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Assessment of Ground Water Quality in Visakhapatnam by using Nemerow's Pollution Index and Water Quality Index

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Abstract:
The present study was intended to assess the ground water quality for drinking purpose and determine the main groundwater pollutants through the water quality index and pollution index Nemerow in the north of the Andhra Pradesh coastal district, Visakhapatnam, India. Principal pollutants of ground water through water quality index (WQI) and Nemerow's Pollution Index (NPI) in North of the Andhra Pradesh coastal district, Visakhapatnam (traffic areas), India. Traffic in various shapes such as gaseous, liquid and solid vehicular traffic, fuel storage and spillage accidents have been identified as important sources of contamination related to ground water traffic. To this total number of twenty ground water samples were collected in pre and post monsoon from the bore wells analyzed (Apha,1995) Finding these results obtained were compared with the Bureau of Indian Standards (BIS,2012) standard values. The Analysis of results revealed that some parameters exceeded the allowed limits. According to NPI values, the main pollutants observed in the present study principal pollutants in the present study are total alkalinity, chloride, total dissolved solids and electrical conductivity in both pre and post monsoon seasons. The analysis reveals that the ground water of the traffic surrounding areas needs some remedy before consumption and it is also necessary to protect it from contamination.

Key words: *Ground water quality, physical chemical parameters, water quality index, Nemerow's Pollution Index, Traffic infrastructure.*

Introduction

Water plays an enormously consequent position in every existing organism. Most of the people are depended only on ground water for drinking and various purposes (Gabriel et al 2010). In developing cities like in Visakhapatnam, now a day's pollution vehicles, road, and traffic way which have a destructive impact on the environment, especially on groundwater. Traffic operations structures to identify the situation assessments include roads, airports, railways, river transport (rivers, lakes, canals) where surface water influences lastingly in groundwater due to infiltration on ground floor pipes and so on (Teresa, E,2005). Wear and corrosion of vehicle parts (brakes, tires, radiators, body parts and motor) is a source of many heavy metals. Road surface degradation and application of (drying salts) contaminated chemical road traffic circulates in the environment causing soil contamination and water closer to the road. Generally, heavy metals, inorganic salts, suspended solids that accumulate on the roads are polluting. Oil, grease, oxides, rubber particles and other solids falling on road surfaces (Morganwalp, 1994). These materials wash the road during rain and slowly filter into groundwater and contaminate groundwater. Various indexes have been developed for the assessment of water quality and occasionally used.

This study was supported by Quality Index and Water Nemerow pollution index to assess the quality of water and contaminants to recognize physicochemical parameters. The WQI is calculated from the point of view of the subterranean adequacy for human consumption, which is vital information for deteriorating water quality in the area and also for improving water quality in the area (NeerjaKalra, 2012). The Nemerow Pollution Index (NPI) is a simplified Pollution Rate predicted by Neme (sswathi, 2015), also known as a raw's pollution index. NPIs provide information about the compass for a particular water quality parameter with reference to its standard value. To calculate and analyze the NPI water quality parameter for a region can be identified the main pollutants in that region. The objective of the present investigation is to establish the ground water quality in Visakhapatnam traffic surrounding the area in pre and post monsoon by using water quality index and Nemerow's pollution index.

Materials and methods

Study area

Vishakhapatnam study area is the coastal area with a rapid development of industrialization and the urban area is located on the north coast of Andhra Pradesh. Based on topographic conditions, the city can be divided into four categories, namely. Mountainous regions, mountain trails, rolling hills, and plains. The topography of the city, with hills on three sides and the sea on the quartet that gives such beauty, seems to increase the risk of falling victim to pollution. Vishakhapatnam is the largest in the state of Andhra Pradesh and the third largest on the east coast of the city of India. The study area is between 17.438 to 17.446 N latitude and 83.185 to 83.207E longitude.

Sample collection

The basic parameters analyzed by the standard procedure EC and the pH of the water samples were measured immediately after collecting the sample using pH-meter (Model L1615 ELICO) and conductivity meter (ELICO CM180 digital conductivity model). An evaporation method is used to determine the total dissolved solids. Total hardness and Ca2 + were determined by titration with standard EDTA and the Eriochrome black-t indicator and murexide indicator and pH adjusted corrected buffer solutions. Mg2 + calculated by TH and calcium hardness. $AgNO_3$ titration using a potassium chromate indicator used for estimating chloride. Sodium and potassium were determined by the flame photometer (model CM-378 ELICO). Phosphate concentration was determined by stannous chloride using a spectrophotometer (UV-1800 model SHIMADZU). Sulfate was analyzed by reaction with barium e chloride which leads to the precipitate formation that could easily be estimated using a turbid metric method. Nitrate concentration was determined by wavelength spectrophotometer of all concentrations expressed in mg / l. Analytical high purity reagents were used during the study and chemical standards (Merck) for each separately prepared element. Heavy metals such as iron, copper, and chromium determined by AAS followed specific standards used for specific metals and cadmium, zinc and nickel analyzed by ICPMS.

