Zagazig J. Agric. Res., Vol. 44 No. (1) 2017 239-246

Agricultural Biochemistry and its Application

http:/www.journals.zu.edu.eg/journalDisplay.aspx?Journalld=1&queryType=Master

# CHARACTERIZATION OF BOTH BANANA PEEL AND WATERMELON PEEL AS NATURAL BIOSORBENT AGENTS OF IRON IN AQUEOUS SOLUTION

**Ayman M.E. Gomaa***

Biochem. Dept., Fac. Agric., Zagazig Univ., Egypt

**Received: 07/12/2016 ; Accepted: 12/12/2016**

**ABSTRACT:** The removal of iron (III) from aqueous solutions was studied using dried banana peel (Bp) and watermelon peel (Wp) as biosorbents. The biosorbents were characterized through the proximate contents of moisture (Bp 3.44% Wp 3.45%), protein (9.2% Bp, 14.25% Wp), fats (Bp 1.78% Wp 1.33%), fiber (36.89% Bp, 33.58% Wp), ash (Bp 21.36% Wp 15.86%) and scanning electron microscopy (SEM). Variable parameters such sorbent dosage (0.1, 0.25, 0.5–2 g/100 ml), and initial concentration of iron (III) (1000, 500, 100 and 50 ppm) and there remediation effects were investigated. Under optimum conditions, Bp showed the highest sorption efficiency *i.e.,* 66.5% for 2% while Wp amounted 55.1% for 0.1%. Under optimum conditions the concentration of 100 ppm showed the highest sorption efficiency which was 56.07% for Bp and 61.1% for Wp at the mean of doses. The results showed that natural dried banana peel and watermelon peel were effective sorbents for removal of iron (III) from aqueous solutions.

**Key words:** Sorption, Fe (III), aqueous solutions, banana peel, watermelon peel, heavy metals.

## INTRODUCTION

Heavy metals released to environment have continuously increasing trends as a result of industrial activities and technological developments, passing a significant threat to the environment and public health due to their toxicity, accumulation in food chain and persistence in nature (Kanawade and Gaikwad, 2011). Metal contamination is considered to be one of the most ubiquitous and complex environmental issues today. Accumulation of heavy metals in soils and water is of particular toxicity because it can impact upon human health through possible contamination of food (Sadon *et al*., 2012). With increasing demand for water for agricultural, domestic, industrial, and recreational purposes, remediation and reuse of contaminated water receive prime attention globally (Opeolu and Fatoki, 2012).

The discharge of industrial effluents to the water resources is one of the major environmental problems that need to be properly addressed. Heavy metals such as iron, copper, lead, zinc and nickel are among the most common inorganic pollutants found in industrial waste-water (Reddy *et al.,* 2011). Heavy metals are toxic pollutants that can accumulate in living tissues and cause various diseases and disorders (Witek-Krowiak *et al.,* 2011).

Iron is one of the major constituents of the lithosphere and comprises approximately 5% of it. It is routinely detected in municipal waste effluent, particularly in cities where iron and steel are manufactured. Iron readily complexes with sulphates in the sediments of many surface levels of water. The primary concern about the presence of iron in drinking water is its objectionable taste. The taste of iron in drinking water can be easily detected even at low concentrations of about 1.8 mg/l (Sadon *et al.,*

**Corresponding author: Tel. :** +201143215496
**E-mail address:** aymangomaa67@yahoo.com

2012). There are many problems that result from iron toxicity, including anorexia, oligura, diarrhoea, hypothermia, diphasic shock, metabolic acidosis and even death. In addition to these, the patient may experience vascular congestion of the gastrointestinal tract, liver, kidneys, heart brain, adrenals and thymus. With acute iron poisoning, much of the damage happen to the gastrointestinal tract and liver which may result from the high localized iron concentration and free radical production leading to heptatoxicity *via* lipid peroxidation and destruction of the hepatic mitochondria. As a result of iron storage disease, the liver becomes cirrhotic. Hepatoma, a primary cancer of the liver, has become the most common cause for death among patients with hemochromatosis (Lauffer, 1992). There is an iron storage disease that results from the inability of the intestine to keep out unwanted iron. Instead, this iron accumulates in the liver causing siderosis and causes damage to the storage chemicals. Also, when siderosis becomes severe in young people, it leads to myocardial disease which is a common cause of death. Impotence may also occur in young men and amenorrhea in young women. Both these problems relating to reproduction are due to iron loading in the anterior pituitary (Emercy, 1991).

