Adsorptive removal of chromium using rice husk and maize stem powder

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Abstract- The mutagenic and carcinogenic properties of hexavalent chromium required the need of remedial measures using rice husk and maize stem powder to avoid high cost involved in traditional methods. Agriculture bye products and wastes have been exploited for remediation of Cr (vi) in order to know the feasibility of biosorption . Carboxylic acid group, hydroxyl group, lignin and carbohydrate present in rice husk and maize stem increase the adsorption potential for Cr (vi). 2 ppm initial concentration of Cr(vi) is treated with 1 gm rice husk upto 1 hour, 2 hours and 3 hours and 2 gm and 3 gm rice husk up to 1 hour decreased the concentration up to a minimum of 0.13 ppm while in case of maize stem powder the equilibrium concentration was 0.247 ppm at pH 7.00. Langmuir adsorption isotherms has been tested from available data. Adsorptive removal of Cr(vi) follows first order kinetics.

Keywords – Chromium (vi), Remediation, Carcinogenic, Langmuir, Rice husk.

I. INTRODUCTION

Carcinogenic properties of hexavalent chromium has drawn the attention of researchers worldwide.Chromium(vi) more than permissible limit in drinking water causes liver cancer and other health problems due to its high toxicity1-2 . The source of Cr(vi) in aqueous medium is both from chromite ore, industries and anthropogenic wastewater discharged from industries, leather tanning chrome plating and use as an anticorrosive agent are causing damage to the living organisms in water bodies. At pH 4-6, chromium is present in water as HCrO4-. Traditional methods of removal of Cr(vi) from aqueous medium are already in practice3-.5 Necessity of innovative method arose due to easy handling, low cost and abundance in nature6. The ability of bentonite minerals as a potential adsorbent of Cr(vi) has been established7. High cation exchange capacity and large surface area of bentonite explain adsorption of heavy metals. Adsorption potential of dead biomass have been studied extensively as available in literature8. Attempts have been made to study different agriculture bye products and wastes for removal of Cr(vi) from aqueous medium9-11. Adsorption of heavy metals depends mainly on ionic interaction on the Surface, surface area, presence of functional group in the agriculture wastes. Polysaccharides e.g starch, cellulose and lignin are present in agriculture byeproducts. Among functional groups carboxylic (-COOH) and hydroxyl (-OH) groups are present along with amines. Adsorption by rice husk and maize stem powder may be explained due to the presence of polysaccharides, lignin and -COOH groups onto the surface. It is a well known fact that carboxyl, hydroxyl, phosphates and amino groups have the capacity to bind with metals12. Keeping in mind these properties and abundance, rice husk and maize stem powder have been selected for study. Rice and maize are the crops extensively grown by the farmers of this area. After the crop is harvested, rice husk is the waste which can be utilized for adsorption13. Two varieties of maize plants are planted and after the harvest maize stems are utilized for adsorption.

In addition to this, a number of biomass from agriculture products are available. Adsorption onto the surface of powdered biomass takes place either in a monolayer or multilayer. Freundlich adsorption isotherm is applicable to multilayer adsorption while Langmuir adsorption isotherm is applicable to monolayer adsorption14.

Adsorption depends on pH, temperature and surface area So it becomes necessary to study adsorption at different pH15-17 values keeping in mind the suitability and optimum. conditions of adsorption. The percentage removal of Cr(vi) and amount adsorbed in mg /g can be calculated as

Percentage Removal = $\frac{ci-ce}{ci} \times 100$ Where, Ci = Initial Concentration , Ce = Equilibrium Concentration

$qt = \frac{ci-ct}{M} \times V$ Where, m = mass of adsorbent, V= volume in litre

II. EXPERIMENTAL

Rice husk is collected from the rice mill and maize stems from the maize field. They are repeatedly washed with deionised water, dried and powdered up to 300 mesh sieve. 1000 ml 2ppm Cr(vi) solution is prepared and 100 ml of this solution is treated with 1 gm rice husk and maize stem powder up to 1 hour, 2 hours and 3 hours. Same experiment is repeated with different masses upto a fixed interval of time . Residual concentration of Cr(vi) is measured spectrophotometrically by U.V double beam spectrophotometer 300. F.T.I.R of the rice husk before and after treatment has been done from 4000-500 cm-1 on F.T.I.R spectrometer. Anhydrous KBr is used as pellet material.

