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PHYSICO- CHEMICAL ANALYSIS OF GROUND WATER OF AJMER CITY IN RAJASTHAN

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ABSTRACT

The physico-chemical analysis of ground water quality of Ajmer city in Rajasthan is presented in this paper. It is important from this point of view to observe the suitability of water for safe drinking and irrigation. The different parameters measured are calcium hardness, magnesium hardness, total hardness, As^{3+}, Cd^{2+}, Pb^{2+}, Hg^{2+}, TDS, F^-, Cl^-, NO_3^-, SO_4^{-2} alkalinity, carbonate hardness, pH and conductivity. From the observed data it is found that parameters like conductivity, TDS, F^-, NO_3^- and hardness are higher in concentration from prescribed values. From the analysis of ground water quality, it is observed that some of the sites are not suitable for drinking purpose as well as domestic purpose.

Key words: Ground water quality, Different parameters.

INTRODUCTION

Water is one of the foremost essential components and it is essentially required by all living organisms[1]. Availability of good quality water for drinking purpose is very essential for healthy human society.[2] About 80% of the earth's surface is covered by water. Out of the estimated 1,011 million Km^3 of the total water present on earth, only 33, 400 Km^3 of the total water is available for drinking, domestic and industrial consumption. The rest of the water is locked up in oceans as salt water, polar ice caps, glaciers and underground. Ground water is also one of the earth's renewable resources, which occur as a part of hydrological cycle. The quality of ground water is the resultant of all the processes and reactions that act on the water from the moment; it condenses in the atmosphere to the time it is discharged by well. Therefore, determining ground water quality is important to observe the suitability of water for particular purpose[3,4] through anthropogenic and other sources like different land conditions, rain conditions, and use of different chemical pesticides and different depths of bore wells. Continued economic growth, green revolution, urbanisation[5]

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and increase in health consciousness are posing enormous stress and threat to the limited fresh water resources. The 26th December, 2004 Tsunami has major impact on the quality of ground water[6] along the south east coast of India. The Tsunami flooded large coastal areas, destroyed vegetation and greatly affected ground water supply. Water quality monitoring involves the sampling and testing of water sources of the public at specific intervals and at different locations. Constant, regular and effective monitoring of water sources can ensure and help in effective water quality management[7].

Natural ground water bodies are subjected to pollution comprising of organic and inorganic constituents. Among the inorganic constituents, metals have been recognized as the most harmful pollutants because they are not biodegradable and often have long term toxic effects. A number of metals are present at trace levels in residential and industrial waste water. These trace metals, significantly As, Cd, Pb, and Hg are considered to be highly toxic while Cu, Zn and Fe etc. can also be considered so, at appropriate levels[8, 9].

The present report discusses the results of physico-chemical analysis of ground water from different points of Ajmer city and surrounding area with reference to its suitability for various uses.

EXPERIMENTAL

Matrials and methods

The water samples have been collected from 22 hand pumps of Ajmer city. Geographically, Ajmer is situated in 26^{o} 27' N latitude and 74^{o} 44' E longitudes on the lower slopes of Taragarh hill, in the Aravalli range. The annual rainfall is below 500 mm. showing a semi-arid climate. The North-Western part is covered with sand dunes and rest of the area is generally flat. Hydrogeologically the major part of the region is occupied by crystalline rocks comprising of calc-schist, amphibolites/Calc-gneiss and biotite schist and alluvium of younger age are other important formations. A small occurrence of fluorspar in Ajmer, has also been reported.

The study has been initiated from July 2006 to Dec. 2009 in different seasons viz; premonsoon, monsoon and postmonsoon period to check the various physico-chemical parameters. Samples have been collected in clean and sterilised polyethylene bottles of 2 L capacity. Standard methods with precise instruments are used to test the samples as per the literature method[10] (APHA and AWWA). All the chemicals and solvents are of AR grade (Sigma-Aldrich). The location of sampling stations (Table 1) and their surrounding are shown in Fig. 1.