Different technologies, such as sorption, chemical precipitation, coagulation/flocculation, evaporation, complexation, membrane filtration, biological operations, electrochemical operations, ion exchange/solvent extraction, *etc.*, have been employed in removing metals from contaminated water and wastewater.

Natural sorbents, mainly obtained from plant byproducts and fruit peels, have been found effective in removing metal ions from waste water without chemical modifications (Hossain *et al.,* 2012a).

Modified sorbents derived from locally available materials such as fruit byproducts have received increasing attention for removal and recovery of heavy metals from wastewater systems. Fruits wastes are inexhaustible, non-edible and renewable polymeric materials which are discarded as byproducts (Moyo *et al.,* 2013).

Banana peel, an agro wastes is discarded all over the world as useless material. It is causing byproduct management problems though it has some compost, cosmetics and sorbent potentiality. It is an abandoned, readily available, low cost and cheap, environment friendly bio-material. Considering the above criteria, banana peel was selected to prepare the biosorbent. A step was taken for preparing biosorbent and used for removal of copper from water (Hossain *et al.,* 2012b). The main aim of this study was to determine the potentiality and sorption capacity of banana peel and Watermelon peel for sorption of $Fe^{3+}$ as biosorbent.

# MATERIALS AND METHODS

## Preparation of Banana and Watermelon Peels

Banana and watermelon peels were procured from a local supermarket in bulk; the fresh banana and watermelon were brought to the laboratory, washed and separated into pulp and peels. The peel of watermelon was removed using a sharp knife, and the underlying pulp was removed by gently scraping with its blunt edge. The peels were then washed thoroughly with distilled water to remove physically sorbed contamination and dried to a constant weight at 40°C in a hot air oven for a period of 72 hr. After drying, the peels were defatted and ground in a mill. Thus, the biomass used in our experiments and characterization studies were dry banana and watermelon peels (BP, and WP).

The surface morphology characteristics of banana, and watermelon peels were carried out by using a scanning electron microscopy probe analyzer (Model jeol, jxa-840 japan).

## Removal Percentage of Iron

Iron solutions were prepared by dissolving $FeCl_3$- $6H_2O$ analytical grade. sorption experiments were carried out in the batch reactors (200 ml) containing natural banana peel and watermelon peel sorbent separately (2, 1, 0.5, 0.25, 0.1 g/dry mater) and 100 ml of $Fe^{3+}$ solutions having different concentrations (1000, 500, 100, and 50 ppm) in distilled water, the contact time is 30 minutes and thin filtered with filter paper watman No. 1, the filtrated solution carried out to determination the remaining of $Fe^{3+}$. The residual of the banana peels and melon dried used in the analysis by electron microscope.

The percentage of removal was calculated from the following equation:

$$\text{Percentage of removal (\%)} = \frac{Ci - Ce}{Ci} \times 100$$

Where:

$C_i$ and $C_e$ were the initial and final concentration of Fe (III) in the aqueous solution, respectively.

Natural dried banana peel and watermelon peel were analyzed for moisture, crude protein, total fats, crude fiber and ash, and were analyzed according to the methods of the Association of Official Analytical Chemists AOAC (2002) $Fe^{3+}$ were determined using the atomic sorption spectrophotometric technique (thermo scientific ICE 3000 SERIES .U.K.), determined by the method of Nation and Robinson (1971).

## RESULTS AND DISCUSSION

### Morphology

The SEM micrographs of the sorbents are shown in Fig. 1. All biomasses were an assemblage of fine particles, which did not have regular or fixed shape and size. The particles were of various dimensions and contained a large number of steps and kinks on the external surface, with broken edges. The surface of the biomaterial had some cavities throughout the surface of the sorbents, indicating that this material possessed good characteristics as natural sorbents for watermelon peel and banana peel.

