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Physico-chemical investigation of groundwater of Pisangan region of Ajmer (Rajasthan) with special reference to fluoride and nitrate

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ABSTRACT

This research is based on physicochemical investigation of groundwater with special reference to fluoride and nitrate to evaluate the quality of groundwater of Pisangan region of Ajmer district (Rajasthan). Pisangan is a tehsil block of Ajmer district (Rajasthan) and located 35.2 km from Ajmer district headquarter. The groundwater resources of Pisangan region (Ajmer) has greatly been affected by the overexploitation and geochemical changes. This research work was investigated the physico-chemical characteristics of groundwater of Pisangan and its surrounding villages. For the physico-chemical investigation, sixteen groundwater specimens were bottled from Pisangan and its surrounding villages during postmonsoon of 2021 and investigated for various groundwater quality parameters with special reference to fluoride (F^-) and nitrate (NO_3^-). It was perceived that the physico-chemical investigation of groundwater of Pisangan and its surrounding villages shown an uneven contamination of both fluoride (F^-) and nitrate (NO_3^-), and most of the groundwater specimens were not as per the drinking water standards of Bureau of Indian Standards (BIS). The groundwater of Pisangan region is found unsuitable for drinking purposes due to presence of fluoride (F^-) and nitrate (NO_3^-) beyond the maximum agreeable limit of drinking water standards of BIS.

Key words: *Pisangan (Ajmer), Groundwater, Physico-chemical parameters, Fluoride contamination, Groundwater pollution.*

Introduction

Globally, water is the most essential element for the nourishment of life on earth surface and all additional generous happenings including domestic, agricultural, industrial and recreational purposes (De, 2000; Kershaw *et al.*, 2000; Kilic, 2020; and Valsami-Jones, 2004). Around the earth, groundwater is the most significant and esteemed natural renewable resource of freshwater and it contains about 30.1% freshwater of the total global freshwater distribution of the earth (Gleick, 1996). It is technologically and economically approachable through tube- wells, open-wells and handpumps for human utilization with diverse composition and purity (Ayotte *et al.*, 2011; Chaudhary and Satheeshkumar, 2018; Chilton, 1996; Velis *et al.*, 2017). Rajasthan (India) is the biggest state of India by area with 10.40% geographical areas of India nevertheless the availability of water resources is very less as compared to geographical area and population High salinity, fluoride (F^-) and nitrate (NO_3^-) contamination is the major scarcity of available groundwater resources of Rajasthan (India) and the contamination usually happened in drinking water resources due to the natural and human-made activities (Coyte *et al.*, 2019; Munoth *et al.*, 2015; State Water Policy, 2010). The groundwater resources of most of region of Rajasthan such as

Ajmer, Alwar, Bhilwara, Dausa, Jaipur, Jalore, Nagour, Pali, Jodhpur and Tank districts shows very high concentration of both fluoride and nitrate (Agarwal and Sharma, 2015; Hussain *et al.*, 2001 & 2013; Jandu *et al.*, 2021; Jhanwar *et al.*, 2021; Munoth *et al.*, 2015; Rahman *et al.*, 2021; Sharma *et al.*, 2017; Singh *et al.*, 2011; Tailor and Chandel, 2010; Tiwari *et al.*, 2020). The groundwater resources of Rajasthan (India) are highly contaminated and it is unsafe for human consumption and therefore, it is necessary to analyse and categorized the groundwater resources for human necessity.

In the present research work, authors report the investigation of groundwater physicochemical parameters of Pisangan region of Ajmer district of Rajasthan (India) with special reference to fluoride (F^-) and nitrate (NO_3^-). For the physico-chemical investigation, sixteen groundwater sampling sites were marked (Fig. 1) and groundwater specimens were bottled from each site of Pisangan and its surrounding villages during post-monsoon of 2021. The physico-chemical parameters, i.e., pH, electrical conductivity (EC), total dissolve solids (TDS), fluoride (F^-), chloride (Cl^-), nitrate (NO_3^-), sulphate (SO_4^{2-}), total hardness (TH) and total alkalinity (TA) of groundwater were estimated in the research laboratory following the standard analytical procedures (SOPs) of American Public Health Association (APHA). The study has revealed that all sixteen groundwater sampling sites of Pisangan and its surrounding villages were found to have high concentration of fluoride and nitrate with other contaminants. Therefore, the groundwater of Pisangan and its surrounding villages were found unsuitable for drinking purpose due to presence of fluoride (F^-) and nitrate (NO_3^-) beyond the maximum agreeable limit of drinking water standards of BIS.

