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# Limnological Studies Related to Physico-Chemical Parameters of Nizamsagar Reservoir, Kamareddy District, Telangana, India

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***Authors' contributions***

*This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.*

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## ABSTRACT

The Nizamsagar Reservoir is one of the oldest irrigation projects in India, constructed across the Manjeera River, a tributary of the Godavari River. The present study aimed to analyse15 different water parameters of Nizamsagar Reservoir from June 2021 to May 2022 from two different locations. Standard methods were used for the analysis of various physico-chemical parameters, and correlation coefficients were calculated to determine the relationships between different types of physico-chemical parameters by using MS Excel software. All the physico-chemical parameters of reservoir water are within the permissible limits according to the standard methods of APHA and AWWA.

*Keywords: Nizamsagar; physico-chemical; reservoir; correlation; Telangana.*

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## 1. INTRODUCTION

Freshwater reservoirs, which include various water bodies such as lakes, ponds, and reservoirs, serve an important role in sustaining life and supporting ecosystems. Freshwater reservoirs, as important components of Earth's ecosystems, provide a wide range of advantages that are critical to the health of both natural habitats and human populations. As a result, protecting and managing these ecosystems in a sustainable manner is critical to ensuring their continuous contribution to the overall health of the world.

Given the vital importance of water as a resource for life on Earth, maintaining its quality is paramount for both human health and environmental well-being. Physico-chemical analysis serves as a method to assess water quality by measuring various physical and chemical parameters. In this context, understanding the main physico-chemical parameters of water and their significance becomes crucial. These parameters provide insights into the overall health and suitability of freshwater reservoirs. Such assessments are indispensable for ensuring that water resources align with their intended purposes.

Physico-chemical parameters of freshwater reservoirs in India have been studied by several researchers in several parts of India.[1] conducted a study on Mahil pond in Orai and found that the water quality was unsuitable for drinking and sustaining resident organisms due to contamination from anthropogenic activities. Another study by [2] focused on Dandiganahalli dam and concluded that the water quality was moderate, with suitable conditions for agriculture, fisheries, and domestic use. [3] Evaluated three reservoirs in Tamil Nadu and found that all water quality parameters were within prescribed limits, suggesting under-exploitation of fish resources. [4] Investigated Bawashaswar Dam and found poor water quality, rendering it unsuitable for drinking, irrigation, and fish culture. [5] studied the physico-chemical parameters and ichthyofaunal diversity of Nizamsagar dam and they reported that the reservoir water was within the permissible limits of American Public Health Association APHA], World Health Organisation (WHO). [6] Assessed Khelna reservoir water and found that all physico-chemical parameters were within normal range, making it safe for drinking and irrigation. These studies highlight the importance of monitoring and managing the physico-chemical parameters of fresh water reservoirs in India to ensure water quality for various purposes. Reddy et al. [7] studied the ichthyofaunal diversity of Nizamsagar reservoir but the physico-chemical parameters of Nizamsagar Reservoir have not been thoroughly investigated. Therefore, the present work aims to address this gap in knowledge by conducting a comprehensive study.

## 2. MATERIALS AND METHODS

### 2.1 Study Area

The Nizamsagar Reservoir is one of the oldest irrigation projects in India. The reservoir is located in the Kamareddy district of Telangana state and is built across the Manjeera River, which is a tributary of the Godavari River. It is situated at 18º 19´ (N) Latitude and 76º 56´ (E) Longitude. The construction of the reservoir began in 1923 and was completed in 1931 by Mir Osman Ali Khan. The project was constructed with the primary goal of providing irrigation to the drought-prone areas of this region and also improving the drinking water supply to the nearby villages.

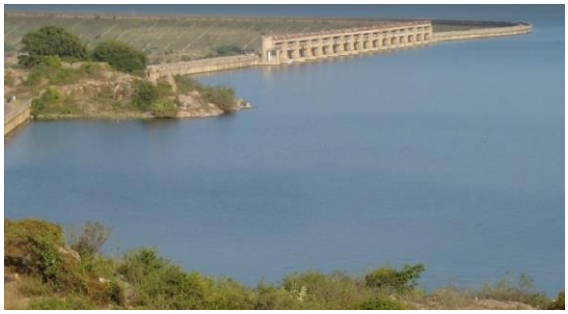

**Fig. 1. Nizamsagar reservoir arial view**

### 2.2 Sample Collection

Water samples were collected on monthly basis on the every month for a period of one year from June 2021 to May 2022 from two different locations. To avoid the changes in water quality throughout the study period, all sample collection and observations were made between 6 a.m. and 12 p.m. The surface water samples were collected by using a clean plastic container and transferred the collected samples to the laboratory as soon as possible. Some of the specific parameters were estimated at the spot after the collection. Standard methods were used for the analysis of various physico-chemical parameters [8,9,10]. Correlation coefficients were calculated to determine the relationships

between different types of physico-chemical parameters by using MS Excel software.

