Adsorption studies of lead from waste water using porous coal-based adsorbent in conjunction with organic chelating agent, Guaiacol

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ABSTRACT

The most significant problem for an industrialised region is pollution from heavy metals in industrial waste water. One of the widely found heavy metal in industrial waste is Lead. In this study, modified granular activated carbon with Guaiacol (2-Methoxyphenol) was used to examine the removal of toxic metal lead from aqueous solutions. Lead was adsorbed using GAC filtrasorb-100 (GAC F-100) and Norit-830 (GAC N-830) at a constant temperature of 25 ± 1°C and a rotational speed of around 500 rpm. For the Freundlich and Langmuir adsorption isotherm models, the adsorption data were thoroughly analysed.

Keywords: Adsorption, toxic metal removal, Lead, Granular Activated Carbon (GAC), Filtrasorb 100 (F-100) Norit-830(n-830), 2-Methoxyphenol, guaiacol.
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INTRODUCTION

As a result of the toxicity, persistence, and bioaccumulation affinities of heavy metals in water bodies, the environment and humans are currently confronting a significant dilemma. Due to their extensive commercial applications, metals and their compounds are crucial to the economic and technical growth of developed nations [1, 2]. One of the heavy elements prevalent in industrial effluent is lead, which when released into waterbodies has a negative impact on both aquatic and terrestrial life. The neurological system, kidney, reproductive system, brain, and liver suffer significant damage from lead poisoning, which can result in disease or death. Strong lead exposure has been linked to infertility, stillbirths, abortion, and neonatal deaths [3-5].Lead occurs naturally in the earth's crust as an insoluble element in forms that are not toxic to living things [6]. Treatment of industrial effluents containing lead is accomplished using a variety of techniques. Chemical precipitation, ion exchange, electrodialysis, and carbon adsorption are some of the crucial procedures for water treatment [7–19]. Many cutting-edge methods for removing heavy metals are now available, but they require significant financial outlays and are not appropriate for small-scale enterprises that only dispose of modest amounts of wastewater. Adsorption is a useful separation and purification method applied in industry, particularly in the treatment of water and waste water [20].In the industrial sector, there is an increasing need to try to develop a way to remove treatable amounts of lead wastes from waste waters utilising granular activated carbon [21–33]. As soon as lead levels in drinking water exceed the permitted limit set by the World Health Organization (WHO) (3-10 g/L), many human illnesses are deemed to be at serious risk [34].

MATERIALS AND METHODS:

Filtrasorb 100 (F-100) and Norit-830 (N-830), two types of granular activated carbon used as inexpensive adsorbents to remove Pb2+, were provided as samples by M/s Calgon Carbon Corporation Ltd. of Pittsburgh, USA. The selected carbon was first reduced to a suitable size and sieved using a 3-level sieve shaker in order to get uniform surface area of the carbon particles. In the adsorption experiment, the sieve shaker was utilised to collect the particles that remained between the sizes of 1400 and 1600. The sieved GAC particles were thoroughly cleaned with hot, double-distilled water several times until all impurities and coal dust were removed and clear water could be seen with the GAC particles. They were then dried for 12 hours in a vacuum oven at 105 0C before being placed in desiccators with anhydrous $CaCl_2$. A known-weight weighing vial was used to separate and place some of the carbon particles in the same desiccator. The bottle was weighed every day until a stable weight was found, indicating that the carbon particles had completely lost their moisture. The right quantity of analytical grade $Pb(NO_3)_2$ (S.D. Fine Chem. Limited) was dissolved in double-distilled water to create a lead ion stock solution. We created a number of solutions with different known lead ion concentrations. To estimate the residual Pb2+ ion concentration, the alizarin red (S) technique was used to produce the Beer's law standard curve for Pb2+ [12].

Throughout the experiment, this study used chemicals of the AR grade. 1,2-dihydroxybenzene (S.D. Fine Chem. Limited) was purified and recrystallized using a traditional method. 1,2-dihydroxybenzene's melting point was tested and compared to the 245 °C value that has been published. In order to further characterise the sample, the molecular weight was calculated using the pH titration technique in comparison to a reference NaOH solution.

