

# Spatial Distribution Pattern of Fluoride and Nitrate in Groundwater Using Advanced Technical Tool - A GIS Approach

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**Abstract** In order to detect the fluoride and nitrate content of the ground water in Koppal city in Karnataka, India and also for its spatial distribution mapping, an experimental work was taken up by selecting 25 bore wells from different stations in and around Koppal city. Ground water samples were collected for both pre-monsoon and post-monsoon seasons and fluoride and nitrate was detected using standard methodology. Locations and altitudes of the selected bore wells were also noted using GPS instrument. Fluoride and Nitrate content, its spatial distribution mapping has been drawn using advanced technical tool (GIS) for the study area. Spatial map has been prepared using an inverse distance weighting technique, which indicates the fluoride and Nitrate content in the study area. The maximum content fluoride was noticed in the Hemareddi Mallamma Nagar, KGW-11 (3.77mg/L) while the minimum was observed in Chikkabaganal, KGW-1(0.97 mg/L). The maximum content of Nitrate was recorded in the Veerapur, KGW-16 (73.98 mg/L) but Dadegal, KGW-13 (13.08 mg/L) showed minimum during the study period.

**Keywords:** fluoride, nitrate, spatial distribution, GIS

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## 1. Introduction

Water is very dynamic in nature and can be a warning resource human beings and other life. Without a good water supply, it is tough to lead a fruitful life and also other life supporting human activities. The quality of water is very significant to create good water supply to the residence and community. Water quality is encouraged by natural and man-made changes counting weather condition, geological variables and irrigation practices. About 200 million people are at risk in world due to fluoride and contamination in drinking water [1]. Other research work done and published extensive studies on contamination water due to fluoride content [2-8].

Nitrate is a significant variable in apprising ground water contamination due to various sources. It also called as indicator to appraise ground water vulnerability to contamination [10]. Nitrates are used in the manufacturing of fertilizers and also to develop from the oxidation of nitrogen and ammonium complexes found in waste-waters. Nitrate present in the waste water is also effects on human body, especially in pregnant women and the children's [11] if the content is more than limit for drinking.

The World Health Organization (WHO) has set a guideline value for Fluoride and nitrate in drinking water of 1.5 mg/L and 50 mg/l as Fluoride and nitrate ion respectively. Fluorosis is a crippling disease due to deposition of fluoride on rigid and soft tissues of body. It is a community health problem caused by additional intake of fluoride through drinking water and food products also due to industrial contaminates over a long period. Intrusion of excess fluoride, maximum group of residence in drinking-water causes the teeth and bones [9]. The Nitrate is based on epidemiological disease like evidence for methaemoglobinaemia due to usage of nitrate contaminated water in equally vulnerable population groups [12]. It is predictable that the conclusions of this work could help to advance effective strategies for integrated water resource management, especially by providing scientific research for decision and management of groundwater sources used for drinking water supply. Materials and Methodology.

### 1.1. Study Area

The area selected for study is situated in Karnataka State, new born city southern end of India. Koppal is surrounded on three borders by hills. It consists historical

landmarks such as the Koppal Fort, the Gavimath and the Malle Mallappa Temple. The region covers about 7,190 km<sup>2</sup> area in and around Karnataka state and lies between the longitudes 15°09'00" to 16°03'30" North Latitude and 75°47'30" to 76°48'10" East Longitude (Figure 1). In the south, the Tungabhadra reservoir present in a distance of about 23 km from the study area. Koppal town and its surroundings commonly called as ‘‘Kopan Nagara’’ has an average elevation of about 529 m above the mean sea level, city is surrounded by hills and lush green paddy field. The average annual normal rainfall of this district is 572 mm. (Ground water Board Booklet).

## 2. Methodology

In the current study, groundwater samples collected from 25 bore wells, located in different villages of Koppal city. Bore wells locations along with their altitudes have been noted using GPS instrument (Table 1). All the selected wells were geographically located using a GPS device (GPSMAP 78S, GARMIN).

Water samples for nitrate estimation were controlled by adding concentrated H<sub>2</sub>SO<sub>4</sub> until to get pH less than 2, and stored at 4°C until the nitrate analysis was conducted. In the laboratory, nitrate were estimated using

spectrophotometric techniques.

