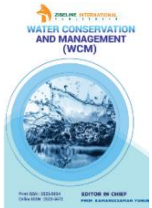
Water Conservation & Management (WCM)

DOI: http://doi.org/10.26480/wcm.03.2025.473.480

ISSN: 2523-5664 (Print)
ISSN: 2523-5672 (Online)
CODEN: WCMABD



RESEARCH ARTICLE

WATER POLLUTION INDEX IN BATANGHARI RIVER DHARMASRAYA REGENCY, WEST SUMATERA PROVINCE, INDONESIA

Andri Warsa[a*], Mochammad Zamroni[a], Dwi Atminarso[a], Rendy Ginanjar[a], Muhammad Nizar[b], Lismining Pujiyani Astuti[a], Didik Wahju Hendro Tjahjo[a]

[a]*Research Center for Conservation of Marine and Inland Water Resources, Cibinong Science Center, Jl. Jakarta-Bogor Km 48 Cibinong, West Java, Indonesia*
[b]*Muhammadiyah University of Palembang, Jalan Jenderal Ahmad Yani 13 Ulu Palembang 30263, South Sumatera, Indonesia*
**Corresponding Author Email: andriwarsa@yahoo.co.id*

Article History:

Received 11 April 2025
Revised 21 May 2025
Accepted 17 June 2025
Available online 23 July 2025

ABSTRACT

The Batanghari River is the longest river in Sumatra, exhibiting a significant fish diversity. Settlements, agricultural and plantation lands, together with gold mine activities, have emerged as sources of contaminants that degrade river water quality. This adversely affects biodiversity and public health. This study aimed to assess the water quality of the Batanghari River through physical, chemical, and biological characteristics to inform sustainable management practices. The research was carried out from 2018 to 2023 at five locations by collecting samples on surface water. The observed water quality parameters included iron (Fe), mercury (Hg), manganese (Mn), copper (Cu), biological oxygen demand (BOD), chemical oxygen demand (COD), fecal and total coliforms, pH, water temperature, and total suspended solids (TSS). The water contamination level was assessed using the cumulative pollution index (CPI) and the water pollution index (WPI). The findings indicated that the water quality in the Batanghari River has deteriorated, classified as significantly contaminated temporally and spatially. The CPI and WPI values observed at all stations varied from 2.11-4.21, with an average of 2.79, whereas the range was from 2.04-4.15, with an average of 2.73, and the highest record at station 5. The CPI and WPI values throughout the observation period varied from 2.16-5.5, with an average of 3.29, and from 2.10-5.48, with an average of 3.26, the highest values is in 2022. The concentration of heavy metals has surpassed quality limits in the following order: Fe>Cu>Mn>Hg. The parameters Fe, TSS, fecal coliform, and COD were the characteristics that significantly influence the values of CPI and WPI.

KEYWORDS

heavy metals, degradation, water quality, river

1. INTRODUCTION

Water is an essential resource that provides numerous benefits to humanity. However, the availability of good water quality has becoming increasingly rare due to contamination. It is important to address pollutants originating from both point and non-point sources, including agriculture, residential areas, and industrial activities (Jacquin et al., 2020). As a result, research and continuous monitoring of water quality have become crucial for the effective management of water resources in rivers, reservoirs, and lakes (Guerreiro et al., 2020). Approximately 59% of rivers in Indonesia are classified as extremely polluted (Basuki et al., 2024). In 2010, 2,517 sub-basins faced water scarcity due to issues related both quality and quantity. Projections indicates that this number will increase to 3,061 by 2050 (Wang et al., 2024). The deterioration of water quality is often driven by industrial development, excessive water consumption, and land changes associated with urbanization and agriculture (Das et al., 2019). Domestic waste contributes to increased turbidity, total dissolved solids, and biochemical oxygen demand, whereas agricultural waste may introduce harmful substances such as pesticides and fertilizers (Saad et al., 2022). River ecosystems are impacted by various factors, including damming, overfishing, invasive species, and water pollution (Chakraborty, 2021). Freshwater ecosystems, in particular, are increasingly threatened by rising turbidity, sedimentation, and the pollution of hazardous substances such as heavy metals (Altowairqi et al., 2024).

The Batanghari River, stretching 870 km in length, is the longest river in Sumatera, Indonesia. It arranges in width from 300 to 500 m and has a depth of 6 to 7 m. This river exhibits a significant diversity of fish species, totalling 131 species, encompassing 14 orders and 25 families (Hertati et al., 2023). The river constitutes a dynamic aquatic environment and serves as a vital freshwater habitat characterized by significant biodiversity (Arbeloya et al., 2021; Tockner, 2021). Although rivers cover less than 1% of the Earth's surface, they serve as habitats for approximately 18,000 fish species (Guohuan et al., 2021). The quality and quantity of fish habitat have become critical elements of riverine ecology (Kuo et al., 2021). Understanding the underlying factors and alterations affecting water quality is crucial for sustainable river management (Anh et al., 2023). Pollution not only diminish the availability of potable water but also escalate the expenses of water treatment prior to consumption (Das et al., 2021). Moreover, pollution adversely affects the fish species diversity (Syanya et al., 2024). For instance, some rivers in Spain have experienced a 74% decline in native fish populations, with water pollution identified as one of the significant contributing factors (Valerio et al., 2022).

The water quality of river is an essential factor serving as fundamental safeguard for public health (Mu et al., 2023; Chen et al., 2024). Water

Quick Response Code	Access this article online	
	Website: www.watconman.org	**DOI:** 10.26480/wcm.03.2025.473.480

Cite The Article: Andri Warsa, Mochammad Zamroni, Dwi Atminarso, Rendy Ginanjar, Muhammad Nizar, Lismining Pujiyani Astuti, Didik Wah ju Hendro Tjahjo (2025). Water Pollution Index In Batanghari River Dharmasraya Regency, West Sumatera Province, Indonesia. *Water Conservation & Management, 9(3): 473-480.*

quality research plays a vital role in informing policy for managing pollution sources and understanding their effects on fish resources (Mondal et al., 2022). Literature reviews indicate that research have been conducted on the water quality of the Bataghari River, Dharmasraya (Erajalita et al., 2022; Rani et al., 2020). The study employed a pollution index method to assess water quality, utilizing some parameters include total dissolved solids (TDS), total suspended solids (TSS), turbidity, pH, electrical conductivity, mercury (Hg), lead (Pb), and copper (Cu) over a one-year observation period. This research uses two methodologies to assess water quality status: the cumulative pollution index (CPI) and the water pollution index (WPI). In addition, this study encompasses a broader range of parameters, specifically iron (Fe), manganese (Mn), biological oxygen demand (BOD), chemical oxygen demand (COD), fecal coliforms, and total coliforms, with observations conducted over several years. Spatial and temporal data analysis is crucial for examining water quality and river contamination levels (Barroso et al., 2024). The aim of this study was to assess the extent of water pollution in the Batanghari River, located in Dharmasraya Regency, West Sumatra Province, by analyzing physical, chemical, and biological parameters. The assessment of pollution levels was conducted spatially and temporally. The results are expected to provide a basic data for the sustainable management of water resources in the Batanghari River.