## 3. RESULTS AND DISCUSSION

During the study period, a total of 15 limnological parameters of water were examined. The monthly variations and statistical data of the various physico-chemical parameters of Nizamsagar Reservoir from June 2021 to May 2022 were depicted in Table 1 and 2.

### 3.1 Water Temperature

Water temperature is measured with the help of mercury thermometer and the values were denoted in degrees Celsius. During the South West Monsoon (SWM) season from June to September 2021, both locations experienced warmer temperatures ranging from 21.8 to 27.4°C The mean temperature during this season was 23.7 and 23.93°C at loc 1 and 2. The standard deviations for water temperatures suggest moderate variability in these measurements, indicating some fluctuations within the SWM season.

In the North East Monsoon (NEM) season from October 2021 to January 2022, water temperatures varied from 18 to 21.8 °C. The mean water temperature was 19.65 and 19.88°C at loc 1 and 2.. The standard deviations for water temperatures were relatively low, indicating more stable conditions during the NEM season. Finally, the summer season (February to May 2022) exhibited higher water temperatures ranging from 21.2 to 31.5 °C. The mean water temperature was 26 and 26.35°C at loc 1 and 2. The standard deviations for water temperatures suggest a higher degree of variability during the warmer months of summer. The equal type of results was noticed by Vasumathi [11]. Overall, temperature dataset provides valuable insights into the thermal dynamics of Nizamsagar Reservoir, which is crucial for ecological and hydrological assessments in the region.

### 3.2 Transparency

Reservoir Water Transparency is measured with Secchi disc and the values are expressed in centimeters. The transparency data reveals variations in water clarity during different seasons. Throughout the South West Monsoon (SWM) season from June to September 2021, transparency values ranged from 30 to 82 cm at both Loc. 1 and Loc. 2. The mean transparency during this period was 52 and 60.5 cm at loc 1 and 2 with a standard deviation of 15.92 and 18.93, indicating a significant variability in water clarity.

In contrast, the North East Monsoon (NEM) season, spanning October 2021 to January 2022, exhibited more stable transparency values ranging from 29.2 to 40 cm. The mean transparency during the NEM season was 32.85 and 32.8 cm, with a lower standard deviation of 2.62 and 4.94. This suggests relatively clearer water conditions and less variability compared to the SWM season. The comparable results were noticed by Vishal et al. [12]. The summer season (February to May 2022) shows an increase in transparency values, ranging from 52 to 96cm, with a mean transparency of 66 and 74.5cm at loc 1 and 2. Higher transparency during the summer months could be associated with reduced precipitation and lower sediment input. Understanding transparency variations is crucial for assessing water quality and ecological conditions of reservoir.

### 3.3 Turbidity

Water Turbidity is measured with Nephlometer. The values were expressed in NephlometricTurbity Units (NTU). The turbidity data provides insights into the clarity of water during different seasons. Turbidity is a measure of the cloudiness or haziness of a fluid caused by large numbers of individual particles. During the South West Monsoon (SWM) season, turbidity values ranged from 5 to 24 NTU at both Loc. 1 and Loc. 2. The mean turbidity during this period was 12.75 and 9.5 NTU, with a standard deviation of 7.54 and 4.65, indicating a moderate level of variability in water clarity. Turbidity values tended to be higher during the monsoon season, which is expected due to increased runoff and sedimentation.

In the North East Monsoon (NEM) season, turbidity values were more consistent, ranging from 15 to 23 NTU. The mean turbidity during the NEM season was 20 and 19.25 NTU at loc 1 and loc 2., with a lower standard deviation of 2.58 and 3.1, suggesting more stable water conditions and lower variability compared to the SWM season. The summer season exhibited lower turbidity values ranging from 5 to 10 NTU, with a mean turbidity of 8 and 7 NTU at loc 1 and 2 and a standard deviation of 1.83 and 2.31. These lower turbidity values during the summer months may be attributed to reduced precipitation and decreased sediment input. Similar type of results were observed by Madhuben [13].

