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Geospatial Variability and Drinking Water Safety Scenario of Groundwater in Aland Taluka, Kalaburagi, Karnataka

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Abstract: Groundwater quality and distribution systems are major concerns in hydrogeology which needs proper understanding in order to relate the quality and quantity of groundwater. Water quality represents the chemical constituents or ionic concentration of water. Drinking water is very sensitive and needs immediate prevention of pollutants to groundwater reserves. In this sense, Water Quality Index (WQI) is one of the essential factors to determine the quality and grade of the groundwater. Groundwater is highly influenced by lithological assemblage prevailing in the area. The study area is covered by Deccan traps which consist of basalts. The variation of water quality from both open wells and bore wells in accordance to the depth variations were analyzed with reference to water table. The significance of the research illustrated the society related problems from water quality using geospatial and decision making tools, and quality of the water using WQI analysis.

Keywords: Ground water quality, fluoride, GIS, geospatial analysis, Kalaburagi.

Introduction

Among 97.2% of water on earth's surface is in the oceans, 2.15% in the form of ice, 0.6% occurs as groundwater and remaining 0.01% of fresh water in streams and lakes. Half of the world population depends on sound quality of groundwater for drinking water needs. In India, 90% of rural population depends on groundwater resource. Fresh water quality has gained its substantial importance in recent decades throughout the world. Groundwater is a finite resource and even large aquifers were drained much of their water, especially during droughts. Groundwater is used for drinking water and the agriculture utilizes largest use of this resource. Groundwater is an important component in many industrial processes. Groundwater is a source of recharge for lakes, rivers and wetlands in case of gaining stream conditions (Todd and Mays, 2005).

Geology of Northern Karnataka

A substantial part of North Karnataka is covered by Deccan trap, representing phenomenal outburst of volcanic activity at the dawn of the Cenozoic era. Further the north terrain is covered by extensive volcanic flows known as Deccan Traps of Cretaceous – Tertiary age, and the district is drained by Krishna and Bhima rivers (Radhakrishna and Vaidyanathan, 2011).

Study Area

The study area belongs to Aland taluka of Gulbarga district in Karnataka. It lies in the north-western part of the district which represents a typical Deccan plateau, deeply indented with ravines. The study area is covered by Deccan traps which consist of basalt. Major groundwater bearing formations in Aland taluka covers granite, gneiss, limestone and vesicular basalt. Groundwater occurs in weathered, fractured and jointed zones within the formation. In weathered zones, ground water occurs in phreatic condition, whereas in the fractured and jointed formation it occurs in semi confined to confined condition. Deccan Trap basalts, which comprise different flows, fractures and interstitial pore spaces, act as good repositories for groundwater storage. Aland taluka lies in the north-western part of the district which represents a typical Deccan plateau with Basalt rocks (CGWB, 2013). The work was contributed by samples from both open and bore wells to analyze the mineral and chemical contents in groundwater.

Materials and Methods

Sampling and Field work

Three days intense field work had been conducted in and around Aland Taluka to collect 19 water samples from both open and bore wells. Nine parameters were considered for the analysis and geochemical tests were carried out as proposed by PRERANA Laboratories (2011) Table 3. The detailed sampling stations and types of well, depth of the well and MSL level are given in Table 1.

Geospatial Techniques

Remote sensing and GIS applications provide a suitable platform to solve water related issues. Geoinformatic tools give an efficient results related to spatial distribution of water quality analysis and recommendations. The following diagrams represent the parameter concentrations of water samples in geospatial approach. The Inverse Distance Weightage

Table 1 Physico-Chemical parameters of groundwater in Aland Taluka, Kalaburagi.

