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Ocimum tenuiflorum Based Bioadsorbent's Defluoridation Competence Against Fluoride Toxicity in Drinking Water

VELLASAMY VEERAPUTHIRAN

Department of Science and Humanity (Chemistry), Dr. G.u. Pope's College of Engineering, Sawyerpuram, Affiliated to Anna University, Chennai, Tamilnadu, India.

Auother's information
VELLASAMY VEERAPUTHIRAN
Department of Science and Humanity (Chemistry), Dr. G.u. Pope's College of Engineering, Sawyerpuram, Affiliated to Anna University, Chennai, Tamilnadu, India.

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Abstract

Due to the seriousness of its significant health risks, fluoride toxicity through drinking water has received more attention globally over the past century.Many researchers tried to find a mechanical and chemical solution to the problem of potable drinking water. One of the accepted, affordable, and efficient methods to remove fluoride from contaminated water is adsorption.In this study, an unique defluoridation method using Holy Basil Ocimum tenuiflorum L. leaves as an effective bioadsorbent.

Holy basil was used to make bioadsorbent using the thermo-charring process, avoiding the use of acid. batch equilibrium adsorption method was used with this bioadsorbent, and the the concentrations of the adsorbent and adsorbate (fluoride), the contact time, the various adsorbent doses, and the various sizes.

In conclusion, the optimal contact time for all fluoride concentrations was determined to be 90 minutes. As is common knowledge, the smaller-sized adsorbent has demonstrated good absorptivity, and 1.5 g/L was determined to be the ideal amount for successful defluoridation.

To determine if the manufactured bioadsorbent could be used in a real water environment, the interference of co-existing anions such as nitrates, chlorides, sulphates, and carbonates was also investigated. Nitrate and chloride co-ions had no effect on the effectiveness of the adsorptive process, while sulphates and carbonates suffered greatly because of their bulky, structured binding to the adsorbent and the absence of fluoride adsorption onto it.The morphological and spectroscopic characterizations

Introduction

Although fluoride is an essential nutrient for humans, it is also a major primary hazard pollutant in drinking water that occurs naturally.

1. The presence of fluoride in drinking water determines whether it is advantageous or detrimental.
2. According to the World Health Organization (WHO), drinking water should have fluoride levels below 1.5 mg/L
3. Even after simple commercial purifications, more people in India are still drinking water that contains greater fluoride levels.
4. The overconsumption of fluoride by the populace led to skeletal and dental fluorosis.
5. easiest method of identifying of brownish or yellowish teeth indicates that a person has dental fluorosis.Fluoride in excess not only causes dental cavities, but it can also have a cascading effect on one's health and impair one's capacity to move physically.
6. As a result, during the past three decades, researchers have focused on eliminating fluoride using a variety of chemical and physical techniques.Many conventional methods are used, and they successfully remove fluoride from drinking water.

7. Biosorption is one of them, however there have only been a very small number of reported attempts.

[11-13]Therefore This research team worked on several herbal plants in order to find a few more capable bioadsorbents for defluoridation and has recently provided one of the best bioadsorbents made from Holy Basil, or Ocimum tenuiflorum, often known as Tulsi in India.

One of the many different medicinal plants mentioned in historical texts and holistic literature is Ocimum tenuiflorum.
It is a widely distributed, inexpensive herbal plant in India, particularly in the south.

The main goals of this project are to use batch tests to investigate the defluoridation efficiency of manufactured bioadsorbent with regard to fluoride concentration, contact time, adsorbent dose, different sizes of adsorbent, and with diverse natural co-anions. In addition to the aforementioned, the typical behaviour and it was noted that the adsorbents' physical characteristics had changed. Experimental Techniques

Preparation of Bioadsorbent:

The powdered holy basil leaves (Ocimum tenuiflorum L., or tulsi) that was chosen as the adsorbent material was acquired from Siddha Pharmacy on the campus of Siddha Medical College in Tirunelveli, India. It was set aside for 24 hours to let the shadow dry.The materials were thoroughly ground after drying to produce fine powdered material. Additionally, this powder sample was air-oven dried for 24 hours at 378 K.

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The dried herbal powder was then thermally roasted using a muffle furnace at 800 °C in place of an acid treatment for charring.After being acquired, the bioadsorbent was chilled for a few hours and further ground. and sieved to the desired various particle mesh sizes, then up to an hour before the experiment, kept in calcium desiccators.In the current investigation, analytical-grade chemicals and reagents were utilised exactly as they were the trial was conducted using water that has been thrice distilled. Wherever necessary, Whatmann No. 41 filter sheets were used for the filtration process.

Studies on batch adsorption:

The batch equilibration method is the most effective way to determine an adsorbent's effectiveness in adsorption tests.
To determine the adaptability of the manufactured bioadsorbent in various climatic circumstances, the batch equilibration method, namely at neutral pH, was used in the current defluoridation study. As an adsorbate solution, the first NaF stock solution was made to 1000 mg/L, and the successive dilutions to different fluoride concentrations were prepared using doubly distilled water.

As a pilot test, 100 mL of a 3.0 mg/L fluoride solution were taken up with various adsorbents in a process known as adsorption diffusion dosimetry. dosages of 0.22 to 2.00 g/L with increments of 0.25 g adsorbent at room temperature and a contact time of 60 minutes.