**Table 1. Physico-chemical parameter values of Nizamsagar Reservoir during the year 2021-22 at Location 1**

| Season | Month | WT | Trsp | Turb | EC | TDS | pH | DO | CO2 | TA | TH | Sulp | Phos | Cl | BOD | COD |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| South West Monsoon (SWM ) | Jun-21 | 27.1 | 68 | 8 | 550 | 0.33 | 7.4 | 7.9 | 3.2 | 180 | 124 | 8 | 1.1 | 186 | 3.8 | 5.4 |
| | Jul-21 | 23.8 | 54 | 10 | 560 | 0.36 | 7.4 | 7.6 | 2.6 | 198 | 102 | 10 | 1.01 | 210 | 3.2 | 6.2 |
| | Aug-21 | 21.8 | 56 | 9 | 620 | 0.38 | 7.6 | 8 | 3.5 | 210 | 90 | 10.2 | 1.04 | 196 | 4.1 | 5.7 |
| | Sep-21 | 22.1 | 30 | 24 | 580 | 0.37 | 7.6 | 7.2 | 5 | 212 | 76 | 7.4 | 1.01 | 186 | 4 | 5.8 |
| | Mean | 23.70 | 52.00 | 12.75 | 577.50 | 0.36 | 7.50 | 7.68 | 3.58 | 200.00 | 98.00 | 8.90 | 1.04 | 194.50 | 3.78 | 5.78 |
| | Std. Dev. | 2.43 | 15.92 | 7.54 | 30.96 | 0.02 | 0.12 | 0.36 | 1.02 | 14.70 | 20.33 | 1.41 | 0.04 | 11.36 | 0.40 | 0.33 |
| North East Monsoon ( NEM) | Oct-21 | 21.6 | 34 | 19 | 486 | 0.29 | 7.1 | 6.2 | 5.2 | 164 | 88 | 6.4 | 0.81 | 164 | 3.2 | 7.4 |
| | Nov-21 | 18.6 | 31 | 21 | 500 | 0.21 | 7.1 | 6 | 6.4 | 148 | 96 | 6.6 | 0.79 | 142 | 3.1 | 8.2 |
| | Dec-21 | 18 | 30.4 | 23 | 510 | 0.19 | 7.3 | 6.8 | 6.4 | 126 | 118 | 7.2 | 0.83 | 132 | 4.3 | 7.6 |
| | Jan-22 | 20.4 | 36 | 17 | 398 | 0.19 | 7.2 | 7.1 | 7.4 | 104 | 104 | 8.5 | 0.74 | 126 | 4 | 8.4 |
| | Mean | 19.65 | 32.85 | 20.00 | 473.50 | 0.22 | 7.18 | 6.53 | 6.35 | 135.50 | 101.50 | 7.18 | 0.79 | 141.00 | 3.65 | 7.9 |
| | Std. Dev. | 1.65 | 2.62 | 2.58 | 51.29 | 0.05 | 0.10 | 0.51 | 0.90 | 26.15 | 12.79 | 0.95 | 0.04 | 16.69 | 0.59 | 0.48 |
| Summer | Feb-22 | 21.2 | 52 | 10 | 410 | 0.18 | 7.9 | 9.2 | 1.2 | 124 | 90 | 10 | 0.76 | 122 | 5.1 | 9.5 |
| | Mar-22 | 23.6 | 60 | 9 | 405 | 0.19 | 7.8 | 9.6 | 0.65 | 138 | 168 | 9 | 0.75 | 114 | 4.9 | 9.4 |
| | Apr-22 | 28 | 74 | 7 | 380 | 0.17 | 7.9 | 10.2 | 0 | 148 | 176 | 9.3 | 0.76 | 106 | 5.4 | 10.4 |
| | May-22 | 31.2 | 78 | 6 | 430 | 0.17 | 7.8 | 9.8 | 0 | 174 | 184 | 8.6 | 0.8 | 98 | 5.4 | 9.2 |
| | Mean | 26.00 | 66.00 | 8.00 | 406.25 | 0.18 | 7.85 | 9.70 | 0.46 | 146.00 | 154.50 | 9.23 | 0.77 | 110.00 | 5.20 | 9.63 |
| | Std. Dev. | 4.47 | 12.11 | 1.83 | 20.56 | 0.01 | 0.06 | 0.42 | 0.58 | 21.10 | 43.49 | 0.59 | 0.02 | 10.33 | 0.24 | 0.53 |

