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Assessment of Physicochemical Parameters in Water Quality Index of Lake City Udaipur, Rajasthan of India.

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Abstract: ***Background:*** Udaipur, sometimes referred to as the 'Venice of the East' for its splendid lakes, is now confronting substantial water quality issues stemming from growing urbanization, tourism, and human-induced stresses. This reserach intends to provide a thorough physico-chemical and biological assessment of the principal lakes in the Udaipur area. The research examines the hydro-chemical dynamics and the interaction between surface water bodies and the underlying aquifers. Systematic water sampling was performed throughout the year to document seasonal fluctuations. The evaluation included essential parameters like pH, Electrical Conductivity (EC), Total Dissolved Solids (TDS), Total Hardness, Alkalinity, Calcium, Magnesium, Chloride, and Sulphate. Additionally, to assess the effects of agricultural runoff and home sewage, the amounts of Nitrate, Ammonium Nitrate, Phosphate, and Potassium were examined. The ecological health of the lakes was assessed using Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), and Dissolved Oxygen (DO) levels, with Fecal Coliform counts serving as a measure of biological pollution. The research further examined trace elements and ions, such as Boron, Fluoride and zinc.

Keywords: Lake Water Analysis, Groundwater Contamination, BOD, COD, Hydro-chemistry, Udaipur Lakes, Water Quality Index (WQI), Fecal Coliform.

INTRODUCTION

Groundwater is a vital natural resource that underpins many human activities, including home use, agricultural irrigation, and industrial operations. In several global locations, especially in dry and semi-arid areas, groundwater serves as the principal supply of freshwater. The quality of groundwater is very variable, affected by geological properties, climatic circumstances, land use patterns, and human activities. Given the escalating demand for water, it is essential to assess and comprehend the physical and chemical characteristics of groundwater to guarantee its safe and sustainable use. Groundwater is essential in India for fulfilling the water requirements of millions. Rising population pressures, urbanization, and agricultural development have intensified groundwater extraction rates, raising worries over the quality and availability of this essential resource. Samuel Otu et al. (2002) studied leaching of trace elements including heavy metals, nonmetals, and radionuclides from surface impoundments of tailings generated during uranium mining and milling often

leads to groundwater contamination. Kalbus et al. (2006) investigated the methodologies for assessing groundwater-surface water interactions. The interactions between groundwater and surface water are essential to the functioning of riparian ecosystems. In the realm of sustainable river basin management, it is essential to comprehend and quantify the exchange processes between groundwater and surface water. Shawky et al. (2007) examined the physical and chemical properties of groundwater in the Baris-El Kharga oasis in relation to the various aquifer systems in the Western Desert, Egypt. The research region, a genuine desert, relies only on groundwater as its primary source of growth, since no surface water nor precipitation is present. Eslamian S. et al. (2011) examined the historical perception of Groundwater and Surface Water (GW-SW) as distinct phenomena, which have been explored independently. The chemical, biological, and physical features of GW-SW are, in fact, distinct. In the transition zone, several processes transpire, resulting in the movement, degradation, transformation, precipitation, or sorption of chemicals. Gupta (2012) examined the assessment of spatial and seasonal variations in groundwater quality in Kolar Gold Fields, India. Underground gold mining in Kolar Gold Fields (KGF), Karnataka, persisted for almost a century, disrupting the groundwater aquifers. Chika C.P. et al. (2014) conducted a hydrogeochemical study of groundwater quality in specific regions of Ohaji Egbema, Eastern Niger Delta, Nigeria. The groundwater resource in Ohaji Egbema was examined for its quality, from which conclusions on its usability, dominant hydrochemical processes in the water system, and potential quality decline are derived. Y. Ravi Kumar et al. (2016) examined the groundwater quality in Anantapur District. Groundwater serves as the primary source for potable water and several activities in Andhra Pradesh. Every person has a fundamental obligation to preserve water resources. Prajapati and Bilas et al. (2017) examined the physicochemical parameters of groundwater quality by a geographical analysis of Varanasi District. The quality of groundwater has significantly deteriorated in recent decades owing to industry and urbanization. The objective of this study to evaluate the physical and chemical characteristics of groundwater in various regions of Udaipur.

