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ADSORPTION AND REMOVAL OF ZINC (II) FROM AQUEOUS SOLUTION USING PEEPAL (*FICUS RELIGIOSA*) LEAF DERIVED CARBON

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Abstract-The present work is an attempt to determine the feasibility and reliability of Peepal (*Ficus religiosa*) Leaf Derived Carbon utilized as an adsorbent for the removal of zinc (II) from aqueous solution. The effects of solution pH, adsorbent dose, temperature, initial metal ionconcentration and contact time on the adsorption process with respect to the zinc (II) removal were investigated. The optimum conditions obtained were 30 min contact time, 0.8g adsorbent dose, 45 ^{0}C, 0.12M Zn and pH 7 for zinc removal. Experimental equilibrium data were analyzed by the Langmuir and Freundlich isotherm models. The results obtained from the experimental work showed that biomass carbon derived from peepal leaves are transformed into adsorbent for removing metal ions from the aqueous solution. Peepal leaf carbon show promising results in removing zinc (II) from aqueoussolution, thus this material could be used as low cost adsorbent to replace the expensive commercial activated carbon during adsorption process.

Keywords- biomass carbon, adsorption, zinc (II), peepal leaf, adsorbent

I. INTRODUCTION

Over the years, the percolation of heavy metals into the water bodies and ecosystem remain as one of the most elusive and pervasive environmental threat to the global occupants. Heavy metal ions are classified as priority pollutants based on their toxicity and mobility in natural water streams. Nevertheless, the heavy metal ions are stable and persistent to environment changes since they cannot either be degraded or destroyed [1]. The increment of industrialization has aggravated the situation due to the mass loading of highly concentrated metal ions containment effluent into the waterways.

To date, various treatment approaches have been applied by scientific community in order to decontaminate the water free from any heavy metal ions. These methods including adsorption, complexation, chemical oxidation or reduction, chemical precipitation, reverse osmosis, ion exchange, solvent extraction, membrane filtration, coagulation, phytoextraction and evaporation [2]. Adsorption is one of the most cost-effective methods due to its ease to operate, high efficiency and low maintenance cost whereas other treatment alternatives may have some disadvantages such as high consumption of reagent and energy, incomplete metal removal, low selectivity, high operational cost and problem in disposing the secondary waste generated during the treatment process [2]. Activated carbon has been the most respective and widely used adsorbent but it is relatively expensive in price. Therefore, this scenario has prompted the exploration of low cost adsorbent to be used as replacement for activated carbon.

The feasibility and reliability of lignocellulosic biomass, natural clay minerals and biological-based materials used as low cost adsorbent has been evaluated by many researchers. These materials including sugarcane bagasse, risk husk, tea leaves, bamboo dust, maize cob, tree sawdust [3], zeolite [4, 5], bentonite [6, 7], montmorillonite [8], *Cephalosporium aphidicola* [9], *Pinus sylvestris* [10], *Saccharomyces cerevisiae* [11], and so forth. Despite the mentioned materials, Ficus religiosa leaf powder can also be utilized as adsorbents to remove heavy metals from aqueous solution[12,13,14,15,16,17].

In this study, the effectiveness of Peepal Leaf Carbon (PLC) used as adsorbent for the removal of Zinc (II) from aqueous solution was evaluated and the results have been presented in a simplified and systematic way. The effects of various operating parameters on adsorption such as pH, initial concentration of Zn ions, adsorbent dosage, temperature and contact time were studied.

II. EXPERIMENTAL

2.1 Preparation of Peepal Leaf Carbon (PLC)

Peepal leaf used as raw material in this work was procured from a local garden. The midrib, which divides the blade into two lamina halves is removed with little hand pressure. The precursor was washed exhaustively with distilled water to remove adhering impurities from the surface, air-dried, cut to 1-2 cm size. The dried mass was finally heat treated in a furnace at 350 ^oC for 2 hours. The heat treated sample was washed several times with dilute HCl followed by de-ionized water until the washings are neutral to pH and its conductivity is minimal. The final mass of carbon lump was dried, ground and sieved to 250 mesh size. The powder prepared in this way is called Neem Leaf Carbon (PLC).

