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Original Article

Hydrogeochemical Investigation and Qualitative Assessment in Jogeshwari Industrial Area of Aurangabad, Maharashtra, India

G.D. Gaikwad[1], S.M. Deshpande[2], K.R. Aher[3], V.R. Dasarwar[2]*

Author's Affiliations:
[1]School of Earth Sciences Swami Ramanand Teerth Marathwada University, Nanded, Maharashtra 431606, India.
[2]Post Graduate Department of Geology, Institute of Science, Caves Road, Aurangabad, Maharashtra 431004, India.
[3]Groundwater Survey & Development Agency, Senior Geologist office, Ghati raod, Survey No.488, Jalna, Maharashtra 431203, India

***Corresponding author**: Aher K.R. Groundwater Survey & Development Agency, Senior Geologist office, Ghati raod, Survey No.488, Jalna, Maharashtra 431203, India.

E-mail: kailashgis@gmail.com

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ABSTRACT

The primary objective of this paper is to study the groundwater quality parameters in the surrounding of Jogeshwari industrial area of Aurangabad district in Maharashtra. Groundwater samples were collected from Thirty-five (35) dug wells and bore wells (10 dug wells and 25 bore wells) at various locations within study area during pre and post-monsoon season. The water samples were analyzed for major ion chemistry using the methods recommended by APHA (1995). The study revealed that most of the parameters under taken to assess the water quality are exceeding the permissible limit and the groundwater samples have shown alkaline nature. The chemical parameters concentration of pH, Total hardness (TH), Calcium (Ca^{2+}), Magnesium (Mg^{2+}), Total dissolve solids (TDS), Electrical conductivity (EC), and chloride (Cl^{-}) have exceeded the maximum discharge limits on the other hands Sodium (Na^{+}) and Sulphate (SO_4^{2-}) values were found within the permissible limits prescribed by Bureau of Indian Standards, rendering wells in the area unfit for drinking or domestic purpose. In the present work attempts have been made to detect groundwater quality by using conventional hydrogeochemical methods.

KEYWORDS: Groundwater quality, spatial variations, Physico-chemical parameters, Jogeshwari,

INTRODUCTION

Water is indispensable because man cannot survive without water. Water is abundant globally but scares locally. Groundwater is ultimate and most suitable for fresh water resource for human consumptions in both urban and rural areas. The importance of groundwater for existence of human society cannot be overemphasized. There are several states in India where more than 90% Population are dependent on groundwater for drinking and other purposes. Groundwater is a source of drinking water, and even today more than half the world's population depends on groundwater for survival. Groundwater is the main source for rural water supply as well as for irrigation purposes. Groundwater is an indispensable commodity in the very limited quality to man and other living beings. Most of the Indian towns and cities do not have access to safe drinking water. Naturally groundwater recharged through rain water. In recent decades, utilization of groundwater has increased at an alarming rate worldwide. Exploitation of groundwater has increased greatly, particularly for irrigation, industrial and drinking purposes. Rapid urbanization and industrialization also tremendously increase the groundwater demand. Groundwater pollution due to industrial processes has attained serious dimensions in India. Both, the quality and quantity of ground water is severely threatened by industrial sewage.

Now it is recognized that the quality of the groundwater is just as important as its quantity. Groundwater is the basic and primary need for vital life processes on this planet, it also the resource adversely affects both qualitatively and quantitatively by all kind of human activity (Dasgupta and Purohit ;2001). Groundwater acts as a reservoir by virtue of large pore space in Earth materials, as a conduit which can transport water over long distances and as a mechanical filter which improves water quality by removing suspended solids and bacterial contamination (Sharma et al., 2001). Groundwater with unique chemicals having properties of dissolving and carrying in suspension a huge variety of chemical, it may get contaminate easily (Elango et al., 1992). The assessment of water quality is very important for knowing the suitability for various purposes. The monitoring of water quality is one of the important tools for sustainable development and provides important information for water management. Groundwater quality is based upon the physical and chemical soluble parameters due to weathering from source rocks and anthropogenic activities. In general, the quality of groundwater depends on the composition of recharge water, the interaction between the water and soil, the soil-gas, the rock with which it comes into contact in the unsaturated zone, and the residence time and reactions that take place within the aquifer (Fetter, 1990). Thus, the principal processes that influence the quality of water in an aquifer are physical, geochemical and biochemical changes in the concentrations of certain constituents due to natural anthropogenic causes may alter the suitability of groundwater.

The quality of groundwater is largely controlled by discharge-recharge pattern, nature of host and associated rocks as well as contaminated activities. Moreover, the nature and amount of dissolved species in natural water is strongly influenced by mineralogy and solubility of rock forming mineral. The quality of groundwater is function of various parameters which determines its solubility for drinking purposes (Trivedy and Goel, 1986). Rapid growth of population, urbanization, industrialization and increasing use of chemicals have resulted in water pollution and this problem is increasing day by day. This is not only a problem of developed countries and urban areas but has also become an uncontrollable problem of developing countries as well as several areas. The Rapid growth of urban area surrounding industrial cluster has further affected the groundwater quality due to over exploitation of resources and improper waste disposal practices (Raja and Venkatesan 2010).

