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Assessment and Mapping of Fluoride Contamination of Groundwater of the Hatigaon Area of Assam, India Using Geographic Information System

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Abstract: ***For this study, the Hatigaon area of Guwahati City of the state Assam, India has been selected to assess the groundwater quality with special reference to fluoride contamination. Spatial variations in groundwater quality with reference to fluoride contamination in the Hatigaon area have been studied using Geographic Information System (GIS). For this study, a total of 115 groundwater samples were collected from 115 pinpoint locations (wells) in the Hatigaon area. The groundwater samples were analyzed for fluoride using Spectroquant Pharo 100 Spectrophotometer and compared with the Bureau of Indian Standards (BIS) and World Health Organization (WHO) standards. Mapping of spatial distributions of fluoride contamination of groundwater of the Hatigaon area was done using ArcGIS and the groundwater fluoride distribution map was obtained. The results revealed that fluoride contents in the groundwater samples ranged between 0.22-11 mg/l. The results obtained in this study and the spatial database established in GIS will be helpful for monitoring and managing groundwater contamination due to fluoride in the study area.***

Keywords: ArcGIS, fluoride, groundwater, water quality

1. Introduction

Groundwater is a major source for all purposes of water requirements in India. In India more than 90% of the rural population and nearly 30% of the urban population depend on groundwater for drinking purpose [1]. Till recently it had been considered as a dependable and generally a safe source of drinking water. Groundwater resources are under increasing threat from contamination by physical, chemical and biological parameters with far reaching consequences for the health of the living beings. Contamination of groundwater can result in poor drinking water quality and potential health problems. Thus groundwater quality is a growing concern throughout the world. Groundwater quality analysis gives information about the health of the groundwater. Thus, water quality assessment is one of the prime concerns all over the world. It involves evaluation of the physical, chemical, and biological nature of water in relation to natural quality, human effects, and intended uses, particularly uses which may affect human health and the health of the aquatic system itself [7].

Fluoride is found in both surface water and groundwater. It is a natural groundwater contaminant that results from dissolution from rocks and soils due to chemical weathering and erosion. Groundwater, especially borehole water contains varying concentrations of fluoride. Drinking water, when derived from fluoride contaminated groundwater exceeding the maximum permissible limit of fluoride concentration of 1.5 mg/l (standard set by WHO and BIS for drinking water) is the cause of fluorosis. Therefore higher concentration of fluoride is considered to be an indicator of groundwater contamination. The factors responsible for the natural concentration of fluoride in groundwater are the physical, geological and chemical distinctiveness of the aquifer, the porosity and acidity of the soil and rocks, the temperature, the action of other chemical elements and the depth of wells. The existence of fluoride toxicity in the groundwater is a matter of great concern in India today. In the state Assam, reports of its presence are pouring in day by day. In Assam, earlier though fluoride endemicity was concentrated in some areas of Karbi-Anglong and Nagaon districts only but presently the gateway of north-east, the city of Guwahati too stands as a victim [2].

Geographic Information System (GIS) has emerged as a powerful tool for storing, analyzing, and displaying spatial data and using the data for decision making in engineering and environmental fields [3, 6]. Groundwater can be most advantageously used only when its quantity and quality is properly assessed. GIS can be used as a database system in order to prepare maps of groundwater quality according to concentration values of different groundwater quality parameters such as fluoride. It can be utilized to locate groundwater quality zones suitable for different usages such as drinking purpose. For any area, a groundwater quality map is important to evaluate the safeness of water for drinking purpose and also as a deterrent indication of potential environmental health problems.

Considering the above aspects of groundwater contamination and use of GIS in groundwater quality mapping, the present study was undertaken to map the groundwater quality with special reference to fluoride contamination in the Hatigaon area of Guwahati city in Kamrup district of the state Assam, India, which is taken as the study area.

2. Research Objectives

This study aims to visualize the spatial distribution of the fluoride levels in groundwater of the study area through GIS. The main objective of the research work is to make a groundwater quality map using GIS, based on the laboratory tests done on 115 groundwater samples representing groundwater resource that were collected from 115 pinpoint locations (wells) in the Hatigaon area of Assam, India. Therefore, the objectives of this research work can be summarized as follows:

1) To assess and provide an overview of present groundwater quality of the Hatigaon area with special reference to fluoride contamination.
2) To determine the spatial distribution of groundwater quality parameter fluoride and to generate the fluoride contamination map for the Hatigaon area.

