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Assessments of Water Quality and Plankton Diversity in the Baur Reservoir, Uttarakhand, India

Promod Joshi [a] and Reeta Joshi [a*]

[a] Department of Zoology, R.H.G.P.G. College Kashipur, U.S. Nagar, Uttarakhand, India.

Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

The current investigation was conducted between January and December of 2022. During the study period water quality was studied in Baur reservoirs two spot, one spot is a barrage area, and the second one is four kilometers away from the first one. The present study is done in Baur Reservoir, which is switched to Gularbhoj in Udham Singh district. Reservoir water is used for irrigation and domestic purposes. Many villages are located near the reservoir, so due to human interaction, water quality may be affected. For this reason, the present study finds parameters of water so we can identify the present water quality status, as we know many similar work done all over India but in this study we find present condition which may be change from past condition and as we know climatic condition are change now days so we can find rainfall in every month and other parameters of reservoir. Various quality parameters are measured, including PH, water temperature, DO, CO2, total alkalinity, total solid, turbidity, total suspended solids and total dissolved solids. All the parameters are within the permissible limit and suitable for domestic use, pisciculture, and agriculture. Water quality parameters have been observed to vary and, with the exception of

**Corresponding author: Email: Ritujoshi502@gmail.com;*

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temperature, all show a positive correlation with the production of phytoplankton and zooplankton in the chosen reservoirs. These parameters include temperature, pH, dissolved oxygen, carbon dioxide, and total dissolved solids. The temperature varies from 240c+ 60c, the pH varies from 7.0 + 2, the dissolved oxygen range varies from 7+ 3, range of carbon dioxide varies from 6+ 5, the humidity range is 50+25, and rainfall throughout varying the all study period. All the physico-chemical parameters are the relation to plankton diversity. In this study, we also find plankton diversity status in Baur reservoir. Plankton diversity can also help to find out the water quality; healthy plankton growth may relate to water quality as well as fish diversity. In the following study, we find the groups Copepoda, Clyadocera, and Rotifera, each containing 6, 6 and 2 respectively. The groups Bacillariophyceae and Chlorophycae each contain 29 and 23, respectively, phytoplankton taxa. The study looked at the association between group variation in physico-chemical parameters for the Cyanophyceae, Dinophyceae, and Euglenophyceae. With the help of this study, we can find the pollutant status and water quality level in the Baur reservoir. All the water quality parameters are under safety level and are good for irrigation purposes and for domestic use. They can filtrate, and may relevant department may take action for tourist activity that causes pollution in reservoir water.

Keywords: Parameters; baur; pisciculture; water quality; turbidity.

1. INTRODUCTION

Water is essential for life; we cannot expect life without it. Approximately 97% of the water on Earth is saltwater, while less than 3% is fresh water. The majority of the freshwater on Earth is frozen in ice caps, glaciers, or aquifers deep below the surface in the shape of lakes, ponds, rivers, and reservoirs. There are several different types of freshwater resources in India. Testing the water for physico-chemical properties is crucial before using it for home, industrial, agricultural, or drinking purposes. It is necessary to examine water using many physico-chemical characteristics [1-4]. Because they facilitate the growth of the industrial, agricultural, and urban sectors, provide electricity, and supply water for irrigation and human use, reservoirs are important for human societies on both a social and economic level[5]. In Uttarakhand State, the experimental reservoirs constructed for irrigation during the post-independence era are a significant source of fish production [6-8]. Biological diversity and the physical-chemical characteristics of the water are critical to the upkeep of a healthy aquatic ecosystem. The biotic community structure, which includes species pattern, distribution, and diversity, reflects changes in the tropical conditions of the water and can be used to determine the effects of pollution on water quality. Primary and secondary production are directly correlated with the physico-chemical properties, specifically water temperature, pH, dissolved oxygen, clarity, and total dissolved solids [9-10]. The primary uses of these reservoirs are for fishing, agriculture, and the production of hydroelectric power. Bepler et al [11-15].The present study is about the physico-chemical and plankton diversity of the Baur reservoir. Baur reservoir is situated in Gularbhoj village in the Gadarpur Block of Udham Singh Nagar district and is fed by the Baur and Kakarata rivers. The total catchment of the reservoirs is 605 square kilometers. The water holding capacity of these reservoirs is 3650 million cubic feet. The total volume content of the dam (TCM) is 8252.Work on this reservoir began in year 1966-67. Its catchment area mainly comprises Tarai and Bhaber, which are spread over an area of 307.2km^2. The dam morphometry, comprises a length of 9.50km and a maximum height of 17.98meters, with a vast expanse of 1271.00 hectares. The reservoir receives an average annual precipitation of 1645mm, with normal monsoons accounting for 1500mm, which could sometimes go as low as 547mm (Uttarakhand irrigation department). The average water level in the reservoir from October to May is approximately 786.5ft. There are approximately nine villages located around the periphery of this reservoir. The dam is an irrigation dam, and its water irrigates the Tarai area of Uttarakhand.

