Jr. of Industrial Pollution Control 39(2)1-11(2023)
www.icontrolpollution.com
Research Article

APPLICATIONS OF GIS TECHNIQUE FOR THE EVALUATION OF GROUNDWATER QUALITY: A CASE STUDY OF PANCHGANGA SUGAR FACTORY LTD, KABNUR, ICHALKARANJI, KOLHAPUR, MAHARASHTRA

NAJIM M. MULLA , DIPAK B. PANASKAR

School of Earth Sciences, SRTM University, Nanded, Maharashtra, India

Citation: Mulla Najim M., Panaskar Dipak B . Applications of Gis Technique for The Evaluation of Groundwater Quality: A Case Study of Panchganga Sugar Factory Ltd, Kabnur, Ichalkaranji, Kolhapur, Maharashtra. J Ind Pollut Control. 2023;39:001

Received: 13-Feb-2023, Manuscript No. ICP-23-89272; **Editor assigned:** 16-Feb-2023, PreQC No. ICP-23-89272 (PQ); **Reviewed:** 02-Mar-2023, QC No. ICP-23-89272; **Revised:** 09-Mar-2023, Manuscript No. ICP-23-89272 (A); **Published:** 16-Mar-2023, DOI: 10.4172/0970-2083.001

Key words: Groundwater, Pollution, Physico-chemical parameters, Spatial interpolation, Hydrochemical facies.

ABSTRACT

The present study reveals the assessment of groundwater quality in and around Panchganga Sugar Factory Ltd., Kabnur, Ichalkaranji, Kolhapur. Groundwater is the main source of irrigation in the study area. Eleven dug-wells and four bore-wells representative groundwater samples were obtained respectively from the "pre" and "post-monsoon" seasons in 2019, in parts of basaltic terrain in order to assess the quality. Water samples collected in the field were analysed in the laboratory for cations and anions using the standard methods. The main water quality parameters considered for this study were pH, EC, TDS, Total Hardness, Ca, Mg, Na, K, Chloride, Total Alkalinity, Carbonate, Bicarbonate and Sulphate. The groundwater quality information IDW maps of the entire study area were created using GIS spatial interpolation techniques for all of the above physicochemical parameters. The results obtained from this study and the spatial database established in GIS will be helpful for monitoring and managing groundwater pollution in the study area. The Piper diagram reveals that the majority of groundwater samples, 40% and 90% represent mixed Ca^{2+}-Mg^{2+}-Cl type hydrochemical facies in pre and post monsoon respectively; 55% and 5% of groundwater samples represent Ca^{2+}-Cl^{-} type hydrochemical facies in pre and post monsoon respectively; and each 5% of groundwater samples represent $Ca^{2+}HCO^{3}$ type facies in pre and post monsoon respectively. According to the Gibbs diagram, the predominant samples of pre-monsoon fall into the evaporation dominance field while post-monsoon samples fall into the rock dominance field of the Gibbs diagram. This can be attributed to the weathering of rock, which is controlling the groundwater chemistry. According to the U.S. salinity diagram, groundwater samples from both seasons fall into the following fields: 24% of samples fall into the C4-S2 field, 14% of samples fall into the C4-S3 field, 3% of samples fall into the C4-S4 field, 17% of samples fall into the C3-S3 field, 27% of samples are in the C3-S2 field, 6% of samples fall into the C3-S1 field, 6% of samples fall into the C2-S4 field, and 3% of samples fall into the C2-S1 field, respectively. The groundwater sample shows medium to very high salinity; hence the water is unsuitable for irrigation purposes. Most of the physiochemical parameters usually show high variations in concentration. The study also shows that the groundwater in the study area has been contaminated. Over all, the data shows that the water is hard in nature and thus unfit for drinking purposes.

INTRODUCTION

Humans have known about groundwater for thousands of years. Groundwater is essential to human existence and growth. Safe, potable water is essential for healthy life. Water pollution causes around 80% of illnesses affecting the global population and more than one-third of mortality in underdeveloped

***Corresponding author's email: najimmulla297@gmail.com**

nations. The most common cause of groundwater contamination is inappropriate garbage disposal on land. Industrial and home chemicals and rubbish dumps are major contributors, as are excessive fertilisers and pesticides used in agriculture, industrial waste lagoons, tailings, and processed wastewater from industry. The studied region had an abundance of high-quality groundwater throughout the pre-industrial period. Industrialization, on the other hand, resulted in a variety of pollutions, including groundwater contamination and air pollution. This research investigates groundwater pollution caused by industrial effluent (Pawar, et al., 1998).

Study Area

The sample collection area is located at latitudes from 16°42′25″N to 16°43′N and longitude from 74°25′30″E to 74°26′45″E. The study area is an intensive agricultural belt and all agriculture land depends on groundwater (Fig.1)

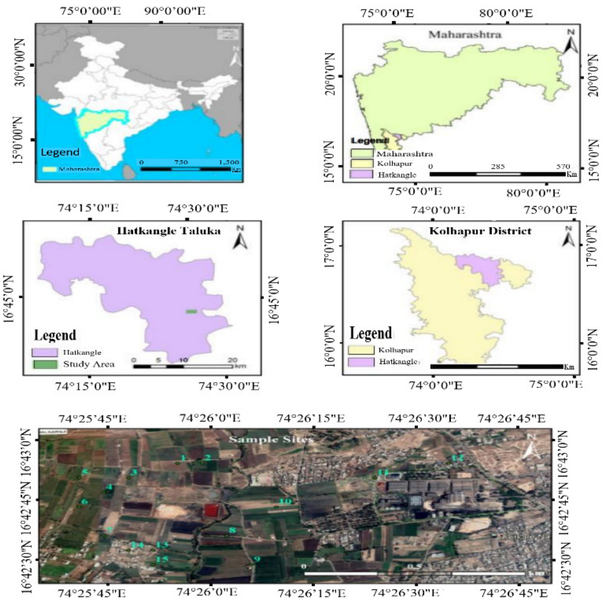

Fig. 1 Location Map of the study area. **Note**: 🟩 Maharashtra; 🟩 Maharashtra; 🟨 Kolhapur; 🟪 Hatkangle taluka; 🟩 Study Area.

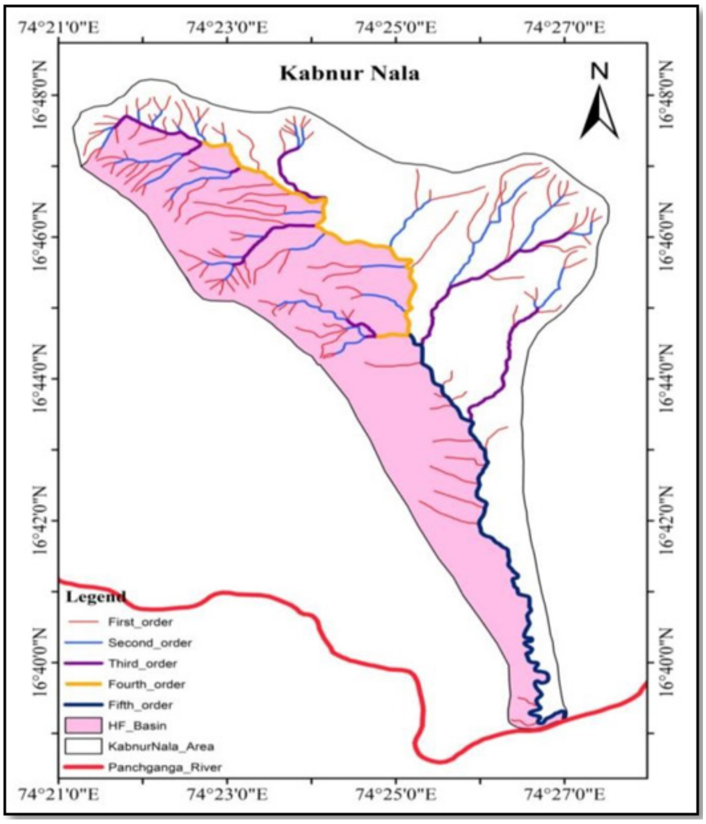

Fig. 2 Drainage pattern of Kabnur nala, Ichalkaranji. **Note**: 🟥 First order; 🟦 Second order; 🟪 Third order; 🟧 Fourth order; 🟦 Fifth order; ▨ HF basin; □ Kabnurnala area; 🟥 Panchganja river.

