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Fish Community Assessment in Serayu Moveable Dam Post-Catastrophic Mortality

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Abstract. Catastrophic mortality occurred in the fish community at Serayu Movable Dam in 2022. The phenomenon was caused by severe water quality alteration due to sediment flushing from Panglima Besar Soedirman Dam. After the incident, the fish community in the reservoir has never been evaluated. This study aimed to assess the fish community status in the Serayu Movable Dam post-catastrophic mortality in 2022. The study was conducted using a survey method, and fish samples were collected three times at six sampling sites at an interval of two weeks. Fish identification was done using the identification key in the references. Various community and water quality parameters were measured. The data obtained were analyzed descriptively by comparing them with standards in the literature. A total of 27 species were identified with a richness index of 4.564, relative abundance of 0.037, diversity index of 2.111, evenness index of 0.693, and dominance index of 0.259. The data proved that the fish community in Serayu Movable Dam has recovered after two years of catastrophic mortality in 2022. It could be due to the characteristic of the riverine ecosystem that can revert due to the continuous replacement of water from various tributaries that flow into the Serayu River in the upstream part of the Serayu Movable Dam, as shown by good water quality. It can be concluded that high ichthyofauna diversity was observed in the Serayu Moveable Dam post-catastrophic mortality. The data are essential scientific bases for sediment flushing management at P.B. Soedirman Dam and management of freshwater fish community in Serayu Movable Dam.

Keywords: abundance; community; diversity; dominance; movable dam

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INTRODUCTION

The fish community in certain ecosystems can be assessed by evaluating various ecological parameters, such as abundance, diversity, dominance, and evenness (Jumani et al., 2018; Lal et al., 2020; Nunes et al., 2020). Those parameters are affected by several other ecology factors, which are broadly divided into biotic and abiotic factors (Gebrekiros, 2016; Sambora et al., 2023; Obayemi et al., 2024). The abiotic factors of the riverine system might be altered due to dam or reservoir construction, ultimately affecting the fish community (Zhu et al., 2025; Li et al., 2024; Mostafavi et al., 2021; Plavova et al., 2017). The negative impacts of the dam have also occurred in the Serayu River, where *Barbonymus balleroides* population above and below the PB Soedirman Reservoir are genetically significantly different (Granzotti et al., 2018; Benejam et al., 2016; Holcomb et al., 2015).

The PB Soedirman Reservoir in Banjarnegara Regency was built on the Serayu River in 1988 (Haryono et al., 2017). The main purpose of the PB Soedirman Reservoir construction is to serve as a water source for hydroelectric power plants. Another function of the PB Soedirman Reservoir is as a water source for irrigation. The PB Soedirman Reservoir has also been used by the community as a place for fish farming by implementing floating net cage farming techniques. The use of fish farming techniques and land erosion from the upstream area has caused the sedimentation process in the PB Soedirman Reservoir to become faster (Andriani et al., 2018) and shorten the functional life of the reservoir (Castillo et al., 2015).

Sediment flushing is one of the methods used by Dam managers to reduce the sediment load in the reservoir and is generally carried out routinely over tens of years (Kondolf et al., 2014). The management of the PB Soedirman Reservoir in Banjarnegara has carried out water flushing to overcome sedimentation. The main purpose of the management in carrying out water flushing is to extend the life of the reservoir function and maintain the reservoir's capacity to generate electricity and as a source of drinking water (Utomo, 2019).

