STUDY OF GROUNDWATER CONTAMINATION DUE TO AGRICULTURAL ACTIVITY UNDER PRAVARA LEFT BANK CANAL, MAHARASHTRA

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ABSTRACT:

Indian economy is agriculture based and chemical fertilizer application has grown exponentially. Studies have shown that agricultural activity, coupled with conventional irrigation method, disposal practices, has resulted in detoriation of groundwater quality. Groundwater is the chief water source for various requirements in many part of the country. Groundwater sample for 2 cases, i.e during no flow in canal and during flow in canal, are collected from agriculturally dominant regions of Pravara left bank canal command consisting of 5 taluka of Ahmednagar district. Laboratory analysis is done to study the groundwater quality . The study show that Nitrate(NO_3^-),(K),sodium (Na^{+})), calcium (Ca^{2+}),pH, Electrical Conductivity (EC),in groundwater sample was under acceptable limit of BIS &WHO, magnesium (Mg^{2+}) and Sulphate (SO_4^{2-}), was within maximum permissible limit of BIS &WHO.SAR value in 96% of water samples showed water to be of good quality. However Bicarbonate (HCO_3-), Chloride (Cl^-), Phosphate (PO_4^{3-}) and RSC in majority of samples showed values above maximum permissible limit of BIS &WHO. Statistical analysis have shown significant correlation between Sodium &SAR, Bicarbonate &RSC, Chloride and Sulphate and moderate correlation between EC and Magnesium, Calcium and Sulphate.

Keywords: *Agriculture, excessive application, chemical fertilizer, Irrigation, groundwater, Pravara left bank canal command*

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1. INTRODUCTION

The Indian usable water resources for the year 2015 were estimated to be 1123 billion m^3. Groundwater is chief source of water for various uses. According estimates it accounts to about 85% of rural and 50% of urban domestic requirement. Groundwater accounts to 89% of Irrigation, 9% of domestic, and 2% industrial requirement of the country(1). Groundwater is rapidly being abused in terms of quality and quantity due anthropogenic activity. Hence it becomes necessary to investigate all factors that cause detoriation of groundwater quality. Agriculture, industry, disposal of various waste are some of the point and non point source of groundwater pollution. Agriculture is a complex activity involving, application of fertilizer, pesticide, herbicide, providing irrigation.(2). Top overburden soil, followed by the geological characteristics plays a major role in the development, retention and transport of contaminants to groundwater table.

Indian economy is mainly dependent on agriculture and currently agriculture products and accounts to 17.9% of country's GDP (3). To boost the declining Indian agricultural productivity, government of India in its 11th five year plan encouraged developmental activities through growth centered activities involving technological development in agriculture, irrigation, use of HYV seeds, pesticide, fertilizer etc. These development no doubt increased food products but paved way for rising trends in groundwater contamination (4)

Independent India was left with 19% of cropped area under irrigation in 1947. India achieved self sufficiency in food grain production and irrigation potential due to sustained effort by central and state governments of the country. Food grain production rose from a mere 52 M.MT in 1952 to 246 M.MT during 2013-14.Under Indian condition, average yield from irrigated land is about 2.5tonne/ha and from unirrigated land is only 0. 5 tonne/ha. (5).

Chemical fertilizers have a great influence, in addition to various other factors on the yield of agricultural products. The application of fertilizers was found to increase the food production by about 50 to 60% as several high yielding varieties were developed, post independence. To meet the growing demand of the agriculture sector , food production and to lessen the burden on import of fertilizer, indigenous production of fertilizer began in India with setting up of a unit to produce Single Super Phosphate (SSP) near Chennai in 1906.Currently India has achieved 80% of self sufficiency in fertilizer production through 30 large scale Urea producing ,21 producing DAP & Complex fertilizer & 5 producing nitrogenous fertilizer industries and is ranked 3 in world for producing fertilizer. The total production of all NPK fertilizer rose from 1.05MT in 1970-71 to16.36MT during 2011-12. The consumption which was 2.17 MT rose to 27.56MT during the same period. India is the second largest consumer of fertilizers in the world after China. It accounted for 15.3 % of the world's N consumption. 19% of phosphatic and 14.4 % of Potassic nutrients in 2008 (6).

Studies conducted by (7) south eastern part of Anantapur District, Andhra Pradesh,india showed that leaching of nitrate was significant upto shallow depth of 90 cms and trace upto 150cms,under controlled conditions of fertilizer, and irrigation application. Hence leaching could be considerable if irrigation and fertilizer application varied.(8) through series of experimentation, showed that an average of 40% of applied N fertilizer, with was lost as leachates. Recovery by plants was around 55%.