3. Materials and Methods

3.1 Study Area

The Hatigaon area is a locality in southern part of Guwahati city in Kamrup district of the state Assam, India. It is situated at latitude of 26.1279°N and longitude of 91.7855°E, at the mean sea level of 55.64 m and referred in Survey of India (SOI) topographic sheet no. n16 (Figure 1). It is surrounded by Ganeshguri, Bhetapara, Sijubari, Beltola Tiniali and Beltola Survey localities.

Hatigaon area has warm summers and cold winters. Winters are also accompanied by occasional rainfalls that bring down the temperature further. Monsoon season commences from the month of June. Monsoons are usually accompanied by severe thunderstorms along with heavy showers. This helps in infiltration and thus recharge of groundwater in this area.

The geology of the study area is represented by the Precambrian Gneissic basement which is intruded by Porphyritic Granites. The basement complex is composed of Granite Gneiss, Biotite Gneiss, Biotite Schist and Quartzite [4, 5]. Fills of varying thickness composed of unconsolidated sand, silt and clay are deposited over the basement Gneissic complex. High fluoride regions occur mostly in all the Gnessic and the Granitic areas. The crystalline Precambrian rocks of the study area are traversed by a number of lineaments, representing fracture zones. These structures facilitate weathering and water seepage. Fluoride ions leach out more from the fractures.

The hydrology of the study area consists of the surface drainage, wetlands and the dug-wells and bore-wells. The Basistha-Bahini river is the trunk channel near this area and along with its host of tributaries form the main conduit for surface water runoff.

3.2 Groundwater sample collection and analysis

For the sampling of groundwater samples of the study area, groundwater samples from different sites (pinpoint locations) were collected from sources (wells) representing underground groundwater. Since the groundwater sources were known to vary with time, grab samples were collected with frequency of one. The samples were taken during September 2016 and were analyzed for the chemical parameter fluoride. Each samples for fluoride analysis were collected in PET bottles of half litre size. Before filling, the bottles used for water sample collection were rinsed out two or three times with the water being collected. Samples from wells were collected only after the well has been pumped to insure that the sample represents the actual groundwater. A total of 115 groundwater samples were collected from 115 pinpoint locations of the study area (Table 3). Sufficient information was recorded to provide positive sample identification at a later date, such as the name from whom the sample was collected, exact location (pinpoint location), source and depth. After collection of the samples, the samples were shifted to the District Level Laboratory (DDL) of Public Health Engineering Department (PHED) of Kamrup district of Assam, India for analysis. The latitude and longitude data of the pinpoint locations were recorded using the GPS instrument GARMIN GPS-60 receiver.

Chemical analysis was carried out to determine the fluoride contents and compared with standard values recommended by WHO and BIS (Table 1). As the groundwater in the study area is extensively used for drinking purpose and previous studies report that groundwater contamination is mainly due to fluoride (PHED, Kamrup district, Assam, India), the groundwater quality analysis in the present study is restricted to measurement of fluoride contents and determination of potential contamination.

Table 1: Recommended permissible limits for fluoride in drinking water

Name of organization	*Acceptable limit (desirable limit)*	*Maximum permissible limit*
World Health Organization (WHO)	1.0	1.5
Bureau of Indian Standards (BIS)	1.0	1.5

The fluoride contents of the groundwater samples were determined by Spectroquant Pharo 100 Spectrophotometer having wavelength range of 320-1100 nm. For the determination of fluoride content in water samples, the Spectroquant Pharo 100 Spectrophotometer method is one of the most effective and efficient methods because it is quick, accurate and hardly takes few minutes for each sample to be tested. The procedure and the reagent system consisted of the approved method for fluoride and analytical grade reagents (Merck). The determination of fluoride contents was achieved at 570 nm wavelength by measuring the absorbance.

