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Physico-chemical and correlation studies of Umrar Dam of Umaria district Madhya Pradesh

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Abstract

The physico-chemical parameters varied seasonally. The Secchi disc values varied from 26.8 to 60.5 cm. The pH remained alkaline between 8 to 9 in both years. The dissolved oxygen varied from 5.2 to 7.8 mg/l during both years. The total alkalinity values ranged between 132.5 and 301.8 mg/l. The total hardness values varied from 221.4 to 322.9 mg/l for the reservoir. Calcium content was fluctuated from 31.5 to 48.3 mg/l. The magnesium values are ranged between 17.3 to 22.4 mg/l. The values of total dissolved solids were observed from 313.7 to 601.1 mg/l. Chlorides and total dissolved solids were maximum during summer and minimum in winter season. In correlation matrix free carbon di-oxide is negatively correlated with all parameters except magnesium. This paper reports the physico-chemical characteristics and correlation matrix of Umrar dam of Umaria district in Madhya Pradesh where limnological studies were conducted from August 2020 to July 2022.

Keywords: Physico-chemical parameters, correlation coefficient, Umrar Dam

Introduction

India has vast fresh water resources in the form of both lentic and lotic ecosystems. The lentic ecosystems include ponds, lakes, tanks and reservoirs. The perennial reservoirs play an important role for domestic, agriculture and aquaculture as a valuable water resource. The lentic ecosystems have long attracted attention of ecologists, both for their importance as a source of drinking water and the development of fisheries. To employ scientific method for aquaculture, understanding of environmental conditions prevailing in the water body is essential. Therefore, the attention is given on the physico-chemical factors which affect fishes and other aquatic inhabitants. Several limnological studies have been carried out in this region (Prajapati, 2016) ^[16]. Most of the studies were carried out in water bodies of urban area. Few of studies from rural area are also reported (Hujare, 2008, Kashyap, 2016, Prajapati, 2016 and Rana, 2016) ^[7, 11, 16, 17]. Thus there is lack of baseline data on limnological characteristics of Umrar dam of Umaria district, which is used for drinking, irrigation and pisciculture activities. Therefore the present study was undertaken.

Material and Methods

Study Area

Umrar dam is an irrigation project situated near of Dadari Villages of Karkeli block of Umaria District. The project has an annual irrigation potential of 2429 ha, Culturable Command Area of 2313 ha. and Gross Command Area of 3238 ha.

This is a medium Irrigation project, completed in the year 1979-1980. It is built across a local River called Umrar River under Ganga basin intercepting a catchment area of 60.22 km². The project comprises of homogeneous earth dam having the total length of main dam 995 m with 1st subsidiary dam of 351 m and 2nd subsidiary dam of 495.60 m. The maximum height of the dam is 24.85 m. The spillway crest has an ogee shape. It is 140 m long. Its latitude is 80°-49'-05" N and longitude is 23°-29'-05" E. It is located in Ganga Basin.

The bottom of reservoir is rocky. The reservoir water is formerly used for irrigation but also for washing, bathing and pisciculture activities. The reservoirs store rain water received from adjoining catchment area and is much influenced by anthropogenic activities. The surface water samples were collected approximately 10 meters from border line monthly from site I, site II and site III. Three sampling sites were selected for each reservoir by considering inlet, outlet of water and anthropogenic activities of local inhabitants.

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The air and water temperature were measured using mercury thermometer. The transparency of water was measured by using Secchi Disc. The pH was determined by using pH meter (Hann). The water samples were transferred to the laboratory for further chemical analysis. Slanderred methods were followed for various physicochemical parameters (APHA, 1985) [3]. Statistical analysis was done to find out the inter relationship and correlation matrix among physicochemical factors.

Results and Discussion

Average values (ranges in parentheses) of physical and chemical parameters recorded at Umrar dam were depicted in table 1. Temperature of water in fluctuated from 24.1 °C (December) to 29.1 °C (May) during first year of study. In the next year, it rose from 26.5.0 °C in winter to 30.5 °C during summer. Overall there were fluctuations in the water temperature of water bodies as the atmospheric temperature of the locality.