Village	Sampling Point	Latitude / Longtitude	Well Type	Depth of Well(ft)	pH	TDS (ppm)	EC (μs)	Alkalanity (ppm)	Iron (ppm)	Nitrate (NO_3)	Fluorite (ppm)	Hardness (ppm)	Chloride (ppm)	MSL (m)
Kadaganchi	1	N 17* 26.774' / E 76*40.066'	Borewell	30-40	8.8	297	621	300	.3	20	2.0	250	75	531
Thanda	2	N17*26.982' / E76*40.670	Borewell	40-50	8.7	363	752	375	0	10	3.0	250	150	560
Load Chincholi	3	N17*28.435' / E76*38.419'	Borewell	50-60	8.1	857	1786	325	0.5	30	1.0	600	225	526
Yellinavudugi	4	N17*31.474' / E76*38.675	Borewell	40-50	8.3	461	956	475	0.0	10	0.5	425	150	518
Nallore	5	N17*30.607 / E76*38.945	Borewell	50-60	8.8	348	712	350	0.0	10	1.0	350	75	527
Kodathangarga (bore)	6	N17*31.873 / E76*36.161	Borewell	30-40	8.2	114	2442	250	1.0	20	1.5	300	375	507
Kodathangarga Open well	7	N17*31.874 / E76*35.162	Openwell	35 Steps	8.1	112	2400	500	0.0	20	1	600	500	507
Bhushnoor	8	N17*32.271 / E734. 756'	Openwell	42 Steps	8.4	145	3131	175	0.0	10	2.0	325	700	503
Anzarimuala	9	N17*33.626' / E76833.783'	Borewell	30-40	9.1	330	755	400	0.0	10	0.5	350	75	506
Savalgi	10	N17*23.393" / E76*44.32.41"	Borewell	40-50	7.00	1500	821	300	0.3	30	3.5	200	230	523
Srichand	11	N17*38.548	Borewell	30-40	7.2	619	715	400	o.3	46	3.5	400	200	518
Sntanoor	12	N17*34.282 / E7683.784	Borewell	50-60	8.00	822	2243	500	0.29	30	2.0	620	200	510
Keroor	13	N17*32.253 / E7634.765"	Borewell	40-50	8.9	742	912	400	0.32	40	2.6	725	430	543
Hirolli	14	N17*34.258 / E7638.756"	Borewell	60-70	9.2	632	2213	400	0.3	20	2.6	745	428	565
Allapur	15	N17*36.253" / E7642.758"	Openwell	52 Steps	9.8	930	2013	400	0.29	40	2.0	632	345	512
Tugaon	16	N17*24'30.95" / E76*43"26.15"	Borewell	40-30	7.8	842	722	200	.32	50	2.1	498	342	563
Kinnisultan	17	N17*26.984 / E7640.672"	Borewell	40-50	8.10	742	812	400	0.3	30	2.4	742	432	532
Karebosga	18	N17*23'33.89" / E76*46'.52.10"	Openwell	45 FT	7.4	412	1532	500	o.21	40	3.2	435	200	1702
Aloor	19	N17*22'43.92" / E76*48.54.12"	Borewell	50-60	7.9	512	945	350	0.26	50	2.6	532	275	526

tool was used to generate spatial distribution maps as the tool allows us to interpolate spatially distributed points of cell values.

Results and Discussion

Geospatial Distribution of Water Quality

Using geospatial maps, it is easy to identify the sample concentrations with respect to relative geologic settings. The present work aims at solving drinking water problems for Aland community. The location map of the study area and geospatial distribution map of sampling sites in Aland taluka is shown in the Figures1 and 2.

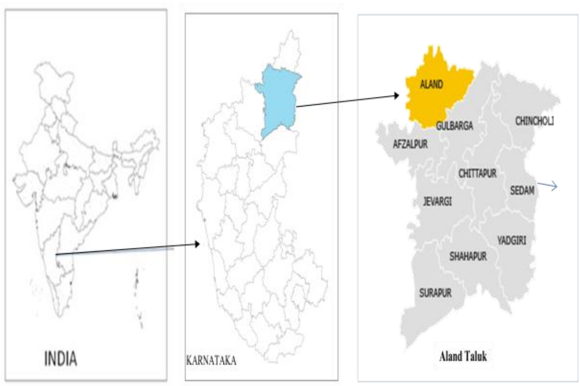

Fig. 1 Location map of the study area.

Geospatial distribution of concentration of pH in Aland taluka has been illustrated in Figure 3. Concentration of pH in the study area ranges from 7.59 – 9.28 ppm.

The map represents the concentration of pH with higher concentrations in few parts of northern, northeastern and southern parts of the study area. The concentration of TDS varies from 145.20 to 859.12 ppm (Fig. 3).

