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Plankton and Fish Assemblages in Three Clay-Mining Reservoirs in Tuban, Indonesia

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Abstract

Biological surveys of mining-associated reservoirs often summarize different assemblages separately, leaving open whether the same sites rank highest across groups. We compared observed phytoplankton, zooplankton, and fish assemblages at Sugihan, Tobo, and Mliwang, three clay-mining reservoirs in Tuban, Indonesia, during the July–December 2022 monitoring period. Plankton was collected with a net and counted microscopically. Fish records combined trap catches with supplementary catches from local fishers. We summarized observed taxon richness, Shannon diversity (H′), Simpson dominance (D), and Pielou evenness (J) and compared reservoir rankings within each assemblage. The survey recorded 25 phytoplankton taxa, 22 zooplankton taxa, and 11 fish taxa. H′ ranged from 2.51 to 2.69 for phytoplankton, 2.17 to 2.67 for zooplankton, and 1.41 to 2.15 for fish. Tobo ranked first for zooplankton richness and H′ but last for fish richness and H′, and had the highest fish dominance (D = 0.29). Mliwang ranked first for phytoplankton and fish richness and H′. These contrasting rankings identify where a single-assemblage survey would miss differences in observed community structure. The results provide a baseline for repeated monitoring with documented effort.

Keywords: Clay mining; Community composition; Fish; Plankton; Reservoir monitoring.

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INTRODUCTION

Mining changes drainage and topography, and water bodies in mining landscapes can develop into freshwater habitat or support local water use. Pit-lake studies have shown that hydrological setting differs among sites and that closure planning depends on the intended end use (Kemanga et al., 2024; Vandenberg et al., 2022). Biological inventories can document which organisms are detected in such waters and establish a baseline for later surveys. The ecological significance of those records depends on the habitat, exposure, and sampling context. A review of sand extraction along the Brantas River in Tulungagung identified erosion and water-quality concerns in a different extraction setting in East Java (Chusairi & Husamah, 2025).

Phytoplankton respond to light and nutrients, zooplankton respond to food availability and predation, and fish assemblages can vary with habitat use and seasonal changes in water conditions (Isles et al., 2021; Li et al., 2025; Ersoy et al., 2019; Keller et al., 2019; Wanjari et al., 2025). In two connected subtropical reservoirs, Kuo et al. (2025) found that water-quality

variables helped explain variation in chlorophyll-a. This comparison highlights why the Tuban diversity values alone cannot identify nutrient conditions. These groups also differ in how they are sampled. Plankton nets retain organisms selectively, and fish catches depend on gear, effort, and taxon-specific detectability. Similar index values can therefore arise from different communities or observation processes. Comparing rankings within each assemblage allows the monitoring results to be read together while retaining those differences. At Boom Beach in Banyuwangi, Ayun et al. (2021) examined phytoplankton composition in relation to saprobity. That coastal application illustrates the value of pairing community records with environmental measurements and interpreting the indicators within their habitat.

Multi-indicator assessment is established in freshwater biomonitoring. For example, Lee et al. (2026) evaluated agreement in community dissimilarity between repeated survey rounds in Korean streams. Here, the available data support a comparison of site order within one monitoring period. Reservoir studies have used zooplankton alongside physicochemical measurements to assess trophic state, and fish surveys have used repeated sampling and documented effort to compare catches in relation to habitat or aquaculture (Espinosa-Rodríguez et al., 2025; Abd Hamid et al., 2023; Wanjari et al., 2025). The question for the Tuban survey was whether the same reservoir would rank highest across phytoplankton, zooplankton, and fish when the same descriptors were applied to each group. Separate summaries provide the individual rankings. Placing them side by side reveals where the rankings agree and where the choice of assemblage changes which site would be selected for follow-up.

