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# PHYSIO-CHEMICAL AND MEASURABLE INVESTIGATION OF WATER OF DISTRICT UDAIPUR NEAR PICHOLA LAKE RAJASTHAN AND ITS STATISTICAL INTERPRETATION

*Aashiq Hussain Ahanger[1] and Dr.KM Sharma[2]*
Carrer Point University Kota, India,
aashiqyousuf29@gmail.com , Kirti.sharma@cpur.edu.in

***Abstract***—*Water the driving force of nature is one of the basic needs required by all life on earth which dominates a majority of the space on our planet. Water is an inorganic, transparent tasteless, odorless and nearly colorless substance. Water is required for different purposes; the suitability of it must be checked before use. Poor condition of water bodies are not only the indicator of the environmental degradation but also threat to the eco system. In industries, improper quality of water may cause hazards and severe economic loss. The study of water sources of the Udaipur city is necessary because they serve as source of water for people of the city, nearby town, villages and countless tourists that visit the city. In the present study an attempt has been made to study the water quality near Pichola Lake of Udaipur (Rajasthan), India. Water samples were taken near Pichola Lake District Udaipur 5.0 km from the city Udaipur for physio-chemical and statistical analysis. In this study it was found that all the sample readings come near to the permissible limit except, fluoride ion, TDS, TA, FC and sodium. Distinctive statistical analysis additionally clarifies the appropriateness of water for domestic purposes but unsuitable for irrigation purposes.*

***Keywords***—*Water quality, Pichola Lake, Udaipur, physio-chemical parameters, statistical analysis*

## 1. Introduction

According to scientific literature, water quality is considered as the second most important resource after air. The volume of water that exists on Earth's surface is referred to as hydrosphere. As a result, many areas of the state are surrounded by forests. One of these is the city of Udaipur, which is located in the southern part of the state. The temperature normally varies from 11.6$^0$C in January to 45$^0$C in May. Udaipur city has a hot semi-arid climate. Average annual rainfall of the district is 637.0mm. However normal rainfall for the period 1901 to 1970 is 633.50mm. The season for rain in the southern part of the district is from December to February. The months of September to November are considered as the post-monsoon season. These periods are mild and normal. These regions have also experienced severe drought conditions in the past. In 1987, a severe drought was recorded at Kotra. The quality of water is also affected by the increasing population, the use of fertilizers and pesticides [24], and the over-exploitation of natural resources.

From Udaipur division, the selected site for the present study is the water near Pichola Lake (5.0 km from Udaipur city).

Lake Pichola is an artificial fresh water lake situated in the Indian state of Rajasthan. The lake provides water to around 60% of the area's population. It also supports various industrial and agricultural uses.

## 1. Materials and Methods

The objective of this research was to determine the quality of water near Pichola Lake through the analysis of different physio-chemical parameters such as pH, Temperature, Conductivity, Turbidity, Fecal Coliform, Total dissolved solids, BOD, COD, TA, TH, Calcium, Potassium, Sodium, Magnesium, Nitrate, Sulphate, Phosphate, Chloride, Fluoride, and Boron dissolved as well as their statistical interpretation.

Various samples were collected near Pichola Lake and also from the web-site of pollution control board Jaipur Rajasthan for comparison. The American Public Health Association [1] has recommended the use of various methods for the analysis of physiological parameters. Different methods are used to determine the physiological and chemical parameters of water. The National Water Monitoring Program of India carries out environmental reports that detail the various physio-chemical parameters of water. The readings were taken for the year 2021 Near Pichola Lake (station code-1481) and were analyzed too. The readings indicated that the weather conditions may have affected the readings.

**Table- 1**
**Physio-chemical analysis of water of near Pichola lake of Udaipur division for year (2021)**

| Physio-chemical parameters | 2021 |
|---|---|
| pH | 7.96 |
| Tempt. | $24^0$C |
| Turbidity | 1.6 NTU |
| TDS | 945 mg/l |
| EC | 1270µmho/cm |
| T A | 354 mg/l |
| T H | 190 mg/l |
| BOD | 36.5 ppm |
| COD | 15.66 mg/l |
| FC | 3 (MPN/100ML) |
| $Ca^{2+}$ | 56.8 mg/l |
| $Mg^{2+}$ | 15.78 mg/l |
| $Na^+$ | 158mg/l |
| $K^+$ | 6.2 µg/l |
| $Cl^-$ | 163ppm |
| $SO_4^{2-}$ | 165.5 mg/l |
| $NO_3^-$ | 1.62mg/l |
| $PO_4^{3-}$ | 0.19mg/l |
| $F^-$ | 1.91 mg/l |
| Boron | 0.28 mg/l |