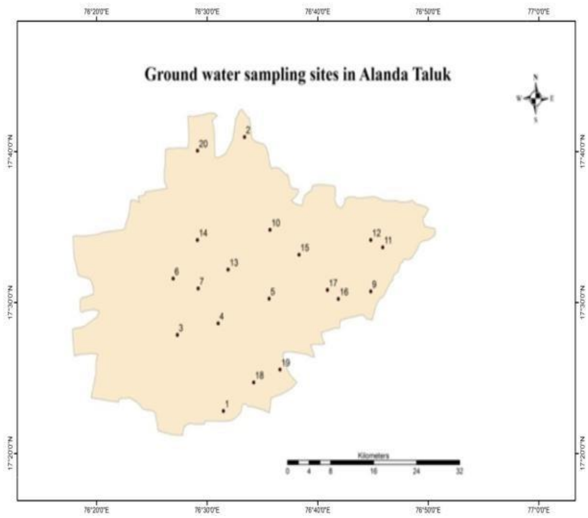

Fig. 2 Groundwater sampling sites in Aland Taluka.

Most of the study area shows higher limit of TDS which might have attributed to application of agricultural fertilizer contributing to the higher concentration of ions into groundwater (Rao, 1986). Though high values of TDS in groundwater are in general not harmful to human population, but it may affect the persons who are suffering from kidney and heart diseases (Gupta, et al., 2004). The concentration of alkalinity in groundwater around Aland Taluka

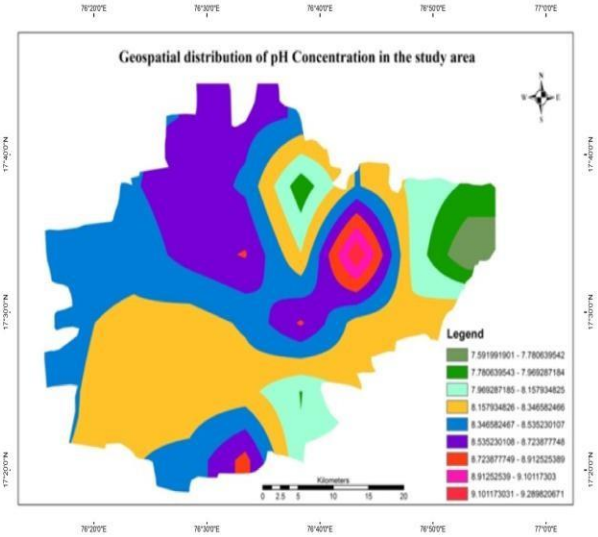

Fig. 3 Geospatial distribution of pH concentration in the study area.

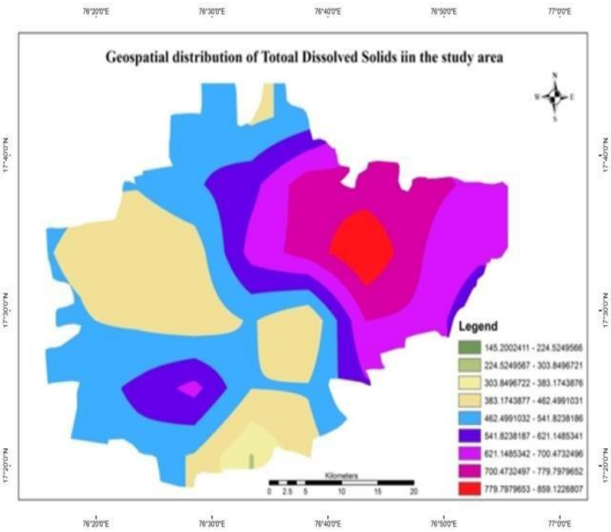

Fig. 4 Geospatial distribution of Total Dissolved Solids in the study area.