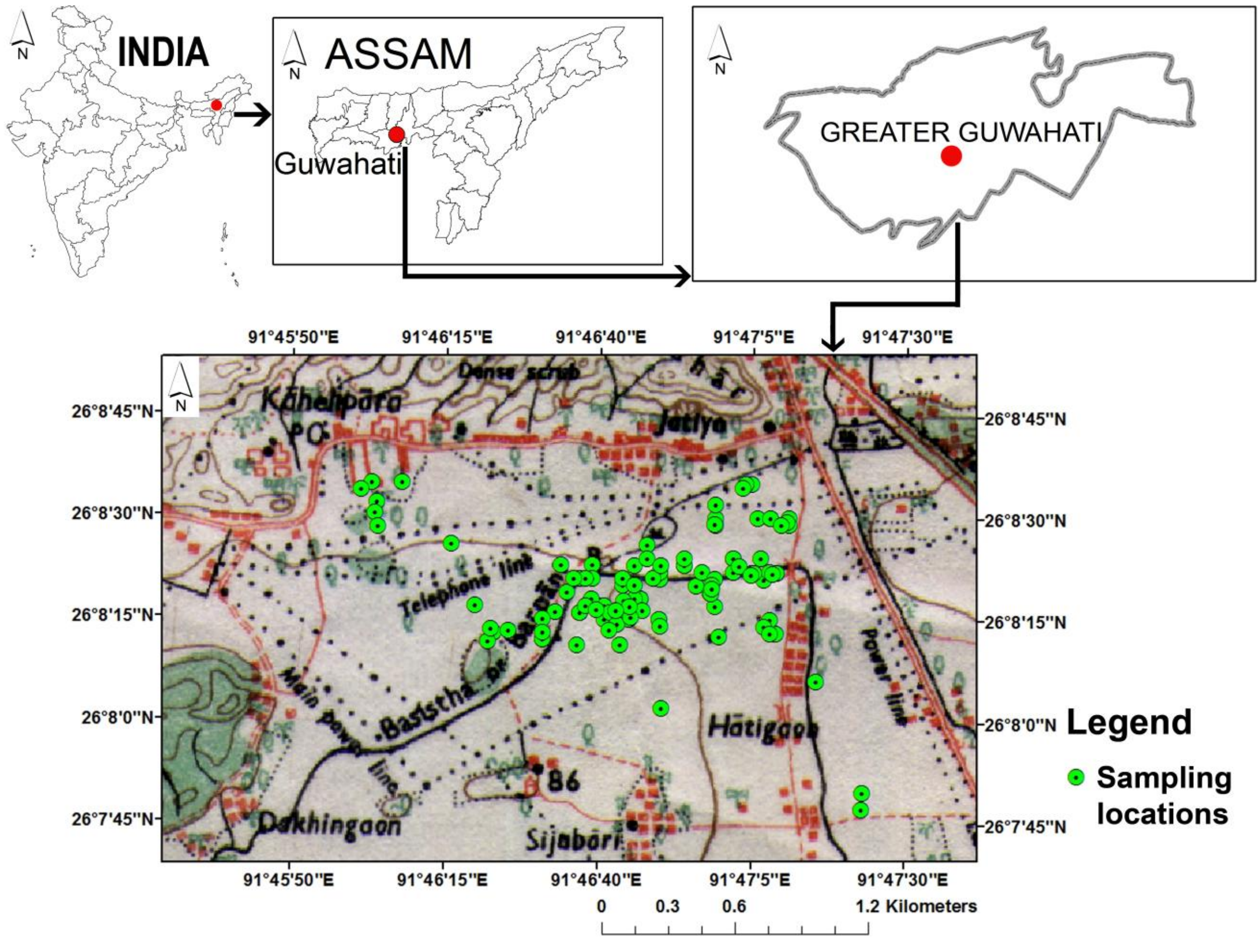

Figure 1: Location map of the study area and the sampling locations

3.2 Preparation of well (sampling) location feature map and the spatial distribution map

The method that was followed to develop a groundwater quality map (with special reference to fluoride contamination) from thematic maps is explained in this section. The ArcGIS software was utilized in the study. The locations of 115 wells (pinpoint locations) all over the study area were obtained by using a handheld GPS instrument GARMIN GPS-60 receiver. GPS technology proved to be very useful for enhancing the spatial accuracy of the data integrated in the GIS. The well location data was then imported to ArcGIS using GCS_Everest_India_Nepal projection and attributes were assigned to each well sample. The digitized maps of India, Assam, Greater Guwahati and SOI topographic sheet no. n16 were used in ArcGIS to generate the final study area map. Based on the location data obtained, well (sampling) location feature map was prepared showing the position of 115 wells from where 115 groundwater samples were collected (Figure 1).

