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ORIGINAL ARTICLE

Physico-Chemical Analysis of Water of Bhagdataal; A Wetland of Balrampur District in Relation to Fish

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ABSTRACT
Through anthropogenic activities such as dam building, river management works, indirectly through developments and disturbances in the landscape of the watersheds in particular effluent discharges and deforestation increasingly threatened the environmental integrity of freshwaters systems, worldwide. In order to access the monthly and seasonally variations of "Bhagda Taal", study on various physico - chemical parameters was carried out from July, 2021 to June 2023 at three representative sites (S1, S2 and S3). The seasons were generally divided into monsoon (July- October), winter (November to February) and summer (March to June). Maximum amount of all the parameters such as BOD, COD, TDS, hardness, chloride, nitrate and phosphate was found in summer season followed by monsoon and winter seasons. The free CO_2, Dissolved oxygen and pH was maximum in winter season followed by monsoon and summer season. Maximum electrical conductivity was found in monsoon followed by winter and summer seasons. The maximum total alkalinity was found in summer season followed by winter and monsoon season. Minimum value of DO and free CO2 during summer season is due to the higher temperature because temperature is inversely proportional to DO. Rest of the parameters such as phosphate, nitrate, chloride, hardness, total alkalinity, TDS, BOD, COD etc were widely fluctuated according to seasons but are under permissible limits of fish culture.
Keywords: *Physico - Chemical Parameters, Seasonal variation, Wetland*

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INTRODUCTION

Wetlands are the areas which contain substantial amount of standing water with little flow. Wetlands are areas where water is primary factor controlling the environment and the associated plants and animal life. They occur where the water table is at or near the surface of the land, or where the land is covered by water [1]. Wetlands are defined as "lands transitional between terrestrial and aquatic ecosystems where the water table is usually at or near the surface or the land is covered by shallow water" [2]. Wetlands are considered biologically the most productive ecosystem and are considered as the kidney of the earth. Wetlands are the intermediate zone between land and water which are permanently or temporarily filled up with static or flowing, fresh, or saline water [3]. Wetlands have been identified as one of the key life supporting ecosystems on this planet [4]. They are widely distributed around the globe in every climatic zone and are thought to cover about 6% of the surface of the earth. Wetlands are cradles of biological diversity, providing the water and primary productivity upon which countless species of plants and animals including fish, amphibians, reptiles, birds, mammals, and invertebrate species depend for survival [5].

Globally these ecotones are among the world's most productive ecosystems as they offering ''sanctuary'' to a wide diversity of plants and animals. Wetlands are also known as "biological supermarkets" for the extensive food chain and rich biodiversity they support [6]. Wetlands are neither ecosystem specific nor confined to particular biodiversity hot-spots. The physico-chemical and biological conditions of the wetlands soil and water can be used to assess the ecological nature of the wetlands. Although extensive works on the physico–chemical conditions of wetlands have already been carried out [7] but till now there is no sufficient baseline data about limnological parameters of Bhagda Taal. Therefore, the present

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study was undertaken to evaluate the Bhagda Taal, a wetland located in the Balrampur district of Tarai region of eastern U.P. in terms of its physico-chemical characteristics in relation to fish production.

MATERIAL AND METHODS

Study Area

The wetland BhagdaTaal (Fig. 1) under exploration is situated in about 16 km away from M.L.K.P.G. College, Balrampur towards South-East direction, in Sanjhwal Premnagar. It is situated between the latitude 270 25/ 48//N to 270 43/08// N, altitude and 82018/48// E to 82030/18// E longitude. It is a large shallow lentic waterbody with about 21 ha catchment area but due to encroachment by villagers presently its catchment area reduces up to about 15 ha. In the summer season its water spread area becomes reduced up to 7.0 to 8.0 ha. This wetland is mainly rainfed and receives runoff water. The Taal has several types of aquatic plants such as *Nymphaea*, and *Nelumbo* along with aquatic birds like Duck, Saras and Bagula. The abundant food attracts hundreds of resident and migratory birds during the winter season. Its water is used for agriculture and fish culture. The sampling were carried out during July 2021 to June 2022 from three selected sites for studies which were designated as S1, S2 and S3.

