

**REMOVAL OF FLUORIDE FROM DRINKING WATER USING LOW
COST ADSORBENTS**

A

Thesis

Submitted in partial fulfilment

FOR THE DEGREE OF

M-TECH IN ENVIRONMENTAL ENGINEERING

Under The Academic Autonomy

Of

DELHI TECHNOLOGICAL UNIVERSITY, DELHI

By

Suman Mann
(2K11/ENE/07)



Under the esteemed Guidance of
Dr. ANUBHA MANDAL
Professor

**DEPARTMENT OF ENVIRONMENTAL ENGINEERING
DELHI TECHNOLOGICAL UNIVERSITY
DELHI – 110042
2014**



**DELHI TECHNOLOGICAL UNIVERSITY
DELHI**

Certificate

This is to certify that the project entitled, “**REMOVAL OF FLUORIDE FROM DRINKING WATER USING LOW COST ADSORBENTS**” submitted by Mrs. Suman Mann in partial requirements for the award of Master of Technology Degree at the Delhi Technological University, Delhi is carried out by her under my supervision and guidance.

Date:

Dr. Anubha Mandal
Department of Environmental Engg.
Delhi Technological University,
Delhi- 110042

ACKNOWLEDGEMENTS

This thesis is the account of six months of devoted work in the field of Environmental Engineering at the Delhi Technological University, Delhi, India, which would not have been possible without the help of many.

A few lines are too short to make a complete account of my deep appreciation for my advisor Dr Anubha Mandal. I would like to thank her for her valuable guidance and constant encouragements which i have received during the six months. Her help in the form of valuable information and research thoughts at proper time has brought life in this project. I feel lucky to get an opportunity to work with her. I am thankful to the kindness and generosity shown by her towards me, as it helped me morally to complete the project.

I express my sincere gratitude to the faculty and non-teaching staff of Civil and Environmental engineering department and the library of Delhi Technological University for providing the relevant information and help when needed during the course of this project work.

I am also thankful to Mr J K Bansal, Lab Incharge, Water and Waste Water Engg Lab, Kasturba polytechnic for Women, Pitampura, Delhi.

Last but not the least, I would like to record deep respect to my husband Mr Sandeep Mann for selflessly extending his support.

Date:

Suman Mann

DECLARATION

I hereby declare that the work embodied in this report is an original investigation carried out by me, on the topic entitled, “**REMOVAL OF FLUORIDE FROM DRINKING WATER USING LOW COST ADSORBENTS**”, for partial fulfilment of degree in Master of Technology (Environmental Engineering), Delhi Technological University, Delhi. To the best of my knowledge and belief, this work has not been submitted to any other University or Institution to confer any Degree or Diploma and all the resource of material used for the thesis have been duly acknowledged.

Name: Suman Mann

Signature:

CONTENTS

S.No	Topic	Page No
1	Certificate	ii
2	Acknowledgement	iii
3	Declaration	iv
4	Table of contents	v
5	List of figures	vi
6	List of tables	viii
7	Abstract	ix
8	Chapter-1(Introduction)	1
9	1.1 Background	1
10	1.2 Effects of fluoride	3
11	1.3 Problem statement	5
12	1.4 Objective of the study	5
13	Chapter-2(Literature review)	7
14	Chapter-3(Materials and methods)	13
15	3.1 Materials	13
16	3.2 Adsorbent collection and preparation	13
17	3.3preparation of adsorbate solution	14
18	3.4 Apparatus required	14
19	3.5Experimental procedure(Methodology)	14
20	Chapter-4(Results and Discussions)	17
21	4.1 Effect of adsorbent dose	17
22	4.2 Effect of pH	19
23	4.3Effect of particle size	21
24	4.4 Effect of contact time	23
25	4.5 Effect of initial concentration	24
26	4.6 Equilibrium of sorption study	26
27	4.6.1 Langmuir isotherm model	27
28	4.6.2 Freundlich isotherm model	30
29	4.6.3 Tempkin isotherm model	32
30	4.7 Kinetic models of adsorption	36
31	4.7.1 Pseudo first order model	36
32	4.7.2 pseudo second order model	38
33	4.7.3 Intraparticle diffusion model	40
34	4.7.4 Elovich model	42
35	Conclusion	45
36	Future scope for study	47
37	References and publications	48
38	Appendix	53