From the study area near the dumping side, "Kabnur Nala" is flowing towards the southward side and meeting the Panchganga River. Drainage marking was completed using line features in Arc-GIS 10.3 software. This drainage pattern is made up of a higher fifth-order drainage system that connects to the Panchganga River (Fig.2).

Regional Geology

The study are covered by basalt rock. It also known by deccan traps. It is one of the most extensive flood eruptions in the world. It covers major portions of Western India, occupying parts of Maharashtra, Gujarat, Madhya Pradesh and Karnataka States (Qureshimatva, et al., 2015; Kaplay, et al., 2004; Ranjana, et al., 2015). They are upper cretaceous and early eocene in age (65 Ma). About 80% of the Maharashtra state is covered by deccan basalt flow with hard and compact in nature (Gautam, et al., 2001). The study area comprises basalt rock with fractures, horizontal/inclined joints, weathered basalt and compact basalt nature (Fig.3).

METHODOLOGY

The physico-chemical parameters such as pH, Electrical Conductivity (EC), Total Dissolved Solids (TDS), Calcium (Ca^{2+}), Magnesium (Mg^{2+}), Sodium (Na^{+}), Chloride (Cl), Bicarbonate, Total Alkalinity (TA), Potassium (K^{-}), Sulphate ($SO4^{-2}$) are analyzed. The physico-chemical parameters are determined by using the Titro-metric method and some of them using the Spectrophotometer and Flame photometer instruments (Apha, 2005). Flow chart indicate the entire methodology of the research (Balakrishnan,et al.,2011; Neelam, et al.,2013; Krishna, et al., 2014; Sarala, et al., 2018) (Fig.4).

RESULTS AND DISCUSSION

Groundwater from study area were analyzed and assessed in order to understand variation of the various parameters and their inter-relationship of various sites in both pre monsoon and post monsoon season (Table 1). Data obtained laboratory analysis of groundwater samples are discussed based on graphs and spatial distribution maps from the GIS is discussed which site is unsuitable-suitable area or where value of the parameter is high or low is denoted by IDW maps (Fig.6).

Most of the physiochemical parameters usually show high variations in concentration (Naeem, et al., 2013; Ajit, et al., 2018; Devendra, et al., 2014; Selvakumar, et al., 2017). In the present investigation, it was observed that the pH value was between 7.0 and 7.8 (Fig.6A).TDS concentrations range between 372.0 and 3567.21 mg/L, according to the BIS limit; all samples, with the exception of two from the post-monsoon season, are unfit for drinking (Fig.6C) (BIS,1994). The concentration of Ca^{2+} is between 66.80 and 375.00 mg/L. The high level of calcium ions may cause stomach problems and is not suitable for household use due to encrustation and scaling (Fig.6D). The concentration of Mg^{2+} varies from 1.82 to 367.53 mg/l. Magnesium deficiency can lead to health problems including high blood pressure and heart disease, and high magnesium content may lead to muscle weakness (Fig.6E). The values of chlorides were found to be in various ranges, from 58.22 mg/L to 615.96 mg/L. The lowest value was recorded after the monsoon. Low concentrations of chloride may affect its taste (Fig.6H). Na^{2+} concentrations range from 39.04 to 214.40 mg/L (Fig.6G). Sample no. 6 has a high concentration, which is unacceptable. The maximum value of sulphate was observed at 435.10 mg/L (Fig.6J). The higher value of sulphate is responsible for corrosion. Excessive alkalinity may cause eye irritation in human and chlorosis in plants (Fig.6K).

With the help of Arc-GIS software, 11 maps each for both pre and post-monsoon seasons are prepared. The chemical concentrations of a water sample are displayed with the help of IDW interpolation tool (Varakala, et al., 2019; Verma, et al., 2015). It is useful in determining the extent of pollution by zone. It indicated that the western side of the study area was contaminated.

Classification of Groundwater Based on Piper Trilinear Diagram

In order to understand the variation in hydro chemical facies with time and space, Cations and anions of water's chemical parameters were plotted on a Piper diagram to analyse the water's hydrochemistry in grapher software (Fig.7) (Table 2).

Classification of Groundwater Based on U. S. Salinity Diagram

US classification diagram is based on Electric Conductivity (EC) Vs SAR ratio. SAR is only one factor in determining the suitability of water for irrigation purpose (Kumari, et al., 2020). for categorize water sample based on salinity and sodium hazard classification. Based on U.S. salinity diagram water samples from pre and post monsoon season plotted (Fig.8). It reveals that, majority water samples fall down in high to very high salinity hazards and medium to very high sodium hazard. hence the water is not suitable for irrigation purpose.

Classification of Groundwater Based on Gibbs Variation Diagram (Gibbs 1970)

The Gibbs variation diagrams suggest the chemistry of groundwater and its controlling factor (Fig.9). By plotting the ratios of $Cl/Cl^{+}HCO3$ and $Na/Na^{+}Ca$ as functions of Gibbs 1970, the mechanism of controlling water chemistry and the functional source of dissolved ions can be assessed. Gibbs' diagram of the water samples shows samples clustered into two classes: the majority of the samples represent rock dominance, while a few samples represent evaporation dominance. This could be related to rock weathering and controlling water chemistry.

Fig. 3 Soil lithology in kabnur nala, ichalkaranji.

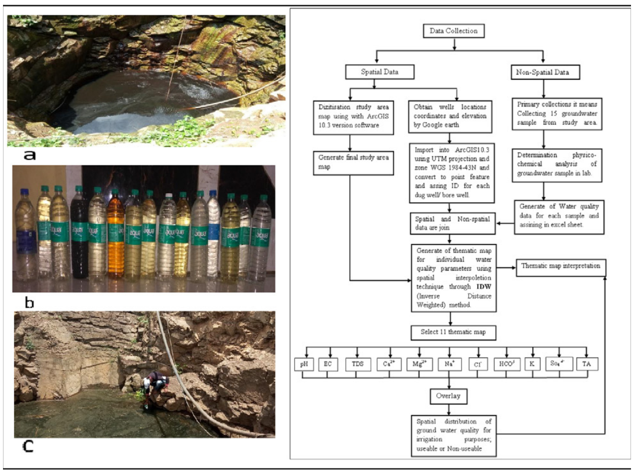

Fig. 4 (a) Dug well number-4, (b and c) Sample collections.

