

Assessment of Ground Water, Quality for Drinking Purposes of Jagdishpur Block of Bhagalpur District, Bihar–A Case Study

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Abstract Quality of water is an important issue rises in present situation. Increase the demand of the water for drinking and other uses are reduce the quality as well as quantity of ground water due to increase the human population and increase the ground water contamination through natural and anthropogenic sources. Jagdishpur Block of Bhagalpur district which is situated in the Indogangetic plains of Bihar the present study was put forth. Global Positioning System (GPS) based 45 ground water samples were collected from the different areas of Jagdishpur Block of Bhagalpur district (N-25.10'57'' E-086.58'857''), Bihar, India. The samples were slightly saline (EC 0.63- 1.65

dS m⁻¹), in nature and alkaline in reaction (pH 7.32–8.67). The cationic elements Ca²⁺ (52.1–151.5 mg l⁻¹), Mg²⁺ (21.7–88.9 mg l⁻¹) were reported to be in excess of the permissible limits and Na⁺ (3.8–22.9 mg l⁻¹) and K⁺ (0.50–5.1 mg l⁻¹) under the permissible limit. Anionic elements like Cl⁻ (3.25–28.74 mg l⁻¹) under the permissible level whereas CO₃²⁻ (0.0–0.0075 mg l⁻¹), HCO₃⁻ (0.0–0.0366 mg l⁻¹) were under the permissible limits and F⁻ (0.3–4.6 mg l⁻¹) was higher in some of the areas. The fluoride content of some of the samples (25 samples) were found higher than the permissible limit (1.5 mg l⁻¹, according to WHO standards) representing the fluoride contamination in the few villages of Jagdishpur Block. Regarding the irrigation water quality, SAR (Sodium adsorption ratio) and RSC (Residual sodium carbonate) value of water were 0.43–2.26 and –229.18 to –101.36 respectively, which are under safe category as per guidelines given by US Soil Salinity Laboratory.

Keywords Fluoride contamination, Water quality, Ground water, Indogangetic plain.

Introduction

Water is not only one of the requirement day to day lives but the development of this natural resource also play a crucial role in socio-economic development process [1]. In recent year, an increasing threat

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Table 1. Physico-chemical characteristics of ground water samples collected from Jagdishpur Block, Bhagalpur district.