Sediment flushing can wash away sediment reaching millions of cubic meters. Extremely high sediment during flushing affected water quality by volumes can increase the concentration of total suspended sediment (TSS) (Espa et al., 2019; Schenk & Bragg, 2021), increase chemical oxygen demand (COD) levels, and reduce oxygen (O2) levels to 0.71 ppm (Schenk & Bragg, 2021), thus having an ecological impact on downstream areas (Peter et al., 2014), including on downstream fauna communities (Schenk & Bragg, 2021; Espa et al., 2019; Reckendorfer et al., 2019; Moridi & Yazdi, 2017). Previous studies have stated that water flushing has a very real ecological impact on fauna communities in downstream areas (Schenk & Bragg, 2021; Espa et al., 2019; Reckendorfer et al. 2019), including fish communities (Grimardias et al., 2019; Moridi & Yazdi, 2017). Nuryanto et al. (2015) stated that fish existence in a river body is affected by the river's chemical characteristics, such as carbon dioxide level, dissolved oxygen, acidity (pH), temperature, and organic and inorganic materials. Moreover, water acidity might further cause morphological alterations (Mustikasari, *et al.,* 2022) and even influence fish sexuality (Sari & Jakaria, 2017.

The latest sediment flushing from the PB Soedirman Reservoir, carried out in April 2022 and has caused catastrophic mass mortality in the fish community in the Serayu Movable Dam, which is located approximately 61 km away from PB. Soedirman downstream. The phenomenon was thought to be caused by adverse water quality due to the lethal content of toxic materials such as suspended solids (TSS), Chemical oxygen demand (COD), nitrate, and ammonia far exceeded the threshold values listed in government regulations on water quality standards for fisheries. Meanwhile, the dissolved oxygen (DO) (Regional Technical Implementation Unit (UPTD) of the Environmental Laboratory unpublished data).

Previous studies have reported that the fish community in the downstream area of the Serayu River, which includes the Serayu Movable Dam, consists of 16 species (Romdhon et al., 2015). The fish community in the Serayu Moveable Dam post-catastrophic mortality in 2022 has never been evaluated. Ecological studies to monitor the fish community status in the Serayu Movable Dam post-sediment flushing in 2022 are urgently needed. This study aimed to assess the fish community status in the Serayu Movable Dam post-catastrophic mortality in 2022. The information obtained is essential as a scientific basis to formulate policies on sediment reduction strategies from reservoirs that are more effective, efficient, and environmentally safe.

METHODS

Sampling location

This study was conducted at Serayu Movable Dam, Banyumas Regency, Central Java, using a survey method. Fish samples were collected from six sampling sites inside and downstream of Serayu Movable Dam (Figure 1).

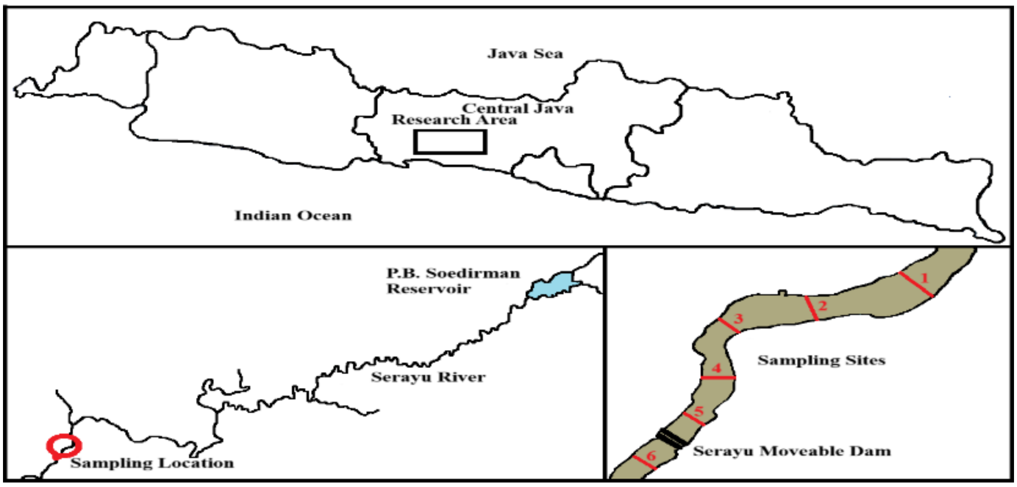

Figure 1. Map of Java Island showing Fish sampling sites inside and downstream of Serayu Movable Dam (1-6)

Table 1. The geographic position of each sampling site

Station	Coordinate
1.	7°31′03.7″S, 109°12′21.5″E
2.	7°31′03″S, 109°12′16″E
3.	7°31′08″S, 109°12′11.2″E
4.	7°31′15.7″S, 109°12′10.1″E
5.	7°31′19.9″S, 109°12′09.2″E
6.	7°31′34″S, 109°12′00.6″E

The determination of sampling stations was based on ease of access to the location and environmental characteristics. The geographic position of each sampling site is summarized in Table 1.