LIST OF FIGURES

FIGURE	PAGE NO
<i>Figure 1.1: Map of India showing endemic states for fluorosis</i>	<i>pg 2</i>
<i>Figure 1.2: Effect of dental fluorosis</i>	<i>pg 3</i>
<i>Figure 1.3: Disabilities caused by skeletal fluorosis</i>	<i>pg 4</i>
<i>Figure3.1: Image of sawdust</i>	<i>pg 13</i>
<i>Figure3.2: Image of Banana peel powder</i>	<i>pg 13</i>
<i>Figure-3.3: Orion 720 A+ ion analyzer with ion selective electrode</i>	<i>pg 14</i>
<i>Figure 3.4: Experimental programme for sawdust</i>	<i>pg 15</i>
<i>Figure 3.5: Experimental programme for Banana peel powder</i>	<i>pg 15</i>
<i>Figure 3.6: Image of jar test apparatus used in the study</i>	<i>pg 16</i>
<i>Figure 4.1: Effect of Adsorbent dose on the adsorption of fluoride using sawdust</i>	<i>pg 17</i>
<i>Figure 4.2: Effect of Adsorbent dose on the adsorption of fluoride using Banana peel powder</i>	<i>pg 18</i>
<i>Figure 4.3: Effect of pH on the adsorption of fluoride using sawdust</i>	<i>pg 19</i>
<i>Figure 4.4: Effect of pH on the adsorption of fluoride using Banana peel powder</i>	<i>pg 20</i>
<i>Figure 4.5: Effect of particle size on the adsorption of fluoride using sawdust</i>	<i>pg 22</i>
<i>Figure 4.6: Effect of particle size on the adsorption of fluoride using Banana peel powder</i>	<i>pg 22</i>
<i>Figure 4.7: Effect of contact time on the adsorption of fluoride using sawdust</i>	<i>pg 23</i>
<i>Figure 4.8: Effect of contact time on the adsorption of fluoride using Banana peel powder</i>	<i>pg 24</i>
<i>Figure4.9: Effect of initial concentration on the adsorption of fluoride using Sawdust</i>	<i>pg 25</i>
<i>Figure4.10: Effect of initial concentration on the adsorption of fluoride using banana peel powder</i>	<i>pg 26</i>
<i>Figure 4.11 Langmuir isotherm for fluoride adsorption using sawdust</i>	<i>pg 28</i>
<i>Figure 4.12: Langmuir isotherm for adsorption of fluoride using Banana peel Powder</i>	<i>pg 29</i>
<i>Figure4.13: Freundlich isotherm for adsorption of fluoride using sawdust</i>	<i>pg 31</i>
<i>Figure 4.14: Freundlich isotherm for adsorption of fluoride using Banana peel Powder</i>	<i>pg 32</i>
<i>Figure 4.15: Tempkin isotherm for adsorption of fluoride using sawdust</i>	<i>pg 33</i>
<i>Figure 4.16: Tempkin isotherm for adsorption of fluoride using Banana peel Powder</i>	<i>pg 34</i>
<i>Figure 4.17: Comparison between the measured and modeled isotherm profiles for the adsorption of fluoride onto sawdust</i>	<i>pg 35</i>
<i>Figure 4.18: Comparison between the measured and modeled isotherm profiles for the adsorption of fluoride onto Banana peel powder</i>	<i>pg 36</i>
<i>Figure4.19: Pseudo-first-order sorption kinetics of flouride onto sawdust</i>	<i>pg 37</i>
<i>Figure4.20: Pseudo-first-order sorption kinetics of fluoride onto Banana peel Powder</i>	<i>pg 38</i>
<i>Figure4.21: Pseudo-second-order sorption kinetics of fluoride on sawdust</i>	<i>pg 39</i>
<i>Figure4.22: Pseudo-second-order sorption kinetics of fluoride on Banana peel Powder</i>	<i>pg 39</i>
<i>Figure4.23: Plots for evaluating intraparticle diffusion rate constant for</i>	<i>pg 41</i>

<i>sorption of fluoride onto sawdust</i>	
<i>Figure4.24: Plots for evaluating intraparticle diffusion rate constant for sorption of fluoride onto Banana peel powder</i>	<i>pg 41</i>
<i>Figure4.25: Elovich model for adsorption of fluoride on to sawdust</i>	<i>pg 42</i>
<i>Figure4.26: Elovich model for adsorption of fluoride on to Banana peel powder</i>	<i>pg 42</i>