To analyse the adsorption isotherm, 200 ml of 0.001 M 1,2-dihydroxybenzene solution were placed in reagent bottles with 300 ml capacity stoppers and stirred with 0.5 g of GAC. A Teflon-bladed stirrer was then used to shake it constantly for five hours at 500 rpm. After five hours, the solution was decanted, and the carbon flakes were meticulously cleaned with double-distilled water. This meant that 1,2-dihydroxybenzene was abundant in the GAC. The same reagent bottle was then used to hold the loaded carbon. It was then filled with 200 ml of a Pb2+ solution with a pH of 6. 5 hours were spent stirring the materials in a thermostat at a constant temperature of 25°C. The initial and final concentrations of the Pb2+ ion in mg/L were then calculated by measuring absorbance at 487 nm with a UV spectrophotometer (Chemito spectrascan UV 2700 Double beam UV Visible spectrophotometer). To guarantee repeated results, the procedure was applied twice.

RESULTS AND DISCUSSION

The adsorption data of Pb2+ on GAC were analysed in the light of Freundlich, Langmuir and Temkin models. The relationship between the liquid phase concentration and surface concentration of adsorbate at equilibrium was obtained to describe adsorption isotherm. The quantity of Lead on the modified GAC was estimated using the equation

$$q_e=(C_o-C_e) \times V/W \quad (1)$$

Where,

qe=Concentration of Lead ion on the modified GAC (mg/millimoles)

Co=Initial concentration of Lead ion (mg/L)

Ce=Final concentration of Lead ion (mg/L)

W=Millimoles of the ligand actually present on GAC (0.5 g).

V=Volume of solution in litres,

The adsorption isotherms of modified F-100 and N-830 GAC obtained by plotting q_e versus C_e and shown in **Figure 1.**

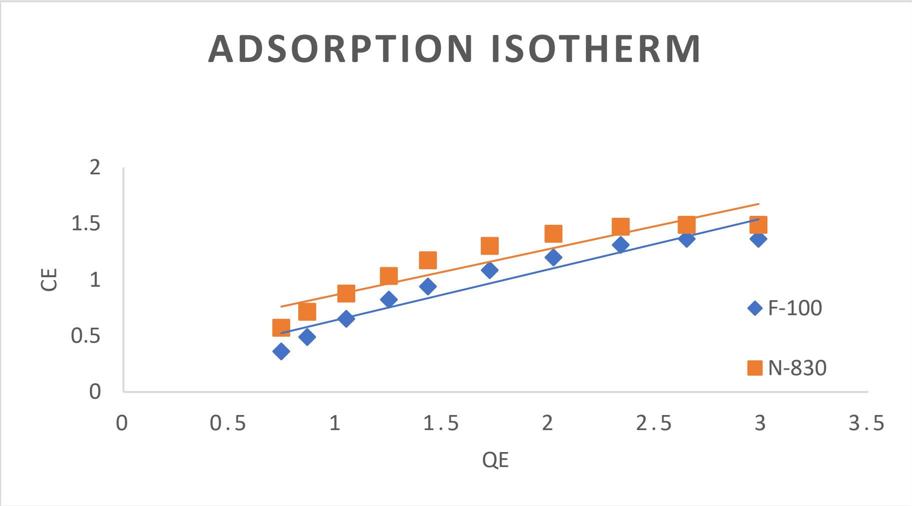

Figure 1. Adsorption Isotherm System: GAC_ Guaiacol_Pb^{2+}

The Langmuir equation could be expressed as
$q_e=Q_ob \times C_e / (1+bC_e)$ (2)
Where,
Qo = Amount adsorbed per unit weight of the GAC to form monolayer.
b = Langmuir constant.
Rearranging equation (2)
$1/q_e = 1/Q_ob \times 1/C_e + 1/Q_o$ (3)
A plot of 1/qe versus $1/C_e$ was found to be fairly linear indicate the validity of isotherm.
The Freundlich equation express as
$q_e=K.C_e1/n$ (4)
Where, k and l/n are Freundlich constants determined experimentally. Using equation (4)
$\log q_e=\log K+1/n \log C_e$ (5)
The linearity in the plot of log qe against log C_e showed validity of Freundlich equation over a range of concentrations.
Langmuir and Freundlich isotherms for F-100 and N-830 are illustrates in **Figure 2 and 3.** The plots of $1/q_e$ against $1/C_e$ were found to be linear indicating the validity of Langmuir model.