Materials and Methods

Description of Pisangan region (Ajmer, Rajasthan): This research work was focused at the physico-chemical investigation of groundwater of Pisangan (Ajmer, Rajasthan) and its surrounding villages with special reference to fluoride (F^-) and nitrate (NO_3^-) contamination in groundwater resources (Fig. 1). Pisangan (Almer) is a tehsil block of Ajmer district (Rajasthan) and it is geographically coordinated between 26.383° North latitude and 74.411° East longitude. In Pisangan tehsil, there are about 64 villages and towns.

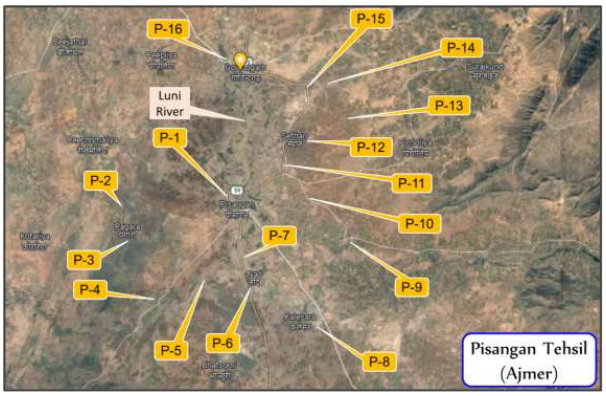

Fig. 1. Satellite view of Pisangan (Ajmer, Rajasthan) and its surrounding villages with highlighted groundwater sampling sites (P-1 to P-16).

Description of the groundwater sampling from Pisangan region (Ajmer, Rajasthan): Groundwater specimens were bottled from various sampling sites from Pisangan (Ajmer, Rajasthan) and its surrounding villages during post-monsoon of 2021 by applying the standard sampling procedure. The groundwater specimens were carefully bottled from various sources such as open-well, tube-well and handpump. All the groundwater specimens were preserved in fresh screw capped polyethylene bottle. The groundwater specimens were then stored in standard condition in cool and dark place in the laboratory for further analysis.

See Fig. 1 for the satellite view of Pisangan (Ajmer, Rajasthan) and its surrounding villages from where the groundwater specimens were bottled for physico-chemical analysis. The code name of highlighted sampling sites in satellite map is quoted in Table 1.

Physicochemical studies of groundwater of Pisangan region (Ajmer, Rajasthan): The groundwater specimens were bottled by applying the previously stated standard procedure and were then estimated for various physico-chemical quality parameters with special reference to fluoride (F^-) and nitrate (NO_3^-). The characterization of groundwater specimens was performed in research laboratory to determine the degree of contamination in comparison to drinking water standards of BIS (BIS, 2012). The groundwater specimens were preliminarily analyzed for pH, EC and TDS at the time of sampling. For the other physico-chemical parameters, the bottled groundwater specimens were brought to the research laboratory and stored in standard con-

Table 1. List of groundwater sampling sites of Pisangan (Ajmer, Rajasthan) and its surrounding villages with their sample code name as quoted in satellite map and types of groundwater sources.

Entry	Code	Name of Sampling Sites	Details (Type of source)
1.	P-1	Pisangan	Handpump
2.	P-2	Devnagar	Open-well
3.	P-3	Pagara	Open-well
4.	P-4	Mewariya	Handpump
5.	P-5	Pratappura	Tube-well
6.	P-6	Nad	Tube-well
7.	P-7	Hanwantpura	Handpump
8.	P-8	Kalesara	Handpump
9.	P-9	Budhwara	Tube-well
10.	P-10	Rampura Dabla	Tube-well
11.	P-11	Fatehpura	Handpump
12.	P-12	Sethan	Handpump
13.	P-13	Samrathpura	Open-well
14.	P-14	Jaswantpura	Open-well
15.	P-15	Akhepura	Handpump
16.	P-16	Govind Garh	Handpump

dition. The parameters such as F^-, Cl^-, NO_3^-, SO_4^{2-}, TH and TA in groundwater specimens were tested in research laboratory. All physico-chemical parameters were analyzed as per the standard operating procedures (SOPs) of APHA (APHA, 1989). The characteristic data of the groundwater specimens given in the Table 2 to 4. In all three tables, the experiential results of groundwater specimens were also compared with the drinking water standards of BIS (BIS, 2012).

