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Assessment of Ground Water Quality at Selected Industrial Areas of Guntur, A.P., India

Osama Asanousi Lamma[1] and A.V.V.S. Swamy[2*]

Department of Environmental Sciences, Acharya Nagarjuna University, Guntur, A.P., India

*Corresponding Author E-mail: arzavvsswamy1962@gmail.com

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ABSTRACT

The quality of ground water adjacent to industrial areas is a matter of grave concern as it directly impacts human health and irrigation. In this paper, the ground water quality in the vicinity of industrial areas of Guntur was assessed in two years i.e. from June 2015 to May 2017. Water samples were analyzed for physico-chemical parameters like Turbidity, pH, Electrical conductivity, Total dissolved solids (TDS), Total Alkalinity (TA), Total Hardness (TH), Calcium (Ca^+), Magnesium (Mg^+), Nitrites (NO_2^-), Chlorides(Cl^-), Fluorides (F^-), Sodium (Na^+), Potassium(K^+) and heavy metals such as Nickel, Zinc and Cadmium on a monthly basis. It was observed that most of the parameters have exceeded the acceptable limits set by IS 10500 Drinking Water Quality Standards. The correlation among the various parameters was also estimated. The study revealed that the groundwater is contaminated with industrial effluents and out of the three stations, two were found contaminated, thus no longer potable.

Key words: *Groundwater, Physicochemical parameters, Correlation co-efficient*

INTRODUCTION

The present study was conducted to make groundwater quality assessment in selected industrial areas of Guntur district in Andhra Pradesh. The quality of groundwater in some parts of the country, particularly shallow groundwater is fast deteriorating due to irresponsible human actions. In general, groundwater quality changes with seasons; type of rock also influences the quality of water in the aquifer and inputs from soil during percolation of water [9]. In fact, industrial waste and the municipal solid waste have emerged as one of the leading causes of surface and ground water pollution[5]. Though a number of studies on groundwater quality assessment have been undertaken all over the world, including various parts of India, yet no significant work on groundwater quality assessment has been attempted so far in the study area i.e. Guntur district. Regular monitoring data is not available due to the absence of such quality assessment studies. It is common knowledge that groundwater is one important source of public water supply.

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Discharges from industries contain a number of chemical pollutants, such aa Ammonia, Arsenic, Phenol, Cyanide, Thiocynide, Copper, Cadmium, Zinc, Chromium, Carbonate, Bi-carbonate, Nitrite, Phosphate, Oil and Grease in addition to total suspended solids, volatile solids and scores of other toxic elements[13].

MATERIALS AND METHODS

Study area

Guntur district is in the central coastal part of Andhra Pradesh, comprising 57mandals under the administrative control of 3 revenue divisions viz., Narasaraopet, Guntur and Tenali. The district has 729 villages and 1036 hamlets. It is spread over a total geographical area that measures11,328 sq. Kms, covering the stretch between North latitudes 15°18’ & 16°50’ and East longitudes 79°10’00” & 80°55’00” (Fig 1).

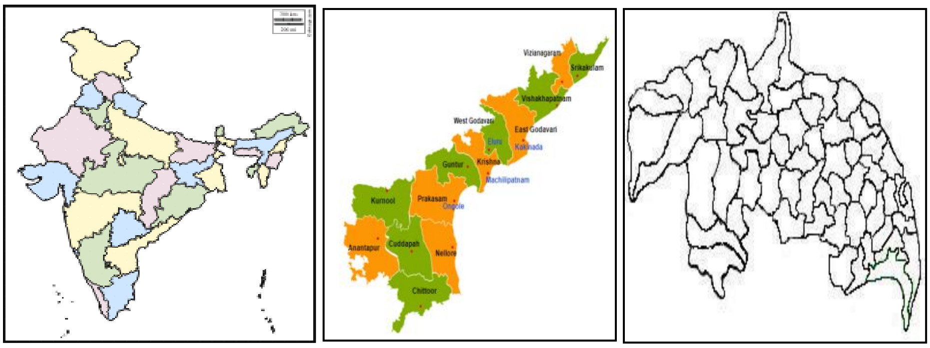


Fig. 1: Location map of study area

Guntur Industrial area

Guntur industrial area has presence of various industries such as, Iron factory, Automobile industries, Lead factory, Distilleries, Plywood factory, Paper packaging factory, Welding rods factory, Gas Industry, Drugs factory etc. Due to the availability of government assigned land and barren land and easy availability of raw materials in nearby places, the Government favoured industries in this area. All these factories discharge industrial effluents into ground water**.** In Autonagar industrial hub, apart from the land, air also has become severely polluted because of the release of soot, containing dust and hazardous vapours. This has prompted the researcher to initiate research for assessing the quality of ground water and its impact on the health of slum dwellers.