Tab. 1. Basic statistics of Pre and Post-monsoon sample results

Parameter	**BIS Limit**	**Pre Monsoon (May 2019)**			**Post Monsoon (December 2019)**		
	(BIS 1994)	**Minimum**	**Maximum**	**Average**	**Minimum**	**Maximum**	**Average**
pH	6.5-8.5	7	7.8	7.4	7.3	7.6	7.4
EC (mS/cm)	700-3000	1372.8	5573.76	2859.69	738	2616	1595.6
TDS mg/L	500-1000	878.59	3567.21	18.3	372	1300	800.33
Ca^{2+} mg/L	75-200	215	375	296.2	66.8	293.92	176.71
Mg^{2+} mg/L	30-100	1.82	367.53	204.88	17.1	145.69	56.67
HCO^3 mg/L	25-400	106.22	448.12	267.59	169.8	536.1	337.85
Na^+ mg/L	200	51.39	214.4	124.09	39.04	189.2	106.49
Cl^- mg/L	250-1000	233.64	615.96	352.29	58.22	397.6	236.26
K^+ mg/L	12	2.37	19.3	8.63	1.9	15.97	7.38
$SO42^-$ mg/L	200-400	16.2	435.1	297.44	10	430	289.63
TA mg/L	200-600	87.07	367.31	219.34	139.18	439.43	276.92
Note: (HCO^3= 25-400 ppm;) (1 ppm=1 mg/L)							
(All values in mg/L. except pH and EC. EC in mS/cm)							

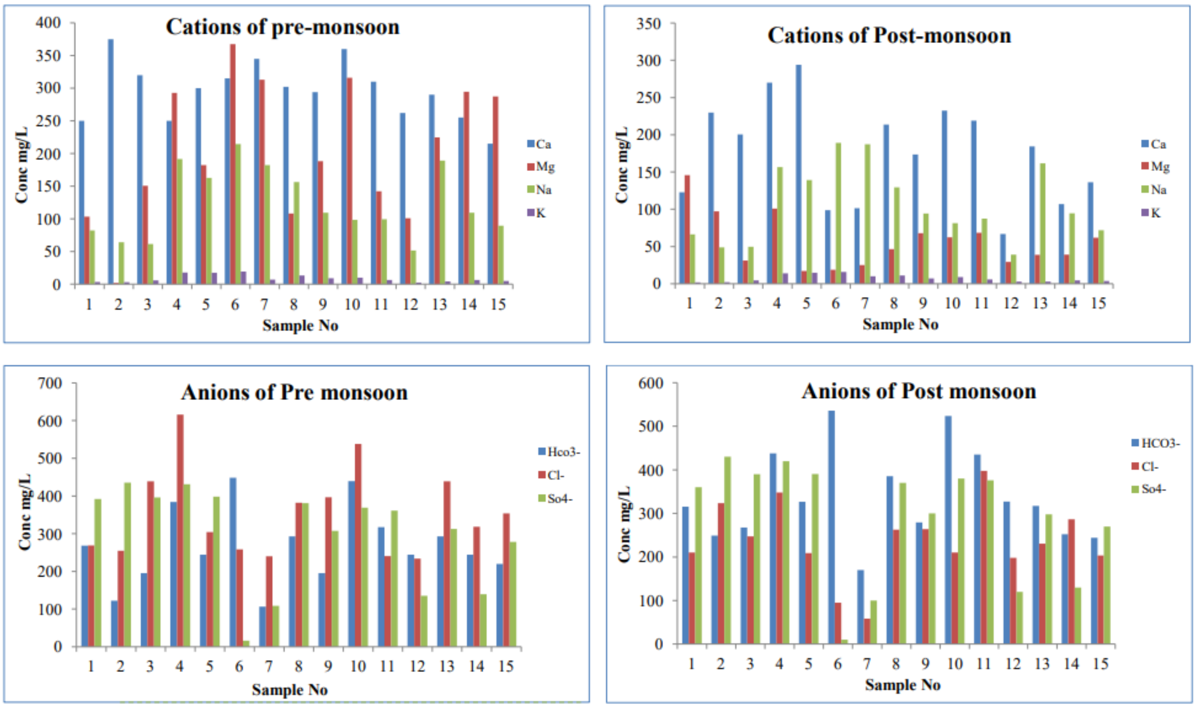

Fig. 5 Graphical representation of samples of Pre and Post-monsoon. **Note**: (Cations) 🟦 Ca; 🟥 Mg; 🟩 Na; 🟪 K; (Anions) 🟦 HCO^{3-}; 🟥 Cl; 🟩 So^{4-}.

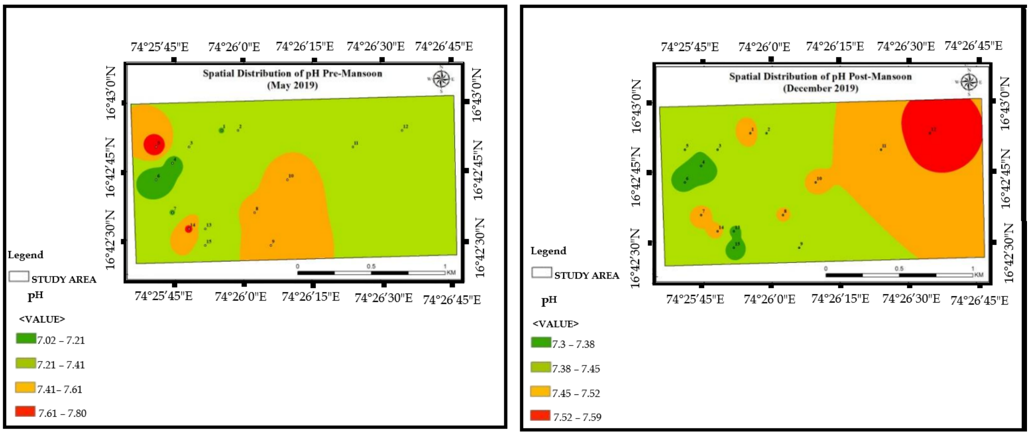

Fig. 6A Spatial distribution of Ph. **Note**: (May 2019) 🟩 7.02-7.21; 🟩 7.21-7.41; 🟧 7.41-7.61; 🟥 7.61-7.80. (December 2019) 🟩 7.3-7.38; 🟩 7.38-7.45; 🟧 7.45-7.52; 🟥 7.52-7.59.

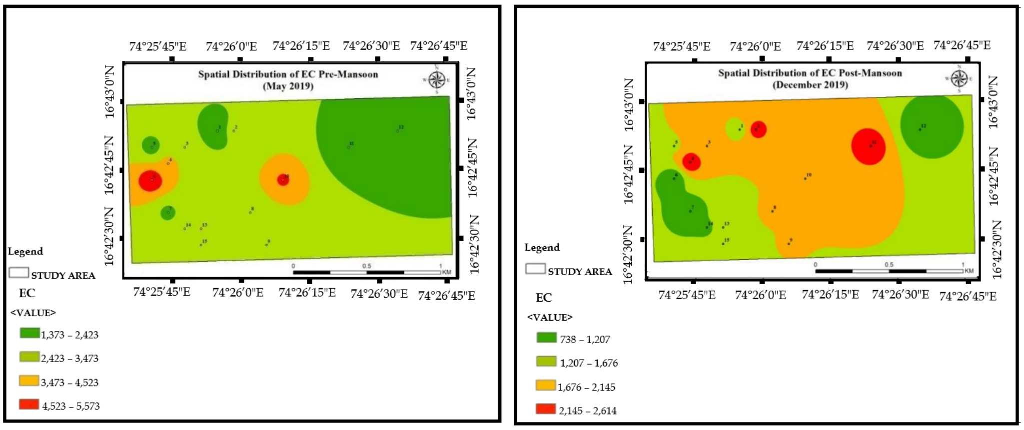

Fig. 6B Spatial distribution of EC. **Note**: (May 2019) 🟩 1,373-2,423; 🟩 2,423-3,473; 🟧 3,473-4,523; 🟥 4,523-5,573.(December 2019) 🟩 738-1,207; 🟩 1,207-1,676; 🟧 1,676-2,145; 🟥 2,145-2,614.

