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Comparison the Efficiency of Cajanus Cajan and Ficus Benghalensis for Lead and Zinc Removal From Waste Water.

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ABSTRACT: *Water is one of the most important natural resources, essential for all forms of life. These natural resources are being contaminated everyday by anthropogenic activities. Water is a vital natural resource, which is essential for multiplicity purposes. Therefore, it is essential to remove heavy metals from water throughbio adsorption process.*

"Cajanus Cajan seed coat and Ficus Benghalensis aerial root has been used for the removal of Pb (II) and Zn (II) from synthetic wastewater. The synthetic wastewater concentration was 1000 mg/l.Temperature kept constant as 35^{o}C.Sorption kinetics models viz., pseudo first order and pseudo second order were applied for the experiment. It was revealed that Pb (II) and Zn (II) removal follows pseudo second order rate expression. Adsorption isotherm was justified by Langmuir and Freudlich adsorption isotherm. IR spectra,NMR spectra andXRD spectra shows the presence of following groups such as –COOH,-OH, aliphatic,-NH_2 which increases the efficiency of bioadsorbents at moderate pH.Proximate analysis also explains the percentage of carbon that means the presence of aliphatic hydrocarbon.The suitable pH for maximum removal of Pb (II) and Zn(II) ions from synthetic water by Cajanus cajan and Ficus benghalensis were 6.

Keywords: *Bioadsorption, Proximate analysis, Sorption Kinetics, Sorption Isotherm and Anthropogenic.*

I. INTRODUCTION

Water pollution is a serious global problem. It causes disease and death.[2]Heavy metal contamination of water is mainly caused by industrialization, modernization, urbanization, mining, electroplating, metal processing, textile, battery manufacturing industries, paper pulp industries, storage battery, automotive discharge and bisleries [1].Heavy metals threat to environment and public health by bioaccumulation, toxicity and reaches in food chain of the ecosystem.Heavy metals ions such as Pb, Cd, Hg, Cr, Ni, Zn and Cu are non-biodegradable. They are natural component of the earth crust. To, small extent, it enters in our bodies via food, drinking water and air. As trace elements, some heavy metals are essential to maintain the metabolism of human body[2]. However at high concentration they lead to poisoning. Main sources of lead release in water are leaded gasoline, tire wear, lubricating oil and grease bearing wear.Zinc emission take place from tire wear, motor oil, grease and brake emission.Lead accumulation causes acute or chronic damage to nervous systems, renal systems, decreases hemoglobin formation, infertility and abnormality in women.[3-4]Excess of zinc suppress Cupper and iron absorption and cause anosmia, acidity in stomach, lethargic, ataxia (lack of coordination of muscle movement). There are several technologies for removing heavy metal from water such as chemical oxidation, ion exchange, reverse osmosis, electrochemical application, membrane process, evaporation, filtration, solvent extraction, chemical precipitation[5-8]. The main disadvantages of these methods are high prize non viable,scale and sludge formation take place. Therefore,the best alternatives to remove heavy metal from the water source arebioadsorption. Due to practical limitation with living microbes, dead biomass agricultural waste or byproducts are preferably used for adsorption. Recent research has been focused on the development of unique materials which increased affinity, capacity and selectivity for the target metals[9].The objective of this research is to develop low cost, easily viable, highly efficient and ecofriendly bioadsorbent like Cajanus Cajan and Ficus Benghalensis for removal of heavy metals Pb and Zn removal.Therefore by the use of Cajanus Cajan seed coat cover and Ficus Benghalensis aerial root as bioadsorbent for the removal of lead and zinc from the water.Because they are easily available, low cost, highly efficient, ecofriendly. Lead and Zinc is chosen due to its presence in water of the Gwalior region.

II. MATERIALS AND METHODS

1.1. *Physico-Chemical Analysis Of The Bioadsorbents:* *Cajanus Cajan coverings collected from pulse industries.Soluble and colored components of coverings were removed by repeated washing with distilled water then coverings dried at 30^oC, powdered and sieved. Ficus benghalensis aerial root are collected by local areas. It is washed with distilled water many times dried in sunlight then dried in oven. Grounded into powder with electrically grinded mixture. Powder is sieved to get proper size particles (350 to 850 micrometer).*

Fig. 1a Aerial Roots of Ficus Benghalensis

Fig.1b Seed coat of Cajanus cajan

In order to analyze physico chemical properties ofbioadsorbents IR spectra, NMR spectra, XRD and proximate analysis are conducted.

1.2. *Infra Red Spectra*-Infra –Red spectra of the bioadsorbent were recorded using Infra – Red spectrophotometer.

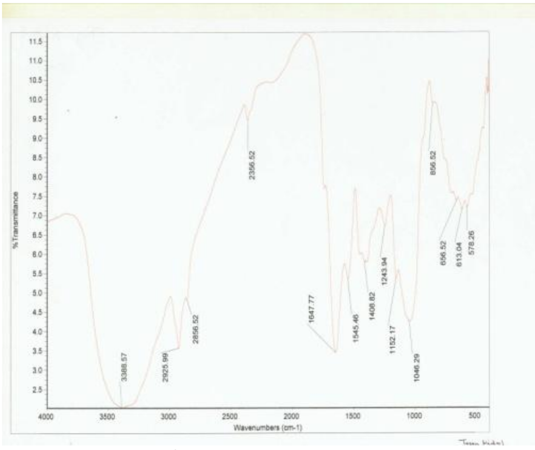

Fig. 2a IR Spectra of Cajanus Cajan

Table I: IR ranges Cajanus Cajan

3388.57	-OH stretching of alcohol, phenols, and carboxylic acids.
2925.99	-C=C-stretching of aliphatic hydrocarbons.
2856.52	-C-H-stretching of aldehyde.
1647.77	-C=O stretching of amide.
1545-1647	-N=O stretching of nitro group.
1152.17	Presence of tertiary alcohol.
1243.94	-C=O stretching of ether group present.
1152.17	-S=O stretching of sulphur dioxide
656 and 613	-Si-O stretching of silicate.
656&613	-Si-O- stretching.

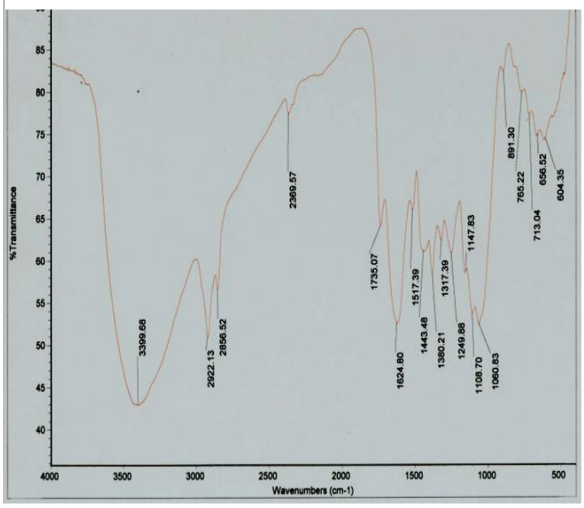

Fig. 2b IR spectra of Ficus Benghalensis

Table II: IR ranges of Ficus benghalensis

Ranges (cm^{-1})	**Functional group posses by Ficus benghalensis**
3399.68	-OH stretching of alcohol (Polymeric association of intermolecular hydrogen bonding).
2922.13	-CH stretching of aliphatic hydrocarbon.
2856.52	-$COCH_3$ shows presence of ether group.
1735.07	-C=O stretching of aldehyde, Carbonyl group.
1624.80	-NH deformation of amine group.
1443.48-1380.21	-CH deformation of –CH2, -CH3.
1317.39	-C=O stretching of t-alcohol.
49.88	-OH group present.
1108.70	Secondary alcohol present.
1060.83	-C=C-O-C stretching of ether.
765.22-713.04	-CH_2 rocking.