Sl. No.	Location	Depth (feet)	pH	Ec (dS ⁻¹ m)	Cl ⁻ (mg/l)	CO ₃ ²⁻ (g/l)	HCO ₃ ⁻ (g/l)	F ⁻ (ppm)	Hardness (mg/l)	Ca ⁺⁺ (mg/l)	Mg ⁺⁺ (mg/l)	Na ⁺ (mg/l)	K ⁺ (mg/l)	SAR	RSC
1	N-25.12'210'' E-086.58'350''	100	8.25	0.85	8.75	0.0045	0.0061	1.2	410	99.4	75.8	8.7	4.2	0.93	-175.17
2	N-25.10'948'' E-086.58'268''	300	7.88	0.71	5.25	0.0000	0.0000	2.1	480	129.9	85.4	12	1.8	1.16	-215.29
3	N-25.06'490'' E-086.58'400''	120	8.25	1.19	17.32	0.0000	0.0122	1.6	360	88.2	66.3	16.9	3.2	1.92	-154.49
4	N-25.0626'6'' E-086.5823'5''	12	7.55	1.50	24.99	0.0015	0.0153	0.3	420	87.4	81.2	18.5	2.8	2.02	-168.52
5	N-25.06'659'' E-086.58'441''	150	8.12	1.08	14.50	0.0000	0.0061	1.1	244	117.8	30.8	7.4	4.1	0.86	-148.61
6	N-25.07'037'' E-086.58'260''	30	7.74	1.09	14.70	0.0060	0.0153	0.8	366	97.8	65.4	12.6	3.9	1.39	-163.22
7	N-25.06'561'' E-036.56'917''	20	7.97	0.85	8.75	0.0015	0.0092	0.5	340	68.9	66.1	17	2.9	2.07	-135.07
8	N-25.07'206'' E-086.57'471''	120	7.69	0.69	4.62	0.0000	0.0153	1.2	310	98.6	51.6	6.4	4	0.74	-150.16
9	N-25.07'174'' E-086.58'836''	20	7.68	1.39	22.29	0.0060	0.0336	0.6	470	151.5	77.7	14.9	3.7	1.39	-229.18
10	N-25.06'620'' E-087.00'517''	120	7.72	0.76	6.47	0.0030	0.0244	1.9	490	125.9	88.9	18	2.6	1.74	-214.68
11	N-25.07'493'' E-087.01'115''	80	8.15	0.88	9.45	0.0000	0.0153	1.1	392	110.6	68.7	16.8	1.9	1.77	-179.26
12	N-27.07'804'' E-087.00'393''	80	7.87	0.89	9.67	0.0000	0.0183	0.7	430	101.8	80.1	4.7	3.4	0.49	-181.86
13	N-25.07'521'' E-086.59'853''	120	7.76	0.98	12.00	0.0030	0.0336	3.4	442	147.5	71.9	22.9	1.7	2.19	-219.32
14	N-25.25'548'' E-086.59'749''	30	8.20	1.16	16.49	0.0000	0.0092	4.6	390	84.2	74.6	6.3	2.8	0.71	-158.78
15	N-25.07'539'' E-086.59'788''	70	8.19	1.44	23.49	0.0000	0.0183	3.6	406	130.7	67.2	8.9	3.7	0.89	-197.83
16	N-25.07'375'' E-086.59'768''	195	8.20	1.10	15.00	0.0045	0.0122	4.3	178	89.0	21.7	13.7	5.1	1.84	-110.68
17	N-25.06'864'' E-085.59'134''	70	8.25	0.94	11.00	0.0000	0.0092	3.5	250	58.5	46.7	16.4	3.5	2.26	-105.23
18	N-25.08'577'' E-086.58'867''	120	7.32	0.87	9.25	0.0000	0.0366	2.5	368	107.4	63.6	5.8	1.4	0.63	-170.96
19	N-25.08'159'' E-086.58'411''	120	7.98	0.91	10.22	0.0030	0.0153	1.4	408	75.4	81.2	7.4	2.5	0.84	-156.50
20	N-25.08'168'' E-086.58'509''	20	7.88	1.59	27.24	0.0000	0.0275	1.9	192	81.8	51.3	11.9	3.6	1.46	-133.03
21	N-25.08'669'' E-086.57'839''	22	7.60	1.65	28.74	0.0060	0.0122	0.9	428	118.6	75.5	16.3	4.1	1.65	-194.10
22	N-25.03'649'' E-086.59'174''	120	7.65	0.82	7.97	0.0015	0.0092	2.0	270	83.4	45.5	8.4	2.2	1.05	-128.89
23	N-25.09'839'' E-086.59'233''	30	8.25	1.04	13.45	0.0000	0.0061	2.2	374	102.6	66.2	4.9	1.1	0.53	-168.82
24	N-25.10'132'' E-087.00'123''	35	7.98	1.00	12.45	0.0015	0.0214	1.7	442	138.7	74.0	6.4	2.7	0.62	-212.66
25	N-25.09'522'' E-087.00'176''	40	7.67	1.14	15.90	0.0000	0.0183	1.2	326	54.5	66.2	10.3	1.5	1.33	-120.73
26	N-25.09'329'' E-086.59'139''	30	7.68	0.63	3.25	0.0045	0.0244	0.3	360	103.4	62.6	14	3.9	1.54	-165.99
27	N-25.09'006'' E-086.58'734''	30	8.02	1.36	21.49	0.0000	0.0061	1.9	256	139.5	28.4	11.7	4.3	1.28	-167.90

Table 1. Continued.