The results of the chemical contents of dried banana peel and watermelon peel are shown in Table 1. Moisture content was 3.44% and the protein content of BP was (9.2%), while the fat was 1.78% and fiber 36.89%. Also, ash valued 21.36%, while the dried watermelon peel chemical composition was 3.45% moisture content and protein content was 14.25% while the fat was 1.33% and fiber 33.58% also, ash 15.86% these were obtained by Raymundo *et al.* (1985) and Hanan and Ahmed, (2013).

### Effect of Initial $Fe^{3+}$ Concentration

The effect of initial $Fe^{3+}$ concentration in the range of 1000 ppm, 500 ppm, 100 ppm and 50 ppm on sorption capacity of dried banana peel and watermelon peel were investigated (Fig. 2 and Fig. 3). It is evident from Fig. 2 that the removal efficiency of $Fe^{3+}$ decreased with the high increasing initial $Fe^{3+}$ concentration while the removal rate increased with low concentrations in the dried banana peel when we install weight. The mean value of percentage of $Fe^{3+}$ removal efficiency was found to be 54% for 50 ppm ,56.07% for 100 ppm ,47.7for 500 ppm and 52.02% for 1000 ppm, while the removal efficiency of $Fe^{3+}$ increased with the high increasing initial $Fe^{3+}$ concentration in the dried watermelon peel when you install weight The percentage of $Fe^{3+}$ removal efficiency was found to be 38.7%for 50 ppm, 61.1% for 100 ppm ,59.4 for 500 ppm $Fe^{3+}$ and 54.09% for 1000 ppm $Fe^{3+}$ and the equilibrium sorption capacity increased with increasing initial concentration indicating that higher initial concentration of $Fe^{3+}$ can enhance the sorption process. The initial $Fe^{3+}$ concentration provides the necessary driving force to overcome the resistances to the mass transfer of iron between the aqueous phase and the solid phase. Physically the increase in initial $Fe^{3+}$ concentration also enhances the interaction between iron and metal powder. Therefore, an increase in initial $Fe^{3+}$ concentration enhances the sorptive uptake of $Fe^{3+}$. This is due to increase in the driving force of concentration gradient, as an increase in the initial $Fe^{3+}$ concentration (Gongming *et al.,* 2014). It is well understood that the amount of metal removal is vastly dependent upon the metal concentration in the solution. As reported by Chojnacka (2006), who studied the effect of initial concentration of $Cr^{3+}$ on sorption by wheat straw, the sorption rate was increased with the increase in the initial metal ion concentration. However, if the amount of biomass remains constant in the system, the metal removal efficiency may be reduced regardless the increased metal concentration (Zhou *et al*., 2007). Furthermore, Hossain *et al.* (2012a) who studied the $Cu^{2+}$ sorption by banana peel reported that the sorbent dose is also decisive for metal removal. They observed the highest $Cu^{2+}$ removal (88%) when the initial $Cu^{2+}$ concentration of 10 mg/l with the sorbent dose of 5 g/l. Similar investigation was conducted by (Anwar *et al*., 2010) to study the