Table III:The results of proximateanalysis of Cajanus Cajan and Ficus Benghalensis are-

Bioadsorbent	***Cajanus cajan***	***Ficus benghalensis***
% of moisture	18.838	18.96
% of volatile matter	17.86	18.22
% of ash	18.83	17.71
% of fixed Carbon	44.88	45

More the percentage of fixed carbon in bioadsorbent is far better.

***1.4. Nuclear Magnetic Resonance** –It is general methodology in which encoding and detection occurs in different physical and molecular environment. NMR spectra of adsorbent by using NMR spectrophotometer(model aV-500).*

***Table IV a: NMR ranges of Cajanus cajan**.*

Tau value	***Functional group***
1.5	Methyne
1.3	sec R_2CH_2
1.5	t-R_3CH

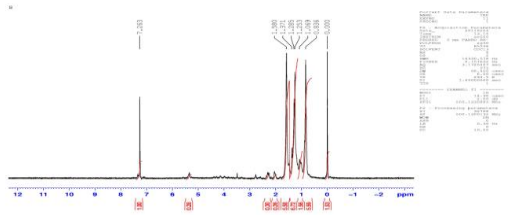

Fig.3a: NMR spectra of Cajanus Cajan

Table IV b: NMR ranges of Ficus benghalensis

Tau value	***Functional group***
7.263	Alcohol group, CH_3NHCOR
3.492	RNH_2, RNHR
1.5, 1.371, 1.333, 1.286, 1.253	$RCONH_2$ RCONHR
0.843, 0.069	=N-OH

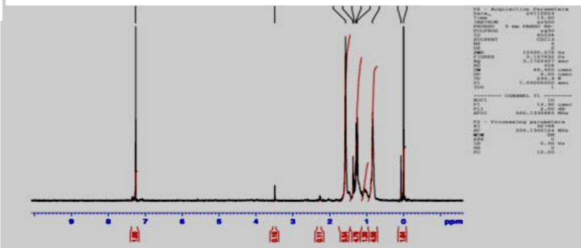

Fig.3b: NMR spectra of Ficus Benghalensis

***2.4 .X- Ray Diffraction** -It represents the amorphous nature of bioadsorbents.*

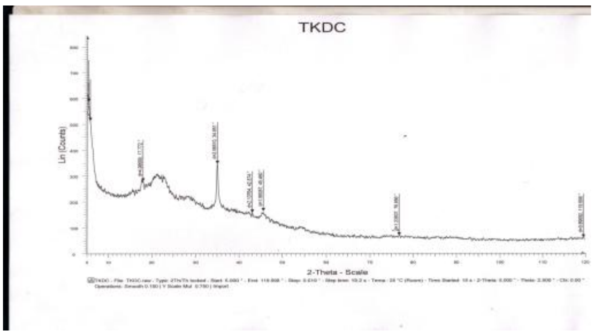

Fig. 4a XRD of Cajanus Cajan

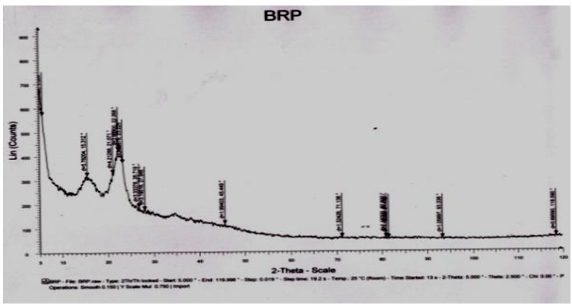

Fig. 4b XRD of Ficus benghalensis

***2.5. Biosorption Experiment:**Batch adsorption experiments were carried out at different pH, contact time, different concentration and adsorbent loading weight.Different pH of the solution was monitored by adding 0.1NHCl and 0.1N NaOH solution. Different concentration of the solution was prepared by diluting stock solution. Required amount of bioadsorbent was then added content was shaken up to required contact time on an electrically rotator shaker at 1200 rpm. The filtration was done using Whatman Filter paper of 125ppm. The filtrates were treated with dithiozone.Lead ions forms lead dithiozonate and Zinc ions forms zinc dithiozonate.Filtrate were separated and analyzed by using U.V.Visible spectrophotometer (Schimadzu) for the percentage of metal removal. Spectra for the percentage of metal removal obtained at wavelength 515 nm .The percentage of metal removal were calculated as:*

% of removal of metal = Ci – Ce / Ci x 100

III. RESULT AND DISCUSSION

3.1. Effect Of pH:*Experiment were performed at 35°c, concentration of adsorbate 100mg/l and varying the pH from 1to 12. It was observed that uptake of Pb (II) and Zn (II) increased with the increase in pH.These optimum uptakes for maximum adsorption of Pb(II)and Zn(II) was found to be 6. Slightly acidic pH supports maximum of adsorption, as the surface of bioadsorbent contains carboxyl group, hydroxyl group, enol group, ester,-SO_2, amide linkage. So the positive end of metal binded to this group of adsorbent at low pH. At the highest pH the surface of bioadsorbent becomes negatively charged and in addition there will be abundance of negatively charge in aqueous solution both of these factors hinders the bioadsorption at high pH.It was observed that at lowest pH when the solution was treated by potassium chromate (K_2CrO_4) dark yellowish color obtained. It also indicates higher percentage of adsorption at low pH as compared to higher pH .So, it represents that the efficiency of adsorption higher at lowest pH .It is highest at 6 .More binding sites are available at this pH.*

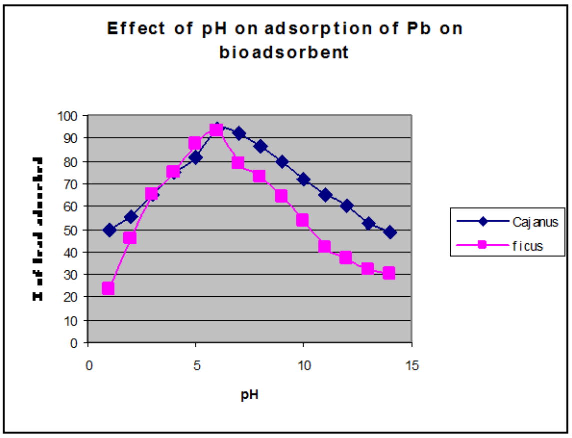

Fig. 5a Effect of pH on adsorption of lead by Cajanus cajan and Ficus benghalensis

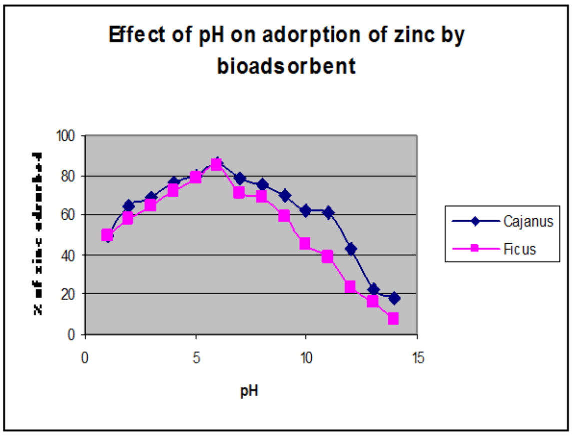

Fig.5b Effect of pH on adsorption of zinc by Cajanus cajan and Ficus benghalensis

3.2. Adsorption Isotherm:*The isotherm constant was calculated from the slope and intercept from Langmuir adsorption isotherm and Freudlich adsorption isotherms.R^2 represents the adsorption process very well.Bioadsorption Isotherms describes how adsorbate interacts with bioadsorbents and equilibrium is established between adsorbed metal ions and residual metal ions during surface bioadsorption. Sorption Isotherm represents the capacity and efficiency of bioadsorbent to metal ions. The Langmuir adsorption explains monolayer coverage of adsorbate over a homogenous adsorbent surface, biosorption of each molecule on to the surface has equal biosorption activation energy. While Freudlich adsorption Isotherm explains heterogeneous surface with a non-uniform distribution of heat of biosorption over a surface and a multilayer biosorption.*

Table V: Sorption Isotherm constants and RL values for sorption of Pb (II) on Cajanus Cajan at different concentration with respect to time.

