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FRONTIERS IN ENVIRONMENTAL REVOLUTIONARY INNOVATION
AN PEER REVIEWED INTERNATIONAL JOURNAL

Macroinvertebrates as a tool to assess the trophic status and water quality of Kaliasote Dam

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Articalinfo

Publisher: Curevita Research Pvt Ltd

Article history: Received 20 June 2025, Revised 20 July, Accepted 25 July 2025

Key words: Trophic status; Macroinvertebrates; Eutrophic; Arthropods, eutrophic.

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Citation: Ganie Nisar Ahmad and Malik Zahoor Ahmad. .2025.Macroinvertebrates as a tool to assess trophic status and water quality of Kaliasote Dam. Frontiers in Environmental Revolutionary Innovation 1,1, 21-33.

Abstract

An assessment was conducted to evaluate the macroinvertebrate diversity of the Kaliasote Dam, aiming to determine its trophic status and water quality. Throughout the study, a total of 56 species were recorded. Phylum Arthropoda, represented by 32 species, was dominant, whereas Phylum Mollusca and Phylum Annelida represented 17 and 7 species, respectively. A comparatively higher number of species were recorded during the summer season in comparison to the monsoon. Based on various chemical parameters, the Kaliasote Dam is classified as an eutrophic water body. However, the presence of macroinvertebrates reveals a moderately to severely polluted nature of Kaliasote waters.

Introduction

Macroinvertebrates are the organisms that spend either part of their life in water or remain permanently in water. These are usually dominated by different species of polychaete, oligochaete worms, gastropods, bivalvia, and various minor insect larvae. Macroinvertebrates play an important role in food chains in an aquatic ecosystem and are influenced positively or negatively by physico-chemical parameters of the environment, depending on their sources (Aura *et al*., 2011). Various physical and chemical conditions of the water body, such as depth, water current, organic content of the sediments, and contaminations of bed sediments, as well as the toxicity of sediments, influence the abundance and distribution of macroinvertebrates (Pearson 1970). Macroinvertebrates are the most commonly used organisms for bio-monitoring in lotic habitats worldwide (Bonada *et al*., 2006). Macrobenthos play an important role in improving and preserving water quality through mineralization and recycling of organic matter (Venkateswarlu, 1986). They offer many advantages in biomonitoring, although a practice for well-balanced monitoring programs, such as quantitative sampling and community analysis, is required (Bae *et al*., 2005). Macroinvertebrates serve as a tool to measure continuous and chronic effects of pollution (Misra *et al*., 2001). In bio-monitoring, benthic macroinvertebrates are common inhabitants of lakes and streams, where they are important in moving energy through food webs. The physical and chemical characteristics of the water bodies are recognizable through the elasticity of the community structure of benthic organisms (Wilhm and Dorris 1968). That is why these make an ideal choice for the biological assessment of water bodies.

Study area

The Kaliasote Dam was constructed as a storage Dam near the Water and Land Management Institute (WALMI), Bhopal, and its tail end is the downstream of the Bhadbhada Spill gates of the Upper Lake. The name “Kaliasote’’ was derived from the name of Kalyan Strote, one of the ministers of Raja Bhoj, who had developed the spillway of Upper Lake. The extra water of the Upper Lake is discharged through 11 radial gates installed for regulating the water level of the Upper Lake. Thus, situated in the downstream of Upper Lake the Kaliasote Dam was constructed to store the outgoing water of Upper Lake discharged through Bhadbhada gates for the purpose of irrigation and water supply. The waste weir of the Kaliasote is draining water into the River Betwa. The water from this Dam is being supplied for the annual irrigation of 4588 ha of land. The Dam has a catchment area of 381.38 km2, and the gross storage capacity is 35.387 MCM.