2. Material And Methods

2.1 Research sites and sampling time

The data was utilized to establish the pollution index of the Batanghari River was obtained from water quality monitoring conducted by the Environmental Service in Dharmasraya Regency from 2018 to 2023. From 2018- 2019, water quality assessments were conducted annually; while, from 2021-2023, they were conducted biannually. Surface water samples were collected using a 4.0 L Kemmerer water sampler at five observation sites in figure 1. The samples were then placed into 250 ml polyethylene bottles. The water samples were preserved by storing them in a coolbox filled with ice.

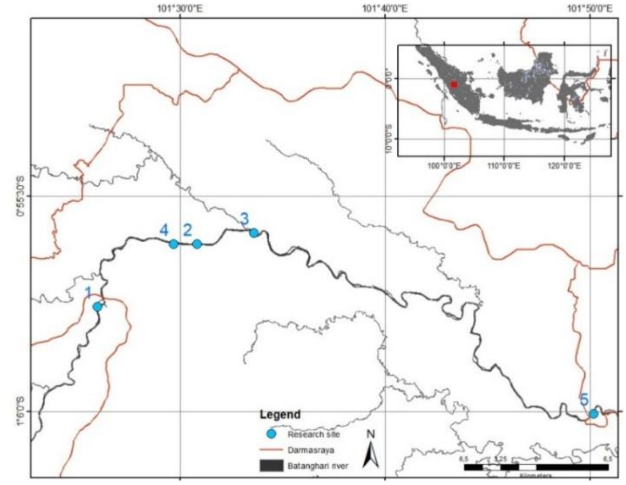


Figure 1: Research site at Batanghari River

The water samples obtained were subsequently analysed in the laboratory based on APHA (2005), with the parameters assessed including iron (Fe), mercury (Hg), manganese (Mn), copper (Cu), biological oxygen demand (BOD), chemical oxygen demand (COD), fecal and total coliform, and total suspended solids (TSS). The water temperature and pH parameters were measured in situ using the Horiba U-50-10 water quality checker. Water quality parameters were included in the calculation of the pollution index, excluding water temperature. The water quality standard was based on Government Regulation of the Republic of Indonesia No. 22/2021 about the Implementation of Environmental Protection and Management in table 1 for class II. Water quality standards for rivers were classified as Class II for recreational activities, aquaculture practices, animal husbandry practices, crop irrigation practices, and other necessary needs.

Table 1: Water quality standards for rivers classified as Class II

Parameters	Unit	Value
Iron (Fe)	mg/L	0.3
Mercury (Hg)	mg/L	0.001
Mangan (Mn)	mg/L	0.1
Copper (Cu)	mg/L	0.02
Biological oxygen demand (BOD)	mg/L	2
Chemical oxygen demand (COD)	mg/L	10
Fecal coliform	MPN/100 ml	100
Total coliform	MPN/100 ml	5000
pH		6-9
Total suspended solids (TSS)	mg/L	40

2.2 Data Analysis

The assessment of the water pollution level in the Batanghari River, Dharmasraya Regency, used two methodologies, namely the Comprehensive Pollution Index (CPI) and the Water Pollution Index (WPI) (Pramanik et al., 2020; Hossain et al., 2020). The computation of this index attempts to obtain a single numerical value that categorizes water quality based on several parameters through a comprehensive approach (Rana et al., 2020). The CPI value was determined by the subsequent equation:

$$CPI = \frac{1}{N}\sum_{i=1}^{n} {C_i}/{S_i} \quad (1)$$

Where:

Ci = Concentration of the ith parameter of the water

Si = Standard permissible concentration of the ith parameter

Table 2: Water quality classification based on CPI

CPI	Status	Water quality and uses
0.0-0.2	Clean	Highly suitable for consumption, irrigation, and industrial purpose.
0.21-0.4	Sub clean	Suitable for domestic, irrigation, and industrial applications.
0.41-0.8	Qualified	Some contaminants were identified, although their concentration complies with the water quality standards, indicating acceptable quality for irrigation and industrial usage.
0.81-1.0	Basically qualified	Concentrations of some contaminants surpass the threshold, indicating low quality, suitable only for irrigation purposes.

Table 2 (Cont.): Water quality classification based on CPI		
1.01-2.0	Polluted	Concentrations of quite a part of pollutants exceed the water quality standard, i.e. very poor quality(polluted) and restricted use for irrigation
≥2.01	Seriously polluted	Concentrations of numerous pollutants significantly exceed water quality standards, indicating highly polluted water quality, necessitating proper treatment prior to use.

The WPI value was determined by the subsequent equation:

$$PLi = 1 + \left(\frac{C_i + S_i}{S_i}\right)$$

where:

PLi = Pollution load of ith parameter

Ci = Observed concentration of ith parameter

Si = Standard or highest permissible limit for ith parameter

if, the pH value < 7 is recommended to use this equation

$$PLi = \frac{C_i - 7}{Si_a - 7}$$

if, the pH value > 7 is recommended to use this equation:

$$Li = \frac{C_i - 7}{Si_b - 7}$$

Where:

Si_a = standard minimum value for pH

Si_b = standard maximum value for pH

The water pollution index (WPI) could be assessed by integrating the PLi value for each parameter, divided by the total number of parameters, using the following equation:

$$WPI = \frac{1}{n}\sum_{i=1}^{n} PLi$$

where:

n = number of water quality parameters

Table 3: Water quality classification based on WPI score	
WPI value	**Category**
<0.50	Excellent
0.50-0.75	Good
0.75-1.00	Moderately polluted
>1.00	Highly polluted

3. Result

3.1 Water quality parameters

The concentrations of various heavy metals, including Fe, Hg and Cu in the Batanghari River waters frequently exceeded water quality standards, both temporally and spatially, except Mn in figure 2. In 2022, the concentrations of heavy metals were elevated when compared to the other observation periods. In 2019, the measured heavy metal concentrations continued to comply with the established water quality standards. The concentrations of Fe, Hg, Mn, and Cu varied from 0.12-6.18 mg/L (average 1.88 mg/L); 0.0004-0.0326 mg/L (average 0.0026 mg/L); 0.01-0.456 mg/L (average 0.103 mg/L); and 0.016-0.05 mg/L (average 0.018 mg/L), respectively. The concentrations of heavy metals Fe, Hg, and Cu exhibited a decline, whereas Mn demonstrated a rise. The highest Fe concentration occurred in 2022, varying from 3.74-6.18 mg/L (average 4.86 mg/L), while the lowest value was recorded in 2019, ranging from 0.120-0.267 mg/L (average 0.160 mg/L). The highest concentration of the heavy metal mercury (Hg) occurred in 2021, varying from 0.0016 to 0.0326 mg/L (average 0.0094 mg/L), while the minimum concentration was recorded in 2019 at 0.0006 mg/L. The highest Mn concentration was recorded in 2023, varying from 0.038 to 0.456 mg/L (average 0.189 mg/L), while the lowest value was observed in 2019 at 0.01 mg/L. The greatest Cu concentration occurred in 2021, varying between 0.02-0.05 mg/L (average 0.04 mg/L), while the lowest was recorded in 2023, ranging between 0.014-0.016 mg/L (average 0.012 mg/L).

