# Removal of iron (III) from aqueous solutions using plant weed Launea procumbens leaves

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**Abstract- Biosorption of heavy metals by certain types of non living biomass is an alternative, highly cost effective technique for the removal from various domestic, industrial metal-containing effluents. Iron is priority metal pollutant in industrial and domestic effluents released due to operations mainly acid mining of metal ores. In the present study, a series of batch experiments were conducted to find the optimum conditions and effect of pH (1-2.5), dosage (1-6 g/L), initial concentrations (10-90mg/L), temperature (30-60oC) and contact time (10-240min) on the removal of Fe III from aqueous solutions. The percentage of iron adsorbed from solution increased with an increase in temperature from 30 to 60oC. The adsorption isotherm modeling studies demonstrated that the experimental data best fit for Langmuir and Freundlich model. The obtained qmax was 17 mg/g of iron ions from aqueous solutions using plant weed Launea procumbens. Parameters like, agitation speed, time, adsorbent dosage and pH were studied at particular concentration. The results indicated that the adsorption capacity was strongly affected by the pH, adsorbent dose, initial concentration, temperature, agitation speed. Optimum biosorption was observed at pH 2.5, biosorbent dose 3gm/L, and agitation speed 120 rpm and biosorption equilibrium was established in 120 mins. The infrared spectra of the biomass before and after treatment with Fe (III), revealed that carboxyl, amine, alkyl bonds may be involved in the uptake of Fe (III) ions.**

**Keywords – Biosorption, Heavy metals, Infrared spectrum, Iron, Launea procumbens, Plant weed.**

## I. INTRODUCTION

Water pollution due to ejection of toxic heavy metals from various types of industries such as textile, metal finishing, electroplating, painting, dyeing, photography, surface treatment is a world wide major environmental concern [1]. Heavy metals form compounds that can be toxic, carcinogenic or mutagenic even in low concentrations [2]. The mobility nature and their toxicity to higher life forms, heavy metals in surface and ground water supplies have been precedence as major inorganic contaminants in environment. They are present in dilute, undetectable quantities, their recalcitrance and persistence in water bodies imply that through natural process such as biomagnification, concentrations may become elevated to such an extent that they begin exhibiting toxic characteristics.

There are different methods like conventional chemical (precipitation/neutralization) or physical (ion exchange, activated carbon sorption and membrane technology) treatment techniques are inherently problematic in their application to metal bearing wastewaters. Chemical methods are proved costly to applicant and cannot be reused.

Biological methods of metal recovery termed as biosorption have been suggested as cheaper, more effective alternatives to existing treatment techniques. The process is a powerful technique for efficient removal of metal ions from domestic and industrial effluents.

The method of binding of metal ions by adsorbents may depend on chemical nature of metal ions (size, ionic charge) type of biomass and process conditions. Biosorbent such as seaweeds, yeast, bacterial crab shells, agricultural products such as wool, rice straw, coconut husk, peat, soybean hulls, and so on [3].

Iron can exist in two forms, soluble ferrous iron (II) and insoluble Ferric iron (III). The presence of iron in water may be attributed to dissolution or rocks and minerals, acid mine drainage, landfill leachate sewage or industries wastes. Generally iron present in ferric state. The presence of iron at concentrations above 0.1 mg/L can cause damage to gills of fish. Free radicals generated on surface of gills will cause oxidation of tissue and leads to massive destruction of gill tissue and anemia. At the pH conditions in drinking water supply ferrous sulphate settle out as rust colored silt, such water tastes unpalatable and stain laundry and plumbing fixtures.

The present study was aimed to examine the sorption of Fe (III) onto Launea biosorbent, and waste available in plenty in a tropical country like India.

## II. MATERIALS AND METHODS

*2.1 All chemical compounds used were of analytical reagent grade.*

A stock of 1000 ppm Fe (III) ions was prepared by dissolving 7.022 g ferric ammonium sulfate (FeNH4(SO4)2 12H2O salt) (Merck) in 500 mL of distilled water. The solution was warmed and oxidized with approximately 0.1% potassium permanganate solution until the solution remained faintly pink. The ultra pure water was obtained using sartorious ultra pure system (arium 611 UF, Germany). A changeable speed shaker 20-500 rpm and equipped with thermostatically control heating bath, temperature 20-60oC was used in batch experiments (Remi) with holding capacity of 12 Erlenmeyer flasks. The residual metal ion concentration was analyzed using UV-VIS spectrophotometer, Model Lambda 25, Perkin Elmer USA at wavelength of 465 nm. Fe (III) metal ions are estimated by ferric thiocyanate spectrophotometric method. Iron (III) and thiocyanate ion react to form an intensely colored complex. The represented experiments data were obtained by taken in triplicate and average values were used in the results.

