

# Adsorption Efficiency of *Albizia Lebbeck* (Indian Siris) As Bio-adsorbent for Quantitative Removal of Lead Metal Ion from Contaminated Waters

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**Abstract** The removal of toxic metals like lead (Pb) is very vital in keeping its hazardous effects in view. The study examined the prospect of using *Albizia lebbeck* (Indian Siris) as a low-cost adsorbent for the removal of lead metal from contaminated waters. A batch experiment was conducted to examine the influence of pH, temperature, initial metal ion concentration; adsorbent dose and contact time, mixing speed on the bio-adsorption of Lead (Pb) by *Albizia lebbeck* (seed). Langmuir and Freundlich's isotherms were used to describe the adsorption of organic and inorganic compounds on a wide variety of adsorbents at equilibrium. The heavy metal Analysis was characterized by Spectroscopy (AAS), amount of removal material by adsorbents through series of batch investigations while the amount adsorbed was calculated by the difference of initial concentrations of the metal ion in solution (mg/L) and final concentrations of metal ion solution (mg/L). The result showed that the sorption capacity increased with an increase in the initial concentration of adsorbate and it was pH-dependent. The rate of metal-binding with biomass is more predominant during the initial stages, which gradually decreases and remains almost constant after equilibrium time. Adsorbent gets involved in metal complexation at active adsorption sites as early as the adsorbent is introduced into the system.

**Keywords:** *Biosorption, Albizia lebbeck, adsorption, pH, Langmuir isotherm, Freundlich isotherms, batch experiment, Atomic Absorption Spectroscopy*

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## 1. Introduction

The rapid development of civilization has resulted in the discharge of many objectionable pollutants into the environment. Environmental pollution due to development in modern industrial practice is one of the most significant problems of this century. One of the major problems of industrial waste is the huge amount of wastewater produced and before it is released to the environment, the high investment is required for the treatment of this effluent. Contamination of water resources by hazardous pollutants has attracted much serious attention in the last few decades. Modern industry is to a large extent responsible for the contamination of the environment. Oceans, lakes, and rivers are being devastated with bacteria and waste matter. This is particularly due to their toxic, acute, and chronic health effects.

In this study, *Albizia lebbeck* (seed) a non-edible plant material is used for removal of the metal ion Pb (II) from aqueous solution with specific objectives to determine the

effect of some parameters such as (pH, initial metal concentrations, adsorbents dose, contact time, rotation per minute) to investigate the adsorption isotherms (Langmuir and Freundlich).

Heavy metal contamination is a general term given to describe a condition having abnormal and high levels of toxicity in the environment. The introduction of heavy metals via both natural and anthropogenic sources has caused tremendous melancholy in the scientific society during the last few decades as these are easily adsorbed on the surface of cell membranes to cause many incurable diseases in both human beings and aquatic flora and fauna.

The effect of heavy metals on a human being cannot be neglected because exposure to these contaminants even at low concentrations; can cause severe dysfunctions [1]. According to some researchers, toxicity of heavy metals on human beings has been reported as; "Heavy metals are subtle and silent killers", which have great power to challenge human life in the future. Toxic metals bioaccumulate in the body and the food chain and usually imitate the action of an essential element in the body as well as interfering with the metabolic process to cause sickness.

The toxicity of heavy metals causes disruptions of mental and central nervous function, lower energy levels, and harm to blood composition, lungs, kidneys, liver, and other essential organs. Chronic exposure may up-shoot in slowly progressing muscular, physical, and neurological disintegrative processes that imitate Parkinson's disease, Alzheimer's disease, multiple sclerosis, and muscular dystrophy. Allergies are not unusual and frequent chronic contact with some metals or their compounds can generate cancer. Humans are habitually exposed to heavy metals in different ways primarily through the breathing of metals in the place of work or polluted neighborhoods, or through the ingestion of unhygienic food, particularly seafood containing high levels of heavy metals.

Heavy metals are enormously distributed in an extensive range of economically vital minerals. They are released into the environment during the mineral extraction process. Hence, mining activities are regarded as the primary anthropogenic source of heavy metals. The international community is commencing to distinguish the undesirable health effects of heavy metals. Heavy metals are chemical elements with a specific gravity that is at least 5 times the specific gravity of water (i.e. sp. gravity >5) and is toxic or poisonous even at low concentration. Heavy metals such as lead (Pb) are widespread in the environment and are extremely hazardous with specific gravity 11.34.

Due to strict environmental regulations from the government concerning the metal discharges are being enforced particularly in industrialized countries like India. The toxicology of heavy metals authenticates their hazardous impacts. Due to their high toxicity, industrial wastewaters containing heavy metals are strictly regulated and must be treated before being discharged into the environment. Traditional and conventional techniques usually employed for the treatment of dye waste water consist of biological, physical and chemical methods most of which are inefficient and expensive [31]. The presently experienced technologies for the removal of heavy metals from industrial effluents emerge to be insufficient and expensive. So there is always a scope for new and innovative techniques which can serve us in a better manner.

