Adsorption of Mercury (II) Ions from Aqueous Solution by Activated Carbon Prepared from Morinda Citrifolia

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Abstract:-Mercury is one of the toxic contaminant in the environment and a major concern in world wide.In this paper the use of morinda citrifolia bark as adsorbent for the removal of Hg(II) ions from aqueous solution in the batch system was studied . Acid treated activated carbon (AMC) was investigated for the removal of Hg(II) from aqueous solution as batch experiments by varying initial concentration, adsorbent dosage, pH, equilibrium time and temperature. A maximum removal of 92% was achieved with an initial Hg (II) concentration of 2 mg/L, pH -5 and adsorbent dose of 0.8 g/ L. The obtained experimental data were fitted to Langmuir and Freundlich equilibrium isotherm models. Both the models were found to provide a better fitting with coefficient of regression .

Keywords:-*Activated carbon, Hg (II), morinda citrifolia bark, adsorption isotherms*

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1. INTRODUCTION

Heavy metal pollution in waste water has always been a serious environmental problem, because heavy metals are not biodegradable and can be accumulated in living tissues [1]. Rapid industrialization has seriously contributed to release of toxic heavy metals to water streams. . Most of the heavy metal containing effluents pollute the water bodies. Some heavy metals are necessary for the growth of plants, beyond certain concentrations become lethal to flora, fauna and microbes. Thus, bioaccumulation leads to food poisoning in human beings and animals. Presence of heavy metals in the aquatic environment has been of great concern to scientists and engineers because of their increased discharge, toxic nature and other adverse effects. Therefore, removal of heavy metals becomes mandatory. Moreover, it was observed that among all the heavy metal ions, Hg (II) stands on the top of toxicity severity list.[1] In addition to it, one of the dominant problems of Hg (II) is bioaccumulation in food chain.[2] It also leads to greater risk of chronic poisoning of endocrine system, reduced fertility, slower growth and development, and abnormal behavior that affects survival,[3,4] even if environmental levels are not very high. Industries responsible for the discharge of mercury include paints, pulp and paper, oil refining, electrical, rubber processing, and fertilizer.[10] According to the USA's Environmental Protection Agency, permissible limit of mercury in wastewater is 0 mg/L, and for Bureau of Indian Standards, it is 0.01 mg/L. Hence, the removal of mercury from the aquatic environment has become a great concern. Hence, adsorption with low-cost adsorbents has been widely used for removal of heavy metals from wastewater. Owing to its better selectivity and regeneration capacity, it could be a better alternative [5] to replace the widely used commercial activated carbon. In addition, they are cheaper and prepared from an alternative material like agricultural waste, bio-waste, etc. Low-cost sorbents prepared from morinda citrifolia studied extensively to remove Hg (II) by adsorption.

2. MATERIALS AND METHODS

2.1. Preparation of sulphuric acid treated carbon from morinda citrifolia bark (AMC)

Approximately 500g of air dried wood powder is prepared by grinding, to this 50 ml of concentrated sulphuric acid is added to 150g then allowed to mechanical sieving machine, manufactured by Jayanth scientific Industries Mumbai. The black product was formed, and it is kept at 300^{o}C for 12 hours followed by washing with water untill free from excess acid and dried at 150 $^{-+}$ 5^{o}C. The carbon product was grind to get 0.75µm - 150µm and sieved in same mechanical seiver placed in air tight container. The various physio-chemical characteristics of AMC were determined by adopting standard procedures.

2.2. Mercury determination

A sample solution containing residual of Hg(II) ions was mixed with 1ml of potassium iodide solution , 5 ml of acetate buffer (pH 4.5), 2ml of rhodamine B,solution and 1ml of freshly prepared gelatin solution. The solutions were mixed thoroughly well and diluted to the mark in 25-mL volumetric flasks with double distilled water .The absorbance of the samples is measured in 10-mm cell at 552 nm against blank. Concentrations of Hg(II) were determined by finding out the absorbance at the characteristic wavelength using a UV/Vis spectrophotometer.

2.3.Chemicals

All the chemicals used were of analytical reagent grade. Double distilled (DD) water was used throughout the experimental studies.

