ISSN No:-2456-2165

Geochemistry and Assessment of Groundwater Quality in Municipal & Industrial (MIDC) Area of Aurangabad City, Maharashtra, India

Tejankar A.V.[1], Chakraborty M. N.[2]
[1]Pro Vice Chancellor, Dr. Babasaheb Ambedkar Marathwada University, Aurangabad (first author)
[2]Junior Research Fellow, Deogiri College, Aurangabad (Corresponding Author)

Abstract: - One of the most important crises of this century is the scarcity of water. The accelerated growth of industries and the indiscriminated discharge of the industrial waste water around their peripheries are causing heavy damage to the groundwater quality. The research paper consists of the assessment or the study of the water samples collected from 55 locations in Aurangabad city out of which 70% samples are collected from industrial areas while the remaining ones are of domestic bore and dug wells. The various geo-chemical parameters of the groundwater samples were firstly determined and then they were studied by adopting certain standard geochemical laboratory methods denoted by APHA (2002) book and also in Trivedi and Gohel (1984). Later on Arc GIS software was used to make maps out of the data collected. From the study we finally have come to a conclusion that most samples that were collected from the study area are polluted. The majority of the collected groundwater samples exceeded the permissible limit given by BIS (1991) and WHO (1993).

The geo-chemical parameters which were analyzed in the laboratory were Ph (Potenz of hydrogen), TDS (Total dissolved solids), TH (Total hardness), Calcium, Magnesium, Sulphate and Chloride. Discussion held by the author with the residents of the area under study is noted. People of the study area are facing health problems like skin, throats infection because of this water. Based on the studies, it has been recommended to the local authorities, to take suitable control measures to reduce pollution level of groundwater sources before it becomes unmanageable.

Keywords: *- Groundwater, Hydrogeochemistry, Contamination, Industrialization, Municipal & Industrial Area, Geochemical Parameters.*

I. INTRODUCTION

A vital and critical role has been played by the water resources in our civilization throughout our history of development. Water resources still in the modern times continue being of critical importance in the economic growth of our society. In a developing economy like India, the aim of development and management of water resources is one of the main strategies for the growth of the economy. But now in the recent years, indiscriminate utilization and use of this resource for various purposes have created several drastic problems like water logging and soil salinity during the agricultural use and environmental pollution of various geochemical parameters because of the various municipal and industrial waste use (Chhoubisa et al. 1995; Jain et al. 1996, 1997; Singh et al 1996; Rao & Rao, 1990; Rao et al. 1997; Rao and Prasad, 1997).

Industries throwing their effluents in flowing waters, do not strictly regulate their pollutant level and directly discharge their effluents into the nearby open pits, these pits get connected to the groundwater channels and directly or indirectly contaminate the groundwater aquifers. These effluents when not treated can pollute and damage the resources (Olayinka 2004). The industrial cluster of Aurangabad is known to be one of the fastest developing industrial sector. This growth has deteriorated all the drinking water sources of the city and groundwater is also one of those resources. As the surface water supply is unable to quench the thirst of the citizens, groundwater is the only source left for quality potable water. But certain problems have aroused about contamination of water in some parts of the city, particularly along the industrial circuits and aligned areas due to the indiscriminate infusion of contaminated water in the drinking water aquifers. Once the groundwater gets contaminated or impure, it becomes unusable as it cannot be restructured or remediated and it stays in the same hazardous condition for decades (Mishra et al. 2005). People in the study area, are using contaminated water for all their daily purposes for example cleaning, washing and other domestic purposes. Hence, the research study aims to assess the pollution of the area and an initiative is taken to collect 55 samples of groundwater from various locations dug well and bore well in and around the Chikalthana, Shendra, Waluj, Paithan MIDC i.e. industrial area of Aurangabad also the area which comes under the municipal corporation and to assess the suitability and causes for decline of water quality in this region. So not only we are studying the industrial contaminants but also the domestic effluents of the groundwater.

II. DETAILS OF THE AREA OF INTEREST

Aurangabad city is head quarter of district and Marathwada region and is located on the latitude of 19°53'50" north and longitude of 75°22' 46" east which covers area of approximately 138.5 sq. km. Aurangabad lies at an important position on the Deccan Plateau. Aurangabad city stands in Dudhna valley which lies in between Lakenvara range and Satara hills which lie in north and south respectively. The valley consists of a general breadth of about 10 miles and is open from the east direction, but on the west, while the northern range show deflections and curvatures towards the city creating a spur close near the suburbs. Along the center it deepens. The study area, Chikalthana, Shendra, Hudco, Paithan MIDC, Waluj industrial area is covered from Toposheet No. 46 M/5 provided by the Survey of India mostly. The area covering 30 sq.km lies to the eastern, western, northern and southern part respectively of Aurangabad city and has more than 2000 industries dominated by chemical, pharmaceutical, pesticides, fertilizer and other similar dependent industries.

A. Topography:

General topography of the city is mostly undulating type. Altitude of the city goes on increasing towards the north. Aurangabad city is surrounded on all the sides by hilly ranges except east that too at the attitude of 611 mt. above msl. On the Northern side the borders are covered by Jathwada (Lakenvara) hill ranges and south boundaries are described by the Satara hills.

B. Climate:

The climate in Aurangabad is mostly a very dry hot summer and a general warm and dry weather throughout the year except in monsoon when the southwest monsoon season arrive from June to September while October and November is the post monsoon season. The temperature of the city mostly lies between 24°C and 44°C during the warm months (April/May) and from 13 to 28°C during the winters (December/January). Annual average rainfall over the city is about 725 mm.

C. Geology:

The entire city is mostly covered of Deccan Trap basaltic terraneous lava flows of aging from the upper Cretaceous to Eocene age. Thin alluvial deposits lie over the deccan flows. The basaltic terrain of the Deccan Trap is the only major geological formation occurs in the Aurangabad district. The traps show horizontal dimensions and each flow consists of two units distinctively. Upper strata consists of vesicular basalts which have their amygdales filled with zeolites, while the bottom layer is massive. A number of lineaments have been identified on the satellite imagery and are analyzed to be fracture zones due to linear pattern which they exhibited by the darker tone and drainage. These lineaments are serve to be very favorable in terms of storage for groundwater. The soil in the region is black which shows the content of Potash and Montmorillonite (Analyzed in laboratory)

