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Research Article

COMPARISION OF GROUND WATER QUALITY AND SEASONAL VIRIATIONS AT THE INDUSTRIAL REGIONS OF GUNTUR CITY, A.P., INDIA

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ABSTRACT

The disposal of industrial effluents on land and the subsequent pollution of ground water is a relatively significant area of research. Industries located in Guntur city of Andhra Pradesh dispose their effluents on land, thereby polluting the adjacent bore-wells. This study attempts to capture the environmental impact of industrial effluents in different industrial locations of Guntur through water quality studies. A seasonal comparision of all the selected stations was also done after which the resulting data was subjected to a detailed statistical analysis by using univariate analysis of variance (ANOVA). Significantly, this study found that the continuous disposal of industrial effluents on land, which has limited capacity to assimilate the pollution load, has led to groundwater pollution. Among the major effects include deterioration in the groundwater quality in shallow wells surrounding the industrial locations and serious consequences and hazardous impact of such polluted groundwater on sectors like domestic and agricultural.

INTRODUCTION

Groundwater is the water located beneath the earth's surface in soil pore spaces and in the fractures of rock formations (Gagan *et al.,* 2016). Groundwater, being a fragile and important source of drinking water, must therefore be carefully managed to maintain its purity within standard limits (Gagan *et al.,* 2016). Groundwater degradation occurs when its quality parameters are changed beyond their natural variations by the introduction or removal of certain substances (Ramesh, 2001). Increased industrialization, urbanization and agricultural activities during the last few decades have degraded the surface water and groundwater quality of Andhra Pradesh, the southern state of India. A rapidly growing population and indiscriminate industrial activities make it essential to assess the quality of groundwater system to ensure the long-term sustainability of resources (Uday *et al.,* 2014). Poor quality of groundwater adversely affects the plant growth and human health (Sahare 2016).

Study Area

The present study has been carried out at various industrial areas falling under the Guntur city limits in Guntur district. Guntur area is diversely represented by different industries such as, Fertilizers, Chemicals, Lead, Battery, Plywood, Packaging, Cotton, Cement, Drugs, etc. Some of these factories have been continually discharging industrial effluents into the groundwater. In the industrial hub, apart from the land, air is also severely polluted because of the release of soot containing dust and hazardous vapours. Hence, in order to develop a holistic view of the enormity of the problem, a study on the quality of ground water in different areas was carried out.

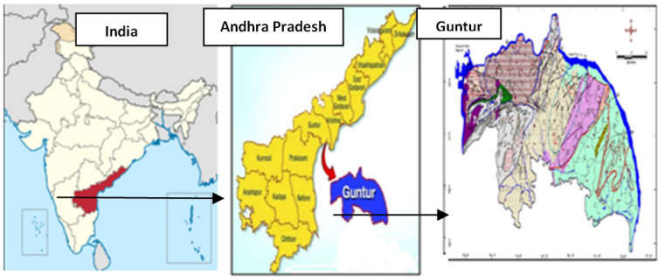

Figure 1 Map showing the study area Guntur

METHODOLOGY

Water Quality Studies

Drinking water samples were collected monthly from places in and around Autonagar region in Guntur district. A total of seven sampling stations were selected for collection of samples from bore-wells in a stretch of about 22 kms. Sampling was done for all seasons for two annual cycles from June 2015 to

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May 2017. All the collected samples were analyzed in the laboratory by using standard methods of analysis (APHA, 1998). To assess the potability of ground water in the various industrial areas falling under the Guntur city limits a comparison was made among the annual means of seven stations for all the parameters during three seasons i.e. rainy, winter and summer seasons. Various physical parameters like pH, EC, and TDS were estimated on the spot with the help of digital portable pH meter, conductivity meter and TDS meter. Turbidity was estimated using Nephelometer. The Total Hardness was measured by EDTA titrimetric method by using EBT indicator. The Argentometric volumetric titration method in the presence of Potassium chromate provided reliable results related to the presence of chloride. Sodium and potassium were analysed by using Flame Photometer (ELICO make), while the obtained data was subjected to a descriptive statistical analysis by using univariate analysis of variance (ANOVA)

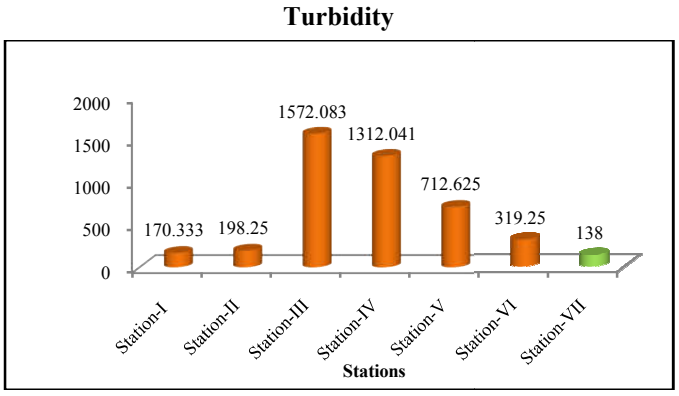
RESULTS AND DISCUSSION

Turbidity

The mean of Turbidity observed from all the ground water samples collected from seven stations was almost similar, ranging between 0.3 NTU and 0.4 NTU at all stations. The seasonal means remained nearly similar with less variation. It was also observed that the maximum Turbidity was recorded at station-II during all three seasons. This indicates that the station II near Dolas Nagar was the most affected. On comparing the seasonal variations, the Turbidity was found high during the summer season at all the stations than during the rainy and winter seasons.

