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Natural adsorbents used to remove the Heavy metal Lead (II) from aqueous solution.

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Abstract:

In this work, only removal of Lead (II) from aqueous solution has been investigated by using low cost adsorbent such as Wheat husk Activated Charcoal Powder (WHACP), ***Morinda tinctoria*** Charcoal Powder (MTCP) as a natural adsorbent. Chemical activation method was used in preparing the activated carbon. Batch mode technique and analyses have performed by using different amounts of adsorbent in solutions with different concentrations of Lead(II). Beside the effect of various amounts of adsorbent used in adsorption efficiency experiments has been studied. The effects of solution pH, adsorbent dose, initial Pb(II) concentration and contact time were examined with aqueous solutions in batch mode. Among Freundlich and Langmuir adsorption models, the Langmuir model provided the best fit to the equilibrium data with maximum adsorption capacity.

Keywords: Adsorption, Wheat husk Activated Charcoal Powder, ***Morinda tinctoria*** Charcoal Powder, Batch mode experiments

Introduction:

Large-scale freshwater pollution poses a serious and growing threat to sustainable development and environmental protection. Human health, agricultural development, industrial development and ecosystems are threatened if water and soil systems are not successfully managed [1]. Heavy metals are used in industrial applications in many industries. Effective removal of heavy metals from industrial wastewater is among the most important issues for many industrialized countries. Many industries produce wastewater that poses a potential hazard to our environment as it contains various heavy metals such as lead, cadmium, nickel, etc.,[2] If left untreated, this wastewater will contaminate soil and water resources Due to their acute toxicity and accumulation in food chains, water poisoning by heavy metals is a significant ecological disaster. Unlike organic contaminants, which are most likely to be recycled, heavy metals do not break down into safe end products. Even at low concentrations, heavy metals are harmful to the marine environment[3]. Copper (Cu), chromium (Cr), mercury (Hg) and lead (Pb) are heavy metals harmful to humans and the environment.

Lead is one of the toxic heavy metals that can pose risks due to exposure from aquatic and air environments [4]. It is one of the main pollutants responsible for soil, water and atmospheric pollution, which is harmful to aquatic and human life even at low concentration [5]. Lead is a heavy, soft, ductile, bluish-gray metal.[6] Lead is of particular interest because of its toxicity and its widespread presence in the environment.[7] Lead is a well-known highly toxic metal considered a priority pollutant.[8] It is an industrial pollutant that enters the ecosystem through soil, air and water. Lead is a systemic poison causing anemia, kidney failure, brain tissue damage and, in extreme poisoning, death.[6][9] It is very toxic in nature. Generally speaking, lead pollution that spreads over land and groundwater comes from natural sources and industrial effluents. Lead can affect almost every organ and system in the human body. The human body can absorb, store, and accumulate these metals, resulting in erythrocyte breakdown, vomiting, salivation, diarrhea, muscle spasms, kidney impairment, persistent lung problems, and skeletal deformities. In particular, children under the age of 6 are most sensitive to the effects of lead exposure. Low blood lead concentrations in children can cause hearing and learning problems, anemia, behavioral abnormalities, stunted growth, lower IQ, and hyperactivity [10]. Inorganic lead is an enzyme inhibitor that also affects the nervous system. It is very toxic in nature. According to the WHO, the maximum permissible limit (MPL) for lead in drinking water is 0.05 mg/l. Industrial discharges contain various organic and inorganic pollutants. Among these pollutants are heavy metals, which may be toxic and/or carcinogenic and are harmful to humans and other living species [11,12,13].

Traditional methods for treating wastewater contaminated with lead and other toxic heavy metals include complexation, chemical oxidation or reduction, solvent extraction, chemical precipitation, reverse osmosis, ion exchange, filtration, membrane processes, evaporation, and coagulation. In addition to classical wastewater treatment techniques, heavy metal adsorption is the most promising separation and purification method, as this technique has significant advantages including high efficiency in removing very low levels of heavy metals from dilute solutions, easy handling, high selectivity, lower operating costs, minimal production of chemical or biological sludge and adsorbent regeneration[14]. In addition, the effect of different amounts of adsorbent used in adsorption efficiency experiments was investigated. The aim of this study was to investigate the adsorption potential of wheat husk powdered activated carbon and ***Morinda tinctoria*** powdered charcoal to remove Pb(II) ions from aqueous solution. The effect of several parameters such as contact time, initial concentration, solution pH value, adsorbent dose, volume and temperature was studied. Adsorption mechanisms of Pb(II) ions onto wheat husk activated carbon powder and ***Morinda tinctoria*** activated carbon powder evaluated in terms of thermodynamics and kinetics. Adsorption isotherms were described using the Langmuir and Freundlich models.

