Geospatial Distribution of Ground Water and Water Quality Index of Lingasugur Taluka, Raichur District, Karnataka: An Emphasis on Fluoride Contamination.

Babu Nallusamy*[*]*, Syed Hamim Jeelani*, Bharathkumar, *L.*, *L. Mallama, and Sharath Raj B

Department of Geology, School of Earth Sciences, Central University of Karnataka, Kadaganchi, Kalaburagi, Karnataka, India

Abstract:

Groundwater quality is a major concern in hydrogeology which needs to be addressed. Raichur district is situated in north-eastern part of Karnataka state. It falls in the northern part of Karnataka state between the two major rivers namely the Krishna and the Tungabhadra. The study area is Lingasugur Taluk. The aim of the research is to analyse the geospatial distribution of water quality and to assess the quality level in terms of water quality index. The pH values were found to be higher concentration in water samples of Santhekallur, Kuppigudda, Sarjapur, Hesarur, Chilkaragi village. The highest alkalinity value 875mg/L was recorded for the water sample in Sarjapur, whereas the lowest at Kasbalingasugur as 125 mg/L. The Geochemical study of water samples were carried out that was collected from 20 stations from insitu sample collection. Almost 80% area is highly affected by fluoride concentration at Hangasadoddi, Santhekallur, Guddenhalli, Kuppigudda, Sarjapur and Halapur villages with a range of 3 ppm. The geology of the area is predominantly intruded by orbicular granite and hornblende biotite granite gneiss. Water quality of the villages represented higher concentrations of alkalinity, hardness, chloride, salinity and fluoride were strongly recommended for industrial or agricultural purposes. According to WQI standard, the water samples from the study area were found not suitable for potable drinking. This contamination is well marked in geospatial map which will be very helpful in decision making processes.

Index Term: Water Quality Index, fluoride contamination, Lingasugur.

INTRODUCTION

There is no place on earth that is so much independent on water. Nearly 97.2% of water on earth is covered by ocean, hence salty, 2.15% is locked in the form of ice, 0.6% occurs as Ground water, and 0.01% as fresh water in streams and lakes. Of this, 30% of fresh water is in ground aquifer. Half of the world populations depend on potable quality of ground water. In India, 90% of rural water supply is from ground water source. Fresh water quality has gained substantial attention in recent years throughout the world. In such a scenario, it is worth researching on the ground water availability and quality which adds to the path of emergence of an upcoming trend in hydrogeology. Keeping these points as the background, an attempt was made to study the qualitative analyses of groundwater and also to detect the causes for the deterioration of water quality. 20 groundwater samples from the study area were collected from Lingasugur taluk, Raichur district, Karnataka, India in spatially distributed manner. Lingasugur lies between 15º 33’- 16º 34’ North latitudes and 76º 14’- 77º 36’ East longitudes. The study area is shown in Fig .1, and it covers an area of about 300 sq. km. Geologically, the area is underlain by the Granites (Orbicular) and Hornblende Gneisses.

The study area of this project is from Lingasugur taluk in Raichur district of Karnataka. It lies in the north-east part of the Raichur district. Granites, gneisses and Dharwar schists are the main rock formations in the district. These formations are grouped under hard rock, as they do not have any primary porosity. However, secondary porosity is developed due to faults, fractures, joints, and due to weathering, which improved permeability and water yielding capacity of these rocks. Groundwater occurs under table conditions in the weathered and jointed hard rock, and under confined to semi confined conditions in the fractured rock. Since the district is covered predominantly by black cotton soils which inhibit percolation and circulation of water, there are pockets of poor quality ground water in the area. Geomorphologically, continuous range of hills are absent in the district but a few cluster of hills are seen towards east, west, northwest, centre, and southwest. Hydrogeological studies are important in assessing the quality of groundwater as attempted from the works of Acheampong and Hess (1998), CGWB, SWR (2011), CGWB, SWR (2001), Correll (1998), Sravanthi and Sudarshan (1998), Edet (2005), Hegde and Kumaresan (2008), Jalali (2007), Kumar et al. (2007), Kumaresan and Hegde (2007), Mondal and Singh (2012), Sahu and Sikdar (2008), Narsimha and Sudarshan (2013) and Venkatayogi (2015).

MATERIALS AND METHODS

A total of 20 groundwater samples from open wells, bore wells and a lake of the study area were collected during March-April 2016. The location of the collected groundwater samples is shown in Table 1. The samples were analyzed for water quality to assess chemical and mineralogical composition of the samples. The analytical data of groundwater samples of the area are presented in Table 2. Contour maps for chloride, nitrate, iron, fluoride concentration, pH, EC and Total Hardness (TH) were prepared to spatially relate the distribution level of groundwater quality and are shown in (Figures 2- 9).