Currently, there is a growing awareness of the impact of these contaminants (heavy metals) in different sites of water bodies (i.e. rivers, groundwater, lakes, etc.). To overcome some of the limitations of physiochemical treatments, there is a need for inexpensive and efficient technology for the treatment of metal-containing wastes so that metal concentration can be reduced to environmentally acceptable levels [2]. Several chemical and physical methods have been applied successfully to reduce the concentration of heavy metals in wastewater effluent before they are released to the external environment. The most commonly used conventional procedures; for removing metal ions from aqueous streams include chemical precipitation, ion exchange, reverse osmosis, solvent extraction, membrane filtration, ultrafiltration, and adsorption. These methods are limited viz., produce sludge, susceptible to adverse weather conditions, require chemicals applied to high concentrations, require high pressure and expensive, responsive to the presence of particles and resins of high cost, require an energy source,

and are not effective for some metals respectively. Since they often involve high capital and operational costs and may be associated with the generation of secondary wastes which need further treatment or purification [3].

Adsorption technique achieved immense significance in industry and environment protection in the last few years through using various adsorbents. Adsorption is effective in natural, physical, biological, and chemical systems, and is extensively used in industrial applications such as activated charcoal, synthetic resins, and water purification. This mass transfer process involves the accumulation of substances at the interface of two phases, such as gas-liquid, liquid-liquid; gas-solid, or liquid-solid interface. Bio-sorption is the ability of biological materials to accumulate heavy metals from wastewater through spontaneous physicochemical pathways. Adsorption has advantages over the other methods, because of its simple design with a sludge-free environment and by involving low investment costs. The adsorbent used must have a high content of carbon or oxygen for efficient adsorption. The substance being adsorbed is the adsorbate and the adsorbing material is termed the adsorbent [4]. In a bulk material, all the bonding requirements (ionic, metallic, or covalent) of the essential atoms of the material are filled. But atoms on the (clean) surface practice a bond deficiency because they are not surrounded by other atoms. Therefore it is vigorously constructive for them to bond with whatever happens to be accessible. The accurate nature of the bonding depends on the details of the species concerned, but the adsorbed material is usually classified as exhibiting physisorption or chemisorptions. The main factors that affect the efficiency of adsorption are the surface area of the adsorbent material, pH of the solution, temperature, properties, and dose of the adsorbent and contact time. The removal efficiency increases with an increase in contact time before equilibrium is attained. The amount adsorbed at the equilibrium time imitates the maximum adsorption capacity of the adsorbent under the operating conditions.

There is growing research curiosity in using alternative low-cost adsorbents. Many such materials have been explored including microbial biomass, compost, peat, leaf mold, palm press fiber, coal, sugarcane bagasse, straw, wool fiber, and by-products of rice mill, soybean, and cottonseed hulls, etc. The low-cost agricultural waste by-products such as sugarcane bagasse, coconut husk, rice husk, sawdust. Oil palm shell, neem bark, etc., for the removal of heavy metals from waste water, have been investigated by various researchers.

The removal of heavy metals from synthetic wastewater was performed by using Rice husk and Groundnut shells as adsorbents [5]. Here batch experiments were conducted to know the influence of various parameters of adsorption on removal of the lead metal ions by agricultural byproducts (Groundnut shell, Rice husk, and combined adsorbents). The equilibrium time required for the adsorption of lead by agricultural byproducts was identified to be 2 hrs.

Application of rice husk and its ash in cadmium removal from an aqueous solution was carried out [6]. Surface modification of the bio-waste was implemented for purification of wastewater contaminated with toxic heavy metals such as Lead [7]. Here waste tea leaf was

used as a bio-waste which was an economic and efficient bio-adsorbent. The aminated tea leaves were illustrated by spectral and elemental analysis. The adsorption capacity for Pb was very high. The aminated tea leaves were detected to be an attractive alternative for the treatment of wastewater contaminated with heavy metals.

Adsorption of heavy metals from water by using banana and orange peels were analyzed [8]. In this study Liquid-phase adsorption removal of  $\text{Cu}^{2+}$ ,  $\text{Co}^{2+}$ ,  $\text{Ni}^{2+}$ ,  $\text{Zn}^{2+}$ , and  $\text{Pb}^{2+}$  in the concentration range of 5–25 mg/L by using low-cost banana and orange peel wastes was examined at 30°C. The application potential of such cellulose-based wastes for Pb removal at trace levels at specific pH emerged to be promising. Removal of heavy metals using rice husk was investigated [9]. After chemical treatment, it was concluded that the adsorption capacity of rice husk was increased for Pb (II).

The adsorption behavior of some low-cost adsorbents was characterized such as peanut husk, fly ash, charcoal, and natural zeolite, with respect to  $\text{Cu}^{2+}$ , and  $\text{Zn}^{2+}$  ions [10]. The batch method was used by taking parameters such as pH, contact time, and initial metal concentration. The results illustrated that peanut husk, charcoal, fly ash, and natural zeolite all hold the potential to remove cationic heavy metal species from industrial wastewater in the order fly ash < peanut husk charcoal < natural zeolite. Removal of poisonous Pb (II) from artificially contaminated water was found by using low-cost natural adsorbents rice husk, sesame, sunflower, and tea waste [11]. The efficiencies of rice husk, sesame husk, sunflower husk, and tea waste for Pb ion removal were examined and sesame husk had high efficiency for metal removal.