Water quality index

In this research, the weighted Arithmetic index method has been utilized for the computation of WQI nine important parameters is selected. WQI has been calculated using the recommended quality standards for bureau Indian standards (BIS,2012) of drinking water.

The quality evaluation was calculated using the following expression.

qi = 100[Vi -Vio] /[Si - Vio] → (1)

Where qi = Quality rating for the ith Water quality parameter ,Vi = Estimated value of the ithparameter in a given water sampling station ,Si = Standard permissible value of the ith parameter ,Vio = Ideal value of ith parameter in pure water (i.e., 0 for all other parameters except pH and Dissolve oxygen (7.0 and 14.6 mg/l respectively)

Wi = k/Si → (2)

Where Wi= unit weight for ith parameter; Si= standard permissible value for nth parameter k = proportionality constant.

The overall WQI is calculated by the following equation.

WQI =∑qiWi/∑Wi → (3)

Water quality index level and Water quality status 0-25 Excellent water quality 25-50 Good water quality 51-75 Poor water quality 76-100 Very poor water quality >100 Unsuitable for drinking.

Nemerow's Pollution Index (NPI)

The Nemerow index estimation manner used toexamining the quality of water. NPI is evaluated for all the parameters for each sample analysed, for indentifying the pollution causing parameters.

The following equation used for evaluated the NPI,

NPI = $Ci/\ Li$

Where, Ci is the Observed concentration of ith parameter; Li is the Permissible limit of ith parameter. Each NPI value shows the relative pollution contributed by single parameter, It should be less than or equal to one. NPI values exceeding 1.0 indicate the presence of impurity in water.

Result and discussion

Physico-chemical parameter effect on ground water:

The analytical results of the chemical analysis and the statistical parameters such as mean, standard deviation. Coefficient variations are presented in Table-1 and 2 and Nemerows pollution index is shown in in table-4. The pH is a measure of the intensity of acidity or alkalinity. The pH value of the water for the samples analyzed sample in the study area mildly acidic to basic nature 6.78 to 8.3 with an average value of about 7.5 except 15% sampling stations in pre-monsoon and in post monsoon the values ranged from 6.7 – 7.34 with mean value of about 7.2 all the water samples show slightly acidic nature. In pre-monsoon and post-monsoon season, all twenty sampling sites are found to have NPI values less than one.

