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INVESTIGATION ON REMOVAL OF FLUORIDE IN WATER USING NATURAL MATERIALS

Abstract

The current study focuses on assessing the efficiency of a natural treatment unit that uses tamarind flakes, sawdust, Tulsi, and fragmented bricks to eradicate fluoride in water. The study aims to determine the optimal conditions for fluoride removal in water using these natural materials and to appraise the effectiveness of the treatment unit. The study involves laboratory experiments using synthetic water sample with known fluoride concentration of 18.4mg/L. The natural treatment unit was constructed using tamarind flakes, sawdust, Tulsi and fragmented brick in different containers. Two different treatment setups of 1mtr and 1.5mtr height for each natural material was made. The known concentration of synthetic water was passed through the treatment unit with two different discharges 10ml/min and 20ml/min and the fluoride was measured in effluent using a fluoride ion-selective electrode method. The study also investigates the effect of several factors on the efficiency of fluoride removal, including the contact time of water to natural materials in the treatment unit. The optimal conditions for fluoride removal were determined by varying these factors and measuring the resulting fluoride removal efficiencies. It was found that fluoride removal efficiency of 90.7% for fragmented brick followed by tamarind (61.5%), Tulsi (50.5%) and sawdust (84.02%) in 1.5mtr treatment unit. While 1mtr thickness setup showed 83.1% for fragmented bricks, tamarind (50.5%), Tulsi (35.3%) and sawdust (75%). It is clearly revealed that fragmented brick manifested high efficiency and least by Tulsi. Further Fragmented brick with other three natural materials also been examined as combination of treatment unit. In this combinations brick with saw dust has

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found highest efficiency of 80.6% and least with Brick and Tulsi of 60.1%. Overall, the study provides valuable insights into the potential of natural materials for fluoride removal in water and the feasibility of using a natural treatment unit for providing safe drinking water in fluoride-affected areas.

Keywords: Natural material, Fluoride, Synthetic water and Treatment unit.

I. INTRODUCTION

Fluoride, an inorganic anion of fluorine with the chemical formula F^-, plays a significant role in various chemical processes and industries, particularly in producing hydrogen fluoride for fluorocarbons. It shares similarities in charge and size with the hydroxide ion and occurs naturally in minerals like fluorite, though it's only found in trace amounts in water. While fluoride can be beneficial in preventing dental cavities when present in the right amount in drinking water, excessive consumption can lead to fluorosis in teeth and bones. Additionally, high fluoride concentrations in streams can be toxic to aquatic life, and fluoride dust and gases in the atmosphere can harm both plants and animals.

Fluoride occurs naturally in various minerals and is abundant in the earth's crust. It is also concentrated in the environment due to industrial activities, releasing large amounts through manufacturing processes and effluents from certain industries. Proper treatment and control are necessary to prevent excessive fluoride levels in the environment.

Currently, there's limited research and theoretical design models for fluoride removal, making the process largely empirical based on past experience. Among several treatment technologies applied for fluoride removal, adsorption process has been explored widely and offers satisfactory results especially with mineral-based and/or surface modified adsorbents [1].The adsorption of fluoride ion onto bone char is endothermic. Bone char can be utilized to remove fluoride ions from drinking water [2]. Fluoride has been reported as one of the major water pollutants with myriads of health implications when present in water beyond permissible limits (>1.5 mg L^{-1}) [3]. However, due to the detrimental impact of fluoride, there's an increasing demand for its removal from groundwater before distribution. While conventional treatment methods are effective, they can be costly in terms of working expenses and energy requirements. Thus, exploring natural methods and materials for fluoride removal could be a viable alternative for medium-sized communities, rural areas, emergency water treatment, and developing countries.

II. OBJECTIVES OF THE PRESENT STUDY

1. The objective of the study is to assess the efficiency of natural treatment unit that uses tamarind flakes, saw dust, tulsi and fragmented bricks for fluoride treatment.
2. To compare the efficiency of different natural materials for removal of fluoride.

III. MATERIALS AND METHODOLOGY

1. Tamarind
2. Tulsi
3. Bricks
4. Tulsi

Methodology: The Methodology adopted for the study has been shown in Figure 1, and the steps have been given below.