The Fava beans were identified as low-cost adsorbent material for removal of Pb (II), Cd (II), and Zn (II) ions from aqueous solutions [12]. This study demonstrated the maximum adsorption capacity of Fava beans for removal of Pb (II) at comparatively high efficiency than Cd (II) and Zn (II) at a small dose amount of Fava beans powder. Rice straw as an agricultural residue to absorb some heavy metals like Cr and Ni from an aqueous solution was analyzed [13]. Optimum pH for chromium of untreated and treated rice straw was found to be pH 4 and pH 6 respectively.

Duckweed was efficiently used for the removal of several metal ions ( $\text{Fe}^{2+}$ ,  $\text{Cu}^{2+}$ ,  $\text{Zn}^{2+}$ , and  $\text{Pb}^{2+}$ ) from wastewater under different conditions [14]. The removal order of metal ions was found to be  $\text{Pb}^{2+} < \text{Zn}^{2+} < \text{Cu}^{2+} < \text{Fe}^{2+}$ . The characterization (the infrared) for the surface of duckweed showed the presence of many functional groups which can bind with metal cations. Wastewater treatment was performed by using low-cost natural adsorbent and concluded that mango peel and *Alisma plantago aquatica* had a high possibility to be used as efficient and economical adsorbents for heavy metal removal [15]. The analyses of the results indicated that egg shells, chitosan, etc. similar to most other natural adsorbents can be utilized in the treatment process of heavy metals and the treatment efficiency may be as high as 100% by choosing the adsorbent amount precisely [16].

Natural adsorbent sawdust was used for removal of color from waste effluent of the textile industry [17]. The

adsorbent was found to be capable of removing color from waste effluent water. In the adsorption process, several other parameters such as BOD, chloride, sulfate, iron, COD was also reduced considerably. Low-cost adsorbents and their utilization techniques for various agro and horticultural waste by-products such as sugarcane, rice husk, bagasse, orange peels, almond shell, sawdust, soybean hulls, cottonseed hulls, rice bran, coconut tree sawdust, sago waste, banana pitch carbon, coconut husk, palm pressed fiber, clay and some bio adsorbents, etc. are abundantly and easily available in India for the elimination of heavy metals from wastewater [18].

Conventional and innovative techniques for removal of heavy metals from electroplating industry wastewater by using low-cost novel adsorption through coconut shell, mango seed and shell, bagasse, waste tea leaves, wood barks, and black alkali were applied. The adsorption of ferrous ions onto acid-activated carbon was prepared from *Albizia lebbek* bark [19]. The method of adsorption for that ferrous ion onto carbon has been analyzed by using the experimental results and confirmed by IR spectra, XRD, and SEM images.

A study on the characterization of activated carbon prepared from *Albizia lebbek* by physical activation was performed [20]. They found that the development of micro-porosity of the *Albizia lebbek* (stem) carbon would lead to potential applications for the removal of metal ions. This could be explained by the surface functional groups of the *Albizia lebbek* carbon, as identified by Fourier Transform Infrared Spectroscopy (FTIR).

The application of Orange peel as an eco-friendly bio adsorbent for textile dyeing effluents was analyzed [3,21]. In this study, the effect of the adsorbent surface was studied by scanning electron microscope. They concluded that orange peel has a potential for removal of anionic dyes from colored textile effluents.

## 2. Materials and Methods

### 2.1. Preparation of Pb (II), Solution

Stock solutions of Pb (II) were prepared by dissolving 1.599 g of  $\text{Pb}(\text{NO}_3)_2$  in 100 ml. DDW, then diluted to 1 L in a volumetric flask with DDW. The solutions contained  $1.000\mu\text{g}/\text{cm}^3$  (1000 ppm) of Pb (II). A stock solution of 100 ppm was prepared by pipetting  $10.0\text{ cm}^3$  from the 1000 ppm stock solution into a volumetric flask and making it up to  $100.0\text{ cm}^3$  marks with double distilled water (DDW). Solutions of different concentrations were prepared by adequate dilution of the stock solution with DDW. Dilute solutions of 0.1 M NaOH and 0.1 M HCl were used to adjust pH to give the required whole number values between 3 and 8. All of the chemicals used were of analytical grade and double distilled water was used wherever necessary for the experimental work.

### 2.2. Adsorbent Preparation

*Albizia lebbek* is a plant species native to tropical subtropical regions of Africa, Australia, and Asia. It is often simply called “Indian Siris” or “labagbo” in Yoruba

language and “rattle seed pods” in the English Language. Adsorbent was prepared according to the method described by [33] with some modification. *Albizia lebbbeck* seeds were collected from local areas of Bargarh (Odisha). Then it was soaked in 1 M HCl for 3 days to remove the original content of heavy metals. The seeds were again washed in distilled water, sun-dried in the air then grind using a pestle and mortar. Mixing was done using ethanol/acetone mixture followed by shaking in a centrifuge severally until no more fat was left in the biomass [7]. After centrifugation, the wet *Albizia lebbbeck* seeds powder was then dried in an oven at 30°C for 24 hrs after which it was crushed again and sieved through 0.5 mm sieves. The initial metal concentration and the metal remaining in the solution were determined using Atomic absorption spectrophotometer (AAS). [9]

### 2.3. Batch Experiments

Batch adsorption experiment was carried out under constant shaking of 100ml of simulated solutions in 250 ml conical flasks in Remi Orbital Shaking Incubator (CIS- 24 BL) RIS-24 BL) in PG Department of Environmental Sciences, Sambalpur University. Samples were withdrawn after a definite time interval and filtered through Whatman filter paper No. 41 and then samples were sent to CPCB, Kolkata for further analysis in atomic absorption spectroscopy(AAS). The experimental work plan of the current experiment is shown in Table 3 and Flow chart 1.

