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Assessment of Physicochemical characteristics and water quality of Kot Dam in Jhunjhunu District (Rajasthan)

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Abstract

The present investigation deals with analysing the physicochemical characteristics of Kot Dam in Jhunjhunu district (Rajasthan) for its quality assessment. The physicochemical parameters such as temperature, pH, DO, TSS, BOD, COD, chloride, sulphates, total hardness, calcium hardness, magnesium hardness, Ca, Mg, phosphates, fluoride, TDS, electrical conductivity and total alkalinity of Kot Dam water showed distinct temporal or seasonal variations. The water quality analysis indicated that the water in Kot Dam was consistently polluted and unsafe for human consumption throughout the study period. Moderate levels of BOD, EC and Total Alkalinity determine the mesotrophic status of the Dam.

Key words : Physicochemical characteristics, Mesotrophic status, Statistical analysis, Pearson Correlation, Kot Dam.

Water is a significant natural resource essential for everyone to meet daily requirements. Water scarcity results from misapplication and adulteration.[10] Physico-chemical parameters determine the water quality and instantly regulate the biological diversity. These physicochemical or abiotic factors are intrinsically non-living elements influenced by natural attributes and activities such as rainfall, bed soil, bedrock in the catchment area, sediment erosion, evaporation, etc. Besides natural events, anthropogenic activities firmly affect the chemical parameters of any aquatic body.[2] Fast industrial development, colonisation, and haphazard use of chemicals and fertilisers are responsible for the rapid depreciation of water quality and the diminution of aquatic biodiversity.

Water bodies and their circumambient areas are inimitable resources and extravagant ecosystems of any nation and its landscape. These freshwater assets have socio, cultural and aesthetic relevance, and maintaining their quality assists in preserving a healthy ambience.[11] The present study evaluated Kot

Dam water's various physical and chemical properties to determine its water quality. It also helped to determine the correlation among these properties to produce a record of the water quality data and suggest mitigation actions for its conservation.

Study area :

Kot Dam is a dam built across the Shakambari hills and is also known as Suraj Sagar Dam. It is located in Jhunjhunu district (Rajasthan), about 13 kilometres from Udaipurwati town. This dam was mainly constructed for the purpose of irrigation and water storage. It was built in 1924 by Raja Bhoop, who ruled the region. The dam's gross catchment area is 11.65 km^2, receiving an average annual rainfall of 50.8 cm.

Table-1. Geographical Features of Kot Dam.

Characteristics	Description
Location	Kot, Jhunjhunu
Coordinates	27°39' N 75°25' E
Height	7.6 m (25ft)
Length	80 m (260ft)
Type of Dam	Masonry with embankment
Catchment area	11.65 km^2
Nature of Catchment area	Steep to gentle slope