Figure 1: Balrampur District: Location of Bhagda Taal

Water Sampling

Water samples were collected fortnightly from three different sites in plastic stoppered bottles, the temperature, Electrical Conductivity, dissolved oxygen, pH, Dissolved Oxygen, TDS and total hardness were recorded on spot with the help of a portable digital Water Quality Meter Model: ISO-TECH SYSTEM (ITS)-901 using glass electrode. Transparency was measured by employing a Secchi disk of 20 cm diameter with four alternating black and white quadrats on the upper surface. The chemical oxygen demand (COD) of wetland water was estimated with the help of ISO-Tech digester System (Model: ITS-CODM25D) digital COD analyser at 1500C and heat for two hours. BOD of wetland water was estimated with the help of Lovibond Water Testing BOD-system BD 600 and BOD incubator using the Nitrification inhibitor ATH at 200C for 3 days. The free carbon dioxide, total alkalinity, phosphates, chloride and nitrates analysis were made in laboratory as per standard methods [8].

RESULTS AND DISCUSSION

Physico-chemical Properties of Taal water

Results of the physico-chemical attributes of the Bhagda Taal water is presented in Table 1. The parameter wise results obtained are elaborated and discussed below:

Water Temperature

Water temperature is an important physical factor in controlling most of the chemical and biological characteristics of fresh waterbodies. It affects all the metabolic, physiological activities and life processes of different trophic levels of aquatic ecosystem. It was observed that water temperature of Bhagda Taal is influenced by the air temperature. The water temperature of ranged from 20.59-28.12°C during July 2021 to June 2023. The range of water temperature is suitable for culture of Indian major carps and exotic carps [9]. In the present study, maximum temperature was recorded during summer season, moderate in monsoon season and minimum in winter season. This investigation is also in close conformity with the finding of other researchers [10-13].

Transparency

Transparency significantly affects the development and distribution of aquatic organisms; it is considered as an important limiting factor in aquatic environments. Water transparency controls the energy relationship at different trophic levels in food chain [14]. In the present study the average water transparency the average maximum water transparency was recorded during winter season, moderate in summer season and minimum in monsoon seasons. This observation is also in close conformity with the finding of some researchers [15-17]. The low transparency during the monsoon season is caused by the inflow of the surface water which is full of silt and the influx of soil particles due to the soil erosion of marginal. The high transparency during the winter season can be attributed to the settling of particles at the bottom of the pond [18]. Transparency during monsoon months in fresh waterbodies were observed by several researchers [19,20]. The transparency of water decreases with increase in the presence of various suspended particles such as clay, silt, plankton, algae, etc. [21]. The 20-40 cm transparency of natural water resources is identifying as a productive waterbody's and it is beneficial for survival, growth and development of fish fauna [22-24].

Hydrogen ion Concentration (pH)

The pH is an index of general environmental conditions of aquatic ecosystem. The majority of aquatic organisms can only tolerate moderate fluctuations and cannot survive in abrupt changes in pH. The alkaline nature of water is suitable for aquatic life [25]. The water of Bhagda Taal established a highly buffered system with average pH range of 8.14 to 8.48during the study period. The maximum pH was recorded during winter season as compared to monsoon and summer seasons during entire study periods. The decline in pH values during summer months is associated with the dissociation of carbonic acid into H^+ and HCO_3^-ions. The higher pH of wetland is the indication of fact that photosynthetic activity has dominance over the respiratory activity of the biota. The optimal pH range for fish culture is 7.5 to 8.5 [26] 6.5 and 8.5[23]. The suitable range of pH for fish culture is 6.7 to 9.5 whereas above or below this level of pH is stressful to the fishes [27]. Thus the pH range of Bhagda Taal is conducive to high fish production as stated by these ecologists.

Table 1. Seasonal variation in physico-chemical properties of Bhagda Taal, Balrampur.

