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WATER QUALITY ANALYSIS OF ANASAGAR LAKE, AJMER, RAJASTHAN

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AUTHORS' CONTRIBUTIONS

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Water quality of Anasagar lake was studied for period of four months on the basis of fortnightly sampling. This study has provided the first data set for water quality of lake. The value of various physico-chemical parameter were temperature (24.50°C to 33.90°C), pH (7.9 to 8.2), electrical conductivity (2.07 to 2.49 mS/cm), dissolved oxygen (7.53 to 8.73 mgL^{-1}), alkalinity (101 to 109 mgL^{-1}), Hardness (121 to 150 mgL^{-1}), total dissolved solid (1344.00 to 1617.00 mgL^{-1}), nitrate (0.88 mg L^{-1} to 1.02 mgL^{-1}), phosphate (0.67 mgL^{-1} to 0.76 mgL^{-1}), depth of visibility during the study period was 48.92 cm. Anthropogenic stressors such as disposal of raw sewage and municipal wastewater, input of detergents due to washing of clothes and bathing, inputs of pesticides and chemical fertilizers due to unsustainable agriculture, aquaculture and horticulture, and urban settlement have forced the lake into the severely polluted and hyper-eutrophic condition.

Keywords: Water quality; electrical conductivity; anthropogenic stressors; pollution.

1. INTRODUCTION

The whole economy of any lake depends on the Physico-chemical properties of water [1]. Various physico- chemical characteristics of different water bodies identify the factor operating upon aquatic ecosystem which indicates not only the condition of water but also expresses the nature of the biological component. All metabolic and physiological activities of life such as feeding, reproduction, movement, and distribution of aquatic organisms are greatly influenced by the physico-chemical parameters of a water body. Temperature, free CO_2, bicarbonate, calcium and magnesium hardness, biological oxygen demand, chemical oxygen demand, dissolved oxygen, dissolved solids and EC are related to biological productivity [2,3]. Thus, these physico-chemical characters are used for the assessment of trophic status and the ecological nature of the water body [4].

Rajasthan is the largest state of the country. There are quite a few freshwater lakes in Rajasthan. Most of them are heavily polluted and are facing an imminent danger of irreparable degeneration. Anthropogenic activities are the main causative agents in the increase of nutrients like phosphates, chlorides, and calcium

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and ultimately lead to eutrophication (Chukwu and Odunzeh, 2006; Shashi Shekhar et al., [5]). Due to unplanned management, the tremendous development of industry and agriculture and disposal of untreated public sewage water, agricultural runoff and other human and animal wastes in to river, lakes, reservoirs and other water bodies are continuously deteriorating their water quality and biotic resources [6,7]. The current research work is proposed to find out the water quality of Anasagar Lake for suitable fish production and primary productivity. The Anasagar lake being a shallo (maximum depth 14 feet) is presently posing a serious threat of its existence due to the disposed of urban sewage coming from the urban settlement of Ajmer city as well as multiple agriculture and urban waste disposal [8]. This study will be helpful in future work on water quality parameters of the reservoir using different analyses and tools for prediction, forecasting of water quality, primary productivity, and fisheries potential.

The Lake Anasagar (26°27'-26°29' N and 74°36'-74°37' E), built by King Anaji of Chauhan dynasty during 1135-1150 AD, is now a critically polluted urban water body of Ajmer. Later the Mughal Emperors made additional constructions to add in the beautification the lake. The 'Baradari', a marble pavilion was built by Shah Jahan and the 'Daulat Bagh' gardens were laid by Jahangir (Development Plan For Ajmer, GOR 2006). The catchment area of lake is 70.55 km^2, and its circumference is 12.88 km (Mathur et al. 2009). The catchment area of the lake includes Nagpahar hills and Taragarh hills. The interrupted catchment area is about 45% and 60% under free catchment, which includes 5 (4 full and 1 partial) villages and some part of the city. The average annual rainfall of Ajmer city is 500 mm. The capacity of the lake is 2052 million liters with an average depth of 5 meters [9]. Originally, it was a monsoon-fed, perennial, shallow freshwater lake that was built as an adaptation to climate variability [8].

It is also a source of aesthetic pleasure and holiday recreation for tourists and local people by providing boating facilities. The lake also attracts a lot of migratory birds. But there is no report available on the water quality of this Lake. Some silent features of Lake are given in physico-chemical components influencing parameters and the delicate dynamics sustained by them is of supreme importance to formulate appropriate environmental management strategies and to protect the lake from degradation. The study of physico-chemical factors could be of great help in successful fishery management also.