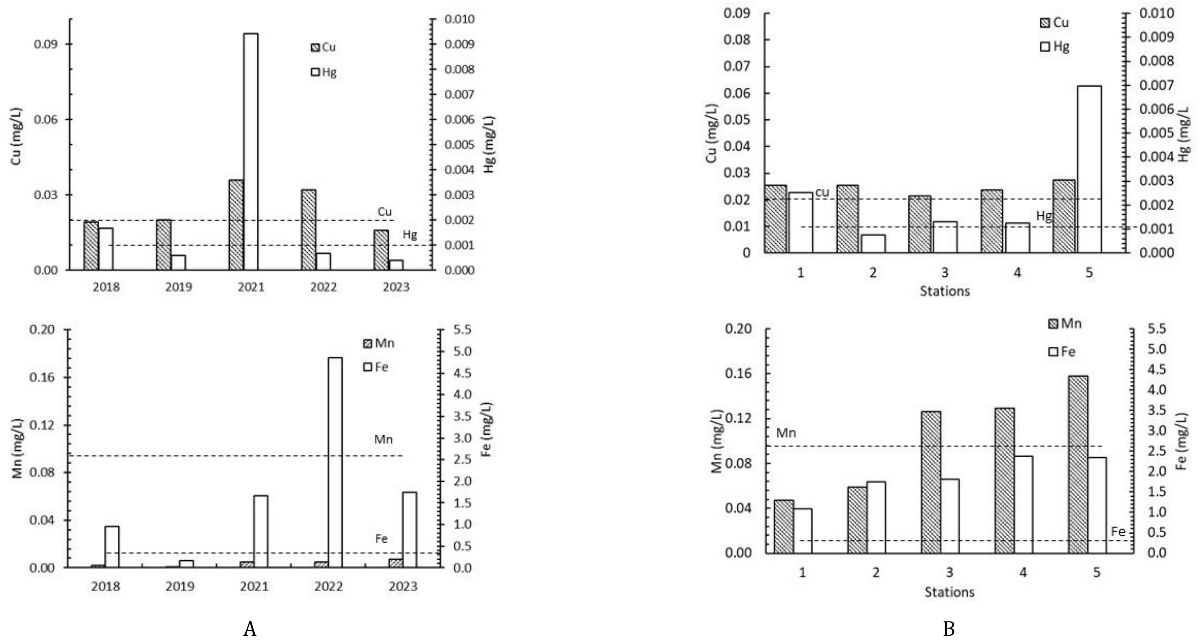
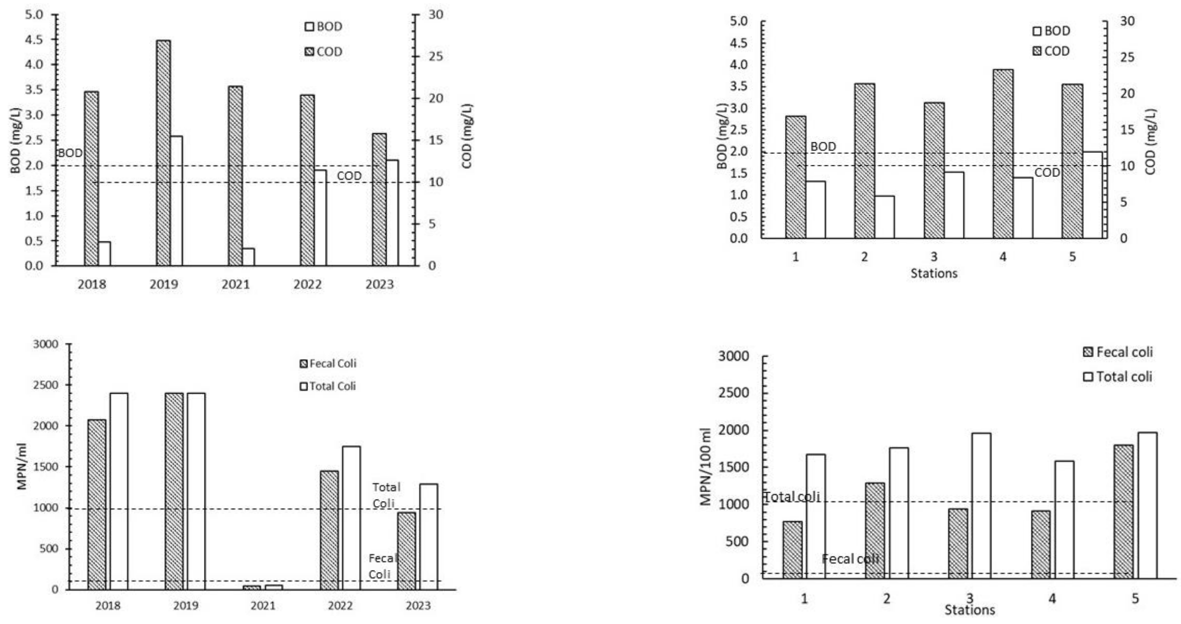


Figure 2: Heavy metal concentration in Batanghari River based on the time of observation (A) and site of observations (B) (------ water quality standards)

The investigation indicated that the highest concentration of heavy metals was generally observed at station 5. The lowest concentrations of Mn and Fe were detected at station 1, but Hg and Cu were identified at stations 2 and 3, respectively. whereas the lowest concentration was recorded at station 1. The highest concentration of Fe was seen at station 4, while the lowest was recorded at station 1, with concentrations varying from 0.144-6.18 mg/L (average 2.379 mg/L) and from 0.120-3.740 mg/L (average 0.120 mg/L), respectively. The highest concentration of Hg was recorded at station 5, with values between 0.0004-0.0326 mg/L (average 0.0070 mg/L) and the lowest concentration was found at station 2, with values ranging between 0.0004-0.0016 mg/L (average 0.0008 mg/L). The highest Mn concentration was recorded at observation site 5, with values between

0.01-0.456 mg/L (average 0.158 mg/L) and the lowest concentration was seen at station 1, ranging from 0.010-0.086 mg/L. The highest copper concentration was recorded at station 5, varying between 0.02-0.05 mg/L, with an average of 0.027 mg/L. Conversely, the lowest concentration was seen at station 1, ranging from 0.016-0.01 mg/L, with an average of 0.012 mg/L.

