

## Application of adsorbent from Dum palm for the removal of Manganese (II), Zinc (II) and Copper (II) ions from aqueous solution

<sup>1</sup>\*Yisa Jonathan, <sup>2</sup>Hassan Hussaina and <sup>1</sup>Jimoh Oladejo Tijani

<sup>1</sup>Department of Chemistry, Federal University of Technology, Minna, Niger State

<sup>2</sup>Department Science Laboratory, Federal Polytechnic, Bida, Niger State  
joeeyisa@yahoo.com

**Abstract:** The batch adsorption of Mn (II), Zn (II) and Cu (II) ions from aqueous solution using frond and leaves of dump palm was investigated. The influence of sorption time, initial metal ion concentration and adsorbent dosage were evaluated. The results showed that these parts of dump palm have relatively high adsorption capacity for these heavy metals ions. The percentage removed was (76%), (64%), (62%) and (64%) (57%) (56%) for Mn (II), Cu (II) and Zn (II) ions respectively for frond and leaves. Adsorption equilibrium was established in 90mins for Mn (II), Cu (II) and Zn (II) ions. The equilibrium data generated fitted well for Freundlich adsorption model. The obtained results show that the both the leaves and the frond of dump palm are favourable for the sorption of the heavy metal ions.

[Yisa Jonathan, Hassan Hussaina and Jimoh Oladejo Tijani. **Application of adsorbent from Dum palm for the removal of Manganese (II), Zinc (II) and Copper (II) ions from aqueous solution.** Journal of American Science 2011;7(10):226-230]. (ISSN: 1545-1003). <http://www.americanscience.org>.

**Keywords:** adsorbent; palm; Manganese; Zinc; Copper; ion; aqueous solution

### 1. Introduction

Industrial activities such as mining electroplating, tanning, metallurgical operations and manufacturing have led to the release of heavy metals into the environment (Sekar *et al.*, 2004). Unlike the organic pollutants which are biodegradable, heavy metal ions like Mn(II), Cu(II) and Zn(II) are not biogradable (Org *et al.*, 2007) thus making them a sources of great concern. Through food chain, the heavy metals bioaccumulate in living organisms and reached level that cause toxicological effects (Ko *et al.*, (2000). Human health, agricultural development and the ecosystems are all at risk unless water and land system are effectively managed (Rao *et al.*, (2009). The chronic effects of high level consumption of copper are liver and kidney damage (Aydin *et al.*, 2008). Long-term exposure to copper can cause irritation of the nose, mouth and eyes and it can result into headaches, stomachs, dizziness and vomiting (Pruss-ustu *et al.*, 2004). Although human beings can handle proportionally large-concentration of zinc, too much zinc can cause adverse health problems such as stomach cramps, skin irritation, vomiting. Very high levels can damage the pancreas and disturb protein metabolisms, and cause arteriosclerosis (Igwe *et al.*, 2005). As a result of the toxicological effects of these metals, interests in heavy metals removal from waste water have been on the rise.

Several methods have been developed to remove heavy metals ions from aqueous solution before discharge into the water bodies. These methods includes, reduction, precipitation, ions exchange reverse osmosis dialysis and adsorption by coated carbon. Most of these methods are expensive so are not affordable for a developing country like Nigeria. They also have limited applications as they cannot remove metals at low concentrations (Ahalya

*et al.*, 2005). With increasing environmental awareness and legal constraints imposed on discharge of effluents, the needs for cost – effective alternative technologies is essential for removal of heavy metals ions from industrial waste water. Agricultural wastes are characterized by ready availability, affordability, eco-friendliness and high uptake capacity for heavy, metals due to the presence of functional groups which can bind metals to effects the removal of heavy metal from effluents (Rafah *et al.*, 2009). Recent studies have shown that heavy metals can be removed using plants materials such as Sour sop seeds (Obboh and Aluyor, 2008), Cassava fibre (Egila and Okorie 2002), Coconut shell (Gimba *et al.*, 2001), Oil palm empty fruit bunch (Rafeah *et al.*, 2009), palm kernel (Tumin *et al.*, 2008), Walnut skin (Chumbar *et al.*, 2003).

However, Palm tree are very common along the major roads in Bida, Nigeria in which the fruits serve as food, although this contains low vitamins and minerals. Apart from this fruits, it is advisable to use dump part of tree as an alternative for removal of heavy metal ions from aqueous solution since its economic value is less. Therefore, the aim of this study was to investigate the removal of Mn(II), Zn(II) and Cu(II) ions from aqueous solutions.