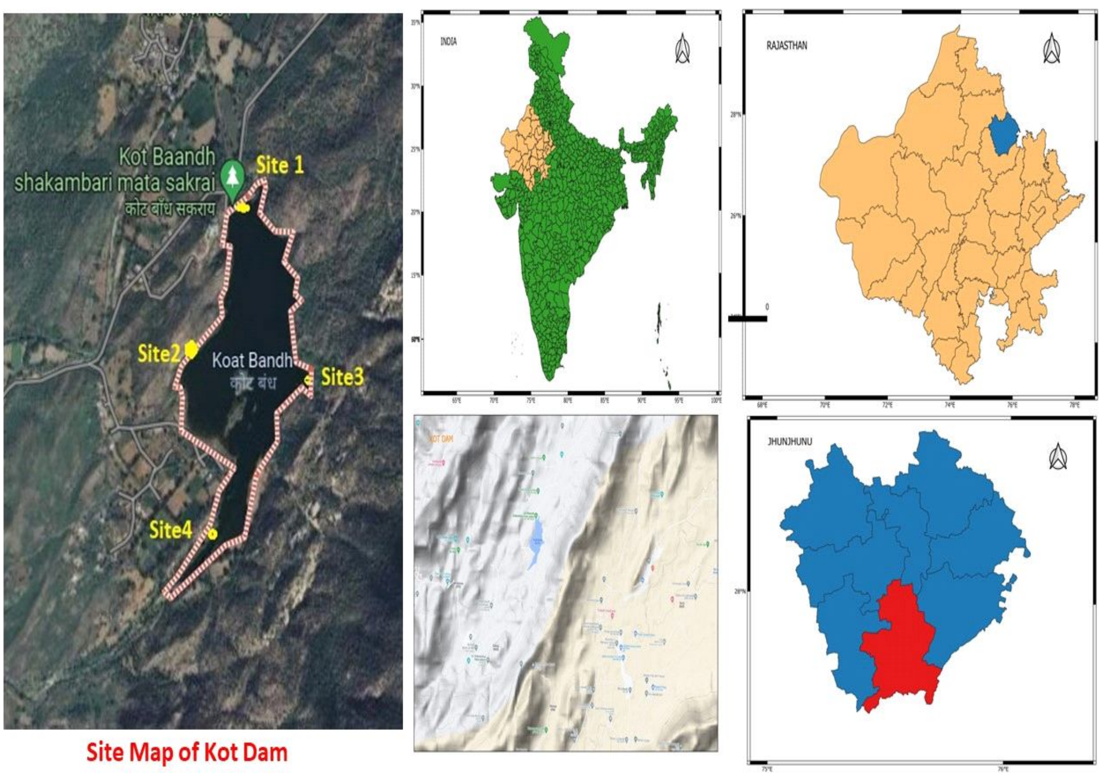

Figure 1. Map of Study Area (Kot Dam)

Collection of water sample :

The Kot Dam survey was carried out from July 2021 to June 2022. The water samples were collected from four different sites, such as the Dam's East, West, North, and South sides, once a month during the early hours between 7.00 to 10.00 a.m. during the study period. Acid polyethene bottles with a 2L capacity were used to collect samples. As soon as samples were collected, they were appropriately tagged and taken to the lab for physical and chemical analysis. The samples were kept at 4°C until they were analysed. Physico-chemical analysis such as temperature, pH, DO, TSS, BOD, COD, chloride, sulphates, total hardness, calcium hardness, magnesium hardness, Ca, Mg, phosphates, fluoride, TDS, electrical conductivity and total alkalinity of the sample were done according to standard methods given in APHA[8] guidelines.

Temperature :

The temperature of a water body plays a significant part in defining an aquatic ecosystem's dynamics. Water temperature is directly related to the dissolving capacity of oxygen, metabolism, and photosynthetic rate of biota in water. Temperature change also influences the toxic waste sensitivity towards different organisms in the water. Water temperature favours the abundance of a particular species.[9] The temperature of the water in Kot Dam ranged from 10.32°C to 36.95°C, with a mean value of 22.50±5.72°C at the 95% confidence level (Table-2).

pH :

The chemical composition of a solution can be expressed using pH. The aquatic biota is affected by pH since many of its metabolic processes are pH-sensitive.[6] The concentration of Carbon Dioxide produced from photosynthesis directly influences the concentration of Hydrogen ions in water.[12] The levels of pH mainly indicate the deterioration in the quality of water. Biological degradation and oxidation of organic matter also influence the pH of a water body. It is an essential factor for algal production. The pH of Kot Dam waters was falling from 6.9 to 7.9, with a Standard Deviation of 0.304. The Mean value with 95% CL was 7.39± 0.19, as shown in Table-2.

Dissolved Oxygen (DO) :

In aquatic ecosystems, dissolved oxygen plays a significant role. The biological and physico-chemical actions in freshwater influence dissolved oxygen concentration. The feasibility and accessibility of nutrients are afflicted by oxygen concentration and, henceforth, the production of freshwater ecosystems.[14] The dissolved oxygen in Kot Dam varied between 4.42 to 8.77 mg/L. The dissolved oxygen decreases with increasing temperatures, followed by the observed values. The low values of DO could be due to the presence of oxidative compounds and inorganic reductants. According to WHO (World Health Organization), the standard value of DO should be more than five mg/L. The mean value of DO was 6.67 ± 0.82 with a Standard Deviation of 1.30 at 95% CL (Table-2).