**Watermelon peel** **Banana peel**

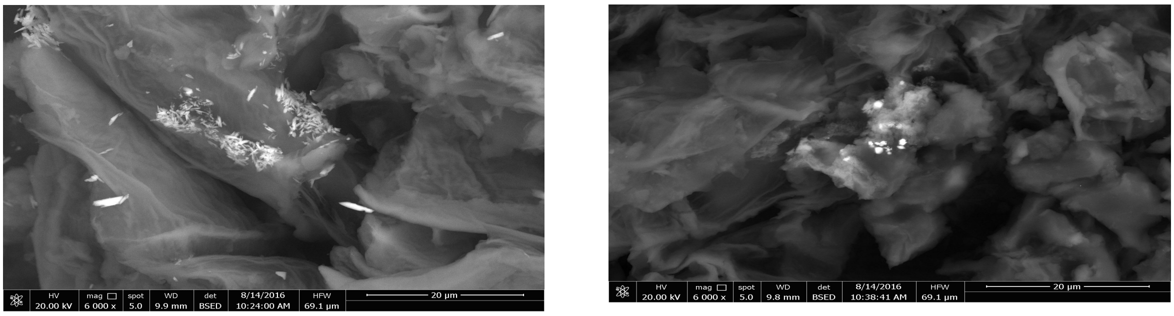

**Fig. 1. Scanning electron microscope micrographs of the sorbents for watermelon and banana peel**

**Table 1. The proximate compositions of studied BP and WP calculated on the basis of dry materials**

| Parameter (%) | BP | WP |
|---|---|---|
| **Moisture** | 3.44 | 3.45 |
| **Protein** | 9.2 | 14.25 |
| **Fats** | 1.78 | 1.33 |
| **Fiber** | 36.89 | 33.58 |
| **Ash** | 21.36 | 15.86 |

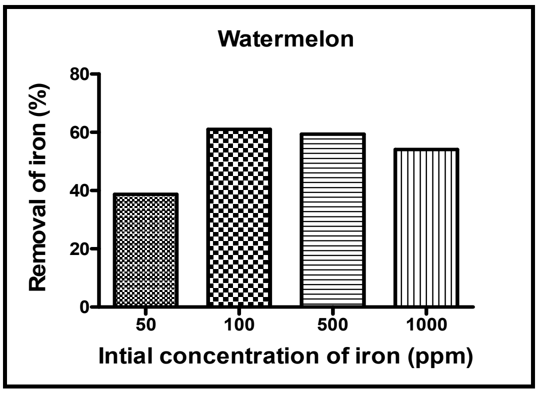


**Fig. 2. The effect of initial $Fe^{3+}$ concentration on adsorption dried watermelon peel**

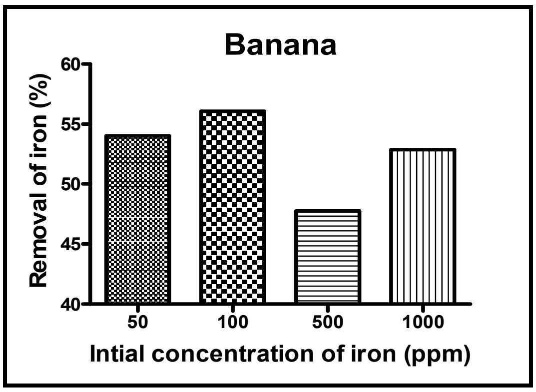


**Fig. 3. The effect of initial $Fe^{3+}$ concentration on adsorption dried banana peel**

effect of sorbent dosage on the sorption of $Cd^{2+}$ and $Pb^{2+}$. They used different dosages of banana peel ranging 10-90 g/l, and the maximum removal was observed at the doses of 30 and 40 g/l, respectively, for $Cd^{2+}$ (89.2%) and $Pb^{2+}$ (85.3%). At the high doses of sorbent, removal of metal may be affected by the partial aggregation among the available active binding sites (Anwar *et al*., 2010), whereas at low doses, lack of active binding sites may result in lower rate of metal removal (Karthikeyan *et al*., 2007).

