

 Columban J. Life Sci.	Vol. 17	No. 1	35-39	2015
--	---------	-------	-------	------

APPLICATION OF ACTIVATED CARBON IN REMOVAL OF IRON AND MANGANESE FROM ALAU DAM WATER IN MAIDUGURI

Mohammed Modu Aji*, Babagana Gutti and Bitrus K. Highina

Department of Chemical Engineering, Faculty of Engineering, University Of Maiduguri, Borno State, Nigeria.

Email: ajimohammed@gmail.com

Received 13 October 2014

Accepted 25 January 2015

ABSTRACT

Groundnut shell activated carbon was evaluated as a biosorbent for the removal of iron (Fe) and Manganese (Mn) from Alau Dam raw water solution. The Alau Dam water has high amount of iron and manganese, it has 3.11mg/l and 1.32 mg/l of iron and manganese respectively, with pH of 6.84 and temperature of 28.6°C. The maximum sorption efficiency of Fe and Mn was found to be 90% and 84% respectively. Sorption was most efficient at adsorbent dose of 5g and at contact time of about 45-50minutes. The Adsorption of both metals increased as the quantity of adsorbent increased. The study points to the potential of new use of agricultural waste (Groundnut shell) activated carbon as an effective adsorbent for the removal of Fe and Mn from raw water solution.

Keywords: Alau, Adsorption, Activated Carbon, metals, raw water

INTRODUCTION

Over the last few decades, adsorption has gained importance as purification, separation and recovery process on an industrial scale. The search for new technologies involving the removal of toxic metals from wastewaters has directed attention to adsorption, based on binding capacities of various biological materials. Watonabe and Ogawa (1929) first presented the use of activated carbon for the adsorption of heavy metals. Activated carbon (AC) is perhaps one of the most widely used adsorbents in industry for environmental applications. Activated carbons are processed carbon materials that are capable of adsorbing various substances from gas and liquid streams, because of their highly developed pore structure and large internal specific surface areas (Abdul and Aberuagba, 2005).

In areas where ground water flows through an organic rich soil, iron and manganese will also dissolve in the groundwater. Iron and manganese can also have anthropogenic sources including industrial effluents, landfill leakages and acid mine drainage. Well casing, pump parts, piping and storage tank can also contribute iron and manganese to groundwater (Siabi, 2003). According to WHO the maximum

permissible limit (MPL) of iron and manganese in drinking water is 0.3 and 0.5 mg/L respectively (Celik and Demirabas, 2005; Sawyer *et al.*, 2003; Kumar, 2004). The demand for contaminated free water for daily consumption is high and most of the geological water formation in Borno state has naturally occurring iron and manganese. Hence, removal of excess concentration of iron and manganese is essential.

Many agricultural wastes have been studied for the possible removal of iron and manganese. These includes: Zheng *et al* (2014) used Biological Activated carbon for the removal of iron and manganese in steel industry drainage. Othman and Syazwani (2013) used Cucumis melo Rind via Chemical activation with nitric acid HNO₃ for the Removal of Fe (II) and Mn (II) from synthetic water. Magda *et al.*, (2013) prepared A.C using Olive stone by Chemical activation using N₂, HNO₃ & (NH₄)₂S₂O₈ in the Removal of Iron and Manganese in ground water. Alemayehu *et al.*, (2012) used Birbira (*militia ferrugina*) leaves by Chemical activation with sulfuric acid for the Adsorption of manganese ions from waste water. To the best of our

knowledge, there is no literature describe about the Potential of using groundnut shell in removal of iron and manganese in raw water solution. So, in this research we applied groundnut shell activated carbon produced via chemical activation for the adsorption of iron and manganese in raw water collected from Alau Dam in Maiduguri.

MATERIALS AND METHODS

Raw Material

Sample Location

The Alau Dam is located between latitude 11° 40' N and 12° 05' N and longitude 130° 05' E and 130° 20' E and is 14 km south-east of Maiduguri Metropolis. The dam supplies raw water to a treatment plant about 100m from University of Maiduguri Gate II. The River Ngadda which comes from Askira area and flows through the Sambisa swamp is the lifeline of the dam. The reservoir retained by the dam covers the area between 322 and 329 m contours, and is underlain by loam and clay soil formations. The climate is that of the Northern Sudan Savannah ecological zone. The mean annual rainfall is 486 mm and the temperature of 27 °C or more. Evaporation sometimes exceeds the rainfall because of high temperature 'on occasional days'. The river is largely used by local farmers for irrigation of commercial crops recreation, bathing and herd watering. The surface waters are the source of raw water for the Maiduguri Treatment Plant. The concentration of the chemical parameters in the dam were higher than at the irrigation site indicating some concentration of impurities from the manure, waste disposal, fertilizers and pesticides used by the farmers. The high concentration of Fe and Mn causes discoloration of the water to reddish brown and black, which stains the laundry and sanitary wares. (Dammo and Sangodoyin, 2014).



