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Geomedical health hazard due to groundwater quality from Anjani - Jhiri River Basin, Northern Maharashtra, India

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Abstract

Two basins was chosen for hydrogeochemical analysis there is Anjani - Jhiri, which is tributary of Girna River, Girna river is one of the major tributary of Tapi River in Maharashtra state, India. According to quality and suitability of groundwater, 27 groundwater samples collected from Anjani and 13 groundwater samples from Jhiri river basins were studied. Major ion chemistry results reveals that the concentration of Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, F^{-}, Cl^{-}, HCO_3^{-}, SO_4^{2-} and NO_3^{-} from groundwater samples get affected by lithology and anthropogenic influences. Groundwater geochemistry results shows that the ($Ca^{2+}$and Mg^{2+}) exceeds than (Na^{+} and K^{+}), (HCO_3^{-}) exceeds (Cl^{-}, SO_4^{2-} and NO_3). In order to trace elements Zn, Fe, Ni, Mn and Cu concentrations were lower, Pb and Cd concentrations were relatively higher than recommended guidelines of WHO and BIS. Assessment of groundwater quality based on graphical representations, piper plot reveals that the groundwater is Ca-Cl-HCO_3 type. Based on the Wilcox diagram groundwater samples falls in C4S1 category, indicates high salinity hazards.

Keywords: Geomedical health hazards, toxic elements, groundwater, Anjani - Jhiri river basin, Maharashtra, India.

Introduction

Groundwater is one of the chief sources for fresh water supply to drinking and agricultural purposes. In recent years, there has been tremendous demand for intensive agricultural activities and population growth[1]. Groundwater studies are gaining more importance all purposes such as household, industrial and agricultural activities in various parts of the world[2]. Improper management of this replenishable resource may lead to groundwater contamination and scarcity. Thus the estimation of groundwater quality is an important for assessment and investigation associated human health hazard. According WHO about 30 percentage diseases due to only caused by intake of polluted water therefore, supply of drinking water should be better quality[3]. The groundwater pollutant can be adversely affected on human health even they are trace amount in groundwater. The main aims of present study to assess the suitability of drinking water according to Bureau of Indian standards guidelines.

Location: Total area under study is about 1245 Km^2 out of Anjani river basin cover an area about 911.71 km^2 and Jhiri river basin 331.94 km^2. Location map of Anjani - Jhiri river basin has shown in figure 1. Study area belongs to survey of India toposheet number 46 O/4, 46 O/8, 46 P/5 and 46 P/1. The study area falls under semi arid climatic zone.

Geology: Geologically study area covered by Deccan Volcanic Basalts which is cretaceous to lower Eocene age and quaternary alluvium covers along the gullies and both banks of river [4]. Geological map of study area has shown in figure 2. The different types of basaltic varieties are occurred viz. amygdaloidal, vesicular, porphyritic, weathered and fractured basalts. The highly weathered basalts exposures are observed in northern, South Eastern and North Eastern part of study area. Massive or porphyritic basalts along with some zeolitic cavities are observed in Southern part. Northern part of study area covered by thick alluvium which is parallel band of silt and clay. Soils are occurred mainly black cotton type, which is the resultant of the weathering of these rocks, which play a significant role in geomorhological units.

Hydrogeology of the study area: The depth of water level in the area under study in open wells ranges from 5 to 10m at Deccan trap and alluvium area their depth was observed up to 30 to 50 meter. Fluctuation of water table varies from 1.5 to 11m. In Alluvium areas water level fluctuation is less as compared to massive basaltic dug/bore wells.

Material and Methods

40 groundwater samples were collected from Anjani - Jhiri basin in pre- monsoon period 2012 (May –June). Sampling locations were presented in table 1. Hydrogeochemical analysis is carried out followed by standard techniques and procedures[5]. pH, conductivity and total dissolved solids are analysed on digital water analysis field kit. Na^{+} and K^{+} level in water samples were analysed by using emission flame photometer. Ca^{2+} and Mg^{2+} were determined by EDTA titrimetric method. HCO_3^{-} and CO_3^{2-} were determined using titration with HCl. Cl^{-}

was titrated by silver nitrate, while SO_4^{2-} was obtained using the gravimetric method.

Fluoride was analysed by spectrophotometric method using SPANDS and acid Zirconium Oxy chloride solution (Spectrophotometer for use at 570 nm). Boron was analysed by spectrophotometric method using Curcumin solution (Spectrophotometer for use at 540 nm). Nitrate in water samples analysed by spectrophotometric method using brucine sulphate solution (Spectrophotometer for use at 540 nm). Cd, Cu, Fe, Pb, Mn, Ni and Zn analysed by double beam Atomic Absorption Spectroscopy. The obtained data of hydrogeochemical analysis compared with recommended guidelines for drinking water standards as per Bureau of Indian Standards[6]. Statistical analyses of data by using Microsoft Excel, Toolpak VBA. Spatial variation map prepared by using Surfer software. A Piper diagram (Piper, 1944), Durov diagram (Durov, 1948) and Wilcox diagram (Richards, 1954) drawn using the Aquachem geoscientific software[7,8,9].