### 2. Materials and Methods

#### 2.1 Adsorbent preparation

The waste biosorbent comprising leaves and frond dump palm were prepared accordingly. The leaves were prepared as adopted from (Nghah and Hanafia 2008). While the frond was prepared separately according to method adopted by Hamand *et al.*, (2008). Collected samples were washed with deionised water to remove dirt and clipped into smaller process. The samples were dried in oven over

70°C for 48 hours. They were ground using mortar and pestle into different sizes at 400  $\mu\text{m}$  sieve size. The chemical modifications of the sample were made according to the similar method previously described by (Vaughan *et al.*, 2001). Both modified and unmodified samples were stored in clean polyethylene containers labeled accordingly prior to analysis.

## 2.2 Preparation of aqueous solution

All the reagents used were of analytical grade and were prepared with high quality distilled-deionised water. An aqueous solution containing Zn(II), Mn(II) and Cu(II) ions were prepared at 1000ppm (1000mg/L concentration following the method of Saeed *et al.*, (2004).

Stock solutions were prepared from salts of copper, manganese and zinc. Other concentration 5, 10, 20, 30, 4 and 50  $\text{mg}/\text{dm}^3$  salts were obtained using serial dilutions methods.

## 2.3 Biosorption Experiments

Batch studies carried out include biosorption dose dependence, time dependence and metal ions concentration describe by (Okieiman Okieimen, (2001). 0.5g of the powdered samples was added to 50 ml of 5mg/L aqueous solution. The mixtures were shaken in a rotary shaker at 150rpm for a predetermined sorption time followed by filtration using What Man filter paper (No. 42). The filtrate containing the residual concentration of Mn (II), Zn (II) and Cu (II) ions were determined using a Flame atomic Absorption spectrophotometer (AAS). All biosorption are performed in triplicate and mean values reported. Influence of biosorbent dosage was investigated by varying the biosorbent dosage. Biosorbent masses used for the study were 0.5, 1.0, 1.5, 2.0 and 2.5g. The study was carried out at room temperature. The agitation time for this experiment was set at 90 minutes. Initial metal ion concentration were 10, 20, 30, 40 and 50mg/L.

## 2.4 Adsorption isotherm

The Freundlich isotherm coefficients were determined by plotting  $\log Q_e$  against  $\log C_0$  and the results are shown in Table II. The Freundlich equation is an empirical equation based on adsorption on a heterogenous surface. Mathematically the equation is written as  $\log x/m = \log K + 1/n \log C$

## 3. Results

Results are shown in Figures 1-12, as the following.

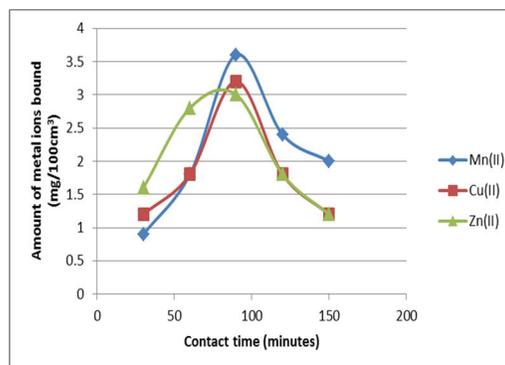


Figure 1: Effect of variation of contact time on the adsorption of Mn(II), Cu(II) and Zn(II) ions on Frond of Dump palm at 33°C.

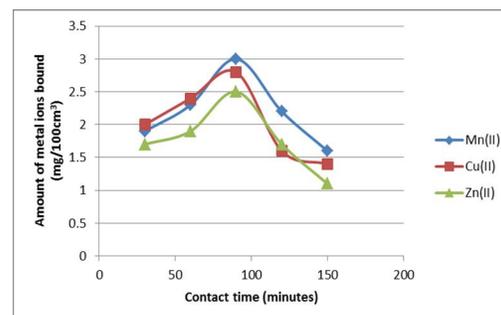


Figure 2: Effect of variation of contact time on the adsorption of Mn(II), Cu(II) and Zn(II) ions on leaves of Dump palm at 33°C.

