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Comparative Study of different Waste Materials as an Adsorbent for Fluoride Removal from Groundwater

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Abstract—*Fluoride in ground water can cause many health related problems and issues. The present study has been undertaken using rice husk (RH), limestone (LS) and brick powder (BP) as locally available waste materials as an absorbent. The efficiency in terms of fluoride removal from groundwater using above mentioned adsorbents has been studied. Also the effect of pH on fluoride removal under different dosing conditions with these adsorbents has been observed in this study. Results from the present study indicate that the removal efficiency has been found to be 31%, 67% and 48% using RH, LS and BP as an absorbent for a pH 6. The maximum removal efficiency of fluoride is observed to be 57% for an optimal dosing of 11 g/L, 56% for an optimal dosing of 15 g/L and 53% for an optimal dosing of 18 g/L for the absorbents RH, LS and BP respectively.*

Keywords*: Rice Husk (RH), Limestone (LS), Brick Powder (BP)*

1. 1. INTRODUCTION

Presence of fluoride in the potable water is one of the important environmental issues because of its adverse and toxic effects. Fluorine in the form of the fluoride anion (F-) is found in the organic and inorganic compounds of the environment [1]. Fluoride pollution has been observed not only in various minerals processing but also in some natural water systems over large areas in Asia, Africa, America, and Europe where the fluoride concentration can range from 0.01 to 3 mg/L in fresh water and 1-35 mg/L in ground water. The presence of fluoride in groundwater has drawn worldwide attention due to its considerable impact on human physiology. The assimilation of fluoride into the human body from the ground water at the level of 1.0 mg/L enhances bone development and prevents dental carriers [2, 3].

There has been an escalation in daily fluoride intake via the total human food and beverage chain. Carbonated soft drinks have considerable amounts of fluorides. Beers brewed in locations with high fluoride water levels may contribute significantly to the daily fluoride intake and sweetened iced teas contain significant amounts of fluoride [4]. In absorption method, different absorbents are used for fluoride removal e.g. Shrimp shell waste [5], Banana peel, groundnut shell and sweet lemon peel [6], activated alumina [7], Phyllanthus Emblica [8], Citrus limetta [9], Bleaching powder [10], Chitosan [11] and other low cost absorbents. Some de-fluoridation techniques developed to control fluoride in water are reverse osmosis, adsorption method using sunflower plant, bagasse ash, burnt bone powder, etc. as adsorbents. However due to high cost, lower efficiency or non-applicability on a mass scale, these techniques are not much in use.

Waste materials used as an adsorbent can reduce the cost of fluoride removal and also it reduces the pollutants from the environment. Various defluorination techniques, such as membrane techniques, application of different chemicals and adsorption methods have been used to remove fluoride. Membrane methods effectively reduce fluoride concentration to acceptable levels [12]; however, these methods are complex, require skilled labor, and demand high initial and maintenance costs [13,14]. The different methods so far tried for removal of excess fluoride from water can be broadly classified into four categories. a) Adsorptive methods, b) ion exchange methods, c) precipitation methods, d) miscellaneous methods. The main objective of the comparative study is to estimate the effect of locally available waste material such as RH, LS, and BP as an absorbent on the removal efficiency of fluoride from groundwater. The removal efficiency of the fluoride is compared on the basis of various varying parameters like pH and adsorbent dosing.

2. MATERIALS AND METHODOLOGY

Groundwater samples were collected from different areas near the college premises. Total 5 samples of different fluoride concentration were collected. All the samples collected were tested in the college laboratory and fluoride concentrations were measured as per standard method [15]. All samples concentrations were measured in triplicates and average of these concentrations has been taken. The initial fluoride concentration is shown in Table 1.

Table 1: Initial fluoride concentration for different samples collected

S.No.	Source of sample	Initial F- conc. (mg/L)
1	Private Hand pump	1.07
2	Borwell	1.30
3	Borwell	1.29
4	Borwell	0.93
5	Private hand pump	0.95

Rice Husk, Brick Powder and Lime Stone were used as an adsorbent. The materials used as an absorbent were collected from nearby places.

Rice husk was carbonized in a laboratory oven at 250°C to 300°C for 4 to 6 hours. The partially carbonized material was then carbonized in a muffle furnace at temperature 500°C to 600°C. The material was cooled to room temperature. The material was then washed with hot boiling water so as to open the pores of carbon. Completely carbonized rice husk was further treated by acid treatment. Fluoride ion was estimated by fluoride ion meter and Batch adsorption studies were made using jar test apparatus (Scientific Corporation, India) equipped with stirring paddles with provision for controlling mixing speed [16,17,18].

For Brick Powder, bricks were washed with distilled water, dried and grounded to obtain a fine powder. The Brick Powder was washed several times with distilled water till the clear water was obtained and was dried in an oven at 110°C for 10hr.

Limestone consists of gypsum. Limestone was properly washed with distilled water to remove dust and was dried at room temperature in the laboratory. The air-dried sample was crushed and sieved with 0.075 mm diameter opening mesh to obtain particle size <0.075 mm.

