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Occurrence of fluoride in groundwater with special reference to health hazards, Nasrullaganj area, district Sehore, Madhya Pradesh

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Abstract
The study of fluoride, north of Nasrullaganj area has been carried out and 35 water samples have been collected from the area. The study of these samples reveals some anomalous values of fluoride in groundwater near Nasrullaganj area. The analysis was carried out following the BIS (2012) and APHA (2012) standards. The study reveals that 50% of the samples are below desirable limit, 44% samples within acceptable range and only 6% samples are above the permissible limit. High values of fluoride are being reported apparently due to heavy usage of groundwater for irrigational and drinking water purposes. The highest value reported is 3.31 mg/L and lowest 0.14 mg/L. The problem needs attention to avoid the health hazards associated with fluoride contamination in groundwater as this may come up as a major heath issue.

Keywords: Fluoride, groundwater, fluorosis, Nasrullaganj, Sehore

1. Introduction
India has reported overwhelming amounts of fluoride concentrations in groundwater in various states. According to the state of fluoride in India, about 10 lakh people from 22 states and 200+ districts are facing deformities due to high concentrations of fluoride, in 2016. The leading states are Rajasthan, Gujarat, Andhra Pradesh, Telangana etc. and Madhya Pradesh has also started reporting high concentrations of fluoride.
Madhya Pradesh has also started reporting high concentrations of fluoride. An assessment study of water samples for fluoride concentrations from 15 districts of Madhya Pradesh reveal, high values of fluoride in Seoni (14.20 ppm), Jhabua (13.86 ppm), Vidisha (4.43 ppm), Shivpuri (3.89 ppm), Gwalior (6.20 ppm), Mandla (3.30 ppm), Bhopal (2.69 ppm), Jabalpur (5.00 ppm) and Dhar (4.07 ppm) (Jinwal & Dixit, 2009) [5] Khatarkar & Tiwari (2009) [6] have reported fluoride contamination from 9 locations in Sehore district. The study of fluoride concentration from Nasrullaganj area has been carried out for assessing the possible health impacts.

2. Materials and Methods
2.1 Study area
The study area is a part of Nasrullaganj, which falls under Survey of India Toposheet No. 55 F/6 and bounded by latitudes 22°40'00''to 22°45'00'' N and longitudes 77°15'00''to 77° 25'00''E thus covering a total of about 158 km^2 area.
Sehore is the nearest railway station and Bhopal, the state capital of Madhya Pradesh is the nearest airport. The entire area can be accessed through all-weather roads. The area of present study lies to the north of Nasrullaganj in Sehore district of Madhya Pradesh (Fig 1).
For the present study a total of 35 ground water samples were collected in order to carry out a detailed geochemical analysis. Samples were collected in airtight polypropylene bottles of one- and two-liter capacity. The chemical analysis has been carried out using standard procedures given by APHA (2012) [2].