Table-1: Physico-chemical characteristic of the study area

S.No	Sampling Station	pH		EC (µS/cm)		Cl^- (mg/l)		Alkalinity (mg/l)		TDS (mg/l)		TH (mg/l)		Ca^{2+} (mg/l)		Mg^{+2} (mg/l)		Na^+ (mg/l)		K^+ (mg/l)		CO_3^{2-} (mg/l)	
		Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
1.	TRF1	7.3	6.9	1640	1520	240	180	220	160	1079	950	344	259	80	66	35	23	73.6	60	34	23	60	40
2.	TRF2	7.5	7.14	1520	1450	186	140	220	160	1023	910	194	142	43	29	21	17	96	78	36	27	50	30
3.	TRF 3	7.52	7.21	2100	2200	484	358	270	200	1400	1380	401	249	98	57	38	26	175	148	105	80	80	60
4.	TRF 4	6.78	6.7	2560	2360	460	380	250	210	1700	1480	314	242	60	51	40	28	260	220	41	28	50	30
5.	TRF 5	7.13	6.7	3870	3450	424	380	270	220	2585	2170	298	241	70	67	30	18	250	210	80	58	30	50
6.	TRF 6	7.32	7.14	2050	1970	270	210	210	160	1368	1230	314	279	50	59	46	32	120	80	40	29	60	40
7.	TRF 7	7.3	7.11	1850	1740	230	190	260	190	1230	1090	314	232	68	55	35	23	110	82	48	33	70	40
8	TRF 8	7.6	7.4	1660	1520	160	124	260	200	1102	950	293	218	32	25	52	38	61	56	45	36	50	30
9.	TRF 9	7.8	7.6	2500	2280	180	110	170	140	1670	1430	320	249	100	80	17	12	27	22	32	20	40	30
10.	TRF 10	8.2	7.9	2300	2140	230	190	230	170	1530	1340	419	286	120	80	29	21	90	78	24	17	50	20
11.	TRF 11	7.6	7.2	2240	2080	210	180	340	200	1510	1320	330	223	58	40	45	30	96	80	57	48	70	40
12.	TRF 12	7.5	7.2	2270	2140	230	190	270	200	1510	1340	299	211	72	55	29	18	150	122	29	18	60	50
13.	TRF 13	7.9	7.5	700	660	83	52	200	150	460	410	204	161	44	38	23	16	34	22	20	12	50	30
14.	TRF 14	7.6	7.3	1220	1180	135	110	220	130	810	740	228	158	60	42	19	13	63	40	24	15	60	40
15.	TRF 15	7.1	6.7	1550	1360	174	126	210	150	1030	850	249	178	65	50	21	13	97	76	15	9	40	30
16.	TRF 16	7.6	7.26	1420	1280	190	150	180	100	940	800	249	182	65	48	21	15	91	74	14	9	20	10
17.	TRF 17	7.25	7.04	1460	1320	180	160	210	130	970	820	238	190	64	53	19	14	95	78	16	4.3	90	30
18.	TRF 18	7.2	6.9	1480	1310	185	164	110	90	980	820	250	205	72	64	17	11	76	62	7	2.2	20	20
19.	TRF 19	7.8	7.35	2050	1980	185	155	190	110	1370	1240	222	164	64	46	15	12	98	79	19	14	60	30
20.	TRF 20	7.13	6.9	1290	1130	170	142	170	110	850	700	231	170	48	37	27	19	85	76	22	15	40	20
	Mean	7.5	7.2	1887	1754	230	184	202	159	1203	1121	338	307	67	52.1	29.0	20.0	107	87.2	35	24	52	33
	S.D	0.33	0.31	666	611	105	88.8	61.1	51.2	420	386	132	118	20	14.9	10.9	7.57	60.7	52.1	23	19.1	18	11
	C.V	0.04	0.04	0.35	0.35	0.46	0.48	0.30	0.32	0.35	0.34	0.39	0.39	0.3	0.29	0.38	0.38	0.57	0.60	0.67	0.77	0.34	0.35