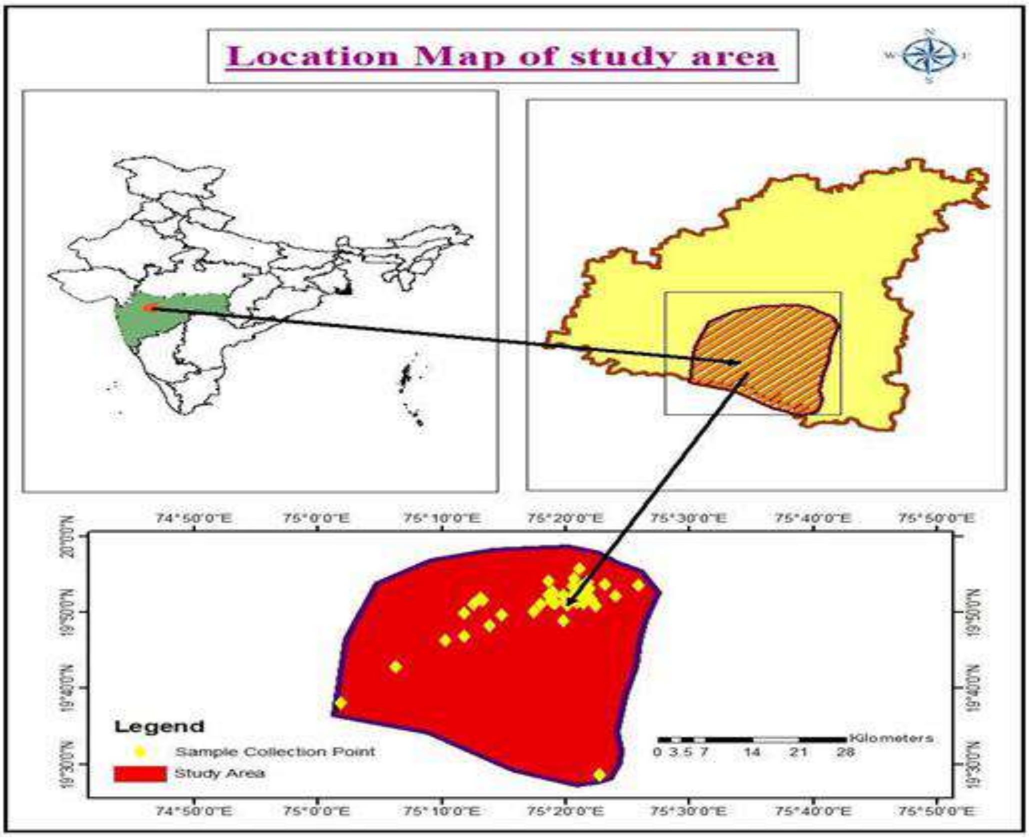

Fig 1:- Map of The Study Area

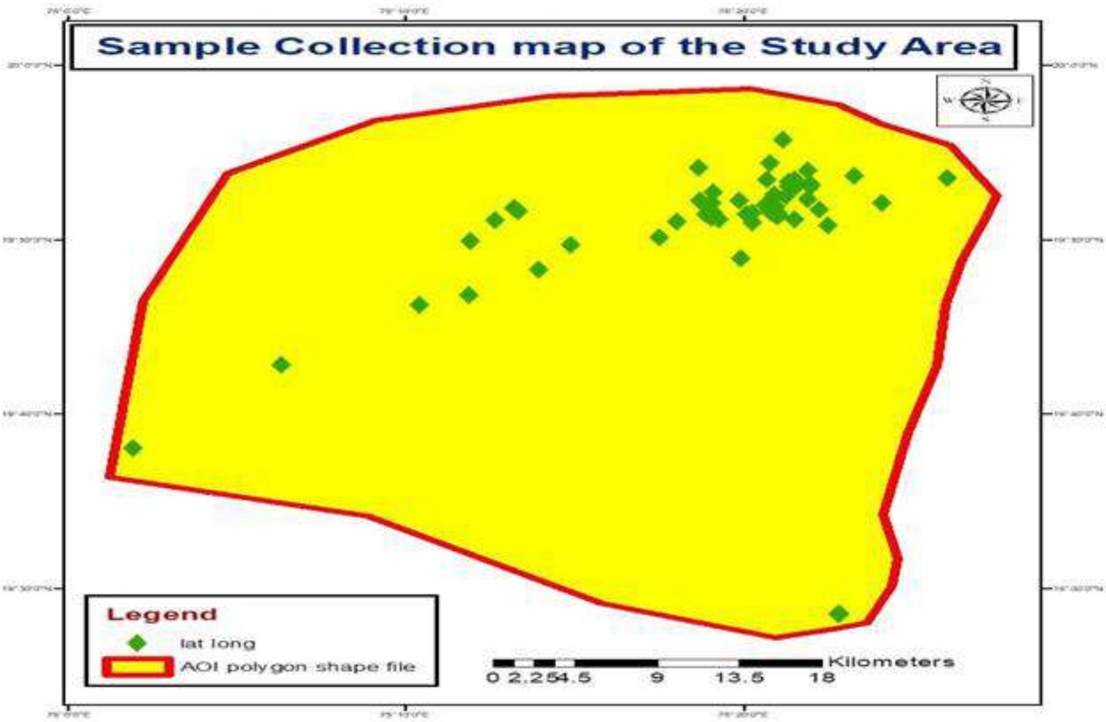

Fig 2:- Sample Collection Map from the Study Area

III. MATERIALS AND METHODS

To evaluate the physicochemical parameters of the study area, various samples of groundwater from 55 selected sites of dug wells and bore wells have been collected in good quality bottles of plastic desirably polyethylene of one-liter capacity. Prior to the collection of samples all the bottles were cleaned with the good quality potable water and then wiped off well with a cotton or muslin cloth. The physical parameters of pH and TDS (Total Dissolved Solvents) were determined during the collection itself. The other chemical parameters were determined and analyzed immediately in the lab as soon as possible according to the standard geochemical methods of water examination given by Trivedi and Gohel (1984). The analyzed final values were compared with the standards given by the Bureau of Indian Standards (BIS, 1991) and World Health Organization (WHO,1993).

A. Hydrogeochemistry:

The quality of groundwater is a vital subject to be understood as it is the main factor to decide its potability for domestic and drinking purposes. The determination of physicochemical parameters of water samples were carried out by adopting standard geochemical methods given by Trivedi and Gohel (1984). The pH and Conductivity was measured with respective electronic machines. TDS was found using the universal formula given by Trivedi and Gohel (1984). The chemical parameters like Total hardness (TH), Calcium (Ca), Chlorides (Cl), was determined titrimetrically. Magnesium (Mg) was calculated by the procedures denoted in the same book which includes the process of taking differential values of Total Hardness and Calcium concentrations and thereafter the results are found. Sulphate (SO4) was determined by using Visible Spectrophotometer.

All the results after the analysis of the various geochemical parameters are denoted in the table no. 1 while table 2 shows the critical parameters and also the conclusion of the various parameters in the BIS (1991) permissible limits in a tabulated format for clear understanding.

➢ *pH:*

The pH values of groundwater ranged from 5.18 to 10.8 with an average value of 7.9 from the above analysis we can observe that the water analyzed is mostly alkaline in nature. The pH is negative log of the activity of the hydrogen ion in a solution. The pH was measured by using pH meter (Elico Cat No CL54 model). The instrument used in this was checked for errors against 4.0 and 9.2 buffer solution. All standard precautions necessary for reliable pH determination were observed.

pH value is a negative logarithm of hydrogen ion concentration H-. It is a quantitative expression for acidity or alkalinity of water. The pH scale extends from 0 to 14 with the value of 7 corresponding to exact neutrality at 25°C. Thus the pH for pure water is 7. If the pH stands to be less than 7, the water is said to be acidic and if it stands to be more than the neutral value then the water is said to be alkaline in nature. Normally the pH value of groundwater ranges from 5 to 8. Water with pH between 7 and 8 is ideal and suitable for most of purposes. As per the Indian Standard Institution (1983), the pH values for drinking water should be in between 6.5 to 8.5. On completion of the analysis maps were made with the use of Arc- GIS software to picturize the data.