Table 1: Average values (ranges in parentheses) of physical and chemical parameters recorded at Umrar dam from August 2020 to July 2022.

Parameters	I year		II year	
WT (°C)	28.1	(26.5-30.5)	25.8	(24.1-29.1)
Transp.(cm)	43.87	(41.87- 47.62)	37	(20.4-45.6)
pH	8.4	(8.3-8.6)	8.3	(8.2-8.6)
EC (μ mhos)	0.51	(0.41-0.60)	0.47	(0.37-0.58)
DO (mg/l)	6.3	(5.5-7.8)	6	(5.2-7.1)
CO ₂ (mg/l)	0.62	(0.15-1.27)	1.6	(0.9-2.38)
TA (mg/l)	210.7	(158.3-301.8)	194.4	(132.5-280.1)
TH (mg/l)	280	(227.4-309)	270.8	(221.4-322.9)
Ca (mg/l)	41.6	(36.2-45.5)	39.7	(31.5-48.3)
Mg (mg/l)	19.8	(17.8- 21.1)	19.9	(17.3-22.4)
Cl (mg/l)	30.1	(23-38.5)	33.5	(23.3-44.7)
TDS (mg/l)	409.7	(329.6-548.8)	432.2	(313.7-601.1)
TN (mg/l)	8.2	(4.6-10.7)	8.3	(4.3-11.1)
TP (mg/l)	0.19	(0.067-0.275)	0.176	(0.007-0.344)

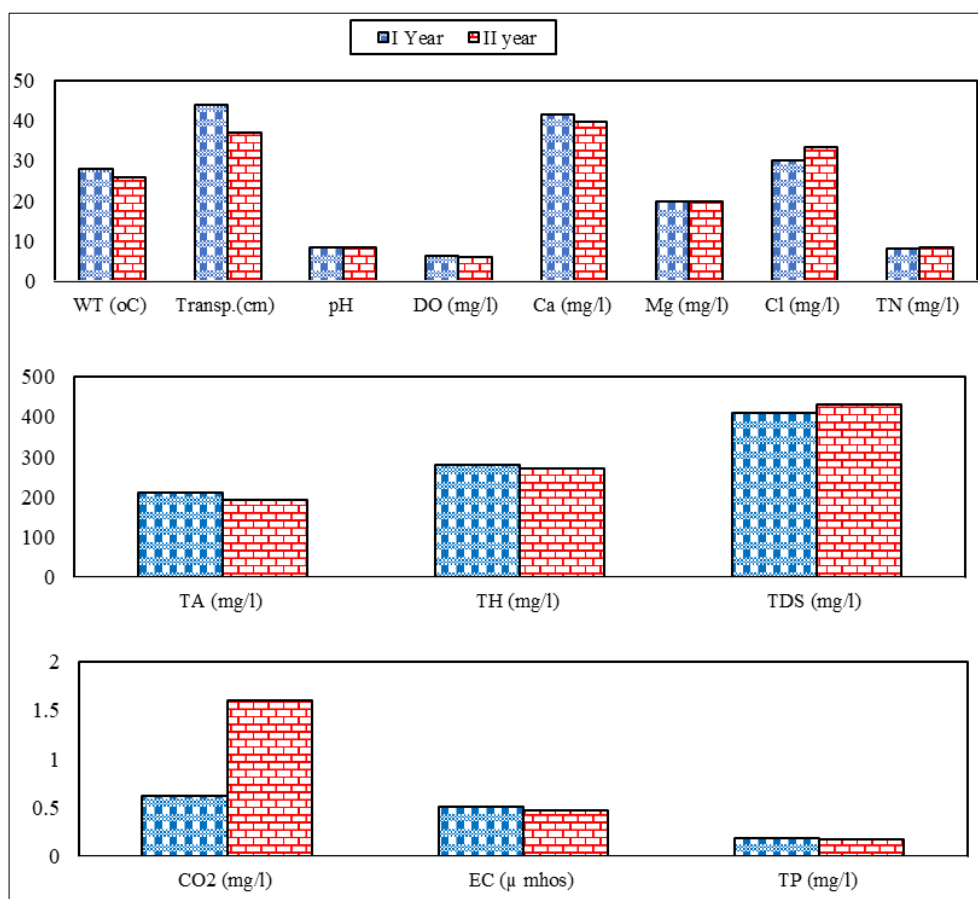


Fig 1: Graph analysis of average values of physical and chemical parameters recorded at Umrar dam from August 2020 to July 2022