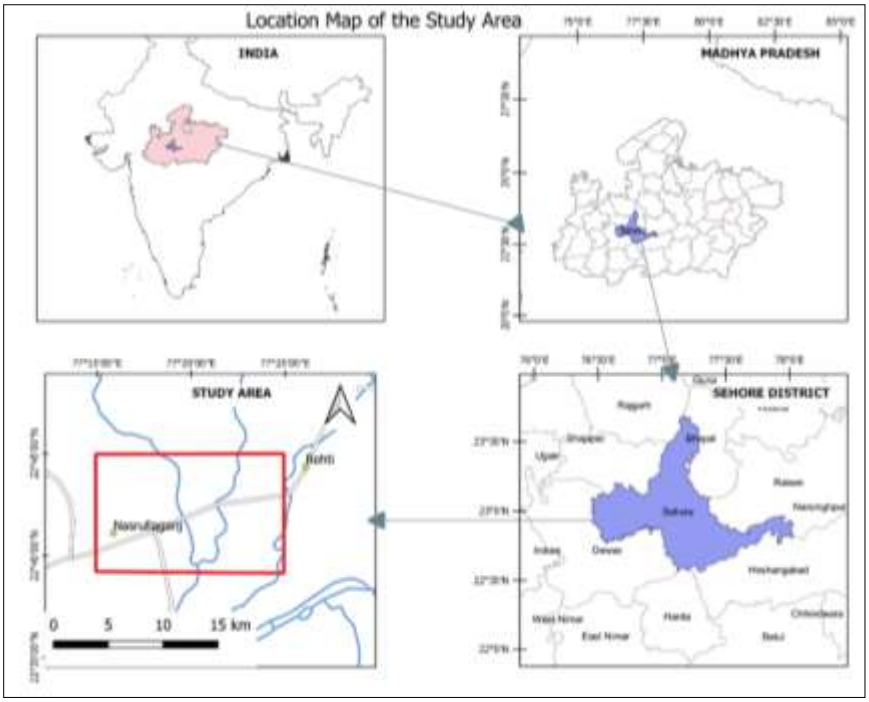

Fig 1: Location Map of the Study Area

2.1 Geology and Geomorphology of the Area

Geologically Granites, are the oldest rocks, overlain by Vindhyans and Deccan basalts followed by laterites and alluvial deposits in the area. The recent formations can be encountered randomly in the area. Major structure in the area is the Narmada-Son Lineament running NNE-SSW (Fig 2). The geological succession of the study area is given in Table 1.

2.2.1 Granite

Granite is seen exposed near Nasrullaganj; and belongs to Paleao-Proterozoic age. These granite gneisses occur as inliers in metasediments, which consist of phyllite, schist, quartzite, gneiss and amphibolite. (Geological Survey of India, 2002) [4].

2.2.2 Deccan Trap formations

The dominant rock types exposed in the study area are Deccan Traps, which cover nearly 30% of the area. The characteristic type of lava flow in the area is "Aa" type. They are disposed along a vertical column in a three-fold system. Each flow normally consists of three parts: (Singh & Singh, 2013) [7]

- an upper fragmentary zone
- a middle massive part
- a lower, impersistent thin layer of basalt clinkers

The top zone displays a fragmentary, brecciated very often highly vesicular and amygdular appearance. The vesicles have a sub-rounded to irregular shaped appearance.

The middle massive part has a widely varying texture ranging from aphanitic to highly porphyritic.

The lower layer of basalt clinker is impersistent and often absent. Wherever present, the thickness of this horizon is highly variable, ranging from a few centimetres to about 0.50 m. In terms of the physical characteristics, this layer is very similar to the to top vesicular amygdular zone.

Another characteristic feature of the Deccan Trap flows in the area is the variation of the flow thickness. A distinctive feature of the flow contacts is that most of them can be demarcated by the presence of a red bole horizon.

Over an altitude range of less than 100m (i.e., between 435-533 msl), as many as 12 flows of Deccan Trap have been identified in the area, with the thickness of the individual flows ranging from 5 to 10 m. It is important to note that the older flows seem to have more thickness compared to the younger ones.

2.2.3 Alluvium

The southern part of the study area is covered by Recent to sub-recent alluvial formations of limited areal extent and fairly good thickness occur adjacent to Narmada river. The alluvial formations comprise of silt, clay, sand, gravel and pebbles cobbles etc. with kankar. (Singh & Singh, 2013) [7].

Table 1: Stratigraphic succession of the study area, Nasrullaganj District Sehore Madhya Pradesh, Source: (Geological Survey of India, 2002) [4]

Lithology	Stratigraphic Status	Group	Age
Non-Calcareous silt, sand and Gravel	Ramnagar Formation	Recent	Middle Pliestocene to Holocene (Quaternary)
Calcified silt, sand and Gravel	Bauras Formation		
Calcareous Sand, silt, clay, gravel and Conglomerate	Baneta Formation		
Laterite			Cainozoic
"Aa" & Basaltic lava flows (2 flows)	Bargonda Formation	Malwa Group. (Deccan Traps)	Cretaceous to Palaeogene
Aa' & compound Basaltic lava flows (7 flows)	Indore Formation		
Aa' & compound Basaltic lava flows (5 flows)	Kankariya Pirukhedi		
Compound to Simple and "Aa" basaltic lava flows (2 flows)	Kalisindh Formation		
Granite			Palaeoproterozoic

Geomorphologically, the area is a part of Malwa Plateau. Major rivers draining the area are Kolar and Amber. These are tributaries to the Narmada river and join about 30 km south of Nasrullaganj near village Neelkanth. Isolated hills form the major water divide towards the northern part. The general slope of the area is towards south west. The elevation ranges from 280m to 570m. Dominant soil type observed is black cotton soil and alluvial at places. Area exhibits the older flood plain of fluvial origin.