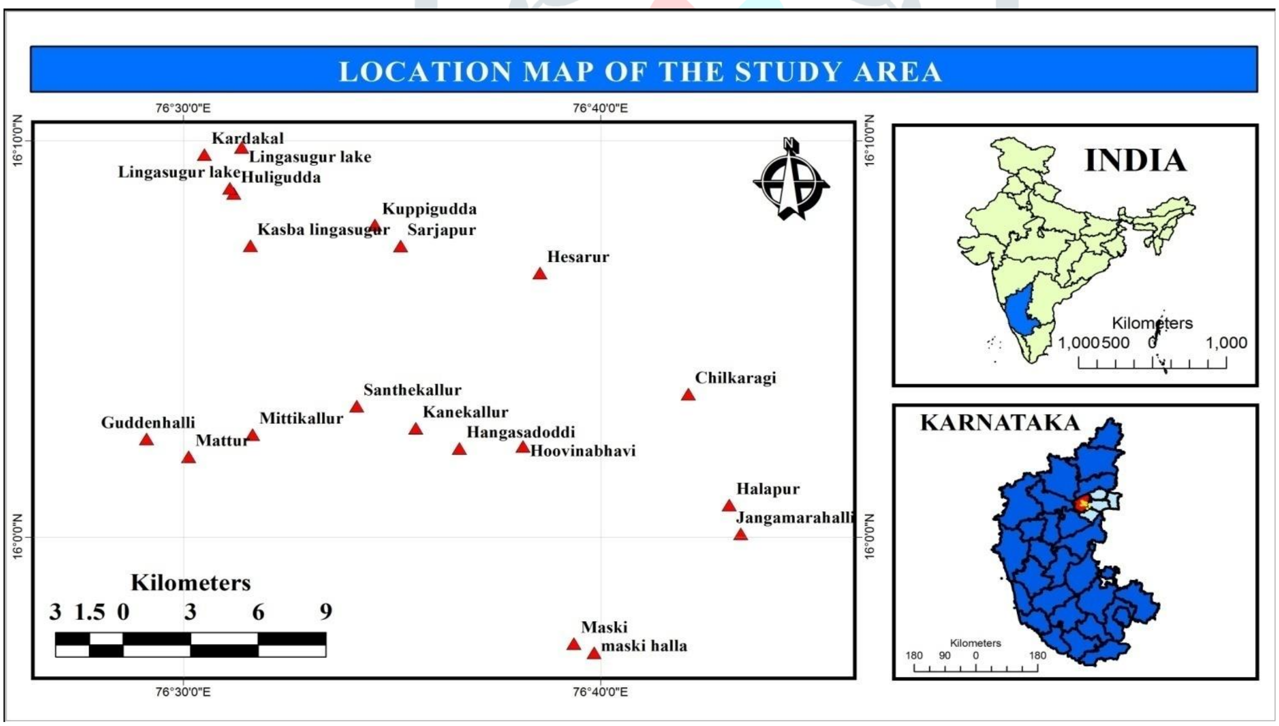

Figure 1 Ground water sampling sites in Lingasugur Taluk

Table 1. Showing sampling point, well type

Sl. No.	Sample Location	Latitude	Longitude	No. of SL	Type
1	Maski	076^{0}39.281'	15^{0}57.196'	1	Borewell
2	Maski halla	076^{0}39.766'	15^{0}56.961'	1	water body
3	Hoovinabhavi	076^{0}38.065'	16^{0}02.293'	1	Borewell
4	Hangasadoddi	076^{0}36.545'	16^{0}02.243'	1	Borewell
5	Kanekallur	076^{0}35.499'	16^{0}02.754'	1	Borewell
6	Santhekallur	076^{0}34.091'	16^{0}03.317'	1	Borewell
7	Mittikallur	076^{0}31.595'	16^{0}02.595'	1	Borewell
8	Mattur	076^{0}30.067'	16^{0}02.033'	1	Openwell
9	Guddenhalli	076^{0}29.063'	16^{0}02.483'	1	Borewell
10	Kasba Lingasugur	076^{0}31.546'	16^{0}07.378'	1	Borewell
11	Huligudda	076^{0}31.146'	16^{0}08.708'	1	Openwell
12	Lingasugur lake	076^{0}31.053'	16^{0}08.834'	1	Lake
13	Kardakal	076^{0}30.445'	16^{0}09.692'	1	Borewell
14	Lingasugur	076^{0}31.339'	16^{0}09.872'	1	Borewell
15	Kuppigudda	076^{0}34.525'	16^{0}07.905'	1	Borewell
16	Sarjapur	076^{0}35.139'	16^{0}07.373'	1	Borewell
17	Hesarur	076^{0}38.471'	16^{0}06.689'	1	Borewell
18	Chilkaragi	076^{0}42.015'	16^{0}03.619'	1	Borewell
19	Halapur	076^{0}42.998'	16^{0}00.808'	1	Borewell
20	Jangamarahalli	076^{0}43.271'	16^{0}00.820'	1	Borewell

Table 2 Physico-Chemical characteristics of ground water in lingasugur taluk.

VILLAGE NAME	SL.No	HARDNESS (mg/l)	ALKALINITY (mg/l)	CHLORIDES (mg/l)	FLUORIDES (%)	IRON (%)	pH	NITRATES (%)	TDS (mg/l)
1.Maski	1	500	300	275	1.5	ND	6.5	20	928
2.Maski halla	2	175	225	125	1.5	ND	7.5	10	416
3.Hoovinabhavi	3	425	300	250	2	0.3	8.0	10	117
4.Hangasadoddi	4	300	275	250	3	ND	7.5	10	900
5.Kanekallur	5	175	250	100	2.0	0.3	7.5	20	447
6.Santhekallur	6	500	375	550	3	0.3	8.5	30	166
7.Mittikallur	7	275	250	175	2.0	ND	8.0	10	466
8.Mattur	8	525	250	175	2.0	0.5	7.5	20	739
9.Guddenhalli	9	325	175	150	3.0	0.5	8.0	10	491
10.KasbaLingasugur	10	200	125	100	1.0	ND	7.0	ND	170
11.Huligudda	11	250	550	125	2.0	ND	8	10	409
12.Lingasugur lake	12	300	275	150	2.0	ND	8.5	10	541
13.Kardakal	13	400	375	425	1.5	0.5	8.0	40	147
14.Lingasugur	14	225	150	125	1.0	0.3	ND	10	172
15.Kuppigudda	15	ND	500	500	3.0	ND	8.5	30	233
16.Sarjapur	16	ND	875	875	3.0	ND	8.5	40	275
17.Hesarur	17	ND	275	275	0.5	ND	8.5	10	106
18.Chilkaragi	18	ND	400	400	1.5	0.5	8.5	10	177
19.Halapur	19	125	500	100	3	ND	6.5	10	654
20.Jangamarahalli	20	225	200	100	2	ND	7.5	30	609
Mean		246.25	331.25	261.25	2.03	0.16	7.43	17	408.15
Max		525	875	875	3	3.2	8.5	40	928
Min		ND	125	100	0.5	ND	ND	ND	106

RESULTS AND DISCUSSION

Groundwater samples from the study area were found to be lower concentrations of hardness, moderate to high alkalinity, and highly rich in fluoride concentrations. Higher amounts of fluoride were found in the drinking water of the study area and almost 80% of the samples are threating to be potable to the general public.

Hardness

The total hardness values were in the range from 125 to 525 mg/l. The samples showed low to moderate hardness in the groundwater (Figure 2). The principal source of the hard water is calcium and magnesium carbonates (Wiener 2000), the hardness graph trends show a tremendous low in the hardness content.

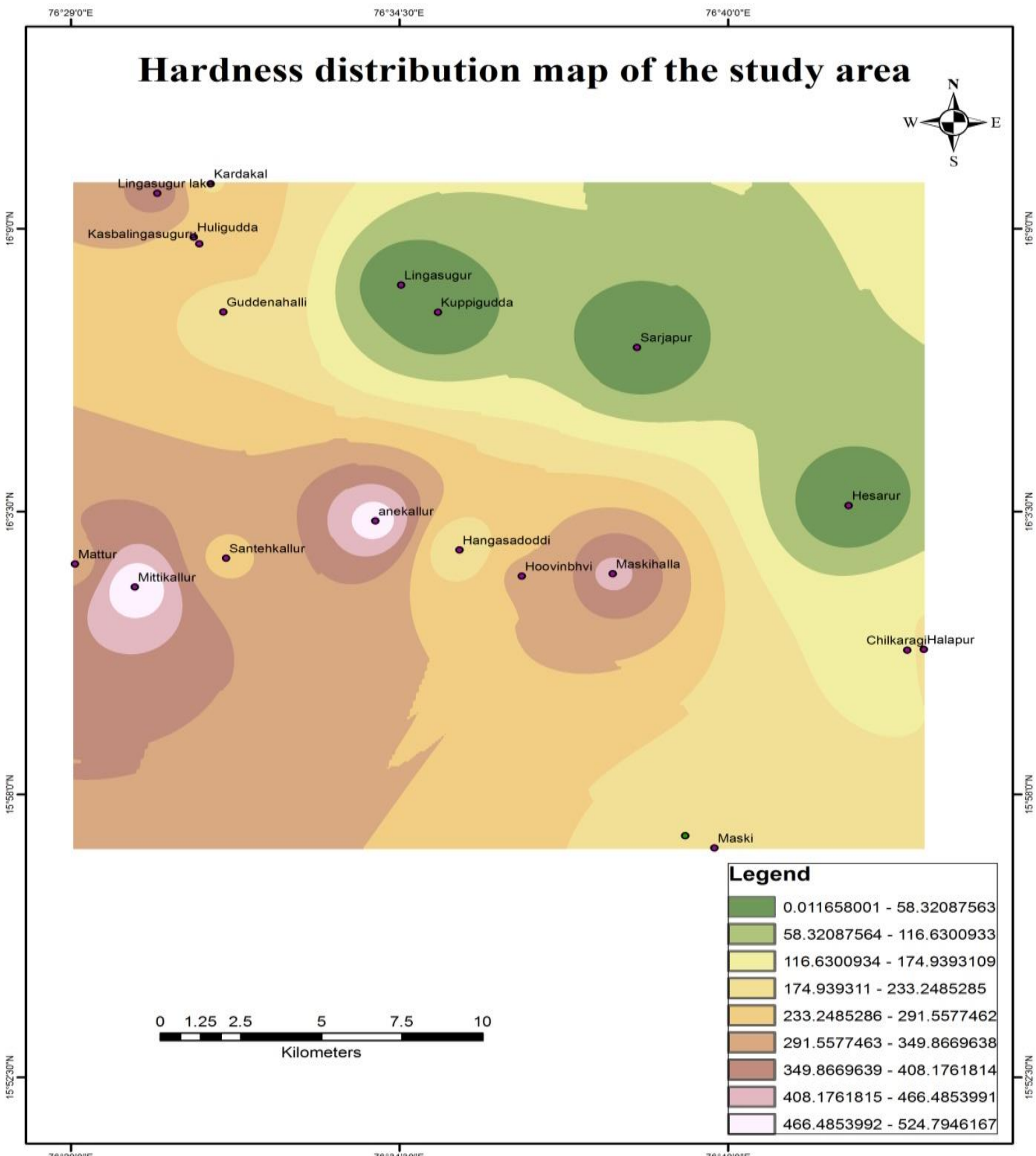

Figure 2 Geospatial distribution of Hardness concentration (ppm) in the study area

