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Research Article

WATER QUALITY ANALYSIS USING PHYSIOCHEMICAL PARAMETERS AND GEOSPATIAL DISTRIBUTION FOR FIVE SELECTED LAKES OF BHANDARA DISTRICT IN MAHARASHTRA STATE, INDIA

Laxman P. Nagpurkar*[1], Shubham C. Ambilkar[2, 3], Vikas P. Bawankule[4]

[1]Department of Chemistry, ManoharBhai Patel College of ACS, Sakoli, Dist. Bhandara, India

[2]Department of Chemistry, Visvesvaraya National Institute of Technology (VNIT), Nagpur, India

[3]Department of Chemistry, Dhote Bandhu Science College, Gondia, India

[4]Maharashtra Remote Sensing Application Centre (MRSAC), VNIT Campus, Nagpur, India

**Corresponding author: lp.nagpurkar@gmail.com*

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ABSTRACT

In order to understand the water quality of five selected fresh water lakes of Bhandara district, Maharashtra (India), physicochemical characteristics viz. water temperature, pH, electrical conductivity (EC), total dissolved solids (TDS), total hardness (TH), dissolved oxygen (DO),chemical oxygen demand (COD) were investigated. Samples were collected from fifteen different points of five lakes (three samples from each lake) during the pre-monsoon and post-monsoon season. To understand the spatial distribution of physiochemical parameters with the help of Geospatial Technology, we used the Inverse Distance Weighted (IDW) interpolation method. The consequences of study were validated by comparing with World Health Organization (WHO) and Bureau of Indian Standard (BIS) criteria for drinking water. All physicochemical parameters were recorded more or less similar ecological status under permissible limit during the study period. This study also reveals that, water quality parameters were found apparently lower during post-monsoon season, which could have been due to dilution of water in post-monsoon season.

Keywords: Water Quality, Physicochemical characteristics, Spatial distribution, Inverse Distance Weighted interpolation method.

1. INTRODUCTION

"Water" without which there would be no life on earth, it is one of the most common yet the most precious resource on earth [1]. Wetlands are probably the earth's most important fresh water resources which provides food and habitat for many aquatic lives including terrestrial, threatened, and endangered species [2]. Similarly, wetlands are essential for both local and global freshwater, providing sustenance not only related to all the flora and fauna but also for many terrestrial lives. Additionally, wetlands contributing to unique biodiversity in a diverse array of species and their complex ecological makeup [3, 4].

During last decades, water quality of rural as well as urban wetland are continuously deteriorating and ultimately its effect on the aquatic environment is due to the anthropogenic activities [5, 6]. Now a days, aquatic environment of water bodies disturbed due to increased human population, use of fertilizers, anthropogenic activities, somewhat mismanagement and unawareness of people, water becomes highly polluted [7, 8]. The emergence of fresh environmental challenges has sparked novel research concepts and created an immediate demand for the monitoring and evaluation of aquatic ecosystems [9].

Several studies [1, 10-15] reveal that, lakes are seasonally influenced by anthropogenic activities. As per as study area is concerned, it is observed that, water bodies have been decreasing continuously [16, 17]. The evaluation of water quality is essential for managing water resources, planning conservation efforts, and addressing concerns about water adulteration. It typically involves examining physical, chemical, and biological factors, and can be assessed using various methods such as water quality index, GIS, and statistical approaches. In the past decade, a number of papers have been proposed on different approaches to relating the same issues [18-22].

On the other hand, climate change can lead to unexpected changes in aquatic ecosystems. Additionally, the role of various factors such as chemical, biological, and physical etc., influence the quality of water as well. As a result, monitoring water quality becomes challenging due to the intricate process of analysing and measuring multiple variables, which can be quite demanding [9, 23].