Fig. 1. Alau Dam Maiduguri

Adsorbate Sample

Raw water sample was taken from *Alau Dam* with plastic containers. It was taken to laboratory on that

very day for testing. The pH of the sample was measured using pH-meter and the temperature with thermometer respectively. Iron and manganese content of the sampled raw water were measured using Automatic Smart Spectrophotometer (ASS) and it shows that, the sample has high concentration of iron (3.11mg/l) and manganese (1.32mg/l) which is in agreement with the findings of Dammo and Sangodoyin (2014) and that of Iduwo et al., (2004) respectively. Hence, the raw water from *Alau Dam* was used as an adsorbate sample in this research.

Adsorption Experiment Based On Adsorbent Dose

100mls of the adsorbate (raw water) solution was measured and contacted with varied masses (1, 2, 3, 4, 5, 6, 7 and 8g) of the adsorbent (groundnut shell A.C) for an equilibrium adsorption time of 1hrs at room temperature followed by intermittent stirring as reported by Uwadiae et al., (2010). The solution was filtered with Whatmann filter paper and the filtrate solution was taken for Automatic Smart Spectrophotometer (ASS) analysis.

Adsorption Experiment Based on Contact Time

The effect of contact time on adsorption was studied. 2g of A.C was added to water sample 100ml at pH 6.8. The mixture was shaken at room Temperature. Aliquots (1 ml each) of the clear solution were pipette out at different time intervals until equilibrium was reached.

RESULTS AND DISCUSSION

Effect of contact time

The effect of contact time is an important parameter in determining the equilibrium time that should be allowed for the maximum uptake of an adsorptive by a given adsorbent.

Table. 1: Chemical Analysis of Water Based on Contact Time with 100ml of adsorbate

S/No	Time(min)	Fe(mg/l)	Mn(mg/l)
1	05	1.57	0.39
2	10	1.40	0.33
3	20	1.07	0.28
4	30	0.66	0.25
5	40	0.56	0.24
6	50	0.50	0.21
7	60	0.50	0.21
8	70	0.58	0.26

Meanwhile, the determination of the uptake from an adsorptive sample at different time intervals permits the construction of an adsorption curve. The Fe and Mn uptakes were followed using solutions of initial

pH=6.8 and initial concentration of the adsorption solution containing 3.11mg/l of iron and 1.33mg/l of manganese.

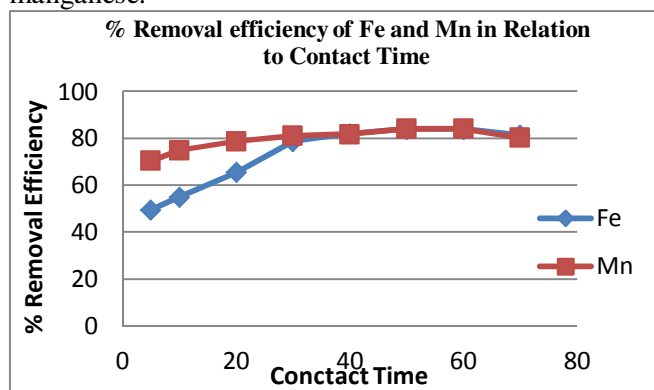


Fig. 2. Percent Removal Efficiency of Iron and Manganese Based on Contact Time

Table. 2: Percent Removal Efficiency of Iron and Manganese Based on Contact Time

Time (min)	Initial concentration (mg/l) Fe	Final concentration (mg/l) Fe	% Removal efficiency	Initial concentration (mg/l) Mn	Final concentration (mg/l) Mn	% Removal efficiency
05	3.11	1.57	49.52	1.32	0.39	70.45
10	3.11	1.40	54.98	1.32	0.33	75.00
20	3.11	1.07	65.59	1.32	0.28	78.79
30	3.11	0.66	78.78	1.32	0.25	81.06
40	3.11	0.56	81.99	1.32	0.24	81.82
50	3.11	0.50	83.92	1.32	0.21	84.09
60	3.11	0.50	83.92	1.32	0.21	84.09
70	3.11	0.58	81.35	1.32	0.26	80.30