Alkalinity

The pH value in groundwater from deeper depth ranges were found between 6.5 to 8.5 and that indicated the high alkaline nature and are not suitable for drinking unless with proper measures. The recommended range of alkalinity for drinking water is 30 to 400 mg/l. A minimum level of alkalinity is desirable because it is considered as a buffer that prevents large variations in pH. Moderately alkaline water > 350 mg/l in combination with hardness forms a layer of calcium or magnesium carbonate that tends to inhibit corrosion of metal piping. Figure 3 shows the alkalinity content with the peaks of highs and lows.

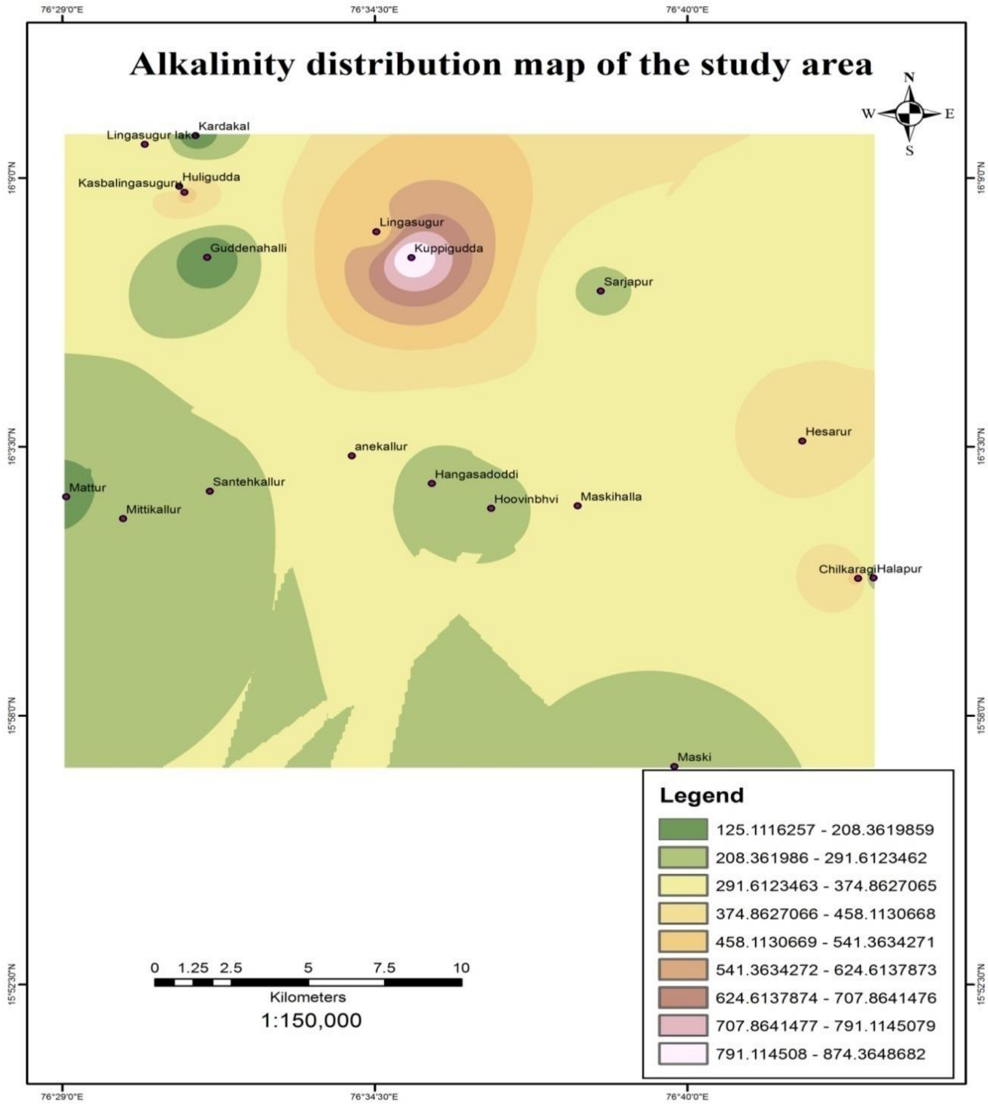

Figure 3 Geospatial distribution of Alkalinity concentration (ppm) in the study

Chloride

The chloride analysis results of Lingasugur taluk is shown in Table 2. It was observed that about 35% of samples based on Chloride concentrations falls under <150 mg/l category. Whereas, 55% of the samples were having chloride concentrations between 150 mg/l to 500 mg/l and 10% of the samples indicated chloride concentration >500 mg/l. The 1 out of 20 samples, highest value (875 mg/l) identified at station number 16, Sarjapur. So, the groundwater based on chloride concentration in Lingasugur taluk was good and were suitable for agricultural purposes. Figure 4 shows the distribution of chloride.