III. RESULT AND DISCUSSION

It has become clear from the data that 93.5 % removal of Cr(vi) takes place with 1gm rice husk treated with 100 ml 2 ppm solution at pH 7. At pH 7, removal percentage is 87% when 100 ml 2 ppm Cr(vi) solution is treated with 1 gm maize stem up to 3 hours At pH 4 percentage removal is up to 79% with rice husk. FTIR of rice husk before and after treatment has been done. S1 and S2 stand for FTIR of rice husk and maize stem before treatment whereas S3 and S4 stand for FTIR of rice husk and maize stem after treatment respectively. Analysis of FTIR peaks of S1(ricehusk) clearly shows the peaks at 3340.67 cm-1 , 2025.3 cm-1, 1731.78 cm-1,1635.03 cm-1 indicating N-H stretching vibration, primary and tertiary alcohol group, long chain alcohol showing O-H stretching vibrations around 3448 cm-1 . It may be concluded that bands at 3300-3500 cm-1 shows the presence of alcoholic, phenolic or acidic OH with hydrogen bonding. The peak at 2025.30 cm-1 shows the presence of CαC group. Ketone or aldehyde around 500-1 cm may be present. These results indicate that the theoretical values for rice husk agree with the experimental values. Rice husk being an organic compound contains certainly aldehyde or ketone, carboxylic groups and hydroxyl groups.

Table-1 : Concentration of 100 ml 2 ppm Cr6+ ion after treatment with 1 gm rice husk at pH 7

Initial concentration	Time	Residual concentration(Ct)	% removal	qt	log qt	log Ct	Ct/qt
2ppm	1 hour	0.140	93%	0.186	-0.7304	-0.8538	.7526
2ppm	2 hour	0.130	93.5%	0.187	-0.7281	-0.8860	.6951
2ppm	3 hour	0.130	93.5%	0.187	-0.7281	-0.8860	.6951

Table – 2 : Concentration of 100 ml 2 ppm Cr6+ ion after treatment with different masses of rice husk for 1 hour.

Initial concentration	Time	Weight	Residual concentration
2 ppm	1 hour	1 gm	0.140
2 ppm	1 hour	2 gm	0.130
2 ppm	1 hour	3 gm	0.130

Table-3 Concentration of 100 ml 2 ppm Cr6+ ion after treatment with 1 gm maize stem at pH 7

Initial concentration	Time	Residual concentration(Ct)	% removal	qt	log qt	log Ct	Ct /qt
2ppm	1 hour	0.29	85.5%	0.171	-0.7670	-0.5376	1.695
2ppm	2 hour	0.27	86.5%	0.173	-0.7619	-0.5686	1.560
2ppm	3 hour	0.26	87%	0.174	-0.7594	-0.5850	1.494

Table – 4 Concentration of 100 ml 2 ppm Cr6+ ion after treatment with different masses of maize stem for 1hour at pH 7

Initial concentration	Time	Weight	Residual concentration	% Removal
2 ppm	1 hour	1 gm	0.29	85.5%
2 ppm	1 hour	2 gm	0.24	88%
2 ppm	1 hour	3 gm	0.24	88%

Table – 5 Concentration of 100 ml 2 ppm Cr6+ ion after treatment with different masses of rice husk at pH 4

Initial concentration	Time	Weight	Residual concentration	% Removal
2 ppm	1 hour	1 gm	0.45	77.5%
2 ppm	1 hour	2 gm	0.43	78.5%
2 ppm	1 hour	3 gm	0.42	79 %

Table – 6 : Concentration of 100 ml 2 ppm Cr6+ ion after treatment with different masses of maize stem at pH 4

Initial concentration	Time	Weight	Residual concentration	% Removal
2 ppm	1 hour	1 gm	0.37	81.5 %
2 ppm	1 hour	2 gm	0.35	82.5 %
2 ppm	1 hour	3 gm	0.34	83 %

