Comparative Study of Fluoride Removal from Synthetic Wastewater by using Bio-adsorbents

S. R. Saranya and N. Anu

Abstract — Contamination of fluoride in drinking water results severe health hazard problem. Adsorption is the most effective and widely used method and is applicable for the removal of fluoride even at low concentrations. So far a variety of biosorbents are used for the fluoride removal from groundwater has been investigated. The present research work is the comparative study of fluoride removal by using biosorbents. Here the bio-adsorbents used are Banana peel (Robusta) and Passion fruit peel and its seeds.

Index Terms — Adsorption, Fluoride, Robusta, Passion fruit, UV spectrophotometer

1 INTRODUCTION

THE consumption of drinking water with a fluoride level greater than about 4 mg L^{-1} causes prevailing dental fluorosis in the population, and the chronic consumption of water containing high levels of fluoride between 4 and 15 mg L^{-1} provokes skeletal fluorosis that is associated with serious bone abnormalities [11]. On the other hand, if the concentration of fluoride less than 0.5 mgL^{-1}, the incidence of dental caries increases considerably [11]. A guideline value of fluoride in drinking water of 1.5 mg L^{-1} was recommended by World Health Organization [12]. In several regions of the world it is well documented that the level of fluoride in drinking water exceeds this guideline value [3]. World-wide 200 million people are affected by the dental fluorosis (Mohan et al., 2012). The concentration of fluoride in water for human consumption may be reduced below the permissible limit by the following methods: ion exchange on polymeric resins, adsorption, reverse osmosis, and electrodialysis [4].

Disposal of fluoride from the industrial waste water is very critical environmental task for the industries. Large part of the waste water is treated by lime softening method to reduce the excess fluoride concentration. It reduces the fluoride concentration by approximately 10-20 mg/l from the waste water [2]. For further removal of F^- , co-precipitation of fluoride with Al^{3+} is extensively employed but this method generates very large amount of sludge [5-6].

S R Saranya, currently pursuing M -Tech degree in Environmental Engineering &Management, Department of Civil Engineering, UKF College of Engineering& Technology, Kollam-691302, Kerala, India. PH-9400602323, E-mail: saranyyasr@gmail.com

Dr. Anu N is currently working as Assistant Professor in Environmental Engineering &Management, Department of Civil Engineering, UKF College of Engineering& Technology, Kollam-691302, Kerala, India. PH-9496344127.. E-mail: anu098@mail.com.

Glass and ceramic production, semiconductor manufacturing, electroplating, coal fired power stations, beryllium extraction plants, brick and iron works, and aluminium smelters etc release high fluoride concentration in waste water [7-8]. Ion exchange method and membrane technologies including reverse osmosis and nano-filtration have been successfully implemented in the removal of trace fluoride concentrations. However, these methods are expensive and energy consuming [9-10]. All these processes are not much efficient as comparable to the adsorption techniques.

Adsorption process, quite attractive, simple and low cost of design and more variety of adsorbent make its convenient method for defluoridation. Conventional adsorbents have been used for defluoridation for long. These adsorbents cause adverse effect on health and are highly costly but the use of bio-adsorbents have no adverse effects on health and render good water quality [2]. The present study aimed to develop spectrophotometric method for determination of fluoride in drinking water using SPADNS method. The objective of the present study is to investigate the effectiveness of naturally occurring and low-cost materials like Passion fruit peel and its seed and Banana (Robusta) peel for removal of Fluorides from water.

2 LITERATURE REVIEW

Several adsorbent materials have been tried in the past to find out an efficient and economical defluoridating agent. Some of those adsorbents are activated coconut shell carbon and activated fly ash, groundnut shell, coffee husk, Phyllanthus emblica, bark of babool, pine apple peel powder, orange peel powder, grind neem and pipal leaves, groundnut shells, etc. On the basis of past research in the field of fluoride removal, a wide range of bioadsorbents were experimented. An overview of some of the research works were represented in table 1. It gives the data of type of adsorbent, initial concentration of fluoride, pH and final the fluoride removal efficiency. Banana peel shows greater removal efficieny about 94.34% at a controlled pH 6 and

initial fluoride concentration were 20 mg/l. the effect of pH, temperature, adsorbent dosage, particle size of adsorbants etc will affect the fluoride removal efficiency.

TABLE 1. COMPARATIVE DATA OF DIFFERENT BIOADSORBENTS (AASH MOHAMMADET.AL)

Adsorbent	Initial fluoride conc.(mg/l)	pH	% Removal
Sawdust raw	5	6	49.8
Wheat straw raw	5	6	60.2
Activated bagasse carbon	5	6	56.4
Neem peepal	5	2	84.9
Available activated Carbon	5	6	57.6
Sweet lemon peel	20	4	59.55
Groundnut shell	20	7	89.9
Banana peel	20	6	94.34

3 MATERIALS AND METHODS

3.1 Preparation of Banana Peel (Robusta) Adsorbent

Banana peels (Robusta) are collected washed three times from the tape water to remove the dust. It is dried in the sun light for three days. Dried banana peels crushed in a mixer grinder and then sieved by 500 μm ASTM mesh. Fig.1 shows the different types of biosorbents used in the current study.