Fe3+ + SCN-1 -----> FeSCN 2+

*2.2 Preparation of Biosorbent*

The Launea leaves were obtained from the ICFAI university campus, Dehradun, Uttarakhand, India. The leaves was then washed with deionized water to clean and then dried in room with light sunlight for a week. Dry leaves were then ground with grinder. After being ground the leaf particles were sieved with 75 mesh sieves. Then, leaf powder was dried at 100oC for 24 hours to get constant weight and stored in desiccator.

*2.3 Bio-adsorption Studies*

The tests were carried out in 50 ml Erlenmeyer flasks containing monometallic solutions with biosorbent contact placed on a shaking incubator having constant stirring at room temperature (30 + 1oC). Samples were taken out at different times and liquid was filtered through Whatmann Filter Paper No.2 and the amount of metal adsorbed was determined spectrophotometrically. The keystone part investigations were carried out in different conditions of pH, concentration, time, amount of adsorbent, temperature etc to check the tendency of adsorption process. For isotherms calculation the optimized pH and biomass concentration were 3g/L kept constant and test was performed at different initial metal concentration (50, 100,150, 200, 250 ppm) using 50 ml of solution in all cases.

*2.4 Analysis of Metal ions*

Metal uptake was calculated from the following expression

$$q_t = \frac{C_0 - C_t}{B} \tag{1}$$

Co is the initial metal concentration (mg/L); Ct is the metal concentration at time t (mg/L); B is the biomass concentration (g/L).

*2.5 Biosorbent characterization*

FTIR analyses were carried on KBr discs with 3% finely ground samples were analyzed in FTIR spectrophotometer, model spectrum BXI, Perkin Elmer. Spectral data processed using Spectrum software at resolution of 4cm-1 and spectra was recorded in the region of 650-4000 cm-1. In order to find out the functional groups involved for metal adsorption an un-reacted and pre-treated biosorbent were analyzed.

## III. RESULTS AND DISCUSSION:

*3.1 Sorption equilibrium studies*

The adsorption studies were performed with a predetermined initial adsorbent dose 200 mg with different initial adsorbate concentration (50, 100, 150, 200, 250 mg/L) solutions and applicability of the data to the Langmuir adsorption isotherm was tested. Tests were run for sufficient time to get equilibrium at initial pH 2.5. These results were adjusted to the Langmuir model that can be expressed as.

$$q_e = \frac{b q_{max} C_e}{1 + b C_e} \tag{2}$$

Where qe is the metal uptake at equilibrium (mg/g of biomass); qmax is the maximum Langmuir uptake (mg/g); Ce is the final metal concentration at equilibrium (mg/L); b is the Langmuir affinity constant (L/mg of the metal). The Langmuir affinity constant was well related to affinity between the biomass and a certain metal, the greater its value the greater its affinity. These sorption parameters can be calculated from the isotherm using a linear representation of the Langmuir model (Ce/qe vs Ce):

$Ce/qe = Ce/qmax + 1/bqmax$ (3)

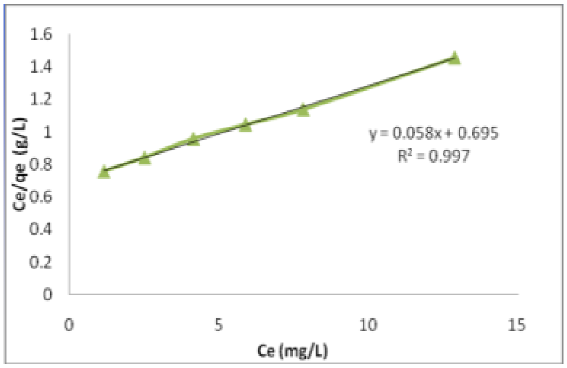

Figure1: Langmuir isotherm for % biosorption of Iron (III)

The Langmuir isotherm is based on these assumptions (Langmuir, 1918).
Metal ions are chemically adsorbed at a fixed number of well defined sites;
Each site can hold only one ion
All sites are energetically equivalent and there is no interaction between the ions.

The essential characteristics of the Langmuir isotherms can be expressed in terms of a dimensionless constant separation factor or equilibrium parameter RL, defined as

$RL = 1(1+bCo)$ (4)

Where Co=initial concentration in mg/L;
b=Langmuir constant

| RL value | Type of isotherm |
|---|---|
| RL>1 | Unfavorable |
| RL=1 | Linear |
| RL<1 | Favorable |

The RL values obtained are less than unity for Fe (III) adsorption. According to McKay et al. (1982), RL values between 0 and 1 indicate favorable adsorption.