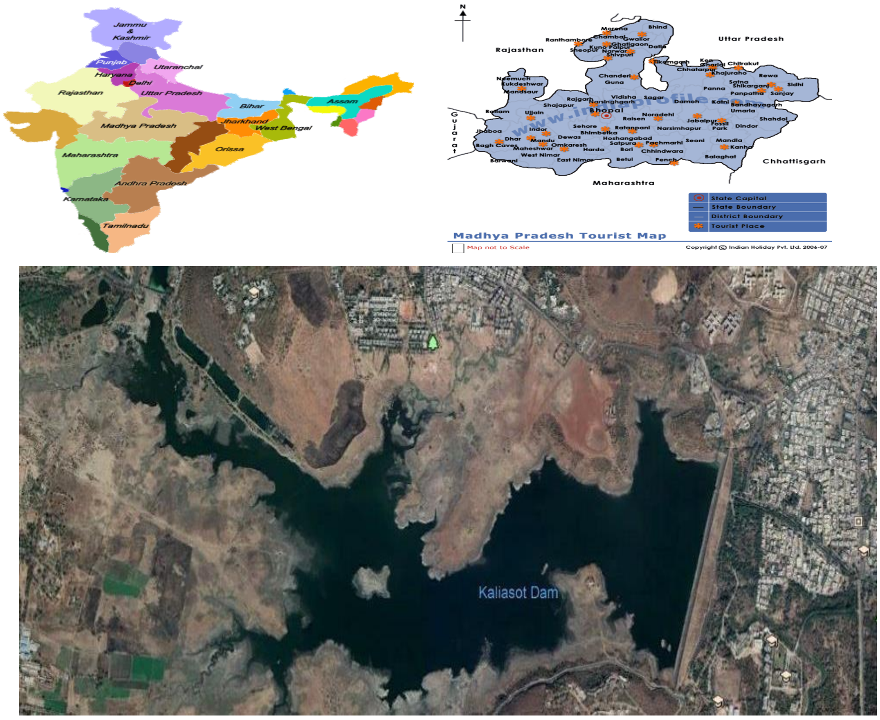


Fig.1: Showing the location Map of Kaliasote Dam.

Methodology

To assess the trophic status and water quality status of Kaliasote dam, various physico-chemical parameters like pH, Alkalinity, Hardness, Conductivity, Nitrites, and Orthophosphates were measured as per the standard methods given in APHA, 2005, and Adoni et al., 2005. Aquatic insects were collected by using different types of nets of varying diameters from the littoral zones of the Lakes. The collected aquatic insects were preserved temporarily in 70% ethyl alcohol and identified up to species level wherever possible by using different identification keys viz., Pennak (1978), McCafferty (1981), Bal and Basu (1994), and Subramanian (2005).

Results and discussions

During the present investigation majority of the macrobenthic species belonged to three Phyla viz. Arthropoda, Mollusca, Annelida. A total 56 species were recorded in which Phylum Arthropoda was represented by 26 species, whereas Phylum Mollusca and Annelida were represented by 16 and 7 species, respectively. A comparatively higher number of species was recorded during the summer season, while in the monsoon lesser number of species was observed during both the years (2015 & 2017). A distinct fluctuation in the availability of the number of species concerning different stations was observed in the molluscan community.

The Molluscan community in Kaliasote dam was represented by 16 species (Fig. 2 & Table- 1). Most of the species appeared with the receding of water at Station-1, which receives excess water from the upper lake during monsoon, and with the onset of summer, most of these species flourished. Pila was the dominant species at this station during the monsoon season, while in winter 2017, a succession in terms of dominance was observed at this station. Thiara tuberculata was observed to be the dominant species. The change in species composition is also correlated with the availability of compatible food and the vegetation community of the Dam. The Annelidan community in Kaliasote Dam was represented by seven species only (Figure- 4 & Table-1). The maximum number of species of this community was also recorded at station-1 during summer 2015 and 2016.