LIST OF TABLES

TABLE	PAGE NO
<i>Table-1.1 Different fluoride doses and their effect on human body.</i>	<i>Pg 4</i>
<i>Table4.1: Effect of Adsorbent dose on the adsorption of fluoride using sawdust and Banana peel powder</i>	<i>pg 17</i>
<i>Table 4.2: Effect of pH on the adsorption of fluoride using sawdust</i>	<i>pg 19</i>
<i>Table 4.3: Effect of pH on the adsorption of fluoride using Banana peel powder</i>	<i>pg 20</i>
<i>Table4.4: Effect of particle size on the adsorption of fluoride using Sawdust and Banana peel powder</i>	<i>pg 21</i>
<i>Table 4.5: Effect of contact time on the adsorption of fluoride using Sawdust and Banana peel powder</i>	<i>pg 23</i>
<i>Table4.6: Effect of initial concentration on the adsorption of fluoride using Sawdust</i>	<i>pg 25</i>
<i>Table4.7: Effect of initial concentration on the adsorption of fluoride using banana peel powder</i>	<i>pg 25</i>
<i>Table 4.8: Experimental results for sawdust</i>	<i>pg 27</i>
<i>Table 4.9: Experimental results for Banana peel Powder</i>	<i>pg 27</i>
<i>Table 4.10 calculations for q_e Langmuir using sawdust</i>	<i>pg 28</i>
<i>Table 4.11 calculations for q_e Langmuir using Banana peel powder</i>	<i>pg 29</i>
<i>Table 4.12 Calculations of Freundlich q_e using sawdust</i>	<i>pg 30</i>
<i>Table 4.13 Calculations of Freundlich q_e using Banana peel powder</i>	<i>pg 31</i>
<i>Table 4.14: Calculation of Tempkin q_e using sawdust</i>	<i>pg 33</i>
<i>Table 4.15: Calculation of Tempkin q_e using Banana peel powder</i>	<i>pg 33</i>
<i>Table 4.16 Comparison of sorption capacities and coefficient of correlation</i>	<i>pg 34</i>
<i>Table 4.17: Calculations of Pseudo-first-order sorption kinetics of fluoride onto Sawdust</i>	<i>pg 37</i>
<i>Table 4.18: Calculations of Pseudo-first-order sorption kinetics of fluoride onto Banana peel powder</i>	<i>pg 37</i>
<i>Table 4.19: Calculations of Pseudo-second-order sorption kinetics of fluoride onto Sawdust</i>	<i>pg 38</i>
<i>Table 4.20: Calculations of Pseudo-second-order sorption kinetics of fluoride onto Banana peel powder</i>	<i>pg 39</i>
<i>Table4.21: Calculations for intraparticle transport model kinetics of fluoride on Sawdust</i>	<i>pg 40</i>
<i>Table4.22: Calculations for intraparticle transport model kinetics of fluoride on Banana peel powder</i>	<i>pg 40</i>
<i>Table4.23: Comparison of the pseudo-first-order, pseudo-second-order, Intraparticle diffusion model and Elovich model for their adsorption rate constants and calculated and experimental q_e values obtained</i>	<i>pg 43</i>

Abstract

Fluoride is a poison that accumulates in our bones. It has been associated with cancer in young males; osteoporosis; reduced I.Q; and hip fractures in the elderly, to name a few. Fluoride in nature exists as mineral deposits and, naturally, contaminates our ground water resources. Besides, surface water is also being polluted by fluoride due to various anthropogenic activities. The permissible limit of fluoride concentration in drinking water is 1.5mg/L according to WHO guidelines. Therefore, knowledge of its removal, using best technique with maximum efficiency is needed. Among various techniques adsorption occupies a prominent place in fluoride removal. As cost is an important consideration in most developing countries, efforts have been made to explore the possibility of using various low cost adsorbents that are abundant, readily available and are derived from waste materials.

In this study, the adsorption behaviour of sawdust and Banana peel powder has been studied in order to consider its application for fluoride removal. The batch adsorption method was employed: Laboratory investigation of the potential of sawdust and Banana peel powder to remove fluoride from aqueous solution has been studied. The effects of various experimental parameters, such as pH, adsorbent dosage, particle size, contact time and initial concentration were investigated. The equilibrium data have been analyzed by the Langmuir, Freundlich and Tempkin isotherm models. The adsorption kinetics also investigated by the pseudo-first-order, pseudo-second-order, intraparticle diffusion and Elovich model.

Key words: Fluoride, Adsorption, Sawdust, Banana peel powder, Batch adsorption