Waste water treatment with agricultural by-products: An investigation with date pit powder

Alghamdi A.A.

Departent of chemical engineering technology,Yanbu Industrial College. Royal commission for Jubail and Yanbu, Kingdom of Saudi Arabia

*corresponding author:e-mail: alghamdia@rcyci.edu.sa

Abstract
Water is very precious and inevitable for every living objects including human beings. Huge quantity of waste water is generated by us every day and there are various methods to regenerate safe and pure drinking water from these waste waters. Researchers all over the world are continuously trying to develop low cost filtration system using various adsorbents. Agricultural waste products are being used as adsorbents and gaining momentum because of various attractive factors such as easy availability, low cost, non-toxic nature etc. In the present investigation, date pit (date stone) powder is used an adsorbent to remove Pb (II). The analysis revealed that date pit powder can be successfully used in a column filtration set-up to remove Pb (II) ions from the waste water streams with high efficiency.
Keywords: Date pit powder; adsorbents; column filtration; Thomas model

1. Introduction

The search for pure and safe drinking water is one of key tasks for almost all the countries for generations. In this search, many different options were explored by various researchers (Chowdhury et. al, 2016).
There are various streams of waste water which need a little treatment to convert it to potable water. An example is domestic waste water. Industrial waste water, on the other hand, needs complex treatment procedures to convert it to safe water. The waste water discharged by the industries may contain toxic heavy metals such as arsenic, cadmium, chromium, copper, nickel, lead and mercury. Contaminated water can reach water sources and can affect aquatic life and also cause health hazards. The high cost involved in waste water treatment necessitated the search for low cost adsorbents. Lignocellulose materials obtained from agricultural waste products were tried as adsorbents in waste water treatment processes mainly because of their ability to remove heavy metals from the polluted water. The low cost, abundance and eco-friendly nature of these materials also accelerated the research in this direction (Abdolali et. al, 2014) developed date palm media filter for the treatment of domestic waste water Riahi et. al, 2009). Khiari et al prepared eco-friendly flocculants based on date palm rachis (Khiari et. al, 2010). A detailed review on the use of date palm as an adsorbent for waste water is published by Tanweer Ahmad and coworkers (Ahmad et. al, 2012). Recently, date pam fibers and coir pith were compared by Alghamdi to assess their effectiveness for the adsorption of Pb (II) ions from aqueous solution. The study showed that date palm fibers have better adsorption capability compared with coir pith (Alghamdi, 2016). In the present investigation, the date pit powder is utilized as an adsorbent for assessing its efficacy in the removal of Pb (II) ions from its aqueous solution.

2. Materials and Methods

The date palm stones were collected from farm located at Medina, Saudi Arabia, and the seeds were crushed and dried for several days. The crushed seeds were separated into different sizes from 90 µm up to 850 µm by using sieve shaker. A filtration set up was fabricated at the laboratory which consists of a column that is 100 cm long with 5 cm inner diameter attached to an overhead tank with adjustable flow rate. At the bottom of the column, a valve with a stainless steel mesh filter of 150 micron is used to support the bed material of date stone powder. 500ppm solution of Pb (II) ions was prepared. Three different sizes of date stone powder were used for the study. They are 355 µm, 425 µm and 500 µm. The column was packed with date stone powder to achieve bed heights of 10, 15 and 20 cm for each size of date stone powder. The solution from the overhead tank was allowed to flow through the bed with fixed flow rate of 70 mL/min. The output liquid was collected in every two minutes during the first 20 minutes and after that every five minutes during 15 minutes, the total time for collecting the samples being 35 minutes. Atomic absorption spectrometer was used to analyze the concentration of Pb (II) ions in the solution before and after the experiments.

3. Mathematical Modeling

One of the widely used mathematical model in column adsorption is Thomas model (Thomas, 1948).The generalized expression of the Thomas model for an adsorption column is given below.

$$\frac{C_t}{C_0} = \frac{1}{1+\exp\left(\left(\frac{KTH}{Q}\right)\left(q_0 X - C_0 V_{eff}\right)\right)} \quad (1)$$

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where, influent and effluent concentrations (mg/L) are denoted as C0 and Ct, kTH is the Thomas kinetic coefficient (mL/min mg), and Q is the volumetric flow rate (mL/min). Adsorption capacity and mass of the adsorbent are denoted as q0 (mg/g) and X(g), and Veff is the effluent volume (ml). The linearized form of the Thomas model is expressed as;

$$\ln\left(\frac{C_0}{c_t}-1\right)=\frac{k_{TH}q_0X}{Q}-\frac{kC_0V_{eff}}{Q} \quad (2)$$

Plot of ln [C0/Ct) − 1] versus t gives the value of Thomas kinetic coefficient designated as kTH, and adsorption capacity of the bed q0. Liner regression coefficient R2 show the fit between experimental data and generalized form of Thomas model equation while the average percentage errors (€ %) calculated according to (3) indicate the fit between the experimental and predicted values of Ct/C0 used for plotting breakthrough curves.

$$£=\frac{\sum_{i=1}^{N}[((\frac{C_t}{C_0})_{exp}-(\frac{C_t}{C_0})_{theo}/(\frac{C_t}{C_0})_{exp}]}{N}x100 \quad (3)$$

4. Results and Discussion

The results obtained from the atomic absorption spectrometer before and after the adsorption studies were evaluated using Thomas model in order to understand the effectiveness of the adsorption by the date stone powder.
According to Thomas model Eq. (3) the liner plot of the experimental data at bed heights of 20, 15 and 10cm is presented in relation between ln((C0/Ct)-1) with respect to time in figures 1.

