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Fluoride Removal From Drinking Water Using Neem Powder As The Adsorbent

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Abstract – *Pollution of drinking water due to presence of fluoride can be mitigated using various methods like adsorption.The neem powder being a natural adsorbent can be used for this purpose which is cheaper and highly effective. This paper discusses the effect of adsorbent size, adsorbent dosage, initial fluoride concentration, contact time, pH of neem powder for treating the drinking water with fluoride concentration of 1 ppm,3 ppm, 5 ppm and 7 ppm..*

***Key Words*: Adsorbent size, adsorbent dosage ,fluoride removal efficiency(FRE), neem powder, initial Fluoride concentration, contact time, effect of pH**

1.INTRODUCTION

Drinking water is often the main source of fluoride intake by humans, especially in areas where their concentrations in groundwater and/or surface water is high. Endemic fluorosis is present in at least 20 states of India, affecting more than 65 million people including 6 million children. Fluoride ion (F) concentrations in India's groundwater vary widely, ranging from 0.01 mg/L to 48 mg/L. Defluoridation of ground water and supply of safe drinking water is the only immediate solution to this problem. The present investigation is an attempt towards a feasible solution. Fluoride is a health affecting substance. The physiological effects of fluoride ingestion on human health have been studied extensively. The acceptable fluoride concentration in drinking water is generally in the range of 0.5 to 1.5 mgl-1. Concentration higher than that affects the metabolism of elements such as Ca, P in human body and lead to dental and skeletal fluorosis. The fluoride content of soils varies from under 20 to several thousand ppm, the higher records being mostly from areas with bedded phosphate on fluoride deposits. Fluoride is present in the soil and rock formation in the form of fluorapatite, fluorspar, amphiboles and micas weathering rock alkali contribute fluoride natural waters . The fluoride present in these minerals is substituted by (OH--) ion under redox conditions resulting in the release of fluoride ions to the circulating waters. Therefore this paper discusses a simple adsorption method using neem powder as the adsorbent to treat F rich water before using it for drinking purposes.

2. MATERIALS AND METHODOLOGY

The adsorbent materials used are Azadirachta indica leaf powder commonly known as neem powder . It is commonly used medicinal herb used for treating various diseases and are easily available. Here the adsorbents is tested for fluoride removal efficiency.

For chemical treatment take 10 g of neem powder and add 100 mL of 0.4 N H_2SO_4 and 20 ml of 30% formaldehyde. This mixture is kept at a constant temperature of 50° C for 3 hours. Then neem powder is washed with distilled water to remove the acid and formaldehyde. Then it is kept in hot air oven to remove moisture.. This is designated as neem powder chemically treated with sulphuric acid and formaldehyde. The neem powder is sun dried to remove moisture. The dried powder is sieved to get the particles having size 150µm-700 µm.

Here the SPADNS spectrometric method is used for the experiment.

3. BATCH STUDY

In batch study we consider the effect of adsorbent size,adsorbent dosage,initial fluoride concentration,contact time,pH of neem powder for treating the drinking water with fluoride concentration of 1 ppm,3 ppm, 5 ppm and 7 ppm respectively.Here we consider neem powder with adsorbent sizes of 150 µm,300 µm and 600 µm.The adsorbent dosage range is from 3 g/l to 17 g/l,the contact time ranges from 30 min. to 200 min. and pH ranges from 6 to 9 respectively.

3.1 Effect of Adsorbent Size

The adsorbent sizes used are 150 µm,300, µm 600 µm and adsorbent dosage is 3 g/l,5 g/l and 7 g/l respectively for fluoride concentrations of 1 ppm,3ppm,5 ppm and 7 ppm.

