Eco. Env. & Cons. 29 (January Suppl. Issue) : 2023; pp. (S415-S417)
Copyright@ EM International
ISSN 0971–765X

DOI No.: http://doi.org/10.53550/EEC.2023.v29i01s.064

Removal of Fluoride using low-cost materials as an adsorbent

Pappu Kumar Yadav[1] and Ajai Singh*[2]

Department of Water Engineering and Management, Central University of Jharkhand, Ranchi 834 205, India

(Received 2 April, 2022; Accepted 2 September, 2022)

ABSTRACT

In the present work, locally available adsorbents such as Sugarcane Bagasse, Coconut Husk and Rice Husk were tested for defluoridation. The characterizations of the three adsorbents were carried out to study the effect of pH, different doses of adsorbent and variation in initial concentration of fluoride at constant temperature of 30±2 °C on removal efficiency of fluoride. It was observed that as the pH value increased, the removal efficiency increased to some time and later became constant in case of Sugarcane Bagasse at adsorbent dose of 0.5g/100 ml at contact time duration of 75 minutes. The removal efficiency decreased with gradual increase in initial fluoride concentration due to the capacity of adsorbent materials. The study revealed the applicability of low-cost adsorbents for the removal of fluoride from drinking water.

Key words : *Low-cost adsorbent, Adsorption, Fluorides, Removal efficiency.*

Introduction

India has declared fluorosis as a critical epidemic and prohibited the use of contaminated water for domestic purpose if the fluoride content is more than 1.5 mg/l. The Bureau of Indian Standards recommend the fluoride content in groundwater not more than 1 mg/l for drinking and cooking purposes (Ganvir and Das, 2011). Nearly 90 million people including 6 million children in the country in 200 districts in 19 states are affected with dental, skeletal and non-skeletal fluorosis (Bera and Ghosh, 2019). Around 30-50% of districts of Bihar are affected by fluorosis. Numerous researchers have explored the defluoridation of drinking water by means of coagulants, continuous fixed-bed column adsorption potential of granular-activated carbon from coconut and charcoal shell, low-cost activated carbon obtained from lemon peels, agricultural biomass-based adsorbents, eggshell powder, bio-waste coconut husk, rice husk ash along and orange peel ash (Waghmare and Arfin, 2015; Talat, *et al.*, 2018; Patel, *et al*., 2019). There is a need to develop cost-effective and eco-friendly treatment processes for defluoridation in order to improve the health condition of affected people living below poverty level. Therefore, fluoride removal by low-cost material such as Rise Husk, Coconut Husk and Sugarcane Bagasse has been investigated in the present research work for Gaya district in Bihar.

Materials and Methods

Average annual rainfall of the district is recorded as 1086 mm. The groundwater occurs under unconfined conditions in the weathered zone and acts as a good repository of groundwater. Aluminum Sulfate, Sodium Hydroxide, Aluminum Hydroxide and Sodium Fluoride were used during the laboratory work. Distilled water was used for washing the bio-

([1]M.Tech Student, [2]Professor)

agriculture waste and purified and deionized water was used for preparation of stock solution using fluoride ion-selective electrode. All the chemical reagents were prepared as per standard methods for the examination of water and wastewater. Stock solution of fluoride was prepared by dissolving 0.221 g of anhydrous Sodium Fluoride in one litre of distilled water. The test solution was taken as 5 mg/l. Standard fluoride solution was prepared by diluting 100 ml of stock fluoride solution to 1000 ml.

Rice husk, collected from a local rice mill, was burnt in muffle furnace to produce rice husk ash. Rice husk ash (RHA) was sieved through 425µm sieve and washed with dilute Hydrochloric acid and again washed with distilled water. Later 500 ml of 0.6 M Aluminium salt solution and 100 g of RHA were added to the stirrer reactor tank of 1000 ml capacity. Sodium Hydroxide with five times the concentration of Aluminium Sulphate was added to reactor. Sodium Hydroxide and Aluminium Sulphate reacted to produce precipitate of Aluminium Hydroxide which deposited on surface of RHA. When the pH of solution reached to the range of 6 -7, addition of NaOH was stopped. The resultant mixture was Aluminium Hydroxide (AH) coated RHA and sodium salt. Cocopeat brick was purchased from the market and soaked in water for 12 h and converted into a powder form. The dried materials were sieved with 2 mm stainless steel sieve and stored in a polyethylene container. A 400 g of the washed coconut husk was mixed with 600 ml of 0.1 mol dm3 NaOH. The mixture of washed adsorbent and sodium hydroxide was heated for 30 min at 120^{o}C with occasional stirring. Buckner funnel and a vacuum pump were used to separate powder adsorbent. The third adsorbent, sugarcane bagasse, was collected from local sugarcane juice corner and it was cut into small pieces, and washed with distilled water. The dried bagasse of sugarcane was treated with 0.1 N HCl. It was again washed with distilled water and treated with sodium carbonate to remove the residual acid and dried in sunlight. The dried bagasse was grounded in powder form and stored in air-tight container.

Results and Discussion

Effects of adsorbent dose, pH and initial concentration were observed. Adsorbent dose varied from 0.10 to 0.70 g/100 ml of RHA, Coconut Husk and Sugarcane Bagasse at constant pH value of 6 and contact duration of 60 minutes. It was observed that with increase in dose, removal efficiency of fluoride increases but after a certain dose, it slightly decreases in case of AH-RHA (Fig. 1). The maximum removal efficiency was obtained at a dose of 0.70g/100 ml which varied from 75 to 89%. The removal efficiency in case of Coconut Husk varied from 61 to 75%. The removal efficiency first increased and later decreased at doses of 0.1 g/100 ml and 0.3 g/100 ml but in the case of 0.5 g/100 ml, removal efficiency continuously increased from 15 to 75%. In case of Bagasse Sugarcane at the dose of 0.1 g/100 ml, 0.3 g/100 ml, 0.5 g/100 ml and 0.7 g/100 ml, the removal efficiency continuously increased upto 75 minutes. The effect of pH was observed by varying the pH from 2 to 14 at an adsorbent dose of 0.50g/100 ml and contact duration of 75 min. The removal efficiency on varying pH was found to be minimum as 30% at pH 5 and maximum efficiency as 53% at pH 13 for Bagasse of Sugarcane.