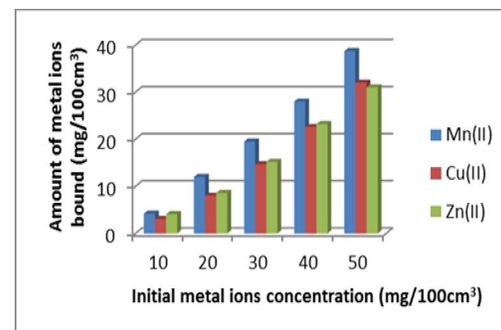


Figure 3: The effect of varying Mn(II), Cu(II) and Zn(II) ion concentrations on the adsorption by Frond at 33°C for 90 minutes.

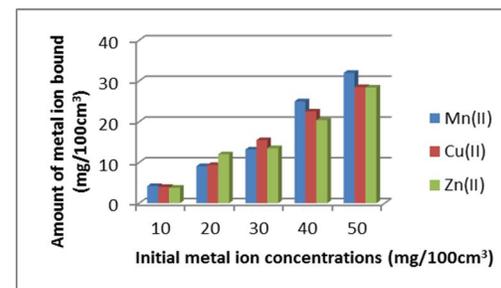


Figure 4: The effect of varying Mn(II), Cu(II) and Zn(II) ion concentrations on the adsorption by Leaves at 33°C for 90 minutes.

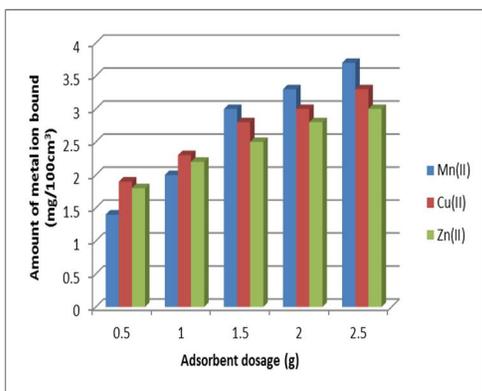


Figure 5: Effect of adsorbent dosage variation on the adsorption of Mn(II), Cu(II) and Zn(II) by Frond of Dump palm.

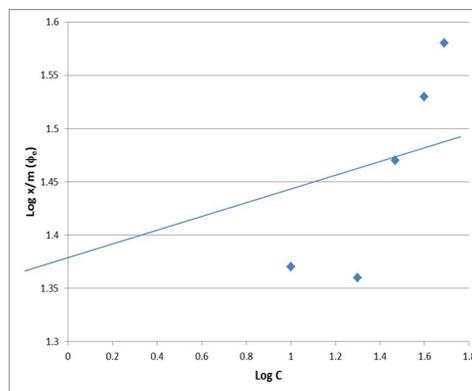


Figure 9: Freundlich adsorption isotherm plot of frond substrate on adsorption of Cu (II) ion

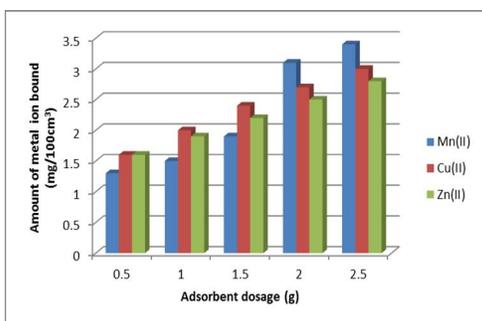


Figure 6: Effect of adsorbent dosage variation on the adsorption of Mn(II), Cu(II) and Zn(II) by Leaves of Dump palm.

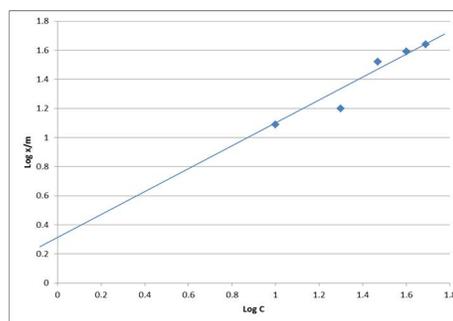


Figure 10: Freundlich adsorption isotherm plot of Leaves substrate on adsorption of Zn (II) ion