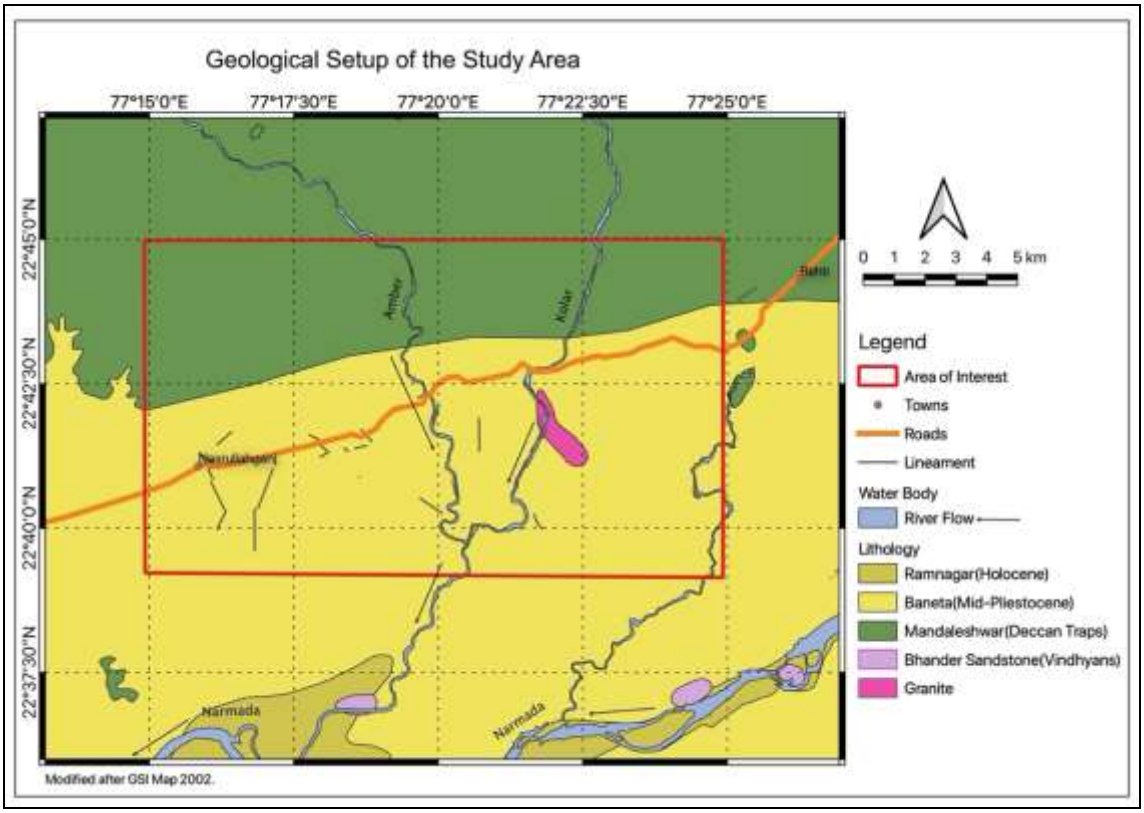

Fig 2: Regional Geology around the area around Nasrullaganj

3. Results and Discussion

The values of fluoride concentrations are given in Table 2.

The study of the table reveals that two samples from pre- and post-monsoon have reported the values above the permissible limits. These are 3.31 mg/L and 1.68mg/L from a borewell, located at Barodiya.

The higher values are more than permissible limits of BIS (2012) [3] i.e., more than 1.5 mg/L. However, the average value in the area is 0.67mg/L.