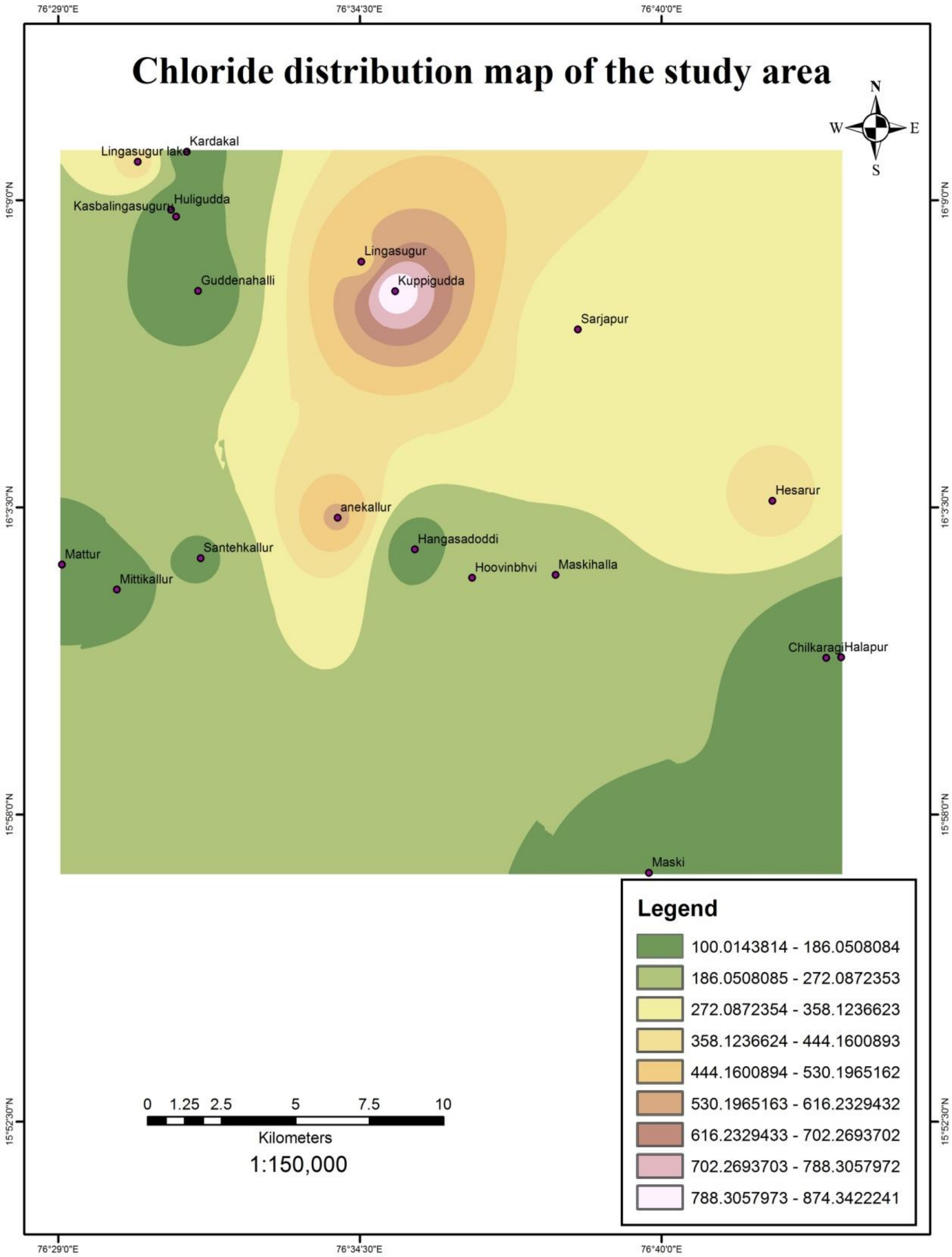

Figure 4 Geospatial distribution of chloride concentration (ppm) in the study area

Fluoride

Rock- water interaction is the main process in which fluoride rich minerals are decomposed and dissociated from the source rocks and dissolved in the ground water. Among all the fluoride rich minerals Fluorite (CaF_2) is the most abundant and occurs in almost all rocks and detrital minerals. Fluoride (Figure 5) in groundwater ranges in the area from 0.5 to 3 %. The fluoride occurrence in groundwater is geogenic in nature and is mainly associated with fluoride bearing minerals in younger granitic formations. It was observed to be lesser in gneisses. Out of the analysed 20 samples, almost all the samples showed very high fluoride concentrations and the values are above the permissible limit i.e. 1.5 mg/l. Since the area is predominant with the occurrence of granites and gneiss, the area is rich in fluorides.

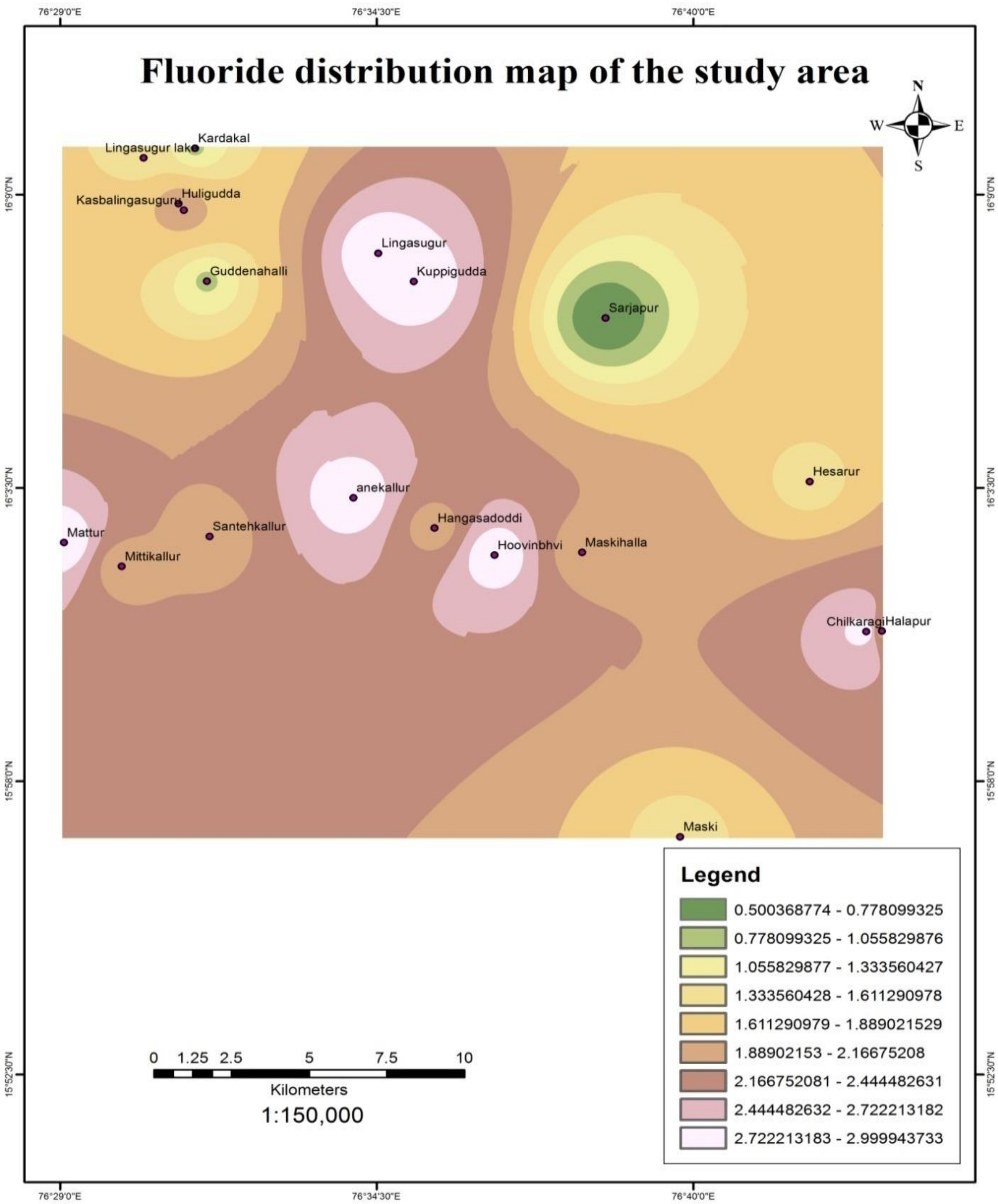

Figure 5 Geospatial distribution of fluoride concentration (ppm) in the study

Iron

Iron is frequently found in water due to large deposits in the earth's surface. Iron can be also introduced into drinking water from pipes in the water distribution system in the presence of hydrogen sulphide, cause the sediment to form that may give blackish colour. According to the BIS standard, (1991) 0 - 0.3 mg/l is acceptable, 0.3 – 1.0 mg/l satisfactory (however may cause staining and objectionable taste), over 1.0 it is unsatisfactory. Here in 20 stations, the highest iron content is occurred in Mattur, Guddenhalli, Kardakal, chilkaragi is 0.5 %. The lowest is observed in 12 villages (maski, maski halla, hangasadoddi, mittikallur, kasbalingasugur, huligudda, lingasugur lake, kuppigudda, sarjapur, hesarur, halapur, jangamarahalli) (Figure 6).

