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Study of Arsenic Removal by Natural Adsorbent Developed from Baruwa Grass (Tripidium bengalense)

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ABSTRACT

In present study, natural adsorbent developed from *Tripidium bengalense* commonly known as baruwa grass. Adsorbent was characterized and examined for arsenic removal efficiency. It was observed by XRD, FT-IR techniques that adsorbent after treatment of arsenic solution expressed extra peaks and bands than untreated adsorbents. Adsorbent capacity was also evaluated in presence of cation and anion, Ca^{+2} ion showed negative effect while PO_4^{-3} ion showed considerable positive effect respectively. Developed adsorbent performance was P^H sensitive and works with maximum efficiency at pH range 6.3- 7.5.

Keywords : Arsenic, natural adsorbent, arsenic removal efficiency, *Tripidium bengalense*

I. INTRODUCTION

Arsenic-contaminated drinking water is a significant public health problem in both industrialised and emerging countries. Arsenic is harmful and likely carcinogenic as consumed by drinking water (Ferguson, 1972) 1st. Various scholars have conducted critical and comprehensive reviews of the causes, behaviour, events, and severity of health consequences correlated with arsenic toxicity and recovery strategies from water all over the world [1,2,3]. Arsenic pollution of water and air has been a significant problem on a global scale in recent years [4].Acute and persistent arsenic poisoning from drinking water has been identified in several countries around the world, where a significant percentage of the water supply is polluted with elevated levels of arsenic [5,6]. In Indian perspective many studies have been done and it was found that in north India specially some districts of U.P. are facing arsenic danger problem [7-38] Many methods has been reported to remove arsenic effectively and use of natural adsorbent is one of them suitable method. Natural adsorbent prepared from plants are exhibiting best result at low cost and in present study natural adsorbent is developed from baruwa grass which is abundantly found, specially at those places where high arsenic contamination has been reported in Indian perspective.

II. MATERIAL AND METHODS

2.1 Development of Natural Adsorbent for Arsenic Removal: *Tripidium bengalense or* baruwa grass were collected, dried and activated charcoal was prepared according to following given methodology

Preparation of activated charcoal from baruwa grass *Tripidium bengalense*: Similarly baruwa grass whole plant parts were air dried and cut in small pieces and carbonized powder was activated at 700⁰c for 15 minute and mass was stored in desiccator.

2.2 Determination of Total Arsenic, As (III) and As (V): Estimation of arsenic were conducted by following methods (APHA 1992)[39]. Estimation of arsenic were done with the help of Atomic absorption spectroscopy (AAS). In this method Arsenic is reduced to As (III) and then to arsine (AsH_3), which is directly aspirated into Argon- Hydrogen flame of an atomic absorption spectrophotometer and measured at 193.7 nm. Arsenic removal study was done by using water taken from sites where arsenic contamination was high. These water samples taken from sites were purified by deionizer and distillation then were utilized for standard solution preparation of arsenic for study purpose.

2.3Adsorption Experiments: Adsorption experiments were done by taking 100 ml arsenic solution of known concentration in 250 ml conical flask . Specific Quantities of adsorbents is added to solution and centrifuged at 130 rpm for 20 minutes. After centrifugation solution is allowed to settle for 30 minutes. This process was done at constant temperature.

The amount of adsorption is calculated in percentage by using following formula

$$\% \text{ of Adsorption} = \frac{C_A - C_B}{C_A} X100$$

C_A and C_B are initial and final concentration of arsenic

The amount of arsenic adsorbed per unit mass is calculated by following formula

$$q = (C_A - C_B) X \frac{V}{W}$$

$$R_d = \frac{\text{Amount of Arsenic adsorbed}}{\text{Amount of arsenic in solution}} X \frac{V}{W}$$

V= Volume of solution, W= weight of adsorbents in gram

Following Studies were conducted for optimization of different experimental conditions

1- Initial arsenic concentration and Contact time period

2- Temperature 3-PH 4-Interference of Ions

5- Amount of adsorbents

3.0 Results and Discussion:

3.1 **Characterization of Adsorbents:** Activated charcoal were characterized on the basis of selected parameters given in table: 1

S.N.	**Parameters**	**Activated charcoal from baruwa grass**
1	Ph	8.4
2	Conductivity	0.27
3	Moisture Content %	5.4
4	Ash %	5.0
5	Bulk Density Kg/L	0.97
6	Specific gravity	1.06
7	Porosity	44.0
8	Surface area m^2/g	1.5146
9	Colour	Black
10	Particle size(micron)	Less than 50 micron

3.2 Adsorption study of removal of Arsenic by activated charcoals from *Tripidium bengalense*

3.2.1 Adsorption study by XRD Analysis:

Arsenic removal study have been performed by using developed activated charcoals from ***Tripidium bengalense*** Patterns of XRD express the adsorption of arsenic on adsorbent as there is some peaks appear at 29.56, 30.10, 41.20 wit intensity between 400-500 prove it, if we compare XRD pattern obtained from non-treated adsorbent Fig 1&2.