The Secchi disc transparency of reservoir ranged from 20.4 to 47.8 cm during both the years of investigation. The lowest transparency was observed during summer and highest values were recorded during rainy season, during

first year and highest values during winter in the next year of study period.

The pH values were variable between 8.0 and 9 with an average of 8.5. The pH of reservoirs remained alkaline

throughout the study period. The annual fluctuations were negligible, indicating good buffering capacity. The water having pH range of 6.5 and 9.0 are most suitable for pond aquaculture (Jhingran, 1982) ^[10]. The desirable pH of drinking water is between 7.0 and 8.5 (W.H.O., 1993) ^[25]. In the present work the highest values of pH during summer may possibly due to removal of sufficient amount of CO₂ by photosynthetic process of the aquatic system (Kaur *et al.* 1997, Solanki, *et al.* 2005, Kashyap, 2016, Prajapati, 2016 and Rana, 2016) ^[12, 22, 11, 16-17].

At Umrar dam, electrical conductivity values showed marked seasonal variations, being maximum (0.60 m mhos) during summer and minimum (0.37 μ mhos) during winter months. Maximum electrical conductivity value during summer and minimum during winter in the lake of Govindgarh of Rewa district, which is in agreement with the observations in present study (Mishra and Singh, 2022) ^[15]. In the first year, the amount of dissolved oxygen in reservoir ranged from 5.5 to 7.8 mg/l with average value 6.3 mg/l. During second year, it fluctuated between 5.2 mg/l and 7.1 mg/l. Similar pattern about dissolved oxygen as 0.41 mg/l in August 2000 and 3.25 mg/l in March 1999 in the aquatic system located at Ampalathara, south of Thiruvanthapuram city (Sobha and Harilal, 2005) ^[21]. It is interesting to note that, dissolved oxygen increased appreciably during summer and decreased in monsoon months. However, very little variation is observed during summer and monsoon.

The minimum dissolved oxygen limit for fish growth is 4.0 mg/l 10. The lowest dissolved oxygen for maintaining fish in healthy condition is 5.0 mg/l and the critical value is 3.0 mg/l (APHA, AWWA and WPCF 1985) ^[3]. In present study the range of dissolved oxygen is found optimum for fish growth. The dissolved oxygen content of the reservoirs is favorable for fish production. The major cause of oxygen depletion during monsoon may be due to reduction in the photosynthetic activity.

The free carbon dioxide values varied from 0.15 to 1.27 mg/l during first year of investigation. During second year, it showed 0.91 to 2.38 mg/l. free carbon dioxide values were decreased during summer and increased during rainy season. The values of free carbon dioxide were very negligible in winter and summer seasons. Free carbon dioxide in water forms carbonic acid which after dissociation gives H⁺ ions thus, decreasing pH values. The free carbon dioxide is essential for photosynthesis. Well aerated waters with very little pollution usually have no or very little free carbon dioxide (Goel *et al.* 1991, Kashyap, 2016, Prajapati, 2016 and Rana, 2016) ^[6, 11, 16, 17].

The values of total alkalinity in Umrar dam water body fluctuated from 158.3 to 301.8 mg/l and 132.5 to 280.1 mg/l during first and second year, respectively. In reservoir, during rains total alkalinity declined while, increased up to summer season. Many workers have observed similar pattern of variations in total alkalinity which supports present findings (Sharma and Jain, 2000 and Sukhija, 2007) ^[19, 24].