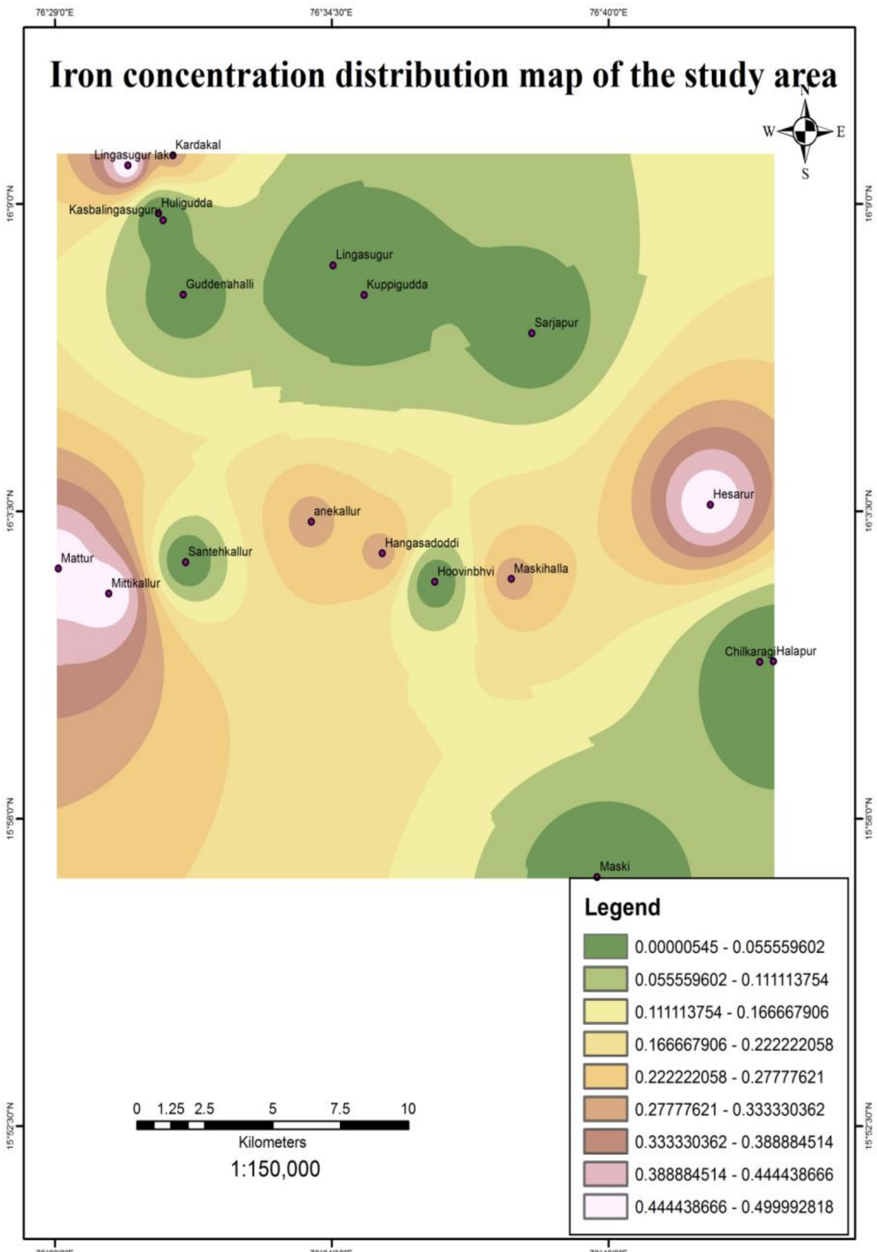

Figure 6 Geospatial distribution of Iron concentration (ppm) in the study area

pH

pH value is an important factor in maintaining carbonate and bio carbonates levels in water. pH is a term used to indicate the alkalinity and acidity of a substance. The pH values in the study area are recorded within the range of 0 – 8.5 for the groundwater samples of the 20 stations. The pH values are found to within the permissible limit of 6.5-8.5 according to the BIS Standards, (1991). The concentrations of Hydrogen ions were considered as an indicator of overall productivity that causes habitat diversity. The pH was observed to declining during winter and increasing during the summer as is evident from the mean values 7. The lower value of pH during rainy season compared to summer may be due to dilution of alkaline substance. The slight alkalinity may be due to the presence of bicarbonate ions, which are produced by the free combination of CO_2 with water to form carbonic acid, which affects the pH of the water, Carbonic acid (H_2CO_3) dissociates partly to produce (H^+) and bicarbonate ions. Here the highest level of pH range had seen to be in 6 villages (Santhekallur, Lingasugur lake, Kuppigudda, Sarjapur, Hesarur, Chilkaragi) with the value of 8.5. The mild alkalinity indicates the presence of weak basic salts in the soil. The low pH does not cause any harmful effect. The trend of the pH shows not much variation and exemplified in the (Figure 7).

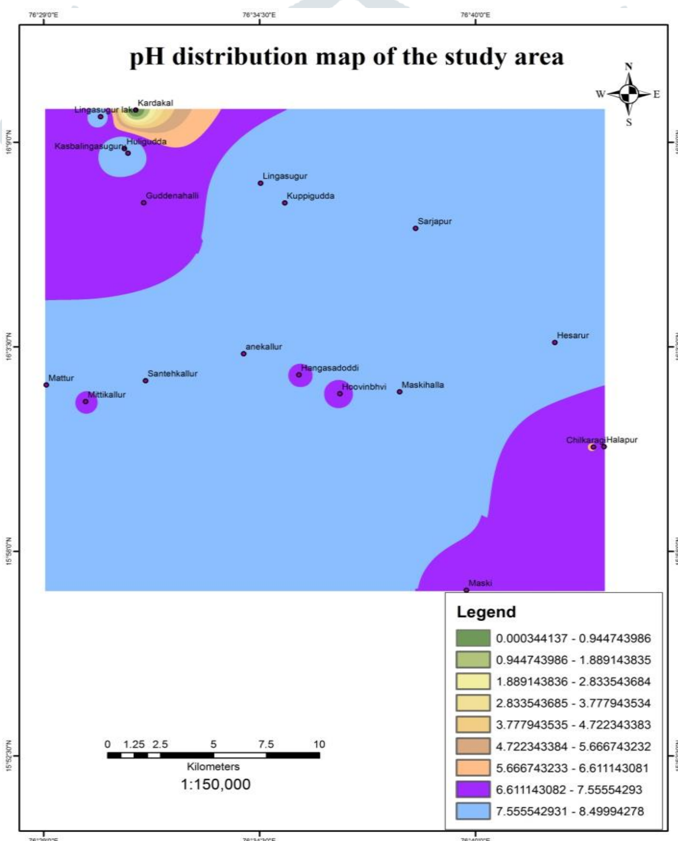

Fig.7 Geospatial distribution of pH concentration in the study area

Nitrate

In study area, nitrate concentration in the water samples represented the values less than permissible limits of 45 % according to the BIS standard, (1991). This indicated that the anthropogenic influences are minimal in ground water (Bhoominathan et al., 2012). High concentration of nitrate > 1- 2 mg/L in ground water will be the result of manure seepage and fertilizers through improper agricultural practice. Higher values of nitrate content are noticed in two villages (Kardakal and Sarjapur) was 40%. The plot represented the variation of nitrate within the intervals (Figure 8).