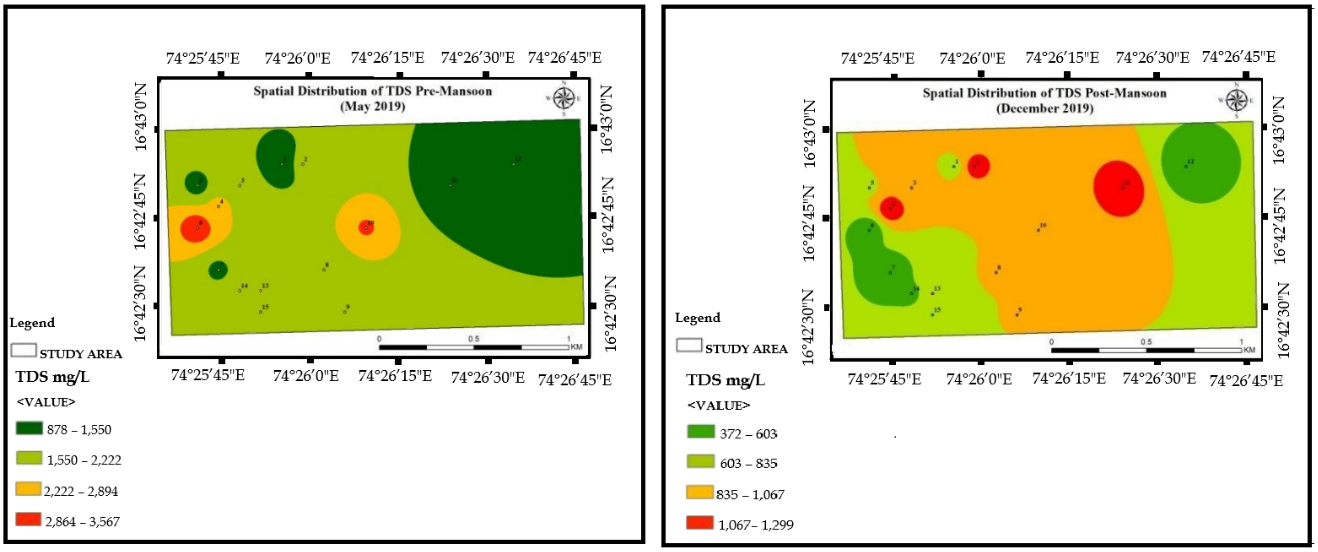

Fig. 6C Spatial distribution of TDS. **Note:** (May 2019) 🟩 878-1,550; 🟨 1,550-2,222; 🟧 2,222-2,894; 🟥 2,894-3,567. (December 2019) 🟩 372-603; 🟨 603-835; 🟧 835-1,067; 🟥 1,067-1,299.

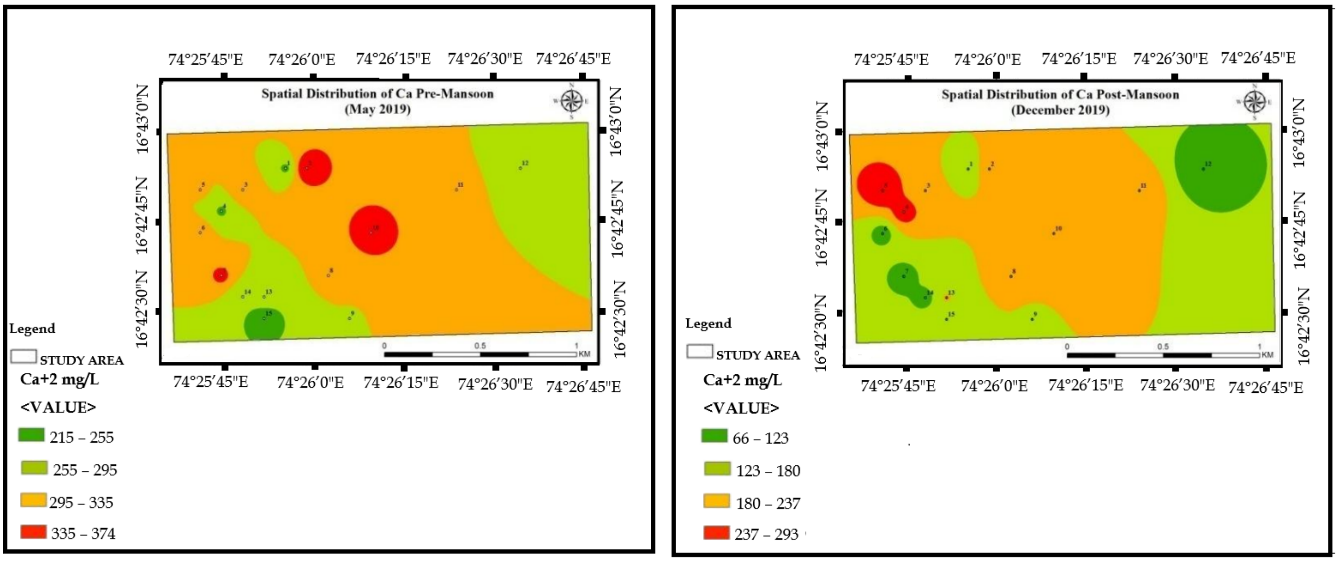

Fig. 6D Spatial distribution of calcium Ca2. **Note**: (May 2019) 🟩 215-255; 🟨 255-295; 🟧 295-335; 🟥 335-374. (December 2019) 🟩 66-123; 🟨 123-180; 🟧 180-237; 🟥 237-293.

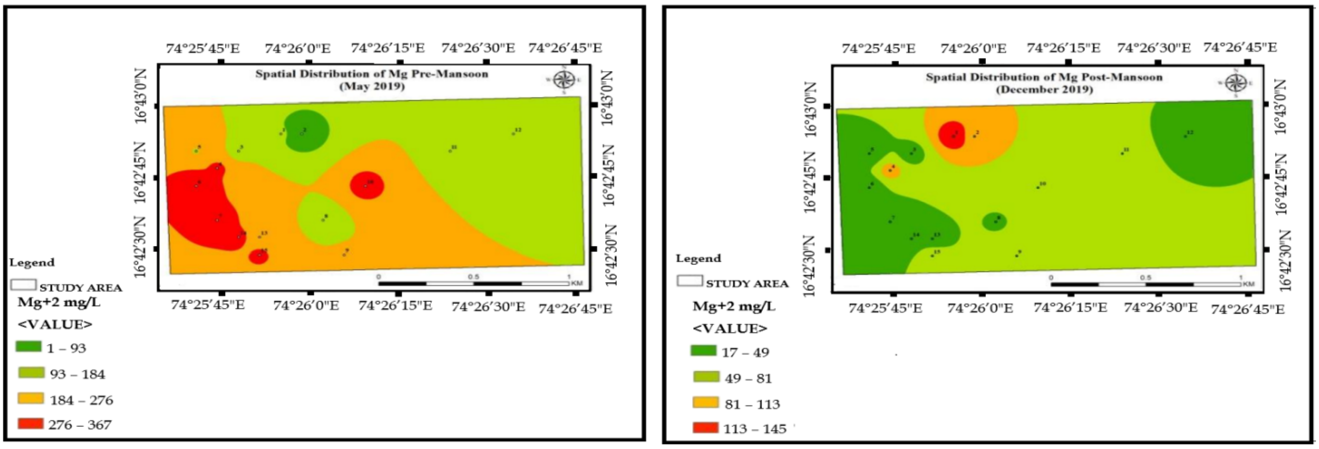

Fig. 6E Spatial distribution of magnesium. **Note**: (May 2019) 🟩 1-93; 🟨 93-184; 🟧 184-276; 🟥 276-367. (December 2019) 🟩 17-49; 🟨 49-81; 🟧 81-113; 🟥 113-145.