Due to their brief life cycles, plankton, which is minute organisms that float with water currents, respond swiftly to environmental changes. The diversity and biomass of the plankton population may be impacted by any unfavorable changes in aquatic habitats. Plankton, based on their capacity to perform certain tasks, phytoplankton and zooplankton are separated into two types' synthesis of photons. The minuscule, free-swimming, microscopic consumers of the aquatic

ecosystem are called zooplankton. Zooplankton plays an important role in secondary production and takes up an in-between space. By moving energy from lower trophic levels to higher trophic levels, an organism can reach a position in the food chain. In freshwater ecosystems, zooplankton serves as a crucial link in the aquatic food chain [16]. According to Pravin and Archana [17], physico-chemical factors play an important role in maintaining plankton levels in aquatic systems.

2. MATERIALS AND METHODS

The water samples have been collected from two selected sampling stations (spot1 and spot 2), where spot 1 is four kilometers away from spot 2. Monthly and seasonal samples have been collected from selected stations of the dam for one year, January to December 2022. The samples from surface water were taken directly in polyethylene bottles, while the bottom samples were collected using a Nansens bottle. The temperature was recorded at the time of sampling on the spot using a centigrade thermometer. The water transparency was measured by a secchi disk, pH was measured with a standard pH meter, and DO, free Co_2, alkalinity, and hardness were determined by the procedures of APHA 1995 [18]. Some of the parameters were recorded at sampling sites, and other was analyzed in the laboratory. 50 liters of water from each of the investigation's two habitats—fluvial and stagnant—were used to filter the plankton samples. Before being analyzed in the lab, the concentration was transferred using a plankton net made of bolting silk number 25 to microscopic specimen tubes, where it was kept in 4% Lugol's iodine solution for phytoplankton and 5% formalin for zooplankton, respectively. For each sample, the measurements were made in triplicate.

To measure zooplankton, the Sedgwick Rafter counting cell was employed, and the population size was calculated using the given methodology after being counted in accordance with industry standards [19]. Under a powerful digital microscope, plankton samples were examined (Motic, China).