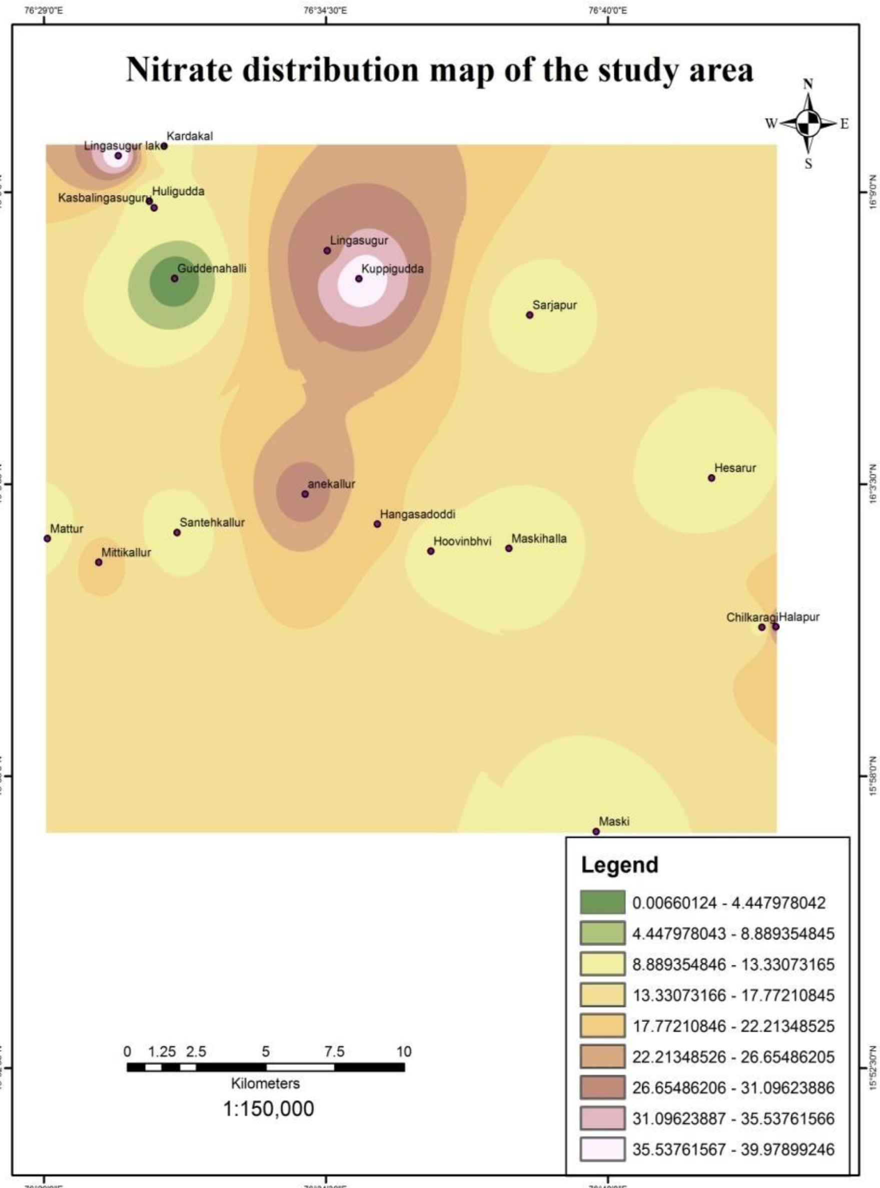

Figure 8 Geospatial distribution of nitrate concentration (ppm) in the study area

TDS

Total dissolved solids are an important parameter which imparts a peculiar taste to water and reduce its potability. TDS is the term used to describe the inorganic salts and small amount of organic matter present in solution of water. TDS values of water samples are within the highest desirable or maximum permissible limit set by WHO. According to the BIS standard, (1991), the TDS level is 1000 – 2000 mg/l. Total dissolved solids are found within the range of 928-106 mg/l. The high values shown in village are 928 mg/l at Maski and the lower is 106 mg/l at Kuppigudda. The high content of dissolved solids increases the density of water and influences osmoregulation of fresh water organisms. The Figure 9 shows there is some slight raise in TDS content in the Maski sample station.

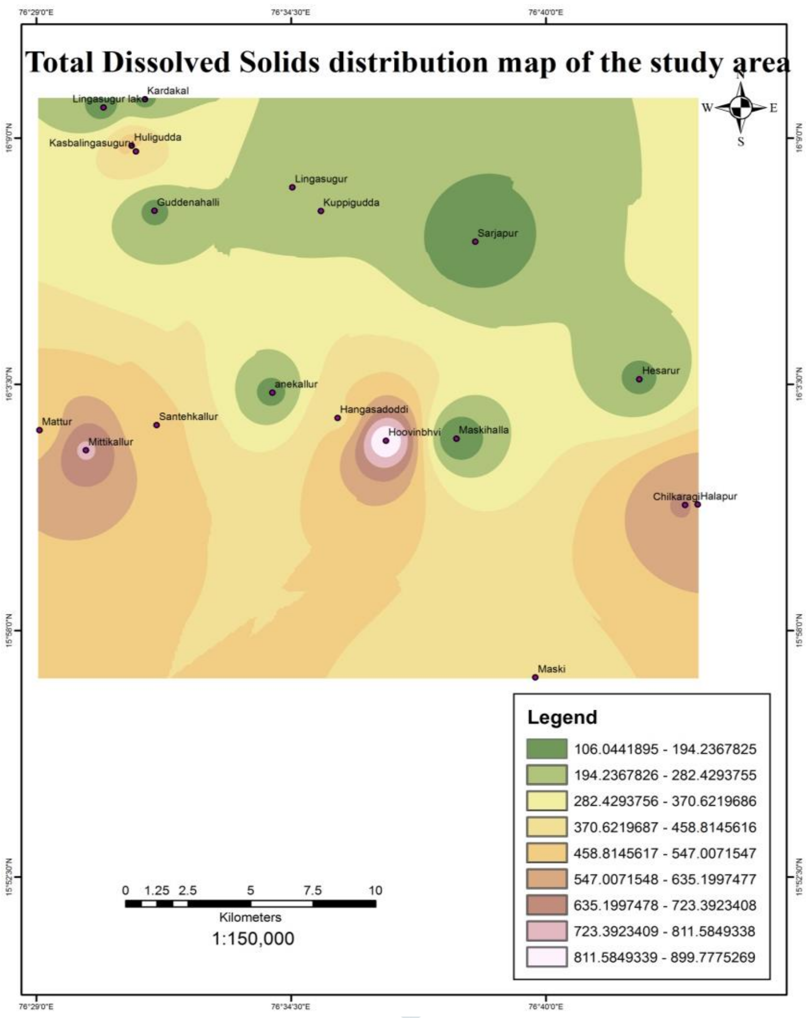

Figure 9 Geospatial distribution of Total Dissolved Solids in the study area

Water Quality Index

Water Quality Index serves as an effective tool to communicate the real time information related to the susceptible damage of water from ground water 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).

To compute WQI, We have to follow three steps

1. The first step involves calculation of weightage factor and calculation of relative weightage factor using the following formulae (Table 3 and 4).
2. The second step involves calculation of quality rating scale and calculation of sub

index of parameters and calculation of WQI.

3. The third step is a decision taking step. I.e., 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 5).

The value of Water quality index is found to be 185.73; hence it said to be poor quality according to WQI standard (Table 5).

