Feasible Quantum Study of Gum Arabic Tree Barks (GATB) Adsorbent Used in Fluoride Removal from Synthetic Solution

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Abstract

This research study based on the use of tree bark of Gum Arabic tree barks in the removal of Arsenic [As (III)] from the synthetic solution by the method of adsorption. This adsorption process involved the parameters such as effect of Dose 2.0 to 10.0 g/L, pH 2-8, Contact time 30 to 240 Min. and initial concentration 0.5 to 2.0 mg/L. This research shows the uptake capacity of activated Gum Arabic Bark. It was noted that the maximum uptake of arsenic was found at pH 4 in both the cases. The removal of arsenic found after 180 Min. rapidly and then it was continue up to 240 Min. As the initial concentration of arsenic increases the % removal of arsenic observed decreases. Dose of adsorbent increases the removal percentage of Arsenic. Gum Arabic bark has a good removal capacity of arsenic.

Groundwater, Arsenic, SSC, Adsorbent, Isotherm
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Introduction

Arsenic exposure is one of the major threats to public health in more than 50 nations including China, Australia, India, Bangladesh, Argentina, Brazil, Thailand, Vietnam, Pakistan, Chile, Bulgaria, Canada, Czech Republic, Egypt, Iran, parts of USA, etc (Bhambulkar, A.V. ,2011).

Arsenic, an element of the earth's crust with an abundance of 1.8 ppm by weight, combines with oxygen, chlorine and sulphur to form inorganic arsenic compounds. Arsenic and its compounds are widely used in agriculture, livestock feed, medicine, electronics, metallurgy, chemical agents etc. Arsenic is of interest in terms of environmental issues and health impacts. Rock-water interactions in aquifer systems are the major cause of release of arsenic and causes deterioration in groundwater quality(Patil, R. N., & Bhambulkar, A. V.,2020). Arsenic is the 12th most common element in nature, and it usually appears in three allotropic forms, including black, yellow, and grey. If heated, it rapidly oxidizes to arsenic trioxide (As_2O_3) and has a garlic odour (Fendorf et al., 2010) (Bhambulkar et al., 2021).

The arsenic poisoning in groundwater was first reported by the Department of Public Health Engineering from the district of Chapai Nawabganj in 1993 (Huq et al., 2020 and references therein). Chakraborti et al. (2016) reported that the degree of the problem in the country was very critical and revealed that the centre part of the southeast Dhaka was the worst affected. Several studies confirm that the shallow aquifers of Bangladesh are badly affected by the high levels of As contamination (Yang et al., 2014; Edmunds et al., 2015). The As concentration in groundwater ranges from < 0.5 to > 4600 μg/L (Whaley-Martin et al., 2017 and references therein). Huq et al. (2020) reports that out of 64 districts, 61 districts contain As exceeding the limit of WHO (10 μg/ L) standards for potable water and it affected more than 85 million people(Bhambulkar et al., 2021), (Chimote, K., & Bhabhulkar, A. ,2012, March), (Bhambulkar, A. V. & Isha. P. Khedikar ,2011).

Arsenic is naturally present at high levels in the groundwater of several countries. it is highly toxic in its inorganic form. Contaminated water used for drinking, food preparation and irrigation of food crops poses the greatest threat to public health from arsenic (Sahare et al. ,2019), (Asare et al. ,2019). Long-term exposure to arsenic from drinking-water and food can cause cancer and skin lesions. It has also been associated with cardiovascular disease and diabetes. In utero and early childhood exposure has been linked to negative impacts on cognitive development and increased deaths in young adults. The most important action in affected communities is the prevention of further exposure to arsenic by provision of a safe water supply.

In typical ground water environments, arsenic may be present in both As (III) and As (V) states. As (III) is generally more mobile in water than As (V), and has higher toxicity1. Due to the withdrawal of excessive amounts of groundwater, problems of increased iron, fluoride and arsenic contamination have been reported in different parts of India. A recent study on cancer risks from arsenic in drinking water indicates that it could cause liver, lung, kidney and bladder cancers besides skin cancer.