3. RESULTS AND DISCUSSIONS

In order to apply the adsorption technique successfully, innovation of cheap, nontoxic and easily available adsorbents are necessary. Bio-adsorbent prepared from agricultural waste and industrial waste i.e. rice husk, brick powder and limestone meet these requirements. Adsorption studies were performed by batch technique to obtain the rate of adsorption. Under optimum conditions i.e. dose of adsorbent, pH and contact time for initial fluoride concentration i.e. 1.30 mg/L

Effect of Adsorbent Dose

The effect of adsorbent dose on the removal of fluoride ion was studied by keeping fluoride ion concentration constant at 1.30rng/L. The response of the adsorbent dose on the removal of fluoride by RH, BP and LS shows that an increase in the adsorption occurs with an increase in the dose of adsorbent. The results show the maximum removal efficiency of fluoride is observed to be 57% for an optimal dosing of 11 g/L, 56% for an optimal dosing of 15 g/L and 53% for an optimal dosing of 18 g/L for the absorbents RH, LS and BP respectively.

Further increase in the dose of adsorbent does not show any considerable improvement. Final fluoride concentration for different adsorbent dosing is presented in Table 2. The contact time for adsorbent dosing was kept 60 minutes and pH was kept at 6. The comparison of fluoride removal by adsorbent dose is shown in Figure 1. Percentage removal of fluoride with different dosing of the adsorbent can be shown in Table 3. It can be observed that the fluoride removal increases with increase in dosing up to 11 g/L in RH, 18 g/L in BP and 15 g/L in LS.

Fluoride removal increases from 26% to 58% for 1-10g/L dosage of RH, 45% to 53% for 1-15g/L dosage of BP and

16% to 56% for 1-15g/L dosage of LS. The maximum fluoride removal was observed by LS.

Table 2: Final Fluoride concentration for various adsorbent dose.

Dosing (g/L)	Fluoride Concentration (mg/L)		
	RH	BP	LS
1	0.962	0.721	1.092
5	0.8502	0.625	0.923
10	0.545	0.615	0.689
15	0.623	0.613	0.572
20	0.848	0.618	0.897

Table 3: Fluoride Removal efficiency for various adsorbent dose.

Dosing (g/L)	% of Fluoride		
	RH	BP	LS
1	26	45	16
5	35	52	29
10	58	53	47
15	52	53	56
20	35	52	31

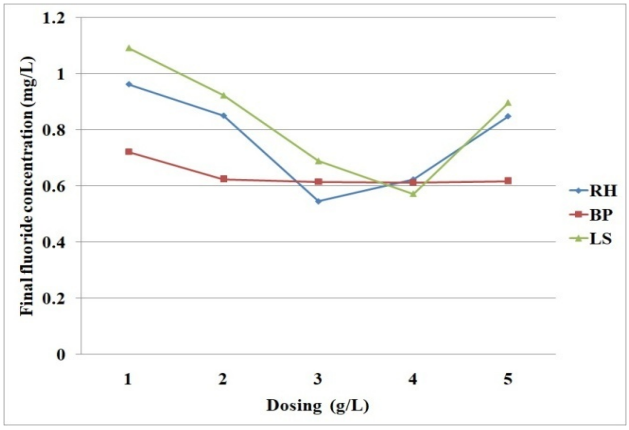

Figure 1: Effect of adsorbent dose on the fluoride concentration by RH, BP and LS

Effect of pH

The effect of pH on the removal of fluoride was studied in the pH range of 5.0-8.0 and results are shown in Fig.2. It was observed that percentage of fluoride removal decreases as the pH of the solution increases. The final fluoride concentration for RH, BP and LS are shown in Table 4. The maximum fluoride removal efficiency was observed 31%, 67% and 48% at pH 6 shown in Table 5, which decreases as the pH of the solution increases for RH, feels sharp as the pH decreases below 6.0 for BP and for LS the fluoride adsorption decreases in basic medium and increases in acidic medium

Table 4: Final Fluoride concentration for various pH values.

pH	RH	BP	LS
5	0.756	1.253	0.356
6	0.897	0.673	0.406
7	1.026	0.625	0.566
8	1.163	0.659	0.632

Table 5: Removal efficiency for various pH values.

pH	RH	BP	LS
5	42	4	73
6	31	48	69
7	21	52	56
8	11	49	51

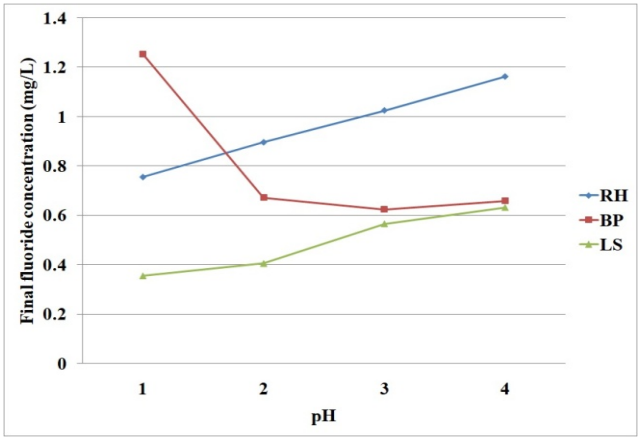

Figure 2: Effect of pH on the fluoride concentration by RH, BP and LS

4. CONCLUSIONS

From the present study, it can be observed that fluoride removal from groundwater by RH, BP and LS is dependent on adsorbent dose, pH and the initial fluoride concentration. The fluoride removal varies with variations in the Adsorbent dosing. It is observed that the fluoride removal increases with dosing up to 11g/L, 15g/L and 18g/L for RH, LS, and BP respectively and decreases afterward. The uptake of fluoride is possible in the range of pH 5 to 8. The percentage of fluoride removal was found to be a function of adsorbent dose at a given initial fluoride concentration.

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