

4PSQUJPO 4UVEZ PG \$E ** GSPN "RVFPVT 4PM 1 SFQBSFFJGLGFFAMARSJB4LGFFAMARFPYB

Jimoh AA 1* , Adebayo GB 2 , Otun KO 1 , Ajiboye AT 1 , Bale AT 1 , Jamiu W 2 and Alao FO 2

¹Department of Chemical, Geological and Physical Sciences, Kwara state University Malete, PMB 1530 Ilorin, Nigeria ²Department of Chemistry, Faculty of Science, University of Ilorin, PMB 1515, Ilorin, Nigeria

Abstract

Activated carbon prepared from vitellaria paradoxa (shea nut) shell using otho-phosphoric acid has been used for the removal of Cd(II) ion from aqueous solution. The adsorbent sample was characterized by some physicochemical and spectroscopic parameters such as pH, point of zero charge (PZC), moisture content, iodine number, loss on ignition, bulk density, XRF, SEM and TEM. The pH and the PZC of the sample were found to be 4.0 and 5.8 respectively. The adsorbent sample has moisture content of 5.22 ± 0.1%, iodine number of 456.50 ± 59%, loss on ignition 10.71 \pm 0.18% bulk density of 0.84 \pm 0.09%. The XRF analysis indicated that Ca, Si and Fe were major constituents in the adsorbent sample. The SEM and TEM analysis results indicated good adsorptive characteristics of the adsorbent. Result from the FTIR analysis indicate presence of some important components such as C=O, O-H, C-O N-H, and P-H which responsible for high adsorptive capacity of the adsorbent. The equilibrium adsorption of &G ,, LRQ GDWD ZDV ZHOO ¿WWHG ZLWK /DQJPXLU DQG)UHXQGOLFK LVRWKHUPV UHVSHFWLYHO\ 7KH NLQHWLF VWXG\UHYHDOHG WKDW SVHXGR VHFRQG RUGHU ¿UVW RUGHU NLQHWLF 7KHUPRG\QDPLF H[SHULPHQW LQGLFDWHG WKDW WKH DG\ .-PRODQG¨6HTXDOV.-PRO.

Vitellaria paradoxa) is found in areas with 400-

1800 mm rainfall per year. It is a multi-purpose tree daily used by rural African communities. e fruit when very ripe is either eaten as a snack, but it is also a famine food. It can be eaten raw or slightly cooked. e pulp can be processed into juice. According to McAllan et al. [14], the pulp could also be removed by fermentation. e nuts are

*Corresponding author: Jimoh AA, Department of Chemical, Geological and Physical Sciences, Kwara state University Malete, PMB 1530 Ilorin, Nigeria, Tel: +2348032422513; E-mail: aquochem@yahoo.com

Received January 20, 2015; Accepted March 24, 2015; Published March 27, 2015

Citation: Jimoh AA, Adebayo GB, Otun KO, Ajiboye AT, Bale AT, et al. (2015) Sorption Study of Cd(II) from Aqueous Solution Using Activated Carbon Prepared from Vitellaria paradoxa Shell. J Bioremed Biodeg 6: 288. doi:10.4172/2155- 6199.1000288

Copyright: © 2015 Jimoh AA, et al. This is an open-a ccess article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

Citation:

Citation: Jimoh AA, Adebayo GB, Otun KO, Ajiboye AT, Bale AT, et al. (2015) Sorption Study of Cd(II) from Aqueous Solution Using Activated Carbon Prepared from Vitellaria paradoxa Shell. J Bioremed Biodeg 6: 288. doi:10.4172/2155-6199.1000288

Page 3 of 10

was 204.2 and 256.2 respectively (Table 1). e result indicated that the activated sample prepared by acid activation possesses good adsorptive capacity. Higher iodine number reects better development of the microporous structure and higher adsorption abilities [29,30]. It was clear that the iodine number of acid activated adsorbents is high due to the phosphoric acid destroying the aliphatic and aromatic species present in plants therefore swily removing the volatile matters during the carbonization process as reported by El-Hendawy [31].

Scanning electron microscopy (SEM)

e surface morphology of the adsorbent was analyzed by scanning electron microscope (SEM). e results of SEM analysis are shown in the micrographs Figures 1-3. e raw sample in Figure 1 showed rough areas of surface of the carbon and very minute micropores.

It was generally observed that the pore structure development is in uenced by many factors, such as inorganic impurities and the initial structure of the carbon precursor [32]. It can clearly be seen in Figure 2 that chemical activation resulted in a porous structure and the opening of pores on the surface of the activated sample.

SEM analysis a er adsorption of Cd in Figure 3 however showed a reduced pore sizes as compared to that of the acid activated sample.

Transmission electron microscopy (TEM)

Transmission electron microscope (TEM) was used to determine the internal morphology of the adsorbent. e results of TEM analysis of the adsorbents, raw sample, activated sample and sample a_{er} adsorption are shown in Figures 4-6.

e internal pore size of the raw sample Figure 4 was between 0.94-2.90 m, those of the activated sample Figure 5 ranged between 5.27-5.92 m. is improvement in pore size of the activated adsorbent could be due to the carbonization in the presence of acid.