The fluoride content was estimated electro-chemically, using fluoride ion selective electrode [13]. This technique is applicable to the measure fluoride in drinking water (0.01 - 10 mg/l). The electrode used to be an Orion fluoride electrode, coupled to an Orion electrometer. Standards fluoride solutions (0.1 - 10 mg/l) were prepared. 1 ml of total ionic strength adjusting buffer grade III (TISAB III) was used to measure and calibrate the instrument.

## 3. Result and Discussion

The groundwater over most of the localities occurs at medium depths. The groundwater levels were measured in all sampling locations. The groundwater level was predicted to vary between 2-6 m below ground level (bgl) during the study period. The water level varied between the two seasons. Since rainfall was the only key source for groundwater recharge, the rainfall pattern during the study period is given in Figure 2. Aquifers are replenished by the seepage of precipitation that falls on the land, but there are many geologic, meteorological, topographic, and human factors that determine the extent and rate to which aquifers are refilled with water (Gleick, 1996).

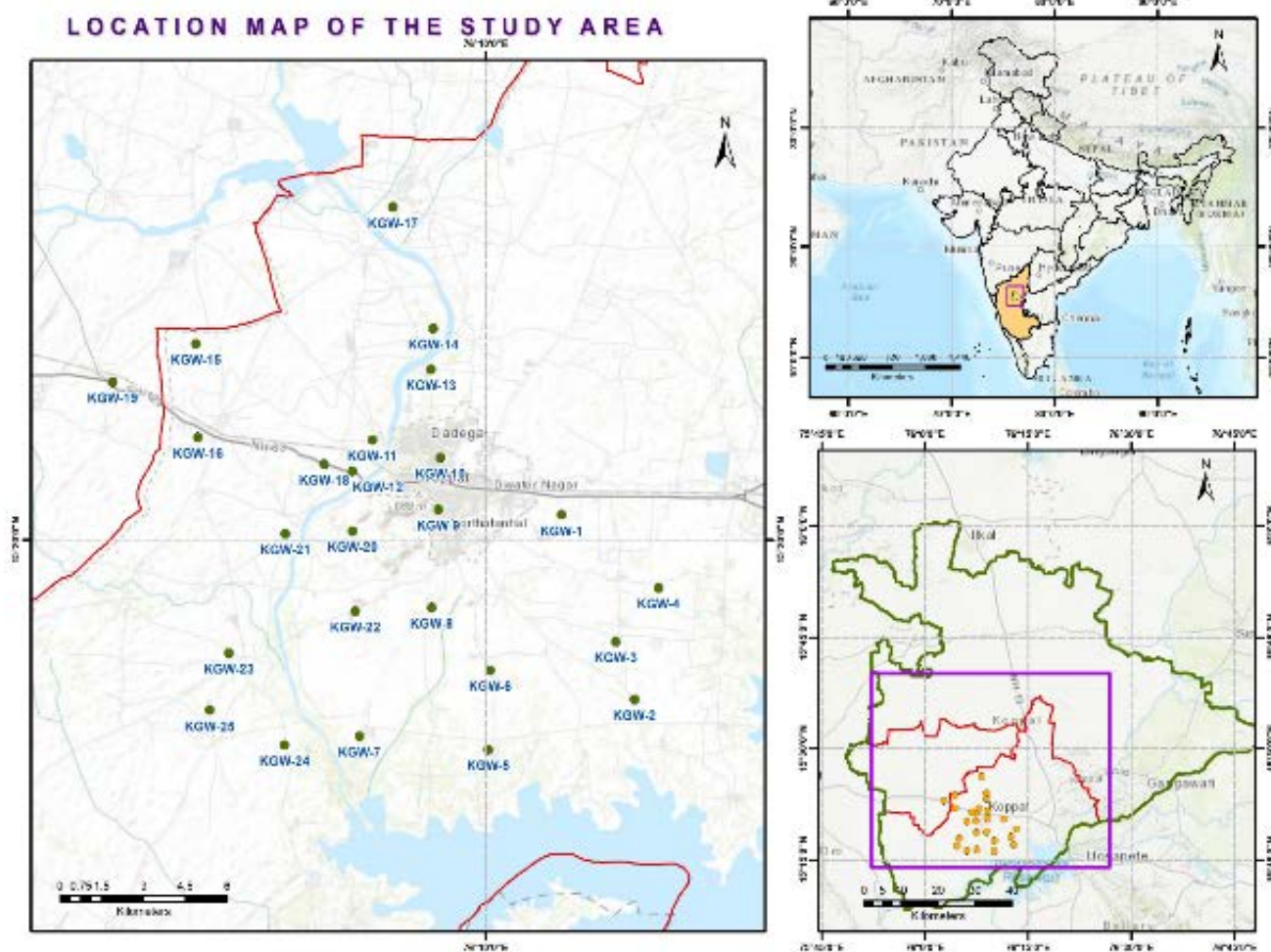


Figure 1. Study area with locations

Table 1. Details of Location with Geological properties of water

Sampling Location	Latitude	Longitude	Name of the Village	Elevation	Bore well		
					Depth	Age	Depth (mbgl)