Sl. No.	Location	Depth (feet)	pH	Ec (dS ⁻¹ m)	Cl ⁻ (mg/l)	CO ₃ ²⁻ (g/l)	HCO ₃ ⁻ (g/l)	F ⁻ (ppm)	Hardness (mg/l)	Ca ⁺⁺ (mg/l)	Mg ⁺⁺ (mg/l)	Na ⁺ (mg/l)	K ⁺ (mg/l)	SAR	RSC
28	N-25.08'682'' E-086.58'661''	25	7.58	0.93	10.70	0.0075	0.0092	0.6	434	109.0	79.3	7.5	3.5	0.77	-188.30
29	N-25.08'666'' E-086.58'908''	25	7.84	1.00	12.50	0.0000	0.0031	1.6	406	108.2	72.7	5.7	2.7	0.60	-180.87
30	N-25.08'899'' E-086.58'653''	120	7.64	1.42	22.99	0.0015	0.0122	0.5	312	96.2	52.7	11.9	4.3	1.38	-148.84
31	N-25.08'975'' E-086.58'483''	120	8.16	1.00	12.50	0.0000	0.0244	1.9	372	59.3	76.3	5.5	1.7	0.67	-135.59
32	N-25.09'850'' E-086.58'312''	120	8.26	1.55	26.24	0.0045	0.0092	2.1	426	94.6	80.9	7.9	3.3	0.84	-175.44
33	N-25.10'094'' E-086.58'683''	80	7.89	0.81	7.75	0.0030	0.0092	1.9	390	103.4	69.9	10.9	2.5	1.17	-173.32
34	N-25.10'396'' E-086.58'131''	20	8.23	1.15	16.24	0.0000	0.0153	2.1	306	67.3	58.2	7.3	0.5	0.92	-125.55
35	N-25.10'606'' E--86.59'485''	20	7.55	0.92	10.57	0.0000	0.0092	0.6	448	128.3	78.0	8.2	1.2	0.81	-206.26
36	N-25.10'688'' E-087.00'173''	30	7.92	1.00	12.50	0.0030	0.0214	0.9	304	77.0	55.4	15.3	1.8	1.88	-132.33
37	N-25.10'579'' E-086.58'857''	50	7.76	1.53	25.74	0.0000	0.0092	1.1	394	110.6	69.1	12	2.4	1.27	-179.76
38	N-25.11'289'' E-086.58'627''	120	8.67	1.62	27.99	0.0000	0.0061	2.2	420	77.8	83.5	7.9	3.1	0.88	-161.26
39	N-25.11'596'' E-086.58'310''	80	0.03	1.21	17.74	0.0045	0.0244	2.6	358	87.4	66.0	3.8	2.8	0.43	-153.38
40	N-25.11'256'' E-086.57'455''	80	8.20	1.00	12.50	0.0000	0.0122	2.3	334	63.3	66.0	13.9	4.1	1.73	-129.36
41	N-25.11'496'' E-086.58'151''	120	8.25	1.00	12.50	0.0000	0.0061	2.0	392	83.4	75.3	6.4	3.9	0.72	-158.67
42	N-25.12'635'' E-086.58'535''	120	7.81	1.08	14.50	0.0015	0.0031	1.2	424	95.4	80.2	7.9	1.6	0.84	-175.57
43	N-25.13'156'' E-086.58'288''	110	8.22	0.88	9.47	0.0000	0.0183	2.0	462	110.6	85.7	14.3	3.1	1.44	-196.34
44	N-25.13'920'' E-086.57'906''	350	8.60	1.64	28.49	0.0000	0.0124	2.1	358	68.9	70.5	8.2	2.3	0.98	-139.45
45	N-25.13'992'' E-086.57'302''	120	7.90	1.07	14.25	0.0000	0.0092	0.6	254	52.1	49.3	5.8	3.5	0.81	-101.36
	Maximum		8.67	1.65	28.74	0.0075	0.0366	4.6	490	151.5	88.9	22.9	5.1	2.26	-229.18
	Minimum		7.32	0.63	3.25	0.0000	0.0000	0.3	178	52.1	21.7	3.8	0.5	0.43	-101.36
	Average		7.96	1.10	14.89	0.0016	0.0145	1.73	371	97.5	66.7	10.7	2.9	1.19	-164.19
	SD		0.29	0.28	6.95	0.0022	0.009	1.02	71	25.1	15.2	4.6	1.0	0.51	31.34

of ground water quantity as well as quality due to human activities has become of great importance particularly in Indogangetic plains [2, 3]. Pollution of ground water is a global concern of the day [2]. Presence of fluoride in water contaminates ground water quality. The pollution of the ground water is due to both anthropogenic as well as geogenic in origin [4].

