Recent Trends in Civil Engineering and Built Environment Vol. 3 No. 1 (2022) 1185–1191

RTCEBE

Homepage: http://publisher.uthm.edu.my/periodicals/index.php/rtcebe
e-ISSN :2773-5184

The Carbonization of Pomelo and Banana Peels as Adsorbent in Heavy Metal Treatment of Groundwater

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DOI: https://doi.org/10.30880/rtcebe.2022.03.01.135
Received 4 July 2021; Accepted 13 December 2021; Available online 15 July 2022

Abstract: The groundwater exploitation could increase the surface water supplies due to its convenient and accessibility. However, the presence of the heavy metals is among the major contaminants of groundwater sources and would be harmful and unsafe to be used if not treated well. The contamination of heavy metal concentration may occur in the groundwater causing by various anthropogenic activities such as agricultural and industrial in the surrounding area. Therefore, this study aims to identify the properties of the groundwater in Universiti Tun Hussein Onn Malaysia (UTHM) related to its heavy metal parameter and focusing on reducing the concentration by using carbonization method on preparing pomelo and banana peels as adsorbent. The heavy metal substances that were tested are iron (Fe), aluminium (Al), zinc (Zn) and manganese (Mn). The parameters in the groundwater shall meet the requirement according to the National Guidelines for Raw Drinking Water.The adsorption process of the pomelo and banana peels signify the effectiveness in reducing the heavy metal concentration in the groundwater. The initial concentration of Fe, Al, Zn and Mn is 4.560 mg/L, 0.970 mg/L, 0.216 mg/L and 1.550 mg/L respectively. After treated using carbonized pomelo peels, the concentration of Fe, Al, Zn and Mn were reduced to 3.470 mg/L, 0.473mg/L, 0.214 mg/L and 0.921 mg/L respectively. Meanwhile for carbonized banana peels, the concentration reduced 0.753 mg/L, 0.339 mg/L, 0.089 mg/L and 0.508 mg/L individually. It shows that the treatment using pomelo and banana peels as adsorbent has successfully reduce the concentration as the pores structure of the adsorbent could adsorbs the substances to its surface easily. As proven in the result of 24%, 51%, 0.9% and 41% percentage of pomelo peels removal efficiency, as well as 84%, 65%, 59% and 67% percentage of banana peels removal efficiency for Fe, Zn, Al and Mn respectively.
Keywords: Carbonization Method, Adsorption, Pomelo Peels, Banana Peels, Heavy Metal.

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1. Introduction

Groundwater could be classified as one of the beneficial natural water resources on earth. Along theyears, the technologies development to access the groundwater become more advanced as it enables the pumping and extraction process easier. According to the National Ground Water Monitoring Programmed, the parameters of the groundwater shall meet the requirement based on the National Guidelines for Raw Drinking Water Quality established by the Ministry of Health in determining the quality status of the groundwater. Thus, the presence of heavy metal is one of the deficiencies in groundwater quality. The ions of heavy metal may concentrate into water system through some manufacturing processes such as fertilizer and pesticides which lead to severe risk to the environment [1]. In result, these toxic heavy metals could affect the health by accumulating in living tissues and dilute through the food chain [2].

In past endeavors have led to establishing various unit process like adsorption, filtration, precipitation, ion exchange, and chemical coagulation. However, among the process stated, the adsorption procedure is considered as the most practical, technical and were, broadly utilized process as it has proven to be the best water treatment method [3,4]. Adsorption could be defined as a phase of transferring process which is broadly use practically for removing any substances from a phases whetherin liquids or gases. In another word, it could be narrated as an improvement of chemical types from a phase of fluid on the surface of a solid or liquid. The adhesions of molecules were removed from the solution by adsorption as it made a direct contact with the solid surfaces [5]. As the use of adsorbent given an advantage because of its renewability and low-cost biomass adsorbent, it has attracted several of the research attention in recent years by using various of natural materials. Examples include breadnut peel, rice hulls, willow branches, peanut hulls, rice straw, bagasse, hemp cellulose, orange peel, and other waste biomass [6].