Table 1: Sampling Stations

S.No	Sampling stations	Location
1	Station-I	Borewell from Yerrabalem site
2	Station-II	Borewell from Dolas Nagar site
3	Station-III	Borewell from Acharya Nagarjuna University site (control station)

Physico-Chemical analysis

Samples were analyzed in the laboratory by using standard methods of analysis (APHA,1998). A.R. Grade chemicals and double-distilled water was used for preparing standard solutions for the analysis. A total of three sampling stations were selected for collection of samples from bore-wells in the industrial locations of Guntur District, in a stretch of about 22 km, out of which the third station i.e., Station-III is designated as the control station. Various physical parameters like pH, EC, and TDS were identified on the spot with the help of digital portable pH meter, conductivity meter and TDS meter. The Total Hardness is measured by EDTA titrimetric method by using EBT indicator. The procedures, instrument, model & make followed for analyzing each parameter is briefly described below:

Table 2: Standard analytical methods used for analyzing physico-chemical parameters

S. No.	Parameters	Methodology
1	Turbidity	NTU
2	pH	Electrometric method Digital pH meter (Hanna model PHEP)
3	Electrical Conductivity (μmhos/cm)	Electrometric method Conductivity meter (Hanna model no. DiST-4)
4	Totlal Dissolved Solids (mg/L)	Electrometric, (Hanna model no. DiST-4)
5	Total Alkalinity (mg/L)	Volumetric analysis, Titrimetric
6	Total Hardness (mg/L) EDTA	Titrimetric method
7	Calcium	Titrimetric method
8	Magnesium	Titrimetric method
9	Nitrite - N (mg/L)	Phenol Disulfonic Acid (PDA) method
10	Chlorides ($Cl^{-)}$	Argentometric method
11	Fluorides	SPADNS method, Colorimeter (ELICO)
12	Sodium (Na^+)	Flame Photometer (ELICO)
13	Potassium (K^+)	Flame Photometer (ELICO)
14	Heavy metals (Ni, Zn, Cd,	AAS (Perkin Elmer-AAnalyst 300)

The concentrations/values of the parameters were expressed as mg/l, unless & otherwise specified

RESULTS AND DISCUSSION

The results of physico-chemical analysis of ground water during two complete annual cycles are presented in Table 3. At all the stations, it was observed that the physico-chemical parameters showed an increase from 2015-16 to 2016-17.

Table 3: Physico-chemical analysis of two annual means of Ground water quality at three Sampling Stations

S.NO	Parameters	Station-I		Station-II		Station-III	
		2015-16	2016-17	2015-16	2016-17	2015-16	2016-17
1	Turbidity	0.325±0.04	0.325±0.04	0.372±0.04	0.39±0.03	0.33±0.04	0.33±0.04
2	pH	7.24±0.1	7.38±0.22	7.11±0.17	7.12±0.24	7.69±0.07	7.76±0.28
3	Electrical Conductivity (μmhos/cm)	1471.66±214-29	1422.16±168.98	1905±274.64	1926.5±202.95	883.75±118.11	1027.5±359.42
4	Total Dissolved Solids	984.25±138.21	938.58±111.52	1247±171.53	1273±134.16	580.75±79.89	675±236.26
5	Total Alkalinity	363.25±19.72	384.83±37.99	373.41±39.52	415.5±27.76	245.75±39.34	224±92.54
6	Total Hardness	406.33±63.02	352.66±22.29	408±166.93	512.5±184.93	281.16±62.04	232±86.58
7	Calcium	79.08±13.62	48.58±24.34	84.91±31.60	74.91±32.53	62.75±15.27	45.83±21.56
8	Magnesium	49.66±9.40	54.33±13.45	47.08±25.11	87.08±42.67	31.83±9.27	27.41±13.18
9	Nitrites(mg/L)	0.018±0.009	0.017±0.009	0.02±0.02	0.021±0.015	0.01	-
10	Chlorides	181.08±33.59	147.83±28.9	236.66±32.2	202.5±56.29	98.08±35.52	116.16±68.34
11	Fluorides	0.94±0.31	0.51±0.1	1.22±0.35	1.3±0.2	0.97±0.35	0.90±0.48
12	Sodium	153.75±8.54	154.5±4.60	95.09±3.17	95.16±4.28	98.41±2.74	93.25±5.78
13	Potassium	10.33±1.37	12±1.65	10.16±1.52	13.16±1.26	9.91±1.24	11.58±2.02
14	Nickel	0.053±0.007	0.041±0.013	0.007±0.002	0.007±0.001	-	-
15	Zinc	0.053±0.009	0.053±0.012	0.337±0.291	0.082±0.09	-	-
16	Cadmium	0.006±0.002	0.008±0.001	-	-	-	-