Sugihan, Tobo, and Mliwang were the three reservoirs represented in the 2022 clay-mining biodiversity monitoring records used for this comparison. The sites occur within a landscape of mining, green belts, and agriculture. The monitoring description documents freshwater fish cultivation and rice-field irrigation at Sugihan. Documented differences in mining history, reservoir dimensions, and habitat among the three sites are needed before site rankings can be interpreted in relation to those characteristics.

The exploratory objectives were to describe observed richness and recorded counts for phytoplankton, zooplankton, and fish, summarize diversity, dominance, and evenness within each assemblage, and compare site rankings for richness and Shannon diversity. The comparison asked whether site rankings depended on the assemblage observed. The survey design supports that descriptive comparison for the three monitored reservoirs.

METHOD

Study Design and Sites

We used biodiversity monitoring records from July–December 2022 for Sugihan (SUG), Tobo (TOB), and Mliwang (MLI), three freshwater reservoirs within the clay-mining landscape of PT Semen Indonesia (Persero) Tbk in Tuban, East Java, Indonesia. The results were summarized at the reservoir level, giving three site summaries per assemblage. The date range describes the monitoring period. The site summaries do not resolve individual visits, stations, or replicates.

Plankton Sampling and Identification

Reservoir water was filtered with a plankton net. The monitoring method estimated filtered volume from the net-mouth area and towing distance. Concentrates were transferred to labelled bottles and preserved with 4% buffered formalin. Phytoplankton and zooplankton were identified microscopically to the lowest practicable taxonomic level and counted. The monitoring protocol cited Tomas (1997) and supplementary freshwater guides. The plankton totals are reported as recorded counts because the available summaries do not specify the counting unit or a conversion to density.

Fish Sampling and Identification

Fish were sampled with traps and supplemented by catches from local fishers. Fish were identified using regional identification references. Table 3 reports pooled counts by reservoir

and taxon, without separate totals for traps and fisher catches. The comparability of effort and gear across sites cannot be verified from these records. We therefore report numbers of fish recorded and use the pooled catches to describe observed composition.

Community Metrics and Interpretation

We defined observed taxon richness (S) as the number of recorded taxon labels with a positive count and total recorded count (N) as the sum of those counts. For relative count $p_i = n_i/N$, Shannon diversity was $H' = -\Sigma p_i \ln(p_i)$, Simpson dominance was $D = \Sigma p_i^2$, and Pielou evenness was $J = H'/\ln(S)$. We retained the taxonomic resolution represented in the available summaries. The fish matrix contains ten species-level labels and one genus-level label (*Pseudogobiopsis* sp.). The plankton summaries do not establish how genus-level and species-level labels were reconciled or whether higher-rank labels represented distinct unresolved material. We recalculated the fish indices from the pooled counts in Table 3. Plankton indices were retained as reported because the underlying counts by taxon and reservoir were unavailable for recalculation.

For the cross-assemblage comparison, we ordered the three reservoirs separately within each assemblage from highest to lowest observed richness and H′. Agreement means identical site order for the same metric. A shared top-ranked site with a different order below it represents partial agreement, and different top-ranked sites indicate discordance in the leading site. With three reservoir-level observations, we used rank order to summarize the records and did not estimate a correlation or perform a significance test. D and J were interpreted alongside richness and H′ within assemblages. Recorded counts were excluded from the rank comparison because the counting units and sampling effort differ.

RESULTS AND DISCUSSION

Observed Richness and Recorded Counts

The survey recorded 25 phytoplankton taxa, 22 zooplankton taxa, and 11 fish taxa across the three reservoirs. Mliwang had the highest observed phytoplankton richness (20 taxa) and fish richness (10 taxa). Tobo had the highest zooplankton richness (18 taxa) and the lowest fish richness (five taxa). Mliwang yielded the highest phytoplankton count (82 recorded units). Fish records ranged from 17 at Mliwang to 69 at Sugihan (Table 1). The raw totals reflect the material recorded by the survey.