KGW-1	15°16'31"N	76°14'41"E	Chikkabaganal	628	15.50	8	4-5
KGW-2	15°20'28"N	76°11'28"E	Belavinal	672	16.89	9	3-4
KGW-3	15°17'01"N	76°12'53"E	Kunikera	668	15.42	10	3-4
KGW-4	15°18'06"N	76°12'31"E	Kunikeri Thanda	664	16.89	12	3-4
KGW-5	15°19'06"N	76°13'21"E	Halavarati	686	17.20	5	4-5
KGW-6	15°16'05"N	76°10'03"E	Hyati	724	16.52	9	4-5
KGW-7	15°17'34"N	76°10'05"E	Hoshalli	718	12.56	7	3-4
KGW-8	15°16'20"N	76°07'33"E	Gondabal	710	14.52	12	2-3
KGW-9	15°18'44"N	76°08'57"E	Chukankal	698	13.89	10	2-3
KGW-10	15°20'34"N	76°09'05"E	Koppal City	664	11.23	9	4-5
KGW-11	15°21'32"N	76°09'07"E	Hemareddi Mallamma Nagar	656	11.56	5	4-5
KGW-12	15°21'52"N	76°07'48"E	Yettinhatti	689	12.89	7	3-4
KGW-13	15°21'17"N	76°07'25"E	Dadegal	721	12.69	6	3-4
KGW-14	15°23'11"N	76°08'56"E	Ojanhalli	720	13.45	8	5-6
KGW-15	15°23'57"N	76°08'59"E	Naregal	724	14.89	12	4-5
KGW-16	15°23'40"N	76°04'23"E	Veerapur	725	16.89	10	3-4
KGW-17	15°21'55"N	76°04'25"E	Halagere	718	17.56	6	2-3
KGW-18	15°26'13"N	76°08'12"E	Kinnal	719	18.56	9	2-3
KGW-19	15°21'25"N	76°06'52"E	Gadag-Koppal Road	724	17.23	4	3-4
KGW-20	15°22'57"N	76°02'46"E	Bhanapur	716	16.85	5	3-4
KGW-21	15°20'10"N	76°07'25"E	Mangalapur	717	14.52	3	4-5
KGW-22	15°20'07"N	76°06'07"E	Kolur	724	13.56	8	4-5
KGW-23	15°18'40"N	76°07'28"E	Gunhalli	720	12.89	9	4-5
KGW-24	15°17'53"N	76°05'01"E	Hiresindogi	719	11.89	10	5-6
KGW-25	15°16'10"N	76°06'06"E	Budihal	698	13.60	4	5-6