Geospatial Technology is increasingly being recognized as a powerful tool for the comprehensive management of geographical information. It provides notable benefits in terms of visualizing and analysing geographic data through the utilization of maps and spatial databases. By combining conventional database operations with statistical analysis, it delivers distinct advantages and unique benefits [24]. The use of Inverse Distance Weighting (IDW) enables the creation of a seamless surface for water quality parameters by interpolating known values at an unknown location. This process helps in comprehending the various scenarios of water quality parameters within the study area. The implementation of the Ramsar Convention on Wetlands, which promotes the wise and sustainable utilization of wetlands, plays a vital role in assisting countries in attaining their Sustainable Development Goal (SDG) targets as determined by the United Nations [3, 25].

Previously study of Assessment and monitoring of surface water in wetlands of Sakoli tehsil [15, 26, 27], suggested the overall water bodies, its water holding capacity of Sakoli tehsil and areas are decreasing continuously. This study aims to achieve the following goals: (i) Evaluate the physical and chemical characteristics of water through the collection and analysis of water quality parameters such as water temperature, pH, electrical conductivity (EC), total dissolved solids (TDS), total hardness (TH), dissolved oxygen (DO), and chemical oxygen demand (COD); (ii) Utilize GIS-based IDW interpolation tools to visually signify the spatial distribution of these parameters. To the best of our knowledge, no such study has so far been reported using the interpolation technique to assess the spatial distribution of water parameter assessment based on physicochemical parameter and GIS techniques for Sakoli tehsil of district Bhandara, Maharashtra (India).

2. MATERIAL AND METHODS

2.1. Description of study area

The research study is conducted within the Sakoli tehsil, which is located in the Bhandara district of Maharashtra state in India (Fig. 1). Sakoli tehsil is surrounded by a variety of lakes, ponds, and hills of varying heights, ranging from small to medium [28, 29]. The neighbouring districts both Bhandara and Gondia are well-known for their wetlands, paddy fields (the primary agricultural crops), forests, and mineral resources. The study area is situated close to the forest corridor of Nawegaon Nagzira Tiger Reserve (NNTR), within the central Indian landscape [30].

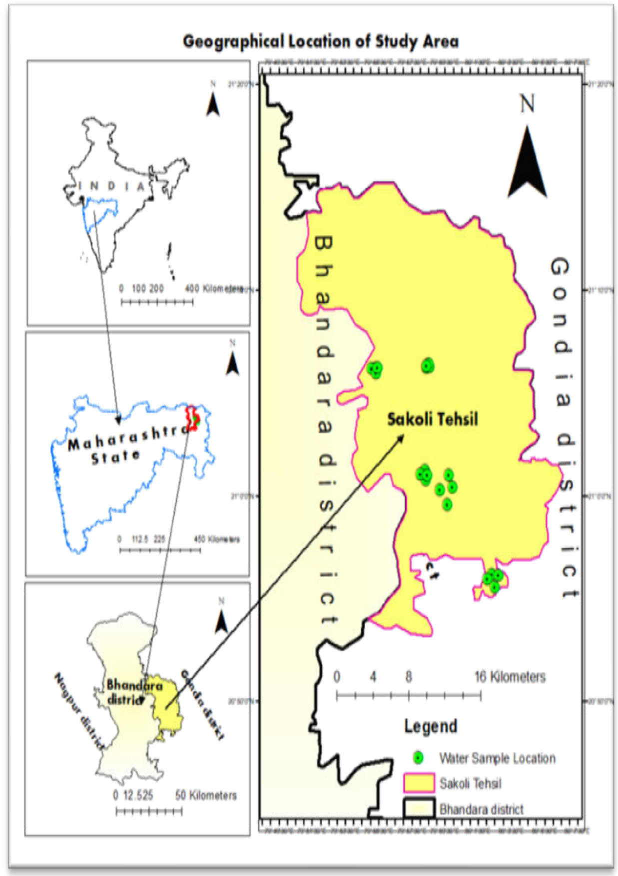

Fig. 1: Geographical location of study area

2.2. Sampling methods for physicochemical parameters

For the current investigation, sampling was conducted during the pre-monsoon season in May 2022 and the post-monsoon season in December 2022. The sampling took place in the morning hours. Water samples were obtained from three locations within each lake, using clean and uncontaminated plastic bottles (Fig. 2). The collected samples were then transported to the laboratory for analysis. During the study, various parameters such as water temperature, pH, dissolved oxygen (DO), total dissolved solids (TDS), chemical oxygen demand (COD) and total hardness (TH) were measured directly at the sampling sites [31, 32].