The COD, fecal, and total coliform levels in the Batanghari River exceeded the water quality standards, although the BOD was below acceptable limits in figure 3. The biochemical oxygen demand (BOD) concentration of the Batanghari River varied between 0.16-5.36 mg/L, with an average of 1.46 mg/L. The maximum BOD concentration was at station 5, varying between 0.40-5.36 mg/L (average 2.01 mg/L), while the minimum was recorded at station 2, ranging between 0.16-2.01 mg/L (average 0.98 mg/L). During the observation time, the peak BOD concentration was recorded in 2023, with values ranging between 0.81-5.36 mg/L (average 2.11 mg/L), while the lowest concentration was recorded in 2021, ranging between 0.16-0.81 mg/L (average 0.353 mg/L). The COD concentration in the Batanghari River exceeded the water quality standard, ranging between 3.64-44.9 mg/L, with an average of 20.3 mg/L. The maximum COD concentration was observed at station 4, ranging between 15.0-44.9 mg/L (average 23.38 mg/L), while the minimum was recorded at station 1, ranging between 7.91-24.0 mg/L (average 16.9 mg/L). According to the observation time, the highest COD concentration occurred in 2019, with a range between 7.91-44.90 mg/L (average 26.84 mg/L), while the lowest concentration was recorded in 2023, varying from 3.64-24.0 mg/L (average 15.8 mg/L).

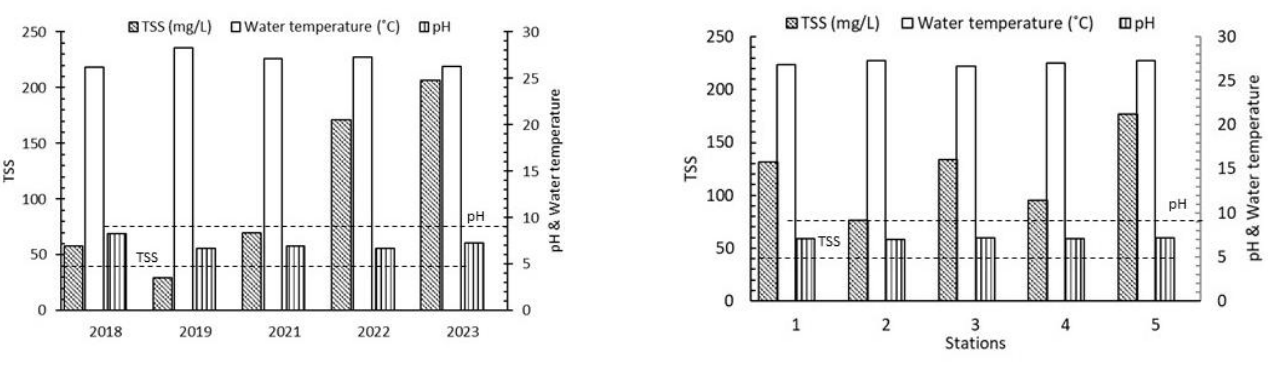


A B

Figure 3: Concentration of BOD, COD, fecal and total coliform in Batanghari River based on time of observation (A) and site of observations (B) (------ water quality standards)

The fecal coliform concentration in the Batanghari River varied from 9.2-3500 MPN/100 ml (average of 1152 MPN/100 ml), whereas the total coliform concentration ranged from 115-4,000 MPN/100 ml (average 1,288 MPN/100 ml). The highest fecal coliform content occurred in 2018, with a range of 400-3,500 MPN/100 ml (average 1,773 MPN/100 ml), while the lowest occurred in 2021, specifically 9.2-150 MPN/L (average 49 MPN/100 ml). The highest fecal coliform concentration was recorded at station 5, ranging between 15-3,500 MPN/100 ml (average 1,795 MPN/100 ml), whereas the lowest was at station 1, ranging between 35-200 MPN/100 ml (average 767 MPN/100 ml). The highest total coliform concentration was recorded at station 5, with values ranged between 15 to 4,000 MPN/100 ml (average 1,968 MPN/100 ml), whereas the minimum was seen at station 4, with values ranging between 35-2,400 MPN/100 ml (average 1,586 MPN/100 ml). The peak total coliform concentration, recorded in 2018, was 2,400 MPN/100 ml, while the lowest, observed in 2021, ranged from 9.2 to 150 MPN/100 ml (average of 49 MPN/100 ml).

The pH and water temperature levels in the Batanghari River complied with water quality criteria; however, the TSS concentration exceeded the water quality standards in figure 4. The pH level of the Batanghari River varied from 5.5 to 8.56, signifying acidic to neutral waters, with temperatures ranging between 25.0-29.3 °C. The pH and water temperature data exhibited insignificant variations depending on the time and site of observation.



A B

Figure 4: TSS concentration, pH, and water temperature in Batanghari river according to time the of observation (A) and site of the observations (B) (------- standard value)

The TSS measurements in the Batanghari River varied from 6.0 to 301.0 mg/L, with an average of 109.6 mg/L. The highest TSS content was recorded in 2022, varying from 58.4 to 301.0 mg/L (average 170.8 mg/L), while the minimum was observed in 2019, specifically 16 to 58 mg/L (average 29.4 mg/L). The highest total suspended solids (TSS) concentration was recorded at station 3, ranging from 25 to 284 mg/L (average 133.5 mg/L), whereas the lowest was at station 2, ranging from 6.0 to 150.0 mg/L (average 76.1 mg/L).

3.2 Water quality state

The water quality of the Batanghari River, as shown by the CPI and WPI index values (based on Table 2 and Table 3), was classified as polluted to extremely polluted (Figure 5). The CPI pollution index varied from 2.11-4.21 (average 2.79), while the WPI pollution index was 2.04-4.15 (average 2.73). The site with the highest pollution index was station 5, with a CPI of 4.21 and a WPI of 4.15, while the lowest was station 1, with CPI and WPI values of 2.11 and 2.04, respectively. The highest CPI and WPI pollution indices, recorded in 2022, were 5.50 and 5.48, respectively, while the lowest indices occurred in 2021, with values of 2.16 and 2.20, respectively. The reduced pollution levels in 2021 were attributable to the COVID-19 pandemic. This resulted in a decline of mining and agricultural activities by the community. This signified that the water pollution in the Batanghari River originated from these activities.