Fish collection and identification

Fish samples were collected by installing gill nets of different mesh sizes (0.5 inches, 1 inch, and 2 inches) at each predetermined sampling site. The nets were installed in the morning and evening. The duration of the gill net installation was three hours for each sampling. Fish sampling was repeated three times with a time interval between sampling for two weeks. Fish samples were grouped based on location, time of collection, and repetition. Fish samples were preserved in an ice box filled with ice cubes. The fish samples were then taken to the Aquatic Biology Laboratory and stored in the freezer.

Fish samples were identified and determined based on their morphological characteristics. The identification process following key characters is available in Fish Taxonomy and Identification manuals (Kottelat et al., 1993; Froese & Pauly 2023). The validity of the scientific name was confirmed by comparing the result to the scientific name listed in Eschmeyer's Catalog of Fishes (Fricke et al., 2023).

Research parameters

Various parameters were calculated to evaluate fish community status in the Serayu Moveable Dam. Those parameters were absolute species richness (S), species richness index (R), absolute abundance, relative abundance (pi), Shannon diversity index (H’), Simpson dominance index (D), and evenness index (E).

Data Acquisition

Absolute species richness or composition was determined based on the number of species obtained during sampling activities. Species richness can also be estimated using the species richness index (R). The species richness index followed the formula proposed by Margalef as implemented by (Prayogo et al., 2022).

$$R = \frac{S-1}{LnN}$$

Remarks:

R	=	Species richness index
S	=	Total number of species
N	=	Total number of individuals
Ln	=	Natural Log

Absolute abundance indicated the total count of individuals collected during the study. Relative abundance (pi) was calculated using the following formula.

$$pi = \frac{ni}{N} X100\%$$

Remarks:
Pi = relative abundance
ni = Number of individuals of the i^{th} species
N = Total number of individuals of all species

This study used the diversity index from Shannon-Wiener (H’) to estimate the diversity status of the fish community in Serayu Moveable Dam. The diversity index was calculated using the following formula, as used by previous study (Aryani et al., 2020).

$$H' = -\sum_{i=1}^{s} pi \ln pi$$

Remarks:
H’ = Diversity Index
s = species number
pi = ni/N
ni = number of individuals of the ist species
N = Total number of individuals of all species

Simpson's dominance index was used during the study. The fish dominance was determined using the formulas used by Erika et al. (2021).

$$D = \sum (ni(ni-1))/(N(N-1))$$

Remarks:
Ni = Number of individuals of the i-th species
N = Total number of individuals of all species
D = 1, indicates that there is only one dominant species in a community
D = 0, showing no dominant species in a community.

Analysis of the level of evenness of individual abundance between each species uses the Evenness Index (E=Evennes) (Sari et al., 2020). The evenness index can be used as an indicator of the presence of dominance symptoms among species in a community. The formula used to calculate the species evenness index is:

$$E = \frac{H'}{\ln S}$$

Remarks:
E = Species evenness index
H' = Species diversity index
S = Number of species.

The water quality status in Serayu Movable Dam was determined by measuring various physical and chemical parameters. The water quality parameters and the measurement methods used during the study are presented in Table 2.

Data Analysis

The data were analyzed descriptively by comparing the results and the standards available in the references.

RESULTS AND DISCUSSION

Species richness

Two hundred ninety-eight (298) fish individuals were collected during the sampling from May to August 2024 from inside and downstream of Serayu Moveable Dam. The samples can be grouped taxonomically into 9 orders, 16 families, and 26 species (S). Some of the obtained species are presented in Figure 2.