The Arthropodan community was represented by 26 species (Fig. 3 & Table-1). This community was more pronounced at Station -4 during the summer season of 2015 and at Station- 3 & 5 during 2016 & 2017 in summer season. The maximum number of species was contributed by Hemiptera and Odonata. Our results are in concordance with the findings of Ganie et al., 2020. Further, hemiptera can survive the stressed conditions and are less dependent on Dissolved oxygen due to their ability to utilize atmospheric oxygen (Bouchard, 2004). Odonata was also numerically well represented, which is indicative of the presence of rich macrophytic vegetation. As per Victor and Onomivbori (1996) Diptera are the most omnipresent of the entire macrobenthic invertebrate group in the tropics. In the present study, species such as *Chironomous* sp., *Culex* sp., and *Ephemera* sp. were resistant to high organic load, thus acting as indicators of pollution. *Chironomous* sp. has been reported as a pollution indicator [Paine and Gaufin (1956) and Servia et al., (1998)] while CPCB (2017) reported Chironomous sp. to be inhabiting less to moderately polluted waters. High abundance of chironomids in aquatic systems is also indicative of the eutrophic nature of the waterbody. Chironomids species diversity and their sensitivity to eutrophic conditions have been used in the classification of lakes into oligotrophic, mesotrophic, and eutrophic categories [Saether, (1975) and Langdon et al., 2006]. *Bellamya* sp., *Lamellidens* sp., *Thiara* sp., *Tubifex* sp., have been reported to inhabit moderately polluted water. Further, *Lymnaea acuminata*, *Indoplanorbis* sp. *Laccotrephes* sps., *Micronecta* sp. *Nepa* sps. *Belostoma* sp. inhabits heavy pollution. However, *Ranatra* sp., *Thiara limeata*, *Limnodrilus hoffmestrii*, and *Bellamya bengalensis* mostly thrive in severely polluted waters (CPCB, 2017).

Table-1: List of macrobenthic species recorded from Kaliasote dam during the study period.

Mollusca	*Bellamya bengalensis, Bellamya dissmilis, Viviparus viviparus, Bithynia Pulchella, Bithynia tentaculate, Thiara tuberculate, Paludo mussulcatus, Pleurocera* sps., *Goniobasis* sps., *Pila globose, Pila virens, Indoplanrobis exustus, Gyraulusconv exiusculus, Lymnaea Auricularia, Lymnaea acuminate* and *Parreysia occata.*
Arthropoda	*Palaemonetes, Mysis* sps., *Syncaris* sps., *Chironomous* sps., *Tipula abdominalis, Culex* sps., *Gomphus* sps., *Hegenius* sps., *Calopteryx* sps., *Anaxjunix, Lestes* sps. *Argia* sps., *Coenagrion* sps., *Dolomedes* sps., *Emphemerlla* sps., *Cordulegaster* sps., *Caenis* sps., *Berosus* sps., *Dineutus* sps., *Camptocerus* sps, *Gerris* sps., *Aquaris remiges, Micronecta, Sigara* sps., *Belostoma* and *Lethocerus* sps.
Annelida	*Tubifix* sps., *Limnodrilus* sps., *Branchura* sps., *Stylaria lacustris, Pheretima* sps., *Glossiphonia* and *Hirudinae.*