2.2 Preparation of adsorbate solution

All chemicals used were of analytical grade. Stock standard solution of Zn^{2+} has been prepared by dissolving the appropriate amount of $ZnSO_4$. $7H_2O$ in deionized water. This stock solution was then diluted to specified concentrations.The pH of the system was adjusted using reagent grade NaOH and HCl respectively. All plastic sample bottles and glassware were cleaned, then rinsed with deionized water and dried at 60˚C in a temperature controlled oven.

All biosorption experiments in this study were carried out in 250 ml Erlenmeyer flasks with a working volume of 100 ml Zn (II) solution. The flasks were agitated on a rotary shaker set at 120 rpm speed and at 35 ^oC temperature. The biomass free supernatant obtained was analyzed for residual Zn(II) concentration was found out volumetrically using EDTA as titrant and EBT indicator.

The amount of metal ion adsorbed per gram of the biomass and was calculated using the equation below:

$$q_e = (Ci - Ce)V/M$$

where q_e is the amount of metal ion biosorbed per gram of the biomass in mg/g, Ci is the initial concentration of the metal ion in mg/L, Ce is the equilibrium concentration of the metal ion in mg/L, M is the mass of the biomass in grams and V is the volume of the metal ion in litres. The experiment was performed in triplicate and the mean value taken for each parameter.

III. RESULTS AND DISCUSSION

3.1 Effect of contact time on Zn (II) adsorption

The effect of contact time on the adsorption of Zn ions using PLC was studied and the results are shown in figure 1.

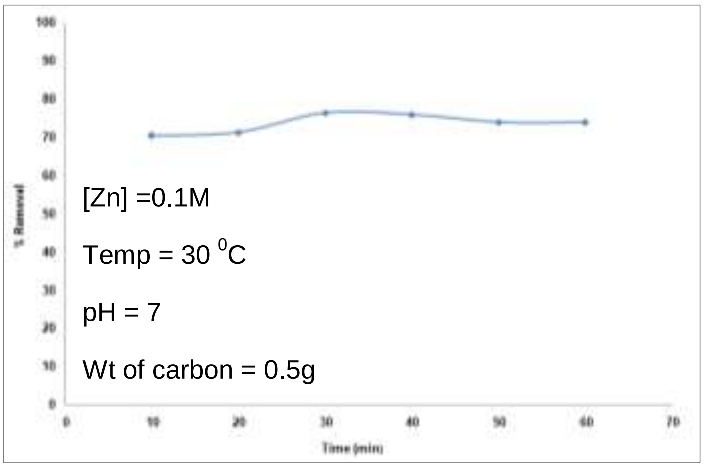

Figure 1: Effect of contact time on adsorption of Zn

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From the results, it was observed that there is a rapid initial adsorption in the first 10 min, followed by a longer period of much slower sorption until about 30 minutes when equilibrium was reached, after which there was no significance increase in Zn (II) ion uptake. Initially Zn(II) ion uptake was rapid because there are plenty of readily available sites for adsorption to occur. Subsequently, biosorption increased in the second phase but with a much slower rate until 30 minutes when equilibrium was reached. From figure 1, it is noted that metal ions removal was increased with an increase in contact time before equilibrium was reached. All parameters such as dose of adsorbent, temperature, initial metal ion concentration and pH of solution were kept constant.

The results indicated that on increasing the contact time from 10 to 30 minutes Zn (II) removal was increased from 70.5% to 76.5% on using PLC as adsorbent. From 30 to 60 minutes, the percentage removal of Zn (II) using PLC starts decreasing which showed that equilibrium was reached at 30 minutes itself. Thus the results illustrated that after 30 minutes desorption predominates over the adsorption which infers that the optimum contact time for maximum removal of Zn (II) ions using PLC was 30minutes. This result is important because equilibrium time is one of the important parameters for an economical wastewater treatment. Recent researches have shown that adsorption equilibrium is dependent on the type of biomass and not on the method of preparation of biomass carbon. Rengaraj et al [18] and Alinnor and Nwachukwu [19] reported equilibrium time of 2 hours for the adsorption of phenol onto palm seed coat activated carbon and sorption analysis of nitrophenol onto fly ash.

3.2 Effect of pH on Zn (II) adsorption

The effect of pH on the adsorption of Zn ions using PLC was studied and the results are represented in figure 2.