Table 1 A comparison of mean Temperature of ground water at six stations

Stations	Annual Mean±S.D. of Turbidity	Seasonal Mean ± S.D. of Turbidity		
		Rainy	Winter	Summer
Station-I	0.325±0.0442	0.3625±0.051	0.3125±0.0353	0.3
Station-II	0.381±0.0394	0.357±0.053	0.385±0.037	0.4±5.934
Station-III	0.325±0.053	0.35±0.075	0.325±0.046	0.3
Station-IV	0.354±0.050	0.337±0.051	0.35±0.053	0.375±0.046
Station-V	0.312±0.044	0.287±0.035	0.3	0.35±0.053
Station-VI	0.383±0.038	0.4	0.375±0.046	0.375±0.046
Station-VII	0.333±0.048	0.325±0.046	0.325±0.046	0.35±0.053



Graph 1 The comparison of mean of Turbidity at all the stations with the control station

ANOVA for Turbidity: From the (Table 2) below, it is clear that the calculated value was greater than the table value. It shows significant differences in the variance analysis among the stations, thereby stating that the Temperature is independent of each station.

Table 2 ANOVA for Temperature of ground water among the six stations

Source of Variation	SS(Sum of squares)	Degrees of freedom	MS(Mean sum of squares)	Variance ratio of F
Between stations	0.114893209	6	0.019148868	9.19665
Within stations	0.335227273	161	0.002082157	
Total	0.450120482	167		

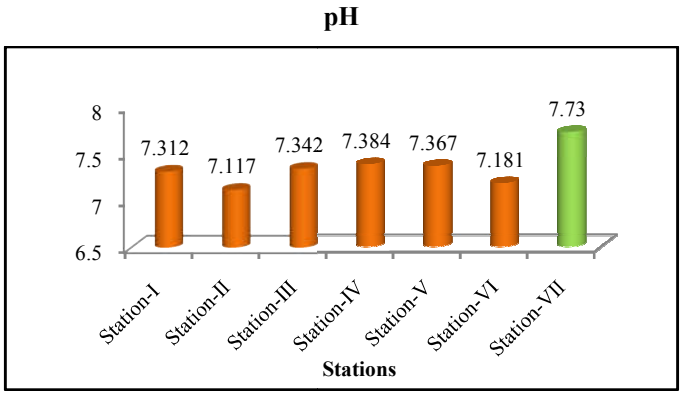
Calculated value of F (6, 161) = 9.19665
Table value of F (4, 55) at 5% level, ($p<0.05$) of significance = 0.27

pH

The pH of ground water at all stations was observed to be near neutral to alkaline during the study period. The highest pH value was observed at station-IV near Autonagar plot and the lowest pH was recorded at station-II located near Dolas nagar. The seven stations were found to be in similar pH ranges during the study period. The slightly low pH adjacent to all the polluted sites might be due to the contamination of ground water due to various industrial activities. A study done by Hussain *et al.,* (2008) revealed similar results in agreement with the present study. On considering the seasonal variations in the ground water samples, the seasonal behaviour of pH remained similar with very less variations during the study period.

Table 3 A comparison of mean pH of ground water at six stations

Stations	Annual Mean±S.D. of pH	Seasonal Mean ± S.D. of pH		
		Rainy	Winter	Summer
Station-I	7.312±0.186	7.325±0.22	7.285±0.074	7.326±0.233
Station-II	7.117±0.207	7.082±0.099	7.07±0.067	7.2±0.338
Station-III	7.342±0.122	7.383±0.114	7.37±0.116	7.273±0.120
Station-IV	7.384±0.148	7.372±0.118	7.43±0.140	7.351±0.186
Station-V	7.367±0.184	7.436±0.136	7.305±0.096	7.361±0.272
Station-VI	7.181±0.130	7.197±0.081	7.151±0.088	7.196±0.199
Station-VII	7.730±0.206	7.63±0.097	7.671±0.104	7.89±0.274



Graph 2 The comparison of mean of pH at all the stations with the control station

ANOVA for pH: From the (Table 4) below, it is clear that the calculated value is greater than the table value. The variance analysis also revealed that there are significant differences among the stations, thus stating that the pH is independent of each station.

Table 4 ANOVA for pH of ground water among the six stations

Source of Variation	SS(Sum of squares)	Degrees of freedom	MS(Mean sum of squares)	Variance ratio of F
Between stations	5.30730058	6	0.884550097	
Within stations	4.769710125	161	0.029625529	29.8577
Total	10.0770107	167		

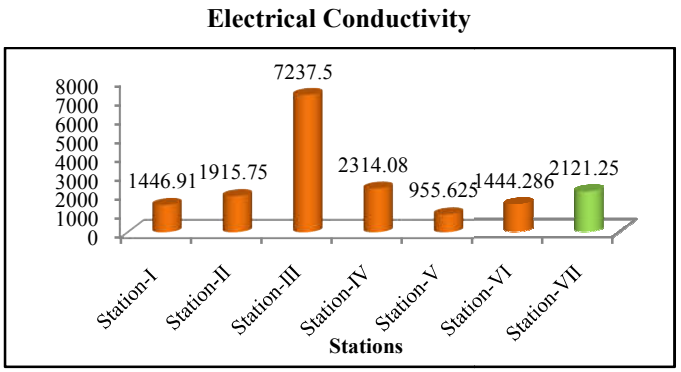
Calculated value of F (6, 161) = 29.8577
Table value of F (4, 55) at 5% level, ($p<0.05$) of significance = 0.27

Electrical Conductivity

The Electrical Conductivity also followed a similar trend of high values at station-VI (near Stadium road) and station-III (near Masjid Omar, Near Autonagar) as there was high mean concentrations of Total Dissolved Solids at these two stations compared to the rest of the stations. The Electrical Conductivity values of all the stations were found exceeding the BIS prescribed standard of 750 µmhos/cm for drinking water. The mean value of Electrical Conductivity at all stations ranged between 955.625 µmhos/cm at station-V, adjacent to Dargha site to 7237.5 µmhos/cm at station-III, located near Masjid Omar, Near Autonagar. This high conductivity values obtained for the groundwater near the sample stations is an indication of its disastrous effect on the water quality. This indicates that mechanic works factories for tractors and cars, scrap factories, plastic companies, tyre manufacturing companies, car wash garages, wood-based factories and crane mechanic works within a diameter of half a kilometre at Station-III might have contributed to high Electrical Conductivity at station-III. Nduka and Orisakwe (2007) in their findings found that the electrical conductivity in ground water was in range of 25 to 342.00 µS/cm, comparatively lower than the present observations. A similar seasonal trend was not observed for all the seven sampling stations during the study period.