Therefore, the selected materials such as pomelo and banana peels in these studies were a waste peels that are easy to find, economical, non-hazardous and environmentally safe biomaterials which can be used as adsorbent in water treatment [7]. For the varieties of the pomelo and banana peels are not being classified in these studies as it will not be one of the consideration. The pomelo peels consisting primarily of cellulose, hemicellulose, and lignin as well as possessed an extensive porous structure in its interior, which was responsible for the successful adsorption [8]. Meanwhile, banana peels seem to be familiar with its usefulness as an adsorbent due to its chemical composition which contained a high amount of hemicellulose, pectin, cellulose, lignin and various polar functional group such as phenolic acid group, carboxylic and hydroxyl [9,10]. Carbonization method takes place when the materials are intended to be converted into activated carbon. The materials that wanted to be carbonized will be heated through certain process and temperature. Furthermore, the carbonization method chosen were observed to be efficient as the structures of adsorb the heavy metal easily to its surface and have a strong oxidant [11].

Therefore, this study intended to conduct groundwater quality by identifying the properties of the groundwater in UTHM related to its heavy metal as well as reducing the concentration of the heavy metal in groundwater by using carbonization method on preparing pomelo and banana peels as adsorbent. In this study, the samples of the current condition in groundwater of the study area were analysed. The properties of the groundwater related to heavy metal parameter could be identified and future research about the groundwater in UTHM could make this study as reference. In addition, this study will trigger the idea of producing heavy metal treatment for groundwater by applying the natural concept along with the best purpose and more environmental-friendly in the future and may contribute a helpful information in treating the heavy metal in the groundwater using the chemical-physical process which is by carbonizing the pomelo and banana peels to act as adsorbent

2. Materials and Methods

The groundwater samples were collected at Tun Dr. Ismail Residential College (1°51'46.2"N, 103°05'22.6"E) which located in Universiti Tun Hussein Onn Malaysia (UTHM). This study area is one of the boreholes owned by the university. The tube wells were approximately 30 m deep shallow borehole and about 2 inch in diameter. It is located near the lake and the residential building. Figure 1 shows the tube well of the borehole near Tun Dr. Ismail Residential College.

Figure 1: Tube well near Tun Dr Ismail Residential College

2.1 Materials Preparation

The pomelo peels were obtained from fruit stall at Kluang, Johor meanwhile banana peels were taken from food stall at Taman Universiti, Parit Raja, Johor. All of the equipment needed for this research are available and provided at the laboratory in Faculty of Civil Engineering and Built Environment (FKAAB), UTHM and Faculty of Electrical and Electronic (FKEE).

2.2 Preparation of Adsorbent

The collected peels were prepared using carbonization method to transform it into activated carbon to acts as adsorbent in treating the groundwater by reducing the concentration of the heavy metal. The adsorbent must be prepared before the water samplings process. The fruit peels that has been collected were cut into a small pieces and washed it with distilled water for removing any impurities and dirt. Next, dried up the peels for 48 hours in an oven at 100˚C to remove its moisture content. Then, removed the dried peels from the oven and kept in the dessicators for 30 minutes. After being dessicated for 30 minutes, kept the dried peels in the oven for 3 hours at 200˚C in order to transform into carbon. Lastly, let the peels cooled down before ground it to a fine powder using grounder and sieve it through 300 μm particle size.

2.3 Water Sampling

After the adsorbent has readily been prepared, the water sampling process would take place. In this case, only one (1) liter of groundwater raw sample was taken in a High Density Polyethylene (HDPE) bottle from the weir after the first flushed out. The bottle has been rinse twice with the groundwater to ensure its purity. Sample should be obtained with the least agitation or disruption possible and to be stored in the chillerwith controlled temperature. It is to ensure that the samples will not affect by the surrounding thus giving error to the result. 1.0g and 2.0g of the carbonized pomelo and banana peels are being mixed inthe 100 ml of the groundwater samples respectively, in result of two (2) samples to be experimented. The samples with pomelo peels in it are left for 80 minutes while the banana peels are left for 120 minutes before being filtered and kept in the chiller.

2.4 Heavy Metal Concentration Analysis

The water samples taken was filtered to remove any impurities and diluted with dilution factor of 100x. 10 ml from the samples was pipetted into 100 ml volumetric flask and reagant dilution (pure water) was poured into the water sample. The samples were stirred and stored in chiller before analyzed by using Inductively Coupled Plasma-Mass Spectrometry (ICP-MS).