Table. 3: Chemical Analysis of Water based on Adsorbent Dose of 100ml of Adsorbate

S/No	Adsorbent Dose (g)	Mn(mg/l)	Fe (mg/l)
1	0.0	1.32	3.11
2	0.5	0.49	1.51
3	1.0	0.47	1.39
4	2.0	0.39	1.22
5	3.0	0.31	0.65
6	4.0	0.26	0.36
7	5.0	0.25	0.35
8	6.0	0.23	0.32
9	7.0	0.21	0.30
10	8.0	0.21	0.30

The Removal efficiency of iron and manganese was calculated using the equation below:

$$\text{Removal efficiency} = [(C_0 - C_t) / C_0] \times 100 \dots\dots\dots 1$$

Where C_0 and C_t are the concentrations of iron and manganese before and after adsorption for a period of

The data obtained show that the metal ion uptake by the activated carbon increased with increasing contact time, with equilibrium being established in less than one hour. This equilibrium time was considered, but more time was allowed particularly in determining the equilibrium adsorption isotherms to ensure the attainment of equilibrium conditions.

Adsorbent Dose

Effect of adsorbent concentration: In this case, the effect of different amounts of adsorbent on the removal of Fe and Mn was considered. Experiments were conducted using different adsorbent concentrations viz., 0.5, 1, 2, 3, 4, 5, 6, 7 and 8g.

time, t , respectively. The Table below present data on the effect of Adsorbent dosage and contact time on

the removal efficiency of iron and manganese by groundnut shell activated carbon. From the table it can be seen that the removal efficiency of iron and

manganese by groundnut shell activated carbon increases with increase in adsorbent dose.

Table. 4: Percentage Removal Efficiency of Iron (Fe) in relation to *Adsorbent Dose*

S/No	Adsorbent dose(g)	Initial concentration (mg/l)	Final concentration (mg/l)	% Removal Efficiency
1	0.0	3.11	3.11	0.0
2	0.5	3.11	1.51	51.45
3	1.0	3.11	1.39	55.30
4	2.0	3.11	1.22	60.77
5	3.0	3.11	0.65	79.09
6	4.0	3.11	0.36	88.42
7	5.0	3.11	0.35	88.75
8	6.0	3.11	0.32	89.71
9	7.0	3.11	0.30	90.35
10	8.0	3.11	0.30	90.35

The adsorption data for the residual concentration of Fe (III) and Mn (II) ions versus the amount of adsorbent used are present in figure below.

Table. 5: Percentage Removal Efficiency of Manganese (Mn) in relation to *Adsorbent Dose*

S/No	Adsorbent dose(g)	Initial concentration (mg/l)	Final concentration (mg/l)	% Removal Efficiency
1	0.0	1.32	1.32	0.00
2	0.5	1.32	0.49	62.88
3	1.0	1.32	0.47	64.39
4	2.0	1.32	0.39	70.45
5	3.0	1.32	0.31	76.52
6	4.0	1.32	0.26	80.30
7	5.0	1.32	0.25	81.06
8	6.0	1.32	0.23	81.60
9	7.0	1.32	0.21	84.09
10	8.0	1.32	0.21	84.09