Results and Discussion

Pisangan is a tehsil block of Ajmer district of Rajasthan and it has a total geographical area of 654 km^2. Pisangan tehsil block is completely a rural zone and there are 64 villages. According to the Census of India (2011), Pisangan tehsil has a total population of 1,27,803 peoples including 65,075 male population and 62,728 female population. Thus, most of the population of the Pisangan tehsil is belongs to the rural areas. The basic necessity of water of Pisangan tehsil is primarily accomplished by the groundwater resources, i.e., open-well, tube-well and handpump, since there are no major resources of surface water. The general problem of the population of Pisangan tehsil is consuming the highly saline, hard and contaminated groundwater and it is harmful for the living beings of the Pisangan tehsil. Therefore, the observations of various physico-chemical parameters are necessary to find the quality of groundwater with special reference to fluoride (F^-) and nitrate (NO_3^-) of Pisangan tehsil of Ajmer (Rajasthan).

To investigate the physico-chemical parameters of groundwater of Pisangan (Ajmer) and its surrounding villages, the groundwater specimens were bottles from sixteen different sampling sites which is mentioned in the Table 1 with sample code and type of sampling sites and sampling sites marked in the satellite map of Pisangan region (Fig. 1). The bottled groundwater specimens of Pisangan (Ajmer) and its surrounding villages were firstly analysed for pH, EC and TDS at the time of sampling and far ahead analysed in the research laboratory for the F^-, Cl^-, NO_3^-, SO_4^{2-}, TH and TA using standard SOPs of APHA (APHA, 1989).

The investigated physico-chemical parameters of groundwater specimens of Pisangan (Ajmer) and its surrounding villages are illustrated in Table 2. All the investigated evaluation is also equated with the standard values as endorsed by the BIS (BIS, 2012).

Results of quality parameters of groundwater of Pisangan region (Ajmer, Rajasthan)

***pH of groundwater*:** The pH of groundwater specimens of Pisangan region (Ajmer) varied in the range of pH 7.03 to pH 8.90 (Table 2) with an average of pH 7.96. Therefore, the pH of the groundwater indicates that the groundwater is slightly to moderately alkaline in nature and suitable for the drinking and other purposes. The pH of twelve sampling sites of Pisangan region (Ajmer) and their averages found under the range of agreeable limits of drinking water standards as given by BIS (BIS, 2012).

***EC of groundwater*:** The EC of groundwater specimens of Pisangan region (Ajmer) varied in the range of 417 µS/cm to 912 µS/cm (Table 2) with an average of 633.25 µS/cm. Therefore, the groundwater resources found to have high EC and the higher EC indicates that the groundwater contains high concentration of dissolved ionic constituents.

***TDS of groundwater*:** The TDS of groundwater specimens of Pisangan region (Ajmer) varied in the range of 783 mg/l to 1899 mg/l (Table 2) with an average of 1254.75 mg/l. Therefore, the groundwater resources found to have high TDS and the higher TDS indicates that the groundwater contains high concentration of dissolved inorganic and organic constituents. The groundwater of all sampling sites of Pisangan region (Ajmer) and their averages ex-

ceeds the agreeable limits of drinking water standards as given by BIS (BIS, 2012). Owing to the high TDS, the groundwater of Pisangan and its surrounding villages is unsafe for drinking.

Fluoride (F^-) in groundwater: F^- in groundwater specimens of Pisangan region (Ajmer) varied in the range of 2.55 mg/l to 8.47 mg/l (Table 2) with an average of 5.528 mg/l. Therefore, the groundwater resources of Pisangan and its surrounding villages found to have high concentration of F^-. The groundwater of all sixteen sampling sites of Pisangan region (Ajmer) and their averages exceeds the agreeable limits of drinking water standards as given by BIS (BIS, 2012). Owing to the high concentration of F^-, the groundwater of Pisangan region (Ajmer) is unsafe for drinking.

Chloride (Cl^-) in groundwater: Cl^- in groundwater specimens of Pisangan region (Ajmer) varied in the range of 196 mg/l to 517 mg/l (Table 2) with an average of 346.31 mg/l. Therefore, the groundwater resources of Pisangan and its surrounding villages found to have moderately high concentration of Cl. The groundwater of twelve sampling sites of Pisangan region (Ajmer) and their averages exceeds the agreeable limits of drinking water standards as given by BIS (BIS, 2012). Owing to the high concentration of Cl^-, the groundwater of Pisangan region (Ajmer) is unsafe for drinking.