(9) of Green Peace India Society, conducted studies on nitrates in groundwater, in the district of Ludhiana, Bhatinda, Muktsar,Punjab which showed, 20 percent of all sampled wells, have nitrate levels above the safety limit of 50 mg/L NO-3 for drinking water established by the World Health Organization (WHO) and wells in 8 of 18 villages sampled have pollution level above safety limits. The study revealed the relation between the fertilizer application and nitrate pollution in the region. It was found that the application of fertilizer was around 322 kg N/ha during 2008-09, more than the prescribed 210 kg N/ha for 2006-07.

Agricultural activity involving application of fertilizer is increasing the prospects of groundwater pollution, and is a growing problem concerning groundwater pollution worldwide(10).

(11) study on Impact of chemical fertilizers on water quality Mysore district, Karnataka, found that, Nitrate and phosphate concentrations were higher than the standard limits of WHO in the groundwater as well as the soil samples. The contamination measured was found to be related to surface run off, leaching of chemical fertilizers into groundwater table.

Study the effect of intense use of Nitrogenous fertilizer on groundwater, in Motala region of Buldana District, Maharashtra revealed Nitrate content(50 mg/l) in groundwater samples higher than the permissible limits(12)

The groundwater pollution studies carried out by NEERI ,Nagpur show that the Nitrate contamination of groundwater is on the rise as nearly about 27% of the water samples of about 4696 showed Nitrate content beyond permissible limit.(13).

Fluoride content in drinking water in 14 states of India are above the prescribed standard of 1.5ppm and around 65% of water sources in Indian villages have fluoride contamination. High Arsenic content, above 50 ppb are reported six district of West Bengal. Similarly studies have reported high salinity, heavy metals, Iron above standard limits in different parts of India. (2)

Large scale Groundwater Pollution due to Hazardous chemical was first detected by Japan Environment Agency in 1982 (14). Presence of trichloroethylene groundwater wells was detected in 1972. 1499 Water samples were analyzed from shallow, deep wells and surface, across Japan. Nitrate levels were above permissible limits in 10% of all wells sampled, highest concentration observed was 80mg/L. In addition to this tricholoroethylene, tetracholoroethylene, tricholoroethane was also found in high concentration.

Fertilizer mismanagement, irrigation frequency, soil conditions are seen as chief source of groundwater pollution in developing countries across the world. Generally in such countries fertilizers application exceeds average prescribed application rates. Punjab, Haryana, 17 districts of Uttar Pradesh($0.3x10^6$ km^2) consume fertilizer equivalent to combined consumption of Gujarat, Maharashtra, Rajasthan, Madhya Pradesh($1.3x10^6$ km^2).In arid ,semiarid region where soil remain dry for most part of the year, potential leaching occurs only when irrigated well(15).
Study was carried out by (16) in Weishan Irrigation District (WID) Shandong Province, China, showed that Fertilizer application has a bearing on the variation in the Nitrate concentration due to variation in Nitrate loading on groundwater .During the study peak values was observed during July and September. Study showed that leaching is associated with irrigation and its type. Nitrate concentration was found to be 20 mg/ l before irrigation and reached 65 mg/l. The highest concentration of 100 mg/ L was observed.
Groundwater in 29taluka in 16 districts shows total hardness exceeding the permissible limits (600 mg/l) 100% of the time. Under MPCB network 7 taluka in 4 districts show Fluoride levels above permissible limits of 1.5 mg/l, 100% of the time.

TDS is an indicator of aesthetics. The analysis shows that 6 taluka in 5 districts of Maharashtra shows 100% exceedance of permissible limit. For aesthetic reasons, a limit of 2000 mg/l as permissible limit has been established as part of the BIS – 10500 (2004-2005). pH Concentration in two taluka of 2 districts show 100% non compliance of BIS standard of 6.5-8.5 mg/l(17).

The current study is conducted to understand the groundwater status in context to the general quality and effect of agricultural activity under Pravara left bank canal command, Maharashtra, India.45 samples were collected from the study area from shallow wells the depth of which varied between 10m to 20m. The water samples are analyzed by standard methods.

