



Research Paper

Efficiency of Activated Carbon Prepared from Banana Peels for Treatment of Heavy Metal Ions from Waste Water

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Abstract: Efficiency of activated carbon derived from banana peels has been studied as effective adsorbent for removal of Cu(II), Zn(II) and Cd(II) ions from waste water. The characteristics of the prepared activated carbon were studied via scanning electron microscope (SEM) and FTIR. Batch experiment were carried out under different conditions of contact time,

initial heavy metal concentration and solution pH (2–10). Results showed that the activated carbon samples showed higher removal efficiency compared to the dried fruits peels for all the heavy metal studied. Cu(II) showed the highest removal efficiency followed by Cd(II) then Zn(II) ions.

Keywords: Activated carbons, Removal, heavy metal ions.

INTRODUCTION

Heavy metal in water bodies has become major issues in many countries. Considerable amount of heavy metal such as lead, mercury, nickel, copper and chromium are polluting fresh waters due to anthropogenic activities. Main sources are from urban and agricultural run-off, farms, industrial effluents, sewage treatment plants, domestic discharges, constructions and earthworks (Cheremisinoff 1995). Heavy metals such as zinc (Zn(II)), copper (Cu(II)) and cadmium (Cd(II)) are known to be hazardous to human health, and major concerns is on the ability of these metals to bio-accumulate in biological systems (Zoumis 2000). Zinc is released into the aquatic environment through several industrial activities, such as

mining, metal coating, battery production and its use in paints, ceramics, wood, fabrics, drugs, sun blocks and deodorants (Dimirkou, 2007; Reilly, 1991). While Cd^{2+} ions diffuse into water and the environment through battery, paper, pulp and ammunition industries. Ingestion of Cu(II) in food, in severe cases may produce fatal hepatic and renal damage (Miryakova, 1996; Forstner and Wittman, 1981). Human exposure to these heavy metals at significant levels is associated with serious health effects (Viraraghavan and Dronamraju 1993; Wahi et al, 2009). The maximum permissible limit set by Malaysian Environmental Quality Act (1974) for Zn(II), Cu(II) and Cd(II) in

Standard B water is 1.0 mg/l, 1.0 mg/l and 0.05 mg/l, respectively.

Various treatment methods are derived by the researches to treat heavy metal ions from waste water such as alkaline precipitation ion exchange, solvent extraction (Jenkins, 1976), electrodialysis (Kurniawan et al, 2006), electrolytes (Arief et al., 2008). However, these methods become noneconomical when dealing with very small concentrations of metals due to the need to use expensive monitoring systems. Adsorption is considered to be one of the most economical and effective methods for removal of metals from wastewaters. Activated carbon was widely used in the removal of dyes and metals from industrial waste waters (Sana et al., 2008). The ease of operation, ease of availability and simplicity of design represent other reasons for the use of such technique (Kuboi and Takeshita, 1989; Idhayachander and Palanivelu, 2010; Hashemian, 2009). The most widely used adsorbent is activated carbon is a due to its high adsorption capacity, high surface area, microspores structure and high degree of surface reactivity. Adsorption capacity of activated carbon strongly depends on its porosity and surface area. Textural property of AC depends on method of preparation and starting material (Mohd Din et al., 2009; Meshko et al., 2001). There are two processes for the preparation of activated carbon: physical activation and chemical activation. Physical activation includes carbonization of a carbonaceous materials followed by treatment by activated reagent like CO₂ or steam Sanghi and Bhattacharya, 2002; Bouchelta, 2008). In chemical activation, a raw material is impregnated with an activating reagent such as ZnCl₂, H₃PO₄, KOH etc. Chemical activation is preferred over physical activation owing to the higher yield, simplicity, lower temperature and shorter

time needed for activating material, and good development of the porous structure (Jia and Thomas, 1999). In this study, attempts were made to prepare activated carbon from banana fruit peels through chemical activation. The effectiveness of the prepared activated carbon in the removal of zinc, copper and cadmium ions from aqueous water are also studied.

