Available online www.jocpr.com

Journal of Chemical and Pharmaceutical Research, 2016, 8(8):1030-1034

Research Article

ISSN : 0975-7384
CODEN(USA) : JCPRC5

Preparation, characterization and application of pineapple peel activated carbon as an adsorbent for water hardness removal

S. D. Ashtaputrey and P. D. Ashtaputrey*

Department of Chemistry, Institute of Science, Nagpur-440001, MS, India

---

ABSTRACT

In the present study locally available, low cost Pineapple Peel has been used as a raw material in the preparation of charcoal at three different temperatures 300^0C, 400^0C and 500^0C.Chemical Activation of the charcoal were done for enhancing its adsorption capacity by using 1N HCl solution. Physico-chemical characterization was carried out by using standard methods given by ASTM, CEFIC and BIS. The surface morphology was studied by SEM technique. Batch experiments were carried out to determine the effect of various parameters such as Adsorbent dose, Contact time and P^H on water hardness removal efficiency of activated carbon using field collected water sample. The experimental results indicate that prepared activated carbon is suitable for removal of water hardness and hardness removal efficiency increases with the increase in contact time and adsorbent dose. The hardness removal efficiency of PPAC300 was found to be maximum in the pH range of 6 to 8.

Key words: Activated carbon, Pineapple peel, Adsorption, Water hardness

---

INTRODUCTION

Charcoal is an excellent adsorbent and has wide applications. Its main use today is in the treatment of water for the removal of hardness. Every region around the world faces the problem of water hardness to more or less extent. Water hardness is mainly due to water contamination by the salts of calcium and magnesium. Water is essential for domestic and industrial use. The hardness of water cause serious health problems to human being like Kidney stone, cardiovascular disorder and Skin stretching and many more in industries. Hence water softening treatment is essential before its domestic as well as industrial use. There are large numbers of methods to soften the water but are of high cost. Hence water softening by adsorption using activated carbon derived from agricultural waste has got importance due to its easily availability and chief cost.

From the literature study it has been observed that the activated carbons prepared from agricultural waste like coconut shell [1], Cotton stalks [2], Ground nut husk [3], Rice hush [4], Corncob [5], Fluted Pumpkin stem waste [6] etc. have been reported. The preparation of activated carbon from Pineapple peel by chemical activation process and its applicability for the removal of water hardness has not been reported. Pineapple (Ananas comosus) holds the third rank in the world of tropical fruit production after Banana and Citrus [7].It belong to Bromeliaceae family. The objective of this research is to study the feasibility of using Pineapple peel waste as a precursor for the production of activated carbon and to determine the water hardness removal efficiency under different conditions like contact time, adsorbent dose and P^H by performing batch experiments.

EXPERIMENTAL SECTION

Adsorbent Preparation: The Pineapple peel waste were collected from local fruit shops of Nagpur city. The collected pineapple waste was cut into small pieces and sundried until all the moisture was removed. The pieces were then dried in an oven at 110^0C for an hour. The dried pineapple peel waste were then carbonized in a muffle furnace (Biotechnics, India, Model BTI40) by placing the sample in a silica crucible at temperatures 300^0C, 400^0C, and 500^0C for one hour each [8]. It was ensure that little or no oxygen was present during carbonization. The charcoal thus produced was withdrawn from the furnace, cooled, Washed with tap water and dried in an oven at 110^0C and ground in a mortar by means of pestle applying moderable pressure. They were sieved through 100 – 200 mesh sieves. Then chemical activation was carried out using 1N aqueous solution of hydrochloric acid (HCl) by placing it in 1N HCl solution in the ratio 1:5. The mixture was left to soak for 12 hours and later heated to form a paste. The paste was placed in a preprogrammed furnace and carbonized at the same temperature of initial carbonization (300^0C, 400^0C, 500^0C) for one hour. The sample was allowed to cool to room temperature overnight. It was then neutralized with NaOH and washed with distilled water till the pH was constant. Then it was dried at 105^0C in an oven and later removed to cool at room temperature. The carbon produced was sieved with 106 µm, put in an air tied bottle and labelled as PPAC300, PPAC400 and PPAC500 respectively and collectively called pineapple peel activated carbons and then stored in plastic containers for further studies.