2.3. Determination of physicochemical parameters

During the study, the water parameters such as temperature, pH, dissolved oxygen (DO), and total dissolved solids (TDS) were measured directly at the sampling sites using the water analysis kit Systronics model-371 (fig. 2). For the measurement of chemical oxygen demand (COD) and total hardness (TH), water samples were collected in 1L sampling bottles and the experiments were conducted in a laboratory setting [33, 34]. All chemicals and reagents used for experiments were of AR grade and purchased from F. D. fine Chem. and Sigma Aldrich, India.

2.4. Spatial analysis and IDW Method

Inverse Distance Weighting (IDW), spatial analysis tools, specify the search distance, closest points, barriers etc., is necessary when employing IDW interpolation to estimate of water quality parameters at unknown locations based on known values. The aim is to generate a continuous surface that improves the comprehension of different water quality situations within the specified research area [34-36]. Different spatial modelling techniques, including kriging and geostatistical methods, are available for use. When it comes to their implementation in GIS, the IDW approach has been selected due to its capability to assess the spatial distribution of water quality, facilitating a comprehensive analysis of the results [37, 38].

The thematic map generation of Sakoli Tehsil was accomplished using ArcGIS 10.8 software. Utilizing the spatial analyst tool within the same software version, the spatial distribution of water quality parameters such as pH, temperature, electrical conductivity (EC), dissolved oxygen (DO), total dissolved solids (TDS), chemical oxygen demand (COD), and total hardness (TH) was determined. For each physiochemical parameter, the spatial distribution maps were prepared using the inverse distance weighted (IDW) interpolation technique (fig. 3 and 4). The process involved employing the IDW technique within ArcGIS software to perform GIS interpolation. This necessitated importing measured value points in CSV format from an excel file and generating a raster surface for spatial analysis.