So, the Anasagar lake was studied for various physico-chemical aspects such as temperature, transparency, pH, Electrical Conductivity (EC), dissolved oxygen, alkalinity, acidity, total hardness, dissolved oxygen, total dissolved solids (TDS), nitrate, phosphate and primary productivity of water (Table 2). The judicious management and proper utilization of water of this lake require a systematic study of its ecology. Adequate information about the various physico-chemical components influencing parameters and the delicate dynamics sustained by them is of supreme importance to formulate appropriate environmental management strategies and to protect the lake from degradation. The study of physico-chemical factors could be of great help in successful fishery management also.

2. METHODOLOGY

Study of physico-chemical quality of water was carried out for a period of four monts from March, 2021 to June, 2021. The water samples were collected on a fortnightly basis from four different locations including areas of maximum and minimum human activities (Fig. 1). For physico-chemical studies, water samples were collected in 500 ml plastic bottles, brought to the laboratory for further analysis. Various physico-chemical parameters were estimated according to APHA [10]. Nitrate (inorganic), phosphate (ortho) and sulphate were estimated by the spectrophotometric method.

2.1 Study Area

The Lake Anasagar (26°27'-26°29' N and 74°36'-74°37' E) was built by King Anaji Chauhan during 1135-1150 AD by raising a dam across Luni River and was used for supply of drinking water in early times. This is the largest and most popular lake in Ajmer. Silante fatures of lakes is depicted in Table 1.

Table 1. Salient features of Anasagar Lake

CHARACTERISTICS	DESCRIPTION
Geographic location	26°25’N-26°29’N(Latitude) 74°38’E-74°42’E (Longitude)
Location in Ajmer	North-West of Ajmer, Rajasthan
Lake type	Artificial lake, constructed by damming overLuni River

CHARACTERISTICS	DESCRIPTION
Lake water spread area	0.97 sq km to 1.87 sq km
Highest flood level	485.305 m above MSL (as revised in 2013)
Catchment area	53 sq km (gross), 20 sq km (intercepted byLake Foysagar), 5 sq km (built up area)
Topography of lake catchment area	Steep to gentle slope with low vegetal cover
Storage capacity of lake	5.68 Million Cum (at HFL)
Lake circumference	7.3 km (at HFL)
Source of water in lake	Rainfall runoff and overflow from LakeFoysagar through Bandi River
Depth	4.4 m
Overflow arrangements	Four overflow gates (size 1.2m X 1.8m)

(Source: Detailed Project Report, 2007: Lake rejuvenation project, Anasagar Lake, Ajmer and Nagar Nigam:2013, Land use details in Anasagar Lake catchment)