MATERIAL AND METHODS

Fresh banana peels were collected from local stores in Riyadh, KSA. The collected peels were first washed by distilled water, then dried in sun light for 7 days then in oven at 100 °C for 24 hrs. After drying, the peels were crushed and sieved to 125 mm sieve and designated as (B). The activated carbon was prepared through chemical activation. 40 g of the fruit peel powder with 120 ml of concentrated H₃PO₄ (1:3 weight ratios) for 6 h in an air condenser system. After cooling, the final products were filtrated and washed several times with sodium bicarbonate solution and distilled water till neutral pH ~ 7. After that, the resultant precipitate was dried at 110°C for 24 h, and subsequently was weighed to determine the yield of the product. Finally it was stored in tightly closed bottles and designated as BAC.

FTIR and Scanning electron microscope (SEM) are used for studying the texture of the various fruit peels and the prepared activated carbon samples. This was carried out by using a JEOL (JEM2010) scanning electron microscope and a Fourier transform infrared spectrometer (BIO-RAD FTS-40).

Removal process of Zn(II) , Cu (II) and Cd(II) ions using both the dried banana peels and the prepared carbon samples were studied as mention earlier in our study.

The removal (R) efficiency was calculated according to the following equation (Fayza S.Hashem, 2016).

$$R \% = (C_i - C_f) / C_i \cdot 100$$

Where: R is the of the removal efficiency and C_i and C_f is the concentration of the heavy metal ion in solution before and solution removal process (mg/L).

Effects of initial concentration of heavy metal solution, contact time and initial pH of the solution were studied.

RESULTS AND DISCUSSION

Samples characterization

Fig.1, 2 show the SEM of both the dry banana peels and the activated carbon prepared from it by chemical activation. For dried peels, Fig.1, banana particles could be identified with limited surface area. After chemical activation by phosphoric acid, an improved in the microstructure are obtained as indicated by dramatic effects occurred on the solid surface which is responsible for pitting and fracturing erosion of the surface. Such treatment increases the efficiency of the activated carbon.