3. RESULTS

The rainfall in Baur Reservoir recorded during study time varied from 5 mm to 54mm. In November and December, there was no rainfall recorded. The maximum rainfall was recorded at 54mm in month of July, and minimum rainfall was recorded in May, which is 5 mm (Fig.1). The humidity value was 45% to 80% higher humidity was recorded in summer and monsoon seasons and lower value of humidity was observed during the winter seasons (Fig. 1). The water temperature varies from 18^0c to 32^0c in spot 1 and 20^0c to 34^0c in spot 2 respectively. The maximum water temperature was recorded in the month of August, which is 32^0c and minimum water temperature was recorded in the month of January, which is 18^0c in spot 1 and 20^0c spot 2. The study's findings support those of Garg et al [20,21] who discovered that summertime temperatures were greater than wintertime ones. Low temperatures throughout the winter may be brought on by chilly air, greater water levels, and less solar radiation, but consistent temperature rises during the summer may be brought on by a clear sky, lower water levels, a longer photoperiod, and more solar radiation. According to research by Verma [22], reservoirs in the Tarai region of Uttarakhand State often see average water temperatures above 20^0c, providing a favorable habitat for the development and survival of tropical fish. During the study period the p^H range varied from 6.8 to 9.0 in spot 1 and 6.8 to 8.4 in spot 2, respectively shown in Fig. 1. The lowest p^H range was recorded at 6.6 and 6.8 in the months of July and November in spots 1 and 2 respectively. The highest p^H was recorded in the months of January and March, which were 8.2 and 8.4 in spot 11 and 2 respectively. The reservoir water remains Alkaline during most part of the year. The value of alkalinity was varied from recorded during the month of May, June, July and August in spot 1and 2, which is varied from 100 ± 10 mg/l and 94 ± 10 mg/l in spots 1 and 2, respectively . The highest alkalinity was recorded in the summer month. According to Sharma et.al. [23,24] the lowest value of alkalinity was recorded in summer month, and the highest value of alkalinity was recorded in winter month. The minimum value of hardness was recorded in February at 78mg/l and 74mg/l in spots 1 and 2 respectively and the maximum value of hardness was observed in May at 120mg/l and 115mg/l in spots 1 and 2, respectively denoted in. According toJoshi [25-27], the increased value observed in summer and monsoon may be due to higher temperatures which may increase the concentration of salt by excess evaporation. The surface water of the reservoir is oxygenated for the majority of the year.