Different concentration (ppm) Pb^{2+}	*Langmuir Model*			*Freudlich Model*			
	q°	*B*	*r^2*	*N*	*K_F*	*r^2*	*R_L*
50	33.079	-2.5380	0.957	-0.963	0.28	0.88	1.04
100	45.024	-5.470	0.969	0.77	0.36	0.7881	1.018
150	56.338	-12.376	0.983	0.80	0.34	0.99	0.141
200	69.108	-40.65	0.99	0.87	0.31	0.99	0.68

In the table values of $r^2$is higher of Langmuir than Freudlich adsorption Isotherm, which means Langmuir equation represented the adsorption process very well. Value of Q° which is defined as the maximum capacity of adsorbent was calculated from Langmuir plots. The equilibrium parameter R_L, which is defined as R_L = 1 / 1+bC_{A0} :O<R_L<1 reflects the favorable adsorption process.In the present research the equilibrium parameter was found to be in the range O<R_L<1 which is shown in table. This indicated to the fact that the adsorption process was favorable and the adsorbent utilizedhave a great potential.

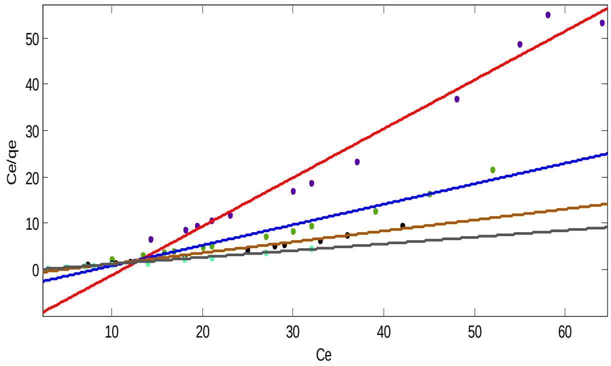

Fig. 6a Langmuir plot: Different Concentration of lead removal by Cajanus cajan verses time

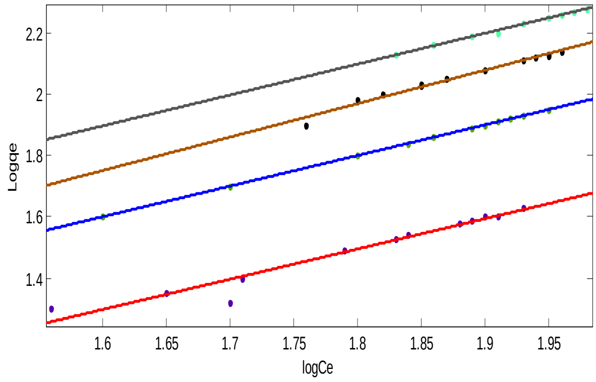

Fig. 6b Freudlich plot: Different concentration of lead removal by Cajanus cajan verses time

Table VI:Sorption Isotherm constants for sorption of different concentration of Zn(II) by Cajanus cajan.

Differentconcentration (ppm)Zn^{2+}	***Langmuir model***			***Freudlich model***			
	q°	***b***	***r^2***	***R_L***	***N***	***K_F***	***r^2***
50	26.413	1.518	0.93	1.03	0.575	0.466	0.98
75	29.985	1.090	0.847	1.052	48.614	-9.57	0.89
100	39.154	1.057	0.95	1.022	61.31	-0.066	0.57
150	45.24	1.3068	0.96	1.013	65.74	-0.068	0.24

From the table it is clear that in the case of adsorption of Zn^{2+} on Cajanus cajan follows Freundlich adsorption isotherm as the value of correlation coefficient exists in the range 0.57 to 0.98 which support it.

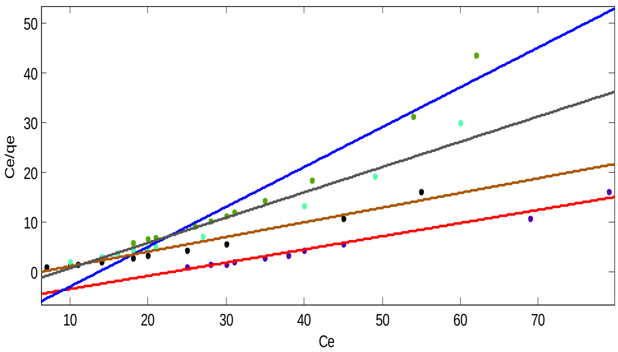

Fig.7a Langmuir plot: Different concentration of zinc removal by *Cajanus cajan* verses time

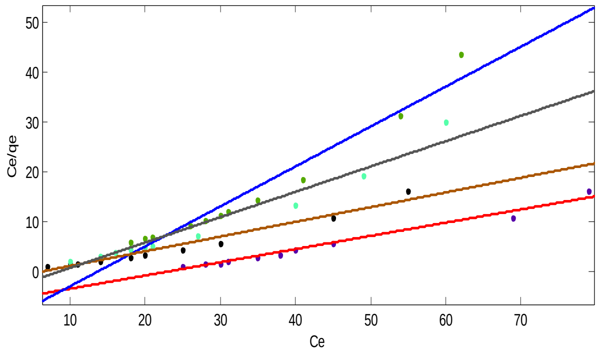

Fig. 7b Freudlich plot: Different concentration of zinc removal by *Cajanus cajan* verses time

TableVII: Sorption isotherm constant and R_L values for sorption of Pb (II)by different doses of Cajanus cajan.

Metal Pb^{2+}	***Langmuir model***			***Freudlich model***			
Different Doses(gm)	***q°***	***b***	***r^2***	***R_L***	***N***	***K_F***	***r^2***
0.25	24.02	-0.063	0.94	1.09	0.53	-0.49	0.98
0.50	1	-0.183	1	1.18	0.64	-0.41	0.99
1	45.45	-0.811	0.99	1.020	0.62	-0.33	0.98
2	60.75	-1.1447	0.98	0.4	0.89	-0.30	0.99

The Isotherm constant were calculated from the slope and intercept. The value of r^2 is higher of Langmuir isotherm than Freudlich Isotherm that indicates that Langmuir Isotherm explains adsorption process better.

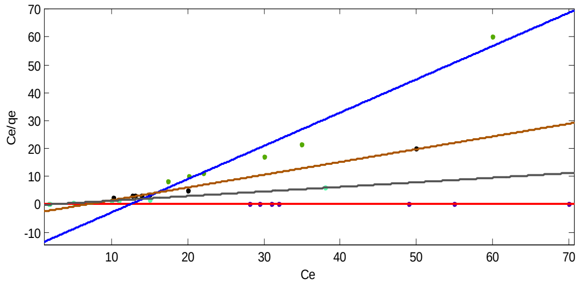

Fig. 8a Langmuir Plot–Different doses of Cajanus *cajan* for lead removal verses time

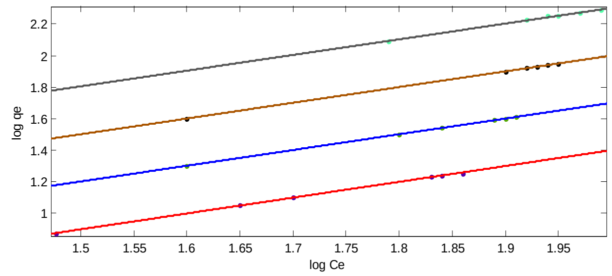

Fig. 8b Freudlich Plot: Different doses of *Cajanus cajan* for lead removal verses time

TableVIII:Sorption Isotherm constant and $R_L$values for sorption of Zinc (II) by different doses of Cajanus cajan.