Table 3 Following formulas were used to calculate various indices

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

Table 4 water Quality Index for the study area in Lingasugur Taluq, *Raichur*

S.No.	Chemical Parameters	BIS	Weightage (wi)	Relative Weightage (Wi)	Quality Rating (Qi)	Sub Index (SIi)
1	pH	6.5-8.5	4	0.13	87.35	11.65
2	TDS	500-2000	4	0.13	20.41	2.72
3	Alkalinity	600	3	0.10	243.43	24.34
4	Iron	0.3-1.0	4	0.13	16.00	2.13
5	Nitrate	45-100	5	0.17	17.00	2.83
6	Flouride	1-1.5	4	1.00	135.33	135.33
7	Hardness	300-600	3	0.10	41.04	4.10
8	Chloride	250-1000	3	0.10	26.13	2.61
			Σwi =30	**ΣWi =1.87**	**ΣQi=586.69**	**ΣSIi=185.73**

Table 5 Water Quality Index

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

Geospatial Analysis

Geospatial distribution maps of potable drinking water to villages were prepared from the obtained results to resolve the issue of drinking water scenario in the present study area. Two maps were prepared to make the following decision making processes for the drinking water supply authority of Lingasuguru Taluk. Accordingly 5 kilometre buffer map and 3 kilometres buffer maps were prepared to take immediate action in the area as represented in Figures 10 and 11 respectively. 5 kilometre buffer map is an indicative for supply of best potable water for the villages within the limit of 5 kms from the 5 parameters satisfying drinking water wells. 3 kilometre buffer map indicates the possibility of supply of drinking water to villages within the 3 kms buffer of 5 parameters satisfying drinking water wells. Accordingly 12 villages were falling under 5 kms buffer zone and 15 villages were falling under 3 kms buffer zone. Hence, it promises that, it is possible to maintain the health of public community by adopting this system of drinking water supply in Lingasuguru Taluk.

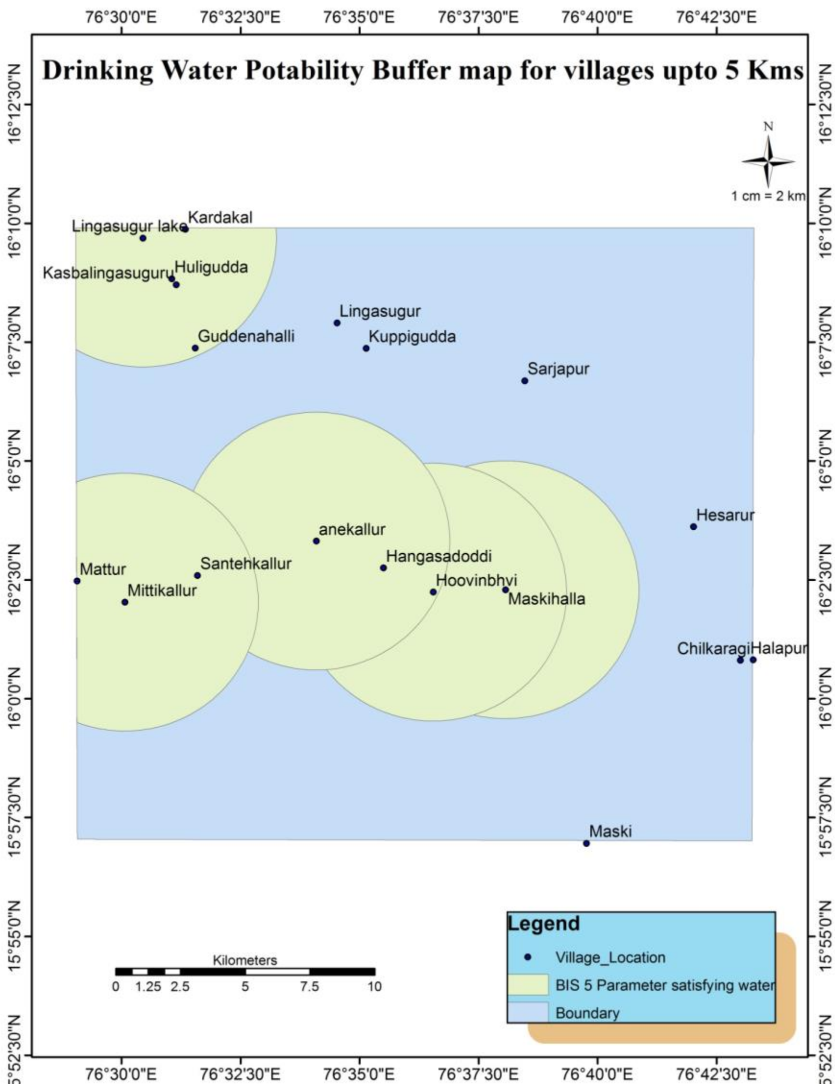

Figure 10 Drinking water supply for villages based on 5 parameters according to 5 km buffer zone.

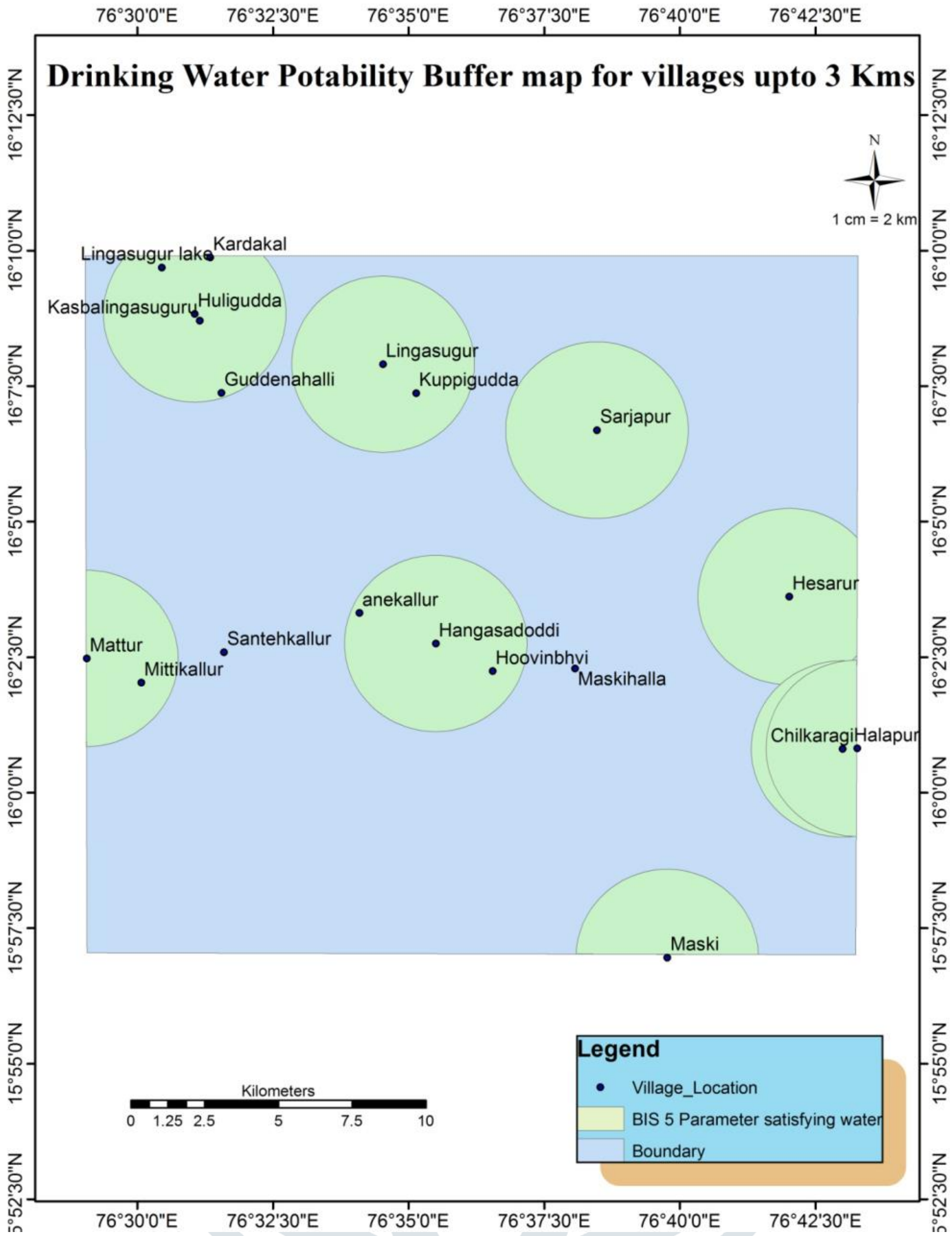

Figure 11 Drinking water supply for villages based on 3 parameters according to 3 km buffer zone.