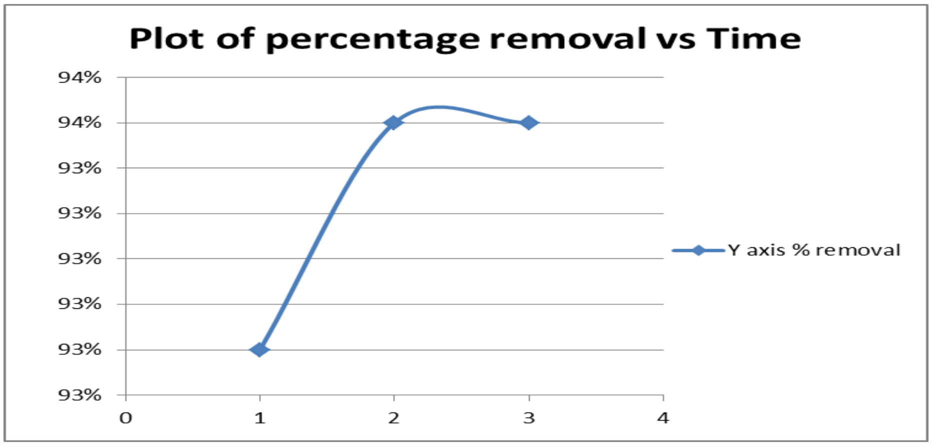

Figure – 1 : Percentage removal of Cr6+ vs time

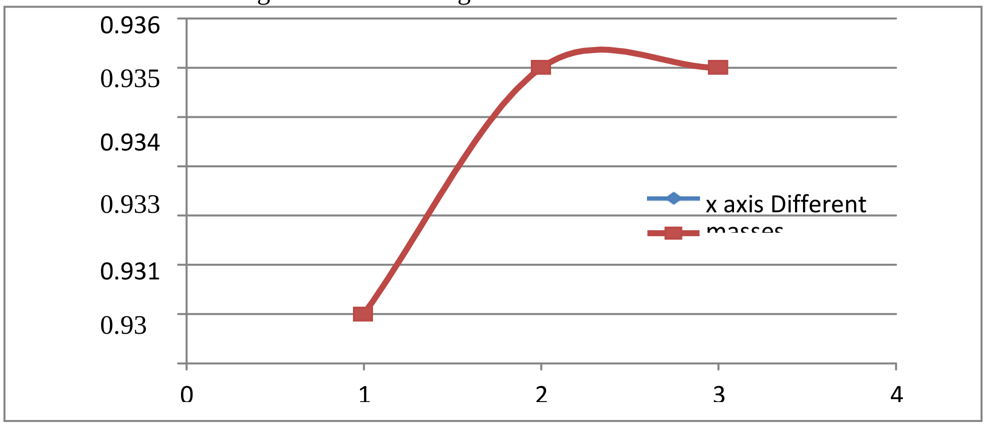

Figure 2 : Percentage removal of Cr6+ Vs different masses .