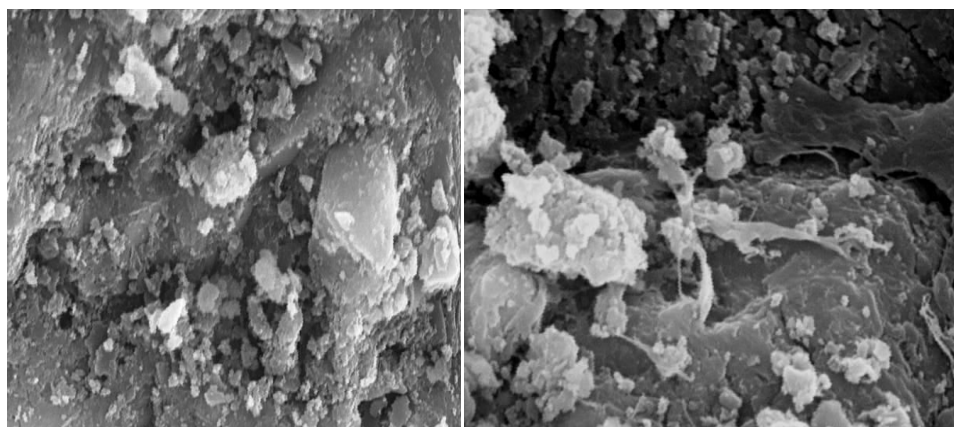


Fig.1 SEM of dried banana peels

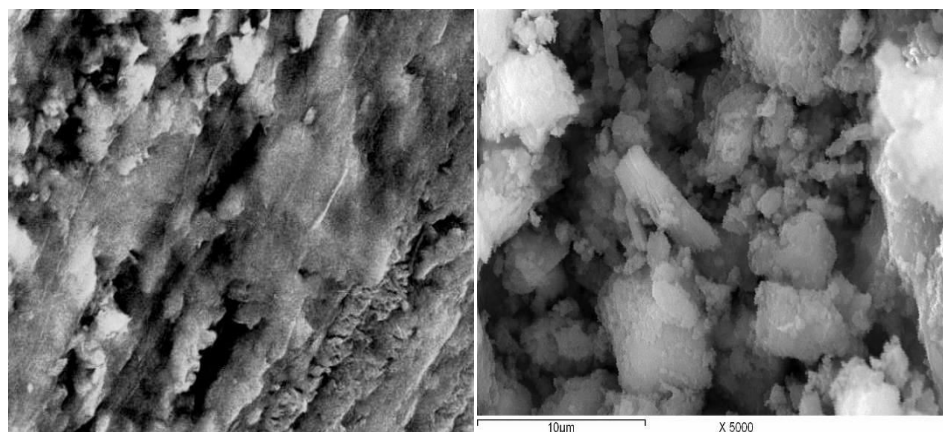


Fig.2 SEM of activated carbon

FTIR

The IR absorption spectra of the activated carbon BAC is shown in Fig 3. IR spectrum shows broad bands in 3300-3500 cm^{-1} region, which could be assigned to OH stretching mode from hydroxyl and phenolic group (Fayza

S.Hashem, 2016). The C=C stretching of alkenes group was detected at bandwidth 2826-2862 cm^{-1} . The C=O stretching of lactones, ketones and carboxylic anhydrides functional groups were detected at bandwidths of 1820-1880 cm^{-1} . Broad band at 1300-1000 cm^{-1} which

could be assigned to C–O stretching in alcohols and phenols that confirming the OH group of this sample. The presence of

these functional group has responsibility for adsorption sites (Rao, 2008).

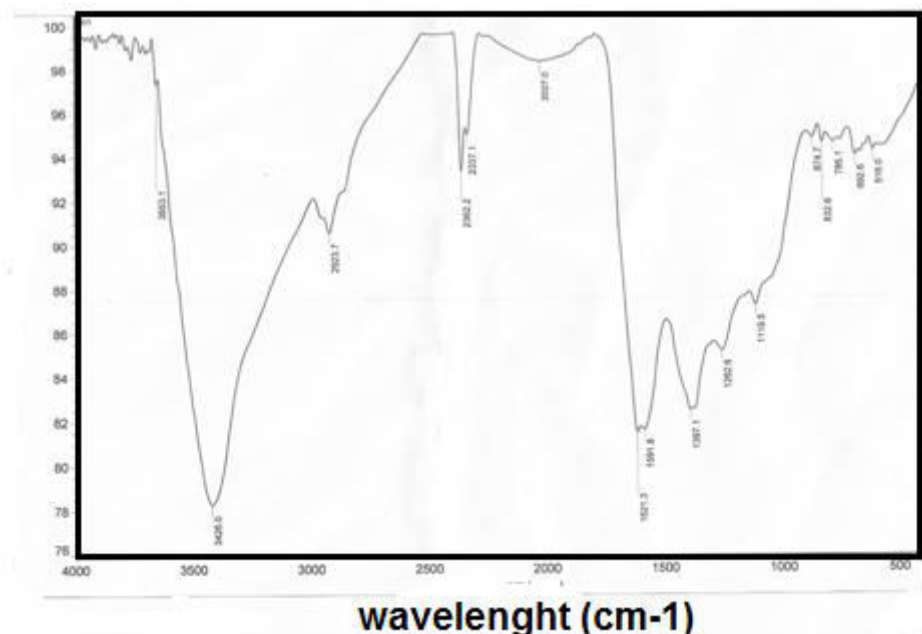


Fig (3): FTIR of BAC

Removal Experiments

Effect of Initial Element Concentration:

The removal efficiency of dry banana peels and activated carbon derived from it for removal of Zn^{2+} , Cu^{2+} and Cd^{2+} ions at different initial concentration are represented in Fig. 4,5. According to the data in Fig.4 the removal efficiency of dry banana peels for all the studied heavy metal ions is concentration dependent. All the three heavy metal ions show removal efficiency which is higher at lower concentrations and decreased by increasing the initial heavy metal concentration in the solution. This could be related to the decrease in the number of the active sites available by increasing the concentration of the heavy metal ions. Also the removal efficiency is selective since it was higher

for Cu ion than Cd ions. While Zn ion shows the lowest removal.