Metal Zn^{2+}	***Langmuir model***			***Freudlich model***			
Different Doses (gm)	***q°***	***b***	***r^2***	***R_L***	***N***	***K_F***	***r^2***
0.25	384.6	6.06	0.079	1.647	6.92	-1.211	0.01
0.50	425.5	2.46	0.05	4.048	0.512	0.509	0.91
1.00	62.42	1.06	0.92	9.345	0.50	0.018	0.99
2.00	41.6	0.87	0.98	0.011	85.4	-0.027	0.37

The correlation coefficient supported Freudlich isotherms.

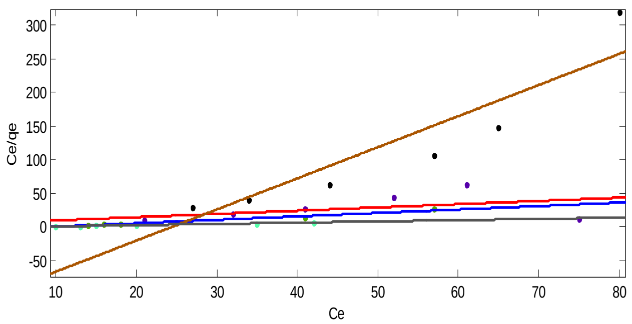

Fig. 9a Langmuir plot: Effect of different doses of *Cajanus cajan* for zinc removal verses time

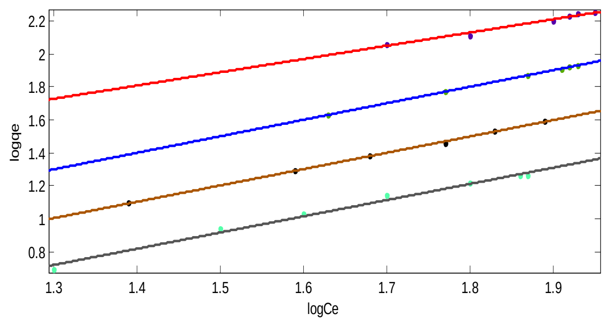

Fig. 9b Freundlich plot: Effect of different doses of *Cajanus cajan* for zinc removal verses time

Table IX: Sorption isotherm constant for different concentration of Pb (II) removal by Ficus benghalensis.

Parameter Pb $^{2+}$ ion	***Langmuir Parameter***		***r^2***	***Freudlich Parameter***		***r^2***
Concentration (ppm)	***Q_o***	***b***		***N4***	***K_f***	
75	0.8064	0.033	0.84	0.983	1.32	0.99
150	2.12	0.073	0.90	0.99	1.48	0.99
200	10.20	0.158	0.39	1.149	3.5	0.27
250	5.414	0.190	0.97	0.71	1.86	0.97

Correlation coefficient of Freudlich adsorption isotherm supports the adsorption of different concentration of lead by Ficus benghalensis.

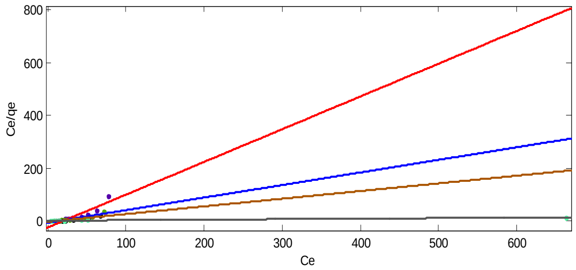

Fig. 10a Langmuir plot - Different concentration of lead removal by Ficus benghalensis verses time

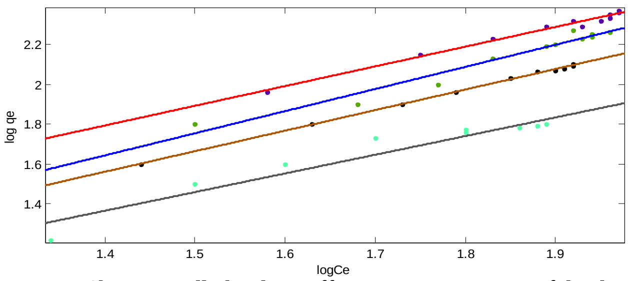

Fig. 10b Freundlich plot-Different concentration of lead removal by Ficus benghalensis verses time.

Table X:Sorption isotherm constant for different doses of Ficus benghalensis for Pb (II) removal verses time.

Parameter Pb^{2+} `ion	Langmuir Parameter		r^2	Freudlich Parameter		r^2
Doses(gm)	Q_{max}	**b**		**N**	K_f	
0.75	0.36	0.067	0.95	1.010	1.94	1
1	0.79	0.080	0.95	1	1.99	1
2	4.34	0.12	0.96	0.98	1.86	0.99
3	9.090	0.28	0.97	0.83	1.28	0.96

Freudlich adsorption isotherm is best fitted for different doses of Ficus benghalensis for lead removal verses time. Correlation coefficient supports it.

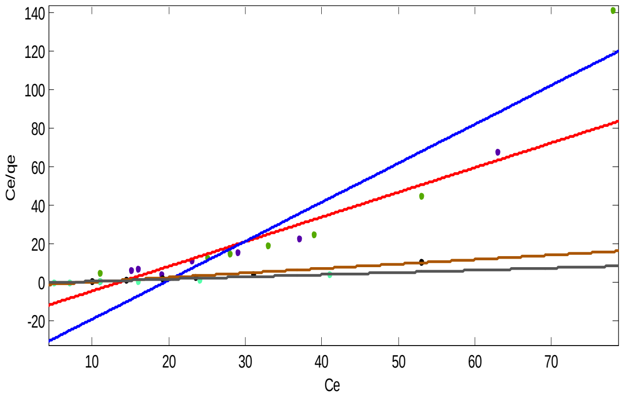

Fig. 11a Langmuir plot-Different doses of *Ficus benghalensis* for lead removal verses time

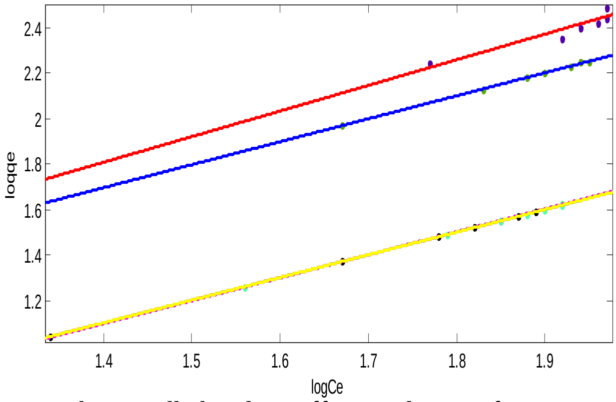

Fig. 11b Freudlich plot-Different doses of *Ficus benghalensis* for lead removal verses time

TableXI: Sorption isotherm constant for different concentration of Zn (II) removal by Ficus benghalensis.

Parameter Zn^{2+} ion	Langmuir Parameter		r^2	Freudlich Parameter		r^2
Concentration (ppm)	Q_{max}	**B**		**N**	K_f	
75	0.66	-0.039	0.90	1.010	1.32	0.99
150	1.92	-0.060	0.92	0.98	1.40	0.99
200	3.703	-0.1032	0.89	1.020	2.13	0.99
250	5.800	0.23	0.95	0.99	2.48	0.99

Freudlich adsorption isotherm supports the adsorption of different concentration of zinc by Ficus benghalensis verses time. Value of r^2 favors it.