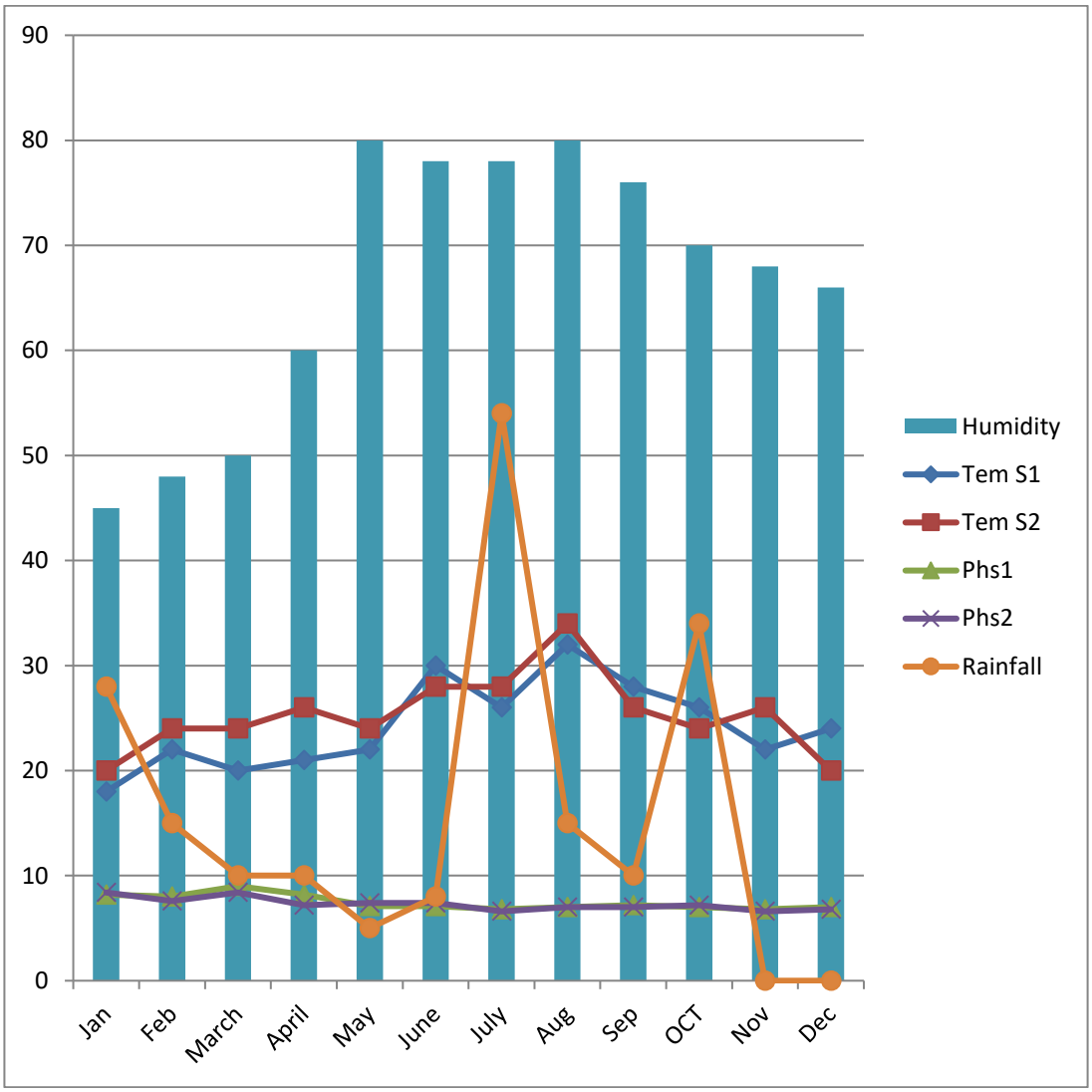

Fig. 1. Monthly variation in physico-chemical parameter in spot 1 and 2 in Baur Reservoir (January 2022 – December 2022)

3.1 Phytoplankton Population

The phytoplanktonic community composition of the research period's Baur reservoirs is shown in Table 2. In Baur Reservoir, phytoplankton belonging to 29 different taxa was discovered, with Bacillariophyceae and Chlorophyceae accounting for the majority of these taxa. Among these genera are Bacillariophyceae, which includes Dinophyceae, 10, Cyanophyceae, 2, Euglenophyceae 1, and 15, Chlorophyceae. The observed phytoplankton was depicted by class, and the Bacillariophyceae (49%) were dominating in terms of phytoplankton diversity. Chlorophycae (32%), Euglenophycae (11%),Cyanophycae (10%), and Dinophycae (21%), in that sequence. The eutrophic status of the ecosystem was demonstrated in the current study by the presence of *Nitzschia sp*., *Naviculla sp*., *Euglena sp*., *Chymbella sp*., *Gomphonima sp*., and *Oscillattoria sp*. at both reservoir sites [7, 28,29]. The Chlorophyceae were the next important group, and according to Kadam et al. [30], they can live in situations with high temperatures, pH levels, and DO. The Baur Reservoir was discovered to have a higher concentration of green algae, which may be related to the reservoir's higher temperature and dissolved oxygen levels. Karthi et al. [31] found 32 phytoplankton species in Lake Vaduvar, including 15 species from each of the families Bacillariophyceae, Chlorophyceae, and Cyanophyceae. According to Sharma [32] research, diatoms comprised 40.31% of the phytoplankton in the Tighra Reservoir near Gwalior. Gadag et al. [33] claim that Oscillatoria

sp. is a biological contaminant and an indicator of nutrient excess in water bodies [34]. In cold settings, diatoms have been seen to flourish [35,36]. However, it has been seen that blue-green algae diversity increases as temperature and DO rise [37], demonstrating the biological burden that all aquatic systems bear. The phytoplankton density in the Baur Reservoir peaked in April (29,000 cells l-1) and declined in September (12,000 cells l-1), based on the usual pattern. At 23,775 x 7,982.436 cells l-1, Site S2 had the highest average phytoplankton density, followed by Site S1(20,125 x 7,019.107 cells l-1). Site S1 had a lower concentration of phytoplankton. With regard to pH, TDS, DO, and zooplankton, there was a positive correlation in the density of phytoplankton. Researchers found a negative correlation between air pressure and water temperature.