Given that 1.5 g/L might offer the best defluoridation, this dose was set as the initial adsorbent dose for all tests with the exception of the examination of the impacts of adsorbent dose. By adjusting the adsorption contact duration from 15 minutes to three hours with a 15-minute increment, the impact of contact time and fluoride concentration was initially investigated. Parallel studies were conducted using solutions with starting fluoride concentrations ranging from 2 to 10 mg/L.The ideal contact time and fluoride concentrations were determined from this group of research and applied to the ensuing batch experiments.

The effect of adsorbent dosage was investigated as previously mentioned, and the impact of adsorbent particle sizes was also investigated by adjusting the adsorbate-adsorbent contact period and various starting fluoride concentrations. Additionally, a series of batch experiments were conducted with natural ground water conditions in the presence of co-anions such as chloride, nitrate, sulphate, and bicarbonates in addition to the fluoride in order to experience the effective defluoridation property of the developed bioadsorbent.

The portable drinking-ground waters of the various zones typically contain bicarbonates in the 200 mg/L to 500 mg/L range, chloride concentrations up to 250 mg/L, nitrates up to 120 mg/L, and sulphates up to 200 mg/L due to the lack of good quality water.[14] As a result, the studies were conducted at various co-anion doses, including 100, 200, 300, 400, and 500 mg/L with 3.0 mg/L. F for attention.

The initial adsorbate concentration was then followed by 3.0 mg/L as similar to the ground water condition in southern India in the other tests, with the exception of the investigation on the effects of different fluoride concentrations.Typically, a rotator shaker with a 200 rpm speed was employed to thoroughly shake the reactants.Then, Whatmann No. filters were used to remove the solutions. filter paper 41 Then, using an ion-selective equipment called the Orion 9, the supernatant liquids were examined for fluoride content.The residue's adsorbent was dried in a hot air oven at 100 °C before being placed in storage for adsorptive characterisation. studies.

The equations 15 qe=(Co-Ce) /W...(1) were used to determine the defluoridation capacity of the adsorbent, where qe is the defluoridation capacity (mg/g), C o is the starting concentration (mg/L), C e is the equilibrium residual concentration (mg/L), and W is the weight of the adsorbent (g). The applications Origin Pro 9.0 and MS-Excel 2013 were used to calculate all of the results.

Characterization of Bioadsorbent:

The physicochemical and microphysical properties of the Ocimum tenuiflorum-based bioadsorbent were investigated using a Bruker AXS D8 Advance, Institution ID: OCPL/ARD/26-002 X-ray diffractometer (NIIST, Trivandrum), and a Philips XL-20 electron microscope equipped with an energy dispersive X-ray analyzer (EDAX) (SAIF, Pondicherry University).Additionally, the Department of Physics at Pondicherry University used a Nicolet 6700 spectrophotometer from Thermo Electronic Corporation, USA, to capture the FT-IR spectra for the experiment.

The Findings and Discussion:

Influence of Fluoride Concentration and Contact Time

In order to determine the best period for greater defluoridation, the contact time between an Ocimum tenuiflorum-based bioadsorbent and its solution was varied while all other factors, such as adsorbent dose, particle size, temperature, pH, and fluoride content, were maintained constant. Accordingly, a study on the change of fluoride in adsorbate was conducted for fluoride concentrations ranging from 2 to 10 mg/L, with each increment being 2 mg/L.

The results of every batch were displayed. This adsorption study has discovered two distinct phases.The first phase of them is quick up to 90 minutes of contact time, and the second phase is extremely slow after that.As a result, a 90-minute contact interval was used for the remaining tests.This is because the bioadsorbent's binding sites are not available for further fluoride adsorption.

Conclusion:

Even though fluoride is a vital component of human health, higher fluoride contamination in drinking water is a serious problem since it has a number of negative health effects.As a result, numerous researchers have used various defluoridation approaches to remove fluoride from drinking water to the allowable limit; among these approaches, adsorption is a simple and affordable one.

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In this work, it was successfully demonstrated that Ocimum tenuiflorum, or Tulsi as it is generally known in India, may be used to make bioadsorbent. The adsorptive capacity of the produced bioadsorbent was determined using the batch equilibrium method by altering the dose, concentration, and particle size of the adsorbent.The results showed that the contact time was For all fluoride concentrations in the ppm range, 90 minutes is an efficient ideal period for defluoridation utilising Ocimumtenuiflorum-based bioadsorbent.

Additionally, the 53 m particle size could cause more fluoride to be released from the solution medium. Importantly, it was discovered that at adsorbent-solution equilibrium, 1.5 g/L of adsorbent could absorb the maximum amount of fluoride accessible. Additionally, batch tests with the presence of coexisting anions, such as chloride, nitrate, sulphate, and bicarbonate, were conducted in order to determine the defluoridation efficiency with respect to the real water environment.

The Sulphate and bicarbonates are primarily present. due to its significant surface area occupied on the adsorbent, interfering with the interactions between the adsorbent and fluoride. But the prepared bioadsorbent's defluoridation ability was not significantly impacted by the presence of nitrates, chlorides, and fluoride.
The greatest defluoridation capability by Ocimum tenuiflorum based bioadsorbent was attained to 1766 mg/kg under all the aforementioned ideal circumstances. SEM, EDAX, XRD, and FT-IR spectral characterizations corroborated the leaching of fluoride to the adsorbent site by presenting significant findings in SEM image morphologies, the presence of the fluoride element in EDAX spectrum, and noteworthy changes in XRD and FT-IR peak heights. That the Ocimum tenuiflorum-based bioadsorbent can be employed for more adsorptive heavy metal removal investigations in addition to serving as a defluoridating agent.

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