Cyprinidae was the most dominant family with 8 species, followed by Bagridae, Cichlidae, and Mastacembelidae with two species, respectively. The taxonomic diversity of the fish community in Serayu Moveable Dam is presented in Table 3

If we focused on the fish community inside the Serayu Moveable Dam, we could realize that 20 species were obtained, from the downstream of the dam of 15. Fish species inhabited both inside and downstream of the dam were nine (Table 4).

Table 2. Physical-chemical parameters and measurement methods used during the research

No.	Parameter	Unit	Tool/method	Source
1.	Dissolved O2	mg/L	Winkler Method	American Public Health Association (2005)
2.	pH	-	pH meter	
3.	Temperature	°C	Thermo-hygrometer	
4.	Brightness	cm	Secchi disc	
5.	Depth	cm	Deep sounder	
6.	TDS	mg/L	Gravimetry	
7.	Current speed	m/second	Current meter	

Table 3. Taxonomic diversity of the fish community in Serayu Moveable Dam collected during the sampling

No.	Order	Family	Scientific Name
1.	Anabantiformes	Channidae	*Channa striata* Bloch, 1793
		Osphronemidae	*Osphronemus goramy* Lacepède, 1801
2.	Anguilliformes	Anguillidae	*Anguilla bicolor* McClelland, 1844
3	Characiformes	Serrasalmidae	*Colossoma macropomum* (Cuvier, 1816)
4.	Cichliformes	Cichlidae	*Oreochromis mossambicus* Peters, 1852
			Oreochromis niloticus (Linnaeus, 1758)
5.	Cypriniformes	Cyprinidae	*Barbodes binotatus* (Valenciennes, 1842)
			Barbonymus gonionotus Bleeker, 1849
			Cyclocheilichthys apogon (Valenciennes, 1842)
			Hampala macrolepidota Kuhl & Van Hasselt, 1823
			Labiobarbus leptocheilus Valenciennes, 1842
			Osteochilus pleurotaenia Bleeker, 1855
			Osteochilus vittatus (Valenciennes, 1842)
			Systomus rubripinnis Valenciennes, 1842
		Danionidae	*Rasbora lateristriata* Bleeker, 1854
		Nemacheilidae	*Nemacheilus pfeifferae* Bleeker, 1853
6.	Cyprinodontiformes	Poeciliidae	*Poecilia reticulata* Peters, 1859
7.	Gobiiformes	Butidae	*Oxyeleotris marmorata* Bleeker, 1852
8.	Siluriformes	Bagridae	*Hemibagrus nemurus* (Valenciennes, 1840)
			Mystus cavasius Hamilton, 1822
		Clariidae	*Clarias batrachus* (Linnaeus, 1758)
		Loricariidae	*Hypostomus plecostomus* (Linnaeus, 1758)
		Siluridae	*Ompok bimaculatus* Bloch, 1794
9.	Synbranchiformes	Mastacembelidae	*Macrognathus aculeatus* (Bloch, 1786)
			Mastacembelus armatus Lacepède, 1800
		Synbranchidae	*Monopterus albus* (Zuiew, 1793)

Table 4. Fish species found inside and downstream of Serayu Moveable Dam

No.	Fish Species	Serayu Inside	Moveable Dam Downstream
1.	*Hemibagrus nemurus*	+	+
2.	*Colossoma macropomum*	+	+
3.	*Monopterus albus*	-	+
4.	*Oxyeleotris marmorata*	+	+
5.	*Systomus rubripinnis*	+	-
6.	*Mastacembelus armatus*	-	+
7.	*Channa striata*	+	-
8.	*Poecilia reticulata*	+	-
9.	*Osphronemus goramy*	+	-
10.	*Cyclocheilichthys apogon*	+	-
11.	*Clarias batrachus*	+	-
12.	*Labiobarbus leptocheilus*	+	-
13.	*Oreochromis mossambicus*	+	-
14.	*Oreochromis niloticus*	+	+
15.	*Osteochilus pleurotaenia*	+	+
16.	*Osteochilus vittatus*	+	+
17.	*Ompok bimaculatus*	+	-
18.	*Hampala macrolepidota*	+	+
19.	*Hypostomus plecostomus*	+	+
20.	*Mystus cavasius*	+	-
21.	*Anguilla bicolor*	-	+
22.	*Macrognathus aculeatus*	+	-
23.	*Barbonymus gonionotus)*	+	+
24.	*Nemacheilus pfeifferae*	-	+
25.	*Barbodes binotatus*	-	+
26.	*Rasbora lateristriata*	-	+
Total		20	15

