STUDIES ON BIOSORPTION OF Pb(II) BY MAIZE STEM AND RICEHUSK POWDER

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ABSTRACT

Adsorption of heavy toxic metals by agricultural solid wastes has emerged as an alternative method of removal. Biosorption of Pb (II) has been studied by rice husk powder and maize stem powder at optimum pH, biosorbent doses, and contact time. Maximum percentage removal has been recorded at pH 7. With an increased dose of maize stem powder and rice husk powder, enhanced biosorption took place. A comparative study of biosorption by maize stem and rice husk powder revealed that maize stem powder had been found more suitable than rice husk powder at pH 7. Furthermore, the effect of contact time on the adsorption of Pb(II) has been studied both by maize stem and rice husk powder. The equilibrium concentration of Pb(II) has been attained in 60 minutes and showed the best fit in the first-order reaction and Langmuir adsorption model. SEM images before adsorption and after adsorption confirmed the insertion of Pb(II) ions onto the surface of biosorbents.

Keywords: Biosorption, SEM Image, Pb (II), Maize Stem, Rice Husk.

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INTRODUCTION

Heavy metal contamination in groundwater has become a matter of grave concern among researchers. Some of the important heavy metals known for their toxicity are chromium, lead, cadmium, and mercury.¹⁻⁴ Lead is a very prominent toxicant which at very low concentrations causes brain damage in children.^{5,6} High levels of lead in the environment cause health risk to living beings. Adverse health effects of Pb(II) ingestion over prolonged duration are kidney damage, anaemia, and even carcinogenic.⁷ Prolonged exposure to Pb(II) causes neurotoxicity like Aluminium.⁸ Chemical precipitation, ion exchange, reverse osmosis, and electrolysis are some of the processes available for the removal of heavy metals from an aqueous medium. Still, efforts are going on to develop low-cost affordable methods of removal in the larger interest of the large chunk of the population. This paper deals with the study of the removal of Pb(II) from an aqueous medium by maize stem powder and rice husk powder in the laboratory at optimum pH, temperature, and adsorbate dose.

Maize stem powder contains fiber and lignin. In the stem portion of the plants, high content of lignin is present along with a small amount of crude protein and lipid. The stem is the main part of the maize plant which has more cellulose and lignin content than the leaves of the plants. The functional groups present in the chemical constituents on the surface of the powder are available for the adsorption of heavy toxic metals. Thus, the surface morphological components contribute to adsorption.^{9,10} Rice husk powder consists of 50% cellulose, 25-30% lignin, and 15-20% silica like other biomass materials.¹¹

Rice husk is also used due to its abundance in the local area of Bhagalpur district. The potential of rice husk and maize powder has been used as adsorbents for removal of Pb(II) from the aqueous medium as traditional methods are economically unfit.¹² Particle size has been fixed at 300 mesh sieve. One of the advantages of removal by agricultural wastes is that disposal problems are also solved and the competitiveness of maize stem and rice husk for removal of Pb(II) from aqueous medium has also been examined.

EXPERIMENTAL

Adsorbent

The rice husk has been collected from a local farmer after the preparation of rice from paddy. Collected rice husk is washed with double distilled water to remove water-soluble impurities and then dried in an oven at 60°C. Maize stems have been collected from the local maize stem field, washed several times, and powdered to a fine mass after drying in an oven. Particle sizes of 300 mesh sieve have been prepared with the help of mesh sieve available in the laboratory.

Reagent and Solution

100 ppm Pb (II) solution has been prepared by weighing lead nitrate and dissolving in 1 liter of double-distilled water. Solution of desired strength of 4 ppm has been prepared by dilution.

0.01% dithiozone reagent is prepared. Lead forms a pink complex, lead dithizonate with dithiozone in CCl_4 .

Method

100 ml 4 ppm Pb (II) solution is taken in a conical flask, 1 gm powder of maize stem is added to the flask and agitated on a magnetic stirrer upto 1hr, 2 hrs and 3hrs. Residual concentration after different time intervals has been measured by U.V double beam spectrophotometer pharo 300. The reagents for these tests for Pb(II) have also been supplied by Merck company known as merckoquant kit. Similar experiments have been repeated with rice husk powder at pH7. Residual concentrations have also been measured by spectrophotometer.

RESULTS AND DISCUSSION

Effect of Contact Time

The biosorption of Pb(II) ions by maize stem powder and rice husk powder has been studied upto different time intervals at pH7. 4 ppm of Pb (II) solution when treated with 1gm maize stem powder, residual concentrations were 0.017, 0.016 and 0.015 at 1 hour, 2 hours and 3 hours respectively (Table-1). The removal percentage was 99.7% (Fig.-1). Maximum percentage removal on treatment with 1 gm rice husk powder up to 3 hours is 94.50% (Fig.-2). Similarly, 4 ppm Pb (II) concentration after treatment with 1 gm rice husk powder upto 3 hours have a maximum percentage of 99.5 % (Fig.-4). The residual concentrations are 0.340 ppm, 0.316 ppm, and 0.228 ppm at 1 hour, 2 hours, and 3 hours, respectively on treatment of 100 ml 4 ppm Pb(II) solution with 1 gm rice husk powder (Table-2). Studies reveal that amount of metal ion adsorption increased with an increase in contact time as more surface area becomes available for adsorption.¹³⁻¹⁵

Table-1: Concentration of 100 ml 4 ppm Pb(II) after treatment with 1 gm maize stem powder.

