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A SURVEY ON FLUORIDE CONCENTRATION IN DRINKING WATER OF TIPPARTHY REVENUE SUB-DIVISION, NALGONDA DISTRICT, ANDHRA PRADESH, INDIA AND BATCH MODE DEFLUORIDATION WITH RENEWABLE RESOURCES

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ABSTRACT

43 water samples belonging to 22 gram panchayats (villages) of Tipparthy revenue sub division Nalgonda district were chemically analyzed for determining fluoride ion concentrations. High fluoride containing regions were identified on the basis of fluoride levels of the water samples and also on the prevalence rate of dental and skeletal fluorosis of the study area. Fluoride maps, which distinguish the regions containing the water sources of deferent ranges of fluoride ion concentrations, were also prepared by isopleth's technique, a statistical method. Water samples containing high fluoride levels were defluoridated with economically cheaper materials prepared from plant byproducts. These materials were successfully decreases the fluoride ion concentration to a permissible limit (0.5 to 1.5 mg/L) without disturbing drinking water quality standards.

Key words: Field survey; Tipparthy revenue sub-division; Defluoridation of water; Plant byproducts; Carbon adsorbents.

INTRODUCTION

The fluorides were widely distributed in nature and it has been estimated that the element fluorine in the form of fluoride constituents 0.32% of the earth's crust[1]. Fluoride could be found in a number of minerals, of which fluorspar, cryolyte and fluorapatite are the most common[2]. Many epidemiological studies of possible adverse effects of the long-term ingestion of fluoride via drinking water have clearly indicated that fluoride primarily produces effects on skeletal tissues (bones and teeth)[3]. Skeletal fluorosis is observed when drinking water contains 3-6 mg/L. Crippling skeletal fluorosis develops where drinking water contains over 10 mg/L of fluoride[4]. In India totally 25 states have been reported as fluoride affected areas but severe problem occurred in the states of Andhra Pradesh[5], Tamilnadu[6], Rajasthan[7] and Madhyapradesh[9].

Several methods are in vogue to remove fluoride from drinking water[8]. These includes use of alumina, bone char, plant byproducts, ion exchange resins and reverse osmosis[10], but the literature survey clearly indicates the materials used in the present studied not reported any where.

Geology of the study area

The area is located approximately 120 km away from the capital of Andhra Pradesh Tipparthy division falls in the survey of India toposheet no.56 P/10. The area lies between 16^0 40' 30" and 16^0 45' 30" latitudes and bounded by 79^0 31' 00" and 79^0 40' 00" longitudes. It is about 45 km south east of Nalgonda district head quarters of Andhra Pradesh.

This area forms part of the past palnad basin and it is contact zone between quartizites of banganapalli and limestones of narji series of Kurnool formations. The terrain is flat to gently undulating except for a

few hillocks and valleys. The soils of the catchment area can be broadly divided into 5 groups, namely medium block soil (12.0%), deep block soil (29.0%), mixed red and black soil (35.0%), red sandy soil (20.0%) and red loamy soil (4.0%). As per census of 2001 the population of the mandal (revenue sub-division) has been recorded as 46,451.

There are number of viable techniques for defluoridation of drinking water, but they are economically rich and non-applicability on mass scale[10]. The present communication present the use and applicability of adsorbent carbon materials prepared from the dry fruits of various plant materials and the obtained results were compared with the commercially activated carbon (CAC) (Ran boxy laboratories Ltd, India).

EXPERIMENTAL

A door-to-door survey was conducted on the residents of the selected villages in the study area along with the registered medical practitioner to standardize the readings. The Jackson index method of dental fluorosis was used. In this survey people are broadly divided into three categories depending on the age limits between 5 to 15, 15 to 25 and above 25 years of age. In each group totally 25 persons were examined and prepared statistical report. After conformation of fluorosis presence totally 43 samples were collected from all drinking water sources from all places in the division and water samples were analyzed for fluoride ion concentration by SPADNS method[11].