The Freundlich isotherm is represented by the equation, where Ce is the equilibrium concentration (mg/L), q is the amount adsorbed (mg/g) and Kf and n are constants incorporating all parameters affecting adsorption process, such adsorption capacity and intensity, respectively. The linearised form of Freundlich isotherm was used to evaluate the sorption data and is represented as

$\ln q = \ln Kf + 1/n \ln Ce$ (5)

Kf and n were calculated from slopes of the Freundlich plots.

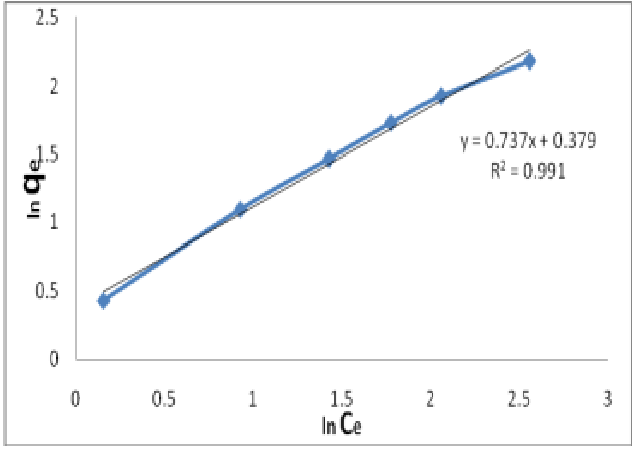

Figure 2: Freundlich isotherm for % biosorption of Iron (III)

### *3.2 Effect of pH*

The optimum pH for biosorption of ferric iron on biosorbent was observed at 2.5. To avoid precipitation of ferric ions as their hydroxides were carried out below pH 3. Actually pH influences metal binding sites and metal form in the solution. At high pH values Fe (III) precipitated due to OH ions in medium. So pH 2.5 is the optimum value for efficient adsorption.

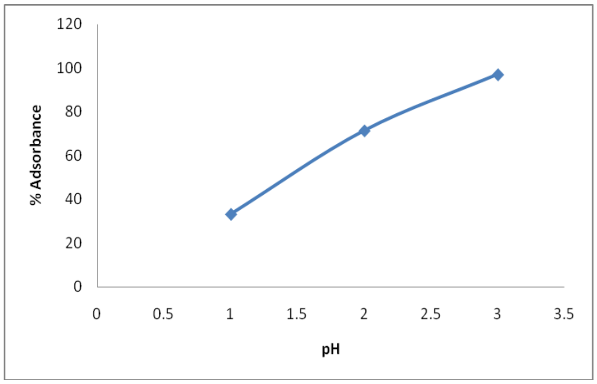

Figure 3: Effect of pH on % biosorption of Iron (III)

### *3.3 Effect of time and initial concentration*

The percentage removal of Fe (III) varies with initial concentration. The equilibrium was achieved within 180 min for 90 ppm with percentage adsorbed was 65 respectively. The concentration of both metal ions and biosorbent is a significant factor to be well thought-out for effective biosorption which determines the sorbent/sorbate equilibrium of the system. Mohanty et al (2008) reported that metal uptake was influenced by factors affecting the mass transfer from bulk solution into binding sites.

The adsorbate concentration were varied from 50-250 mg/L and carried out batch studies to locate the optimized initial concentration of Fe (III) concentration. The percentage removal of Fe (III) with variation in initial concentration decreases may be probably due to the fact that for a fixed adsorbent dose, the total available adsorption sites are limited thereby adsorbing almost the same amount of Fe (III) causing a decrease in percentage removal of Fe (III) equivalent to an increased initial adsorbate concentration.

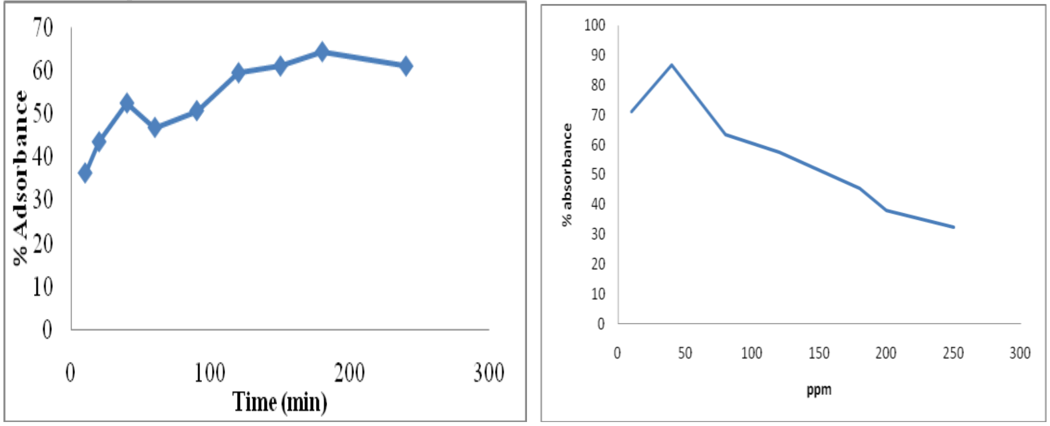

Figure 4 a & b: a. Contact time and % biosorption of Iron (III); b. Variation of initial concentration with % biosorption of Iron (III)