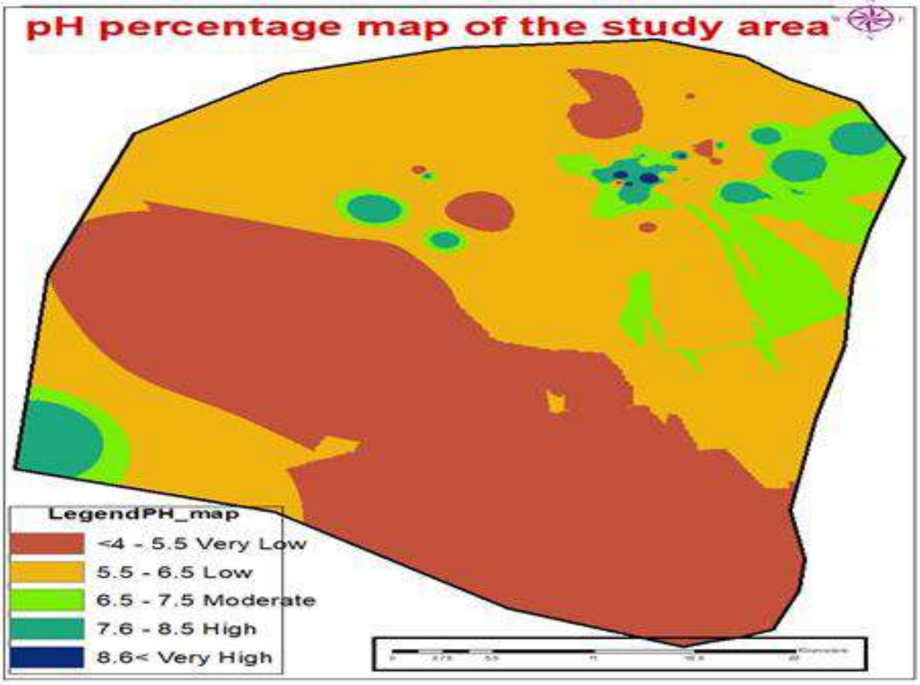

Fig 3:- pH Percentage Map of the Study Area

➢ *Total Dissolved Solids (TDS):*

The total dissolved solid (TDS) amounts represent the general nature of water. The TDS value analyzed ranged from 380 to 3210. The specified desirable total limit is 500mg/1, and the maximum permissible limit is 2,000mg/l. The analysis report shows 7 (12.73%) samples were exceeding the permissible limit as prescribed. Water with high TDS value has inferior value and induces a non-favorable physiological reaction in human health and it also causes a gastrointestinal irritation (B.S.Shanker et.al 2008). In natural water dissolved solids are composed of Carbonates, Bicarbonates, Chlorides, Sulphate and Phosphate. Dissolved salts are very important parameter in drinking water. Total dissolved solids were calculated by using following formula given by APHA (1995).

$$TDS= EC \times 0.65$$

Total dissolved solids of groundwater include all solids in solution, whether ionized or not and do not include suspended matter. On completion of the analysis maps were made with the use of Arc- GIS software to picturize the data.

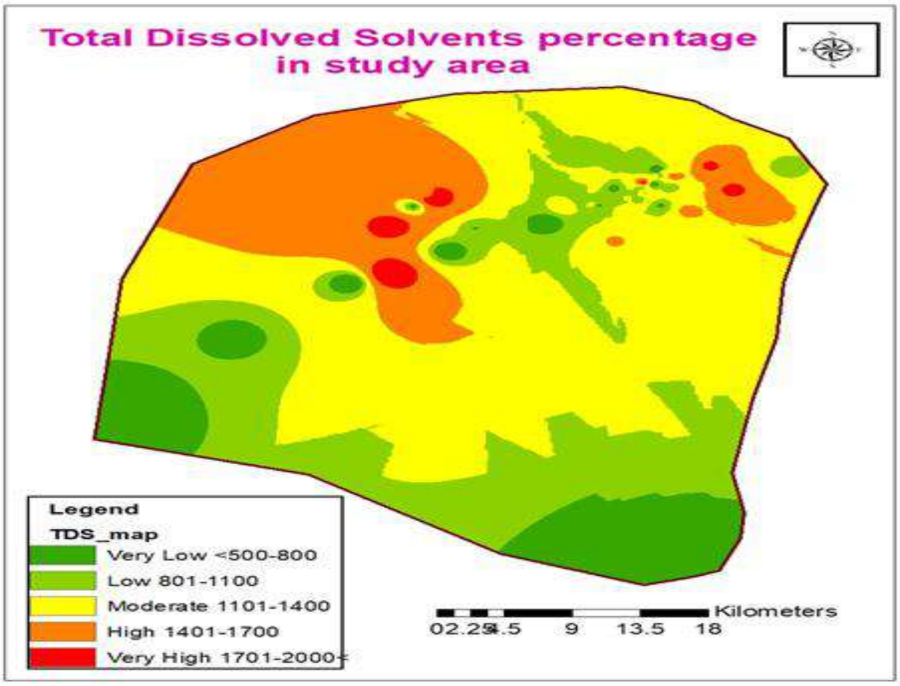

Fig 4:- Map Showing Total Dissolved Solids Percentage in the Study Area

ISSN No:-2456-2165

➢ *Calcium (Ca):*

Light percentage of calcium is always present (rocks or minerals present in rocks), which may be because of some industrial wastes, mining by-products, and agricultural wastes led into the groundwater sources. When the water samples were analyzed in laboratory various results were found which ranged from 15 to 919 mg/l with an average value of 260.66 mg/l. The limit of Calcium (Ca) for drinking water desirably is specified as 75 mg/l and a maximum permissible limit of 200 mg/l. When analyzed, the observations were: 2 (3.64%) samples were exceeding the maximum permissible limit. Calcium is the major constituent of many rock forming minerals. The element calcium occurs in the upper continental crust. Calcium minerals occur as Silicates, Carbonates, Phosphates, Sulphates and Borates. In 50 ml groundwater sample was taken and 2 ml of 1N Sodium Hydroxide (NaOH) solution was added. Then approximately 100 to 200mg of murexide indicator was added. Contents of the flask were titrate against 0.01N Ethylene Diamine Tetra acetic acid (EDTA) solution resulting pink colour changes to purple, which indicates the end point titration. On completion of the analysis maps were made with the use of Arc- GIS software to picturize the data. The samples were analyzed by using the following formula:

$$\text{Total calcium in Mg/l} = \frac{\text{ml EDTA used X 400.8}}{mlofsample}$$