Sample collection

Water samples have been collected from all the existing sources of drinking water in the study area for investigation and chemical analysis. For the present investigation, separate sets of samples are collected for chemical and biological analysis from the source. The bottles for sample collection have been thoroughly cleaned by rinsing with 8M HNO_3 solution, followed by repeated washing with double distilled water. They are further rinsed with sample water before collection. Physico-chemical analysis was done by standard procedure[11].

Material preparation

Defluoridating materials were prepared from the dry fruits, collected from the plants Enterolobium saman (ESC), Acasia arabica (AAC), Prosopis juliflora (PJC) belongs to Mimosideae family and Citrus limon (CLC) belongs to Rutaceae family in the plant kingdom. These materials are available as agricultural wastes and carbonized at 400 to 500^{o}C in muffle furnace. The prepared carbons were chemically treated with 0.5 M HNO_3 solution and then washed with distilled water and finally sieved in to 75μ particles size.

Defluoridation method

0.5g of adsorbent carbon was mixed with 100 ml of water samples and stirred at 120 rounds/minute speed on Remi shaker for 30 minutes. Solution was filtered through whatman no 42 filter paper and the filtrate was examined for further fluoride ion concentration on U.V. visible spectrophometer (model no: Elico U.V-2600).

Experimental conditions were obtained with the above prepared carbon adsorbents in batch mode study as 45 minutes agitation time, 4 g/L adsorbent concentration; optimum pH range is 7-8. The same conditions were applied in defluoridation of drinking water samples in batch mode study.

RESULTS AND DISCUSSION

Ground water is the only source of potable water for majority of people in the study area. However, the inhabitants here are averse to drink bore well water or water from public water system. They say that water drawn from great depths is not tasty, hence their preference to open well water or hand pump water. A survey of residents of the selected villages in the study area on the impact of water used for drinking on health of the users revealed that, most of the residents suffer from dental discoloration, early tooth decay and bone deformations. The practicing physicians of the study area also confirmed our observations. A perusal of the Table 1 would reveal that symptoms of dental fluorosis (SDF) in female population were more common than the male population. However, this anomaly was observed to be more prevalent between 5 and 15 years of age, which decreases with increase in age. Similarly maximum percentage of bone deformation (BDF) was observed in Chinnasuraram village while in Indlur village it was observed

to be minimum, The concentration of fluoride in all samples of study area has varied from 1.4 to 4.5 mg/L, 1.57 to 3.02 mg/L and 1.06 to 3.02 mg/L, in hand pump, bore well and open well water samples respectively. From chemical analysis the study area was broadly classified into five categories depending upon the concentration (Table 5) of fluoride ion. 14 water samples from bore well, 19 from hand pump, 5 samples from open well water was fallen within the range of 1.5 to 4.50 mg/L concentration of fluoride ion, but only 1 from bore well, 3 from open well water samples having less than 1.5 mg/L concentration. As per census of 2001 the population of the revenue sub division has been recorded as 46,451.

Defluoridation studies of potable water samples

Water samples collected from various villages of Tipparthy sub-division (Tables 2 to 4) indicate that samples 1 to 19 of hand pump water, samples 20 - 35 of bore well water and samples 36 to 40 of open well water contain excess of fluoride beyond the permissible world health organization limit 1.5 mg/L[2]. Hence the defluoridation studies have been carried out on these particular samples using prepared bio adsorbents from ESC, AAC, PJC and CLC. The results were compared with those of CAC. In order to reduce the fluoride content below the permissible limit, optimum condition reported in previous have been used.

For water samples, which contain fluoride range between 3.0 and 4.0 mg/L, the dose of adsorbent is 4.5 g/L and for those water samples, which contain fluoride, ranging from 1.5 to 3.0 mg/L, the dose adsorbent is 4.0 g/L. The optimum contact time is 45 minutes with constant stirring at 200 rpm speed. The concentrations of fluoride ion in these samples after defluoridation have also been reported in the same tables.