Table 1: Sampling stations

Hand Pump No.*	Location
359	Opp Post Office, Ramnagar, Pushkar Road
355	Near Gents Toilet, No. 2, Pushkar Rd, Vishram Sthal
909	Bathroom No.1, Pushkar Road, Vishram Sthal
898	Near Wall Pushkar Road, Vishram Sthal
472	Lakdi ki Tall, Pushkar Road
471	Near. Graveyard, Pushkar Road
288	Near RSEB Chowki, Vaishali Byepass
1160	House No. 20/17, Near Dumb & Deaf School
558	Near Ashiyana Sadan, Link Road
164	Ana-Sagar Link Road
613	infront of Mahadev Mandir, ASC Road,
167	Near Kamla Devi Nursing Home ASC Road
155	Infront of Jawahar Rang Munch, Lohagal Road
199	Shantipura, ASC Road,
264	Opp. BOB, ASC Road, Vaishali
250	Near RIICO Unit, Vaishali
256	Infront of Shri Krishna Store, Vaishali Nagar
375	Pancholi Choraha, Ramnagar
372	Govt. Sec. School, Ramnagar
402	Near Chouhan Auto Repairs, Rishi Ghati
398	Near Bhagchand ki Kothi, Rishi Ghati
198	Sunder Villas Gali, Subhash Bagh Road

* These are the numbers assigned by PHED to the hand pumps.

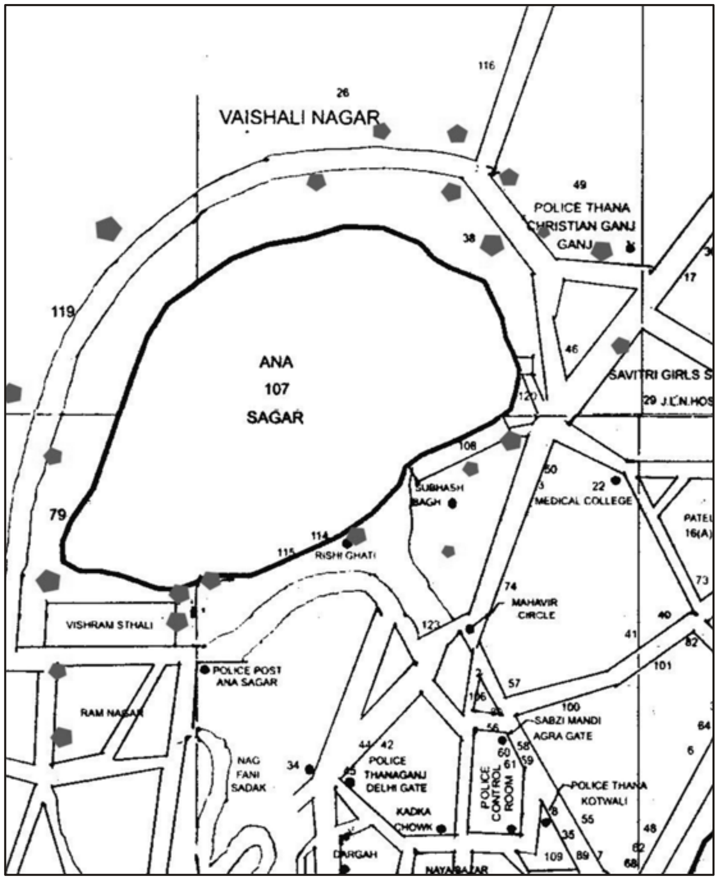

Fig. 1: Description of study area (Ajmer city)

RESULTS AND DISCUSSION

The results of water analysis of the samples collected are summarized in Table 1 and the observed results for different parameters for three seaons for twenty two hand pumps are shown in Fig. 1 in order to visualize the quality and their trends in deterioration over different seasons.

The physico-chemical investigation of the water samples for the following features of the ground water viz; calcium hardness, magnesium hardness, total hardness, As, Cd, Pb, Hg, TDS, fluoride, chloride, nitrate, sulphate, alkalinity, carbonate hardness, pH and conductivity etc. have been analyzed by standard methods and compared with standards of the World Health Organization (WHO) and Bureau of Indian Standards (BIS). The findings of these major chemical parameters have been summarized in Table 2.