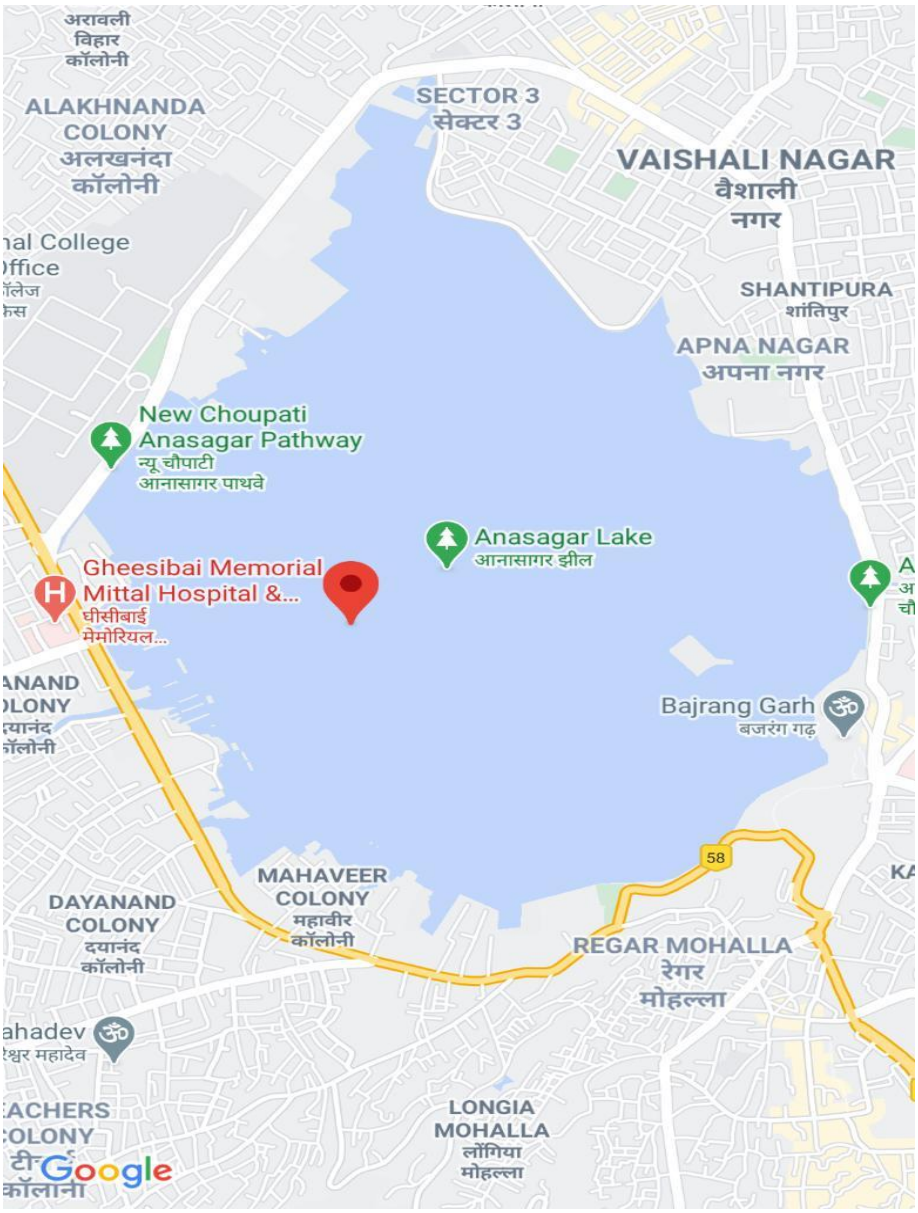

Fig. 1. Location of Sampling points in Anasagar Lake
(Pic: Google maps)

Table 2. Water quality parameters of Anasagar Lake

S.N	Parameters	Observations										
		I	**II**	**III**	**IV**	**V**	**VI**	**Mean**	**Max**	**Min**	**SD**	**CV %**
1.	Air Temperature (^{0}C)	30.775	31.225	37.775	39.65	41.05	40.87	36.89	41.05	30.78	4.71	12.78
2.	Water Temperature (^{0}C)	24.50	25.10	27.2	33.12	33.90	33.77	29.60	33.90	24.50	4.48	15.14
3.	Depth of Visibility (cm)	40.75	44.5	53	51.75	54	49.5	48.92	54.00	40.75	5.24	10.70
4.	EC (mS/cm)	2.07	2.19	2.28	2.27	2.45	2.49	2.29	2.49	2.07	0.16	6.90
5.	TDS (mg l^{-1})	1344.00	1418.50	1483.50	1469.25	1589.25	1617.00	1486.92	1617.00	1344.00	102.78	6.91
6.	pH	7.97	8.12	8.20	7.90	8.05	7.95	8.03	8.20	7.90	0.11	1.41
7.	Dissolved O_2 (mg l^{-1})	7.53	8.03	8.23	8.38	8.73	8.38	8.21	8.73	7.53	0.41	4.94
8.	Carbonate Alkalinity (mg l^{-1})	4.00	3.50	4.00	4.50	4.50	5.00	4.25	5.00	3.50	0.52	12.34
9.	Bicarbonate Alkalinity (mg l^{-1})	113.50	115.50	101.50	111.50	104.00	96.00	107.00	115.50	96.00	7.68	7.18
10.	Total Alkalinity (mg l^{-1})	117.50	119.00	105.50	116.00	108.50	101.00	111.25	119.00	101.00	7.31	6.57
11.	Total Hardness (mg l^{-1})	140.25	128.25	133.00	134.25	150.00	121.00	134.46	150.00	121.00	9.97	7.41
12.	Nitrate-N (mg l^{-1})	0.883	0.998	0.988	0.963	0.918	1.018	0.96	1.02	0.88	0.05	5.36
13.	Ortho-P (mg l^{-1})	0.67	0.76	0.76	0.72	0.73	0.72	0.73	0.76	0.67	0.03	4.58
14.	Gross Primary Productivity (g C m^{-3} h^{-1})	0.113	0.117	0.110	0.107	0.110	0.111	0.11	0.12	0.11	0.003	3.04
15.	Net primary productivity (g C m^{-3} h^{-1})	0.062	0.067	0.068	0.067	0.067	0.065	0.07	0.07	0.06	0.002	3.32
16.	Community Respiration (g C m^{-3} h^{-1})	0.051	0.050	0.042	0.041	0.043	0.043	0.05	0.05	0.04	0.004	9.64