Conclusion

The chemical analysis of groundwater samples illustrated the present groundwater quality of Lingasuguru Taluk. The results indicated that the groundwater is suitable for irrigation purposes but not permissible for drinking without proper treatment. The geospatial analysis results of the study area shows higher concentration of pH recorded in few parts of northern, north-eastern and southern region. The high values of TDS (928 mg/l) shown in Maski village and the lowest value is 106 mg/l at Hesarur. The northern part of the study area show more concentration of the TDS. Water quality of the villages that shows higher alkalinity, extreme hardness, rich in chloride, salinity and high fluoride content have to be used for industrial or agricultural purpose. Antrhopogenetic activities were found to be nil in the study area. Accumulation of various ions present in the ground water could be due to intense chemical weathering which leached away the ions from the country rocks, probably granitoid. Maski halla, Kanekallur, Mittikallur, Huligudda, Hesarur, Chilkaragi, Jangamarahalli village samples were satisfying 5 parameters. This indicates the potable nature of drinking water. Kasba lingasugur, Ligasugur, are the two wells satisfying the 7 parameters even though most of the samples represented with non-potable nature of groundwater samples, it is immediate to take appropriate measures as the study area falls under the drought prone region of Raichur district. Maski halla, Kanekallur, Mittikallur, Huligudda, Hesarur, Chilkaragi, Jangamarahalli, Kasba lingasugur, and Lingasugur have permissible fluoride concentration indicated that it is possible to maintain the health of public community by adopting this system of drinking water supply in Lingasuguru Taluk.

References

1. Acheampong S.Y., Hess J.W. (1998) Hydrogeological and hydrochemical framework of the shallow groundwater system in the southern Voltaian sedimentary basin, Ghana. Hydrogeology Journal, Vol.6, pp. 527–537.
2. BIS standard, (1991). Specifications for Drinking Water, IS:10500. (1991). Bureau of Indian Standards, New Delhi.
3. Boominathan. M, Karthick. B, Sameer Ali and Ramachandra, T.V., 2012. Spatial Assessment of Groundwater Quality in Kerala, India., The IUP Journal of Soil and Water Sciences, 5 (1).
4. CGWB, SWR. (2011) Rainfall data analysis of Karnataka, Unpublished Report, Central Groundwater Board. CGWB,
5. SWR. (2001) Groundwater Exploration Report, Karnataka, Unpublished Report, Central Groundwater Board.
6. Correll, D.L. (1998) The role of Phosphorus in the eutrophication of receiving waters: A review. Journal of Environmental Quality, Vol. 27, pp. 261-166.
7. Edet A., Okereke C. (2005) Hydrogeological and hydrochemical character of the regolith aquifer, northern Obudu Plateau, southern Nigeria, Hydrogeology journal, Vol. 13, pp.391–415.
8. Hegde S.S. and Kumaresan K. (2008) Fluoride in the Deeper Crystalline Aquifers in drought affected areas in parts of Karnataka – Occurrence and remedial measures. Geological Society of India Golden Jubilee Volume, No. 69, pp. 264-287.
9. Jalali M. (2007). Hydrochemical identification of groundwater resources and their changes under the impacts of human activity in the Chah Basin in Western Iran. Environmental Monitoring Assessment, Vol.130, pp.347–364.
10. Kumar M., Kumari K., Ramanathan A., Saxena R. (2007) A comparative evaluation of groundwater suitability for irrigation and drinking purposes in two intensively cultivated districts of Punjab, India. Environmental Geology, Vol. 53, pp.553–574.
11. Kumaresan K. and Hegde S.S.(2007) Specific Yield Determination in Nangli Well Field, Kolar district, Karnataka – A case study. Proc. National seminar on Agriculture development and Rural drinking water, April 2007, Bhopal AICGWBOA, pp. 1-7.
12. Mondal, N.C. and V.P. Singh (2012) Chloride migration in groundwater for a tannery belt in southern India. Environmental Monitoring Assessment, Vol. 184, No.5, pp.2857-2879.
13. Mishra, P.C. and R.K. Patel. (2001). Study of the pollution load in the drinking water of Rairangpur, a small tribal dominated town of North Orissa. Indian J. Environment and Ecoplanning.5 (2):293-298.
14. Mufid al-hadith. (2012). Application of water quality index to assess suitability of groundwater quality for drinking purposes in Ratmao –Pathri Rao watershed, Haridwar District, India, American Journal of Scientific and Industrial Research, 2012, 3(6): 395-40.
15. Narsimha, A. and Sudarshan, V. (2013) Hydrogeochemistry of groundwater in Basara area, Adilabad District, Andhra Pradesh, India. Journal of Applied Geochemistry, Vol. 15 (2), pp. 224-237. Sahu P. Sikdar P.K. (2008) Hydrochemical framework of the aquifer in and around East Kolkata wetlands, West Bengal, India, Environmental Geology, Vol. 55, pp.823–835.
16. Ramakrishnaiah, C.R., Sadashivaiah, C., And Ranganna, G. (2009). Assessment of Water Quality Index for The Groundwater in Tumkur Taluk, Karnataka State, India, E-Journal of Chemistry, 6(2), 523-530.
17. Sravanthi, K. and Sudarshan, V. (1998) Geochemistry of groundwater, Nacharam industrial area, Ranga Reddy district, AP, India, J. Env. Geochem, Vol. 1 (2), pp. 81-88.

18. Srinivas Kushtagi and Padaki Srinivas. (2011). Studies on water quality index of ground water in Aland taluk, Gulbaga district, Karnataka,International journal of applied biology and pharmaceutical Technology 2(4), 252- 256.
19. Srinivas Rao. G, Nageswararao .G. (2013). Assessment of Groundwater quality using Water Quality Index, Arch. Environ. Sci. 7, 1-5.
20. Tiwari, T.N. and M.A. Mishra. (1985). A preliminary assignment of water quality index of major Indian rivers. Indian J. Environmental Protection.5: 276-279.
21. Vasanthavigar, M., K. Srinivasamoorthy, K. Vijayaragavan, R. Rajiv Ganthi, S. Chidambaram, P. Anandhan, R. Manivannan, and S. Vasudevan. (2010)0. Application of water quality index for groundwater quality assessment: Thirumanimuttar sub-basin, Tamilnadu, India. Environmental Monitoring Assessment, 171:595–609. doi: 10.1007/s10661-009-1302-1.

22. Venkatayogi, S. (2015) Geochemistry of Fluoride Bearing Groundwater in Parts of Telangana State, India. Journal of Water Resource and Hydraulic Engineering, Vol. 4 (4), pp. 380-387.