*Available online at*www.scholarsresearchlibrary.com

Scholars Research Library

Archives of Applied Science Research, 2014, 6 (6):128-137
(http://scholarsresearchlibrary.com/archive.html)

ISSN 0975-508X
CODEN (USA) AASRC9

Emphasizing the ground water quality characteristics of industrialization in Visakhapatnam

P. Pavitra[1*], Y. Satyanarayana[1#], L. Vaikunta Rao[1], Ch. Rama Krishna[2] and D. Mallikarjuna Rao[2]

[1]Department of Chemistry, Institute of Science, GITAM University, Visakhapatnam, A.P., India
[2]Department of Environmental Studies, Institute of Science, GITAM University, Visakhapatnam, A.P.

ABSTRACT

The present study reveals that emphasizing the groundwater quality in and around the industrial region of Visakhapatnam area, Andhra Pradesh. Ground water is mainly polluted due to organic, inorganic pollutants, heavy metals and pesticides. Ground water samples collected from different sampling stations and analyzed for different water quality parameters such as p^H, EC, TDS, Ca^{2+}, Mg^{2+}, TH, Cl^-, CO_3^{-2}, HCO_3^-, Na^+, K^+, NO_3^-, Fe^{2+}, F^-, Cu^{2+}, Pb^{2+}, Zn^{2+}, Cr^{3+} using standard techniques in laboratory. The results obtained were compared with the Bureau of Indian Standards (BIS: 10500, 2012) guidelines for drinking water. The main objective of this study is to identify the quality of ground water especially in industrial area and to calculate water quality index (WQI) for different ground water sources at industrialized area. For calculating the WQI, Ten parameters have been considered. The WQI for these samples ranged between 37 to 115. Water quality index value is poor quality in one area i.e Parawada. Piper diagram represents that the ground water is calcium carbonate Ca-Mg-Na-Cl-SO42-.The analysis revealed that some of the groundwater quality parameters slightly above the desirable limits and not suitable for drinking water and it also needs to be protected from the perils of contamination by giving some of treatment.

Keywords: Ground water, Physico-chemical parameters, water quality index, Industrialization, piper diagram

---

INTRODUCTION

Groundwater is the main important resource for industrial, domestic and agriculture purposes. People depend upon the ground water for life survival. Industrialization as effected by the quality of ground water due to over-exploitation and improper waste disposal [1-3]. Industrial wastes causing heavy and varied pollution in aquatic environment leading to pollute water quality and depletion of aquatic biota [4]. Land use patterns, geological formation, rainfall pattern and infiltration rate are reported to affect the quality of groundwater with nature has led to the deterioration of good quality of water [5]. It is necessary that the quality of drinking water should be checked at regular time of interval. Mines, petroleum processing units, steel, smelter plants, pulp paper, textile and agriculture industries etc. are major sources for water contamination[6]. Wastes entering these water bodies are both in solid and liquid forms. As a result, water bodies which are major receptive of treated and untreated or partially treated industrial wastes have become highly polluted [7]. The waste water of an industry is dumped into streams; it gets into natural sources and causes change in physico-chemical composition of ground water which ultimately becomes unsuitable for use [8]. Today we use many different chemicals and various synthetic products the main causes of ground water pollution [9].This untreated effluent spared on land surface and it enter into aquifer and contaminated the groundwater. This contaminated groundwater cause of many disorders in human being and crops[5,11]. Due to short fall of rain, improper management of rain water results in the pollution of ground water. Most of the Indian rivers and freshwater streams are seriously polluted by pharmaceutical, paper and printing industry, effluents which includes wastes like metals, detergents, acids, alkalis, sulfates chlorides, nitrates, dissolved and suspended solids, organic and microbial impurities[4] Ground water often consists of eight majors' chemical elements – Ca^{2+}, Mg^{2+}, Cl^-, HCo_3^-, CO_3^{2-} ,Na^+, K^+ and SO_4^{2-}The objective of the present study is to discuss the major's chemistry of groundwater of the hydro chemical characteristics. Industrialization is the index of modernism which leads to alternation in the physical and chemical properties of environment [12]. Heavy unplanned industrial establishments have negatively affected the groundwater quality Contamination problems in the study area. Water quality index is main important technique to communicate information of the ground water quality and it suitability for drinking purpose [13]. The objective of the present work is to assess the ground water quality of different parameters in the industrial region of Visakhapatnam for interrupting the hydro geochemical data.

