EVALUATION OF LEAD ION SORPTION BY NITRIC AND POTASSIUM HYDROXIDE ACTIVATED *Cissus populnea* STEM CARBON

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Abstract:

Activated carbon has proven to be a way out for most heavy metal ions contaminants in water. Evaluation of Pb^{2+} adsorption was carried out using an activated carbon from *Cissus populnea* stem. Adsorption was very slow at 6 – 24 hours. The removal efficiency of Pb^{2+} by KOH-AC and HNO_3-AC increases with increasing presence of the adsorbent due to the availability of adsorption sites on the activated carbons. However, as the Pb^{2+} concentration becomes excessive, the removal efficiency increases. It may be noted that the efficiency of adsorption was generally high (>70 %) with both activated carbons. From the graphs, KOH-AC absorbs much of Pb^{2+} than HNO_3-AC. The pH of KOH-AC which is closer to pH of 7 absorb the most of the Pb^{2+}. The increase of pH increases the rate of adsorption. Acid activated shows lowest decrease at maximum amount of NaCl.

Keywords: ***Cissus populnea, lead, activated carbon***

Introduction

In early 2016, Centers for disease control and prevention released a report on lead poising that killed several people after consuming farm crops. The investigation of other villages in Zamfara state revealed that the lead poisoning was widespread. Thousands of children had dangerous level of lead in their blood (CDCP, 2016). Contamination of water by toxic heavy metal has been a major environmental problem since long (Jessica *et al.,* 2020). Some of the past episodes of heavy metal contamination in the aquatic environment have increased the awareness of the toxicity. To alleviate the problem of water pollution by heavy metals, several researches has led to the discovery of materials that are both efficient and cheap. In view of these, interest has recently risen in the investigation of some unconventional methods and low-cost materials for sorption of heavy metal ions from wastewater (Dass *et al.,* 2017). Against these backdrops, this study focuses on *cissus populnea*, an otherwise promising method for the removal of heavy metals from industrial wastewater. The aim of this study is to evaluate the sorption of lead ions in a solution using a KOH and HNO_3 activated carbon from *Cissus populnea* stem:

Lately, some of the plants emerged to produce Activated carbon for wastewater treatment processes. Recently, the activated carbon is abundantly utilized as an air purifier in atmospheric air contaminant cleaning, color removal of industrial and automobile exhaust, food and pharmaceutical products also used as refrigerator deodorizers and in advanced applications such as nuclear plants (Zoha *et al.,* 2020). In the late 1930's undoubtedly, AC gained huge momentum and popularity in industrial sectors, for both gaseous and aqueous phase applications.

Due to lead non-biodegradable nature and continuous use, its concentration accumulates in the environment with increasing hazards (Kshyanaprava and Alok, 2023).

Material

Chemicals / reagents

Cissus populnea stem, Beaker, conical flask, mortar and pestle, Spatula, separating funnel, distilled water, volumetric flask, Lead, Sodium hydroxide, nitric acid, Glass rod, measuring cylinder, filter paper, Petri dish, weighing balance

Preparation of reagents:

Lead: Dissolve 1.5980 g of lead nitrate [$Pb(NO_3)_2$] in 100ml of deionizer water. Dilute to 1L in a volumetric flask (1000 ppm AAS standard)

Potassium Hydroxide: Dissolve 33 g of KOH in 500ml of deionizer water

Nitric Acid: 63 ml was dissolved in 500 ml of deionizer water

Sampling and sample preparation

Cissus populnea was collected from Otukpo market Benue State. The samples were sun dried and cut into pieces in order to enhance carbonization, purification, chemical activation using the methods. *Cissus populnea* is carbonized in a specially constructed chamber, after cooling the charred products were grounded with the use of mortar and pestle to produce a fine powder. Chemical activation was done using different chemical reagents like NaOH and HNO_3, sample of the carbon was poured into two different beakers containing dilute sodium hydroxide and nitric acid, the content of the beaker was thoroughly mixed until a pastes of each was formed. The pastes of the sample were transferred into a Petri dish, dried for 24 hours after which it washed with distilled water, then filtered and dried again.

Determination of metal ion in solution

The ion chosen for the study was Pb^{2+}. A concentration of 200 ppm of the metal ion was prepared with distilled water from the above concentration, 50 ml of the solution of metal ion was taken into a beaker, 2 g of *Cissus populnea* stem was added and then shaken vigorously for 1hour using flask shaker. The mixture was filtered and the residual metal ion concentration is determine using AAS (Dass *et al.,* 2017).