2. Study Area

The study area is along the Pravara left bank canal, which is the main source of water for major use. The canal is 72 km in length and covers the taluka of Sangamneer, Rahata, Rahuri, Srirampur and Newasa of Ahmednagar district,(north latitudes 18°19’ and 19°59’ and east longitudes 73°37’ and 75 °32) of Maharashtra state. Pravara left bank and right bank canal originates from Ozar pickup weir, 42 km downstream of Bhandardhara dam across Pravara river. The study area falls in the semi arid region of western Maharashtra, and has average rainfall of 497 mm.

3. MATERIAL AND METHOD

Groundwater samples were collected in two conditions, Case 1. *When there is no flow in canal*, and Case 2. *When there is flow in canal*. 45 samples along the Pravara left bank canal covering 5 taluka of Ahmednagar district, was collected. All precaution were observed for sample collections. Standard methods as per (18) was adopted for Physico-chemical determination of parameters- pH, Electrical Conductivity (EC), sodium (Na^{+}), calcium (Ca^{2+}), magnesium (Mg^{2+}), carbonate (CO_3-), Bicarbonate (HCO_3-),Chloride (Cl^-), Sulphate (SO_4^{2-}), SAR, RSC, Potash (K),Phosphate ($PO_4^{3—}$) and Nitrate(NO_3^-)

Table 1: Case 1-No flow in canal

Sample No	pH	EC	Na^+	Ca^{2+}	Mg^{2+}	HCO_3-	Cl^-	SO_4^{2-}	SAR	RSC	K	PO_4^{-3}	$(NO_3^-$
		dS/m	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	meq/l	meq/l	mg/l	mg/l	mg/l
S1	7.43	1.11	123.05	88.97	59.52	402.6	0	393.36	2.47	0	1.56	1.80	2.05
S2	7.23	0.97	84.64	56.11	62.88	414.8	0	240.15	1.84	0	3.12	2.60	1.4
S3	7.64	6.3	93.38	87.37	138.72	793	0	338.61	1.44	0	2.73	1.75	0.45
S4	7.78	1.22	124.43	58.91	70.56	414.8	0	360.22	2.58	0	2.73	1.30	2.0
S5	7.57	0.86	128.8	58.91	73.2	317.2	3261.4	0	2.63	0	2.34	1.40	0.75
S6	7.64	0.63	198.03	69.73	59.04	268.4	2268.8	0	4.2	0	3.9	0.35	0.10
S7	7.47	1.07	123.05	91.38	94.8	488	3403.2	0	2.14	0	1.56	2.0	2.15
S8	8.68	1.77	112.47	68.93	51.84	146.4	0	494.70	2.48	0	1.95	0.40	2.25

