Removal of Fluoride in Ground Water from K Bevinahalli Village, Harihara by using Amla Powder and Turmeric Powder as Adsorbents

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***Abstract*— Ground water seems to be the most important natural source of potable water for millions of individuals. Fluoride pollution in groundwater is a big problem in k bevinahalli village, harihara taluk davanagere district. There is no proven or recommended cost effective strategy for lowering fluoride levels in the home. In this experiment, fluoride in ground water are eliminated to a suitable extent using natural adsorbents. The adsorbents are used at different dosages until the best optimal dosage was found. The breakthrough curves obtained were analysed with Thomas model and Yoon-Nelson models. The results show that the amla and turmeric powders as low cost natural adsorbents can be successfully employed for the removal of fluoride from ground water.**

Key words— Amla powder; Turmeric powder; Defluoridation; Adsorption; Fixed bed; Removal efficiency; Low cost adsorbents

I. INTRODUCTION:

Humans typically ingest fluoride through water. Fluoride in drinking water may be useful or hazardous to one's health depending on the concentration. Ground water is the world's principal source of freshwater. Groundwater with dissolved ions over the permissible limit is hazardous to human consumption. Fluoride levels in groundwater that are too high (0.6 to 1.5 mg/l) are a serious problem in many regions of the world. Fluorides are typically present in ground water as a result of water's solvent effect on the earth's crust's rocks and soil. Fluoride ions have a significant role in human physiology. At low concentrations, its presence can either block or promote enzymatic activities, and its interactions with other organic and inorganic body components can disturb normal physiological functions in the human body.

Fluorosis is caused by naturally occurring high fluoride concentrations in ground water. It is a major health problem. This range is 0.6 to 1.2 ppm, according to the Bureau of Indian Standards (BIS). The World Health Organization recommends a fluoride content in drinking water of 0.6 to 1.5 ppm (WHO). Fluoride removal techniques include precipitation, Ion exchange, adsorption, and membrane processes. The majority of these methods have high operational and maintenance costs. These techniques have low fluoride reduction capacities, lack fluoride selectivity, and have negative effects on water quality. Adsorption technique is quite simple, and adsorbents are widely available. This study has concentrated on low-cost and effective adsorption media.

II. MATERIALS AND METHODS:

2.1 Equipement

Fluoride ion was determined by using different methods such as analytical and titration method. In this experiment fluoride can be determined by using Orion Ion meter. Also usage of p^H meter, TDS meter, spectrophotometer, and turbidity meter.

2.2 Material development:

Amla powder was used as the adsorbent in this study. Amla is a member of the Phyllanthaceae family. For centuries, ayurvedic medicine has used it to treat everything from diarrhoea to jaundice. Amla was purchased in the market as a dry powder and subjected to sieve analysis to determine grain size. Turmeric powder was also used as an adsorbent in this study. Turmeric is a ground russet that belongs to the Zingiberaceae family. It contains active ingredients and can be used as a home remedy for a variety of diseases. It is also referred to as an antibiotic. As a result, it can be used to treat fluoride and subjected to sieve analysis to determine grain size.

2.3 Experimental set up of fixed bed column:

The column shown in the figure was created for experimental purposes. The acrylic column had an internal diameter of 30 mm and a height of 450 mm. To prevent adsorbent and adsorbent uplift from escaping, the bottom and top of the column were filled with glass beads and glass wools. The column was treated with fluoride solutions of varying concentrations under various experimental conditions to investigate the effect of flow rate (15, 20, 25 ml/min) and bed height (2, 4, 6 cm) on column adsorption. Separate sets of down flow packed bed column experiments were carried out to optimize various operating parameters such as bed height (2, 4 and 6), flow rate (15, 20 and 25 ml/min), and pH, which will be maintained constant at temperature.

Figure 1: Pictorial view of column chromatography

III. RESULTS AND DISCUSSION:

Physio-chemical characteristics and initial characterization of fluoride in ground water is shown in figure.