3.1.1 Effect of 150 µm Sized Adsorbent on FRE

Table -1: Effect of 150 µm Sized Adsorbent on FRE

Adsorbent Dosage (g/l)	Initial Fluoride Concentration (mg/l)	Final Fluoride Concentration (mg/l)	Fluoride removal (%)
3	1	0.421	57.90
	3	1.350	55.00
	5	2.441	51.18
	7	3.442	50.82
5	1	0.351	64.90
	3	1.155	62.83
	5	1.970	60.60
	7	2.853	59.24
7	**1**	0.251	**74.90**
	3	0.851	**71.63**
	5	1.498	70.04
	7	2.148	69.31

Here 150 µ sized adsorbent is used for removal of fluoride content of 1 mg/l , 3 mg/l , 5 mg/l and 7 mg/l for adsorbent dosages of 3 g/l , 5 g/l and 7 g/l

3.1.2 Effect of 300 µm Sized Adsorbent on FRE

Here 300 µ sized adsorbent is used for removal of fluoride content of 1 mg/l , 3 mg/l , 5 mg/l and 7 mg/l for adsorbent dosages of 3 g/l , 5 g/l and 7 g/l.

Adsorbent Dosage (G/L)	Initial Fluoride Concentration (Mg/L)	Final Fluoride Concentration (Mg/L)	Fluoride Removal (%)
3	1	0.462	53.80
	3	1.441	51.96
	5	2.420	51.60
	7	3.489	50.16
5	1	0.396	60.40
	3	1.224	59.20
	5	2.091	58.18
	7	2.957	57.76
7	**1**	0.287	**71.30**
	3	0.950	**68.33**
	5	1.594	68.12
	7	2.412	65.54

Table – 2: Effect of 300 µm Sized Adsorbent on FRE

3.1.3 Effect of 600 µm Sized Adsorbent on FRE

Here 600 µ sized adsorbent is used for removal of fluoride content of 1 mg/l , 3 mg/l , 5 mg/l and 7 mg/l for adsorbent dosages of 3 g/l , 5 g/l and 7 g/l.

Table – 3: Effect of 600 µm Sized Adsorbent on FRE

Adsorbent Dosage (G/L)	Initial Fluoride Concentration (Mg/L)	Final Fluoride Concentration (Mg/L)	Fluoride Removal (%)
3	1	0.482	51.80
	3	1.555	48.17
	5	2.631	47.38
	7	3.789	45.87
5	1	0.444	55.60
	3	1.355	54.83
	5	2.298	54.04
	7	3.344	52.23
7	**1**	0.341	**65.90**
	3	1.025	**65.83**
	5	1.768	64.64
	7	2.612	62.68

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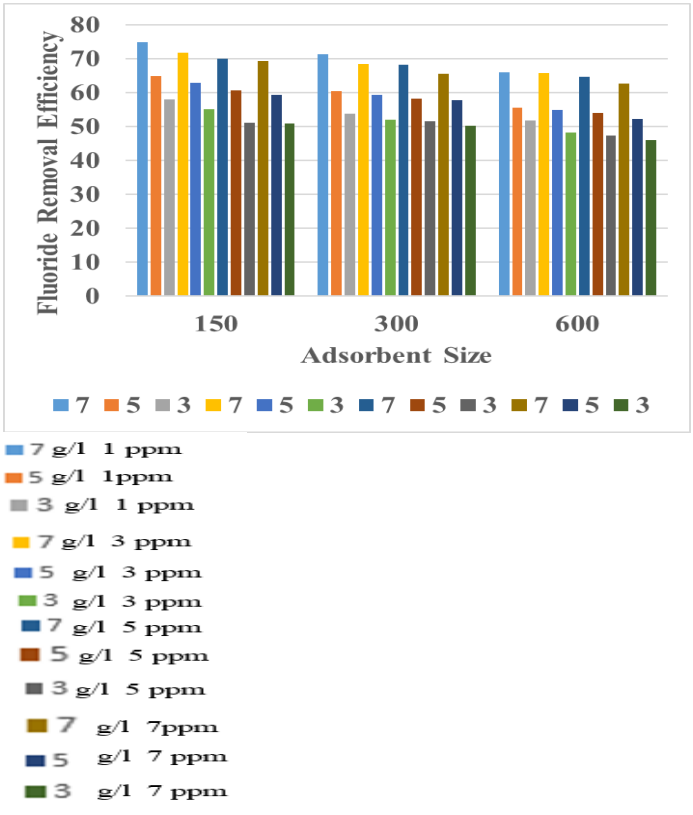