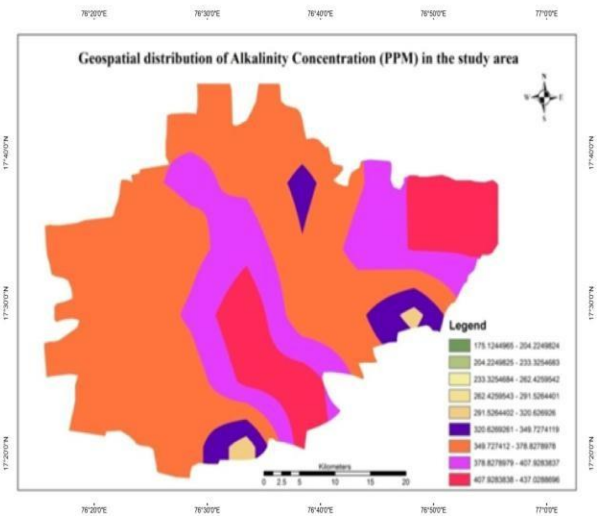

Fig. 5 Geospatial distribution of Alkalinity concentration (ppm) in the study area.

varies from 175.12 to 437.02 ppm (Fig. 5). The highest value was determined in the North east part of the study area. According to Hem, (1985), carbon dioxide species that harvest alkalinity in the surface or groundwater, owing to respiration by plants and oxidation of organic matter which makes enriched in carbon dioxide trapped in the unsaturated-zone. Basalt rock in the Aland taluka shows numerous fracture zones which may support the above statement through which carbon dioxide enriched and dissolved in the groundwater leads the higher concentration of alkalinity. The map shows geospatial distribution of iron concentration in groundwater samples from Aland taluka iron concentration varies from 0 to 0.49722 ppm (Fig. 6).

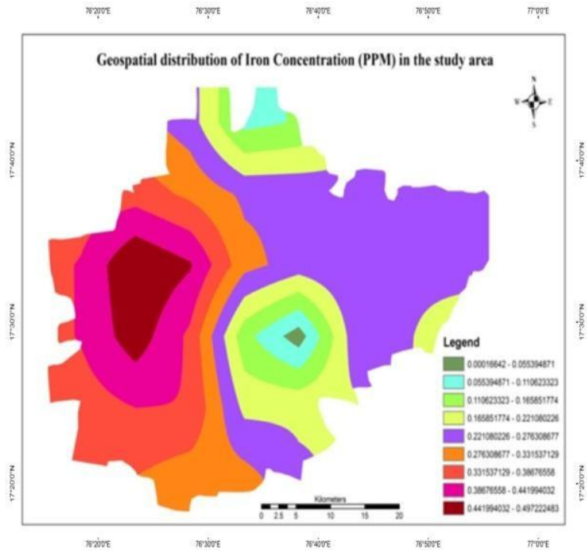

Fig. 6 Geospatial distribution of Iron concentration (ppm) in the study area.

According to Hem (1985), iron content in the igneous rocks is very high and occurs in these minerals in the ferrous Fe^{2+} oxidation state, when these minerals are attacked by water or groundwater. Consequently the iron might be released to the water due to dissolution activates. The major rock type present in the study area is Deccan Basalts, which releases the surplus amount of iron in the groundwater during water and country rock interaction. Nitrate concentration in Aland taluka groundwater varies from 10.00 to 39.28 ppm. Map shows the concentration of nitrate with high at extreme north – eastern part of the study area (Fig. 7). Comley, (1945) and Gilly et al., (1984) stated that high contents of the nitrate cause gastric carcinomas and blue baby diseases, methemoglobinemia in the case of children. But there was no such incident reported in the study area due to less concentration of nitrate found in the groundwater. The fluoride concentration in the Aland taluka groundwater varies from 1.11 to 2.87 ppm (Fig.8). Higher contents of fluoride in the study area are due to possibility of fresh volcanic ash enriched in fluoride content and the ash that is interbedded with other sediments may perhaps cause high fluoride concentrations in groundwater in the study area (Hem 1985).