Table 2: Physico-chemical parameters of ground water samples

S. P.	Parameters															
	Ca^{2+} Hardness	Mg^{2+} Hardness	Total Hardness	As^{3+}	Cd^{2+}	Pb^{2+}	Hg^{2+}	TDS	F^-	Cl^-	NO_3^-	SO_4^{-2}	Alkali-nity	CO_3^{-2} Hardness	pH	Cond.
A	50	40	90	0.7	0.01	0.001	0.002	1238	3.5	240	90	235	410	90	7.8	1782.72
B	20	400	420	0.8	0.01	Nil	0.003	2500	3.2	245	170	205	360	360	7.2	3600
C	100	140	240	0.9	0.05	Nil	0.023	1265	5.9	240	130	216	590	240	7.8	1821
A	50	20	70	0.9	0.01	Nil	0.001	826	6.8	140	5	150	480	70	7.9	1189.44
B	30	30	60	0.9	0.01	Nil	Nil	1220	6.6	135	5	145	470	60	7.6	1756.8
C	40	30	70	0.86	Nil	0.035	0.012	1235	6.2	139	45	140	470	70	7.6	1778.4
A	170	80	250	1.06	0.01	0.02	0.013	1769	3.2	430	100	165	540	250	7.7	1547.36
B	60	240	300	1.1	0.07	0.03	0.011	1700	3.5	470	65	160	230	230	7.8	2448
C	90	80	170	1.1	0.001	0.06	0.012	870	3.9	170	45	188	230	170	7.6	1252.8
A	80	40	120	1.06	0.002	0.04	0.045	1136	3.3	290	35	120	400	120	7.8	1707.84
B	60	120	180	1.01	0.01	0.02	0.023	900	4.9	180	20	104	220	180	7.6	1296
C	90	60	150	0.23	0.02	0.01	0.023	645	5.4	110	45	130	220	150	7.7	928.8
A	160	80	240	0.56	0.05	0.04	0.011	1393	1.6	800	30	100	370	240	7.8	2005.92
B	50	300	350	0.88	0.004	0.01	0.012	1450	1.9	410	90	92	250	250	7.7	2088
C	220	180	400	0.13	0.01	0.02	Nil	1200	2.4	300	35	150	250	400	7.8	1728
A	160	110	270	0.21	Nil	0.05	0.01	1009	0.5	220	100	78	260	260	7.9	1452.96
B	70	310	380	1.5	Nil	0.06	Nil	930	0.6	200	145	68	120	120	7.6	1339.2
C	590	60	650	1.2	Nil	0.07	0.021	1410	0.9	270	45	170	120	540	7.6	2030.4
A	80	140	220	0.11	0.05	0.04	Nil	3450	2.2	1360	15	230	500	220	7.9	4968
B	170	110	280	0.16	0.006	0.01	Nil	3000	3.2	1100	15	220	360	280	7.7	4320
C	160	240	400	0.15	0.003	0.01	0.023	2520	3.8	760	20	220	360	400	7.7	3628.8

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S. P.	Parameters															
	Ca^{2+} Hardness	Mg^{2+} Hardness	Total Hardness	As^{3+}	Cd^{2+}	Pb^{2+}	Hg^{2+}	TDS	F^-	Cl^-	NO_3^-	SO_4^{-2}	Alkali-nity	CO_3^{-2} Hardness	pH	Cond.
A	60	100	160	0.14	0.002	0.01	0.024	980	1.7	170	35	130	440	160	7.8	1411.2
B	40	180	220	0.06	0.001	0.01	0.021	950	1.7	180	25	124	250	220	7.8	1336
C	140	70	210	0.08	0.001	Nil	Nil	860	2.2	160	20	180	250	210	7.8	1238.4
A	90	60	150	0.09	0.04	0.001	Nil	860	0.9	170	50	80	240	150	7.9	1238.4
B	50	260	310	0.06	0.06	0.001	0.017	930	1.5	130	95	76	220	220	7.8	1339.2
C	160	140	300	0.07	0.07	0.01	Nil	700	1.6	110	25	210	220	300	7.8	1008
A	160	140	300	0.05	0.08	0.02	0.025	1220	0.7	190	45	96	500	300	7.8	1756.8
B	60	330	390	1.1	0.08	0.03	Nil	940	1.3	130	90	92	230	230	7.8	1353.6
C	150	120	270	1.2	0.08	0.02	Nil	5660	1.2	90	45	110	230	270	7.6	950.4
A	90	270	360	1.4	0.09	0.05	Nil	1225	1.3	230	60	130	440	360	7.9	1720.8
B	70	310	380	0.01	0.04	0.04	0.023	1195	1.2	210	165	124	280	280	7.6	1720.8
C	160	200	360	0.05	0.03	0.04	0.024	1040	1.3	180	40	130	280	360	7.7	1497.6
A	100	270	370	0.04	0.05	0.01	0.011	1180	1.7	210	90	130	290	220	7.9	1699.2
B	130	230	360	0.06	0.06	0.02	Nil	1150	0.8	200	160	124	240	240	7.8	1656
C	180	40	420	0.07	0.08	0.02	0.027	925	1	140	160	140	240	420	7.6	1332
A	100	10	110	0.05	0.05	0.02	Nil	880	1.4	140	20	60	580	110	7.9	1267.2
B	50	60	110	0.06	0.05	0.04	0.013	360	1.8	40	20	48	120	110	7.8	518.4
C	110	60	170	0.04	0.05	0.06	0.025	280	0.5	50	210	50	120	170	7.8	403.2
A	90	190	280	0.06	0.04	0.03	0.021	2030	0.6	540	160	196	280	0	7.8	2923.2
B	60	460	520	0.02	0.04	0.03	0.021	1800	0.8	410	155	184	160	160	7.6	2592
C	240	230	470	0.03	0.04	0.05	0.011	1500	0.9	290	45	150	160	470	7.7	2160