Table 1. Experimental work plan for synthetic water

Low Cost Adsorbent For Pb	Run	pH	Initial Metal Conc. (mg/L)	Adsorbent Dose(g/L)	Contact time (min.)	Mixing speed (rpm)
Indian Siris (Seed)	11	3:07	20	10	30	200
	12	5	10:50	10	30	200
	13	5	20	10:50	30	200
	14	5	20	10	30:120	200
	15	5	20	10	30	50:200

#### 2.3.1. Calculation of % Removal of Metal ions by Adsorbents

Removal efficiency was calculated by adopting the method as provided in [34]. Amount of removal material by adsorbents through series of batch investigations were appointed by the following equation:

$$\text{Removal \%} = \left\{ (C_o - C_f) / C_o \right\} \times 100$$

Where,

$C_o$  = Initial concentration (ppm) of metal ions in solution (Before mixing adsorbent)

$C_f$  = Equilibrium concentration (ppm) of metal ions in solution (After mixing adsorbent)

#### 2.3.2. Adsorption of Heavy Metal on Bio-adsorbents

The amount of adsorbed metal ions were calculated from the decrease in the concentration of metal ions in the medium by considering the adsorption volume and used amount of the biosorbent [32]. The amount of metal ions

adsorbed by the adsorbent is calculated using the following equation:

$$Q_e = (C_o - C_e) V / M$$

Where,

$Q_e$  = Amount of heavy metal adsorbed on adsorbent at equilibrium (mg/g)

$C_o$  = Initial concentrations of the metal ion in solution (mg/L)

$C_e$  = Final concentrations of metal ion solution (mg/L)

$V$  = solution volume (L)

$M$  = mass of the sorbent (g)

### 2.4. Langmuir Isotherm

Based on Langmuir adsorption theory, molecules are adsorbed at a fixed number of well-defined active sites which are homogeneously distributed over the surface of the adsorbent. These active sites have the same affinity for adsorption of a mono molecular layer, and there is no interaction between the adsorbed molecules [22,23].

The Langmuir equation may be written as -

$$q_e = \frac{qm KL Ce}{1 + KL Ce}$$

And can be expressed in its linear form as-

$$C_e / q_e = 1 / q_m KL + C_e / q_m$$

Where,

$q_e$  = The amount adsorbed (mg/g),

$C_e$  = The equilibrium concentration of the metal ion (mg/L),

$qm$  (mg/g) = The maximum amount of adsorbed metal ion per unit mass of sorbent corresponding to complete coverage of the adsorptive sites,

$KL$  (L/mg) = (b) The constant related to the free energy of adsorption (mg/L).

### 2.5. Freundlich Isotherm

Freundlich isotherm model elucidates the adsorption on heterogeneous surfaces with interactions occurring between the adsorbed molecules and is not restricted to the formation of a monolayer. This isotherm is generally used to explain the adsorption of organic and inorganic compounds on a wide variety of adsorbents [22,24].

The Freundlich isotherm is characterized by the equation:

$$Q = K_f C_{eq}^{1/n}$$

Where,

$C_{eq}$  = The equilibrium concentration (mg/l)

$q$  = The amount adsorbed (mg/g)

$K_f$  and  $n$  = constants incorporating all parameters affecting the adsorption process, such as adsorption capacity and intensity, respectively.

The linearised forms of Freundlich adsorption isotherm was used to evaluate the sorption data and is represented as:

$$\text{Log } q_e = \text{log } K_f + 1/n \text{ log } C_e$$

The plot of  $\text{log } q_e$  versus  $\text{log } C_e$  has a slope with the value of  $1/n$  and an intercept magnitude of  $\text{log } K_f$ .



Plate 1. Indian Siris tree (*Albizia lebeck*)



Plate 2. Indian siris (seed)

### 3. Result

In the present study, adsorption of lead on Indian Siris (seed) was examined by optimizing various parameters

like pH, initial metal concentration, adsorbent dose, contact time, and mixing speed (Table 2)

#### 3.1. Effect of change in pH

pH plays a significant role in adsorption processes. The purpose of this study was to find out the suitable pH at which lead (II) adsorption was maximum. The experiment was conducted at initial metal ion concentration 20 mg/L, adsorbent dose 10 g/L, contact time 30 min., and mixing speed 200 rpm. pH 3, 4, 5, 6, 7 were taken into study. The experimental result shows that at pH 4 lead (II) adsorption was 99.1 % followed by 98.57 % in pH 5, 98.96 in pH 6, and 97.8 % in pH 7. The maximum percentage of lead (II) adsorption was found to be 99.33 % in pH 3. (Figure 1, Table 2). So pH 3 was chosen as optimum in the experiment.

