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# WATER QUALITY INDEX FOR THE ASSESSMENT OF GROUNDWATER QUALITY IN PALWAL DISTRICT, HARYANA

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## ABSTRACT

**This paper aims at studying the various physico-chemical parameters and development of water quality index to determine the groundwater quality and see its suitability for consumption in rural villages in Palwal district, Haryana, India. Water quality index of the study area was calculated on the basis of BIS standards of drinking water largely varied from being in a very poor category to water unsuitable for consumption and needed some treatment before it can be utilized for various domestic purposes.**

**KEY WORDS** : Groundwater, Physico-chemical parameters, Water quality index.

## INTRODUCTION

Groundwater is a vital resource and is one of the biggest sources of freshwater (Jha *et al.,* 2020). Half of drinking water supplies are met by groundwater in the low-income regions of the world (Carrard *et al.,* 2019). One of the biggest advantages of groundwater for its use as a source of drinking water is it is protected from many naturally occurring contaminants (Gronwall *et al.,* 2020) but agriculture involving excessive use of fertilizers and pesticides, urbanization, exponential population growth and industrialization (Burri *et al.,* 2019) are some of the threats which have deteriorated the groundwater quality. Quality of groundwater is an important concern especially in Indian villages where the population is mostly dependent on groundwater for quenching its thirst (Sekhri *et al.,* 2014). Consuming polluted water leads to many water related diseases and thus puts an unnecessary burden on pockets of people therefore it has become necessary for regular monitoring of groundwater quality to see its suitability for consumption and accordingly adopt measures for its protection. Many techniques and methods can be used to study groundwater quality based on various parameters (Adnan *et al.,* 2019; Jing *et al.,* 2013; Bhunia *et al.,* 2018). Water quality index (WQI) is one of the most effective methods to get information on groundwater quality. WQI is a mathematical formula which converts large data of various parameters into a simple numerical value which can be easily understood by the general public (Kawo *et al.,* 2018).

The study area comprises rural villages in Palwal district, Haryana in which people are dependent on groundwater for their domestic and daily needs. This paper focuses on comparing the various parameters obtained with BIS drinking water standards and calculation of WQI value to see its suitability for potable use.

### Study Area

The study area consisted of 25 villages of Palwal district located in Haryana. Palwal has a geographical area of 1364.55 sq.km and lies between $27^0 50'$ : $28^0 15' 40''$ north latitudes and $77^0$ 05 and $77^o 05'$ : $77^0 33'$ east longitudes. Palwal district is divided into 6 development blocks- Palwal, Prithla, Hathin, Hodal, Badoli and Hasanpur. Palwal is bound on eastern side by Uttar Pradesh, Mewat on western side and Faridabad district on eastern side. Agra canal and Gurgaon canal are the two main canals which pass through western and central part of the district.

**Table 1.** Sample codes of collected groundwater

| Sample code | Name of village |
|---|---|
| S1 | Alahapur |
| S2 | Firozpur |
| S3 | Prithla |
| S4 | Sikanderpur |
| S5 | Asawati |
| S6 | Allika |
| S7 | Rehrana |
| S8 | Joharkhera |
| S9 | Kishorpur |
| S10 | Tatarpur |
| S11 | Harfali |
| S12 | Teharki |
| S13 | Badha |
| S14 | Nagli Panchagi |
| S15 | Chandpur |
| S16 | Jaindapur |
| S17 | Paltli Kalan |
| S18 | Patli Khurd |
| S19 | Rakhota |
| S20 | Naya Gaon |
| S21 | Megpur |
| S22 | Jatola |
| S23 | Meerapur |
| S24 | Gadpuri |
| S25 | Sehrala |