3. RESULTS AND DISCUSSION

This study has provided the first data set for various physico-chemical factors of the lake. The temperature regime of a lake is a function of seasonal/diurnal ambient air temperature, the morphometry, and setting of the lake. The temperature variation is one of the factors in the lake ecosystem, which may influence other physico-chemical characteristics and also influence the distribution and abundance of flora and fauna [11]. A rise in the temperature of the water leads to an increase in the rate of chemical reaction in the water besides reducing the solubility of gases. In the present study, water temperature varied between 24.50 to 33.90°C. As ambient temperature increases in summer, lake water also warms up. The air temperature was always higher than the water temperature. The recorded high value during summer could be attributed to high solar radiation [12], Haroon et al., 2010 and [13].

Under natural conditions, lakes and ponds may become turbid in the monsoon due to the increased surface runoff which has carried out so many things from the catchment area to the water body. Das and Srivastava [14], depth of visibility levels can indicate the land use pattern in the catchment area use and it also helps in determining primary productivity levels of a water body. In Anasagar lake average mean of depth of visibility from all stations was 48.92 cm.

The pH of the water was always on the alkaline side; it ranged from 7.90 to 8.20. It was relatively high due to the summer period during the study period, probably be due to high biological activity [15] including photosynthesis [16]. Alkaline water can support higher productivity [17] and can support good fishery also [18]. Most of the natural waters are generally alkaline due to the presence of a sufficient quantity of carbonates [19]. Seasonal variations in pH may be attributed to various factors like removal of CO_2 for photosynthesis, dilution of lake water by rainwater influx, primary productivity, salinity, and temperature changes and decomposition of organic matter [20].

The EC was found to fluctuate between 2.07 to 2.49 mS/cm. EC showed an increasing trend with the advent of summer [21]. It is generally low during monsoon and rises during summer and it also showed a positive correlation with temperature. EC depends upon the temperature of the water (Horne and Goldman, 1994). As water temperature increases, EC also increases because warmer conditions enhance evaporation of lake water resulting an increase in electrolytes. The fluctuations in the values of EC observed during the present study could also be due to variations in the rate of decomposition of organic matter. Decomposition of organic matter releases dissolved substances and nutrients whereas continuous evaporation leads to an increase in electrolytes. Both of these factors can increase EC of water [22].

The dissolved oxygen content was observed in the range of 7.53 to 8.73mgL^{-1}. The DO in water is a very important parameter as it serves as an indicator of the physical, chemical, and biological activities of the water body. Two main sources of dissolved oxygen are the diffusion of oxygen from the air and photosynthetic activity [23]. It is well known that temperature affect the dissolution of oxygen [24]. DO is mainly regulated by the photosynthetic activity of algal flora when free CO_2 is utilized (Hosmani and Bharti, 1980).

The total alkalinity was found between 101 to 109 mgL^{-1}. This range of alkalinity makes the reservoir a nutrient-rich and highly productive water body [25]. The increase in alkalinity in the summer season can be attributed to a decrease in water volume due to an increased rate of evaporation at high temperatures which also coincides with higher concentration of nutrients and bicarbonates (Hazelwood and Parker, 1961). Most of the water is rich in carbonate–bicarbonates with little concentration of other alkalinity imparting ions (Trivedy and Goel, (1984). Bicarbonates form a major source of carbon for aquatic flora, particularly for the phytoplankton in the absence of free CO_2 [26].