MATERIALS AND METHODS

DESCRIPTION OF THE SAMPLING STUDY

The study area is located between 17.395 to 17.661N latitude and 83.055 to83.201E longitude. It is situated in the middle of Chennai-Kolkata Coromandal Coast. The city is home to several State-owned heavy industries and a steel plant, one of India's largest seaports and has the country's oldest Shipyard. Visakhapatnam has the only natural harbour on the east coast of India. It is nestled among the hills of the Eastern Ghats and faces the Bay of Bengal on the east. Present investigation on the study of the sampling stations around the industrialized in Visakhapatnam Laurus company-2, Paravada-MRO office, Paila gangaraju, Rama temple, Thanam, Thadi, Sri sai play wood, Sankar foundation hospital, Sujatha hospital, banoji colony, Malkapuram (akccps), Scindia, Mindi (mg,wpf,gvmc), Mindi (mg,rrw,gvmc), Mindi (mg,gw,wpf), Ultratech cement, Mindi (jpu), Sri rama clinic Gajuwaka, Hindustan zinc limited, Old gajuwaka, New gajuwaka, Peda gantyada

Fig-1: Study area map

Visakhapatnam study area map

Table-1: Sampling Sites with Latitude and Longitudes

Sl.No	SAMPLING STATION	LATITUDE	LONGITUDE
1	LAURUS COMPANY-2	17.395 N	83.055 E
2	PARAVADA-MROOFFICE	17.379 N	83.050 E
3	PAILA GANGARAJU	17.377 N	83.047 E
4	RAMA TEMPLE	17.377 N	83.047 E
5	THANAM	17.389 N	83.042 E
6	THADI	17.402 N	83.046 E
7	SRI SAI PLAY WOOD	17.410 N	83.122 E
8	SANKAR FOUNDATION HSPTL	17.411 N	83.122 E
9	SUJATHA HOSPITAL OG	17.431 N	83.123 E
10	BANOJI COLONY	17.410 N	83.130 E
11	MALKAPURAM POLICE STATION	17.412 N	83.155 E
12	NAVY PARK SCINDIA	17.413 N	83.160 E
13	MINDI	17.418 N	83.126 E
14	M RESERVOIR RAW WATER	17.418 N	83.126 E
15	MINDI GROUND WATER	17.418 N	83.126 E
16	ULTRATECH CEMENT	17.420 N	83.126 E
17	MINDI JPU	17.420 N	83.128 E
18	SRI RAMA CLINIC GJK	17.412 N	83.131 E
19	HINDUSTHAN ZINC LIMITED	17.681 N	83.211 E
20	OLD GAJUWAKA	17.682 N	83.202 E
21	NEW GAJUWAKA	17.720 N	83.221 E
22	PEDA GANTYADA	17.661 N	83.201 E

ANALYTICAL METHODOLOGY:

Ground water samples were collected after well inventory survey from 22representatives bore well along the industrial areas in Visakhapatnam. The samples were collected after 10 minute of pumping and stored in sterilized screw-capped polyethylene bottles of one liter capacity and analyzed in laboratory Samples collected from the study sites were properly labeled and a record was prepared.. The temperature, pH, and conductivity of the water samples were determined on the spot using a thermometer; ELICO L1615 Model P^H meter and ELICO CM180digital conductivity meter in the laboratory. Various standard methods were used for the determination of other parameters Total alkalinity was determined by visual titration method using methyl orange and phenolphthalein as indicator. Total hardness and calcium were measured by EDTA titrimetric method using EBT indicator respectively. The chloride ions were generally determined by titrating the water samples against a standard solution of AgNO3 using potassium chromate as an indicator. Sulphate, Phosphate and nitrate of the water samples were estimated by UV visible spectrophotometer. SHIMAD2U UV-1800 Model Na^+, K^+ were determined using flame photometer ELICO CM-378 Model (Apha, 2005). Heavy metals like Iron, Chromium, Copper, Zinc and Lead analyzed by using Atomic Absorption Spectra photometer AA-400 model[10]. Fluoride analyzed by using ion selective electrode method. Cole Parmer WW-27504-14Model.

HYDROGEOCHEMICAL TECHNIQUES

WATER QUALITY INDEX:

The WQI provides comprehensive information of the quality of ground water for most domestic uses. Water quality index is commonly used for the detection and evaluation of water pollution and may be defined as a rating, reflecting the composite influence of different quality parameters on the overall quality of water [6]. WQI is calculated from the point of view of the suitability of groundwater for human consumption. Hence, for calculating the WQI in the present study, 10 parameters have been considered. Water quality and its suitability for drinking purpose can be examined by determining its quality index. The standard for drinking purpose has been considered for calculating of WQI. Recommended by the Indian council of Medical Research and unit weight are given in table. The standards of United states public health services , World health organization , Indian standards have been the quality rating q_i for I^{th} water quality parameter i=(1,2,3…..n) was obtained from the relation

$Q_i=100(v_i/s_i)$ – (1)

Where v_i = value of the I th parameter at a given sample
S_i = standard permissible value of Ith parameter.