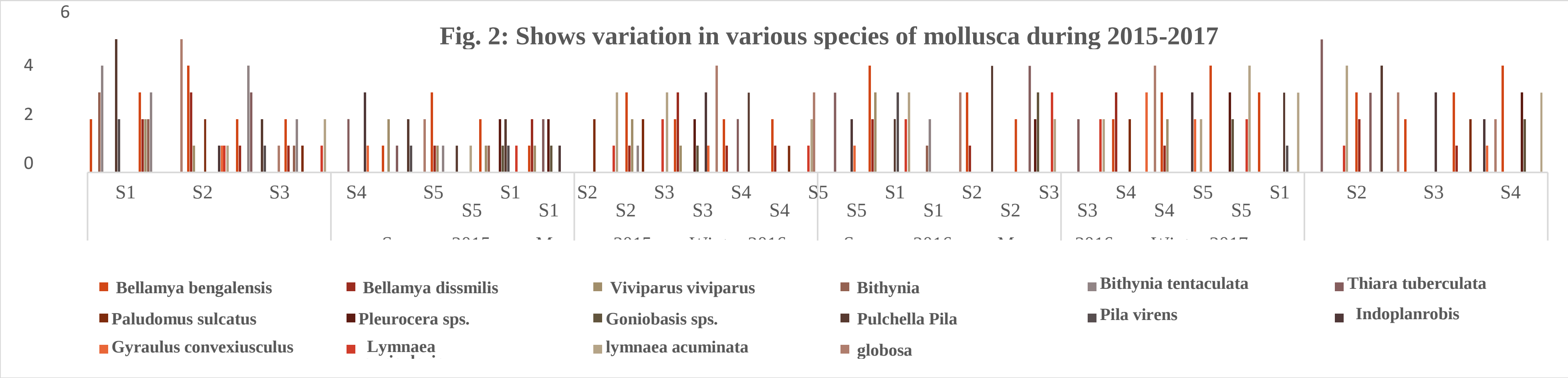


Fig. 2: Shows variation in various species of mollusca during 2015-2017

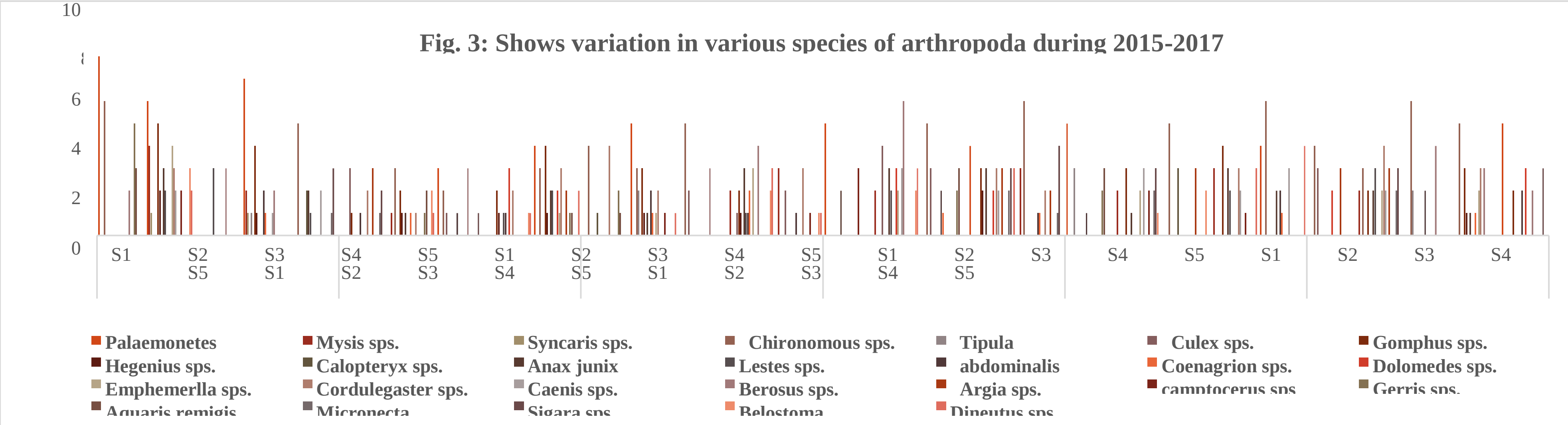


Fig. 3: Shows variation in various species of arthropoda during 2015-2017

Fig. 4: Shows variation in various species of Annelida during 2015-2017.