3.2 Preparation of Passion Fruit Seed Adsorbent

It's collected washed in tape water and dried in sun light for one week. Dried Material crushed in mixer grinder and then sieved in 500 μm mesh ASTM. Sieved material is collected for further use.

3.3 Preparation of Passion Fruit Peel Adsorbent

It's collected washed in tape water and dried in sun light for one week. Dried Material crushed in mixer grinder. Since its size were not reduced, carbonized in muffle furnace at temperature 100°C for 1 hour. The material from muffle furnace was cooled to room temperature and then sieved in 500 μm mesh ASTM. Sieved material is collected for further use.

Fig.1. Biosorbents used for adsorption

3.4 Preparation of standard curve

A stock solution of 10 mg/l of fluoride was prepared by dissolving 221 mg of unhydrous sodium fluoride (NaF) in 100 ml distilled water and fluoride standard samples in the range of 0.2 mg/l to 1 mg/l were then prepared from stock solution (Table 2). Fluoride concentration was determined, at all stages of the process, by spectrophotometer using SPADNS reagent. This method is based on the reaction between fluoride and zirconium dye. The fluoride dissociates a part of the dye, forming a colourless anionic complex. The amount of fluoride is inversely proportional to the colour of the solution, that is, colour becomes progressively lighter as fluoride concentration increases. Take 5 ml each of SPADNS solution and zirconyl acid solution and mixed well (Fig.2). The spectrophotometer was set to zero absorbance with reference solution and absorbance readings of standard were obtained. Reference solution was used as a blank solution. Spectrophotometer used at 570 nm wavelength was taken as per standard method procedure (Fig.3)

TABLE 2
FLUORIDE SOLUTION OF DIFFERENT CONCENTRATION

Volume (ml)	1	2	3	4	5
F(ppm)	0.2	0.4	0.6	0.8	1

IJSER

Fig.2. Reference and fluoride standard solutions

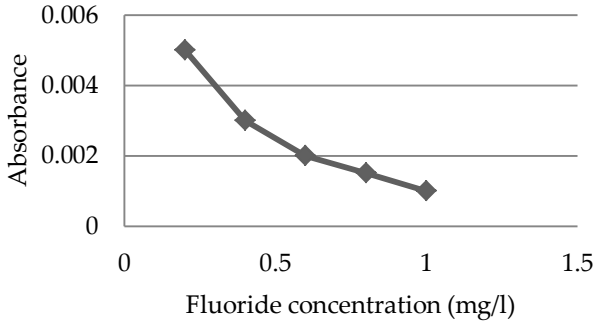

Fig.3. Calibration curve for Fluoride

3.5 Methodology

5 ml of standard solution was taken in 5 conical flasks and diluted to 50 ml. Adsorbents were added in varying proportion (0.1 g, 0.2 g, 0.3 g, 0.4 g, 0.5 g). The adsorbate and the adsorbent were then being mixed properly by using a shaker for 20 min at 170 rpm. The samples were taken out and filtered using Whatman No. 42 filter paper (Fig. 4). The filtered water was taken and added 10 ml of acid - Zirconyl SPADNS reagent, a wine red colour appeared. Treated samples are then analysed using a UV spectrophotometer and final Fluoride concentration after the adsorption can be found out.

Fig.4. 3 sets of 5 samples each (A1-A5, B1-B5, C1-C5) kept for filtration

4 RESULTS AND DISCUSSION

The present study provides the comparison of fluoride removal efficiency of bio-adsorbents such as ash of Passion fruit peel, Banana (Robusta) peel powder and Passion fruit seed powder from a solution contaminated with 1 mg/l fluoride under variable adsorbent dosages. The fluoride concentration and removal efficiencies for different bioadsorbents at different adsorbent dosage are shown in Table 3.