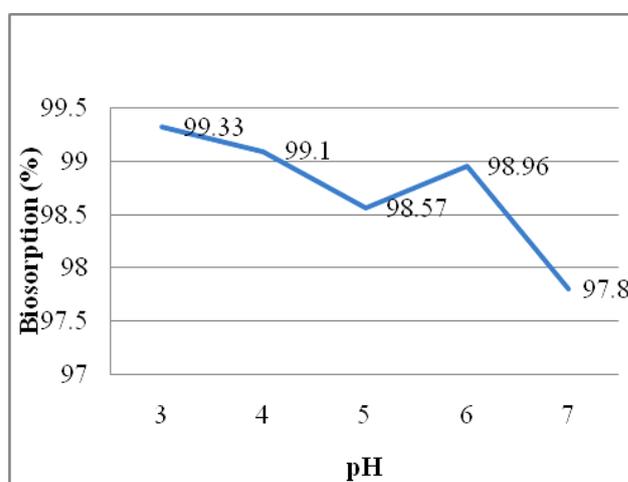


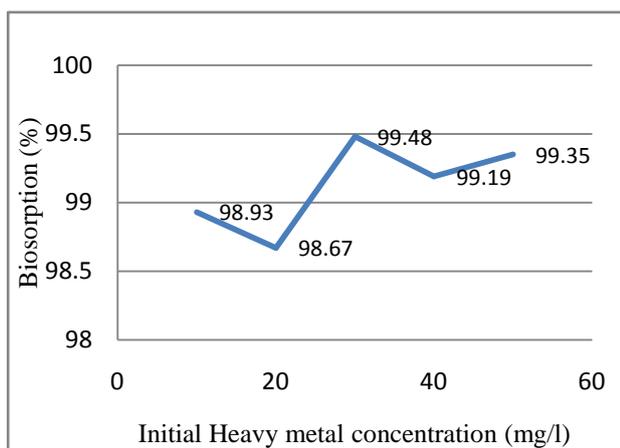
Figure 1. Effect of pH on biosorption (%) of lead (II)

Table 2. Biosorption (%) Indian Siris with altered Physico-chemical parameters for Lead (II)

Test no.	Initial Heavy metal Conc. (mg/L)	pH	Adsorbent dose(g/L)	Contact time (min)	Mixing speed (rpm)	Temperature(°C)	Final Heavy metal Conc. (mg/L)	Biosorption (%)
1	20	3	10	30	200	37.6	0.134	99.33
2	20	4	10	30	200	37.6	0.179	99.1
3	20	5	10	30	200	37.6	0.286	98.57
4	20	6	10	30	200	37.6	0.207	98.96
5	20	7	10	30	200	37.6	0.439	97.8
6	10	5	10	30	200	37.2	0.107	98.93
7	20	5	10	30	200	37.2	0.265	98.67
8	30	5	10	30	200	37.2	0.155	99.48
9	40	5	10	30	200	37.2	0.324	99.19
10	50	5	10	30	200	37.2	0.325	99.35
11	20	5	10	30	200	36	< 0.1	> 99.5
12	20	5	20	30	200	36	< 0.1	> 99.5
13	20	5	30	30	200	36	0.128	99.41
14	20	5	40	30	200	36	0.11	99.45
15	20	5	50	30	200	36	0.17	99.15
16	20	5	10	30	200	37	< 0.1	> 99.5
17	20	5	10	60	200	37	0.11	99.45
18	20	5	10	90	200	37	0.159	99.2
19	20	5	10	120	200	37	0.178	99.16
20	20	5	10	30	50	36.5	0.118	99.41
21	20	5	10	30	100	36.5	0.119	99.4
22	20	5	10	30	150	36.5	< 0.1	> 99.5
23	20	5	10	30	200	36.5	0.1	99.5
24	20	5	10	30	250	36.5	0.1	99.5

### 3.2. Effect of Change in Initial Concentration

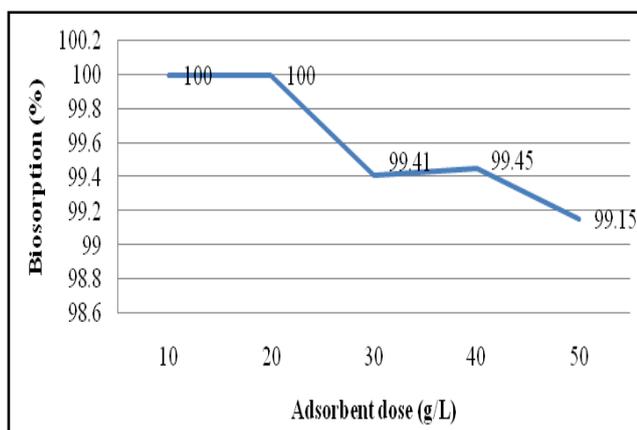
In this study, the adsorption of lead (II) with change in initial concentration was studied, initial concentration ranging from 10 mg/L to 50 mg/L was taken for study. The experiment was conducted at pH 5, adsorbent dose 10 g/L, contact time 30 min, and mixing speed 200 rpm. The experimental result shows at 10 mg/L, 20 mg/L, 40 mg/L, 50 mg/L lead (II) removal of 98.93%, 98.67 %, 99.19 %, 99.35 % respectively. Maximum lead (II) removal was found in 30 mg/L with 99.48 % adsorption (Figure 2, Table 2) so an initial heavy metal concentration of 30 mg/L was chosen as optimum in the experiment for lead (II) removal.