Materials and Method:

Materials: Wheat husk Activated Charcoal Powder (WHACP), ***Morinda tinctoria*** Charcoal Powder (MTCP) is used as adsorbent.

Chemicals: Lead nitrate ($Pb(NO_3)_2$, 99%), sodium hydroxide pellets (NaOH, 98%), potassium hydroxide pellets (KOH, 80%) and nitric acid (HNO_3, 75%) were purchased from Nice Chemical Limited, Cochin . Ethanol (EtOH, 96%), methanol (MeOH, 99.8%), hydrochloric acid (HCl, 36%) and anhydrous (Na_2SO_4) sodium sulfate were obtained from Mercurys Scientific Chemicals, Salem. All chemicals were used as received without further modification unless otherwise noted.

Preparation of Adsorbate: A stock solution of Pb(II) (1000 mg/l) was prepared in distilled water. Working solutions were obtained by dilution when necessary, the pH of the desired working solutions was adjusted with 0.1 M either NaOH or HNO_3. The effect of initial Pb(II) concentration on sorption was investigated by varying the initial ion concentration in the range of 10-50 ppm at 27°C for 2 h.

Preparation of Adsorbents: The washed and dried raw materials were ground into fine particles using a Jencod grinder and sieved to a particle size of 300 µm. 200 g of the sample was impregnated with concentrated orthophosphoric acid at an acid/precursor ratio of 0.4:1 (mass basis) for MT and 2:1 for the other materials. The impregnated samples were dried in an oven at 120°C for 24 hours. The dried samples were carbonized in a muffle furnace at 500 °C for 2 h. After cooling to ambient temperature, the samples were washed several times with deionized water until pH 6-7, filtered with Whatman No. 1 filter paper, and then dried in an oven at 110°C for 8 h. The samples were crushed and sieved through sieves of various sizes and then stored in a tight bottle ready to use.

Batch Type Experiments: Batch adsorption experiments are conducted to determine the lead sorption rate and adsorption capacity by WHACP and MTCP. An aqueous lead concentration of 100 ml is taken into beakers to which equal amounts of Wheat Husk Activated Carbon Powder (WHACP), ***Morinda tinctoria*** Activated Carbon Powder (MTCP) are added and mixed at stirring revolutions per minute, to keep the adsorbent material in a state of agitation. The total amount of wheat husks and ***morinda tinctoria*** charcoal are taken in equal amounts to obtain 10 mg, 15 mg, 20 mg, 25 mg, and 30 mg, respectively. The contact time of the adsorbent material for the lead aqueous solution is kept at 20 minutes, 40 minutes, 60 minutes, 80 minutes, 100 minutes, and 120 minutes.

Adsorption isotherms: Adsorption isotherms were evaluated by varying the initial concentrations of metal ions from 10 to 50 mg/L. In the isothermal experiments, considering the results regarding the effects of the independent variables on the responses, the values of the other independent variables (i.e., adsorbent dosage, contact time, temperature (27°C) and constant pH at 6.2) were kept constant. In order to diagnose the nature of adsorption (homogeneous or heterogeneous) on the adsorbents, four theoretical isothermal models, namely Langmuir and Freundlich, were used.

Result and Discussion:

From limited project work, it was found that pH, contact time and adsorbent dosage play an important role in the adsorption of the heavy metal lead (II) from an aqueous solution. In this research, the removal rate of Pb(II) ions in water is mainly controlled by the pH of the solution. The optimum pH for Pb(II) removal was 6.2 pH. To achieve this goal, a series of batch experiments was carried out with an adsorbent dose of 10, 15, 20, 25 and 30 mg per 100 ml of the tested solution. When the adsorbent dose increased, the removal percentage of metal ions also increased. Fig(1 & 2) A maximum removal of 98% of lead was achieved with 30 mg of activated carbon from wheat husks.

