Journal of Advanced Zoology

ISSN: 0253-7214
Volume 44 Issue S-6 Year 2023 Page 359:368

Evaluation of Surface Water Quality Using Water Quality Index (WQI) and GIS Tool Of Anantapur Location

D Anush[1*], S. Sharada[2], Sowjanya D[3]

[1,2,3]*Department of Chemical Engineering, JNTUA College of Engineering Ananthapuramu, Affiliated to JNTU Anantapur, Andhra Pradesh,515002, India.*
Email: anushd16@gmail.com[1], sharadas.chemengg@jntua.ac.in[2], sowjanyad.chem@jntua.ac.in[3]

**Corresponding author's E-mail: anushd16@gmail.com*

Article History

Received: 06 June 2023
Revised: 05 Sept 2023
Accepted: 25 Nov 2023

Abstract

The objective of this study is to estimate the quality of surface water in a semi-arid area of India, specifically in the pond located in Old Town, BKS Katta Road, Anantapur. The water quality index (WQI) is used to calculate the quality of the water samples taken from the pond, and a map of the water quality was created using geographic information system (GIS). The samples were analyzed for various factors including Electrical Conductivity (EC), Odour, Taste, pH, Temperature, Calcium (Ca2+), Magnesium, Total dissolved solids (TDS), Bicarbonate (HCO-3), Chloride (Cl-), Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Dissolved Oxygen (DO), Nitrate (NO-3) and Iron (Fe-). Based on these analyses, spatial distribution maps were also prepared using GIS. The WQI values swayed from 61.875 to 74, ensuring that the pond water samples were of the highest quality and safe for direct consumption.

Keywords: *Water quality index (WQI), Geographic information system (GIS), Spatial distribution, Pond water*

1. Introduction

Water scarcity is a growing concern globally, with the imbalance between supply and demand becoming more urgent. Rapid urbanization and population growth are depleting water resources faster than ever before, resulting in a decline in water quality worldwide. Factors such as population growth, economic expansion, and efficient water use influence water supply, while cultural and societal variables affect the quality of water accessible to people. India, with 17.74% of the earth's inhabitants, has only 4.5% of the freshwater supplies available. The water deficit in the country is due to rainfall changes, evaporation, and varying habits of water use across different regions.

Water demand in India is rising rapidly. 78% of the total water reserve is used for irrigation. India depends on this reserve for 80% of its domestic water needs and 45% of its irrigation needs. As a result of rapid economic growth and demographic changes, all sectors are experiencing increased water demand. Water pollution is another significant challenge, with 70% of India's surface water resources contaminated. The main causes of pollution are sewage, growing manufacturing, infrastructure development, untreated urban runoff, and sewage. Municipal wastewater treatment capacity is inadequate, and bacterial and organic pollution levels in waterbodies have reached disastrous levels.

Urbanization affects ponds, leading to the overuse of resources and inappropriate waste disposal. Quality evaluation of water is crucial before using it for drinking or other purposes. Anthropogenic activities, such as adding harmful chemicals, reduce water quality and cause a loss of aesthetic value due to the decrease in the catchment area. The location's meteorological and geological conditions also affect the research of its physicochemical properties.

A powerful tool called the Geographic Information System (GIS) has been developed for importing, analyzing, and presenting spatial data, which is also used as a decision-making method in many fields including engineering and environmental sciences. This method can organize, quantify, and clarify a significant amount of spatial data quickly. In recent years, it has been effectively used for various water quality assessment-related tasks. A water quality map is essential in providing guidelines for drinking water and agriculture and avoiding environmental or health issues. Previous studies have shown that GIS is an effective tool for managing water reserves, calculating its availability and quality criteria.

2. Materials And Methods

Study Area: The study region falls within SOI toposheet no. 57F/10, is situated between the latitudes N14°40′00″ and N14°42′30″ and the longitudes E77°35′00″ and E77°40′00″ with an average elevation of 335m above MSL. Red soil dominates the region. The chief source of rainfall in this area is seasonal. The majority of the year is hot and dry in Anantapur's semi-arid climate. With average high temperatures in the 37–40 °C range, summertime begins in late February and peaks in May. Pre-monsoon showers arrive in Anantapur as early as March, mostly due to north-easterly winds coming in from Kerala. About 250 mm of precipitation falls during the monsoon, which begins in September and lasts until early November. About 560 mm of rain occurs on average each year. Fig.1 illustrates the study area. Sampling Coordinates are presented Table 1.