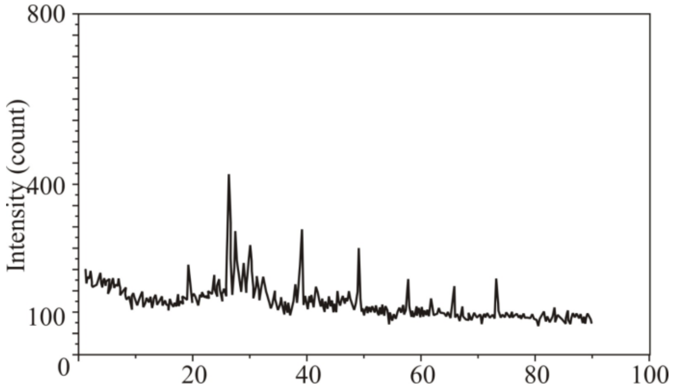

Fig:1 XRD before adsorption

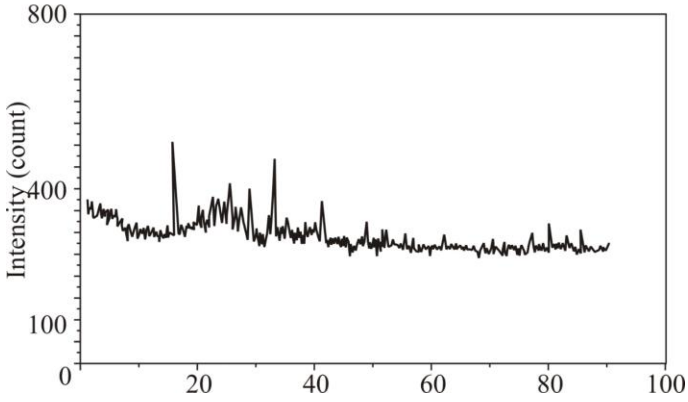

Fig:2 XRD After adsorption

3.2.2 Study of activated charcoals by FT-IR: Infra-red spectra of treated and untreated charcoals were scanned in I R range 4000 cm-1 to 500 cm-1.Figure 3.0 express comparable treated and non-treated I R spectra of charcoal obtained from. *Tripidium bengalense* Untreated charcoal have less intense peak in –NH, -CH, OH str. Region and very few peaks in single bond region and a less intense peak in double bond region. Treated charcoal have additional peaks in single bond region as well more intense peak in NH, -CH, OH str. Region.

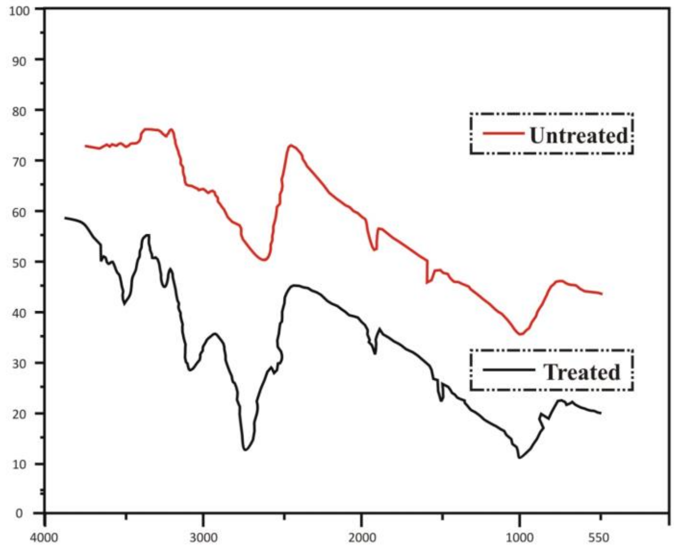

Fig:3 Comparable I.R. absorption pattern

3.2.3 Characterization of activated charcoals SEM Analysis: The analysis of surface was done by SEM at a resolution 2500 with ten micrometer particle size. The images obtained for treated and untreated charcoals indicate activity of adsorbent for arsenic adsorption. Fig. 4 SEM results of adsorbent. These images are with different surface morphology i.e. morphologies of treated and untreated adsorbents are different. In untreated adsorbents surface is rough and some cavities with pores are visible. In treated adsorbent morphologically smooth surface are visible which indicates multilayer adsorption on surface.