### *3.4 Effect of temperature*

The influence factor, temperature has significance effect on the process of adsorption. The percentage of Cr (VI) adsorption was studied as a function of temperature in the range of 30-50*C. The results obtained are presented in Fig. The increase in percentage of adsorption with rise in temperature may be due to change in chemistry of biosorbent desorption caused by an increase in the available thermal energy. Higher temperature induces higher mobility of the adsorbate and available of energy. The other condition may be change in the structure of functional groups present in the biosorbent

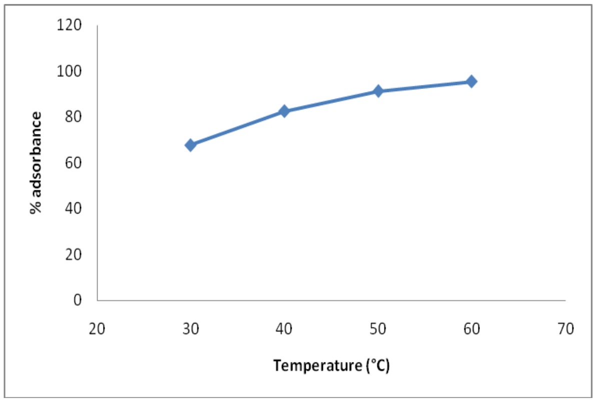

Figure 5: Effect of temperature on % biosorption of Iron (III)

### *3.5 Infrared spectra analysis*

An un-reacted biosorbent sample and treated biosorbent with Fe (III) solution were scanned using FTIR and percentage transmission for various wave numbers are presented in figure 6 for treated sample. Identification of absorption bands using obtained spectra and their assignment to corresponding functional groups are tabulated.

Wave number of 3000 and 3750 cm-1 indicates the presence of OH groups on the bisorbent surface. The trough that is observed at 2926 cm-1 and 893 cm-1 indicates the presence of C-H groups. The 1649 cm-1 band is a result of CO stretching mode, conjugated to a NH deformation mode and is indicative of amide band. The trough at 1124 cm-1 is due to CO or CN groups. This reveals the presence of several functional groups for binding Fe (III) ions on biosorbent surface.

| Wave number (cm-1) | Functional Group |
|---|---|
| 3431 | -OH, -NH |
| 2926 | -CH |
| 2345 | -OH |
| 1120 | -C-O, -C-N |
| 1437 | -CH |
| 1060 | -OH |

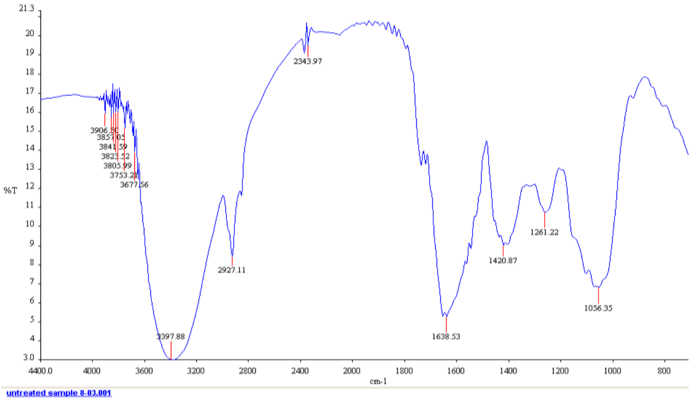

Figure 6: FTIR Spectrum of Launea with Fe (III)

## IV. CONCLUSION

In the current study the potential of Launea leaves has been assessed for the biosorption of Fe (III). In the batch mode studies, adsorption was dependent on contact time, pH, initial ion concentration and dosage. Adsorption satisfied Langmuir and Freundlich isotherm models. Infrared spectral analysis shows that several functional groups like amide, hydroxyl and carboxyl groups are available for biosorption of metal ions. Biomass residues like plant derived have several advantages such as costly nutrients are not required for its culturing and growth (unlike microbial biomass), the processing conditions are not restricted and a wider range of operating conditions pH, temperature, and metal concentrations are possible. Finally it can be viewed as part of waste management strategy.

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