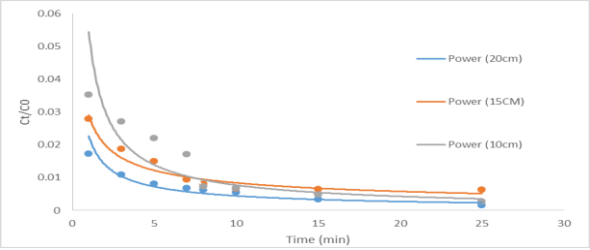

Figure 1. 500µm particle size

The figure shows that the Thomas model give a good fit of the measured adsorption breakthrough curves for adsorption of Pb (II) on date stone powder. Also, from this liners plot the effect of size on the column adsorption parameters such as Thomas kinetic coefficient (kTH) and the maximum solid phase concentration of the solute (qeq) can be determined from the slopes and y-intercepts. The results are shown in Tables 1 below.

Table 1. Parameters for date stone powder with 500 µm size

Bed size (cm)	Flow rate (mL/ min)	K_{TH} $\frac{mL}{min.mg}$	q_{eq} mg	q_{total} mg	Correlation coefficient
20	70	0.118146	0.307599	56.70288	0.9688
15		0.111888	0.360246	53.6377	0.6152
10		0.096656	0.542341	54.7222	0.8561

As seen from the analysis, the maximum Pb (II) uptake and total adsorbed Pb (II) quantity values increased with time for all the particle sizes, which indicate the effectiveness of date stone powder to adsorb Pb (II) ions from its aqueous solution. In a recent study (Vera et al, 2018), sugarcane bagasse was used for adsorption of Pb (II) and Cd (II) ions from their aqueous solutions and Thomas model was successfully used to quantify the adsorption capacity of the bagasse. In another study, rice husk was utilized for removal of Pb (II) and Cr (VI) ions (Mitra et al, 2019) and similar approach was adopted to corroborate the adsorption kinetics.

5. Conclusion

A laboratory column filtrations setup was fabricated and the adsorption of Pb (II) ions onto this adsorbent was monitored. Atomic absorption spectrometer was used to measure the Pb (II) ions concentration in the effluent before and after each experiment. Thomas model was applied to study the efficiency of the date stone powder for adsorbing Pb (II) ions. It was observed that for date stone powder, the breakthrough point was giving clear evidence of the occupancy rate of the adsorbent with Pb (II) ions in all particle size ranges. The material can be further developed to fabricate cost effective filtration columns for the removal of heavy metals from contaminated water.

References

S. Chowdhury, M. A. J. Mazumder, O. Al-Attas, and T. Husain,(2016), Heavy metals in drinking water: Occurrences, implications, and future needs in developing countries, *Sci. Total Environ*, **569–570**,476–488

A. Abdolali, W. S. Guo, H. H. Ngo, S. S. Chen, N. C. Nguyen, and K. L. Tung,(2014),Typical lignocellulosic wastes and by-products for biosorption process in water and wastewater treatment: A critical review, *Bioresour. Technol.*, **160**, 57–66

K. Riahi, A. Ben Mammou, and B. Ben Thayer,(2009), Date-palm fibers media filters as a potential technology for tertiary domestic wastewater treatment, *J. Hazard. Mater*., **161**, 2–3, 608–613.

R. Khiari, S. Dridi-Dhaouadi, C. Aguir, and M. F. Mhenni,(2010), Experimental evaluation of eco-friendly flocculants prepared from date palm rachis, *J. Environ. Sci.*, **22**, 1539–1543.

T. Ahmad et al.(2012), The use of date palm as a potential adsorbent for wastewater treatment: a review, *Environ. Sci. Pollut. Res.*, **19**, 5, 1464–1484.

A. A. Alghamdi (2016), An investigation on the use of date palm fibers and coir pith as adsorbents for Pb(II) ions from its aqueous solution, *Desalin. Water Treat*., **57**, 26, 12216–12226.

H. C. Thomas,(1948), CHROMATOGRAPHY:A PROBLEM IN KINETICS, *Ann. N. Y. Acad. Sci*., **49**, 2, 161–182.

Vera, Luisa Mayra, et al. "Fixed bed column modeling of lead (II) and cadmium (II) ions biosorption on sugarcane bagasse." Environmental Engineering Research 24.1 (2018): 31-37.

Mitra, Tania, Nirjhar Bar, and Sudip Kumar Das. "Rice husk: green adsorbent for Pb (II) and Cr (VI) removal from aqueous solution—column study and GA–NN modeling." SN Applied Sciences 1.5 (2019): 486.