A comparative study of the results of some physico-chemical analysis of water from bore well, hand pump and open well before defluoridation and after defluoridation, indicate that water quality parameters like pH, EC, TDS, PO_4^{3-}, SO_4^{2-}, Cl^-, K^+ etc. values were increased slightly, but negligible in many water samples when the adsorbents ESC, AAC, PJC, CLC and CAC are used for the Defluoridation process. Among the adsorbents, ESC, AAC and PJC decrease the fluoride content in potable water samples to a considerable extent without affecting the permissible limits of other water quality parameters. The order of adsorption capacity in the removal of fluoride by these adsorbents is ESC > AAC > PJC > CLC > CAC.

CONCLUSION

The result of the study indicates that the area under study is fully affected with endemic fluorosis, and the concentration of fluoride ion in all water sources varies from place to place. All of these results may arise due to the nature of rock and soil formation. Especially higher concentrations were observed in bore well and hand pump water. The low cost adsorbents ESC, AAC and PJC remove fluoride content from potable water to a larger extent compared with the other adsorbent CLC. Hence the adsorbents ESC, AAC and PJC can be used for the defluoridation of potable water at house hold level. Finally the results also suggest that the area fully contaminated with fluoride and not suitable for drinking purpose and proper care must be taken by the people.

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Table-1: Occurrence of dental fluorosis and bone deformation in studied villages of Tipparthy revenue sub-division

Name of the Village	Sex	Age group, year	No. of individual examined	(SDF)	(BDF)	% of SDF	% of BDF	Mean of total % SDF	Mean of total % BDF
Keshirajpally	M	5-15	25	22	5	88	20	41.33	9.33
		15-25	25	6	2	24	8		
		>25	25	3	3	12	12		
	F	5-15	25	17	2	68	8		
		15-25	25	8	1	32	4		
		>25	25	6	1	24	4		
Chinnasuraram	M	5-15	25	19	6	76	24	54	10.6
		15-25	25	12	2	48	8		
		>25	25	6	2	24	8		
	F	5-15	25	23	3	92	12		
		15-25	25	12	1	48	4		
		>25	25	9	2	36	8		
Indlur	M	5-15	25	24	2	96	8	56	4.67
		15-25	25	15	1	60	4		
		>25	25	14	1	56	4		
	F	5-15	25	18	1	72	4		
		15-25	25	9	1	36	4		
		>25	25	4	1	16	4		
Tipparthy	M	5-15	25	24	2	96	8	62.67	8.0
		15-25	25	17	2	68	8		
		>25	25	12	1	48	4		
	F	5-15	25	20	4	80	16		
		15-25	25	12	2	48	8		
		>25	25	9	1	36	4		
Dacharam	M	5-15	25	18	2	72	8	58.67	7.33
		15-25	25	16	1	64	4		
		>25	25	13	3	52	12		
	F	5-15	25	17	2	68	8		
		15-25	25	15	1	60	4		
		>25	25	9	2	36	8		
Indugala	M	5-15	25	19	6	76	24	50.67	8.0
		15-25	25	12	1	48	4		
		>25	25	8	1	32	4		
	F	5-15	25	18	2	72	8		
		15-25	25	10	1	40	4		
		>25	25	9	1	36	4		

Table-2: Fluoride ion concentration (before and after defluoridation) of hand pump water samples