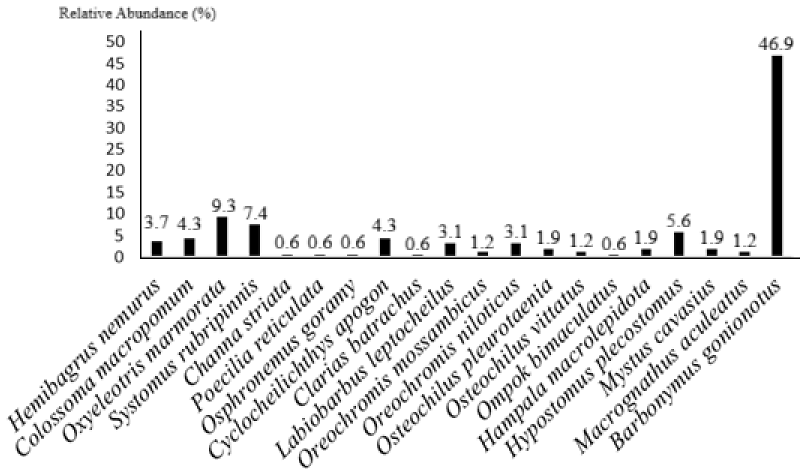

Figure 2. Species relative abundance inside Serayu Moveable Dam

The total number of species obtained during the study inside Serayu Moveable Dam indicates high species richness (Table 4). Previous studies have noted that riverine ecosystems inhabited by more than 16 fish species prove that this riverine ecosystem has high species richness (Nuryanto et al. 2015; Nuryanto et al. 2016). Our finding of 20 species inside the dam showed higher species richness than that reported in a previous study by Romdhon et al. (2015) and Wahyuni & Zakaria (2018). Romdhoni et al. (2015) found 16 fish species in the downstream areas of the Serayu River, while Wahyuni & Zakaria (2018) reported that 13 fish species inhabit the Luk Ulo River. If we count all of the obtained species during the study (Table 3), we found even higher species richness than that reported by Romdhoni et al. (2015) and Wahyuni & Zakaria (2018) because we found 26 fish species from inside and downstream of Serayu Movable Dam.

Ecological perspective

Several ecological parameters were measured to evaluate the fish community in Serayu Movable Dam post-catastrophic mortality in 2022. The parameters include relative abundance (Figure 2).

Species' relative abundance ranged from 0.6% to 46.9% (Figure 2). The values indicated the highly variable presence of each species in the community during the study. The most abundant species was *B. gonionotus* (Silver barb) with a relative abundance of 46.9%. The value proved that the silver barb was the most common species in the Serayu Movable Dam post-catastrophic mortality in 2022. The phenomenon could be due to the restocking program of that species conducted by the local government immediately after the post-catastrophic mortality in 2022 (personal interview with local fishermen). The second common species was *O. marmorata* with a relative abundance of 9.3%. The phenomenon could be due to two reasons. Firstly, the species is among the dominant introduced species in P.D. Soedirman Dam, which might be transported during sediment flushing from P.B. Soedirman Dam to Serayu Movable Dam. Secondly, *O. marmorata* is a tough fish, so some of them can survive when there is a catastrophic death event and survive on the Serayu Movable Dam.

Species richness, Shannon-Wiener diversity, dominance, and evenness indexes obtained during the study are summarized in Table 5.