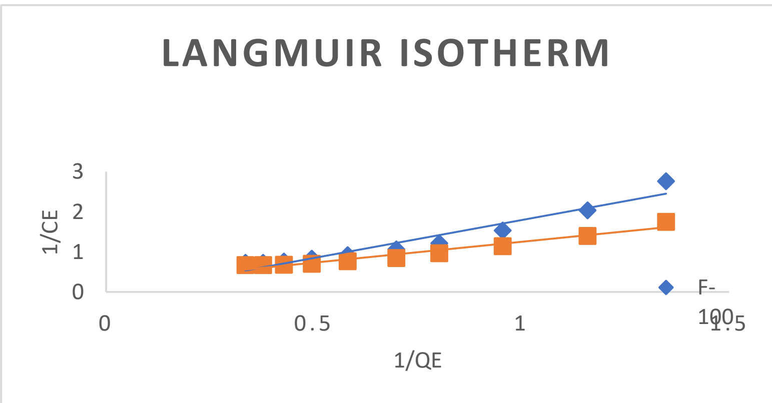

Figure 2: Langmuir Adsorption Isotherm System: GAC-Guaiacol -Pb^{2+}.

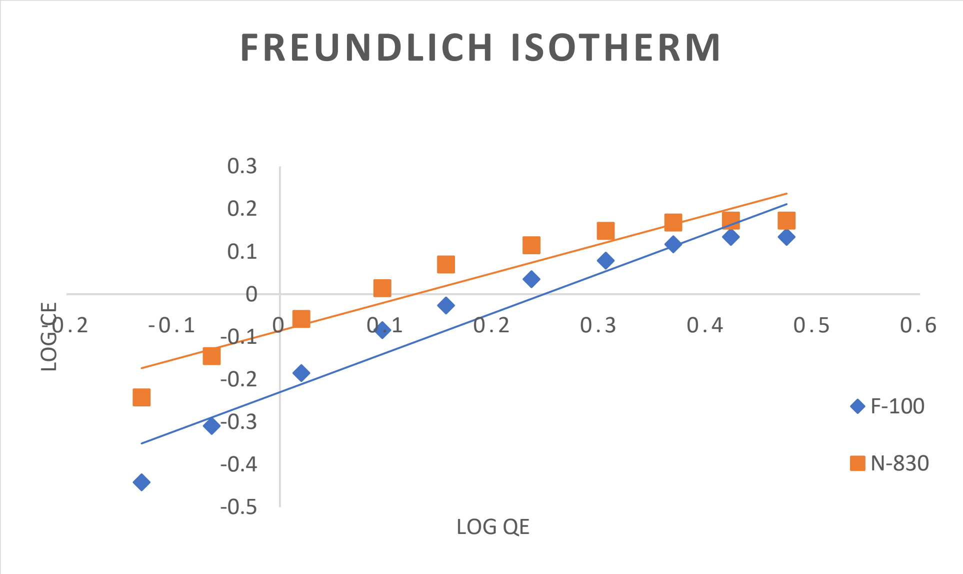

Figure 3: Freundlich Adsorption Isotherm System: GAC-Guaiacol -Pb^{2+}.

CONCLUSION

This study analyzed the productivity of adsorbent GAC in the expulsion of Pb^{2+} particles from fluid stage in presence ofGuaiacol. The principal benefits of the adsorption study incorporate expense viability, effortlessness and offers adaptability in plan. From the plot of q_e against C_e, it is seen that at first Ce increments with q_e yet at the immersion level q_e will in general be steady which shows monolayer arrangement of Lead particle on the pores site of surface of adsorbent GAC. The exploratory information seen to be of the positive sort and oppressed for adherence to Langmuir. In adsorption concentrate on N-830 stacked with Guaiacoladsorbs lead to a momentous degree when contrasted with F-100. This is presumably because of presence of enormous dynamic sites accessible on GAC surface and its porous nature.

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