- The pilot plants are made up of acrylic sheets with dimensions of 20x20cm and a height of 1.5m in two segments of 0.5m and 1m respectively

- The sheets are tightened using nut and bolted connection to prevent the leakage
- The pilot plant is setup on the stand with a sieve and a perforated mesh to collect the effluent sample from the bottom.

Figure 1: Methodology Adopted for the Study

1. **Pre-Treatment of Materials:** The materials like tulsi, neem saw dust, tamarind flakes and bricks are washed thoroughly with distilled water and it is oven dried at 104 °C. Washing it with distilled water removes all the dust impurities and organic substances present in it. It is oven dried to remove moisture content and by this process the materials is free from all the impurities and this increases its efficiency of fluoride removal.

2. **Preparation of Influent Sample:** 0.221g of NaF is taken and is added to 100ml distilled water. From which 10ml is taken out and is diluted to 100ml. This diluted 100ml is added to the drinking water accordingly such that it induces 1mg/l of fluoride for 1ml of addition.

3. **Designing of Rate of Discharge:** The discharge of 10ml/min and 20ml/min was done by siphon method. First the influent sample was allowed to flow in the measuring jar by opening the influent valve to the desired flow. By using stop watch, the quantity of water filled for one minute in the measuring jar is noted down. This is repeated until we get 10ml/min and 20ml/min.

4. **Treatment Process**

   Setup 1: The first setup of pilot plant involves filling up of materials like neem saw dust, tamarind flakes, fragmented bricks and tulsi separately up to a height of 1m in the treatment unit. These pre-treated materials were filled in the treatment unit separately. The influent sample is allowed to pass through treatment unit at a rate of 10ml/min and 20ml/min and effluent sample is collected and tested for fluoride content.
   Setup 2: The second setup involves combination of different materials with bricks. Bricks were used as a common material with neem saw dust, tamarind flakes and tulsi. They were filled to a height of 1m in segments (0.5m bricks + 0.5m other materials). Then the influent is allowed to pass at a discharge rate of 10ml/min and 20ml/min respectively and the effluent is collected and tested for fluoride content.
   Setup 3: In third setup, materials neem saw dust, fragmented bricks, tamarind flakes and tulsi were filled separately in the treatment unit up to a height of 1.5m. Then the influent

is allowed to pass at a discharge rate of 10ml/min and 20ml/min respectively and the effluent is collected and tested for fluoride content.

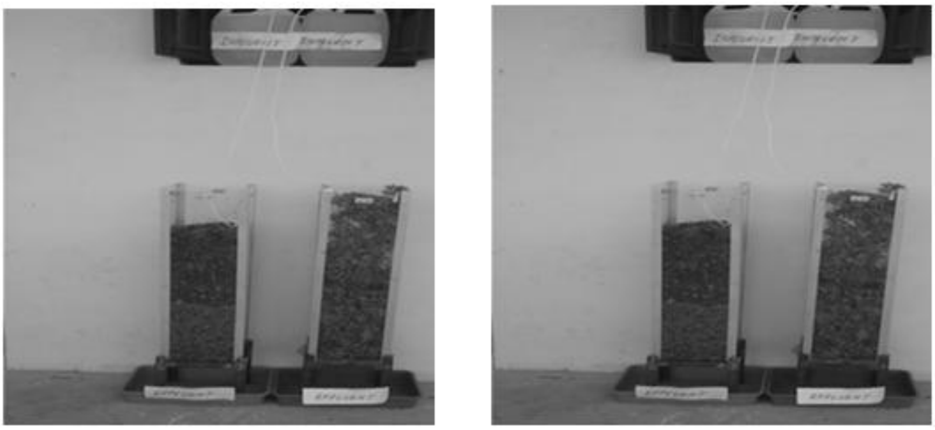

Figure 2: Setup 1 where Materials are filled in the Pilot Plant up to a Height of 1m

Figure 3: Setup 2 where the Combination of Materials (0.5m Bricks + 0.5m Other Materials) are Filled in the Pilot Plant up to a Height of 1m

Figure 4: Setup 3 Where Materials Filled to a Height of 1.5m in the Treatment Unit

IV. RESULTS AND DISCUSSIONS

The results of the study have been provided and discussed in this section

The first setup of pilot plant involves filling up of materials like neem saw dust, tamarind flakes, fragmented bricks and tulsi separately up to a height of 1m in the treatment unit. The results of setup1 are shown in Table 1.