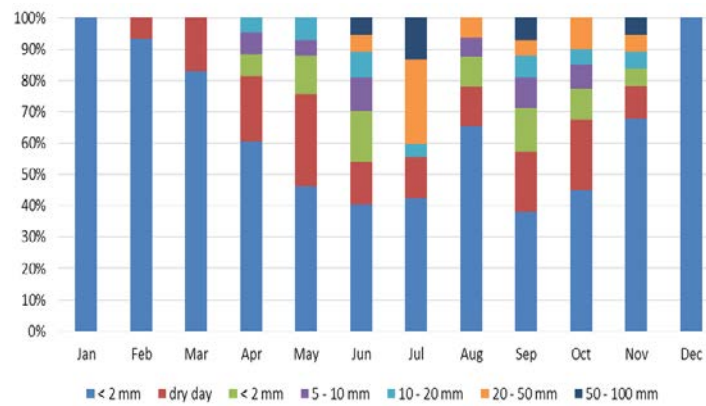


Figure 2. Rain fall patter of the Study area

From the experimental study, it is predicted that the Koppal city (Figure 3 and Figure 4) is affected by the fluoride content and also it is isolated within the areas.

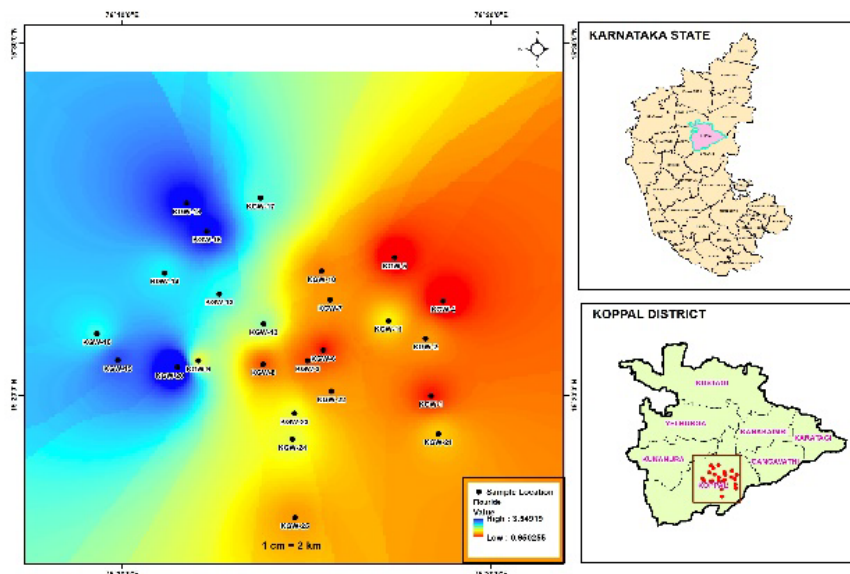


Figure 3. Spatial variation of Fluoride in Pre-monsoon season

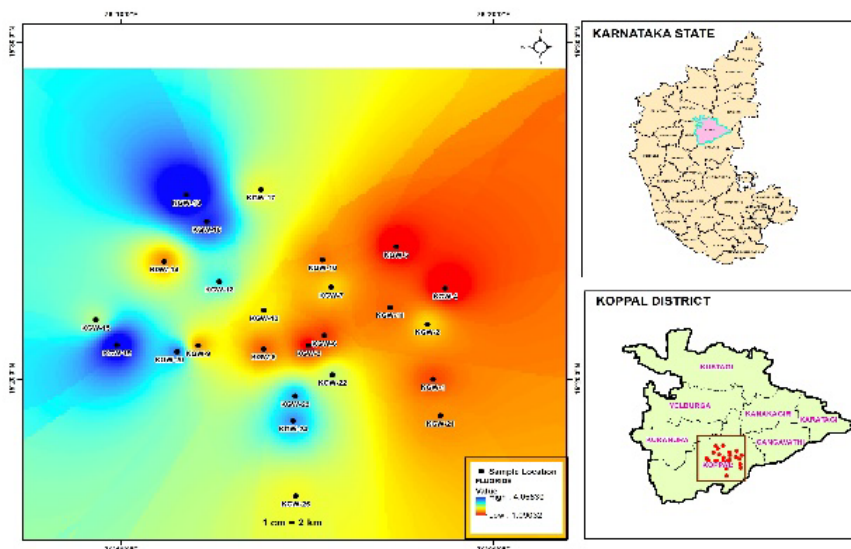


Figure 4. Spatial variation of Fluoride in Post-monsoon season

The areas except KGW-1, KGW-2, KGW-8 and KGW-20 all the sampling stations are having greater than 1.5 mg/L need specific consideration to identify appropriate ways to treat the water to provide good water sully including good health and societal inferences in them [14,15].