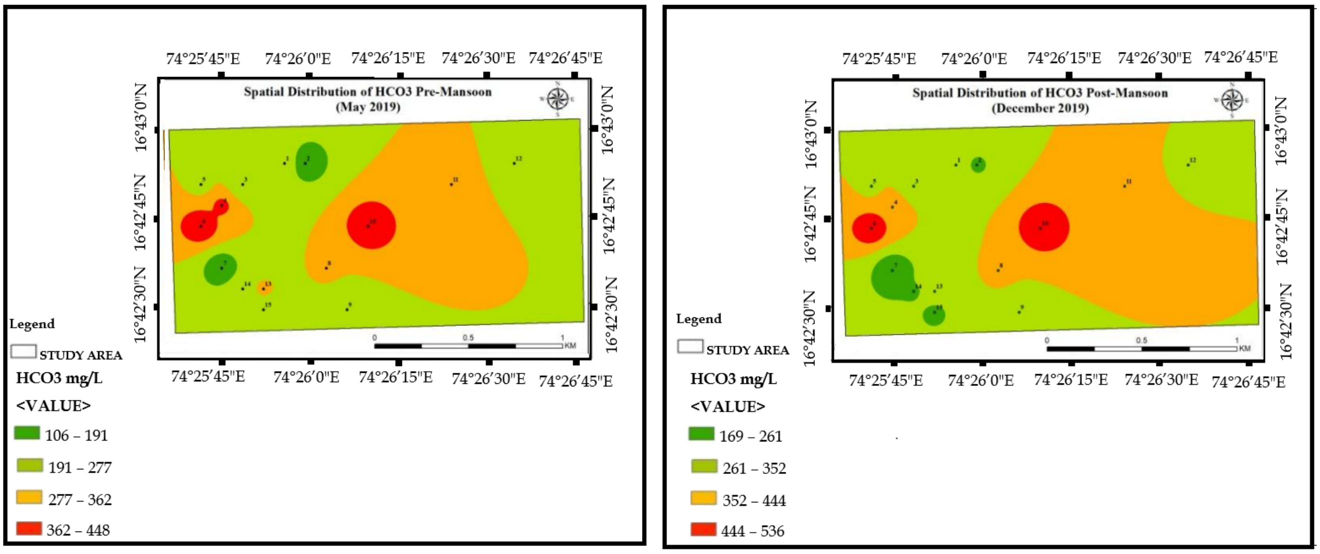

Fig. 6F Spatial distribution of bicarbonate. **Note**: (May 2019) 🟩 106-191; 🟩 191-277; 🟧 277-362; 🟥 362-448. (December 2019) 🟩 169-261; 🟩 261-352; 🟧 352-444; 🟥 444-536.

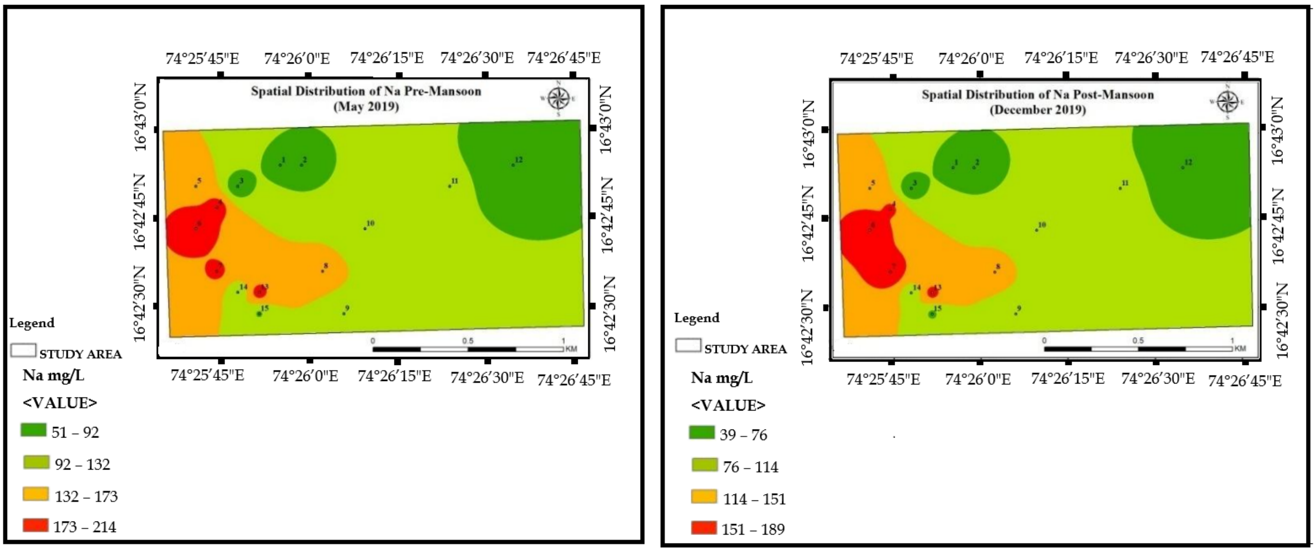

Fig. 6G Spatial distribution of sodium. **Note**: (May 2019) 🟩 51-92; 🟩 92-132; 🟧 132-173; 🟥 173-214.(December 2019) 🟩 39-76; 🟩 76-114; 🟧 114-151; 🟥 151-189.