Table 1: Locations of sampling stations

Sample Location	Northing	Easting
S1	14.6731	77.6356
S2	14.6808	77.6364
S3	14.6889	77.6333
S4	14.6758	77.6264
S5	14.6850	77.6272
S6	14.6792	77.6161
S7	14.6644	77.6211
S8	14.6628	77.6294

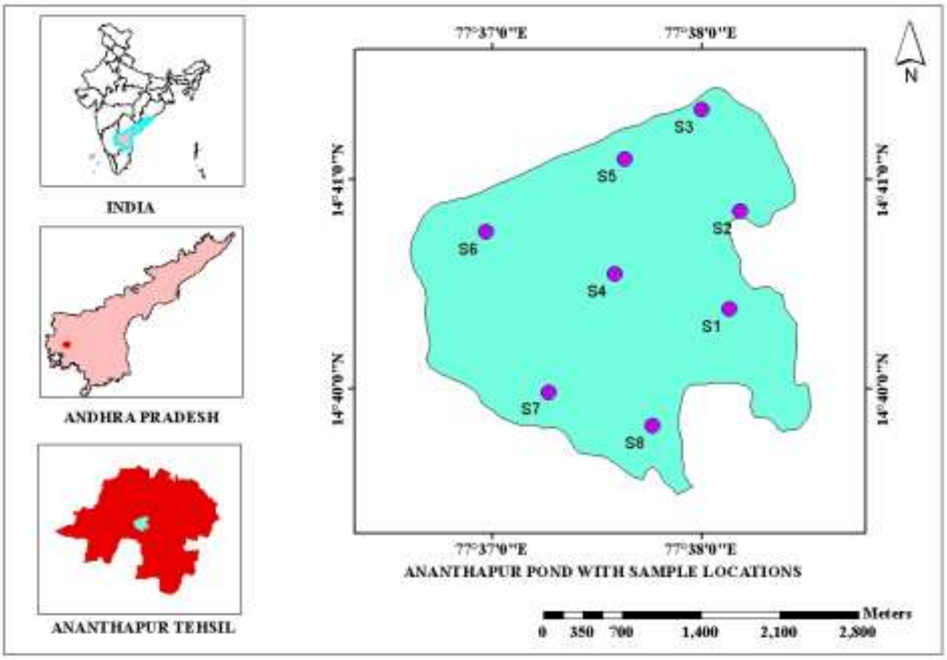


Fig. 1. Map illustrating the study region and locations where samples were taken.

Water sampling and testing were conducted at eight pre-selected locations between April 4 and April 21, 2023, with an emphasis on uniform distance and some variation based on geographic setting and accessibility. The sampling station coordinates were recorded using GPS. Water specimens were collected in 1-liter PET (polyethylene terephthalate) bottles that were thoroughly cleaned and triple-rinsed with deionized water and pond water from the sampling site before sampling. Water samples were collected from 20-30 cm below the surface and stored in airtight containers before being taken to the lab. The samples were then assessed for numerous physicochemical qualities as per the guidelines outlined in APHA (2021). These qualities included pH, taste, heat Turbidity, Odour, EC, TDS, DO, COD, BOD, HCO_3^-, Cl^-, NO_3^-, Ca^{2+}, Mg^{2+}, Fe^- and PO_4^{3-}.

In an attempt to evaluate the quality of water, different measuring devices were used. pH meter, mercury thermometer and turbidity meter were used to measure pH, temperature and turbidity respectively.

Spectrophotometer was used to determine the levels of chloride, iron, phosphate, and nitrate in the water. Calcium, magnesium, DO, BOD, and COD were calculated through the titration method. These measuring techniques are suggested by the American Public Health Association (APHA, 2021) and the test results are compared with the water quality criteria specified by APHA 2021.

Water quality index (WQI): It displays the entire water health of every water entity both in space and time. To determine the water quality index, each variable that has an impact on water quality is assigned a weight between 1 and 5. According to Vasanthavigar et al., (2010) and Krishna et al., (2015) pH and EC can have an overall weight of 4, nitrate and TDS can have a max weight of 5. Cl and HCO3- bicarbonate are given a weight of 3. Due to their low importance to the purity of the water, Ca2+, Na+, and Mg2+ were given weights of 2, 2, and 1 respectively. The calculation of relative weightis done according to Eq. (2.1). In Table 2, the related values are shown.

$$W_i = \frac{w_i}{\sum_{i=1}^{n} w_i} \quad (2.1)$$

Where, w_i is each parameters weight, W_i is the relative weight and n is the number of parameters.

Table 2. Relative weight of WQI parameters

Chemical Parameters	**WHO standard (2022)**	**Weight (wi)**	**Relative Weight (Wi)**
EC (µS/cm)	500	4	0.138
pH (on scale)	6.5-8.5	4	0.138
TDS (mg/l)	500	5	0.172
Cl^- (mg/l)	250	3	0.103
Ca^{2+} (mg/l)	75	2	0.069
Mg^{2+} (mg/l)	50	1	0.034
HCO^-_3 (mg/l)	125	3	0.103
NO^-_3 (mg/l)	45	5	0.172
Fe^- (mg/l)	0.2	2	0.069
		∑wi=29	∑wi=1.000

In the second step, quality rating (q_i) of each parameter is calculated using Eq. (2.2)

$$q_i = \frac{C_i}{S_i} * 100 \quad (2.2)$$

Where q_i is the quantity rating, C_i is each parameters concentration in water sample(mg/l) and S_i is each parameter’s WHO standard(mg/l).

WQI is finally determined using Eq. (2.3).

$$WQI = \sum W_i * q_i \quad (2.3)$$

Based on the WQI obtained the Quality of water is decided using the following Table 3.

A statistical tool for assessing and quantifying the link between two different factors is the Pearson correlation coefficient. Its value ranges from -1 to 1, and it is commonly used to analyze water quality data and assess their interdependence. For the spatial analysis of various physicochemical attributes, we used ArcGIS 10.8.2. We created maps of the physicochemical parameters' location in space using the IDW interpolated method.