Plant Description:

- **Plant height**
  7 to 15 M
- **Flower color**
  Yellow
- **Seed color**
  Black
- **Seed shape**
  Round

Fig.1: Plant Description of Gum Arabic Tree Barks Source:
https://pixabay.com/images/search/gum%20arabic/

In this study Tree bark of Gum Arabic were selected and modified by providing the physical activation process. These adsorbents have found a good efficiency for the removal of arsenic from the synthetic solution.

MATERIAL AND METHODS

The chemicals were used in this research analysis are of analytical grade. Experimental Stock solution containing 1000 mg/l of As (III) was prepared by dissolving Analytical Grade As_2O_3 in distilled water. Stock solution is used for making the required experimental solutions. The pH of the adsorbate solution was adjusted using 0.1 N HCl or 0.1 N NaOH aqueous solutions without any further adjustment during the sorption process (Sonali Sambhaji Devghare et al. ,2021), (Roshan Patle et al. ,2021).

Material

Gum arabic barks were collected and cut in to the small size of pieces and the washed and dried naturally for 2 days. Dried bark was then grounded and sieved to obtain fine particles. The powdered bark was washed several times with 0.1 N HNO_3 and then with distilled water so that all the traces of acid was removed. Finally, it was dried in a oven for 6 hours and used for study.

Method of analysis

Experimental analysis of arsenic was performed in batch analysis and their estimation was carried out by silver diethyldithio carbonate method. Effect of doses, Effect of pH, Effect of initial concentrations, Effect of contact time and the particle size were the parameters selected for this research study.

In effect of doses of As (III) 2.0 to 10 g/L, pH 2.0 to 8.0, Contact time 30 to 240 Min. and initial concentration 0.5 to 2.0 mg/L were selected and studied experimentation at room temperature. Samples of 100 ml arsenic solution for different concentrations were analyzed.

CHARACTERIZATION OF ADSORBENT

In this research different instruments were used for the characterization of GATB. It was subjected to detailed characterization by using X-ray Diffraction (XRD), Scanning Electron Microscopy (SEM).

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 PPSC did not show any significant changed in loaded and unloaded GATB with fluoride. (Fig.2), thereby indicating the amorphous nature of the product.

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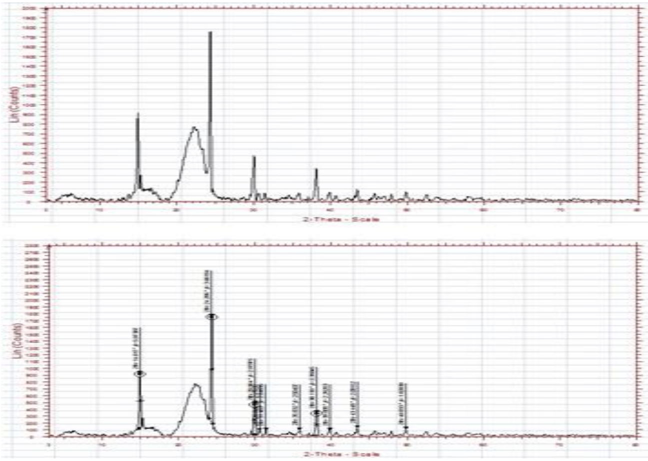

Fig.3: Chemical Compositions of GATB

Scanning Electron Microscopy (SEM)