The equation ensures that $q_i = 0$ when a pollutant is absent in water while $q_i = 100$ if the value of this parameter is equal to its permissible value for drinking water

Quality rating for ph and DO requires special handling the permissible range of ph for drinking water is 7-8.5 quality rating for pH may be

$q_P{}^H$= 100[$V_p{}^h$ -7.0/8.5-7.0] — (2)

So the weights for various water quality parameters are assume med to be inversely proportional to the standard for the corresponding parameters

$w_i = k/s_i$ --- (3)
w_i = unit weight for i^{th} parameter i=(1,2,3….n)

k= constant proportionality which is determined from the condition and k = 1

$^{12}\Sigma_{j=1}\ w_i = 1$----- (4)

To calculate the WQI, first the sub index (SI) corresponding the Ith parameter calculated. These are given by the product of the quality rating Qi and unite weight of the ith parameter

Si= $q_i w_i$ ---- (5)

This overall water quality index was calculated by aggregating the sub index (si) this could be written as

WQI = [$^{12}\Sigma_{j=1} q_i w_i$/ 12Σ$j_{=1}$wi] ----- (6)

WQI=$^{12}\Sigma_{j=1} q_i w_i$------ (7)

Table-2: BIS Standards and Calculated Relative Weight (Wi) for Each Parameter water quality classification based on WQI value[5]

S. no	Chemical parameters	Indian standards	Relative weight W_i
1	P^H	6.5-8.5	0.133
2	Alkalinity	200	0.005
3	TDS	500	0.002
4	Total hardness	200	0.005
5	Calcium	75	0.013
6	Magnesium	30	0.033
7	Chloride	250	0.004
8	Nitrate	45	0.022
9	Sulphates	200	0.005
10	Iron	0.3	3.33

in this research, the computed WQI values ranges from. The computed WQI values are classified into five types namely, excellent water (WQI below 50), good water (WQI 50-100), poor water (WQI 100-200), very poor water (WQI 200-300) and water unsuitable for drinking (WQI above 300).

Table-3: Water quality classification based on water quality index

WQI Value	Water Quality
<50	Excellent
50-100	Good water
100-200	Poor water
200-300	Very poor water

Table-4: Physico- chemical parameters of the study area

SAMPLING STATION	p^H	EC (µS/cm)	Cl^- (mg/l)	TA (mg/l)	TH(mg/l)	Ca^{2+} (mg/l)	TDS (mg/l)	Mg^{2+} (mg/l)	Na^+ (mg/l)	K^+ (mg/l)	So_4^{2-} (mg/l)
LAURUS COMPANY-2	7	650	50	160	110	20	600	14	60.2	11.5	35
PARAVADA-MROOFFICE	7	430	60	70	140	48	400	5	16	20.2	40
PAILA GANGARAJU	6.5	2580	250	210	570	144	2400	26	140	10.3	125
RAMA TEMPLE	6.5	4260	514.9	180	700	152	4400	36	296	18	172
THANAM	7.1	3800	405	320	170	132	2800	21	414	4.5	254
THADI	6.9	1000	50	80	120	44	800	2.4	42	4	84
SRI SAI PLAY WOOD	6.8	1640	372	260	440	96	2800	48	261	7.2	196
SANKAR FOUNDATION HOSPITAL	6.8	2050	150	120	230	88	1800	2.4	188	12.6	197
SUJATHA HOSPITAL OG	7	1820	180	200	230	44	1600	21	182	13.3	188
BANOJI COLONY	7.08	620	55	220	150	28	600	19	44	7.3	28
MALKAPURAM POLICE STATION	7.1	1410	185	200	300	68	900	31	119	16	86
NAVY PARK SCINDIA	6.8	1700	220	160	270	80	1500	17	161	8	104
MINDI	7.76	620	58	80	100	36	900	2.4	44	7.4	54
M RESERVOIR RAW WATER	7.9	620	43	80	100	32	600	5	43.5	7.4	43
MINDI GROUND WATER	7.18	2000	179	160	500	28	800	103	90	21.4	234
ULTRATECH CEMENT	7.8	620	160	190	480	64	2000	77	79	19.3	198
MINDI JPU	7.78	700	46	80	120	24	200	14	4.6	1.4	19
SRI RAMA CLINIC GAJUWAKA	6.81	2170	203	140	420	112	1800	33	143.5	9.1	192
HINDUSTHAN ZINC LIMITED	7.44	1390	118	100	290	96	1800	12	77.3	7.7	135
OLD GAJUWAKA	7	2840	275	310	420	108	2200	36	250	2.6	189
NEW GAJUWAKA	6.71	1940	235	290	540	132	1000	50	151	21.6	219
PEDA GANTYADA	6.76	2530	189	130	350	84	1780	33	142	15	196
MEAN	7.07	1699	181.6	210	306	75	1530	27.6	134	11.17	135.8
STANDARD DEVIATION	0.411	10530	127	0.752	178.5	41.9	998.9	24.9	101.8	6.185	76
COEFFICIENT VARIATION	0.058	0.6196	0.699	0.356	0.581	0.556	0.652	0.902	0.760	0.553	0.560