S9	7.30	1.37	84.64	100.2	71.28	463.6	0	341.01	1.57	0	3.12	1.8	0.90
S10	7.52	0.71	112.7	55.71	71.52	366	2694.2	0	2.34	0	1.95	0.35	6.79
S11	7.43	0.91	128.34	99.39	66.24	427	0	435.15	2.43	0	0.78	1.45	1.3
S12	7.74	0.78	98.44	64.92	75.84	475.8	2268.8	0	1.96	0	5.46	0.45	2.15
S13	7.84	0.42	154.1	60.92	54.72	280.6	2836	0	3.44	0	1.17	1.75	1.2
S14	7.70	0.49	343.16	37.67	48	512.4	2552.4	0	8.7	0	5.46	0.40	1.15
S15	8.15	0.38	679.19	64.12	49.44	231.8	2410.6	0	15.44	0	7.8	1.45	1.6
S16	7.74	0.52	152.49	109.01	75.6	305	2552.4	0	2.73	0	1.56	0.20	2.25
S17	7.37	0.58	207.23	105.01	58.56	378.2	2410.6	0	4	0	5.46	1.3	3.25
S18	7.29	1.95	136.85	178.75	125.04	219.6	0	1043.2	1.91	0	1.56	0.15	0.125
S19	7.22	1.32	121.67	82.16	117.12	439.2	2694.2	0	2.01	0	1.95	1.5	1.1
S20	7.73	0.36	64.17	64.92	73.44	268.4	2552.4	0	1.29	0	7.02	0.20	0.05
S21	7.63	0.88	126.73	67.73	100.8	378.2	0	538.89	2.27	0	4.68	0.50	1.35
S22	7.90	0.85	72.91	69.33	51.36	231.8	2977.8	0	1.61	0	8.58	0.45	3.30
S23	7.93	0.64	57.73	44.88	79.2	341.6	2836	0	1.18	0	1.75	0.55	1.8
S24	7.76	0.49	62.1	58.11	66	305	2977.8	0	1.32	0	6.24	0.35	2.7
S25	7.62	0.92	42.32	68.13	45.12	366	3403.2	0	0.97	0	8.58	0.65	2.65
S26	7.40	2.42	48.76	151.50	81.36	500.2	0	404.41	0.79	0	6.63	0.65	0.60
S27	7.31	1.87	71.3	118.23	79.68	439.2	0	414.97	1.24	0	7.8	0.60	3.4
S28	8.02	0.64	45.31	36.87	49.44	341.6	2836	0	1.14	0	5.46	0.60	0.20
S29	7.70	0.85	192.97	101.40	47.28	341.6	3119.6	0	3.96	0	8.58	0.60	5.6
S30	7.47	1.28	51.75	113.82	87.12	390.4	0	429.38	0.88	0	5.85	0.55	1.3
S31	7.72	4.04	60.95	99.39	120.48	622.2	0	365.50	0.97	0	6.63	0.50	1.0
S32	7.73	2.81	142.14	58.11	113.28	683.2	0	352.54	2.49	0	0.78	0.025	1.2
S33	7.44	2.29	199.64	63.72	62.88	646.6	0	313.63	4.23	2.18	1.17	0.50	1.1
S34	7.55	1.78	712.31	28.05	59.76	683.2	2836	0	17.3	4.82	6.24	0.60	2.1
S35	7.99	0.47	471.5	44.08	88.08	1183.4	2977.8	0	9.38	9.86	5.07	0.50	3.6
S36	8.50	2.51	128.11	42.48	73.44	854	3261.4	0	2.74	5.76	3.9	0.025	5.7
S37	7.99	2.18	230.46	33.26	44.88	793	2268.8	0	6.1	7.6	1.95	0.30	4.75
S38	7.38	0.98	273.24	48.09	38.16	463.6	2552.4	0	7.11	2.02	1.56	0.10	0.50
S39	7.80	0.57	245.18	49.29	46.56	451.4	1134.4	0	5.99	1.06	1.56	0.40	1.45
S40	7.81	1.75	135.01	35.27	33.12	817.4	0	0	3.91	8.88	1.17	0.025	3.85
S41	7.5	2.1	263.35	50.1	42	631.35	2304.25	389.04	5.1	3.1	3.9	0.10	3.45
S42	7.7	1.68	225.4	70.14	52.56	463.6	1506.62	360.22	8.3	4.4	1.95	0.40	3.15
S43	7.45	1.45	241.5	78.15	91.2	719.8	1063.5	444.27	6.1	6.75	5.85	0.20	1.60
S44	7.30	0.92	331.2	128.25	54	896.7	999.69	0	5.5	0	4.29	0.50	0.90
S45	7.80	1.65	350.75	85.77	69.6	622.2	453.76	0	2.6	0	3.12	0.40	1.95