Table 3. Water purity based on WQI

S.No	Water type	Range
1	Excellent	<50
2	Good	50-100
3	Poor	100-200
4	poor	200-300
5	Water that is unfit for human consumption	>300

3. Results and Discussion

Water is the lifeblood of our ecosystem. It influences the processes, functions, and characteristics of surface water, shaping the quality of every water body. However, the quality of these bodies is deteriorating due to increasing human pressure from agricultural, domestic, and industrial sources. It's crucial that we monitor our water quality to identify the sources of pollution and protect our precious resources. In the present study, we aim to assess the water quality of Anantapur Pond and determine its WQI. Using GIS, we categorized the research location based on parameter concentration to provide a comprehensive picture of the pond's physicochemical characteristics. By using the Pearson correlation coefficient, we can identify the relationship among the water parameters that affect water quality. Let's work together to ensure the health of our water bodies and protect our environment for future generations.

Table 4. Statistics of the chemical composition of pond water

S.No	Parameters	Min	Max	Mean	Std. Deviation
1	EC (µS/cm)	473	634	548.00	55.85
2	pH (on scale)	6.82	7.89	7.17	0.35
3	TDS (mg/l)	315	420	364.38	35.60
4	Cl^- (mg/l)	0.016	0.068	0.04	0.02
5	Ca^{2+} (mg/l)	50.64	86.3	67.11	10.74
6	Mg^{2+} (mg/l)	22.32	31.57	26.50	3.05
7	HCO^-_3 (mg/l)	203	257	230.50	18.15
8	NO^-_3 (mg/l)	0.82	1.578	1.37	0.24
9	Fe^- (mg/l)	0.048	0.069	0.06	0.01

Providing safe, clean drinking water is a fundamental necessity for any community. WHO sets strict standards for water quality, and we are proud to say that our water meets all of them. Our pH, TDS, Turbidity, Total Hardness, and chloride levels are all within the recommended limits, ensuring that our water not only meets the minimum standards but is also free from any pollutants that could cause a threat to public well-being. By adhering to WHO standards, we are committed to safeguarding the health of our community and promoting the availability of clean, fresh water. We understand that access to safe drinking water is essential, and we take this responsibility seriously. To give you an idea of our water's purity, Table 4 presents the Statistics of the chemical composition of pond ware during dry periods. Moreover, the spatial distribution of tested parameters is illustrated in Fig.2, Fig.3 and Fig.4.

The pH range observed in the current study was between 6.82 (lowest) and 7.89 (maximum), which falls within the acceptable range of 6.5-8.5 as per the standards. During the study period, the water temperature varied between 26.4-28.4°C due to environmental conditions but found to be within the standard limit. Taste and odour studies uncovered that all the samples were agreeable. For ingestion, electrical conductivity (EC) of water should not exceed 500 µS/cm. The EC measured in this investigation varied from 473 to 634 µS/cm. TDS varied from 315 to 420 mg/l, which is below the WHO limit of 500 mg/l for drinkable water.

The DO level in the water varied from 3.1-5.3 mg/L. Clean water has higher DO levels than murky water. During the analysis, the chemical oxygen demand (COD) level was observed to varied from 0.72 to 1.58 mg/l. The BOD varied from 1.89 to 2.85 in the pond over the course of the study. Bicarbonate levels ranged from 203 to 257 mg/l in the present research, which is under the acceptable threshold of 600 mg/l.

The Cl concentrations in the research ranged from 0.03 to 0.068 mg/l, which surpasses the allowable threshold of 250 mg/l. However, the amount of chlorine in groundwater is low, making it safe for human consumption.Nitrate levels in the study ranged from 0.82 to 1.578 mg/l, which is within the permitted limits. The calcium concentration ranged from 44.54 to 86.3 mg/l, which is within the acceptable range of 75 mg/l. Magnesium levels ranged from 20.84 to 31.57 mg/l, which is marginally greater than the acceptable level of 50 mg/l. Iron levels ranged from 0.048 to 0.069 mg/l, which is within the permissible limit of 0.2 mg/l. Phosphorus levels were also analysed, and all the values were observed to be inside the tolerable range of 5 mg/l.