Fig.5 shows the removal efficiency of activated carbon prepared from banana peels for various heavy metals. For all studied heavy metal ions, using activated carbon as adsorbent leads to increase the removal efficiency of these toxic ions from waste water. About from 6 to 40% increase in the removal percentage were recorded for the studied heavy metals ions. The analogue of removal of ions with the initial ion concentration varies according to the type of the heavy metal. Since Zn^{2+} ions show an decrease in the removal efficiency with increasing the initial concentration of the heavy metal ions in the solution, Cu^{2+} and Cd^{2+} show variable trend.

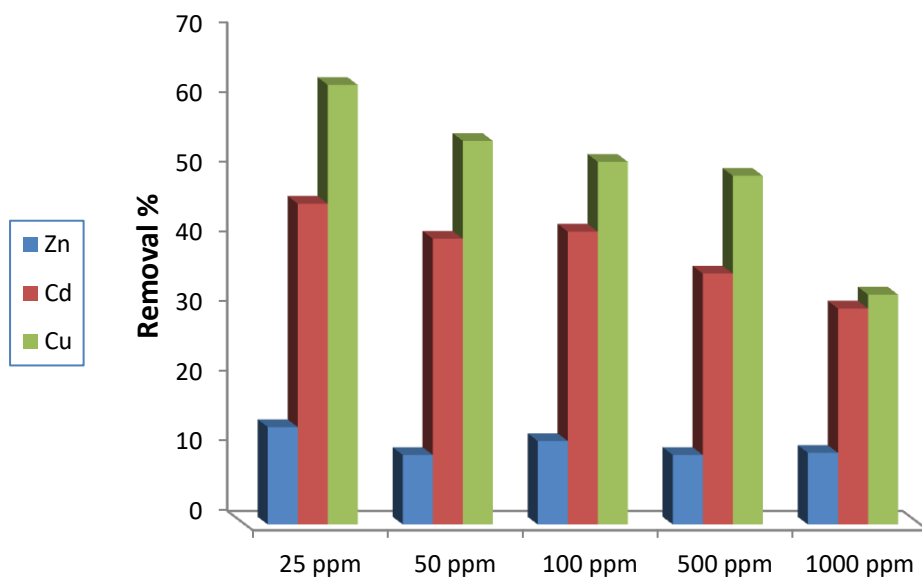


Fig.4 Removal efficiency of dry banana peels for heavy metals ions at various initial concentrations.

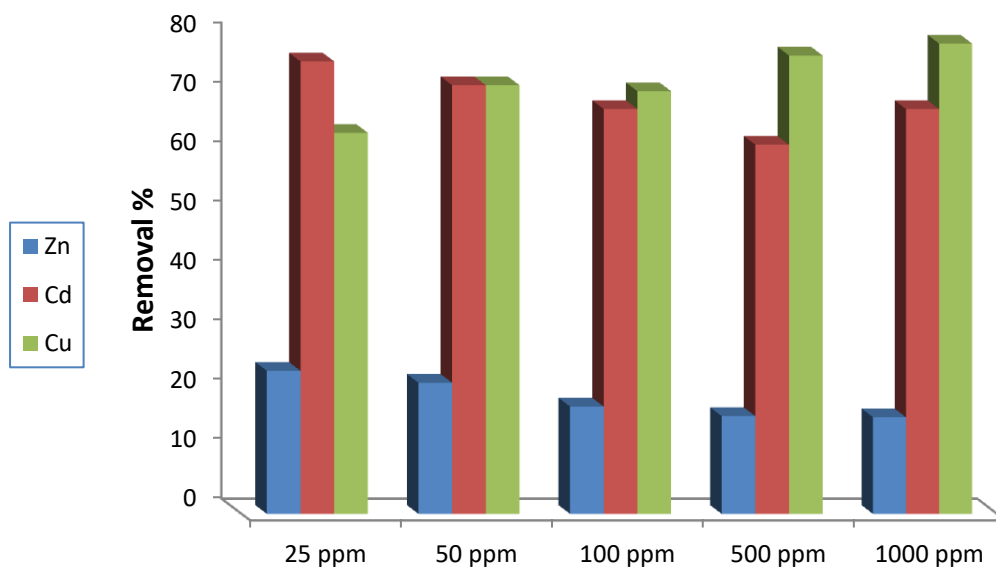


Fig.5 Removal efficiency of activated carbon for heavy metals ions at various initial concentrations