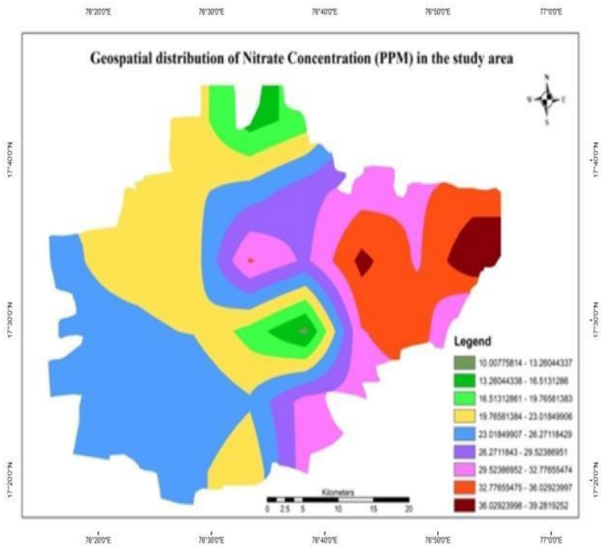

Fig. 7 Geospatial distribution of Nitrate concentration (ppm) in the study area.

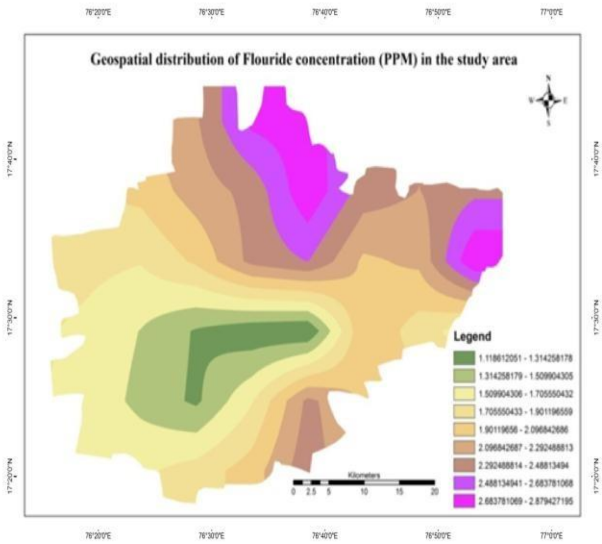

Fig. 8 Geospatial distribution of Fluoride concentration (ppm) in the study area.

Roberson and Barnes (1978) stated the occurrence of fluoride species in volcanic condensates from Hawaii (owing to the similarity of charge and radius). It is possible that fluoride may substitute for hydroxyl ions at mineral superficial site. The F^- content of groundwater can originate from the dissolution of fluoride bearing minerals in the bed rock and therefore, bed rock mineralogy is, a general, a primary factor for the variation in F^- content of groundwater (Chae et al., 2007). Fluoride contamin-ation of groundwater is a function of many factors such as availability and solubility of fluorine bearing minerals, temperature, pH, concentration of calcium and bicarbonate ions in water (Chandra and Thergaonkar, 1981; Largent, 1961). Another study from Iran shows that amount of fluoride ion in the water from an aquifer is more than the universal maximum admissible concentrations and the people of villages are suffering from dental and probably skeletal fluorosis owing to fluoride content in their drinking water supplies from basaltic springs and wells (Moghaddam et al., 2007).

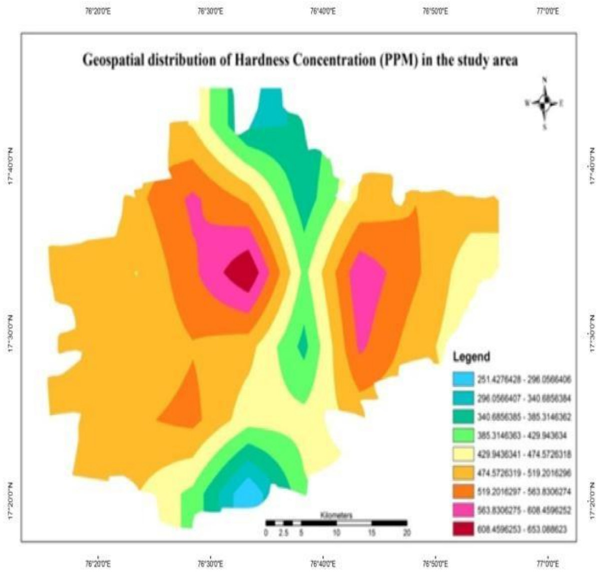

Fig. 9 Geospatial distribution of Hardness concentration (ppm) in the study area.