**Table 2. Physico-chemical parameter values of Nizamsagar Reservoir during the year 2021-22 at Location 2**

| Season | Month | WT | Trsp | Turb | EC | TDS | pH | DO | CO2 | TA | TH | Sulp | Phos | Cl | BOD | COD |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| South West Monsoon (SWM ) | Jun-21 | 27.4 | 82 | 5 | 580 | 0.34 | 7.5 | 8.2 | 4 | 196 | 136 | 8.1 | 1 | 192 | 3.9 | 5.4 |
| | Jul-21 | 23.9 | 64 | 8 | 590 | 0.39 | 7.5 | 8.1 | 3.1 | 208 | 110 | 10.2 | 1.05 | 212 | 3.3 | 6.5 |
| | Aug-21 | 22 | 60 | 9 | 640 | 0.39 | 7.6 | 8.4 | 4 | 222 | 96 | 10.1 | 1.06 | 200 | 4.2 | 6 |
| | Sep-21 | 22.4 | 36 | 16 | 610 | 0.38 | 7.5 | 7.4 | 5.1 | 224 | 84 | 7.4 | 1.1 | 194 | 4.1 | 6 |
| | Mean | 23.93 | 60.50 | 9.50 | 605.00 | 0.38 | 7.53 | 8.03 | 4.05 | 212.50 | 106.50 | 8.95 | 1.05 | 199.50 | 3.88 | 5.98 |
| | Std. Dev. | 2.46 | 18.93 | 4.65 | 26.46 | 0.02 | 0.05 | 0.43 | 0.82 | 13.10 | 22.35 | 1.42 | 0.04 | 9.00 | 0.40 | 0.45 |
| North East Monsoon ( NEM) | Oct-21 | 21.8 | 32 | 19 | 516 | 0.29 | 7.2 | 6.4 | 6.2 | 168 | 92 | 6.3 | 0.81 | 172 | 3.1 | 8 |
| | Nov-21 | 18.8 | 30 | 22 | 515 | 0.22 | 7.2 | 6.6 | 7.1 | 154 | 94 | 6.5 | 0.8 | 146 | 3.3 | 8.2 |
| | Dec-21 | 18.3 | 29.2 | 21 | 514 | 0.2 | 7.4 | 7 | 6.8 | 136 | 124 | 7.4 | 0.84 | 134 | 4.2 | 7.8 |
| | Jan-22 | 20.6 | 40 | 15 | 428 | 0.19 | 7.3 | 7.2 | 7.9 | 110 | 110 | 8.5 | 0.74 | 130 | 4.1 | 8.8 |
| | Mean | 19.88 | 32.80 | 19.25 | 493.25 | 0.23 | 7.28 | 6.80 | 7.00 | 142.00 | 105.00 | 7.18 | 0.80 | 145.50 | 3.68 | 8.20 |
| | Std. Dev. | 1.62 | 4.94 | 3.10 | 43.51 | 0.05 | 0.10 | 0.37 | 0.71 | 25.03 | 15.01 | 1.00 | 0.04 | 18.93 | 0.56 | 0.43 |
| Summer | Feb-22 | 21.5 | 56 | 9 | 424 | 0.19 | 7.9 | 9.6 | 1.4 | 136 | 94 | 10.1 | 0.76 | 126 | 5 | 10 |
| | Mar-22 | 24 | 62 | 9 | 410 | 0.19 | 7.9 | 10.1 | 0 | 146 | 176 | 10 | 0.76 | 118 | 5.1 | 10.1 |
| | Apr-22 | 28.4 | 84 | 5 | 400 | 0.18 | 7.8 | 10.4 | 0 | 154 | 184 | 9.5 | 0.77 | 112 | 5.5 | 10.6 |
| | May-22 | 31.5 | 96 | 5 | 465 | 0.19 | 7.8 | 9.9 | 0 | 182 | 192 | 8.6 | 0.81 | 102 | 5.6 | 10.4 |
| | Mean | 26.35 | 74.50 | 7.00 | 424.75 | 0.19 | 7.85 | 10.00 | 0.35 | 154.50 | 161.50 | 9.55 | 0.78 | 114.50 | 5.30 | 10.28 |
| | Std. Dev. | 4.46 | 18.72 | 2.31 | 28.58 | 0.01 | 0.06 | 0.34 | 0.70 | 19.76 | 45.47 | 0.69 | 0.02 | 10.12 | 0.29 | 0.28 |

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**Table 3. Correlation analysis of physico-chemical parameter values of Nizamsagar Reservoir during the year 2021- 22**

| | AT | WT | Trsp. | Turb. | EC | TDS | pH | DO | CO2 | TA | TH | Sulp. | Phos. | Chl. | BOD | COD |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AT | 1 | | | | | | | | | | | | | | | |
| WT | 1.00 | 1.00 | | | | | | | | | | | | | | |
| Trsp. | 0.93 | 0.92 | 1.00 | | | | | | | | | | | | | |
| Turb. | -0.82 | -0.80 | -0.95 | 1.00 | | | | | | | | | | | | |
| EC | -0.18 | -0.19 | -0.22 | 0.20 | 1.00 | | | | | | | | | | | |
| TDS | -0.03 | -0.05 | -0.10 | 0.01 | 0.91 | 1.00 | | | | | | | | | | |
| pH | 0.59 | 0.57 | 0.70 | -0.73 | -0.37 | -0.25 | 1.00 | | | | | | | | | |
| DO | 0.73 | 0.71 | 0.84 | -0.84 | -0.50 | -0.36 | 0.95 | 1.00 | | | | | | | | |
| CO2 | -0.77 | -0.76 | -0.84 | 0.84 | 0.36 | 0.20 | -0.91 | -0.94 | 1.00 | | | | | | | |
| TA | 0.32 | 0.31 | 0.22 | -0.20 | 0.82 | 0.87 | 0.05 | -0.04 | -0.15 | 1.00 | | | | | | |
| TH | 0.74 | 0.74 | 0.75 | -0.61 | -0.56 | -0.54 | 0.57 | 0.75 | -0.70 | -0.19 | 1.00 | | | | | |
| Sulp. | 0.36 | 0.32 | 0.59 | -0.77 | -0.13 | 0.05 | 0.72 | 0.72 | -0.65 | 0.10 | 0.27 | 1.00 | | | | |
| Phos. | 0.10 | 0.08 | 0.06 | -0.09 | 0.92 | 0.94 | -0.11 | -0.22 | 0.10 | 0.88 | -0.38 | 0.10 | 1.00 | | | |
| Chl. | -0.19 | -0.21 | -0.22 | 0.12 | 0.90 | 0.97 | -0.40 | -0.49 | 0.34 | 0.75 | -0.64 | -0.01 | 0.89 | 1.00 | | |
| BOD | 0.55 | 0.55 | 0.63 | -0.57 | -0.61 | -0.58 | 0.88 | 0.89 | -0.75 | -0.25 | 0.73 | 0.49 | -0.41 | -0.72 | 1.00 | |
| COD | 0.22 | 0.23 | 0.27 | -0.22 | -0.94 | -0.91 | 0.48 | 0.58 | -0.48 | -0.69 | 0.60 | 0.18 | -0.91 | -0.93 | 0.69 | 1.00 |