Table-2: Physico-chemical characteristic of the study area

Sr.No.	Sampling station	SO_4^{2-} (mg/l)		PO_4^{3-}(mg/l)		NO_3^-(mg/l)		HCO_3^- (mg/l)		Fe^{2+} (mg/l)		Cr^{3+}(mg/l)		Zn^{2+}(mg/l)		Ni^{2+} (mg/l)		Cu^{2+} (mg/l)		Pb2+ (mg/l)	
		Pre	post	pre	**post**	pre	**post**	pre	**post**	pre	**post**	pre	**post**	pre	**post**	pre	**post**	pre	**post**	pre	**post**
1.	TRF1	60	52	3	2.4	13.7	10	160	120	0.012	0.01	0.008	0.006	0.09	0.05	0.001	0.0007	0.001	0.0009	0.001	0.0008
2.	TRF2	55	49	3	2.5	15	9	170	130	0.011	0.008	0.006	0.003	0.08	0.06	0.0014	0.001	0.002	0.0014	0.0014	0.001
3.	TRF 3	95	72	6.2	5	12	9	190	140	0.02	0.015	0.005	0.003	0.12	0.08	0.0011	0.0007	0.012	0.01	0.0012	0.001
4.	TRF 4	90	73	3	2	13	7	200	180	0.021	0.014	0.011	0.001	0.14	0.1	0.0016	0.001	0.019	0.012	0.0017	0.0011
5.	TRF 5	55	38	2	1.5	11.2	8	240	170	0.022	0.019	0.012	0.008	0.19	0.12	0.0012	0.0007	0.018	0.009	0.0011	0.001
6.	TRF 6	84	61	1.3	1	12	9	150	120	0.025	0.02	0.01	0.001	0.14	0.09	0.001	0.0008	0.02	0.01	0.001	0.0009
7.	TRF 7	85	76	1.5	0.9	7	4	190	150	0.014	0.01	0.001	0.0007	0.2	0.18	0.0015	0.001	0.011	0.008	0.0002	0.0001
8.	TRF 8	75	68	2	0.8	3.1	2	210	170	0.011	0.004	0.002	0.0012	0.25	0.17	0.0017	0.0013	0.024	0.02	0.001	0.0007
9.	TRF 9	65	58	1.5	1	23	24	130	110	0.012	0.01	0.0014	0.001	0.24	0.2	0.0011	0.001	0.012	0.01	0.0011	0.008
10.	TRF 10	125	104	2	1.4	20	16	180	150	0.021	0.015	0.0012	0.001	0.29	0.23	0.0014	0.0011	0.025	0.021	0.0015	0.001
11.	TRF 11	90	73	2.2	2	18	12	270	160	0.02	0.016	0.004	0.003	0.21	0.19	0.0012	0.001	0.021	0.02	0.0012	0.001
12.	TRF 12	115	97	2	1.6	28	21	210	150	0.023	0.018	0.002	0.0014	0.3	0.2	0.0011	0.0008	0.01	0.008	0.0011	0.0008
13.	TRF 13	50	41	2.8	2	14.6	9	150	120	0.022	0.015	0.006	0.004	0.32	0.24	0.001	0.0007	0.015	0.01	0.0009	0.0005
14.	TRF 14	45	39	3.1	2	11	8	160	90	0.021	0.018	0.002	0.0013	0.31	0.22	0.0009	0.0005	0.014	0.008	0.0008	0.0004
15.	TRF 15	70	59	4.23	3.4	12	9	170	120	0.015	0.009	0.003	0.002	0.32	0.24	0.001	0.0007	0.009	0.006	0.0012	0.009
16.	TRF 16	75	50	1.23	1	11	7	160	90	0.016	0.012	0.0029	0.002	0.29	0.23	0.0012	0.001	0.011	0.007	0.0013	0.001
17.	TRF 17	80	61	1.7	1	11	6	120	100	0.019	0.011	0.0031	0.0027	0.28	0.19	0.0014	0.001	0.008	0.005	0.0015	0.0011
18.	TRF 18	52	42	2.8	2	16.5	11	90	70	0.011	0.007	0.0015	0.001	0.24	0.2	0.0012	0.0007	0.001	0.0008	0.001	0.0007
19.	TRF 19	48	35	4.2	3	35.5	29	130	80	0.012	0.008	0.0014	0.0008	0.1	0.09	0.0011	0.0005	0.002	0.001	0.001	0.0008
20.	TRF 20	76	65	2.3	2	15	10	130	90	0.01	0.006	0.0012	0.001	0.11	0.08	0.001	0.0007	0.005	0.003	0.0014	0.001
	Mean	74.5	60.7	2.6	1.9	15.1	11	170.	125.	0.017	0.012	0.004	0.002	0.211	0.158	0.0012	0.0008	0.012	0.009	0.001	0.002
	s.d	21.9	18.7	1.2	1.0	7.2	6.6	42.7	32	0.00	0.00	0.00	0.00	0.08	0.07	0.00	0.00	0.01	0.01	0.00	0.00
	C.V	0.29	0.31	0.46	0.53	0.48	0.6	0.25	0.26	0.29	0.38	0.83	0.84	0.40	0.42	0.19	0.25	0.63	0.72	0.28	1.49

Electrical conductivity (EC) is a measure of water capacity to convey electric current The EC values widely variation from 700 µs/cm 3870 µs/cm with mean 1886 µs/cm in pre-monsoon and 660 µs/cm to 3450 µs/cm with mean 1734µs/cm in after monsoon. Examining the EC (Saxena et al. 2004;Mondal et al. 2009) Ground water was classified into three categories freshwater(<1500 µs/cm), brackish water (1500-3000µs/cm) and saline water (>3000µs/cm) based on the classification 45% of the samples are found in fresh water,40% are found in brackish, 5% is saline water and 55% samples are in fresh water,35% are in brackish water 5% is saline water during pre and post monsoon respectively. In our entire study, 30% of the sample in pre-monsoon season and post monsoon have NPI value less than one rest of all are found to have large NPI values in comparison to one indicating the presence of higher amounts of total dissolved solids.

Total dissolved solids range from 460 mg/l– 2585 mg/l with mean 1203mg/l and 430 mg/l to 2170 mg/l with mean 1121mg/l during pre and post monsoon period. Minerals, salts, metals, and nonmetals dissolved in water. TDS comprises principally inorganic salts (calcium, magnesium, potassium, sodium, bicarbonates, chlorides, and sulfates dissolved in water. In our study, the NPI values are very much higher for alkalinity in pre-monsoon while in post monsoon season 32% of the samples have less than one. Some of the components of Carbonate, Bicarbonate, and Hydroxide are total alkalinity. The dissolution of salts and minerals, which are present in soil due to rise in water table. Excess alkalinity gives the bitter taste to water and reacts with cations forming precipitates, which can damage the pipes, valves, etc. Total alkalinity ranges from 110 mg/l to 270 mg/l with an average value of about 202 mg/l in pre-monsoon while in post monsoon 90 mg/l to 220mg/l with a mean value of about 159 mg/l. According to NPI values, 15% shows less than one NPI in pre-monsoon whereas in post monsoon all the sampling stations show less than one. Hardness relating to the concentration of calcium and magnesium which contributes carbonate. unless carbonate is associated with sodium or potassium which don't contribute to hardness. In present study The obtained concentrations range from 80mg/l to 650mg/l with mean 331mg/l to 190mg/l to 580mg/l with mean 303 mg/l. above 70% of the sampling stations shows above the acceptable limit. According to Durfor and Becker (1964) hardness of water classified as soft water, 0 to 60 mg/L (as $CaCO_3$); moderately hard water, 61 to 120 mg/L; hard water, 121 to 180 mg/L; and very hard water, over 180 mg/L. A hardness level of about 100 mg/L or less is generally not a problem in waters used for ordinary domestic purposes (Hem, 1985). In premonsoon 19 and in postmonsoon 15 water samples shows NPI value greater than one represent pollution with reference to this parameter