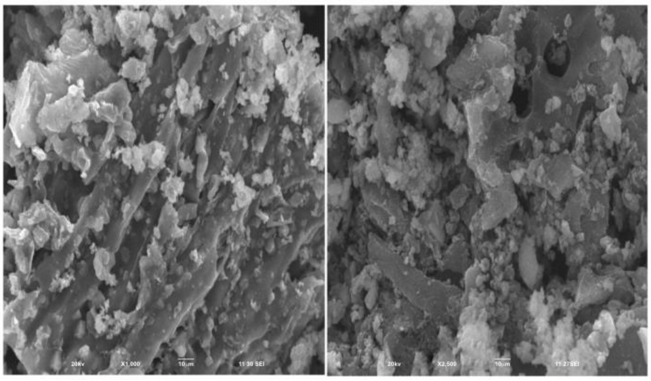

Fig. 4 **SEM Analysis** of activated charcoals from root of ***Tripidium bengalense*** untreated and treated form

3.2.4 Study of Effect of Contact Time and Initial Arsenic Concentration on adsorption for activated charcoals developed from root of *Tripidium bengalense*

Initially adsorption rate was fast due to presence of large number of cavities or active sites for adsorption and after some time slow adsorption occur due to less possibility of As adsorption on remaining vacant sites due to repulsive interaction with already occupied cavities. Adsorbents are efficient to remove nearly 78% As at 0.30 g/L concentration but as the concentration of solute increases percentage of removal increases probably due to no uniform adsorption and repulsive interaction between solute particles Fig:5

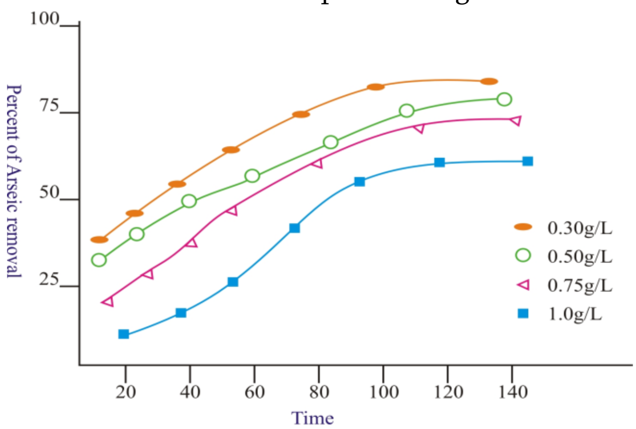

Fig : 5

3.2.5 Study of Effect of Adsorbent Dose on Arsenic Removal for activated charcoals developed from *Tripidium bengalense*

The arsenic removal capacity of adsorbents obtained from *Rubia cordifolia* and *Tripidium bengalense* increases with increase in adsorbent dose. The reason for this is the increase in surface area and adsorption sites with the increase the absorption dose.

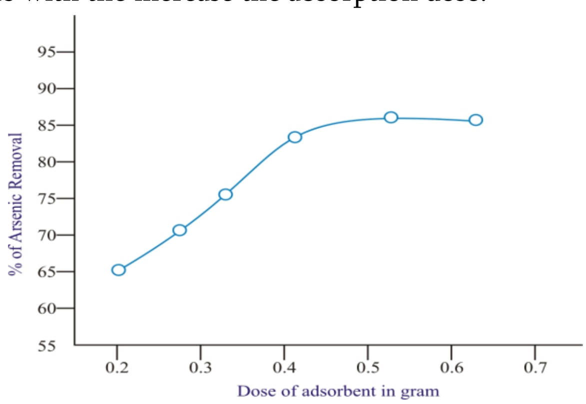

Fig : 6

3.2.6 Study of effect of Co- Ions on Arsenic Removal for activated charcoals developed from *Tripidium bengalense*: Study of effect of Co ions were done by preparing standard solution of arsenic with known amount of Co-ions. As exhibited in figure- 7 when *Rubia cordifolia* adsorbent takes for study phosphate exerts large effect on arsenic removal this is due to equal negative charge on phosphate as that of arsenic. Chloride and has small effect while sulfate exert negligible effect on arsenic removal although it was in higher concentration. Figure -8 exerts the effect of cations sodium ion almost have no effect but calcium ion has positive effect on arsenic removal while magnesium has less effect on arsenic removal.