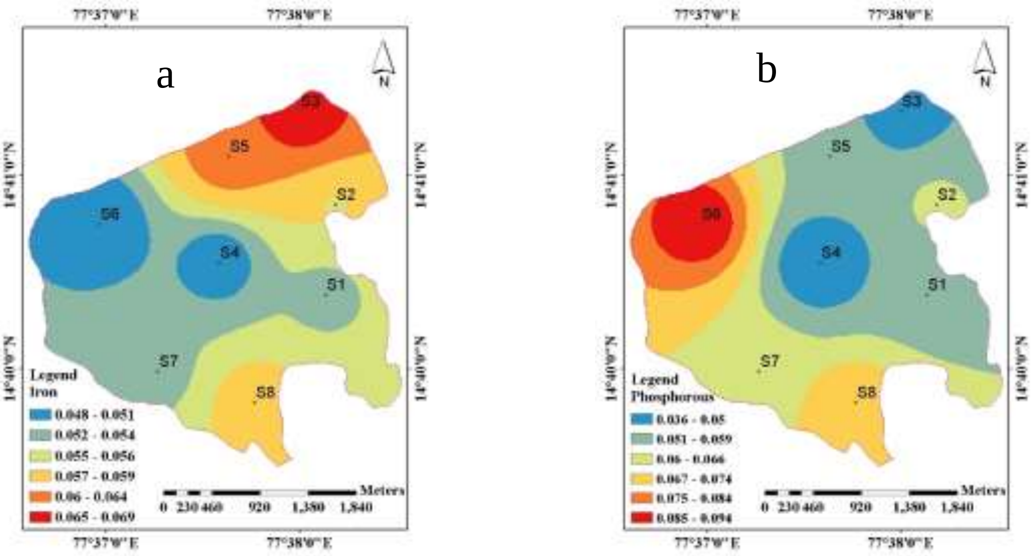
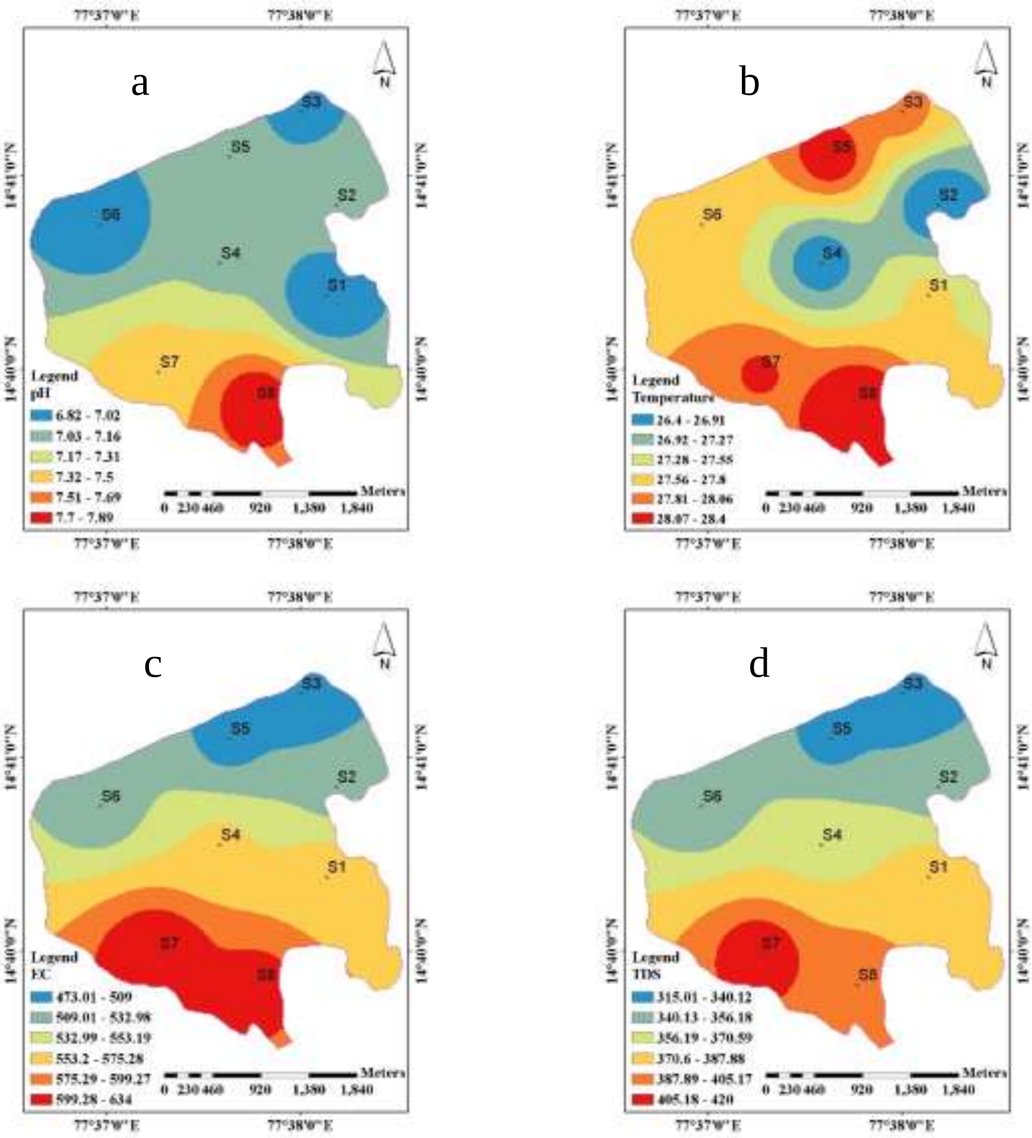