Note: All ionic concentration are expressed in mg/lit. except EC(µmho/cm), Tempt. ($^0$C) Turbidity (NTU) and Fecal Coliform (MPN/100 ml)

## 1. Result and Discussion

### 1.1. Water Quality Parameters

Different physio-chemical parameters were reported in Table-1. A single sample was taken for 2021 year and was analyzed for the following parameters viz, pH, temperature, turbidity, TDS, EC, TA, TH, BOD, COD, Fecal Coliform, $Ca^{2+}$, $Mg^{2+}$, $Na^+$, $K^+$, $Cl^-$, $SO4^{2-}$, $NO3^-$, $PO4^{3-}$, $F^-$ and boron dissolved. Following parameters for water quality were studied in the water and compared with standard allowable limits.

**3.1.1 pH** – One of the important parameter which tells us the acidic and alkaline nature of water. It is basically vital for varied biochemical reactions. [23][26]. Permissible limit for potential of hydrogen in water is 6.5 – 8.5. [1] Less pH causes TB (tuberculation) and corrosion while higher pH causes Incrustation and sediment deposit. [14]

**3.1.2 Temperature**- A vital parameter which not only influence water chemistry but also governs biological activity and growth of living organisms. It influences the different kinds of organisms that can live in water bodies also.

**3.1.3 Turbidity**-Turbidity indicates the cloudiness of the liquid which is formed by the accumulating individual particles that are not visible by our naked eyes like smoke in air. The Permissible limit for turbidity is 5-10 NTU. What we found during post monsoon, water turbidity is 1.6 NTU for the current location.

**3.1.4 Total Dissolved Solids (TDS**)- TDS indicates the total amounts of charged ions including minerals, salts or metals dissolved in a given volume of water. It is usually expressed in mg/lit. It originates from natural sources, sewage, urban runoff, chemicals used in water treatment processes, industrial waste water and nature of hardware used in water transport. [28] Allowable limit is 1500mg/lit. [4]

**3.1.5 Electrical Conductance-**The capacity of a water system to pass electric flow is measured using the electrical conductance [27]. This concentration is ionized form of dissolved salt or inorganic chemicals. Permissible limit is 200-1000 μmho/cm.

**3.1.6 Total Alkalinity**- The capacity of a water body to maintain the pH level and the metal content is known as its buffering capacity. It is used to regulate the amount of acids in a water body. The general level of fresh water for alkalinity level is 20-200 mg/lit.

**3.1.7 Total Hardness**- A polyvalent cation is a measure of the concentration of various cations in a water body. Some of these include magnesium, iron, manganese, and calcium. The higher the polyvalent cation is due to the excessive use of certain chemicals. The total hardness of water is allowed to be 300 mg/lit on the basis of ICMR. The higher the concentration of these cations, the more difficult the water is to handle [18].

**3.1.8 Biochemical Oxygen Demand (BOD**)- The oxygen utilization of a water body for its biochemical degradation is known as the BOD. It provides the necessary oxygen for the removal of organic materials and the formation of new ones. Allowable limit for BOD is 3-5 ppm which represents moderately clean level.

**3.1.9 Chemical Oxygen Demand (COD) -**The chemical oxygen demand, also known as COD, is a measure of the water's capacity to consume oxygen during the decomposition of organic matter. It is expressed in mg/lit. Ideally COD should be zero.

**3.1.10 Fecal Coliform-**Fecal Coliform is a group of bacteria that can be found in the intestines and feces of animals. It can contribute to the spread of diseases such as typhoid fever and bacterial gastroenteritis. The permissible level of Coliform should be non-detectable in 100 ml.

**3.1.11 Calcium**- The main source of calcium is the erosion of rocks such as limestone. The excess amount of this mineral can reduce the absorption of other minerals in the body. Allowable limit is 75-200 mg/lit.

**3.1.12 Magnesium**- High levels of magnesium can also make water unpleasant to drink. The main source of this mineral is through the erosion of rocks and minerals. Allowable limit of Magnesium is 30-150 mg/lit.