STUDY AREA

The industrial belt of Jogeshwari is situated near about 19.2 km away from the Aurangabad district headquarter. The study area covered in part of the Survey of India Toposheets No. 46 M/5 and 46 M/1. lies between latitude 19^0 48′ 00″ N and 19^0 50′ 30″ N and longitude 75^0 11′ 30 ″ E and 75^0 13′ 30″ E. (Figure 1). The minimum to maximum temperature in the study area ranges from 11.1°C to

29.3°C, respectively. The study area experiences hot summer and a general dryness throughout the year except during the south west monsoon season, the average annual rainfall in the study area is about 740 mm. The study area falls under the basaltic lava flows of Deccan Volcanic Province. While alluvium deposits containing clay, silt and sand occupies a small portion. The important soil types are clayey, loamy and black cotton soil. The occurrence and movement of groundwater is controlled by the dissimilarity in water holding and yielding properties of these formations.

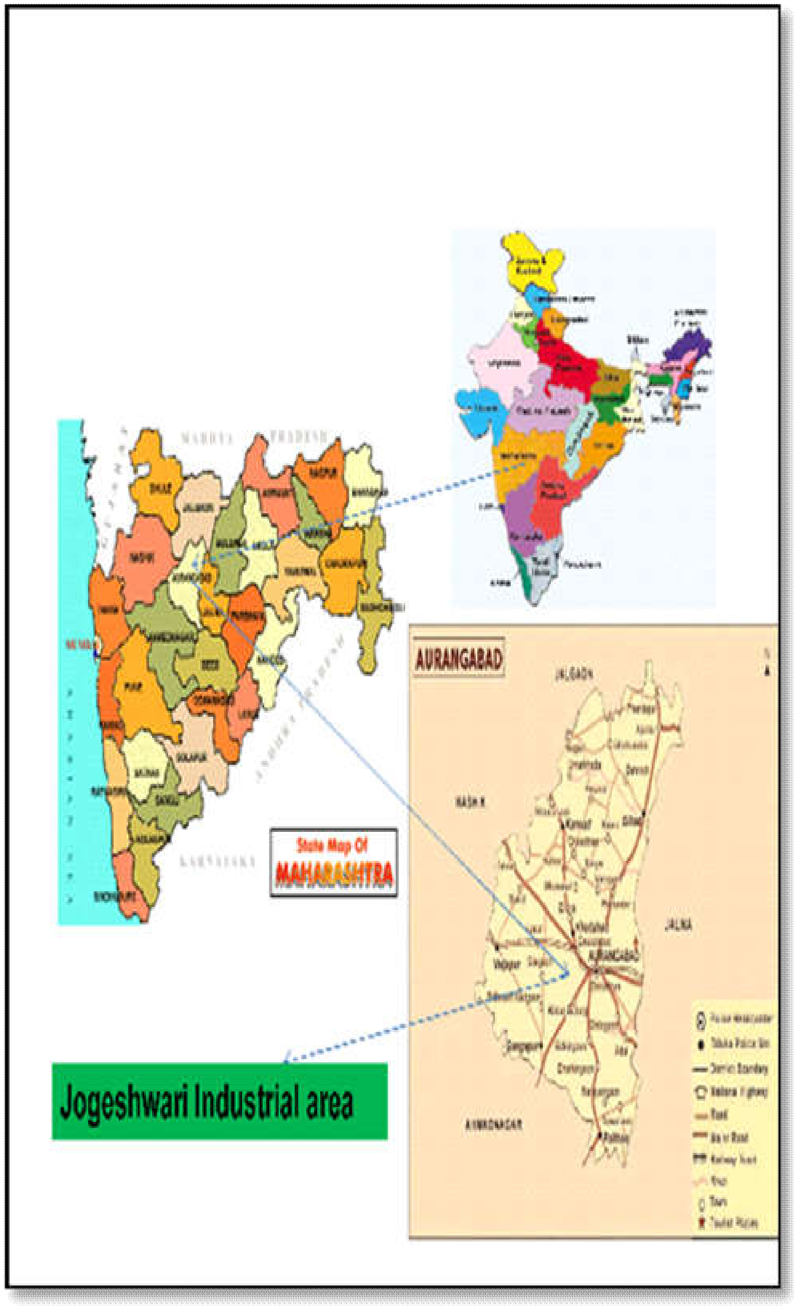


Figure 1: Location Map of the Study Area

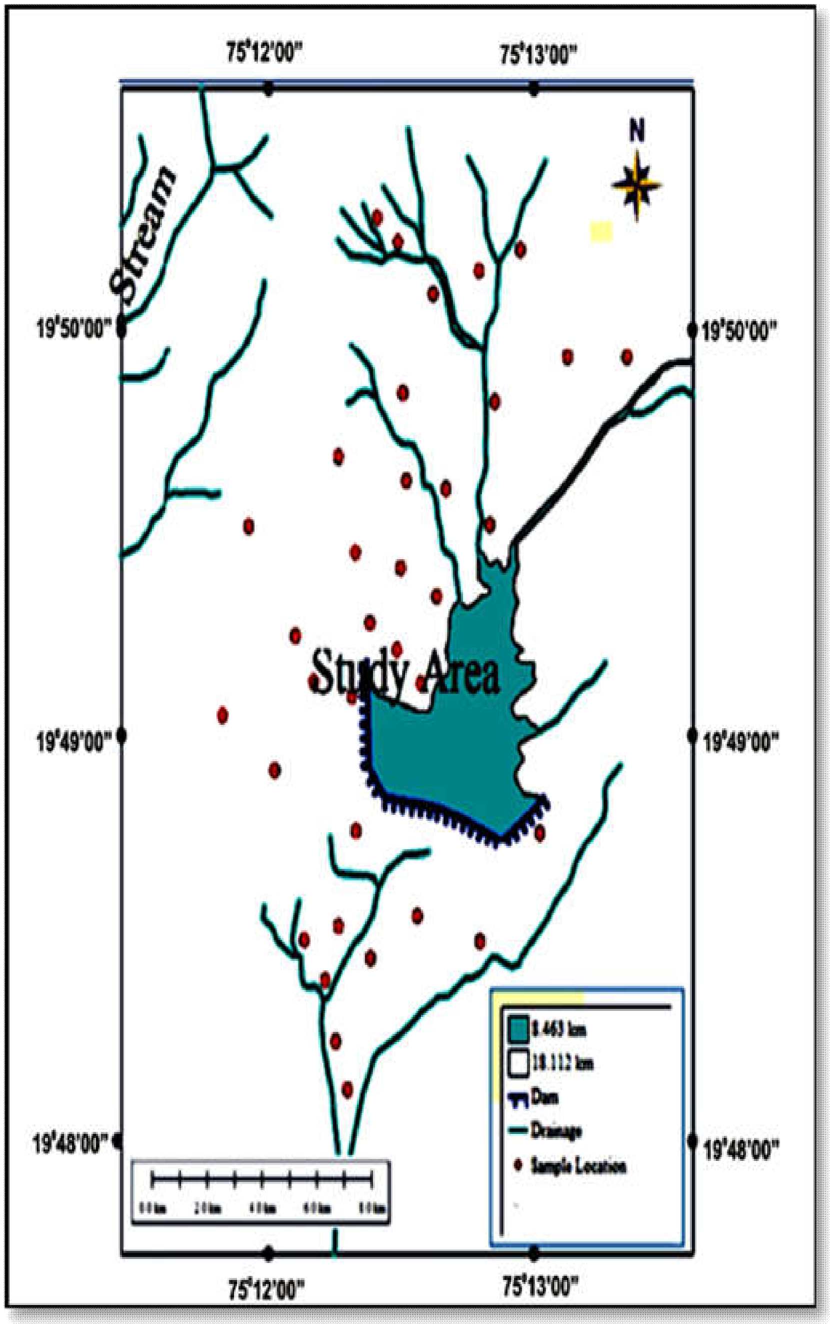


Figure 2: Sample location and drainage map of study area

MATERIAL AND METHODS

The sampling locations consist of Jogeshwari industrial belt of Aurangabad. Thirty-five (35) groundwater samples were collected (10 dug wells and 25 bore wells) at various locations within study area during pre and post-monsoon season (Figure 2). The Samples were stored in new 1000 ml polyethylene bottle that had been rinsed with distilled water twice before sampling. The EC and pH were measured in the field by portable EC and pH meters. In the laboratory, the water samples were analyzed for major ion chemistry using the methods recommended by APHA (1995). Total dissolved solids were estimated by ionic calculation method. Total alkalinity (TA); Carbonate (CO_3) and Bicarbonate (HCO_3) were estimated by titrating with 0.1N HCL. Total hardness (TH) and Calcium (Ca) were determined by titration method. Na and K^+ were measured by flame photometer, Cl^- was estimated by standard $AgNO_3$ titration and SO_4 were determining by UV visible spectrophotometer. Results of chemical analysis and comparison of physical parameters along with standards are represented in Table 1.

RESULTS AND DISCUSSION

Groundwater chemistry;