Table 2: Case-2 Flow in canal

Sample No	pH	EC	Na^+	Ca^{2+}	Mg^{2+}	HCO_3-	Cl^-	SO_4^{2-}	SAR	RSC	K	PO_4^{3-}	(NO_3^-)
		dS/m	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	meq/l	meq/l	mg/l	mg/l	mg/l
S1	7.45	1.2	117.3	83.36	56.52	410.05	63.81	381.83	2.1	0	1.56	1.63	1.85
S2	7.28	1.15	79.12	51.90	57.84	396.63	45.02	232.94	1.6	0	2.34	2.42	1.27
S3	7.60	6.48	106.03	79.15	147	771.90	38.99	322.76	1.38	0	3.9	1.66	0.41
S4	7.65	1.08	143.06	51.30	69.12	402.73	99.26	331.40	2.42	0	3.51	1.20	1.91
S5	7.48	0.8	142.14	55.71	69.84	307.54	2318.43	110.46	2.4	0	1.95	1.33	0.69
S6	7.54	0.58	207	64.12	55.32	263.60	1740.59	52.83	3.66	0	3.12	0.33	0.20
S7	7.45	0.98	134.55	87.77	93.00	475.95	2088.00	0	2.01	0	1.56	1.9	1.94
S8	8.56	1.5	117.99	70.14	47.4	153.16	81.53	420.26	2.25	0	2.34	0.39	2.02
S9	7.31	1.15	90.39	96.59	72.24	442.39	56.72	312.19	1.3	0	3.9	1.64	0.82
S10	7.49	0.6	109.25	49.89	65.04	352.69	2261.71	0	1.95	0	1.56	0.24	6.48
S11	7.5	0.84	112.7	92.78	65.4	418.59	42.54	408.25	2.1	0	1.17	1.32	1.18
S12	7.73	0.69	94.3	60.92	72.6	461.31	1971.02	68.68	1.45	0	4.68	0.43	1.90
S13	7.88	0.4	143.29	59.31	51.84	271.53	2365.22	19.21	3.18	0	0	1.61	1.01
S14	7.69	0.38	331.2	36.87	45.6	497.31	2070.28	31.21	8.52	0	6.63	0.28	1.03
S15	8.05	0.51	665.85	61.32	47.28	240.41	2006.47	24.01	13.9	0	7.02	1.32	1.46
S16	7.79	0.41	166.06	105.81	74.16	323.40	2367.35	0	2.51	0	0.78	0.19	2.10
S17	7.45	0.45	211.6	99.39	52.2	363.67	2178.40	0	3.74	0	5.85	1.12	3.05
S18	7.33	1.74	143.52	167.53	127.68	210.51	0	917.37	1.63	0	0.39	0.10	0.10
S19	7.25	1.38	123.74	79.15	114.96	426.52	2437.18	0	1.6	0	0.78	1.38	0.90
S20	7.74	0.3	70.84	62.12	71.16	241.03	2290.07	0	1.01	0	5.46	0.18	0.10
S21	7.7	0.76	118.91	58.91	97.8	361.84	63.81	513.92	1.94	0	3.9	0.46	1.24
S22	7.85	0.68	69.23	63.12	48.6	225.16	2538.22	55.234	1.37	0	7.02	0.41	3.07
S23	7.92	0.6	64.17	43.08	75	326.45	2309.56	36.02	1.07	0	0.975	0.40	1.65
S24	7.71	0.39	54.05	54.50	61.44	289.84	2399.96	0	1.18	0	5.46	0.30	2.60
S25	7.6	0.81	43.7	63.72	40.56	372.22	2736.74	0	0.88	0	5.85	0.50	2.50
S26	7.48	1.65	52.67	148.29	76.2	486.32	127.62	376.55	0.68	0	5.46	0.60	0.40
S27	7.37	1.85	75.9	113.22	77.28	430.19	0	391.44	1.12	0	4.68	0.55	3.18
S28	7.91	0.55	26.68	33.86	47.64	327.06	2417.69	0	1.01	0	3.9	0.55	0.15
S29	7.65	0.8	190.44	97.19	43.8	331.34	2247.53	38.42	3.67	0	9.75	0.52	5.15
S30	7.48	1.04	57.5	98.59	84	377.10	120.53	417.86	0.8	0	3.9	0.50	1.28
S31	7.7	3.85	66.01	95.19	117.84	606.54	205.61	367.42	0.88	0	5.46	0.40	0.85
S32	7.74	2.58	140.76	52.90	110.16	673.66	0	292.98	2.11	0	1.17	0.03	1.04
S33	7.5	2.15	194.35	61.12	60.12	660.85	63.81	297.78	4.32	1.8	1.404	0.45	0.92

S34	7.48	1.7	686.78	24.84	56.4	692.57	2630.39	124.87	16.54	4.6	3.9	0.55	1.87
S35	8.16	0.3	495.19	39.67	85.2	1159.38	2531.13	4.80	9	9.7	3.9	0.45	3.60
S36	8.29	2.35	123.28	37.07	75.36	860.38	3045.15	0	2.52	5.95	3.51	0.025	5.78
S37	8.06	2.1	234.6	28.25	42.24	804.24	1676.78	0	5.84	7.4	0.78	0.27	4.52
S38	7.45	0.73	264.5	45.69	36.12	450.32	2180.17	0	7.05	2	1.56	0.075	0.38
S39	7.78	0.6	239.2	49.89	47.64	436.90	1091.86	0	5.5	0.98	0.78	0.27	1.23
S40	7.84	1.6	137.54	29.25	35.76	797.53	159.52	24.01	3.62	8.65	0	0.02	3.75
S41	7.48	2.35	270.48	45.09	40.44	620.57	1846.94	381.35	4.85	3	3.51	0.08	3.21
S42	7.69	1.5	220.8	68.73	49.8	450.33	1418.00	348.21	8.04	4.15	1.17	0.37	2.9
S43	7.48	1.51	232.3	74.54	89.16	701.73	967.78	434.67	5.92	6.5	5.46	0.30	1.38
S44	7.51	0.74	327.75	123.24	51.84	883.57	854.34	0	5.11	0	3.51	0.46	0.74
S45	7.87	1.48	346.15	80.16	67.56	611.42	336.77	0	2.37	0	1.95	0.37	1.76

