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EXPERIMENTAL STUDY OF FLUORIDE REMOVAL BY USING AGRICULTURE WASTE OF BANANA STALK: A PROMINENT LOW COST BIO-ADSORBENT

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Abstract

This study involved batch experimental parameters and characterizations of adsorbent. Dose of precursor of Banana Stalk were found too high and hence the adsorbent was chemically activated. This Banana Stalk Coke (BSC) tested as an adsorbent ranges 1.0 g/L - 10 g/L were considered in the study of dose optimization where as pH 2.0-9.0 were selected. Initial concentrations 2 mg/L -15 mg/L were considered with a contact time 1 hrs to 12 hrs. Maximum uptake capacity of fluoride was obtained at pH 5.0 for a optimized dose of 1 gm/L at a contact time of 4.0 hrs. Freundlich and Langmuir models were found suitable in this research study.

Keywords: Defluoridation, adsorption, BSC, Langmuir & Freundlich Isotherm

INTRODUCTION

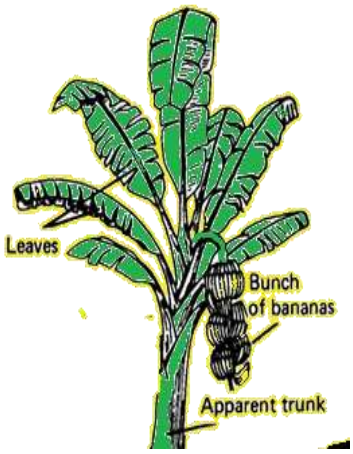
Removal of fluoride is a need as the water resources are dead year by year. Fluoride is a salt of element fluorine and it has dwell significance. Intake of fluoride is less or more with reference to the prescribed limit by various agencies such as WHO 1.5 Mg/L and BIS 1.0 Mg/L both are dangerous to the living being but its small concentration within the range protects bone and teeth too.Naturally fluoride originates in ground water due to leaching or dissolution from fluoride bearing rocks. Fluorspar, cryolite, fluorapatite and sellaite are the main fluoride rich rocks that contaminate the ground water after leaching or dissolution. Volcanic ash and rocks are often enriched in fluoride. Fertilizers such as superphosphate, NPK (nitrogen phosphorous potassium) and potash also contain remarkable quantity of fluoride to contaminate ground water.

Carbon-based materials have shown great usefulness for water purification because they exhibit excellent adsorption characteristics and after modifications properties of these materials may be tailored as per requirement. Challenges

associated with the development and use of cost effective and environmentally friendly materials and methods for de-fluoridation of water have also been discussed. Millions of people from different countries of the world are deeply dependent on the groundwater. In many regions people are exposed to fluoride (F-) via drinking water. So, pollution of groundwater with fluoride (F-) is a public health concern in many parts of the world (Patil, R. N., & Bhambulkar, A. V.,2020).

There are reports that excessive fluoride intake for extended period causes adverse effects of health such as fluorosis, cancer, arthritis, and other diseases. It has also been observed that fluoride in excess affects human intelligence, especially in children, who are most susceptible to early fluoride toxicity. Exposure to fluoride more than the recommended value is associated with a number of health issues. Dental fluorosis, skeletal fluorosis, neurological problems, thyroid problems and other health problems are the main health issues associated with high exposure of fluoride.

.**Plant Description:**



- **Avg. plant height**
  Up to 9 ft.
- **Leaves**
  8-12 Nos.
- **Stalk color**
  Brown / Green
- **Origin**
  Asian tropics

Fig.1: Banana Plant

MATERIAL AND METHODS

Banana Stalk was selected for this research and then chemically activated BSC was used in the experimental process. AR grades chemicals are used in this study. Stock solution was prepared by using NaF in a liter of distilled water diluting the known quantity of it. The concentration range of adsorbate test solutions was prepared from the stock solutions varied between 5 - 15 mg/L. In every experiment fresh solution was prepared and used for experimentation. 0.1 N HCl and 0.1 N NaOH were use for the pH adjustment. Adsorption method is selected & used because of its cheapness and effectiveness .