However, aer adsorption, the internal pore size of the Cdembedded adsorbent reduces between 2.43-2.86 m Figure 6. is observation indicated that the adsorbent eective on Cd adsorption,

Figure 2: SEM Micrograph of activated sample.

Figure 3: SEM Micrograph of activated sample after adsorption.

Figure 4: TEM Micrograph of raw sample.

Figure 5: TEM Micrograph of activated sample.

since the internal pore sizes reduced Cd-embedded adsorbent. is implies that Cd ions occupied spaces in adsorbent.

XRF elemental analysis

e elemental analysis of the adsorbent as revealed by XRF (Table Figure 1: SEM Micrograph of raw sample. (2) result showed that Ca, Si and Fe are present as major constituents Citation: Jimoh AA, Adebayo GB, Otun KO, Ajiboye AT, Bale AT, et al. (2015) Sorption Study of Cd(II) from Aqueous Solution Using Activated Carbon Prepared from Vitellaria paradoxa Shell. J Bioremed Biodeg 6: 288. doi:10.4172/2155-6199.1000288

Page 4 of 10

the modied and metal-loaded adsorbents. ese groups might have been destroyed or evaporated during carbonization or converted into another functional group.

e sharp stretch vibrations found within band range 2284-2400 cm¹ appeared to represent functional group of phosphorus belonging to phosphine (P-H). e presence of phosphine group is expected to increase the adsorptive capacity of the adsorbents.

e stretch vibrations of C=O in ketones and aldehydes were found in the range 1700-1735 cm[35]. is peak appeared in raw and Cdloaded adsorbent but absent in activated adsorbent. is observation may be attributed to the loss of Couring carbonization process and do not reappear a er activation.

e bend vibrations of N-H at band range 1450-1550 cm

Na, Ti and Zn are minor constituents while Mg, Al, P, Mn, Co, Ni, Cu and Cd are in traces.

e point of zero charge of activated sample was determined by potentiometry method. e graph of the pH of sample solution and that of the blank solution were plotted as shown in Figure 7. It could be observed that the pH drop for the sample solution and the blank solution intercepted at pH 5.8, this shows that the prias found to be 5.8 for vitellaria paradoxa. Cation adsorption becomes enhanced at higher pH than pHpzc, while adsorption of anions equally enhanced at pH less than pHpzc [33].

FTIR Results of the raw sample, activated sample and a er adsorption

e comparisons of the Fourier transform infra-red result spectra of raw, modied and aer adsorption of the vitellaria paradoxa were given in gures. e FTIR spectrum of the raw reveals complex nature of the adsorbent as evidenced by the presence of a large number of peaks. e band between 3000-3500 cmas been assigned to free and intermolecular bonded hydroxyl (O-H) group of alcohol, phenol or carboxyl [34]. ese bonds were present in raw, modied and metalloaded adsorbents; indicating participation of the (O-H) functional group in the metal binding. e peaks at 2918.40 cm2046.54 cm $1, 1633.76$ cm and 1427.37 cm have been assigned to C-H, CAC, CAN and C=C respectively in the raw but were completely absent in

œ¦¡••¥—¯¼½¾³¯±Á¸½ÃÀ¼¯º

Citation: Jimoh AA, Adebayo GB, Otun KO, Ailboye AT, Bale AT, et al. (2015) Sorption Study of Cd(II) from Aqueous Solution Using Activated Carbon Prepared from Vitellaria paradoxa Shell. J Bioremed Biodeg 6: 288. doi:10.4172/2155-6199.1000288

trend could be as a result of the increase in the electrostatic interactionained constant at pH above 6. e maximum percentage removal between the Cd(II) the absorbent active sites. Moreover, this can beCd(II) was 95.62%.

explained by the fact that more adsorption sites were being covered
explained by the fact that more adsorption sites were being covered
explained by the fact that more adsorption sites were being covered as the metal ions concentration increases [37]. In the case of low It was observed that pH signi cantly a ect the adsorption process.
metal ions concentration, the ratio of the initial number of moles of

metal ions to the available surface area of the adsorbent is large and

subsequently the fractional adsorption becomes independent of initial concentration. However, at higher concentrations, the available sites of the prst stTd 7 Tw rapi6(csoraseions penn 75%sed ncreased, adsorption become fewer and hence the percentage removal of metal

ions which depends upon the initial concentration decreases [38]. It could however be deduced from the result above the equilibrium

concentration is at 200 mg/L.

E ect of pH: e e ect of initial solution pH on the adsorption capacity at equilibrium condition was studied. e result for the adsorption of Cd(II) is shown in Figure 8 using 200 mg/L as initial metal concentration. It could be seen that the removal concentration and percentage removal is pH dependent. It was clear that the degree of metal ions adsorption onto the adsorbent increased from 50.48 mg/L to maximum of 57.37 mg/L of Cd(II) when the solution pH was increased from 2-6. However, at the adsorption capacity of the adsorbent

Citation: Jimoh AA, Adebayo GB, Otun KO, Ajiboye AT, Bale AT, et al. (2015) Sorption Study of Cd(II) from Aqueous Solution Using Activated Carbon Prepared from Vitellaria paradoxa Shell. J Bioremed Biodeg 6: 288. doi:10.4172/2155-6199.1000288

Page 6 of 10

deposited metal ions penetrated to the interior of the adsorbent through intra-particle di usion which was slower process. is is in accordance with the observation of other similar studies (Figure 10) [40,41].