Cationic constituent in ground water

Calcium and magnesium

Calcium and magnesium are very common elements which are present in all natural waters. The most common source of calcium and magnesium in groundwater is through the erosion of rocks, such as limestone and dolomite, and minerals, such as calcite and magnetite. Calcium ranges fluctuates between 5mg/l to 65 mg/l with mean 75mg/l and 4mg/l to 69 mg/l with mean 64 mg/l during pre and post monsoon period.out of twenty water samples four water samples in pre-monsoon and 3 water samples in post monsoon found to be NPI value greater than one.Magnesium concentration fluctuates between 10mg/l to 55 mg/l with mean 32mg/l and 9mg/l to 50 mg/l with mean 25mg/l during pre and post monsoon period. In pre 7 samples and in post monsoon seasons 3 samples are representing NPI values greater than one.

Sodium and potassium

Sodium ranges from 27mg/l to 385 mg/l with mean 126mg/l and 22mg/l to 334 mg/l with mean 108 mg/l during pre and post monsoon period. Sodium originates from leaching of surface and underground deposits of salt and decomposition of various minerals. Human activities contribute through de-icing and washing products. Sampling stations 4 and 5 represent more than one NPI value. potassium was less dominated 20%, 15% and 15%, 10% due to pre and post monsoon respectively. The order of cationic abundance was Ca2+> Mg2+ >Na+>k+ in both pre and post monsoon.

Anionic constituent in groundwater

Chloride and Sulfate

Chloride is a major anion to evaluate the quality of ground water the higher concentration chloride causes Some anthropogenic factors commonly cited as influences on chloride levels in water include road salting during the winter, improper disposal of oil-field brines, contamination from sewage, and contamination from various types of industrial wastes (Hem, 1985, 1993). In the present study Chloride values in the range between 83mg/l to 454mg/l with mean 213mg/l and 52mg/l to 410mg/l with mean 183 mg/l in pre and post monsoon respectively. 4 samples in pre-monsoon and 3 water samples in post monsoon shows greater than one NPI. Sulfate concentration was ranged from 45mg/l to 142mg/l with mean 66 mg/l and 25 mg/l to 130 mg/l with mean 58mg/l during pre and post monsoon season. Nitrate Values ranged from 0.36 mg/l to 3.6 mg/l with mean 1.9mg/l and 0.54 mg/l to 2.5 mg/l with mean 1.46mg/l during pre and post monsoon season. All the water samples show less than one NPI. Among the major anions bicarbonate dominated representing an average 55% samples chloride was secondary dominated, Sulphate and nitrate less dominated. The order of anionic abundance in the ground water HCO_3>Cl> SO_4> NO_3 in pre-monsoon and in post monsoon order of abundance of anions are Cl-> HCO_3>SO_4> NO_3

Water quality index

The calculation of water quality index for pre and post monsoon season is taken in Table -3 and found 40% of the water samples good quality, 45%samples have poor water quality in pre-monsoon, whereas in post monsoon except 10th sampling area remaining water samples have good quality.