Effect of pH of the removal solution:

Fig.6,7 show the variation of the removal efficiency of the heavy metals with pH of the removal solutions. Both the dry banana peels and the activated carbon prepared from it show removal efficiency for Zn^{2+} , Cu^{2+} and Cd^{2+} ions which change with the pH of the solution. Also, all the studied

samples showed percentage of removal which increase by increasing the pH values from 2 to 6. In pH range 8-10 the percentage of removal decreased in all the studied samples. The highest removal recorded for all these heavy metal ions was pH=6. At pH 8, the removal efficiency nearly unchanged or slightly increased

when the activated carbon used as substrate for adsorption. While as, for dry banana peels the removal efficiency decreased for all the heavy metal studied. This could be explained by decreasing the number of negatively charged adsorbent sites and increasing the number of positively charged sites at low pH values. This did not favor the adsorption of positively charged cations like M^{2+} due to electrostatic repulsion. Increasing the pH values to become near the neutral or alkaline values will lead to deprotonation

of the acid sites on the adsorbent surface and the surface becoming negatively charged with high attractive properties. This leads favor the adsorption of the positively charged ions. At alkaline pH, Heavy metal ions will hydrolysis to become $Cu(OH)^+$, $Cd(OH)^+$ and $Zn(OH)^+$ (Wahi, 2009) and as consequence, the heavy metal positive charge was reduced to +1 which make low interaction with the adsorbent surface besides the metal hydroxides could be precipitates.