2.4 .BATCH ADSORPTION EXPERIMENT

Adsorption experiments were performed in batch mode for acid treated morinda citrifolia carbon (AMC). A stock solution 1000 mg/L Hg (II) ions was prepared by dissolving 0.3385g of mercuric (II) chloride in distilled water and diluted to 250ml, further Experimental solutions of the desired concentrations were obtained by successive dilutions with distilled water, all the experiments were conducted using 250ml Erlenmayer flask with 50ml of Hg(II) solutions by adding known weight of the adsorbent (AMC). The mixture were agitated in a mechanical shaker with 225 rpm, manufactured by macro scientific works, Jawaharlal Nagar, Delhi-7. The pH of the solution adjusted by 1M HCl & NaOH and pH was measured with a systronics digital pH meter using a combined glass electrode samples were withdrawn at appropriate time intervals and filtered through whatman 40 filter paper. The residual concentration of mercury was determined by spectrophotometer.

3. RESULT AND DISCUSSION

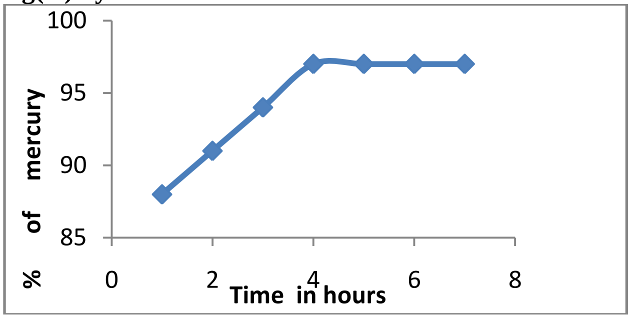
3.1. EFFECT OF INITIAL CONCENTRATION

The effect of initial Hg (II) concentration in the range of 2 to 25 mg/L on AMC bark adsorption investigated under the normal room temperature , contact time of 6 hours, adsorbent dosage of 0.5mg/50 ml. It is seen that the removal of Hg (II) dependent on initial concentration of Hg (II). The percentage of Hg (II) removal decreases from 2mg/lit to 25mg/lit as the metal ion concentration increases.

3.2.EFFECT OF CONTACT TIME

Effect of contact time for the removal of Hg (II) shown in figure.1 using AMC was studied at 2mg / L initial Hg(II) concentrations. The adsorbent dosage of 0.5g/50 ml of adsorbate in order to determine the equilibrium time for maximum adsorption capacity. The results indicate that the rate of Hg (II) removal progressively decreased, and it reach the equilibrium adsorption. Therefore, the equilibration time was set conservatively at 6 hours for further experiments. The adsorption rate was first initially increases, the extent of ion uptake decreases significantly by increasing the contact time, depending on the reduction rate of vacant sites on the adsorbent surface. The adsorption curve with respect to time indicates the possible monolayer coverage of Hg (II) on outer surface of adsorbent.

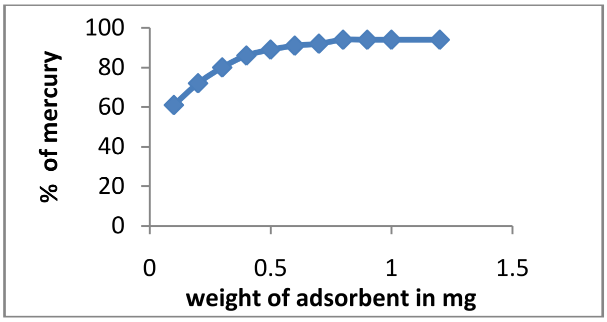
Fig.1 Effect of Contact Time on the adsorption of Hg(II) by AMC



3.3.EFFECT OF ADSORBENT DOSAGE

Effect of adsorbent dosage on adsorption of Hg (II) is studied by changing the adsorbent dosage from 0.1g to 1.5 g, as shown in the figure.2. The various doses consisting of 0.1 g to 1.5 g/50 ml of the adsorbent is mixed with the Hg (II) and the mixture was agitated in a mechanical shakers. The percentage of adsorption for different doses was determined by keeping other factors constant

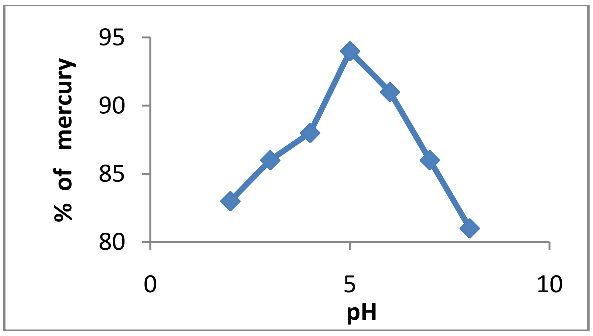
Fig.2 Effect of adsorbent dose on adsorption of Hg (II) by AMC