The GPS data and the well location map thus obtained forms the spatial database. From the 115 numbers of wells, the 115 groundwater samples that were collected were analyzed to obtain the fluoride contents. The water quality data thus obtained forms the non-spatial database. It is stored in excel format and linked with the spatial data in ArcGIS. The values of fluoride levels for various sample locations were classified into five classes in 'Layer Properties' and plotted in the integrated map. 'Graduated colour' scheme symbology was used so that the five classes can be pictorially identified having different symbols and colours. Thus the spatial and the non-spatial database formed are integrated using the ArcGIS software for the generation of spatial distribution map of the groundwater quality parameter fluoride for the study area (Figure 2).

3.3 Criteria for acceptability and rejection in water quality

In this stage, the criteria for suitability and non-suitability of the groundwater samples were elucidated for analysis. This was performed based on the water quality standards stipulated by the WHO and BIS. Table 1 shows the corresponding permissible limits of fluoride for drinking purpose as recommended by WHO and BIS. Ranks were assigned for the wells depending on the respective tested fluoride values, as given in the Table 2.

Table 2: Criteria for acceptability and rejection in water quality

Parameter	*Rank*	*Criteria*	*Remarks*
Fluoride	1	<1.0 mg/l	Desired
	2	1.0-1.5 mg/l	Acceptable
	3	>1.5 mg/l	Non acceptable

4. Results and Discussions

The fluoride contents in the groundwater samples that were analyzed and their levels in different locations of the study area are shown in Table 3. Fluoride contents were found to be very high in the groundwater samples of the study area. From Table 3, it can be seen that the fluoride concentrations in the groundwater samples of the study area range between 0.22-11 mg/l. A very high fluoride content of 11 mg/l is found in the Hatigaon Lakhiminagar area (Sample no. 35) which poses a great risk for the residents of the study area. As against it, a low fluoride content of 0.22 mg/l is found in the Hatigaon Lakhiminagar site (Sample no. 2) which is within the acceptable limit (1.0 mg/l).

Table 3: Details of the groundwater samples and analysis results.

Sample no.	*Pinpoint location*	*Latitude (N) in degrees*	*Longitude (E) in degrees*	*Source*	*Depth in feet*	*Fluoride in mg/l*
1	Dr. Utpal Kumar Misra, Hatigaon	26.13500	91.78767	D.T.W.	750	5
2	Kesab Ch. Baishya, Lakhiminagar, H. No. 7	26.13942	91.78484	S.T.W.	20	0.22
3	Th. Jagjit Singha, Hatigaon	26.13694	91.77306	S.T.W.	40	0.3
4	Narendra Ch. Das, House No. 106	26.13889	91.77889	Boring	380	3.7
5	Nirupama Devi, Lakhiminagar	26.14000	91.78389	Boring	500	9.7
6	N. Bhuyan, Lakhiminagar	26.14000	91.78389	Boring	378	4.4
7	D.N. Das, House No. 9	26.13944	91.78472	Boring	275	1.71
8	Nripen Medhi, House No. 29	26.14167	91.78306	Boring	450	5.3
9	Shahid Ali, House No. 2	26.13944	91.78583	Boring	650	6.7
10	Chandana Hazarika, House No. 2	26.14167	91.78556	D.T.W.	660	9.3
11	Harendra Chakraborty, House No. 24	26.14139	91.78306	D.T.W.	650	9.6
12	Tultul Das, House No. 14	26.13944	91.78389	D.T.W.	700	7.6
13	Kamal Ch. Das, Namghar Path	26.13833	91.77972	D.T.W.	380	7.8
14	Keshab Handique, Lakhiminagar	26.13917	91.77889	D.T.W.	550	9.3
15	Nani Sharma, Lakhiminagar	26.13972	91.77750	D.T.W.	480	7.5
16	Dulal Borbaruah, Lakhiminagar	26.13917	91.77694	D.T.W.	240	1.53
17	Pranita Sharma, House No. 49	26.13778	91.77694	D.T.W.	250	1.6
18	Dr. G.C. Pathak, House No.10	26.13944	91.78472	D.T.W.	180	1.99
19	Mr. Sharma, Sharma store	26.13889	91.78222	Boring	260	5.3
20	Ruhini Das, Lakhiminagar	26.13861	91.77639	D.T.W.	425	7.9
21	Dipanjal Hazarika, Lakhiminagar	26.13833	91.77972	D.T.W.	650	9.4
22	H.N. Sharma, House No. 4	26.14306	91.78472	D.T.W.	375	1.56
23	Subarna, House No.11	26.14306	91.78444	D.T.W.	180	1.67
24	Manjushree Deka, Lakhiminagar	26.13917	91.77750	D.T.W.	400	4.6
25	Shirajul Hague, House No. 4	26.13917	91.78528	D.T.W.	530	9
26	Chandan Kr. Baishya, House No. 65	26.13750	91.77806	D.T.W.	150	1.91
27	Bhadreswar Talukdar, House No.127	26.13944	91.78250	D.T.W.	750	6.5
28	Nip Jyoti Sharma, House No. 9	26.13944	91.78472	D.T.W.	280	1.67
29	Prabhat Ch. Das, House No. 21	26.14222	91.78306	D.T.W.	575	7
30	Dilip Das, Hatigaon	26.13806	91.77778	D.T.W.	115	1.58
31	N.C. Dutta, House No. 22	26.14306	91.78444	D.T.W.	680	9.5
32	Anil Baruah, Lakhiminagar	26.13778	91.77583	D.T.W.	460	6.3