Table-5: Physico chemical parameters of the study area

SAMPLING STATION	Po_4^{3-} (mg/l)	No_3^- (mg/l)	Fe^{2+} (mg/l)	$Hco3^-$ (mg/l)	Cr^{3+} (mg/l)	Cu^{2+} (mg/l)	Zn^{2+} (mg/l)	Ni^{2+} (mg/l)	Pb^{2+} (mg/l)
LAURUS COMPANY-2	4.55	2.08	0.15	160	0.01	0.02	1	0.001	0.001
PARAVADA-MROOFFICE	4.8	6.83	0.22	70	0.012	0.015	1.5	0.0014	0.0011
PAILA GANGARAJU	4.2	33.51	0.18	210	0.011	0.022	1.2	0.0011	0.0014
RAMA TEMPLE	5.35	40	0.36	180	0.01	0.024	1.2	0.0013	0.0013
THANAM	3.2	19.3	0.22	280	0.015	0.019	1.22	0.0017	0.001
THADI	3.25	9.21	0.3	60	0.014	0.02	1.3	0.0015	0.0011
SRI SAI PLAY WOOD	4.7	40	0.2	270	0.012	0.024	1.25	0.009	0.0015
SANKAR FOUNDATION HOSPITAL	4.2	40	0.18	120	0.013	0.01	1.4	0.008	0.0014
SUJATHA HOSPITAL OG	3.75	2.68	0.125	200	0.012	0.022	1.8	0.004	0.0017
BANOJI COLONY	4.15	21	0.23	180	0.011	0.024	1.6	0.0024	0.002
MALKAPURAM POLICE STATION	4.8	29	0.3	180	0.014	0.024	1.8	0.0019	0.0021
NAVY PARK SCINDIA	5.55	32	0.11	160	0.016	0.021	2	0.005	0.0022
MINDI	10	23	0.12	40	0.014	0.01	1	0.001	0.001
M RESERVOIR RAW WATER	13	2.3	0.11	40	0.001	0.01	1.1	0.0012	0.0011
MINDI GROUND WATER	24	2.7	0.12	140	0.001	0.011	1	0.0013	0.0012
ULTRATECH CEMENT	20	2.5	0.15	180	0.01	0.015	1.4	0.006	0.0014
MINDI JPU	6.25	2.9	0.23	60	0.012	0.014	1.5	0.0045	0.0015
SRI RAMA CLINIC GAJUWAKA	15.2	5	0.1	100	0.013	0.02	1.2	0.0012	0.001
HINDUSTHAN ZINC LIMITED	1.4	31	0.12	90	0.014	0.021	1.1	0.0015	0.0015
OLD GAJUWAKA	6.2	28	0.14	270	0.001	0.014	1.4	0.0018	0.0012
NEW GAJUWAKA	3	25	0.11	250	0.009	0.018	1.2	0.0015	0.001
PEDA GANTYADA	5	31		130	0.013	0.019	1.8	0.0016	0.002
MEAN	7.115	19.5	0.177	153.1	0.0108	0.018	1.362	0.002	0.0014
STANDARD DEVIATION	5.819	14.29	0.072	75.4	0.004	0.004	0.289	0.0023	0.0004
COEFFICIENT VARIATION	0.817	0.733	0.41	0.492	0.403	0.2708	0.212	0.868	0.275

Correlation between the different parameters of groundwater of Visakhapatnam showed both positive and inverse relations between the parameters, some moderately correlated and some well correlated (Table 4). Highest positive correlation was observed between Chloride and conductivity (0.88) followed by conductivity and TDS indicating strong dependence between them nitrate moderately correlated with pH. Phosphate showed good positive correlation with sulphates[14].

Table-6: Correlation coefficient for physico chemical parameter of study area

	pH	EC (µS/cm)	Cl- (mg/l)	TH (mg/l)	Ca^{2+} (mg/l)	TDS (mg/l)	Mg^{2+} (mg/l)	Na^{+} (mg/l)	K^{+} (mg/l)	So_4^{2-} (mg/l)	Po_4^{3-} (mg/l)	No3- (mg/l)	Fe2+ (mg/l)	Hco3- (mg/l)	Cr3+ (mg/l)	Cu2+ (mg/l)	Zn2+ (mg/l)	Ni2+ (mg/l)	Pb2+ (mg/l)
pH	1																		
EC (µS/cm)	-0.603	1																	
Cl- (mg/l)	-0.551	0.881	1																
TH (mg/l)	-0.494	0.610	0.708	1															
Ca^{2+} (mg/l)	-0.603	0.80	0.813	0.698	1														
TDS (mg/l)	-0.47	0.818	0.902	0.663	0.8002	1													
Mg^{2+} (mg/l)	-0.054	0.227	0.366	0.691	0.1348	0.2125	1												
Na^{+} (mg/l)	-0.492	0.86	0.904	0.428	0.7344	0.8157	0.1726	1											
K^{+} (mg/l)	-0.229	0.057	0.132	0.484	0.0882	0.0359	0.5364	-0.067	1										
So_4^{2-} (mg/l)	-0.374	0.698	0.686	0.632	0.6132	0.6175	0.6018	0.7199	0.3051	1									
Po_4^{3-} (mg/l)	0.4184	-0.155	-0.11	0.233	-0.279	-0.125	0.661	-0.230	0.3159	0.203	1								
No_3- (mg/l)	-0.524	0.507	0.557	0.402	0.644	0.588	-0.099	0.5062	-0.044	0.261	-0.50	1							
Fe^{2+} (mg/l)	-0.235	0.197	0.271	0.044	0.1164	0.253	-0.159	0.1565	-0.024	-0.212	-0.33	0.222	1						
Hco_3- (mg/l)	-0.482	0.560	0.711	0.509	0.5611	0.5406	0.4263	0.7454	0.0913	0.5919	-0.21	0.383	0.061	1					
Cr^{3+} (mg/l)	-0.209	-0.022	0.022	-0.24	0.1461	0.0960	-0.446	0.0731	-0.145	-0.10	-0.51	0.283	0.2477	-0.083	1				
Cu^{2+} (mg/l)	-0.561	0.269	0.407	0.272	0.3555	0.3789	-0.016	0.2971	-0.021	0.0335	-0.49	0.330	0.402	0.4525	0.4619	1			
Zn^{2+} (mg/l)	-0.191	-0.024	-0.01	-0.12	-0.081	-0.082	-0.133	0.0291	0.0179	-0.071	-0.29	0.154	0.107	0.1227	0.3695	0.3298	1		
Ni^{2+} (mg/l)	0.0057	-0.106	0.141	0.032	-0.018	0.1861	0.0992	0.1951	-0.080	0.2176	-0.02	0.259	0.0019	0.2210	0.2170	-0.010	0.3074	1	
Pb^{2+} (mg/l)	-0.136	-0.041	0.008	0.008	-0.091	-0.006	-0.001	0.0328	-0.195	0.1146	-0.23	0.3611	0.103	0.1214	0.3276	0.455	0.829	0.3242	1