Material

Banana Stalk was collected from the Tahasil Chandur Bazar, District Amravati. Selected Banana Stalk was washed several times so that the dust particles get removed. Dried Stalk was then cut into the pieces of size 1 inch and then placed in oven for 24 hrs. to make completely dry. These dried pieces of banana Stalk were then mixed with alum based solution and placed in muffle furnace for a period of 2.0 hrs at 500^0C and removed it after 24 hrs (Bhambulkar, 2011).

This burned material then pulverized and washed several times by distilled water so that the ash present in these was removed completely. This

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activated bio carbon named Banana Stalk Carbon (BSC) used in further experimental study analysis.

Method of analysis

SPADNS photometric method was used for the determination of fluoride ions, at 570 nm using the double beam UV–vis spectrophotometer (UV–VIS-8500, Tech comp Ltd, Hong Kong). The pH of the solution was measured by using the pH meter of the Elico model (LI613) (Bhambulkar & Patil, 2020) .

CHARACTERIZATION OF ADSORBENT

X-ray Diffraction (XRD), Scanning Electron Microscopy (SEM). Chemical compositions of BSC were also estimated in this research study.

Table:1: Banana pseudo stem fibre (Mohiuddin et al., 2014).

Elements	Percentage
Cellulose	50.0 %
Interwoven with	30.0 %
lignin	18.0 %
pectin	5.0 %
water soluble material	3.0 %
ash	5.0 %

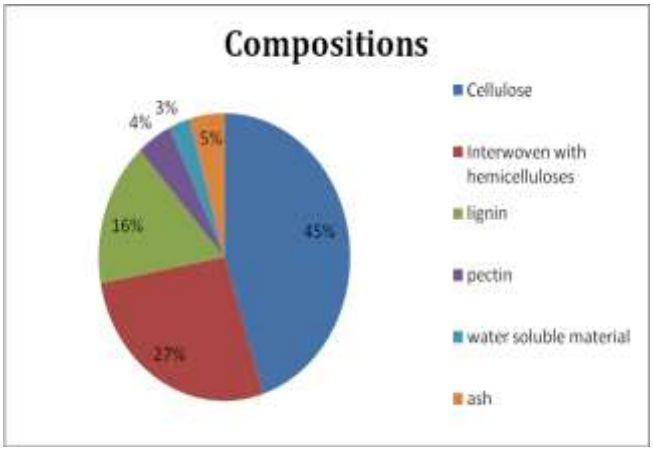

Fig. 2: Banana pseudo stem

X-ray Powder Diffraction (XRD)

In this test samples were scanned for 2ø range from 5 to 60°.The X-ray diffraction spectrum pattern of the BSC did not show any significant changed in loaded and unloaded BSC with fluoride. (Fig.2), thereby indicating the amorphous nature of the product.

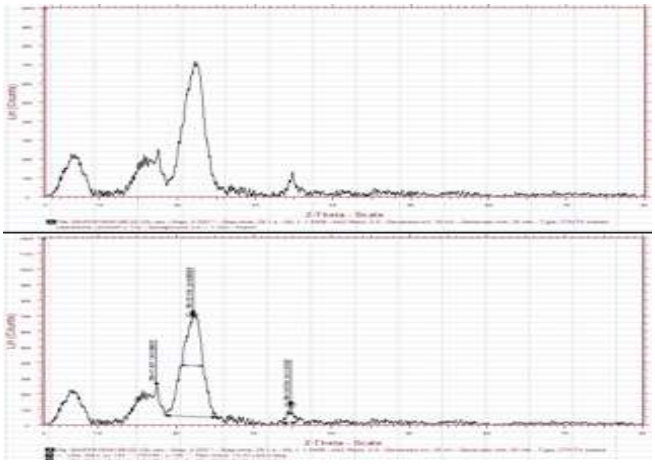

Fig.3: XRD analysis of BSC

To foretell changes in the crystal structure of the treated Banana Stalk Coke, XRD was conducted on the BSC. Since a few decades ago, X-ray diffraction (XRD) analysis has been one of the most popular methods in the scientific period for determining the kind of material and the identification of crystals. XRD patterns of Banana Stalk Coke before and after fluoride ions were adsorbed. The BSC prior to fluoride ion adsorption is depicted in figure 9 as having symmetric, sharp peaks. This peak indicates that the structure is crystalline, and the figure below illustrates the position and kind of peaks following the adsorption of fluoride ions. It was discovered that no peaks had formed, suggesting

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that the structure is amorphous. Scan angles for the samples were 2° and 5.