MATERIALS & METHODS

Udaipur, known as the city of lakes, is positioned around 600 meters above sea level, nestled between the verdant hills of the Aravali range at a latitude of 24°35' N and a longitude of 73°42' E. Numerous lakes, such as Pichhola, Fateh Sagar, and Swaroop Sagar, are integral to the social, cultural, and economic activities of Udaipur. The city is referred to as the 'Venice of the East' and has been designated as the 'World's Most Beautiful City' by visitors and media globally. The city has a population of around 700,000 and has a unique tropical climate characterized by a pronounced monsoonal influence. The year is segmented into three seasons: summer (April to June), monsoon (July to October), and winter (November to March). The average temperature fluctuates from 5°C in winter to a high of 41°C in summer. The yearly average precipitation varies from 62.5 cm to 125 cm under typical monsoon conditions. While the city is renowned from a tourist perspective, it has also seen the development of several industries in and around Udaipur, particularly in the Madri Industrial Area and adjacent regions (such as Hindustan Zinc Ltd. and the Gudli Industrial Area). The normal activities of local residents, coupled with excessive tourist traffic, result in significant pollution. Both the residential and industrial sectors of the city are impacted by water contamination.

Udaipur were chosen to evaluate the effects of water pollution on the biochemical and physiological parameters of human health: Udai Sagar Lake, Pichola Lake,. Ten distinct sample stations were constructed at intervals of 10 meters throughout these locations. The data displayed indicates the average values derived from a minimum of three daily recordings per location. Samples were sent to the laboratory in plastic containers, where Most Probable Number (MPN) activity was promptly assessed.

Laboratory analysis

The aim of the present investigation is to study the accumulation of the studies on ground water characteristics of certain areas of Udaipur district with special reference to pollution. The present study incorporates many such issues which have not been studied earlier, especially with reference to physico-chemical assessment of heavy metals (Cd, Cr, Pb and Zn) in ground water, total coliform bacteria (MPN) in ground water, fluoride, Dissolved oxygen and Biological oxygen demand in ground water of the Udaipur city and its surrounding areas. For the present study water samples were collected regularily for one year from January, 2023 to December, 2024. Seasonally water samples have been collected in 2.5 liter capacity cans after rising is properly from each location. In general, the shorter the time that elapses between collection of a sample and its analysis the more reliable will be the analytical results. Various Physico-chemical and metallic parameter like pH, dissolved oxygen, total hardness, alkalinity, Chloride, C.O.D, total dissolved solids, phosphate, nitrate, were analyzed. (APHA, 1995, Manivaskam 1986, NEERI, 1988). The heavy metals concentration was determined by digesting the water samples with concentrate HNO3 and the analyzed by atomic absorption spectroscopy.