Table-3: Water quality index for pre and post monsoon seasons

	pH		TH (mg/l)		TA (mg/l)		TDS (mg/l)		Ca^{2+}(mg/l)		Mg^{+2} (mg/l)		Cl^{-}(mg/l)		SO_4^{2-} (mg/l)		NO_3^{-}(mg/l)		ΣQiWi		ΣQiWi/ΣWi	
	pre	post	pre	post	pre	post	pre	post	pre	post	pre	post	pre	Post	pre	post	pre	post	pre	post	pre	post
TRF1	2.66	-0.88	0.86	0.64	0.55	0.4	0.43	0.38	1.38	1.14	3.85	2.53	0.38	0.28	0.15	0.13	0.67	0.49	10.9	5.1	49	23
TRF2	4.43	1.24	0.48	0.35	0.55	0.4	0.40	0.36	0.74	0.50	2.31	1.87	0.29	0.22	0.13	0.12	0.73	0.44	10.1	5.5	45	25
TRF3	4.61	1.86	1.00	0.62	0.67	0.5	0.56	0.55	1.69	0.99	4.18	2.86	0.77	0.57	0.235	0.18	0.59	0.44	14.3	8.6	65	39
TRF4	-1.9	-1.06	0.78	0.60	0.62	0.52	0.68	0.59	1.04	0.88	4.4	3.08	0.74	0.60	0.225	0.18	0.64	0.34	7.2	5.8	32	26
TRF5	1.15	-1.33	0.74	0.60	0.67	0.55	1.03	0.87	1.21	1.16	3.3	1.98	0.67	0.60	0.137	0.09	0.55	0.39	9.5	4.9	43	22
TRF6	2.84	1.24	0.78	0.69	0.52	0.4	0.55	0.49	0.86	1.02	5.06	3.52	0.43	0.33	0.21	0.15	0.59	0.44	11.8	8.3	53	37
TRF7	2.66	0.98	0.78	0.58	0.65	0.47	0.49	0.44	1.17	0.95	3.85	2.53	0.37	0.30	0.21	0.19	0.34	0.2	10.5	6.6	47	30
TRF8	5.32	3.55	0.73	0.54	0.65	0.5	0.44	0.38	0.55	0.43	5.72	4.18	0.25	0.2	0.187	0.17	0.15	0.1	14	10.1	63	45
TRF9	7.09	5.32	0.8	0.62	0.42	0.35	0.67	0.57	1.73	1.39	1.87	1.32	0.29	0.17	0.162	0.14	1.12	1.17	14.2	11.1	64	50
TRF10	10.6	7.98	1.04	0.71	0.57	0.42	0.61	0.54	2.08	1.39	3.19	2.31	0.37	0.30	0.312	0.26	0.98	0.78	19.8	14.7	89	66
TRF11	5.32	1.77	0.82	0.55	0.85	0.5	0.6	0.53	1.00	0.7	4.95	3.3	0.34	0.29	0.225	0.18	0.88	0.59	15	8.4	68	38
TRF12	4.43	1.77	0.74	0.52	0.67	0.5	0.6	0.54	1.24	0.95	3.19	1.98	0.37	0.30	0.287	0.24	1.37	1.03	12.9	7.8	58	35
TRF13	7.98	4.43	0.51	0.40	0.5	0.37	0.18	0.16	0.76	0.66	2.53	1.76	0.13	0.08	0.125	0.12	0.71	0.44	13.4	8.4	61	38
TRF14	5.32	2.66	0.57	0.39	0.55	0.32	0.32	0.3	1.04	0.73	2.09	1.43	0.21	0.17	0.112	0.09	0.54	0.39	10.8	6.5	48	29
TRF15	0.89	1.77	0.62	0.44	0.52	0.37	0.41	0.34	1.12	0.86	2.31	1.43	0.27	0.20	0.175	0.14	0.59	0.44	6.9	6	31	27
TRF16	5.32	2.31	0.62	0.45	0.45	0.25	0.38	0.32	1.12	0.83	2.31	1.65	0.30	0.24	0.187	0.12	0.54	0.34	11.2	6.5	51	29
TRF17	2.22	0.35	0.59	0.47	0.52	0.32	0.39	0.33	1.10	0.92	2.09	1.54	0.28	0.25	0.2	0.15	0.54	0.29	7.9	4.6	36	21
TRF18	1.77	-0.89	0.62	0.51	0.27	0.22	0.39	0.33	1.24	1.10	1.87	1.21	0.29	0.26	0.13	0.10	0.81	0.54	7.4	3.4	33	15
TRF19	7.09	3.1	0.55	0.41	0.45	0.27	0.55	0.5	1.10	0.79	1.65	1.32	0.3	0.25	0.12	0.08	1.74	1.42	13.6	8.2	61	37
TRF20	1.15	-0.89	0.57	0.42	0.42	0.27	0.34	0.28	0.83	0.64	2.97	2.09	0.27	0.22	0.19	0.16	0.73	0.49	7.5	3.7	34	17