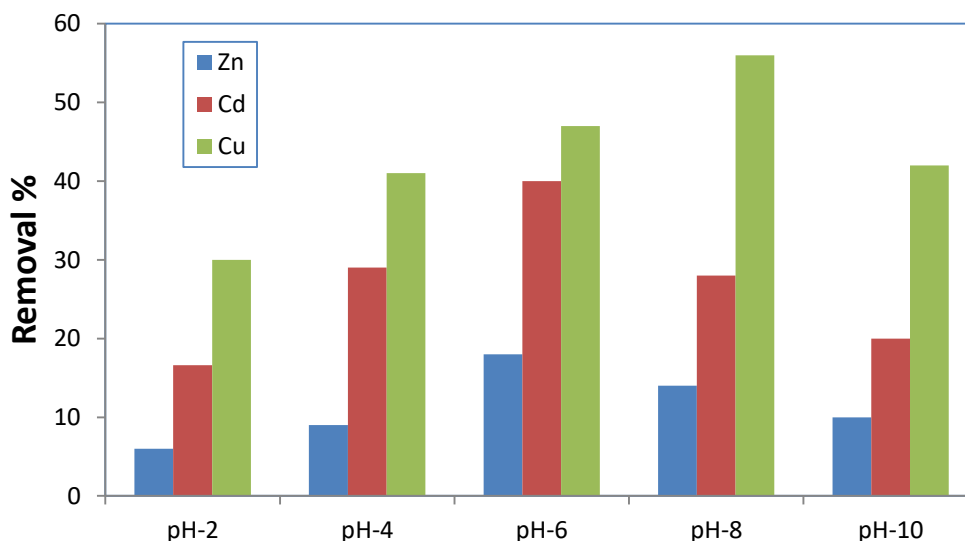


Fig.6 Removal efficiency of dry banana peels for heavy metals ions at pH values

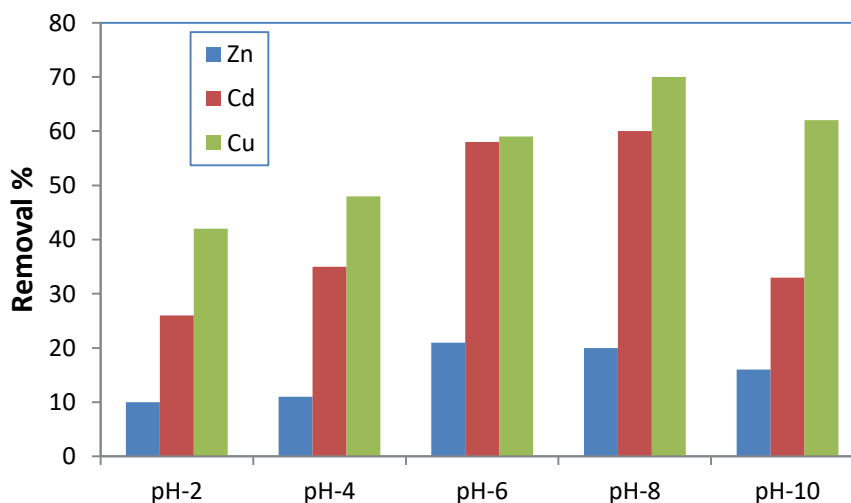


Fig.7 Removal efficiency of activated carbon for heavy metals ions at pH values

Contact time

Studying the effect of contact time on the removal efficiency was carried out to investigate the removal rate. Figs. 8,9 show the relation between the between the removal efficiency of Cd^{2+} , Cu^{2+} and Zn^{2+} and contact time (minutes). This was carried out by immersing 1.5 g of dry banana peel or activated carbon prepared from it on a conical flask containing 25 ml of heavy metal ions at initial concentration (100 mg/L) and pH of the solutions were adjusted at 6. According to Fig.8. the removal of all the heavy metal studied on banana peels is increased by increasing the contact time. Also this process is fast and the equilibrium reached within 1 hour. However, not all the heavy metal ions are removed from solutions but about 69, 57 and 28% of Copper, cadmium and zinc ions are removed from their solutions in the first hour using dry banana peel as adsorbent.

Fig.9 shows the removal efficiency of activated carbon derived from banana peels to for removing Cd^{2+} , Cu^{2+} and Zn^{2+} ions from their solutions. Comparing the obtained data by those recorded in Fig.8 we can concluded that for all the heavy metals, the efficiency of removal increased by using activated carbon relative to dry peels. However the percentage of removal slightly increased in the initial removing times (within the first 15 minutes) it highly improved at later times for all the studied heavy metals especially copper and cadmium. This could be related to the mechanism of the removing process which depends mainly on diffusion in the first contact times (Ghazy and El-Mosy, 2009; Saeed, 2005). According to the values of the removal percentages, the removal of various metal ions is in the order $\text{Cu}^{2+} > \text{Cd}^{2+} > \text{Zn}^{2+}$