RESULT

Physico-chemical Parameters: Udai Sagar lake **(January- February 2023 to November-December, 2023):**
During the first year of the study, an analysis of various physico-chemical parameters of Udai Sagar Lake in Udaipur city revealed that the concentrations of Ammonia Nitrogen recorded at different sampling sites were 0.86 mg/l (1), 0.84 mg/l (2), 0.76 mg/l (3), 0.84 mg/l (4), 0.90 mg/l (5), and 1.1 mg/l (6), respectively (the bold numbers in brackets indicate different sampling months of the study schedule as indicated in Table 4.1). In the lake area, the different samples of B.O.D. were recorded as 2.37 mg/l (1), 1.8 mg/l (2), 2.8 mg/l (3), 2.9 mg/l (4), 2.4 mg/l (5), and 2.3 mg/l (6), respectively. The amount of dissolved Boron recorded at the different sampling sites was 0.35 mg/l (1), 0.38 mg/l (2), 0.21 mg/l (3), 0.35 mg/l (4), 0.38 mg/l (5), and 0.35 mg/l (6) in Udai Sagar Lake, respectively. The levels of C.O.D. recorded at the different sampling sites were 31.76 mg/l (1), 27.88 mg/l (2), 44.28 mg/l (3), 29.79 mg/l (4), 27.44 mg/l (5), and 31.6 mg/l (6) in the lake area, respectively. While in the lake area, the different samples of Calcium were recorded as 73.6 mg/l (1), 65.6 mg/l (2), 43.2 mg/l (3), 62.4 mg/l (4), 64 mg/l (5), and 33.6 mg/l (6), respectively. The amount of Chloride recorded at the different sampling sites was 224 mg/l (1), 248 mg/l (2), 236 mg/l (3), 244 mg/l (4), 256 mg/l (5), and 256 mg/l (6) in Udai Sagar Lake, respectively. In terms of Conductivity, the levels recorded at the different sampling sites were 1170 µS/cm (1), 1380 µS/cm (2), 1290 µS/cm (3), 1290 µS/cm (4), 1560 µS/cm (5), and 1963 µS/cm (6) in the lake area, respectively. While in the lake area, the different samples of Dissolved Oxygen were recorded as 5.1 mg/l (1), 4.8 mg/l (2), 5.5 mg/l (3), 5.6 mg/l (4), 4.7 mg/l (5), and 4.9 mg/l (6), respectively. The amount of Fecal Coliform recorded at the different sampling sites was 93 MPN/100ml (1), 93 MPN/100ml (2), 120 MPN/100ml (3), 93 MPN/100ml (4), 150 MPN/100ml (5), and 93 MPN/100ml (6) in Udai Sagar Lake, respectively. The amount of Fluoride recorded at the different sampling sites was 0.92 mg/l (1), 0.98 mg/l (2), 0.80 mg/l (3), 0.84 mg/l (4), 0.84 mg/l (5), and 0.92 mg/l (6) in Udai Sagar Lake. In terms of the amount of Magnesium recorded at the different sampling sites, the values were 38.1 mg/l (1), 51.7 mg/l (2), 33.2 mg/l (3), 25.4 mg/l (4), 45.9 mg/l (5), and 59.5 mg/l (6) in the lake area, respectively. In terms of the amount of Nitrate recorded at the different sampling sites, the values were 3.12 mg/l (1), 5.24 mg/l (2), 2.8 mg/l (3), 3 mg/l (4), 3.12 mg/l (5), and 3.12 mg/l (6) in the lake area. The concentration of Nitrite recorded at the different sampling sites was 0.010 mg/l (1), 0.008 mg/l (2), 0.005 mg/l (3), 0.012 mg/l (4), 0.005 mg/l (5), and 0.008 mg/l (6) in the lake area. The concentration of pH recorded at the different sampling sites was 8.3 (1), 8.08 (2), 8.08 (3), 8.56 (4), 8.03 (5), and 7.39 (6) in the lake area. In terms of the amount of Phenolphthalein Alkalinity recorded at the different sampling sites, the values were 4 mg/l (1), 4 mg/l (2), 0 mg/l (3), 12 mg/l (4), 0 mg/l (5), and 0 mg/l (6) in the lake area, respectively. In terms of the amount of Phosphate recorded at the different sampling sites, the values were 0.3 mg/l (1), 0.3 mg/l (2), 0.4 mg/l (3), 0.3 mg/l (4), 0.3 mg/l (5), and 2.17 mg/l (6) in the lake area, respectively. In terms of the amount of Potassium recorded at the different sampling sites, the values were 7.5 mg/l (1), 8.2 mg/l (2), 7.5 mg/l (3), 9.4 mg/l (4), 9.2 mg/l (5), and 14.8 mg/l (6) in the lake area, respectively. The concentration of Sodium recorded at the different sampling sites was 70 mg/l (1), 92 mg/l (2), 134 mg/l (3), 154 mg/l (4), 168 mg/l (5), and 180 mg/l (6) in the lake area. In terms of the amount of Sulphate recorded at the different sampling sites, the values were 100 mg/l (1), 102 mg/l (2), 126 mg/l (3), 95 mg/l (4), 134 mg/l (5), and 156.57 mg/l (6) in the lake area, respectively. The Temperature recorded at the different sampling sites was 20°C (1), 26°C (2), 24°C (3), 28°C (4), 24°C (5), and 24°C (6) in the lake area, respectively. In terms of the amount of Total Alkalinity recorded at the different sampling sites, the values were 120 mg/l (1), 132 mg/l (2), 88 mg/l (3), 92 mg/l (4), 104 mg/l (5), and 100 mg/l (6) in the lake area, respectively. The amount of Total Coliform recorded at the different sampling sites was 150 MPN/100ml (1), 240 MPN/100ml (2), 210 MPN/100ml (3), 150 MPN/100ml (4), 150 MPN/100ml (5), and 150 MPN/100ml (6) in Udai Sagar Lake, respectively. In terms of the amount of Total Dissolved Solids recorded at the different sampling sites, the values were 776 mg/l (1), 992 mg/l (2), 902 mg/l (3), 998 mg/l (4), 1210 mg/l (5), and 1276 mg/l (6) in the lake area, respectively. The amount of Total Hardness recorded at the different sampling sites was 340 mg/l (1), 376 mg/l (2), 244 mg/l (3), 260 mg/l (4), 348 mg/l (5), and 328 mg/l (6) in the lake area, respectively. In terms of the amount of Turbidity recorded at the different sampling sites, the values were 4.2 NTU (1), 4.9 NTU (2), 5.7 NTU (3), 8.4 NTU (4), 3.7 NTU (5), and 9.55 NTU (6) in the lake area, respectively.