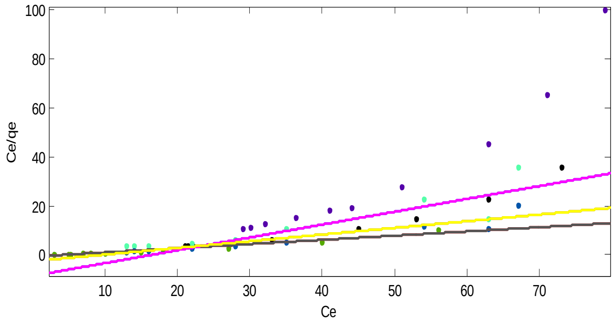

Fig.12a Langmuir plot- Different concentration of zinc removal by *Ficus benghalensis* verses time

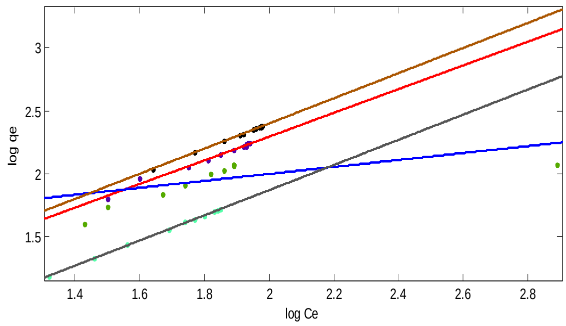

Fig. 12b Freundlich plot-Different concentrations of zinc removal by *Ficus benghalensis* verses time

Table XII:Sorption isotherm constant for different doses of Ficus benghalensis for Zn (II) removal.

Parameter Zn^{2+} ion	Langmuir Parameter		r^2	Freudlich Parameter		r^2
Doses (gm)	Q_{max}	**b**		**N**	K_f	
0.75	0.59	-0.049	0.91	1.018	1.8	0.99
1	2.406	-0.125	0.98	1.000	-	1.00
2	4.694	-0.148	0.96	1.000	1.99	1.00
3	8.410	-0.33	0.97	1.030	3.3	0.99

Freudlich adsorption isotherms explain adsorption of zinc by different doses of Ficus benghalensis verses time. Correlation coefficient supports it.

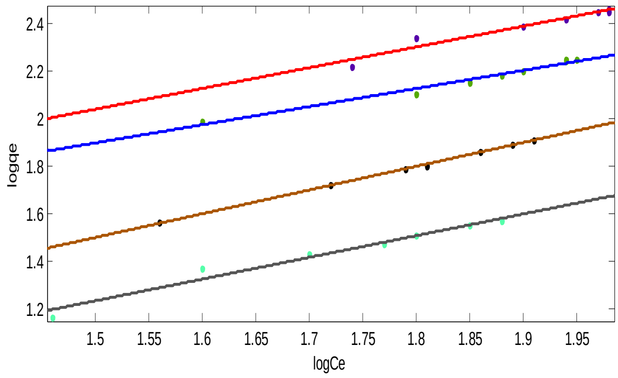

Fig. 13a Langmuir plots-Different doses of *Ficus benghalensis* for zinc removal verses time

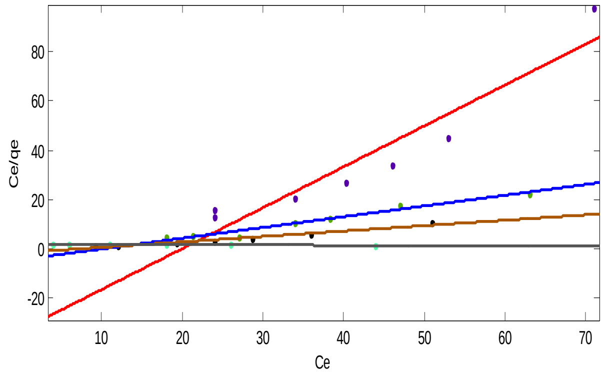

Fig. 13b Freudlich plot-Different doses of *Ficus benghalensis* for zinc removal verses time

3.3. *Sorption Kinetics*:*In order to predict the adsorption kinetics model Pb(II) and Zn(II) pseudofirstorder and pseudo second order were applied to the data .The effect of the different concentration verses time were investigated to find best kinetic models. Linear fit models were generally observed for all the concentration and time.*

TableXIV:Sorption kinetics constant for different concentration of Pb(II) removal by Cajanus cajan.

Pb(II) Parameters)	***Pseudo first order***			***Pseudo second order***		
Concentration(ppm)	K_1	q_e	r^2	K_1	***h***	r^2
50	-161.08	0.28	0.98	106.3	3.2	0.973
100	-164.41	0.248	0.98	88.8	6.57	0.793
150	-145.34	0.236	0.97	101.0	7.19	0.989
200	-96.8	0.212	0.98	117.6	7.75	0.970

The value of correlation coefficient supports Pseudo second order model.

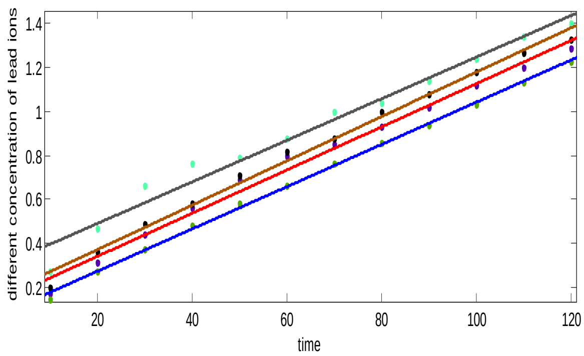

Fig.14a Pseudo first order model- Different concentration of lead removal by *Cajanus* verses time

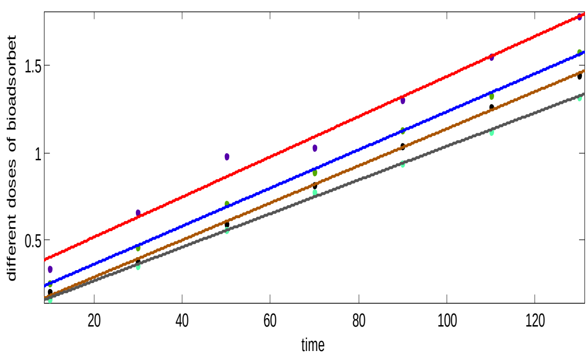

Fig.14b Pseudo second order model – Different concentration of lead removal by *Cajanus cajan* with respect to time

Table XV:Sorption Kinetics constant obtained for different doses of Cajanus cajan.

Parameters Doses (gm) Pb^{2+}	***Pseudo first order***			***Pseudo second order***		
	K_1	q_e	r^2	K_1	***h***	r^2
0.25	-0.0035	1.87	0.90	0.012	5.58	0.71
0.5	-0.0024	1.75	0.080	0.0103	9.407	0.55
1	-0.0039	1.52	0.78	0.0083	7.40	0.48
2	0.0076	0.73	0.88	0.0092	8.13	0.99

In order to predicts sorption kinetic models of Pb (II) pseudo first order and pseudo second order were applied. The effect on the Pb (II) by different doses of adsorbent verses time were investigated to find best kinetic model. Good correlation coefficient was observed for Pseudo second order equation.

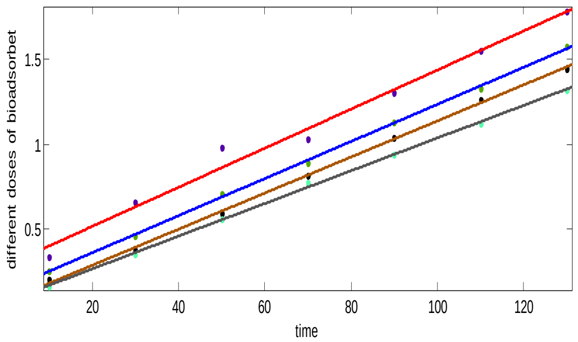

Fig. 15a Pseudo first order model – Different doses of *Cajanus cajan* for lead removal respect to time

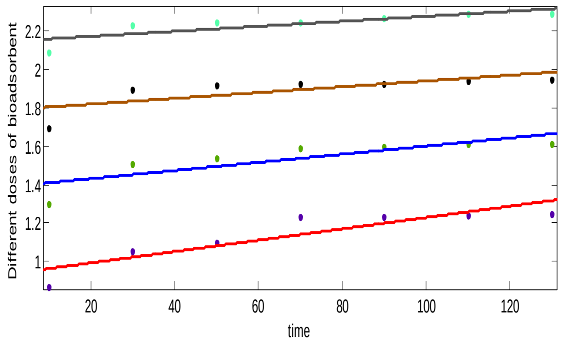

Fig. 15b Pseudo second order model- Different doses of *Cajanus cajan* for lead with respect to time

TableXVI:Sorption kinetics constant for different concentration of zinc (II) removal by Cajanus cajan.