Table-4: Pollution causing parameters evaluated through Nemerow's pollution index (NPI) in pre and post monsoon season

	p^H		EC (μS/cm)		Ca^{2+}(mg/l)		Mg^{+2} (mg/l)		Na^+ (mg/l)		K^+ (mg/l)		Cl^-(mg/l)		TH (mg/l)		TA(mg/l)		TDS (mg/l)		NO_3^-(mg/l)	
	pre	post	pre	post	pre	post	pre	post	pre	post	pre	post	pre	post	pre	post	pre	post	pre	post	pre	post
TRF1	0.85	0.81	1.09	1.01	1.06	0.88	1.17	0.76	0.36	0.3	1.7	1.15	0.96	0.72	1.72	1.30	1.1	0.8	2.16	1.9	0.34	0.34
TRF2	0.88	0.84	1.01	0.97	0.57	0.39	0.70	0.57	0.48	0.39	1.8	1.35	0.74	0.56	0.97	0.71	1.1	0.8	2.05	1.82	0.38	0.38
TRF3	0.88	0.85	1.4	1.47	1.3	0.76	1.27	0.87	0.87	0.74	5.25	4	1.94	1.43	2.00	1.25	1.35	1	2.8	2.76	0.3	0.30
TRF4	0.79	0.78	1.7	1.57	0.8	0.68	1.33	0.93	1.3	1.1	2.05	1.4	1.84	1.52	1.57	1.21	1.25	1.05	3.4	2.96	0.32	0.33
TRF5	0.83	0.78	2.6	2.3	0.9	0.89	1.00	0.6	1.25	1.05	4	2.9	1.70	1.52	1.49	1.21	1.35	1.1	5.17	4.34	0.28	0.28
TRF6	0.86	0.84	1.37	1.3	0.67	0.79	1.53	1.07	0.6	0.4	2	1.45	1.08	0.84	1.57	1.40	1.05	0.8	2.7	2.46	0.3	0.30
TRF7	0.85	0.84	1.23	1.1	0.9	0.73	1.17	0.77	0.55	0.41	2.4	1.65	0.92	0.76	1.57	1.16	1.3	0.95	2.46	2.18	0.18	0.18
TRF8	0.89	0.87	1.1	1.01	0.43	0.33	1.73	1.27	0.30	0.28	2.25	1.8	0.64	0.5	1.47	1.09	1.3	1	2.2	1.9	0.08	0.08
TRF9	0.91	0.89	1.6	1.52	1.33	1.07	0.57	0.4	0.13	0.11	1.6	1	0.72	0.44	1.60	1.25	0.85	0.7	3.34	2.86	0.58	0.58
TRF10	0.96	0.93	1.5	1.43	1.6	1.07	0.97	0.7	0.45	0.39	1.2	0.85	0.92	0.76	2.09	1.43	1.15	0.85	3.06	2.68	0.5	0.5
TRF11	0.89	0.85	1.5	1.39	0.7	0.53	1.50	1	0.48	0.4	2.85	2.4	0.84	0.72	1.65	1.12	1.7	1	3.02	2.64	0.45	0.45
TRF12	0.88	0.85	1.5	1.43	0.96	0.73	0.97	0.6	0.75	0.61	1.45	0.9	0.92	0.76	1.49	1.06	1.35	1	3.02	2.68	0.7	0.7
TRF13	0.92	0.89	0.47	0.44	0.59	0.5	0.77	0.53	0.17	0.11	1	0.6	0.33	0.2	1.02	0.81	1	0.75	0.92	0.82	0.37	0.37
TRF14	0.89	0.86	0.8	0.79	0.8	0.56	0.63	0.43	0.31	0.2	1.2	0.75	0.54	0.44	1.14	0.79	1.1	0.65	1.62	1.48	0.28	0.28
TRF15	0.83	0.79	1.03	0.9	0.87	0.67	0.70	0.43	0.48	0.38	0.75	0.45	0.70	0.5	1.24	0.89	1.05	0.75	2.06	1.7	0.3	0.3
TRF16	0.89	0.86	0.95	0.85	0.87	0.64	0.70	0.5	0.45	0.37	0.7	0.45	0.76	0.6	1.24	0.91	0.9	0.5	1.88	1.6	0.28	0.27
TRF17	0.85	0.83	0.97	0.88	0.85	0.71	0.63	0.47	0.47	0.39	0.8	0.21	0.72	0.64	1.19	0.95	1.05	0.65	1.94	1.64	0.28	0.27
TRF18	0.84	0.81	0.98	0.87	0.96	0.85	0.57	0.37	0.38	0.31	0.35	0.11	0.74	0.65	1.25	1.02	0.55	0.45	1.96	1.64	0.41	0.41
TRF19	0.91	0.86	1.37	1.32	0.85	0.61	0.5	0.4	0.49	0.39	0.95	0.7	0.74	0.62	1.1	0.82	0.95	0.55	2.74	2.48	0.89	0.89
TRF20	0.83	0.81	0.86	0.75	0.64	0.5	0.9	0.63	0.42	0.38	1.1	0.75	0.68	0.57	1.15	0.85	0.85	0.55	1.7	1.4	0.38	0.37