## Effect of Natural Dried Banana Peel and Watermelon Peel Dosage

The effect of dried banana peel and watermelon peel dosage was studied in the range of 2%, 1%, 0.5%, 0.25% and 0.1% for the initial $Fe^{3+}$ concentration 1000 ppm, 500 ppm, 100 ppm and 50 ppm. The variation of the removal efficiency of $Fe^{3+}$ ions with natural dried banana peel and watermelon peel dosage were shown in Figs. 4 and 5. It can be observed that the removal efficiency increases with the increase in natural banana peel dosage initially. Gongming *et al. (*2014) reported that this trend is expected because the number of adsorbent particles increases with increasing the natural dosage which leads to more $Fe^{3+}$ sorbed onto their surfaces. The percentage of $Fe^{3+}$ removal efficiency when we install concentration was found to be 51.03% for 0.1% ,49.45% for 0.25% ,42.1 for 0.5%, 54.1 for 1% and 66.5% for 2% dried banana peel, While the removal efficiency of $Fe^{3+}$ decreased with the high increasing of watermelon peel dosage. The percentage of $Fe^{3+}$ removal efficiency when we install concentration was found to be 55.1% for 0.1%, 55% for 0.25% ,51.4 for 0.5% , 51.9 for 1% and 53.1% for 2% dried watermelon peel. This result can be explained as when the adsorption dose reached a certain rate, the adsorption site was used up, hence with reduced tendency of the particles to absorb any more ions to its surface, so removal rate of heavy metal ions no longer increased (Onundi *et al.,* 2010). For adsorbent dosage above and Iron (III) removal efficiencies (metal uptake per gram of biomass) decreased with increasing biomass concentration. This could be attributed to partial cell aggregation that occurs at high biomass concentrations, causing a decrease in the number of active sites (Esposito *et al.,* 2001).

## Effect of Contact Time

A fast rate of iron (III) adsorption was noted during the first 20 min. of the sorbate–sorbent contact for the heavy metal. The rate of heavy metal was higher in the first 20 min. because of the larger surface area of the sorbent available for the sorption of the metal (El-Ashtoukhy *et al.,* 2008). So 30 minutes contact time was suitable.

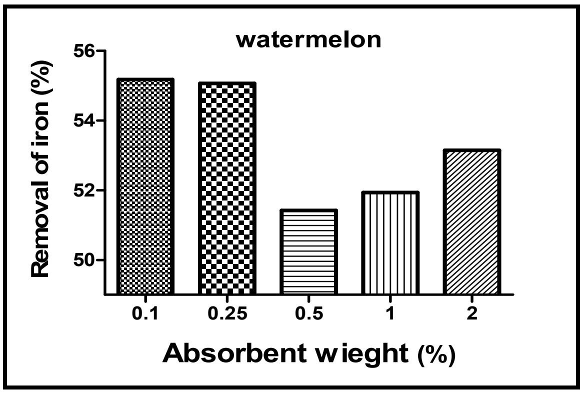


**Fig. 4. The mean value (%) of the removal efficiency of $Fe^{3+}$ ions with natural dried watermelon peel dosage**

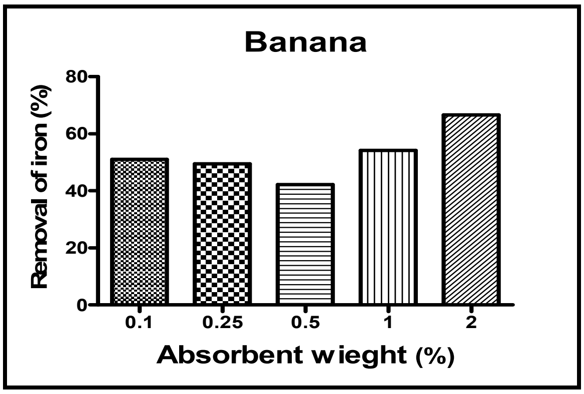


**Fig. 5. The mean value (%) of the removal efficiency of $Fe^{3+}$ ions with natural dried banana peel dosage**

## Comparison of the Banana Peel and Melon Peel As Biosorbents

Comparison of the variation of the removal efficiency of $Fe^{3+}$ ions with natural dried banana peel and watermelon peel dosage and concentration were shown in Fig. 6 a, b, c and d and the comparing of watermelon rind at different concentrations are better than a banana peel results which are given in the removal of iron from aqueous solutions.

## Conclusion

The present investigation showed that both natural dried banana peel and watermelon peel were effective sorbents for the removal of $Fe^{3+}$ from aqueous solutions. The removal of $Fe^{3+}$ by natural dried banana peel and watermelon peel were found initial $Fe^{3+}$ concentration, dosage of the sorbent. The removal efficiency of $Fe^{3+}$ increases with the increase of sorbent dosage in dried banana peel and decreases with the increase of sorbent dosage watermelon peels. While the removal efficiency of $Fe^{3+}$ increases with the increase of initial $Fe^{3+}$ concentration with watermelon peel, and *vice versa* in the case of the banana peel that mean that the use of watermelon peel is the best from the banana peel when the iron removal from aqueous solutions.