Fig. 2. Spatial behaviour of (a) Iron and (b) Phosphorous



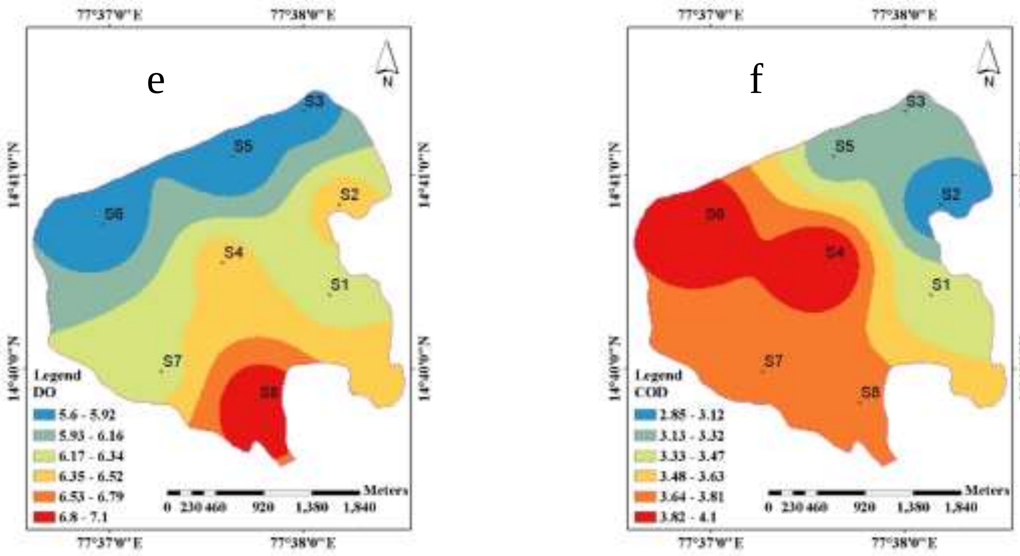
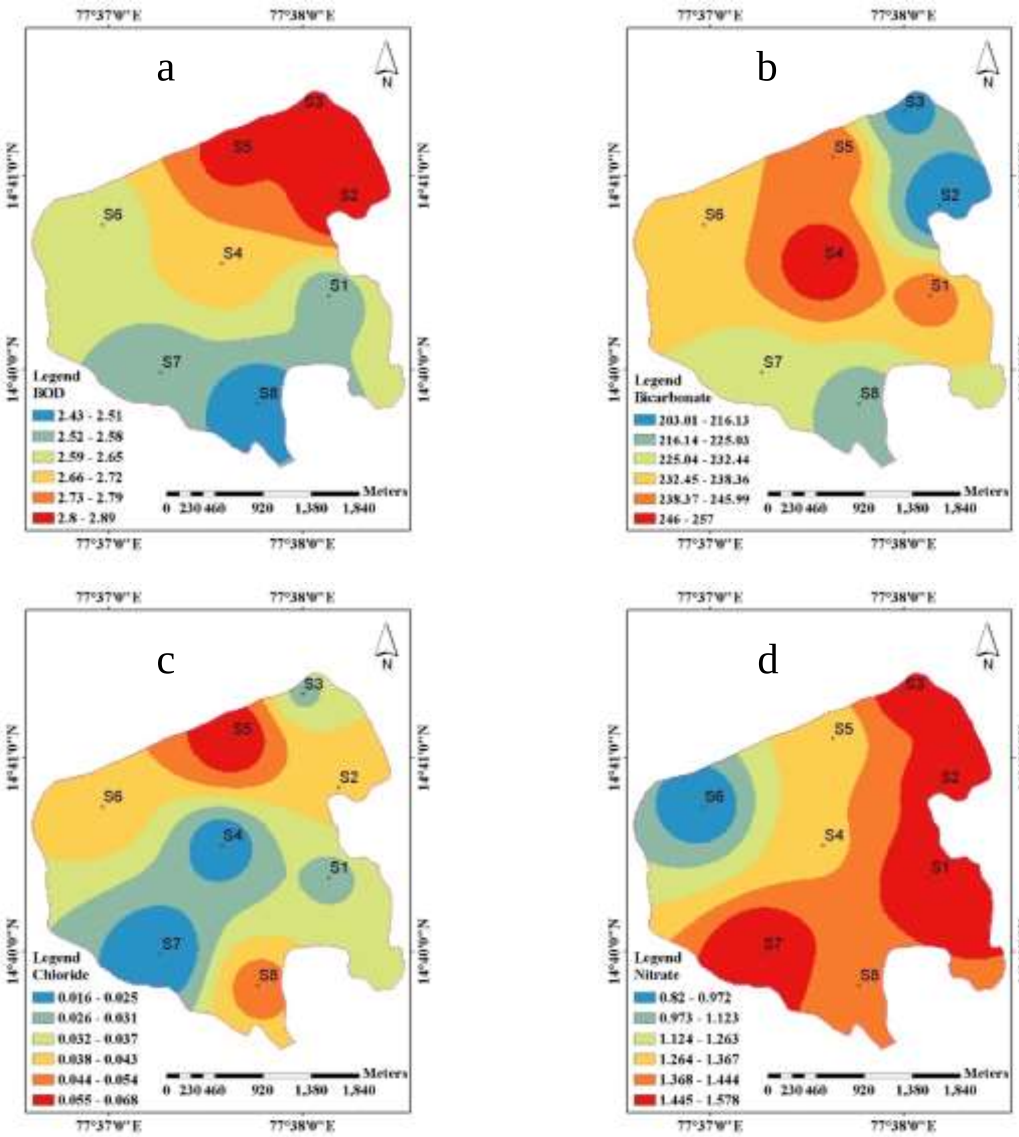


Fig. 3. Spatial behaviour of (a) pH, (b) Temperature, (c) EC, (d) TDS, (e) DO and (f) COD.