Parameters ConcentrationZn (II)	***Pseudo first order***			***Pseudo second order***		
	K_1	q_e	r^2	K_1	h	r^2
50	-0.0046	0.28	0.99	133.3	1.618	0.96
100	-0.004741	0.280	0.92	98.4	6.30	0.99
150	-0.006257	0.245	0.92	98.4	6.30	0.99
200	-0.007881	0.254	0.93	158.4	2.299	0.72

The good correlation coefficient is obtained for Pseudo second order equation so it is best fitted model.

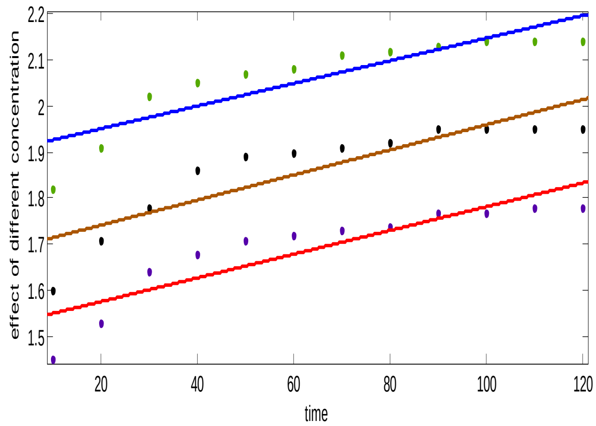

Fig.16a Pseudo first order model: Different concentration of zinc removal by *Cajanus cajan* verses time

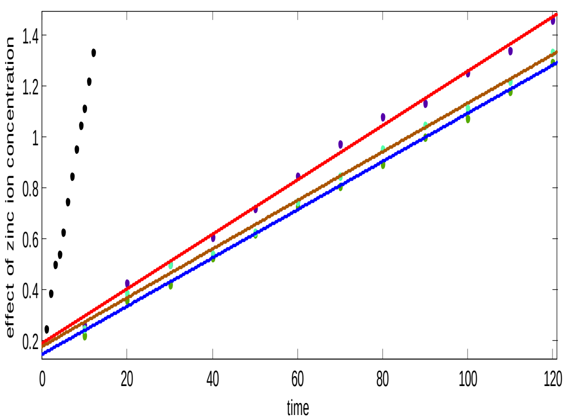

Fig.16b Pseudo second order model: Different concentration of zinc removal by *Cajanus cajan* verses time

Table XVII:Sorption kinetics rate constant obtained for zinc removal by different dosesof Cajanus cajan.

Parameters Doses (gm) Zn^{2+}	***Pseudo first order***			***Pseudo second order***		
	K_1	Qe	r^2	K_1	h	r^2
0.25	0.0045	1.94	0.99	0.036	0.617	0.96
0.50	0.0075	1.90	0.92	0.045	0.158	0.99
1.00	0.0081	1.75	0.92	0.098	0.158	0.99
2.00	0.0098	1.79	0.93	0.109	0.434	0.72

The value of r^2 supports Pseudo second order kinetics equation for the adsorption of Zn(II) ions by Cajanus Cajan .

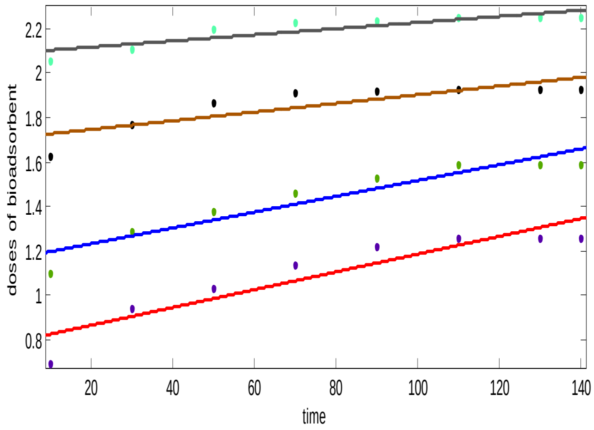

Fig.17a Pseudo first order model Effect of different doses of *Cajanus cajan*for zinc removal with respect to time

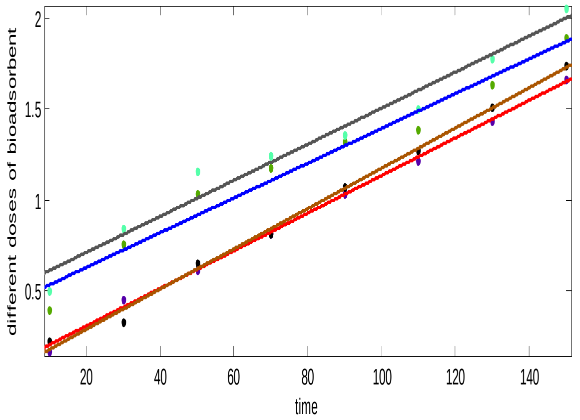

Fig.17b Pseudo second order model- Effect of different doses of *Cajanus cajan* for zinc removal with respect to time

Table XVIII: Sorption kinetics rate constant for different concentration of lead and zinc removal by Ficus benghalensis verses time.

Parameter Concentration (ppm)	***Pseudo first order lead ion***		***r^2***	***Pseudo second order lead ion***		***r^2***	***Pseudo first order zinc ion***		***r^2***	***Pseudo second order zinc ion***		***r^2***
	K_s	***Q_e***		***K_1***	***h***		***K_s***	***Q_e***		***K_1***	***h***	
75 150 200 250	0.0090 0.0082 0.0075 0.0064	26.8 57.6 86.8 127. 3	0.6 6 0.7 2 0.7 4 0.6 9	102.8 107.3 111.9 112.3	0.0003 0.0003 0.036 0.0000 5	0.9 8 0.9 9 0.9 9 0.9 9	3.4 6 1.1 9 0.6 2 0.3 9	8.12 4.0X10^7 4.12X1 0^2 5.37	0.9 0 0.9 2 0.8 9 0.9 5	1.003 7 0.98 1.003 7 1.003 7	- 8.03 7.04 0 3.16 2.45	0.99 0.99 0.99 0.99

Pseudo Second order kinetics is followed by different concentration of lead and zinc removal by Ficus benghalensis verses time. It is well supported by correlation coefficient.