Seasons	July 2021 to June 2022				July 2022 to June 2023			
	Sampling Sites			Average±SD	Sampling Sites			Average±SD
	S1	S2	S3		S1	S2	S3	
Temperature (°C)								
Monsoon	27.3	26.53	28.78	**27.54±1.47**	28.53	26.83	28.63	**27.99±1.62**
Winter	21.15	19.43	21.20	**20.59±2.33**	21.33	20.05	21.08	**20.82±2.28**
Summer	28.58	27.35	27.78	**27.90±3.05**	28.73	27.45	28.17	**28.12±3.20**
Transparency (cm)								
Monsoon	35.08	49.08	35.66	**39.94±6.48**	35.80	50.00	36.08	**40.62±6.77**
Winter	66.45	70.83	67.45	**68.25±3.54**	66.48	71.28	66.98	**68.25±3.59**
Summer	59.50	66.03	61.05	**62.19±4.33**	61.13	66.38	61.28	**62.93±3.64**
Hydrogen ion Concentration(pH)								
Monsoon	8.35	8.08	8.13	**8.18±0.42**	8.30	8.13	8.08	**8.17±0.38**
Winter	8.53	8.43	8.45	**8.47±0.04**	8.53	8.43	8.48	**8.48±0.08**
Summer	8.18	8.08	8.08	**8.11±0.38**	8.18	8.13	8.13	**8.14±0.34**
Electrical conductivity(µmhos/cm)								
Monsoon	173.0	172.75	170.75	**172.17±12.48**	165.0	170.25	171.75	**169.00±13.50**
Winter	164.25	166.00	165.25	**165.17±1.34**	162.50	167.75	160.75	**163.66±4.96**
Summer	138.00	133.50	136.00	**135.83±9.14**	134.50	137.25	132.75	**134.83±7.09**
Free CO2(mg/L)								
Monsoon	2.88	2.83	2.95	**2.88±0.52**	2.80	2.73	2.83	**2.78±0.36**
Winter	4.33	4.38	4.40	**4.37±0.16**	4.13	4.13	4.20	**4.15±0.37**
Summer	2.80	2.98	3.00	**2.92±0.62**	3.22	3.07	3.18	**3.16±0.46**
Dissolved Oxygen(mg/L)								
Monsoon	7.65	7.83	7.65	**7.71±0.35**	7.80	8.00	7.68	**7.83±0.36**
Winter	8.73	9.10	8.70	**8.84±0.41**	8.65	9.25	8.68	**8.86±0.43**
Summer	7.65	7.68	7.68	**7.67±0.44**	7.60	7.75	7.60	**7.65±0.41**
Biological Oxygen Demand (mg/L)								
Monsoon	2.93	2.8	2.7	**2.81±0.41**	2.83	2.68	2.85	**2.79±0.28**
Winter	2.7	2.65	2.68	**2.67±0.63**	2.75	2.70	2.70	**2.72±0.64**