The range of hardness is recorded (227.4 and 309.6 mg/l) and (221.4 and 322.9 mg/l) during winter and summer season of first and second year of investigation, respectively. The highest hardness values in summer season are mainly attributed to rising temperature, thereby increasing the solubility of calcium and magnesium salts (Garg, 2003) ^[5]. The permissible limits prescribed is 300 mg/l (BIS, 1991) ^[4]. The hardness of reservoir lies beyond

the limit during summer months and hence the water is not suitable for drinking as it is hard. The higher hardness values in summer season are mainly attributed to rising temperature thereby increasing the solubility of calcium and magnesium salts (Garg, 2003, Kashyap, 2016, Prajapati, 2016 and Rana, 2016) ^[5, 11, 16, 17].

In Umrar dam calcium content was found minimum during winter (36.2 and 31.5 mg/l) and maximum in summer (45.5 and 48.3 mg/l) in both the years. The maximum desirable limit of calcium in drinking water is 75 mg/l11 (BIS, 1991) ^[4]. The calcium content in the reservoirs was below the desirable limit. Similar pattern of change in calcium content in Aliyar reservoir of Coimbatore district (Subhashini and Saradhamani, 2005) ^[23].

Magnesium values remained higher in summer 22.4 mg/l, followed by rainy season and decreased during winter 17.3 mg/l. The concentration of magnesium was minimum compared to concentration of calcium possibly due to lesser occurrence of magnesium minerals in the bottom of reservoir.

The permissible limit of magnesium for drinking water is 50 mg/l11 (BIS, 1991) ^[4]. The present results of the reservoir were within the permissible limit. The highest values of magnesium in pre monsoon season were recorded (Shrivastava and Mansood, 2007) ^[20].

The average value of chloride was 33.5 and 30.1 mg/l during first and second year. The chloride values in the reservoir were increased during summer and decreased in winter of two consecutive sampling years. The permissible limit of chloride is 200 mg/l for drinking water (BIS, 1991 & W.H.O. 1993) ^[4, 25]. In general, concentration of chlorides is affected by several factors, such as increased human and cattle activities. This also indicates the organic load of animal origin.

The lowest values of total dissolved solids were observed during winter (329.6 and 313.7 mg/l at I and II year), while in summer, it reached upto 548.8 and 601.1 mg/l. The total dissolved solid indicates the general nature of water quality. The water containing 500 mg/l total dissolved solids is the desirable limit for potable water (BIS, 1991 & W.H.O. 1993) ^[4, 25]. It is evident that the total dissolved solid values were beyond the desirable limit with onset of summer. In rainy and winter seasons, reservoir water was within the limit. This investigation highest total dissolved solids values were obtained during summer, which can be attributed to high rate of evaporation and consequently decreased water level leading to accumulation of dissolved solids.

On the basis of concentration of total dissolved solids water is classified and accordingly Umrar dam water is only desirable in rainy and winter and permissible during summer (ICMR, 1975) ^[8].

The amount of total nitrogen is 4.6 mg/l in December. It increased in May up to 10.7 mg/l. During second year similar trend was observed in winter and summer (4.3 to 11.1 mg/l).

The range of total nitrogen is between 0.1 to 4.0 mg/l, highest values were observed during summer44. However, limnologists described the highest range of total nitrogen in March with decreasing range in monsoon to winter (Jain *et al.* 2005 & Kosygin and Haobijam, 2005) ^[9, 13].

Phosphorus is an essential nutrient for plant growth, but too much phosphorus cause excessive growth of algae and weeds. Hence it is used as an indicator of the pollution for algal growth in fresh water ecosystem. The values for total

phosphorus were 0.067 and 0.275 mg/l in December and May, respectively during first year. In the second year, the range was 0.007 and 0.344 mg/l during winter and summer. In the reservoir, total phosphorus levels were recorded maximum during summer of both the consecutive sampling years. The minima is observed during winter and then in monsoon. Similar observations have reported (Anand and Sharma, 2000 & Sobha and Harilal, 2005) [2, 21]. The presence of high concentration of phosphorus in water may lead to pollution. The water bodies classified on the basis of phosphorus content (Lee *et al.* 1981) [14].