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S. P.	Parameters															
	Ca^{2+} Hardness	Mg^{2+} Hardness	Total Hardness	As^{3+}	Cd^{2+}	Pb^{2+}	Hg^{2+}	TDS	F^-	Cl^-	NO_3^-	SO_4^{-2}	Alkali-nity	CO_3^{-2} Hardness	pH	Cond.
A	110	190	300	0.07	Nil	0.01	0.014	1780	1	360	125	170	530	230	7.9	2563.2
B	80	290	370	0.04	0.03	0.02	0.015	1700	2.8	460	155	160	410	370	7.7	2448
C	130	250	380	0.01	Nil	0.01	Nil	1150	0.3	190	200	160	410	380	7.6	1656
A	150	120	270	Nil	0.001	0.02	Nil	740	3.7	110	35	100	390	160	7.7	1065.6
B	80	190	270	0.05	0.06	0.03	Nil	810	0.9	120	40	96	230	230	7.8	1166.4
C	60	210	270	0.06	0.05	0.04	0.014	620	0.5	90	70	108	230	270	7.7	892.8
A	90	110	200	1.01	0.04	0.05	0.017	890	0.8	120	30	110	400	200	7.8	1281.6
B	90	160	250	1.04	0.05	0.06	0.017	775	1.2	150	80	104	200	200	7.6	1116
C	220	90	310	1.1	0.05	0.04	0.017	640	1.2	100	80	120	200	310	7.8	921.6
A	80	140	220	0.02	0.056	0.01	0.021	1325	1.5	240	100	155	280	310	7.9	1843.2
B	60	330	390	0.02	Nil	0.02	0.021	Nil	0.7	280	120	148	100	220	7.7	1908
C	310	90	400	0.03	0.05	0.03	0.023	1390	0.9	310	40	160	100	100	7.8	2001.6
A	140	270	410	0.06	0.06	0.05	0.025	1960	1	370	125	135	670	400	7.8	2822.4
B	110	300	410	0.05	0.07	0.06	0.024	1470	2.1	250	125	128	320	410	7.8	2116.8
C	240	290	530	0.04	0.06	Nil	0.024	1450	2.6	300	150	220	320	320	7.6	2088
A	80	120	200	0.05	0.05	0.01	0.024	1780	2.9	270	125	170	580	530	7.9	2563.2
B	50	300	350	0.06	0.07	Nil	0.022	1545	1.1	270	15	164	250	200	7.6	2224.3
C	200	60	260	0.05	0.04	0.01	0.011	1290	1.3	140	160	120	250	260	7.7	1857.6
A	310	280	590	0.02	0.06	0.01	0.011	2900	1.7	820	80	172	290	290	7.9	4176
B	60	930	990	0.05	0.06	Nil	0.011	2830	0.8	900	25	164	220	220	7.6	4075.2
C	600	140	740	0.03	0.04	0.001	0.011	2670	1.2	660	140	228	220	530	7.8	3844.8
A	150	50	200	0.02	0.02	0.001	Nil	1420	1.2	240	60	160	420	200	7.8	2044.8
B	220	80	300	0.01	0.01	0.02	Nil	1250	1.5	250	100	152	190	190	7.6	1800
C	200	140	340	0.01	0.01	0.03	Nil	1110	1.7	190	80	204	190	340	7.7	1598.4

S. P. Sampling period; A = Premonsoon; B = Monsoon; C = Postmonsoon; Unit – Conductance in mhos and remaining in mg/L (except pH)

Hardness is defined as the some of polyvalent cation present in the water, notably calcium and magnesium. Calcium and magnesium are the two major scale forming constituents in most raw water supplies. The presence of calcium and magnesium in ground water is mainly due to its passage through or over deposits of limestone, dolomite, gypsum and other gypsiferous materials. Calcium content in all experimental water samples is varying from 20 to 600 ppm. Calcium salts are non-toxic except at very high doses (100 mL for 20 days) in human body, hyper calcemia causes comma and death, if in serum; calcium level rises to 160 ppm. The suggested limit of calcium is 75 ppm. Magnesium in too high concentration causes nausea, muscular weakness and paralysis in human body, when it reaches up to the level of about 400 ppm. The suggested limit of magnesium is 80 ppm (WHO), in this area magnesium concentration has been observed from 10 to 930 ppm.