(All the values are expressed in mg/l except where specifically mentioned)

Graphs on the comparison of mean of parameters in ground water with control station

A comparative account of three stations is represented by the graphs shown below.

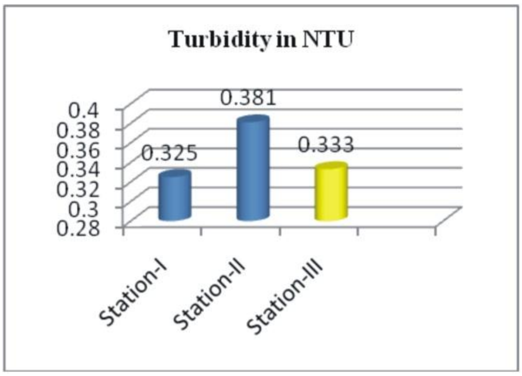


Figure 2

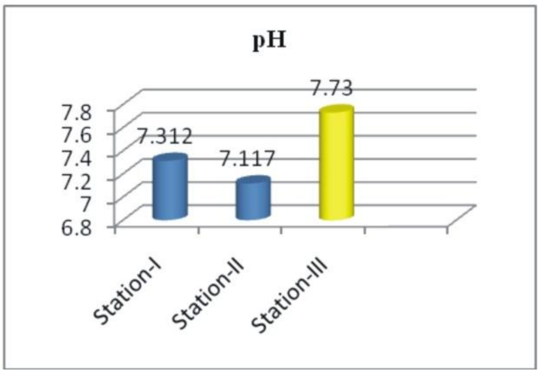


Figure 3

Turbidity: It is an expression of certain light scattering and light absorbing properties of the water sample caused by the presence of clay, silt, suspended matter, colloidal particles, plankton and other microorganisms (WHO, 1984). Turbidity of water affects other water quality parameters such as colour, when it is imparted by colloidal particles. It also affects the chemical quality of drinking water through the formation of complexes between the turbidity causing humic matter and heavy metals [12&3]. Turbidity of all the water samples was found within the permissible limit of the WHO. Excluding the control station, the turbidity values ranged between 800 mg/L at station-I (Yerrabalem) during winter seasons to 1650 mg/L at station-II (Dolas Nagar) during winter season. At control station, the turbidity values were comparatively low, ranging between 356 mg/L and 1320 mg/L during winter and summer seasons.

pH: One of the important factors that serve as an indicator of pollution of a water body is the pH. The pH of natural water can provide important information about many chemical and biological processes and shows an indirect correlation with a number of different impairments. pH is the scale of intensity of acidity and alkalinity of water and measures the concentration of hydrogen ions [1]. The pH of the ground water at station-I (Yerrabalem) was nearer to neutral i.e. 7.312±0.186. All the samples showed pH within the standards specified by BIS for drinking water. The lowest pH (i.e.7) recorded was in February 2016 and the highest pH (i.e. 7.84) was in August, 2016. The pH was found to be near-neutral to alkaline as well as within the BIS-specified range of 6.5-8.5 for drinking water during all the three seasons. The pH was more or less consistent; and the seasonal variations were negligible during the study period.