Table 2: Fluoride Concentration in ground waters of Nasrullaganj area.

S. No.	Location	Fluoride concentration (mg/L)	
		Pre Monsoon	***Post Monsoon***
1	Rehti	0.629	0.246
2	Nadiyakhera	0.291	0.386
3	Chandpura	0.27	0.284
4	Malajpur	0.147	0.436
5	Dhamanda	0.7	0.399
6	Chichliyakalan	0.716	0.326
7	Nipaniya	0.81	0.287
8	Ambar	0.477	0.226
9	Khatyakheri	0.45	0.577
10	Barodiya	3.31	1.68
11	Mehrugoan	0.407	0.234
12	Jogla	0.634	0.342
13	Rithwar	0.38	0.287
14	Nasrulaganj	0.224	0.436
15	Chandgrahan	0.287	0.524
16	Kalwana	**1.02**	0.784
17	Pipaliya khalsa	0.602	0.512
18	Rimjhiriya	0.705	0.542

A relative distribution of fluoride content within the samples can be seen in Figure 3, in the study area, as function of the desirable and permissible limits of BIS (2012) [3] and U.S Public Health Services. It is interesting to note that 50% of

the samples have fluoride content below the desirable limit with 44% of the samples lying within the desirable and permissible limits. 6% of the samples have Fluoride above the permissible limit.

The area covering these 44% samples can be considered to be suitable for drinking purposes in terms of fluoride content while the area covering these 50% samples needs additional fluoride treatment/augmentation for safeguarding the villagers from health issues like dental caries etc.

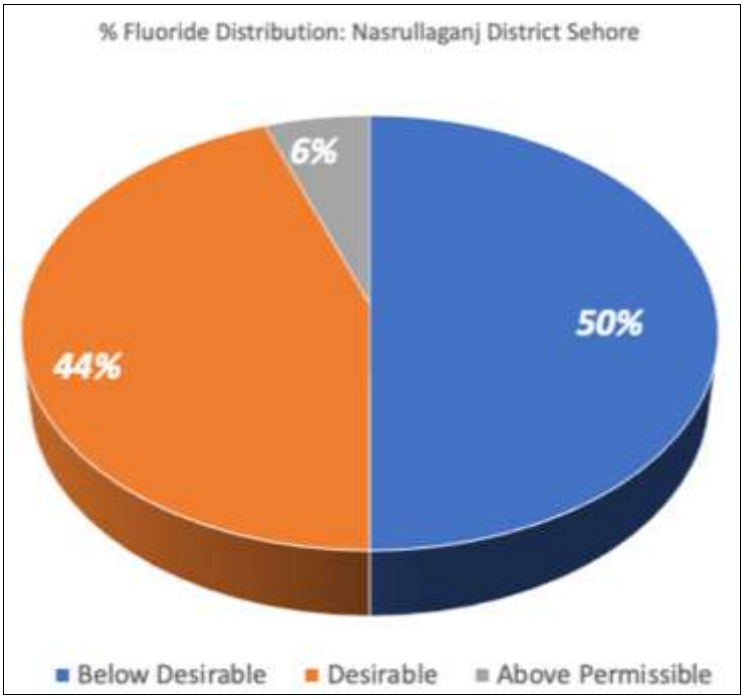

Fig 3: Ground water fluoride content distribution within the study area in terms of desirable and permissible limits of BIS (2012) [3]

