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Mapping of Feasibility of Groundwater for Drinking Water Zones of Akkalkot Taluk, Solapur, India using GIS Techniques

Mustaq Shaikh[1], Farjana Birajdar[2]

[1]Groundwater Surveys and Development Agency, Pune, India

[2]Centre of Studies in Resources Engineering, IIT Bombay, Mumbai, India

Abstract: ***The chemical characteristics of groundwater with respect to drinking water quality in Akkalkot Taluk of Solapur District have been studied. 68 groundwater samples were examined for pH, nitrate, dissolved solids, alkalinity, hardness, fluoride, chloride, calcium, iron, magnesium, sulphate. The obtained values are compared with WHO water quality standards and concluded that most of the groundwater samples are potable for drinking.***

Keywords: Groundwater, drinking water, GIS techniques, Akkalkot.

1. Introduction

Groundwater is the most fundamental thing which is required to sustain the life on the earth. It is used for domestic, industries and agriculture purposes in most parts of the world, since it is a replenishable resource and has intrinsic benefits than surface water [1]. The demand for the fresh water is increasing day by day as the population is increasing at faster rate. Many villages and cities in Maharashtra obtain groundwater through pipe water supply scheme and private borewells. The water table in the Akkalkot taluk is declining from last few years. Therefore the fresh water requirement is getting fulfilled by borewells. The over extraction of groundwater, through borewells for irrigation practices affects the quality and quantity of groundwater.

In most part of the world, the studies are going on to assess the groundwater quality [2]; [3]; [4]. In India various groundwater quality studies have been carried out by many scientist and researchers [5]; [6]; [7]; [8]. Hence, an assessment of groundwater quality is very important phenomenon which needs to have scientific approach. The geographical information system (GIS) can be used as simple and valuable tool for decision making on the groundwater quality of the region. The spatial interpolation technique of the GIS software is very useful for defining the spatial distribution of various hydrochemical parameters. The GIS techniques have been used by many researchers in groundwater quality studies [9]; [10]; [11].

In the present study, from the Akkalkot taluk of Solapur district of Maharashtra, India the overexploitation of groundwater for irrigation and domestic needs creating declining in groundwater quality trend. The borewells are playing the major part groundwater abstraction tool. Therefore, the groundwater quality in the Akkalkot taluk is deteriorating from last few years. Therefore, in the present study an attempt is to be made to study the groundwater quality of the Akkalkot taluk. The objectives of the present study is to carry out a preliminary investigation and interpretation of the groundwater quality in Akkalkot taluk and to demarcate the regions where the groundwater is suitable or unsuitable for drinking purpose based on geochemical studies and spatial distribution studies in GIS environment.

2. Study Area

The area of study is bounded in between latitudes $17^0$18’3” to $17^0$43’59” N and longitudes $75^0$25’48” to $75^0$53’24” E. It covers an area of 1396.80 Km^2. The Akkalkot taluk of Solapur district as shown in fig.1