The areas like KGW-1, KGW-2, KGW-8, KGW-20 and KGW-21 during pre-monsoon but only two location KGW-1 and KGW-20 during post-monsoon are well within permissible limit of Fluoride in drinking water. However, the areas around Koppal city, Hemareddy Mallamma Nagar, Yettinhatti, Dadegal and Hiresindogi have shown fluoride content above 3.0 mg/l. The results predicts that the areas having fluoride content more than 1.5 mg/l certainly affect health of the community (Table 2).

Water containing nitrate contents above 45 mg/L is not suitable for human uses and its continuously used nitrate intake is related with different health situations. In Koppal city, the source for water is ground water due lack of

sewerage and drainage arrangements gives maximum vulnerable to man-made pollution. Out of 25 groundwater samples Nitrate contents varied from 13.08 and 73.98 during post-monsoon and 15.36 and 72.93 during in Dadagal (KGW-13) and Veerapaura (KGW-13) respectively. Nitrate always indirectly and directly depends upon the  $Cl^-$ ,  $SO_4^-$  and  $K^+$  chlorides, which may designate potential pollution from domestic and irrigational activities surrounding bore well water [11,16].

The spatial distribution of nitrate contents (Figure 5 and Figure 6) in the aquifer predicted that an enhancing trends in nitrates during the study period. From the health risk appraisal [17,18], it was noted that that children consumed at present nitrate values are at a maximum risk (HIMAX  $\frac{1}{4}$  1.30) than adults (HR < 1.0) [USEPA, 2001]] and hence, there is a strong necessity for executing actual approaches to control ground-water quality and to best management and switch nitrate contamination sources.

Table 2. Fluoride and Nitrate content of Ground Water Samples

Sampling Location	Name of the Village	Fluoride, mg/L		Nitrate, mg/L	
		Pre-Monsoon	Post-Monsoon	Pre-Monsoon	Post-Monsoon
KGW-1	Chikkabaganal	0.97	1.09	46.00	46.30
KGW-2	Belavinal	1.44	1.88	53.02	44.99
KGW-3	Kunikera	1.54	1.84	34.38	29.54
KGW-4	Kunikeri Thanda	2.44	2.23	37.68	27.97
KGW-5	Halavarati	2.68	2.88	33.73	43.72
KGW-6	Hyati	2.89	2.23	19.13	29.72
KGW-7	Hoshalli	1.51	1.95	24.72	20.44
KGW-8	Gondabal	1.49	2.23	19.53	19.62
KGW-9	Chukankal	2.51	2.15	20.60	20.75
KGW-10	Koppal City	3.32	2.64	42.17	21.09
KGW-11	Hemareddy Mallamma Nagar	3.77	3.41	44.72	20.13
KGW-12	Yettinhatti	3.45	2.65	31.98	37.66
KGW-13	Dadegal	3.12	3.01	15.36	13.08
KGW-14	Ojanhalli	1.70	2.69	17.29	17.40
KGW-15	Naregal	1.55	2.18	44.20	44.42
KGW-16	Veerapur	1.73	2.23	72.99	73.98
KGW-17	Halagere	1.54	2.07	43.72	44.09
KGW-18	Kinnal	3.42	2.23	56.46	56.82
KGW-19	Gadag-Koppal Road	1.70	2.17	52.32	52.55
KGW-20	Bhanapur	1.24	1.16	69.49	64.80
KGW-21	Mangalapur	1.54	2.20	21.18	21.28
KGW-22	Kolur	1.83	2.34	45.77	31.42
KGW-23	Gunhalli	2.70	1.95	41.66	41.85
KGW-24	Hiresindogi	3.05	2.68	25.27	35.65
KGW-25	Budihal	1.73	2.17	26.56	30.94