Chart – 1: Effect of Adsorbent Size on FRE

3.2 Effect of Adsorbent Dosage

The study of the effect of adsorbent dosage on the fluoride removal efficiency was carried out with a dosage of 3 g/l, 5 g/l, 7 g/l, 9 g/l, 11 g/l, 13 g/l, 15 g/l and 17 g/l. Table 4 shows the fluoride removal efficiency at varying adsorbent dosages. The study is done by keeping adsorbent size as 150 µm and varying initial fluoride concentration as 1 mg/l , 3 mg/l, 5 mg/l and 7 mg/l.

Table - 4: Effect of Adsorbent Dosage on Fluoride Removal Efficiency

Adsorbent size (Micron)	Adsorbent dosage (g/l)	Initial fluoride concentration (mg/l)	Final fluoride concentration (mg/l)	Fluoride Removal
150	3	1	0.421	57.90
		3	1.340	55.33
		5	2.331	53.34
		7	3.351	52.12
	5	1	0.355	64.50
		3	1.142	61.93
		5	1.958	60.84
		7	2.799	60.01
	7	1	0.261	73.90
		3	0.846	71.80
		5	1.494	70.12
		7	2.143	69.36
	9	1	0.254	74.60
		3	0.822	72.60
		5	1.401	71.98
		7	2.100	70.00
	11	1	0.245	75.50
		3	0.777	74.10
		5	1.344	73.12
		7	1.989	71.58
	13	**1**	0.223	**77.70**
		3	0.701	**76.63**
		5	1.290	74.20
		7	1.910	72.71
	15	1	0.240	76.00
		3	0.734	75.53
		5	1.294	74.12
		7	1.980	71.71
	17	1	0.240	76.00
		3	0.734	75.53
		5	1.294	74.12
		7	1.980	71.71