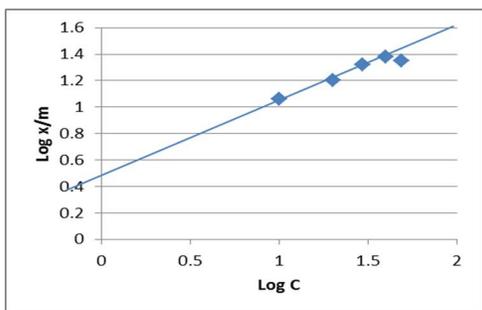


Figure 7: Freundlich adsorption isotherm plot of frond substrate on adsorption of Mn (II) ion

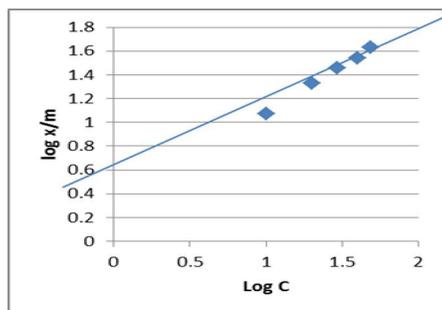


Figure 11: Freundlich adsorption isotherm plot of Leaves substrate on adsorption of Cu (II) ion

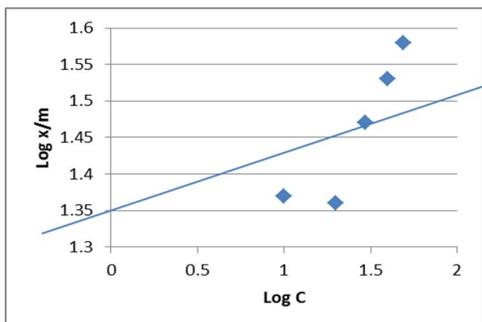


Figure 8: Freundlich adsorption isotherm plot of frond substrate on adsorption of Zn (II) ion

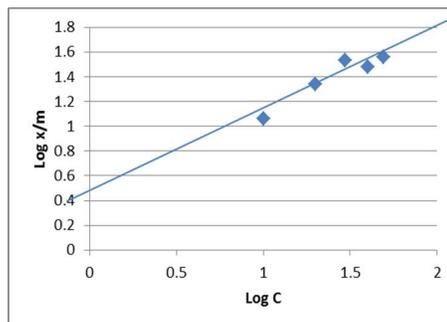


Figure 12: Freundlich adsorption isotherm plot of Leaves substrate on adsorption of Mn (II) ion

#### 4. Discussions

##### 4.1 The effect of contact time on metal ion adsorption

The effect of contact time on the adsorption of Mn (II), Zn (II) and Cu (II) ions solution were shown in Figure 1 and 2. There is general increase in the % adsorption of the metal ions with time. However, the adsorption reached equilibrium in 90 minutes and that Mn (II) ions had the highest percent removal of 72.0 and 60.0 for frond and leaves respectively, followed by Cu (II) 64.0 and 56.0 frond and leaves. While Zn (II) ion had (60.0 and 50.0%) for frond and leaves respectively. There was gradual decline in adsorption after 90mins. The rapid initial rate increase followed by a slow rate at later period could be attributed to the availability of excess adsorption sites on the adsorbent. The initial high adsorption rate might possibly be due to ion exchange followed by a slow chemical reaction of the metal ions with active groups on the sample (Okuo and Oviawe, 2007). The trend observed might be due to saturation of the adsorption sites after 90mins, after which there is little or no percentage increase in adsorption despite increased agitation time. Further more Mn (II) ions had a higher removal percentage for all the adsorbent. This could be explained by considering that Mn (II) ions had a smaller ionic radius than Cu (II) and Zn (II) and as such. It tends to diffuse to the potential adsorption sites easier than other metal ions. This corroborated well with the finding of Abia *et al.*, (2003) who reported that ions with smaller ionic radii are more strongly attracted to the adsorbent site than the larger Hence a larger percentage of Mn (II) ions was removed more than other metal ions. The order of percentage removal is Mn > Cu > Zn in both substrates.