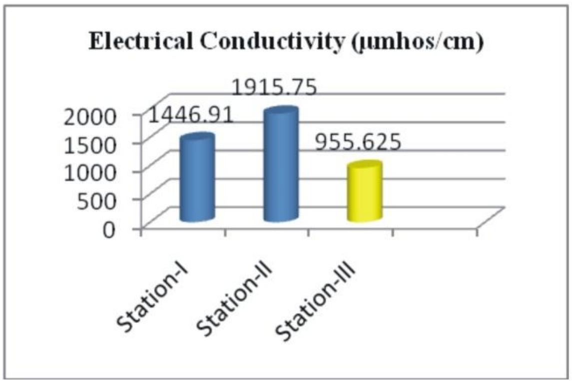


Figure 4

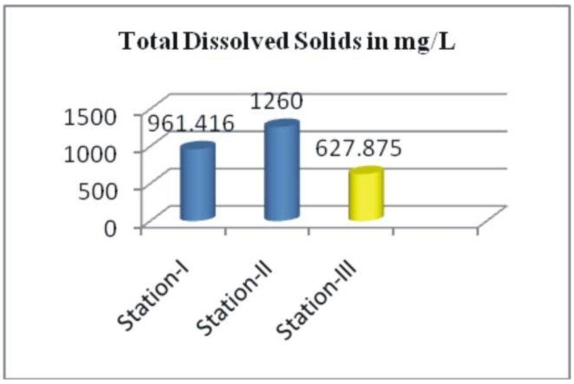
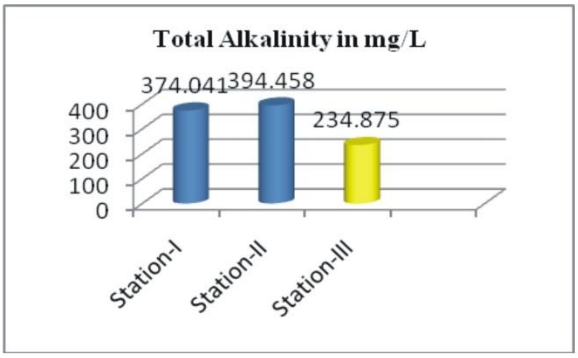


Figure 5

Electrical conductivity (EC): EC is a measure of ionic content of water. Conductivity is typically reported in units of micro Siemens per centimetre[10]. The Electrical Conductivity of the ground water slightly exceeded the maximum permissible limit of 750 µmhos/cm, as prescribed by BIS. The lowest value of Electrical Conductivity (i.e. 1150 µmhos/cm) was recorded in October 2015, and the highest (i.e. 1840 µmhos/cm) was recorded in February 2016. Electrical Conductivity was found to be high in summer followed by rainy and winter seasons at Station-I and Station-III. And the Electrical Conductivity was found to be high in rainy season followed by winter and summer seasons during the study period at station-II.

Total Dissolved Solids (TDS): The salinity of groundwater can be indicated by Total Dissolved Solids (TDS). Water containing more than 500 ppm TDS is not considered desirable for drinking water supplies[15]. The mean of Total Dissolved Solids (TDS) in the ground water samples at the study area recorded was more than the permissible limit as prescribed by BIS (i.e. 500 mg/L). The lowest value of Total Dissolved Solids (i.e. 800 mg/L) was recorded in January, 2017, and the highest value of Total Dissolved Solids (i.e. 1214 mg/L) was in February, 2016.



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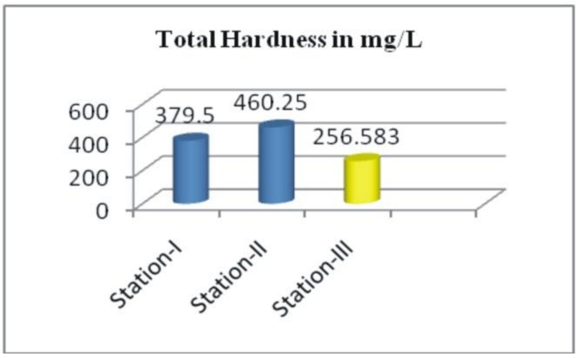

Figure 7

Alkalinity: The alkalinity of water is due to the presence of various minerals. The various ionic species that contribute to alkalinity include bicarbonate, phosphate, borate and organic acid[7&14]. The mean recorded alkalinity was more than the limit set by BIS (Desirable) of 200 mg/L. The lowest value of Total Alkalinity was recorded at 328 mg/L in October, 2015 and the highest was at 480 mg/L in December, 2016. And Total Alkalinity was observed to be higher than the limit set by BIS (Desirable) of 200 mg/L during the three seasons.

Hardness: Hardness is the property of water which prevents the lather formation with soap and increases the boiling points of water. Hardness of water mainly depends upon the amount of calcium or magnesium salts or, both[8] . The mean of Total Hardness concentration in ground water recorded was slightly higher than the BIS standard value at 300 mg/L. The lowest value of Total Hardness was recorded as 280 mg/L in the month of May, 2016 and the highest was 520 mg/L in February, 2016.