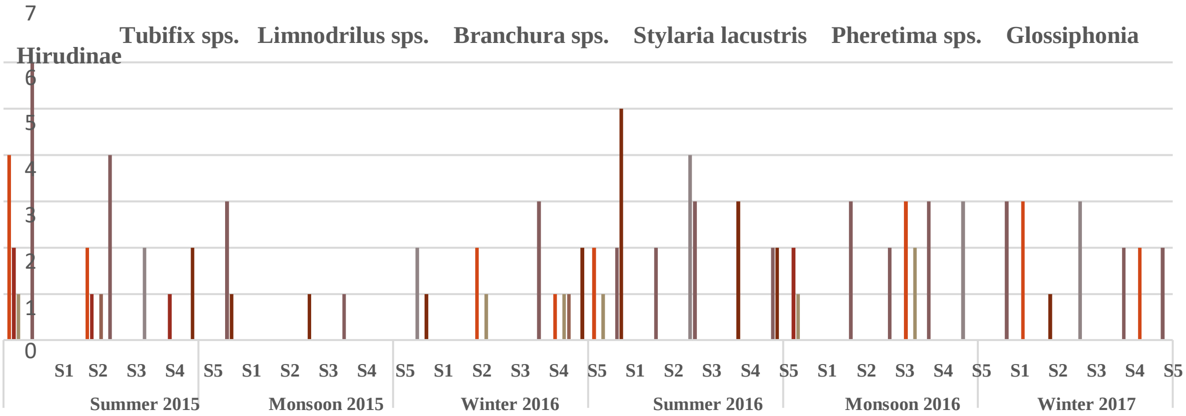


Fig. 5: Simpson Diversity index (D) of Macrobentic Fauna at various stations of K1 aliasote Dam during the period 2015-2017.

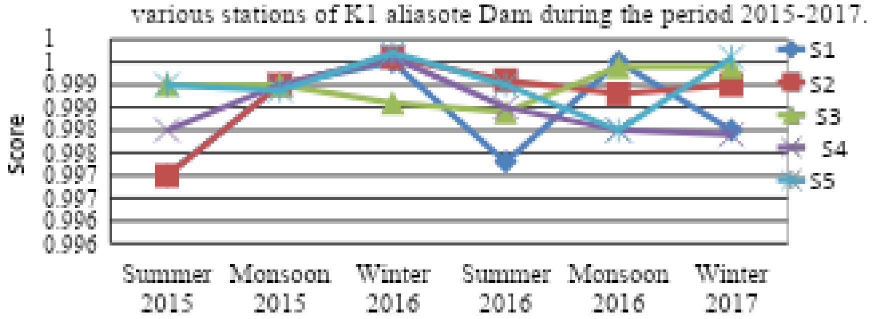


Fig. 6: Shanon Diversity index (H) of Macrobentic Fauna at various stations of Kaliasote Dam during the period 2015-2017.