The effect of contact time on the effective removal of metal ions was studied. Both metals showed a steady trend of increasing the sorption rate during the sorbate-sorbent contact process, and the removal rate became almost insignificant due to the rapid depletion of adsorption sites. The rate of metal removal is initially higher due to the greater surface area of the adsorbent available for adsorbing the metals. In these studies, ***Morinda tintoria*** and wheat husk charcoal removed 95% and 98% of lead (II), respectively. 98%. removal was achieved in 120 minutes. Furthermore, no significant changes were observed in the removal of both metal ions from the solution after 24 h of equilibration

Adsorption isotherms:

Equilibrium adsorption isotherms are one of the promising data for understanding the mechanism of adsorption. Different isotherm equations are well known and two different isotherms are chosen here studies, which are Langmuir and Freundlich isotherms. The Langmuir adsorption isotherm assumes that adsorption occurs at specific homogeneous sites in the adsorbent and was successful application in many adsorption processes of monolayer adsorption [15]. The mechanism of metal uptake is particularly dependent on the concentration of heavy metals. Initial concentration. For the comparative study of Pb(II) removal, 10 and 50 mg/L metal ions were selected. At a concentration of metal ions of 50 mg/l and an optimal dose of 30 mg of charcoal from wheat husks, the maximum removal of Pb(II) was achieved within 120 minutes. This observation clearly shows that the removal of metal ions depends purely on the amount of adsorbent and the contact time[16]. Heavy metals are adsorbed on specific sites provided by acidic functional groups on biochar, while with increasing metal concentrations, specific sites become saturated and exchange sites due to excessive biochar surface become filled. It is clear that as the initial concentration increases, the metal removal decreases. A nonlinear plot of the amount of Pb(II) adsorbed at equilibrium versus the equilibrium concentration for the Langmuir model, Freundlich model, and experimental data is shown in Fig.(3,4,5& 6).

This study revealed that the adsorbent prepared from wheat husk charcoal was effective for Pb(II) removal from an aqueous solution. The Langmuir isotherm model provided a better fit to equilibrium adsorption These data indicate a multilayer adsorbate-adsorbent system with a predominance of chemisorption. The maximum removal efficiency of 98.1 ± 0.01% was achieved at the optimal adsorbent dose of 30 mg/l, contact time of 120 min and pH 6.2. From the limited experiment so far it has been found that the maximum adsorption of lead (Pb) is up to 98%. The future scope is to analyze the adsorption isotherm for the equilibrium study for this lead adsorption from aqueous solution.

Fig.1 Effect of contact time (min) on % removal of Pb(II) ions for: a) 50 ppm in the presence of different amounts of wheat husk activated carbon (temp. = 27°C, pH = 6.2 and equilibrium time = 2 h)

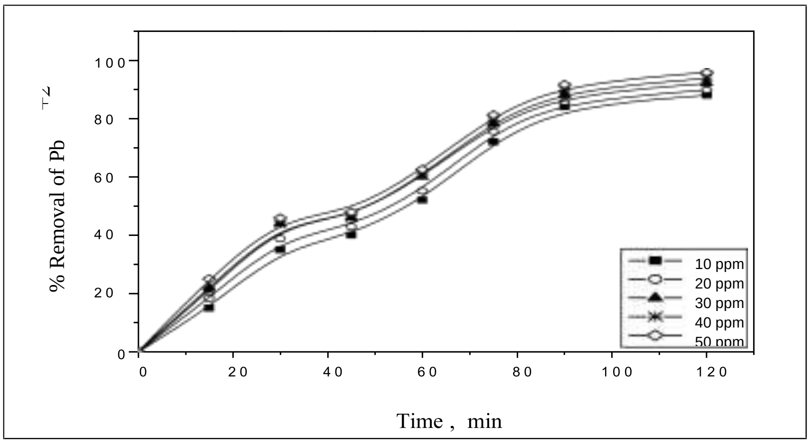


Fig.2 Effect of contact time (min) on % removal of Pb(II) ions for 50 ppm in the presence of different amounts of ***morinda tintoria*** activated carbon (temp. = 27°C, pH = 6.2 and equilibrium time = 2 h)