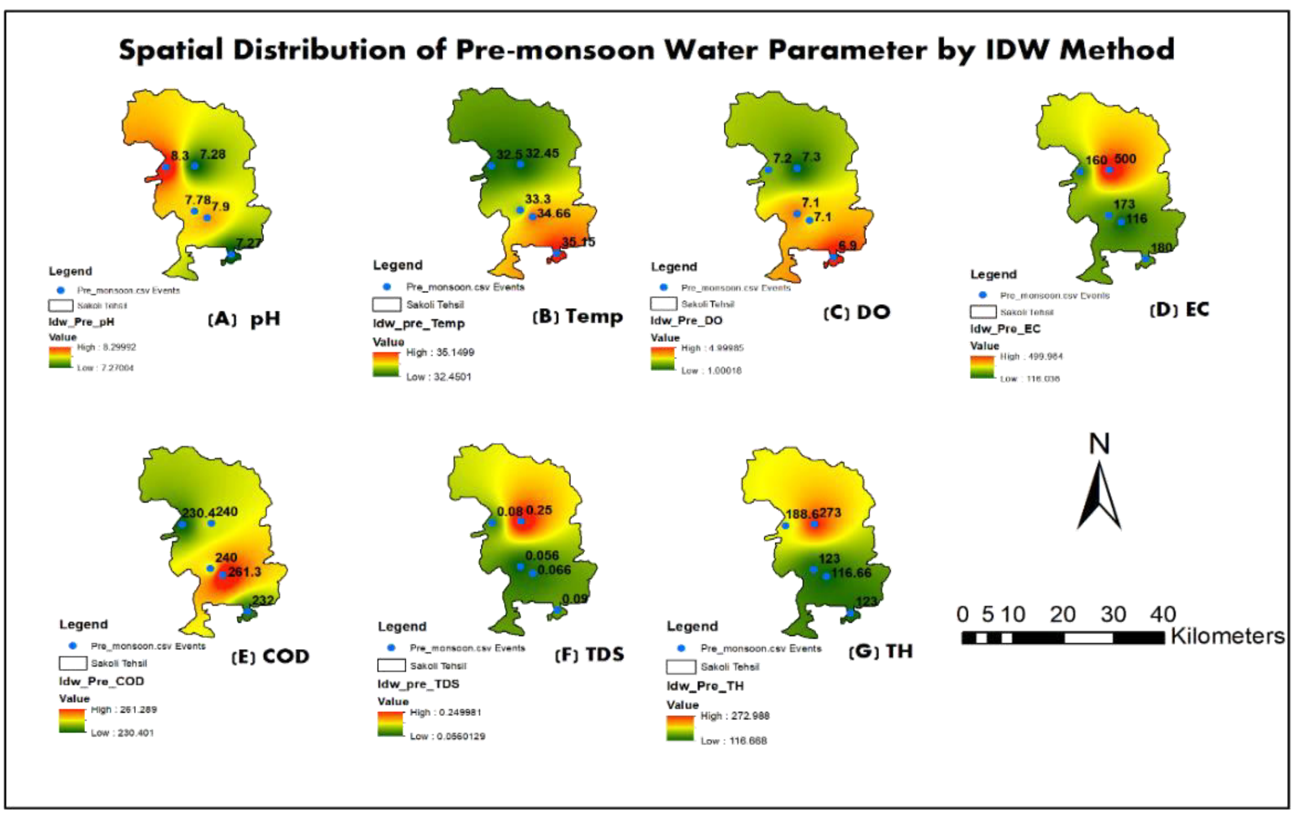

Fig. 3: Spatial distribution of pre-monsoon water parameter by IDW method

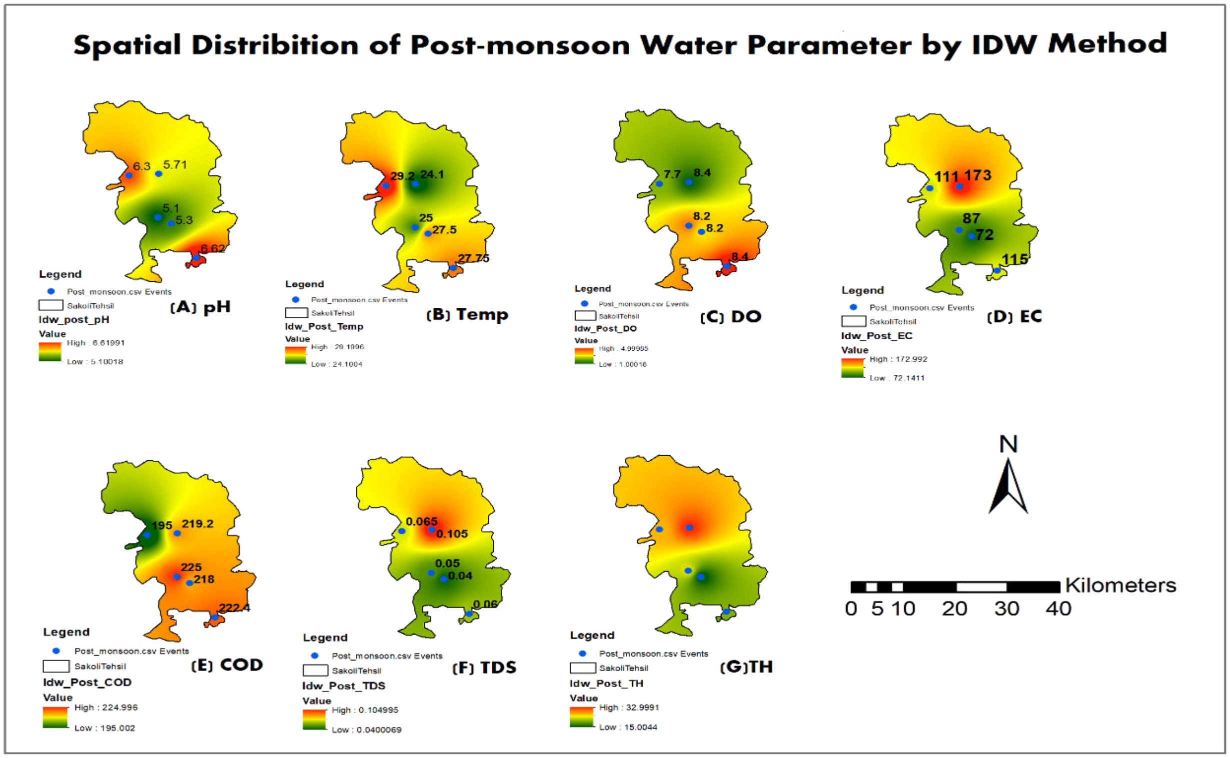

Fig. 4: Spatial distribution of post-monsoon water parameter by IDW method

3. RESULTS AND DISCUSSION

We collected fifteen samples from five lakes in the study area with three samples taken from each lake. To determine the values of physiochemical parameters, we averaged the collected data. Additionally, the spatial distribution analysis to examine the average values across the study area. In this study, we achieved this physiochemical water parameter values for both the pre-monsoon and post-monsoon seasons using interpolated sample point data. The obtained results of the physicochemical parameters for the same are tabulated in Table 1 and Table 2.

Table 1: Results of physiochemical parameters collected during pre-monsoon season from different locations

Sr. No.	Name of Lake	Temp. (°C)	DO (mg/L)	pH	EC µS/cm	TDS (mg/L)	COD (mg/L)	TH (mg/L)
1	Bodra	32.45	7.3	7.28	500	250	240.0	273.0
2	Gudhari	32.50	7.2	8.3	160	80	230.4	188.6
3	Shivnibandh	34.66	7.1	7.9	116	66	261.3	116.66
4	Khandala	33.30	7.1	7.78	173	56	240.0	123.0
5	Siregaon	35.15	6.9	7.27	180	90	232.0	123.0

Table 2: Results for physiochemical parameters collected during post monsoon season from different locations

Sr. No.	Name of Lake	Temp. (°C)	DO (mg/L)	pH	EC µS/cm	TDS (mg/L)	COD (mg/L)	TH (mg/L)
1	Bodra	24.1	8.4	5.71	173.0	0.105	219.2	33.0
2	Gudhari	29.2	7.7	6.3	111.0	0.065	195.0	27.5
3	Shivnibandh	27.5	8.2	5.3	72.13	0.040	218	15.0