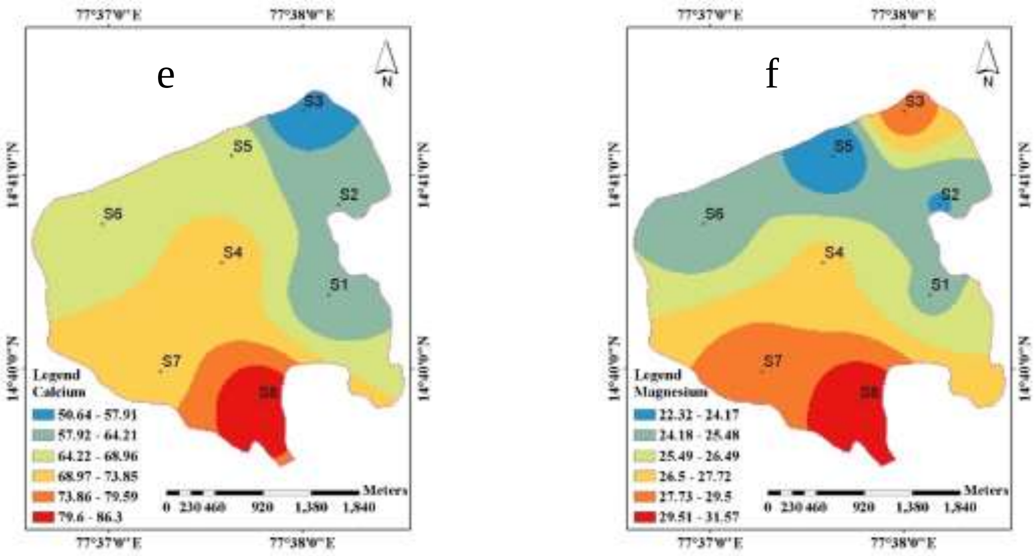


Fig. 4. Spatial behaviour of (a) BOD, (b) Bicarbonates, (c) Chloride, (d) Nitrate, (e) Calcium and (f) Magnesium

Water Quality Index (WQI): The water condition of Ananthapur Pond is assessed using a comprehensive Water Quality Index (WQI), It incorporates several variables and their respective dimensions to generate a unified score. The water purity level falls within the range of 63.156 to 74.445, as illustrated in Table 5. Fig. 5 displays the scores of water quality for each of the examined water samples.

Table 5. WQI value and categorization

S. No	Sample Location	WQI value	remark
1	S1	69.406	Good water
2	S2	63.156	Good water
3	S3	61.875	Good water
4	S4	71.611	Good water
5	S5	67.597	Good water
6	S6	66.458	Good water
7	S7	73.991	Good water
8	S8	74.445	Good water

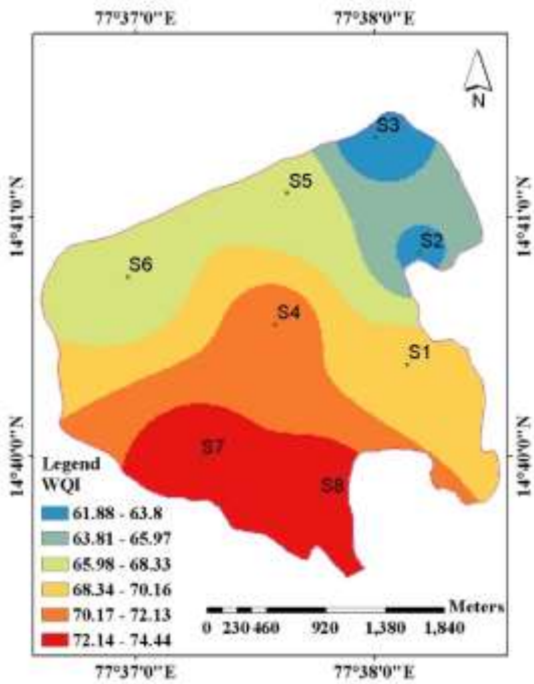


Fig. 5. Spatial behaviour of WQI of Ananthapur pond

Determining the relationship between water sample concentrations by Pearson's Correlation

Pearson's coefficient of correlation test (two-tailed) was employed to determine the relationship between water sample concentrations of physicochemical properties, presented in Table 4.5. It was noticed that the TDS has a sharp correlation of 1.00 with EC and 0.78 with turbidity. Turbidity has a strong correlation of 0.79 with EC and 0.74 with pH. Calcium has a significant correlation of 0.85 with pH and 0.74 with Turbidity. BOD has a very strong negative correlation of -0.86 with Turbidity and -0.82 with EC and TDS. Pearson's Correlation Matrix is presented in Table 6.