Table 5 A comparison of mean Electrical Conductivity of ground water at six stations

Stations	Annual Mean±S.D. of Electrical Conductivity	Seasonal Mean ± S.D. of Electrical Conductivity		
		Rainy	Winter	Summer
Station-I	1446.91±190.41	1444.286±199.423	1415.714±180.171	1486.143±253.635
Station-II	1915.75±236.41	2121.25±209.109	1908.5±88.838	1717.5±196.959
Station-III	7237.5±1340.60	18481.25±2493.376	18250±2131.397	17762.5±1255.772
Station-IV	2314.08±557.80	10918.75±4555.211	13100±3842.618	17712.5±745.342
Station-V	955.625±271.746	6650±916.515	6987.5±793.612	8075±1779.847
Station-VI	1444.286±199.423	2092.5±562.716	2293.5±572.868	2556.25±503.868
Station-VII	2121.25±209.109	855.625±95.372	842.5±170.27	1168.75±355.786



Graph 3 The comparison of Electrical Conductivity between all stations and control station

The control area at Acharya Nagarjuna University was shown having comparatively lower Electrical Conductivity than all the other sampling stations, indicating a pollution-free zone.

ANOVA for Electrical Conductivity: From the (Table 6) below, it is clear that the calculated value is greater than the table value. The variance analysis revealed significant differences among the stations, thus making Electrical Conductivity independent of each station.

Table 6 ANOVA for Electrical Conductivity of ground water among the six stations

Source of Variation	SS(Sum of squares)	Degrees of freedom	MS(Mean sum of squares)	Variance ratio of F
Between stations	6828900203	6	1138150034	312.7972
Within stations	585817755.3	161	3638619.598	
Total	7414717959	167		

Calculated value of F (6, 161) = 312.7972
Table value of F (4, 55) at 5% level, ($p<0.05$) of significance = 0.27

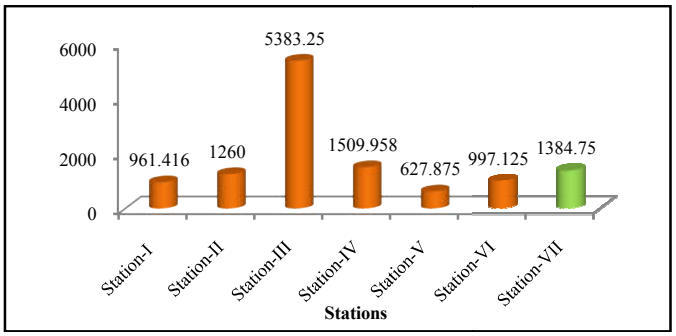
Total Dissolved Solids

The Total Dissolved Solids also followed a similar trend of high values at station-VI (near Stadium road) and Station-III (near Masjid Omar, Near Autonagar). The Total Dissolved Solids values of all the stations exceeded the BIS-prescribed standard of 500 mg/L for drinking water. The mean value of Total Dissolved Solids at all stations ranged between 627.875 mg/L at station-V adjacent to Dargha site to 5383.25 mg/L at station-III, located near Masjid Omar, near Autonagar. This indicates the adverse effect of mechanic works factories for tractors and cars, scrap factories, plastic factories, tyre manufacturing units, car wash garages, wood-based factories and crane mechanic works within a diameter of half a kilometre at station-III possibly having contributed to high Total Dissolved Solids at station-III. Joshi and Seth (2008) conducted physico-chemical studies on the groundwater samples collected from different locations of Sambhar lake city and its adjoining areas and reported high TDS values in range of 233 to 4800 mg/L. Similar results of TDS were reported by (Niloufer *et al.,* 2016). A similar seasonal trend was not observed in any of the seven sampling stations during the study period. The control area at Acharya Nagarjuna University was seen having comparatively lower Total Dissolved Solids than all the other sampling stations, indicating a pollution-free zone.

Table 7 A comparison of mean pH of ground water at six stations

Stations	Annual Mean±S.D. of Total Dissolved Solids	Seasonal Mean ± S.D. of Total Dissolved Solids		
		Rainy	Winter	Summer
Station-I	961.416±125.017	997.125±90.709	917.5±119.901	969.625±158.147
Station-II	1260±151.189	1384.75±136.130	1269.375±37.255	1125.875±129.384
Station-III	5383.25±1753.07	11649.125±3040.39	11930.75±1464.109	11673.75±931.670
Station-IV	1509.958±372.306	7180.5±3030.803	8664.75±2561.096	11690.25±491.926
Station-V	627.875±179.074	7180.5±3030.803	8664.75±2561.096	11690.25±491.926
Station-VI	997.125±90.709	1377.75±371.948	1465±385.156	1687.125±332.553
Station-VII	1384.75±136.130	561.125±65.766	551.25±102.821	771.25±234.889

Total Dissolved Solids



Graph 4 The comparison of mean of Total Dissolved Solids at all the stations with the control station

ANOVA for Total Dissolved Solids: It is apparent from the (Table 8) below that there are significant differences among the stations, showing that Total Dissolved Solids is independent of each station.

Table 8 ANOVA for Total Dissolved Solids of ground water among the six stations

Source of Variation	SS(Sum of squares)	Degrees of freedom	MS(Mean sum of squares)	Variance ratio of F
Between stations	2930486240	6	488414373.4	219.5889
Within stations	358099635.9	161	2224221.341	
Total	3288585876	167		

Calculated value of F (6, 161) = 219.5889
Table value of F (4, 55) at 5% level, (p<0.05) of significance = 0.27