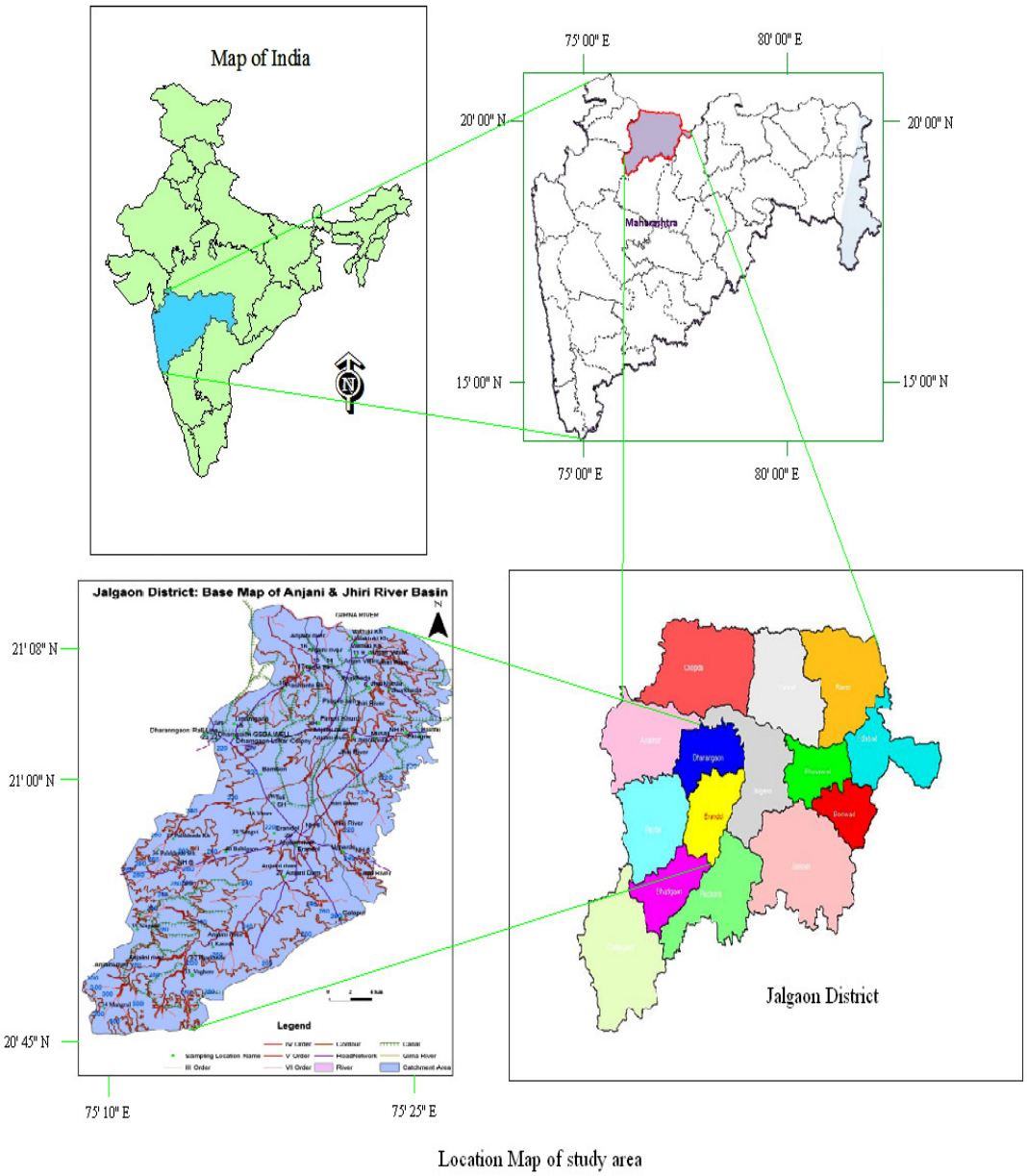

Figure-1
Location map of Anjani – Jhiri river basin Jalgaon district, India

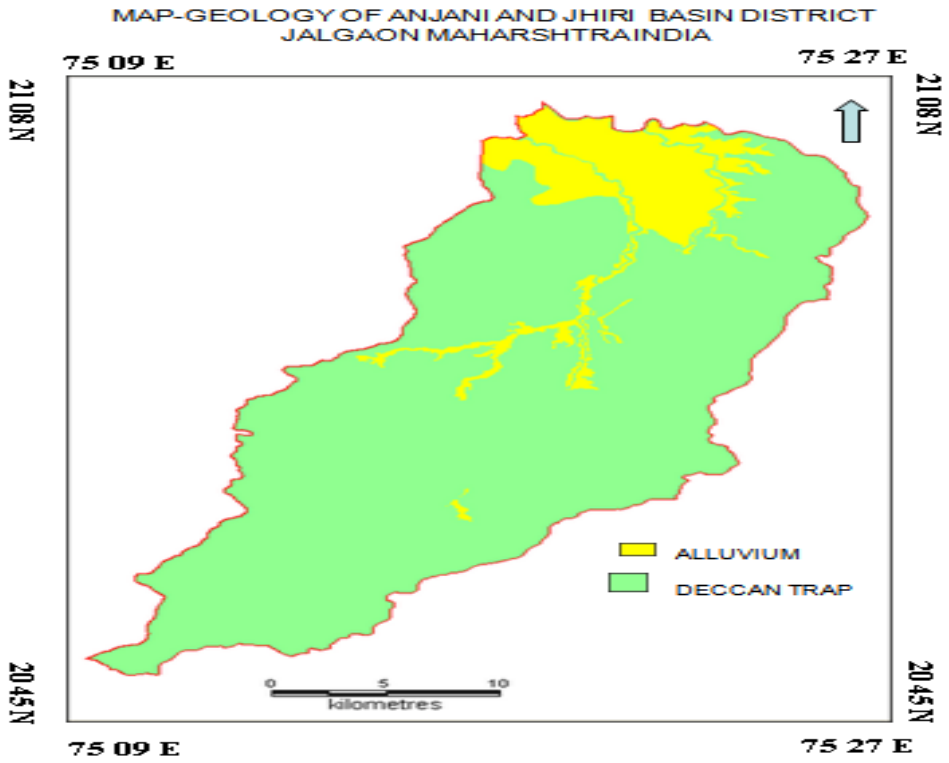

Figure-2
Geological map of Anjani - Jhiri River Basin Jalgaon District, India

Results and Discussion

Physicochemical parameters: Analytical results of physicochemical parameters were presented in table 2. pH values was observed within the range of 6.4 to 8.0; with an average value is 7.3 which is indicate water having alkaline nature. EC in analysed groundwater samples was observed varies from 323 to 3,776 µmohs/cm; with an average value was 1,451 µs/cm, whereas WHO limit is 1400 µs/cm. Electrical conductivity value is increasing towards the downstream of catchment and deep aquifer as compared to upstream and shallow aquifer respectively. The TDS concentrations was observed ranges from 2,010 to 2,445 ppm with an average concentration of TDS is 938.9 ppm, whereas BIS limit is 500 ppm indicates that the 90% groundwater samples beyond the permissible limit as per drinking water standards.

Cations Chemistry: Dominance of cation in study area is as follows $Ca^{++} > Na^{+} > Mg^{++} > K^{+}$. Ca^{++} range was observed varies from 12 to 296 ppm with an average 75.9 ppm, whereas BIS limit is 75 ppm. Ca^{++} suggests that the majority of groundwater samples are beyond its permissible limit prescribed by BIS standards. Mg^{++} concentration was observed range from 4.0 ppm to 49 ppm with an average 21.1 ppm suggests that majority of samples from the area under study within the limits. Na^{+} was observed ranges from 12.8 to 31.6 ppm with an average 19.7 ppm; suggests that the Na^{++} Concentration is good for all water samples. K^{+} level groundwater from the study area was observed ranged from 0.4 to 6.7 ppm with an average level is 2.2 ppm; suggests that the majority of samples inside the permissible limits according to Bureau of Indian standards.

Anion Chemistry: Dominance of anion in the groundwater from study area is as follows $HCO_3^{-} > Cl^{-} > SO_4^{2-} > CO3^{-2}$. Bicarbonate is a most dominant anion in the ground water from the area under study. Bicarbonate as well as carbonate represents the major sum of alkalinity. The higher concentration of bicarbonate with respect to chloride suggests the strong chemical weathering taking place in the area. The chloride level in analysed water samples was observed varies from 16.0 to 598 ppm with an average 194.3 ppm. Chloride concentration is suitable for human consumption because of 80 % water samples within the desirable limit of drinking water standards (250 ppm Cl^{-}). The concentration of sulphate in all analysed water samples are observed within the desirable limit according to Bureau of Indian standards (200 ppm SO_4^{2-}). The carbonate concentration in all groundwater samples was negligible. The source of bicarbonate into natural water may be cause of carbonate containing minerals and combination of CO2 with rainwater [10].

Table-1
Sampling locations

Sample ID	Latitude in decimal	Longitude in Decimal	DWL	Altitude	Village
1	21.01	75.41	20	199.9	Eklangne
2	21.01	75.39	13	194.4	Musai
3	21.02	75.37	17.5	189.2	Chinchpura
4	21.04	75.36	21	188.3	Pimple sim
5	21.05	75.37	41	185.9	Pimri khurd
6	21.06	75.38	33	186.2	Jurkheda
7	21.06	75.4	29.5	180.1	Jurkheda
8	21.06	75.4	11.5	180.1	Jurkheda
9	21.09	75.39	22	178.6	Anjan vihire
10	21.09	75.39	*	173.7	Anjan vihire
11	21.09	75.37	27	178.3	Vaktuki
12	21.09	75.37	*	176.1	Vaktuki
13	21.09	75.37	*	176.1	Vaktuki
14	21.07	75.37	24	180.7	Sonwad
15	21.08	75.35	*	172.2	Sonwad
16	21.09	75.33	17.5	170	Ahire BK
17	21.07	75.33	13.5	176.1	Tarde BK
18	21.06	75.32	13.5	185.3	Pashtane BK
19	21.03	75.28	11.5	203.9	Dharangaon
20	21.02	75.45	18.5	210.3	Paldhi
21	20.91	75.37	*	232.2	Umarde
22	20.86	75.36	7	216.9	Dharngaon
23	20.91	75.32	10	212.6	Dharngaon Rail line
24	20.9	75.33	*	211.8	Lohar colony
25	20.94	75.32	13	222	Bambhori
26	20.83	75.38	10.5	218.9	Toli
27	21.01	75.27	*	232.4	Anjani dam
28	21.01	75.26	11	220.6	Erandol
29	21.01	75.28	12.5	224.6	Erandol
30	20.99	75.29	11.9	238.2	Galapur
31	20.86	75.3	3.5	259.5	Kasoda
32	20.82	75.26	4.5	257.4	Pharkande
33	20.8	75.23	4.2	282.8	Vaghera
34	20.79	75.16	3.8	288	Mangrul
35	20.86	75.21	4.4	280	Nagaon
36	20.9	75.24	4.2	236	Palskhede Bk
37	20.92	75.22	3.8	238	Palskhede Kh
38	20.93	75.29	3.6	260	Vitner
39	20.91	75.28	5.2	262	Sangvi
40	20.89	75.26	3.9	246	Babalgaon