The concentration of hardness in Aland taluka varies from 251.42 to 296.05 ppm. The concentration of hardness in water was found to be high in north west part of the study area (Fig. 9).

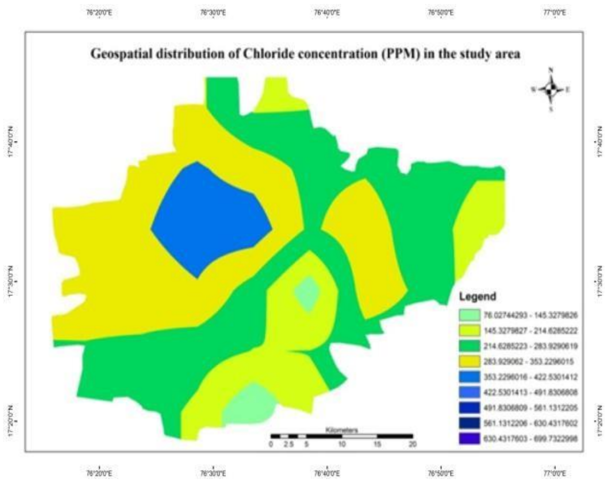

Fig. 10 Geospatial distribution of Chloride concentration (ppm) in the study area.

The chloride concentration around Aland taluka varies from 76.02 to 699.73 ppm (Fig. 10). The highest value (700 ppm) has been identified in Bushnoor village in the study area. In natural waters, chloride comes from weathering of chloride minerals. It is due to distribution of chlorite in all types of rocks in one or the other form. Hence, it was found high in groundwaters, where the temperature is high and rainfall is less (Ramakrishnalah, *et al*, 2009). Alanda taluka lies in Gulbarga district, which is characterized by high temperature throughout the year and recorded least rainfall (Ramakrishnalah et al., 2009). People having heart and kidney problems have high risk when exposed to high amount chlorides but no such case has been reported in the village and surrounding areas. Thus, people having heart and kidney issues have high risk (Weiner, 2000).

Geospatial Analysis

In order to give a solution for water issues prevailing in Aland taluka, following decisions were made using geospatial analysis. Figure 11 indicates the maximum probability of meets conditions for drinking water. The supply of water is restricted to 5 kms range, which meets more than 5 and 6 parameters with respect to Indian standards. This water can be used for drinking purpose. Figure 12 indicates the buffer zone for each samples in which the supply of water for all villages is preferred which meets the 3, 4, 5 and 6 parameters. During the drought prone and emergency situations, these wells can serve potable drinking water to community, but before usage of this water for drinking purpose, necessary actions like chlorination of water, using RO purifiers must be done. Through this study it is recommended that 3 km buffer zone was suitable for potable drinking water for the villages in this Taluka.

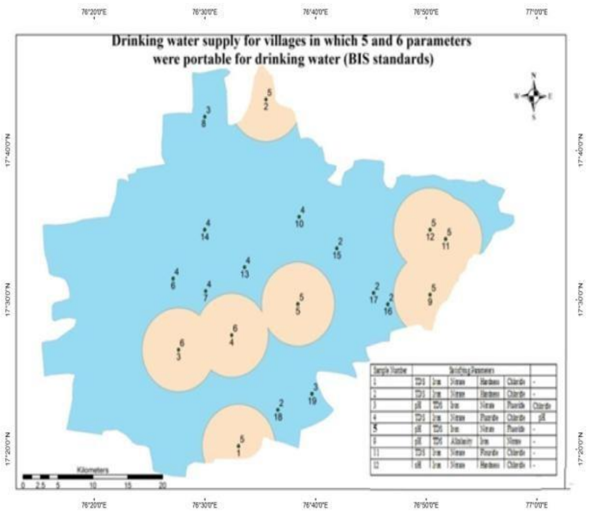

Fig. 11 Drinking water supply for villages based on 5 and 6 parameters according to 5 km buffer zone.