The results of 35 Groundwater samples physico-chemical parameters obtained were evaluated in accordance with the standards prescribed under Indian standard drinking water specification IS: 10500:2012 of Bureau of Indian Standards. The parameters exceeding the BIS permissible limits along with their permissible limits are discussed in table no. 1.

pH

The pH of a water sample measures its hydrogen ion concentration and indicates whether the sample is acidic, neutral or basic. The pH of groundwater sample varies from 7.14 to 8.22 for pre-monsoon season. In the post-monsoon season the pH varied from to 6.95 to 7.56. The pH of ground water sample in the pre-monsoon season was slightly higher than the post-monsoon season which indicate that the pH is weakly alkaline in post-monsoon season, gradually increases and becomes moderately alkaline in post-monsoon season (Figure 3.1). It is also observed that in pre-monsoon and post monsoon season all groundwater samples are within permissible limit as prescribed by BIS (1991).

Electrical Conductivity (EC)

The conductivity is the measure of capacity of a substance to conduct the electric current. Most of the salts in water are present in their ionic forms and capable of conducting current. The measurement of electrical conductivity is directly related to the concentration of ionized substance in water and may also be related to problems of excessive hardness and other mineral contamination (Jain et. al., 2009). The conductivity of groundwater sample ranged from 850 to 8760 µmhos/cm for pre-monsoon season. In the post-monsoon season the conductivity varied from 1950 to 9810 µ/mhos/cm. The EC of the most of the ground water sample in the post-monsoon season of is higher as compare to the EC of pre-monsoon season of (Figure 3.2). The higher values of EC in post-monsoon season can be related to the dissolution of minerals during these seasons (Ballukraya and Ravi 1999).

Total dissolved solids (TDS)

The determination of total dissolved solids is a measure of all salts in solution. The total dissolved solids indicate the general nature of salinity of water it ranged from 553 to 5694 mg/l for pre-monsoon season. In the post-monsoon season 2015 the total dissolved solids varied from 1268 to 6377 mg/l. The TDS of groundwater sample in the post-monsoon season was higher as compared to the TDS of the pre-monsoon season (Figure 3.3). The high concentration of TDS in groundwater in post-monsoon season may be attributed due to leaching of salts from ground surface by recharge (Ritesh Vijay et al., 2010).