*indicates Tube/Bore well water, DWL – Depth of water level in meter

Table-2
Analytical results of physico-chemical parameters and trace elements in groundwater from Anjani and Jhiri river Basin, Maharashtra (India)

Sample ID	PH	EC	TDS	TH	TA	Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO_3^{-2}	HCO_3^{-}	Cl^{-}	SO_4^{2-}	PO_4	NO_3^{-}	B	F
1	6.8	1050	685	360	306	95	15.9	14.4	2.2	36	320	125	33	44	8.8	0.8	0.8
2	7	1143	745	386	310	55	16.2	15.4	2.9	32	325	166	58	36	3.6	0.6	0.4
3	7.1	3194	2075	932	275	176	21	16.5	1.4	00	335	598	130	88	5.4	0.8	0.3
4	6.5	3776	2445	887	516	166	21.2	19.3	2	36	580	473	115	8	8	0.9	0.4
5	7.1	1430	930	279	510	32	15	18.4	0.9	24	570	146	18	12	1.2	1.2	0.7
6	7.5	2011	1305	434	444	85	17.3	20.1	1	36	520	215	65	8	1.2	0.6	0.5
7	6.8	323	210	115	116	45	11.4	12.9	6.7	00	150	20	24	4	9.8	0.6	0.6
8	6.9	1151	750	366	226	88	13.8	16.8	1.8	24	290	100	32	26	10.4	0.9	0.3
9	7	1566	1020	395	522	62	15.4	18.2	2.2	42	615	140	65	44	10.8	0.6	0.3
10	7.2	2760	1790	405	604	84	15.9	22.6	2.6	36	745	285	129	2.5	10.2	0.8	0.5
11	7.4	1572	1025	193	789	24	13.2	21.6	1.3	60	840	76	12	45	9.7	0.6	0.4
12	7.4	3589	2335	521	801	48	18.2	20.9	1.4	40	935	326	97	66	9.9	0.6	0.3
13	7.3	1797	1165	164	776	26	12.8	18.7	1.6	40	875	130	24	16	8.2	0.8	0.7
14	7.8	1309	850	144	616	16	12.9	22.6	0.8	36	675	84	16	88	0.8	0.8	1.4
15	7.5	1746	1134	472	424	78	17.2	16.4	1.6	32	520	236	64	44	1.2	0.6	1.2
16	7.2	1341	870	366	388	84	16.3	19.4	1.2	24	440	166	53	56	10.8	0.6	0.7
17	7.4	1385	900	376	324	82	16.2	22.6	1.2	36	420	208	51	38	9.8	0.7	0.7
18	7.8	3165	2057	926	468	116	21.3	20.4	1.4	24	560	521	122	48	3.2	0.9	1.2
19	6.8	1700	1140	1240	280	276	14	14.8	0.4	14	320	290	150	8	6.9	0.7	1.3
20	6.6	639	415	194	166	54	16.7	18.4	1.3	36	160	16	40	11	1.8	0.6	1.6
21	6.4	591	385	154	198	18	13.7	16.8	4.6	90	135	90	37	46	1.2	1.2	1.7
22	7.6	998	648	235	589	32	18.2	19.4	3.2	36	835	192	50	3.5	26.8	1.6	1.7
23	7.8	430	280	285	434	36	37.6	24.6	4.2	32	555	84	59	2.6	12.3	1.3	1.7
24	7.1	905	588	574	266	88	14.7	22.6	2.8	36	365	220	21	1.8	9.2	0.6	0.3
25	7.3	615	400	409	214	54	19.7	26.4	2.6	30	270	188	38	1.6	54	0.6	0.9
26	6.8	921	598	421	346	76.9	24.3	28.2	2.7	32	320	229	44	1.2	16.8	0.6	0.7
27	7.1	1572	1021	975	401	88	22	31.6	2.6	60	440	425	45	1.8	22.4	0.9	0.5
28	7.8	803	521	1266	284	296	23.2	20.8	1.9	32	358	294	24	1.2	25.5	0.3	0.3
29	7.6	2884	1874	290	276	102	32.5	16.4	2.2	24	332	87	32	1.6	17.2	0.9	1.1
30	6.9	1686	1095	185	436	31.4	46.9	12.8	2.8	36	520	124	46	2.8	14.6	1.3	1.3
31	7.3	505	326	170	400	21	29	14	1.7	60	280	70	26	1.1	1.9	0.3	0.6
32	7.2	396	346	174	326	27	23	18	2.3	28	276	42	40	1.2	2.2	0.6	0.7
33	7.8	812	512	202	554	44	19	22	2.9	26	500	89	30	0.9	3.8	0.8	0.6
34	7	2045	1248	491	212	192	4	24	1.4	00	201	500	26	0.4	1.2	0.8	0.4
35	7.5	1036	639	394	666	78	49	22	2.7	18	526	172	12	0.6	1.4	0.5	0.7
36	7.6	2012	1238	274	978	26	47	26	1.2	30	871	260	18	1.2	0.9	0.6	0.9
37	8	955	578	102	776	15	11	22	1.9	12	701	80	22	0.8	1.2	0.8	0.9
38	7.9	790	497	292	437	47	29	18	1.2	16	406	140	23	1.8	0.8	0.8	0.6
39	7.7	560	336	356	587	58	36	13	1.8	30	514	20	12	1.6	0.9	0.6	0.3
40	7.9	900	578	132	497	12	21	17	5.6	30	426	145	36	1.2	0.8	0.5	1.1
Maximum	8	3776	2445	1266	978	296	49	31.6	6.7	90	935	598	150	88	54	1.6	1.7
Minimum	6.4	323	210	102	116	12	4	12.8	0.4	00	135	16	12	0.4	0.8	0.3	0.3
Mean	7.3	1451.6	938.9	413.4	443.5	75.9	21.1	19.7	2.2	31.7	475.7	194.3	48.5	19.2	8.7	0.8	0.8
Median	7.3	1230	800	363	429	56.5	17.8	19.4	1.9	32	440	156	37.5	3.8	7.5	0.7	0.7
STDEV	0.41	897.79	580.83	296.8	199.49	64.88	10.17	4.26	1.27	16.59	211.33	143.12	35.86	25.17	10.1	0.26	0.43
BIS limit	6.5/8.5	1400	500	300	200	75	30	NA	10	NA	NA	250	200	NA	45	1	1.5

All parameters given in ppm, except pH and EC in µs/cm, BIS - Bureau of Indian Standards

NO_3^- : Nitrate concentration in few groundwater samples falls above the desirable limits of bureau of Indian standards (45 ppm) they may be cause of unnecessary use of nitrogenous fertilisers. NO_3^- concentration is higher in downstream of catchment may be cause of excessive use of nitrogenous fertilizers. Line plot of use of chemical fertilizers in last seven year's in Jalgaon district has shown in figure 3. Nitrate is not directly toxic to humans but high concentration of nitrate in drinking water is injurious to human, predominantly for infants less than 1 year old. Unnecessary consumption of nitrate in drinking water by pregnant women has been associated with the risk of methaemoglobinaemia or blue baby syndrome in new born babies. Some researchers have found that higher levels of nitrate in drinking water is harmful to human and animals; they are also can cause methemoglobinemia and abortions in cattle and concentrations between 40 ppm and 100 ppm of nitrate are considered harmful. NO_3^- level in the groundwater samples from the area under study were observed varies from 0.8 ppm to 54 ppm with an average concentration is 8.7 ppm, whereas BIS limit is 45 ppm. Spatially, NO_3^- concentration higher in central and north-western parts than, southern part of study area (figure 4).