Table 1: Test Results for 1m Setup (Setup 1)

Material Used	Influent (mg/l)	Discharge at 10ml/min	Efficiency for 10ml/min discharge	Discharge at 20ml/min	Efficiency for 20ml/min discharge
Fragmented Bricks	18.4	3.1	83.1%	3.9	79.1%
Tamarind Flakes	18.4	9.1	50.5%	9.89	47%
Tulsi	18.4	11.9	35.3%	12.4	32.6%
Saw Dust	18.4	4.6	75%	5.1	72.2%

The second setup involves combination of different materials with bricks. Bricks were used as a common material with neem saw dust, tamarind flakes and tulsi. The results of setup2 are shown in Table 2.

Table 2: Test Results for 1m Combination Setup (Setup 2)

Material Used	Influent (mg/l)	Discharge at 10ml/min	Efficiency for 10ml/min discharge	Discharge at 20ml/min	Efficiency for 20ml/min discharge
Tulsi + Bricks	18.6	7.5	60.1%	8.25	55.64%
Tamarind Flakes + Bricks	18.6	6.3	66.1%	7.1	61.8%
Sawdust +Bricks	18.6	3.6	80.6%	4.85	73.9%

In third setup, materials neem saw dust, fragmented bricks, tamarind flakes and tulsi were filled separately in the treatment unit up to a height of 1.5m. The results of setup3 are shown in Table 3.

Table 3: Test Results for 1.5m Setup (Setup 3)

Material Used	Influent (mg/l)	Discharge at 10ml/min	Efficiency for 10ml/min discharge	Discharge at 20ml/min	Efficiency for 20ml/min discharge
Fragmented Bricks	19.4	1.8	90.7%	2.5	87.1%
Tamarind Flakes	19.4	7.47	61.5%	7.9	59.27%
Tulsi	19.4	9.6	50.5%	9.9	48.9%
Saw dust	19.4	3.1	84.02%	3.9	79.89%