Table 6. Correlation Matrix of various samples

Parameters	EC	pH	Turbidity	TDS	Cl^-	COD	BOD	DO	Ca2+	Mg2	HCO-3	PO43-	NO-3	Fe-
EC	1.00													
pH	0.67	1.00												
Turbidity	0.79	0.74	1.00											
TDS	1.00	0.66	0.78	1.00										
Cl-	-0.42	0.06	-0.17	-0.38	1.00									
COD	0.43	0.18	0.57	0.39	-0.40	1.00								
BOD	-0.82	-0.46	-0.86	-0.82	0.24	-0.58	1.00							
DO	0.72	0.75	0.60	0.71	-0.26	0.14	-0.50	1.00						
Ca2+	0.71	0.85	0.74	0.69	0.11	0.50	-0.57	0.66	1.00					
Mg2+	0.56	0.70	0.70	0.53	-0.44	0.36	-0.53	0.63	0.42	1.00				
HCO-3	0.08	-0.29	-0.10	0.06	-0.06	0.60	-0.20	-0.25	0.18	-0.31	1.00			
PO43-	0.16	0.15	0.56	0.20	0.36	0.18	-0.44	-0.04	0.27	-0.06	-0.19	1.00		
NO-3	0.32	0.24	-0.14	0.32	-0.35	-0.46	0.05	0.40	-0.08	0.31	-0.27	-0.66	1.00	
Fe-	-0.47	0.07	-0.34	-0.46	0.35	-0.61	0.45	-0.22	-0.35	0.17	-0.47	-0.35	0.39	1.00

4. Conclusion

1. According to the analysis, Ananthapur Pond's surface water is fresh, making it suitable for drinking and farming. The research area's water parameters are all well within the range

1. The main reason for the overall water quality for being within the permissible limit is due to the addition of surface runoff due to the unconventional rains caused during the study period.

2. The study has thrown light on the hydrochemistry, quality and suitability for drinking purpose of pondwater. TDS has high significant correlation of 1.00 with EC, 0.78 with turbidity. Turbidity has

strong correlation of 0.79 with EC, 0.74 with pH. Calcium has significant correlation of 0.85 with pH, 0.74 with Turbidity.

3. BOD has very strong negative correlation of -0.86 with Turbidity, -0.82 with EC and TDS. In addition, the sample analysis of pondwater from the area are within the good water class and are fit for consumption.
4. The application of Water Quality Index (WQI) in this scholarly expedition bequeaths a systematic portrait of groundwater quality in the parched recesses of the year 2023. A methodical revelation, this tool not only navigates the depths of aqueous quality but also unfurls as a beacon for the public, elucidating the aqueous tapestry in the realms of quality management.

References:

1. Abbasnia, A., Alimohammadi, M., Mahvi, A.H.,2018. Assessment of groundwater quality and evaluation of scaling and corrosiveness potential of drinking water samples in villages of Chabahr city, Sistan and Baluchistan province in Iran. Data Brief 16, 182–192. https://doi.org/10.1016/j.dib.2017.11.003.
2. Amadi, A.N., Olasehinde, P.I., Okosun, E.A., Yisa, J,2010. Assessment of the water quality index of Otamiri and Oramiriukwa rivers. Phys. Int. 1 (2) (2010), 116–123. http://dx.doi.org/10.3844/pisp.2010.116.123.
3. APHA "Standard Methods for the Examination of water and wastewater. American Public Health Association 23rd edition", Washington DC, USA (2021).
4. Arya, V Kumar, M Raikwa, A Dhaka and Minakshi, 2011. Physico-chemical Analysis of Selected Surface Water Samples of Laxmi Tal (Pond) in Jhansi City, UP, Bundelkhand Region, Central India", J. Exp. Sci. 2, 8, pp. 01- 06. https://www.semanticscholar.org/paper/Physico-chemical-Analysis-of-Selected-Surface-Water-Arya-Kumar/a8d4e833903bfad29b4f7827d536bc7758bf685b.
5. Bhutiani, R., Khanna, D.R., Kulkarni, D.B. and Ruhela, M, 2014. Assessment of Ganga River ecosystem at Haridwar, Uttarakhand, India with reference to water quality indices. Appl. Water Sci. https://doi: 10.1007/s13201-014-0206-6.
6. Boateng TK, Opoku F, Acquaah SO, Akoto O, 2016. Groundwater quality assessment using statistical approach and water quality index in Ejisu-Juaben Municipality, Ghana. Environmental Earth Sciences 75:1–14. https: doi:10.1007/s12665-015-5105-0.
7. Horton, R.K. 1965. An index number system for rating water quality, Journal of Water Pollution. Cont. Fed., 3, pp 300-305.
8. Helena B, Pardo R, Vega M, Barrado E, Fernandez JM, Fernandez L, 2000. Temporal evolution of groundwater composition in an alluvial aquifer (Pisuerga River, Spain) by principal component analysis. Water Res 34(3): pp 807–816. https://doi.org/10.1016/S0043-1354(99)00225-0.
9. Jagadeeswari, P.B. and Ramesh, K. 2012. Water quality index for assessment of water quality in South Chennai Coastal Aquifer, Tamil Nadu, India. International Journal of Chem. Tech Research,4(4), 1582-1588. https://www.researchgate.net/publication/287499638_Water_quality_index_for_assessment_of_water_quality_in_South_Chennai_coastal_aquifer_Tamil_Nadu_India.
10. Mohamed AK, Liu D, Song K, Mohamed MA, Aldaw E, Elubid BA, 2019. Hydrochemical analysis and fuzzy logic method for evaluation of groundwater quality in the North Chengdu Plain, China. Int. J. Environ. Res. Public Health, 16(3), 302. https://doi.org/10.3390/ijerph16030302.
11. M R Mahananda, B P Mohanty and N R Behera, 2010. Physico-chemical analysis of surface and ground water of Bargarh District, Orissa, India, Intel. J. Res. Rev. Appl.Sci., 2, 3. https://www.arpapress.com/volumes/vol2issue3/ijrras_2_3_10.pdf
12. Nafyad, K., Shankar, K., 2018. Groundwater quality assessment using water quality index and GIS technique in Modjo River Basin, central Ethiopia. J. Afr. Earth Sci. 147, 300–311. https://doi.org/10.1016/j.jafrearsci.2018.06.034.
13. Nagaraju, A., Suresh, S., Killham, K., Hudson-Edwards, K. 2006. Hydrogeochemistry of waters of Mangampeta barite mining Area, Cuddapah Basin, Andhra Pradesh, India. Turk. J. Eng. Environ. Sci. 30, 203–219. https://www.researchgate.net/publication/228658849_Hydrogeochemistry_of_Waters_of_Mangampeta_Barite_Mining_Area_Cuddapah_Basin_Andhra_Pradesh_India.
14. Poornima Verma, Prasoon Kumar Singh, Ritu Ranjan Sinha, Ashwani Kumar Tiwari. 2020. Assessment of groundwater quality status by using water quality index (WQI) and geographic information system (GIS) approaches: a case study of the Bokaro district, India; Applied Water Science 10:27. https://doi.org/10.1007/s13201-019-1088-4.
15. Popugaeva D, Kreyman K, Ray AK., 2020. Assessment of Khibiny Alkaline Massif groundwater quality using statistical methods and water quality index. Can J Chem Eng 98(1):205–212. https://doi.org/10.1002/cjce.23601.
16. Rajagopal T, Thangamani A and Archunan G., 2010. Comparison of physico-chemical parameters and phytoplankton species diversity of two perennial ponds in Sattur area, TamilNadu. Journal of Environmental Biology. 31(5) 784 – 794. https://www.jeb.co.in/journal_issues/201009_sep10_supp/paper_09.pdf