Biological and Chemical Oxygen Demand (BOD and COD) :

The amount of dissolved oxygen

necessary for microorganisms to biochemically break down organic molecules is known as the "biochemical oxygen demand" (BOD). Assessing the quality of water BOD is a globally acknowledged parameter. It varied between 3.2 to 5.4 mg/L during the study period, whereas the COD varied from 10.67 to 16.37 mg/L. These values imply the presence of organic matter of unrecognised origin. The Standard Deviation recorded for BOD and COD were 0.678 and 1.71, respectively. The mean value for BOD at a 95% confidence level was 4.33 ± 0.43, and for COD, it was 13.61 ± 1.09. (Table-2).

Total alkalinity (TA) and Total dissolved solids (TDS) :

The lakes are classified into three groups based on their alkalinity level: nutrient-poor (4-50 mg/L), moderate nutrients (50-100 mg/L), and nutrient-rich (100-600 mg/L).[5] According to this distribution, the present study site (Kot Dam) falls under the nutrient-rich category with an alkalinity range of 132.5 – 230.75 mg/L. The calculated Standard Deviation was 28.86, with a Mean 95% Confidence Level of 184.10 ± 18.34. A higher concentration of dissolved solids increases water viscosity and affects freshwater organism osmoregulation.[4] The total dissolved solids ranged from 135.75 to 350 mg/L. The low values of TDS were noted in January 2022, when the water is considerably calm, compared to the rainy season, when the water carries all the mud. The mean value of TDS at 95% CL was 223.25 ± 48.54 with a Standard Deviation of 76.40 (Table-2).

Total suspended Solids (TSS) and Total Hardness (TH) :

A high level of suspended matter in water makes the water turbid, resulting in a decline in photosynthetic rate, depreciation of dissolved oxygen, and increased eutrophication. The TSS in Kot Dam was found in the range of 11.25 mg/L (January 2022) and 41.5 mg/L (August 2021), with an average of 22.91 mg/L. The calculated Standard Deviation was 11.32, and the average 95% CL was 22.91 ± 7.19. The hardness of water is primarily due to cations such as calcium and magnesium and anions such as carbonates, bicarbonates, and sulphates as they form bonds. Higher levels of total hardness in freshwater are mainly due to high photosynthetic activity, utilisation of free carbon dioxide, conversion of bicarbonates into carbonates and precipitation of calcium salts.[7] The Total Hardness in Kot Dam was found in the range of 99 mg/L (July 2021) to 177.25 mg/L (June 2022), as shown in Table-2.

Electrical conductivity (EC) :

The conductivity of water is mainly due to the anions and cations dissociated from dissolved electrolytes. It is a superior index to assess the trophic status of a water body as oligotrophic waters, which depict poor electrical conductance, which indicates fewer free ions, responsible for limiting the effect on productivity. The range of conductivity (227- 591 μS/cm) found at Kot Dam falls under the moderate range (200-1000 μS/cm) that most freshwater lakes possess. According to EC values, Kot Dam has mesotrophic status. The calculated Standard Deviation was 128.78, and the average 95% CL was 375.12 ± 81.82 (Table-2).

Table-2. Statistical evaluation for physicochemical parameters of Kot Dam water sample