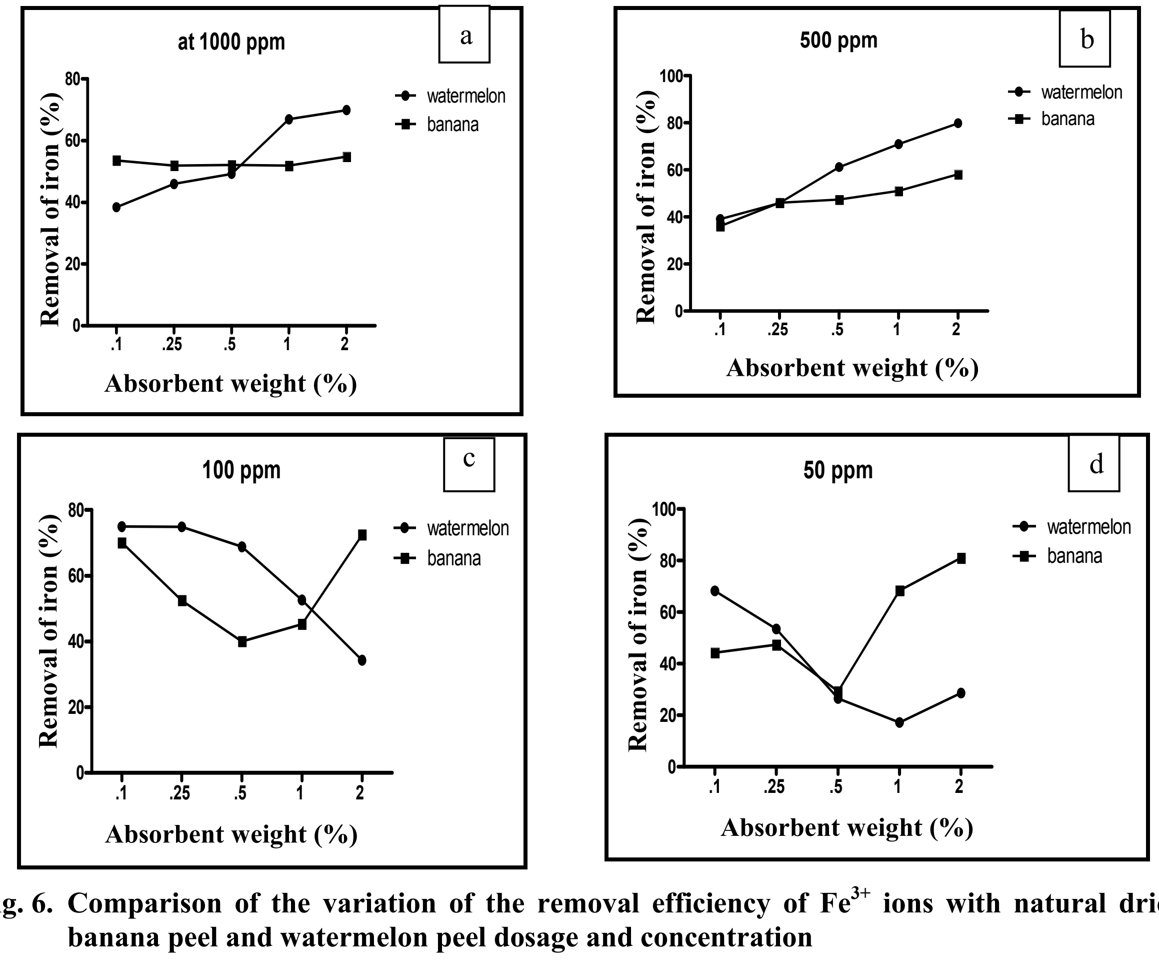


**Fig. 6. Comparison of the variation of the removal efficiency of $Fe^{3+}$ ions with natural dried banana peel and watermelon peel dosage and concentration**

## REFERENCES

Anwar, J., U. Shafique, W. Zaman, M. Salman, A. Dar and S. Anwar (2010). Removal of Pb(II) and Cd(II) from water by adsorption on peels of banana, Bioresour. Technol., 101: 1752-1755.