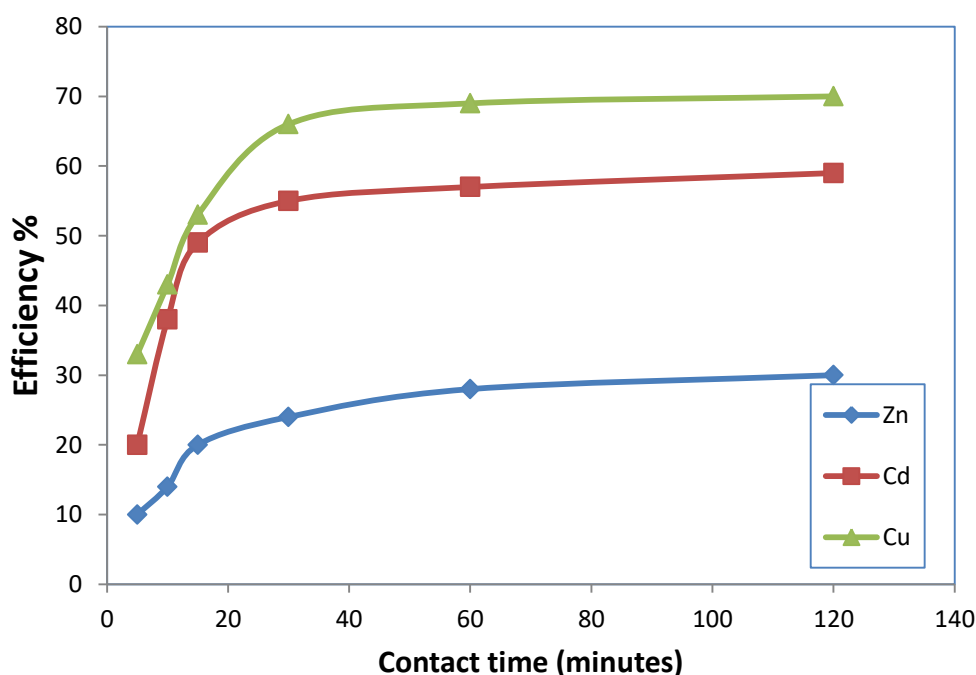


Fig.8.Effect of contact time of the removal efficiency of heavy metal ions on dry banana peels.

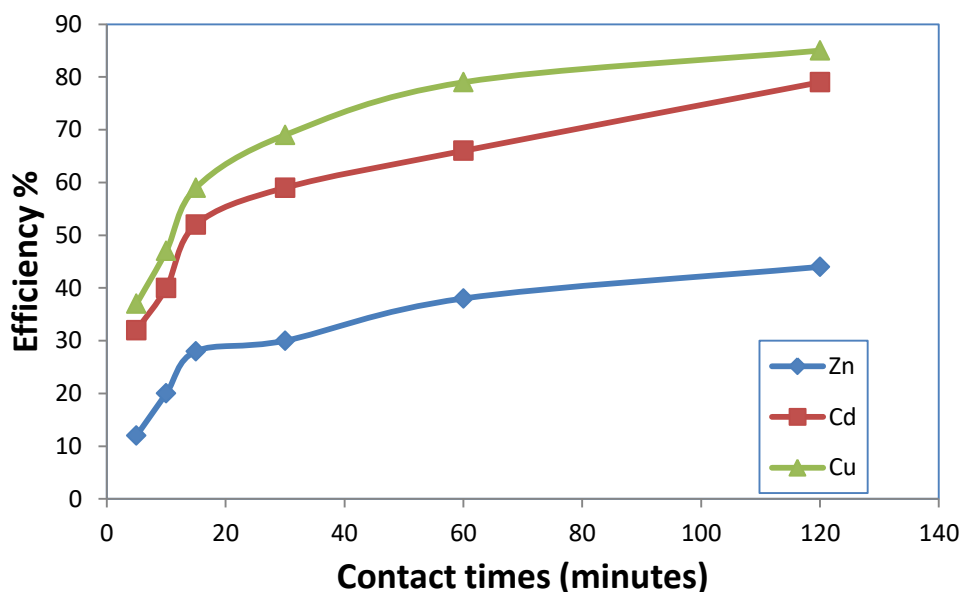


Fig.9. Effect of contact time of the removal efficiency of heavy metal ions on activated carbon

Conclusion: According to the obtained results, the activated carbon samples prepared from banana peels has higher removal efficiency compared to the dried fruits peels for all the heavy metal studied. -Cu(II) showed the highest removal efficiency followed by Cd(II) then Zn(II) ions.

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REFERENCES

Cheremisinoff P.N. (1995) Handbook of Water and Wastewater Treatment Technology, Marcel Dekker Inc, New York.

Zoumis T. Calmano W. and Forstner U. (2000) Demobilization of heavy metals from mine wastewaters, Acta Hydrochim. Hydrobiol. 28, 212–218.

Dimirkou A. (2007) Uptake of Zn^{2+} ions by a fully iron-exchanged clinoptilolite. Case study of heavily contaminated

drinking water samples, Water Res. 41 2763–2773.

Reilly C. (1991) Metal Contamination of Food. London: Elsevier Applied Science. 3-10. City.

Miryakova T. F. (1996) Heavy Metals in Macrophytes of the Rybinskoe Reservoir. Water Resources 23(2), 213-219.