Table 1. Observed taxon richness and recorded counts by assemblage and reservoir

Assemblage	Metric	SUG	TOB	MLI
Phytoplankton	Richness	16	17	20
	Recorded count	49	73	82
Zooplankton	Richness	13	18	14
	Recorded count	49	80	38
Fish	Richness	9	5	10
	Recorded count	69	40	17

Among the more frequently reported phytoplankton labels were *Chlamydomonas* sp. (24 records), *Plectonema* sp. (18), *Melosira varians* (14), *Spondylosium panduriforme* (14), and *Trachelomonas armata* (13). The zooplankton summary listed *Brachionus* sp. (22 records) and an entry labelled "*Favella ehrenbergi*" (20 records). The latter identification is provisional. The corresponding published name, *Favella ehrenbergii*, has been redescribed as a marine ciliate (Gong et al., 2010), so the freshwater record requires re-examination of the original material. These are pooled record totals. Their distribution across reservoirs and the effect of any identification changes on the indices require the underlying count matrix.

Diversity, Dominance, and Evenness

Reported H′ ranged from 2.51 to 2.69 for phytoplankton, 2.17 to 2.67 for zooplankton, and 1.41 to 2.15 for fish (Table 2). Tobo had the highest zooplankton H′ and the lowest fish H′.

Across the nine assemblage–reservoir combinations, D ranged from 0.08 to 0.29 and J from 0.85 to 0.94. The highest D occurred in Tobo's fish catch, in which 18 of 40 individuals were recorded as *Oryzias javanicus* (Table 3).

Table 2. Shannon diversity (H′), Simpson dominance (D), and Pielou evenness (J) by assemblage and reservoir

Assemblage	Site	H′	D	J
Phytoplankton	SUG	2.55	0.09	0.92
Phytoplankton	TOB	2.51	0.11	0.89
Phytoplankton	MLI	2.69	0.08	0.90
Zooplankton	SUG	2.17	0.16	0.85
Zooplankton	TOB	2.67	0.08	0.92
Zooplankton	MLI	2.35	0.12	0.89
Fish	SUG	2.06	0.14	0.94
Fish	TOB	1.41	0.29	0.88
Fish	MLI	2.15	0.13	0.93

Tobo's fish catch illustrates how high evenness can coexist with low observed richness. J was 0.88 for the five taxa recorded there, whereas Mliwang had ten recorded fish taxa and J of 0.93. Taxonomic resolution also affects the indices. Combining categories can lower observed richness and H′ and raise D, while J can move in either direction because its denominator depends on S. If higher-rank labels are treated as separate categories despite overlapping with named taxa, apparent richness can increase. Differences in mesh retention, subsampling, and taxonomic resolution could therefore alter plankton rankings, especially where index values are close. Surveys of Collembola across land-use types in the upper Brantas watershed, sea cucumbers across reef sites in Sapeken, and molluscs in the Cengkrong mangroves likewise illustrate how richness and relative abundance describe different features of an assemblage (Husamah et al., 2016; Rahardjanto, Husamah, et al., 2020; Rahardjanto, Tosiyana, et al., 2020).

Fish Composition and Recorded Catch

The pooled fish catch contained 126 individuals across 11 recorded taxa. *Oryzias javanicus* was the most frequently recorded fish (28 individuals), followed by *Rasbora argyrotaenia* (25) and *Puntius brevis* (18). Mliwang yielded ten taxa in 17 fish, whereas Sugihan yielded nine taxa in 69 fish. Because capture effort and gear-specific detectability are unresolved, the small Mliwang catch cannot establish low local fish abundance. The counts reflect both the fish encountered and the process by which they were captured.