Characterization of Adsorbent: The basic characteristics of activated carbons (PPAC) like P^H, Conductivity, Moisture content, Ash content, Volatile content, Iodine value, Methylene blue value and Fixed carbon were analyzed by standard procedures of ASTM [9], BIS [10] and CEFIC[11]. The surface morphology analysis of adsorbents was carried out by Scanning Electron Microscopic (SEM) technique.

Adsorbate: For the present study the water sample from 225 feet deep bore well was collected from Bokhara, Nagpur in the state of Maharashtra and stored in a temperature below 4^0C to prevent microbial activities. Hardness of the water sample before treatment with adsorbent prepared was determined by EDTA titration as describe by Cash [12]

Batch Experiments: Batch adsorption experiments were performed to study the adsorption behavior of PPACs on water hardness removal under different adsorption conditions like adsorbent dose (20 to 140 g/lit at an interval of 20g/lit) [13], Contact time (2 to 16 hours at difference of 2 hours) [14] and P^H (2 to 12).All the experiments were performed at room temperature. In each experiment a known amount of activated carbon was added to 50 ml of hard water sample with known P^H and vigorously shaken using Rotary flask shaker, Tanco. After which the solutions were filtered by using whatmann filter papers and filtrates were collected for analysis. In each experiment the conditions were kept constant except for the one in which its effect is studied.

Analysis of Hardness removal efficiency: The hardness of water sample after the adsorption study under different conditions was determined in a similar manner as it was determined before adsorption [12].The percentage removal efficiency was calculated using the following equation [15]. MS excel were used to performed the statistical calculations and plotting graphs.

$$\textbf{\% Hardness removal efficiency} = \frac{Ci - Cf}{Ci} \text{ X } 100$$

Where Ci =Initial Hardness of water sample in mg/lit and Cf = Final Hardness of water sample in mg/lit

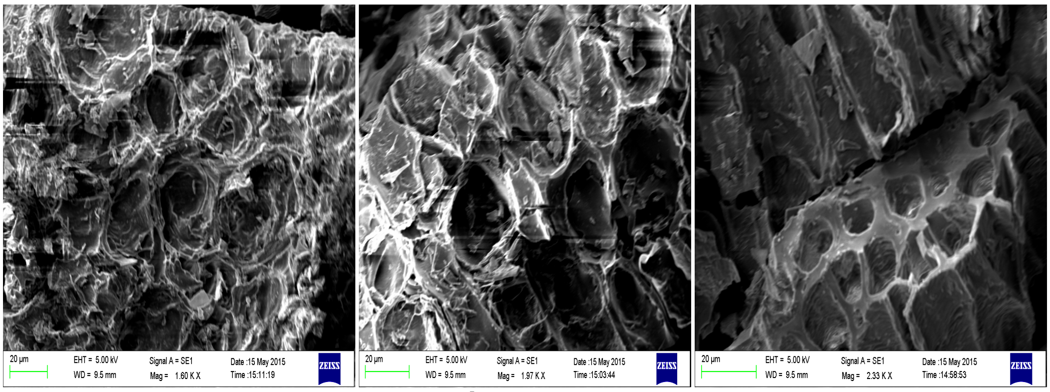
RESULTS AND DISCUSSION

Characterization of Adsorbent (PPAC): The studied various physico-chemical characteristics values of activated carbons PPAC are reported in table: 1.