The permissible limit of hardness in drinking water according to WHO is 600 ppm. Total hardness at some stations has been found much higher than the said limit. The total hardness (Ca^{2+}, Mg^{2+}, Cl^{-}, SO_4^{2-}) of all water samples has been found to be above the permissible limits, varying from 60 to 990 ppm. This is mainly attributed to natural action i.e. rock, weathering rather than man made pollution, which has been affecting the soil nature like aeration and permissibility of earth surface.

The environmental presence of arsenic derives from both; natural and anthropogenic sources. It occurs naturally when aquifers pass through bedrock containing arsenic. Significant amounts of arsenic are also introduced into the environment from anthropogenic sources, metal mining and smelting being the most important. Arsenic is a carcinogen and a potential health hazard[11] known to produce skin, bladder & lung cancers and diarrheal diseases. According to some current estimates, approximately 1.8 million people still die every year from diarrheal diseases[12] mostly in developing countries (WHO, 2008). The WHO and U.S. Environmental Protection Agency (EPA) recommended limit for arsenic in drinking water is currently 10 μg/L (WHO, 2006).

Cadmium is extensively used in the manufacture of batteries, paints, plastics etc. It is also used in plating iron products such as nuts and bolts for corrosion protection. At extreme levels[13], it causes an illness called itai-itai disease characterised by brittle bones and intense pain. Exposure for prolonged periods at low levels causes high blood pressure, sterility among males, kidney damage and flue like disorders. The maximum and minimum concentration of cadmium has been registered to be 0.09 and nil ppm.

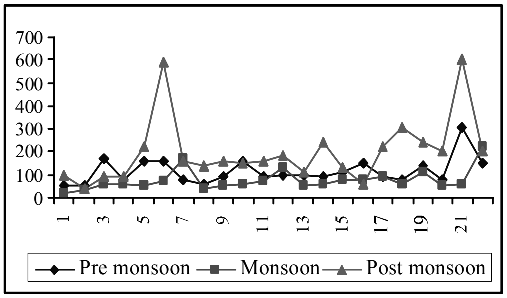
Lead (II) is the abundant of the natural heavy metal. The primary form of lead in nature is galena (PbS), a relatively insoluble ore. Lead also occurs as plattnerine (PbO_2), cerussite ($PbCO_3$) and anglesite ($PbSO_4$). From the observation, lead content in water samples has been found from nil to 0.07 ppm. The sources of lead to water is, manufacture of pesticides, insecticides and storage batteries or from contact with gasoline containing lead activities. Lead poisoning[14] has been recognized for many years. Higher level exposure of lead in the water system, results in metallic taste. Simultaneously, the lead may be redistributed i.e. deposited in bones, teeth or brain. In bones, lead is immobilized and does not contribute to the general toxic symptom of the patient. Organic lead compounds have an affinity for the central nervous system and produce lesions there. A dry burning sensation in the throat, cramps, etching and encrusted with the coagulated proteins of the necrotic mucosa, will occur; thereby, hindering further absorption of the lead muscular spasms, numbness and local palsy may appear.

Mercury is widely used in amalgams, scientific instruments, batteries, arc lamps, extraction of gold & silver and the electrolytic production of chlorine. Its salts are used as fumigants for control of plant disease and insects. The most spectacular incident of mercury poisoning[15,16] in humans resulted from ingestion of sea food taken from Minamata Bay, Japan during the late 1950's, the high concentration of mercury in the fishes was found to be due to methy-1-magnesium cation and dimethy-1-magnesium, which were shown to be produced by bacterial action in botton muds under anaerobic condition. The maximum permissible limit of Hg in drinking water is 0.002 ppm. (WHO 1984).

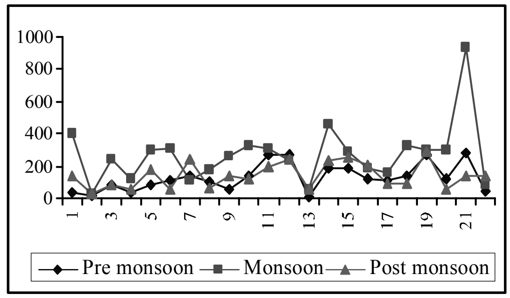
Total dissolved solids have ranged from 280 to 5660 ppm. All values are high as compared to permissible limit. This may be due to contamination of inorganic salts like carbonate, chloride, sulphate, nitrate etc. and also organic substance (ketones, esters and carboxylic acids i.e. aromatic or aliphatic) which are generally found in polluted water Dissolved solids are important parameters in water quality management.