Throughout 2023, data was collected across six bimonthly periods, each containing 32 observations. The year began with the January-February period showing the lowest activity, with a sum of 3,243.45 and an average of 101.36. As the year progressed, there was a general upward trend in both totals and variability. By mid-year (May-August), averages stabilized between 110.29 and 111.68. The final months saw a significant surge in values. The September-October period reached an average of 133.59, and the year concluded with the November-December period hitting a peak sum of 4,697.91 and an average of 146.81. Notably, the Variance also increased dramatically toward the end of the year, rising from 60,549.28 in the first period to a high of 163,538.29 in the final period, suggesting much wider fluctuations in the data during the holiday months.

The Analysis of Variance (ANOVA) was conducted across the six groups, involving a total of 191 degrees of freedom. The Between Groups variation, which measures the differences between the group means, shows a Sum of Squares (SS) of 45,175.99 and a Mean Square (MS) of 9,035.19. In contrast, the Within Groups variation (the "error" or noise within the data) is substantially higher, with an SS of 18,081,782.61 and an MS of 97,213.88. The calculated F-statistic for this test is 0.0929, which is significantly lower than the F-critical value of 2.26. This results in a very high P-value of 0.993.

Physico-chemical Parameters: Pichola lake **(January- February 2023 to November-December, 2023):**
During the first year of study, an analysis of various physico-chemical parameters of Pichola Lake at Udaipur City revealed that the concentrations of Ammonia Nitrogen recorded at the different sampling sites were 0.24 mg/l **(1)**, 0.52 mg/l **(2)**, 0.84 mg/l **(3)**, 0.62 mg/l **(4)**, 0.58 mg/l **(5)**, and 1.14 mg/l **(6)**, respectively (the bold number in brackets indicates the different sampling months of the study schedule as indicated in Table No. 4.2). While in the lake area, these were recorded for the different samples of B.O.D. as 1.52 mg/l **(1)**, 2.3 mg/l **(2)**, 2.1 mg/l **(3)**, 1.7 mg/l **(4)**, 1.5 mg/l **(5)**, and 1.75 mg/l **(6)**, respectively. The amount of Dissolved Boron recorded at the different sampling sites was 0.26 mg/l **(1)**, 0.33 mg/l **(2)**, 0.4 mg/l **(3)**, 0.48 mg/l **(4)**, 0.40 mg/l **(5)**, and 0.35 mg/l **(6)** in Pichola Lake, respectively. In terms of C.O.D. recorded at the different sampling sites, the values were 24.61 mg/l **(1)**, 29.52 mg/l **(2)**, 21.32 mg/l **(3)**, 18.45 mg/l **(4)**, 25.98 mg/l **(5)**, and 15.17 mg/l **(6)** in the lake area, respectively. While in the lake area, these were recorded for the different samples of Calcium as 35.2 mg/l **(1)**, 38.4 mg/l **(2)**, 30.4 mg/l **(3)**, 24 mg/l **(4)**, 25.6 mg/l **(5)**, and 28.8 mg/l **(6)**, respectively. The amount of Chloride recorded at the different sampling sites was 96 mg/l **(1)**, 92 mg/l **(2)**, 68 mg/l **(3)**, 88 mg/l **(4)**, 64 mg/l **(5)**, and 66 mg/l **(6)** in Pichola Lake, respectively. In terms of Conductivity, the values recorded at the different sampling sites were 490 µS/cm **(1)**, 550 µS/cm **(2)**, 440 µS/cm **(3)**, 450 µS/cm **(4)**, 482 µS/cm **(5)**, and 6073 µS/cm **(6)** in the lake area, respectively.