Table 5. Ecological biodiversity indexes

No	Parameter	Value
1	Species richness index (R)	3.73
2	Shannon-Wiener index (H')	2.08
3	Dominance index (D)	0.24
4	Evenness index (E)	0.69

The species richness index was 3.73 (Table 5). The value proves that fish species richness in Serayu Movable Dam two years post-catastrophic mortality is categorized as medium. The decision was made based on standard values, as has been used by Prayogo et al. (2022), species richness between 2 and 4 is classified as medium species richness. Our results showed a lower species richness index reported by Prayogo et al. (2022), who reported a species richness index of 4.48 in the Talai River and 8.20 in the Keriau River, which is categorized as high species richness. The comparison to that of Prayogo et al. (2022) was not congruent because of the differences in areas of study. Our study was conducted in a dam or reservoir, which is only a small part of a river, while Prayogo et al. (2022) carried out the research along the river, meaning much longer and wider areas. Therefore, it is reasonable that we observed a lower species richness than that of Prayogo et al. (2022). Previous studies reported that longer and wider areas or rivers might have a higher species richness because of a much higher microhabitat to support various species of fish (Nuryanto et al., 2015, Nuryanto et al., 2016).

Shannon diversity index (H') was 2.078 (Table 5). The obtained index might prove that fish species diversity in the Serayu Movable Dam post-catastrophic mortality was at a medium level. The decision was based on the values proposed by Odum (1971) that the diversity index ranges from 1 to 3, indicating medium species diversity. We compared our Shannon-Wiener index to a similar index reported by previous studies, which are summarized in Table 6.

This result proved that the fish community in Serayu Moveable Dam's two years post-catastrophic mortality is suggested to revert. This assumption is supported by the fact that even though the research was only carried out in the Serayu Movable Dam, it had a diversity index similar to a study along the rivers and a more stable and larger reservoir, i.e. Koto Panjang Reservoir. Even we observed a higher diversity index compared to research in Sihutang Dam, China, reported by Liu et al. (2018) as presented in Table 6. Nevertheless, the comparison to Liu et al. (2018) was not one hundred percent congruent since both studies were carried out in different geographic regions with different climates. The current study was done in the tropical region, while the previous study by Liu et al. (2018) was carried out in the subtropical region. There is a common acceptance that tropical areas have higher biodiversity. Therefore, it is reasonable that we obtained higher fish diversity in the Serayu Moveable Dam compared to the Shitungan Dam (Liu et al., 2018).

During the study, we obtained a dominance index (D) of 0.24 (Table 5). The observed D value indicates that there was no dominance has occurred in the fish community on Serayu Moveable Dam two years (2024) post-catastrophic mortality in 2022, even though *B. gonionotus* had the highest abundance (46.9%, Figure 2). Low dominance or no dominance in fish communities has also been reported by previous researchers in several rivers in Kapuas Hulu (Prayogo et al. 2022), Linggang River (Erika et al. 2021), and Sari et al. (2020) in Pelepat River. We determined dominance did not occur in the community since the observed value was close to 0 (0.24). According to Prayogo et al. (2020), D similar to zero (0) indicates no dominance has occurred, while D equal to one (1) proves that dominance occurred in the community. The dominance status did not happen in the fish community in the Serayu Moveable Dam during the study, indicating that the fish community had almost reached an equilibrium. The high presentation of Silver Barb (*B. gonionotus*) could be due to the restocking effort carried out by the local Government of Banyumas immediately after catastrophic fish mortality in 2022 (personal communication with local fishermen). We assume that if no restocking program has been made, the fish community in Serayu Moveable will completely recover. The abundance of *B. gonionotus* could also be due to the nature of *B. gonionotus* prefers habitats with weak river currents (Samitra & Rozi, 2018).

The Evenness index is among the common index measured in community studies (Prayogo et al., 2022; Erika et al. 2021; Sari et al., 2020; Samitra dan Rozi, 2018). The evenness index in Serayu Moveable Dam post-catastrophic mortality was 0.69 (Table 5). This value was higher than that reported from Kotopanjang reservoir (0.19). The observed value proved that fish species in the Serayu Moveable Das were unevenly distributed. According to Samitra & Rozi (2018), a low E value indicates that fish species do not have a similar distribution.