3.2 Zooplankton Population

Table 3 displays the zooplankton composition of the Baur reservoir during the course of the investigation. 14 genera of zooplankton from three distinct families, including Clyadocera (7 genera), Copepooda (5 genera), and Rotifera (2 genera), are found in the Baur Reservoir. When the observed zooplankton composition was represented by class, Cladocera (52%) and Copepoda (34%) made up the majority of the donors, followed by Rotifera (14%), in terms of diversity. The reservoir frequently contained members of the zooplankton genera Moina sp., Cerriodaphnia sp., Brachionus sp., Chydorus sp., and Messocyclops sp. Cladocerans make roughly 36% of the Kaliasote Reservoir's makeup, according to Sedamkar et al [37, 8]. The reservoir frequently contained members of the zooplankton genera Moina sp., Cerriodaphnia sp., Brachionus sp., Chydorus sp., and Messocyclops sp. In the Madhya Pradesh Lony Dam, [19] found 29 species of zooplankton at a moderate density. Cladocerans make roughly 36% of the Kaliasote Reservoir's makeup, according to Dubey et al. [38]. A related investigation into some biotic elements in the Nanak Sagar reservoir was done by Joshi and Tripathi [39].

Fig. 2. Microscopic image of some phytoplankton

Fig. 3. Microscopic image of zooplankton

Table1. Monthly variation of Physico-chemical parameters of baur reservoir (January to December 2022)

Months	Temp.		Ph		DO		Co_2		T.D. Solid		Humidity	Rainfall	Hardness		Alkalinity	
	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2			S1	S2	S1	S2
Jan	18	20	8.2	8.4	9.2	9.0	10.0	9.6	120	130	45	28	88	84	150	160
Feb	22	24	8.0	7.6	8.8	9.2	12.0	12.2	140	110	48	15	86	82	130	140
March	20	24	9	8.4	6.2	7.1	7.2	9.0	122	130	50	10	96	88	130	120
April	21	26	8.2	7.2	7.8	8.4	6.1	7.0	120	125	60	10	100	94	118	110
May	22	24	7.1	7.4	8.2	8.6	7.0	7.2	132	136	80	5	120	115	110	115
June	30	28	7.1	7.4	8.1	7.8	8.4	7.2	140	140	78	8	115	120	100	96
July	26	28	6.8	6.6	9.8	9.6	8.4	8.2	132	135	78	54	110	115	105	100
Aug	32	34	7.0	7.0	8.4	7.2	7.1	6.8	145	146	80	15	100	98	100	94
Sep	28	26	7.2	7.0	7.8	7.2	6.1	7.0	114	128	76	10	98	96	110	100
Oct	26	24	7.0	7.2	7.0	7.4	6.2	7.4	116	126	70	34	105	98	115	105
Nov	22	26	6.8	6.6	8.0	7.8	7.6	6.8	112	122	68	-----	98	104	115	110
Dec	24	20	7.0	6.8	7.6	7.4	6.0	6.2	106	110	66	-----	96	98	120	115

	Temp	pH	DO	Co_2	T.D. Solid	Humidity	Rainfall	Hardness	Alkalinity
SD	3.94	0.64	0.89	1.70	11.58	12.92	17.22	11.0006	16.38
Mean	24.79	6.94	8.05	7.88	126.54	66.58	9.65	99.33	115.78

Table2. Qualitative composition of phytoplankton (January to December2022)

Class	Species	Spot-1	Spot-2
Bacillariophyceae	*Nitzchia sp.*	+ +	+
	Achnanthes sp.	+	++
	Navicula sp.	+++	-
	Amphora sp.	-	+
	Gomphonema sp.	++	+
	Synedra sp.	+	++
	Gyrosigma sp.	-	+
	Fragillaria sp.	+++	-
	Caloneis sp.	++	++
	Epithemia sp.	-	++
	Pinnularia sp.	+	+
	Rhopalodia sp.	++	+++
	Denticula sp.	-	++
	Cymebella sp.	+	+
	Amphipleura sp.	+	++
Chlorophycae	*Chlorococcus sp.*	+++	+
	Cosmarium sp.	++	-
	Spirogyra sp.	+	++
	Hyalotheca sp.	-	++
	Mougeotia sp.	+	-
	Zygnemaa sp.	++	++
	Scenedesmus sp.	-	+
	Rhizoclonium sp.	++	-
	Ulothrix sp.	++	+
	Ankistrodesmus sp.	+++	+
Cyanophyceae	*Oscillatoria sp.*	++	+
	Microcystis sp.	+++	+
Euglenophyceae	*Euglena sp.*	++	++
Dinoophyceae	*Ceratium sp.*	++	++