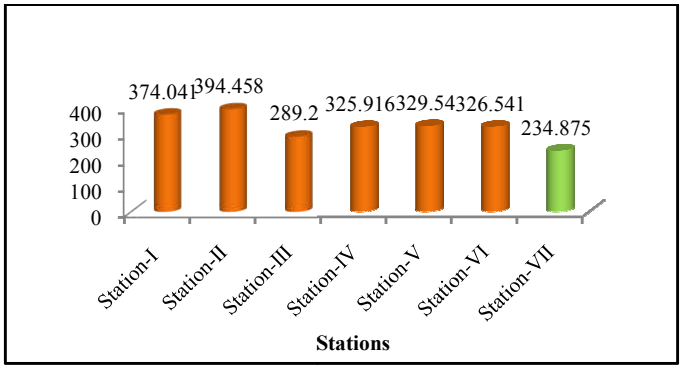
Total Alkalinity

The Total Alkalinity in ground water is due to the presence of salts of hydroxides, carbonates and bicarbonates, silicates and phosphates. The mean of Total Alkalinity in ground water samples ranged between 234.875mg/L at station-VII (control station) to 394.458mg/L at station-II located near Dolas Nagar sampling site. With the exception of the control area, the lowest Alkalinity value was identified to be at station-III located at Masjid Omar, Near Autonagar site. It was observed that Total Alkalinity was more in the ground water samples collected from the industrial sites, while it was less in the ground water samples collected at the control station clearly indicating the pollution from various industries. The ground water at station-II was identified to have more Alkalinity than the remaining stations during the study period. Including station-VII (control station), all the stations were shown having high mean concentration of Total Alkalinity that was much higher than the BIS specified limit of 200 mg/L, thus indicating that the ground water was poor in quality, having high concentrations of salts. Singh *et al.,* (2012) reported higher alkalinity values that ranged from 498 to 1289 mg/lit in their study at Dholpur District, Rajasthan. On considering the seasonal behaviour of the Total Alkalinity in ground water, it is observed that highest concentration of Total Alkalinity was recorded at station-II and lowest concentration was recorded at station-III during all the seasons.

Table 9 A comparison of mean Total Alkalinity of ground water at six stations

Stations	Annual Mean±S.D. of Total Dissolved Solids	Seasonal Mean ± S.D. of Total Alkalinity		
		Rainy	Winter	Summer
Station-I	374.041±31.593	378.875±21.229	388.25±45.512	355±9.258
Station-II	394.458±39.720	401.125±16.779	423.75±22.587	358.5±43.395
Station-III	289.20±23.351	289.625±16.335	299±25.900	279±25.002
Station-IV	325.916±37.129	328.25±27.514	342±47.425	307.5±28.879
Station-V	329.54±56.230	321.25±14.684	345.875±43.366	321.5±88.516
Station-VI	326.541±28.621	329.125±22.382	327.5±20.667	323±41.720
Station-VII	234.875±70.424	216.625±24.916	213±34.125	275±108.364

Total Alkalinity



Graph 5 The comparison of mean of Total Alkalinity at all the stations with the control station

ANOVA for Total Alkalinity: From the (Table 10) below, it is clear that the calculated value is greater than the table value. The variance analysis also revealed that there is significant difference among the stations, showing that Total Alkalinity is independent of each station.

Table 10 ANOVA for Total Alkalinity of ground water among the six stations

Source of Variation	SS(Sum of squares)	Degrees of freedom	MS(Mean sum of squares)	Variance ratio of F
Between stations	399827.5749	6	66637.92915	34.71311
Within stations	309067.8299	161	1919.675962	
Total	708895.4048	167		

Calculated value of F (6, 161) = 34.71311
Table value of F (4, 55) at 5% level, (p<0.05) of significance = 0.27

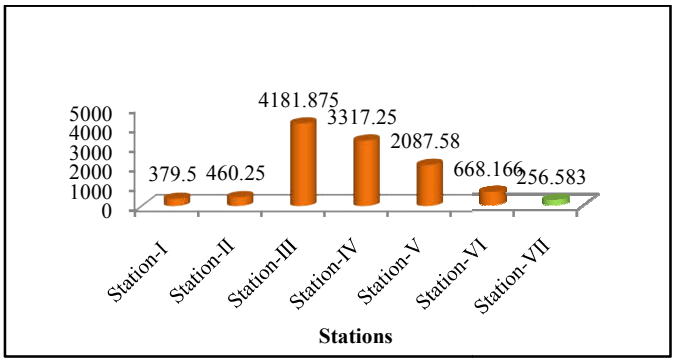
Total Hardness

Hardness of water is not a specific constituent but a variable and complex mixture of cations and anions with calcium and magnesium as the principal Hardness causing ions. The mean concentration of Total Hardness in ground water samples ranged between 256.583 mg/L at station-VII (control station) to 4181.875 mg/L at station-III located near Masjid Omar, Near Autonagar site. Except station-VII (control station), the rest of the stations were having high mean concentration of Total Hardness, which was much more than the BIS specified limit of 300 mg/L, indicating that the ground water quality was poor with the water branded as "very hard water". On comparision, Total Hardness was higher in ground water at the control station than other industrial sites. It was observed that the major contribution for Hardness in ground water may be from

leachate contamination from the industrial sites. On considering the seasonal behaviour of Total Hardness in ground water, it was observed that the highest concentration of Total Hardness during rainy and winter seasons was recorded at station-III and lowest concentration was recorded at station-I. During summer season, the highest concentration of Total Hardness was observed at station-IV and the lowest concentration was recorded at station-I.

Table 11 A comparison of mean Total Hardness of ground water at six stations

Stations	Annual Mean±S.D. of Total Hardness	Seasonal Mean ± S.D. of Total Hardness		
		Rainy	Winter	Summer
Station-I	379.5±53.747	383.5±18.693	359.5±29.890	395.5±86.491
Station-II	460.25±180.369	388.5±201.927	439.75±190.585	552.5±117.077
Station-III	4181.875±582.331	4218.125±633.222	4167.5±727.731	4160±425.877
Station-IV	3317.25±1406.423	2506.75±1270.308	3067.5±1114.267	4377.5±1239.835
Station-V	2087.58±849.719	2331.75±999.074	1374.25±160.980	2556.75±668.630
Station-VI	668.166±250.722	525.25±91.138	699.25±294.858	780±269.365
Station-VII	256.583±77.834	234.25±39.008	213±52.230	322.5±52.230



Graph 6 The comparison of mean of Total Hardness at all the stations with the control station

ANOVA for Total Hardness: From the (Table 12) below, it is clear that the calculated value is greater than the table value. The analysis of variance revealed that there are significant differences among the stations, thus making Total Hardness independent of each station.