Table 6. Shannon-Wiener diversity index comparison

No.	Study	Study Site	H'	Status
1.	Current (our)	Serayu Moveable Dam	2.08	Medium
2.	Prayogo et al. (2022)	Lisum River	2.04	Medium
3.	Budiman et al. (2021)	Batang Uleh River	2.43	Medium
4.	Aryani et al. (2020)	KotoPanjang Reservoir	2.10	Medium
5.	Muhammad et al. (2020)	Tembesi River	2.01-2.18	Medium
6.	Sari et al. (2020)	Batang Pelepat RIver	2.24	Medium
7.	Erika et al. (2018)	Linggang River	1.87-2.15	Low-Medium
8.	Samitra & Rozi (2018)	Kelingi River	0.33-1.22	Low
9.	Liu et al. (2018)	Sihutang Dam China	1.39-1.76	Low

Table 7. Water quality parameters inside Serayu Moveable Dam

No.	Parameter	Value	Standard**	
		Current Study	Class II	Class III
1.	DO (mg/L)	6.45-9.29	4	3
2.	Temperature (°C)	26.60-32.10	Dev 3	Dev 3
3.	TDS (mg/L)	74.30-108.00	1,000	1,000
8.	pH	6.06-9.60	6-9	6-9

Note:
* Local government of Banyumas (unpublished)
** Standard Gov. Reg. No. 22 Year 2021 Appendix VI part II: Class II and III for freshwater aquaculture

The water quality status inside the Serayu Moveable Dam was estimated based on various parameters. The result of water quality parameters measurement during the study and its standard values for freshwater aquaculture are presented in Table 7.

Based on the water quality standard for aquaculture classes 2 and 3 (Table 7), the mean values of the water quality parameters were at an allowable level for freshwater aquaculture (Governmental Law of the Republic of Indonesia No. 22 Year 2021). These parameters were dissolved oxygen, TDS, pH, and temperature. In contrast, DO concentration post-sediment flushing ranged between 2.58-2.78 mg/L (Local Government Agency, unpublished data), which was below standard even for class 3 qualification (3 mg/L). The water quality during the study is a strong argument that the fish community in Serayu Moveable Dam tended to recover such the community condition before catastrophic mortality in 2022 caused by severe water quality alteration due to sediment flushing from the upstream dam, i.e. P.B. Soedirman Reservoir.

This study provides the first data about the fish community and water quality in Serayu Moveable Dam post-catastrophic mortality in 2022 due to sediment flushing from P.B. Soedirman Reservoir. The data are essential scientific bases for sediment flushing management at P.B. Soedirman Dam and management of freshwater fish community in Serayu Movable Dam.

CONCLUSION

According to the results, it can be concluded that the fish community in Serayu Moveable Dam has recovered after a mass mortality in 2022. However, continuous monitoring is necessary to ensure the sustainability of the fish community in the Serayu Moveable Dam. Further study is necessary, such as barcoding of the fish community in Serayu Moveable Dam, to certainly identify valid species names.

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AUTHOR CONTRIBUTION STATEMENT

All authors contributed significantly to the work reported in this manuscript. DNW conceived and designed the study, conducted the data analysis, and led the manuscript writing. SR was responsible for data collection and contributed to data interpretation. CMI critically reviewed the manuscript for important intellectual content, assisted in the literature review, and provided substantial feedback during the manuscript drafting process. All authors read and approved the final manuscript and agreed to be accountable for all aspects of the work.

INFORMED CONSENT STATEMENT

Fish samples were bought from fishermen, threated and preserved following standard protocol.

CONFLICT OF INTEREST STATEMENT

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

USE OF ARTIFICIAL INTELLIGENCE (AI)-ASSISTED TECHNOLOGY

The authors declare that no artificial intelligence (AI) tools were used in the generation, analysis, or writing of this manuscript. All aspects of the research, including data collection, interpretation, and manuscript preparation, were carried out entirely by the authors without the assistance of AI-based technologies.

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