Table-7: Water quality index

parameters	WHO standards	Unit weight (Wi)	S1 qiwi	S2 qiwi	S3 qiwi	S4 qiwi	S5 qiwi	S6 qiwi	S7 qiwi	S8 qiwi	S9 qiwi	S10 qiwi	S11qiwi
PH	6.5-8.5	0.133	3.32	3.32	0	0	3.99	2.66	1.99	1.99	3.32	3.857	3.99
Alkalinity	200	0.005	0.4	0.175	0.525	0.45	0.8	0.2	0.65	0.3	0.5	0.55	0.5
TDS	500	0.002	0.24	0.16	0.96	1.76	1.12	0.32	1.12	0.72	0.64	0.24	0.36
Total hardness	200	0.005	0.05	0.06	0.25	0.514	0.405	0.05	0.372	0.15	0.18	0.055	0.185
Calcium	75	0.013	0.353	0.851	2.55	2.68	2.34	0.771	1.702	1.556	0.771	0.492	1.197
Magnesium	30	0.033	1.54	0.55	2.86	3.96	2.31	0.26	5.28	0.26	2.31	2.09	3.41
Chloride	250	0.004	0.08	0.09	0.4	0.82	0.64	0.08	0.595	0.24	0.28	0.08	0.296
Nitrate	45	0.022	0.102	0.336	1.653	1.973	0.952	0.454	1.973	1.973	0.132	1.036	1.43
Sulphates	200	0.005	0.08	0.1	0.312	0.43	0.635	0.21	0.49	0.492	0.47	0.07	0.215
Iron	0.03	3.33	165	242	198	396	242	330	220	198	137	253	330
ΣWi		3.552											
ΣQiWi			171	247	207	408	255	335	234	205	146	261	341
ΣQiWi/ΣWi			48	69	58	115	71	94	65	57	41	73	96

Table-8: Water quality index

Chemical parameters	WHO standards	Unit weight (Wi)	S12qiwi	S13 qiwi	S14 qiwi	S15 qiwi	S16 qiwi	S17 qiwi	S18 qiwi	S19 qiwi	S20 qiwi	S21qiwi	S22qiwi
PH	6.5-8.5	0.133	1.995	8.379	9.31	4.522	8.645	8.512	2.06	6.25	3.32	1.396	1.72
Alkalinity	200	0.005	0.4	0.2	0.2	0.4	0.475	0.2	0.35	0.25	0.775	0.725	0.325
TDS	500	0.002	0.6	0.36	0.24	0.32	0.8	0.08	0.72	0.72	0.88	0.4	0.71
Total hardness	200	0.005	0.22	0.058	0.043	0.17	0.16	0.04	0.203	0.118	0.275	0.235	0.189
Calcium	75	0.013	1.40	0.63	0.55	0.492	1.13	0.425	1.98	1.702	1.91	2.34	1.48
Magnesium	30	0.033	1.87	0.264	0.55	11.3	8.47	1.54	3.63	1.32	3.96	5.5	3.63
Chloride	250	0.004	0.352	0.09	0.06	0.28	0.25	0.07	0.32	0.18	0.44	0.37	0.30
Nitrate	45	0.022	1.57	1.13	0.11	0.13	0.12	0.14	0.24	1.52	1.38	1.23	1.52
Sulphates	200	0.005	0.26	0.135	0.1075	0.585	0.495	0.0475	0.48	0.3375	0.4725	0.547	0.49
Iron	0.03	3.33	121	132	121	132	165	253	110	132	154	121	132
ΣWi		3.552											
ΣQiWi			129	143	132	150	185	264	119	144	167	133	142
ΣQiWi/ΣWi			36	40	37	42	52	74	33	40	47	37	40