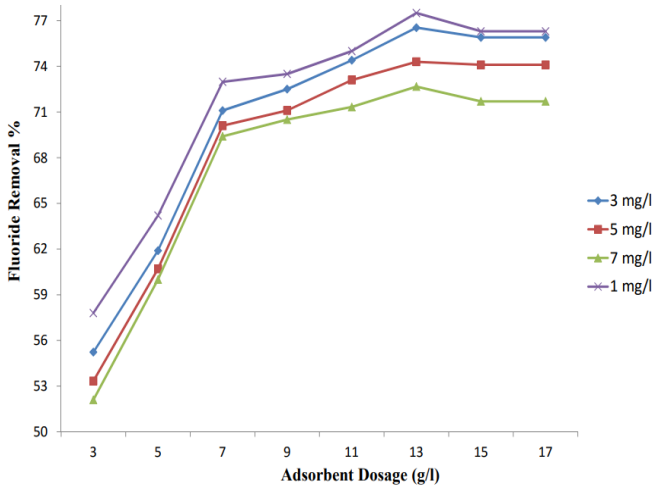

Chart -2: Effect of Adsorbent Dosage

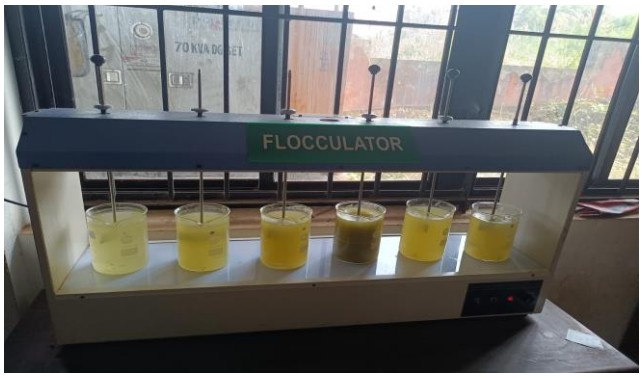

Fig -1: Mixing of Sample

3.3 Effect of Initial Fluoride Concentration and Contact time

The effect of initial concentration on the extent of removal of the fluoride was studied by varying the concentrations from 1 mg/l, 3 mg/l, 5 mg/l and 7 mg/l, while keeping the adsorbent size and dosage as 150 µm and 13 g/l.

Table. 5 shows the effect of initial concentration on fluoride removal capacity of adsorbent.

In this study contact time considered are 30, 90, 150 and 180 minutes. At initial concentration 3 mg/l gives a removal efficiency of 78.57 % in 150 minutes, 76.14 % in 90 minutes and 70.35 % in 30 minutes. At 5 mg/l initial fluoride concentration gives a removal efficiency of 71.39% in 150 minutes, 70.95 % in 90 minute and 68.57 % in 30 minutes. At 7 mg/l initial fluoride concentration gives a removal efficiency of 70.23 % in 150 minutes, 69.54 % in 90 minutes and 66.42 % in 30 minutes.The FRE at 1 ppm is not considered since it is under permissible limits.

Table – 5: Effect of Initial F concentration and Contact Time

Time (min.)	Initial F conc. (ppm)	Final F conc. (ppm)	Fluoride Removal Efficiency (%)
30	1	0.274	72.56
	3	0.889	70.35
	5	1.572	68.57
	7	2.351	66.42
90	1	0.228	77.21
	3	0.716	76.14
	5	1.453	70.95
	7	2.132	69.54
150	1	0.199	80.15
	3	**0.643**	**78.57**
	5	1.431	71.39
	7	2.084	70.23
180	1	0.206	79.36
	3	0.644	78.54
	5	1.475	70.51
	7	2.091	70.13
200	1	0.214	78.57
	3	0.663	77.89
	5	1.472	70.57
	7	2.090	70.15

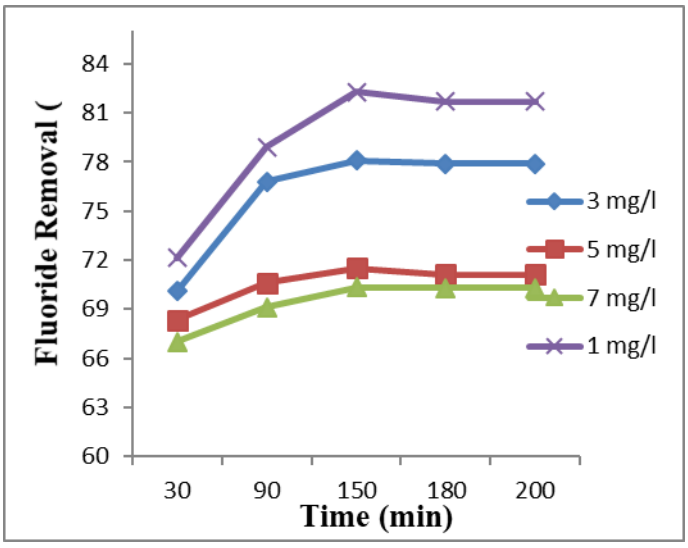

Chart – 3: Effect of initial F conc. and contact time on FRE

3.4 Effect of pH

The effect of pH on the extent of removal of the fluoride was studied by varying the pH from 5, 6, 7 and 8 while keeping the adsorbent size and dosage as 150 µm and 13 g/l and initial fluoride concentration 3 mg/l. Table 6 shows the effect of pH on fluoride removal.

Here the initial Fluoride concentration was 3 ppm while adsorbent size 150 microns,contact time 150 min and adsorbent dosage 13 g/l.