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

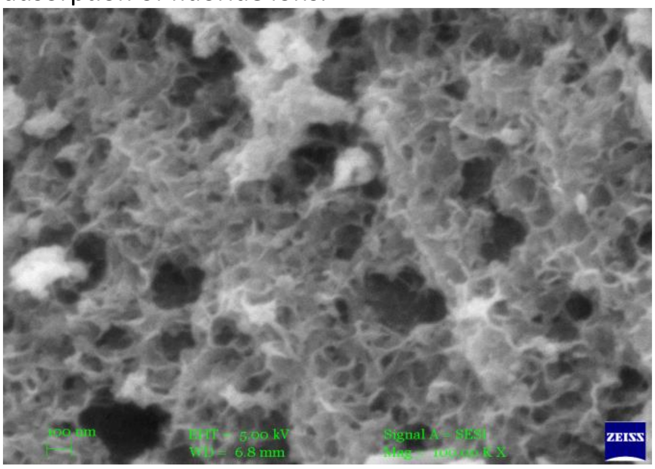

Fig.4: Unloaded image of adsorbent GATB

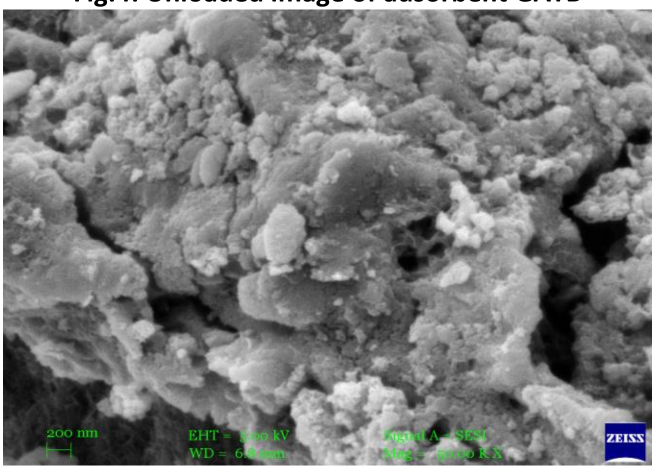

Fig.5: Loaded image of adsorbent GATB

BATCH ADSORPTION STUDY

This study were carried out by using the chemically activated bark of GATB at different doses for the effect effect and % removal capacity. Initial concentrations, pH, Contact time, Particle size etc. atre the parameters analyzed in this study. The optimum conditions are used for the further study (Ganorkar R. A. et al. ,2014), (Bhambulkar & Patil, 2020), (Khobragade, Bhambulkar, & Chawda, 2022) , (Jamulwar, N., Chimote, K., & Bhambulkar, A. ,2012).

KINETIC ADSORPTION MODEL

In order to estimate equilibrium adsorption rate for the uptake of arsenic on to GATB, time dependent sorption studies were conducted. Adsorption kinetics was monitored by adding known weight of GATB into 100 ml sample volumes and analyzed in sequences.

RESULTS AND DISCUSSION

Effect of Dose

The adsorbent doses of GATB were used from 2 g/L to 10 g/L. The values obtained from the experimentation and plot a graph Dose Vs. % removal of arsenic shows the increased in % removal while increases the dosage of GATB. 6 g/L dose was selected as an optimum dose of adsorbent having % removal 84.92 % for the standard conditions at room temperature shown in fig.5.

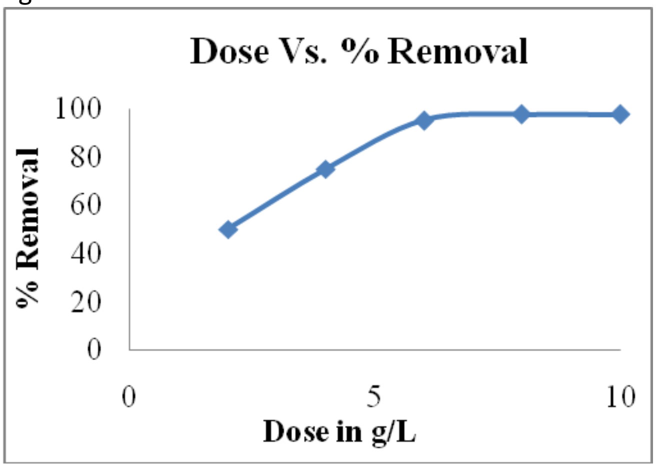

Fig. 6: Dose of Adsorbent Vs. % Removal.

IC: 0.4 mg/L; pH 7; rpm 150, temp.30^{0}C; Vol. 100 mL

Effect of pH

pH has a important role in this study. The effect of pH on removal of arsenic is shown in Fig. 6. Different ranges of pH starts from 2 to 8 were analyzed and found the optimum pH level for the removal of arsenic. The gradual increased was observed up to pH 5. The maximum removal of arsenic was observed

96.45 % at pH 5. This pH was used in further experimental study.