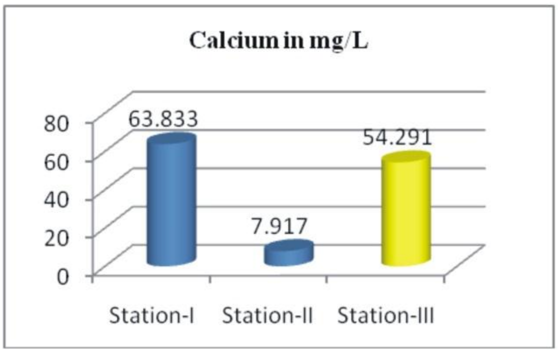

Figure 8

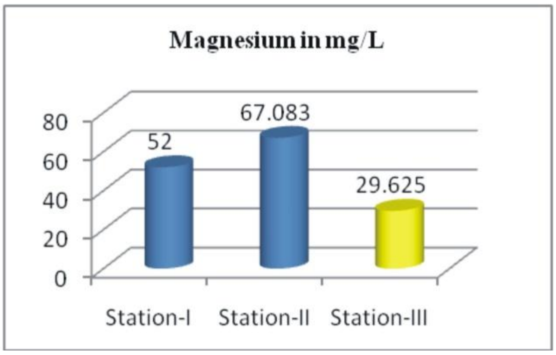

Figure 9

Calcium: Calcium (Ca^{2+}) is directly related to hardness of water[4]. The mean of Calcium concentrations was below the BIS standard of 75 mg/L. The lowest concentration of Calcium was recorded at 6 mg/L in the month of January, 2017 and the highest was at 96 mg/L in the months of February, March and April in 2016. Calcium concentration was high during rainy season followed by summer and winter seasons. And the concentrations of Calcium did not exceed the BIS specified limit of 75 mg/L for drinking water.

Magnesium: Magnesium (Mg^{2+}) is also directly related to hardness. The Magnesium concentration recorded was higher than the prescribed standard of 50 mg/L. The lowest concentration of Magnesium was 39 mg/L in February, 2017 and the highest was 73 mg/L in April, 2017.

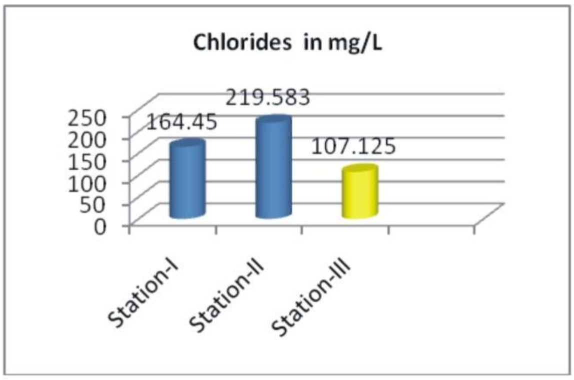

Figure 10

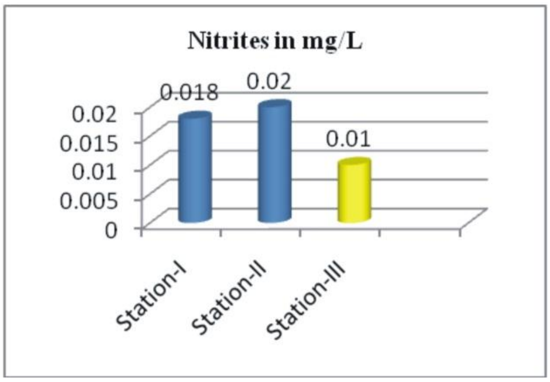

Figure 11

Chloride: Chloride (Cl^-) is minor constituent of the earth's crust. Rain water contains less than 1 ppm Chloride[6]. Chloride in the samples ranged between 120 and 240 mg/L, which was considerably less than permissible limit of 250 mg/L as specified by the BIS. The lowest value of Chloride was recorded at 120 mg/L in the months of September and October of 2016 and March of 2017, with the highest at 240 mg/L in the months of March and April 2016. The Chloride concentration was found to follow a trend of high values during summer season followed by rainy and winter seasons. Nitrates were found to penetrate both surface water and ground water as a consequence of agricultural activity. The high nitrogen content is an indicator of Organic Pollution[16].

Nitrites: The concentration of Nitrites was absent at three stations for so many months. The highest concentration of 0.03 mg/L was recorded in the months of April and December, 2016. At the stations, the concentration of Nitrites was high during the winter season followed by rainy and summer seasons.