		C_i	C_f				
S.No	Name of the Village		ESC	AAC	PJC	CLC	CAC
1	Keshiraj pally	2.98	0.6	0.72	0.8	0.89	1.97
2	A.Duppalapally	3.02	0.6	0.72	0.82	0.91	1.99
3	Pathapalle	3.01	0.6	0.72	0.81	0.9	1.99
4	Kankanalapally	2.85	0.57	0.68	0.77	0.86	1.88
5	Thanedaripally	2.82	0.56	0.68	0.76	0.85	1.86
6	Peddasuraram	2.68	0.54	0.64	0.72	0.8	1.77
7	Chinnasuraram	2.09	0.42	0.5	0.56	0.63	1.38
8	Choullagudem	2.94	0.59	0.71	0.79	0.88	1.94
9	Pajjur	1.86	0.37	0.45	0.5	0.56	1.23
10	Anthaigudem	1.57	0.31	0.38	0.42	0.47	1.04
11	Yarragaddalagudem	2.69	0.54	0.65	0.73	0.81	1.78
12	Gaddikodaram	2.54	0.51	0.61	0.69	0.76	1.68
13	Indlur	2.32	0.46	0.56	0.63	0.7	1.53
14	Gollagudem	2.87	0.57	0.69	0.77	0.86	1.89
15	Mamidala	2.65	0.53	0.64	0.72	0.8	1.75
16	Alligudem	2.36	0.47	0.57	0.64	0.71	1.56
17	Godorigudem	2.76	0.55	0.66	0.75	0.83	1.82
18	Yallammagudem	2.34	0.47	0.56	0.63	0.7	1.54
19	Pavirala gudem	2.64	0.53	0.63	0.71	0.79	1.74

Table-3: Fluoride ion concentration (before and after defluoridation) of bore well water samples

		C_i	C_f				
S.No	Name of the village		ESC	AAC	PJC	CLC	CAC
20	Pathapalle	2.18	0.44	0.52	0.59	0.65	1.44
21	Kankanalapaly	2.3	0.46	0.55	0.62	0.69	1.52
22	Thanedaripally	3.24	0.65	0.78	0.87	0.97	2.14
23	Peddasuraram	4.5	0.9	1.08	1.22	1.35	2.97
24	Chinnasuraram	4.24	0.85	1.02	1.14	1.27	2.8
25	Choullagudem	3.02	0.6	0.72	0.82	0.91	1.99
26	Pajjur	2.97	0.59	0.71	0.8	0.89	1.96
27	Anthaigudem	3.02	0.6	0.72	0.82	0.91	1.99
28	Yarragaddalagudem	1.42	0.28	0.34	0.38	0.43	0.94
29	Kothagudem	1.86	0.37	0.45	0.5	0.56	1.23
30	Dacharam	2.64	0.53	0.63	0.71	0.79	1.74
31	Madgulapally	2.09	0.42	0.5	0.56	0.63	1.38

32	Vodderigudem	3.42	0.68	0.82	0.92	1.03	2.26
33	Indugala	3.08	0.62	0.74	0.83	0.92	2.03
34	Aregudem	3.62	0.72	0.87	0.98	1.09	2.39
35	Velmagudem	3.26	0.65	0.78	0.88	0.98	2.15

Table-4:Fluoride ion concentration (before and after defluoridation) of open well water samples

		C_i	C_f				
S.No	Name of the village		ESC	AAC	PJC	CLC	CAC
36	Pajjur	2.97	0.59	0.71	0.8	0.89	1.96
37	Bandavarigudem	1.68	0.34	0.4	0.45	0.5	1.11
38	Gangannapalem	2.6	0.52	0.62	0.7	0.78	1.72
39	Indlur	2.44	0.49	0.59	0.66	0.73	1.61
40	Marrigudem	3.02	0.6	0.72	0.82	0.91	1.99
41	Rajupet	1.06	No need to Defluoridation process				
42	Malaprajgudem	1.08					
43	Gavvavarigudem	1.02					

*C_i (mg/L) - initial concentration, C_f (mg/L) - final concentration of fluoride ion in mg/L.

Table-5: Classification of fluorotic areas basing on the concentration limit

Concentration range (mg/L)	Water sample category		
	Hand pump	Bore well	Open well
0.50 – 1.50	Nil	1	3
1.50 - 2.00	2	1	1
2.00 – 2.50	4	3	1
2.50 – 3.00	11	2	2
3.00 – 3.50	2	6	1
3.50 – 4.50	Nil	2	Nil

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