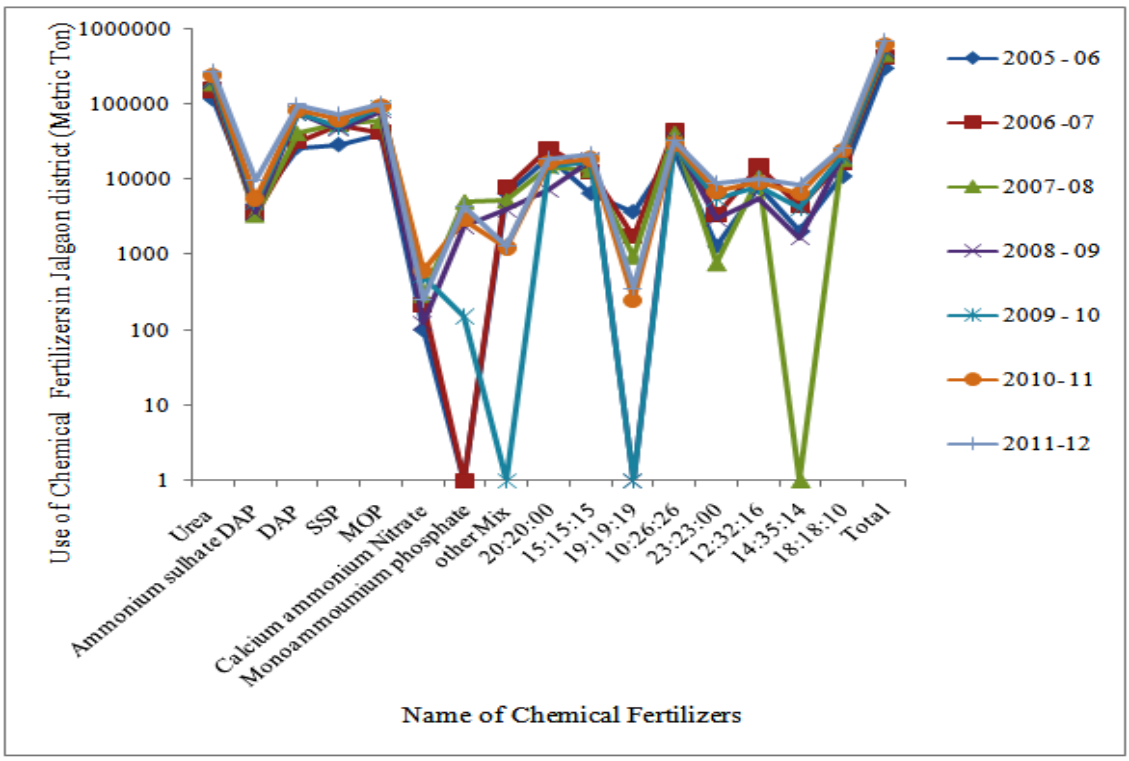

Figure-3
Line plot of utilization of chemical fertilizer [Source: Maharashtra Agricultural Department]

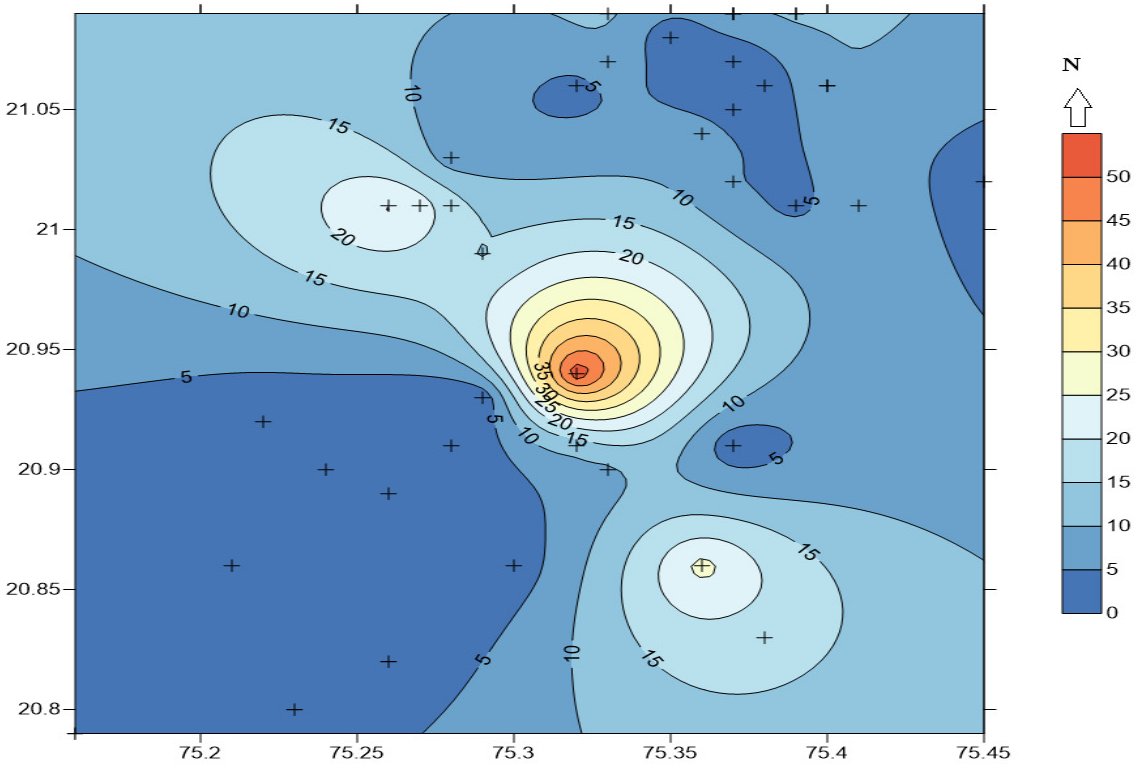

Figure-4
Spatial variation of NO_3

Fluoride ion: A strong negative correlation between Ca and F in the groundwater that contents Ca in excess of that required for the solubility of fluoride minerals has been earlier reported[11]. The fluoride level also depends on the level of groundwater; whereas the shallow dug wells have lower fluoride concentrations due to leaching and less residence times, the water-rock interaction in the deep bore holes have more concentration due to longer residence times[12]. The Ca^{++} levels are lower than those of Na^{+}, they may be indicate the higher level of F^{-} content in groundwater. Fluoride levels in groundwater from the study area were observed ranged from 0.3 ppm to 1.7 ppm with an average concentration is 0.8 ppm, where BIS limit is 1.5 ppm. Spatially, F concentration trend shows higher in north western part than the southern part of study area due presence of thick alluvium and deep aquifers (figure 5).