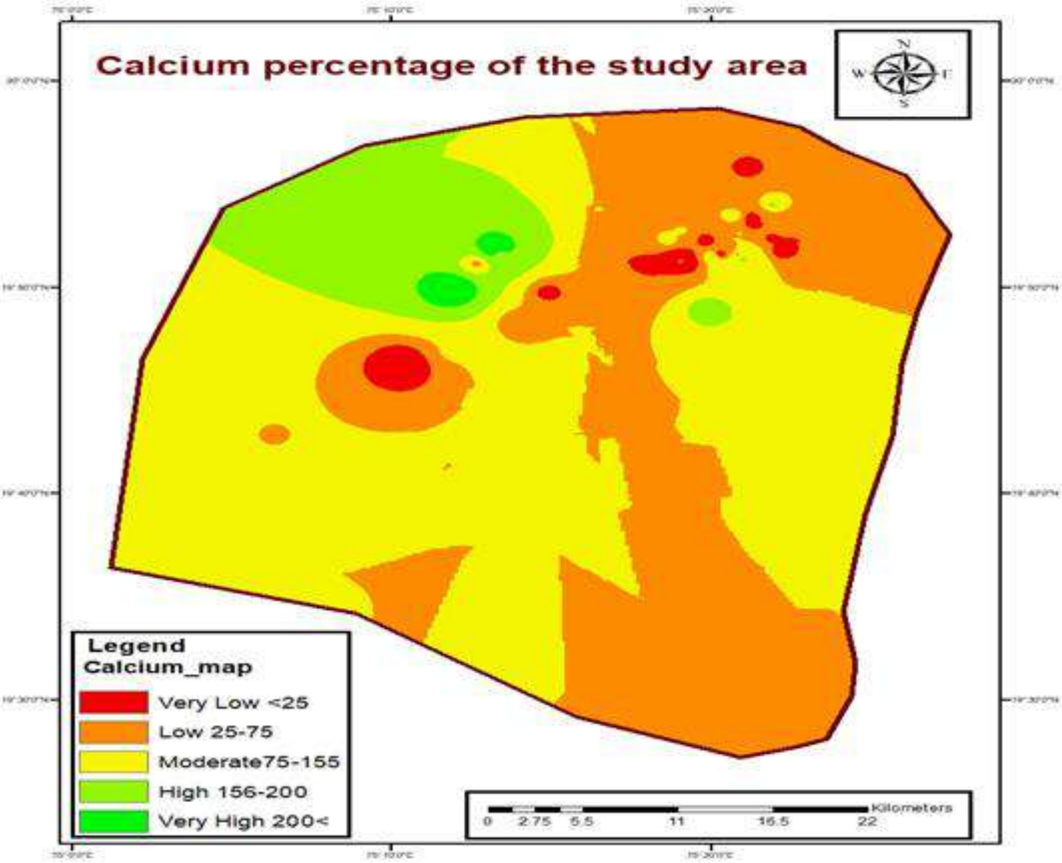

Fig 5:- Calcium Percentage Map of the Study Area

➢ *Magnesium (Mg):*

Magnesium principally gets added to the natural waters through various kinds of rocks, sewage and industrial wastes. Magnesium (Mg) concentration in the water samples has been seen to vary from 12.4 mg/l to 189.59 mg/l with mean values ranging to 930.37 mg/l. The desirable value of Mg lies from 30 mg/l up to a maximum permissible limit of 100 mg/l where 11% i.e. (20) samples exceeded the permissible limit given by WHO. Excessive calcium and magnesium percentage in waters show the percentage hardness present in water and is not potable (D.K.Tank et al 2010). (Table.2)Magnesium is an important component of basic igneous rocks such as dunites, pyroxenites and amphibolites; volcanic rocks such as basalts, metamorphic rocks such as talc and tremolite-schists; sedimentary rocks such as dolomite. Natural water contains magnesium in association with calcium, but this concentration is generally lower than the calcium. The principal sources of magnesium in the natural water are various kinds of rocks, sewages and industrial wastes. On completion of the analysis maps were made with the use of Arc- GIS software to picturize the data.

The magnesium was determined by using the following formula:

Mg^{++} mg/ l = Total hardness (as mg/1$CaCO_3$) - calcium hardness (as mg/$CaCO_3$) X 0.244

Where,

Calcium hardness (as mg/1 $CaCO_3$) = Ca, mg/l X 2.497

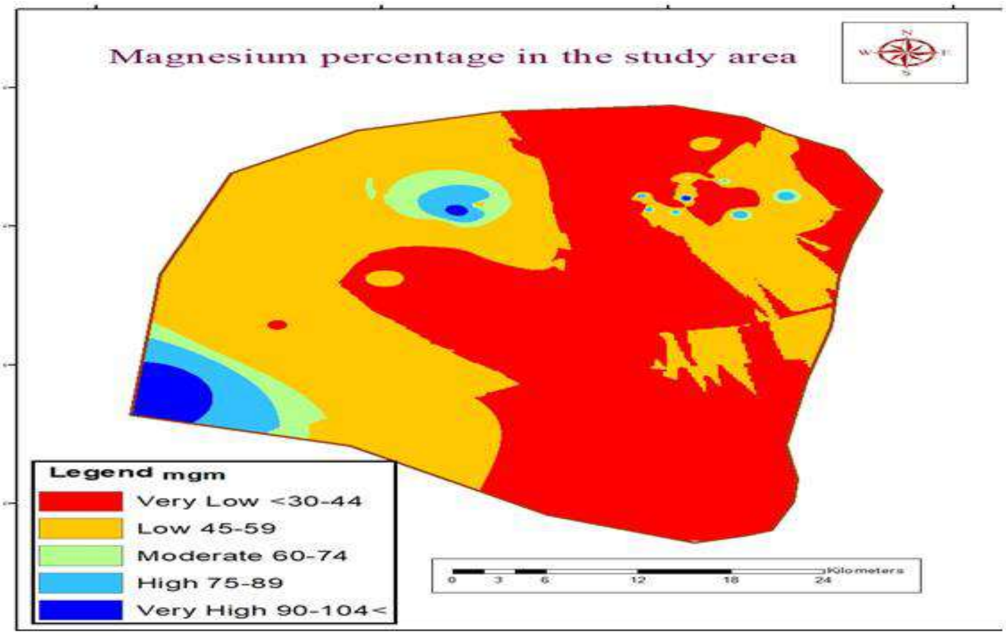

Fig 6:- Magnesium Percentage Map of the Study Area

➢ *Total Hardness:*

Total hardness of drinking water varies from 100 to 995 mg/l with a mean value of 547.5 mg/I. Desirable or minimum limit of total hardness (TH) for drinking water specified by BIS (1991) is 300 mg/l and the permissible limit of drinking water is 600 mg/l. It is observed through the analysis that 15 (27.27 %) samples exceeded the maximum permissible limit. The high amount of hardness in the study area is because of the disposal of indiscriminate untreated sewage and industrial wastes directly in groundwater sources (B.S. Shanker et al 2008). Hardness is not just a specific constituent, it is a variable and complex mixture of anions and cations. It is a relation which is shown by water on its reaction with soap. Dissolved solvents and polyvalent metallic ions cover it. In fresh water, the principal hardness causing ions are Ca^{++} and Mg^{++} where in the hardness. Groundwater sample (100-ml) was taken and some amount of buffer solution (1ml) was added and after that a pinch of Eric-chrome Black-T indicator was added. Contents of the flask were titrated against 0.01 N Ethylene Diamine Tetra Acetic Acid (EDTA) solutions at the end of titration wine red color changes to blue. The total hardness was calculated by using following formula.

$$\text{Total hardness in mg/1 as } CaCO_3 = \frac{ml EDTA used X\ 1000}{\text{ml of sample.}}$$