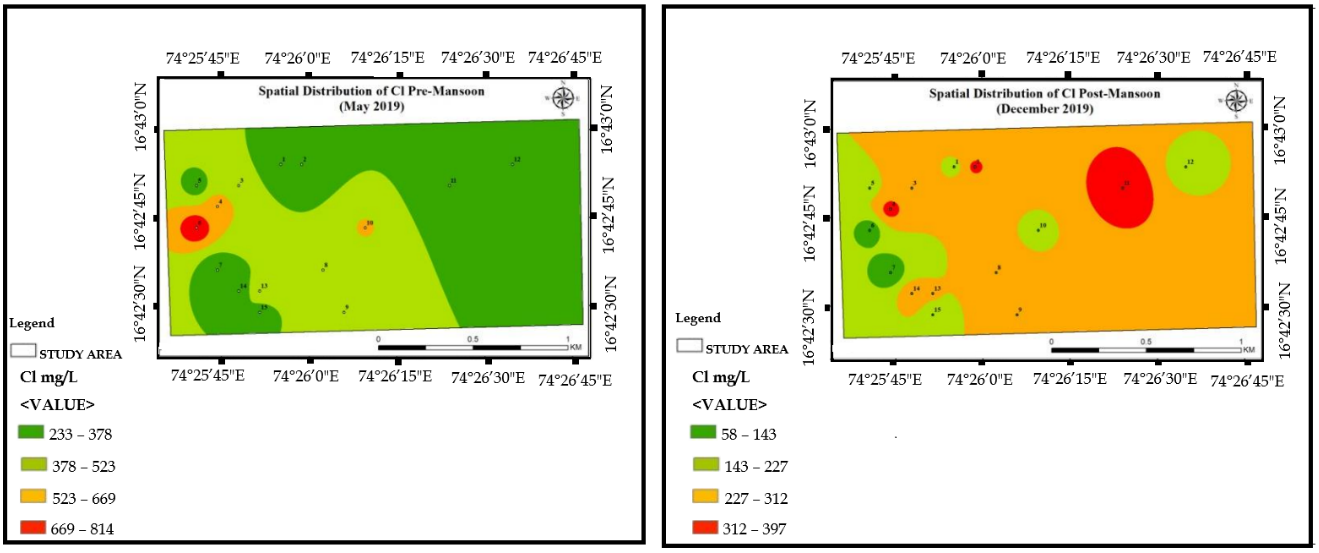

Fig. 6H Spatial distribution of chloride. **Note**: (May 2019) 🟩 233-378; 🟩 378-523; 🟧 253-669; 🟥 669-814. (December 2019) 🟩 58-143; 🟩 143-227; 🟧 227-312; 🟥 312-397.

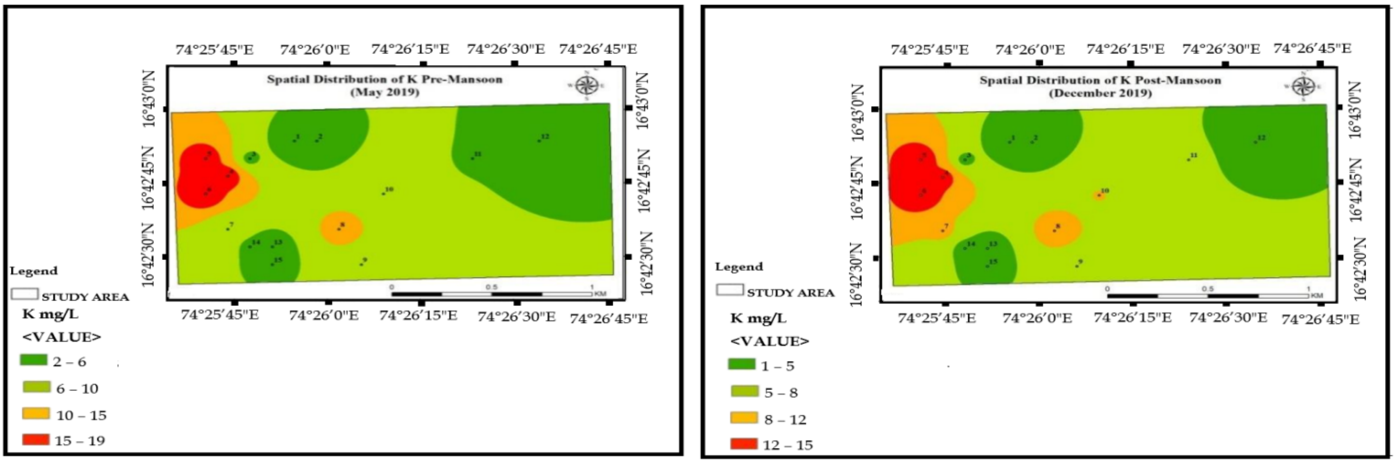

Fig. 6I Spatial distribution of potassium. **Note**: (May 2019) 🟩 2-6; 🟩 6-10; 🟧 10-15; 🟥 15-19. (December 2019) 🟩 1-5; 🟩 5-8; 🟧 8-12; 🟥 12-15.

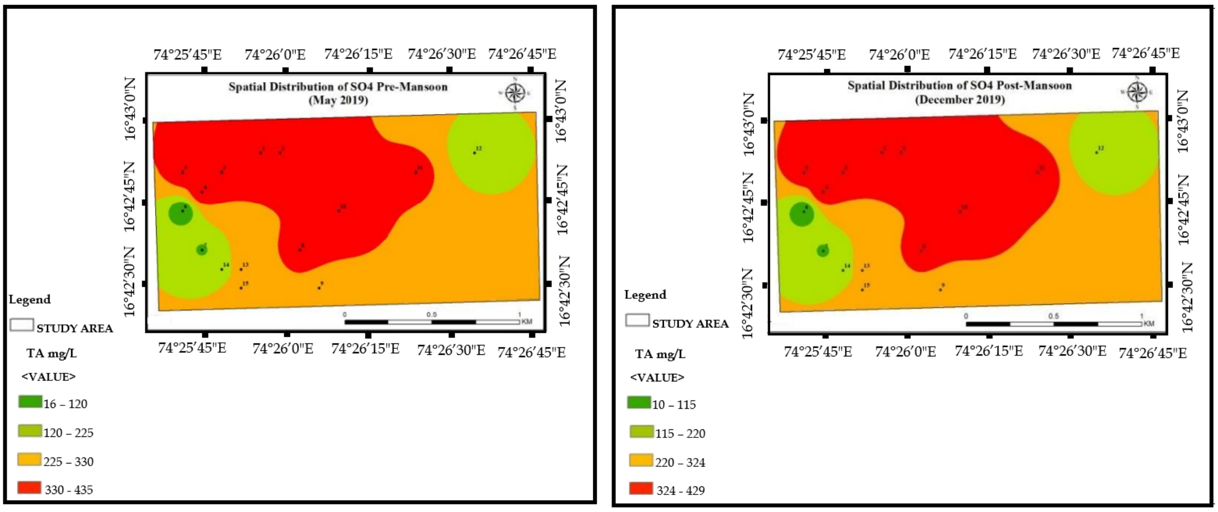

Fig. 6J Spatial distribution of sulphate. **Note**: (May 2019) 🟩 16-120; 🟩 120-225; 🟧 225-330; 🟥 330-435. (December 2019) 🟩 10-115; 🟩 115-220; 🟧 220-324; 🟥 324-429.