Scanning Electron Microscopy (SEM)

Scanning electrons microscopes analysis was performed to understand the morphology. From Fig.3, it is observed that the openings are enough to remove fluoride from water. From Fig.4, shows the openings are blocked after adsorption of fluoride ions.

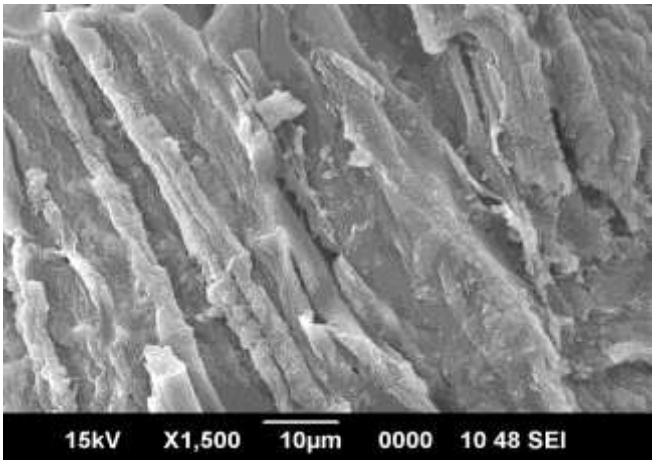

Fig.4: Loaded image of adsorbent BSC

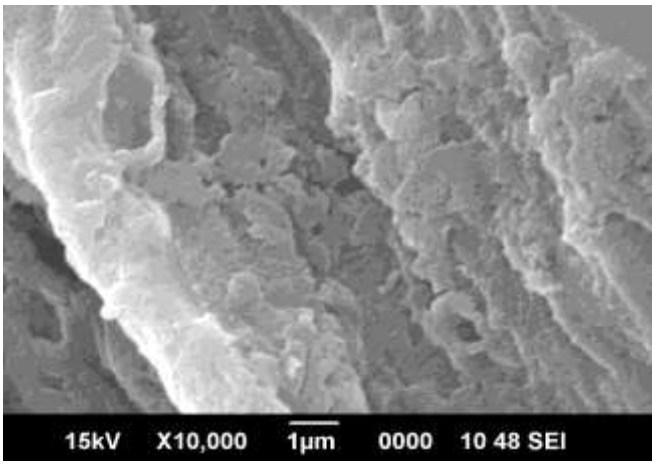

Fig.5: Unloaded image of adsorbent BSC

BATCH ADSORPTION STUDY

Batch adsorptions were carried out by shaking 100 ml of fluoride samples in a controlled rotary shaking machine (Model no. CIS-24, Remi Instruments, Mumbai, India) in a glass stopper bottles of 200 ml capacity at different dosages of adsorbent with speed of 180 rpm. This solution was then filtered through Whatman filter paper no. 42 and the analyzed for the estimation of fluoride. The analysis was done by using double beam spectrophotometer. All adsorption experiments were conducted at a 27-30 0C temperature and investigate the effect of various parameters like adsorbent dose, pH, temperature, initial fluoride concentrations, contact time etc.

RESULTS AND DISCUSSION

Effect of Dose

This experimental study for the estimation of fluoride quantity by using different BSC doses which evaluated the optimum requirement of dose for the fluoride ions removal from the aqueous solution. The initial fluoride concentration was taken 5.0 mg/L. The analyzed report estimated the % removal efficacy of chemically activated Banana Stalk Carbon (BSC) at different doses and quantities. The selected doses for the analysis were 0.5 g/L – 3.0 g/L of BSC and found it is one of the low-cost, effective predominant adsorbent in the process of Defluoridation which shown in fig.1.