### 3.4 Electrical Conductivity (EC)

Electrical conductivity is also estimated by the using Elico model conductivity meter. The electrical conductivity (EC) data provides information about the water's ability to conduct an electric current, which is influenced by the presence of dissolved ions. During the South West Monsoon (SWM) season, EC values ranged from 550 to 640 µS/cm at both Loc. 1 and Loc. 2. The mean EC during this period was 577.5 and 605 µS/cm at loc/1 and loc.2, with a standard deviation of 30.96 and 26.46, indicating a moderate level of variability. Higher EC values during the monsoon season may be attributed to increased runoff and the introduction of minerals and ions into the water.

In the North East Monsoon (NEM) season, EC values ranged from 398 to 516 µS/cm. The mean EC during the NEM season was 473.5 and 493.25 µS/cm at loc.1 and loc.2, with a standard deviation of 51.29 and 43.51. The lower mean EC and higher standard deviation suggest greater variability in ion concentrations during the NEM season. The summer season exhibited lower EC values ranging from 380 to 465µS/cm, with a mean EC of 406.25 and 424.75 µS/cm at loc. 1 and loc.2 and a standard deviation of 25.56 and 28.58. Lower EC values during the summer months may be indicative of reduced ion concentrations, potentially due to lower rainfall and less mineral input. Similar types of results were observed by Kalpana et al. [14]. Understanding EC variations is crucial for assessing water quality, as it provides insights into the composition of dissolved substances in the reservoir.

### 3.5 Total Dissolved Solids (TDS)

Total dissolved solid of the reservoir water is estimated by the using Electrode containing digital portable TDS meter of BSK Technologies Company. TDS is a measure of the total amount of inorganic and organic substances present in the water in a dissolved form. During the South West Monsoon (SWM) season, TDS values ranged from 0.33 to 0.39 g/lit at both Loc. 1 and Loc. 2. The mean TDS during this period was 0.36 and 0.38 g/lit at loc.1 and loc.2, with a relatively low standard deviation of 0.02 at both locations, indicating a stable and consistent level of dissolved solids during the monsoon season.

In the North East Monsoon (NEM) season, TDS values ranged from 0.19 to 0.29 g/lit. The mean TDS during the NEM season was 0.22 and 0.23 g/lit, with a slightly higher standard deviation of 0.05 at both locations, suggesting a bit more variability in dissolved solids concentration. The summer season exhibited TDS values ranging from 0.17 to 0.19 g/lit, with a mean TDS of 0.18 and 0.19 g/lit and a low standard deviation of 0.01 at both locations. This indicates a relatively stable and consistent level of dissolved solids during the summer months. Same type of findings was reported by Hussain et al. [15].

The TDS data provides valuable information about the water quality in Nizamsagar Reservoir, and the stable and consistent levels observed in both monsoon and summer seasons are positive indicators for water quality management. Monitoring TDS levels is crucial for understanding the overall composition of dissolved substances in the reservoir and assessing its suitability for various uses, such as drinking water supply, agricultural and irrigation.

### 3.6 pH

pH is a standard parameter estimated on the spot of the reservoir by using of OEM company supplied pH meter. The pH data provides insights into the acidity or alkalinity of the water during different seasons. During the South West Monsoon (SWM) season, pH values ranged from 7.4 to 7.6 at both Loc. 1 and Loc. 2. The mean pH during this period was 7.50 and 7.53, with a low standard deviation of 0.12 and 0.05 at loc.1 and loc.2, suggesting a relatively stable and neutral pH during the monsoon season. In the North East Monsoon (NEM) season, pH values ranged from 7.1 to 7.4. The mean pH during the NEM season was 7.18 and 7.28, with a standard deviation of 0.06 at both locations, indicating a bit more variability in pH during this period.

The summer season shows higher pH values ranging from 7.8 to 7.9. The mean pH during the summer months was 7.85, with a standard deviation of 0.06 at both locations. The increase in pH during the summer months may be influenced by factors such as reduced rainfall and increased evaporation. The present research results were identical to Balakrishna et al. [16]. The data suggests that Nizamsagar Reservoir maintains a relatively neutral pH throughout the different seasons.