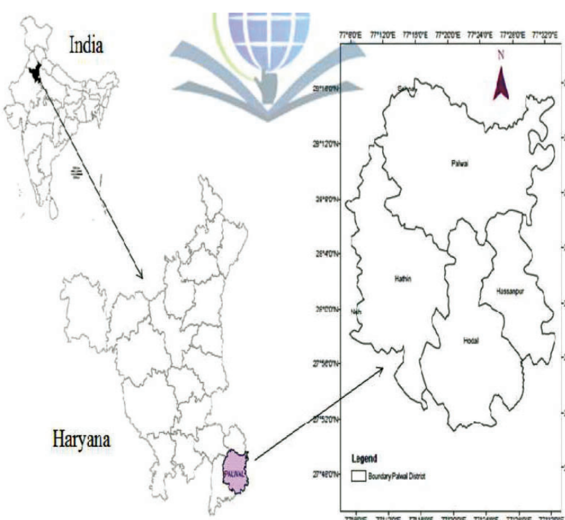



**Fig. 1.** Location map of the study area

## Geology

Palwal distinct basement is composed of a quartzite layer formed in the Achaean age which is overlaid by sediments of older alluvium of Pleistocene age. Floodplains located near the lowlands are formed of newer formed alluvium of Holocene age overlying older alluvium. Newer formed alluvium is found within floor plains of the Yamuna River and overlies the older alluvium. Older alluvium consists of calcareous Kankar which are devoid of newer alluvium. Quaternary eolian sediment is found in the northwest part of the area.

## Hydrogeology

Palwal district is occupied by the Gangetic alluvial plains of quaternary age and falls in the Yamuna sub-basin of the Ganga basin. Permeable granular zones in the district are composed of fine to medium grained sand and occasionally consist of coarse sand and gravel. Groundwater occurs in alluvium and underlying quartzite. Alluvium consists of sand, gravel, silt and Kankar, which is the groundwater-bearing horizon. The depth of the water table ranges from 2.00 to 20.75 mbgl in the pre-monsoon period to 2.00 to 9.40 mbgl in the post-monsoon period and the average gradient of the water table is of 1m/km with groundwater flowing in a north to south direction.

# MATERIALS AND METHODS

Groundwater samples were collected in both pre-monsoon (June 2020) and postmonsoon (October 2020) seasons respectively and analysed. Total of 25 samples of groundwater were collected from tube wells and hand pumps at different locations of study area both during pre-monsoon and post-monsoon season in 2020. The pH and total dissolved solids (TDS) were measured immediately in the field after sampling. Water samples were collected in polyethylene bottles and stored at 10°C, to analyze various major anionic and cationic concentrations in the laboratory by following standard guidelines and procedures (APHA, 2017).

## Need for Water Quality index

Water quality index (WQI) is an important tool which can be used to evaluate the water quality status by converting selected physico-chemical parameters of water into a numerical dimensionless value which provides information about water quality in a particular location and can be easily understood by the general public. By the easy nature of WQI and their scientific basis WQI has become an important tool in the evaluation of water quality. World-wide many methods of WQI assessment have been developed but uptil now there has been a dearth for calculating the steps used in finding WQI in a uniform pattern thus there is a growing interest to find the accurate WQI. In 1965, WQI was developed by Horton based on eight water parameters. The Canadian Council of Ministers of Environment (CCME) again worked on WQI in the mid-nineties (Dede *et al.*, 2013). Following steps were used for the calculation of WQI:

In the first step, each of the chosen eleven parameters were assigned a weight(wi) 1-5 based on its importance in the water quality (Batabayal *et al.*, 2015) as shown in Table 2. Nitrates was assigned the maximum weight of 5, fluorine, pH, sulphates and TDS were allotted weight of 4, chlorine, total alkalinity (TA) was given 3 and calcium, magnesium and total hardness were given a scale of 2 depending on the overall influence in the water quality.

In the second step, relative weight (Wi) of each chemical parameter was calculated by weighted arithmetic index method given by the equation (Kachroud *et al.*, 2019)

$$W_i = \frac{w_i}{\Sigma_{i=1}^{n} w_i}$$

**Table 2.** Weight(wi) and relative (Wi) to each parameter

| Physico-Chemical Parameter | Standard | Weight (wi) | Relative Weight (Wi) |
|---|---|---|---|
| pH | 6.5-8.5 | 4 | 0.1212 |
| Total Hardness | 300-600 | 2 | 0.0606 |
| Total Alkalinity | 200-500 | 3 | 0.0909 |
| Ca | 75-200 | 2 | 0.0606 |
| Mg | 30-100 | 2 | 0.0606 |
| Cl | 250-1000 | 3 | 0.0909 |
| TDS | 500-2000 | 4 | 0.1212 |
| $SO_4$ | 200-400 | 4 | 0.1212 |
| $NO_3$ | 45-100 | 5 | 0.1515 |
| F | 1-1.5 | 4 | 0.1212 |
| | | $\Sigma w_i$=33 | $\Sigma W_i = 1$ |