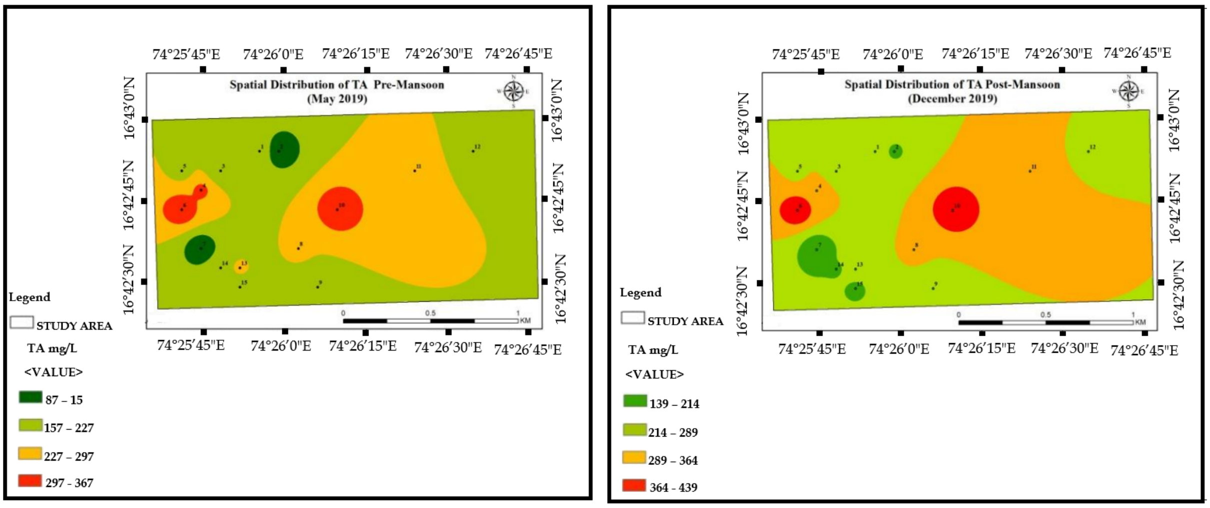

Fig. 6K Spatial distribution of total alkalinity. **Note**: (May 2019) 🟩 87-157; 🟩 157-227; 🟧 227-297; 🟥 297-367. (December 2019) 🟩 139-214; 🟩 214-289; 🟧 289-364; 🟥 364-439.

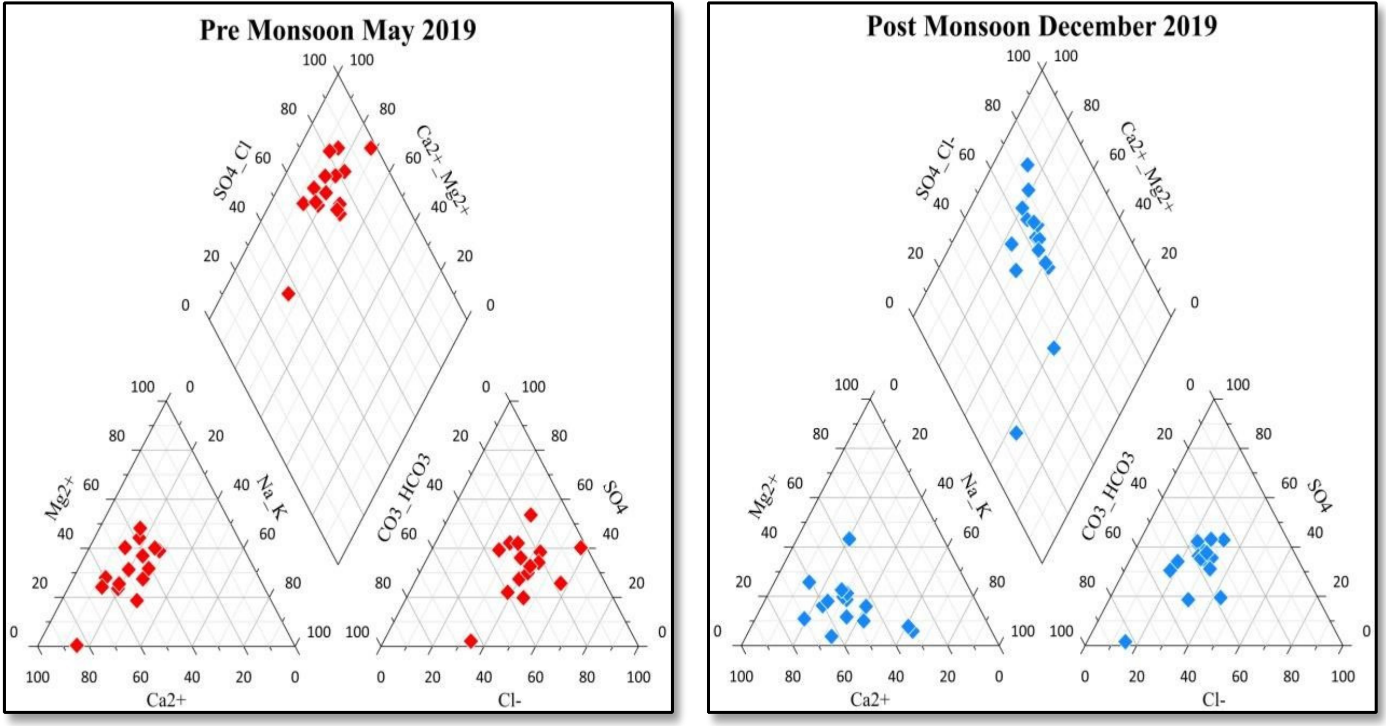

Fig. 7 Piper trilinear diagram for pre and post-monsoon.

Tab. 2. Identified facies based on piper trilinear diagram.

Type of facies based on piper trilinear	Pre-monsoon	Post-monsoon
Calcium Chloride facies (CaCl)	55%	5%
Mixed type facies (CaMgCl)	40%	90%
Magnesium Bicarbonate facies	5%	5%

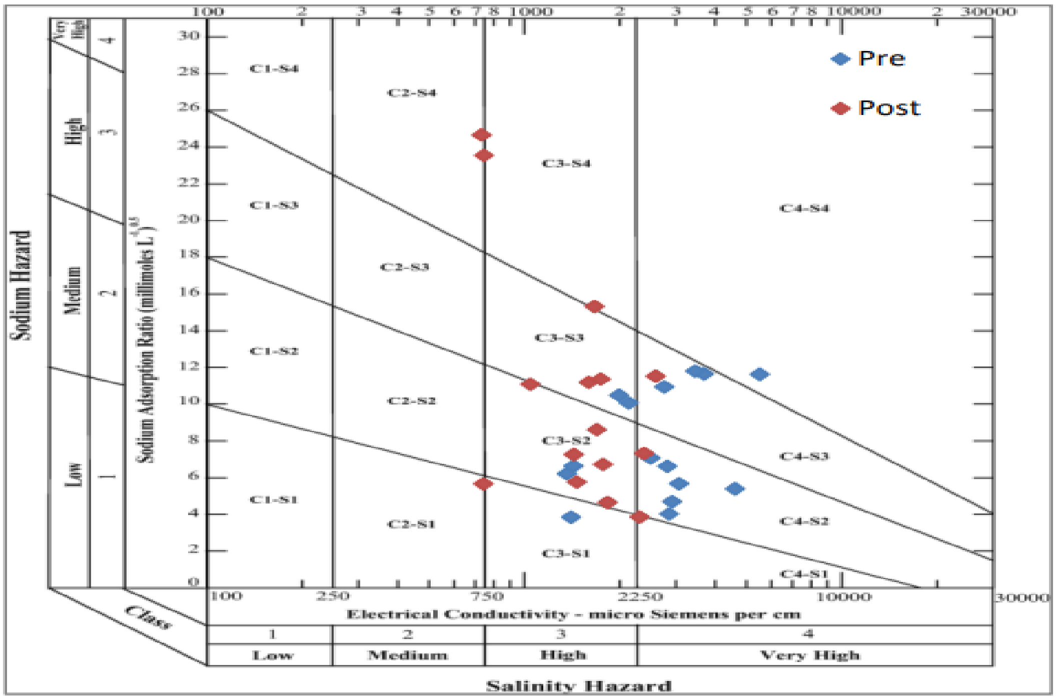

Fig. 8 U.S. salinity diagram for Pre and Post-monsoon. **Note**: ◆ Pre; ◆ Post.