Effect of ionic strength on sorption capacity

Useful information regarding salt effect was obtained by measuring sorption capacity of *Cissus populnea* stem in various mass of NaCl. Selection mass was adjusted with 0.1, 0.5, 1, and 2.0 g of NaCl in 200 ppm to obtain various desired concentration. 2.0 g of *Cissus populnea* stem was added to the sample to 50 ml of the prepared solution and the equilibrium concentration of the residual metal ion was determined. It was shaken for 1hour using flask shaker then the mixture was filtered and the residual metal ion

concentration is determine using AAS (Barminas and Osemeahon, 2005)

Effect of initial metal ion concentration on sorption capacity

To investigate the initial metal ion concentration on sorption capacity, different sample consisting of 50 ml of the metal ion concentration from 10 ppm, 20 ppm, 40 ppm, 60 ppm, 100 ppm, but each containing 2 g of *Cissus populnea* stem were prepared and shaken for 1hour until equilibrium was obtained, the synthetic waste water was filtered and analyzed for residual metal ion concentration using AAS (Dass *et al.*, 2017)

Effect kinetic of sorption: of time on

To determine the kinetic of sorption, five different set of samples consisting of 2 g of *Cissus populnea* stem and 50 ml of metal ion solution was prepared as the sample undergoes agitation with flask shaker. They were removing at a predetermined time interval from 1hrs, 2 hours 3hours, 6hours and 24hours. The solution was filtered and analyzed for residual metal (Dass *et al.*, 2017).

Effect of pH on sorption capacity

To determine the effect of pH, the pH of 50 ml of 200 ppm of the metal is taken using the pH meter. Another 50 ml of 200 ppm of the metals is taken and 2 drops of HCl is added while the pH is determining, this is repeated by adding 3drops of concentrated HCl and taking note of the pH. The above process is repeated by adding 2-3 drops of dilute NaOH to 50ml of 200ppm of respective metal, these was also repeated by adding 4-5 drops of dilute NaOH solution and taking note of the pH 2 g of *Cissus populnea* stem is added to each solution mixture and shaken for one hour using a flash shaker. The solution is filtered and analyzed for residual metal ion concentration using AAS (Dass *et al.*, 2017).

Results and Discussions

Effect of Sorption Capacity of Pb^{2+} using KOH-AC and HNO_3-AC

KOH is seen to give large surface area compare to HNO_3, in this case it is found out that KOH were found to improve or maintain the bio-sorption capacity while HNO_3 result in a significant reduction in the bio-sorption capacity thus bases activated is found to be more effective. The adsorption of water was higher with the KOH activated carbon at 99.3% while 98.5% was observed for HNO_3 activated carbon.

Mikytsabu *et al.*, 2021, studied the sorption efficiency of Sesame stem activated carbon in Cadmium ion solution. It can be seen that the higher sorption capacity was recorded for the adsorption of the Cadmium ion 88.4 %. The adsorption capacity can be explained base on the formation of covalent bond with a ligand. Base on this fact, Cadmium forms a covalent bonding easily with NH_2.

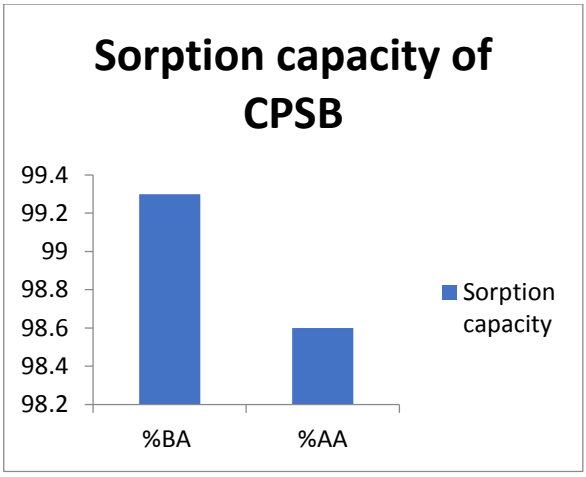

Figure 1: Effect of Sorption Capacity of cadmium using KOH-AC and HNO_3-AC

The effect of contact time on adsorption efficiency of Pb^{2+} by KOH-AC and HNO_3-AC produced from Cissus populnea stem.