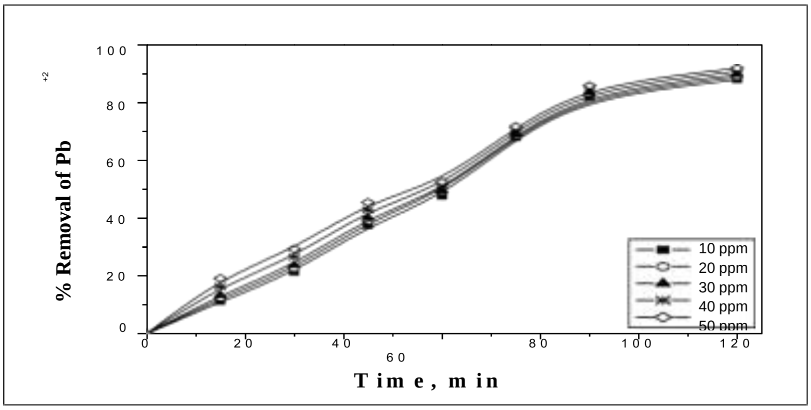


Fig.3 Langmuir adsorption isotherm for Pb(II) ions adsorption onto different amounts of wheat husk charcoal powder at constant temperature 27°C and contact time 120 min

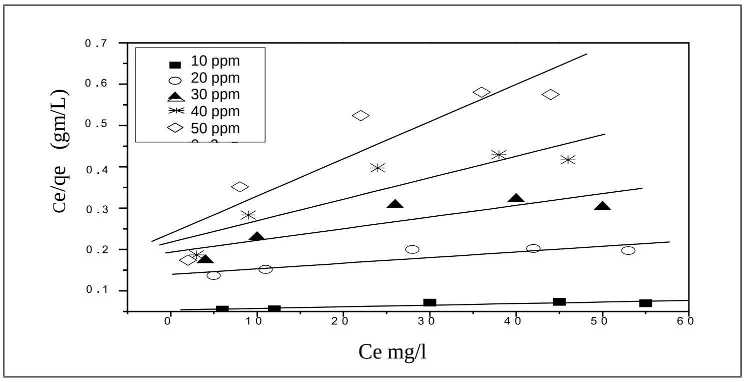
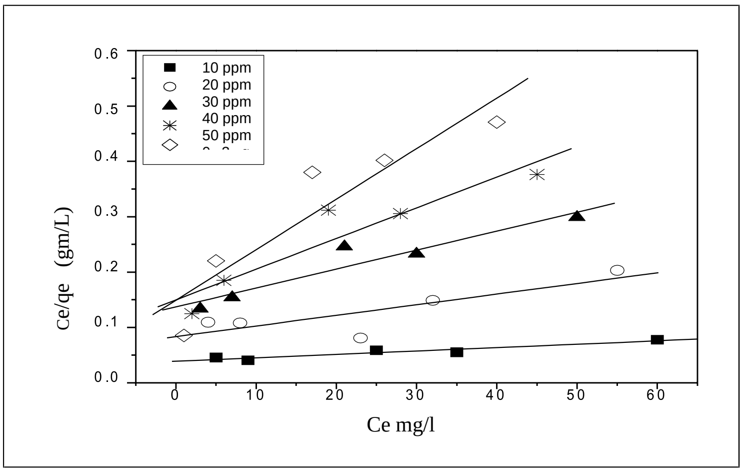


Fig. 4 Langmuir adsorption isotherm for Pb(II) ions adsorption onto different amounts of ***Morinda tintoria*** charcoal powder at constant temperature 32°C and contact time 120 min