Summer	3.40	3.43	3.25	**3.36±0.40**	3.43	3.30	3.25	**3.33±0.31**
Chemical Oxygen Demand (mg/L)								
Monsoon	32.48	32.28	33.25	**32.67±4.60**	33.45	32.33	33.20	**32.99±4.74**
Winter	22.53	23.33	22.33	**22.73±0.89**	22.75	23.85	23.53	**23.37±2.83**
Summer	35.43	35.75	35.80	**35.66±4.75**	35.68	36.28	37.03	**36.33±4.52**
Total Alkalinity (mg/L)								
Monsoon	89.70	88.95	90.60	**89.75±6.19**	90.33	90.15	90.15	**90.21±5.77**
Winter	95.55	94.4	98.4	**96.12±3.62**	96.05	94.95	98.95	**96.65±3.80**
Summer	106.75	105.55	107.28	**106.53 ±2.04**	106.35	106.43	105.8	**106.19±1.62**
Total Hardness (mg/L)								
Monsoon	77.10	75.18	78.18	**76.81±5.13**	79.63	77.73	80.40	**79.25±4.98**
Winter	68.28	67.98	68.53	**68.26±3.85**	74.83	72.40	74.63	**73.95±8.99**
Summer	95.65	95.65	94.50	**95.27 ±1.82**	95.55	95.50	96.60	**95.88±1.32**
Total Dissolved Solids (mg/L)								
Monsoon	212.25	208.5	201.00	**207.25 ±43.42**	219.00	236.75	229.75	**228.50 ±45.14**
Winter	156.0	153.5	158.0	**155.83 ±6.17**	162.25	154.00	158.25	**158.17 ±5.20**
Summer	346.75	328.0	342.75	**339.16 ±24.35**	338.25	308.00	322.25	**322.83 ±40.33**
Chloride (mg/L)								
Monsoon	6.38	5.90	6.35	**6.21 ±0.22**	6.48	6.00	6.33	**6.27±0.20**
Winter	4.70	4.25	4.65	**4.53±0.55**	4.83	4.35	4.58	**4.59±0.59**
Summer	7.33	6.98	7.28	**7.19±0.80**	7.30	6.90	7.18	**7.13**
Nitrate (mg/L)								
Monsoon	0.48	0.47	0.50	**0.48±0.03**	0.48	0.47	0.49	**0.48±0.03**
Winter	0.39	0.35	0.39	**0.37±0.05**	0.40	0.36	0.42	**0.39±0.05**
Summer	0.82	0.77	0.83	**0.81±0.11**	0.82	0.77	0.82	**0.80 ±0.11**
Phosphate (mg/L)								
Monsoon	0.30	0.26	0.31	**0.29±0.03**	0.31	0.28	0.32	**0.31±0.04**
Winter	0.17	0.14	0.16	**0.15±0.02**	0.17	0.15	0.17	**0.16 ±0.02**
Summer	0.52	0.48	0.52	**0.51 ±0.06**	0.53	0.48	0.51	**0.51 ±0.06**

Electrical Conductivity (µmhos/cm)

The conductivity of a waterbody depends upon the nature and concentration of ionized substances present in the water. The EC reflects the amount of total soluble salts i.e., nutritional level of the water and distribution of macrophytes. High conductance leads to eutrophication and finally leads to pollution of waterbody [13]. Increased conductivity in the taal or any waterbody indicated accumulation of dissolved salts [28]. Seasonal difference in the conductivity is mainly due to increased concentration of salts as result of evaporation.EC between 20 and 1500 µs/cm is suitable for aquaculture [24]. The average Electrical conductivity of Bhagda Taal water varied between 134.83 to172.17 µmhos/cm during the study period. The average minimum EC of Bhagda Taal water was recorded in the month of June and maximum in the month of October. The maximum EC was recorded during monsoon season, moderate in winter season and minimum in summer seasons. Similar results were observed by some researchers [13, 29-33]. High value of electrical conductivity in monsoon season indicates the presence of higher concentration of ions due to addition of some domestic product from households, chemical fertilizer from agricultural land through rainwater run-off and due to increase in organic matters such as plant debris into the wetland.

Free Carbon Dioxide

The presence of free carbon dioxide in waterbodies usually derived from atmospheric sources, biotic respiration and the decomposition of organic matter by saprophytes [21]. The increased rate of organic decomposition resulted in release of carbon dioxide into the water and thus increased the levels of free carbon dioxide in the waterbody [34]. It plays an important role in the photosynthesis of producer or primary fish food organisms. In the present study the average free carbon dioxide in the water of Bhagda Taal varied between 2.78 to 4.37 mg/L during the study period. The maximum average free carbon dioxide in Bhagda Taal water was found in winter season, moderate in summer season and minimum in monsoon season. This investigation is also in close conformity with the finding of others [35,36]. Thus, it is evident that high CO2 values were associated with low rainfall and moderate temperature. Low free carbon dioxide was found during the monsoon season, when phytoplankton density was low, and high free carbon dioxide during the winter, when phytoplankton production was higher than monsoon season. High concentration of free carbon dioxide during monsoon months could probably be associated with

active decomposition of organic matter in the wetland [21]. The concentration of free CO**2** was higher in bottom layers than in the surface layers of the water body throughout the year [37].