2.5 Percentage Removal

The percentage removal was calculated for each of water parameter using Equation 1 as shown below. It is very important in identifying the effectiveness of the water treatment.

$$Percentage\ removal(\%) = \frac{Initial\ reading - Final\ reading}{Initial\ Reading} \times 100\% \quad Eq.1$$

3. Results and Discussion

3.1 Analysis on concentration of heavy metal before and after treated using pomelo peels

Based on the result within four (4) parameters of the heavy metal before treatment, it shows that Fe has the highest concentration which is 4.56 mg/L among the other and exceeded the permissible limit 0.3 mg/L. The concentration of Mn is also exceeded the benchmark value for 0.1 mg/L as the result tested shows its concentration of 1.55 mg/L. The permissible limit for Al is 0.2 mg/L and the concentration in the groundwater at the study area is 0.216 mg/L. Followed by 0.97mg/L for concentration of Zn that presence in the groundwater at the study area which is below the benchmark value indicates that the groundwater is safe from excess of Zn. However, the concentration value of the heavy metals does reduce after getting treated using the pomelo peels as adsorbent. According to the observation, carbonized pomelo peels able to reduce as much as 24% for Fe, 51% for Zn, 0.9% for Al and 41% for Mn. Table 1 shows the result of the concentration of heavy metal before and after treated using pomelo peels.

Table 1: Concentration of heavy metal before and after treated by using pomelo peels

Heavy Metal	Before treatment (mg/L)	After treatment (mg/L)	National Guidelines for Raw Drinking Water Quality (mg/L)
Iron	4.560	3.470	0.3
Zinc	0.970	0.473	3.0
Aluminum	0.216	0.214	0.2
Manganese	1.550	0.921	0.1

To briefly paraphrase, the carbonized pomelo peels are indeed having the ability to reduce the concentration of heavy metal. These findings could be supported by previous studies that claimed the pomelo peels efficiency in acting as adsorbent [5,6,8]

3.2 Analysis on concentration of heavy metal before and after treated using Banana Peels

Based on the result, the adsorption process took place and reducing the concentration of the heavy metal successfully. The concentration of Fe before and after treatment is 4.56 mg/L and 0.753 mg/L respectively. However, both values still did not meet the permissible limit stated by the National Guidelines for Raw Drinking Water Quality which is 0.3 mg/L. The concentration of Zn has been reduced to 0.339 mg/L from 0.97mg/L after treating it with carbonized banana peels. Followed by the concentration of Al and Mn, which both reduced from 0.216 mg/L to 0.089 mg/L and 1.55 mg/L to

0.508 mg/L respectively. Generally, carbonized banana peels has reduced the heavy metal as much as 84%, 65%, 59% and 67% for Fe, Zn, Al and Mn respectively.

The treatment in using banana peels has successfully reduce the concentration of Al below the permissible limit, thus meet the requirement of drinking water standard. Taking everything into account, the banana peels has been proved to be able to reduce the concentration of the heavy metal as result shows a significant difference between before and after the treatment. It can be supported by previous studies that claimed the effectiveness of the banana peels acting as adsorbent to treat heavy metal [7,9,10,12] In addition, the irregular morphology and porous surface of the carbonized banana peels gives it an advantages in adsorbing the contamination[13]. Table 2 shows the result of the concentration of heavy metal before and after treated by using banana peels.

Table 2: Concentration of heavy metal before and after treated by using banana peels

Heavy Metal	Before treatment (mg/L)	After treatment (mg/L)	National Guidelines for Raw Drinking Water Quality (mg/L)
Iron	4.560	0.753	0.3
Zinc	0.970	0.339	3.0
Aluminum	0.216	0.089	0.2
Manganese	1.550	0.508	0.1

Analyzing the environment around the study area, the concentration of Fe is the highest as its accumulation in the groundwater are due to a consequence of its normal nature in underground geological formations and the absorption of water that penetrate these formations. Meanwhile, Al concentration remains the lowest as the study area is not within the landfill area. At the same time, Mn display as the second highest concentration obtained while taking into consideration that according to International Manganese Institute, Mn naturally presence in the water sources particularly in depleted oxygen or anaerobic systems. Considering the value of the concentration, the presence of Zn in the groundwater may occur due to agriculture and horticulture activities.

3.3 Efficiency of removal between pomelo and banana peels

The studies conducted validate the facts that using pomelo and banana peels can reduce the concentration of the heavy metal and the result contribute on proofing their effectiveness. In addition, the weight of the dosage for both peels are difference as the chosen weight were based on previous research. 1.0g of pomelo peels gives a maximum removal as with the higher dosage the percentage removal decreased due to decreased adsorbent sites [14]. Meanwhile, for the banana peels, the higher the dosage use, the higher the percentage removal [12]. To sum up the analysis, the higher percentage removal for pomelo peels in 51% in reducing Zn and the lowest is only 0.9% in reducing Al. While banana peels are effectively reducing Fe with a percentage removal as much as 84% and less efficient in reducing Al with percentage removal of 59%. Table 3 shows the percentage removal of each heavy metal for the type of fruit peels used as adsorbent.