Nitrate (NO_3^-) in surface water: NO_3^- in groundwater specimens of Pisangan region (Ajmer) varied in the range of 46.36 mg/l to 78.21 mg/l (Table 2) with an Average of 56.76 mg/l. Therefore, the groundwater resources of Pisangan and its surrounding villages found to have high concentration of NO_3^-. The groundwater of all sampling sites of Pisangan region (Ajmer) and their averages exceeds the agreeable limits of drinking water standards as given by BIS (BIS, 2012). Owing to the high concentration of NO_3^-, the groundwater of Pisangan region (Ajmer) is unsafe for drinking.

Sulphate (SO_4^{2-}) in groundwater: SO_4^{2-} in groundwater specimens of Pisangan region (Ajmer) varied in the range of 66.95 mg/l to 280.76 mg/l (Table 2) with an average of 127.64 mg/l. Therefore, the groundwater resources of Pisangan and its surrounding villages found to have moderately low concentration of SO_4^{2-}. The groundwater of two sampling sites of Pisangan region (Ajmer) exceeds the agreeable limits of drinking water standards as given by BIS (BIS, 2012).

***TH of groundwater*:** TH of groundwater specimens of Pisangan region (Ajmer) varied in the range of

Table 2. Physicochemical parameters of groundwater specimens of Pisangan and its surrounding villages bottled during post-monsoon of the year 2021 and their comparison with drinking water standards of BIS.

Groundwater Specimens	Groundwater Physicochemical Parameters								
	pH	EC	TDS	F^-	Cl^-	NO_3^-	SO_4^{2-}	TH	TA
BIS Std. *	6.5-8.5	-	500	1.00	250	45	200	200	200
P-1	8.61	851	1676	8.25	511	66.15	245.50	306.9	222.7
P-2	8.78	879	1723	6.98	438	69.40	174.65	298.0	195.6
P-3	8.90	912	1899	8.47	517	78.21	280.96	421.1	254.3
P-4	8.10	741	1587	3.68	349	55.63	142.52	276.3	218.0
P-5	7.71	550	994	4.60	372	56.78	96.34	219.7	176.2
P-6	8.20	645	1242	7.70	216	61.95	102.46	246.4	210.5
P-7	7.98	603	1178	9.52	278	51.23	98.74	259.0	210.4
P-8	8.56	689	1390	7.64	295	56.51	76.95	406.9	245.2
P-9	8.24	674	1334	3.09	386	56.98	84.22	389.5	265.7
P-10	7.50	418	783	3.48	219	48.90	66.95	192.2	168.4
P-11	7.79	466	856	2.63	196	50.47	165.42	198.6	179.5
P-12	7.32	457	945	4.57	224	52.64	134.02	210.6	197.2
P-13	7.85	499	1094	3.61	375	46.36	112.53	236.1	210.4
P-14	7.03	417	852	2.55	398	49.85	75.65	213.3	201.7
P-15	7.50	653	1247	3.74	365	51.66	95.81	310.9	245.6
P-16	7.28	678	1276	7.93	402	55.48	89.67	345.2	225.7

Note: EC measure in µS/cm; and other parameters except pH measures in mg/L; EC = Electrical Conductivity; TDS = Total dissolve solids; TH = Total Hardness as $CaCO_3$; TA = Total Alkalinity as $CaCO_3$; * BIS-2012 (IS 10500: 2012) agreeable drinking water standards (BIS, 2012).

192.20 mg/l as $CaCO_3$ to 421.10 mg/l as $CaCO_3$ (Table 2) with an average of 283.17 mg/l as $CaCO_3$. Therefore, the groundwater resources of Pisangan and its surrounding villages found to have high TH and the higher TH indicates that the groundwater contains high concentration of calcium and magnesium hardness. The groundwater of fourteen sampling sites of Pisangan region (Ajmer) and their averages exceeds the agreeable limits of drinking water standards as given by BIS (BIS, 2012). Owing to the high hardness, the groundwater is unsafe for drinking.

***TA of groundwater*:** TA of groundwater specimens of Pisangan region (Ajmer) varied in the range of 168.40 mg/l as $CaCO_3$ to 265.70 mg/l as $CaCO_3$ (Table 2) with an average of 214.19 mg/l as $CaCO_3$. Therefore, the groundwater resources of Pisangan and its surrounding villages found to have high TA and the higher TA indicates that the groundwater contains high concentration of carbonates and bicarbonate alkalinity. The groundwater of eleven sampling sites of Pisangan region (Ajmer) and their averages exceeds the agreeable limits of drinking water standards as given by BIS (BIS, 2012). Owing to the high alkalinity, the groundwater is unsafe for drinking.