Table 12 ANOVA for Total Hardness of ground water among the six stations

Source of Variation	SS(Sum of squares)	Degrees of freedom	MS(Mean sum of squares)	Variance ratio of F
Between stations	367534483.8	6	61255747.3	136.5279
Within stations	72235582.5	161	448668.2143	
Total	439770066.3	167		

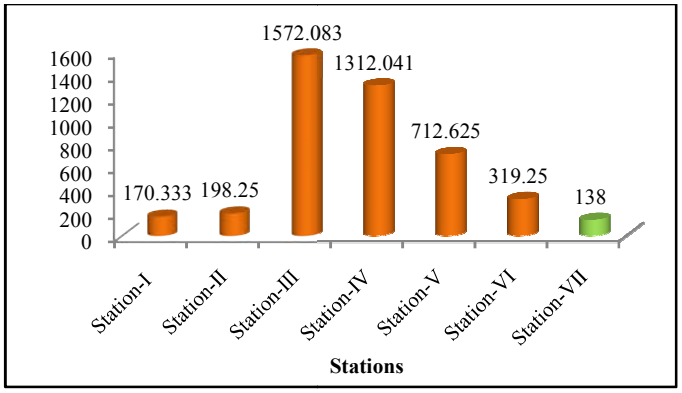
Calculated value of F (6, 161) = 136.5279
Table value of F (4, 55) at 5% level, ($p<0.05$) of significance = 0.27

Calcium Hardness

The mean concentrations of Calcium Hardness in ground water ranged between 138 mg/L at station-VII and 1572.083 mg/L at station-III at Masjid Omar, near Autonagar. Similar concentrations were observed at station-IV located at Autonagar plot. no. 127. Comparatively lower concentrations of Calcium Hardness were recorded at station-II, station-V and station-VI. All the stations were much below the standard of 75 mg/L during the study period. From the study, it can be identified that the contribution of Calcium to Total Hardness of water is comparatively less. And the reason for high Total Hardness in water may be due to presence of other ions in water. On considering the seasonal behaviour of Calcium Hardness in ground water, a similar seasonal variation was not observed for calcium hardness. As the summer concentrations of Calcium Hardness were high, it indicated that the effect of rain on the Calcium Hardness was less at all the stations except at station-I where the concentration was high during the rainy season.

Table 13 A comparison of mean Calcium Hardness of ground water at six stations

Stations	Annual Mean±S.D. of Total Hardness	Seasonal Mean ± S.D. of Calcium Hardness		
		Rainy	Winter	Summer
Station-I	170.333±50.581	180±44.284	171±28.020	160±73.694
Station-II	198.25±73.189	150.75±33.788	188±70.565	256±70.492
Station-III	1572.083±359.927	1561.25±614.013	1575±107.304	1580±192.130
Station-IV	1312.041±621.681	1121.5±700.922	1133.375±573.729	1681.25±464.402
Station-V	712.625±423.485	534.125±379.328	566.25±232.559	1037.5±458.0003
Station-VI	319.25±127.809	242±37.992	389.25±146.068	326.5±135.696
Station-VII	138±48.303	141±43.279	113.5±41.345	159.5±53.470



Graph 7 The comparison of mean of Calcium Hardness at all the stations with the control station

ANOVA for Calcium Hardness: From the (Table 14) below, it is clear that the calculated value is greater than the table value. The analysis of variance revealed that there are significant differences among the stations, showing Calcium Hardness as independent of each station.

Table 14 ANOVA for Calcium Hardness of ground water among the six stations

Source of Variation	SS(Sum of squares)	Degrees of freedom	MS(Mean sum of squares)	Variance ratio of F
Between stations	50303018.49	6	8383836.416	81.30261
Within stations	16602144.63	161	103118.9107	
Total	66905163.12	167		

Calculated value of F (6, 161) = 81.30261
Table value of F (4, 55) at 5% level, ($p<0.05$) of significance = 0.27

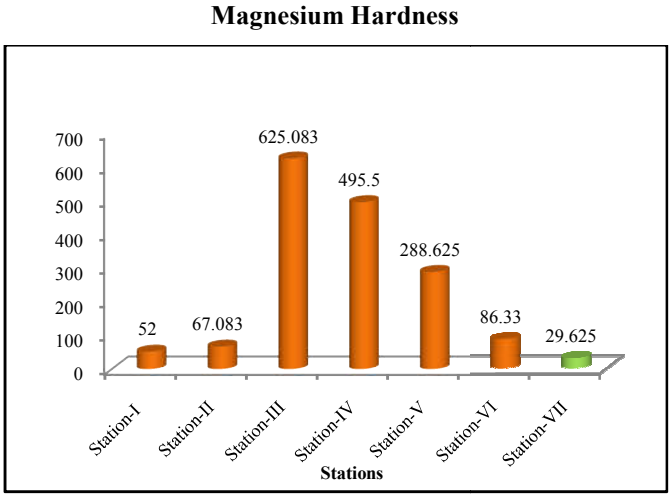
Magnesium Hardness

The mean concentration of Magnesium Hardness in ground water samples ranged between 121.33 mg/L at station-VII (control area) and 2612.5 mg/L at station-III located near Masjid Omar, near Autonagar. Except the control area, the minimum Hardness was identified at station-I, located at the Yerrabalem site. At stations I, VI and VII, the concentrations of Magnesium Hardness were more or less similar. Except station-VII (control area), the rest of the stations were having high mean concentration of Magnesium Hardness, which was

much higher than the BIS specified limit of 50 mg/L, indicating that the much of the contribution to high Total Hardness of ground is due to Magnesium ions than Calcium ions. On comparision of the Magnesium Hardness with the control station, the Hardness in ground water was found much greater from the samples collected at the industrial sites. As other sources of contamination were not observed at all the sites, the major contribution for more Hardness in ground water may be due to leachate contamination from the industrial sources. On considering the seasonal behaviour of the Magnesium Hardness in ground water, it was observed that highest concentration of Magnesium Hardness during rainy season was recorded at station-II and lowest concentration was recorded at station-VI during the winter season.