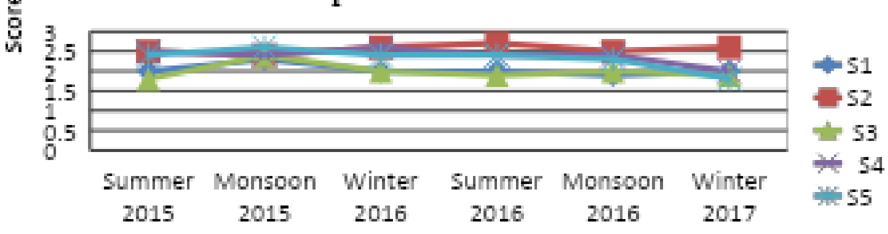


Fig. 7: Shows BMWP score of Kaliasote Dam during 2015-17

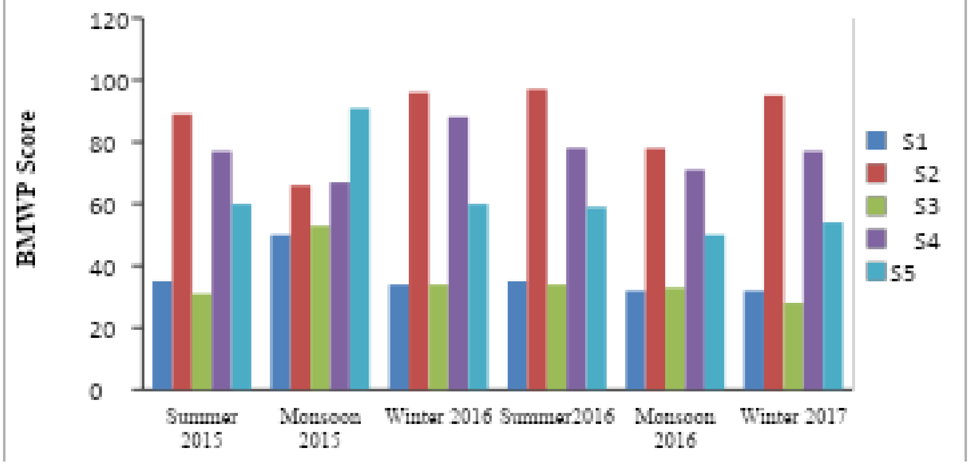
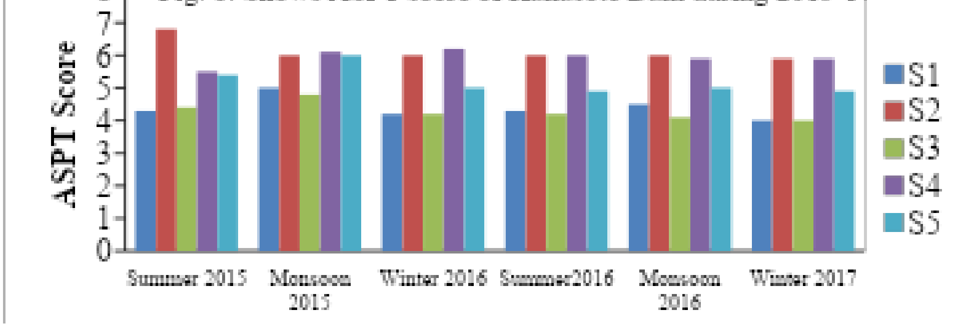


Fig. 8: Shows ASPT score of Kaliasote Dam during 2015-17



In general, the biodiversity of the Kaliasote dam based on Simpson's Index (D) varied concerning season and stations. Minimum diversity was observed during most of the time observed at Station-2. During summer 2015, the maximum Simpson's Index (D) was observed at Station-1, while Station-3 depicted minimum diversity. During monsoon 2015, diversity did not depict much fluctuation. In the winter of 2016, the diversity values varied at different stations maximum being at station-1, followed by station-5. During summer, 2016 minimum diversity based of Simpson's index was recorded at station-2, while in winter 2016, it was maximum at station 3 (Fig. 5). Simpson index values range between 0 and 1 with 0 representing no diversity and 1 representing maximum diversity (Pielou, 1969). Based on Shannon's H index, maximum diversity was found during summer 2016 at station-2 and minimum during summer 2015 at station -3. Shannon-Weaver index (H) values range between 1.5 - 3.5 and rarely exceed 4 (Fig. 6). In general, during the entire study period, the values for (H) (Shannon-Weaver Index) were always below 4, which confirms that a diverse aquatic insect community exists in Kaliasote dam (Margalef, 1972).

In general, the BMWP score was observed to be slightly high during the summer months. Station- 2, Station- 4 and Station-5 depicted higher scores than the rest of the stations, signifying the presence of a greater number of species at these three stations. Whereas, station-1- 1 and station-3- 3 show a lower score, signifying the presence of less number of species. During summer, 2015, the highest score of BMWP was observed at station-2 and 4, while the lowest value was recorded at station- 1 and 3 (Fig. 7). The ASPT values, on the other hand, show slightly higher values during the summer months of 2015 (Fig. 8).