**Figure 2.** Effect of initial heavy metal conc. on biosorption (%) of Lead (II)

### 3.3. Effect of Change in Adsorbent Dose

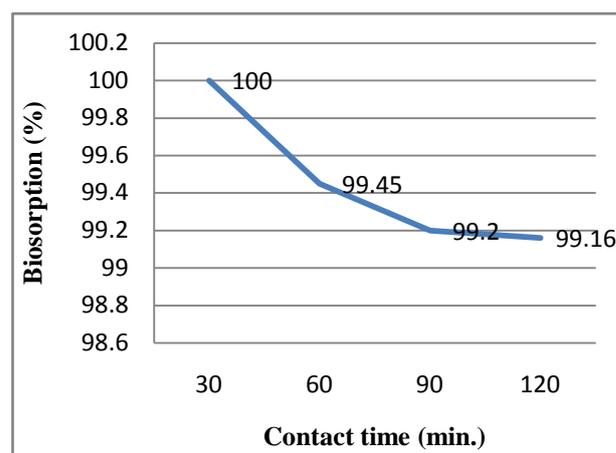
Adsorption of heavy metal ions in solution increases with an increase in adsorbent dose. The purpose of the study was to find out appropriate adsorbent doses for lead (II) removal. The study was conducted at pH 5, initial metal concentration 20 mg/L, contact time 30 min., and mixing speed 200 rpm. The adsorbent dose changes from 10g/L to 50 g/L. The experimental result showed at 30 g/L and 40 g/L, 50 g/L the adsorption of lead (II) was found out to be 99.41 %, 99.45 %, and 99.15 % respectively. Removal of lead (II) was maximum in adsorbent dose 10 g/L and 20 g/L, with more than 99.5 % adsorption (Figure 3, Table 2) so adsorbent dose 10 g/L was chosen as optimum.



**Figure 3.** Effect of adsorbent dose on biosorption (%) of Lead (II)

### 3.4. Effect of Change in Contact Time

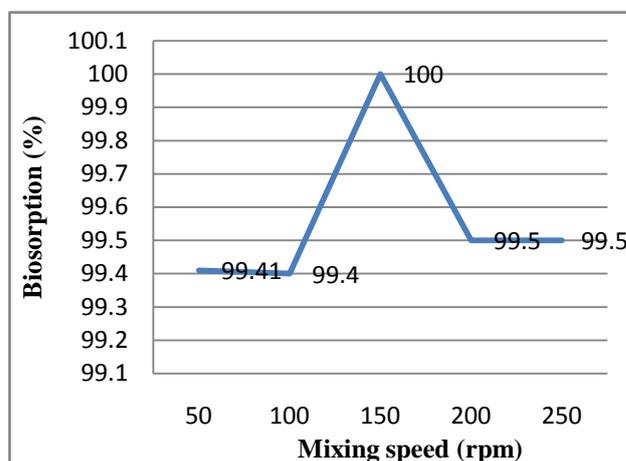
The purpose of the study was to determine the contact time at which maximum adsorption of metal ions of lead (II) occurs. This study was conducted at pH 5, initial metal concentration 20 mg/L, adsorbent dose 10 g/L, and mixing speed 200 rpm. Contact time of 30 min, 60 min, 90 min, and 120 min was taken for study. The result showed at 60 min, 90 min, and 120 min. Lead (II) removal of 99.45 %, 99.2 %, and 99.16 % respectively. Maximum lead (II) removal was found in 30 min. with more than 99.5 % of adsorption. (Figure 4, Table 2) So contact time of 30 minutes was chosen as optimum.



**Figure 4.** Effect of contact time on biosorption (%) of Lead (II)

### 3.5. Effect of Change in Mixing Speed

The purpose of this study was to determine the mixing speed at which adsorption of lead (II) was maximum. The present study was conducted at initial metal ion concentration 20 mg/L, pH 5, contact time 30 min., and adsorbent dose of 10 g/L. Mixing speed of 50 rpm, 100 rpm, 150 rpm, 200 rpm, and 250 rpm was taken in to study. The experimental result shows at 50 rpm, 100 rpm, 200 rpm, 250 rpm the lead (II) removal of 99.41%, 99.4 %, 99.5%, and 99.5% respectively. Removal of lead (II) was found to be optimum in 150 rpm with more than 99.5 % of adsorption. (Figure 5, Table 2) So mixing speed 150 rpm was chosen as optimum.



**Figure 5.** Effect of mixing speed on biosorption (%) of Lead (II)

## 4. Discussion

### 4.1. Effect of pH

pH influences the surface charge of the adsorbent, the degree of ionization, and the species of the adsorbate. So the pH of the aqueous solution is an important controlling parameter in the heavy metal adsorption process [25]. Adequate pH range can avoid precipitation of metal hydroxides. Metal removal can be increased with increasing solution pH [29]. The increase of sorption capacity with an increase of pH can be explained on the basis of the surface functional charge of the adsorbent and degree of ionization. At low pH, a higher concentration of  $H^+$  ions with high mobility competes with metal cations for adsorption on the same functional group. At higher pH, the concentration of  $H^+$  ions decreases, and the solubility of metal ions also decreases which results in higher metal uptake.