The tested results of effect of different doses on the fixed initial fluoride concentration shows as the amount of dose of adsorbent BSC increases the capacity of % removal of fluoride also increases up to certain limit. The removal % of fluoride increases up to 93.21 % for a dose

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quantity 1.0 g/L. which was essential to achieve the desired limit of 1 mg/L of fluoride. The optimized dose 1.0 g/L of BSC was used for the further study. The adsorbent BSC has a good capacity to remove fluoride ions from aqueous solution.

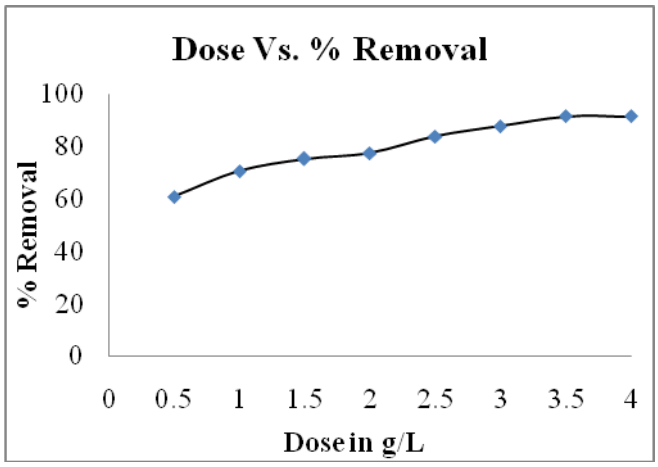

Fig. 6: Dose of Adsorbent Vs. % Removal.

IC: 10 mg/L; pH 7; rpm 150, temp.30^{0}C; Vol. 100 mL

Effect of pH

Fluoride solution pH is an important parameter in Defluoridation. The adsorbent BSC was used by diluting in a known quantity of pH solutions ranges from 2-7.

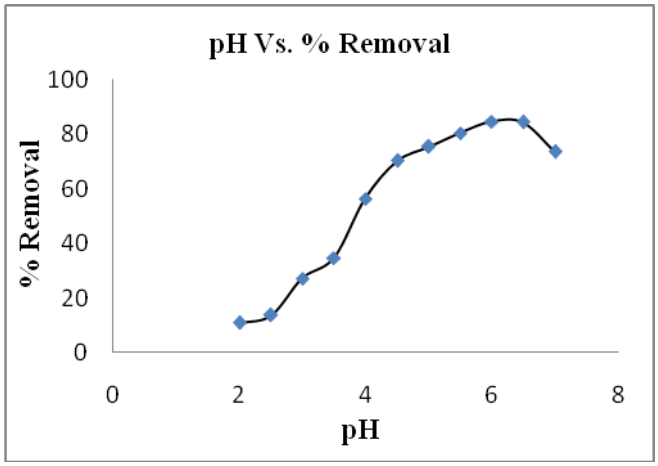

Fig.7: pH Vs. % Removal.

IC: 10 mg/L; pH 7; rpm 150, temp.30^{0}C; Vol. 100 mL

The results shows the effective removal up to pH range 4.5 to 6.0 and then it falls down which shows removal capacity of fluoride ions decreased with increase in pH as shown in fig.2. The drop of pH recorded due to the competition of the hydroxyl in the process of fluoride adsorption .

Effect of initial metal ion concentration

In this study it was observed that the tested initial concentrations vary from 5.0 mg/L to 15 mg/L are the variations in the removal percentage of fluoride ions. The maximum removal was recorded on minimum initial concentrations, while as the initial concentration of fluoride increases the rate of % removal of fluoride decreases [10] shown in fig.3.

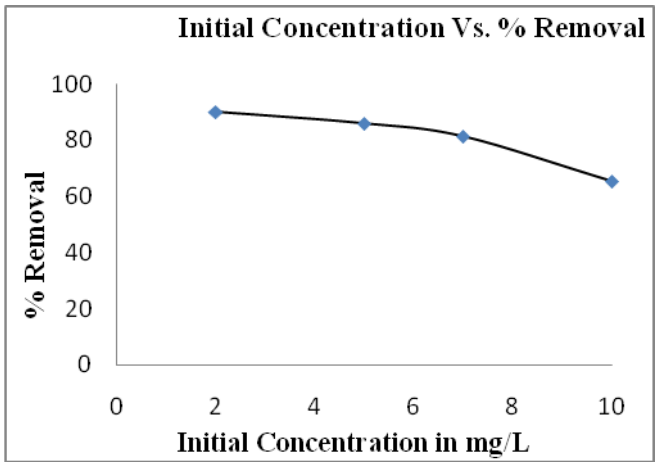

Fig. 8 : Initial Concentration Vs. % Removal.