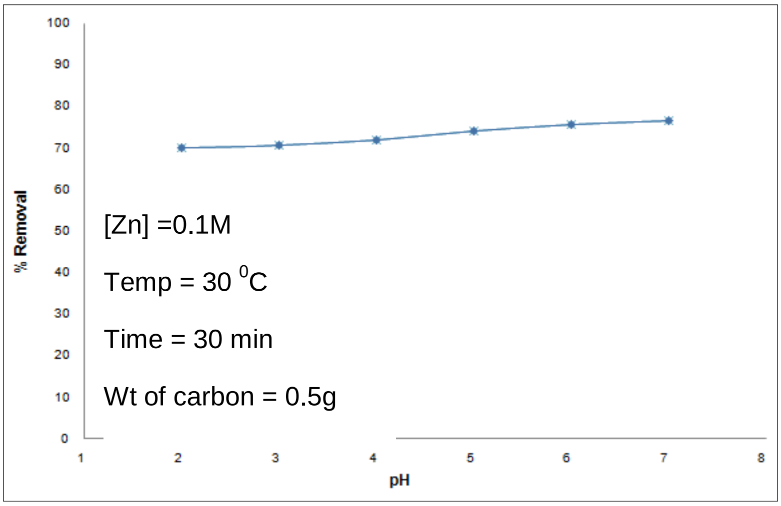

Figure 2: Effect of pH on adsorption of Zn

pH is an important parameter influencing heavy metal adsorption from aqueous solutions. It affects both the surface charge of adsorbent and the degree of ionization of the heavy metal in solution. The pH range of 2 -7 was chosen, as the precipitation of Zn(II) is found to occur at pH ≥ 7 [20]. The removal of metal ions from solution by adsorption is highly dependent on the pH of the solution. The biosorption of Zn(II) ions increases steadily with increase in intial pH and the maximum equilibrium adsorption capacity of 76.5% is observed at pH 7. Increases in metal removal with increase in pH can be explained on the basis of the decrease in competition between proton and metal cations for same functional groups and by decrease in positive surface charge, which results in a lower electrostatic repulsion between surface and metal ions. Decrease in adsorption at higher pH (> pH 7) is due to formation of soluble hydroxy complexes [21, 22] The adsorption of Zn (II) ion was found mainly to be influenced by solution pH.

3.3 Effect of adsorbent dose on Zn (II) adsorption

The effect of adsorbent dose on the adsorption of Zn ions using PLC was studied and the results are shown in figure 3.

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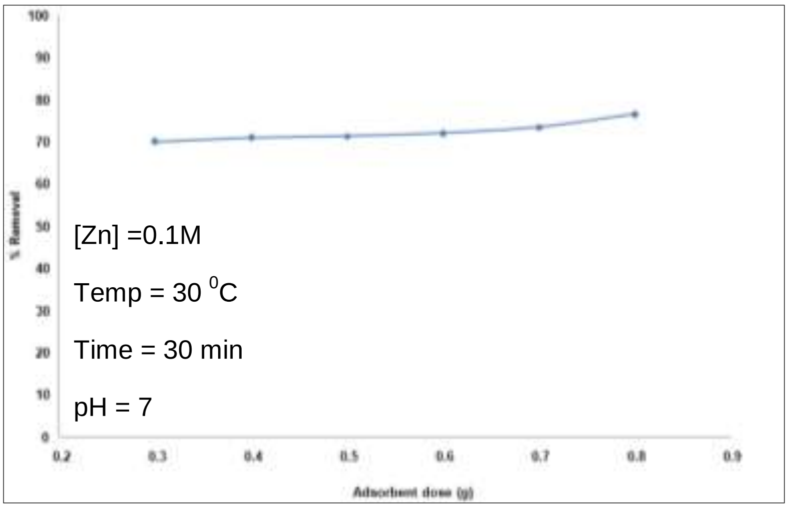

Figure 3: Effect of adsorbent dose on adsorption of Zn

Adsorption efficiency of Zn (II) adsorption was studied by varying the amount of adsorbent from 0.3 to 0.8g keeping other parameters (pH, metal ion concentration, temperature and contact time) constant. This shows that removal efficiency of the zinc usually improved on increasing adsorbent doses. This may occur due to the fact that the higher dose of adsorbents in the solution provides the greater availability of exchangeable sites for the ions. From the figure it is clear that only slight increase in adsorption after a certain amount of adsorbent was added (0.5g). The maximum % removal of Zn (II) was about 76.5% for PLC at dosage of 0.8g. This result also suggests that after a certain dose of adsorbent, the equilibrium conditions reached and hence the amount of ions bound to the adsorbent and the amount of free ions in the solution remain constant even with further addition of the dose of adsorbent. Our findings are in good support with M. Hussein et al [23].