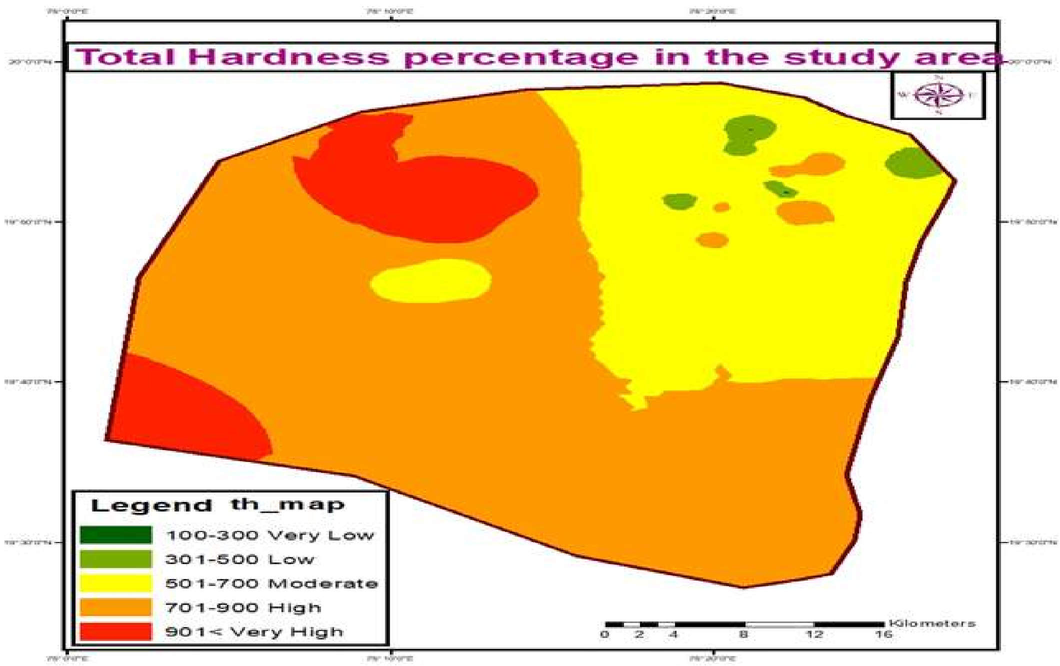

Fig 7:- Map of the Total Hardness Percentage in the Study Area

ISSN No:-2456-2165

➢ *Chloride (Cl):*

The Chloride (Cl) ion concentration of the study area is found to be lying between 22.4 to 590.6 mg/l with a mean value of 306.5 mg/l. No samples exceeded the maximum permissible limits as prescribed (Table.2). Excessive chlorides impart a bitter taste to water, corrode steel and may cause cardiovascular problems. (Anandha Parameshwari & Kalpanadevi, 2006). Chloride contain in igneous rocks is low. Chloride content more than 250 mg/l is generally objectionable for drinking purpose. Groundwater containing more than 350 mg/l is objectionable for irrigation and industrial uses. 50 ml groundwater sample was taken and 2 ml potassium chromate (K_2CrO_4) solution was added. Contents of the flask were titrated against 0 .02N silver nitrate at the end of the titration yellow colour change to red colour. On completion of the analysis maps were made with the use of Arc- GIS software to picturize the data.

Formula for chloride determination:

$$\text{Cl in mg/l} = \frac{\text{ml of AgNO3 used X Normality of AgNO3 X 35.5 X 1000}}{\text{ml of sample}}$$

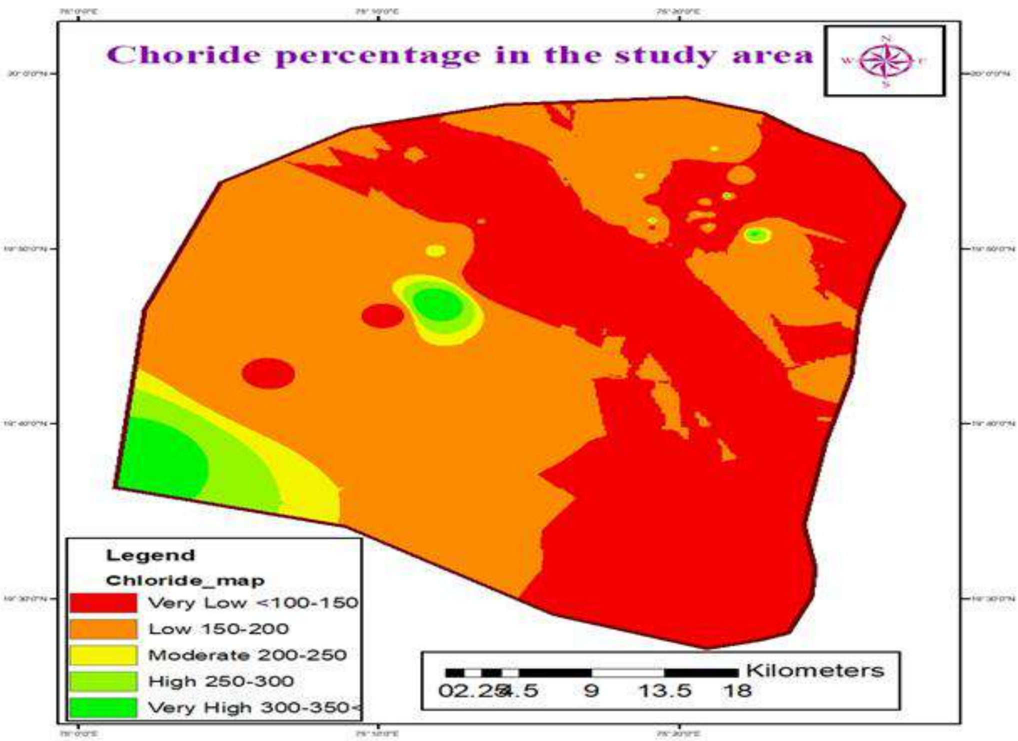

Fig 8:- Map of Chloride Percentage in the Study Area

➢ *Sulphate (SO4):*

The content of sulphate in groundwater is mostly because of the various procedures going on above the ground such as oxidation, precipitation, solution, and concentration. As the water traverses through rocks it undergoes all the chemical changes in its constituents (Karanth 1987). The Sulphate (SO4) percentage of groundwater samples after analysis were assumed to be ranging from 1.84 to 672 ppm with an average value 336.92 ppm. This shows that 13 (23.64 %) of samples were exceeding the maximum permissible limit. The sulphate was determined by the Turbidetric method. For the determining the sulphate 50 ml groundwater sample was taken and 2.5 ml conditioning reagents was added then spoonful of Barium chloride was added to the contents of test tube. The absorption spectra of this precipitated suspension are measured at 420 nm by using Elico visible Spectrophotometer SL 171 model (Mini Spec). Initially the optical density was measured for every alternate 5 samples such as 5, 10, 15 and so on. Then the concentration v/s absorbance standard graph was prepared on the basis of the same data, on this study area was plotted on the standard graph and the concentration was found out; Later maps were made using Arc GIS software.