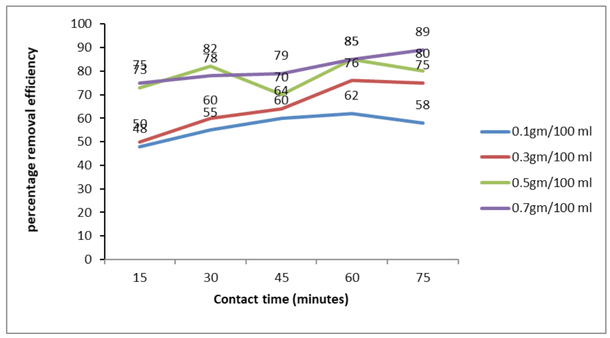

Fig. 1. Effect of dose of AH coated RHA on fluoride removal efficiency (%)

Similarly, for AH coated rice husk, the removal efficiency varied from 63 to 92%. For coconut husk, the removal efficiency varied from 22 to 79% where the efficiency constantly increased for pH value 2 to 7 and then decreased for pH 7 to 9 and further increased for the range of pH 9 to 11 (Fig. 2). Further, removal efficiency decreased with increase in initial fluoride concentration as shown in Fig. 3. This is because capacity of adsorbent materials exhausted sharply due to increase in initial fluoride concentration. Due to fact that for fixed dose of adsorbent, available adsorption sites were limited which got saturated at higher initial concentration.

The removal efficiency of fluoride was found to be a function of the adsorbent dosage and time duration at a given initial solute concentration. The removal efficiency on varying the pH was observed to

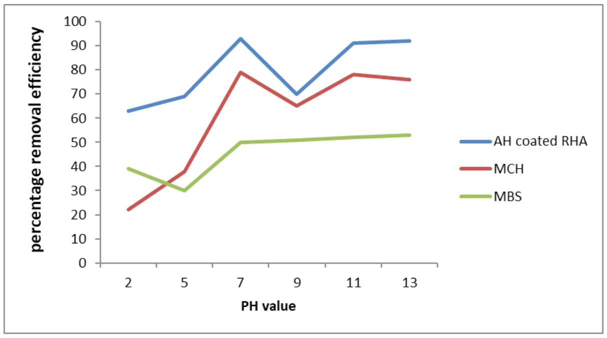

Fig. 2. Percentage removal efficiency and pH value

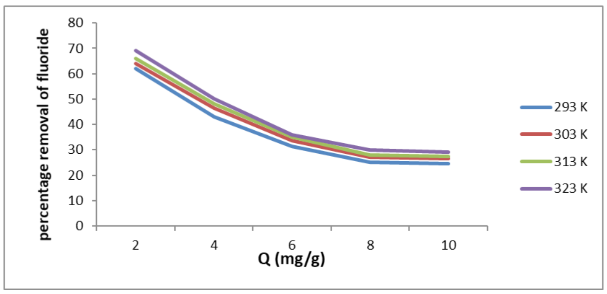

Fig. 3. Effect of initial concentrations on percentage removal efficiency of fluoride

be minimum at pH 5 and maximum at pH 13 (53%) for Bagasse Sugarcane. Similarly, for AH coated RHA, the removal efficiency varied from 63 to 92%. The rate of fluoride removal efficiency increased initially and then slowed down gradually until it achieved equilibrium with increase in contact duration. The removal efficiency decreases with increase in initial fluoride concentration due to capacity of adsorbent materials sharply due to increase in initial fluoride concentration. For coconut husk, the removal efficiency varied from 22 to 79%. It increased for pH value 2 to 7 and then decreased for pH 7 to 9 and further increased for pH 9 to 11. People living below the poverty line may be benefitted.

References

Bera, B. and Ghosh, A. 2019. Fluoride dynamics in hydrogeological diversity and Fluoride Contamination Index mapping: a correlation study of North Singbhum Craton, India. *Arabian Journal of Geosciences.* 12 (24): 802.

Ganvir, V. and Das K. 2011. Removal of fluoride from drinking water using aluminium hydroxide coated rice husk ash. *Journal of Hazardous Materials.* 185 (2-3): 1287-1294.

Kumar, G.K., Kamath, M.S. and Mallapur, P.S. 2016. Defluoridation of water by using low cost activated carbon prepared from lemon peels. *J. Basic Appl. Eng. Res.* 3: 658-660.

Patel, R.K., Kumar, S., Chawla, A.K., Mondal, P., Teychene, B. and Pandey, J.K. 2019. Elimination of Fluoride, Arsenic, and Nitrate from water through adsorption onto nano-adsorbent: A Review. *Current Nanoscience*. 15 (6) : 557-575.

Talat, M., Mohan, S., Dixit, V., Singh, D.K., Hasan, S.H. and Srivastava, O.N. 2018. Effective removal of fluoride from water by coconut husk activated carbon in fixed bed column: Experimental and breakthrough curves analysis. *Groundwater for Sustainable Development*. 7: 48-55.

Waghmare, S.S. and Arfin, T. 2015. Fluoride removal from water by various techniques. *Int. J. Innov. Sci. Eng. Technol*. 2: 560-571.