Table 15 A comparison of mean Magnesium Hardness of ground water at six stations

Stations	Annual Mean±S.D. of Magnesium Hardness	Seasonal Mean ± S.D. of Magnesium Hardness		
		Rainy	Winter	Summer
Station-I	213.75±45.699	243.125±224.046	288.25±224.046	319±127.494
Station-II	283.458±184.554	2720±879.074	2657.5±648.553	2460±645.157
Station-III	2612.5±709.011	1720±723.384	1613.75±718.071	2696.25±1205.391
Station-IV	2010±1003.030	1417.75±717.218	1176.875±547.533	893.25±378.114
Station-V	1162.62±582.460	274.5±87.764	334.5±149.863	453.5±191.93
Station-VI	354.166±161.759	102±6.845	99±36.015	163±52.839
Station-VII	121.33±46.541	243.125±224.046	288.25±224.046	319±127.494



Graph 8 The comparison of mean of Magnesium Hardness at all the stations with the control station

ANOVA for Magnesium Hardness: From the (Table 16) below, it is clear that the calculated value is greater than the table value. The analysis of variance revealed that there are significant differences among the stations, showing Magnesium Hardness as independent of each station.

Table 16 ANOVA for Magnesium Hardness of ground water among the six stations

Source of Variation	SS(Sum of squares)	Degrees of freedom	MS(Mean sum of squares)	Variance ratio of F
Between stations	143071889	6	23845314.83	87.3827
Within stations	43934275.5	161	272883.6987	
Total	187006164.5	167		

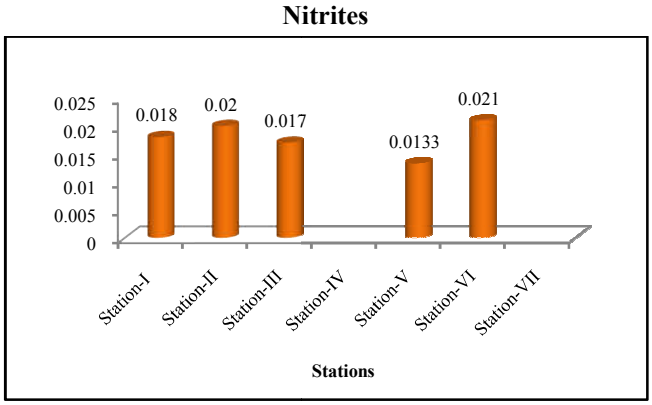
Calculated value of F (6, 161) = 87.3827
Table value of F (4, 55) at 5% level, ($p<0.05$) of significance = 0.27

Nitrites

The mean of Nitrites in ground water ranged between 0.0133 mg/L at station-V and 0.021 mg/L at station-VI. The Nitrate concentrations at all the stations were far below the BIS specified limit of 45 mg/L, indicating that a minor Nitrites pollution at the study area. The highest concentration of Nitrites were observed at station-VI and the lowest concentration was observed at station-V during the study period. The Nitrite concentration was absent at the control station during the study period. Similar ranges were observed in various studies, Hussain and Rajadurai (2013). On comparision of seasonal variations at the seven stations, it was observed that the lowest concentration of Nitrites was recorded at station-I and station-II during rainy and summer seasons; and the highest concentration was recorded at station-II during winter season at Dolas Nagar site.

Table 17 A comparison of mean Nitrites concentration in ground water at six stations

Stations	Annual Mean±S.D. of Nitrites	Seasonal Mean ± S.D. of Nitrites		
		Rainy	Winter	Summer
Station-I	0.018±0.009	0.01	0.026±0.005	0.0175±0.009
Station-II	0.020±0.016	0.01	0.036±0.015	0.01
Station-III	0.017±0.007	0.02	0.015±0.005	0.02±0.014
Station-IV	-	-	-	-
Station-V	0.0133±0.005	-	-	0.013±0.005
Station-VI	0.021±0.007	0.02±0.01	0.024±0.005	0.015±0.007
Station-VII	-	-	-	-



Graph 9 The comparison of mean of Nitrites at all the stations with the control station

ANOVA for Nitrites: From the (Table 18) below, it is clear that calculated value is greater than the table value. The analysis of variance revealed that there are significant differences among the stations, showing Nitrate concentration as independent of each station.

Table 18 ANOVA for Nitrites concentrations in ground water among the six stations

Source of Variation	SS(Sum of squares)	Degrees of freedom	MS(Mean sum of squares)	Variance ratio of F
Between stations	0.018249531	6	0.003041588	15.82349
Within stations	0.030947387	161	0.00019222	
Total	0.049196917	167		

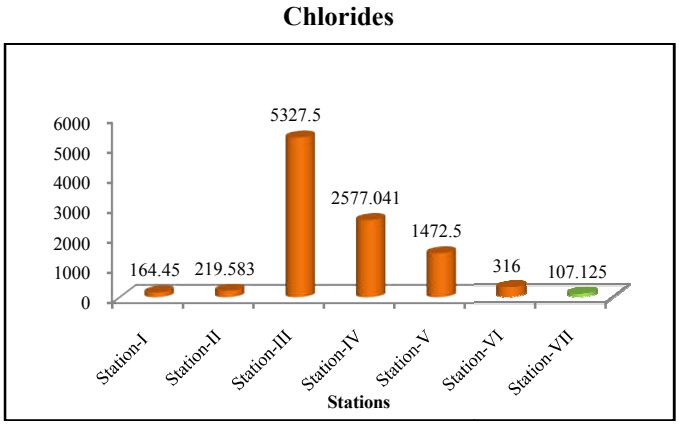
Calculated value of F (6, 161) = 15.82349
Table value of F (4, 55) at 5% level, ($p<0.05$) of significance = 0.27

Chlorides

Chlorides in water are usually taken as an indication of pollution due to dispersion of leachate in ground water. The mean of Chlorides in ground water ranged between 107.125 mg/L at station-VII i.e., at control station and 164.45 mg/L at station-I at Yerrabalem site. On comparision of stations near industrial sites with the control station, it was observed that the leachate contamination to the ground water was chiefly due to industrial sites. On comparision of seasonal variations at the six stations excluding the control station, it was observed that highest concentration of Chlorides was observed at station-III during rainy season and lowest concentration was observed at station-I during winter season.