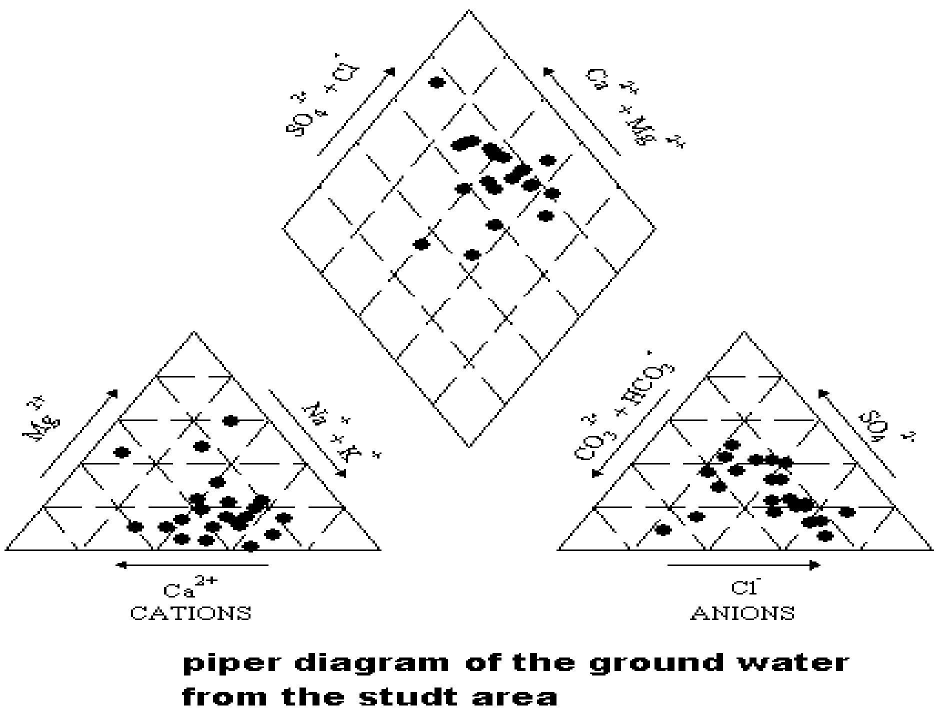
50	Excellent	$S^1,S^9,S^{12},S^{13},S^{14},S^{15},S^{18},S^{19},S^{20},S^{21},S^{22}$
50-100	Good water	$S^2,S^3, S^5,S^6,S^7,S^8,S^{10},S^{11}$
100-200	Poor water	S^4
200-300	Very poor water	-
WQI Value	**Water Quality**	**Sampling stations**

The minimum WQI has been recorded from Gajuwaka (src) (Sample No.18), while maximum WQI has been recorded from Rama templeparawada (SampleNo.4)

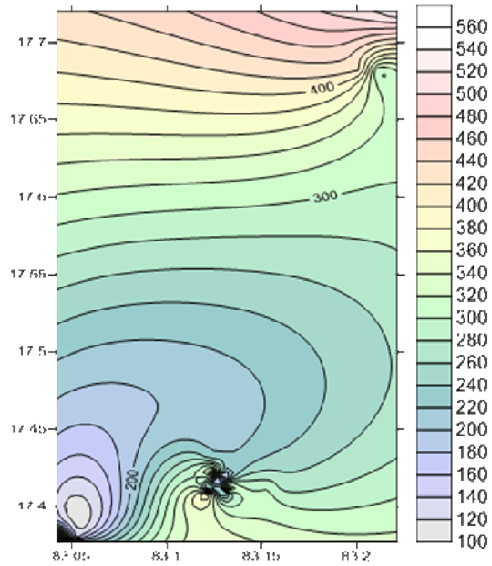
The concentration of 8 major ions (Na^+,K^+,Mg^{2+},Ca^{2+},Cl^-,Co_3^{2-},HCO_3^- and SO_4^{2-}) are represented on the piper line diagram. The relative concentration of the cations and anions are plotted in the lower triangles, and the resulting two points are extended into the central field to represent the total ion concentration. Piper diagram drawn by using software GW chart (version1.260.0) A Piper diagram (see Fig. 2) was created for the Visakhapatnam area using the analytical data obtained from the hydrochemical analysis[15]. 40% of the samples are plotted in the Ca-Mg-So42-Cl field. This results in area of permanent hardness. Ca-Mg-HCO3 is the region of water indicates temporary hardness 15 % of the samples showed this region. Composition of Na-K-CO3-HCO3 indicates alkalinity.20% samples showed this region. 25% of the samples showed the region Na-K-So4-Cl considered as salinity.