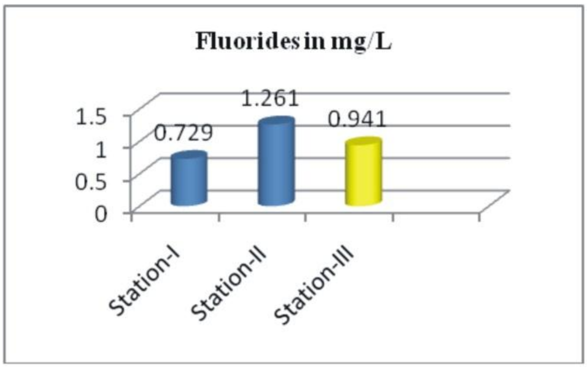

Figure 12

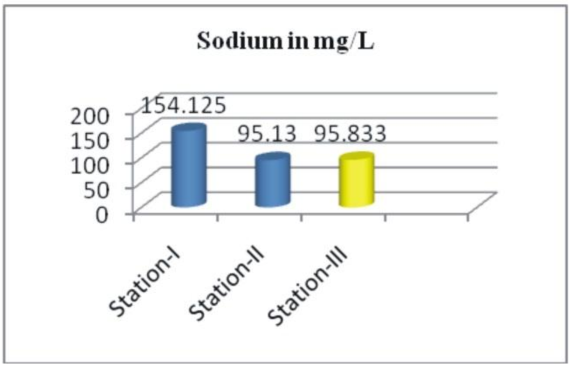

Figure 13

Fluoride: Fluoride, an element never exists in its elemental state in nature as it is the most reactive non-metal. So it is found in the environment in combination with other elements, including fluorspar, rock phosphate, cryolite, apatite, mica, hornblende, except oxygen and noble gases. Drinking-water is typically the largest single contributor to daily fluoride intake[8]. The concentrations of Fluorides in groundwater were higher than the desirable limit of 1 mg/L in all the samples collected. The lowest value of Fluoride was recorded at 0.3 mg/L in August 2016, and the highest was 1.3 mg/L in the months of July and October of 2015 as well as February of 2016. The concentration of Fluoride was high during the rainy season followed by summer and winter seasons.

Sodium: Sodium content of around 200 ppm is harmful to persons suffering from cardiac and renal diseases and with toxemia associated with pregnancy in women[11]. The mean concentration of Sodium in all the samples was higher that the desirable limit of 200 mg/L as prescribed by the BIS. The lowest value of Sodium (i.e.145 mg/L) was recorded in the months of March 2016 and the highest (i.e.170 mg/L) in May 2017. The Sodium concentrations were found to be high during winter season followed by rainy and summer seasons.

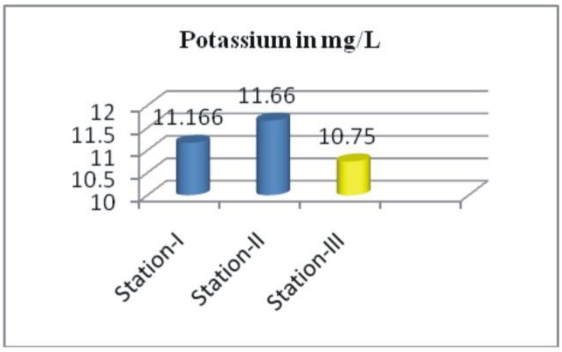

Figure 14

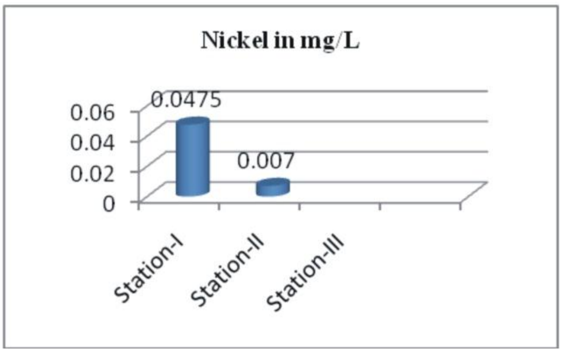

Figure 15

Potassium: High concentration of Potassium may be attributed to the contamination by sewage[2]. The Potassium concentrations varied widely in the samples collected at the three stations. The lowest value of Potassium was recorded at 9 mg/L in December to February 2015 and March 2017, where as the highest (i.e. 15 mg/L) was in December 2016. The Potassium concentration was almost similar during the three seasons.