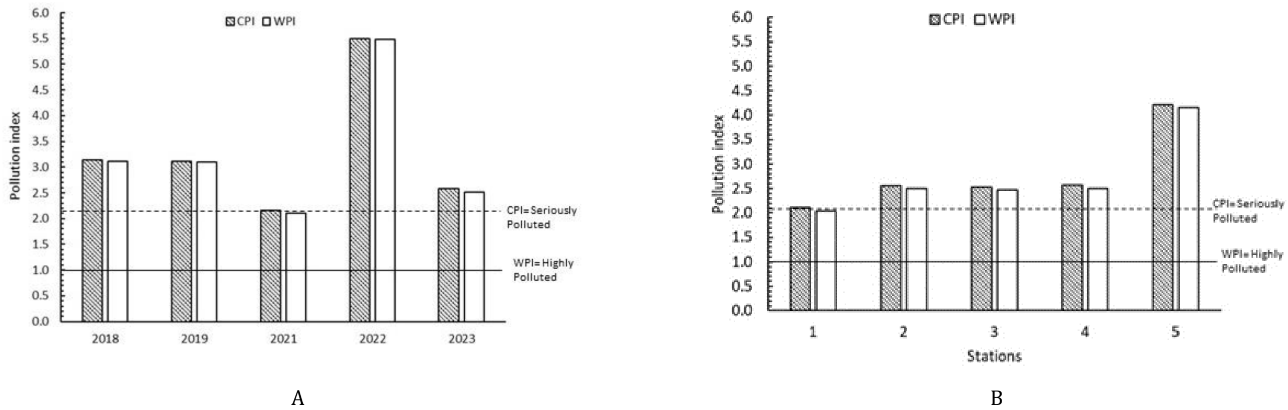


Figure 5: CPI and WPI s in Batanghari River based on time of observation (A) and site of observation (B) (---------- standard value)

The concentrations of heavy metals have surpassed quality limits in the following sequence, namelly Fe > Cu > Mn > Hg. The parameters Fe, TSS, fecal coliform, and COD were main contributors to CPI and WPI values. The aforementioned characteristics classified the water quality of the Batanghari River as severely contaminated, necessitating attention to these factors. The land use of the Batanghari River surrounding involved oil palm plantations, residential areas and gold mining. This pertained to anthropogenic activities observed in the Batanghari River, Dharmasraya, West Sumatra. Gold mining activities involved the dispersion of soil along riverbanks, hence generating a source of total suspended solids (TSS). Organic matters and fecal coliform originated from oil palm farms, rice fields, and residential areas. The waste loaded into the Batanghari River correlated with the elevated intensity of precipitation. Rainfall in 2021, measuring 2.891 mm, was lower than that of 2018 and 2019, which recorded 3.892 mm and 2.921 mm, respectively.

4. Discussion

The purpose of this study was to investigate regional and temporal variability in water quality in the Batanghari River using CPI and WPI indices. The data found substantial contamination, notably in 2022 and at station 5, with Fe, TSS, COD, and faecal coliform quantities that exceeded national norms. These findings highlight the importance of anthropogenic activities particularly gold mining, agriculture, and household waste in decreasing water quality.

Water quality is determined by physical, chemical, and biological characteristics, which influence fish growth (Adams et al., 2021; Nunn et al., 2025). The degradation of the aquatic environment will result in alterations to species composition, distribution, and abundance of fish (Shukla et al., 2024; Nunn et al., 2025). These conditions would additionally affect the community's social structure and the environment's ecological (Nair et al., 2023). The biological response of organisms to different contaminants was contingent upon their life cycle stage, physiological traits, mobility, and susceptibility to pollutants (Markert et al., 2024). pH, total suspended solids (TSS), turbidity, and water temperature influence the community structure and diversity of fish species in aquatic ecosystems (Luo et al., 2023). This is attributable to the sensitivity of ecological and community processes to habitat quality.

Settlement-related land use typically exhibits elevated biochemical oxygen demand (BOD), fecal coliform levels, and phosphate concentrations (Rojas-Pena et al., 2024). Land use as an agricultural and settlement results in diminished water quality in the polluted river, characterized by increased turbidity, total solids, and fecal coliform levels (Nugraha et al., 2020). The Lom River in Cameroon, adjacent to a gold mining, exhibits an acidic-neutrality pH (5.3-8.12), significant turbidity (117-810 NTU), and elevated content of suspended particles (22.89-700 mg/L) (Ngounouno et al., 2021; Ayiwouo et al., 2022). Acidic waters resulting from gold mining also occurred in the Offin River, with a pH range of 5.24-6.53 (Gyekye et al., 2023). Gold mining activities adversely affect surface water by significantly elevating mercury concentrations beyond the acceptable water quality standard (Torrance et al., 2021). Elevated TDS will impact fertilization success and egg development, thereby influencing fish stock recruitment (Weber-Scannell et al., 2007). Moreover, the transparency adversely impacts fisheries productivity in aquatic environments by interfering with fish reproductive and growth patterns (Bunnell et al., 2021). Elevated TDS and water temperature, along with reduced pH, will diminish the survival rate of fish larvae (Nyanti et al., 2018).

Gold mining activity in the Singing Hilir River results in a light-heavy pollution category (Atika et al., 2024). Anthropogenic pollution diminishes the abundance and diversity of freshwater fish globally (Thomson-Laing et al., 2024). Water pollution adversely affects fish biota by diminishing immunological response, impairing metabolic functions, and damaging gills and epithelial layers, leading to diseases such as tail and fin rot, gill disease, and liver tissue damage (Malik et al., 2020). Gold mining is a source of heavy metal contaminants in aquatic ecosystems. Heavy metals induce fish poisoning during the early developmental stages and disrupt fish immunity and metabolism (Bellier et al., 2024). Mercury will impact reproductive processes, including successful spawning, fertilization, and reduced fecundity (Chen et al., 2021). These concentrations of Hg, Pb, As, Mn, and Fe in the Offin River, adjacent to a gold mine, range from 0.09-0.11 mg/L; 0.02-0.028 mg/L; 0.018-0.02 mg/L; 0.090-0.122 mg/L; and 0.184-0.188 mg/L, respectively (Gyekye et al., 2023). Concentrations of mercury (Hg), total suspended solids (TSS), and turbidity are typically elevated in rivers impacted by gold mining activities (Corredor et al., 2021). Concentrations of Ni, Cd, Mn, Fe, Pb, and Hg that are above quality norms render the water unsuitable for consumption (Ngounouno et al., 2021; Ayiwouo et al., 2022). The concentration of mercury in the Batanghari River, West Sumatra has surpassed the water quality standard for class II. Research conducted between 2007 and 2014 indicated that the concentration of mercury (Hg) in the water and sediment of the Batanghari River varied from <0.0005 to 0.0645 mg/L, attributed to traditional gold mining activities (Ratnaningsih et al., 2019). The Batanghari River's water quality was classified as lightly polluted, with Pb and Hg concentrations of <0.002-0.0034 and 0.0006-0.0024 mg/L, respectively, with an average TDS value ranging from 25-29.7 mg/L (Rani et al., 2020; Erajalita et al., 2022). The research conducted by the Ministry of Environment in 2016 indicated that the Batanghari River categorized into the extremely contaminated category.