In this study we have analyzed twenty two water samples from Visakhapatnam along the industrial area. The results observed that some parameters shown higher values and which are not within the limits of WHO standards also. . Due to heavy growth of human habitations, reclamation of land, anthropogenic activities, lack of proper sewage systems, and lack of efficient system of percolation of rain water in the area may be getting polluted. Chloride concentration Most of the samples are within the permissible limit. A limit of 250 mg/L chloride has been recommended as desirable limit and 1000 mg/L as the permissible limit for drinking water (BIS, 2012). Concentration exceeded the permissible limit at the sampling stations Ramatemple (515mg/l), Thanam (405mg/l), Sri sai playwood (372mg/l), Oldgajuwaka(275mg/l), New gajuwaka.(235mg/l) Electrical conductivity above the permissible limit in the sampling sites Rama temple (4260µs/cm), Thanam (3800µs/cm), Old gajuwaka (2840µs/cm), Conductivity range not suggetioned by BIS (2012). Alkalinity in water due to presence of some basic dissolved salts like Carbonate, bicarbonate, Borates, phosphates, silicates, The desirable limit for TA in drinking water is 200 mg/l and permissible limit is 600 mg/l prescribed by BIS (2012). Concentration above the desirable limit in the sampling stations Rama temple (320mg/l), Sri sai playwood (260mg/l), Old gajuwaka (310mg/l), New gajuwaka.(290mg/l). A limit of 200 mg/l Total hardness has been recommended as desirable limit and 600 mg/l as the permissible limit prescribed by BIS (2012). Total hardness ranges exceed the desirable limit in the sampling sites Paravada-pg(570mg/l), rama temple (700mg/l), Sri sai playwood (440mg/l), Malkapuram(akccps) (300mg/l), Scindia (270mg/l), Mindi-meghadri gadda ground water (500mg/l), Ultratech cement limited (480mg/l), Sri rama clinic Gajuwaka (420mg/l), Hindusthan zinc limited (290mg/l), Old gajuwaka (420mg/l), New gajuwaka (540mg/l), Peda gantyada (350mg/l). Calcium concentration exceeded the desirable limit in the sampling sites Paravada-pg (144mg/l), Rama temple (152mg/l), Thanam (132mg/l), Sri sai playwood (96mg/l), Sankar foundation hospital (88mg/l), Sri rama clinic Gajuwaka (112mg/l), Hlndusthan zinc limited (96mg/l), Old gajuwaka (108mg/l), New gajuwaka (132mg/l). A limit of 75mg/l Calcium has been recommended as desirable limit and 200 mg/l as the permissible limit prescribed by BIS (2012). Total dissolved solids concentration above the permissible limit in the sampling stations parawada,(pg) (2400mg/l), Rama temple (4400mg/l), Sri sai playwood, thanam (2800mg/l), Sankar foundation hospital (1800mg/l), Old gajuwaka (sh) (1600mg/l), Scindia (1500mg/l), (2000mg/l), Gajuwaka(src) (1800mg/l), Hindusthan zinc limited (1800mg/l), Old gajuwaka (2200mg/l), New gajuwaka (1000mg/l), Peda gantyada (1780mg/l). Due to the natural and percolation of minerals, landfill leachates, Feedlots, salts in to the ground water table. The desirable limit for TDS in drinking water is 500 mg/l and permissible limit is 2000 mg/l. Magnisium concentration above the desirable limit in the sampling stations Mindi-mg,gw(103mg/l), Ultra tech cement (77mg/l), New gajuwaka (50mg/l). A limit of 30mg/l Magnisium has been recommended as desirable limit and 100 mg/l as the permissible limit prescribed by BIS (2012) Sodium concentration exceed the desirable limit in the sampling stations Rama temple-paravada (296mg/l), Thanam (414mg/l), Sri sai playwood (261mg/l), Old gajuwaka (250mg/l). Sulphate concentration exceeded the permissible limit in the sampling stations Thanam (254mg/l), Mindi meghadrigadda,ground water (234mg/l). Bureau of Indian standard has prescribed 200 mg/L as the desirable limit and 600 mg/L as the permissible limit for sulphate in drinking water

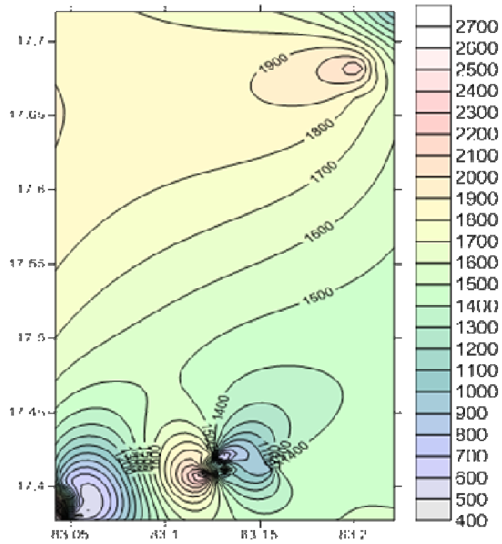
Figure2: Piper diagram



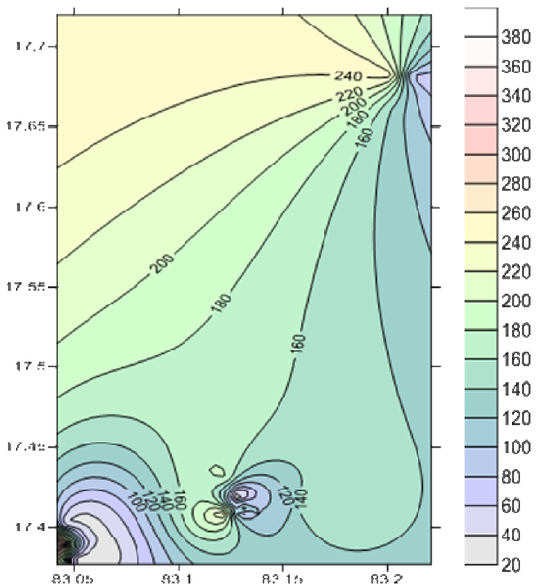
figure(3) spatial variation contour maps