Nickel: The lowest value of Nickel was recorded as 0.045 mg/L in the month of December 2016, and the highest value of Nickel was at 0.09 mg/L) in the month of January, 2017. The concentration was observed to be slightly higher than the limit that was prescribed by the BIS. No noticeable seasonal variations were observed in case of Nickel concentrations at the three stations; but the concentration was found to be slightly high during winter season.

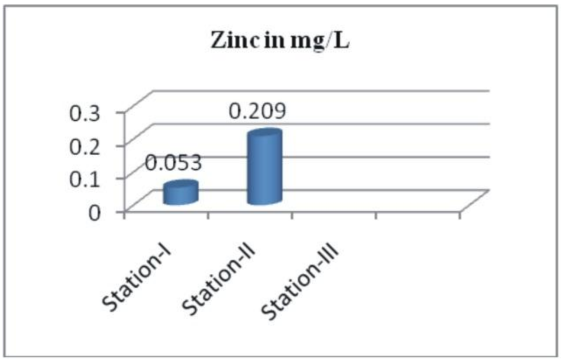

Figure 16

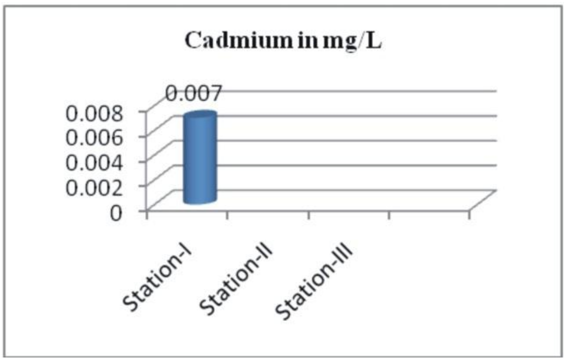

Figure 17

Zinc: The mean concentrations of Zn were far below the BIS specified standard of 5mg/L (Table 2). The lowest value of Zinc was recorded at 0.04 mg/L in the months of December, 2016 and March, 2017, and the highest was 0.078 mg/L in January, 2016. The concentrations of Zinc showed no significant variations among the three seasons.

Cadmium: The concentration of Cadmium was absent at station II and the control station i.e. station-III during the study period. The lowest concentration of Cadmium was reported in the months of July, October and November of 2015, whereas the highest concentration of 0.012 mg/L was recorded in the month of June, 2017 at station-I. The concentrations of Cadmium showed no significant variations during the three seasons. The concentrations were found to be slightly higher than the BIS-specified limit of 0.003 mg/L during the three seasons.

Statistical Analysis

Statistical analysis can be applied to represent the data of the water research work, which is useful in understanding the internal relations among various parameters used for physicochemical analysis. As the initial part of statistical analysis, the mean and standard deviation for the values of different parameters was calculated as shown in **Table-4**.

Correlation is a broad class of statistical relationships between two or more variables. Hence, it can be considered as a normalized measurement of covariance. The correlation study is useful to find a predictable relationship that can be used in practice. It is used for the measurement of the strength and statistical significance of the relation between two or more water quality parameters.

TABLE 4: Correlation coefficient for different physicochemical parameters in groundwater

	Turbidity	***pH***	***EC***	***TDS***	***TA***	***TH***	***Ca^{2+}***	***Mg^{2+}***	***NO_2^-***	***Cl^-***	***F^-***	***Na^+***	***K^+***
Turbidity	1												
pH	-0.65	1											
EC	0.784	-0.981	1										
TDS	0.773	-0.985	1	1									
TA	0.487	-0.98	0.924	0.931	1								
TH	0.741	-0.992	0.998	0.999	0.948	0.999							
Ca^{2+}	-1	0.629	-0.767	-0.755	-0.463	-0.695	1						
Mg^{2+}	0.719	-0.995	0.995	0.997	0.957	1	-0.7	1					
NO_2^-	0.549	-0.992	0.949	0.955	0.997	0.977	-0.526	0.976	1				
Cl^-	0.785	-0.981	1	1	0.923	0.994	-0.768	0.995	0.949	1			
F^-	0.963	-0.42	0.587	0.572	0.232	0.498	-0.97	0.504	0.302	0.588	1		
Na^+	-0.618	-0.195	0.003	0.022	0.385	0.108	0.64	0.101	0.317	0.001	-0.808	1	
K^+	0.822	-0.967	0.998	0.997	0.898	0.986	-0.805	0.987	0.928	0.998	0.636	-0.06	1

Note: Correlation is significant from 0.5 to 1.0 and -0.5 to -1.0

As shown above, Turbidity has negative correlation with pH and Calcium. As the Turbidity increases, the pH and Calcium decrease. Turbidity has moderately positive correlation with all other parameters. All the analysed parameters have a negative correlation with pH, while rest of the parameters have shown a significant strong correlation with each other.