All chemical parameters except pH are in mg/l
Lower value gives the desirable weight and higher value denotes the permissible limit in absence of alternative source

In the third step, quality rating (qi) for each parameter is assigned by dividing the concentration of each parameter by its standard value (BIS standard value) and multiplying the result by 100

qi =(Ci/Si) × 100

Where is the quality rating
Ci is the concentration of each chemical parameter in given water sample
Si is the Indian standard for drinking water for each chemical parameter of water

In the fourth step, for calculating WQI the subindex (SI) for each chemical parameter is determined by adding together all the sub index values of the groundwater samples obtained.

SIi = Wi x qi

WQI = ΣSIi - n

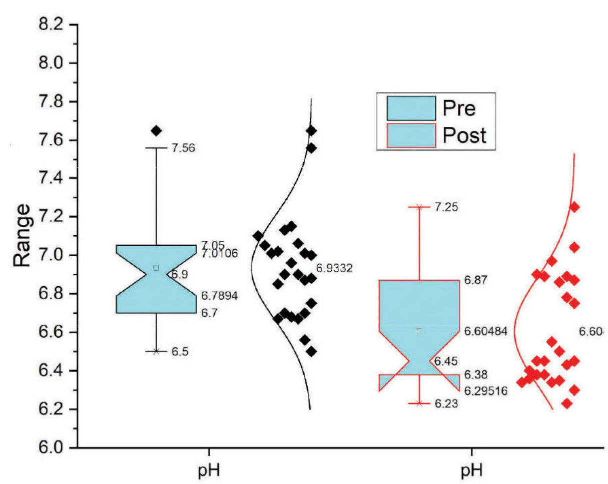
- Where SIi = subindex of ith parameter
- Wi = relative weight of ith parameter
- Qi = quality rating depending on concentration of ith parameter
- n = no. of chemical parameters

## RESULTS AND DISCUSSION

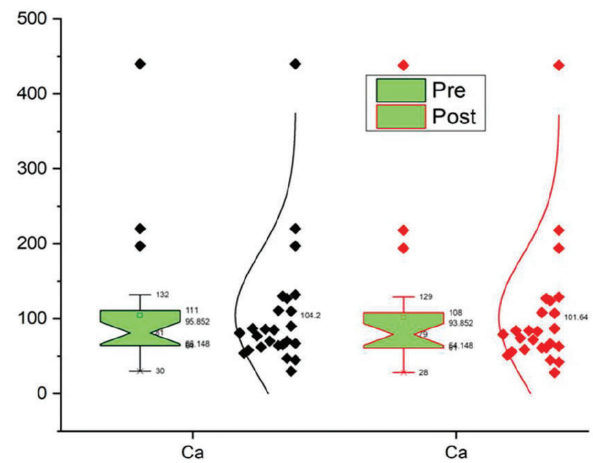
### Water Quality

pH: pH is one of the most important and common test parameters used for evaluation of water quality. pH which is a measure of hydrogen ion concentration was determined using the potentiometric method which involves using a standard hydrogen electrode and a reference electrode. Standard limit for pH in drinking water varies from 6.5-8.5 as per Indian standards of drinking water. Health-wise there is no threat from altered pH in drinking water but pH less than 6.5 or greater than 8.5 can result in staining and scaling.