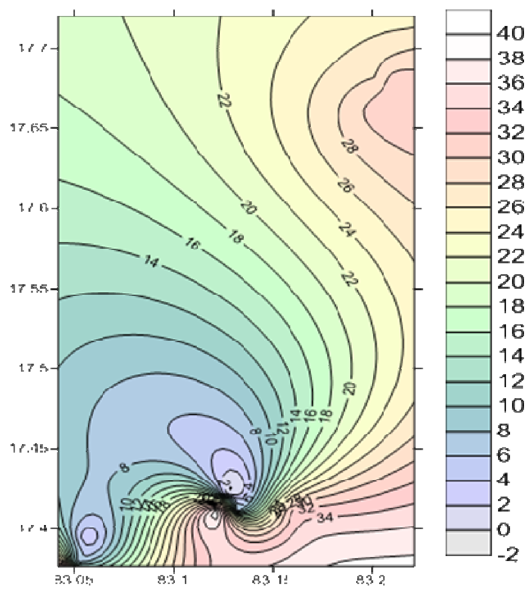
Spatial variation contour for TH(mg/l) Concentration



Spatial variation contour for TDS (mg/l)Concentration



Spatial variation contour for Sodium(mg/l)Concentration



Spatial variation contour for Nitrate (mg/l)Concentration

It determines the geospatial origin of water materials due to the isotopic signal underlying this method is the spatial variation stable in water. contour maps were constructed using Surfur-7.0 and Are GIS -9.0 software's to delineate spatial variation of physic- chemical characteristics of ground water samples.

CONCLUSION

This study has realized that organic and inorganic pollutents constitute major source of water pollution.The results considered that the groundwater of the study area in general cannot be considered of good quality its chloride, total hardness, electrical conductivity, total alkalinity, sodium, sulphates, nitrates, above the desirable limit but below the permissible limit WHO BIS(2012). From the above papers we have concluded that due to increase in industrialization water quality of drinking water get decreases, and hence there is a need of proper analysis of water and prior treatment This study also presents the usefulness of Multivariate Statistical Techniques in groundwater quality assessment, identification of significant parameters to get better information about source of pollution.

Acknowledgement
Our thanks are due to the University Grants Commission, New Delhi, India for providing the funding for carry out the research work.

REFERENCES

[1] C.Ramachandraiah *Advances in applied science research* **2011**; 2(2): 197-201.
[2] J.Sirajudeen and R.Abdul Vahith *World journal of pharmacy and pharmaceutical sciences.* Volume 3, Issue 7, 881-893 ISSN 2278 – 4357
[3] A.Zahir Hussain, Mohamed M.Hanipha and Raj Kumar *Research Journal of Pharmaceutical, Biological and Chemical Sciences*. ISSN: 0975-8585
[4] Simpi Basavaraja, S.MHiremath, KNS Murthy, K.N.Chandrashekarappa, N.Anil Patel, E.TPuttiah . *Global journal of science frontier research* ISSN: 0975-5896
[5] R.S Pawer, D.B.Panaskar& V.M.Wagh *International Journal of Research in Engineering & Technology* ISSN(E): 2321-8843; Vol. 2, P, 31-36
[6] R.N.yadav., DagarNavin kumar, Y.Rajdeep and Gupta Priyanka, *Journal of current chemical and pharmaceutical sci*ences, ISSN 2277-2871. 2(3), **2012**, 198-208
[7] Gyawali Saroj, Techato Kuaanan and Yuangya Chumpol **2012** Effects of Industrial Waste Disposal on the Surface Water Quality of U-tapao River, Thailand *International Conference on Environment Science and Engineering*. IPCBEE vol.32.
[8] Shivasaranappa, Padaki Srinivas, Mallikarjun S.Huggi **2011** *International journal of Environmental Sciences* Volume 2,No 2, ISSN 0976-4402
[9] C.R.Ramakrishnaiah, C.Sadashivaiah and G.ranganna *E-Journal of Chemistry* ISSN: 0973-4945;
[10] APHA: Standard method for examination of water and waste water.**2005** 21st Edn. APHA, AWWA, WPCF, Washington DC, USA.
[11] C.Ratnakant Sheth and M.Basavaraj Kalshetty **2011** *International journal of applied biology and pharmaceutical technology.* ISSN 0976-4550 Volume: 2: Issue-1: Jan-Mar
[12] S.P.Bhalme, P.B.Nagarnaik *International Journal of Engineering Research,* ISSN: 2248-9622 Vol. 2, pp.3155-3158
[13] P.Santhosh and D.Revathi *Journal of Chemical, Biological and Physical Sciences* ISSN: 2249 –1929
[14] P.J.Taluk, Sajil Kuma (**2013**), *Geoscience* 54 12208-12211