3.4.EFFECT OF pH

Figure.3 represents the effect of pH on the removal of Hg (II) by AMC. It is clear that AMC is effective for the removal of Hg (II) over the pH range 2-8 .The pH of the solution is an important controlling parameter in the heavy metal adsorption process. The experiments were carried out using 2 mg/L Hg (II) with 0.8g/50ml adsorbent mass at room temperature for 6 hrs. The experiment showed that the optimum pH was 5 for the adsorption of Hg(II) ions by AMC

Fig.3 Effect of pH on adsorption of Hg (II) by AMC



3.5.Adsorption isotherm

In the present work, the study of Langmuir and Freundlich isotherm models were used to describe the equilibrium data.The isotherm models describe the mono-component of mercury adsorption on activated carbon.. The parameters of each isotherm were listed in Table.1 along with the linear regression coefficients, R2 .Results showed Langmuir Freundlich that isotherm (fig 4&fig 5) best fitted with the equilibrium data higher than several others adsorbents and is good adsorbent for mercury removal from aqueous solutions. Studies of Langmuir isotherms indicated how sorbate distributes itself between the liquid phase and solid phase, the energy of absorption is constant. There is no migration of adsorbate molecules on to the phase. The model developed by Langmuir is given by the following linearized equation.

1/qe = 1/qm + (1/qmKL) (1/Ce) ------------------- [1]

qm & KL are the Langmuir constants represents the maximum adsorption capacity. Where constants b and Qm relate to the energy of adsorption and adsorption capacity and their values are obtained from the slope and intercept of the plot of 1/qe versus 1/Ce as shown in the figure6&7.The adsorption data obtained are best fitted to the Freundlich isotherm which is the earliest known relationship described by the following equation,

Log q_e = log K_f + 1/n log Ce --------------------------- [2]

Where, K_f and n are Freundlich constants which correspond to adsorption capacity of AMC adsorbent. The slope (1/n) and intercept (K_f) of a log, log plot of q_e vs Ce are determined. The results of both regressed isotherms are calculated from the graph value. The values of n are greater than one indicating the adsorption is favorable. Adsorption isotherms express the relation between the amount of adsorbed metal ions per unit mass of adsorbent (q_e) and the metal concentration in solution (C_e) at equilibrium. The data of sorption equilibrium in this work was tested with Langmuir, Freundlich and as expressed in Equations 1 & 2, respectively. The experimental data on the effect of an initial concentration of metal on the carbon of the test medium were fitted to the isotherm models and all of the constants are presented in Table .1

Fig.4 .Langmuir adsorption isotherm on the adsorption of Hg(II) by AMC

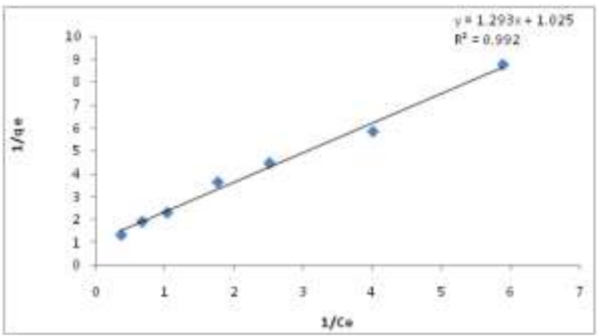


Fig.5.Freundlich adsorption isotherm on the adsorption of Hg(II) by AMC

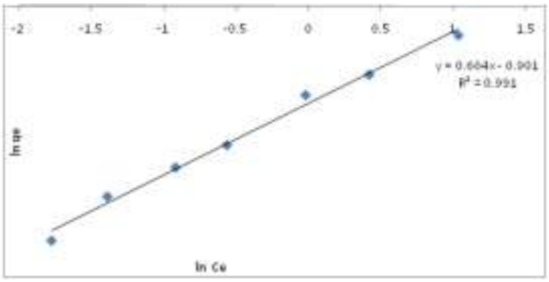


TABLE -1

Langmuir constants			Freundlich constants		
q_m mg/g	K_L	R^2	K_F	n	R^2
0.9756	0.7928	0.992	1.4062	1.5060	0.991

4. CONCLUSION

Activated carbon prepared from the morinda citrifolia is capable of removing Hg(II) effectively from aqueous solution. The percentage removal of metal ion adsorbed was found to vary marginally with initial solution pH, adsorbent dose, contact time and temperature. adsorption followed pseudo-second order model, first order model. The studied adsorption isotherm process best fitted with Langmuir, freundlich equilibrium model, the study revealed the potential of Acid treated morinda citrifolia activated carbon as a better alternative in removing heavy metals completely from waste water.

5. ACKNOWLEDGEMENT

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