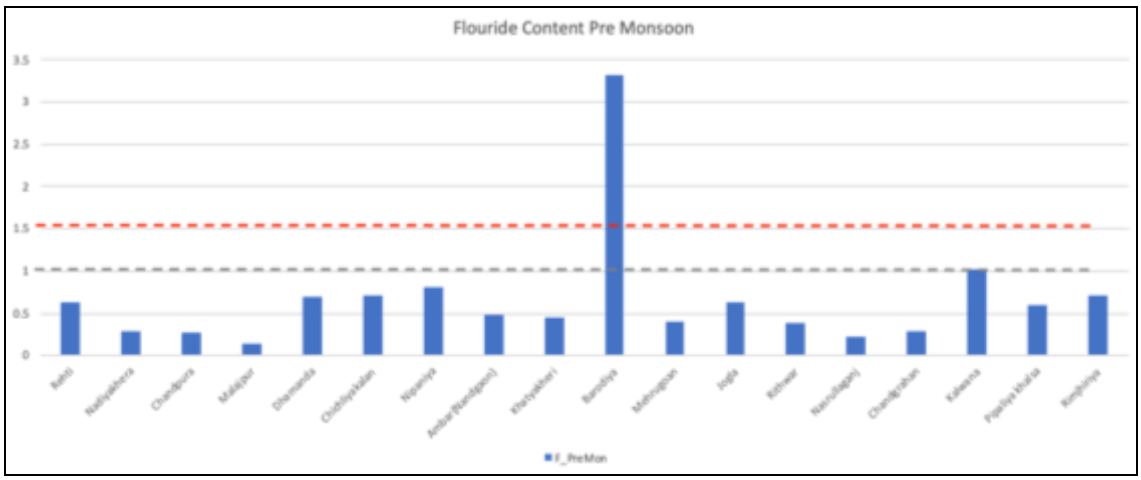

Fig 4: Bar graph representing Fluoride content during Pre- Monsoon period.

The distribution of fluoride concentration is represented with the help of bar graph, this can be seen in Figure 4. It is noteworthy that out of 18 samples, 16 are below the desirable limit of 1mg/L, whereas only 2 samples have reported the values above the desirable limit are 1.02 mg/L and 3.31 mg/L. The lowest value is of 0.14 mg/L.

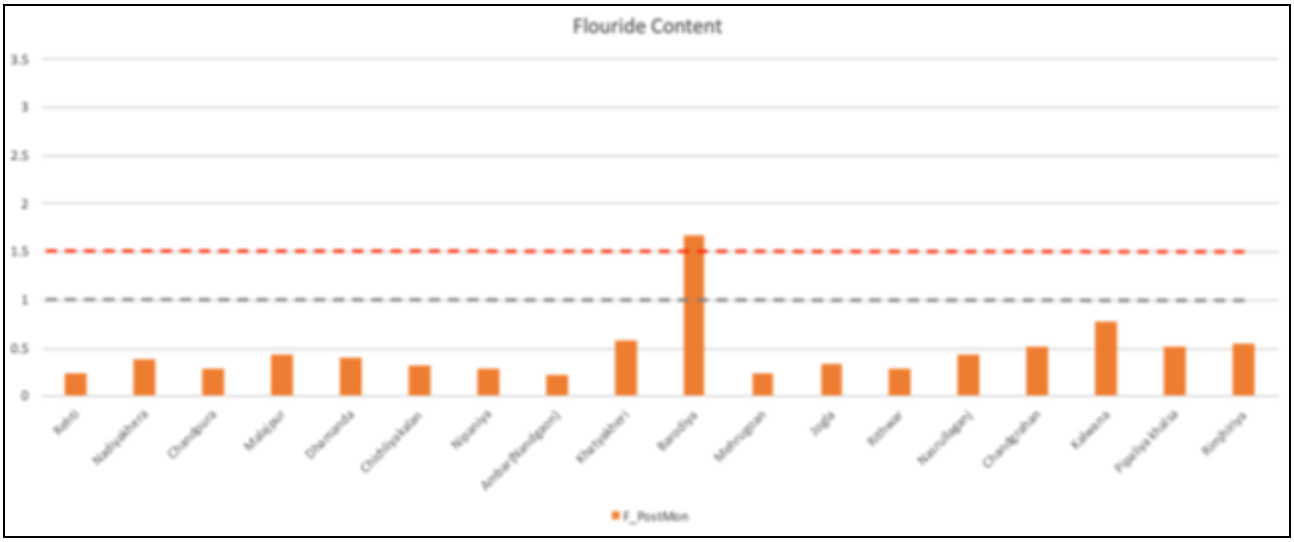

Fig 5: Bar graph representing Fluoride content during Post-Monsoon period.