Table 3. Pooled fish counts from traps and supplementary fisher catches by taxon and reservoir

Recorded taxon	Family	SUG	TOB	MLI	Total
Aplocheilus panchax	Aplocheilidae	8	0	1	9
Channa striata	Channidae	2	0	1	3
Mystacoleucus obtusirostris	Cyprinidae	7	0	0	7
Oreochromis mossambicus	Cichlidae	0	4	1	5
Oreochromis niloticus	Cichlidae	8	0	1	9
Oryzias javanicus	Adrianichthyidae	9	18	1	28
Poecilia reticulata	Poeciliidae	0	8	1	9
Pseudogobiopsis sp.	Gobiidae	7	0	2	9
Puntius brevis	Cyprinidae	12	3	3	18
Rasbora argyrotaenia	Danionidae	14	7	4	25
Barbodes binotatus	Cyprinidae	2	0	2	4
Total		69	40	17	126

Note. The source label *Systomus binotatus* is listed under the accepted combination *Barbodes binotatus* (Fricke et al., 2026). *Rasbora argyrotaenia* is placed in Danionidae (Froese & Pauly, 2026). *Pseudogobiopsis* sp. was identified to genus only. Zeros indicate no individuals recorded in the pooled catches.

Abd Hamid et al. (2023) used repeated sampling and catch per unit effort to compare fish assemblages near and farther from tilapia cages in Malaysia's Temengor Reservoir. Sugihan's fish cultivation and its records of *Oreochromis niloticus* justify documenting stocking and harvest in subsequent surveys. The Tuban records have no comparable aquaculture gradient or effort-standardized fish catches. Wanjari et al. (2025) sampled India's Gosikhurd Reservoir over a year and related fish observations to environmental measurements. Repeated surveys of that kind would help determine whether the fish ranking observed in Tuban recurs under comparable sampling conditions.

Agreement in Reservoir Rankings Across Assemblages

Mliwang ranked first for phytoplankton and fish in both richness and H′. Tobo ranked first for zooplankton on both metrics and last for fish. The full phytoplankton and fish H′ rankings were identical (MLI > SUG > TOB), while the zooplankton H′ ranking was TOB > MLI > SUG. The richness rankings of all three assemblages differed (Figure 1). This descriptive agreement for some comparisons and discordance for others identifies which observations would be missed if monitoring used only one assemblage.

Metric	Assemblage	1st	2nd	3rd
Taxon richness	Phytoplankton	MLI	TOB	SUG
	Zooplankton	TOB	MLI	SUG
	Fish	MLI	SUG	TOB
Shannon diversity	Phytoplankton	MLI	SUG	TOB
	Zooplankton	TOB	MLI	SUG
	Fish	MLI	SUG	TOB

Figure 1. Reservoir rankings from highest (1st) to lowest (3rd) observed richness and Shannon diversity within each assemblage. MLI = Mliwang, TOB = Tobo, and SUG = Sugihan. Rankings use Tables 1 and 2.

In a subtropical Australian reservoir, Hunt and Matveev (2005) manipulated nutrient supply and zooplankton community structure to investigate phytoplankton growth. Their experiment illustrates the additional evidence needed to distinguish resource effects from grazing effects. In central Mexican reservoirs and lakes, Espinosa-Rodríguez et al. (2025) compared zooplankton indicators with physicochemical trophic-state metrics. Our H′ values describe the distribution of counts among recorded taxa and serve a different purpose from those trophic-state indicators. The Tobo contrast could reflect habitat structure, nutrient supply, predation, stocking, or harvest. Gear selectivity, mesh retention, and differences in effort could also contribute. The available observations cannot distinguish these explanations.

The comparison pools observations within one monitoring period and lacks matched environmental measurements. Site rankings cannot resolve seasonal or temporal stability or establish the effects of mining. Uncertain catch provenance and effort constrain fish comparisons, while missing counts by plankton taxon and reservoir prevent independent verification of the plankton indices. These constraints limit the comparison to observed profiles in the 2022 monitoring records.

Shoreline and catchment mapping could document changes in littoral habitat and surrounding land use between survey rounds. Indonesian mangrove studies illustrate how field observations can complement imagery and how repeated mapping can document habitat change (Bulloh et al., 2026; Husamah, Rahardjanto, Hudha, et al., 2026; Husamah, Rahardjanto, & Romadoni, 2026). Reviews of mangrove carbon estimation and verification also illustrate the need to match remote-sensing products to the variable of interest and document how they are validated (Romadoni et al., 2025, 2026). For the Tuban reservoirs, mapped habitat variables would complement repeat plankton and fish surveys.