Water Quality Index

Water Quality Index (WQI) is one of the important and more effective tools to communicate the real time information related to the susceptible damage of water from groundwater quality (Tiwari and Mishra, 1985; Mishra and Patel, 2001; Ramakrishnaiah et al., 2009; Vasanthavigar et al., 2010; Srinivas and Padaki, 2011; Mufid al-hadith, 2012 and Srinivas Rao and Nageswara Rao, 2013). It helps policy makers, scientists and researchers in order to undertake decisions.

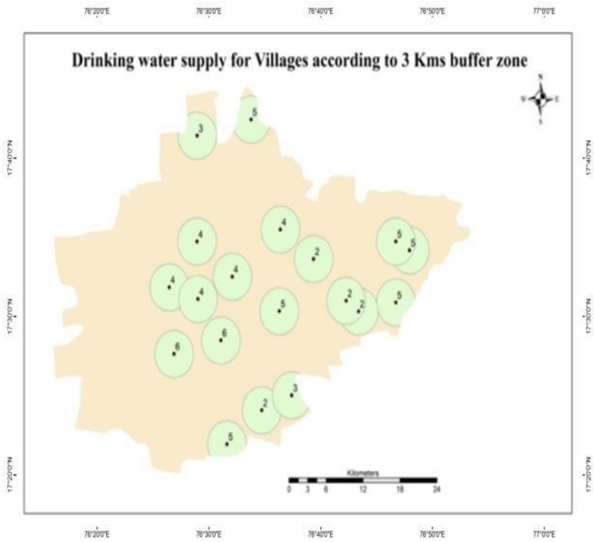

Fig. 12 Drinking water supply for villages based on 5 and 6 parameters according to 3 km buffer zone.

To compute WQI, we have to follow three steps

The first step involves calculation of weightage factor and calculation of relative weightage factor using the following formulae (Table 2 and 3).

Table 2 Formulas used to calculate various indices.

Index	Short form	Formulae
Relative weightage	Wi	$Wi=Wi/\sum_{=1}^{n}Wi$
Qualitative Rating Scale	Qi	$Qi=(Ci/\sum i)*100$
Subindex	SIi	$SIi=Wi*Qi$
Water Quality Index	WQI	$\sum SIi$

Table 3 Water Quality Index for study area in Aland Taluka.

S.No.	Chemical Parameters	BIS	Weightag (wi)	Relative Weightage (Wi)	Quality Rating (Qi)	Sub Index (SIi)
1	pH	6.5-8.5	4	0.12	97.89	11.52
2	TDS	500-2000	4	0.12	29.16	3.43
3	EC	600	3	0.09	243.43	21.48
4	Alkalinity	200-600	4	0.12	62.72	7.38
5	Iron	0.3-1.0	4	0.12	24.63	2.90
6	Nitrate	45-100	5	0.15	26.11	3.84
7	Flouride	1-1.5	4	1.00	134.74	134.74
8	Hardness	300-600	3	0.09	79.82	7.04
9	Chloride	250-1000	3	0.09	28.06	2.48

The second step involves calculation of quality rating scale and calculation of sub index of parameters and calculation of WQI.

The third step involves the decision taken parameters; the result obtained by the WQI is divided into 5 equal parts and is classified as excellent drinking water, good potable water, poor water and water not suitable for drinking (Table 4).

Table 4 Water Quality Index.

WQI Range	Condition
<50	Excellent drinking water
50 – 100	Good portable water
100 – 200	Poor water
200 – 300	Very poor water
>300	Water not suitable for drinking

The value of water quality index is found to be 194. 80, hence it said to be poor quality according to WQI standard (Table 3).

Conclusion

Geospatial distribution shows the maximum probability of satisfying condition for drinking purpose in which we can supply water up to 5 kms range. Using geospatial technique, buffer zone for each samples were prepared, which can be supplied water to all villages. In which it includes the borewells which meet the 3, 4, 5 and 6 parameters. Kadaganchi, Thanda, Nallore, Open well of Kodathangarga, Bushnoor, Anzirumula, Savalgi and Karebosga village wells were satisfying 5 parameters of Bureau of India Standards (BIS), 1991. So these samples can be preferred to water for drinking purpose. Yellinavudugi is the only well which satisfies 6 parameters of BIS standards. According to WQI standard the water from the study area was found not suitable for potable drinking.

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