Table-5: Water quality classification based on WQI values

WQI values	Water quality	Sampling stations	
		Premonsoon	**Post monsoon**
0-25	Excellent		TRF1,TRF2,TRF5,TRF17,TRF18, TRF20
25-50	Good water	TRF1,TRF2,TRF4,TRF5,TRF7,TRF14,TRF15,TRF17, TRF18,TRF20	TRF3,TRF4,TRF6,TRF7,TRF8,TRF9,TRF11,TRF12,TRF13,TRF14,TRF15,TRF16,TRF19
50-75	Poor water	TRF3,TRF6,TRF7,TRF8,TRF9,TRF11,TRF12,TRF13,TRF16	TRF10
75-100	Very poor water	TRF10	NIL

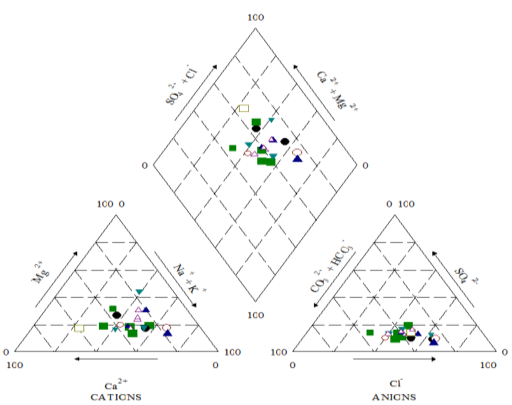

Fig:1-Piper diagram of ground water for Pre monsoon

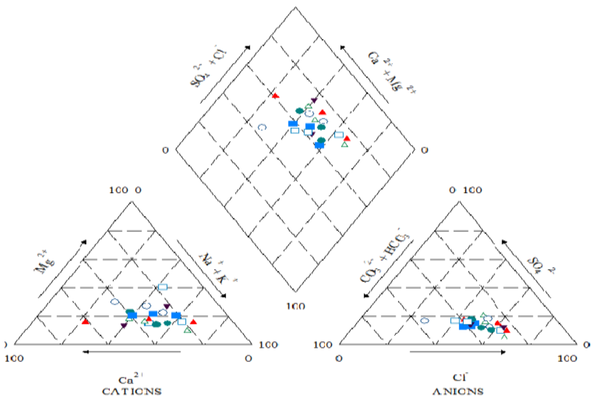

Fig:2-Piper diagram of ground water for Post monsoon

Classification of groundwater based on Piper trilinear diagram

Major cations and anions are basic constitutes to determine the type of water by Piper diagram.the diagram consists of two triangles between the diamond shaped left triangle shows cations and right shows anions. In this study, Piper diagram shows that there is a mixture of two types of water with the variable concentration of major ions. These are In the first group, the positions of data points in the Piper and represent as Ca-SO_4-Mg-Cl and Na-Ca-HCO_3-Cl- type water in pre and post monsoon, Indicating calcium and magnesium are the main cations and chloride is the main anion. These two facies indicate that groundwater samples are associated with alkaline earth ions such as calcium, magnesium and strong acid Anions such as chloride and sulfate. The source of calcium and magnesium in these regions is likely to be fluvial deposits and marine deposits.

Conclusions

In this study, we sampled and analyzed twenty samples of groundwater. The observed results showed that some higher value parameters and the sequence were more abundant cations Na >Ca>Mg > K in pre and post monsoon. The alkaline earth metal Ca exceeds alkaline metal Na +. The order of anionic abundance in groundwater HCO_3>Cl> SO_4> NO_3 in pre-monsoon and in the post-monsoon abundance of anions are in the order of Cl> HCO_3> SO_4> NO_3. High concentrations of EC, TDS, and THL observed in most samples. According to the correlation coefficient, total dissolved solids correlate with calcium, magnesium, sodium, and chloride at both stations. It indicates that groundwater was slightly contaminated due to excessive exploitation and anthropogenic activity. According to Piper diagram water Ca-Na-Cl and Na-Ca-HCO_3 type, it indicates water saline and hardness.NPIs based on total alkalinity, chloride, total dissolved solids, calcium and electrical conductivity have more than an NPI value some sampling stations of water pre and post monsoon stations. Water Quality Index represents 50% of samples shows poor water quality in pre monsoon. The result of this study revealed that groundwater in some areas with poor quality sampling water is not potable for the purpose.

Therefore, there is no need for frequent water quality controls and should adopt an environment management plan appropriate to control the pollution of drinking water due to small deviation is there in some sampling stations.

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