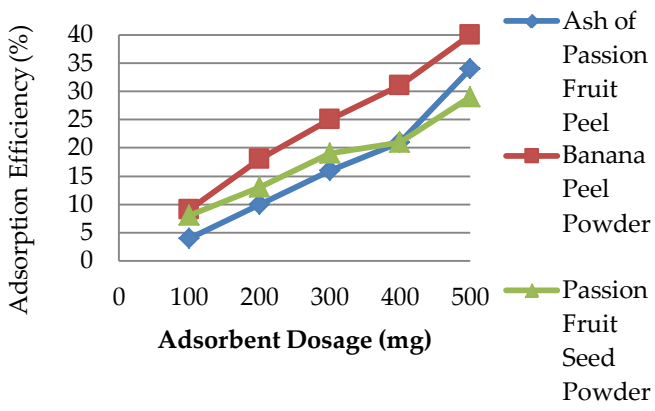

Fig.5. Comparison of fluoride removal efficiencies of different Bio Adsorbents

TABLE 3
FLUORIDE CONCENTRATIONS AND FLUORIDE REMOVAL EFFICIENCY AFTER BIOADSORPTION

Adsorbents	Samples	Adsorbent Dosage (g)	Initial Conc. (mg/l)	Final Conc. (mg/l)	Removal Efficiency (%)
Ash of Passion Fruit Peel	A1	0.1	1	0.96	4
	A2	0.2	1	0.90	10
	A3	0.3	1	0.84	16
	A4	0.4	1	0.79	21
	A5	0.5	1	0.66	34
Banana (Robusta) Peel Powder	B1	0.1	1	0.81	9
	B2	0.2	1	0.82	18
	B3	0.3	1	0.75	25
	B4	0.4	1	0.69	31
	B5	0.5	1	0.60	40
Passion fruit Seed Powder	C1	0.1	1	0.92	8
	C2	0.2	1	0.87	13
	C3	0.3	1	0.81	19
	C4	0.4	1	0.79	21
	C5	0.5	1	0.71	29

Different bio-adsorbents were studied for testing the efficiency of fluoride removal. From the graph the three curves obtained were almost similar. This may be because

of lower concentration of fluoride that has been selected first. If higher concentration were opted then higher variation may be obtain. Adsorption dosage and pH are also two most important factors. While comparing among three curves banana peel powder shows about greater removal efficiency about 40% at 500 mg adsorbent dosage. Adsorbents efficiency about more than 25% and 30 % were shown by Passion fruit seed powder and ash of Passion fruit peel respectively at 500 mg adsorbent dosage.

5. CONCLUSION

Greater removal efficiency was observed by using banana peel powder. Banana is also easily available in any season and cheapest when compared with Passion fruit. From the result it's observed that Fluoride removal efficiency increases with increase in adsorbent dose. The present study may find application in the development of sustainable, low cost, eco-friendly and house hold water treatment system for removal of fluoride.

ACKNOWLEDGEMENT

The authors would like to thank UKF College of Engineering and Technology for a financial grant. We would also express our gratitude towards Dr. K Mophin Kani and Dr. Anu N for their support and guidance in elaboration of this study.

REFERENCES

[1] Tej Pratap Singh, C. B. Majumder, (2015), Removal of fluoride using treated banana peel in batch reactor: kinetics and equilibrium studies, World journal of pharmacy and pharmaceutical sciences, Vol 4, Issue 09, 693-704.

[2] AashMohammad, CB Majumder, (2014), Removal of fluoride from synthetic waste water by using "Bio-adsorbents", International Journal of Research in Engineering and Technology, Vol 3, Issue 04, 776-785.

[3] Fawel, J., K. Bailey, J. Chilton, E. Dahi, L. Fewtrell and Y. Magara, (2006), Fluoride in Drinking Water, IWA Publishing, London, UK.

[4] Roberto Leyva-Ramos, Nahum A. Medellin-Castillo, Araceli Jacobo-Azuara, Jovita MendozaBarron, Lilia E. Landin-Rodriguez, Jose M. Martinez-Rosales and Antonio Aragon-Piña (2008) Fluoride removal from water solution by adsorption on activated alumina prepared from pseudo-boehmite by Journal of Environmental Engineering & Management, 18(5), 301-309.

[5] C.J. Huang, J.C. Liu, (1999), Precipitation floatation of fluoride containing waste water Fromsemiconductor manufacturer, Water Res. 33, 3403–3412.

[6] S. Meenakshi, N. Viswanathan, (2007), Identification of selective ion-exchange resin for fluoride sorption, Journal of Colloid Interface Science. 308, 438–450.

[7] L.A. Richards, M. Vuachere, A.I. Schafer, (2010) Impact of pH on the removal of Fluoride, nitrate and boron by nanofiltration/reverse osmosis, Desalination 261 331– 337.

[8] B.D. Turner, P. Binning, S.L.S. Stipps, (2005) Fluoride removal by calcite: evidence of Fluoride precipitation and surface adsorption, Environ. Sci. Technol. 39 9561–9568.

[9] F. Shen, X. Chen, P. Gao, G. Chen, Electrochemical removal of fluoride ions from industrial wastewater, Chem. Eng. Sci. 58 (2003) 987–993

[10] G. Zhang, Y. Gao, Y. Zhang, P. Gu, (2005), Removal of fluoride from drinking water by membrane coagulation reactor, Desalination 177 143–155.

[11] Latham, M.C, (1997), Human Nutrition in the Developing World, Food and Agriculture Organization of the United, Rome, Italy.

[12] World Health Organization (WHO), (2004), Guidelines for Drinking-Water Quality, 3rd Ed., WHO, Geneva, Switzerland.

[13] Anandu Aravind, Dayal Kurian Varghese, Arshik K, Meera S Prasad, Vinish V Nair, (2015), Defluoridation of Water Using Low-Cost Bio-adsorbents: A Comparative Study, International Journal of Engineering Technology Science and Research, Vol 02, Issue 5. 118-126.

[14] Sharad Sharma, Vibhuti, Vishal and Aditya Pundhir, (2014), Removal of Fluoride from Water Using Bioadsorbents, Current Research in Microbiology and Biotechnology, Vol 2, No. 6, 509-512.

IJSER