During post-monsoon period, fluoride concentration in water samples can be seen in bar graph shown in Figure 5. It is noteworthy that out of 18 samples, 17 are below the desirable limit of 1mg/L, and the remaining 1 sample shows the value 1.68 mg/L, which is above the permissible limit. The lowest value during post-monsoon is in the order of 0.23 mg/L.

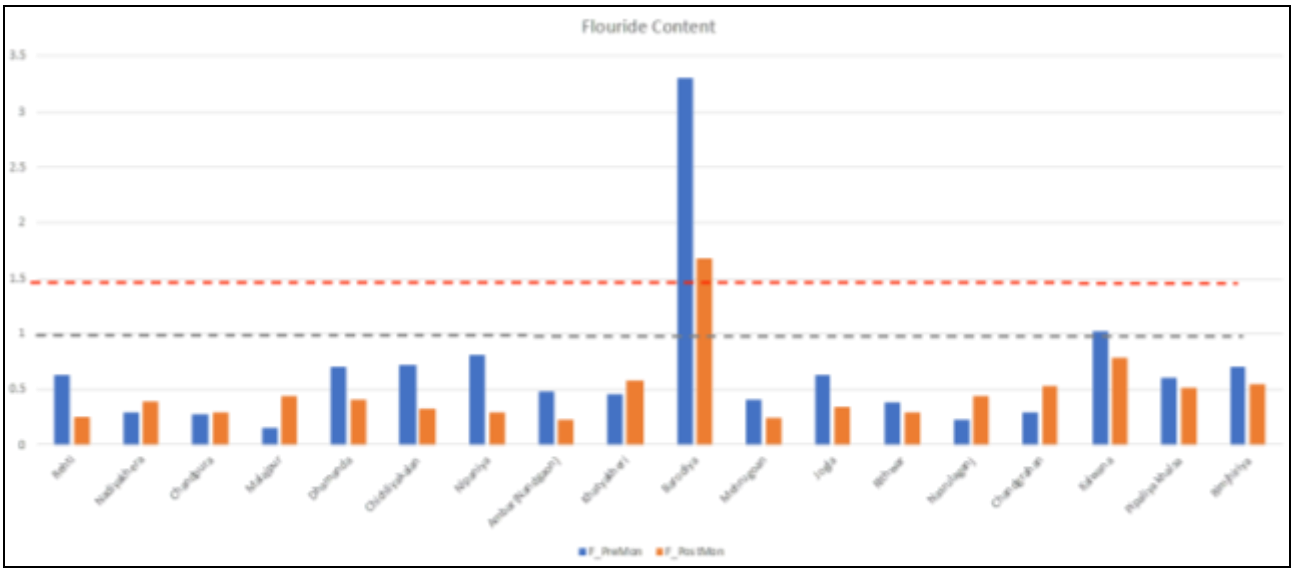

Fig 6: Bar graph illustrating the comparison of Fluoride content in Pre- and Post-Monsoon periods.

A comparison of pre- and post-monsoon fluoride content can be seen in Figure 6 with the help of bar graph. It shows the distribution of the fluoride concentration in the ground water samples collected from the study area it is important to note that the fluoride content generally reduces after monsoon.

The reduction in fluoride concentration values during post-monsoon ranges from 0.09 mg/L to 1.63 mg/L. It is interesting to note that 6 samples, however, display an increase of fluoride content after monsoon. The increase in fluoride values after monsoon ranges from 0.014 mg/L to 0.289 mg/L. A general high in fluoride content can be seen within the pre-monsoon analysis.

The spatial distribution of fluoride concentration in water samples can be seen in the Figure 7 (pre-monsoon) and Figure 8(post-monsoon), which have been prepared with with the help of absolute point values obtained by the analysis of fluoride. It ranges from. 0.25mg/L to more the 1.75mg/L.

The area falling into a particular colour range indicates the possible value ranges that can be assumed for a specific region radiating from the centre which is a real number.