Parameters	Min.	Max.	Mean	Std. Dev (SD)	Coefficient of variation (CV%)	SV	SE	Confidence Level (95%)	Mean + 95%CL
Temperature (℃)	10.325	36.95	22.50208	9.013156	40.05476	81.23698	2.601874	5.722554	22.50±5.72
pH	6.9975	7.9425	7.396875	0.304247	4.113179	0.092566	0.087828	0.192	7.39±0.19
Dissolved O_2 (mg/L)	4.425	8.775	6.677083	1.304209	19.53262	1.700961	0.376493	0.828655	6.67±0.82
TSS (mg/L)	11.25	41.5	22.91667	11.32843	49.43315	128.3333	3.270236	7.197741	22.91±7.19
COD (mg/L)	10.675	16.3775	13.61146	1.716745	12.6125	2.947212	0.495581	1.090767	13.61±1.09
BOD (mg/L)	3.2	5.4	4.335417	0.678606	15.65262	0.460507	0.195897	0.431166	4.33±0.43
Chlorides (mg/L)	20.45	80	48.1375	18.49039	38.41162	341.8946	5.337716	11.74823	48.13±11.74
Sulphates (mg/L)	10.5	36.5	23.875	8.063315	33.77305	65.01705	2.327678	5.123186	23.87±5.12
Total Hardness (mg/L)	99	177.25	147.6458	22.33664	15.12853	498.9257	6.448034	14.19203	147.64±14.19
Ca Hardness (mg/L)	58.5	91.75	77.4375	11.54543	14.90935	133.2969	3.332878	7.335614	77.43±7.33
Mg Hardness (mg/L)	40.5	90.75	69.22917	15.64756	22.60255	244.8461	4.517061	9.941985	69.22±9.94
Ca (mg/L)	23	36.5	30.66667	4.60895	15.02919	21.24242	1.330489	2.928387	30.66±2.92
Mg (mg/L)	14	22.25	18.70833	2.828092	15.11675	7.998106	0.8164	1.796884	18.70±1.79
Phosphates (mg/L)	0.28475	1.186	0.58675	0.286261	48.78754	0.081945	0.082636	0.181881	0.58±0.18
Fluorides (mg/L)	0.22275	0.417	0.330104	0.064063	19.40676	0.004104	0.018493	0.040703	0.33±0.04
TDS (mg/L)	135.75	350	223.25	76.40101	34.22217	5837.114	22.05507	48.54288	223.25±48.54
Conductivity (µS/cm)	227	591	375.125	128.7875	34.33189	16586.22	37.17775	81.82768	375.12±81.82
Total Alkalinity (mg/L)	132.5	230.75	184.1042	28.86557	15.67893	833.2211	8.332772	18.34031	184.10±18.34

Table-3. Pearson Correlation matrix of eighteen different physicochemical parameters

	Temperature	pH	DO	TSS	COD	BOD	Chlorides	Sulphates	Total Hardness	Ca Hardness	Mg Hardness	Ca	Mg	Phosphates	Fluorides	TDS	Conductivity	Total Alkalinity
Temperature	1																	
pH	-0.76	1																
DO	-0.97	0.88	1															
TSS	0.63	-0.85	-0.72	1														
COD	0.81	-0.97	-0.90	0.87	1													
BOD	0.77	-0.98	-0.88	0.85	0.99	1												
Chlorides	0.56	-0.07	-0.43	0.04	0.25	0.18	1											
Sulphates	0.43	-0.31	-0.42	0.05	0.31	0.28	0.18	1										
Total Hardness	0.22	-0.22	-0.28	-0.03	0.14	0.18	-0.16	0.19	1									
Ca Hardness	0.53	-0.39	-0.54	0.08	0.30	0.30	-0.01	0.65	0.77	1								
Mg Hardness	-0.13	-0.03	0.03	-0.09	-0.03	0.04	-0.28	-0.26	0.84	0.30	1							
Ca	0.52	-0.38	-0.54	0.08	0.30	0.30	-0.01	0.65	0.78	1	0.32	1						
Mg	0.51	-0.36	-0.52	0.05	0.27	0.28	0.00	0.65	0.77	1	0.31	1	1					
Phosphates	0.77	-0.23	-0.65	0.16	0.35	0.29	0.90	0.31	0.11	0.35	-0.17	0.34	0.35	1				
Fluorides	0.67	-0.13	-0.52	0.05	0.20	0.12	0.63	0.63	0.00	0.50	-0.46	0.49	0.50	0.82	1			
TDS	0.63	-0.94	-0.77	0.83	0.89	0.92	-0.04	0.16	0.09	0.20	0.00	0.20	0.18	0.10	-0.01	1		
Conductivity	0.62	-0.94	-0.76	0.83	0.88	0.92	-0.06	0.15	0.07	0.19	0.00	0.19	0.16	0.08	-0.03	1	1	
Total Alkalinity	-0.83	0.96	0.91	-0.87	-0.96	-0.95	-0.25	-0.33	0.01	-0.28	0.23	-0.28	-0.25	-0.38	-0.31	-0.90	-0.90	1