While in the lake area, these were recorded for the different samples of Dissolved Oxygen as 6.2 mg/l **(1)**, 6.2 mg/l **(2)**, 5.8 mg/l **(3)**, 6.1 mg/l **(4)**, 5.9 mg/l **(5)**, and 6.2 mg/l **(6)**, respectively. The amount of Fecal Coliform recorded at the different sampling sites was 23 MPN/100ml **(1)**, 39 MPN/100ml **(2)**, 23 MPN/100ml **(3)**, 23 MPN/100ml **(4)**, 23 MPN/100ml **(5)**, and 39 MPN/100ml **(6)** in Pichola Lake, respectively. The amount of Fluoride recorded at the different sampling sites was 0.38 mg/l **(1)**, 0.74 mg/l **(2)**, 0.84 mg/l **(3)**, 0.70 mg/l **(4)**, 0.96 mg/l **(5)**, and 0.445 mg/l **(6)** in Pichola Lake. In terms of Magnesium recorded at the different sampling sites, the values were 17.6 mg/l **(1)**, 20.5 mg/l **(2)**, 13.7 mg/l **(3)**, 12.7 mg/l **(4)**, 14.6 mg/l **(5)**, and 15.6 mg/l **(6)** in the lake area, respectively. Nitrate levels recorded at the different sampling sites were 2.68 mg/l **(1)**, 3.04 mg/l **(2)**, 2.2 mg/l **(3)**, 1.7 mg/l **(4)**, 2.06 mg/l **(5)**, and 5.4 mg/l **(6)** in the lake area. The concentration of Nitrite recorded at the different sampling sites was 0.005 mg/l **(1)**, 0.012 mg/l **(2)**, 0.010 mg/l **(3)**, 0.004 mg/l **(4)**, 0.010 mg/l **(5)**, and 0.020 mg/l **(6)** in the lake area. The pH values recorded at the different sampling sites were 8.5 **(1)**, 7.46 **(2)**, 8.69 **(3)**, 8.41 **(4)**, 8.4 **(5)**, and 8.39 **(6)** in the lake area. In terms of Phenolphthalein Alkalinity recorded at the different sampling sites, the values were 8 mg/l **(1)**, 0 mg/l **(2)**, 12 mg/l **(3)**, 8 mg/l **(4)**, 0 mg/l **(5)**, and 4 mg/l **(6)** in the lake area, respectively. Phosphate levels recorded at the different sampling sites were 0.1 mg/l **(1)**, 0.3 mg/l **(2)**, 0.5 mg/l **(3)**, 0.3 mg/l **(4)**, 0.28 mg/l **(5)**, and 0.12 mg/l **(6)** in the lake area, respectively.