Based on the fluoride concentration distribution in the water samples, the area can be subdivided in two broad zones separated by an imaginary line that can be drawn from villages Jogla in the west to Pipaliya in the east. The area to the north of this E-W line shows fluoride values on the higher side as compared to the area south of this E-W line. An observation reveals that the area south of this E-W line appears to have fluoride concentration in water below the desirable limit. The population consuming water in the southern part is likely to be exposed to the health conditions caused due to low fluoride concentrations, viz. dental caries, tooth decay etc. The low fluoride levels could be considered for fluoridation in drinking water or topical introduction can also be suggested to reduce the occurrence of dental

problems. (Aoun, *et al*., 2018) [1].

The area north of this E-W line has values above the desirable limit. It is important to highlight the anomalously high fluoride concentration in the water sample from Barodiya (3.31 mg/L, Pre-monsoon, 1.68 mg/L, Post-monsoon). The population consuming water from this part is likely to be exposed to health conditions like fluorosis, osteosclerosis etc.

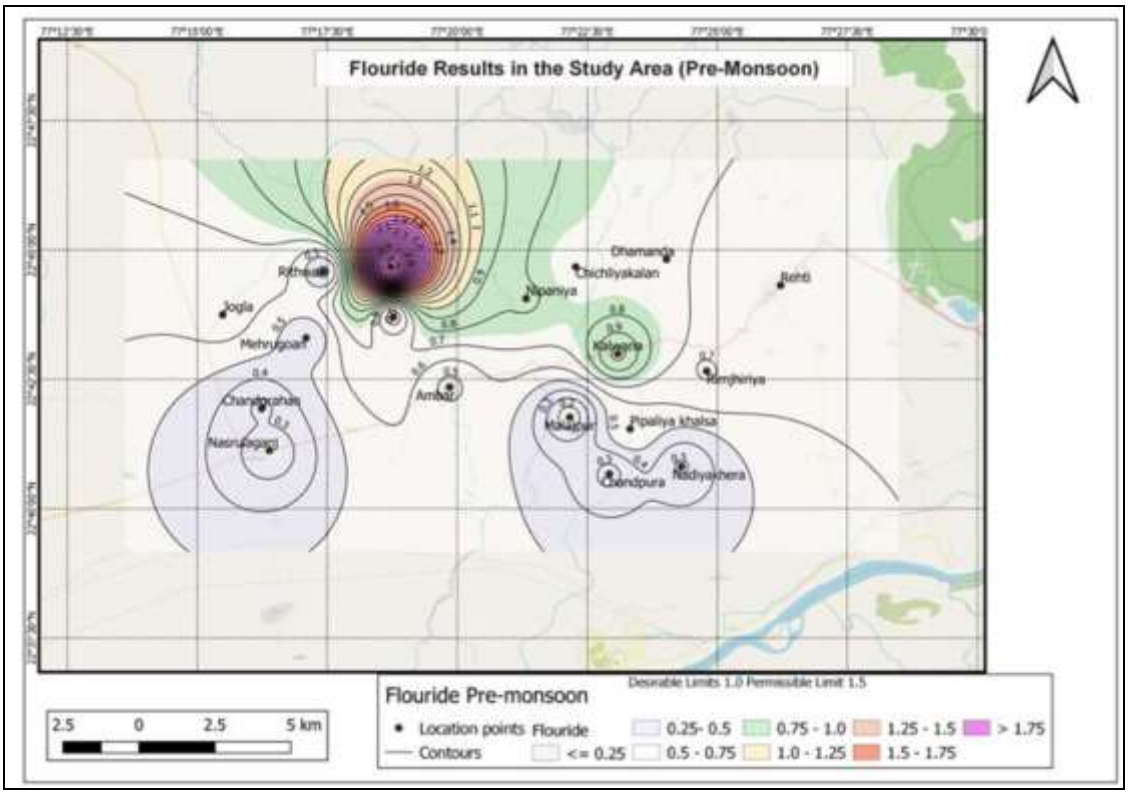

Fig 7: Spatial Distribution of Fluoride in groundwater samples of Nasrullaganj area, during Pre-Monsoon spell.