The results related to ions adsorption of Pb (II) ions by contact time using KOH-AC and HNO_3-AC produced from *Cissus populnea* stem showed increases in absorption from 1 hour to 3 hours and a slight increase along the hours until 24 hours. Sorption was very slow at 6 – 24 hours possibly due to near saturation adsorbent surface. Thus, this obtained contact time was used in other adsorption studies. The results indicated that this time is less than the contact time of these metal ions on some other adsorbents. The results of this research on the effect of contact time were similar to those of research titled "Removal of metal ions (copper and lead) from synthetic wastewater by activated carbon produced from Eucalyptus Camaldulensis Dehnh shell related to copper metal". Also, research related to removal of Lead and cadmium from aqueous solutions by activated carbon prepared from Povak tree skin was consistent with studies of (Mikyitsabu *et al.*, 2021) on kinetics and equilibrium of lead adsorption from aqueous solutions on activated carbon produced from maize cobs (2012) with equilibrium contact time of 90 min. Additionally, these were associated with the other study by titled "Dynamic of copper adsorption by inexpensive activated carbon" (María *et al.*, 2020).

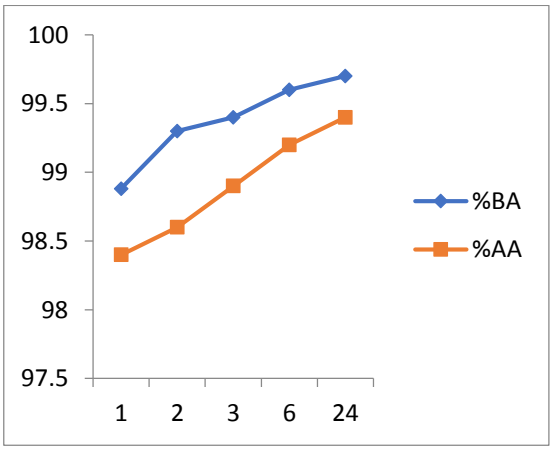

Figure 2: The effect of contact time on adsorption efficiency of lead by KOH-AC and HNO_3-AC produced from *Cissus populnea* stem.

Effect of metal ion concentration in the sorption of lead using KOH-AC and HNO_3-AC prepared from Cissus populnea stem.

The effect of initial heavy metal concentration was studied within the range of 10ppm, 20ppm, 40ppm, 60ppm and100ppm. The results of the study are shown in Fig. 3. The removal efficiency of Pb^{2+} by KOH-AC and HNO_3-AC increases with increasing presence of the adsorbate due to the availability of adsorption sites on the activated carbons. However, as the Pb^{2+} concentration becomes exceedingly high, the removal efficiency increases. It may be noted that the efficiency of adsorption was generally high (>70 %) with all of the chemically activated carbons. It is generally accepted that the mechanism for metal removal is related to the surface properties of activated carbons. The results showed the possibility of exhibiting varied pore sizes, large quantity of oxygen containing functionalities and total negative surface charge which synergistically can provide active sites for adsorption of heavy metal salts. Improvement in the adsorption efficiency with the activated carbons (KOH-AC and HNO_3-AC) as shown (Fig. 3) may therefore be linked to the improved surface properties resulting from chemical activation.

The adsorption increased as adsorbent dosage of CaO NPs increased. With increasing CaO NPs adsorbent dosage, the binding sites or available surface area for adsorption increases, and it leads to the increasing of Pb (II) removal efficiency at neutral pH, 105 min contact time and 60mg/l initial concentration of Pb (II) ion (Ramachandran, *et al.*, 2020).

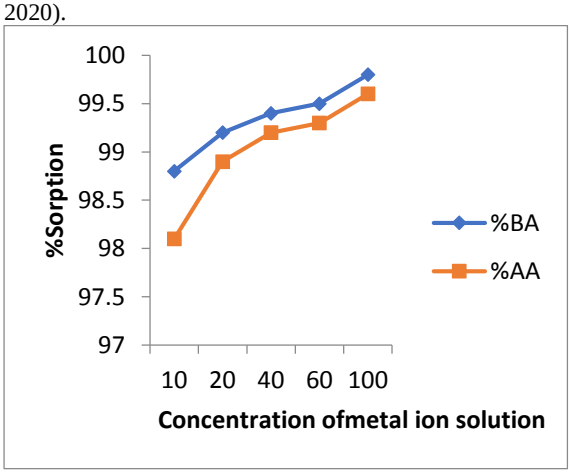

Figure 3: Effect of metal ion concentration in the sorption of lead using KOH-AC and HNO_3-AC prepared from *Cissus populnea* stem.

