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Research article

STUDIES ON ESTIMATION OF FLUORIDE LEVEL AND DEFLUORIDATION OF DRINKING WATER USING AGROWASTE MATERIALS

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ABSTRACT: Water samples of dug wells from different villages of Chandrapur district analysed for fluoride contamination, registered significant amount of fluoride content in drinking water. More than 50% villages' water samples showed significant amount of fluoride content, which is comparatively higher than permissible limit prescribed by World Health Organisation (WHO 1.5ppm).Therefore, present study was undertaken for defluoridation of drinking water using low cost adsorbent materials. Charcoal prepared by using agrowaste like Cocos nucifera shells and fibers were utilized for defluoridation. In addition to that the materials like natural coal and fly ash were also used. Adsorption of fluoride was highest in charcoal of Cocos nucifera shell then natural coal and charcoal of Cocos nucifera fiber showed moderate adsorption while fly ash registered meagre adsorption capacity. Thus, Cocos nucifera shell and Cocos nucifera fiber as agrowaste materials are ecofriendly and economical viable adsorbents, thus it can be conveniently used for defluoridation of drinking water.
Key words: - Drinking water; Agrowaste materials; Defluoridation; Chandrapur district

INTRODUCTION

Water is frequently referred as a universal solvent, because it has ability to dissolve almost all substances that comes in its contact. Some elements are essential in trace amount for human being while higher concentration of the same can cause toxic effects. Fluoride is one of them. Due to rapid urbanization and growth of modern industries (anthropogenic source of fluoride) as well as geo chemical dissolution of fluoride bearing minerals fluoride concentration is increasing in the environment including water resources. [1] The high concentration in the drinking water leads to destruction of enamel of teeth and causes a number of conditions referred collectively as fluorosis. Permissible limit of fluoride as per WHO guidelines for drinking water is $\leq$ 1.5 ppm American Public Health Association [1-3] and as per Bureau of Indian Science specification permissible limit is 1.2 ppm. [4] Exposure to fluoride in drinking water has number of adverse effects on human health including crippling skeletal fluorosis that is a significant cause of morbidity in a number of regions of the world. Fluoride is more toxic than lead, it also reduces IQ in humans. [5] In order to enrich our knowledge regarding fluorosis, extensive studies were undertaken to elucidate specially, the fluoride distribution in drinking water and dental fluorosis. [6] In addition to epidemiological study of a skeletal fluorosis and prevalence and severity of dental fluorosis in some villages in Chandrapur district [7, 8] were reported earlier.
Fluoride pollution in the environment occurs through natural and anthropogenic sources. Fluoride is frequently encountered in mineral deposits and generally released into groundwater by slow natural degradation of fluoride bearing rocks. Fluoride distribution in groundwater depends on solubility of CaF_2 in groundwater which may be controlled by various factors like lithology, rock weathering and other chemical parameters present in groundwater, hydrochemical facies and climate of the area. [9] The conventional method of removal of fluoride i.e. defluoridation includes ion-exchange, reverse osmosis and adsorption. The ion-exchange and reverse osmosis are relatively expensive; therefore, still adsorption is the viable method for the removal of fluoride. Recently considerable attention has been devoted to develop better and suitable adsorbents for defluoridiation. Adsorption is cheapest, simplest, easily available process for defluoridation in India. [10].

Therefore it was thought imperative to develop the convenient and accessible technique for defluoridation process. At the same time the same should be economical viable to meet the need. Thus present investigations were undertaken to cater the need of society.

MATERIALS AND METHODS

Sample collection

For the present investigations,12 villages viz. Dhoptala, Korpana, Matha1, Matha2, Arvi, Khamona, Aarvi, Gadegaon, Wadegaon, Goigaon, Wansadi, Gadchandur from Chandrapur district in Maharashtra State, India were identified and water samples from dug wells collected which then subjected to analysis for fluoride content. Chandrapur district of Maharashtra is threatened by high fluoride contamination in groundwater. The study has been undertaken in selected endemic villages to determine fluoride contamination in groundwater. Present area includes some fluorosis endemic and nearby villages of Korpana and Rajura tehsils which lies in south western part of Chandrapur district. For the present investigation groundwater samples were collected during post monsoon season (October 2011).

Fluoride estimation

Fluoride ion concentration from water was measured with U.V.–Visible Spectrophotometer (model no.1700 Schimadzu) by SPADNS method.

Defluoridation of drinking water

Various adsorbents (charcoal) were prepared from agrowaste materials like *Cocos nucifera* shells and *Cocos nucifera* fibers. Similarly, natural coal and fly ash were also used as adsorbents for defluoridation of drinking water. Fly ash collected from thermal power station of Chanrdapur city and natural coals were collected from nearby coal mines area.