A shared monitoring register could link each sample to its station, date, field measurements, and laboratory record. The Sukoharjo landfill study provides an Indonesian example of evaluating an environmental information system with users (Werdianto et al., 2025). Studies on spring protection, river stewardship, and mangrove management in East Java also show how local groups can contribute to conservation activities (Husamah & Hudha, 2018; Rahardjanto et al., 2025, 2026). At Sugihan, fishers and reservoir managers could help maintain the stocking and harvest records.

Laboratory procedures should specify how samples are labelled, processed, and retained, and how taxonomic decisions are documented. Reviews of tropical laboratory research and green laboratory practice provide broader guidance on resource use, waste reduction, and the oversight of digital tools. Work on technical communication offers a complementary framework for making procedures clear to field and laboratory teams (Adara et al., 2026; Fauzi & Fatmawati, 2025; Husamah et al., 2024, 2025). Field-to-laboratory surveillance of mosquito populations in Malang illustrates the value of retaining collection locality in the reporting of biological observations (Agustin et al., 2024). If a later survey uses molecular identification to check ambiguous records, it should validate the workflow for reservoir samples. Nuryady et al. (2026) provide an example of workflow validation for a different sample type.

CONCLUSION

The 2022 monitoring records show that reservoir rankings depended on the assemblage and metric used. Tobo ranked highest in observed zooplankton richness and Shannon diversity and lowest in both fish measures. Mliwang ranked highest in phytoplankton and fish richness and Shannon diversity despite yielding the smallest recorded fish catch. These profiles provide a baseline for follow-up at the three reservoirs. Temporal stability, reservoir health, and mining effects remain unresolved with the available sampling and environmental records.

RECOMMENDATION

Follow-up monitoring should retain separate profiles for plankton and fish, repeat fish sampling at Tobo to evaluate its low observed richness, and check whether Mliwang's small recorded catch recurs under comparable effort. Future surveys should use fixed stations, record plankton sampling volumes and counting units, document fish gear and effort, and keep standardized and supplementary fish catches separate. Repeated wet- and dry-season sampling paired with measurements of nutrients, chlorophyll-a, dissolved oxygen, conductivity, transparency, depth, and littoral habitat would help evaluate environmental explanations. Documenting stocking and harvest would help interpret fish records at Sugihan.

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AUTHOR CONTRIBUTIONS STATEMENT

Name of Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
Supiana Dian Nurtjahyani	✓	✓	✓	✓	✓				✓	✓			✓	
Dwi Oktafitria	✓	✓				✓		✓	✓	✓	✓		✓	
Avivi Nur Aina	✓		✓	✓	✓	✓		✓	✓	✓			✓	
Susanti Dhini Anggraini	✓					✓		✓	✓	✓	✓		✓	
Agrifa Tarigan						✓		✓	✓	✓			✓	
Moch Khalik Hermawanto								✓	✓	✓			✓	

CONFLICT OF INTEREST STATEMENT

The authors declare that they have no known competing financial or personal interests that could have influenced the work reported in this article.

ETHICAL APPROVAL

This study involved secondary analysis of biodiversity monitoring records collected in 2022 and did not involve additional field sampling or experimental procedures conducted specifically for the present analysis. The original monitoring activities included plankton sampling and fish collection. Information concerning institutional ethical approval and relevant sampling permits for the original monitoring programme was not available in the records examined for this manuscript.

DATA AVAILABILITY

The study draws on the 2022 biodiversity monitoring report. Table 1 provides reservoir-level richness and count summaries, Table 2 reports the derived indices, and Table 3 provides the pooled fish count matrix. The materials accompanying this revision do not include the complete phytoplankton and zooplankton count matrices, the underlying sampling logs, or fish counts separated by capture source.

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