TABLE 1: Ground water physio-chemical characterization of K Bevinahalli

Sl. no	Parameters	Units	WHO Standards	Results
1	pH	-	6.5 – 7.5	8
2	TDS	mg/l	500-2000	1750
3	Colour	Hazen	5-25	5
4	Calcium	mg/l	100-200	230
5	Magnesium	mg/l	200-400	115
6	Total hardness	mg/l	300-600	380
7	chloride	mg/l	200-300	240
8	fluoride	mg/l	0.5-1.5	3.8
9	Turbidity	NTU	5-10	5

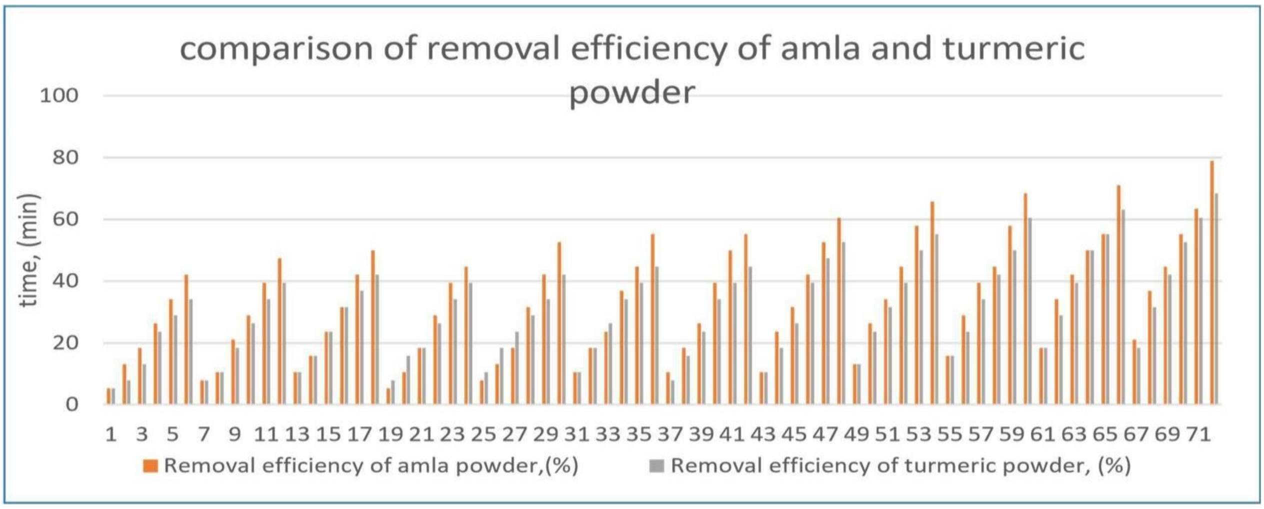

Figure 2: Comparison of removal efficiency of Amla powder and Turmeric powder

Many adsorbents have been tried to remove fluoride from ground water. As an adsorbent, amla powder and turmeric powder were used, producing good results and acting as an excellent defluoridating agent. It can be used in column studies, and the material is relatively inexpensive. Fluoride removal for a given adsorbent size increased with time, flow rate, and bed height and reached a constant value or equilibrium after about 150-180 minutes. The removal capacity increased as particle size increased. This method is straightforward, and adsorbents are widely available. Amla powder has a removal efficiency of 78.94%, while turmeric powder has a removal efficiency of 68.42%. Turmeric powder was found to be less effective than amla powder for defluoridation. However, it is also an effective defluoridating agent.

Model Thomas parameter:

The q_e and K_{TH} values are calculated using the Thomas model by assimilation of the test data into a standard equation and summarization in a table

TABLE 2: Thomas model parameters using linear Regression Analysis for constant initial concentration of fluoride water for Amla powder as adsorbent (Q: 15, 20, 25ml/min and Z: 2, 4, 6cm)

C_0 (mg/l)	Z (cm)	Q (ml/min)	K_{TH}	q (mg/g)	R^2
3.8	2	15	1.14×10^{-4}	1.267	0.996
3.8	2	15	4.7×10^{-4}	1.267	0.9733
3.8	2	15	4.31×10^{-4}	1.267	0.9804
3.8	2	15	4.23×10^{-4}	1.267	0.9768
3.8	4	20	1.302×10^{-4}	0.634	0.9826
3.8	4	20	3.34×10^{-4}	0.634	0.9546
3.8	4	20	4.02×10^{-4}	0.634	0.9726
3.8	4	20	3.71×10^{-4}	0.634	0.9568
3.8	6	25	1.27×10^{-4}	0.423	0.9562
3.8	6	25	3.34×10^{-4}	0.423	0.9546
3.8	6	25	3.8×10^{-4}	0.423	0.947
3.8	6	25	4.02×10^{-4}	0.423	0.978