RESULTS AND DISCUSSION

It is revealed from table.1 that fluoride concentration ranged between 0.57ppm to 11.70ppm.The various water samples has expressed significant concentration of fluoride. The sources of fluoride include natural fluoride in food stuffs and water in Dongargaon village of Chandrapur district (Fluoridated water usually 5.5 mg/L). [11] Defluoridation studies were carried out using various adsorbent viz; prepared activated charcoal from *Cocos nucifera* shells and *Cocos nucifera* fibers, natural coal and fly ash by adsorption technique and findings in table no 2 to 6. Maximum percentage removal of fluoride using 125µ *Cocos nucifera* shell for one hr. (95.85%) followed by 125µ *Cocos nucifera* fibre for half hr. (84.17%). 250µ natural coal also shown good adsorption at one hr. (87.92%) and at half hr. (78.13%) It is followed by Cocos *nucifera fibre 125*µ *(87.30%) and 250*µ (86.75%) for one hr. Fly ash also shown good adsorption (78%).

Similar attempt have been made to remove fluoride by fly ash. [12] As well as similar studies were reported on to remove fluoride from drinking water upto 100ppm chemically modified fly ash [13] activated carbon prepared from various row material like rice husk, wheat husk exhibits good fluoride uptake capacity. [14] Low cost adsorbents like Red mud, Pine apple peel powder, Orange peel powder, Horse gram powder, Chalk powder, Ragi seed powder, Multhani mitti and concrete have been used to remove fluoride and same reported by. [15] It is mentioned that the concentration ranged between 71.25% to 85% (for half hr. contact time) in table-7. Simillarly for 1 hr. contact time it has been ranged between 75.38% to 95.85% (for 1 hr. contact time) in table no.8 along with different adsorbents. When compared with standard i.e. commercial charcoal, conc. of fluoride is reduced to 0.622ppm from 2.40ppm resulting 74.09% removal. In respect to final concentration and corresponding % removal of fluoride for contact time half hr. the superior adsorbents were 125 µ *Cocos nucifera* shell, 250 µ *Cocos nucifera* shell, 125µ natural coal, 250µ natural coal, 125 µ *Cocos nucifera* fiber and 250µ *Cocus nucifera* shell, expressing conc. of fluoride in ppm against % fluoride removal as 0.380ppm is 84.17%, 0.400ppm is 83.34%, 0.525ppm is 78.13%, 0.528ppm is 78.00%, 0.597ppm is 75.13%, 0.601ppm is 74.96% respectively & inferior were 75µ natural coal, 250µ fly ash, 125µ fly ash & 75µ fly ash, expressing conc. of fluoride in ppm against % fluoride removal as 0.632ppm is 73.67%, 0.636ppm is 73.50%, 0.687ppm is 71.38%, 0.690ppm is 71.25%, respectively, and for contact time one hr. superior adsorbents were 125 µ *Cocos nucifera* shell, 250 µ *Cocos nucifera* shell, 250 µ natural coal, 125 µ *Cocos nucifera* fibre, 250µ *Cocos nucifera* fibre, 125 µ natural coal, expressing conc. of fluoride in ppm against % fluoride removal as 0.100ppm is 95.85%, 0.167ppm is 93.05%, 0.290ppm is 87.92% ,0.305ppm is 87.30%, 0.318ppm is 86.75%, 0.324ppm is 86.50%, respectively and inferior were 75µ natural coal, 250µ fly ash,125µ fly ash,75µ fly ash expressing conc. of fluoride in ppm against % fluoride removal as, 0.362ppm is 84.92%, 528ppm is 78.00%, 0.577ppm is 75.96%, 0.591ppm is 75.38%, respectively. (Tables 1 to 8).

Table-1. Estimation of Fluoride concentration from different villages of study area

S. No.	Villages	Fluoride conc. in ppm
1	Dhoptala	11.70
2	Korpana	0.57
3	Matha1	2.64
4	Matha2	2.22
5	Khamona	1.80
6	Arvi	1.10
7	Arvi	1.13
8	Gadegaon	2.31
9	Goigaon	0.90
10	Wadegaon	1.68
11	Wansadi	1.75
12	Gadchandur	1.11

Table-2. Name of adsorbent: *Cocos nucifera* (shell)

Adsorbent dose:1 gm Initial concentration of fluoride in water sample: 2.40ppm ,Temp:29^{O}C					
S. No.	**Particle size**	**Contact time**	**Absorbance**	**Final fluoride conc. in ppm.**	**% of fluoride removed**
1	125 µ	30	0.219	0.380	84.17
2	125 µ	60	0.286	0.100	95.85
3	250 µ	30	0.200	0.400	83.34
4	250 µ	60	0.270	0.167	93.05

Table-3. Name of adsorbent: *Cocos nucifera* (fiber)

Adsorbent dose:1 gm Initial concentration of fluoride in water sample: 2.40ppm Temp:29^{O}C					
S. No.	**Particle size**	**Contact time**	**Absorbance**	**Final fluoride conc. in ppm**	**% of fluoride removed**
1	125 µ	30	0.167	0.597	75.13
2	125 µ	60	0.237	0.305	87.30
3	250 µ	30	0.166	0.601	74.96
4	250 µ	60	0.234	0.318	86.75%