Dissolved Oxygen

Dissolved oxygen is a very important parameter in assessing water quality, as it acts as an indicator of the physical, chemical and biological functions of a water body [21]. It is also important in precipitation and dissolution of inorganic substances in water [13]. The DO of Bhagda Taal ranged between 7.65 to 8.86 mg/L. The maximum average dissolved oxygen in Taal water was found in winter season, moderate in monsoon season and minimum in summer season during the study period. The highest dissolved oxygen was recorded during winter season may be attributed to high photosynthetic activity. The highest dissolved oxygen in winter may be due to low atmospheric temperature and minimum dissolved oxygen in summer may be due to high metabolic rate of organisms [17]. Oxygen depletion in rainy season may be due to the low photosynthetic or respiratory activity of heterotrophic organisms and also probably due to the biological oxidation of organic matter and the combined effects of temperature and photosynthetic activity. The dissolved oxygen concentration above 5.0 ppm throughout the year shows that the wetland is very much productive [22,26,38].

Biological Oxygen Demand (BOD)

BOD is a critical parameter used to assess the organic pollution and overall water quality of wetlands or a natural waterbody. It measures the amount of dissolved oxygen consumed by microorganisms while they decompose organic matter in water [14]. In the context of a wetland, it is an important indicator of its ecological health and its ability to perform natural water treatment functions [21]. According to WHO, BOD level in any waterbody above 6 mg/L is to be considered polluted. The higher BOD may be associated with presence of various microbes in water which probably accelerated their metabolic activities with increasing concentration of organic materials received by the waterbody through run-off [14,39] or due to high quantity of biologically oxidisable matter [40]. In the present study the average biochemical oxygen demand (BOD) in the water of Bhagda Taal varied between 2.67 to 3.36 mg/L during the study period. The maximum average BOD level of Bhagda Taal water was found in summer season, moderate in monsoon season and minimum in winter seasons during the study period. The finding of present investigation was similar to the result observed by other researchers [13, 41-44]. Higher BOD in summer season may be due to rise in temperature and utilization of dissolved oxygen by microbes in stabilization of organic materials [43,45,46].

Chemical Oxygen Demand (COD)

The COD is the quantity of oxygen needed for the chemical oxidation and breakdown of organic and inorganic molecules in water. It communicates the quantity of oxidizable organic matter that has dissolved in water, including non-biodegradable materials. In the present study the average COD in the water of Bhagda Taal varied between 22.73 to 36.33 mg/L during the study period. This range of COD was falls within the range of COD in Tehri dam of Garhwal [47]. The maximum average COD value of Bhagda Taal water was found in summer season, moderate in monsoon season and minimum in winter season during the entire study period. The higher value of COD in summer and lower in winter corroborates with the finding of other workers [13, 46]. This matter and increased anthropogenic pressures such as inflow of agricultural runoff and domestic wastewater in the wetland [48]. Other researcher also found minimum COD in monsoon and maximum in Summer in lentic waterbodies [41].

Total Alkalinity

Alkalinity is directly related to the productivity of water bodies because it regulates the pH and free carbon dioxide of the water bodies. Wetland waters are rich in carbonates, bicarbonates and hydroxides that imparts total alkalinity [32,49]. These surface waters alkalinity may result from wastes discharged from adjoining area and microbial decomposition of organic matter present in waterbody [50]. The total alkalinity ranged between 89.75 and 106.53 mg/l during the entire study period indicates that Taal water is nutrient rich as well as high productive [25,38]. The maximum average total alkalinity of the Bhagda Taal water was found in summer season, moderate in winter season and minimum in monsoon season during the study period. The present finding is similar to that of other researchers [16,17,24,51]. During summer season the number of carbonates and bicarbonates increases due to faster degradation of plants, living organism and organic waste might also lead in the increase in a carbonate and bicarbonate, resulting an increase an alkalinity of wetland [52,53]. Surface runoff from catchment areas also increases alkalinity in post monsoon period i.e., winter as seen in the present investigation. However, variations of alkalinity in different sites of this wetland affirm that such changes were on account of internal nutrient dynamics and not because of external factors.