TABLE 3: Thomas model parameters using Linear Regression Analysis for constant initial concentration of fluoride water for Turmeric powder as adsorbent (Q: 15, 20, 25ml/min and Z: 2, 4, 6cm)

C_0 (mg/l)	Z (cm)	Q (ml/min)	K_{TH}	q (mg/g)	R^2
3.8	2	15	3.2×10^{-4}	1.267	0.9724
3.8	2	15	3.3×10^{-4}	1.267	0.9546
3.8	2	15	3.1×10^{-4}	1.267	0.991
3.8	2	15	3.4×10^{-4}	1.267	0.8819
3.8	4	20	3.7×10^{-4}	0.634	0.9808
3.8	4	20	2.9×10^{-4}	0.634	0.9665
3.8	4	20	4.0×10^{-4}	0.634	0.9726

3.8	4	20	3.4×10^{-4}	0.634	0.9776
3.8	6	25	4.1×10^{-4}	0.423	0.9732
3.8	6	25	3.4×10^{-4}	0.423	0.965
3.8	6	25	2.4×10^{-4}	0.423	0.947

The experimental adsorption capabilities derived using the Thomas model are virtually equivalent, as shown in table 4.53. As a result, the experimental and theoretical results are in good agreement. As the flow rate rose, both the extreme adsorption capacity and the constant K_{TH} dropped. This is due to the fact that the solute stayed in the bed for a shorter amount of time. As bed height climbed, the value of q increased, whereas K_{TH} values declined. This was because there were more reactive sites available at greater bed heights. Q rise as fluoride concentration increased, whereas K_{TH} declined.

Yoon-Nelson Model parameter:
Time taken for 50% of the adsorbate for breakthrough curve was established using Yoon Nelson model. The K_{YN} and t are obtained by assimilate the test data in standard equation and these are sum up in table.

TABLE 4: Yoon-Nelson model parameters using Direct Regression Analysis for constant Initial concentration of fluoride water for Amla powder as adsorbent (Q: 15, 20, 25ml/min and Z: 2, 4, 6cm

C_0 (mg/l)	Z, (cm)	Q (ml/min)	K_{YN} min-1	t (hrs)	R^2
3.8	2	15	0.0133	180	0.9238
3.8	2	15	0.0144	180	0.9488
3.8	2	15	0.112	170	0.9143
3.8	2	15	0.0091	130	0.9306
3.8	4	20	0.0126	180	0.9652
3.8	4	20	0.0126	176	0.9772
3.8	4	20	0.0107	170	0.9435
3.8	4	20	0.008	120	0.9052
3.8	6	25	0.0105	180	0.9812
3.8	6	25	0.0093	170	0.9235
3.8	6	25	0.0102	168	0.9316
3.8	6	25	0.008	110	0.9356

TABLE 5: Yoon-Nelson model parameters using Direct Regression Analysis for constant Initial concentration of fluoride water for Turmeric powder as adsorbent (Q: 15, 20, 25ml/min and Z: 2, 4, 6cm

C_0 (mg/l)	Z (cm)	Q (ml/min)	K_{YN}	t (hrs)	R^2
3.8	2	15	0.0132	180	0.9627
3.8	2	15	0.0102	180	0.9427
3.8	2	15	0.0112	180	0.9142

3.8	2	15	0.0087	150	0.9639
3.8	4	20	0.0114	180	0.9679
3.8	4	20	0.0086	180	0.9414
3.8	4	20	0.0107	175	0.9435
3.8	4	20	0.0079	120	0.9307
3.8	6	25	0.0093	180	0.952
3.8	6	25	0.0093	180	0.9235
3.8	6	25	0.0092	170	0.9334
3.8	6	25	0.0083	96	0.9215

This study looked at fluoride removal in a fixed bed column. Amla powder and turmeric powder were used as adsorbents in this investigation. The experiment was conducted out in a 45 cm long fixed bed column with a 3 cm internal diameter. When the flow velocity, bed depth, and starting fluoride content were all lowered, adsorption was found to be higher. The fixed bed column was simulated using the Thomas and Yoon Nelson models. The experimental and theoretical results agreed. According to the findings, exploding Amla powder and Turmeric powder in a column can be employed as an active adsorbent for fluoride removal.