### 4.2. Effect of Initial Metal Ion Concentration

The rate of adsorption is a purpose of the initial concentration of metal ions. In the present study, the maximum adsorption of heavy metals was 30 mg/L. Results indicate that higher adsorption was found to take place at lower concentrations. This may be due to the interaction of all metal ions present in the solution with binding sites. At higher concentrations, more metal ions are left unadsorbed in solution due to saturation of adsorption sites [25,26,27]. The number of ions adsorbed from a solution of higher concentrations is more than that removed from less concentrated solutions. At lower metal ions concentration, the percentage uptake was higher due to the larger surface area of adsorbent being available for adsorption [28]. When the metal ions concentration became higher, the percentage removal reduced since the available sites for adsorption became less due to saturation of adsorption sites. At a higher concentration of metal ions, the ratio of the initial number of moles of metal ions to the adsorption sites accessible was higher, resulting in a lower adsorption percentage. The properties of adsorbates (concentration, ionic nature of standard redox potential) may play an important role in metal ion adsorbent interaction, but can only partly explain high-or-low-adsorption capacities [30].

### 4.3. Effect of Adsorbent Dose on Pb (II)

The experimental result of the study shows the maximum percent of heavy metal ion adsorption occurs in the lead (II) -10 gm/L. The percentage of metal removal increased with the increasing amount of adsorbent dose [12,21,25]. This may be attributed to the availability of more and more binding sites for the complexation of metal ions. Further increment in adsorbent dose did not cause a significant improvement in adsorption, as seen in the case of lead (II) adsorption. This seems to be due to the binding of almost all ions to the adsorbent and equilibrium is reached between the ions bound to the adsorbent and those remaining unadsorbed in the solution.

### 4.4. Effect of Contact Time

The purpose of the experiment was to determine the contact time required to reach the equilibrium between the

solid phase (adsorbent) and liquid phase (synthetic water). Experimental result shows that the for Pb (II) it was found out to be 30 min. It can be remarked that the percentage uptake increases with time and after some time, it reaches a constant value where no more metal ion can be removed from the solution [25,27,29]. At this point, the number of metal ions being adsorbed by the adsorbent was in a state of dynamic equilibrium with the number of metal ions desorbed from the adsorbent. The time required to attain this state of equilibrium is termed as the equilibrium time. The amount of metal ion adsorbed at the equilibrium time reflects the maximum adsorption capacity of the adsorbent under these particular conditions. In the case of Pb (II) the adsorption of metal ions was very fast and maximum adsorption takes place during the initial 30 min. It can be elucidated that the rate of metal-binding with biomass is more prevalent during the initial stages, which progressively decreases and remains almost constant after equilibrium time.

### 4.5. Effect of Mixing Speed

Mixing speed is considered as an important parameter in the process of adsorption of heavy metals. Adsorption of heavy metal increases along with an increase in mixing speed to a level, and then it becomes almost constant towards the end. Pb (II) shows optimum adsorption at 150 rpm mixing speed. From the result, it can be observed that there is a gradual increase in adsorption of heavy metal initially and then it becomes almost constant towards the end. Result shows in 50 rpm and 100 rpm, the adsorption of heavy metal was very slow as in low mixing speed no complete mixing of the solid phase (adsorbent) and liquid phase (synthetic water) occurred and the adsorbent surface was not fully exposed to heavy metal solution.

The adsorption isotherm was evaluated using the linearized Langmuir model.

Table 3. Langmuir parameters and correlation coefficient

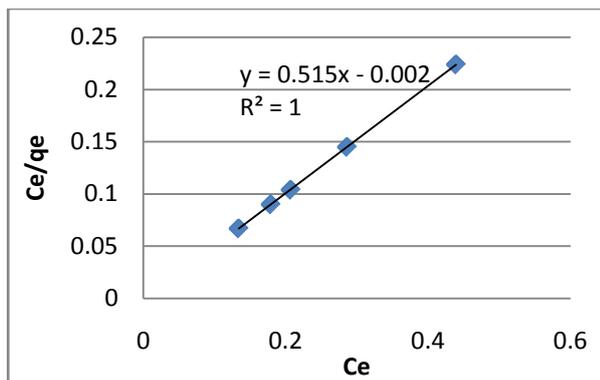
Metal ions	$q_m$ (mg/g)	Temp. ° c	b(L/mg)	$R^2$
Lead(II)	99.5	36	0	0.99

The current study of Langmuir adsorption isotherm shows  $q_m$  value 99.5 and b value- 0. Langmuir isotherm model  $R^2$  is in good agreement with the experimental data. The experimental results revealed that *Albizia lebbek* can be used as an efficient bio-adsorbent for the removal of lead (II).

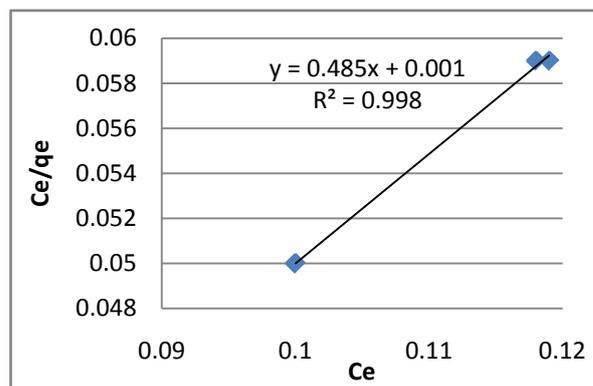
The linearized Langmuir adsorption isotherm model for change in pH, change in adsorbent dose, change in contact time and change in mixing speed by Indian Siris of Lead (II) indicates that the model is fit well to the model with  $R^2$  value 1, 0.88, 0.99, 0.99 as shown in Figure - 6(a), Figure - 6(c), Figure - 6(d), Figure - 6(e) respectively. But in case of change in initial heavy metal concentration, the Langmuir adsorption isotherm model is not fit good as shown in Figure - 6(b).