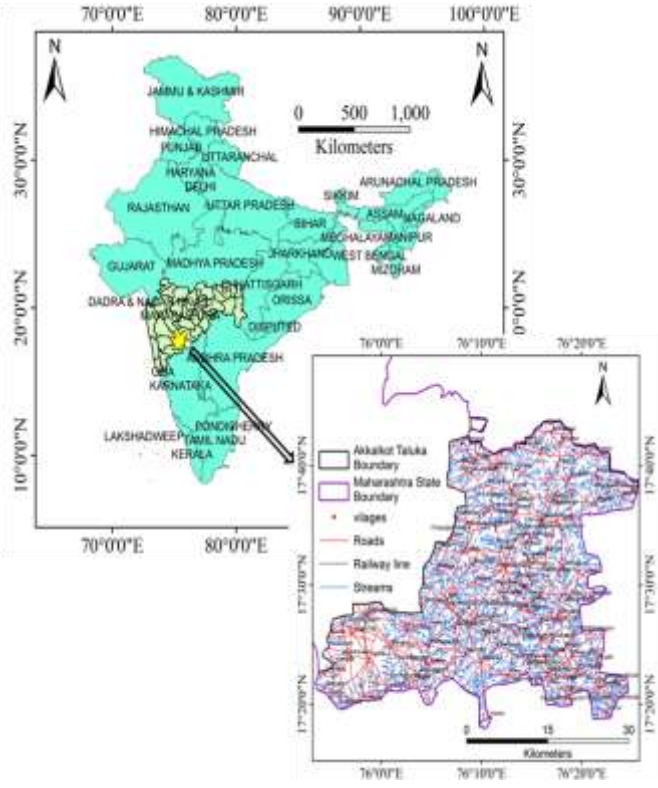


Figure 1: Study Area

3. Geology

Geologically, Deccan basalt covers the major part of Akkalkot taluk of Solapur district. The thickness of basaltic flows varies from place to place as 2 mts to 20 mts. Each flow unit is made up of vesicular basalt on top and massive basalt at bottom and the flows are separated by red/green bole. In the present study area, the Basalt is having massive grey coloured, pinkish vesicles and filled by secondary minerals. The 54 dug wells have been examined to get the knowledge about the sub surface lithology. The area constitutes flows that range in thickness from 2 mts to 24 mts. The flows are almost horizontal which follow the topography of the area. The physical characteristics in terms of lithology and porosity, permeability of the basalt are not uniform throughout in spatial occurrence of the flows thereby showing local variations in aquifer characteristics. The major lithology of the area is showed in table no. 1

Table 1: Major Lithology of the area

Sr. No.	*Formation*	*Age*	*Lithology*
1)	Alluvium	Recent	Clay, silt, sand with pebble
2)	Deccan Trap	Upper cretaceous to lower Eocene	Vesicular and Amygduloidal basalt and massive basalt. The flows are generally separated by red bole.

4. Methodology

A total of 68 groundwater samples are collected from bore wells during January 2015. The acid washed polyethylene bottles of 1 litre have been used to collect the groundwater samples. All safety measures were taken while sampling analysis and transportation of groundwater samples to the laboratory. Electrical conductivity (EC) and hydrogen ion concentration (pH) were determined on the sampling site by using digital meters. The groundwater samples were analyzed at the laboratory for various chemical parameters viz. calcium, magnesium, chloride, sodium, potassium, iron, fluoride, bicarbonate, and sulphate by employing standard methods as suggested by the American public health association (APHA 1989). The volumetric titration method has been used to analysed calcium, magnesium, bicarbonate, and chloride. To estimate the concentration of calcium and magnesium the ethylene di-amine tetra acetic acid (EDTA) titration method was used. Bicarbonate concentration was estimated by acid titration (H_2SO_4). To obtain the volume of chloride the argentometric titration method was used. The sodium and potassium ions determined from flame photometer study. The spectrophotometer was used to determined sulphate. The total hardness of the groundwater is obtained from the following equation [13].

$$TH = 2.497Ca\ 2+ + 4.115Mg2+ \text{ mg/l}\ldots\ldots (1)$$

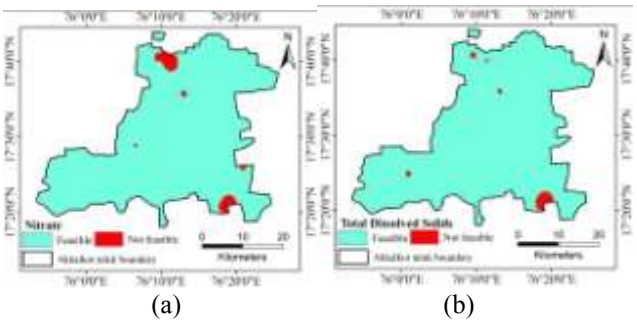
Total dissolved solids (TDS) were estimated by calculation method. The GIS techniques have been used to create spatial distribution map to show the variation in concentrations of the various chemical parameters using inverse distance weighted (IDW) raster interpolation technique.

5. Results

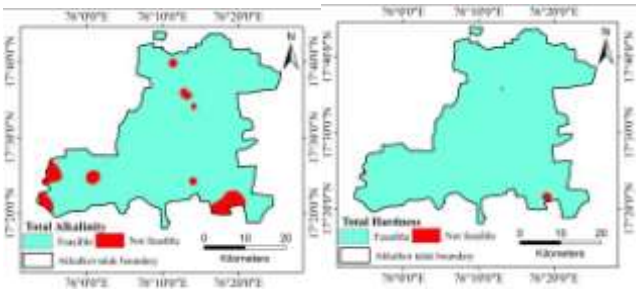
Physico-chemical characters of the groundwater in the study area (Table 2) indicate that pH of groundwater varies from 7.1 to 8.3 and it is found within the range of desirable limit of 7.5 to 8.5 [14] (fig. 2g). The total hardness of groundwater varies from 28 to 820 mg/l. The range of permissible limit for total hardness is 600 mg/l [14]. The 3 samples out of 67 samples are showing total hardness greater than 600 mg/l. Therefore, 3 village's viz. Korsegaon, Sindhkhed and Chincholi groundwater are not suitable for drinking purpose as per BIS 1991 (fig.2d). The iron (Fe) content varies from 0.04 to 0.37 mg/l which is well within the acceptable limit for drinking water purpose (fig. 2i). The chloride (Cl) content varies from 24 to 696 mg/l, which is found within the range of permissible limit of 1000 mg/l. The estimated total dissolved solids (TDS) vary from 246 to 3,653 mg/l. The permissible limit for TDS is 2000 mg/l [14]. The total dissolved solids in five villages are not suitable as per BIS standard for drinking water suitability and those are viz. Hannur, Mangrul, Sindkhed, Pitapur and Chincholi (fig. 2b). The large difference in the value reveals the changes in water level, differential weathering and leaching of minerals into groundwater. The thickness of weathered zone varies from 3 mts to 8.5 mts. TDS can be high because of addition of ions into groundwater by weathering and leaching of minerals from the host rocks. Theses observation made in this research as there are no industrial contaminants found in the field. The calcium values of groundwater varies from 11 to 329 mg/l and 5 samples are showing >200 mg/l of contamination, therefore these 5 villages (Devika kavathe, Hannur, Korsegaon, Sindhkhed, Chincholi) are not suitable for drinking purpose (fig. 2f).