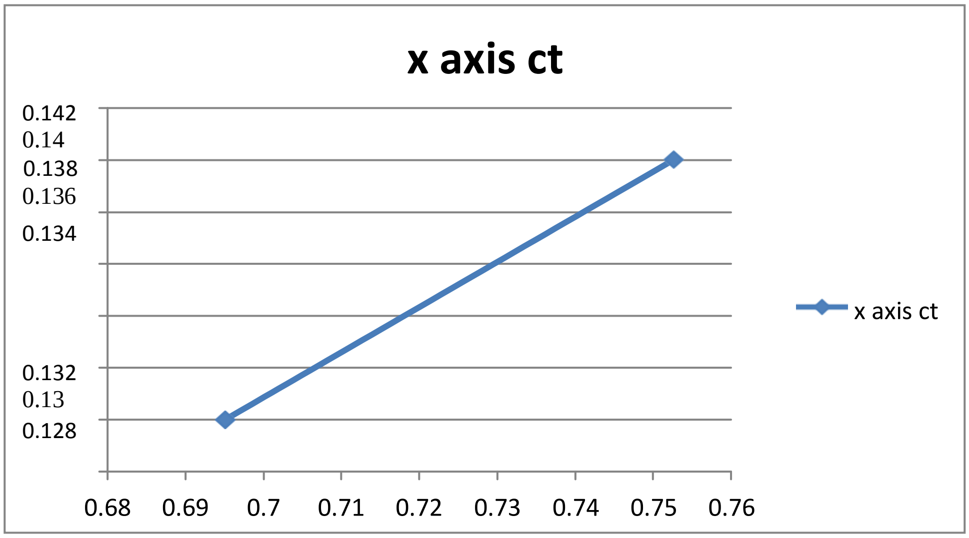

Figure-3 Plot of Ct /qt Vs Ct

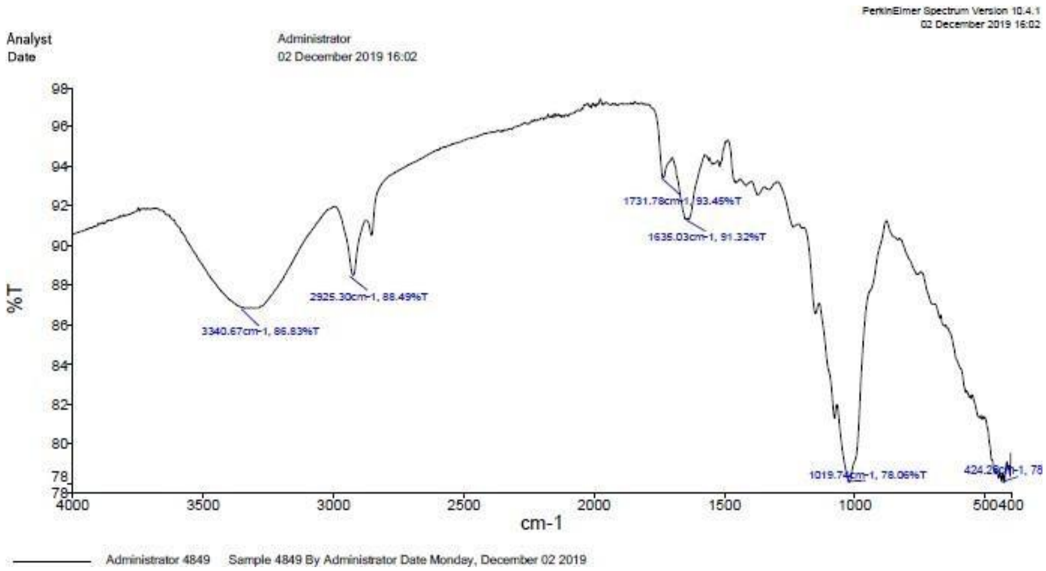

Figure 4 : FTIR of rice husk

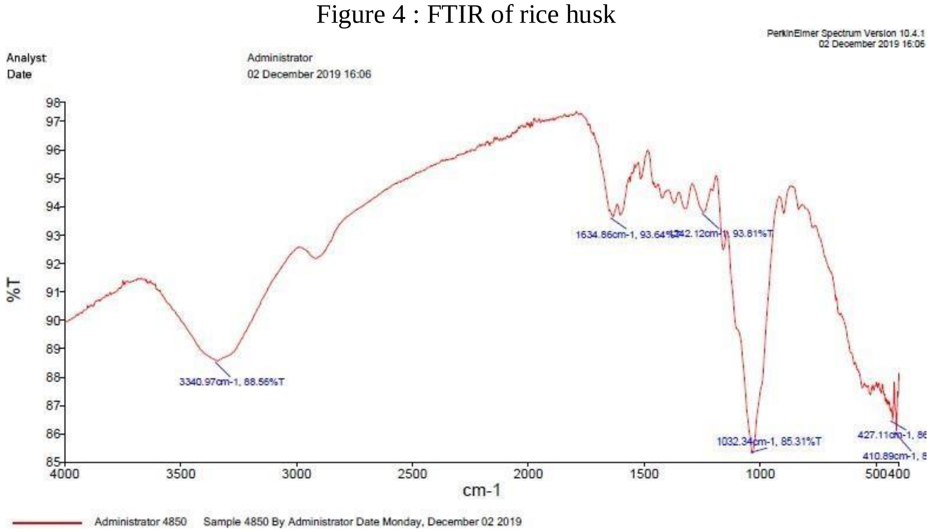

Figure 5 : FTIR of maize stem powder

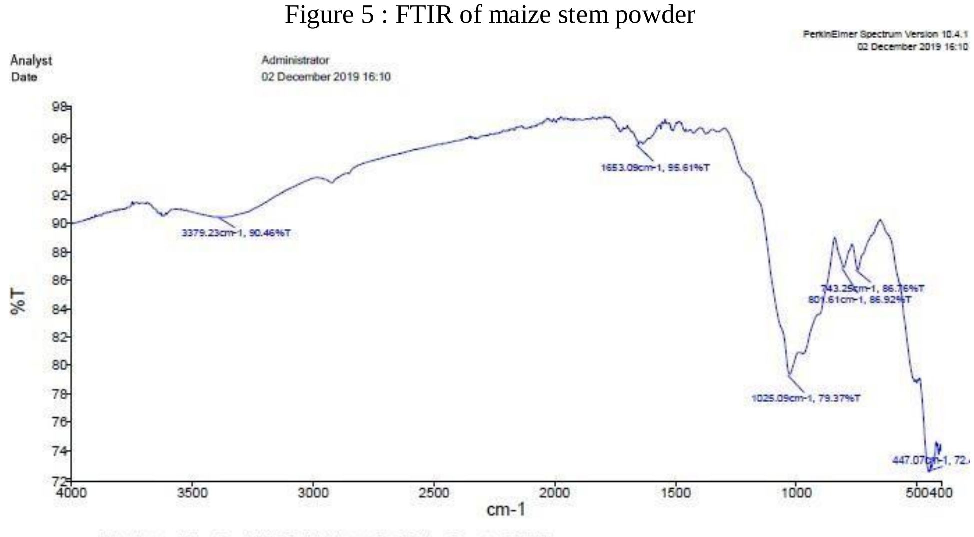

Figure 6 : FTIR of rice husk after adsorption

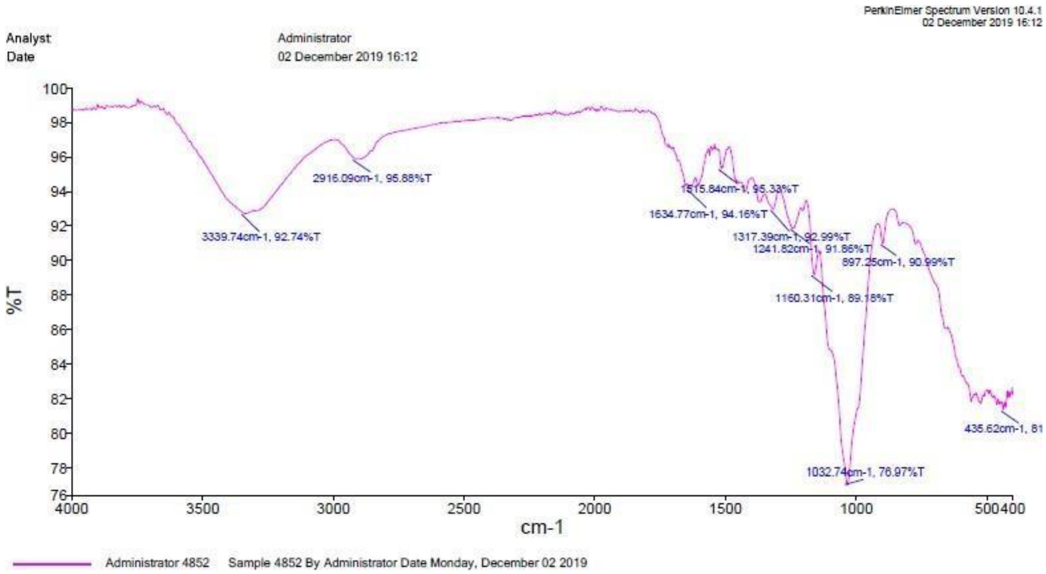

Figure 7 : FTIR of maize stem powder after adsorption

Peaks of rice husk in I.R after treatment show that adsorption has taken place.Shifts in peaks of I.R clearly indicate adsorption. FTIR of maize stem also indicates the presence of alcoholic, aromatic and acidic OH with hydrogen bonding. After the adsorption has taken place on the surface of surface of maize stem, the peaks changed. The trends in the FTIR suggest that adsorption has taken place on the surface of maize stem. Active functional sites and functional groups are on the surface of rice husk and maize stem powder. The shifts in percentage transmittance in FTIR before and after adsorption in the range of 4000 cm -1to 500 cm-1 indicate sorption of chromium. Figure 1,2 show percentage removal of Cr(vi) vs time and figure- 3 represents plot of Ct /qt vs Ct. Linearity of the graph shows that monolayer adsorption takes place on the surface and thus Langmuir adsorption isotherm is followed.

IV. CONCLUSION

Results reveal that rice husk powder is more efficient for removal of Cr(VI) at pH7 and so rice husk may be used as an alternative for bioremediation . Linearity of the graph between Ct /qt and Ct shows that monolayer adsorption takes place on the surface and thus Langmuir adsorption isotherm is followed.

V. REFERENCES

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