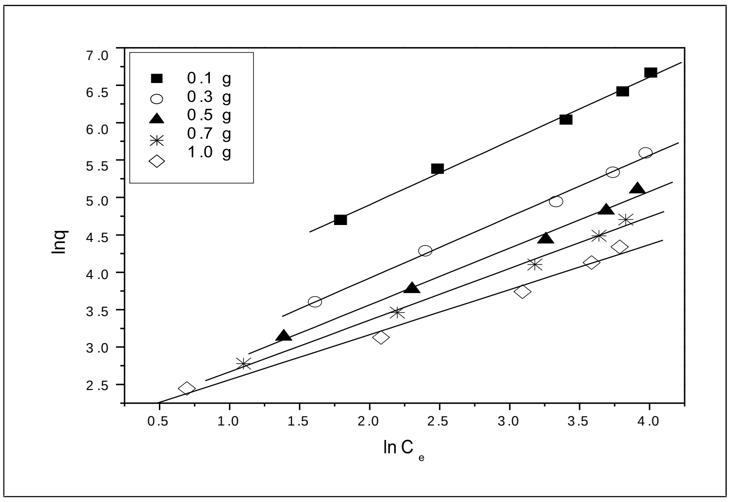


Fig.5 Freundlich adsorption isotherm for Pb(II) ions adsorption onto different amounts of Wheat husk powder carbon at constant temperature 27°C and contact time 2 h.

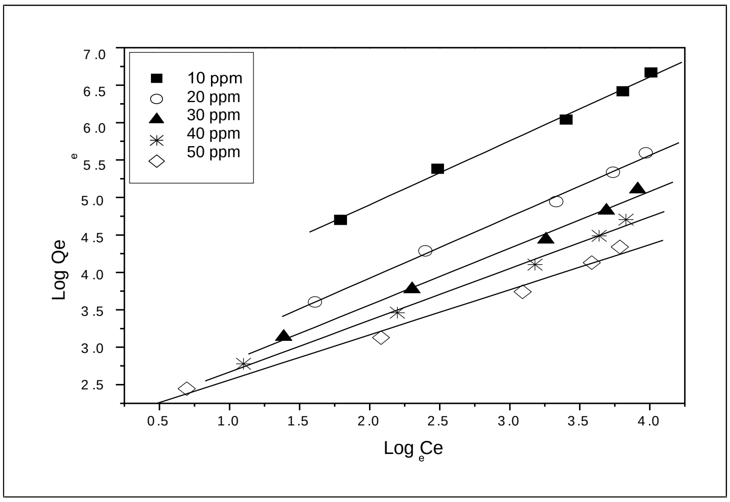
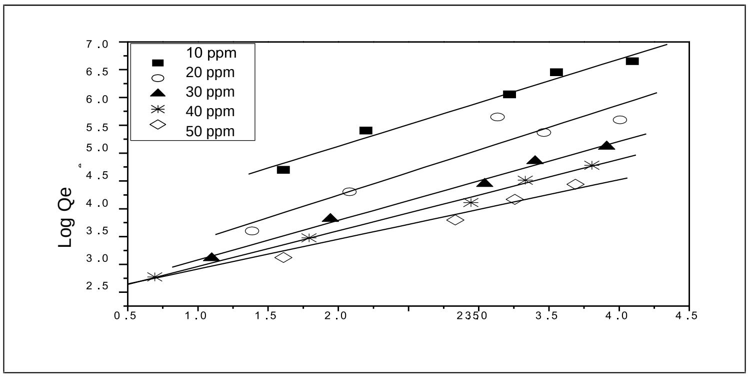


Fig.6 Freundlich adsorption isotherm for Pb(II) ions adsorption onto different amounts of at ***morinda tintoria*** Charcoal at constant temperature 27°C and contact time 2 h



Conclusions:

In this research, wheat husk charcoal powder and ***Morinda tintoria*** charcoal powder were tested as a low-cost, abundant and ecological adsorbent for the removal of Pb(II) ions from an aqueous solution. The variables considered were: initial concentration of metal ions, solution pH, contact time, temperature and adsorbent dose. The adsorption efficiency was correlated with the chemical components of wheat husk carbon using the Langumir and Freundlich techniques. The result showed the optimal capacity at pH = 6.2, contact time 120 minutes, adsorbent dose 30 mg/l and temperature 27°C and initial concentration of ions. The adsorption isotherms could be better described by the Langumir model, suggesting a multilayer adsorption process.

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