Table 3--Fertilizer consumption for 2010-2012(Metric Tonne)

Sr No	Fertilizer type	District average consumption	Total average consumption in study area	% of total average consumption in study area
1	16:20:20	78	36	46
2	20:0:13	28	24	86
3	19:19:19	87	69	79
4	20:20:13	376	80	21
5	Urea	81126	30788	38
6	DAP	28670	12356	43
7	Ammonium Sulphate	1752	1004.30	57
8	MOP	254	88	35
9	14:35:14	1164	390	34
10	16:16:16	761	489	64
11	10:26:26	11493	5225	45
12	23:23:0	5723	2609	46
13	15:15:15	9354	3369	36
14	12:32:16	24773	10617	43
15	CAN	326	199	61
16	20:20:0	14465	5529	38
17	SOP	28	24	86

(Source: District Zilla Prashid: Ahmednagar)

4. RESULTS AND DISCUSSION:

The results of physico chemical analysis of the water samples are presented through table Table1 and Table 2. Average Fertilizer consumption in the taluka under study and the district as a whole is presented in table 3.The table show that the study area contribute to 57% of Ammonium sulphate , 45% of 10:26:26, 43% of 12:32:16,38% of Urea and 20:20:0 consumption, of the total average consumption of the entire district. Urea, DAP, 10:26:26, Ammonium sulphate, 12:32:16, 20:20:0 are the most widely used fertilizer in the study area.

4.1 pH: The acidic or alkaline nature of water is represented by its pH and is an important parameter in terms of water quality. A maximum value pH of 8.68 and minimum value of 7.22 was observed for the water samples in case

1(no flow in the canal), and maximum value of 8.56 (Umbargaon) and minimum values of 7.25 was observed for the water samples in case 2 (flow in the canal). 98% of all the samples are in both case within the BIS &WHO limits for groundwater (19) except the sample at station No8. None of the sample had pH less than 6.5.

4.2 EC: The capacity to conduct electric current is expressed in terms of Electric conductivity and is measure of inorganic dissolved solids, ions carrying positive & negative charges. It also depends on the temperature of water.EC is an effective tool to classify water into good, medium, bad and very bad category. During the study the EC of water varied between 6.30 ms/cm(6300µmho/cm) to 0.36 ms/cm (360µmho/cm) for case 1 and 6.48ms/cm(6480µmho/cm) to 0.30 ms/cm (300µmho/cm) for case 2.About 67% and 29% of sample in both case fell within acceptable and maximum permissible limit respectively. In general majority of water sample varied between good to medium quality. (19&20),

4.3 Calcium & Magnesium: Natural water acquires hardness due to presence of Calcium and Magnesium. These enter water by leaching of sources like limestone, marble, calcite, magnasite, dolomite etc.(21)The concentration of calcium varied between 8.92 meq/l(178.75 mg/l) to 1.40 meq/l(28.05 mg/l) for case 1 and for case2 varied between 8.36 meq/l(167.53 mg/l) to 1.24 meq/l(24.84 mg/l).69%and 31% of samples in case 1 and 62%&38% of sample in case were under acceptable and permissible limit.((19&22). The concentration of Magnesium varied between 11.56 meq/l(140.45 mg/l) to 3.18 meq/l(38.63 mg/l)for case1 and between 12.25 meq/l(148.83 mg/l) to 3.0 meq/l(36.45 mg/l) for case 2.All samples were above acceptable limit of 30mg/l. 91% of sample were within the permissible limits of BIS & WHO standards((19& 23). The magnesium concentration was above maximum permissible limit (100mg/l) in6 samples in case 1and 5 samples in case 2.The study region is dominated by amygdaloidal basalt and presence of Anorthite may be responsible for the Ca& Mg in groundwater in the region.

4.4 Carbonate and Bicarbonate: Carbonate minerals in nature like limestone, magnasite, dolomite etc results in the presence of carbonate and bicarbonate in groundwater and affects the pH of water. Presence of limestone as geological formation contributes to carbonates leading to increase in hardness and alkalinity. Carbonate concentration was found negligible 0.00 mg/l in all the sample in both cases. Bicarbonate concentration varies between 19.4 meq/l(1183.78mg/l) to2.40(146.44 mg/l) for case1 and 19meq/l(1159.57 mg/l) to2.51(153.16mg/l) in case 2. All samples were found to be above permissible limits of 120mg/l.((19& 22).