Table: 1. characteristics values of activated carbons

Sr. No.	Characteristic	PPAC300	PPAC400	PPAC500
1	P^H	6.84	5.81	6.36
2	Conductivity (µS)	1022.7	978.3	1142.5
3	Ash Content (%)	24.58	27.15	31.17
4	Volatile Content (%)	42.27	40.21	38.23
5	Moisture Content (%)	18.32	15.94	13.73
6	Iodine Value (mg/g)	1145.14	1040.95	967.58
7	Methylene blue Value(mg/g)	286	233	158
8	Fixed Carbon (%)	14.83	16.70	16.87

From the table: 1, it is observed that all the activated carbons were having slight acidic P^H. The carbons of P^H ranges 6 to 8 are useful for most applications [16-17].Hence the studied activated carbons could be acceptable for water hardness removal .All activated carbons exhibited high conductivity values suggested that acid and water wash may not have been able to reduce leachable ash to level observed in commercial carbons [17].This could be due to presence of substantial amount of water soluble minerals remained in activated carbons. Moderate values of ash content suggested good mechanical strength and adsorptive capacity. Even though moisture content of the carbon has no effect on its adsorptive power, it dilutes the carbon and necessitates the use of additional weight carbon during treatment process. PPAC500 has the lowest value of moisture content and all the activated carbons moisture content values are near normal and comparable with the values reported earlier [18].Volatile matter is due to the presence of organic compounds in the precursor that is raw material. All activated carbons have low value of fixed carbon percentage. The Iodine adsorption and Methylene blue value indicates the adsorption capacity of activated carbons and are often reported in mg/lit. It also helps to determine the surface area which results from the porosity characteristic of activated carbons. PPAC300 activated carbon shows the highest Iodine value (1145.14mg/lit) and Methylene blue value (286 mg/lit) indicating the highest surface area and porosity. Scanning Electron microscope (SEM) was used to analyze the surface morphology of the activated carbons. The porosity of the surface of activated carbons acts as the active sites for adsorption and increases the surface area. The surface area of activated carbons is found to be consist of highly packed bundles of deep long cylindrical pores and some pits as seen in the SEM images indicating the good adsorptive capacity .However at higher temperature broken pore structure observed .Which may be due to the decomposition of volatile matters followed by densification during carbonization process [14]. Electron Microscope images of activated carbons PPAC300, PPAC400, PPAC500 are shown in fig.1 (a-c) respectively.



a b c

Fig.1: SEM images of a) PPAC300 b) PPAC400 c) PPAC500

Hardness removal efficiency: The water sample collected for studying the hardness removal efficiency of an adsorbent was having hardness 586 mg/lit as determine by EDTA titration method.

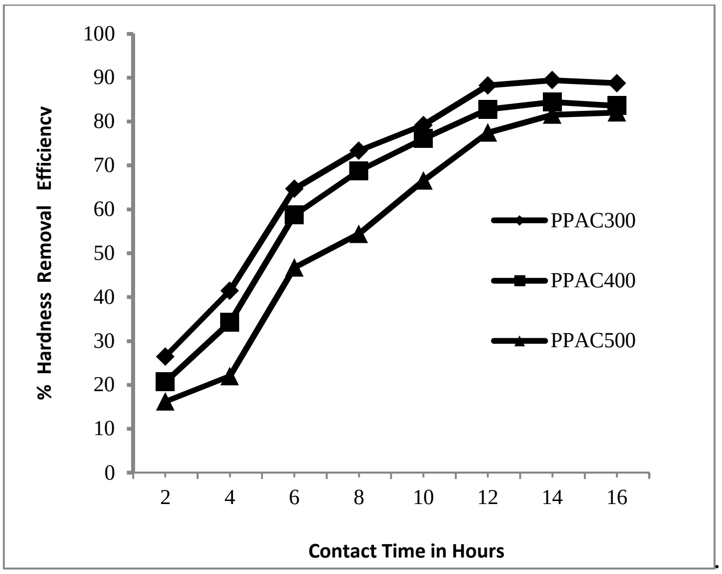


Fig.2: Effect of contact time on hardness removal efficiency of PPACs at neutral pH & adsorbent dose 0.1g/cm^3

Effect of contact time: The effect of contact time was studied at room temperature at an interval of two hours. The result obtained is shown in fig.2. From the graph it is noticed that the hardness removal efficiency of all activated carbons increases with increase of contact time up to 12 hours. After which there was no noticeable change in the hardness removal efficiency for further increase in contact time. Hardness removal efficiency of PPAC300 was found to be more than the others as expected due to more surface area. The increase in hardness removal efficiency up to 12 hours may be due to large number of vacant sites of adsorption at initial stage where as no change in hardness removal efficiency after 12 hours contact time might be due to the repulsive forces between adsorbed solute molecules on the surface of adsorbent and that in the contacted water sample.