Discussions

1. Graph for 1m Combination Setup (Setup 1)

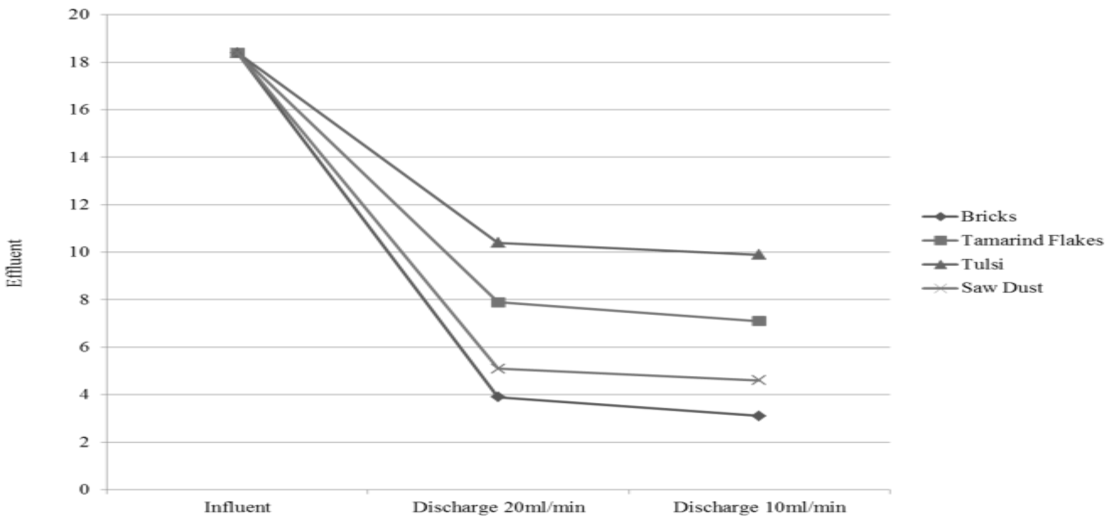

Figure 5: Graph showing results of Fluoride Content for 1M Setup

The Figure shows the fluoride content in the influent sample is about 18.4mg/l. The fragmented bricks reduced the fluoride content from 18.4mg/l to3.1mg/l at the discharge rate of 10ml/min and 18.4mg/l to 3.9mg/l at a discharge rate of 20ml/min and gave an efficiency of 83.1% and 79.1% fluoride removal respectively. The tamarind flakes reduced the fluoride content from 18.4mg/l to 9.1mg/l at the discharge rate of 10ml/min and 18.4mg/l to 9.89mg/l at a discharge rate of 20ml/min and gave an efficiency of 50.5% and 47% fluoride removal respectively. The tulsi reduced the fluoride content from 18.4mg/l to 11.9mg/l at the discharge rate of 10ml/min and 18.4mg/l to 12.4mg/l at a discharge rate of 20ml/min and gave an efficiency of 35.3% and 32.6% fluoride removal respectively. The Saw dust reduced the fluoride content from 18.4mg/l to 4.6mg/l at the discharge rate of 10ml/min and 18.4mg/l to 5.1mg/l at a discharge rate of 20ml/min and gave an efficiency of 75% and 72.2% fluoride removal respectively

2. Graph for 1m Combination Setup (Setup 2):

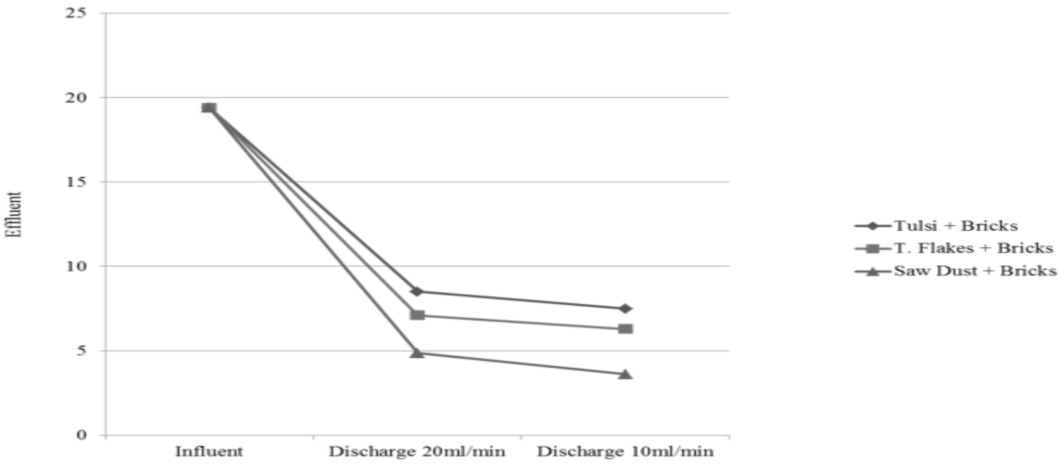

Figure 6: Graph Showing Results of Fluoride Content for 1M Combination Setup

The figure portrays that the fluoride content in the influent sample is about18.6mg/l. The fragmented bricks and tulsi reduced the fluoride content from 18.6mg/l to 7.5mg/l at the discharge rate of 10ml/min and 18.6mg/l to 8.25mg/l at a discharge rate of 20ml/min gave an efficiency of 60.1% and 55.64% fluoride removal respectively. The tamarind flakes and bricks reduced the fluoride content from 18.6mg/l to 6.3mg/l at the discharge rate of 10ml/min and 18.6mg/l to 7.1mg/l at a discharge rate of 20ml/min and gave an efficiency of 66.1% and 61.8% fluoride removal respectively and the saw dust and bricks reduced the fluoride content from 18.6mg/l to 3.6mg/l at the discharge rate of 10ml/min and 18.6mg/l to 4.85mg/l at a discharge rate of 20ml/min and gave an efficiency of 80.6% and 73.9% fluoride removal respectively.