Calcium (Ca)

Calcium is the fifth element and the third most abundant metal in the earth’s crust. Carbonate rocks are the chief source of calcium in natural water and on global scale they contribute 80% or more of the calcium in streams. This element is essential for the life of plants and animals, for it are present in the animal’s skeleton, in tooth, in the egg’s shell, in the coral and in many soils. The Ca content of ground water showed variation from 88.24 to 548.78 mg/l for pre-monsoon season. In the post-monsoon season the Ca varies from 110.48 to 623.58 mg/l. It is seen that most of the ground samples contents of Ca in post-monsoon season was higher as compared to the Ca of the pre-monsoon (Figure 3.4). It is also seen that (42.85 %) of the ground water samples of post-monsoon season and (51.42 %) of the pre-monsoon season, show the calcium contents below permissible limit and (48.57%) and (57.14%) shows exceeding permissible limit of pre and post-monsoon season respectively prescribed by BIS (1991) (Table 1) . The higher contents of Ca in post-monsoon suggest that Ca is derived from the lithology i.e. the calcium deposits presents in the alluvium as well as from the basalt and due to dissolution of precipitates of $CaCO_3$ and Ca Mg $(CO_3)_2$ during recharge (Datta and Tyagi 1996; Lakshmanan et al. 2003)

Magnesium (Mg)

The principal sources of Magnesium in the natural waters are various kinds of rocks, sewage and industrial wastes are also important contributors of magnesium. Also, in groundwater the magnesium is derived part from silicates and part from magnesium calcite or dolomite. The values of Magnesium from groundwater ranged between 52.35 to 226.32 mg/l for pre-monsoon season. In the post-monsoon season the values of Magnesium varied from 46.23 to 212.35 mg/l (Table 2.1 and 2.2). Most the Mg contents of groundwater sample of the pre-monsoon season are higher as compare to the post-monsoon season (Figure 3.5). It is also seen that (65.71 %) of the ground water samples of post-monsoon season and (60%) of the pre-monsoon season, show the magnesium contents below permissible limit and (40%) and (34.28%) shows exceeding permissible limit of pre and post-monsoon season respectively prescribed by BIS (1991) (Table 1). High value of Mg indicates that the groundwater is polluted because of industrial effluents (Pondhe et. al., 1997).

Total Hardness (TH)

Total Hardness is the quality parameter of groundwater mainly depends upon the amount of calcium or magnesium salts or both. The values of Total Hardness of ground water varied from 307 to 1508 mg/l for pre-monsoon season. In the post-monsoon season the values of Total Hardness varied from 353 to 1666 mg/l. It is seen that the total hardness of the post-monsoon season ground water samples was high as compare to pre-monsoon season (Figure 3.6). It is also seen that (54.28 %) of the ground water samples of post-monsoon season and (42.85%) of the pre-monsoon season, show the total hardness contents below permissible limit. It was observed that (45.71%) of the ground water sample of the pre-monsoon seasons and (57.14 %) of the ground water sample of the post-monsoon seasons, shows exceeding maximum permissible limit prescribed by the BIS (1991) during both the season of (Table 1). The higher values of hardness in the study area can be attributed to the disposal of untreated, improperly treated sewage and industrial wastes. Variation of Total hardness was more in post-monsoon samples as compared to pre-monsoon season due to leaching of calcium and magnesium bicarbonate through recharge. (Ritesh Vijay et. al., 2010).

Chloride (Cl)

Chloride originates from sodium chloride which gets dissolved in water from rocks and soil. It is good indicator of groundwater quality and its concentration in groundwater will increase if it mixed with sewage or sea water. Chloride salts, being highly soluble and free from chemical reactions with minerals of reservoir rocks, remain stable once they enter in solution. Most chloride in groundwater is present in sodium chloride, but the chloride content may exceed the sodium due to base-exchange phenomena. The Chloride (Cl^-) content of ground water varied from 327 to 1278 mg/l during pre-monsoon season. In the post-monsoon season the Chloride content varied from 469 to 2840 mg/l. Form the figure 3.7 it is seen that the sulphate contents of the groundwater of post-monsoon season is comparatively higher than its contents of the pre-monsoon season. It is also seen that the Cl^- contents of ground water is (97.14%) more than desirable limit and (2.85%) samples were exceeding maximum permissible limit in pre monsoon season and (77.14%) samples are more than desirable limits and (22.85%) samples are exceeding maximum permissible limit in post monsoon season, prescribed by the BIS (1991) (Table 1). The higher concentration of Chloride can definitely be attributed to the industrial activities in the vicinity, as these locations are very close to a cluster of Automobile Industries, Wire and plastic industries (Srinivasamoorthy et. al., 2008).

Bicarbonate (HCO_3)

Alkalinity is the measure of the capacity of the water to neutralize a strong acid. The Alkalinity in the water is generally imparted by the salts of carbonates, silicates, etc. together with the hydroxyl ions in Free State (Trivedi and Goyal, 1986). The dissolved carbon dioxide derived from rain is the primary source of carbonate and bicarbonate ions in groundwater. The Bicarbonate Alkalinity (HCO_3) content of the ground water ranged from 45 to 405 mg/l in pre-monsoon season. In the post-monsoon season, the HCO_3 value varied from 190 to 500 mg/l (Table 1). From the figure 3.8 it is observed that the bicarbonate content of the groundwater of post-monsoon season is comparatively higher than its contents of the pre -monsoon season.