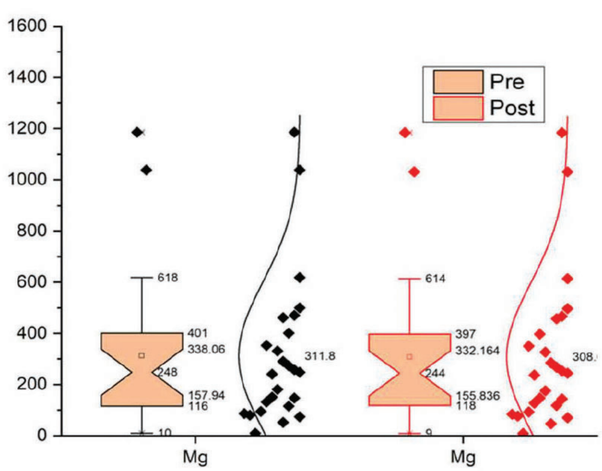
pH of the study area varied from 6.5- 7.65 in the pre-monsoon season with an average mean of 6.93 which is within the acceptable range whereas in post-monsoon pH concentration varied from 6.23 to 7.25 with an average mean of 6.60. From the table it is clear that pH values of the Palwal district are within the maximum desirable limits (8.5), which is also a maximum permissible limit as per IS 10500:2012.



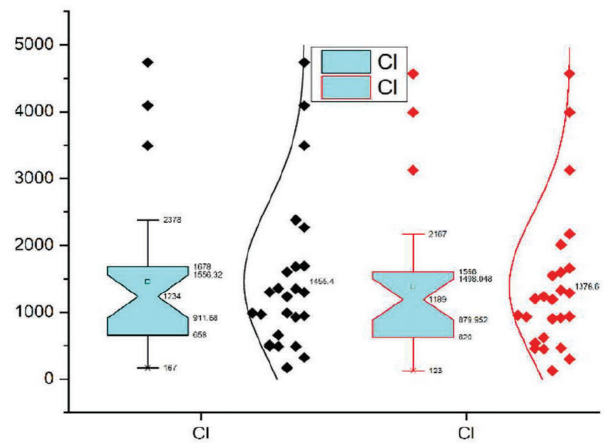
**Calcium:** is the most abundant cation in an uncontaminated source of drinking water, responsible for hardness in water and was determined by EDTA titration. Acceptable limit set by BIS for calcium in drinking water is 75 mg/l and 200 mg/l has been set up as a permissible limit. Calcium concentration in groundwater samples in the pre-monsoon season varied from 30 mg/l to 440 mg/l showing an average mean value of 104.2 mg/ l. Calcium concentration in post- monsoon ranged from 28 mg/l - 438 mg/l with an average mean of 101.64 mg/l. Tatarpur showed the highest calcium concentration (440 mg/l) while Gadpuri showed the minimum concentration of calcium as 28 mg/l.



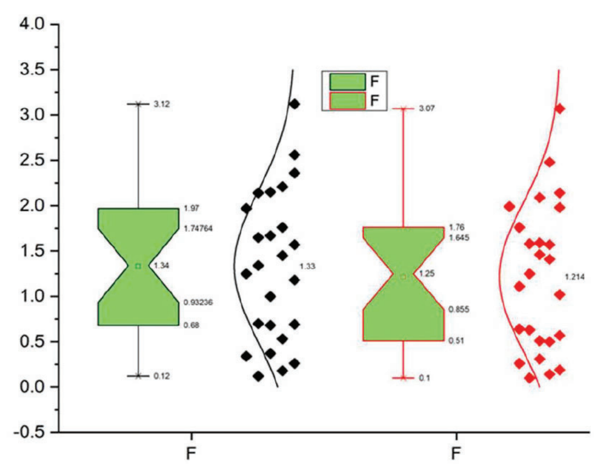

**Magnesium:** is one of the most abundant cation in freshwater and is essential for both plant and animal nutrition. It is responsible for causing hardness in water. Standard values of 30 mg/l (accepted limit) and 100 mg/l (permissible limit) have been set up by BIS for magnesium. Concentration of magnesium in groundwater samples varied from 9 mg/l to 1184 mg/l with an average mean of 308 mg/l in pre-monsoon season and in post-monsoon season magnesium concentration varied from 10 mg/l to 1186 mg/ l . Concentration of magnesium was minimum in Nayagaon village and maximum concentration was found in Paltli Khurd.