4	Khandala	25.0	8.2	5.1	87.3	0.050	225.0	23.66
5	Siregaon	27.75	8.4	6.62	115.0	0.060	222.4	20.5

Table 3: Physiochemical parameters values as per BIS and WHO Standard [39, 40]

Sr. No	Water Parameters	BIS Standard	WHO Standard
1	Temp. (°C)	10-20	-
2	DO (mg/L)	-	-
3	pH	6.5 - 8.5	6.5 - 8.5
4	EC µS/cm		
5	TDS (mg/L)	≤500	-
6	COD (mg/L)	250 mg/L	-
7	TH (mg/L)	200 mg/L as $CaCO_3$	180 mg/L

3.1. Temperature

Water temperature plays a vital role when it comes to aquatic plants and animals. In this study, the lowest temperature was observed during the post-monsoon season, whereas the highest temperature occurred in the pre-monsoon period. Throughout the study, the recorded values for water temperature ranged from a minimum of 24.1°C to a maximum of 35.15°C. Factors such as a high water level and reduced solar radiation could contribute to the low water temperature during winter, whereas a low water level, increased solar radiation, and a clear atmosphere might explain the higher temperature during summer. Similar types of results are reported in literature [41-43].

3.2. Dissolved Oxygen

It is considered to be the best indicator for evaluating the condition of a water body. In the pre-monsoon season, the desired level of dissolved oxygen is approximately 7 mg/L, while during the post-monsoon period, this value tends to increase and reach around 8 mg/L. The post-monsoon period exhibits higher levels of dissolved oxygen, possibly attributed to lower atmospheric temperatures, whereas the pre-monsoon period tends to have comparatively lower levels due to the higher metabolic activity of organisms.