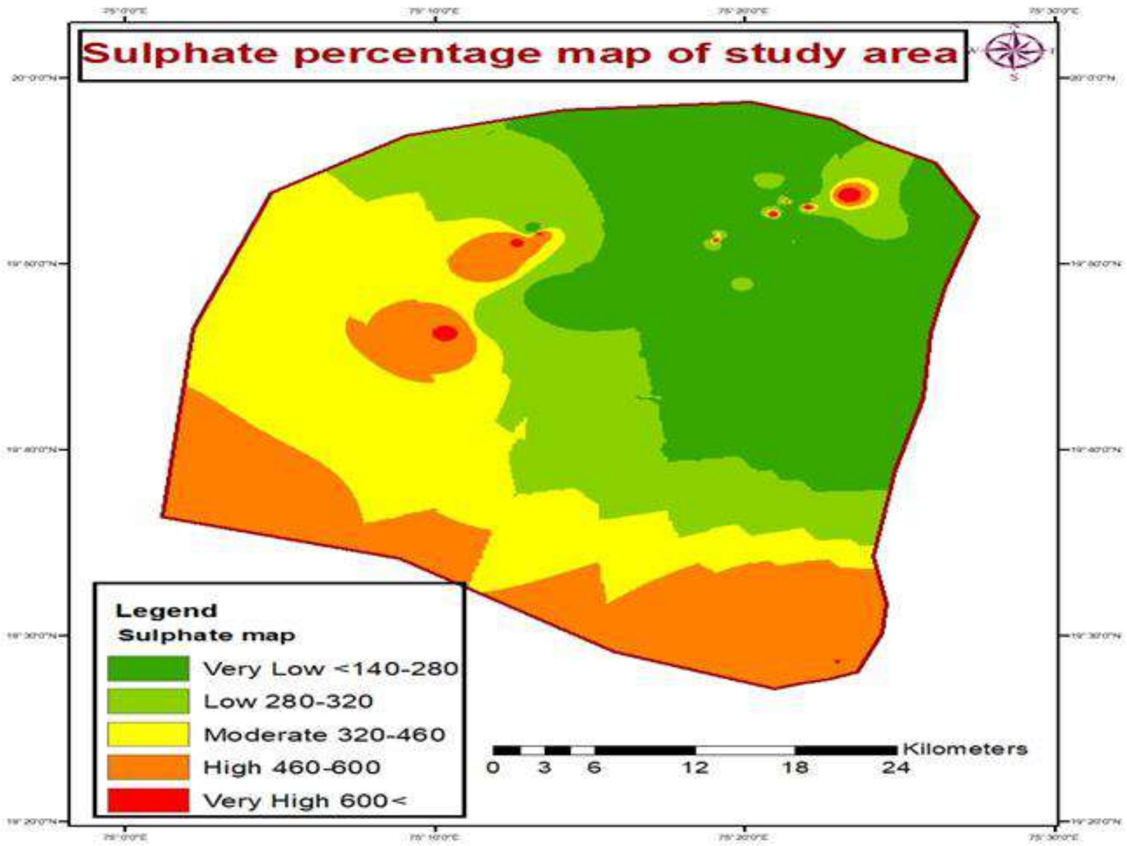

Fig 9:- Map of Sulphate Percentage of the Study Area

Sr no.	Location	Source	PH	TH	Ca	Mg	TDS	
1	Omkareshwar, Garkheda	BW	8.75	360	52.109	189.59	394.76	969
2	Railway Stn MIDC	BW	8.72	110	36.87	44.55	306.1	887
3	Nirlep MIDC	BW	9.67	152	34.468	71.608	451.5	978
4	MIT sewer	BW	9.26	240	20.04	134.01	258.3	699
5	Waluj C sector Sterlite company	DW	6.8	670	248	124	71	1640
6	Garkheda Stadium	BW	7.2	352	123.4	52	340.8	1540
7	Shivaji Nagar	BW	7.7	115	20	23.2	238.5	1127
8	Jawahar Nagar police station	BW	7.2	352	123.4	52	213	1450
9	Janki Hotel, Sutgirni Chowk,	BW	8.9	480	112.2	89.7	220.2	902
10	Beed by pass, garden court hotel	BW	7.5	575	108.2	113.9	190	1310
11	Karnapura Temple	BW	7.6	320	110	51.2	305.1	910
12	SBH Colony	BW	10.8	429	140.5	70.4	190.8	780
13	Waluj MIDC, Pandharpur	BW	6.2	385	48.1	82.2	132.1	811
14	Bhanudasnagar	BW	8.3	165	72.1	22.7	213	831
15	Vishnunagar	BW	7.8	167	59.3	26.3	249.9	858
16	Kailas nagar	BW	7.8	510	114.6	96.5	180.2	860
17	Seven hills	BW	7.6	286	16.8	90.1	93.7	380

18	University temple	BW	5.83	385	79.4	45.56	362.1	930
19	Bauddha Vihar	BW	5.18	189	52.6	14.06	628.2	789
20	Limbe Jalgaon	BW	6.23	359	23.5	73.27	193.48	525
21	Waluj shivrai phata	BW	6.13	268	85.45	13.33	727	2890
22	Dhoregaon Gangapur	BW	7.1	489	82.72	68.91	243.5	726
23	Ranjangaon K-sector	BW	7.65	760	73.2	140.84	286.3	702
24	Kaygaon papermills	BW	8.39	785	83.4	140.72	590.6	488
25	Waluj Gangapur	BW	8.34	465	68.5	71.72	62.5	536
26	Beed by pass, Guru Lawns	BW	8.76	687	79.2	119.37	521.14	1696
27	Dnyaneshwar nagar	BW	7.56	370	89.48	35.76	59.48	699
28	Dargah Sewer	BW	6.2	236	68.5	15.84	224.3	1275
29	Cidco N4	BW	7.2	144	48.9	23.2	22.4	814
30	Airport Colony	BW	8.62	390	80.9	110	220	2380
31	Mitra Nagar	BW	7.4	190	85.26	86	101	780
32	Balaji Nagar	BW	7.9	230	65.89	55	85.7	536
33	Kalikamata Mandir	BW	7.26	100	144	20.9	454.4	1187
34	Cidco N1	BW	7.8	161	133	83.3	355	1128
35	Nath Mandir	BW	7.6	446	69.23	69.08	168	556
36	Nath Mandir	DW	6.15	578	78.75	44.64	185	887
37	Shreeyash College	BW	7.2	453	158.2	65	254	1520
38	Renuka Mata Mandir	BW	7.3	100	20	23.2	268.6	1127
39	Varad Ganesh Mandir	BW	7.5	315	87	23.85	226	1420
40	Shajapur Beer Factory	BW	8.7	995	262.3	82.96	370	2600
41	Waluj Beer Factory	BW	8.5	880	158.5	80	301	3200
42	Harpool	BW	7.3	153	49.31	72.8	360	1235
43	taj hotel	BW	7.8	133	59.8	18.6	211.6	997
44	Osmanpura	BW	7.9	165	34.5	19.24	86.5	615
45	Padampura	BW	8.8	598	70.5	128	288.3	1122
46	Kanchanwadi	BW	7.8	230	65.8	55	85.71	523
47	Prozone mall	BW	7.4	115	60.2	13.4	85	428
48	MIDC(Cidco N1)	BW	8.6	520	85.2	110	220	897
49	Wockhardt Cidco	BW	5.8	523	72.8	120.5	203.1	1527
50	Naregaon	BW	8.5	530	72.8	90.99	238	2360
51	Mondha Naka, Kharakua	DW	9.5	960	86.56	78.36	389	2569
52	Sindhi Colony	BW	7.6	185	69.25	85.23	125	658
53	President hall, Cidco MIDC	BW	8.3	656	78.6	96.25	246	2465
54	Best Price, Kanchanwadi	BW	7.3	328	48.9	22.4	246	1280
55	Jawahar Colony	BW	7.4	168	34.6	18.24	84.24	1220