Table 3: Details of the groundwater samples and analysis results.

Sample no.	*Pinpoint location*	*Latitude (N) in degrees*	*Longitude (E) in degrees*	*Source*	*Depth in feet*	*Fluoride in mg/l*
33	A.W. Ansari, Samannay Path	26.13917	91.78306	D.T.W.	440	6.1
34	Hari Mohan Kalita, Lakhiminagar	26.13667	91.77528	D.T.W.	600	8.3
35	Prabhat Baruah, Lakhiminagar	26.13750	91.77528	D.T.W.	700	11
36	Prasen Saikia, Lakhiminagar	26.13667	91.77528	D.T.W.	350	5.4
37	Nepen Kalita, House No. 64	26.13806	91.77806	D.T.W.	80	1.57
38	Rupali Saha, Lakhiminagar	26.13694	91.77528	H.T.W.	240	5.3
39	Jonah Pathak, Namghar Path	26.13833	91.77944	D.T.W.	130	1.51
40	P. Das, Namghar Path	26.13806	91.77889	D.T.W.	130	1.51
41	M.M. Pathak, Namghar Path	26.13778	91.77861	D.T.W.	135	1.74
42	L.N. Sonowal, Jatia, Hatigaon	26.14167	91.78639	D.T.W.	80	1.54
43	Dinesh Ch. Talukdar, House No. 71	26.13972	91.77944	D.T.W.	585	7.6
44	N. Hazarika, Namghar Path	26.13750	91.77917	D.T.W.	400	6.1
45	Arukan Das, House No. 22	26.13833	91.77750	D.T.W.	300	3.5
46	C.P. Ramchiary, Kalapahar Path	26.13806	91.77222	D.T.W.	180	1.76
47	Subhas Baruah, Hatigaon	26.14139	91.78639	D.T.W.	600	8.7
48	Jayan Kr. Deuri, Hatigaon	26.13778	91.77694	D.T.W.	550	4.27
49	Biren Sharma, Jeuti Path	26.14056	91.78000	D.T.W.	360	5.7

50	Rajendra Nath Sharma, House No. 59	26.13806	91.77722	D.T.W.	450	7.5
51	Chandra Kalita, Naharani Path	26.13694	91.78583	D.T.W.	550	7.3
52	M.C. Bora, House No. 7	26.14167	91.78500	D.T.W.	560	7.2
53	Simanta Das, Lakhiminagar	26.14056	91.77111	D.T.W.	130	1.75
54	Basu Dev Das, Seuj Man Path	26.13972	91.78417	D.T.W.	350	1.84
55	Pankaj Saikia, Seuj Man Path	26.14167	91.78556	D.T.W.	550	7
56	Nalinibala Das, Namghar Path	26.13750	91.77917	D.T.W.	223	1.6
57	Chakreswar Kaji, Medhi Phukan Path	26.13944	91.78056	D.T.W.	200	1.76
58	Rubul Dutta, Nava Milan Path	26.13972	91.78167	D.T.W.	140	1.57
59	Dhruba Jy. Kalita, Kalapahar Path	26.14306	91.76750	H.T.W.	45	1.53
60	Anupama Das, Namghar Path	26.13778	91.77861	D.T.W.	590	7
61	D.N. Das, Namghar Path	26.13750	91.78056	D.T.W.	130	1.53
62	Babul Hague, M. Phukan Road	26.13806	91.78306	D.T.W.	480	8.2
63	Phatik Ch. Kalita, Lakhiminagar	26.13917	91.78056	D.T.W.	550	7.9
64	Chandra Bhusan Das, Birayan Path	26.13944	91.78056	D.T.W.	330	3.9
65	Muslima Handique, M. Phukan Path	26.13750	91.78056	D.T.W.	650	8.2
66	J. Begum, Lakhiminagar	26.13889	91.77944	D.T.W.	400	5.6
67	Binapani Deka, Lakhiminagar	26.13917	91.77722	D.T.W.	700	8.6
68	Biswanath Deuri, Lakhiminagar	26.13972	91.77611	D.T.W.	170	1.98
69	Dhiren Ch. Kalita, Lakhiminagar	26.13917	91.77667	D.T.W.	150	1.86
70	Babul Ch. Nath, Sewali Path	26.13750	91.78556	D.T.W.	400	4.9