##### 4.2 The effect of initial metal ions concentration on the adsorption of the metal ions.

The impact of concentration on the adsorption capacity of dump palm sample for Mn<sup>2+</sup>, Cu<sup>2+</sup> and Zn<sup>2+</sup> are shown in Figure 3 and 4. As can be seen from the two figures, there was a general increase in adsorption of these metals up to a concentration of 50 mg/L. The result showed that the amount of metal ions bound by the cellulosic substrates depended on the metal ions types and the concentration of the metal ions. The percentage removal followed the order. Mn(II)> Cu(II) >Zn(II). The differences on the amounts of metal ion uptake can be explained in terms of difference in the ionic sizes, atomic weight of the metal ions and nature, distribution of active groups on the substrate and made of concentration and contact time. The maximum adsorption was obtained from frond samples (78%) then leave (52%). However, these metal exhibited less adsorption percentage compared to the Mn(II) ion. It has been noted the smaller the

ionic radius the higher the adsorption rate (Uzun and Guzel, (2000); Igwe and Abia, (2003).

Besides, higher initial concentration led to an increase in the affinity of the ions towards the active sites (Al-Ashel *et al.*, (2003). Further more, a comparison of the two adsorbents clearly showed that at any given metal ion concentration, Frond sample could bind more of the metal ions than leave sample. This confirmed that the nature of the cellulosic materials had a unique role on the adsorption mechanism.

##### 4.3 The effect of variation of adsorbent mass on adsorption of metal ions

The percentage removal and uptake level of Mn (II), Cu (II) and Zn (II) ions from solutions by frond and leave samples are shown in Figure 5 to 6. It was observed that with a general increase in the adsorbent dose from 0.5g-2.5g, there is a corresponding increase in uptake level. This is due to increase in the available binding sites in the adsorbent (Obloh and Aluyor, 2008). The trend could be explained in terms of progressive increase in the electrostatic interaction between the adsorbent and metal ions. Moreover, more adsorption sites were being covered as the dose of the adsorbent increased (Igwe and Abia, 2003). An increase in percent removal of 78% and 70.0% were observed for frond and leave samples respectively as the dose increase from 0.5-2.5g. A Comparison of the two substrates clearly showed that at any given adsorbent dose of the frond could adsorb metal ion more than leave sample. This is probably due to the fact that the larger the surface area of adsorbent, the more the adsorption

##### 4.4 Adsorption isotherm

The sorption data of the metal ions investigated on frond and trunk parts substrate were plotted logarithm mathematically as shown in Figure 7 to 12. They all fitted the Freundlich adsorption isotherm. The values of correlation coefficient as determined indicate that the adsorption process conforms to the Freundlich isotherms (Salam and Adekola, 2005). The results also show that the R<sup>2</sup> values for two substrates are greater than 0.9 for Freundlich isotherm, so the adsorption was favourable.

##### Conclusion

The removal of these metal ions from aqueous solutions strongly depended on initial metal ions concentration and contact time. The maximum adsorption was obtained from frond samples than the leaves. However, the percentage removal of Cu (II) and Zn (II) ion by the two substrates were observed to be low when comparing to the amount of Mn (II) ion adsorbed.

**Corresponding Author:**

Dr. J. Yisa  
 Department of Chemistry,  
 Federal University of Technology, P.M.B.65  
 Bosso Campus, Minna, Niger State, Nigeria  
 E-mail: joeyisa@yahoo.com