Initial Concentration	Time	Residual Concentration	% Removal	q_t	$\log q_t$	$\log C_t$	C_t/q_t
4 ppm	1 hour	0.017	99.5	0.398	- 0.4001	- 1.7695	0.04271
4 ppm	2 hour	0.016	99.6	0.398	- 0.4001	- 1.7958	0.04020
4 ppm	3 hour	0.015	99.7	0.399	- 0.4001	- 1.8239	0.03759

Fig.-1: Percentage Removal of Pb(II) after Treatment with 1 gm Maize Stem Powder

Table-2: Concentration of 100 ml 4 ppm Pb(II) after Treatment with 1 gm Rice Husk Powder

Initial Concentration	Time	Residual Concentration	% Removal	q_t	$\log q_t$	$\log C_i$	C_i/q_t
4 ppm	1 hour	0.340	91.5	0.366	- 0.4365	-0.4685	0.9289
4 ppm	2 hour	0.316	92.1	0.368	- 0.4341	-0.5003	0.8586
4ppm	3 hour	0.228	94.5	0.377	- 0.4236	-0.6420	0.6047

Fig.-2: Percentage Removal of Pb(II) after Treatment with 1 gm Rice Husk Powder

The Effect of Biosorbent Dose

The effect of biosorbent dose on Pb(II) removal has been studied with 1 gm, 2 gm, 3gm of maize stem powder, and rice husk powder for upto 1 hour. From Table-3 and 4 it has become clear that removal efficiency increases with an increase in biosorbent dose. But a decrease in removal percentage has been observed when 100 ml 4ppm Pb(II) solution is treated with 3gm adsorbent upto 1hour (Fig.-3 and 4). The decrease in removal percentage may be attributed to the release or desorption of some Pb(II) with increased biosorbent dose.

Percentage removal has been determined from the formula:

$$\text{Percentage removal} = \frac{C_i - C_t}{C_i} \times 100$$

Where C_i is the initial concentration, C_t is the concentration at time t

Table-3: Concentration of 100 ml 4 ppm Pb(II) Ion after Treatment with Different Masses of Rice Husk Powder

Initial Concentration	Time	Weight	Residual Concentration	% Removal
4 ppm	1 hour	1 gm	0.340	91.5
4 ppm	1 hour	2 gm	0.35	91.25
4 ppm	1 hour	3 gm	0.42	89.5

Table-4: Concentration of 100 ml 4 ppm Pb(II) Ion after Treatment with Different Masses of Maize Stem Powder

Initial Concentration	Time	Weight	Residual Concentration	% Removal
4 ppm	1 hour	1 gm	0.017	99.5
4 ppm	1 hour	2 gm	0.309	92.5
4 ppm	1 hour	3 gm	0.463	88.4

Fig.-3: Percentage Removal of Pb(II) after Treatment with Different Masses of Rice Husk Powder

Adsorption Isotherm

The analysis of experimental data has been done to see a fit of the Freundlich and Langmuir adsorption isotherms (Fig.-5,6 and 7). Freundlich isotherm applies to multilayer adsorption whereas Langmuir refers to monolayer adsorption.¹⁶⁻¹⁸ A plot of C_t/q_t against C_t for maize stem powder and rice husk powder show Langmuir adsorption isotherm. q_t is calculated as-

$$q_t = (C_i - C_e) / m \times V$$

where m is the mass of adsorbent and V is the volume in liters.

When $\log q_t$ is plotted against $\log C_t$, it applies to Freundlich adsorption isotherm.¹⁹⁻²¹

Fig.-4: Percentage Removal of Pb(II) Ion after Treatment with Different Masses of Maize Stem Powder

Fig.-5: Langmuir Isotherm of Pb(II)-Maize Stem Powder System at 26°C and pH 7

Fig.-6: Langmuir Isotherm of Pb (II)- Rice Husk Powder System at 26°C and pH 7

Fig.-7: Freundlich Isotherm of Pb(II)- Rice Husk System at 26°C and pH 7

SEM Images

SEM images analyze microstructure morphology and microstructure.(Fig.-8 and Fig.-9) So high-resolution images of particles at different magnifications before and after adsorption confirm that adsorption of lead (II) on the surface has taken place.^{20,21}Involvement of surface groups e.g hydroxyl, carboxylic takes place in the adsorption.

Fig.-8: Sem Image before Adsorption

Fig.-9: Sem Image after Adsorption

CONCLUSION

Rice husk and maize stem waste biomass are abundant in this region. So these agricultural solid wastes have been chosen as an adsorbent for the removal of Pb(II) from an aqueous solution. From the tables and graphs, it has become clear that Langmuir adsorption isotherm is a better fit for adsorption of Pb(II) onto the surface of rice husk and maize stem powder at pH 7 and 26°C. Maize stem powder and rice husk powder both have been established as potential adsorbents of Pb(II). But maize stem powder has better removal efficiency than Pb(II). Maximum removal percentage of 99.7% or almost complete removal has been recorded with 1gm of maize stem powder after treatment with 100 ml 4 ppm Pb(II)solution upto 3 hours. Thus, it may be concluded that the selected adsorbent is inexpensive, effective, and feasible.

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