**3.1.13 Sodium-** High levels of sodium can also contribute to the development of conditions such as high blood pressure, heart and kidney disease. it must be in the range of 30-60 mg/lit.

**3.1.14 Potassium**– High concentration of potassium can also cause adrenal insufficiency, kidney failure, and heart disease. However lower levels of potassium is beneficial for both humans as well as plants.

**3.1.15 Chloride**- In most cases, the concentration of chlorides in water varies widely. In 1991, the WHO set a maximum limit of 200 ppm and a maximum limit of 600 ppm. [26] Its effects on the taste and appearance of water are considered essential to water quality.

**3.1.16 Sulphate** – Sulphate is a common component found in almost all water sources. [27] It can cause a laxative effect if it reaches a concentration of up to 400 milligrams per lit.

**3.1.17 Nitrate**– The maximum concentration of nitrate that can be found in water is 50 milligrams per lit. [4] Also, high concentrations of nitrate can cause blue-baby disease and Methemoglobinemia.

**3.1.18 Phosphate**- It's believed that the concentration of phosphate found in fresh water is regulated at a range of 0.005 to 0.05 milligrams per lit. Main source of phosphate are sewage and industrial waste disposal in fresh water. But let me tell you basically, it promotes growth of micro-organism. [8]

**3.1.19 Fluoride**- Water fluoridation is a process that involves the addition of fluoride to prevent cavities. The recommended concentration of fluoride in water is 1.0 to 1.5 milligrams per lit. Excess concentration causes fluorosis and deformation in joints.

**3.1.20 Boron Dissolved**- This substance can be found in water at a concentration of up to 1-5 milligrams per lit. it is considered as an essential nutrient present in plants.

**3.2 Water quality criteria for irrigation**

The water quality of a farm depends on its irrigation purpose. The concentration of dissolved constituents can also determine its quality. The quality of water is often an aspect of an irrigation study to evaluate the conditions of water flow in an area. The quality of water is also an important aspect of an irrigation study to evaluate the salinity and alkalinity levels in an area. Good soil and water management techniques can help improve the quality of water on a farm. Total dissolved Solids and the sodium content in relation to the amounts of calcium and magnesium or SAR [2] determines the suitability of water for irrigation. These calculations are based on various statistical factors such as the sodium percentage, the soluble sodium content, and the Chloro alkaline index.

**Statistical Representation of Water Parameters**

**3.2.1 Sodium Absorption Ratio (SAR)**:

Sodium Absorption Ratio is one of the vital parameter given by Richard in 1954 [19]. The main basic concept behind the sodium absorption is to find out the alkalinity of soil water used for irrigation purposes. [12]

$$\textbf{Sodium Absorption Ratio (SAR)} = \frac{Na}{\sqrt{Ca+Mg/2}}$$

Note: $Ca^{2+}$, $Mg^{2+}$ and $Na^{+}$ are expressed in mg/l.

**3.2.2 Chloro alkaline indices (CAI)**: Chloro Alkaline Indices is used to calculate the Base Exchange proposed by Schoeller [20]. Chloro alkaline indices are used to calculate ion exchange between the surrounding area and water.

For its calculation use following equation

$$\mathbf{CAI = [Cl^{-} - (Na^{+} + K^{+})/Cl^{-}}$$

Note: Remember all ionic concentrations are measured in mg/l.

- CAI >0: Base Exchange reaction absent i.e. there is any existence of anion cation exchange type of reactions.
- CAI <0: Exchange taking place between sodium and potassium in water with calcium and magnesium in the rocks by Base Exchange Reactions manner. [17]

**3.2.3 Percentage Sodium (%Na):** This method is used for rating the irrigation waters which is consumed on the basis of percentage and electrical conductivity given by Wilcox.

For its calculations use the formula:- $$\%Na = \frac{(Na+K)}{Na+K+Mg+Ca} \times 100$$

Note: Remember all ionic concentrations are expressed in mg/l.

**3.2.4 Kelly's ratio (KR)**: Kelly ratio indicates the assessment ratio for measuring the suitability of water for agriculture purpose. The suitability and unsuitability of water for the purpose of agriculture on basis of KR is due to alkali hazards. [9]

Kelly's ratio was calculated by using the equation mentioned below:

$$\textbf{Kelly Ratio (KR)} = \frac{Na}{Ca+Mg}$$

KR ≤1: it indicates it is Suitable for Irrigation and show good quality

KR>1: it indicates it is Unsuitable for irrigation purpose

Note: Remember all ionic concentration are expressed in mg/l.