< 0.0079 mg/l: Oligotrophic

0.008 to 0.011 mg/l: Oligomesotrophic
0.012 to 0.027 mg/l: Mesotrophic
0.028 to 0.039 mg/l: Meso-eutrophic
> 0.040 mg/l: Eutrophic

According to above criteria, the reservoir may be placed under the category of oligotrophic in winter season.

Impact of human activities on the quality of water in Nyaruzinga wetland of Bushenyi District, Uganda (Safari *et al.* 2012) [18].

The correlation coefficients (r) were calculated and correlation matrix was obtained. The values of correlation matrix of Umrar dam is given in table 2.

Table 2: Correlation matrix of physico-chemical parameters of Umrar dam

	WT	pH	EC	DO	CO ₂	TA	TH	Ca	Mg	Cl	TDS	TN	TP
WT	1												
pH	0.791*	1.000											
EC	0.769*	0.609**	1.000										
DO	0.852*	0.899*	0.636**	1.000									
CO ₂	-0.478	-0.709	-0.174	-0.765	1.000								
TA	0.851*	0.896*	0.737*	0.967*	-0.730	1.000							
TH	0.782*	0.759*	0.765*	0.681**	-0.191	0.729*	1.000						
Ca	0.832*	0.682*	0.811*	0.697**	-0.193	0.770*	0.900*	1.000					
Mg	0.796*	0.544	0.802*	0.494	0.007	0.590**	0.858*	0.932*	1.000				
Cl	0.876*	0.763*	0.801*	0.794	-0.358	0.852*	0.788*	0.926*	0.830*	1.000			
TDS	0.793*	0.824*	0.751*	0.850*	-0.637	0.935*	0.636**	0.774*	0.625**	0.894*	1.000		
TN	0.750*	0.558	0.822*	0.632**	-0.052	0.703*	0.853*	0.941*	0.852*	0.866*	0.709*	1.000	
TP	0.756*	0.832*	0.742*	0.701*	-0.288	0.763*	0.968*	0.833*	0.789*	0.782*	0.691**	0.781*	1.000

*Significant at 1% level (>0.708), **Significant at 5% level (>0.576)

Very high positive correlation was found between Calcium and magnesium (0.926), chlorides (0.972), total nitrogen (0.941). Total hardness and calcium (0.900) and total phosphorus (0.968). Total alkalinity and dissolved oxygen (0.967), total dissolved solids (0.935).

Very poor positive correlation was recorded in magnesium and free carbon dioxide (0.007), dissolved oxygen (0.494) and pH (0.544). Limnological and correlation studied in perennial reservoirs of Khanapur tahsil of Sangli district, Maharashtra (Alaka and Patil, 2013) [11]; Sarfa and Mohan Ram lake Shahdol district (Prajapati, 2016 and Rana, 2016) [16-17].

It is interesting to note that free carbon dioxide was negatively correlated with all parameters except magnesium.

Conclusion

The physical parameters like temperature, relative humidity, transparency, pH and EC are important. The transparency lies in moderate range. The pH of the reservoir was alkaline throughout the study period. The range of EC suggests good quality water for agricultural productivity. The concentrations of chemical parameters of the reservoir were well under the prescribed limits of surface water.

The level of dissolved oxygen is favorable for fish culture. Free carbon dioxide level is comparatively very low, which shows well aerated waters of reservoirs. The range of total alkalinity indicates the productivity. Nutrient richness of reservoir was good.

The total hardness of reservoir was beyond the permissible limit only in late summer; otherwise it is in moderate indicating suitability for domestic use. Chlorides are within the range in reservoir indicating suitability of water for domestic as well as for irrigation purpose. The low

concentration of total nitrogen and total phosphorus affects the productivity of reservoir.

The reservoir showed higher total dissolved solids with onset of summer which are beyond the level. Water from reservoirs is suitable for irrigation as well as aquaculture and rich in phytoplankton diversity. The reservoir was oligotrophic in nature.

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