Accumulation of heavy metals in aquatic environments adversely affects fish populations regarding both quality and quantity (Thirumala et al., 2024). This results from bioaccumulation and biomagnification that cannot be eliminated from the fish's body by metabolic processes (Almashhadany et al., 2025). The presence of heavy metals beyond the threshold adversely affects fish reproduction, evidenced by a diminished gonadosomatic index, reduced fecundity, lower hatching rates, impaired fertilization, and abnormalities in reproductive organs (Taslima et al., 2022). Fish exposure to heavy metals will disrupt the release of reproductive hormones (Bhattacharya et al., 2021). Heavy metal contamination in aquatic habitats can result in genetic degradation, physiological alterations, and ecological disruptions in fish, posing a cancer risk to humans who consume them (Saad et al., 2025). In 2021, the concentrations of Cd, Cu, and Hg in the Batanghari River within the Jambi sector ranged from 0.021-0.0782 mg/L, 0.0241-0.075 mg/L, and 0.017-0.032 mg/L, respectively, surpassing class I water quality regulations (Badariah et al., 2023). Gold mining in Africa utilizes 205-496 tons of mercury annually (Mulenga et al., 2024). Mercury pollution renders water unsuitable for drinking standards, leading to mutagenicity and adversely affecting fisheries activities (Martin et al., 2020).

5. Conclusion

The deterioration of water quality will result in diminished functionality and benefits of water, as well as a reduction in aquatic biodiversity. The water pollution level in the Batanghari River is classified as severely polluted, according to the site and time of observation. The parameters that have exceeded the water quality standards include iron (Fe), total suspended solids (TSS), fecal coliform, and chemical oxygen demand (COD). The greatest pollution index value, determined by the site of observations, is at station 5, and the time of observations is in 2022. In 2021, the water quality of the Batanghari River was enhanced, exhibiting a pollution index value between 2.01 and 2.16, attributed to diminished gold mining and plantation activities owing to the COVID-19 pandemic. This may indicate that the pollution in the Batanghari River originates from domestic waste, gold mining, agricultural land, and oil palm plantations.

Acknowledgment

The authors are grateful to the National Research and Innovation Agency, Republic of Indonesia (BRIN) and Indonesia Endowment Fund for Education Agency (LPDP) for funding this research. For the data sources, we are thankful to the Service Office of the Environment, Dharmasraya Regency's.

Conflicts Of Interest

Authors declare no conflict of interest The authors contributed as the primary contributor to this paper. All authors read and approved the final paper.

References

Adams, T.E., Edokpia, R.O., Okonji, V.A., and Yakubu, A.F. 2021. Dynamics of dissolved oxygen in relation to pH and survival of fish culture in fiber glass tank. International Journal of Environment, Agriculture and Biotechnology, 6(3), Pp. 158-166. https://dx.doi.org/10.22161/ijeab.63.18

Almashhadany, D.A., Rashid, R.F., Altaif, K.I., Mohammed, S.H., Mohammed, H.I., and Al-Bader, S.M., 2025. Heavy metal (Ioid) bioaccumulation in fish and its implications for human health. Italian Journal of Food Safety, 14, 12782.

Altowairqi, T.K., and Shafi, M.E., 2024. A comprehensive review of biodiversity of freshwater fish species in Valleys worldwide and the kingdom of Saudi Arabia. Journal of Advanced Veterinary and Animal Research, 11(2), Pp. 356-366. http://doi.org/10.5455/javar.2024.k784

Anh, N.T., Can, L.D., Nahn, N.T., Schmalz, B., and Luu, T.L., 2023. Influences of key factor on river water quality in urban and rural areas: A review. Case Studies in Chemical and Environmental Engineering 8, 100424. https://doi.org/10.1016/j.cscee.2023.100424

APHA (American Public Health Association)., 2005. Standar Methods for the examination of Water and Waste Water Including Bottom Sediment and Sludges. 21st edition. In: Eaton AD, Clesceri, L.S., Rice, E.W., Grennberg, A.E. Amer. Publ. Health Association Inc. New York. 1296p

Arbeloya, E., Fernandez, S., Clusa, L., Dopico, E., and Garcia-Vazquez, E., 2021. River connectivity is crucial for safeguarding biodiversity but may be socially overlooked. Insights from spanis university students. Frontiers in Environmental Science, 9, 643820. doi: 10.3389/fenvs.2021.643820

Atika, B., Purwanto, E., and Prianto, E., 2024. Condition of Sangingi River water quality due to unlicensed gold mining (PETI) in Tanjung Pauh Village, Sangingi Hilir District, Kuantan Sengingi Regency. Jurnal Perikanan dan Kelautan, 29(3), Pp. 355-360

Ayiwouo, M.N., Yamgouot, F.N., Mambou, L.L.N., Kingni, S.T., and Ngounouno, I., 2022. Impact of gold mining on the water quality of Lom river, Gankombol, Camerron. Heliyon, 8, e12452. https://doi.org/10.1016/j.heliyon.2022.e12452

Badariah., Sukmawati, N., Heraningsih, S.F., Rainiyati., Riduan., and Putri, R.D., 2023. Heavy metal contamination of Batanghari River, Jambi, Indonesia: determination based on sediment enrichment factor value. Journal of Degraded and Mining Lands Management, 10(4), Pp. 476-4768. doi:10.15243/jdmlm.2023.104.4761

Barroso, G.R., Pinto, C.C., Gomes, L.N.L., and Oliveira, S.C., 2024. Assessment of water quality based on statistical analysis of physical-chemical, biomonitoring and land use data: Manso River supply reservoir. Science of the Total Environment, 912, 169554. https://doi.org/10.1016/j.scitotenv.2023.169554

Basuki, T.M., Indrawati, D.R., Nugroho, H.Y.S.D., Pramono, I.F., Setiawan, O., Nugroho, N.P., Nada, F.M.H., Nandini, R., Adi, R.N., Purwanto., and Sartohadi, J., 2024. Water pollution of some major river in Indonesia: The status, regulation, and recommendations for its mitigation. Polish Journal of Environmental studies, 33(4), Pp. 3315-3530. DOI: 10.15244/pjoes/178532

Bellier, B., Bancel, S., Rochard, E., Cachot, J., Geffartd, O., and Villeneuve, B., 2024. Assessment of the impact of chemical pollution on endangered migratory fish in two major rivers of France, including spawning grounds. Science of the Total Environment, 931, 172748. https://doi.org/10.1016/j.scitotenv.2024.172748

Bhattacharya, S., and Munshi, C., 2021. Endocrine disruptor in freshwater: impacts on teleost reproduction. Proceedings of the Zoological Society, 74, Pp. 369-677. https://doi.org/10.1007/s12595-021-00397-z