3.4 Effect of temperature on Zn(II) adsorption

The effect of temperature on removal of zinc ion using PLC was studied within the range of 35 to 60 ^{0}C and the results are represented in figure 4. Other parameters such as dose of adsorbent, pH, metal ion concentration, contact time and pH of solution were kept constant. The temperature dependence of the adsorption process is related with several thermodynamic parameters.

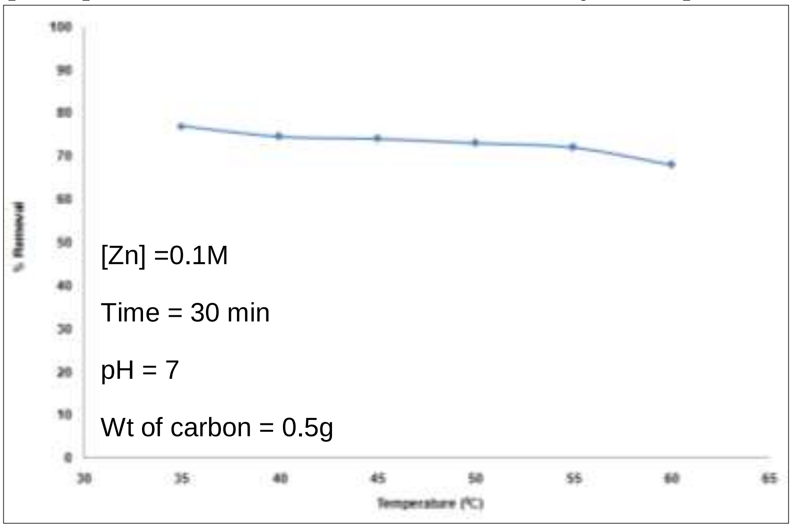

Figure 4: Effect of temperature on adsorption of Zn

The temperature showed the negative effect on adsorption of Zinc using PLC. With increase in temperature from 35 to 60 ^{0}C the removal of zinc ions was decreased from 76.9 to 68.0% for PLC. From the figure 4 it is clear that the low temperatures are in favour of zinc ion removal. This may be due to a tendency for the zinc ions to escape from the solid phase to the bulk phase with an increase in temperature of the solution. The result shows that adsorption mechanism related with

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removal of zinc is physical in nature. The adsorption process takes place from the electrostatic interaction, which is in general related with low adsorption heat. This implies that the adsorption process was exothermic in nature. Similar findings are also reported by other researchers [24, 25]

3.5 Effect of initial metal ion concentration on Zn (II) adsorption

The effect of initial zinc concentration on the zinc adsorption rate was studied in the range 0f 0.06-0.16M (variation of 0.02M) at pH 7, temperature 30 ºC, 0.5g of adsorbent and 0.1M metal ion concentration and 30 min contact time. The results obtained are represented in figure 5.

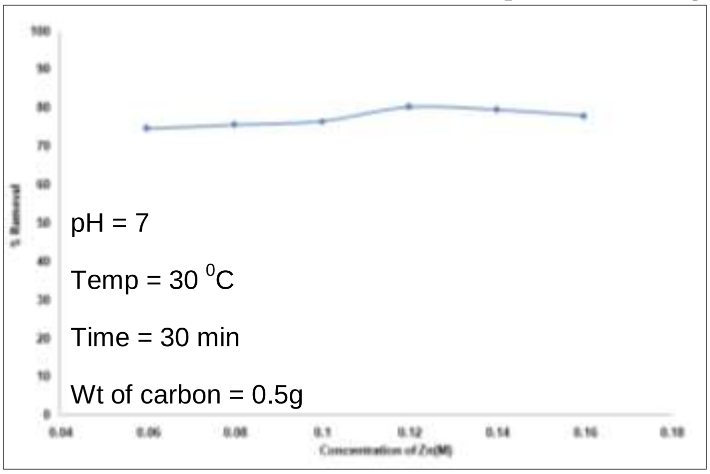

Figure 5: Effect of initial metal ion concentration on adsorption of Zn

From the figure 5 it was observed that the percentage of removal decreased with increase in initial zinc concentration. The poorer uptake at higher metal concentration was resulted due to the increased ratio of initial number of moles of zinc to the vacant sites available. For a given adsorbent dose the total number of adsorbent sites available was fixed thus adsorbing almost the equal amount of adsorbate, which resulting in a decrease in the removal of adsorbate, consequent to an increase in initial zinc concentration. Therefore it was evident from the results that zinc adsorption was dependent on the initial metal concentration. Similar results have been also reported by several researchers [26, 27, 28]