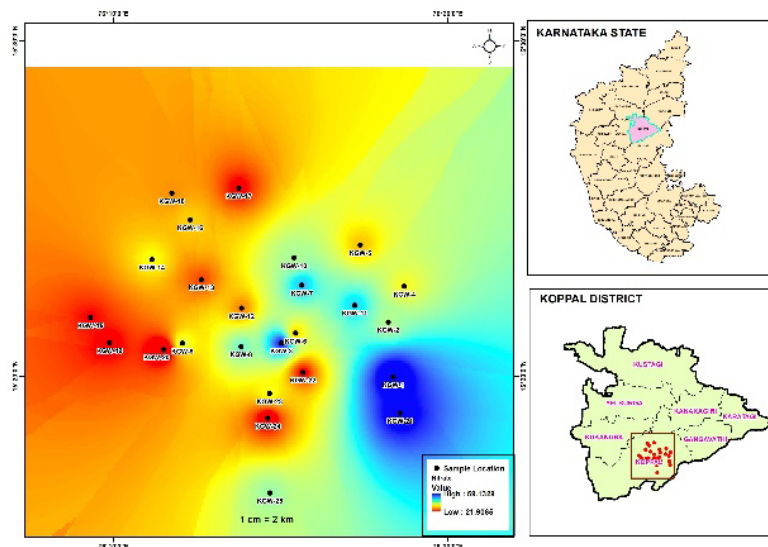


Figure 5. Spatial variation of Nitrate in Pre-monsoon season

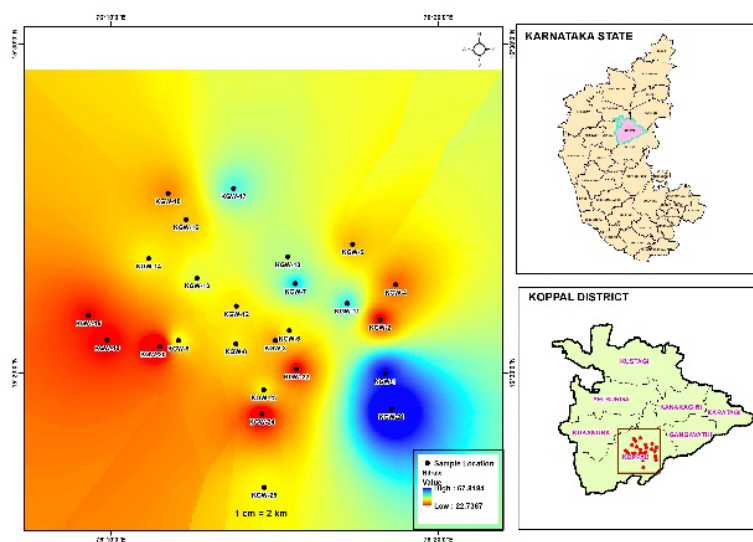


Figure 6. Spatial variation of Nitrate in Post-monsoon season

## 4. Conclusion

The lack of resources and low-cost efficient methodology suitable to the suffering communities control the development of an effective fluoride and fluorosis control and prevention program in developing nations.

- In the present study, the maximum content fluoride was noticed in the Hemareddi Mallamma Nagar, KGW-11 (3.77mg/L) while the minimum was observed in Chikkabaganal, KGW-1(0.97 mg/L). The maximum content of Nitrate was recorded in the Naregal, KGW-15 (44.42 mg/L) but Dedegal, KGW-13 (13.08 mg/L) showed minimum.
- Out of 25 groundwater samples Nitrate contents varied from 13.08 and 73.98 during post-monsoon and 15.36 and 72.93 during in Dadagal (KGW-13) and Veerapaura (KGW-13) correspondingly.
- However, it must be reflected that this values of fluoride and Nitrate is highly vulnerable to continuous usage changes states and present unsustainable socio-economic status in the area, which could decrease the quality of the groundwater.