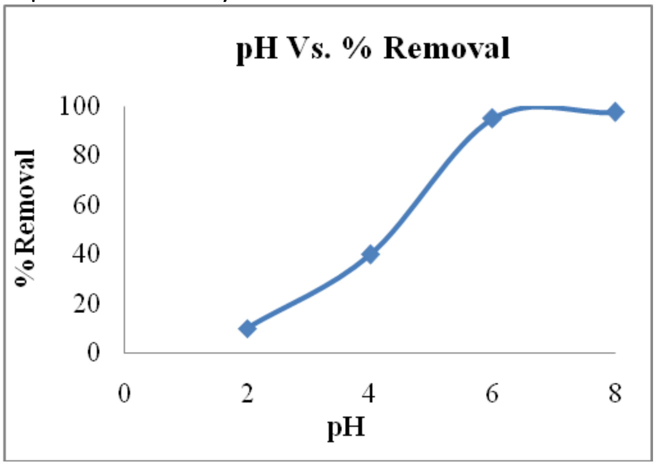

Fig.7: pH Vs. % Removal.
IC: 0.4mg/L; pH 7; rpm 150, temp.30^{0}C; Vol. 100 mL

Effect of initial metal ion concentration
Initial concentration study tested different initial concentrations of arsenic solution ranges from 10ppb to 50ppb. For the optimum condition of Dose and pH at the agitation of 150rpm with the contact time 240 Min. The results show the decrease in % removal while increased in initial concentrations of GATB. This is happened because of the saturated sites of adsorbent with the increase in metal ion concentrations shown in fig.8.

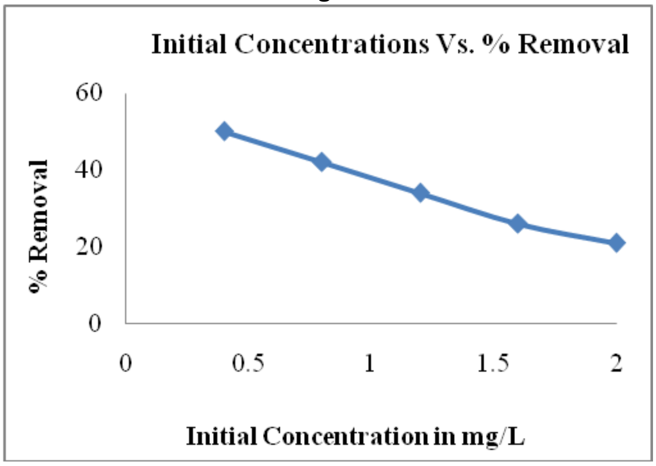

Fig. 8 : Initial Concentration Vs. % Removal.
IC: 0.4-2.0 mg/L; pH 7; rpm 150, temp.30^{0}C; Vol.100 mL

Effect of Particle Size
Adsorbent particle size has a important part in batch adsorption study which affects the process of adsorption. The particle sizes of 75 µm to 300 µm were selected and used in this research. In fig. 4, the result shows that the increase the particle size of adsorbent GATB, decreases the removal capacity of Arsenic. Hence it proved that the removal capacity of adsorbent is also depends on the particle size of adsorbent used.

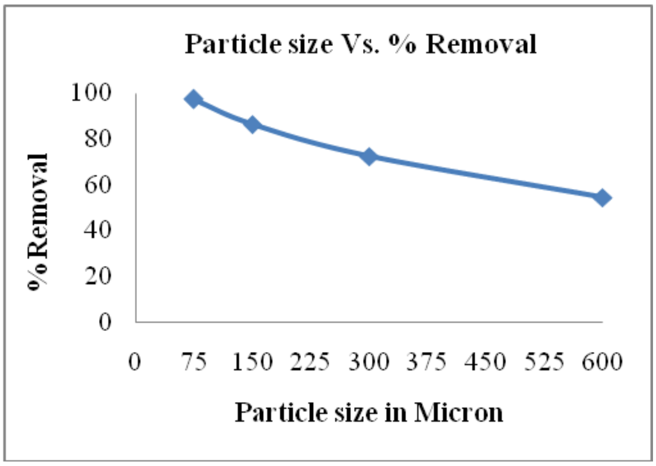

Fig. 9: Particle Size Vs. % Removal
IC: 0.5mg/L; pH 7; rpm 150, temp.30^{0}C; Vol. 100 mL

Effect of Contact Time
In the research study of batch adsorption 15 to 240 Min. contact time were selected and it has observed that as the contact time increases the % removal of Arsenic was also increases. The results shown in fig. 10 shows that the optimum contact time recorded 240 Min. to achieved required quantity of Arsenic removal from the synthetic solution. Initially it was increase gradually and at 240 Min. maximum removal of arsenic was noted by using GATB at room temperature with 150 rpm.