Table-4. Name of adsorbent: Fly ash

Adsorbent dose:1 gm Initial concentration of fluoride in water sample: 2.40 ppm, Temp:30^{O}C					
S. No.	**Particle size**	**Contact time**	**Absorbance**	**Final fluoride conc.in ppm**	**% of fluoride removed**
1	75 µ	30	0.282	0.690	71.25
2	75 µ	60	0.312	0.591	75.38
3	125 µ	30	0.284	0.687	71.38
4	125 µ	60	0.316	0.577	75.96
5	250 µ	30	0.299	0.636	73.50
6	250 µ	60	0.330	0.528	78.00

Table 5. Name of adsorbent: Natural coal

Adsorbent dose:1 gm, Initial concentration of fluoride in water sample: 2.40ppm Temp:30^{O}C					
S. No.	**Particle size**	**Contact time(min)**	**Absorbance**	**Final fluoride conc.in ppm**	**% of fluoride removed**
1	75 µ	30	0.300	0.632	73.67
2	75 µ	60	0.378	0.362	84.92
3	125 µ	30	0.331	0.525	78.13
4	125 µ	60	0.389	0.324	86.50
5	250 µ	30	0.330	0.528	78.00
6	250 µ	60	0.399	0.290	87.92

Table 6. Name of adsorbent: Standard commercial charcoal

Adsorbent dose:1 gm Initial concentration of fluoride in water sample: 2.40ppm Temp:30^{O}C					
S. No.	**Particle size**	**Contact time(min)**	**Absorbance**	**Final fluoride conc. in ppm**	**% of fluoride removed**
1	300 µ	30	0.303	0.622	74.09
2	300 µ	60	0.380	0.355	85.21

Table 7. Performance of different adsorbents on basis % fluoride removal

Initial concentration of fluoride in water sample: 2.40ppm		contact time- half hr.
Adsorbent name	Final conc. of fluoride (ppm) in water sample	% of fluoride removed
125 µ *Cocos nucifera* shell	0.380	84.17
250 µ *Cocos nucifera* shell	0.400	83.34
250 µ natural coal	0.525	78.13
125 µ natural coal	0.528	78.00
125 µ *Cocos nucifera* fibre	0.597	75.13
250 µ *Cocos nucifera* fibre	0.601	74.96
250 µ Commercial charcoal	0.622	74.09
75 µ natural coal	0.632	73.67
250 µ fly ash	0.636	73.50
125 µ fly ash	0.687	71.38
75 µ fly ash	0.690	71.25

Table 8. Performance of different adsorbents on basis % fluoride removal

Initial concentration of fluoride in water sample: 2.40ppm		contact time- one hr.
Adsorbent name	Final conc. of fluoride (ppm) in water sample	% of fluoride removed
125 µ *Cocos nucifera* shell	0.100	95.85
250 µ *Cocos nucifera* shell	0.167	93.05
250 µ natural coal	0.290	87.92
125 µ *Cocos nucifera* fibre	0.305	87.30
250 µ *Cocos nucifera* fibre	0.318	86.75
125 µ natural coal	0.324	86.50
250 µ Commercial charcoal	0.355	85.21
75 µ natural coal	0.362	84.92
250 µ fly ash	0.528	78.00
125 µ fly ash	0.577	75.96
75 µ fly ash	0.591	75.38

CONCLUSIONS

Water sample of dug well from 12 different villages of Chandrapur district registered significant amount of fluoride content in drinking water. Out of 12 villages Dhoptala village recorded highest fluoride content (11.70ppm) 8 times more than permissible limit prescribed by WHO. Six villages also showed significant amount of fluoride content (1.80 to 2.64 ppm) which is also comparatively higher than permissible limit. Only five villages have fluoride content within permissible limit. Therefore, it could be stated that 60% villages were found fluoride affected. Hence it could be concluded that 60% villages under studies have recorded the higher level of fluoride content in drinking water as compared to prescribed level suggested by WHO. Therefore it is to state that the defluoridation process of drinking water using appropriate adsorbents is necessary for such villages with appropriate adsorbents.

Adsorbent material used *Cocos nucifera* shell and fiber, fly ash, Natural coal has expressed significant adsorption capacity however adsorbent prepared from *Cocos nucifera* shell reported highest adsorption capacity. Natural coal and adsorbents prepared from *Cocos nucifera* fiber shown moderate adsorption capacity and fly ash registered meager adsorption capacity.

Thus, it could be concluded that adsorbents namely *Cocos nucifera* shell and *Cocos nucifera* fiber of the agro waste material are ecofriendly and economical viable adsorbents, thus they can be conveniently used for defluoridation technique. To develop water filter for the people of fluoride affected areas by using agro waste and waste from industries of those areas, these inexpensive, ecofriendly and economical viable techniques leads to betterment of the society of fluoride affected areas.

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