Biotic indices are numerical expressions combining a quantitative measure of species diversity with qualitative information on the ecological sensitivity of individual taxa, among others. The biological monitoring working party (BMWP) is a procedure for measuring water quality using families of macro-invertebrates as biological indicators, having different tolerances to pollutants. The BMWP score equals the sum of the tolerance scores of all macroinvertebrate families in the sample. A higher BMWP score is considered to reflect a better water quality. Alternatively, the Average Score Per Taxon (ASPT) score is calculated. The ASPT equals the average of the tolerance scores of all macroinvertebrate families found, and ranges from 0 to 10. The main difference between the two indices is that ASPT does not depend on the family richness.

During this period, apart from qualitative and quantitative analysis of the macrobenthic community, the range of Saprobic Score (BMWP and ASPT) was also derived based on seasonal data on macrobenthic parameters and values were compared with the index of Biological Water Quality Criteria developed by the Central Pollution Control Board (CPCB), GOI. Based on the observations, Stations 1 to 5 have been categorized to define the water quality class of different regions of the Dam (Table-2) with the conjunction of Physicochemical parameters. Further, on the basis of different chemical parameters, the Kaliasote dam is categorized among eutrophic water bodies (Table-3).

Conclusion

The present investigation concludes that the water quality of the Kaliasote Dam, though in general is good, signs of deterioration has been noticed at several places due to various factors. All the water samples contain a significant amount of nitrate and orthophosphate at times, which provides nutrition for the growth and multiplication of microorganisms. The presence of aquatic insects with reference to the state of pollution in Kaliasote Dam is documented (Ganie et al., 2020). In general, on the basis of physical, chemical, and macroinvertebrate studies, the Dam water can be classified as a moderately polluted water body. However, the results of chemical parameters reveal its eutrophic nature.

Table-2: Status of Kaliasote Dam at different stations based on observation on WQI and Macrozoobenthic characteristics following the Biological Water Quality Criteria Developed by CPCB

Stations	Range of Saprobic Score (BMWP)	Range of Diversity ++	Water Quality	Water Quality Class	Indicator colour
Station-2	7 and More	0.2-1	Clean	A	Blue
Station-4	6-7	0.5-1	Slight Pollution	B	Light Blue
Station-3 & 5	3-6	0.3-0.9	Moderate Pollution	C	Green
Station-1	2-5	0.4 & less	Heavy Pollution	D	Orange
	0-2	0-0.2	Severe Pollution	E	Red

Table-3: Present Trophic Status of Kaliasote Dam based on different physico-chemical parameters.

Physico-chemical parameters	Trophic status	Range	Kaliaste Dam	Reference
pH (Units)	Acidobiontic	< 5.5	7.78 (Alkaliphilous)	Venkateshwarlu (1983)
	Acidophilous	5.5-6.5		
	Alkaliphilous	7.5-9.0		
	Alkabiontic	> 9.0		
Alkalinity (mgl^{-1})	Medium Hard	> 10-35	94.53 (Nutrient rich)	Spence (1964)
	Hard	> 35-200		
	Nutrienr poor	1.0-15.0		
	Moderately rich	16.0- 60.0		
	Nutrient rich	> 60		
Conductivity	Productive water	> 100	290 (productive water)	Alikunhi (1957)
	Eutrophic	> 200	290 (Eutrophic)	Lee *et al.*, (1981)
Hardness (mgl^{-1})	Soft	< 75.0	80.90 (Moderately Hard)	Sawyer (1960)
	Moderate hard	75.0- 150		
	Hard	150-300		
	Very hard	> 300		
	Soft	0-60	106 (Moderately Hard)	Kannan (1991)
	Moderate hard	61-120		
	Hard	121-180		
	Very hard	> 180		
Nitrate (mgl^{-1})	Oligotrophic	0.2	1.34 (Eutrophic)	Wetzel (1975)
	Mesotrophic	0.2-0.4		
	Eutrophic	0.5-1.5		
Orthophosphate (mgl^{-1})	Oligotrophic	0.005	1.28 (Eutrophic)	Wetzel (1975)
	Mesotrophic	0.005-0.01		
	Eutrophic	0.03-0.1		

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