Total Hardness

Total hardness is defined as the sum of calcium and magnesium concentrations, both expressed as $CaCO_3$ mg/L. It is an index of fertility of the aquatic ecosystem. It is the index of fertility of the aquatic ecosystem [16,21]. The total hardness ranged between 68.26-95.88 mg/L indicates that water of the Taal is suitable for fish culture [9]. The result is supported by the findings of others [21]. Other researchers observed 78 to 117 ppm and 76 to 123 ppm in Baghel Taal and Semara Taal, wetland of eastern U.P., respectively [16,17]. The highest hardness was noticed in summer season and lowest in winter seasons. The maximum hardness present during summer season in this study may be attributed to decrease in water level/ volume and increased rate of evaporation at high temperature.

Total Dissolved Solids

The estimation of TDS of a wetland is an important factor in determining its overall status of productivity. Higher concentrations of dissolved solids may be harmful to aquatic life [54]. High TDS in waterbody is indication of eutrophication which finally leads to water pollution [13]. In the present study the average TDS in the water of Bhagda Taal varied between 155.83 to 339.16 mg/L during the study period. In the present investigation, the maximum TDS of Bhagda Taal was found in summer season, moderate in monsoon season and minimum in winter season during the entire study period. This investigation was similar to the result of some researchers [24,51]. The maximum amount of total dissolved solids in summer season when the water level comes down considerable due to evaporation whereas moderate level of TDS in monsoon season due to runoff water from the catchment area.

Chloride

Chloride plays a critical role for determining the quality of water [55]. The maximum average chloride content in Bhagda Taal water was found in summer season, moderate in monsoon season and minimum in winter season during the study period. The higher chloride content during summer months may be attributed increase input of organic wastes of human origin and reduced water level whereas in monsoon there is influx of organic wastes or contaminated water from the catchment area and being a suitable as well as convenient habitat for cattle of the surrounding villages.

Nitrate

The most chemically stable available form of nitrogen is nitrate [56]. High nitrate concentration is responsible for algal blooms in water body. Surface runoff, decayed vegetations and animal matter are the main sources of nitrates in water body. The nitrate content of the water ranged between 0.37- 0.81mg/L. In the present investigation the range of nitrate concentration were agreeable with the observation of nitrates in other wetlands of eastern Uttar Pradesh [16,17,57]. Its maximum concentration was observed in the summer season, moderate in monsoon and minimum in winter seasons.

Phosphate

Phosphate is considered as one of the most critical nutrients necessary for the maintenance of primary productivity of aquatic ecosystem [9]. They are essential for the growth of organisms and a nutrient that limits the primary productivity of the water body. In the present study the phosphate content was ranged between 0.15- 0.51mg/L. It was minimum during winter months and maximum during the summer months. . Similar result was also recorded by other researchers [13,51]. In relation to nutrient status, the wetland falls into medium to high productive group [9,26]. Low phosphate contents during winter months and high during summer or post monsoon months may be due to low decomposition of organic matters during summer season [58].

CONCLUSION

Individually or in combination with physic-chemical properties of water play an important role in fish production in a waterbody. The morphometric nature of Bhagda Taal and moderate temperature of waters were found favorable for good growth of plankton. The alkaline range pH of the taal water was favorable for high rate of fish production. The alkalinity range of this wetland was also indicative of good productivity. Thus, it can be concluded that the physico- chemical condition of water of Bhagda Taal is good for fish production if we managed scientifically. It can be realized optimally by stocking of fast growing Indian major carps, Catla, Rohu, Mrigal and Calbasu in ratio 4:3:3 or by stocking of Indian major carp and exotic carp in ratio 3:3:2:2 for Catla, Rohu, Mrigal and Common carp, respectively @ 1000-1500 fingerlings/ha.

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CONFLICT OF INTEREST

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