3.6 Adsorption Isotherms

The relationship between the amount of Zn (II) ion and its equilibrium concentrations are described using the Freundlich and Langmuir models and the plots are represented in Figures 6 and 7. Langmuir isotherm constants were determined from a plot of Ce/qe against Ce while that of Freundlich isotherm constants were determined from the plot of ln qe against ln Ce as shown in Table 1. The isotherm correlation coefficient (R^2) of Langmuir and Freundlich model equations for the adsorption of Zn (II) ion PLC was 0.998 and 0.964 respectively. The results obtained showed that Langmuir biosorption model was the best fit for the biosorption of Zn (II) ion using PLC indicating a physical biosorption.

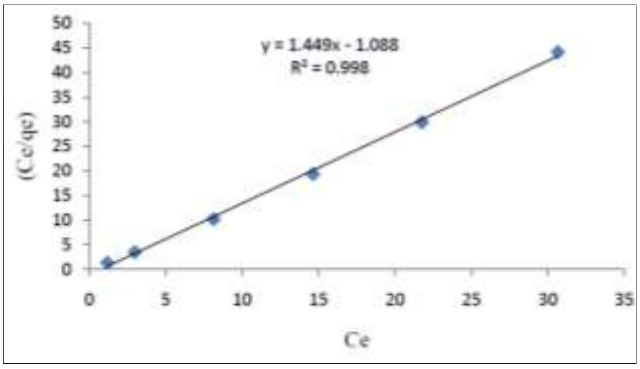

Figure 6: Langmuir adsorption isotherm for Zn adsorption

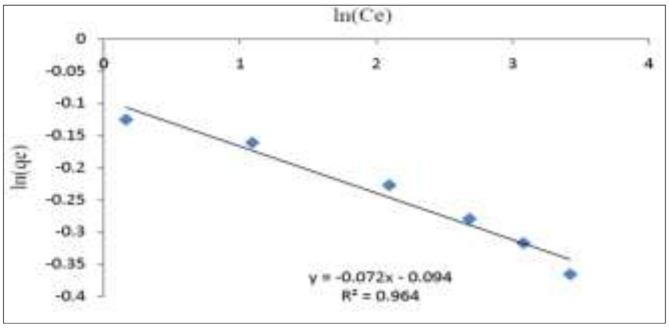

Figure 7: Freundlich adsorption isotherm for Zn adsorption

Table 1: Langmuir and Freundlich parameters for Zn (II) ion removal at 298 K

Adsorption Models	K_L	K_F	q_m(mg/g)	R^2	N
Langmuir	1.322		0.6901	0.998	
Freundlich		1.099		0.964	13.389

To summarize, we have described how biomass carbon powder from PEEPAL LEAF can be produced and attempted to evaluate its potential as an adsorbent for removal of zinc from waste water.

IV. CONCLUSION

The present investigation is carried out to study the suitability of a novel indigenous adsorbent, peepal leaf derived carbon (PLC) for the removal of heavy metal such as zinc from the wastewater.

1. Influence of process parameters such as pH, adsorbent dosage, temperature, contact time, initial metal ion concentration were at moderate levels such that they can affect the removal efficiencies of the Zn were concerned.
2. The optimum pH of solution for Zn removal was found to be 7.
3. Within the scope of the experimental investigation the optimum temperature was found to be 35 ^{0}C.
4. The optimum time for adsorption of zinc was found to be 30 minutes.
5. Initial metal ion concentration showed the negative effect on adsorption efficiency i.e. at lower levels the adsorption was higher.
6. Adsorbent dosage showed the positive effect on adsorption efficiency i.e. at higher adsorbent dose the adsorption was higher.
7. Our research work is designed in such a way of take waste, make products, and turns them to resources which is the reverse of the global scenario of take resources, make products, and turn them to waste.

Thus, from the results of adsorption data, it was concluded that the PLC was found to be excellent adsorbent for the adsorption of zinc from waste water.

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