Table 3: Details of the groundwater samples and analysis results.

Sample no.	*Pinpoint location*	*Latitude (N) in degrees*	*Longitude (E) in degrees*	*Source*	*Depth in feet*	*Fluoride in mg/l*
71	Pankaj Barman, Sewali Path	26.13722	91.78528	D.T.W.	300	2.6
72	Mridul Gogoi, Namghar Path	26.13778	91.77833	D.T.W.	240	1.7
73	Ila Saikia, Vinayak Path	26.13972	91.78167	D.T.W.	150	2.4
74	Bhabin Deka, Janakpur	26.13656	91.77281	H.T.W.	130	2
75	Nishi Jyoti Das, Juripar	26.13644	91.77686	D.T.W.	465	7.5
76	Jiaur Rahman, Kalapahar Path	26.14306	91.76889	D.T.W.	220	1.78
77	Sadullah, Vinayak Path	26.14000	91.78167	D.T.W.	200	2.8
78	Anju Das, Sanjog Path	26.13047	91.78981	D.T.W.	160	1.61
79	Debakanta Das, Sanjog Path	26.12977	91.78975	D.T.W.	125	0.99
80	H. Talukdar, Jyoti Path	26.14000	91.78000	D.T.W.	625	6.1
81	Prabodh Kr. Barman, Lakhiminagar	26.13917	91.78028	D.T.W.	590	7.3
82	Aman Ali Ahmed, S.K. Path	26.13389	91.78067	H.T.W.	450	5.9
83	Salima Khatun, Lakhiminagar	26.14291	91.78429	D.T.W.	150	0.87
84	Dr. Rumi Dev, Lakhiminagar	26.13729	91.77863	D.T.W.	150	1.11
85	Dhajendra N. Das, Lakhiminagar, H. No. 6	26.13946	91.78554	D.T.W.	120	1.01
86	Jina Sarma, Lakhiminagar	26.13704	91.77831	D.T.W.	140	1
87	C.R. Das, Namghar Path	26.13788	91.77979	D.T.W.	150	0.79
88	Narayan Das, Sewali Path	26.13725	91.78061	D.T.W.	145	0.81
89	B.C. Khound, Sewali Path, House No. 21	26.13645	91.77877	D.T.W.	110	1.34
90	Mr. Nunna, Sewali Path, House No. 8	26.13682	91.78328	D.T.W.	150	0.97
91	Dr. I. Bordoloi, Sewali Path	26.13694	91.78558	D.T.W.	100	1.37
92	Narayan Deka, Lakhiminagar	26.14004	91.78512	D.T.W.	85	0.8
93	Nalini Baishya, Lakhiminagar	26.13711	91.77294	S.T.W.	40	0.94
94	Amar Konwar, Lakhiminagar	26.13702	91.77375	D.T.W.	150	1.21
95	Rajendra Das, Lakhiminagar, House No. 3	26.13944	91.78587	D.T.W.	90	0.76
96	Gautam Das, Lakhiminagar, House No. 8	26.13943	91.78481	D.T.W.	100	1.16
97	Hiramoni Basumatary, Kalapahar Road	26.14226	91.76774	D.T.W.	180	1.13
98	A.K. Patgiri, Namghar Path	26.13759	91.77925	D.T.W.	180	1.24
99	K.R. Das, Namghar Path	26.13827	91.77896	D.T.W.	170	1.15
100	Umesh Das, Namghar Path, House No. 18	26.13803	91.77921	D.T.W.	160	0.63
101	Monoranjan Das, Lakhiminagar, H. No. 5	26.13940	91.78566	D.T.W.	90	1.18
102	Pratap Ch. Borah, Kalapahar Path	26.14181	91.76767	D.T.W.	160	1.14
103	Nareswar Bayan, Medhi Phukan Path	26.13973	91.78060	D.T.W.	275	1.04
104	Ramananda Das, Samannay Path, H. No. 25	26.13860	91.78283	D.T.W.	110	1.09
105	Kulen Barpujari, Lakhiminagar	26.13788	91.77769	D.T.W.	100	1.46
106	B.S. Raj Medhi, Kalapahar Path	26.14125	91.76781	D.T.W.	190	1.23
107	N. Kalita, Kalapahar Path	26.14274	91.76701	D.T.W.	178	0.91
108	Ratan Deka, Lakhiminagar, House No. 62	26.13785	91.77859	D.T.W.	135	1.44