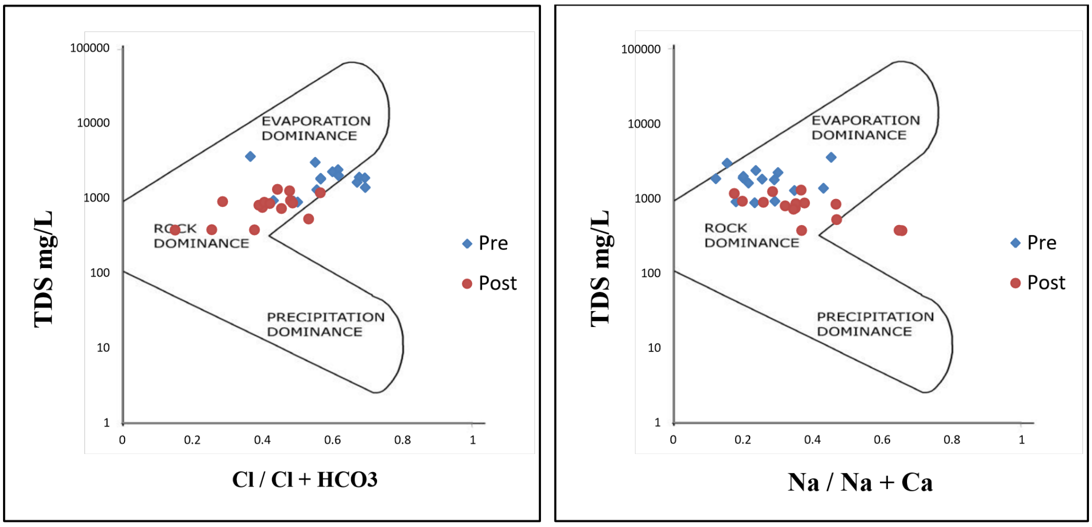

Fig. 9 Gibbs variation (Gibbs 1970) diagram for pre and post-monsoon. **Note**: ◆ Pre; ● Post.

CONCLUSION

The majority of physiochemical parameters often exhibit wide concentration fluctuations. High TDS may be due to the percolation of channel water containing solids, agricultural waste, and industrial seepages. According to BIS, a water sample with a TDS level over 500 mg/L is not acceptable for drinking and might cause digestive problems. The current study discovered a high calcium content. It may cause stomach problems. A higher concentration of sulphate is responsible for corrosion. Hence, water is not recommended for drinking without prior treatment. Using GIS software, the concentration of water samples displayed using the IDW tool indicates that, the western side of the study region is the most contaminated. The Piper diagram indicates that the water is permanently harder, making it unfit for drinking. According to Gibbs, the chemistry of the groundwater is being regulated by the weathering of rocks. Apparently, a groundwater sample has medium to extremely high salinity, according to the U.S. since of the excessive salinity, the water is therefore unsuitable for irrigation because it reduces agricultural output. Government and non-government organizations should encourage young people to construct structure and artificial techniques in order to improve quality of water.

ACKNOWLEDGEMENTS

We are grateful to the Secretary, Ministry of Earth Sciences, Govt. of India, for providing administrative and financial support to present this work. I am also thankful to the Project Director, BGRL for providing valuable guidance and support. I sincerely record my appreciation to my esteemed teacher Prof. K. Vijay Kumar. He has been a constant source of inspiration to me. I express my deepest regards to my parents, who constantly encouraged me and provided every possible help during this study. I am very thankful to Ananda Ghevade, Deepak Wable and those who have directly or indirectly helped me complete research.

DATA AVAILABILITY

The results produced in this work can be made available after a special request to the corresponding author.

COMPLIANCE WITH ETHICAL STANDARDS

The authors declare that they have no conflict of interest and adhere to copyright norms.

REFERENCES

Pawar N, Pondhe G and Patil S. 1998. Groundwater pollution due to sugar-mill effluent, at sonai,maharashtra, india. *Environ Geol*. 34(5):151-158.

Qureshimatva, Umerfaruq M and Rupesh. 2015. Determination of physico-chemical parameters and water quality index (wqi) of chandlodia lake, ahmedabad, gujarat, india. *J Anal Toxicol*. 5(4)125-135.

Kaplay R and PatodeH. 2004. Groundwater pollution due to industrial effluent at tuppa, new nanded, maharashtra. *India Environ Geol*. 46(6):871-882.

Ranjana Y, Wahane JK and Choubey ON. 2015. Impact of sugar industry effluents on the quality of groundwater near bankhedi sugar industry dist. narsinghpur (mp) india. *J Ind Pollut Control*. 31(2):267-270.

Gautam S. 2001. Generation of deccan trap magmas. *J Earth Syst Sci*. 110(12):409-431.

American Public Health Association (APHA).2005. Standard methods for examination of water and wastewater. Washington.

Balakrishnan P, Saleem A and Mallikarjun N. 2011. Groundwater quality mapping using geographic information system (gis): a case study of gulbarga city, karnataka, india. *Afr j environ sci technol*. 5(12):1069-1084.

Neelam S, Madhuri, Rishi and Herojeet RK. 2013. Groundwater quality variation with respect to aquifer dispositioning in urbanized watershed of chandigarh, india. *Int j env ecol family urban stud*. 3(2):87-98.

Krishna k, Logeshkumaran ,Magesh NS, Prince SG and Chandrasekar.2014. Hydro-geochemistry and application of water quality index (WQI) for groundwater quality assessment, anna nagar, part of chennai city, tamil nadu, india. *Appl Water Sci*. 5(6): 335–343.

Sarala and Ravi B P.2018. Assessment of groundwater quality parameters in and around jawaharnagar, hyderabad . *Int J Sci Res Publ*. 2(10):1-6.

Naeem K, Syed T H, Abdus S, Nargis J and Kyong SK. 2013. Physicochemical investigation of the drinking water sources from mardan, khyber pakhtunkhwa, pakistan. *int j phys sci*. 8(33):1661-1671.

Ajit L, Bharamgunde S S, Bankar DB, Adam V S, Bankar VL and Devkar R R. 2018. Study of physicochemical characteristic of groundwater around kala nala basin, ichalkarnji, kolhapur, mahrashtra, india. *Int J Appl Sci Eng*. 6(3):2072-2077.

Devendra D, Shriram D and Atul K. 2014. Analysis of ground water quality parameters: a review. *Res J Engineering Sci*. 3(5):26-31.

Selvakumar S, Chandrasekar N and Kumar G. 2017. Hydrogeochemical characteristics and groundwater contamination in the rapid urban development areas of coimbatore, india, water resources and industry. *Water Resour Ind*. 17(7):26-33.

BIS .1994. Drinking water specifications are: 10500. Bureau of Indian standards. New Delhi.

Varakala L, Srinivas B, Sudhakar G and Shankar S.2019. Groundwater quality assessment in part of krishna river basin, weepangandla and chinnambhavi area, mahabubnagar district telangana india. *JAppl Geochem*. 21(3):292-300.

Verma S and Khan JB. 2015. Analysis of water quality by physico-chemical parameters in fateh sagar talab in bagar, dist. of jhunjhunu (raj), india. *J Pharm Biol Sci*. 10(5):41-45.

Kumari M and Rai SC. 2020. Hydrogeochemical evaluation of groundwater quality for drinking and irrigation purposes using water quality index in semi arid region of india. *J Geol Soc India*. 95(2): 159-168.