AOAC (2002). Association Official Analytical Chemists. Official Methods of Analysis. Gaithersburg, MD, USA. Chapt., 4: 20 – 27.

Chojnacka, K. (2006). Biosorption of Cr (III) ions by wheat straw and grass: a systematic characterization of new biosorbents, Pol. J. Environ. Stud., 15: 845-852.

El-Ashtoukhy E.-S.Z, N.K. Amin and O. Abdel Wahab (2008). Removal of lead (II) and copper (II) from aqueous solution using pomegranate peel as a new adsorbent, Desalination, 223: 162–173.

Emercy T. (1991). Iron and Your Health: Facts and Fallacies (London: CRC Press),183-197.

Esposito, A., F. Pagnanellilodi, A. Solisio and F. Vegliò (2001). Biosorption of heavy metals by sphaerotilus natans: an equilibrium study at different pH and biomass concentrations. Hydrometallurgy, 60: 129–141.

Gongming Q., L. Maolin, W. Fei and L. Xinggang (2014). Removal of $Fe^{3+}$ from aqueous solution by natural apatite., J. Surf. Eng. Mat. and Adv. Technol., 4: 14-20.

Hanan, M.A. and A.R. Ahmed (2013). Utilization of watermelon rinds and sharlyn melon a natural source of dietary fiber and antioxidants. Home Econ. Dept., Fac. Specific Ed., Ain Shams Univ., Cairo, Egypt Ann. Agric. Sci., 58 (1): 83–95

Hossain, M.A., H.H. Ngo, W.S. Guo and T.V. Nguyen (2012a). Biosorption of Cu (II) from water by banana peels based biosorbent. experiments and models of adsorption and desorption. J. Water Sustainability, 2(1): 87–104.

Hossain, M.A., H.H. Ngo, W.S. Guo and T.V. Nguyen (2012b). Removal of copper from water by adsorption onto banana peel as bioadsorbent. Int. J. Geomate, 2 (4):227-234.

Kanawade, S.M. and R.W. Gaikwad (2011). Removal of zinc ions from industrial effluent by using cork powder as adsorbent. Int. J. Chem. Eng. and Applic., 2: 199-201.

Karthikeyan, S., R. Balasubramanian and C.S.P. Iyer (2007). Evaluation of the marine algae *Ulva fasciata* and *Sargassum* sp. for the biosorption of Cu (II) from aqueous solutions, Bioresour. Technol., 98: 452-455.

Lauffer, R. (1992). Iron and Human diseases (London: CRC Press). 275-319

Moyo, M., L. Chikazaza, A. B. Dekhil, Y. Hannachi, A. Ghorbel and T. Boubaker (2013). Bioremediation of lead (II) from polluted wastewaters employing sulphuric acid treated maize tassel biomass. J. Chem. and Ecol., 5: 689– 695.

Nation, J.L. and F.A. Robinson (1971). Concentration of some major and trace elements in honeybee, royal jelly and pollen, determined by atomic absorption spectrophotometer. J. Apic. Res., 10 (1): 35-43.

Onundi, Y.B., A.A. Mamun, M.F. Al Khatib, and Y.M. Ahmed (2010). Adsorption of copper, nickel and lead ions from synthetic semiconductor industrial wastewater by palm shell activated carbon, Int. J. Environ. Sci. and Technol., 7 (4): 751–758.

Opeolu, B.O. and O.S. Fatoki (2012). Dynamics of zinc sorption from aqueous matrices using plantain (*Musa* sp.) peel biomass, Afr. J. Biotechnol., 11: 13194-13201

Raymundo, S.O., P.B. Hernández, G.R. Morales, F.U. Núñez, J.O. Villafuerte, V.L. Lugo, N.F. Ramírez, C.E.B. Díaz, and P.C. Vázquez (1985). Characterization of lignocellulosic fruit waste as an alternative feedstock for bioethanol production. Fruit residue to ethanol, Bio-Res., 9(2):1873-1885.