## References

- [1] Ayoob, S. and Gupta, A.K. (2006). Fluoride in Drinking Water: A Review on the Status and Stress Effects. *Critical reviews in Environmental Science and Technology*, 36, 433-487.
- [2] Arif, M., Hussain, J., Hussain, I. and Neyol, S. (2011). Fluoride Contamination of Ground Water of Merta Block in Nagaur District, Rajasthan, India. *The Conference of Advance in Environmental Chemistry (AEC)*, Aizwal, 146-148.
- [3] Arif, M., Hussain, I., Hussain, J., Sharma, S. and Kumar, S. (2012). Fluoride in the Drinking Water of Nagaur Tehsil of Nagaur District, Rajasthan, India. *Bulletin of Environmental Contamination and Toxicology*, 88, 870-875.
- [4] Hussain, J., Sharma, K.C. and Hussain, I. (2005). Fluoride Distribution in Groundwater of Banera Tehsil in Bhilwara District, Rajasthan. *Asian Journal of Chemistry*, 17, 457-461.
- [5] Hussain, J., Shrama, K.C., Arif, M. and Hussain, I. (2007). Fluoride Distribution and Modelling Using Best Subset Procedure in Nagour District of Central Rajasthan, India. *The 27th Conference of the International Society for Fluoride Research (ISFR XXVII)*, Beijing.
- [6] Hussain, I., Arif, M. and Hussain, J. (2011). Fluoride Contamination in Drinking Water in Rural Habitations of CentralRajasthan, India. *Environmental Monitoring and Assessment*, 184, 5151-5158.
- [7] Sharma, K.C., Arif, M., Hussain, I. and Hussain, J. (2007). Observation on Fluoride Contamination in Groundwater of

- District Bhilwara, Rajasthan and a Proposal for a Low Cost Defluoridation Technique. The 27th Conference of the International Society for Fluoride Research (ISFR XXVII), Beijing.
- [8] Choubisa S.L., Choubisa L. and Choubisa D.K. (2001). Endemic Fluorosis in Rajasthan. *Indian Journal of Environmental Health*, 43, 177-189.
- [9] Arif, M., Hussain, J., Hussain, I., Kumar, S. and Bhati, G. (2014). GIS Based Inverse Distance Weighting Spatial Interpolation Technique for Fluoride Occurrence in Ground Water. *Open Access Library Journal*, 1: e546.
- [10] Evans, T. A., & Maidment, D. R. (1995). A spatial and statistical assessment of the vulnerability of Texas groundwater to nitrate contamination. CRWR online report 95e2. Centre for Research in Water Resources, The University of Texas at Austin.
- [11] Sajil, K. P. J., Jegathambal, P., & James, E. J. (2014). Chemometric evaluation of nitrate contamination in the groundwater of a hard rock area in Dharapuram, South India. *Applied Water Science*, 4, 397e405.
- [12] WHO. (2011). *Guidelines for drinking-water quality* (4th ed.). Geneva: World Health Organization.
- [13] APHA (1991). *Standard Methods for the Examination of Water and Wastewater*. 17th Edition, American Public Health Association, Washington DC.
- [14] Arif, M., Hussain, J., Hussain, I. and Kumar, S. (2013). An Assessment of Fluoride Concentration in Groundwater and Risk on Health of North Part of Nagaur District, Rajasthan, India. *World Applied Sciences Journal*, 24, 146-153.
- [15] Sharma, K.C., Arif, M., Hussain, I. and Hussain, J. (2007). Observation on Fluoride Contamination in Groundwater of District Bhilwara, Rajasthan and a Proposal for a Low Cost Defluoridation Technique. The 27th Conference of the International Society for Fluoride Research (ISFR XXVII), Beijing.
- [16] Deutsch, W. J., and Siegel, R. (1997). *Groundwater geochemistry. Fundamentals and applications to contamination*. Florida, USA: Lewis Publishers.
- [17] Euan, A. J. (2012). Caracterizacion defuentes no puntuales de contaminación. Parte complementary Del Proyecto YUC-2008-C06-108520.
- [18] Jamaludin, N., Sham, S. M., and Ismail, S. N. S. (2013).
- [19] Health risk assessment of nitrate exposure in well water of residents in intensive agriculture area. *American Journal of Applied Sciences*, 10, 442e448.
- [20] Gleick, P. H., 1996. Water resources. In *Encyclopedia of Climate and Weather*, ed. by S. H. Schneider, Oxford University Press, New York, vol. 2, pp.817-823.



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