Toxic trace elements: Analytical results of the trace elements were presented in table 3. Cu, Fe, Mn, Ni and Zn elements was observed within the acceptable limit according to drinking water standards; however cadmium and lead beyond the limits.

Cadmium: A cadmium concentration in all water samples was observed beyond the desirable limits (BIS, 2003). Phosphate fertilizers are one of the major sources of cadmium pollution in the study area, Jalgaon district having 3rd rank for use of chemical fertilizers in India. Utilization of chemical fertilizer in agricultural sector of Jalgaon district has shown in figure 6. The data suggest that the total use of chemical fertilizer increases in last few years; in 2005-06 utilization is about 3, 02,560 M ton while 2011-12 increases up to 6, 88,112 M Tons[13]. Another source of cadmium pollution is wastage of electric batteries, electronic components[14]. The Cadmium concentration in groundwater was observed varies from BDL to 1.56 ppm. With an average concentration 0.158 ppm whereas as desirable limit is 0.01 ppm as per recommended guidelines by BIS. Spatial variability map (figure 6) shows that the cadmium concentration higher in groundwater samples from urban area as compared to other areas.

Lead: Lead concentration in the most of water samples beyond the permissible limits recommended by BIS. The source of lead in aquatic system from motor vehicle fumes and from decomposition of lead pipes[15]. Low pH and low alkalinity waters can contain higher concentrations of lead[16]. Long term exposure of lead can affect harmfully to nervous system and kidney[17]. Lead concentration in groundwater from the area under study was observed varies from BDL to 0.78 ppm. Average concentration of Pb is 0.34 ppm, whereas desirable limit is 0.05 ppm as recommended guidelines by BIS. Spatial variability map (figure 7) shows that the lead concentration higher in alluvial aquifer (north-eastern part of study area) as compared to basaltic aquifer (South and Western part).

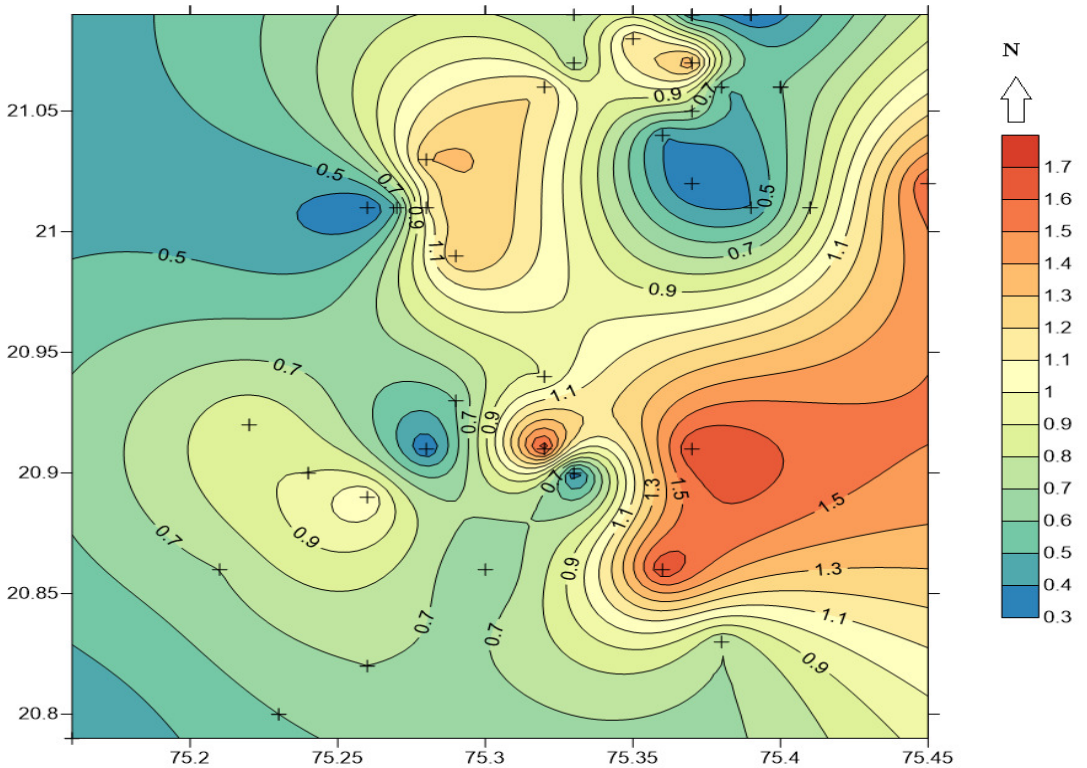

Figure-5
Spatial variation of fluoride

Table-3
Analytical results of the trace elements from groundwater samples All parameters are expressed in ppm

Sample ID	Cd	Cu	Fe	Mn	Ni	Pb	Zn
1	0.007	0.045	0.745	0.046	00	0.677	0.045
2	0.075	0.081	0.006	0.043	0.007	0.355	0.054
3	0.011	0.078	0.215	0.047	00	0.544	0.043
4	0.014	0.098	0.024	0.058	0.055	0.655	0.067
5	0.021	0.047	0.311	0.055	0.009	0.567	00
6	0.026	0.875	0.075	0.065	0.076	0.423	0.053
7	0.035	0.235	0.006	0.064	00	0.544	0.056
8	0.006	0.099	0.035	0.054	0.066	00	0.043
9	0.068	0.344	0.065	0.057	00	0.544	0.065
10	0.077	0.055	0.074	0.088	0.008	0.545	0.044
11	0.005	0.077	0.028	0.769	0.007	0.495	0.053
12	0.035	0.099	0.006	0.088	00	0.356	0.047
13	0.076	0.097	0.9	0.055	0.008	0.466	0.076
14	0.01	0.046	0.008	0.087	0.01	0.786	00
15	0.085	0.058	0.65	0.064	0.066	0.756	0.076
16	0.046	0.065	0.98	0.079	0.006	0.787	00
17	0.058	0.064	0.008	0.056	0.006	0.768	0.074
18	0.007	0.065	0.056	0.044	0.001	0.096	0.043
19	0.097	0.045	0.067	0.075	0.005	0.475	0.087
20	0.085	0.055	0.006	0.087	0.007	0.456	0.053
21	0.049	0.056	0.007	0.096	0.006	0.659	0.088
22	0.252	0.066	0.073	0.047	0.042	0.057	0.079
23	0.053	0.057	0.075	0.067	0.005	0.056	0.088
24	0.097	0.066	0.076	0.088	0.077	0.009	0.095
25	0.532	0.065	0.054	0.055	0.002	0.055	0.009
26	0.065	0.044	0.087	0.068	0.005	0.025	0.099
27	0.674	0.034	0.087	0.088	0.004	0.098	0.098
28	0.985	0.066	0.067	0.056	0.006	0.005	0.067
29	1.568	0.054	0.079	0.053	0.004	0.456	0.043
30	0.434	0.025	0.068	0.045	0.007	0.098	0.075
31	0.005	0.047	0.371	0.126	0.005	0.024	0.027
32	0.24	0.067	0.009	0.078	0.072	0.037	0.033
33	0.005	0.031	0.114	0.084	0.064	0.033	0.028
34	0.055	0.039	0.036	0.012	0.023	0.038	0.023
35	0.146	0.046	0.022	0.026	00	0.027	0.046
36	0.01	0.063	0.008	0.032	00	0.079	0.031
37	0.14	0.079	0.026	0.057	00	0.037	0.037
38	0.055	0.033	0.054	0.087	0.006	0.654	0.044
39	0.113	0.133	0.018	0.093	0.012	0.485	0.072
40	0.015	0.077	0.012	0.023	0.041	0.564	0.047
Maximum	1.568	0.875	0.98	0.769	0.077	0.787	0.099
Minimum	0.005	0.025	0.006	0.012	00	00	00
Mean	0.158	0.094	0.14	0.082	0.018	0.345	0.053
Median	0.056	0.064	0.061	0.061	0.006	0.44	0.05
STDEV	0.304	0.138	0.245	0.114	0.025	0.279	0.027
BIS limit	0.01	0.05	0.3	0.07	0.1	0.05	5