(-, +, ++, +++ as mentioned in Table 3)

Table 3. Qualitative composition of zooplankton in year January.2022- December2022

Class	Species	Spot-1	Spot- 2
Copepoda	*Cyclops sp.*	++	++
	Eucyclops sp.	++	-
	Mesocyclops sp.	++	+
	Diaptomus sp.	++	+
	Nauplius larva	++	+
Clyadocera	*Daphnia sp.*	++	-
	Chydorus sp.	++	-
	Alona sp	++	++
	Bosmina sp	++	-
	Diaphanosoma sp.	-	+
	Ceriodaphania sp.	++	++
	Monia sp.	++	+
Rotifer	*Brachionus sp.*	++	+
	Notholca sp.	++	-

= Absence, + = Rare, + + = Presence, + + + = Abundance

Over the course of the two-year investigation, they detected 14 distinct genera and species of zooplankton (rotifera and crustaceans), but no genera/species of protozoa. *Mesocyclops sp*. and Diaptomus sp. are indicators of organic contamination in the streams, according to

Rajagopal et al. [39]. Rotifers prefer alkaline settings, and Ana et al. [40] claim that this abundance indicates eutrophication. This pattern was also observed in the Baur Reservoir, where the zooplankton population increased (3,400 individuals l-1) in November but fell (1,500 individuals l-1) throughout the month. The average density of zooplankton at sites S1 and S2 was 2,575677.706 and 2,325575.077 individual's l-1, respectively [41]. It was discovered that zooplankton negatively correlated with temperature and positively correlated with phytoplankton, pH, DO, and TDS.The results of the ANOVA (p 0.05) indicated that there were significant differences in zooplankton density between the chosen sites. According to Manickam et al. [42], the zooplankton population rose during the summer and fell during the monsoon season. Researchers [43,44] report that there was a lot of turbidity, little light, and a black sky. all result in a decrease in zooplankton diversity. The overall zooplankton density may have increased over the summer, according to Manickam et al. [42], because of steady limnological conditions and high primary producer standing crops that improve the availability of food.

4. DISCUSSION

The results of this investigation demonstrated that these water bodies' limnological features are favorable for the greatest development of phytoplankton and zooplankton. These two spot of this reservoir are highly interfered by human, so we can say the parameters of these spot with respect to reservoir. It has been shown that the limnological features influence the architectures of phytoplankton and zooplankton. There is some variation in the zooplankton and phytoplankton population structure depending on the limnological features of the chosen environments. In April, the Barrage area site had the highest phytoplankton concentration, whereas in November, the same site had the highest zooplankton density. Numerous phytoplankton and zooplankton pollution indicator species, along with the limnological characteristics of these water bodies, show that organic pollution has an impact on the water in the Baur reservoir. This impact can be lessened by employing appropriate management practices, such as balancing food webs. All the physico-chemical parameters shows that reservoir water can be used for irrigation purposes and with only two spots we can say this because these areas of this reservoir are mostly interrupted by humans, especially spot 1. With the help of this study, we can find the present status of reservoir water.

5. CONCLUSION

The investigation conducted between January 2022 to December 2022 assessed the water quality of the Baur Reservoir, which is used for irrigation and domestic purposes, in Udham Singh District. Water quality was evaluated at two spots, one near a barrage and the other four kilometers away. Various parameters, including pH, temperature, dissolved oxygen (DO), carbon dioxide (CO2), total alkalinity, total solids, turbidity, total suspended solids, and total dissolved solids, were measured. The study found all parameters within permissible limits, suitable for domestic use, pisciculture, and agriculture. The study also observed a positive correlation between these parameters and the production of phytoplankton and zooplankton. Additionally, the diversity of plankton species was assessed, indicating a healthy ecosystem. The study highlights a positive correlation between physico-chemical parameters and plankton diversity, indicating a healthy water ecosystem. Continuous monitoring and potential measures to mitigate pollution, especially from tourism, are recommended to sustain water quality.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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