Bunnell, D.B., Ludsin, S.A., Knight, R.L., Rudstam, L.G., Williamson, C.E., Hook, T.O., Collingsworth, P.D., Lesht, B.M., Barbiero, R.P., Scofield, A.E., Rutherford, E.S., Gaynor, L., Vanderploeg, H.A., and Koops, M.A., 2021. Consequences of changing water clarity on the fish and fisheries of the Laurentian Great Lakes. Canadian Journal of Fisheries and Aquatic Sciences, 78(10), Pp. 1524-1542. dx.doi.org/10.1139/cjfas-2020-0376

Chen, Q., An, J., Xie, D., Gong, S., Lian, X., Liu, Z., Shen, Y., and Li, Y. 2021. Suppression and recovery of reproductive behaviour induced by early life exposure to mercury in zebrafish. Comparative Biochemistry and Physiology, Part C, 239, 108876. https://doi.org/10.1016/j.cbpc.2020.108876

Chen, Z., Zhao, Y., Liang, N., Yao, Y., Zhao, Y., and Liu, T., 2024. Pollution, cumulative ecological risk and source apportionment of heavy metals in water bodies and river sediments near the Luanchuan molybdenum mining area in the Xiaoqinling Mountains, China. Marine Pollution Bulletin, 205, 116621. https://doi.org/10.1016/j.marpolbul.2024.116621

Corredor, J.A.G., Perez, E.H., Figueroa, R., and Casas, A.F., 2021. Water quality of streams associated with artisanal gold mining; Suarez Department of Cauca, Colombia. Heliyon, 7, e07047. https://doi.org/10.1016/j.heliyon.2021.e07047

Chakraborty, S.K., 2021. River Pollution and Perturbation: Perspectives and Processes. In: Riverine Ecology Volume 2. Springer, Cham. https://doi.org/10.1007/978-3-030-53941-2_5

Das, A., and Biswas, S.P., 2019. Water quality assessment based on fish and macroinvertebrate diversity indices of River Mara Bharali in Assam, India. International Conference on Fisheries and Aquaculture, 5, Pp. 1-10. DOI: https://doi.org/10.17501/23861282.2019.5101

Das, I., Karmaker, N., and Khan, R.A., 2021. Reasons and consequences of river water pollution and their remediation: in contex of Bangladesh, 07(01), Pp. 023-034. https://doi.org/10.30574/gscarr.2021.7.1.0066

Erajalita, A., and Afdal., 2022. Identifikasi pencemaran air Sungai Batanghari di Pulau Punjung Kabupaten Dharmasraya menggunakan parameter fisika dan kimia. Jurnal Fisika Unand, 11(4), Pp. 448-454. https://doi.org/10.25077/jfu.11.4.448-454.2022

Guohuan, S., Maxime, L., Jun, X., Shengli, T., Sebastien, V., and Sebastien, B. 2021. Human impacts on global freshwater fish biodiversity. Science, 371(6531), Pp. 835-838. https://doi.org/10.1126/science.abd3369

Guerreiro, M.S., Abreu, I.M., Monteiro, A., Jesus, T., and Fonseca, A., 2020. Consideration on the monitoring of water quality in urban streams: a case study in Portugal. Environmental Monitoring and Assessment, 192(6), 347. https://doi.org/10.1007/s10661-020-8245-y

Gyekye, K.A., Owusu, P., and Ofori, A., 2023. Gold mining effects on water quality in Domenase and Nkotumso along River offin, Upper Denkyira West District. West African Journal of Applied Ecology, 31(2), Pp. 43-56.

Hertati, R., Syafrialdi., Maryeni, S., 2023. Monitoring keanekaragaman jenis ikan di Sungai Batanghari Provinsi Jambi. Innovative: Journal of Social Science Research, 3(2), Pp. 8866-8873.

Hossain, M., and Patra, P.K., 2020. Water pollution index- A new integrated approach to rank water quality. Ecological Indicators, 117, 106668. https://doi.org/10.1016/j.ecolind.2020.106668

Jacquin, L., Patitjean, Q., Cote, J., Laffaille, P., and Jean, S. 2020. Effects of pollution on fish behavior, personality, and cognition: some research perspectives. Frontiers in Ecology and Evolution, 8(86), Pp. 1-12. doi: 10.3389/fevo.2020.00086

Kuo, P.H., Shih, S.S., and Otte, M.L., 2021. Restoration recommendations for mitigating habitat fragmentation of a river corridor. Journal of Environmental Management, 296,113197. https://doi.org/10.1016/j.jenvman.2021.113197

Luo, Z., Yang, C., Wang, L., Liu, Y., Shan, B., Liu, M., Chen, C., Guo, T., and Sun, D., 2023. Relationships between fish community structure and environmental factors in the nearshore waters of Hainan Island, South China. Water, 15(8), 901. DOI:10.3390/d15080901

Malik, D.S., Sharma, A.K., Sharma, A.K., Thakur, R., and Sharma, M., 2020. A review on impact of water pollution on freshwater fish species and their aquatic environmental. In Advances in Environmental Pollution Management: Wastewater Impacts and Treatment Technologies 1, Eds. Kumar, V., Kamboj, N., Payum, T., Singh, J. and Kumar, P: Pp. 10-28. https://doi.org/10.26832/aesa-2020-aepm-02

Markert, N., Guhl, B., and Feld, C.K., 2024. Water quality deterioration remains a major stressor for macroinvertebrate, diatom and fish communities in German rivers. Science of the Total Environment, 907, 167994. https://doi.org/10.1016/j.scitotenv.2023.167994

Martin, A., Arias, J., Lopez, J., Santos, L., Venegas, C., Duarte, M., Ortiz-Ardila, A., de Parra, N., N., Campos, C., and Zambrano, C.C., 2020. Evaluation of the effect of gold mining on water quality in Monterey, Bolivar (Colombia). Water, 12, 2523. https://doi.org/10.3390/w12092523

Mondal, P., Adhikary, P., Sadhu, S., Choudhary, D.K., Tahkur, D., Shadab, M., Mukherjee, D., Parvez, Sk.Y., Pradhan, S.R., Kuntia, M.A.S., Manna, U., and Das, A., 2022. Assessment of the different point sources of pollutants on the river water quality and the evaluation of bioaccumulation of heavy metals into the fish ecosystem thereof. International Journal of Experimental Research and Review, 27, 32-38. DOI: https://doi.org/10.52756/ijerr.2022.v27.003

Mu, M., Gao, L., Zhang, H., Ge, J., Zhang, Z., Qiu, Y., and Zhao, X., 2023. Effect of land use on water quality at different spatial scales in the middle reaches of Huaihe River. Journal of Freshwater ecology, 38(1), 2176373. https://doi.org/10.1080/02705060.2023.2176373

Mulenga, M., Ouma, K.O., Monde, C., and Syampungani, S., 2024. Aquatic mercury pollution from artisanal and small-scale gold mining in Sub-Saharan Africa: status, impacts and interventions. Water, 16, 756. https://doi.org/10.3390/w16050756

Nair, N.V., and Nayak, P.K., 2023. Exploring water quality as a determinant of small-scale fisheries vulnerability. sustainability, 15, 13238. https://doi.org/10.3390/su151713238

Ngounouno, M. A., Ngueyep, L.L.M., Kingni, S.T., Nforsoh, S.N., and Ngounouno, I., 2021. Evaluation of the impact of gold mining activities on the waters and sediments of Lom River, Wakaso, Cameroon and the restorative effect of Moringa Oleifera seeds. Applied Water Science, 11, 113. https://doi.org/10.1007/s13201-021-01445-x

Nugraha, W.D., Cahyo, M.R.D., and Hardyanti, N., 2020. The influence of land use to river water quality level by using the water quality index of national sanitation foundation (WQI-NSF) methods (case study: Klampok River, Semarang District). E3S Web of Conferences 202, 04006. https://doi.org/10.1051/e3sconf/202020204006.