4.5 Sodium and potassium:
Sodium is found in water due to weathering, extraction of geological formation, like feldspar. Potassium in groundwater results due to Fertilizer leaching, sewage disposal through soil.The sample analysis showed sodium concentration varies between 30.97 meq/l(712.3 mg/l) to1.84 meq/l(42.32mg/l) in case 1 and 29.86 meq/l(686.78 mg/l) to1.16meq/l(26.68mg/l) in case 2. Sodium concentration at 13 samples in case 1 and 14 samples in case 2, were observed to be above permissible limits(200mg/l ,WHO). Potassium concentration varied between0.22 meq/l(8.58 mg/l) to0.02 meq/l(0.78mg/l) in case 1 and 0.25 meq/l(9.75 mg/l) to0.01 meq/l(0.39mg/l) in case 2.All samples had potassiumconcentration below the specified limit.(22&23).

4.6 Chloride: Various natural activities like weathering, leaching leads to accumulation of chloride in groundwater. Chloride values varied between 96.00meq/l (3403.20mg/l) to 12.8meq/l (453.76mg/l) for case 1. In case 2, the value varied between 78.90meq/l (2797mg/l) to 3.27meq/l (115.92 mg/l).27 (60%) of sample samples in case1, were found to have high chloride concentration above permissible limit (1000mg/l,) only 2 samples were found to be within permissible limit (250mg/l).16 sampling stations showed zero concentration.26 (58%) samples in case2, was found to have very high chloride concentration of 1000mg/l, (19), 13(29%) samples were found to within acceptable limits (250mg/l). Three samples showed zero concentration.

4.7 Sulphate: Sulphate in groundwater results due to oxidation of sulphate ore, waste from, industries Groundwater sample analysis showed sulphate to have a maximum value of 21.72 meq/l . (1043.21mg/l)to minimum value of 5meq/l(240.1mg/l) in case1 and maximum value of 19.1 meq/l(917.37.64mg/l) to a minimum value of 0.1meq/l(4.83mg/l) in case 2.10 samples were within permissible limit(200 mg/l),8 samples were above maximum permissible limit(400mg/l) and 27 samples had zero concentration in case 1, and 12 sample each were within acceptable and maximum permissible ,15 sample were observed to have zero concentration.(19)

4.8 SAR & RSC: The permeability of soil is affected by the sodium concentration in soil which due to process of deflocculation of ingredients of soil resulting in clogging of soil pores leading to reduced movement of water, affecting the calcium and magnesium concentration .SAR measures comparative concentration of sodium with calcium and magnesium concentration and express the suitability of water for use. During the study SAR values for case 1 varied between 17.34 meq/l to 0.79meq/l and were between 16.54meq/l to 0.68 meq/l in case 2.SAR values in 43 samples were observed to have value less than 10meq/l and 2 samples between 10-18meq/l for both cases, indicating that majority of water sample were good and only 2 samples was of medium quality.(20 &24).RSC is another tool for measuring sodium risk to the soil. For all values above zero, sodium risk in soil increases as water appends more carbonate than divalent cations. During study maximum value of 9.86 meq/l and minimum 0.00meq/l for case1 and maximum of 9.70meq/l, and minimum of 0.00meq/l was observed.(20&24)

4.9 Phosphate: The process of weathering of rocks results in the release of phosphorus in the form of water soluble phosphate ions(26**)**. During the study, the phosphate varied between 2.60 mg/l to 0.025 mg/l for case 1 and for case 2, Phosphate varied between 16.48 mg/l to 0.47 mg/l. Only 4samples in case 1 and 6 samples in case 2 were in acceptable limit (23) (<12 mg/l), and 87% and 91% in case 1 and 2 were above maximum permissible limit (12 mg/l).