Table 19 A comparison of mean Chlorides of ground water at six stations

Stations	Annual Mean±S.D. of Chlorides	Seasonal Mean ± S.D. of Chlorides		
		Rainy	Winter	Summer
Station-I	164.45±35.037	165.625±20.255	161.25±30.367	166.5±51.799
Station-II	219.583±48.126	251.5±25.315	218.75±67.16	166.5±51.799
Station-III	5327.5±469.66	5422.5±306.209	5242.5±712.054	188.5±13.763
Station-IV	2577.041±35.037	1238.62±447.88	2225±1194.59	4267.5±1532.39
Station-V	1472.5±663.83	1762.5±413.82	1341.25±579.81	1313.75±892.13
Station-VI	316±148.584	245.5±74.032	334±214.21	368.5±109.40
Station-VII	107.125±54.063	84.625±12.77	86.25±8.647	150.5±78.352



Graph 10 The comparison of mean of Chlorides at all the stations with the control station

ANOVA for Chlorides: From the (Table 20) below, it is clear that the calculated value is greater than the table value. The analysis of variance revealed that there are significant differences among the stations, showing Chloride concentration as independent of each station.

Table 20 ANOVA for Chloride concentrations in ground water among the six stations

Source of Variation	SS(Sum of squares)	Degrees of freedom	MS(Mean sum of squares)	Variance ratio of F
Between stations	541480421.8	6	90246736.97	177.4667
Within stations	81872973.03	161	508527.7828	
Total	623353394.9	167		

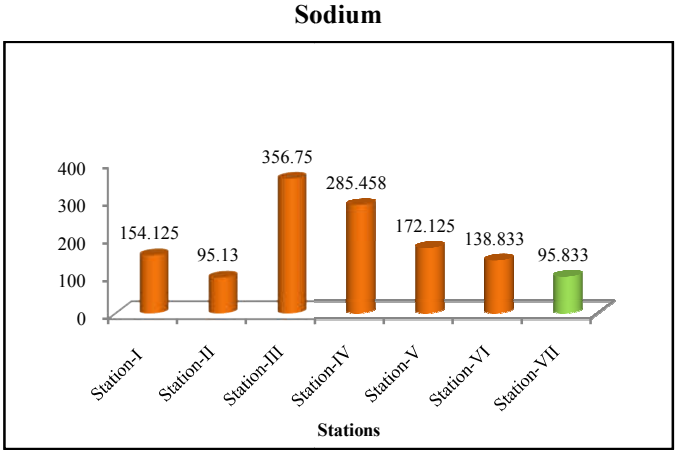
Calculated value of F (6, 161) = 177.4667
Table value of F (4, 55) at 5% level, ($p<0.05$) of significance = 0.27

Sodium

The Sodium values in ground water varied widely due to high solubility of Sodium salts and minerals. The mean of Sodium in ground water ranged between 95.13 mg/L at station-II i.e., Dolas Nagar and 356.75 mg/L at station-III i.e., Masjid Omar, near Autonagar. The Sodium concentrations were observed to be almost similar at all the stations, but comparatively low at the control station, indicating the leachate contamination to the ground water due to industrial sites during the study period. Hussain *et al.,* (2008) also reported similar ranges in their study. On comparision of seasonal variations at the seven stations, it was observed that highest concentration of Sodium was observed at station-V located near Dargha site during winter season, whereas the lowest concentration was observed at station-IV near Autonagar plot. no. 127 during rainy and winter seasons.

Table 21 A comparison of mean Sodium concentration in ground water at six stations

Stations	Annual Mean±S.D. of Sodium	Seasonal Mean ± S.D. of Sodium		
		Rainy	Winter	Summer
Station-I	154.125±6.719	154.125±6.719	95.130±3.708	356.75±19.682
Station-II	95.130±3.708	285.458±6.192	172.125±5.674	138.833±5.529
Station-III	356.75±19.682	95.833±5.155	153.87±6.49	154.75±5.994
Station-IV	285.458±6.192	153.75±8.345	94.625±4.502	139.875±6.556
Station-V	172.125±5.674	95.125±3.72	366.5±6.279	351.25±26.559
Station-VI	138.833±5.529	352.5±19.086	285.87±4.29	284.75±8.066
Station-VII	95.833±5.155	285.75±6.453	137.62±5.950	139.87±6.556



Graph 11 The comparison of mean of Sodium at all the stations with the control station

ANOVA for Sodium: The analysis of variance revealed that there are significant differences among the stations, showing Sodium concentration as independent of each station.

Table 22 ANOVA for Sodium concentrations in ground water among the six stations

Source of Variation	SS(Sum of squares)	Degrees of freedom	MS(Mean sum of squares)	Variance ratio of F
Between stations	1439221.429	6	239870.2381	2938.648
Within stations	13141.79277	161	81.62604205	
Total	1452363.222	167		

Calculated value of F (6, 161) = 2938.648
Table value of F (4, 55) at 5% level, ($p<0.05$) of significance = 0.27