Water quality index (WQI) represents a single

value expression that determines the overall water quality of the certain locations. It converts the complex water quality data into information that is understandable and usable by the public [3]. Horton has firstly use the concept of WQI then developed by [5, 6] and further improved by Deininger (Scottish development department (1975). The approach helps in understanding the ground water quality and suitability for human consumption.

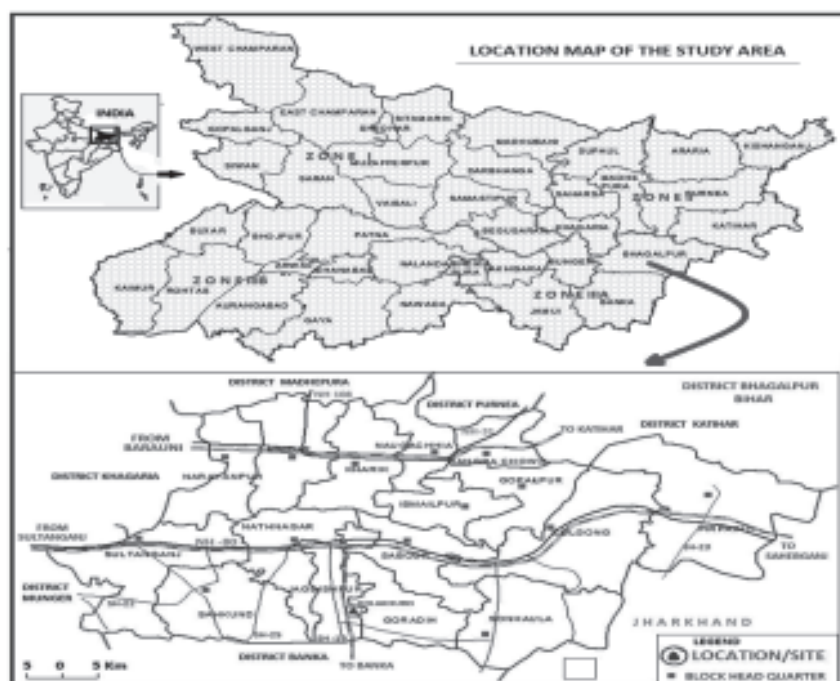


Fig. 1. Location of map to the sampling site area in Jagdishpur Block of Bhagalpur district.

Jagdishpur Block of Bhagalpur district in Bihar is known for famous Katarni rice. The best quality of this rice crop is exportable and fetches prosperity in the region. To produce this rice crop good quality of irrigation water is required. During socio-economic survey of the area some symptoms of fluorosis was observed in the population. Some villages of this Block are highly contaminated with fluoride. To understand and quantify the fluoride contamination in ground water and ground water quality used for drinking and irrigation in the surveyed area water samples were collected. This study will help to develop suitable management of the ground water used for various human and agricultural purposes.

Materials and Methods

Study area

The study area is situated in the latitude and longitude N-25.10'579'' and E-086.58'857'', respectively in

the location Jagdishpur Block, Bhagalpur district, Bihar (India) (Fig. 1). Bhagalpur is situated on the bank of Ganga river, even though most of the people fulfill their need of water from ground water [7]. The climate is subtropical with an average annual rainfall and evaporation value of about 1300 and 2,100 mm, respectively (average of 30 years). South-West monsoon (July to September) contributes 80% of total

Table 2. Represent the Water Quality Index (WQI) value and status of water quality.

WQI value	Water quality status
<50	Excellent
50–100	Good
100–200	Poor
200–300	Very Poor
>300	Water unsuitable for drinking purpose