The magnesium values of groundwater vary from 3 to 295 mg/l. The 14 villages namely, Kalappawadi, Motyal, Shegaon, Sangvi Khurd, Umarge, Kalkarnjal, Korsegaon, Hannur, Pitapur, Nanhegaon, Mangrul, Boblad, Sindhkhed, Chincholi etc are showing Mg concentration >100 mg/l. The maximum allowable limit of Mg in water is 100 mg/l for drinking water therefore these villages are not suitable for drinking, as shown in figure no.2j. The sulphate value from the groundwater samples in the study area shows values between 7 to 579 mg/l. The maximum allowable concentration of sulphate in groundwater for drinking water is 400 mg/l. The 3 villages are showing >400 mg/l of sulphate concentration. Therefore groundwater use of these 3 villages namely, Hannur, Sindkhed and Chincholi etc are not suitable as per [14]. The sulphate concentration of groundwater samples are shown in figure no.2k. The nitrates values of groundwater samples are vary from 0.9 to 156.4 mg/l. the maximum allowable concentration of nitrates for drinking purpose is 100 mg/l. The 8 villages namely, Jeur, Nanhegaon, Boblad, Ibrahimpur, Pitapur, Sindhkhed, Chincholi and Hannur etc are showing (table no.2) greater concentration than the maximum allowable limit of drinking water suitability. The nitrates concentration from the groundwater samples is shown in (fig. 2a). The fluoride concentration from groundwater in the study area is varies from 0.01 to 1.95 mg/l. The maximum allowable limit of fluoride in groundwater is 1.5 mg/l. Accordingly, the 7

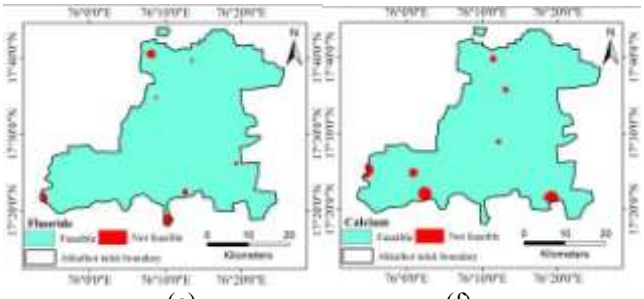
villages namely, Dahitanewadi, Chungi, Nagore, Tolnur, Sheogaon, Haidre and Borgaon etc showing >1.5 mg/l of fluoride in groundwater samples. Hence, these 7 villages are not suitable for drinking water suitability (table no. 2). The concentration of fluoride from the groundwater samples is shown in (fig. 2e). The alkalinity a value of groundwater samples is varies from 92 to 1512 mg/l. The maximum allowable concentration of alkalinity for drinking water is 600 mg/l. The 9 groundwater samples from villages namely, Mangrul, Shegaon, Kalappawadi, Hannur, Sangavi Khurd, Boblad, Korsegaon, Sindhkhed and Chincholi etc are showing > 600 mg/l concentration of alkalinity. Hence these 9 villages are not suitable for drinking water. The fig. 2c (table 2) shows the concentration of alkalinity of groundwater samples. The calculated values by the experiment for determining drinking water suitability of groundwater are tabulated in table 2; these values are used to generate the final water quality map for physico-chemical parameters of the study area.