Sodium (Na)

Most of the sodium salts are soluble in water, but take no active part in chemical reactions, as do the salts of alkaline earths. Sodium salts tend to remain in solution unless extracted during evaporation. The sodium (Na) content of the groundwater ranged from 28 to 112 mg/l in pre-monsoon season. In the post-monsoon season, the Na value varied from 31 to 186 mg/l (Table 1). The sodium (Na) content of the groundwater of the post-monsoon season is higher as compare to the pre-monsoon season (Figure 3.9).

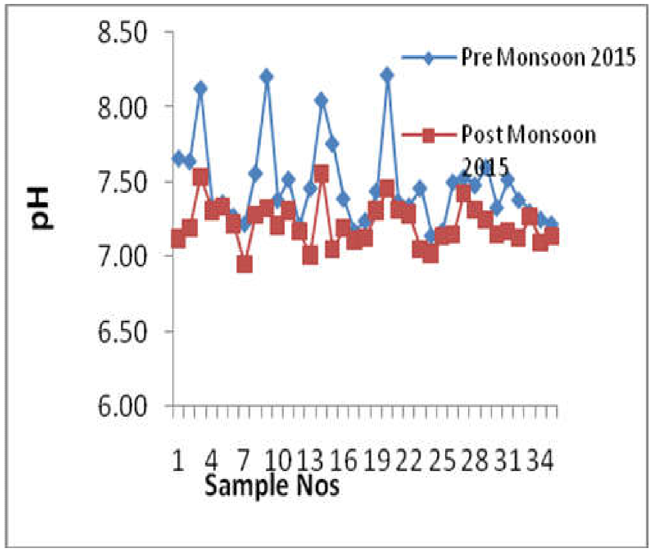
Potassium (K)

Potassium is an essential element for humans, plants and animals and derived in food chain mainly from vegetation and soil. The main sources of potassium in ground water include rain water, weathering of potash silicate minerals, use of potash fertilizers and use of surface water for irrigation. The potassium (K) content of the groundwater ranged from 0 to 15 mg/l in pre-monsoon season. In the post-monsoon season, the K value varied from 0 to 16 mg/l (Table 1). The Potassium (K) is not present in all groundwater sample therefore it is not possible to comment on the basis of variation diagram.

Sulphate (SO_4)

The Sulphate content in groundwater generally occurs as soluble salts of calcium, magnesium and sodium. Groundwater present in igneous or metamorphic rocks contains less than 100 mg/l sulphate (Davis and Dewiest 1966). The sulphate content of atmospheric precipitation is only about 2 mg/l, but a wide range in sulphate content in groundwater is made possible through oxidation, precipitation, solution and concentration, as the water traverses through rocks. The sulphate (SO_4) content of the groundwater ranged from 59.45 to 102.76 mg/l in pre-monsoon season. In the post-monsoon season, the sulphate (SO_4) value varied from 70.76 to 104.97 mg/l (Table 1).

Form the figure 3.10 it is seen that the sulphate contents of the groundwater of post-monsoon season is comparatively higher than its contents of the pre-monsoon season. It is also observed that the SO_4 content of 100% of the groundwater is below desirable limit in both seasons (Table 1). The increases of SO_4 in post-monsoon season may be due to action of leaching and anthropogenic activities in an environment by release of sulfur gases from industries and urban utilities get oxidized and enter into the groundwater system (Saxena, 2004).



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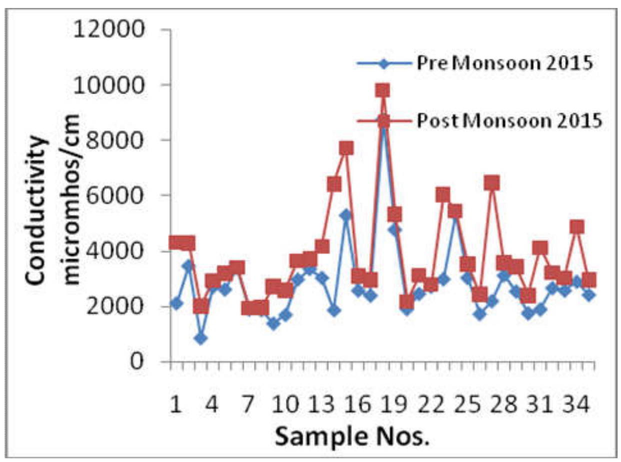

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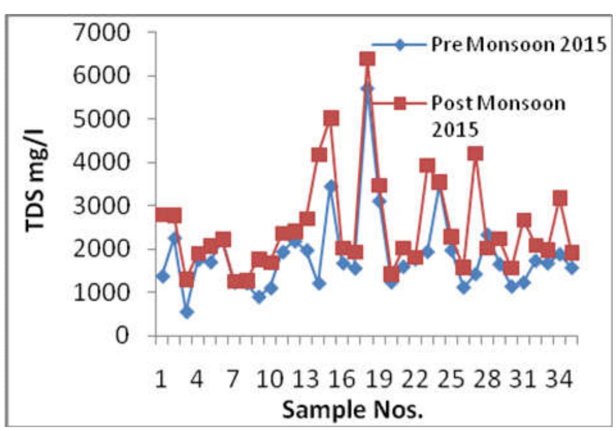