Potassium levels recorded at the different sampling sites were 2.3 mg/l **(1)**, 3.4 mg/l **(2)**, 2.8 mg/l **(3)**, 3.9 mg/l **(4)**, 2.6 mg/l **(5)**, and 5.4 mg/l **(6)** in the lake area, respectively. The concentration of Sodium recorded at the different sampling sites was 43 mg/l **(1)**, 55 mg/l **(2)**, 38 mg/l **(3)**, 53 mg/l **(4)**, 48.3 mg/l **(5)**, and 74 mg/l **(6)** in the lake area. Sulphate levels recorded at the different sampling sites were 35 mg/l **(1)**, 47.5 mg/l **(2)**, 41 mg/l **(3)**, 35.5 mg/l **(4)**, 37 mg/l **(5)**, and 35 mg/l **(6)** in the lake area, respectively. The Water Temperature recorded at the different sampling sites was 24°C **(1)**, 29°C **(2)**, 24°C **(3)**, 24°C **(4)**, 24°C **(5)**, and 22°C **(6)** in the lake area, respectively. Total Alkalinity recorded at the different sampling sites was 76 mg/l **(1)**, 84 mg/l **(2)**, 80 mg/l **(3)**, 68 mg/l **(4)**, 72 mg/l **(5)**, and 80 mg/l **(6)** in the lake area, respectively. The amount of Total Coliform recorded at the different sampling sites was 75 MPN/100ml **(1)**, 75 MPN/100ml **(2)**, 64 MPN/100ml **(3)**, 39 MPN/100ml **(4)**, 39 MPN/100ml **(5)**, and 75 MPN/100ml **(6)** in Pichola Lake, respectively. Total Dissolved Solids recorded at the different sampling sites were 338 mg/l **(1)**, 408 mg/l **(2)**, 324 mg/l **(3)**, 342 mg/l **(4)**, 313 mg/l **(5)**, and 394 mg/l **(6)** in the lake area, respectively. Total Hardness recorded at the different sampling sites was 160 mg/l **(1)**, 180 mg/l **(2)**, 132 mg/l **(3)**, 112 mg/l **(4)**, 124 mg/l **(5)**, and 136 mg/l **(6)** in the lake area, respectively. Turbidity recorded at the different sampling sites was 4.1 NTU **(1)**, 4.4 NTU **(2)**, 3.7 NTU **(3)**, 15.1 NTU **(4)**, 5.11 NTU **(5)**, and 1.88 NTU **(6)** in the lake area, respectively. The amount of Iron recorded at the different sampling sites was 0 mg/l **(1)**, 0.127 mg/l **(2)**, 0 mg/l **(3)**, 0 mg/l **(4)**, 0.220 mg/l **(5)**, and 75 mg/l **(6)** in Pichola Lake, respectively. The amount of Nickel recorded at the different sampling sites was 0.016 mg/l **(2)** in Pichola Lake. Finally, the amount of Zinc recorded at the different sampling sites was 0.09 mg/l **(2)** and 0.068 mg/l **(5)** in the lake, respectively.

The data collection for 2023 was organized into six bimonthly groups, with each group consisting of 32 observations. The year began with an average of 45.99 in the January-February period, which slightly increased to a peak average of 52.40 during March-April. Mid-year values for the periods of May-June, July-August, and September-October remained relatively stable and lower, with averages ranging between 41.27 and 41.85. The year concluded with a secondary rise in the November-December period, reaching an average of 50.71. Variability followed a similar trend, with the highest variance recorded in the final period at 15,692.86.

A One-Way ANOVA was performed to determine if the differences between these bimonthly averages were statistically significant. Variation Analysis: The variation Between Groups resulted in a Sum of Squares (SS) of 2,732.14 with 5 degrees of freedom, while the variation Within Groups (representing the internal noise of the data) was much higher at 2,238,054.34 across 186 degrees of freedom. Test Statistics: The calculated F-value is 0.0454, which is significantly lower than the F-critical value of 2.2627. Significance: The resulting P-value is 0.9989.

Table-4.1 Physico-chemical Parameters of at different investigation sites of Udai Sagar lake at Udaipur city, during first year (January 2023 to December, 2023) of study.

Parameter	Jan–Feb 2023 (1)	Mar–Apr 2023 (2)	May–Jun 2023 (3)	Jul–Aug 2023 (4)	Sep–Oct 2023 (5)	Nov–Dec 2023 (6)
Ammonia Nitrogen (mg/l)	0.86	0.84	0.76	0.84	0.90	1.10
B.O.D. (mg/l)	2.37	1.80	2.80	2.90	2.40	2.30
Boron Dissolved (mg/l)	0.35	0.38	0.21	0.35	0.38	0.35
C.O.D. (mg/l)	31.76	27.88	44.28	29.796	27.44	31.60
Calcium as Ca (mg/l)	73.6	65.6	43.2	62.4	64.0	33.6
Chloride (mg/l)	224	248	236	244	256	256
Conductivity (µmho/cm)	1170	1380	1290	1290	1560	1963
Dissolved Oxygen (mg/l)	5.1	4.8	5.5	5.6	4.7	4.9
Fecal Coliform (MPN/100ml)	93	93	120	93	150	93
Fluoride as F (mg/l)	0.92	0.98	0.80	0.84	0.84	0.92
Magnesium as Mg (mg/l)	38.1	51.7	33.2	25.4	45.9	59.5
Nitrate as N (mg/l)	3.12	5.24	2.80	3.00	3.12	3.12
Nitrite as N (mg/l)	0.010	0.008	0.005	0.012	0.005	0.008
pH	8.3	8.35	8.08	8.56	8.03	7.39
Phenolphthalein Alkalinity	4	4	0.0	12	0.0	0.0
Phosphate as PO4 (mg/l)	0.3	0.3	0.4	0.3	0.3	2.17
Potassium as K (mg/l)	7.5	8.2	7.5	9.4	9.2	14.8
Sodium (mg/l)	70	92	134	154	168	180
Sulphate (mg/l)	100	102	126	95	134	156.57
Temperature (°C)	20	26	24	28	24	24
Total Alkalinity (mg/l)	120	132	88	92	104	100
Total Coliform (MPN/100ml)	150	240	210	150	150	150
Total Dissolved Solids (mg/l)	776	992	902	998	1210	1276
Total Hardness as CaCO3 (mg/l)	340	376	244	260	348	328
Turbidity (JTU/NTU)	4.2	4.9	5.7	8.4	3.7	9.55
Iron as Fe (mg/l)	0.0	0.0	0.0	0.0	0.0	0.0
Cadmium as Cd (mg/l)	0.0	0.0	0.0	0.0	0.0	0.0
Copper as Cu (mg/l)	0.0	0.0	0.0	0.0	0.0	0.0
Lead as Pb (mg/l)	0.0	0.0	0.0	0.0	0.0	0.0
Nickel as Ni (mg/l)	0.0	0.0	0.0	0.0	0.0	0.0
Total Chromium as Cr (mg/l)	0.0	0.0	0.0	0.0	0.0	0.0
Zinc as Zn (mg/l)	0.0	0.0	0.0	0.0	0.0	0.0