Effect of adsorbent dose: The effect of adsorbent dose was studied at room temperature at a difference of 20g/lit adsorbent dose. The result obtained is shown in fig.3. From figure it is noticed that the hardness removal efficiency increases with increase in adsorbent dose up to 100g/lit. After which there was no noticeable change in the hardness removal efficiency for further increase in adsorbent dose. Hardness removal efficiency of PPAC300 was found to be more than the others as expected due to more surface area. The increase in hardness removal efficiency up to the dose of 100 g/lit may be due to increasing availability of surface area due to increasing dose [19]. No change in hardness removal efficiency after 100 g/lit of adsorbent dose might be due to the maximum adsorption limit [20].

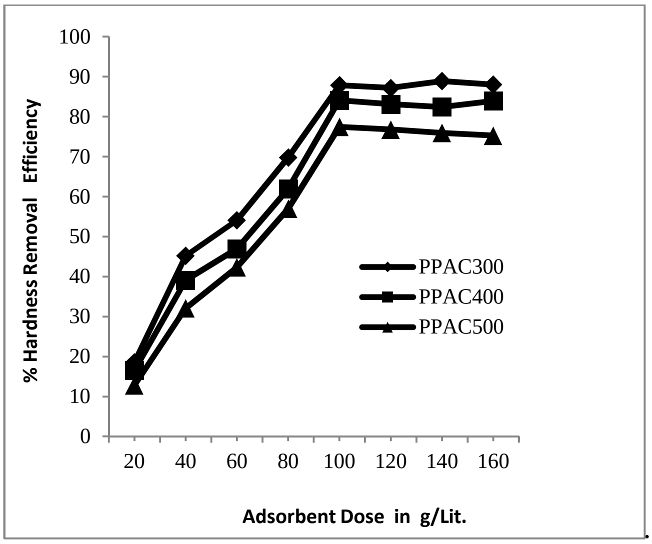


Fig.3: Effect of adsorbent dose on hardness removal efficiency of PPACs at neutral pH & contact time of 2 hours

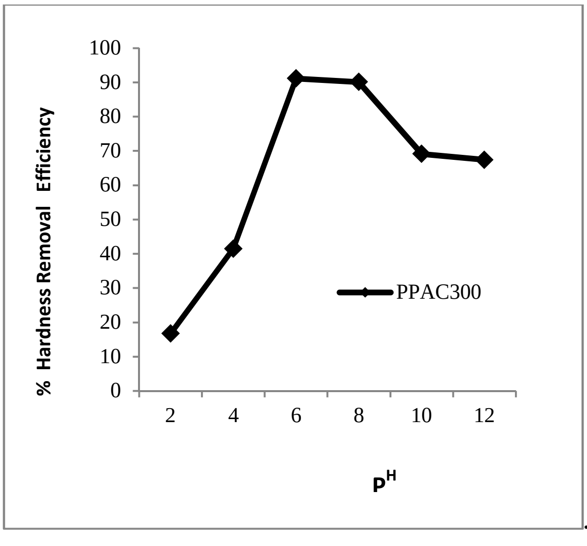


Fig.4: Effect of pH on hardness removal efficiency of PPAC300 at contact time of 2 Hours & adsorbent dose of 0.1g/cm^3

Effect of pH: The effect of pH was studied at room temperature for only PPAC300 sample as it shows the maximum hardness removal efficiency with respect to both contact time and adsorbent dose. The result obtained is shown in fig.4. From figure it is noticed that there was increase in hardness removal efficiency from pH 2 to 6. This might be due to the fact that with increase in pH, the hydronium ion (H_3O^+) concentration decreases therefore there is more possibility of adsorption of ions responsible for the hardness. Above pH 8 hardness removal efficiency first decreases up to pH 10. It might due to the increase in hydroxyl ion (OH^-) concentration which gets adsorbed to higher extent because of slight acidic nature of adsorbent. Above pH 10 hardness removal efficiency almost constant due to equilibrium adsorption state. Thus it is cleared that around pH range 6 to 8, PPAC300 carbon shows more effectiveness towards hardness removal.