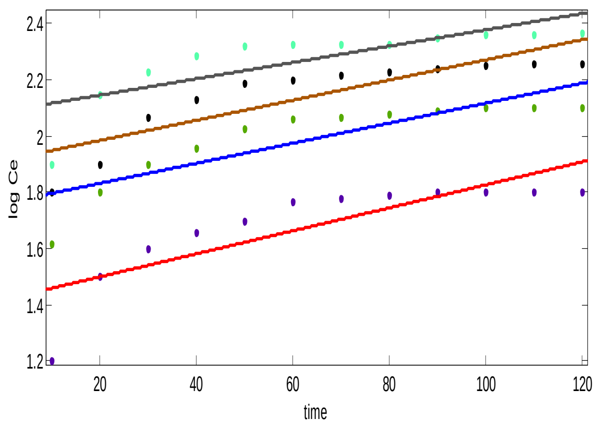

Fig.18a Pseudo first order model- Effect of different concentration of lead removal by *Ficus benghalensis* verses time

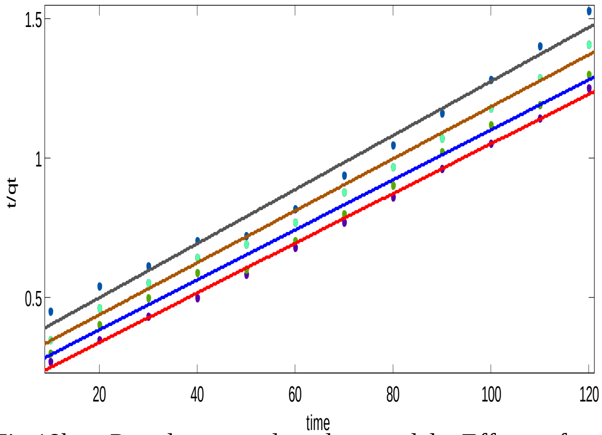

Fig.18b Pseudo second order model: Effect of different concentration of lead removal by *Ficus benghalensis* verses time

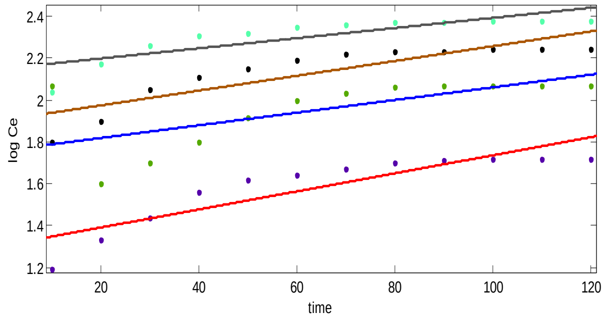

Fig.19a Pseudo first order model- Effect of different concentration of zinc removal by *Ficus benghalensis* verses time.

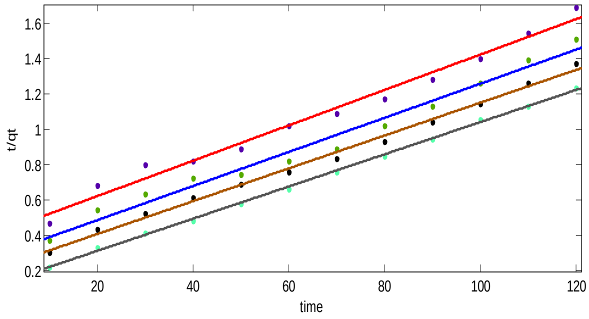

Fig.19b Pseudo second order model: Effect of different concentration of zinc removal by *Ficus benghalensis* verses time

TableXIX:Sorption Kinetics constant for lead and zinc adsorption by different doses of Ficus benghalensis verses time.

Doses gm	Pseudo first order lead ion		r^2	Pseudo second order lead ion		r^2	Pseudo first order zinc ion		r^2	Pseudo second order zinc ion		r^2
	K_s	Q_e		K_1	h		K_s	Q_e		K_1	h	
0.75	0.008	15.17	0.99	98.81	0.0003	0.99	0.002	17.7	0.81	84	0.0004`	0.98
1	0.005	22.3	0.70	96.24	0.0005	0.98	0.005	42.2	0.83	94.07	0.0004	0.90
2	0.004	107.6	0.77	98.42	0.0008	0.99	0.003	108.1	0.86	99.8	0.0006	0.99
3	0.004	186.2	0.88	101.9	0.0011	0.99	0.003	190.5	0.75	104.1	0.00009	0.99

Pseudo second order kinetics explains the adsorption of lead and zinc by different doses of Ficus benghalensis verses time. Good correlation coefficient supports it.

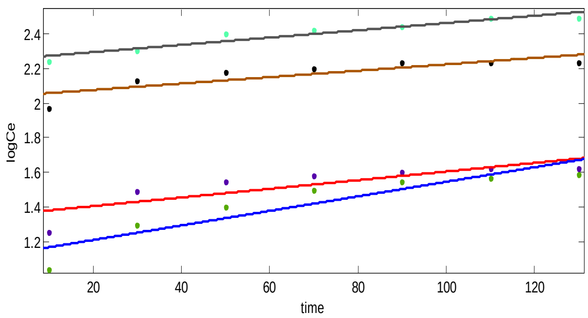

Figure:20a Pseudo first order model- Effect of different doses of *Ficus benghalensis* for removal of lead verses time

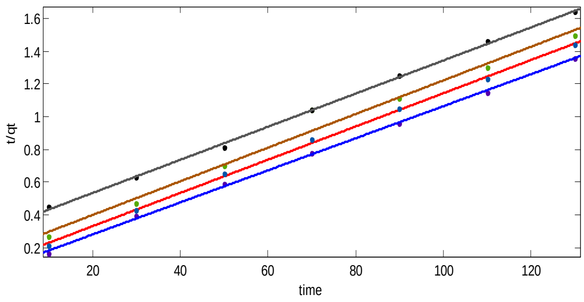

Figure:20b Pseudo second order model- Effect of different doses of *Ficus benghalensis* for lead removal verses time

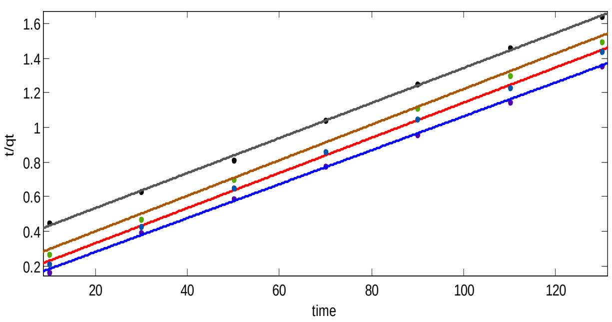

Fig. 21a Pseudo First order: Effect of different doses of *Ficus benghalensis* for zinc removal verses time

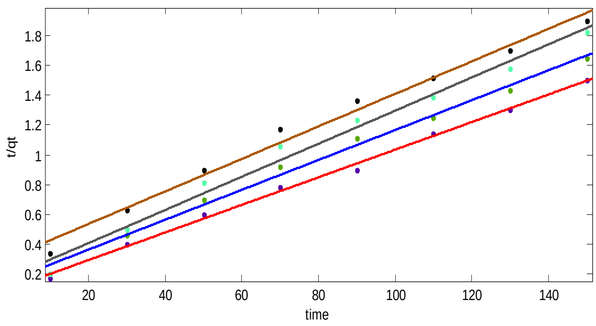

Fig. 22b Pseudo second order model- Effect of different doses of *Ficus benghalensis* for zinc removal verses time

IV. CONCLUSION

Cajanus Cajan and Ficus benghalensis is considered as an effective and efficient bioadsorbent for the removal of lead and Zinc ions from wastewater. It was observed that the suitable pH for the removal is 6 .The value of correlation coefficient for lead ions were higher for Langmuir adsorption isotherm which indicates monolayer adsorption takes place.On the other hand for the Zinc ions follows Freundlich sorption isotherms. The best correlation coefficient for lead ions was obtained by Pseudo second order reaction for concentration and doses with respect to time and zinc ions by pseudo second order for concentration and for doses. The removal of lead and zinc ions take place at low pH more effectively which was observed when treated with dithiozone. Dark colored at pH 6. For Ficus Benghalensis follows Freundlich adsorption isotherm for different concentration as well as for different doses. But for sorption kinetics it follows Pseudo second order for different concentration as well as well as different doses.

IR spectra, NMR spectra, XRD spectra explained that there are many functional group such as –COOH, -OH ,-CHO, aliphatic hydrocarbon which increase the process of bioadsorption at low pH and follows Langmuir and Freundlich adsorption isotherms and pseudo second order kinetics . The data thus useful in designing an efficient treatment plant for lead and zinc ions from wastewater by Cajanus cajan and Ficus benghalensis. These bioadsorbents are chosen for the metal removal because they are easily available, biodegradable,cheap, ecofriendly, efficient and effective.