Since some fluoride compounds in the earth's upper crust are soluble in water, fluoride is found in both; surface water and ground water of Ajmer district, Rajasthan. In the ground water, the natural concentration[17] of fluoride depends upon the geological, chemical and physical characteristics of the aquifer, the porosity and the acidity of soils and rocks, the temperature, the action of other chemical elements and the depth of wells. Because of the large number of variables the fluoride concentration in ground water varies from 0.1 ppm to more than 11 ppm in Ajmer district[18].

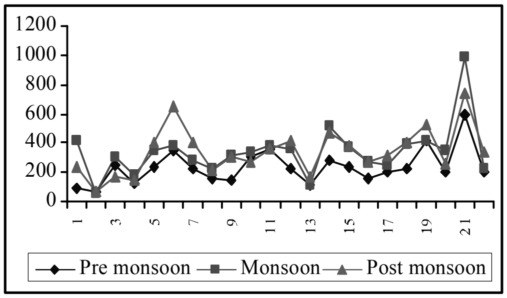
Fluoride is no doubt essential up to 1 ppm according to WHO and BIS. The excess amount of fluoride of water is poisonous[19]. High levels of fluoride lead to dental and/or skeletal fluorosis[20]. Millions of people are suffering from these diseases due to fluoride contamination. The fluoride content of all water samples in the study area ranged from 0.3 to 6.8 ppm.