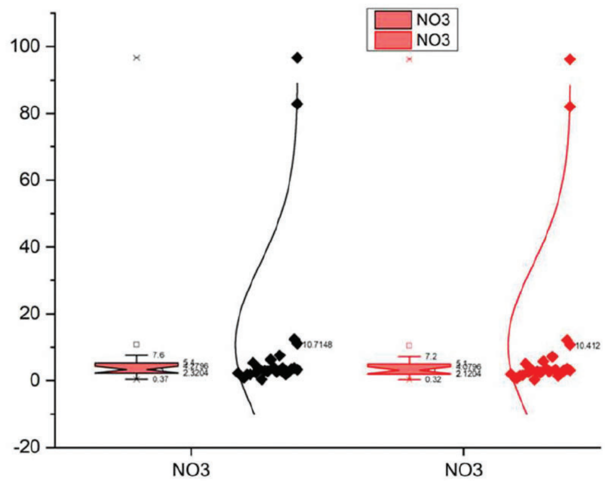

**Chloride:** Groundwater naturally contains chloride along with alkali and alkaline earth metals. BIS has set 250 mg/l as the acceptable limit for chloride in groundwater. Large amounts of chloride in drinking groundwater can alter the taste of water. Most of the villages in the study area showed high concentration of chlorides in drinking water. In the pre-monsoon season chloride range varied from 167 mg/l (seen in Nayagaon) - 4734 mg/l (Allika) with an average mean of 1455.4 mg/l whereas the post-monsoon chloride levels varied from 123 mg/l to 4567 mg/l.



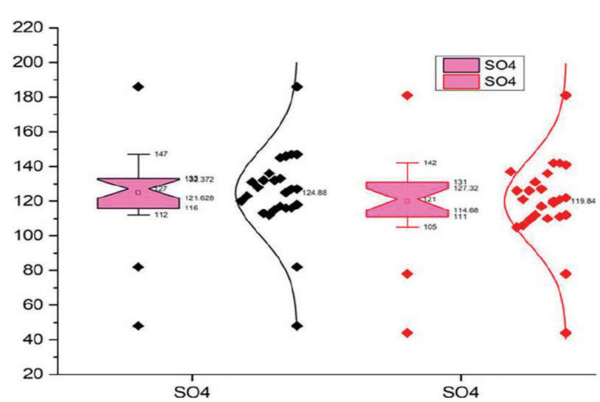

**Fluoride:** is a naturally occurring element found in groundwater due to weathering of rocks and leaching of minerals and sediments containing fluoride. BIS has prescribed 1mg/l as the acceptable limit and 1.5 mg/l as the permissible limit for fluoride in drinking water. Long term exposure to



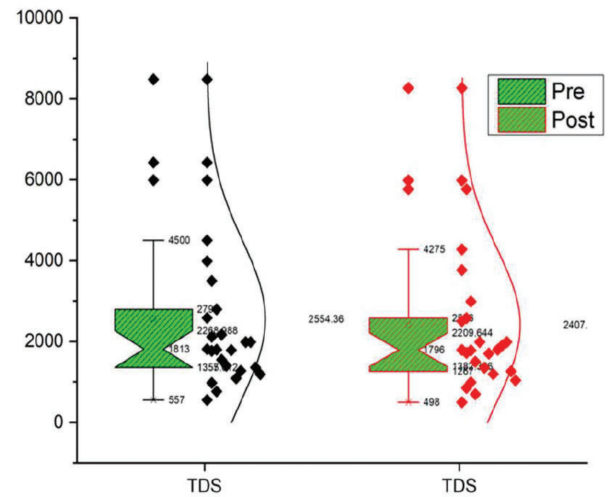
water containing excess fluoride can result in dental and bone disorders. High concentration of fluoride in groundwater was observed in the villages of Alahapur, Firozpur, Prithla, Sikanderpur, Asawati, Allika and Patlikalan. Kishorpur recorded the highest concentration of fluoride with a value of 3.12 mg/l. In the pre-monsoon season fluoride value varied from 0.12 mg/l (Rakhota) to 3.12 mg/l with an average mean of 1.33 mg/l whereas in postmonsoon the concentration of fluoride varied from 0.1mg/l to 3.07 mg/l.