Table no. 3: Details of the groundwater samples and analysis results.

Sample no.	*Pinpoint location*	*Latitude (N) in degrees*	*Longitude (E) in degrees*	*Source*	*Depth in feet*	*Fluoride in mg/l*
109	Tapan Bhuyan, Lakhiminagar, House No. 28	26.14142	91.78303	D.T.W.	90	1.29
110	Gopal Ch. Das, Samanay Path, H. No. 24	26.13859	91.78290	D.T.W.	100	0.72
111	Mahendra Nath, Lakhiminagar, H. No. 9	26.13936	91.78469	S.T.W.	60	0.82
112	Abdul Malik Ansary, Samannay Path	26.13892	91.78294	S.T.W.	60	0.78
113	N.A. Laskar, Samannay Path	26.13878	91.78293	D.T.W.	170	1.31
114	Nilima Pathak, Jatia, Hatigaon	26.14152	91.78630	D.T.W.	140	0.39
115	Mrigen Bora, Jatia, Hatigaon	26.14140	91.78605	D.T.W.	180	1.29

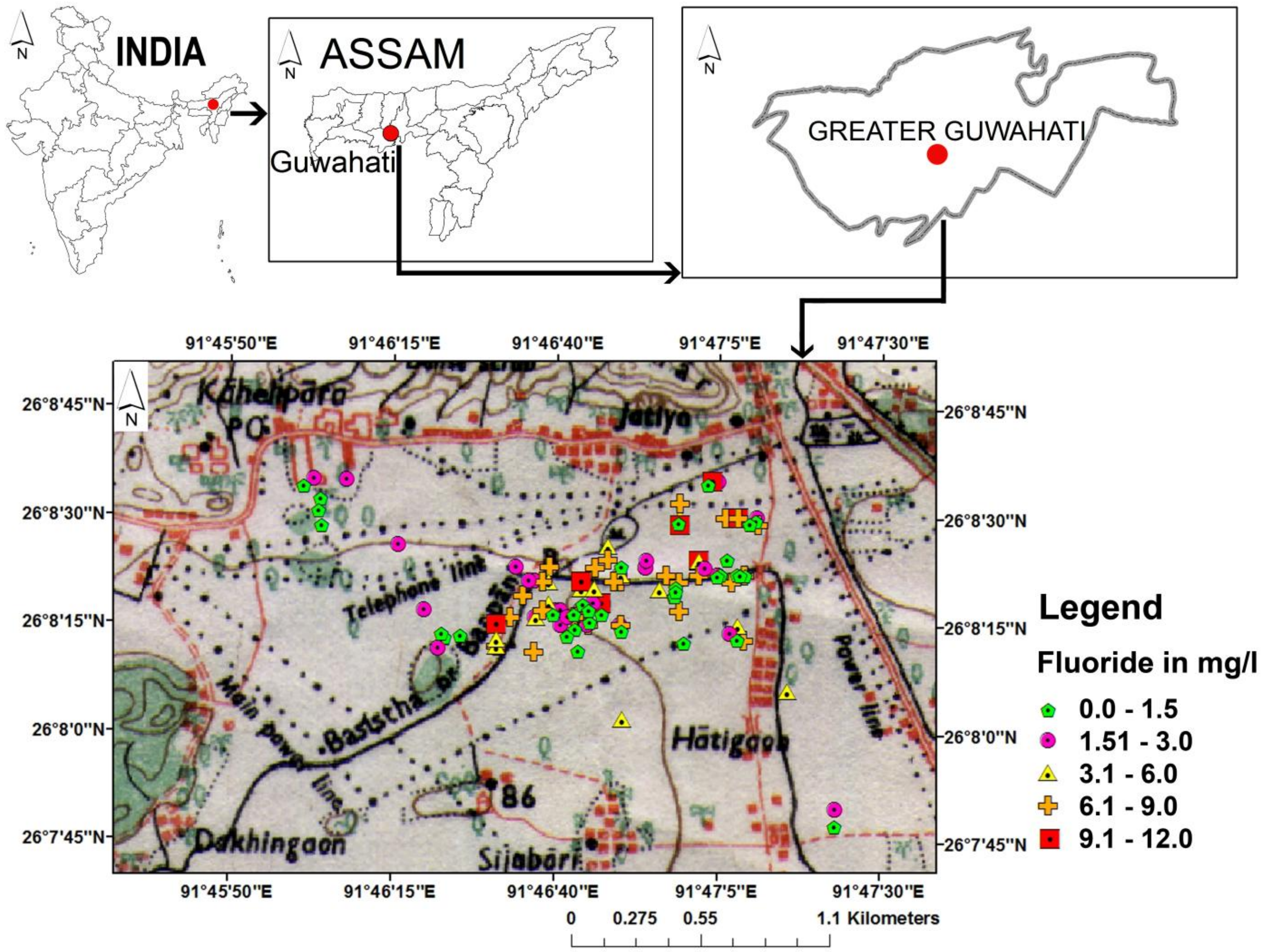

Figure 2: The final groundwater quality map showing the spatial distributions of fluoride contents

Fluoride concentrations have complied with a value above 1.5 mg/l for 79 wells (68.70%) out of 115 wells (pinpoint locations) that exceeded the maximum contaminant level of 1.5 mg/l given in WHO and BIS standards. On the contrary, 36 wells (31.30%) out of 115 wells have complied with fluoride content values below the maximum permissible limit of 1.5 mg/l. However, only 17 wells (14.78%) in the study have the desired and acceptable level of fluoride content of 1.0 mg/l acceding to the standards. Table 4 shows the wells with the ranks that were assigned depending on the respective tested fluoride values.

Table 4: Wells with the ranks assigned depending on the respective tested fluoride values

Parameter	*Rank*	*Criteria*	*No. of Wells*	*Remarks*
Fluoride	1	<1.0 mg/l	17	Desired
	2	1.0-1.5 mg/l	19	Acceptable
	3	>1.5 mg/l	79	Non acceptable

Groundwater quality maps are useful in assessing the usability of the water for different purposes. Figure 2 shows the spatial distributions of the levels of fluoride of the pinpoint locations in the study area. The spatial integration for groundwater quality mapping with special reference to fluoride contamination was carried out using ArcGIS and a groundwater quality map is created depicting the spatial distributions of fluoride contamination of groundwater. The spatial distributions