0 indicates BDL, Where BDL = below the detected level

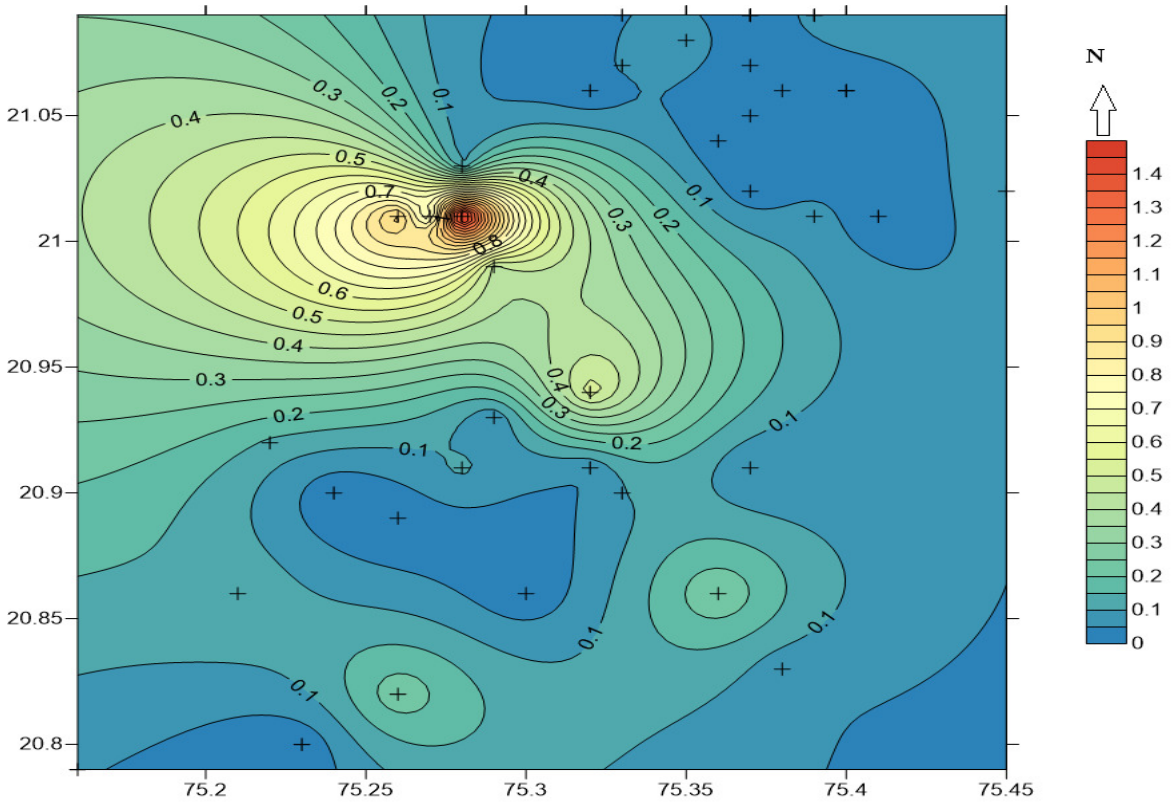

Figure-6
Spatial variation of Cadmium

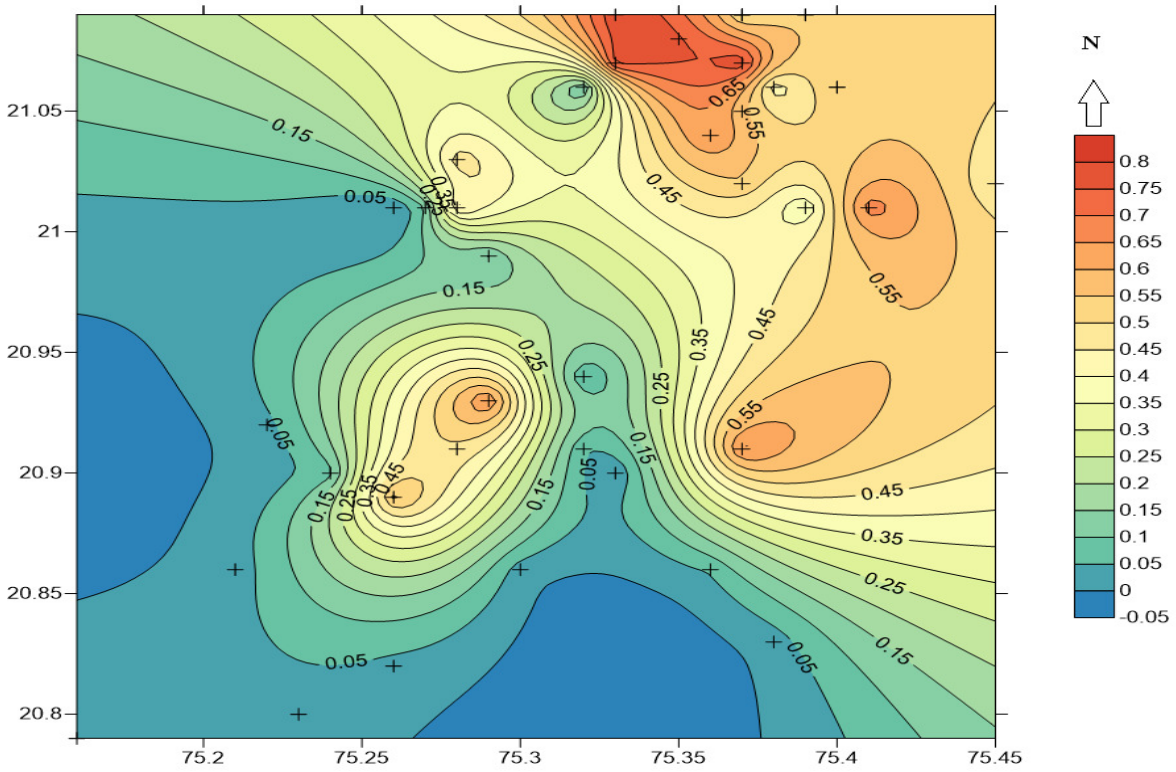

Figure-7
Spatial variation of Lead

Graphical explanation of water quality data: Piper Trilinear diagram: The piper trilinear diagram consisting of three distinct fields, two triangular fields and one diamond shaped fields. The piper trilinear diagram has been used for variation and differences in chemical composition of water samples. The chemical composition of water samples from area under study were plotted in piper trilinear diagram (figure 8). The diagram shows that the water belongs to Ca-Cl-HCO_3 facies. The piper plot shows that water is dominant of calcium bicarbonate. Ca, HCO_3 indicate temporary hardness and overall hydrogeochemistry of the area under study is dominated by Ca, Mg, Cl and HCO_3.

Expanded Durov Diagram: The expanded Durov diagram (figure 9) provides a distinct classification of dominant cations and anions. From the graphical representation of the study area shows dominance of calcium bicarbonate.

US Salinity Hazard Wilcox Diagram: This diagram (figure 10) indicates type of salinity hazards[18]. It is marked that, majority of water samples fall under category C3S1 which is indicates groundwater of study area high salinity hazards. 4 samples shows C4S1 category which indicates very high salinity hazards. 3 samples fall under category C2S1 moderate salinity hazards and low sodium content.