**3.3.5 Calculation of Indices: Langelier Saturation Index (LSI)** is an equilibrium index which indicates thermodynamic driving force for $CaCO_3$ scale formation and growth which was given by Langelier. By the use of pH this can be explained in the following manner. [13]

- LSI <0: absent potential scale and thus water will dissolve $CaCO_3$.
- LSI >0: means Scale can form and CaCO3 precipitation may occur.
- LSI =0: Represents order line scale potential.

For this calculation, Langelier Saturation Index, value of total alkalinity (as $CaCO_3$), Calcium hardness as $CaCO_3$), total dissolved solids (TDS) and value of pH and temperature of water (°C) required.

$$\mathbf{LSI = pH - pHs}$$

pHs may be defined as the pH at saturation in calcite or $CaCO_3$.
For its calculation let us follow the equation

$$\mathbf{pHs = (9.3 + P + Q) - (R + S)}$$

Where $P = (\log_{10} [TDS] - 1)/10$
$Q = -13.12 \times \log_{10} (°C + 273) + 34.55$
$R = \log_{10}$ [Ca Hardness as $CaCO_3$] $-0.4$
$S = \log_{10}$ [Total alkalinity as CaCO3]
We can calculate LSI by help of these equations.

LSI is very much helpful in predicting the scaling or corrosive potential of the water.

- If water dissolves $CaCO_3$, water is corrosive and has a -ive value.
- If the water deposits $CaCO_3$, it has a scaling potential and a +ive value.

**Table- 2**
**Statistical Analysis of Water Near Lake Pichola**
**(statio code-1285)**

| **Statistical Parameters** | **2021** |
|---|---|
| (SAR) | 26.22 |
| (CAI) | -0.007 |
| % Na | 69.3 |
| KR | 2.17 |
| LSI | 0.193 |

**Note**: All ionic concentrations are expressed in mg/lit.

**Table- 3**
**Classification on the basis of Statistical Analysis**

| Statistical Analysis Parameters | Categories | Range |
|---|---|---|
| Sodium Absorption Ratio (SAR) | Excellent | 0-10 |
| | Good | 10-18 |
| | Fair | 18-26 |
| | Poor | >26 |
| Chloro Alkaline Indices (CAI) | Base Exchange Reaction | Negative value |
| | Cation Exchange Reaction | Positive value |
| Sodium Percentage (%Na) | Excellent | 0-20 |
| | Good | 20-40 |
| | Permissible | 40-60 |
| | Doubtful | 60-80 |
| | Unsuitable | >80 |
| Kelly Ratio(KR) | Suitable | <1 |
| | Marginal suitable | 1-2 |
| | Unsuitable | >2 |

**Table- 4**
**Interpretation of Langelier Saturated Index (LSI) Test result**

| Serial No. | LSI index | Appearance | Water conditions issues required |
|---|---|---|---|
| 1 | -4.0 | Very severe corrosive | Conditioning required |
| 2 | -3.0 | Severe corrosive | Conditioning usually suggested |
| 3 | -2.0 | Moderate corrosive | Some conditioning is suggested |
| 4 | -1.0 | Mild corrosive | Required some conditioning |
| 5 | -0.50 | Slight corrosive | May need some conditioning |
| 6 | 0.00 | Balanced | Conditioning not suggested |
| 7 | 0.50 | Faint scale coating | Conditioning not suggested |
| 8 | 1.0 | Slight scale coating | Some visual appearance shown |
| 9 | 2.0 | Mild scale coating | Should consider some Conditioning |
| 10 | 3.0 | Moderate scale coating | Should use some Conditioning |
| 11 | 4.0 | Severe scale coating | Usually Conditioning required |

## 2. Conclusion

- The findings and conclusions of this research were based on the statistical data collected during the course of the study.
- The readings are within the permissible range except few.
- Most of the samples used for the study are alkaline but little poor statistical characteristics.
- Concentrations of cations and Anions are within the acceptable limits for drinking water except few.
- The water's suitability is evaluated on the basis of certain parameters such as salinity hazards, SAR, CAI, % Na and KR. Although most of the samples are within the permissible range but because of little variation, are not suitable for irrigation.
- The variation of these parameters can be observed in the geological regions and the anthropogenic activities carried out in these areas.

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