### 3.7 Dissolved Oxygen (DO)

The Dissolved oxygen of reservoir water is estimated by the modified wrinkle's method (Welch et al., 1968) by the using of Winkler A (MnSO4), B (Alkaline Potassium Iodide) and C (Sodium Thio Sulphate- Hypo) and Starch as an indicator. Values were denoted in milligrams per liter. The Dissolved Oxygen (DO) data provides important insights into the availability of oxygen in the water, which is crucial for supporting aquatic life. DO levels are influenced by various factors, including temperature, pressure, and organic matter decomposition. The data shows variations in DO levels across different seasons.

During the South West Monsoon (SWM) season, DO levels ranged from 7.2 to 8.4 mg/lit at both Loc. 1 and Loc. 2. The mean DO during this period was 7.68 and 8.03 mg/lit, with a standard deviation of 0.36 and 0.43 at loc.1 and loc.2, indicating a moderate level of variability in DO. Higher DO levels during the monsoon season can be attributed to increased aeration and water flow.In the North East Monsoon (NEM) season, DO levels ranged from 6 to 7.2 mg/lit. The mean DO during the NEM season was 6.53 and 6.8 mg/lit, with a standard deviation of 0.51 and 0.37, suggesting some variability in DO levels during this period. Lower DO levels in the NEM season could be influenced by reduced aeration and organic matter decomposition [17].

The summer season demonstrates higher DO levels ranging from 9.2 to 10.4 mg/lit. The mean DO during the summer months was 9.70 and 10 mg/lit, with a standard deviation of 0.42 and 0.34 at loc.1 and loc.2. Higher DO levels in the summer can be attributed to increased water temperatures, which reduce the solubility of oxygen.The equal forms of results, were reported by Selim [18], Ani et al. [19].The data suggests that Nizamsagar Reservoir maintains generally healthy DO levels throughout the different seasons, with variations influenced by seasonal factors. Monitoring DO is essential for assessing water quality and the overall health of aquatic ecosystems in the reservoir.

### 3.8 Carbon Dioxide ($CO_2$)

Carbon dioxide parameter was estimated by using phenopthaline indicator and NaOH solution, the pink color is taken as the end point. During the South West Monsoon (SWM) season, $CO_2$ levels ranged from 2.6 to 5.1 mg/lit at both Loc. 1 and Loc. 2. The mean $CO_2$ during this period was 3.58 and 4.05mg/lit, with a standard deviation of 1.02 and 0.82 at loc.1 and loc.2, indicating a moderate level of variability in $CO_2$ concentration. Higher $CO_2$ levels during the monsoon season can be attributed to factors such as increased organic matter decomposition and reduced aeration.

In the North East Monsoon (NEM) season, $CO_2$ levels ranged from 5.2 to 7.9 mg/lit. The mean $CO_2$ during the NEM season was 6.35 and 7 mg/lit, with a standard deviation of 0.9 and 0.71 at loc.1 and loc.2, suggesting some variability in $CO_2$ levels during this period. Higher $CO_2$ levels in the NEM season may be influenced by reduced water movement and potential stagnation.

The summer season exhibited lower $CO_2$ levels ranging from 0 to 1.4 mg/lit. The mean $CO_2$ during the summer months was 0.46 and 0.35 mg/lit, with a standard deviation of 0.58 and 0.70 at loc.1 and loc.2. Lower $CO_2$ levels in the summer can be associated with increased photosynthesis and aeration, leading to a decrease in $CO_2$ concentration. Similar type of results was made by Joshi et al. [20].

### 3.9 Total Alkalinity (TA)

Total alkalinity can be estimated by titrating the sample against with a strong acid using phenopthaline as indicator and alkalinity due to carbonate it determined, to second end point using methyl orange indicator. The Total Alkalinity (TA) data provides information about the water's ability to resist changes in pH, indicating its buffering capacity. The data reveals variations in TA levels across different seasons.

During the South West Monsoon (SWM) season, TA levels ranged from 180 to 224 mg/lit at both Loc. 1 and Loc. 2. The mean TA during this period was 200 and 212.5 mg/lit, with a standard deviation of 14.7 and 13.1 at loc.1 and loc.2, indicating a moderate level of variability in buffering capacity. Higher TA levels during the monsoon season suggest an increased ability of the water to resist changes in pH.In the North East Monsoon (NEM) season, TA levels ranged from 104 to 168 mg/lit. The mean TA during the NEM season was 135.5 and 142 mg/lit, with a higher standard deviation of 26.15 and 25.03 al loc.1 and loc.2, suggesting more variability in buffering capacity during this period. Lower TA levels in the NEM season may be associated

with reduced alkalinity and potential changes in water chemistry.

The summer season shows TA levels ranging from 124 to 182 mg/lit. The mean TA during the summer months was 146 and 154.5 mg/lit, with a standard deviation of 21.1 and 19.76 at loc.1 and loc.2. The moderate variability in TA levels during the summer months indicates a continued ability of the water to resist changes in pH.