3.3. pH

The pH of water represents the levels of hydrogen ions (H^+ ions) and indicates whether it is acidic or alkaline. During the pre-monsoon season, the pH of the water was observed to be mostly neutral to slightly alkaline, ranging from 7.2 to 8.3, which is ideal for supporting aquatic life. However, in the post-monsoon season, the pH value was found to decrease, possibly due to the influx of runoff and water dilution. It is worth noting that the collection sites appear to be free from significant pollution sources. Similar results are reported in literature [27, 43-45].

3.4. Electrical Conductivity (EC)

The electrical conductivity quantifies how well a water sample can conduct electricity. During the pre-monsoon season, the EC value was observed to be at its highest, possibly because of the greater influx of ions from the runoff of weathered materials in the surrounding area. Similar type of result was reported by [42]. The value is notably higher for Bodra Lake (500 µS /cm), it might be due to the saturation of dissolved solids and reduced water availability during summer (Fig. 5).

Fig. 5: Site photographs during pre-monsoon and post-monsoon seasons of Bodra lake

3.5. Total Dissolve Solids

The measure of all inorganic and organic substances in a water sample is known as total dissolved solids (TDS). For the pre-monsoon season, the TDS exhibited significant variations, ranging from a minimum value of 56 mg/L to a maximum of 250 mg/L. In the post-monsoon season, the TDS levels range from 40 mg/L to 105 mg/L. These findings align with the research conducted by researcher [27, 43], and the values fall within the standard range set by the BIS and WHO (Table 3).

3.6. Chemical Oxygen Demand

The COD levels indicate the existence of pollutants in the water that cannot be easily broken down by natural processes and need oxygen for decomposition. During the seasonal study it is revealed that, COD values were higher during the pre-monsoon period, likely due to the release of waste from nearby areas, including domestic and agricultural sources. In contrast, COD values were lower in the post-monsoon period, likely because the deeper water and increased volume at the site caused dilution effects. Similar results are reported in literature [27, 46, 47].

3.7. Total Hardness

The hardness levels of all the samples during pre-monsoon varied from 116.6 to 273 mg/L, except for bodra lake, which had a concentration of 273 mg/L. However, the hardness values for pre-monsoon were generally lower, ranging from 15 to 33.0 mg/L. It is worth noting that all samples, except for bodra lake, fall within the permissible limit set by the BIS (200 mg/L). The high hardness in bodra lake during pre-monsoon may be attributed to the presence of saturated salts and degraded biomaterials from the summer, leading to an increased ion content percentage in the water.

4. CONCLUSION

In this study, water quality and its spatial distribution are assessed for the pre-monsoon and post-monsoon seasons. This approach would help in finding out an element that is concentrated or deficient which may need attention for resource management point of view. The study therefore, concludes that all physicochemical parameters are recorded more or less similar ecological status under permissible limit during the study period.

The results of this study suggest that water quality parameters showed a significant decrease during the post-monsoon season, possibly due to the dilution of lake water during this time. Among the lakes observed, Shivnibandh Lake displayed a relatively lower total hardness value compared to the others, which could be attributed to the limited presence of aquatic vegetation observed in the lake throughout the study period. With the exception of Shivnibandh Lake, the decline in water quality in other lakes can be attributed to the rise in human activities such as agricultural practices, cattle grazing, and domestic waste dumping. Based on the analysis of water parameters before and after the monsoon season, the findings suggest that the majority of the sampling sites displayed satisfactory water conditions, although there were indications of deteriorating water quality as well. Hence, it is necessary to continuously monitoring and conducts research activities to assess the status and functionality of wetlands, identify emerging risks, and evaluate the effectiveness of conservation efforts. Employ scientific data to inform decision-making and employ adaptive management approaches.

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Conflict of Interest

The authors declare that they have no conflicts of interest

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