Table-4.2 Physico-chemical Parameters of at different investigation sites of Pichola lake at Udaipur city, during first year (January 2023 to December, 2023) of study.

Parameter	Jan–Feb 2023 (1)	Mar–Apr 2023 (2)	May–Jun 2023 (3)	Jul–Aug 2023 (4)	Sep–Oct 2023 (5)	Nov–Dec 2023 (6)
Ammonia Nitrogen (mg/l)	0.24	0.52	0.84	0.62	0.58	1.14
B.O.D. (mg/l)	1.52	2.30	2.10	1.70	1.50	1.75
Boron Dissolved (mg/l)	0.26	0.33	0.40	0.48	0.40	0.35
C.O.D. (mg/l)	24.61	29.52	21.32	18.45	25.98	15.17
Calcium as Ca (mg/l)	35.2	38.4	30.4	24.0	25.6	28.8
Chloride (mg/l)	96	92	68	88	64	66
Conductivity (µmho/cm)	490	550	440	450	482	607
Dissolved Oxygen (mg/l)	6.2	6.2	5.8	6.1	5.9	6.2
Fecal Coliform (MPN/100ml)	23	39	23	23	23	39
Fluoride as F (mg/l)	0.38	0.74	0.84	0.70	0.96	0.445
Magnesium as Mg (mg/l)	17.6	20.5	13.7	12.7	14.6	15.6
Nitrate as N (mg/l)	2.68	3.04	2.20	1.70	2.06	5.40
Nitrite as N (mg/l)	0.005	0.012	0.010	0.004	0.010	0.020
pH	8.5	7.46	8.69	8.41	8.40	8.39
Phenolphthalein Alkalinity	8	0.0	12	8	0.0	4
Phosphate as PO4 (mg/l)	0.1	0.3	0.5	0.3	0.28	0.12
Potassium as K (mg/l)	2.3	3.4	2.8	3.9	2.6	5.4
Sodium (mg/l)	43	55	38	53	48.3	74
Sulphate (mg/l)	35	47.5	41	35.5	37	35
Temperature (°C)	24	29	24	24	24	22
Total Alkalinity (mg/l)	76	84	80	68	72	80
Total Coliform (MPN/100ml)	75	75	64	39	39	75
Total Dissolved Solids (mg/l)	338	408	324	342	313	394
Total Hardness as CaCO3 (mg/l)	160	180	132	112	124	136
Turbidity (JTU/NTU)	4.1	4.4	3.7	15.1	5.11	1.88
Iron as Fe (mg/l)	0.0	0.127	0.0	0.0	0.220	0.0
Cadmium as Cd (mg/l)	0.0	0.0	0.0	0.0	0.0	0.0
Copper as Cu (mg/l)	0.0	0.0	0.0	0.0	0.0	0.0
Lead as Pb (mg/l)	0.0	0.0	0.0	0.0	0.0	0.0
Nickel as Ni (mg/l)	0.0	0.016	0.0	0.0	0.0	0.0
Total Chromium as Cr (mg/l)	0.0	0.0	0.0	0.0	0.0	0.0
Zinc as Zn (mg/l)	0.0	0.09	0.0	0.0	0.068	0.0