CONCLUSION

In the present study, the activated carbons were prepared by chemical activation process and the experiments have been conducted to find out the effectiveness of prepared carbons towards the water hardness removal with different dosages, contact time and pH. From the study it can be concluded that acid activated pineapple peel carbon PPAC300 was found more effective with respect to different dosages and contact time than the others and also effective adsorbent for the removal of water hardness around the pH 6 to 8.

Acknowledgements
The authors gratefully acknowledge the Director, Institute of Science, Nagpur and Head, Department of Chemistry, Institute of Science, Nagpur for providing the facilities and support.

REFERENCES

[1] XinYang Wang; DanXi Li; Bao Min Yang, et al. *Advance Material Research*, **2012**, 12, 366-373.
[2] M Ozdemir; T Bolgaz; et al.*Journal of analytical and applied pyrolysis*,**2011**, 92, 171-175.
[3] D Shivakumar. J Nouri,*Pollution Reaserch*,**2015**, 1(4), 297-304.
[4] D Shivakumar; N Murugan; R Rajeshwaran; T Shobana; C Soundarya; VS Vanitha. *International journal of ChemTech Research*, **2014**, 6, 4373-4378.
[5] Min Song, Dao Sheng; Rui Xiao; et al. *Biomass and Bioenergy*, **2013**, 48, 250-256.
[6] OA Ekpete; M Horsfall JNR.. *Reseach Journal of Chemical Science,* **June 2011**, 1(3), 10-15.
[7] KZ Nadzirah; S Zainal, A Noriham; I Normah; AM Siti Roha; H Nadya., *International Food Research Journal*, **2013**, 20(1), 225-231.
[8] M Rahman; M Asadullah; MM Haque; MA Motin; MD Sultan; MAK Azad. *Journal of Surface Science Technology,* **2006**, 22(3-4), 133-140.
[9] ASTM, American Society for Testing Materials. Standard test methods for activated carbons. 1980.
[10] BIS, Bureau of Indian Standards. Activated carbons, powdered and granular- Methods of sampling and tests. 1990.
[11] CEFIC, European Council of Chemical Manufacturers federations. Test methods for activated carbons. 1986.
[12] D Cash, EDTA titration 2: Analysis of calcium in a supplyment tablet; Analysis of magnesium in Epsom salt: Hardness of water. Mohawk college of applied arts and techonology, 2008.
[13] D Shivakumar; D Shankar. *Journal of Chemical and Pharmaceutical Sciences*, **2015**, 8(4), 916-920.
[14] Cecillia Rolence; Revocatus Lazaro Machunda; Karoli Nicholas Njau. *International Journal of Science, Technology and Society*, **August 2014**, 2(5), 97-102.
[15] VC Srivastava; ID Mall; IM Mishra.*Chemical Engineering and Processing: Process Intensification*, **2008**, 47(8) , 1269-1280.
[16] F Okiemmen; C Okiemen; A Wuana. *Journal of Chemical Society of Nigeria*, **2007**, 32, 126-136.
[17] Q Khadija; B Inamullah; K Rafique; KA Abdul. *International Journal of Chemical and Biomolecular Engineering*, **2008**,1(3),145-149.
[18] Ponnusamy Shivakumar; Nachimuthu Palanisamy. *Advances in Applied Science Research*, **2010**,1(1), 58-65.
[19] C Rolence; RL Machunda; KN Njau. *Research Journal in Engineering and Applied Science*, **2014**,3(3), 199-207.
[20] S Chakrabarty; HP Sarma. *International Journal of Chem Tech Research*, **2012**, 4(2),511-516.