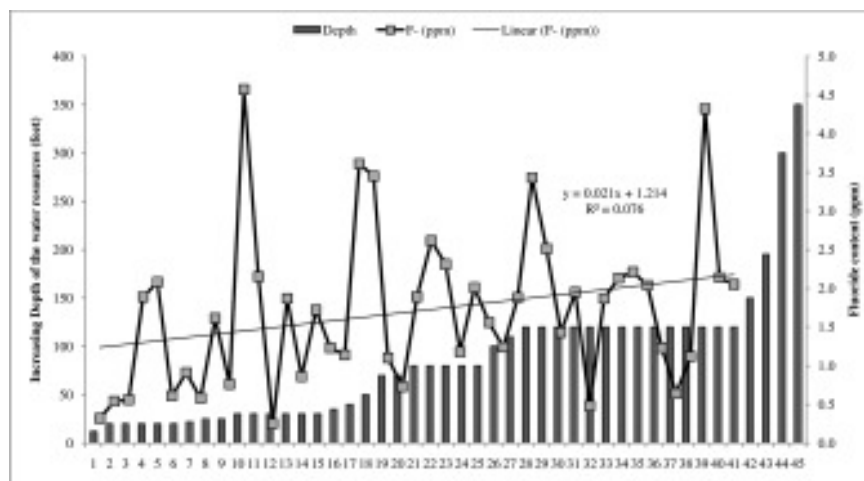


Fig. 2. Representing increasing depth of the water resources and fluoride content of the water samples.

rainfall. The monthly mean temperature ranges from 20 to 45°C, while the annual mean temperature is 31°C.

Sampling and analysis

GPS Based forty five ground water samples were collected from the different depths in the region during the pre-monsoon period (April–May 2013). The ground water samples were collected in one liter narrow mouth prewashed polyethylene bottles. The physico-chemical parameters, namely, pH, EC, Hardness, Ca^{++} , Mg^{++} , Na^+ , K^+ , CO_3^{--} , HCO_3^- , Cl^- and F^- were analyzed in the laboratory as per the standard procedure of APHA (1992). The pH and EC were measured using table ions meters. Total hardness and Ca^{++} were estimated by EDTA titrimetric methods, and Mg^{++} estimated by the difference of the hardness and Ca^{++} . CO_3^{--} and HCO_3^- and Cl^- were estimated by titrimetric methods. Na^+ and K^+ were estimated by flame photometer. Cl^- was estimated by standard AgNO_3 titration. F^- content in ground water was determined by SPANDS method using Spectrophotometer. WQI was calculated using these eleven physico-chemical parameters known as standard drinking water quality parameters. Table 2 represents the WQI value and the status of the water quality for drinking purpose [8].

Results and Discussion

The physico-chemical characteristics of the ground water were determined and represented in (Table 1). Water samples were slightly saline (EC 0.63–1.65 dS m^{-1}), in nature and alkaline in reaction (pH 7.32–8.67). All cationic elements Ca^{2+} (52.1–151.5 mg l^{-1}), Mg^{2+} (21.7–88.9 mg l^{-1}) were reported to be in excess of the permissible limits and Na^+ (3.8–22.9 mg l^{-1}) and K^+ (0.50–5.1 mg l^{-1}) under the permissible limit. Anionic elements like Cl^- (3.25–28.74 mg l^{-1}), CO_3^{2-} (0.0–0.0075 mg l^{-1}), HCO_3^- (0.0–0.0366 mg l^{-1}) were under the permissible limits whereas F^- (0.3–4.6 mg l^{-1}) was above the permissible limit for some of the water samples (Permissible limit for the F^- was 1.5 mg l^{-1}). Total hardness of the water samples range in between 178 to 490. Regarding the irrigation water quality, SAR (Sodium adsorption ratio) and RSC (Residual sodium carbonate) value of water were 0.43–2.26 and –101.36 to –229.18, respectively which are under safe category.

pH is a one of the most operational water quality parameter, with the optimum pH required often being range of 6.5–8.5 [9] is the standard guideline value. The maximum water samples are falling in between the standard guideline value and show alkaline in