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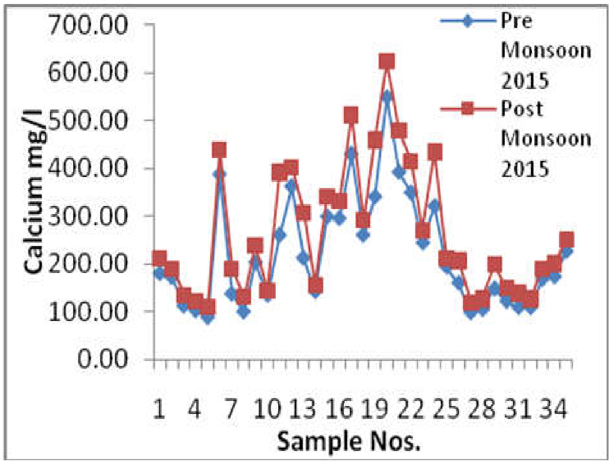

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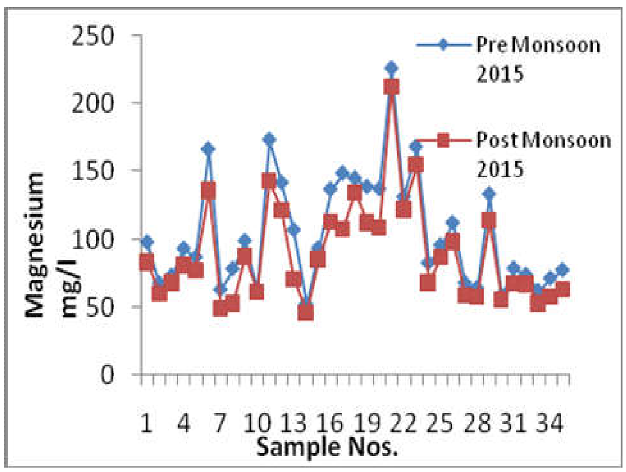

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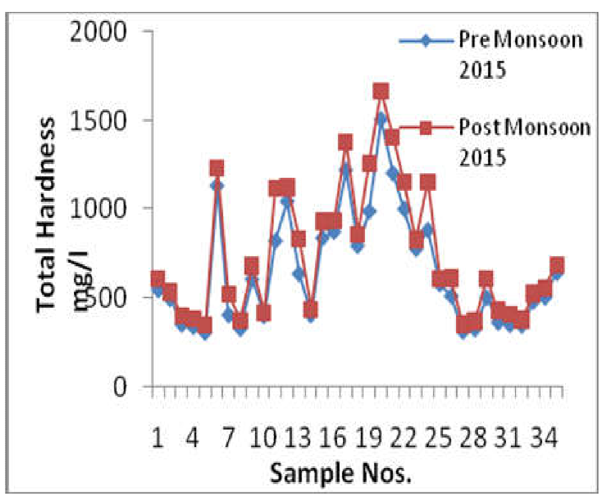

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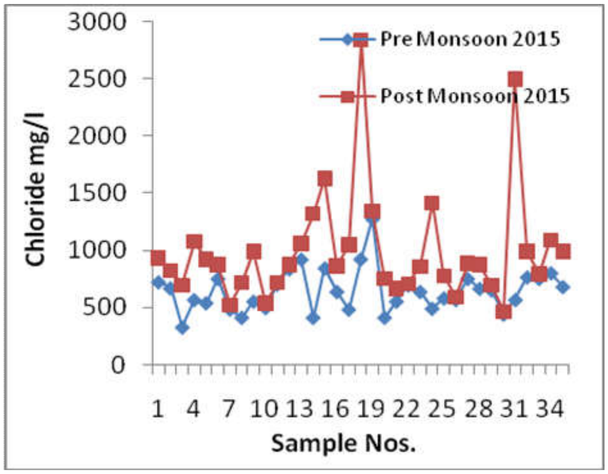

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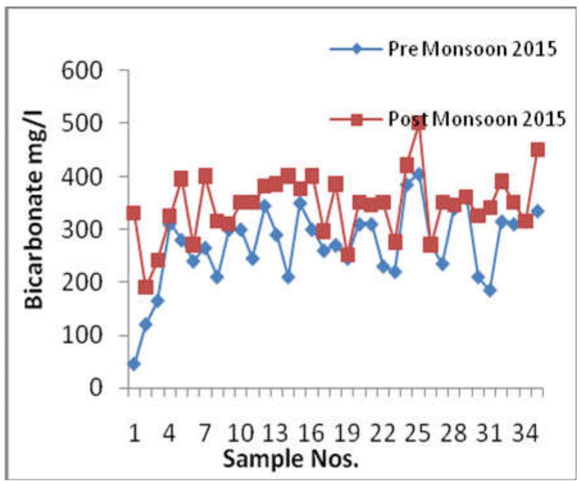

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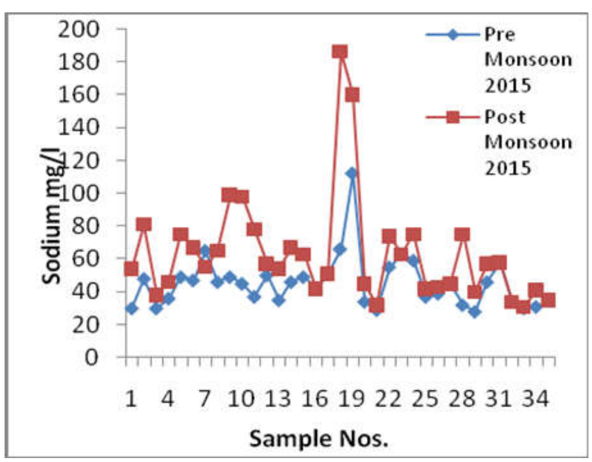