The Langmuir and Freundlich isotherms were implemented to the adsorption process and their constants were evaluated. The Langmuir adsorption isotherm model was found to be most appropriate for the description of the adsorption process.

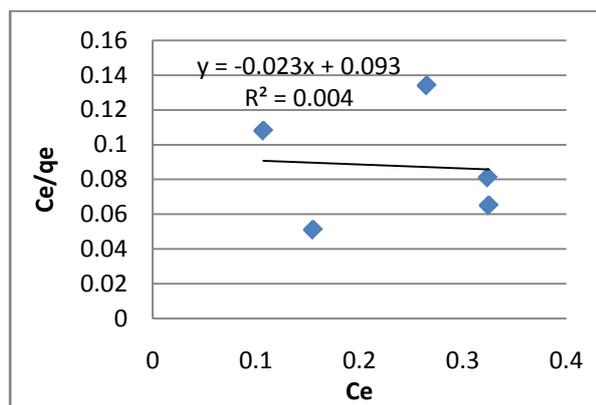
**Langmuir adsorption isotherm models of *Albizia lebbek* for Lead(II)**



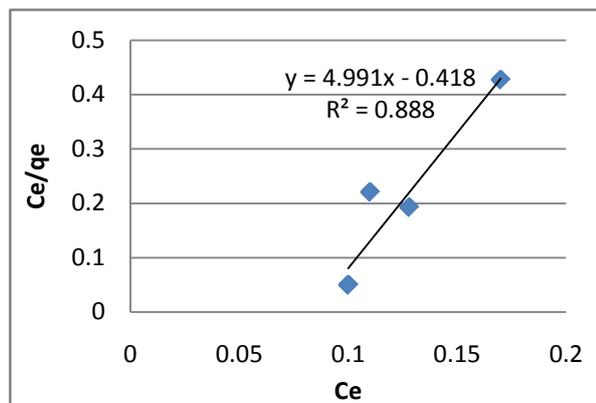
**Figure 6(a).** Langmuir adsorption isotherm models for change in pH of Lead(II)



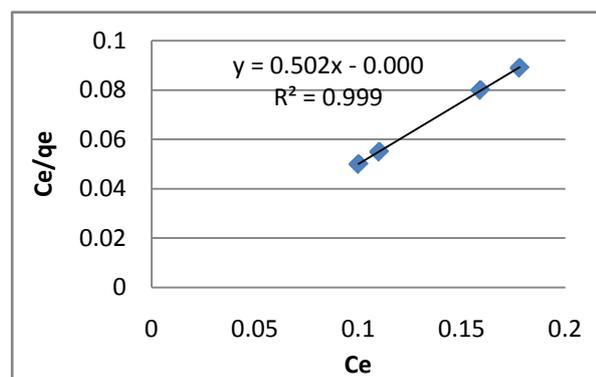
**Figure 6(e).** Langmuir adsorption isotherm models for change in mixing speed of Lead(II)



**Figure 6(b).** Langmuir adsorption isotherm models for change in initial heavy metal concentration of Lead (II)



**Figure 6(c).** Langmuir adsorption isotherm models for change in adsorbent dose of Lead (II)



**Figure 6(d).** Langmuir adsorption isotherm models for change in contact time of Lead (II)

## 5. Conclusion

Adsorption is a process that has been developing immensely as environmental issues rise. Adsorption has been used to remove many pollutants from wastewater, whether seawater or industrial wastewater, purifying drinking water, or as a polishing phase at the end of sewage treatment. These pollutants include heavy metals, which is the focus of this work. A high removal, simplicity, and high adsorption capacity of adsorbent are the main advantages of the adsorption method. Heavy metals are toxic and hazardous to humans, marine life and the water body in which it is contained. The metals studied in this work include lead due to their abundance in water, in addition to their toxicity. The adsorbent used was Indian siris (seed), due to their high availability in Odisha. Batch tests were conducted in order to study the potential of the adsorbent for heavy metal removal. Batch tests revealed that Indian siris (seed) behave as good adsorbents in removing the metals at different conditions. These conditions varied in pH, adsorbent dose, initial concentration, contact time and mixing speed. The present study shows that lead (II) can be removed best on pH 3, initial heavy metal concentration 30 mg/L, adsorbent dose 10 g/L, contact time 30 min., and mixing speed 150 rpm. Langmuir adsorption isotherm model  $R^2$  is in good agreement with the experimental data ( $R^2 \sim 1$ ). So it can be concluded that *Albizia lebbek* can be used as an efficient bio-adsorbent for the removal of lead (II). The seeds of *Albizia lebbek*, a non edible plant can be used as low cost bio-adsorbent for removal of lead metal ion from contaminated water. The process can be made economical by regenerating and reusing the biosorbent after removing the heavy metal ions from large volumes of water or effluents.

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