17. Rakotondrabe F, Ngoupayou JRN, Mfonka Z, Rasolomanana EH, Abolo AJN, Ako AA., 2018 Water quality assessment in the Bétaré-Oya gold mining area (East-Cameroon): multivariate statistical analysis approach. Sci Total Environ 610–611:831–844. https://doi.org/10.1016/j.scitotenv.2017.08.080.
18. Ravikumar P, Aneesul Mehmood M, Somashekar RK., 2013. Water quality index to determine the surface water quality of Sankey tank and Mallathahalli lake, Bangalore urban district, Karnataka, India. Appl Water Sci 3:247–261. https://doi:10.1007/s13201-013-0077-2.
19. Rocha CH, Casquin AP, Pereira RO., 2019.Correlations chart: Tool to analyse the dynamics of water quality parameters". Rev Bras Eng Agric Ambient 23: pp 383–390. http://dx.doi.org/10.1590/1807-1929/agriambi.v23n5p383-390.
20. Shabbir R, Ahmad SS., 2015. Use of geographic information system and water quality index to assess groundwater quality in Rawalpindi and Islamabad Arabian. Journal for Science and Engineering 40:2033– 2047. https://doi:10.1007/s13369-015-1697-7.
21. Shardendu and Ambasht, R.S., 1988. Limnological studies of a rural pond and an urban tropical ecosystem, oxygen enforms and ionic strength, Journal of Tropical Ecology, 29 (2), pp 98-109. https://www.semanticscholar.org/paper/Limnological-studies-of-a-rural-and-an-urban-oxygen-Shardendu-Ambasht/6cba18b723ab75207ead6c4f986f4496d22997be.
22. Twari AK, Singh AK, Mahato MK., 2018. Assessment of groundwater quality of Pratapgarh district in India for suitability of drinking purpose using water quality index (WQI) and GIS technique. Sustain Water Resour Manag 4:601–616, (2018). https://doi.org/10.1007/ s40899-017-0144-1.
23. Tyagi, S., Sharma, B., Singh, P. and Dobhal, R., 2013. Water quality assessment in terms of water quality index. Am. J. Water Resource, 1(3), 34–38. https:// DOI: 10.12691/ajwr-1-3-3.
24. Vasanthavigar, M., Srinivasamoorthy, K., Vijayaragavan, K., Rajiv Ganthi, R., Chidambaram, S., Anandhan, P., Manivannan, R., Vasudevan, S., 2010. Application of water quality for groundwater quality assessment: Thirumanimuttar Sub basin, Tamil Nadu, India. Environ. Monitor. Assess. 171 (1–4), 595–609. https://doi.org/10.1007/s10661-009-1302-1.