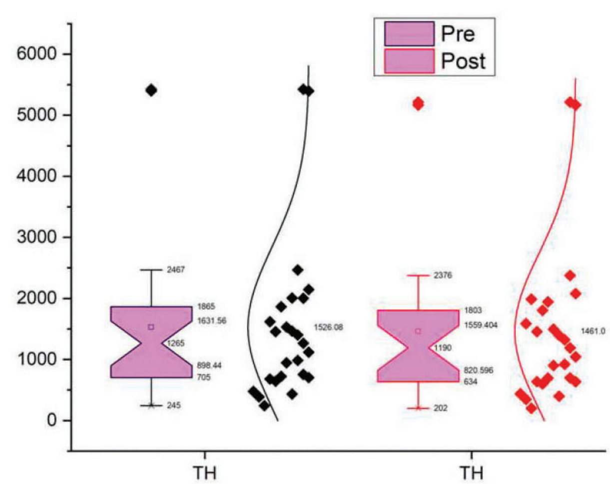

**Nitrates:** ia an important parameter of groundwater capable of inflicting diseases especially among infants. Fertilizers, industrial and domestic sewage are the major contributors of nitrogenous wastes. BIS has prescribed 45 mg/l as the acceptable limit for nitrates in drinking water. In the pre-monsoon season nitrate concentration varied from 0.37 mg/l to 96.7 mg/l with an average mean of 10.71 mg/l while in post monsoon season nitrate concentration ranged from 0.37 mg/l to 96.2 mg/l with an average mean of 10.41 mg/l. Asawati recorded the highest nitrate concentration while the lowest was observed in Paltli Kalan.




**Sulphates:** come from disintegration of salts of sulphuric acid and are found naturally in all water sources. BIs has prescribed 200mg/l as the acceptable limit and 400 mg/l (permissible limit) for sulphates and these are not a major source of health threat. Sulphate concentration in the pre-monsoon season ranged from 48 mg/l to 186 mg/l with an average of 124.88 mg/l whereas post monsoon concentration varied from 44mg/l- 181 mg/l with an average of 119.84 mg/l.




**TDS:** Natural and anthropogenic sources can contribute to high TDS in groundwater leading to altered taste and colour. High mineralization can be indicated in water containing high TDS. According to the BIS parameter, water containing TDS level less than 500 mg/l is considered excellent for potability. TDS level in the study area varied from 557 mg/l - 8480 mg/l with an average of 2554.36 in the pre-monsoon season and in post monsoon seasonTDS level varied from 498 mg/l - 8267 mg/l



with an average of 2407.52 mg/l. Kishorpur and Tatarpur recorded the minimum and maximum TDS levels respectively.

**TH:** Hardness ($CaCO_3$) of the water ranged from 202 mg/l to 5425 mg/l in the study area. Of all the groundwater samples analyzed, Nayagaon (22 mg/l), Gadpuri (345mg/l) had hard water and all the remaining 23 study areas contained very hard water.

**TA:** Alkalinity in groundwater is mainly due to the presence of bicarbonate of alkaline earth metals. Alkalinity above 200 mg/l in water provides it with an unpleasant taste but is not a major health threat. In the pre-monsoon season TA varied from 108 mg/l- 845 mg/l with an average of 543.92 mg/l and in post monsoon season alkalinity ranged from 98 mg/l-812 mg/ l with an average mean of 521.92 mg/l. Kishorpur showed minimum TA as 108mg/l while maximum value was observed in Joharkhera (845 mg/l).

**Table 3.** Classification of water based on WQI

| WQI range | Water category |
|---|---|
| 0-50 | Excellent |
| 50.1-100 | Good |
| 100.1-200 | Poor |
| 200.1-300 | Very Poor |
| >300 | Unfit for consumption |

## Water Quality Index

Based on WQI, drinking water can be classified into five main categories (Kangabam *et al.*, 2017; Uddin *et al.*, 2021) as shown in table 3. WQI for the year 2020 in the study area was calculated and it showed that during pre-monsoon season none of the sample came in excellent category, 4% of groundwater samples came in good category, 28% belonged to poor category, 40% groundwater samples in very poor category and 28 % groundwater samples were unfit for consumption. WQI for the post monsoon %compliance of 2020 again showed none of the groundwater samples were in excellent category, 4%