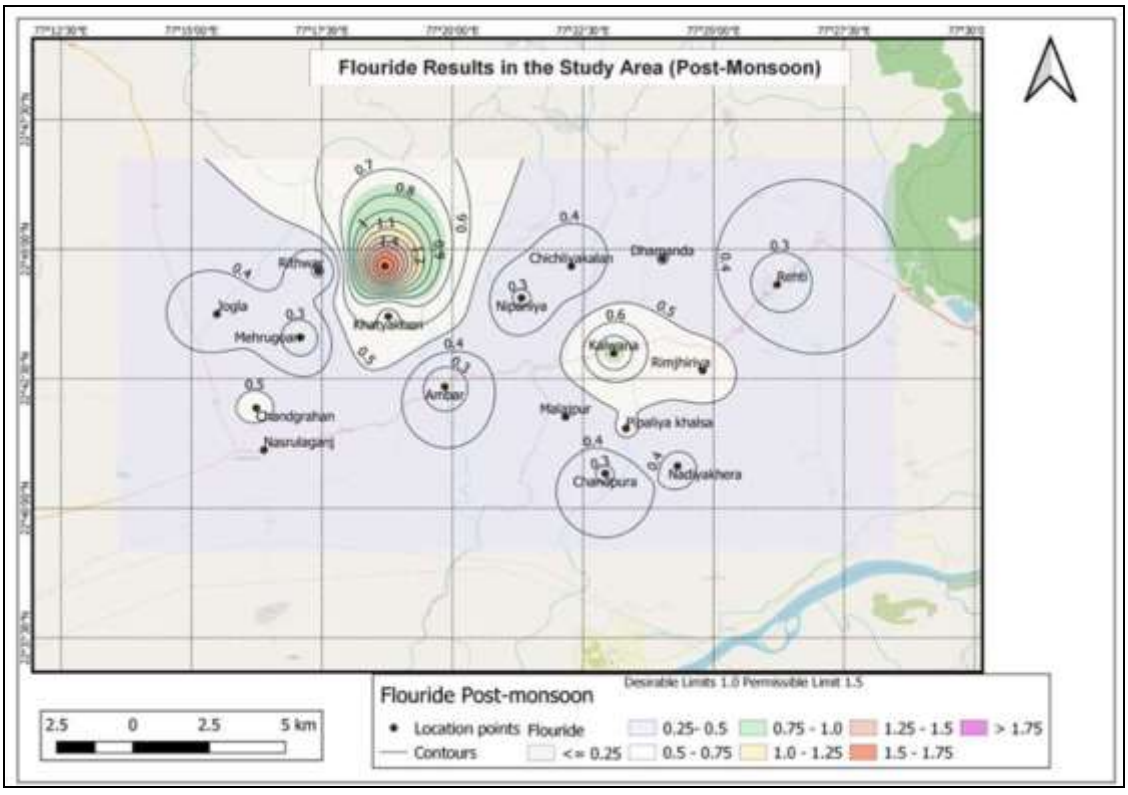

Fig 8: Spatial Distribution of Fluoride in groundwater samples of Nasrullaganj area, during Post-Monsoon spell

4. Discussion

Fluoride gets access to the human body through water. Limited intake and continuous presence in saliva helps in preventing the tooth decay, whereas excess intake causes fluorosis. Fluorosis is a major health problem, which is characterised by osteoporosis, osteosclerosis, dental

mottling and crippling deformations.

The high value of fluoride concentration in ground water during pre-monsoon spell indicate the possibility of water samples collected from the fractured vesicular basalts, which has been reported as the bedrock here (Singh & Singh, 2007) [8]. The ions from the leaching of fluoride rich minerals within the vesicular basalts could be contributing to the fluoride content in the groundwater.

The lower levels of post-monsoon fluoride concentration in water samples from certain areas is possibly due to the rise in water column, which dilutes the fluoride content. The higher levels of post monsoon fluoride concentration in water samples from the other areas could be anthropogenic sources with contribution from fertilizers.

5. Conclusion

The depth of the well and prolonged usage of groundwater is apparently playing a major role in the higher values of fluoride in the area. Ground water recharge and wells of shallow depths would serve to reduce the fluoride contamination of groundwater from the bedrock. Educating community about the presence of fluoride in the groundwater and its hazards. Introduction of defluorination of water at the community and domestic level will help to make water safe for drinking purpose.

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