A maximum of 80.25 % FRE was obtained at pH 6.5 and decreases as the pH increases.

Table – 6: Effect of pH on FRE

pH	Final Fluoride Concentration (mg/l)	Removal Efficiency (%)
6.5	0.593	**80.25**
7	0.613	79.56
8.5	0.644	78.54

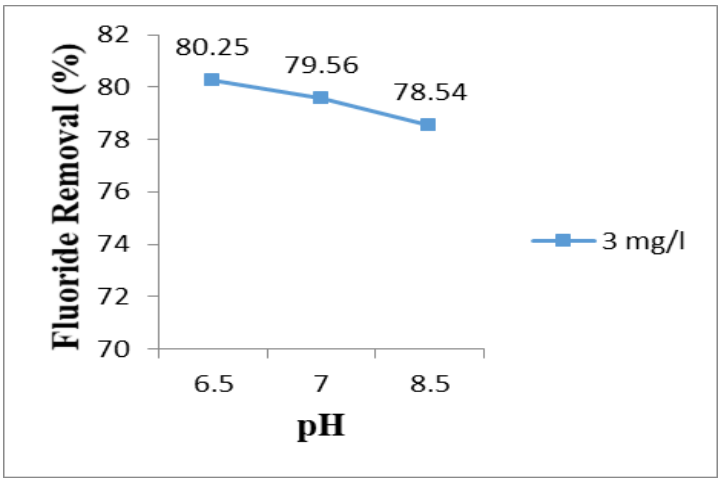

Chart – 4: Effect of pH on FRE

4. RESULTS AND DISCUSSION

A maximum of 74.9 % and 71.63 % FRE was got for 150 µm sized adsorbent at 1 ppm and 3 ppm respectively at 7 g/l adsorbent dosage.For the other two sizes also the maximum FRE was got at 7 g/l adsorbent dosage which was lesser than 150 µm.

The maximum fluoride removal efficiency occurs at 13g/l adsorbent dosage (77.70 %) at 1 ppm fluoride concentration.Since 1ppm Fluoride concentration is uner permissible limit,the next maximum value is taken (76.63 %) at 3 ppm fluoride content.The fluoride removal efficiency increases from adsorbent dosage 3g/l to 13 g/l after which the fluoride removal efficiency get reduced for adsorbent dosages of 15 g/l and 17 g/l ie,there is no significant increase in fluoride removal efficiencies after 13 g/l adsorbent dosage.

Based on initial F concentration and contact time, the maximum FRE was 78.57 % at 3 ppm for contact time of

150 min. at 150 µm sized adsorbent at 13 g/l adsorbent dosage (FRE at 1 ppm is not considered since 1 ppm is under permissible limit).

Based on effect of pH ,the maximum FRE was 80.25 % for pH 6.5 and it was decreased as increase in the pH .

5. CONCLUSIONS

From the experiment it is evident that neem powder can be used as a natural adsorbent in fluoride removal from drinking water and the effect of adsorbent size , adsorbent dosage , effect of initial fluoride concentration, effect of pH was also studied from the experiment . Decreasing the adsorbent size increased the FRE since more surface area was present for adsorption to take place.Increasing the adsorbent dosage from 3 g/l to 17 g/l showed that an increase in fluoride removal efficiency upto 13 g/l only after which the efficiency reduced for 15 g/l and 17 g/l adsorbent dosage , giving the maximum FRE at 13g/l . As the initial fluoride content increased , a reduction in FRE occurred and as the contact time increased the FRE also increased upto 150 min. after that no significant increase in FRE occurred. As the pH increased the FRE got reduced , but at lower pH , the FRE increased due to ionic transfer process which increased the FRE. Also the fluoride containing water treated with neem powder is safe to use after treatment since it is a medical powder when reaches inside the human body causes no harmful effects. Also treatment of fluoride containing water with neem powder is cheap compared to other conventional high cost methods.

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