TDS represents salts like carbonates, bicarbonates, sulphates, phosphates, chlorides, and nitrates of calcium, magnesium, sodium, potassium, iron etc. which are dissolved in natural water. The higher values of total dissolved solids in natural waters are generally due to increased anthropogenic activity, stagnation and concentration of water, which hampers water quality (Manickam et al., 2014). The high amount of dissolved solids increases the density of water and influences osmoregulation. The high TDS reduces the solubility of gases like oxygen and as a result, such water is not suitable for domestic, industrial uses, and drinking purposes. The TDS range in Anasagar lake during the study period was 1344.00 to 1617.00 mgL^{-1}.

Total hardness in water is the sum of the concentration of alkaline earth metal cation such as Ca^{++}, Mg^{++}. The total hardness is the total soluble magnesium and calcium salts present in the water expressed as its $CaCO_3$ equivalent. In the other words, the measure of the capacity of water to react with soap is called the hardness of water [27]. In most natural

waters the predominant ions are bicarbonates, associated mainly with calcium and then with magnesium. Hardness decreased in monsoon and increased in summer. Increased hardness in summer may be due to excessive evaporation [28]. Total hardness during the study period was 121 to 150 mgL^{-1}. In the aquatic environment, calcium serves as one of the micronutrients for most of the organisms.

Nitrogen is an important nutrient governed by geological conditions, organic load and rate of mineralization in the water body. The most stable form of nitrogen is nitrate. Nitrate is a highly oxidized form of nitrogen found in natural waters. The high concentration of nitrate in water is indicative of pollution. Higher concentrations of nitrate ions are undesirable in drinking water because they can cause methemoglobinemia in infants of less than 6 months old (Egereonu and Nwachukwu, 2005).

During the investigation, 0.88 mg l^{-1} to 1.02 mg l^{-1} level of nitrate nitrogen was recorded. Natural waters in their unpolluted state contain only minute quantities of nitrate. Nitrate is a major ingredient of farm fertilizer and is necessary for crop production. When rains, varying nitrate amounts wash from farmland into nearby waterways. Another possible way of nitrate input might be through oxidation of ammonia in the form of nitrogen to nitrite and consequently to nitrate [29,30].

Phosphorus is well recognized as a key nutrient in deciding the fertility and productivity of a water body. It is an essential element as a nutritive substance important for plant growth and is also a basic element in the metabolic reactions of plants and animals (Sunilkumar 1998). It controls the rapid algal growth and the primary productivity in aquatic habitats. The dissolved phosphate concentration ranged from $0.67mgL^{-1}$ to $0.76mgL^{-1}$ in the investigated water body. The variation may also be due to the process like adsorption and desorption of phosphate and buffering action of sediment under varying environmental conditions [29].

Primary productivity depends upon the turnover rate of nutrients like phosphate and nitrates. Thus, this parameter gives an idea of living and non-living food availability for fishes (Baghela 2006). The average value of GPP of all stations was 0.110 $gCm^{-3}h^{-1}$. Low primary productivity found in the present study may be assigned to heavy pollution and anthropogenic activity which was observed during study period. Anthropogenic stressors such as disposal of raw sewage and municipal wastewater, input of detergents due to washing of clothes and bathing, inputs of pesticides and chemical fertilizers due to unsustainable agriculture, aquaculture and horticulture, and urban settlement have forced the lake into the severely polluted and hyper-eutrophic condition (i.e., very nutrient-rich and highly productive lake characterized by frequent and severe algal blooms and low transparency) [31], Dubey et al. 2011.

4. CONCLUSION

The study validates the fact that this freshwater lake remains oligotrophic during summer and winter but becomes loaded with nutrients during monsoon reaching eutrophic condition. Unchecked use of fertilizers has augmented the process. The lake was found to be slightly eutrophic during monsoon months. This may be due to increased nutrient load during monsoon. Nutrients and other organic matter from the agriculture fields in the catchment area are brought to the lake due to influx of rain water. Pollution level is higher nearby Mittal hospital and back side of lake. It can be lead to deterioration of water quality as well as degradation in ecological balance. In recent years, it is reported that mass mortality of aquatic fauna seen in this lake due to this pollution. They continue to be degraded through habitat loss due to human activities and conservation methods are urgently required to maintain the integrity and biodiversity of such ecosystems. The sustainability of Anasagar Lake ecosystem will depend upon managing the nearby agricultural setups as well as other disturbing factors. Moreover, human activities in and around the lake should be regulated. Governments must take a serious eye over the issue as it is just the beginning of the deterioration of the ecosystem.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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