CONCLUSION

The findings of the study suggest that seasonal and site-specific variations have a definitive impact on the groundwater quality at the industrial sites around Guntur. Thus, at industrial areas around the city, a careful management and consideration of all the seasonal factors and site specifications must be attempted by following a sound and sustainable programme. At all the stations, it was observed that the physico-chemical parameters consistently increased from 2015-16 to 2016-17, indicating the cumulative effect of sources of pollution in the study area. It may be concluded that there is a definite impact of industrial waste on the quality of groundwater. Hence, it is recommended that the industrial effluents be properly treated and discharged outside. A zero liquid discharge (ZLD) is the best way that is widely practiced in all industrial cities.

REFERENCES

1. Annalakshmi, G. and Amsath, A., Studies on the hydrobiology of river Cauvery and its tributaries Arasalar from Kumbakonam region (Tamilnadu, India) with reference to zooplankton, *IJBPT*, **3(1):** 269 (2012).
2. Abdularfiu, Majolagbe, O, *Advances in Applied Science Research*, 2(1):289-298 (2011).
3. Daud, N.N.N., Izehar, N.H., Yusuf, B., Mohamed, T.H. and Ahsan, A., Groundwater Quality Improvement by Using Aeration and Filtration Methods, *Int. J. Environ. Chem. Eco.Geo. Geophy. Engi.*, **7(6):** 309 (2013).
4. Gopalkrushna, M., Determination of Physico-Chemical parameters of Surface Water Samples in and around Akot City *Int. J. Res. Chem. Environ.*, **1(2):** 183 (2011).
5. Gupta, D.P., Sunita, J.P., Saharan, Physiochemical analysis of ground water of selected area of Kaithal city (Haryana) India, *Researcher*, **1 (2):** 1–5 (2009).
6. Khadri, S.F.R., Pande, C., Moharir, K., *Int. J. Sci. Engi. Res.*, **4 (9):** 1856 (2013).
7. Kondulkar, S.R., Khandelwal, M.G., Chaudhari, U.E., Wanjari, A.K. and Markam, G.M., Physico-Chemical Analysis of Ground Water Affected by Ganapati Visarjan, *IJARCS*, **2(11):** 8 (2015).
8. Leelavathi, Ch., Sainath, U.K., Rabbani, A.K., Physicochemical Characterization of ground water of Autonagar, Vijayawada, Krishna district, *International Journal of Engineering Development and Research*, **4(2):** 1324-1328 (2012).
9. Matini, L., Tathy, C. and Moutou, Seasonal groundwater quality variation in Brazzaville, Congo, J.M., *Res. J. Chem. Sci.*, **2(1):** 7 (2012).
10. Maurya, P.K., Zaidi, J. and Pal, A., Physico-chemical properties of Barua Sagar lake water, Jhansi, Uttar Pradesh. India, *Elixir Pollution*, **42:** 6355 (2012).
11. NAS.” Water quality criteria”. *Nat. Academic sciences*. **23(1972):105 (1977)**
12. Ojo, O.I., Otieno, F.A.O. and Ochieng, M., Groundwater: Characteristics, qualities, pollutions and treatments: An overview, *Int. J. Water Res. Environ. Engi.*, **4(6):** 162 (2012).
13. Sarkar, R., Gupta, M.K. and Parashar, P., Chemical Analysis and Quality of Ground Water Samples in Industrial Area in Jaipur, *Suresh Gyan Vihar University International Journal of Environment, Science and Technology*, **3(1):** 12-20 (2017).
14. Seenivasan, C., Bhavan, C., Radhakrishnan, P.S. and Kamalakannan, M., Groundwater quality in Tirupur, Tamilnadu, India: A pilot-assessment, *Res. Environ. Life Sci.*, **3(1):** 27 (2010).
15. Sharada, S. and Yasovardhan, N., *Int. J. Em. Trend Engi. Devlop.*, **4(3):** 321 (2013).
16. Sihabudeen, M.M., Ali and Hussain, A.Z., Assessment of Physico-Chemical quality of Ground Water samples in and around Trichy Town, Tamilnadu, India, *Archives of Applied Science Research*, **8 (4):** 31-34 (2016).