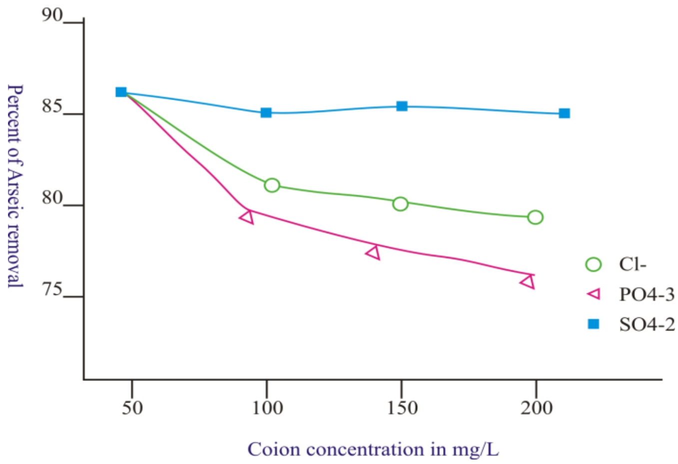

Fig.7

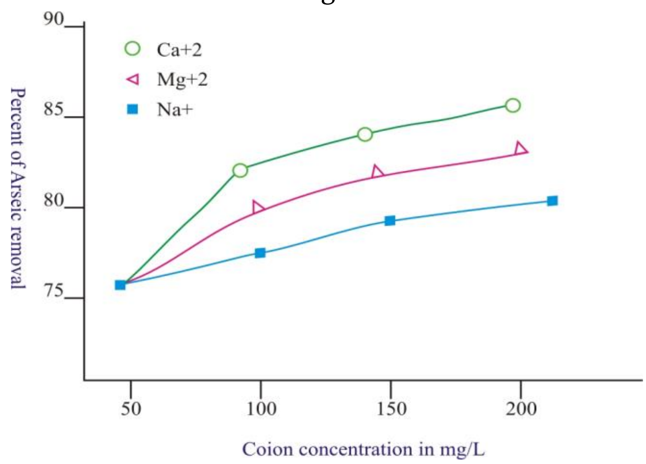

Fig: 8

3.2.7 Effect of PH on Arsenic Removal:

The effect of pH on was determined by varying pH between 3 to 11 keeping other parameter constant during study

4.0 Different Adsorption Isotherms : Values related to different adsorption isotherm are given in table 2 Adsorption Isotherm for Tripidium bengalens: Equilibrium constants of various isotherm models for the adsorption of Arsenic on activated charcoal from Tripidium bengalense

Isotherm	Isotherm constants	Temperature		
		303K	313K	323K
Langmuir	K_a(L/mg)	0.4343	0.6075	0.7586
	q_{max}(mg/g)	16.90	20.12	21.64
	r^2	0.9751	0.9805	0.9829
	SD	0.0420	0.0283	0.0209
Freundlich	K_f(mg/g)(mg/L)$^{-1/n}$	0.0914	0.1122	0.1303
	n	2.3868	2.9059	3.4178
	r^2	0.9662	0.9736	0.9745
	SD	0.0269	0.0240	0.0236
Temkin	a (L/mg)	0.0238	0.0142	0.0473
	b(mg/g)	0.2670	0.2316	0.2063
	r^2	0.9835	0.9845	0.9837
	SD	0.0122	0.0113	0.0107

Table : 2

4.1 Langmuir adsorption Isotherm: According to Longmuir theory adsorption occurs at homogeneous active sites on adsorbents. For *Tripidium bengalens* a plot between Ce/qe and Ce gave straight line and slope is 1/qm and intercept is given by 1/Ka qm. According to data given in table 2 and plot adsorption of arsenic on *Tripidium bengalens* adsorbent follow the Longmuir isotherm. The capacity of adsorbent is nearly similar to other reported such type of adsorbent.