map of fluoride contamination of groundwater of the study area derived shows a small region in the study area where the groundwater is potable (with reference to fluoride levels). It can be seen from the map that a few regions have groundwater that is potable only after proper fluoride removal/reduction treatment. However in the remaining parts of the study area, the water is non-potable due to fluoride contamination. From the fluoride contaminated groundwater quality map, it can be said empirically that the fluoride levels in groundwater in the study area are above the prescribed limits and are not potable and require to be processed before consumption.

5. Conclusion

The Hatigaon area is located on a land with bedrocks beneath it containing high fluoride levels. The main source of fluoride in drinking water in this area is the bedrock structure underground that can reach the aquifer. With the application of down-the-hole boring technology for piercing the bedrock under alluvium layers to exploit rock-fractured-water, the people are in fact extracting more fluoride.

The spatial distribution map of fluoride contamination of groundwater of the study area indicates that the fluoride levels are above maximum permissible limits for 68.70% of the sample wells. The spatial distribution map of groundwater quality in the study area indicated that majority of the samples collected are not satisfying the drinking water quality standards prescribed by the WHO and BIS. The results obtained give the necessity of making the public, local administrator and the government to be aware on the contamination of groundwater by fluoride prevailing in the study area. The government needs to make a scientific and feasible planning for identifying an effective groundwater quality management system and for its implementation. Since, in future the groundwater will have the major share of water supply schemes, plans for the protection of groundwater quality is needed. Present status of groundwater necessitates for the continuous monitoring and necessary groundwater quality improvement methodologies implementation.

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