Forstner U. and Wittman C.T.W. (1981) Metal Pollution in the Aquatic Environment, Springer, New York, pp: 211.

Viraraghavan T, and Dronamraju M. M. (1993) Removal of Copper, Nickel and Zinc from Wastewater by Adsorption using peat. Environmental Science Engineering 28:1262-1276.

Wahi R., Ngaini Z., and Jok U.V. (2009) Removal of Mercury, Lead and Copper from Aqueous Solution By Activated Carbon of Palm Oil Empty Fruit Bunch. World Applied Science Journal (Special Issue for Environment), 84-91.

Jenkins D.W. (1976) In the Proceedings of the International Conference on Environmental Sensing and Assessment, Vol.1, Wiley Inter science. New York

Kurniawan T. A. Chan G.Y.S. Lo W. H. Babel S. (2006) Physico-chemical treatment techniques for wastewater laden with heavy metals, Chem. Eng. J. 118 83–98.

Arief V. O. Trilestari K. Sunarso, J. Indraswati, N. Ismadji S. (2008) Recent progress on biosorption of heavy metals from liquids using low cost biosorbents: characterization, biosorption parameters and mechanism studies, Clean Soil Air Water 36 937–962.

Sana T. Shiomori K., Kawano Y. (2005) Extraction rate of nickel with 5 dodecylsalicylaldehyde in a vibro-mixer. Sep. Purif. Technol. 44, 160-165.

Kuboi Y. Takeshita R., (1989) Extension of bath life by electrodialysis method at electroless nickel plating baths. In: American EN 89 Conference. New York.

Idhayachander R., Palanivelu K. (2010) Electrolytic recovery of nickel from spent electroless nickel bath solution. E-J. Chem. 7, 1412-1420.

Hashemian S (2009) Modified Sawdust for removal of methyl violet from aqueous solutions. Asian J. Chem. 21(4): 3622-3630.

Mohd Din, A. T. Hameed B. H. and Ahmad A. L. (2009) “Batch adsorption of phenol onto physiochemical-activated coconut shell,” Journal of Hazardous Materials, vol. 161, no. 2-3, pp. 1522–1529,

Meshko V., Markovska L, Mincheva M., and Rodrigues A. E, (2001) Adsorption of basic dyes on granular activated carbon and natural zeolites, Water research, 35(14)3357-3366

Sanghi R. and Bhattacharya B, (2002) Review on decolorisation of aqueous dye solutions by low cost adsorbents, coloration technology, 118(5) 256-269

Bouchelta, C. Medjran, M. S. Bertrand, O. J. Bellat J. (2008) Anal. Appl. Pyrol. 28 70–77.

Y.F. Jia, K.M. (1999) Thomas, Adsorption of cadmium ions on oxygen surface sites in AC, Langmuir 16 1114–1122.

Fayza S. Hashem, Khairia M. Al-qahtani, Foziah F. Al-Fawzan¹, Mashael Alshabanat, (2016) Comparative Study on Activated Carbon Prepared from Various Fruit Peels, International Journal of Innovative Research in Science, Engineering and Technology , Vol. 5, Issue 3, March.

Rao M.M., Ready D.D.K.K, Venkateswarl. P and Sessaiah. K. (2008) Removal of Mercury from Aqueous Solution Using Activated Carbon Prepared From Agriculture by-product/Waste. J. Environmental Management., 90(1), 634-643.

Wahi R., Ngaini Z., and Jok U.V. (2009). Removal of Mercury, Lead and Copper from Aqueous Solution By Activated Carbon of Palm Oil Empty Fruit Bunch. World Applied Science Journal (Special Issue for Environment), 84-91.

Ghazy S. E., and El-Mosy S. M. (2009), “The Sorption Of Lead From Aqueous Solution By Modified Activated Carbon

Prepared From Olive Stones”, African
Journal of Biotechnology 8(17), 4140-4148.

Saeed A., Akhter M. W. and M. Iqbal,
(2005) Removal and recovery of heavy

metals from aqueous solution using papaya
wood as a new biosorbent, Separ. Purif
Technol., 45, 25-31.