3. Graph for 1.5m Setup (Setup 3)

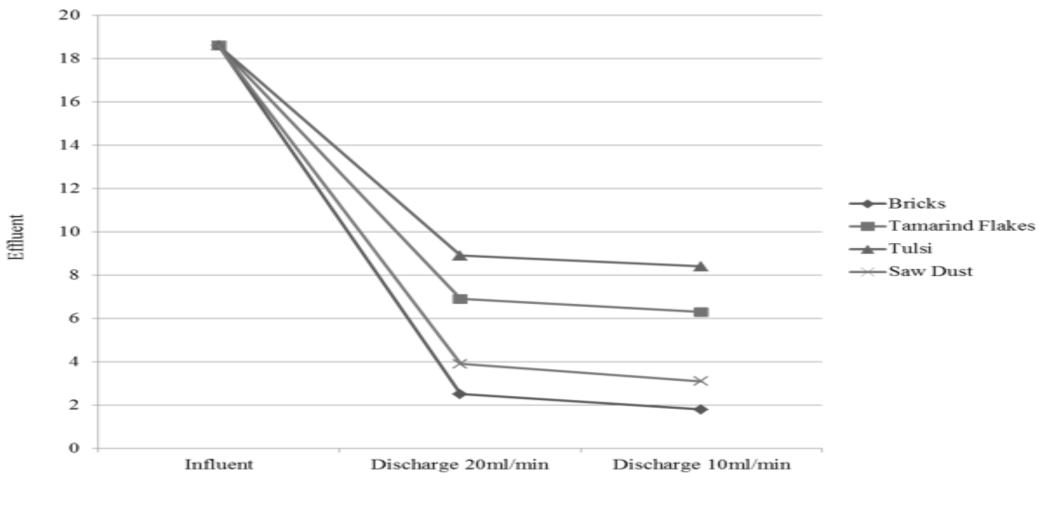

Figure 6: Graph Showing Results of Fluoride Content for 1.5M Setup

The figure depicts that the fluoride content in the influent sample is about19.4mg/l. The fragmented bricks reduced the fluoride content from 19.4mg/l to1.8mg/l at the discharge rate of 10ml/min and 19.4mg/l to 2.5mg/l at a discharge rate of 20ml/min and gave an efficiency of 90.7% and 87.1% fluoride removal respectively. The tamarind flakes reduced the fluoride content from 19.4mg/l to 7.47mg/l at the discharge rate of 10ml/min and 19.4mg/l to 7.9mg/l at a discharge rate of 20ml/min and gave an efficiency of 61.5% and 59.27% fluoride removal respectively. The tulsi reduced the fluoride content from 19.4mg/l to 9.6mg/l at the discharge rate of 10ml/min and 19.4mg/l to 9.9mg/l at a discharge rate of 20ml/min and gave an efficiency of 50.5% and 48.9% fluoride removal respectively and the saw dust reduced the fluoride content from 19.4mg/l to 3.1mg/l at the discharge rate of 10ml/min and 19.4mg/l to 3.9mg/l at a discharge rate of 20ml/min and gave an efficiency of 84.02% and 79.89% fluoride removal respectively.

V. CONCLUSIONS

1. The treatment plants seem to be a viable alternative to conventional fluoride treatment technology especially for small to medium sized community.
2. The treatment gives an efficiency of 90.7%, 84.02%, 61.5%, 50.5% fluoride removal when fragmented bricks, saw dust, tamarind flakes and tulsi are used up to a depth of 1.5m.
3. The efficiency of fluoride removal was 83.1, 75%, 50.5%, 35.5% when fragmented bricks, saw dust, tamarind flakes and tulsi are used up to a depth of 1m.
4. It gave an efficiency of 80.6%, 66.1%, and 60.1% of fluoride removal when materials are used in combination up to a depth of 1m keeping fragmented bricks as the common material.
5. The efficiency of the treatment can be increased by increasing the depth thereby increasing the retention time of the water sample in each unit.
6. It is efficient and economical method of fluoride treatment.

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