4.10 Nitrate: The concentration of Nitrate varied between 6.79 mg/l to 0.05 mg/l for case1 and 9.75 mg/l to 0.39 mg/l for case 2.All samples were well within the prescribed limits of 45mg/l.(19)

Table 4: Case 1-Correlation Matrix

	pH	EC	Na^+	Ca^{2+}	Mg^{2+}	HCO_3-	Cl^-	SO_4^{2-}	SAR	RSC	K	PO_4^{3-}	NO_3^-
pH	1												
EC	-0.0012	1											
Na^+	0.110	-0.140	1										
Ca^{2+}	-0.473	0.171	-0.262	1									
Mg^{2+}	-0.229	**0.532**	-0.258	0.430	1								
HCO_3-	0.008	0.421	0.327	-0.202	0.136	1							
Cl^-	0.246	-0.460	0.213	-0.417	-0.311	-0.102	1						
SO_4^{2-}	-0.254	0.407	-0.247	**0.547**	0.462	-0.102	**-0.740**	1					
SAR	0.132	-0.150	**0.949**	-0.363	-0.339	0.273	0.255	-0.240	1				
RSC	0.243	0.109	0.374	-0.419	-0.185	**0.710**	0.109	-0.115	0.448	1			
K	0.049	-0.116	0.112	0.104	-0.097	-0.096	0.252	-0.157	0.109	-0.093	1		
PO_4^{3-}	-0.313	-0.007	-0.078	0.121	0.135	-0.185	-0.106	0.010	-0.094	-0.348	-0.149	1	
NO_3^-	0.296	-0.068	0.054	-0.249	-0.298	0.215	0.318	0.269	-0.084	0.411	0.111	-0.230	1

Table 5: Case 2- Correlation Matrix

	pH	EC	Na^+	Ca^{2+}	Mg^{2+}	HCO_3-	Cl^-	SO_4^{2-}	SAR	RSC	K	PO_4^{3-}	NO_3^-
pH	1												
EC	-0.042	1											
Na^+	0.153	-0.104	1										
Ca^{2+}	-0.415	0.102	-0.240	1									
Mg^{2+}	-0.219	**0.562**	-0.231	0.401	1								
HCO_3-	0.124	0.418	0.356	-0.219	0.151	1							
Cl^-	0.230	-0.425	0.228	-0.418	-0.329	-0.077	1						
SO_4^{2-}	-0.286	0.387	-0.209	**0.501**	0.460	-0.109	**-0.724**	1					
SAR	0.141	-0.113	**0.936**	-0.355	-0.334	0.307	0.282	-0.192	1				
RSC	0.321	0.109	0.380	-0.429	-0.156	**0.717**	0.150	-0.111	0.459	1			
K	0.021	-0.062	0.107	0.100	-0.103	-0.095	0.212	-0.096	0.104	0.157	1		
PO_4^{3-}	-0.346	0.059	-0.074	0.127	0.149	-0.174	-0.165	0.036	-0.105	0.328	-0.062	1	
NO_3^-	0.306	-0.056	0.053	-0.272	-0.296	0.238	0.328	-0.284	0.079	0.436	0.113	0.248	1

5. STATISTICAL ANALYSIS:

Correlation analysis between the various parameter is conducted. The interrelation between parameter was estimated using Pearson correlation analysis. A strong relation exist for correlation coefficient (near +1 or -1),. A zero value represents no relationship between the parameters with a considerable level of 0.05%. Strong correlation exist for r > 0.7,modrate between 0.5 to 0.7(11 &25). Strong positive correlation was observed in case1, between Sodium and SAR (0.94), Bicarbonate with RSC (0.71), Chloride had a strong negative correlation with Sulphate (-0.74). Moderate correlation existed between EC &Magnesium(0.56),Calcium with sulphate (0.50).In case 2,strong positive correlation was observed between Sodium with SAR(0.93),Bicarbonate with RSC(0.71),Chloride had a negative correlation with Sulphate(-0.72). Moderate correlation existed between EC &Magnesium (0.56), Calcium with sulphate (0.50).The high level of RSC, bicarbonate, chloride, present in groundwater is due to presence of sodium and calcium bicarbonates, calcium and magnesium chlorides

6. CONCLUSION:

Groundwater caters to major water requirement in rural area of the country. The degradation of groundwater quality results from natural and anthropogenic activity making groundwater unfit for human consumption at many places. Agriculture activity contributes to groundwater contamination. Studies carried out reveal that groundwater quality in the study area vary from moderate to good, in both cases under study. pH, EC, were within acceptable limits for drinking water, and Ca, Mg, Po_4^{-3},$S0_4^{-}$,were within maximum permissible limits of WHO& IS10500-2012. The SAR, value represented good quality water for irrigation, however higher Bicarbonates and chlorides, RSC restricts the use and needs treatment for agriculture purpose. No standard limits have been stipulated by BIS for Phosphate, but WHO recommends 0.1mg/l. About 87% of the sample showed concentration above 01mg/l, overuse of organic fertilizers, waste disposal in the region may have lead to leaching of phosphate constituents into groundwater. Water quality is not much affected by Nitrates.

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