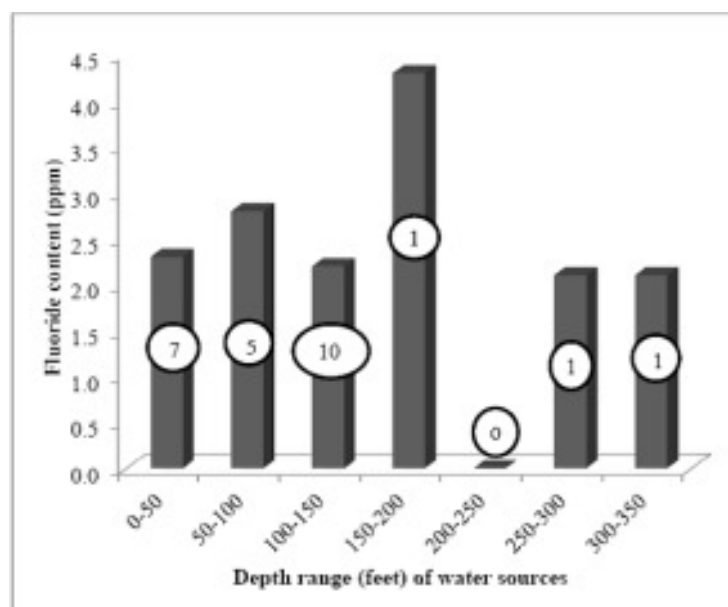


Fig. 3. Representing average fluoride content of the water samples (above the permissible limit 1.5 ppm) and depth range of water sources (*Data in circle show the number of water samples).

nature. EC is one of the most important prolific adverse environmental impacts associated with irrigation. Saline condition severely limits the choice the crop, adversely affected seed germination and yield of crop. Most of the water samples are slightly saline in nature and have slightly harmful effect on agricultural land and crop (EC value less than 1.5 is safe for irrigation) [9]. Based on the permissible limit proposed by BIS, 1991. The concentration of Ca^{2+} and Mg^{2+} lie between the limits (Table 1). Hence, safer for drinking to some extent but since, the water samples have high concentration of Ca^{2+} ion that will on ingesting for long period may be increased the risk of kidney stone [10]. The concentrations of HCO_3^- and Cl^- are below the permissible limit and hence, have no known adverse health effect. Richards (1954) categorized the ground water on the basis of SAR values (<10 as excellent; between 10—18 as good; 18—26 as fair; and < 26 as of poor quality). Based upon the SAR value of the water samples, they are safe to use for irrigation purpose [11].

The F^- content of some of the water samples were

found higher than the permissible limit 1.5 mg l^{-1} (Figs. 2 and 3), based on the permissible limit proposed by the World Health Organization. Figure 2 showed F^- content in different water samples was increased with increasing depth of the water sources ($R^2=0.0769$). This may be due to presence of more fluoride containing minerals in lower depth of the water sources. Figure 3 represented the ground water samples above the permissible range based on depth range of the water sources. The no of water samples 7 (0—50 feet), 5 (50—100 feet), 10 (100—150 feet), 1 (150—200 feet), 1 (250—300 feet) and 1 (300—350 feet) were found above the permissible range. F^- is an essential element for maintaining normal development of healthy teeth and bones. However, higher F^- concentration causes dental fluorosis and skeletal fluorosis such as molting teeth, deformation of ligaments and binding of spinal card [12]. The analysis of some of the water samples recorded higher concentration of F^- . This showed that the fluoride contamination in the few villages of Jagdishpur Block, Bhagalpur district and population in the villages affected with dental fluorosis and skeletal fluorosis.

Table 3. WQI of Jagdishpur Block of Bhagalpur district.

Sam- ple No.	WQI	Suita- bility for drinking	Sam- ple No.	WQI	Suita- bility for drinking	WQI Percentage (%)
1	69.62	Good	29	63.84	Good	Excellent-2.22
2	112.96	Poor	30	94.02	Good	Good - 64.44
3	82.71	Good	31	101.96	Poor	Poor - 33.33
4	65.24	Good	32	100.97	Poor	
5	68.37	Good	33	98.99	Good	
6	65.40	Good	34	68.20	Good	
7	50.53	Good	35	63.21	Good	
8	84.04	Good	36	81.07	Good	
9	65.20	Good	37	102.3	Poor	
10	107.12	Poor	38	118.22	Poor	
11	67.8	Good	39	108.06	Poor	
12	60.15	Good	40	98.78	Good	
13	154.57	Poor	41	79.14	Good	
14	178.96	Poor	42	99.64	Good	
15	144.45	Poor	43	98.04	Good	
16	171.06	Poor	44	56.65	Good	
17	146.83	Poor	45	64.21	Good	
18	158.27	Poor				
19	82.26	Good				
20	99.37	Good				
21	109.64	Poor				
22	101.94	Poor				
23	91.74	Good				
24	83.02	Good				
25	47.26	Excellent				
26	94.57	Good				
27	65.47	Good				
28	90.93	Good				