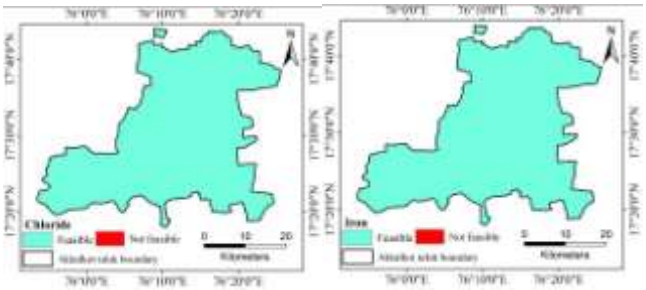
(a) (b)



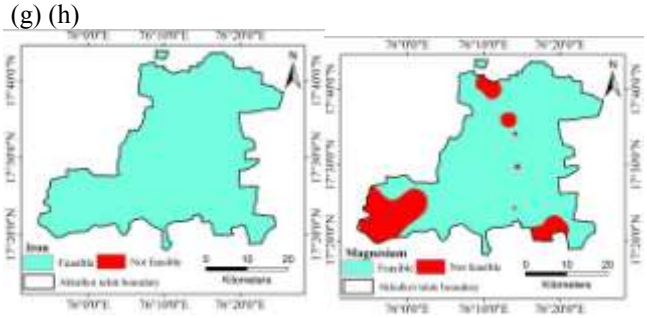
(c) (d)



(e) (f)



(g) (h)



(i) (j)

(k)

Figure 2: Feasibility of drinking water as per with respect to (a) Nitrate; (b)Total Dissolved solids; (c) Akalinity ; (d) Total Hardness ; (e) Fluoride; (f) Calcium ; (g) pH ; (h) Chloride ; (i) Iron ; (j) Magnesium ; (k) Sulphate.

6. Conclusions

In this study, various chemical parameters viz. pH, total hardness, Fe, Cl, dissolved solids, Ca, Mg, SO_4, NO3, F, alkalinity of groundwater in Akkalkot taluk of Solapur district is performed and suitable or unsuitable zone for drinking have been mapped by using geographical information system. The GIS technique is very useful to delineate the spatial variation of groundwater quality and the present area is comes under good quality zone. The pH, Fe and Cl values are observed to be suitable for drinking water in Akkalkot taluk. It is observed from the generated maps of total dissolved solids, total hardness, calcium, magnesium, sulphate, nitrates, fluoride and alkalinity that groundwater quality is decreasing towards South of the Akkalkot taluk. Therefore, the downstream lands of the study area are having mainly polluted groundwater. Thus, the use of groundwater for drinking purposes in these areas needs to be treated before used. The areas of poor groundwater quality can be targeted for more detailed investigation at micro level. The results of this study show that GIS technique can be useful in decision-making processes such as identifying suitable and unsuitable areas of drinking water zones