IC: 10 mg/L; pH 7; rpm 150, temp.30^{0}C; Vol. 100 mL

Effect of Particle Size

Particle size has a great importance in the study of fluoride removal by adsorption. The particle sizes of 75 µm to 300 µm were selected and used in this research. Fig. 4 clearly shows the decrease in percentage removal in the increase in particle size [11]. This results proved that the removal capacity

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of adsorbent is highly depends on the particle size of adsorbent used.

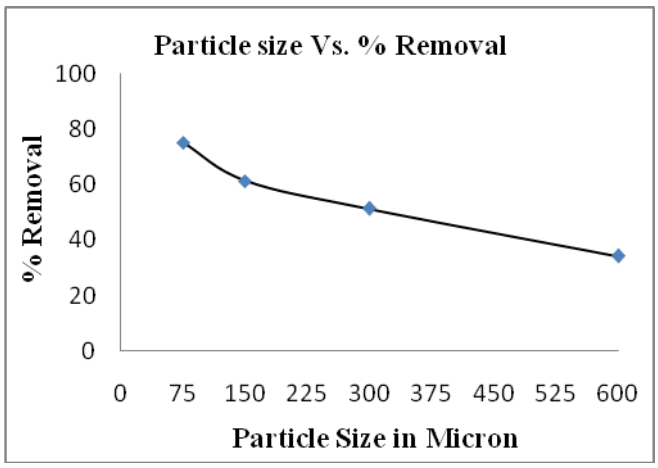

Fig. 9: Particle Size Vs. % Removal

IC: 10 mg/L; pH 7; rpm 150, temp.30^{0}C; Vol. 100 mL

Effect of Contact Time

Contact time is an important parameter in batch experimental study. It is a time dependant study in which the adsorbent allowed to rest at a defined time with the fixed agitation. This analysis recorded the efficiency of BSC at different time of contacts.

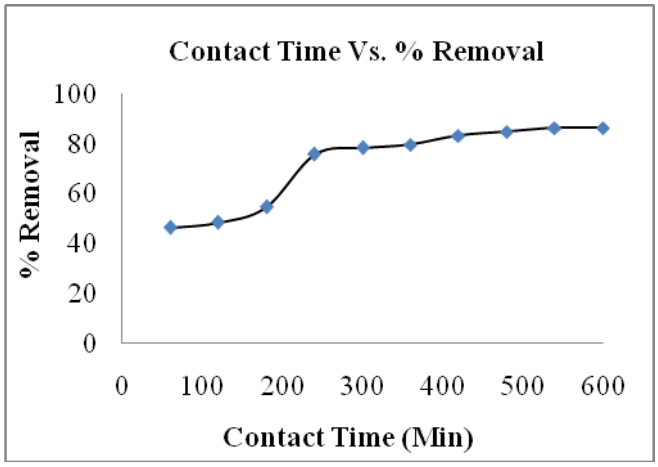

Fig. 10: Contact time Vs. % Removal

IC: 10 mg/L; pH 7; rpm 150, temp.30^{0}C; Vol. 100 mL

The obtained results show the capacity of BSC adsorbent increases with increase in contact time. The maximum required fluoride removal obtained at 240 Min. shown in fig.5.