Effect of pH in the sorption of lead using KOH-AC and HNO_3-AC prepared from Cissus populnea stem.

pH is an important parameter in the adsorption process. In this study the effect of pH was tested by changing pH of solution using 2 to 6 drops of 0.05 Mol/dm^3 and 0.01 Mol/dm3 of NaOH and HCl respectively in concentration of 200 ppm from Pd^{2+} metal ions solution. The graph above shows that KOH-AC absorbs much of the Pb^{2+} better than the HNO_3-AC this may be due to the pH of KOH-AC which is closer to pH of 7 which absorb the most of the Pb^{2+}. Increasing solution pH increases the rate of adsorption because of electrostatic forces. The process continued until pH reached to neutral after that, increasing pH did not show positive effect on increasing absorption. This is because of reduced mobility of ions resulting from changing the properties and its load. The highest absorption was obtained in pH closer to 7. In most of the studies, best pH for removal heavy metals was between5-8. This means that as KOH-AC were neutralized using HCl dilute acid the absorption increase. Similar observation was made when dilute NaOH drops was added to HNO_3-AC. Both pH showed increase in absorption when the pH tends to shift towards the 5-8 rang of the pH scale. Positively charged metal ions and positively charged sites were incapable of binding metal ions due to electrostatic repulsion. Because of this, low removal percentage of Pb^{+} was observed. There were fewer H^{+} ions taking place in the solution when pH increased and as a result more negatively charged sites were made and higher metal ion removal was introduced by electrostatic attraction. In alkaline conditions of pH greater than 7, the removal efficiency was reduced. This is because at low pH (<7), positively charged Pb (II) species are dominant and adsorption on CaO NPs takes place at a faster rate. But in the case of pH values (pH>7), the adsorption was reduced due to different production of lead species with different charges like Pb $(OH)^{+}$, and Pb $(OH)_2$. (Ramachandran, *et al.*, 2022)

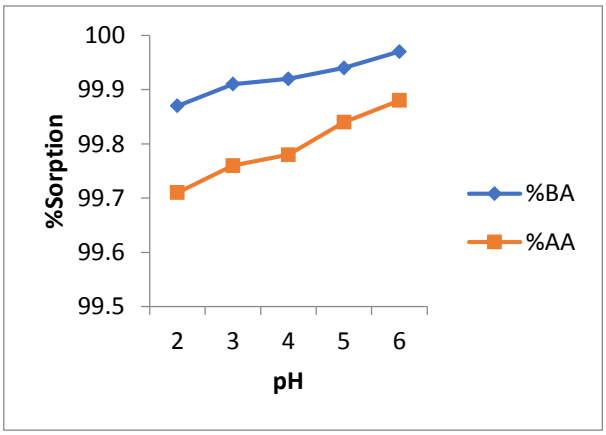

Figure 4 Effect of pH in the sorption of lead using KOH-AC and HNO_3-AC prepared from *Cissus populnea* stem.

Figure 5: effect of ionic strength on sorption efficiency of *Cissus populnea* stem bark activated carbon on metal ion

It is seen that the sorption capacity of *Cissus populnea* stem activated carbon decrease with increase in ionic strength. Acid activated shows lowest decrease at maximum amount of NaCl this is attributed to the fact that the sorption of metal ions decreases. When the ionic strength can however be explained because of competition of Na^{+} with other metal ion for electrostatic binding to the *Cissus populnea* stem.

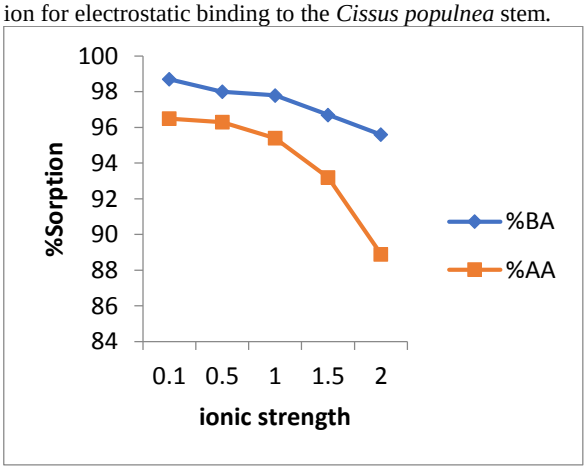

Figure 5: shows the effect of ionic strength on sorption efficiency of *Cissus populnea* stem bark activated carbon on metal ion

Conclusion

The removal efficiency of $Pd^{2+}$by KOH-AC and HNO_3-AC increases with increasing presence of the adsorbate due to the availability of adsorption sites on the activated carbons. However, as the Pd^{2+} concentration becomes exceedingly high, the removal efficiency increases. It may be noted that the efficiency of adsorption was generally high (>70 %) with all of the chemically activated carbons. Acid activated shows lowest decrease at maximum amount of NaCl this is attributed to the fact that the sorption of metal ions decreases.

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