Table 2: Physico-chemical characteristics of groundwater

Sample No.	pH value	T.H (mg/l)	Fe (mg/l)	Cl (mg/l)	T.D.S (mg/l)	Ca (mg/l)	Mg (mg/l)	SO4 (mg/l)	NO3 (mg/l)	F (mg/l)	T.Alk. (mg/l)
1	7.5	260	0.12	62	429	66	23	57	5.3	0.21	196
2	7.5	364	0.1	122	718	64	49	37	58.3	0.9	272
3	7.7	172	0.14	30	294	37	19	7	22.6	0.67	148
4	7.2	676	0.13	278	1502	223	29	52	56.5	0.67	528
5	7.4	344	0.18	62	676	98	24	26	50.5	0.55	304
6	7.5	292	0.07	50	509	32	51	43	6.9	0.81	268
7	7.4	1176	0.11	268	1976	186	171	300	110.5	0.64	752
8	8.3	260	0.07	108	418	11	56	55	10.6	1.95	164
9	7.5	488	0.09	122	870	80	69	24	64	0.37	400
10	7.5	480	0.13	168	839	91	61	100	60.9	0.83	376
11	7.3	284	0.37	136	501	61	32	16	29.7	0.45	244
12	7.8	2044	0.12	696	3653	329	295	522	142.2	1.44	1512
13	7.8	356	0.08	84	585	24	71	15	16.2	1.56	292
14	7.5	208	0.1	82	345	48	21	7	4.7	0.54	200
15	8.3	288	0.04	132	468	21	57	63	18.7	1.54	228
16	7.5	920	0.17	388	1157	223	88	147	98.1	0.65	520
17	7.6	292	0.27	106	494	40	46	48	29.9	0.77	192
18	7.7	180	0.13	28	302	38	20	12	3	0.59	156
19	7.5	372	0.14	240	475	112	22	78	56.7	1.16	252
20	7.1	260	0.05	58	637	59	27	46	55.2	0.58	196
21	7.5	324	0.09	130	623	53	46	55	5.8	0.37	256
22	7.3	492	0.1	136	825	96	61	121	56.7	0.77	380
23	7.3	384	0.12	164	759	131	13	147	23.3	0.47	180
24	7.6	424	0.09	156	760	51	71	78	43.6	1.9	280
25	7.5	232	0.11	112	562	74	12	60	42.7	0.22	128
26	7.3	400	0.13	184	954	115	27	76	76.6	0.17	244
27	7.3	480	0.08	216	1076	144	29	60	54	0.03	432
28	7.4	1144	0.1	386	2054	240	131	518	156.4	0.17	716
29	7.5	508	0.12	186	845	101	62	77	112.5	0.14	464
30	7.3	584	0.09	160	943	144	54	99	102.6	0.02	472
31	7.5	728	0.13	240	1274	122	102	83	99.2	0.05	672
32	7.6	324	0.14	80	692	125	3	48	56.3	0.1	260
33	7.6	700	0.1	308	1206	77	122	120	93	0.1	496
34	7.6	500	0.1	240	910	61	84	113	25.3	0.14	328
35	7.8	220	0.09	70	347	43	27	39	30.8	0.32	188
36	7.3	348	0.06	88	562	93	28	29	38.3	0.01	280
37	7.6	208	0.05	52	493	46	22	18	43	0.22	192
38	7.6	196	0.17	82	413	48	18	20	30.8	0.01	176
39	7.4	1164	0.21	444	1768	253	128	50	76.4	0.34	864
40	7.3	420	0.11	146	772	90	47	121	91	0.1	260
41	7.1	648	0.21	206	1014	173	52	114	86.4	0.05	480
42	7.4	1180	0.17	472	2054	208	159	219	97.5	0.28	660
43	7.5	716	0.18	270	1216	114	104	185	52.3	0.24	500
44	7.5	372	0.12	118	637	83	40	28	36.3	0.24	280
45	7.8	220	0.13	120	336	42	28	11	7.4	0.58	112
46	7.5	528	0.16	122	872	112	60	151	74.2	0.59	296
47	7.5	360	0.17	162	606	56	53	62	9.7	1.6	252
48	7.8	892	0.09	498	1788	106	151	259	108.8	0.29	568
49	7.5	404	0.11	120	764	91	42	142	42.3	0.7	264
50	7.6	488	0.22	148	1009	82	68	73	70	0.84	408
51	7.8	848	0.27	416	2477	114	136	222	125.4	0.82	528
52	7.7	128	0.18	60	246	18	20	17	0.9	1.34	92
53	7.5	284	0.18	68	390	88	15	37	25.9	0.78	248
54	7.6	608	0.1	240	978	95	90	77	93.3	0.63	360
55	7.8	824	0.11	202	1372	146	111	77	70.2	0.23	732
56	7.7	352	0.13	106	675	48	56	35	41	1.2	292
57	7.5	512	0.09	174	1017	91	68	120	80.6	0.2	300
58	7.5	892	0.1	342	1638	184	104	268	50.7	1.8	664
59	7.5	256	0.05	52	406	64	23	25	49	0.8	188
60	7.4	1416	0.16	530	2392	260	185	579	135.1	1.1	960
61	7.5	244	0.14	30	415	55	26	14	23	1.5	224
62	7.6	444	0.05	114	910	74	63	87	50.9	0.85	316

63	7.6	416	0.11	100	770	91	45	59	82	1.4	340
64	7.7	284	0.11	44	460	42	43	14	10.1	1	260
65	7.7	520	0.14	170	919	69	84	190	41.9	0.77	284
66	7.7	192	0.09	24	361	51	15	20	32.3	1.6	180
67	7.8	620	0.19	166	1192	64	111	350	50.5	0.4	260
68	7.5	432	0.13	120	777	123	30	74	53.2	1.4	272

7. Acknowledgement

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Author Profile

Mustaq Ahmad Jabir Shaikh received the B.Sc. and M.Sc. degrees in Geology from Shivaji University, Kolhapur and Solapur University, Solapur in 2006 and 2009, respectively. He also completed Post Graduate Diploma in drilling technology from Dr. Babasaheb Ambedkar Marathwada University Aurangabad in 2007. He received M.Tech degree in Geoinformatics and Natural Resources Engineering from Indian Institute of Technology, Bombay, Powai, Mumbai in 2012. He is working as Assistant Geologist in Groundwater Surveys and Development Agency, Government of Maharashtra from 2012 to till date. He is pursuing Ph.D from Savitribai Phule Pune University.