Bioadsorbent	**Cajanus cajan**		**Ficus benghalensis**	
Metal ions	**Pb(II) ions**	**Zn(II) ions**	**Pb(II) ions**	**Zn(II) ions**
ph	6	6	6	6
Sorption Isotherm				
Concentration	Langmuir Isotherm	Freundlich Isotherm	Freundlich Isotherm	Freundlich isotherm
Doses	Freundlich Isotherm	Freundlich Isotherm	Freundlich Isotherm	Freundlich Isotherm
Sorption Kinetics				
Concentration	Pseudo First Order reaction	Pseudo Second Order reaction	Pseudo Second Order reaction	Pseudo Second Order reaction
Doses	Pseudo Second Order reaction	Pseudo Second Order reaction	Pseudo Second Order reaction	Pseudo Second Order reaction

V. ACKNOWLEDGEMENT

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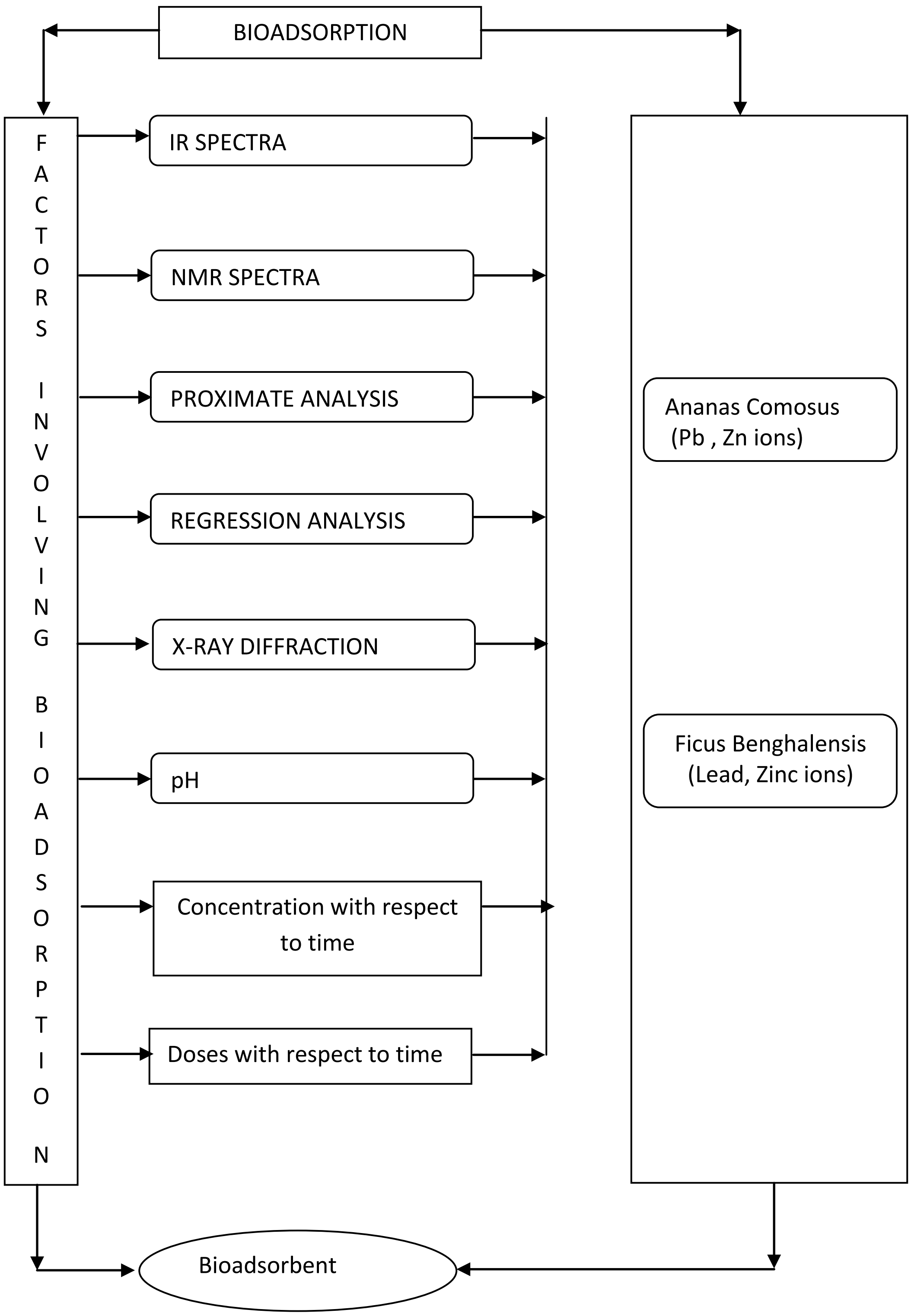
6. Schematic presentation for the process of bioadsorption



REFERENCE

[1] R. W. Gaikwad, Removal of Cd [II] from aqueous solution by activated charcoal derived from coconut shell, *EJEAF, Agric. Food Chem.*,2004, ISSN 1579-4377.

[2] Ning chuan, Fengb,Xueyi Guoa, Bioadsorption of heavy metals from aqueous solution by chemically modified orange peel,*Journal of hazardous material, Volume 185,*2011, 49-54.

[3] Meral Yurtsever, Bioadsorption of Pb (II)ions by quebracho tannin resin,*Journal of Hazardous materials*, *163*,2009, 58-64.

[4] Hala .Y.EI –Kassas and Eman M.El –Taher, Optimization of batch Process Parameters by response surface Methodology for Mycorhiza remediation of chrome –VI by a chromium resistant strain of Marine Trichoderma Viride, *American –EurasianJ.Agric.&Environ.Sci., 5(5):*2009, ISSN 1818 -6769.

[5] A. K. Bhattacharya, Adsorption ofZn (II) from aqueous solution by using different adsorbent,*Thermal Eng .,123*, 2006, 43-5.

[6] B. Volesky, Z. H. Holan, Bioadsorption of heavy metals, *Biotechnology Prog*., 1995, 235-250.

[7] B. Volesky,Detoxification of metal bearing effluents bioadsorption for the next century.*Hydrometallurgy*,2001,59.

[8] N. Ahalya, Bioadsorption of heavy metals also review paper. *Res.J.Chem. Environment*, 2003, 71-79.

[9] K. K. Singh, Removal of lead from aqueous solution by agricultural waste maize bran,*Bioresource Technol., 97* , 2006, 2124-2130.

[10] Nuria Miralles, Cesar Valderrama, Ignasi casas, Maria Martinez, and Antonio Florida, Cadmium and lead removal from aqueous solution by Grape stalk waste: Modeling of a Fixed Bed column,*J.Chem.Eng*., *55*, 2010, 3548-3554.

[11] Zhen Wu, Hong Li, Jian Ming and Ghoul Zhao, Optimization of Adsorption of Tea Polyphenol into oat beta – Glucan using Response surface Methodology, *J.Agric.FoodChem.59*, 2011, 378-385.

[12] Juddith Kammerer, Reinhold Carle and Dietmar R., Kammre, Adsorption and Ion Exchange Basic Principles and their Application in Food Processing. *J.Agric. Food Chem.*, *59,* 2011, 22-42.

[13] M. M. Aslam, Removal of copper from industrial effluent by adsorption with economically viable materials,*EJEAF chemistry*, 3(2), 2011, ISSN 1579-4377.

[14] N. T. Abdel - Ghani, M. Hefny, G. A. F. El - Chaghaby, Removal of lead from aqueous solution using low cost abundantly available adsorbents, Int. *J. Environ. Sci. Tech.*,2007, 67 - 73.

[15] B. M. W. P. K. Amarasingh, R. A. William, Tea waste as a low cost adsorbent for removal of Cu and Pb from wastewater. *Chemical Engineering Journal*, Vol. – 132, 2007, 299 - 509.