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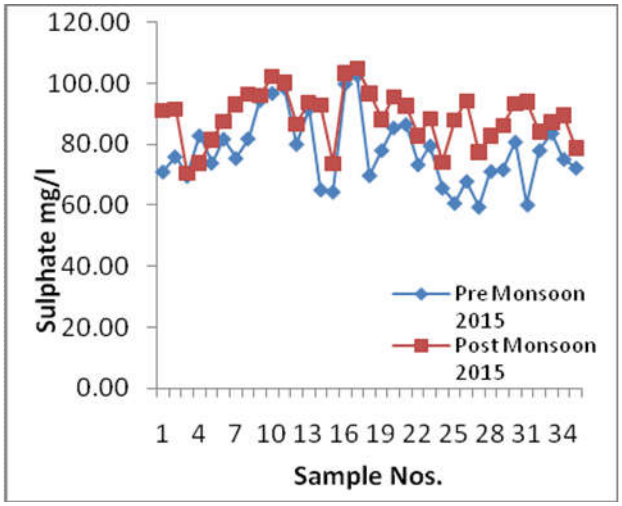

Figure 3.10:

Table.1: Comparison of chemical parameter of groundwater samples with standards.

Sr. No.	Quality Parameter	WHO International Standards, 2006		Bureau of Indian Standards IS: 0500:1991		Season Year	<DL	>DL< MPL	>MPL
		Highest desirable	Maximum permissible	Highest desirable	Maximum permissible				
1	**pH**	6.5-8.5	6.5-9.2	6.5- 8.5	-	Pre-monsoon	-	100	-
						Post-monsoon	-	100	-
2	**Total Hardness as $CaCO_3$ (mg/l)**	100	500	300	600	Pre-monsoon	-	54.28	45.71
						Post-monsoon	-	42.85	57.14
3	**Calcium (mg/l)**	75	200	75	200	Pre-monsoon	-	51.42	48.57
						Post-monsoon	-	42.85	57.14
4	**Magnesium (mg/l)**	30	150	30	100	Pre-monsoon	-	60.00	40.00
						Post-monsoon	-	65.71	34.28
5	**Electrical Conductivity (mg/l)**	500	1500	--	--	Pre-monsoon	--	2.86	97.14
						Post-monsoon	--	--	100
6	**Total dissolved solids (mg/l)**	500	1500	500	2000	Pre-monsoon	-	74.28	25.71
						Post-monsoon	-	37.14	62.85
7	**Chloride (mg/l)**	200	600	250	1000	Pre-monsoon	-	97.14	2.85
						Post-monsoon	-	77.14	22.85
8	**Sulphate (mg/l)**	200	400	200	400	Pre-monsoon	100	-	-
						Post-monsoon	100	-	-
9	**Sodium (mg/l)**	--	200	--	--	Pre-monsoon	100	-	-
						Post-monsoon	100	-	-

3.1. Classification of Groundwater based on Pipers trilinear diagram

Piper trilinear (Piper 1944) is used in the present study to determine the hydrochemical facies. These diagrams express similarity and dissimilarity in the chemistry of water based on major cations and anions. Piper (1944) has developed a form of trilinear diagram, which is an effective tool in segregating analysis data with respect to sources of the dissolved constituents in ground water, modifications in the character of water as it passes through an area and related geochemical problems. The chemical analysis data of all the samples collected from Jogeshwari industrial area of Aurangabad has been plotted on trilinear diagram. The Piper trilinear diagram combines three areas of plotting, two triangular areas (cations and anions) and an intervening diamond-shaped area (combined field). Initially the data in parts per million (mg/l) was corrected into equivalents per million (epm). Using this diagram, water can be classified into different hydrochemical facies.

It is seen from the figure 4, out of 35 samples of pre-monsoon season, 35 samples (100%) represent to Alkaline earths (Ca + Mg) exceeds alkalies. (Na+K), and 35 samples (100%) represents Strong acids exceeds weak acids hydrochemical facies, 35 samples (100%) samples fall in "non-carbonate hardness (secondary salinity) exceeds 50%" facies (Table 2). From the figure 5, it is seen out of 35 samples of post-monsoon season 2015, 35 samples (100%) represent to Alkaline earths (Ca + Mg) exceeds alkalies (Na+K) and 35 samples (100%) represents Strong acids exceeds weak acids hydrochemical facies, 35 samples (100%) samples fall in "non-carbonate hardness (secondary salinity) exceeds 50%" facies. (Table 2).