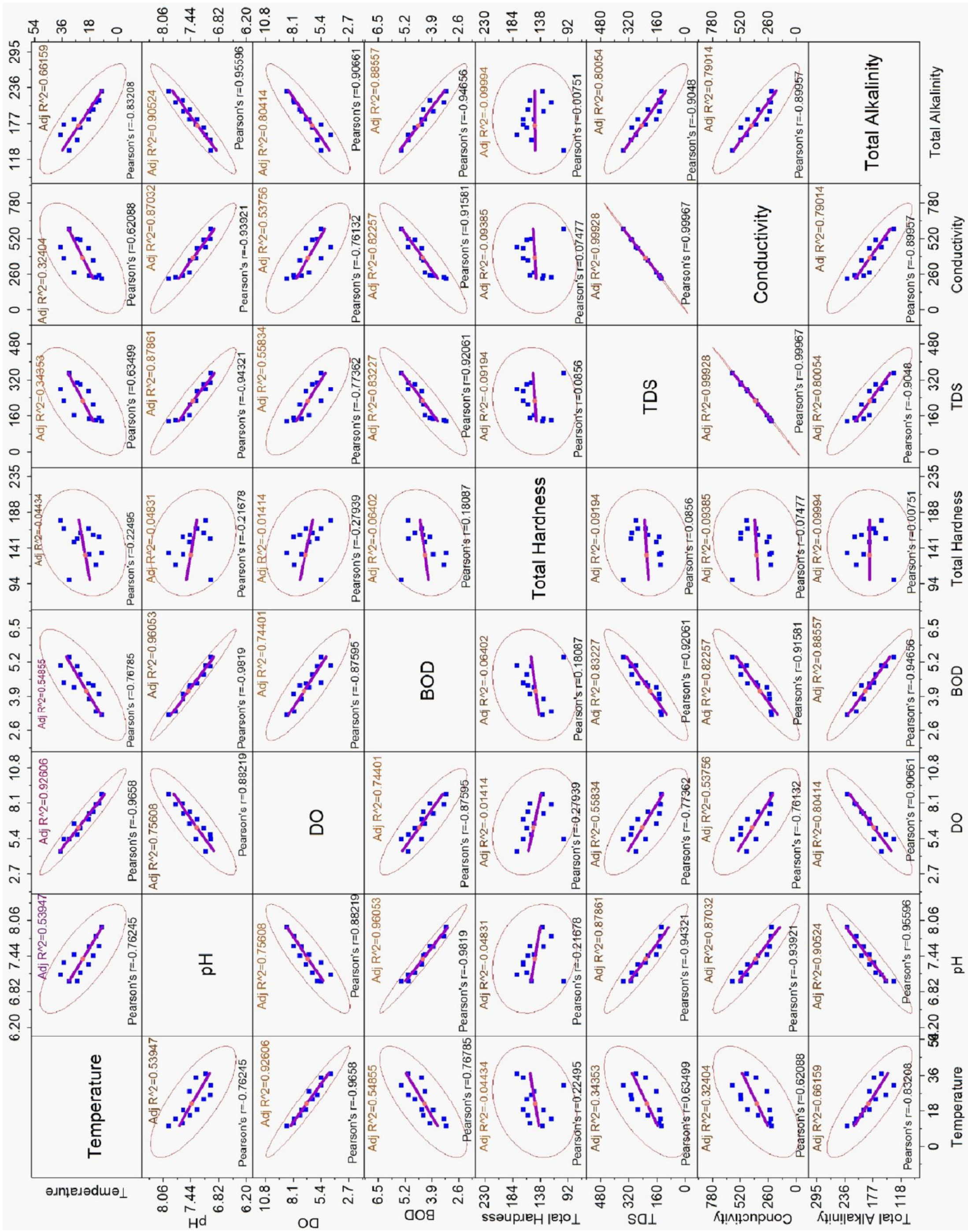

Figure 2. Graphs showing scatter matrix between the physicochemical parameters of Kot Dam.

Chlorides and Phosphates :

Organic wastes of animal origin have high chloride content; thus, chloride in a water body indicates pollution caused by animal wastes. Chlorides may also be due to the dissolution of salts deposited in soil.[3] Kot Dam water had chlorides ranging from 20.45 to 80 mg/L. The average 95% CL was 48.13 ± 11.74, and the Standard Deviation was 18.49.