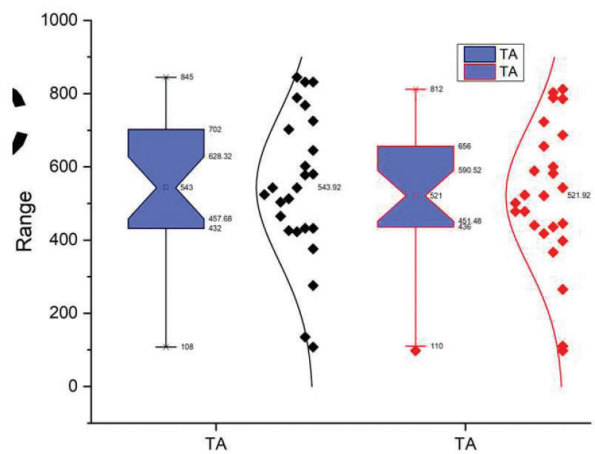



**Table 4.** Water quality classification based on WQI for the year 2020 (Pre monsoon andpost monsoon)

| S.No | WQI range | Water category | % Compliance pre-monsoon | % Compliance post monsoon |
|---|---|---|---|---|
| 1 | 0-50 | Excellent | 0 | 0 |
| 2 | 50.1-100 | Good | 04 | 04 |
| 3 | 100.1-200 | Poor | 28 | 32 |
| 4 | 200.1-300 | Very Poor | 40 | 36 |
| 5 >300 | Unfit for consumption | 28 | 28 | |

**Table 5.** Basic statistics of physico-chemical parameters of collected groundwater samples

| Parameter | Pre-Monsoon | | | | | Post-Monsoon | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Min | Max | AM | MD | SD | Min | Max | AM | MD | SD |
| pH | 6.5 | 7.65 | 6.93 | 6.9 | 0.26 | 6.23 | 7.25 | 6.6 | 6.45 | 0.27 |
| Ca | 30 | 440 | 104.2 | 81 | 81.21 | 28 | 438 | 101.64 | 79 | 81.27 |
| Mg | 10 | 1186 | 311.8 | 248 | 282.83 | 9 | 1184 | 308.08 | 244 | 282.45 |
| Cl | 167 | 4737 | 1455.4 | 1234 | 1132.98 | 123 | 4567 | 1378.4 | 1189 | 1075 |
| F | 0.12 | 3.12 | 1.33 | 1.34 | 0.81 | 0.1 | 3.07 | 1.214 | 1.25 | 0.79 |
| $NO_3$ | 0.37 | 96.7 | 10.71 | 3.3 | 23.55 | 0.32 | 96.2 | 10.41 | 3.1 | 23.45 |
| $SO_4$ | 48 | 186 | 124.88 | 127 | 23.96 | 44 | 181 | 119.84 | 121 | 23.93 |
| TDS | 557 | 8480 | 2554.36 | 1813 | 1908.6 | 498 | 8267 | 2407.52 | 1796 | 1837 |
| TA | 108 | 845 | 543.92 | 543 | 196.03 | 98 | 812 | 521.92 | 521 | 189.14 |
| TH | 245 | 5425 | 1526.08 | 1265 | 1289.4 | 202 | 5214 | 1461.04 | 1190 | 1246.35 |

Note : Min- minimum; max- maximum; AM- average mean; SD- standard deviation; TDS total dissolved solids; TA- total alkalinity; TH- total hardness groundwater samples were in good category, 32% in poor category, 36% in very poor range and 28% of the groundwater samples were unfit for consumption.

## CONCLUSION

It can be easily seen that groundwater in the study area is highly contaminated and needs some pre-treatment before it can be utilized for potability. WQI in the study area has revealed that more than 40% of ground water samples fall under the very poor category and above 20% of groundwater samples were unfit for drinking. Excess groundwater extraction, growing industries, excessive use of fertilizers and growing urbanization are the major causes of deteriorating water quality in the study area. TDS of the study area is also very high which can lead to an increase in salinity of soil. Apart from assessment of water quality for drinking purposes, WQI analysis can also be useful for establishing water treatment plants, choosing pipe material while laying of pipes and also it can help the town planners to select suitable places for industries, residential areas and waste disposal sites.

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