**References**

1. Sekar, M.V., Sakgathi and S. Rengaraj. Kinetic and Equilibrium study of Pb(II) onto activated carbon. *Journal of Colloid and Interface*, 2004; 279: 307-313.
2. Org, S., C. Seng. And P.L.M. Kinetic of adsorption of Cu(II) from aqueous solution on rice husk and modified rice husk, *J. Environ. Agric and Food Chem.* 2007; 6(2): 1764 – 1774.
3. Ko, D.C.K., Porter. J.F., Micky., G. Optimized correlation for the fixed bed adsorption of metals ion on bone *Chemical Eng. Science*, 2000; 55:5819-5829.
4. Rao, MM., Redddv. D.H.K.K., Venkate Swarlu R. and Seshialy. Removal of Mercury from aqueous solutions using activated carbon prepared from Agric. Bye Product, Waste, *Journal of Environmental Management*, 2009; 90(1): 634 – 643.
5. Aydin, H.B., Bulut., Y. and Yerlikaya., C. Removal of Cu (II) from aqueous solution by adsorption onto low-cost adsorbent. *Journal of Environment Management*, 2008; 87: 37-45.
6. Pruss-Ustun A, Fewtrell L, Landrigan PJ, Ayuso-Mateos JL. Lead Exposure In: Ezzati, M., A.D. Lopez, A. Rodgers, and C.J.L. Murray. Comparative Quantification of Health Risks: Global and Regional Burden of Disease Attributable to Selected Major Risk Factors. World Health Organization, Geneva. 2004; 1495-1552.
7. Igwe, J.C., Ogunewe., D.N. and Abia., A.A. Competitive adsorption of Zn (II) Cd and Pb (II) ions from aqueous and non aqueous solution by maize cob and husk, *African Journal of Biotechnology*, 2005; 4 (10): 1113-1116.
8. Ahalya, N. Ramarchandra, T.V and Kana, madi, R.D. Biosorption of heavy metals, *Research Journal of Chemical and Environment*. 2003; 7: 78-78.
9. Rafeah, W., Ngaina., Z and Usun Jok. V. Removal of Mercury, Lead and Copper from aqueous solution by activated carbon of palm oil empty fruit bunch. *World Applied Science Journal*, 2009; 84 – 91.
10. Oboh, OL, Aluyor., E.O. . The removal of heavy metal ions from aqueous solution using sour soap seeds as biosorbent. *African Journal of Biotechnology*. 2008; 7(24): 4508 - 4511.
11. Egila, J.N and Okorie, E.O. Influence of pH on the Adsorption of trace metal on Ecological and Agricultural adsorbent, *Journal of Chemical Society of Nigeria*, 2002; 27(II): 95-98.
12. Gimba, C.E., Olayemi., J.Y. Ifijeh., D.O.H. and kagbu., J.A. Adsorption of dyes by powdered and granulated activated carbon from coconut shell. *Journal of Chemical Society of Nigeria* 26(II),2001; 25-27.
13. Tumin., N.D., Lugman., A.C., Zaiwani., Z., and Abdul Rashid., S. Absorption of copper from aqueous solution by flais guineesis Kernel activated carbon, *Journal of Engineering Science and Technology*, 2008; 3(2): 180 – 189.
14. Chubar, N. Carraltio, J.R. and Neira., C.M.J. Cork Biomass as biosorbent for Cu(II), Zn(II) and Ni (II) colloid surf, *A Physiochem Eng. ASP.* 2003; 250 :57-65.
15. Ngah, W.S.W and Hanafiah M.A.K.M. Removal of heavy metal ions from waste by domically modified plant waste as adsorbent A.review: *Bioresources Technology*, 2008; 99: 3935-3948.
16. Hameed, B.H., Tan., L.A.W. Ahmed A.L. Optimization of basic dye removal by oil fibre-based activated carbon using response surface methodology, *Journal of Hazadous Materials*, 2008; 158:324.332.
17. Vaughan, T.C.W., Seo, W.E. Marshall, C. Removal of selected metal ions from aqueous solutions using modified corn cobs. *Bioresource Technology*, 2001; 78: 135 -139.
18. Saeed A, Muhammed I, Waheed Akhtar M. Removal and recovery of lead (II) from single and multimetal (Cd, Cu, Ni, Zn) solutions by crop milling waste (black gram husk). *J. Hazardous Mater.* 2004; 117: 65-73.
19. Okieimen, C.O and Okieimen, F.E. Enhanced Metal Sorption by Groundnut (*Arachis hypogea*) husks. Modified with Thioglycolic acid, *Bulletin Pure Applied Science*, 2001; 20:3 - 20.
20. Okuo, M.J and Oviawe, A.P . Selection Sorption of mixed heavy metal ions using fibre modified with citric acid. *Journal of Chemistry Society of Nigeria*, 2007; 32(2): 247-253.
21. Abia, A.A, Horsfal M. and Didi, O. The Use of Chemically modified and unmodified cassava waste for the removal of Cd, Cu and Zn ions from aqueous solution, *Bioreserch Technology*, 2003; 9: 345 – 548
22. Uzun., I and Guzel. N. Adsorption of some heavy metal ions from aqueous solution by activated carbon and comparison of percent adsorption results of activated carbon with those of some other adsorbent *Turkish Journal of Chemistry*, 2000; 24: 249 – 297.
23. Igwe, J.C., and Abia., A.A. Maize cob and husk as Adsorbent for removal of Cd, Pb and Zn ions from waste. *International Journal of Physical Science*, 2003; 211-215.
24. AL-ashel, R. Banat., Z., Al-Omari and Duviniak, K. Beneficial reuse of children feathers in removal of heavy metal from waste water. *Cleaner Production*, 2003; 11:321-326.

8/11/2011