IV. CONCLUSION:

Experiments were carried out to study the efficacy of Amla powder and Turmeric powder for water defluoridation, and it was observed that flow rate, adsorbent dosage, contact duration, starting fluoride concentration, and adsorbent bed depth in the column all had an effect on adsorption. The Thomas and Yoon-Nelson models may be used to describe the behavior of model parameters at the constant initial Fluoride concentration. As a consequence, the Fixed Bed column of Amla powder and Turmeric powder with continuous flow technique was determined to be exceptionally successful and cost effective in the adsorption process for removing fluoride from ground water.

References:

[1] Meena Chakraborty, Madhurima Pandey and Piyushkant Pandey, "Fixed bed column performance of Tinospora cordifolia for defluoridation of water", vol. 21 Issue 5, pp.2324-2333, 2021.

[2] Vinish V Nair1, Anandu Aravind, Dayal Kurian Varghese, "Defluoridation of water by composite bed of low-cost bio-adsorbents", International Journal of Advanced Technology in Engineering and Science,Vol.no.4, Issue no. 2, February 2016.

[3] Nikhil Chavan1, Hema Patel, "Removal of Fluoride from Water Using Low Cost Adsorbents", International Journal of Science and Research, Volume 4 Issue 6, pp. 2634-2637, June 2015.

[4] Sivasankar V, Ramachandramoorthy T and Chandramohan A, "Fluoride removal from water using activated and MnO2-coated Tamarind Fruit(Tamarindusindica) shell: Batch and column studies", J. Hazard Mater., Vol. 177, Issues 1-3, pp. 719– 729, May 2010.

[5] Keerthi B. Gurani and Dr. S. R. Mise, "Modeling of Fixed Bed Column Adsorption Studies Fluoride by Phoenix Dactylifera (Date Palm) Seeds provide Activated Carbon", National volatiles and essential oils, volume 8(4) pp.10417-10423, 2021.

[6] Sai kiran mani and Rajni Bhandari, "Efficient Fluoride Removal by a Fixed-Bed Column of Self-Assembled Zr(IV)-, Fe(III)-, Cu(II)-Complexed Polyvinyl Alcohol Hydrogel Beads", American Chemistry Society , pp.15048-15063, 2022.

[7] Naincy Sahu, Chandra Bhan, Jiwan Singh, "Removal of fluoride from an aqueous solution by batch and column process using activated carbon derived from iron infused Pisum sativum peel: characterization, Isotherm, kinetics study", Environmental engineering research volume 26(4) pp.1-11, 2021.

[8] Murugan M. and Subramanian E., "Studies on Defluoridation of water by Tamarind seed and unconventional biosorbent", Journal of Water and Health, vol. 4(4), pp.453-461, 2006.

[9] Himanshu Patel, "Fixed-bed column adsorption study: a comprehensive review", Applied Water Science, vol. 9, pp.1-45, 2019.

[10] Satyanarayana D.N. V, Smt. M. Sudheera, “Removal of fluoride Using Brick Powder by Adsorption”, International Journal of Research and Analytical Reviews, volume 2, issue 4, pp.114-121, Oct. – Dec. 2015.
[11] Bhagawati P.B, Shivayogimath C.B and Hiremath M.N, “Column investigation of fluoride on activated carbon prepared from Almond shell”, Journal of Institution of Public Health Engineers, India, Vol. 2012-13.No.2, pp. 1-8, July 2012.
[12] Ramesh S.T, Gandhimathi R, Nidheesh P. V and Taywade M, “Batch and Column Operations for the Removal of Fluoride from Aqueous Solution Using Bottom Ash”, Environmental Research, Engineering and Management, vol. 60, Issue 2, pp. 1220, 2012.