Suitability of groundwater for irrigation use: Salinity and sodicity are the most important parameter of water quality concerns in irrigated areas of arid and semi-arid regions[19]. The effects of salinity and sodicity on soils such as change the soil structure, permeability and aeration, which indirectly affect plant growth. The irrigation quality parameters is an important for classification of water such as sodium adsorption ratio (SAR), residual sodium carbonate (RSC), corrosivity ratio (CR) and electrical conductance (EC). Salinitization is a major cause of loss of the crop production mainly in well irrigated area. When the SAR values more than 10 would represents a high sodium hazard. Edet and Okereke stated that electrical conductivity of water less than 200 µS/cm is low salinity and if sodium adsorption ration is less than 1.5) it is excellent for irrigation[20].

SAR is express as [21], SAR = $\mathbf{Na/\frac{Na}{\sqrt{(Ca+mg)}\ /2}}$ (1)

In present study SAR values were observed range from 0.24 to 1.05 with an average 0.57; suggest that the all water samples are excellent category (table 4).

RSC value of 1.25 (suitable for irrigation), 1.25 to 2.5 (marginal for irrigation) and >2.5 (not suitable for irrigation).

$RSC = (CO_3 + HCO_3) - (Ca + Mg)$ (2)

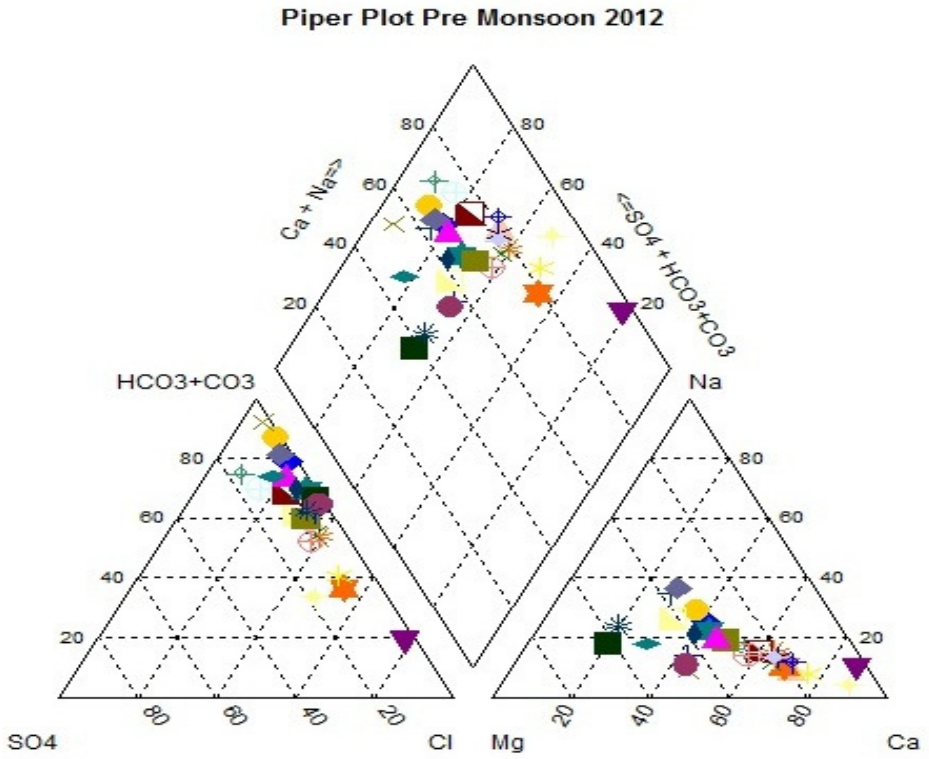

Figure-8
Piper Trilinear diagram

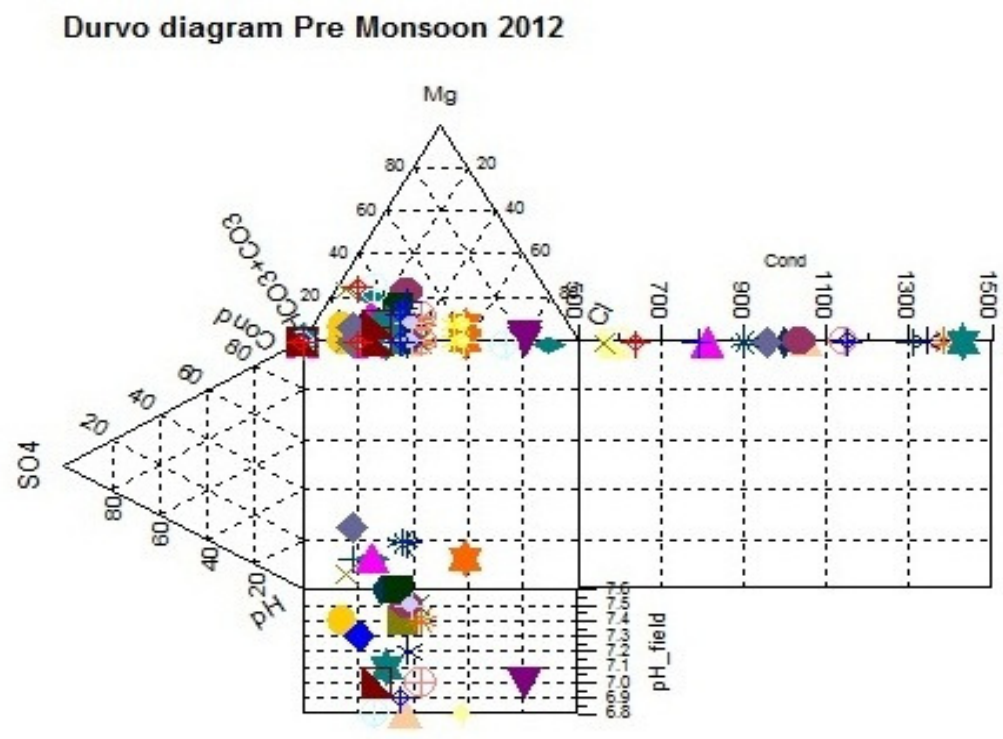

Figure-9
Expanded Durov diagram

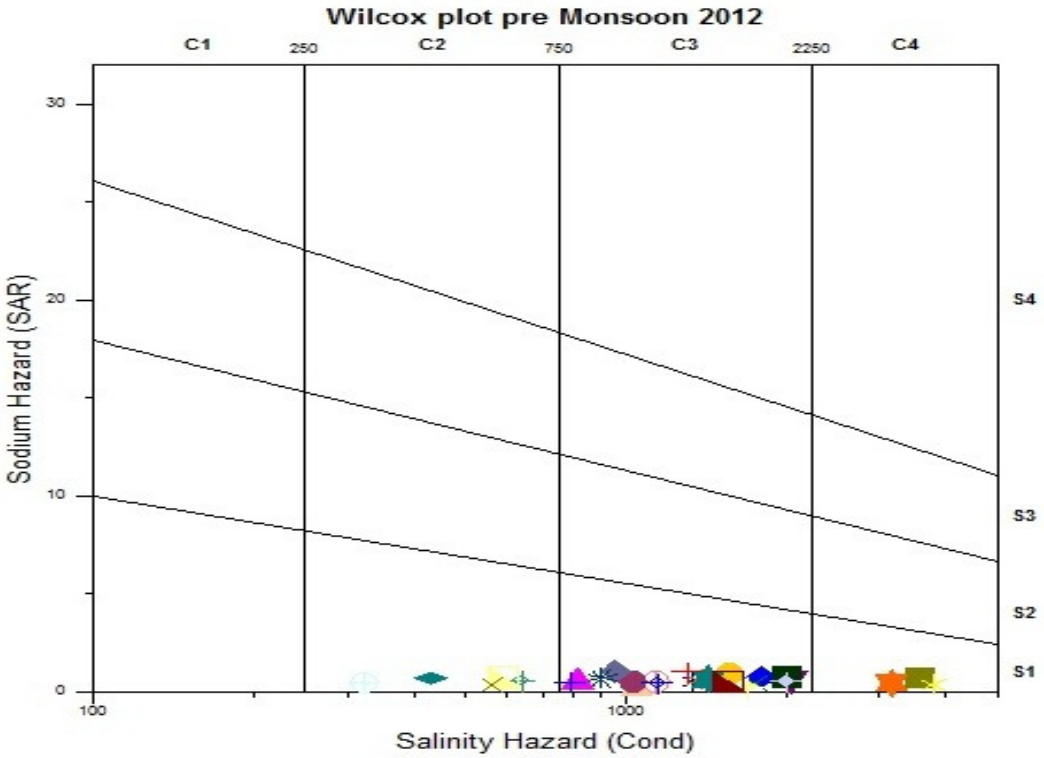

Figure-10
Wilcox Salinity diagram

The RSC values of present study was observed between ranges from -9.93 to 13.49 with an average - 1.42 in pre monsoon seasons suggest that the most of samples not suitable for irrigation purposes. A high value of RSC in water leads to an increase in adsorption of sodium in the soil system[22].

The corrosivity ratio (CR) denotes susceptibility of groundwater to corrosion and is expressed as the ratio of alkaline earths to saline salts in groundwater. The effects of corrosion are losses in the hydraulic capacity of pipes[23].

Corrosivity ratio expressed as, $CR = \frac{(Cl)+(SO4)}{2(HCO3+CO3)}$ (3)

The corrosivity ratios were observed range from 0.04 to 2.33 in water samples from the area under study (table 4). Corrosivity ratio indicates that the 55 % samples are safe (CR < 1) and 45 % are unsafe (CR > 1). Hence the majority of water is safe for long-distance transportation through metallic pipe lines, but in the unsafe areas, PVC pipes should be used for water supply.

Correlation Coefficient: Relationship of physico-chemical parameters from water and their coefficient correlation is a normally use for measurement of recognized the correlation between two variables. The correlation matrices for 17 variables were prepared and presented in table 5. EC and TDS, EC and Cl show strong positive correlation. TDS and Cl also exhibit high positive correlation with $SO_4^{2-}$and Cl^-ions. $F^-$and B, $SO_4^{2-}$and TDS, SO_4^{2-} and TDS are also exhibits the good positive correlation pairs.

Table-4
Statistical summary of Irrigation water quality parameters from Anjani - Jhiri Basin

Sample ID	SAR	RSC	CR	Sample ID	SAR	RSC	CR
1	0.36	0.39	0.63	25	0.78	1.11	1.11
2	0.47	2.32	1.24	26	0.72	0.48	1.04
3	0.31	-5.03	1.74	27	0.78	3.01	1.70
4	0.37	0.67	1.45	28	0.31	-9.77	0.50
5	0.67	7.31	1.24	29	0.36	-1.52	0.37