E ect of temperature: s (Figuen.86

Citation: Jimoh AA, Adebayo GB, Otun KO, Ajiboye AT, Bale AT, et al. (2015) Sorption Study of Cd(II) from Aqueous Solution Using Activated Carbon Prepared from Vitellaria paradoxa Shell. J Bioremed Biodeg 6: 288. doi:

Citation: Jimoh AA, Adebayo GB, Otun KO, Ajiboye AT, Bale AT, et al. (2015) Sorption Study of Cd(II) from Aqueous Solution Using Activated Carbon
Prepared from Vitellaria paradoxa Shell. J Bioremed Biodeg 6: 288. doi:10.41

Page 8 of 10

 $\Delta G = \Delta H - T \Delta S$

Citation: Jimoh AA, Adebayo GB, Otun KO, Ajiboye AT, Bale AT, et al.

Citation: Jimoh AA, Adebayo GB, Otun KO, Ailboye AT, Bale AT, et al. (2015) Sorption Study of Cd(II) from Aqueous Solution Using Activated Carbon Prepared from Vitellaria paradoxa Shell. J Bioremed Biodeg 6: 288. doi:10.4172/2155-6199.1000288

Page 10 of 10

- 36. Hu Y, Dong X, Nan J, Jin W, Ren X, et al. (2011) Metal-organic framework membranes fabricated via reactive seeding. Chem Commun (Camb) 47: 737-739
- 37. / D U D R X V H Q L D L \$ + % H Q F K H L N K / 0 of copper from aqueous solutions by adsorption using sawdust. Desalination $185 \cdot 483 - 490$
- 38. Yu LJ, Shukla SS, Dorris KL, Shukla A, Margrave JL (2003) Adsorption of chromium from aqueous solutions by maple sawdust. J Hazard Mater 100: 53-63
- 39. Sari A, Tuzen M (2009) Kinetic and equilibrium studies of biosorption of Pb(II) and Cd(II) from aqueous solution by macrofungus (Amanita rubescens) biomass. J Hazard Mater 164: 1004-1011.
- 40. Sangi MR, Shahmoradi A, Zolgharnein J, Azimi GH, Ghorbandoost M (2008) Removal and recovery of heavy metals from aqueous solution using Ulmus FDUSLQLIROLD DQG)UD[LQXV H[FHOVLRU WUHH
- 41. Qaiser S, Anwar RS, Muhammad U (2009) Biosorption of lead(II) and chromium(VI) on groundnut hull: Equilibrium, kinetics and thermodynamics study. Journal of Biotechnology.
- 42. Annadural G, Juang RS, Lee DJ (2003) Adsorption of heavy metals from water using banana and orange peels. Water Sci Technol 47: 185-190.
- 43. Garg VK, Gupta R, Kumar R, Gupta RK (2004) Adsorption of chromium from aqueous solution on treated sawdust. Bioresour Technol 92: 79-81.
- 44. Quek SY, Wase DAJ, Forster CF (1998) The Use of Sago Waste for the 6RUSWLRQ RI /HDG DQG &RSSHU $:DWHU$ 6\$
- 45. Fuste CM, Pons MP (1993) Uranium uptake by immobilized cells of (SHULPHQ WR3tandom Massival RIPS K66B28UA philed MDc@biology Biotechnology 39:661-665
	- 46. Langmuir I (1918) The adsorption of gases in plane surfaces of glass, mica and Platinum. J American Chem Society 40: 1361-1403.
	- 47. Vijayakumar G, Tamilarasan R, Dharmendirakumar M (2012) Adsorption, kinetic, equilibrium and thermodynamic studies on the removal of basic dye rhodamine-B from aqueous solution by the use of natural adsorbent perlite: J Mater Environ Sci 3: 157-170
	- 48. Mohan D, Singh KP (2002) Single and multi-component adsorption of cadmium and zinc using activated carbon derived from bagasse--an agricultural waste. Water Res 36: 2304-2318.
	- O H D Y H V $-$ + D | D U G 0 D W H U
49. Hema M, Arivoli S (2007) Comparative study on the adsorption kinetics and thermodynamics of dyes onto acid activated low cost carbon. Int J Phys Sci $2:10-17.$
	- 50. Lawal OS, Sanni AR, Ajayi IA, Rabiu OO (2010) Equilibrium, thermodynamic and kinetic studies for the biosorption of aqueous lead(II) ions onto the seed husk of Calophyllum inophyllum. J Hazard Mater 177: 829-835.
	- 51. Chowdhury S, Mishra R, Saha P, Kushwaha P (2011) Adsorption thermodynamics, kinetics and isosteric heat of adsorption of malachite green RQWR FKHPLFDOO\ PRGL¿HG ULFH KXVN 'HVDOLQD