Phosphates are essential nutrients that contribute to Eutrophication when present in excess concentration. Thus, phosphate is also a criterion in lake Eutrophication models.[13] Moderate levels of phosphates make the water suitable for the growth of plankton and other freshwater communities. The maximum level of phosphates was found in June 2022 (1.18 mg/L), as shown in Table-2. This could be because of the reduced volume of water due to evaporation, the increased density of biota, which produces metabolic waste, high water temperature, and high biodegradation, releasing this nutrient from the sediments.[1]

Calcium and Magnesium :

In July 2021, the lowest recorded levels of calcium and magnesium were 23 mg/L and 14 mg/L, respectively. Likewise, in June 2022, the highest observed concentrations of Ca and Mg reached 36.5 mg/L and 22.25 mg/L, respectively. Annual average concentrations for calcium and magnesium are presented in Table-2, with values of 42.16 mg/L and 16.5 mg/L, respectively.

Fluoride and Sulphate :

Water naturally contains fluorides. The fluoride in Kot Dam was found in the range of 0.41 mg/L (May 2022) and 0.22 mg/L (December 2021), with an average of 0.33 mg/L. Sulphate dissolved in water comes mainly from anthropogenic and natural sources. The water may taste bitter or medicinal if the sulphate concentration exceeds 250 mg/L. The sulphate in Kot Dam was found in the range of 10.5 mg/L (January 2022) and 36.5 mg/L (March 2022), with an average of 23.87 mg/L. Drinking water with high sulphate content might cause diarrhoea and dehydration in human beings (Table-2).

The correlation analysis for the various physico-chemical parameters of Kot Dam water was conducted using Pearson's Correlation Coefficient (r). The degree of correlation between these parameters is summarised in Table-3 and visually presented in Figure 2.

Temperature exhibited negative correlations with pH (r = -0.76), dissolved oxygen (DO) (r = -0.97), and total alkalinity (r = -0.83). Conversely, it displayed positive correlations with total suspended solids (TSS) (r = 0.63), chemical oxygen demand (COD) (r = 0.81), biological oxygen demand (BOD) (r = 0.77), chlorides (r = 0.56), sulphates (r = 0.43), total hardness (r = 0.22), calcium hardness (r = 0.53), phosphates (r = 0.77), fluorides (r = 0.67), total dissolved solids (TDS) (r = 0.63), and conductivity (r = 0.62).

However, pH exhibited positive correlations with total alkalinity (r = 0.96) and DO (r = 0.88) but displayed negative correlations with other physicochemical parameters, as detailed in Table-3.

DO demonstrated a strong positive

correlation with total alkalinity (r = 0.91) and a strong negative correlation with BOD (r = -0.88). Additionally, total alkalinity showed a strong negative correlation with BOD (r = -0.95).

Furthermore, TDS exhibited a strong positive correlation with TSS (r = 0.83), COD (r = 0.89), BOD (r = 0.92), and a strong negative correlation with pH (r = -0.94). These relationships provide valuable insights into the interplay between the different water quality parameters in Kot Dam.

The current study shows that several water quality parameters, including temperature, pH, dissolved oxygen (DO), total suspended solids (TSS), chloride, sulphates, total hardness, calcium hardness, magnesium hardness, calcium (Ca), magnesium (Mg), phosphates, fluoride, and total dissolved solids (TDS), remained within the permissible limits. However, parameters such as biological oxygen demand (BOD), chemical oxygen demand (COD), total alkalinity, and conductivity exceeded the recommended limits of the CPCB (Central Pollution Control Board) and BIS (Bureau of Indian Standards) guidelines. The hydrobiological characters are not static according to the analysis of Kot Dam waters. The hydrochemical changes influence these characteristics in the catchment area. It has been established that Kot Dam was moderately polluted during the study period, and its water was not safe for human drinking throughout the year but could be utilised for aquaculture and irrigation. However, the increased pH values imply that the equilibrium between carbonate and bicarbonate is altered. The high values of BOD and total alkalinity in the dam water indicate the presence of organic matter, diverse microorganisms, and non-biodegradable oxygen-demanding contaminants. Managing and maintaining the physicochemical parameters within more precise limits is necessary to optimise Kot Dam's potential for pisciculture. The study also recommends regularly monitoring water quality before supplying the dam water for domestic and agricultural purposes.

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