Nunn, A.D., Ainsworth, R.F., Qu, Y., Keller, V.D.J., Bachiller-Jareno, N., Antoniou, V., Eastman, M., Rizzo, C., Peirson, G., Eley, F., Johnson, A.C., and Cowx, I.G., 2025. Responses of fish to nationwide improvements in the water quality of a densely populated and heavily modified country over four decades. Water Research, 274, 123163. https://doi.org/10.1016/j.watres.2025.123163

Nyanti, L., Soo, C.L., Danial-Nakahie, M.S., Ling, T.Y., Sim, S.F., Grinang, J., Ganyai, T., and Lee, K.S.P., 2018. Effects of water temperature and pH on total suspended solids tolerance of Malaysian native and exotic species. AACL Bioflux 11(3): Pp. 565-575

Pramanik, A.K., Majumdar, D., and Chatterjee, A. 2020. Factors affecting lean, wet-season water quality of Talaiya reservoir in Koderma District, India During 2013-2017. Water Science, 34(1), Pp. 85-97. https://doi.org/10.1080/11104929.2020.1765451

Rana, R., and Ganguly, R., 2020. Water quality indices: challenges and applications-an overview. Arabian Journal of Geosciences, 13, 1190. https://doi.org/10.1007/s12517-020-06135-7

Rani, D., and Afdal., 2020. Identifikasi pencemaran air Sungai Batanghari di Kecamatan Sitiung Kabupaten Dharmasraya berdasarkan tinjauan fisik dan kimia. Junal Fisika Unand, 9(4), Pp. 510-516. https://doi.org/10.25077/jfu.9.4.510-516.2020

Ratnaningsih, D., Suoth, A., Yunesfi, S., Naniek, T.W., Fauzi, R., Hidayat, M.Y., and Harianja, A.H., 2019. Mercury distribution in Batanghari watershed. Ecolab, 13(2), 117-125. doi: http://dx.doi.org/10.20886/jklh.2019.13.2.117-125

Rojas-Pena, JI., Zapata-Munoz, Y.L., Huerfeno-Maoreno, G.J., Trujillo-Gonzales, J.M., Serrano-Gomez, M., Castillo-Monroy, E.F., Torres-Mora, M.A., Garcia-Navarro, F.J., and Jimenez-Ballesta, R., 2024. Assessing the impacts of land use on water quality in the Acacias River Basin, Colombia. Water, 16, 1903. https://doi.org/10.3390/w16131903

Saad, A.M., Asari, F.F.A.H., Affabdi, S., and Zid, A., 2022. River pollution: A mini review of causes and effects. Journal of tourism, Hospitality and Environment Management, 7(29), Pp. 139-151. DOI 10/35631/JTHEM.729011

Saad, M.I., Doma, H.M., Alfaghi, I.A., and Fitori, A., 2025. Effect of aquatic pollution on fish in Libya: A Review. International Journal for Multidisciplinary Research, 7(1), Pp. 1-7.

Shukla, R., and Tiwari, A., 2024. The impact of water quality on fisheries and fish diversity. International Journal of Research Publication and Reviews, 5(8), Pp. 1894-1896.

Syanya, F.J., Winam, Z.O., and Matia, W.M. 2024. Vanishing splendor: a comprehensive review of the decline in the original fish fauana of Lake Victoria. Marine and Fishery Sciences, 37(1), Pp. 209-231. https://doi.org/10.47193/mafis.3712024010107

Taslima, K., Al-Emran, Md., Rahman, M.S., Hasan, J., Ferdous, Z., Rohani, Md.F., and Shahjahan, Md., 2022. Impacts of heavy metals on early development, growth and reproduction of fish-A review. Toxicology Reports, 9, Pp. 858-868. https://doi.org/10.1016/j.toxrep.2022.04.013

Thirumala, M., Naik, S.J.K., Vanaja, K., and Kumar, K.P. 2024. Assessment of heavy metal of water and its impacts on fishes of Kachpoor Lake, Kamareddy, Telangana, India. Uttar Pradesh Journal of Zoology, 45(19), Pp. 148-160. 10.56557/upjoz/2024/v45i194511Thomson-Laing, G., Howarth, J.D., Atalah, J., Vandergoes, M.J., LI, X., Pearman, J.K., Fitzsimons, S., Moy, C., Moody, A., Shepherd, C., McKay, N., and Wood, S.A., 2024. Sedimentary ancient DNA reveals the impacts of anthropogenic land use disturbance and ecological shifts on fish community structure in small lowland lake. Science of the Total Environment, 922, 171266. https://doi.org/10.1016/j.scitotenv.2024.171266 R

Tockner, K. 2021. Freshwater: Global distribution, biodiversity, ecosystem services, and human pressure, In: Bogardi, J.J., et al. Handbook of water resources management: Discources, concepts and examples. Springer, Cham. https://doi.org/10.1007/978-3-030-60147-8_16

Torrance, K.W., Redwood, S.D and Cecchi, A., 2021. The impact of artisanal gold mining, ore processing and mineralization on water quality in Marmato, Colombia. Environmental Geochemistry and Health, 43, 4265-4282. https://doi.org/10.1007/s10653-021-00898-y

Valerio, C., Baquero, R.A., Nicola, G.G., Garrido, A., and De Stefano., 2022. Shedding light on the decline of Iberian freshwater fish species over the period 1980-2020. Freshwater Biology, 67, Pp. 1690-1707. DOI: 10.1111/fwb.13963

Wang, M., Bodirsky, B.L., Rijneveld, R., Beier, F., Bak, M.P., Batool, M., Droppers, B., Popp, A., van Vliet, M.T.H., and Strokal, M., 2024. A triple increase in global river basins with water scarcity due to future pollution. Nature communications, 15, 880. https://doi.org/10.1038/s41467-024-44947-3

Weber-Scannell, P.K., and Duffy, L.K., 2007. Effect of total dissolved on aquatic organism: A review of literature and recommendation for Salmonid species. American Journal of Environmental Sciences 3(1): Pp. 1-6