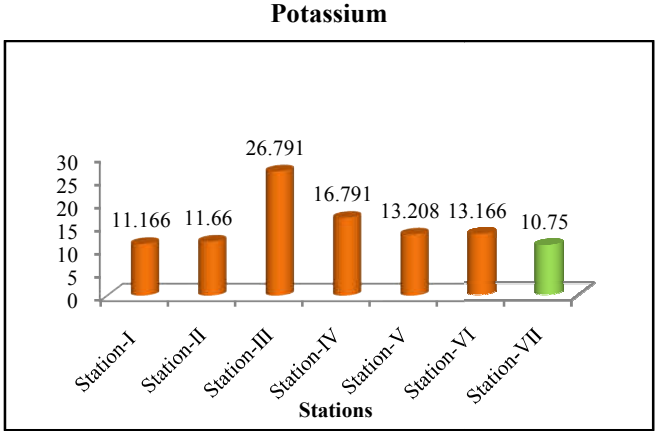
Potassium

The mean of Potassium in ground water ranged between 10.75 mg/L at station-VII to 11.166 mg/L at station-I. The lowest concentration of Potassium was recorded at station-I located near Yerrabalem site and highest concentration was recorded at

sStation-III near Masjid Omar, Autonagar. The Potassium concentrations were observed to be high at all the stations, but low at the control station, indicating leachate contamination to the ground water due to industrial sources. Hussain *et al.,* (2008) also reported similar ranges in their study. On comparision of seasonal variations at the six stations, it was observed that highest concentration of Potassium was at station-III during summer season and the lowest concentration was observed at station-VII i.e. control station during winter season.

Table 23 A comparison of mean Potassium concentration ground water at six stations

Stations	Annual Mean±S.D. of Potassium	Seasonal Mean ± S.D. of Potassium		
		Rainy	Winter	Summer
Station-I	11.166±1.711	11.25±1.035	11.125±2.295	11.125±1.807
Station-II	11.66±2.057	11.625±2.615	11.25±2.251	13±1.603
Station-III	26.791±3.911	26.625±4.172	25.5±3.927	28.25±33.615
Station-IV	16.791±2.843	16.125±2.295	16.875±3.356	17.375±3.020
Station-V	13.208±2.449	12±2.070	13.125±2.695	14.5±2.138
Station-VI	13.166±1.551	13.625±1.767	13±1.603	12.875±1.356
Station-VII	10.75±1.847	11.25±2.121	10±1.414	11±1.927



Graph 12 The comparison of mean of Potassium at all the stations with the control station

ANOVA for Potassium: As the calculated value is greater than the table value in the analysis of variance, it revealed that there are significant differences among the stations, thus showing Potassium concentration as independent of each station.

Table 24 ANOVA for Potassium concentrations in ground water among the six stations

Source of Variation	SS(Sum of squares)	Degrees of freedom	MS(Mean sum of squares)	Variance ratio of F
Between stations	4626.222222	6	771.037037	128.5746
Within stations	965.4861111	161	5.996808144	
Total	5591.708333	167		

Calculated value of F (6, 161) = 128.5746
Table value of F (4, 55) at 5% level, ($p<0.05$) of significance = 0.27

CONCLUSION

The present study on physico-chemical characterization and seasonal variations of the groundwater quality concluded that ground water generally showed more alkalinity, apart from being very hard in nature. On comparision of the selected stations with the control station, it was revealed that industrial activities make severe impact on the ground water quality. The comparatively high concentrations of nitrites, chlorides, sodium and potassium indicate the degradation of ground water quality due to industrial leachate contamination.

The study also revealed the underlying variations in the pollution potential as well as difference in the assimilative capacities of absorbing the pollutants at various locations determined the environmental impacts of various types of industrial effluents. Since industrial effluent has a tendency to increase with better economic growth, hence, the land disposal mechanism could pose even more serious environmental dangers to agriculture and other sectors as far as use of potable water is concerned. Hence, countries such as India must seriously follow a secure approach in case of industrial effluent disposal for minimizing the long term environmental and health hazards or adverse economic implications.

References

1. APHA (American Public Health Association), Standard method for examination of water and waste water New York, 20th edition, 1998.
2. Gagan, M., Amit, C., Avinash, K., and Ajendra, K., (2016). Impact of industrial effluent on ground water and surface water quality- A case study of Dhampur region (U.P.), *India, Journal of Chemical and Pharmaceutical Sciences*, 9(2), 709-713.
3. Hussain., A.Z., and Rajadurai., D., (2013). Assessment of ground water pollution on the bank of river Amaravathi at Karur district, Tamil Nadu, Advances in Applied Science Research, 4(4):6-10.
4. Hussaina, M., Ahmedb, S.M., Abderrahman, W., (2008). Cluster analysis and quality assessment of logged water at an irrigation project, eastern Saudi Arabia, *Journal of Environmental Management* 86, 297–307.
5. Joshi, A., and Seth, G., (2008). Physico-chemical characteristics of Ground Water of Sambhar Lake City and its adjoining area, Jaipur District, Rajasthan, (India), *Int. J. Chem. Sci.*, 6(4), 1793-1799.
6. Niloufer, S., Rao, K.V., Swamy, A.V.V.S., (2016). Impact of Municipal Solid Waste Dumpsite on the Ground Water Quality in Vijayawada, *International Journal of Applied and Pure Science and Agriculture*, 2(5), 31-41.
7. Nduka, J.K.C., and Orisakwe, O.E., (2007). Heavy metal levels and physico – chemical quality of potable water supply in Warri, Nigeria, Annali di Chimica, 97, 867-874.
8. Ramesh R, Point and Non-point sources of Groundwater Pollution: Case Studies along the East Coast of India, In: Subramanian V, and Ramanathan A.L, (Eds.), Proceedings of the International Workshop on Ecohydrology, Capital Publishing Company, New Delhi, India, 2001, 107.
9. Sahare, A.B., (2016). Physico-chemical studies of ground water samples from villages of Narkhed and Warud tehsil of Vidarbha region Maharashtra, India, Pelagia Research Library, Der Chemica Sinica, 7(2), 76-81.
10. Singh, M.K., (2012). Dhaneshwar Jha2 & Jyoti Jadoun, Assessment of Physico-chemical Status of Groundwater

Samples of Dholpur District, Rajasthan, India, *International Journal of Chemistry*; 4(4) 96-104.

11. Uday, V.S., Amar, A., Kunwar, P.S., and Ratnakar, D., Netra, P.S., (2014). Groundwater quality appraisal and its hydrochemical characterization in Ghaziabad (a region of indogangetic plain), Utta Pradesh, India, *Appl Water Sci.*, 4, 145–157.

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