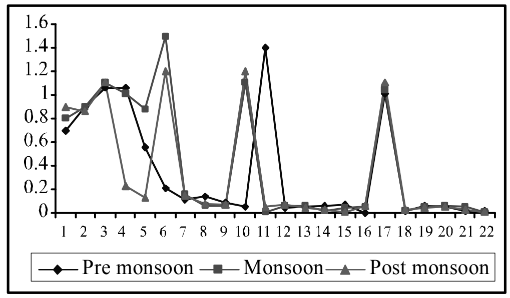
Variation in calcium hardness



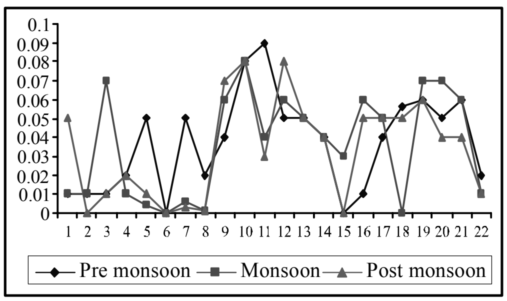
Variation in magnesium hardness



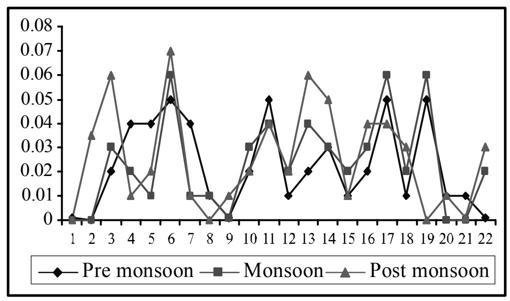
Variation in total hardness



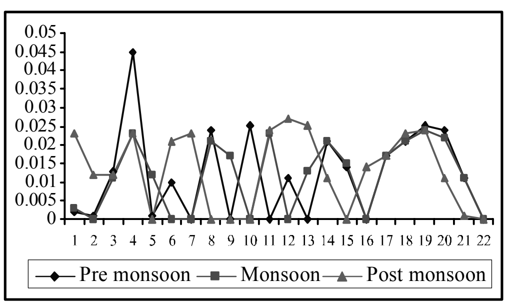
Variation in As



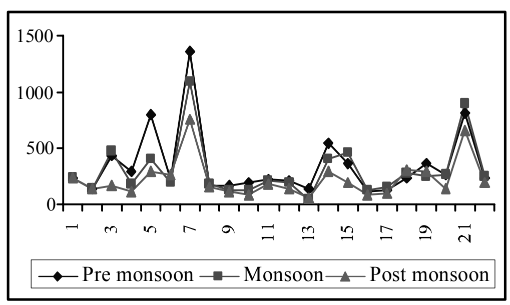
Variation in Cd



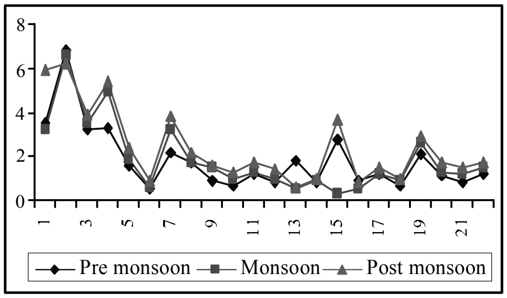
Variation in Pb



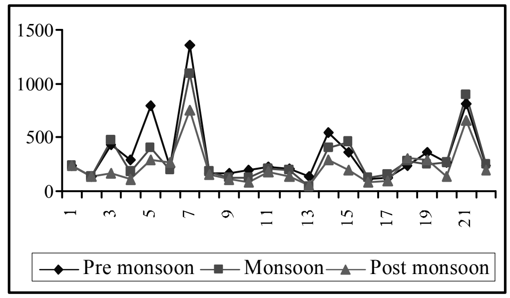
Variation in Hg



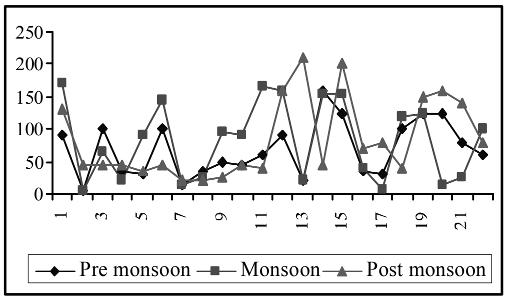
Variation in TDS



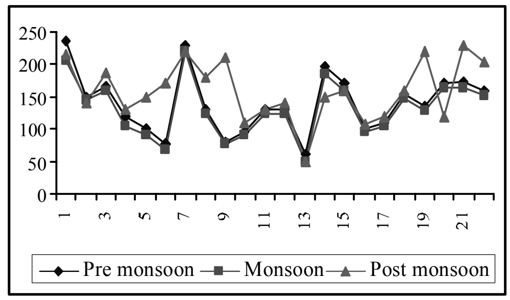
Variation in fluoride



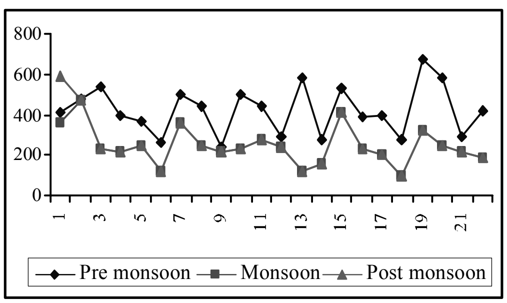
Variation in chloride



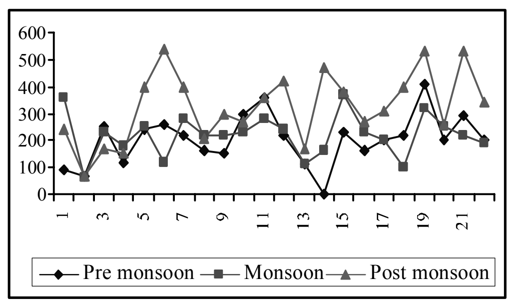
Variation in nitrate



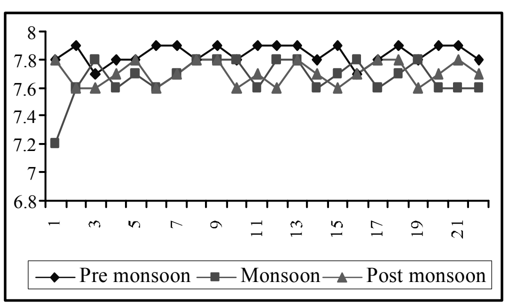
Variation in sulphate



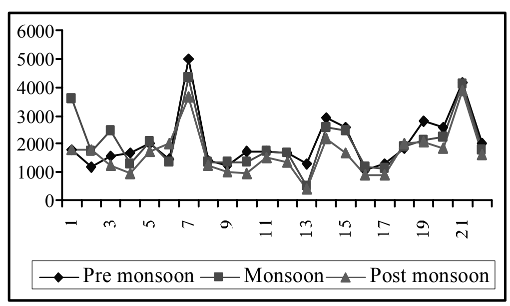
Variation in alkalinity



Variation in carbonate



Variation in pH



Variation in conductivity

Fig. 1: Physico-chemical parameters in ground water at twenty two sites

The chloride contents of water samples has been observed between 40 to 1360 ppm. The chloride contents in the ground water may be contributed from minerals like apatite, mica, hornbleds and also from the liquid inclusions in the igneous rocks. Excess chloride content in water imparts a salty taste. Peoples, those who are not accustomed to high chloride can be subjected to laxative effects[21]. Its permissible limit is 250 ppm and harmless upto 1500 ppm.