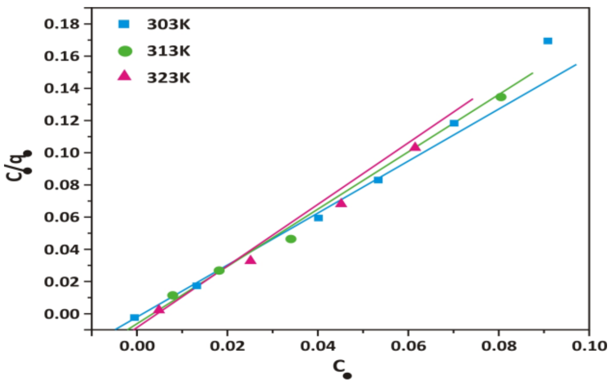

Fig. 9 Longmuir adsorption Isotherm

4.2 Freundlich Isotherm: The plot for Freundlich isotherm is given in figure. Intercept of graph exhibit Freundlich constant Kf and slope express value of n. The factor n indicate towards favorable adsorption. Good capacity of adsorption is determined by value n, if value of n is greater than 1 adsorption is considered as good. Present value is nearly 2.3 to 3.4 which is good acceptable value. The r^2 value was 0.9745 is providing acceptance about applicability of Freundlich isotherm to relate amount of adsorbed arsenic with equilibrium concentration present in solution.

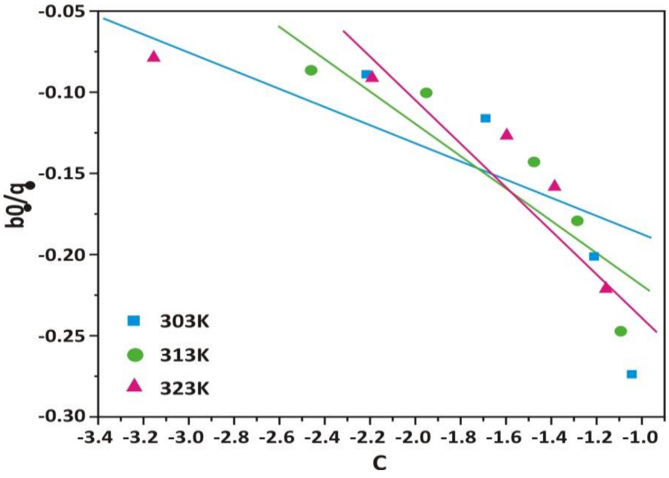

Fig. 10 Freundlich Isotherm adsorption Isotherm

4.3 Temkin Isotherm: Temkin plot is given in figure 10 its linear shape expressed adsorption of relation between adsorption and adsorbent. Value of r^2 is equal to .98 which favours adsorption.

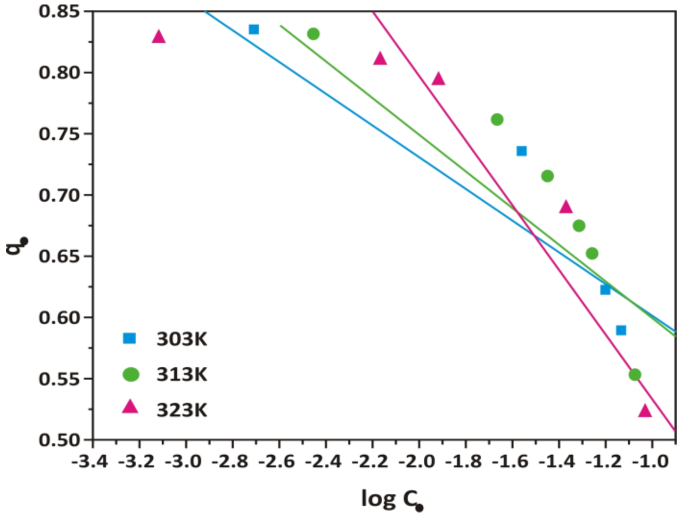

Fig. 11 Temkin adsorption Isotherm

III. Conclusion

Removal of arsenic can be done by various methods like coagulation, anion exchange, separation, precipitation and by using natural adsorbent. Present study focused on to develop cost effective natural adsorbent from naturally occurring materials. Baruwa grass is common grass available mostly near the floodplain of Ganga river where arsenic contamination in ground water is major problem. Adsorbent developed from baruwa grass has been examined for their efficiency for removal of arsenic under certain conditions like presence of co-ion, pH. It was founded that very less amount (0.30 g/L) of this developed charcoal is sufficient to remove arsenic at a desirable concentration when arsenic concentration was 100 ppm.

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