Using the eleven parameters mentioned above, a single mathematical value was calculated called as WQI. The generated score for different water samples collected from Jagdishpur Block, Bhagalpur district along with water quality status has been shown in the (Table 3). The computed WQI values that varied from 47.26 to 178.96. The results indicated that at some of the locations where WQI values obtained were low (<100) are safe for human consumption and for other domestic purpose either directly or with some easier and cheaper treatment methods. Further, distribution of water samples in percentage according to quality basis was reported in (Table 3). According to expressed data ground water may be categorized into 2.22% of water sample falls in excellent categories and 64.44% falls in the good water category, and 33.33% of water samples were found poor. Similar re-

sults were reported for different locations by [12]. Thus, the present study has very clearly brought out that all the samples, based on WQI are maximum found in the portable category and fit for human consumption, and remaining some samples are found poor quality can be consumed after cheaper treatment method.

Conclusion

Water quality of the Jagdishpur Block of Bhagalpur district was deteriorates due to excess amount of fluoride contamination in ground water and causes fluorosis in human being on consumption 55.6% of the water samples have higher fluoride content (above the permissible limit) in the location. Fluoride content increases on increasing water depth. As for as water quality is concerned two-third of the water samples were good to excellent quality while one-third of the water samples were poor quality. Ground water of the Jagdishpur Block is safe for irrigation purpose.

References

1. Etim EE, Odoh R, Itodo AU, Umoh SD, Lawal U (2013) Water quality index for the assessment of water quality from different sources in the Niger Delta Region of Nigeria. *Frontiers Sci* 3 : 89—95.
2. Verma DK, Mandal J, Padbhushan R, Kumar S, Lal M (2016) Water quality index for the assessment of ground water quality in the Sabour Block of Bhagalpur district, Bihar. *Int J Agric, Environ and Biotechnol* 9 : 467—472.
3. Sirajudeen J, Abdul VR (2014) Applications of water quality index for ground water quality assessment on Tamil Nadu and Pondicherry, India. *J Environm Res and Develop* 8 : 443—450.
4. Chodhury M, Rakshit A (2012) Chemical aspects of ground water quality in the shallow aquifers in selected districts of Eastern Uttar Pradesh. *Int J Agric, Environ and Biotechnol* 5 : 345—351.
5. Kouras A, Katsoyiannis I, Voutsas D (2007) Distribution of arsenic in ground water in the area of Chalkidiki. *J Hazard Mater* 147 : 890—899.
6. Raju N, Ram JP, Dey S (2009) Ground water quality in the Lower Varuna River Basin, Varanasi District, Uttar Pradesh. *J Geol Soc Ind* 73 : 178—192.
7. Raju NJ, Dey S, Das K (2009) Fluoride contamination in ground waters of Sonbhadra District, Uttar Pradesh, India. *Curr Sci* 96 : 979—985.
8. Verma DK, Kumar S, Mandal J, Padbhushan R (2015) Evaluating quality of ground water collected from inten-

- sively cropped areas in Sabour Block of Bhagalpur district, Bihar, India. *Ecol Environ and Conserv* 21 : 53—59.
9. WHO (2011) Guideline for drinking water quality, 4th (edn.) World Hlth Organ. Geneva.
 10. Verma DK, Dhara PK, Kole RK, Hazra GC, Mandal SK, Mishra P, Viveka N (2017) Water quality study for drinking purposes through the mathematical Water Quality Index (WQI) of Canning Block, Coastal Belt in South 24 Parganas, West Bengal. *Environ Ecol* 35 : 2939—2945.
 11. Feizi M, Hajabbasi MA, Mostafazadeh-Fard B (2010) Saline irrigation water management strategies for better yield of safflower (*Carthamus inctorius* L.) in an arid region. *AJCS* 4 : 408—414.
 12. Gupta H, Nag A (2014) Physico-chemical analysis of some water ponds in and around Santiniketan, West Bengal, India. *Int J Environm Sci* 4 : 676—682.