6	0.52	4.06	1.13	30	0.34	4.31	0.75
7	0.44	-0.73	0.28	31	0.47	-1.43	0.19
8	0.44	0.02	0.56	32	0.62	-2.30	0.18
9	0.54	7.12	1.03	33	0.70	-2.89	0.17
10	0.59	7.91	1.65	34	0.47	-9.93	2.22
11	0.88	13.49	0.74	35	0.48	-7.32	0.28
12	0.65	12.77	2.33	36	0.70	-4.15	0.25
13	0.75	13.33	1.32	37	1.05	-1.25	0.11
14	1.02	10.41	0.95	38	0.51	-4.19	0.31
15	0.44	4.28	1.33	39	0.33	-4.85	0.04
16	0.51	2.48	0.91	40	0.69	-1.32	0.30
17	0.60	2.66	1.08	Maximum	1.05	13.49	2.33
18	0.46	2.43	2.04	Minimum	0.24	-9.93	0.04
19	0.24	-9.23	0.72	Average	0.57	-1.42	-0.93
20	0.56	-0.25	0.26	Median	0.56	1.11	0.92
21	0.73	3.19	1.20	STDEV	0.2	6.36	0.64
22	0.68	11.80	1.64	Excellent	2.5	1	<1 .00
23	0.68	5.28	0.60	Good	2.5 - 5.00	1.00 - 2.00	----
24	0.59	1.58	1.01	Unsuitable	> 10.00	> 2.50	> 1.00

Where, SAR = Sodium Absorption Ratio, RSC = Residual Soluble Carbonate, CR = Corrosivity Ratio

Table-5
Correlation matrix of physicochemical parameters

	EC	TDS	Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO_3^{2-}	HCO_3^{-}	Cl^{-}	SO_4^{2-}	PO_4	NO_3^{-}	B	F^{-}
EC	1													
TDS	1	1												
TH	0.43	0.44												
TA	0.28	0.27												
Ca^{++}	0.34	0.34	1											
Mg^{++}	-0.04	-0.05	-0.14	1										
Na^{+}	0.07	0.06	-0.01	0	1									
K^{+}	-0.39	-0.38	-0.3	0.06	-0.11	1								
CO_3^{2-}	-0.12	-0.11	-0.34	0.01	0.11	0.08	1							
HCO_3^{-}	0.41	0.4	-0.29	0.14	0.25	-0.27	0.13	1						
Cl^{-}	0.71	0.7	0.61	-0.1	0.33	-0.27	-0.22	0.08	1					
SO_4^{2-}	0.65	0.67	0.47	-0.15	-0.08	-0.17	-0.13	0.08	0.63	1				
PO_4	0.35	0.36	-0.01	-0.33	-0.14	-0.28	0.12	0.15	0.22	0.29	1			
NO_3^{-}	-0.07	-0.06	0.15	0.01	0.35	0.15	0.09	-0.05	0.09	0.02	-0.18	1		
B	0.11	0.11	-0.21	0.03	-0.01	0.16	0.12	0.2	0.03	0.12	0.01	0.13	1	
F^{-}	-0.19	-0.19	-0.23	0.14	-0.06	0.19	0.19	-0.04	-0.23	0.06	0	0.03	0.52	1

Conclusion

Groundwater of Anjani - Jhiri river basin shows that the (Ca^{2+} and Mg^{2+}) exceeds than (Na^{+} and K^{+})), (HCO_3^{-}) exceeds (Cl^{-}, SO_4^{2-} and NO_3). The groundwater of study area shows dominance of calcium bicarbonate facies they may be cause of intense chemical weathering calcic plagioclase feldspar from basalts. Concentration of cations and anions shows that calcium, chloride and bicarbonates gradually uniform increase whereas sodium, potassium, magnesium and sulphate decrease. Trace elements are observed within the permissible limit of drinking water standards except cadmium and lead. Trace elements are released into groundwater from municipal waste, wastage of agrochemicals and fertilizers. Trace elements from groundwater in Anjani - Jhiri River basin was generally acceptable except Pb and Cd concentrations.

A medical survey was carried out in that village higher values of nitrate and total hardness were observed. From these surveys no medical report on methaenoglobinaemia disease was observed. The total dissolved solid is higher than the 1400 ppm noticed in Dharngaon areas from area under study. The medical questionnaires data correlate with TDS; few Urine stone patients were observed in the study area they may be cause of them.

Medical survey data shows that the hypertension, Anemia, Cardovascular, kidney stone, Skin disease patient frequency was observed in the area under study insignificant percentage they may be one cause of poor quality of drinking water.

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