Table 1

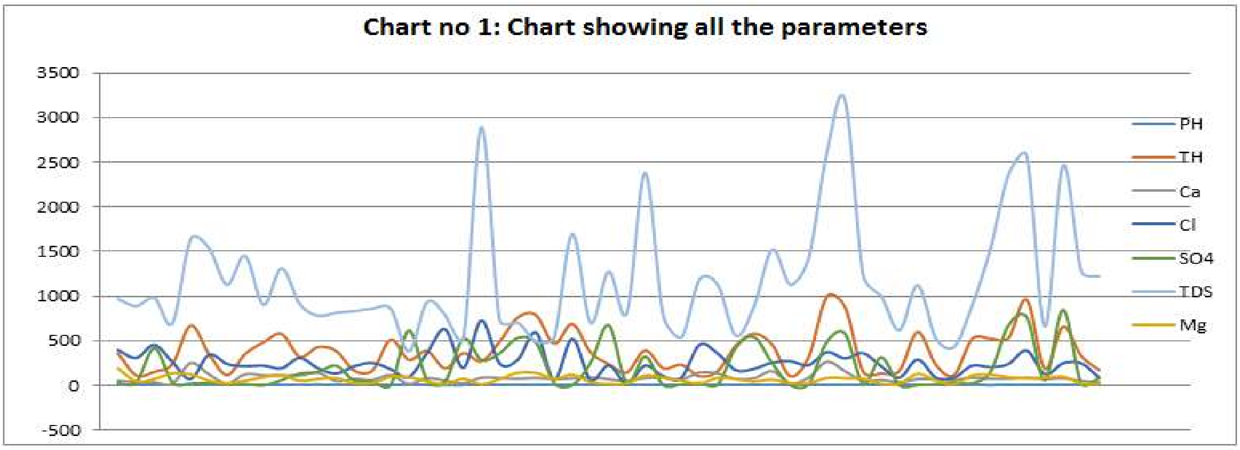

Fig 10

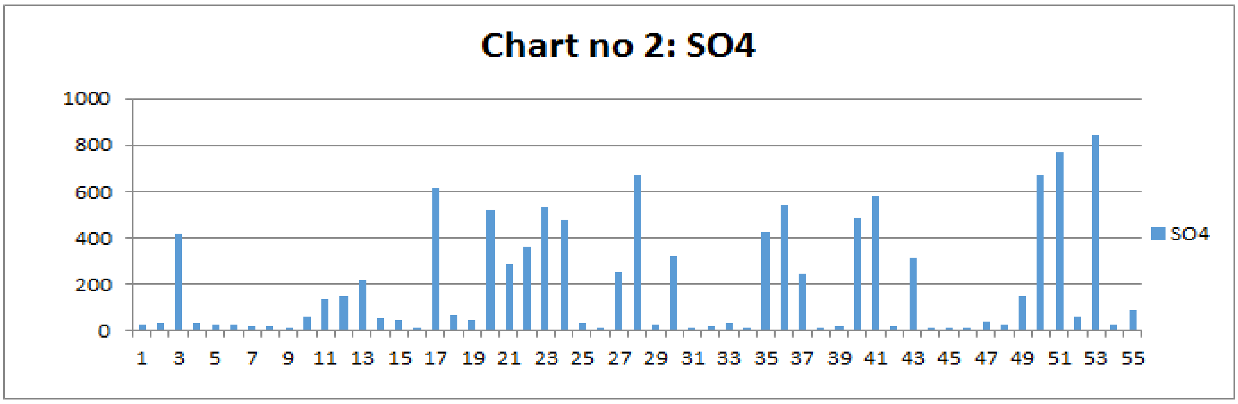

Fig 11

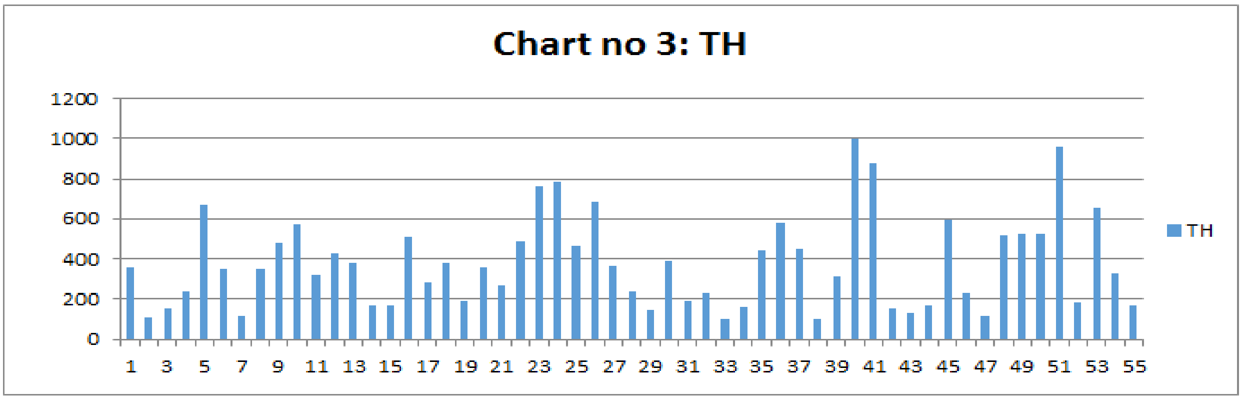

Fig 12

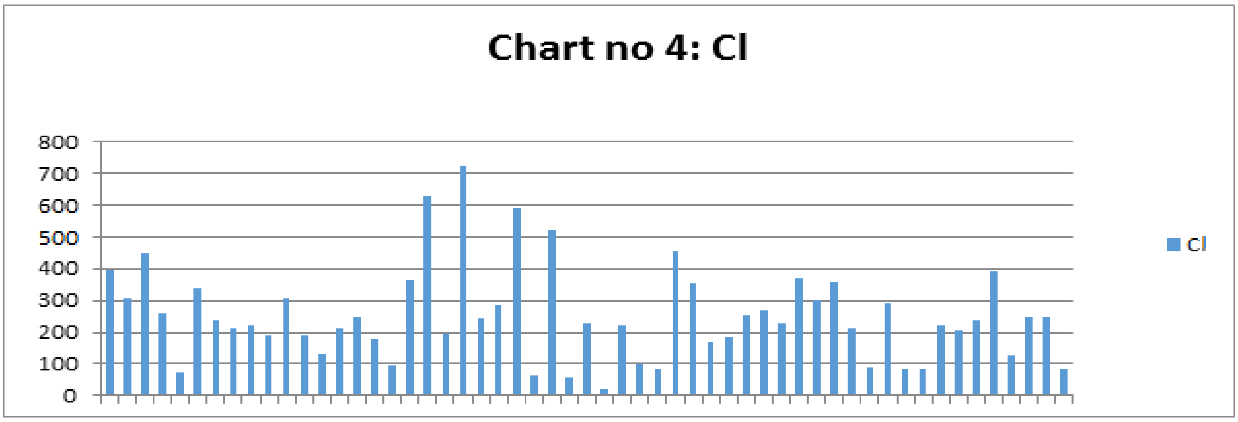

Fig 13

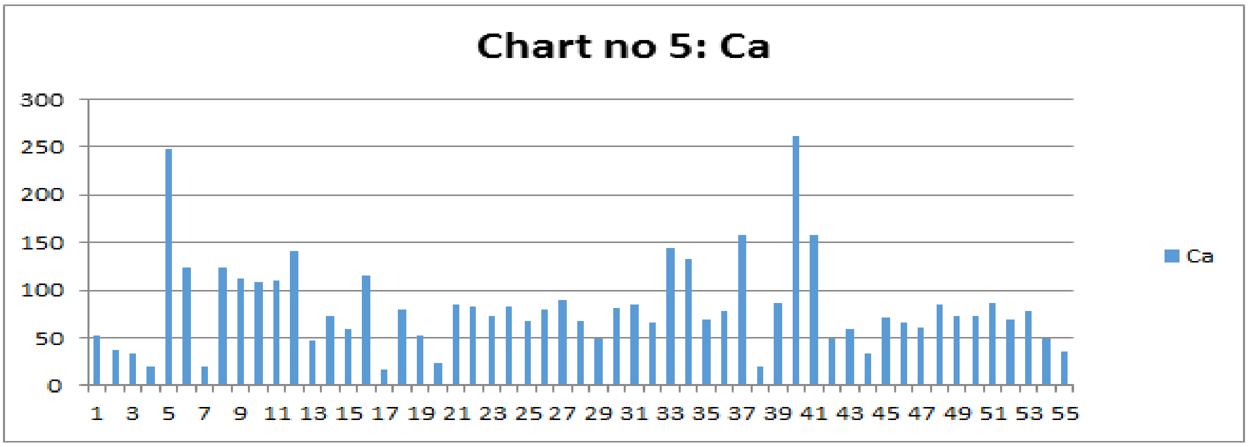

Fig 14

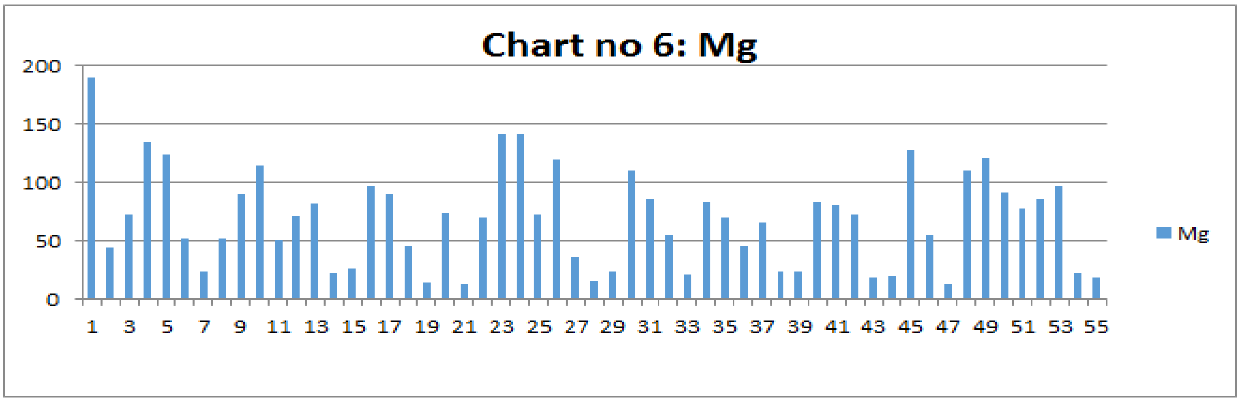

Fig 15

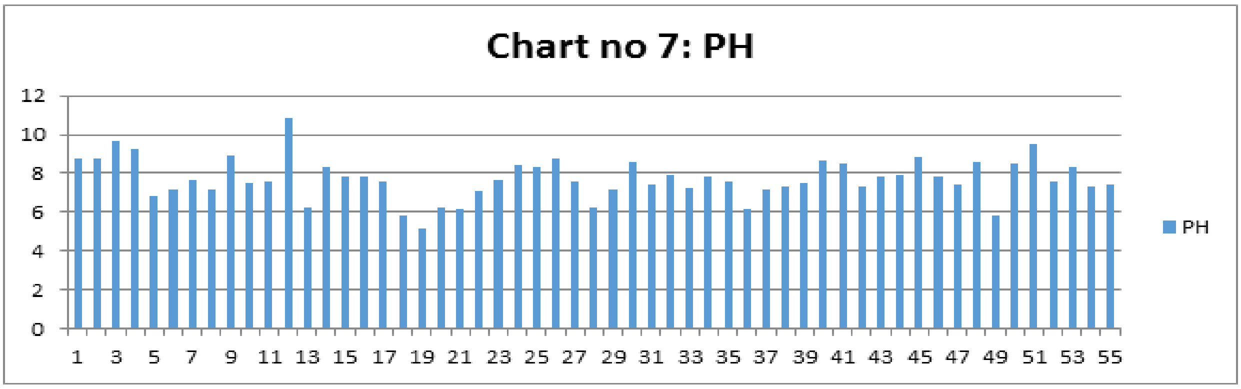

Fig 16

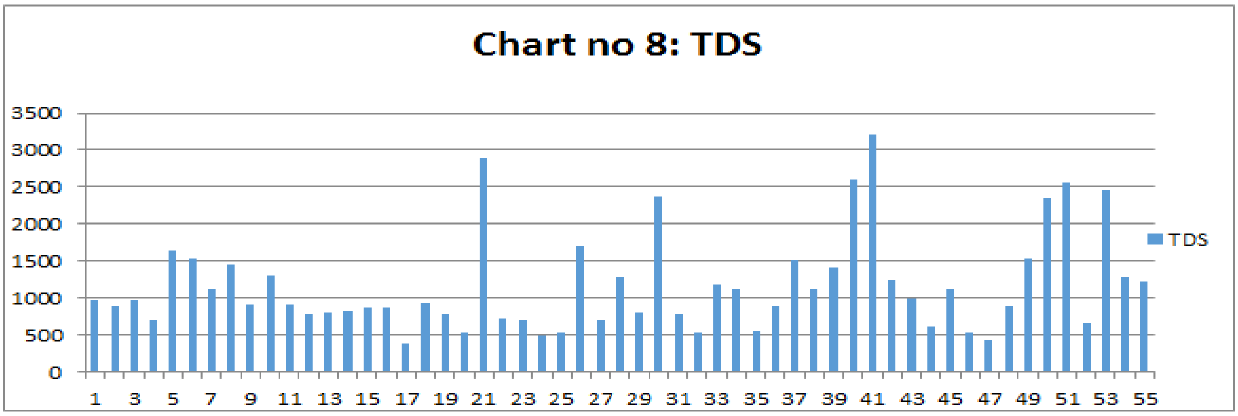

Fig 17

ISSN No:-2456-2165

Sr. No	Parameters	BIS permissible limit	Sample numbers which have exceeding permissible limits	Total no. of samples exceeding permissible limits	Percentage of samples exceeding permissible limits
1.	pH	6.5 to 8.5	1 to 5, 9,12 to 14,18 to 21,24 to 26,28,30,36,40,41,45,48 to 51,53	27	49.09%
2.	TDS	2000	21,30,40,41,50,51,53	7	12.73%
3.	Total Hardness	600	5,23,24,26,28,30,36,40,41,45,48,49,50,51,53	15	27.27%
4.	Chloride	1000	NA	NA	NA
5.	Magnesium	100	1,4,5,10,23,24,26,30,45,48,49	11	20%
6.	Sulphate	400	3,17,20,23,24,28,35,36,40,41,50,51,53	13	23.64%
7.	Calcium	200	5,40	2	3.64%

Table 2

IV. CONCLUSIONS

The samples of groundwater were collected from the various industrial and municipal areas of Aurangabad, which when analyzed, described the drastic condition of the city drinking water source. The analysis reports describe the various water quality parameters like pH (49.09%), TDS (12.73%), Total Hardness (27.27%), Calcium (3.64%), Magnesium (20), Sulphate (23.64%) exceeded the maximum permissible limit prescribed. The findings clearly indicate that the groundwater is getting contaminated alarmingly due to rapid industrialization and indiscriminate dumping of sewage into the domestic waste pipelines. Discussions with the residents of the study area revealed that a most of people belonging here faced various health problems of skin, throat, infections and intestine ailments which are mostly water borne, using this water.

Based on the above research, recommendations are made to the local authorities to take measures to reduce the pollution levels of groundwater sources before it becomes unmanageable. Water treatment facility which has been designed for providing potable water to the residents of the area should be brought to use. To meet the increasing need of the residents and industries potable groundwater can be made available to them in a better way. The best way to control the groundwater pollution by protecting it from contamination and increase the groundwater resources by recharging it through rainwater harvesting and various artificial recharge systems put up in the area. The residents living in the area should be made aware of the possibilities and solutions which are available.

ACKNOWLEDGMENTS

The authors are extremely grateful to the Principal of Deogiri College, Aurangabad for the Support, encouragement and laboratory facilities provided to the authors during the course of this work. I am thank full to DST Inspire for the fellowship and monetary funds.

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