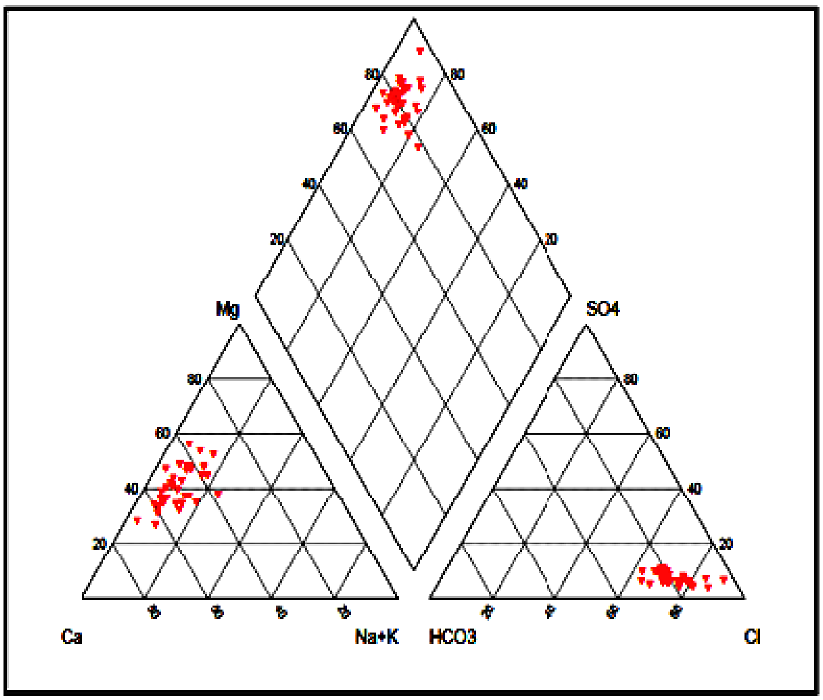

Figure 4: Piper Trilinear diagram- pre-monsoon.

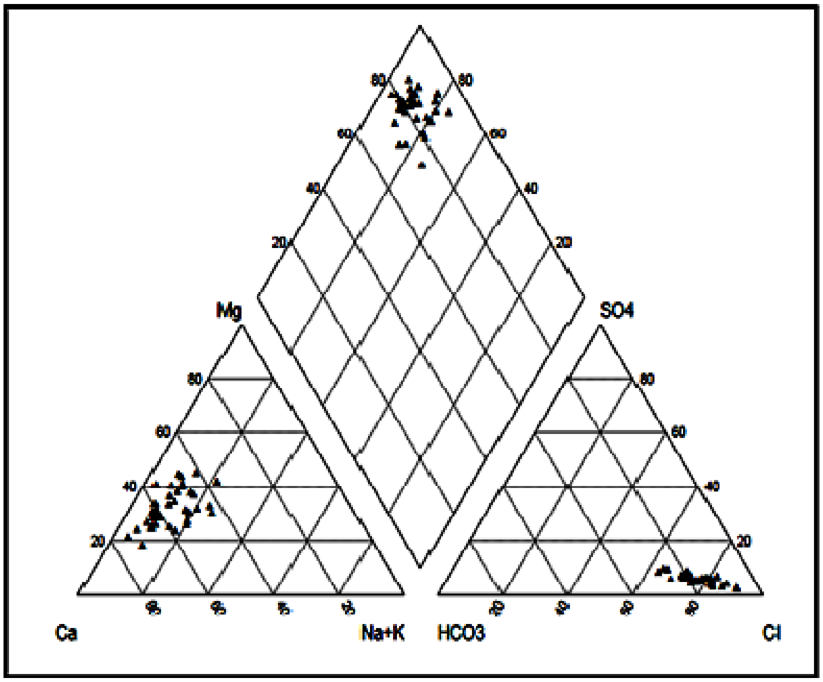

Figure 5: Piper Trilinear diagram- post-monsoon.

Table 2: Distribution of Groundwater samples according to water types with reference to the Piper's trilinear diagram

Sr. No.	Type of Facies	Pre-monsoon	Post-monsoon
1	Alkaline earths exceeds alkalies	35	35
2	Alkalies exceeds alkaline earths	-	-
3	Weak acids exceeds strong acids	-	-
4	Strong acids exceeds weak acids	35	35
5	Carbonate hardness (secondary alkalinity) exceeds 50%	-	-
6	Non-carbonate hardness (secondary salinity) exceeds 50%	35	35
7	Non-carbonate alkali (primary salinity) exceeds 50%	-	-
8	Carbonate alkali (primary alkalinity) exceeds 50%	-	-
9	None of the cation and anion pairs exceeds 50%	-	-

CONCLUSION

Drinking water quality: According to the chemical composition of groundwater of the study area. pH is in the range of 7.14 to 8.22 in pre monsoon season 2015 and 6.95 to 7.56 in pre monsoon season, indicating near to neutral. TDS, which is a measure of the total concentration of dissolved salts, is in pre-monsoon 553 to 5694 mg/L and in post monsoon 1268 to 6377 mg/L. The concentration of TA varies in pre-monsoon from 45 to 405 mg/L and in post-monsoon from 190 to 500 mg/L. The concentration of TH varies in pre-monsoon 360 to 1508 mg/L and 353 to 1666 mg/L in post-monsoon. To ascertain the suitability of groundwater for drinking and public health purposes, hydro geochemical parameters of the study area are compared with the guideline recommended by World Health Organization (WHO, 2006) and BIS (1991) which shows that groundwater has unsuitability for drinking purposes and public health because the concentration of TDS, TH, Ca, Mg and SO_4 in the groundwater are observed to be more than the concentrations of recommended limits for drinking purpose. The observed chemical variations in both seasons may be because of rock-water interactions, ion-exchange reactions and percolation of industrial waste water from the surrounding industrial fields. Most of the parameters under taken to assess the water quality are exceeding the permissible limit. Overall the groundwater increases major ion concentration because of industrial activity in and around the study area. The influences of human interventions have adversely affected the groundwater quality in the study area.

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