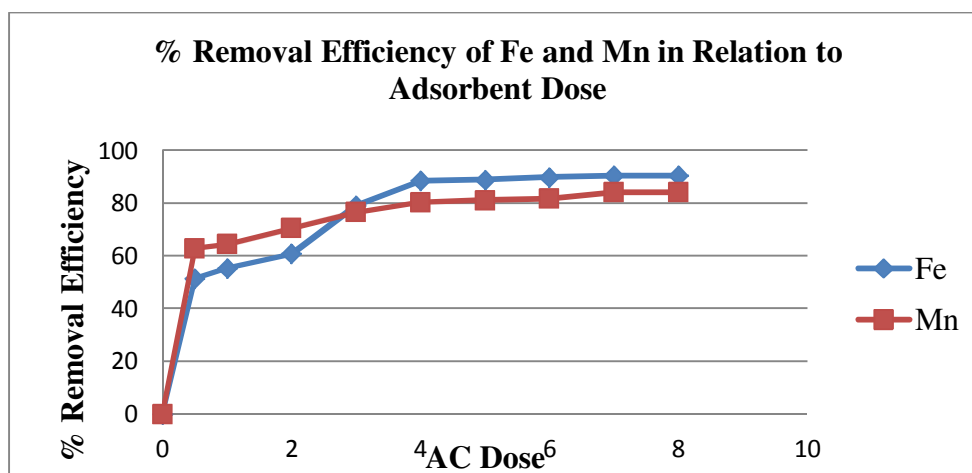


Fig. 3. Percent Removal Efficiency of Iron and Manganese Based on adsorbent dose

The results indicate that a greater amount of ions was removed from the solution with increasing amount of the adsorbent in the system. This effect may be explained in terms of the availability of a greater surface area with a higher number of functional groups on the AC surface.

CONCLUSION

Removal of Iron (Fe) and Manganese (Mn) from the raw water solution of Alau Dam using activated carbon prepared from groundnut shell has been achieved. This is an indication that Groundnut Shell could be an excellent precursor for preparation of AC for iron and manganese uptake in water. The data obtained show that the metal ion uptake by the activated carbon increased with increasing both adsorbent dose and contact time, with equilibrium being established in less than one hour at about 45-50minutes. Results from the analysis indicated that, contact time and initial adsorbent concentration (AC Dose) have some significant effect on the removal of iron and manganese.

REFERENCES

- Abdul, A. & Aberuagba, F. (2005). Comparative Study of the Adsorption of Phosphate by Activated Carbon from Corncobs, Groundnut Shell and Rice-husk. *A.U.J.T.* 9 (1) p59– 63
- Alemayehu A. M., Siva T. R and Prasada Rao A. V. (2012). Adsorption Of Mn(II) Ions From Waste Water Using A.C Obtained From Birbira (Molita Ferruginea) Leaves. *Global Journal Of Science, Frontier Research Chemistry Vol. 12 Issue 1 Version 1.*
- Celik A. and A. Demirabas. (2005) "Removal of heavy metal ions from aqueous solutions via adsorption onto modified lignin wastes", *Energy Sources*, 27, 1167-1177.
- C. N. Sawyer, P. L. McCarty and G. F. Parkin (2003) "Chemistry for Environmental Engineering and Science" Tata McGraw-Hill Publishing, New Delhi 5th Edn., 660-661 and 717.
- D. A. Kumar, (2004) "Environmental Chemistry", New Age International, New Delhi, 5th Edn., 280.
- Dammo M. N. and Sangodoyin A. Y. (2014). Socio-economic activities around Alau Dam and the quality of raw water supply to Maiduguri Treatment Plant, Nigeria. *Water Practice & Technology Vol 9 No 3* doi: 10.2166/wpt.2014.042
- Idowu R. T., Inyang N. M. and Ezenwaji H. M. G. (2004). Heavy Metals Concentrations in West African Sahel Reservoir. *Animal Research International* 1(1): 12-15
- Magda A. Aki., Yousof A. M and Abdul E. S. (2013) Removal of iron and manganese in water samples using activated carbon derived from local agro-residues *J. Chem Eng process technology* 4, 154. Doi: 10, 4172/2157-7048.1000154.
- Othman N and Syazwani M. A. (2013) Cucumis melo rind as biosorbent to remove Fe(II) and Mn(II) from synthetic ground water solution. *Advance materials research vol. 795*, pp266-271
- Siabi, W. K (2003) Potential of Activated Carbon for manganese and iron removal 29th WEDC International conference towards the MDG's Abuja Nigeria.
- Uwadiae S. E., Yerima Y and Azike R. U (2010). A Comparative Study of Sorption of Heavy Metals Ions by Granular Activated Carbon from Coconut Shell, Saw Dust and Groundnut Shell. *Journal of Sciences and Multi-Disciplinary Research Vol 2*
- Watobe T., and Ogawa K., (1929). Activted carbon for purifying copper electrolytes. *Chem.abstr* 24, 1037
- Zheng X., Jin X., Zhenzhen W and Weihao Li (2014). Removal of iron and manganese in steel industry drainage by biological activated carbon. *Desalination and water treatment.* www.destwater.com doi: 10.1080/19443994.2014-963682