Reddy, D.H.K., D.K.V. Ramana, K. Seshaiah and A.V.R. Reddy (2011). Biosorption of Ni (II) from aqueous phase by *Moringa oleifera* bark, a low cost biosorbent. Desalination, 268: 150–157.

Sadon, F.N., A.S. Ibrahem and K.N. Ismail (2012). An overview of rice husk applications and modification techniques in wastewater treatment, J. Purity, Utility React. Environ., 1: 308-334.

Witek-Krowiak, A., R.G. Szafran and S. Modelski (2011). Biosorption of heavy metals from aqueous solutions onto pea-nut shell as a low-cost biosorbent. Desalination, 265: 126–134.

Zhou, M., Y. Liu, G. Zeng, X. Li, W. Xu and T. Fan (2007). Kinetic and equilibrium studies of Cr (VI) biosorption by dead Bacillus licheniformis biomass, World J. Microbiol. Biotechnol., 23 : 43-48.

## تمايز قشرة الموز والبطيخ كعوامل إزالة طبيعية لمعدن الحديد من المحاليل المائية

**أيمن محمد السيد جمعه**

قسم الكيمياء الحيوية الزراعية- كلية الزراعة - جامعة الزقازيق- مصر

تمت دراسة استخدام كلا من قشرة البطيخ والموز المجففة (٤٠ درجة مئوية و لمدة ٧٢ ساعة) كعوامل طبيعية فى إزالة كاتيون الحديد من الوسط المائى باعتبار انه احد المعادن الثقيله التى تمثل خطرًا شديدًا على الصحة العامة فى حالة تلوث المياه به وقد تم عمل تحليل لكلا من مسحوق القشرتين وقد اظهرت النتائج احتواء قشره الموز على نسبه بروتين ٩,٢% وألياف ٣٦,٨٩% والرماد ٢١,٣٦% بينما كانت نتائج التحليل لقشرة البطيخ تتضمن بروتين ١٤,٢٥% وألياف ٣٣,٥٨% والرماد ١٥,٨٦% كما تم عمل مسح باستخدام الميكروسكوب الالكترونى للقشرة بعد عمليه الإزالة لكاتيون الحديديك وقد أظهرت النتائج شكل تجميع المعدن داخل الأنسجة فى شكل يشبه الشكل الإبرى، وقد استخدمت تركيزات مختلفة من القشرة المجففة وكذلك تركيزات مختلفه لمعدن الحديد للوقوف على طبيعة الامتصاص وقد استخدمت كميات) ٠,١ ، ٠,٢٥ ، ٠,٥ – ٢ جرام/١٠٠ ملليلتر (من القشرة لكلا من الموز والبطيخ كما استخدمت التركيزات التالية من كاتيون الحديديك) ١٠٠٠ ، ٥٠٠ ، ١٠٠ و ٥٠ جزء في المليون )ppm( (وقد أوضحت النتائج إن استخدام مسحوق قشره الموز بتركيز ٢% أعطى نسبه إزالة ٦٦,٥% وفى حالة استخدام مسحوق قشر البطيخ بتركيز ١%، سجلت نسبه إزالة ٥٥,١% أما فى حالة التركيزات المختلفة لكاتيون الحديديك أعطى التركيز ١٠٠ppm نسبه إزالة ٥٦,٠٧% فى الموز أما فى البطيخ فكانت نسبه الإزالة ٦١,١% مع ثبات العوامل الأخرى وقد أشارت النتائج إلى أن كلا من مسحوق قشرة البطيخ والموز تعتبر عوامل طبيعية لإزالة و تقليل تركيز كاتيون الحديديك فى المحاليل المائية.

---

**المحكمون :**

**١- أ.د. نجــاح الشــحات علي** أستاذ الكيمياء الحيوية المتفرغ – كلية الزراعة – جامعة عين شمس.

**٢- أ.د. محمود زكي سطوحي** أستاذ الكيمياء الحيوية المتفرغ – كلية الزراعة – جامعة الزقازيق.