Discussion

The groundwater of Pisangan region (Ajmer) was estimated for numerous physico-chemical parameters with special reference to fluoride (F^-) and nitrate (NO_3^-) contamination. The groundwater quality parameters such as pH, EC, TDS, Cl^-, F^-, NO_3^-, SO_4^{2-}, TH and TA were estimated for the groundwater specimens of Pisangan (Ajmer) and its surrounding villages throughout the research work in the year 2021. The average results of the groundwater quality parameters of the current study has shown in Table 3 and indicated that the quality parameters such as pH and SO_4^{2-} doesn't exceed the agreeable limits of drinking water standards while the TDS, F^-, Cl^-, NO_3^-, TH and TA exceeds the agreeable limits of drinking water standards as prescribed by BIS (BIS, 2012). The high F^- and NO_3^- may cause several negative impacts on the health of human beings. The excess concentration of F^- can cause mild dental and skeletal fluorosis (Brindha and Elango, 2011) and excess concentration of NO_3^- can cause methemoglobinemia in human beings (Munoth *et al.*, 2015). The presence of both F^- and NO_3^- in high concentration in groundwater resources is due to the overexploitation, geographical changes and presence of natural minerals that can dissolve in groundwater resources. NO_3^- pollution in groundwater resources is caused by the severe use of nitrogen containing fertilizers and manures, domestic/ municipal wastewater, animal wastes, industrial wastewater effluents, and chemical wastes (Singh and Craswell, 2021). Natural and man-made pollution of groundwater in Pisangan (Ajmer) and its surrounding villages are the major problems and therefore, the groundwater resources are severely contaminated with F^- and NO_3^-. Since, the Pisangan region (Ajmer) has large amount of pollutants, the ground-

Table 3. Physicochemical estimation of groundwater of Pisangan (Ajmer) and its surrounding villages during post-monsoon of the year 2021 and their averages along with comparison with BIS drinking water standards.

Quality Parameters	Observed range	Average	BIS (IS-10500: 2012) *Maximum Limits		Percent Samples exceeding acceptable limits of standards (%)
			Acceptable Limit	Permissible Limit	
pH	7.03 – 8.90	7.96	6.5-8.5	NR	25%
EC	417 – 912	633.25	-	-	-
TDS	783 – 1899	1254.75	500	2000	100%
Fluoride (F^-)	2.55 – 8.47	5.528	1.00	1.50	100%
Chloride (Cl^-)	193 – 517	346.31	250	1000	75%
–Nitrate (NO_3^-)	46.36 – 78.21	56.76	45	NR	100%
2–Sulphate (SO_4^-)	66.95 – 280.76	127.64	200	400	12.50%
TH as $CaCO_3$	192.20 – 421.10	283.17	200	600	87.50%
TA as $CaCO_3$	168.40 – 265.70	214.19	200	600	68.75%

Note: EC measure in µS/cm; and TDS, F^-, Cl^-, NO_3^-, SO_4^{2-}, TH and TA measures in mg/L; NR = No Relaxation; EC = Electrical Conductivity; TDS = Total dissolve solids; TH = Total Hardness; TA = Total Alkalinity; and * BIS-2012 (IS 10500: 2012) drinking water standards (BIS, 2012).

water resources of Pisangan region (Ajmer) is unsafe for human drinking as per the guidelines of BIS.

Conclusion

The geographical area of Pisangan region (Ajmer, Rajasthan) is in the foremost prominence for the estimation of physico-chemical parameters with special reference to fluoride (F^-) and nitrate (NO_3^-). Pisangan is a tehsil block of Ajmer district (Rajasthan) and located 35.2 km from Ajmer district headquarter. The groundwater resources of Pisangan region (Ajmer) has greatly been affected by the overexploitation and geochemical changes. This research work was investigated the physico-chemical characteristics of groundwater of Pisangan (Ajmer) and its surrounding villages. In this research work, the groundwater specimens were bottled from sixteen sampling sites of Pisangan (Ajmer) and its surrounding villages during post-monsoon of 2021 and further estimated for numerous physicochemical parameters with special reference to fluoride (F^-) and nitrate (NO_3^-). It was perceived that the physico-chemical investigation of groundwater of Pisangan and its surrounding villages shown an uneven contamination. The groundwater quality parameters such as TDS, F^-, Cl^-, NO_3^- TH and TA were recorded above the maximum agreeable limits while pH and SO_4^{2-} were recorded under the agreeable limit as prescribed by BIS. Due to presence of large concentration of both F^- and NO_3^- in groundwater of Pisangan region, it is found unsuitable for drinking purposes.

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