominance, and evenness describe different dimensions of assemblage structure and should therefore be interpreted together.

Ecological Implications for Mining-Water Management

For monitoring and management, the results suggest that maintaining riparian and submerged vegetation, reducing excess sediment loading, and protecting littoral microhabitats would likely improve community stability. The present manuscript therefore contributes not only a tabulated species list, but also a more integrated ecological narrative that connects study area, method, habitat setting, and community response.

From a management perspective, the relatively broad assemblage observed at Mliwang indicates that this site may provide a useful within-landscape comparison for future monitoring. This does not mean that Mliwang represents an undisturbed reference ecosystem; instead, its current community profile can serve as a preliminary benchmark against which subsequent temporal changes at the three water bodies may be evaluated. The more restricted assemblage observed at Tobo warrants additional investigation to determine whether the pattern persists under standardized and replicated sampling.

Maintaining vegetated littoral zones, protecting shoreline heterogeneity, limiting excessive sediment input, and supporting natural ecological succession are reasonable precautionary management measures for these water bodies. Nevertheless, the effectiveness of such actions should be evaluated through repeated biomonitoring rather than inferred exclusively from the present dataset. Monitoring should also consider the multifunctional uses of the water bodies, including irrigation, aquaculture, agricultural activities, and post-mining habitat development.

Study Limitations and Directions for Future Research

Several limitations should be considered when interpreting the findings. First, the available monitoring records did not completely document the number of sampling stations, transects, subsamples, sampling duration, sampled surface area, or sediment volume. Therefore, the abundance values represent raw observational counts rather than standardized organism densities. Differences in abundance and richness may partly reflect variation in sampling effort or organism detectability.

Second, the relatively small number of recorded individuals limits the generalization of the observed patterns. The absence of clearly documented biological replicates also prevented inferential statistical testing of differences among sites. Accordingly, the present results should be regarded as an exploratory baseline rather than as a definitive assessment of mining impacts or ecological status.

Third, the absence of quantitative water-quality, sediment, vegetation, and hydrological data prevented direct evaluation of the environmental drivers underlying assemblage variation. Finally, the absence of voucher specimens and detailed diagnostic photographs limited taxonomic verification, particularly for taxa with questionable habitat or biogeographic compatibility. Explicit recognition of these limitations is important because it prevents descriptive community patterns from being interpreted as demonstrated causal relationships.

Future research should expand this baseline study by integrating macrozoobenthos data with physicochemical water parameters, sediment characteristics, aquatic vegetation, and seasonal sampling in order to better explain the ecological drivers of community variation among sites. Longitudinal monitoring across dry and wet seasons would be especially valuable for identifying temporal changes in abundance, diversity, and dominance in clay-mining waters. In addition, the inclusion of functional feeding groups, pollution-tolerance categories, and spatial analysis of habitat connectivity would strengthen the ecological interpretation of macrozoobenthos assemblages and improve their application as bioindicators for adaptive management and post-mining freshwater restoration.

Future sampling should apply equal sampling areas or durations, establish replicated sampling units, and examine comparable littoral habitats at all sites. Standardized field procedures would allow abundance to be expressed as density or catch per unit effort and would support more robust statistical comparisons. Subsequent surveys should also preserve representative voucher specimens, prepare diagnostic photographs, document the morphological characters used for identification, and employ DNA barcoding when species-level identification remains uncertain. These methodological improvements would enable future research to distinguish more reliably between sampling effects, habitat variation, seasonal dynamics, and mining-related environmental pressures.

CONCLUSION

Macrozoobenthos assemblages in the clay-mining waters of PT Semen Indonesia consisted of 45 individuals from 13 species and 11 families, with freshwater gastropods as the dominant group. Mliwang showed the highest abundance, species richness, and diversity, Sugihan showed moderate diversity with the highest evenness, and Tobo showed the lowest richness and diversity together with the highest dominance.

This preliminary baseline assessment recorded 45 macrozoobenthos individuals representing 13 provisional taxa assigned to 11 families in three clay-mining water bodies in Tuban, East Java. Gastropod morphotypes dominated the observed assemblages, particularly *Melanoides tuberculata* and *Tarebia granifera*. Mliwang had the highest observed abundance, taxon richness, and Shannon–Wiener diversity, Sugihan had the highest Pielou evenness, and Tobo had the lowest observed richness and diversity together with the highest Simpson dominance. These results demonstrate spatial variation in the recorded assemblages but do not establish causal effects of substrate, vegetation, habitat filtering, or mining activities.

The findings should be treated as an exploratory biodiversity baseline because sampling effort, biological replication, physicochemical variables, and several taxonomic identifications were not sufficiently documented or verified. Future monitoring should employ standardized and replicated sampling, quantitative assessment of water and sediment conditions, seasonal observations, preservation of voucher specimens, and expert or molecular taxonomic verification. Such improvements will allow macrozoobenthos data to be used more reliably for adaptive habitat management and ecological evaluation of clay-mining water bodies.

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CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this paper.

CREDIT AUTHORSHIP CONTRIBUTION STATEMENT

Nurtjahyani, S. D.: conceptualization, methodology, formal analysis, supervision, project administration, funding acquisition, writing – original draft, and writing – review & editing. **Oktafitria, D.:** formal analysis, investigation, resources, data curation, validation, writing – original draft, and writing – review & editing**. Wulan, S.:** resources, investigation, and visualization. **Tarigan, A.:** resources, investigation, and writing – review & editing. **Hermawanto, M. K.:** resources, investigation, and writing – review & editing.

DECLARATION OF THE USE OF AI

During the preparation of this work the authors used CHAT-GPT Pro in order to language alignment and reducing typographical errors in the manuscript. After using this tool/service, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author.

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