### 3.10 Total Hardness (TH)

Total hardness was estimated by using EDTA solution and Erichrome black-T as the indicator and the values were showed in mg/lit. During the South West Monsoon (SWM) season, TH levels ranged from 76 to 136 mg/lit at both Loc. 1 and Loc. 2. The mean TH during this period was 98 and 106.5 mg/lit, with a standard deviation of 20.33 and 22.35 at loc.1 and loc.2, indicating a notable variability in hardness levels. Higher TH values during the monsoon season may be influenced by factors such as increased runoff and mineral input into the reservoir. In the North East Monsoon (NEM) season, TH levels ranged from 88 to 124 mg/lit. The mean TH during the NEM season was 101.5 and 105 mg/lit, with a lower standard deviation of 12.79 and 15.01 at loc.1 and loc.2, suggesting less variability in hardness levels during this period. Lower TH values in the NEM season may be associated with reduced mineral input and lower water flow [21].

The summer season exhibited TH levels ranging from 90 to 192 mg/lit. The mean TH during the summer months was 154.5 and 161.5 mg/lit, with a higher standard deviation of 43.49 and 45.47 at loc.1 and loc.2. The increased variability in TH during the summer may be attributed to factors such as higher temperatures and increased mineral dissolution. Identical results were noticed by Yogesh et al. [22], Narendra et al. [23].

### 3.11 Sulphates

Sulphates are estimated by the using of spectrophotometer. During the South West Monsoon (SWM) season, Sulphate levels ranged from 7.4 to 10.2 mg/lit at both Loc. 1 and Loc. 2. The mean Sulphate concentration during this period was 8.9 and 8.95 mg/lit, with a standard deviation of 1.41 and 1.42 at loc.1 and loc.2. The moderate variability in Sulphate levels during the monsoon season suggests consistent but slightly fluctuating concentrations of sulfate ions.

In the North East Monsoon (NEM) season, Sulphate levels ranged from 6.3 to 8.5 mg/lit. The mean Sulphate concentration during the NEM season was 7.18 mg/lit at both locations, with a standard deviation of 0.95 and 1 at loc.1 and loc.2. The lower variability in Sulphate levels during the NEM season indicates a relatively stable concentration of sulfate ions. The summer season exhibited Sulphate levels ranging from 8.6 to 10.1 mg/lit. The mean Sulphate concentration during the summer months was 9.23 and 9.55, with a lower standard deviation of 0.59 and 0.69 at loc.1 and loc.2. The reduced variability in Sulphate levels during the summer suggests a more consistent concentration of sulfate ions.

### 3.12 Phosphates

Stannous chloride method was employed to determine the phosphate content of the reservoir water sample. The resultant blue colour in intensities were measured at 690 mm range using spectrophotometer, the value of phosphate present in the samples were calculating referring to the standard graph and reading or expressed in mg per liter. During the South West Monsoon (SWM) season, Phosphate levels ranged from 1.0 to 1.1 mg/lit at both Loc. 1 and Loc. 2. The mean Phosphate concentration during this period was1.04 and 1.05 mg/lit at loc.1 and loc.2, with a small standard deviation of 0.04 at both locations. The low variability suggests consistent concentrations of phosphate ions during the monsoon season.

In the North East Monsoon (NEM) season, Phosphate levels ranged from 0.74 to 0.84 mg/lit. The mean Phosphate concentration during the NEM season was 0.79 and 0.80 mg/lit at loc.1 and loc.2, with a standard deviation of 0.04 at both locations. The relatively stable concentrations of phosphate ions during the NEM season indicate consistent water quality. The summer season exhibited Phosphate levels ranging from 0.75 to 0.81mg/lit. The mean Phosphate concentration during the summer months was 0.77 and 0.78 mg/lit at loc.1 and loc.2, with a small standard deviation of 0.02 at both locations. The low variability in Phosphate levels during the summer suggests a stable concentration of phosphate ions.

### 3.13 Chlorides

For estimation of chlorides using potassium dichromate indicator and silver nitrite by

titrometric method, the values are expressed in mg per liter. Chloride levels ranged from 186 to 212 mg/lit at both Loc. 1 and Loc. 2 during the SWM season. The mean Chloride concentration during this period was 194.5 and 199.5 mg/lit, with a standard deviation of 11.36 and 9 at loc.1 and loc.2. This suggests a relatively consistent and moderate concentration of chloride ions during the monsoon season. Similar type of results was made by Reddy et al. [5].

Chloride levels ranged from 126 to 172 mg/lit during the NEM season. The mean Chloride concentration during the NEM season was 141 and 145.5 mg/lit, with a standard deviation of 16.69 and 18.93 at loc.1 and loc.2. The higher standard deviation indicates more variability in chloride concentrations during the NEM season compared to the SWM season. Chloride levels ranged from 98 to 126 mg/lit during the summer months. The mean Chloride concentration during the summer season was 110 and 114.5 mg/lit with a standard deviation of 10.33and 10.12 at loc.1 and loc.2. The relatively low standard deviation suggests a more stable concentration of chloride ions during the summer season.