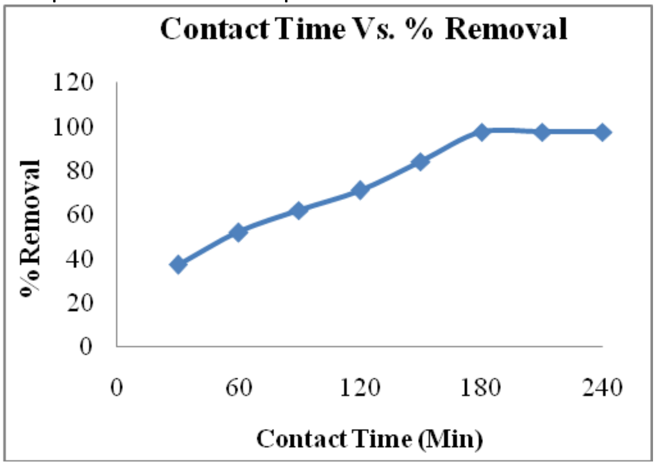

Fig. 10: Contact time Vs. % Removal
IC: 0.4mg/L; pH 7; rpm 150, temp.30^{0}C; Vol. 100 mL

ADSORPTION MODEL
Langmuir and Freundlich isotherms were plotted and studied on the basis of analytical data which were well fitted in Langmuir than Freundlich isotherm. This achieved good adsorption capacity of adsorbent which shown in fig.11 & 12.

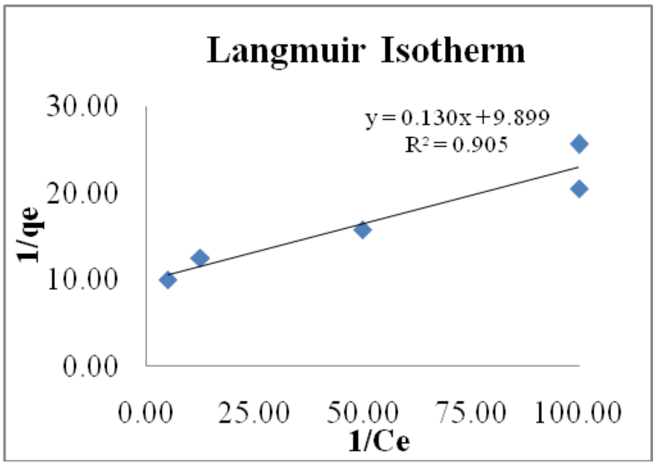

Fig. 11: Langmuir Adsorption Isotherm

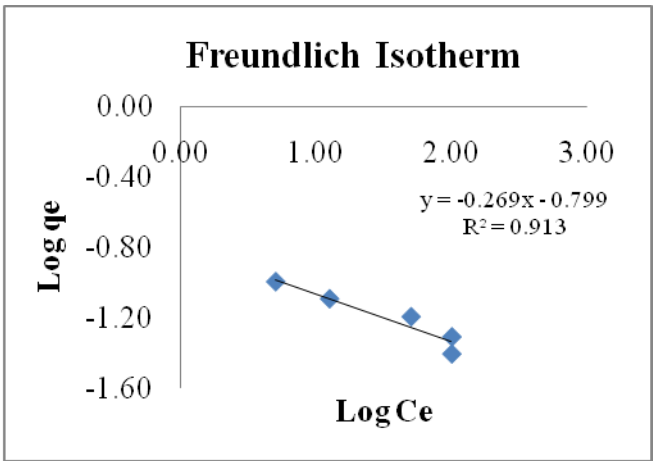

Fig. 12: Freundlich Adsorption Isotherm

CONCLUSIONS

This research study analyzed several parameters and characterizations during the experimentations and on the basis of results found following conclusions are made.

This study concludes that the adsorbent GATB used in this research study is a efficient and low cost adsorbent for the removal of excess As (III) from water. The available commercial activated carbons are expensive and hence the substrate raw materials employed are widely available and inexpensive. The optimum conditional parameters were studied and found the maximum removal capacity at optimum dose of GATB is 6.0 g/L, pH 5, Contact time 180 Min., Particle size 75 Micron etc.

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