DISCUSSION

Sajil Kumar and James (2013) emphasized the physicochemical characteristics and their origins in groundwater within the Thirupathur area of Tamil Nadu, South India. This research presents the physicochemical characteristics and their sources in groundwater within the Thirupathur area of Tamil Nadu, India. Groundwater samples were collected and analyzed using conventional methodologies for this purpose. The majority of samples exhibited significant seasonal fluctuation, with elevated concentrations seen during the pre-monsoon season. The fluoride concentration was notably concerning in several areas. Groundwater is mostly characterized by Na+, Ca2+, HCO3-, and Cl-.

Behailu TW et al. (2017) assessed an investigation of the physical and chemical parameters of groundwater used for drinking in the Konso area of Southwestern Ethiopia. To enhance water quality, a method must be established to safeguard water sources from chemical contamination via efficient protection, frequent inspections, and timely interventions, ensuring precise measures are implemented regularly prior to distribution for use. This study aims to assess

the concentrations of common cations, anions, heavy metals, and physical properties in the drinking water delivery system of Konso and its surrounding region in Southwestern Ethiopia. Water samples were obtained from 23 distinct sites within the region where hand pumps or motorized supply systems are used for drinking purposes.

Ali & Ali (2018) investigated the hydrochemical properties and conducted a geographical study of groundwater quality in some regions of the Bundelkhand Massif, India. The challenges of water quality have surpassed those of quantity, as environmental issues intensify daily throughout many regions of the globe.

Popoola, L.T. et al. (2019) conducted an evaluation in of the physico-chemical parameters of natural groundwater in significant industrial and residential areas of the Lagos metropolitan. This research examined groundwater quality sampled from two industrial and residential sites in Lagos metropolis. The prescribed standard techniques of the American Public Health Association were used to assess the physico-chemical parameters of each groundwater sample, including pH, electrical conductivity (EC), dissolved oxygen (DO), total dissolved solids (TDS), biochemical oxygen demand (BOD), chemical oxygen demand (COD), anions (Cl−, NO3−, SO42−, PO43−), and heavy metals (Cu, Zn, Pb, Mn, Fe, Co, Cd, and Cr).

Ojekunle et al. (2020) reported an investigation of the physicochemical parameters of groundwater in selected industrial districts of Ogun State. This research sought to evaluate the effects of industrial operations in Ogun State, Nigeria. A total of 96 samples were collected throughout both dry and wet seasons for the examination of physicochemical quality markers. Hydrochemical assessments were conducted in accordance with APHA standards, while the hydrochemical facies of groundwater samples were analyzed using Piper Trilinear software. Ram A et al. (2021) published an evaluation of groundwater quality using the water quality index (WQI) inside a GIS framework. Groundwater serves as a crucial source for potable water in the hard rock terrain of the Bundelkhand massif, namely in the Mahoba District of Uttar Pradesh, India. This investigation tries to assess the appropriateness of groundwater for human consumption. The criteria analyzed to assess groundwater quality were pH, electrical conductivity, total dissolved solids, alkalinity, total hardness, calcium, magnesium, sodium, potassium, bicarbonate, sulfate, chloride, fluoride, nitrate, copper, manganese, silver, zinc, iron, and nickel. The water quality index (WQI) is used to classify water quality as outstanding, good, bad, etc., providing valuable insights for the public and policymakers in the relevant region.

CONCLUSION

The hydro-chemical and microbiological examination of the lacustrine systems in Udaipur, Rajasthan, offers essential insights into the declining water quality of this semi-arid area. This study demonstrates that water bodies are subjected to considerable human-induced and seasonal stress. An first observation is the concerning increase in BOD (Biochemical Oxygen Demand) and COD (Chemical Oxygen Demand) levels over the September-October timeframe, which corresponds with a reduction in Dissolved Oxygen (DO). This pattern indicates a substantial inflow of organic materials and post-monsoon runoff. The detection of Fecal Coliform further substantiates biological pollution, making several water sources unsuitable for direct consumption without rigorous treatment.

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