ADSORPTION MODEL

A different adsorption isotherm was prepared and the analytical data matched well with Langmuir than Freundlich, which achieved the good adsorption capacity of the adsorbent. The interaction of the adsorbate and the adsorbent was the focus of the isotherm study. The information was seen in a relationship between the Langmuir and Freundlich adsorption isotherms. The Freundlich isotherm is equilibrium based adsorption based on homogeneous surfaces, where as the Langmuir isotherm is an assumption based on the removal due to monolayer sorption happening on a homogeneous surface of the adsorbent without any collaboration between adsorbed particles. The linear equations for the Langmuir and Freundlich isotherms are provided below and are denoted by the equations (a) & (b, respectively.

$$\frac{1}{qe} = \frac{1}{(qmaxKL)}\frac{1}{Ce} + \frac{1}{qmax}$$

Equation (a)

The greatest quantity of fluoride that may be adsorbed which is shown by qmax in mg/g in the equation above. The equilibrium fluoride concentration is indicated by Ce in mg/L and the Langmuir isotherm constant is indicated by KL in L/mg.

$$log\ q_e = log\ K_f + \frac{1}{n}\log C_e$$

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Equation (b)

Ce is the equilibrium fluoride concentration, and qe is the amount adsorbed in mg/g in equation 2; K_F is the observational consistent of Freundlich in mg/g and 1/n is the Freundlich type. The direct plot shows the Langmuir and Freundlich isotherm application in fig.11 and 12.

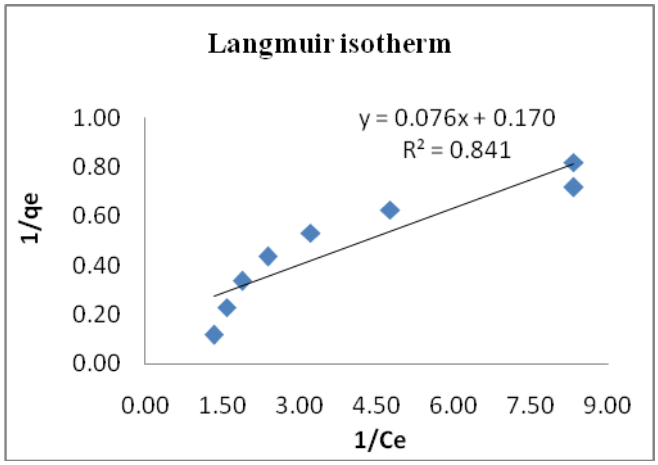

Fig. 11: Langmuir Adsorption Isotherm

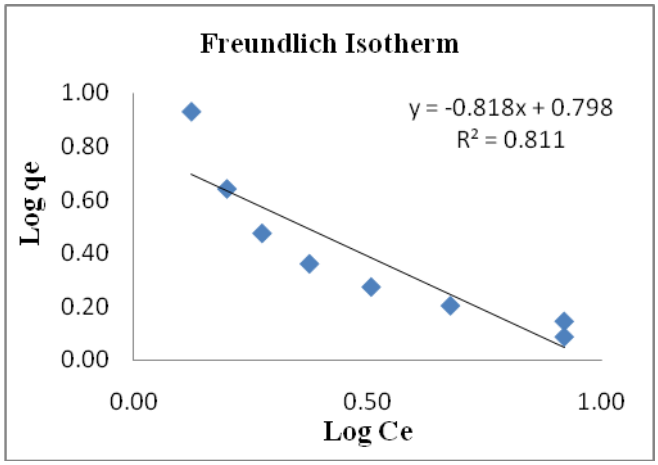

Fig. 12: Freundlich Adsorption Isotherm

CONCLUSIONS

The results tabulated on the basis of research experimentations and facts findings following conclusions are made.

1. Banana Stalk Coke (BSC) is one of the effective Bio adsorbent found in the process of Defluoridation.
2. Banana Stalk Coke (BSC) required chemical activation before the used as an adsorbent for the effective removal of fluoride ions.
3. The optimum dose of Banana Stalk Coke (BSC) was found 1.0 g/L for removal of fluoride of 5.0 mg/L concentration.
4. Maximum removal of fluoride was noted at pH range 4.5-6.0.
5. Contact time for the best removal of fluoride conents was noted 240 Min.
6. Adsorption capacity of Banana Stalk Coke (BSC) was found more on particle size of 75 micron at standard conditions.
7. In adsorption Freundlich and Langmuir models were tested and found the best fitted model was Langmuir than the Freundlich.
8. All the physicochemical parameter of drinking water was found within permissible limits (BIS 10500 -1991) after treatment.

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