Importance of analysing the concentration of nitrate is felt due to its deterious effects on infants. Nitrate poisoning brings about a condition called methemoglobinamea. Nitrate forms nitrosoamines in stomach, which causes gastric cancer.

Nitrogen occurs in water as nitrite or nitrate anion and ammonium cation. Nitrate is present as species of nitrogen in water over a considerable range of condition. The source of nitrate in water may be natural or man made. Naturally present atmospheric nitrogen is fixed as nitrate by soil bacteria "*Nitro bacillus*" which get dissolved into water. Nitrogen of atmosphere is also fixed by lightening, which dissolves in rain water. The excess fertilizer used in agriculture is the major source of nitrate in ground water. Beside these, animal and human being produces considerable amount of nitrogenous organic waste that tend to concentrate in the ground water of surrounding. In all the samples tested, nitrate has been varied from 5 to 210 ppm.

The desirable limit of sulphate in drinking water prescribed by WHO is 200-400 ppm. High values of sulphate are generally not harmful to human beings but high concentration of these may affect the persons, who are suffering from kidney and heart disease. The presence of sulphate in water may result from the dissolution of minerals such as gypsum and anhydrite and from the oxidation of various sulphide minerals such as pyrite and galena. Presence of sulphate has less effect on the taste of water compared to the presence of chloride. High value of sulphate above 500 ppm produces bitter taste to water and exerts adverse effect on human. All the water samples collected have satisfied the drinking water quality so far the presence of sulphate is concerned i.e. 48 to 230 ppm.

Alkalinity of natural water is due to dissociation of salts. The constituents of alkalinity in natural water system mainly include carbonates, bicarbonates and hydroxides. These constituents result from dissolution of mineral substances in the soils and atmosphere. Carbonate and bicarbonate may originate from microbial decomposition of organic matter. The WHO acceptable limit is 200 ppm, beyond this limit, the taste may become unpleasant, where as in the absence of alternate source of water, an alkalinity up to 600 ppm is acceptible (Ministry of Rural Development, Govt. of India). The total alkalinity values are ranging from 100 to 670 ppm.

pH value of all these samples has been found with in the limits. pH is the measure of hydrogen ion activity, thus it is a good measure of acidity and alkalinity in water. Presence of phosphates, silicates, borates, fluorides and some other salts in dissociated form may also affect the pH. In very pure waters with dissolved carbon dioxide and in mineral waters in zone of oxidation, the pH may be lowered appreciably. Normally the pH of ground waters ranges between 6.0 to 8.5, but lower or higher values have also been reported in some thermal springs and polluted water[22]. The pH is the significant factor in dissolution of various minerals in ground water. It controls the solubility of various salts like calcite, dolomite, fluoride etc. The pH is a major parameter in determining the corrosivity of water. In general, with increasing pH value, the rate of corrosion[23]increases. The observed pH value varied from 7.2 to 7.8 ppm.

Conductivity is a measure of the current carrying capacity; thus, gives a clear idea of soluble salts present in the soil. Conductivity values are ranging from 403.2 to 4968 μ mohs/cm. All the samples are above the permissible limits. If the conductivity and TDS values exceed, it may lead to scaling in boilers, corrosion and quality degradation of the product.

The study clearly reveals that all the hand pumps chosen for study are not managed properly and show signs of organics and inorganic pollution load. Findings of these investigations cited in Table 2, reveal that these stations being in the near vicinity of Ana Sagar are badly polluted. The stations situated in the slum areas surrounded by motor garages are under the threat of toxic metal load, which is going to affect the people residing in the area using such ground water. In the present state, these sites are not safe for public use and may lead to poor ground water quality. For that, there is an immediate and urgent need for their treatment incorporating the following recommendation.

- Diverting the domestic sewage to flow away from the lake totally.
- Giving proper treatment to domestic sewage and permitting its entry into the lake.
- Quantifying the domestic sewage, which enters into lake and planning for effective sewage treatment plant and minimizing the pollution load.
- Continuous monitoring of water quality in lake will help to take necessary actions in minimising the chances of further deterioration.

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