## 3.14 Biological Oxygen Demand (BOD)

Winkler's method was employed to determine the biological oxygen demand in reservoir water sample. BOD data provides crucial information about the organic pollution and the amount of oxygen required by microorganisms to decompose organic matter. BOD levels ranged from 3.2 to 4.2 mg/lit at both Loc. 1 and Loc. 2 during the SWM season. The mean BOD concentration during this period was 3.78 and 3.88 mg/lit at loc.1 and loc.2, with a small standard deviation of 0.4 at both locations. This suggests a relatively consistent and moderate BOD concentration during the monsoon season. The present results agreed with Mahesh et al. [24].

BOD levels ranged from 3.1 to 4.3 mg/lit during the NEM season. The mean BOD concentration during the NEM season was 3.65 and 3.68 mg/lit, with a higher standard deviation of 0.59 and 0.56 at loc.1 and loc.2. The increased variability in BOD concentrations during the NEM season indicates fluctuations in organic pollution levels.BOD levels ranged from 4.9 to 5.6 mg/lit during the summer months. The mean BOD concentration during the summer season was 5.20 and 5.3 mg/lit, with a small standard deviation of 0.24 and 0.29 at loc.1 and loc.2. This suggests a relatively stable concentration of BOD during the summer season.

## 3.15 Chemical Oxygen Demand (COD)

Chemical oxygen demand was estimated by reflux method values are expressed in mg per liter.COD levels ranged from 5.4 to 6.5 mg/lit at both Loc. 1 and Loc. 2 during the SWM season. The mean COD concentration during this period was 5.78 and 5.98 mg/lit, with a small standard deviation of 0.33 and 0.45 at loc.1 and loc.2. This indicates a relatively consistent and moderate COD concentration during the monsoon season.COD levels ranged from 7.4 to 8.8 mg/lit during the NEM season. The mean COD concentration during the NEM season was 7.9 and 8.2 mg/lit, with a standard deviation of 0.48 and 0.43 at loc.1 and loc.2. The moderate standard deviation suggests a moderate variability in COD concentrations during the NEM season. Similar types of findings were made by Srinidhi et al. [21]

COD levels ranged from 9.2 to 10.6 mg/lit during the summer months. The mean COD concentration during the summer season was 9.63 and 10.28 mg/lit, with a slightly higher standard deviation of 0.53 and 0.28 at loc.1 and loc.2. This indicates a moderate variability in COD concentrations during the summer season. Monitoring COD is crucial for assessing water quality, as elevated levels can indicate increased pollution and potential harm to aquatic ecosystems.

## 3.16 Correlation Analysis

The correlation analysis data was presented in the table 2. Each value in the matrix indicates the correlation coefficient between two specific parameters, ranging from -1 to 1. A positive correlation implies a direct relationship, while a negative correlation indicates an inverse relationship. A correlation coefficient closer to 1 or -1 suggests a stronger correlation, while values closer to 0 suggest a weaker correlation.

A strong positive correlation of 1.00 is observed between atmospheric temperature (AT) and water temperature (WT), indicating a direct relationship. Transparency demonstrates a strong negative correlation with turbidity (-0.95), indicating that higher turbidity levels are associated with reduced water transparency. EC and TDS exhibit strong positive correlations (0.91), suggesting that increased mineral content

leads to higher electrical conductivity in the water. pH shows positive correlations with DO (0.95) and transparency (0.84), indicating that higher pH levels are associated with increased DO and water transparency. $CO_2$ is negatively correlated with transparency (-0.84), pH (-0.91) and DO (-0.94), suggesting that increased $CO_2$ levels may contribute to reduced transparency and lower pH.

Total Alkalinity exhibit a strong positive correlation with Phosphates (0.88) and Chlorides (0.75), indicating a shared relationship, possibly related to the mineral content of water. Sulphates show positive correlations with pH (0.72), indicating potential sources of these ions. Phosphates demonstrate a strong positive correlation with EC (0.92) and TDS (0.94).Chloride exhibits positive correlations with EC (0.90), TDS (0.97) and other parameters, suggesting its association with mineral content.BOD exhibit strong positive correlations with pH (0.88) and DO (0.89) indicating a potential relationship between organic and inorganic pollutants. COD demonstrates a strong negative correlation with EC (-0.94), TDS (-0.91), Phosphates (-0.91) and Chlorides (-0.93).

This correlation matrix provides additional clarity on the relationships between various water quality parameters in Nizamsagar Reservoir. These insights can guide further investigations and monitoring efforts to better understand the factors influencing water quality, supporting effective water management strategies. The correlation studies of various water parameters were conducted by Narendra et al. [23], Bhandari and Nayal [25], Vinod et al. [26].

## 4. CONCLUSION

In the present study all the physico-chemical parameters of reservoir water are within the permissible limits according to the standard methods of Bureau of Indian Standards (BIS), World Health Organisation (WHO) and American Public Health Association (APHA). Based on the findings, the water in the Nizamsagar reservoir is not significantly polluted and is suitable for various purposes, including domestic, aquaculture and irrigation uses. With minor restoration efforts, the reservoir water can also be considered suitable for drinking purposes. These findings will help in planning better conservation measures and management of this reservoir.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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