Table 3: Percentage removal of each heavy metal for the type of fruit peels used as adsorbent

Heavy metal	Percentage removal of Pomelo Peels, %	Percentage removal of Banana Peels, %
Iron	24	84
Zinc	51	65
Aluminium	0.9	59
Manganese	41	67

With a different optimum dosage of both the peels, the result still could indicate the comparison between the effectiveness of pomelo and banana peels in reducing the heavy metal. Based on the findings, the efficiency of pomelo peels to reduce the concentration of Zn is remarkable but unnoticeable for Al removal. Meanwhile, banana peels are more efficient in reducing the concentration of Fe but less efficient in reducing the concentration of Al. Result shown similarity of the pomelo and banana peels within the poor percentage removal of Al.

4. Conclusion

By way of conclusion with a proven result, the concentration of Fe presence in the groundwater of the study area is the highest followed by Mn, Al and Zn. The concentration of Zn has obtained to be the lowest which is about 0.97 mg/L below the permissible value and met the standard guidelines before treatment. For the adsorbent dosage of 1.0g of pomelo peels, it shows that the carbonized pomelo peels are able to reduce concentration of Zn effectively. Meanwhile, for 2.0g of carbonized banana peels are capable on reducing the concentration of Al and Zn below the benchmark value and met the standard stated in the National Guidelines for Raw Drinking Water Quality. As a final observation, the carbonization of pomelo and banana peels as adsorbent are capable to treat the presence of heavy metal in groundwater simultaneously a low-cost adsorbent material.

Acknowledgement

The authors would like to thank the Faculty of Civil Engineering and Built Environment and Faculty Electric and Electronic Engineering, Universiti Tun Hussein Onn Malaysia for its support.

References

[1] Belkhiri L, Tiri A. & Mouni L. (2018). Assessment of Heavy Metals Contamination in Groundwater: A Case Study of the South of Setif Area, East Algeria. IntechOpen, 18-31.

[2] Da'na E. (2017). Adsorption of Heavy Metal on Funtionalized-Mesoporous Silica: A review. ELSEVIER, 145-157.

[3] Kashif MU. (2017). A Review on The Adsorption of Heavy Metals by Clay Minerals, with Special Focus on The Past Decade. Chemical Engineering Journal, Volume 308, 438-462

[4] Khattak M. M. Rahman, Zahoor M, Muhammad B, Khan F.A, Ullah R & Naser M. AbdEI-Salam (2017). Removal of Heavy Metals from Drinking Water by Magnetic Carbon Nanostructures Prepared from Biomass. Journal of Nanomaterial, 1-10.

[5] Hamidon N, Nazri N, Awang M, Sunar N. M, Muhammad M. S, Mohd Aris N. A, Harun H, A. Hamid H, R. Ali & Abdul Rahman M.A. (2019). Surface Water Treatment using Pomelo's Peel(Citrus Grandis) and Biosand Filter as Iron (Fe) Adsoprtion in Kangkar Senangar's River. International Journal of Innovative Technology and Exploring Engineering (IJITEE), 2278-3075.

[6] Ren Y, Cui C & Wang P. (2018). Pomelo Peel Modified with Citrate as a Sustainable Adsorbent for Removal of Methylene Blue from Aqueous Solution. Molecules, 23(6), doi:10.3390/molecules23061342 .

[7] R. Subashree, N. Surya Praba & Dr. G. Anusha (2017). Treatment of Wastewater using Banana and Lemon Peels as Adsorbent. IJETSR, Vol.4, Issue 9, 1289-1291.

[8] Zhang G, Sun Y, Guo Y, Liu J, Wu L & Lin J. (2018). The Application of Pomelo Peel as a Carrier for Adsorption of Epigallocatechin-3-gallate. Wiley Online Library.

[9] Opeyemi AO, Maurice SO & Christian W. (2016). Application of Banana Peels Nanosorbent for The Removal of Radioactive Minerals from Real Mine Water. Journal of Environmental Radioactivity, 369-376.

[10] Ali A. (2017). Removal of Mn(II) From Water Using Chemically Modified Banana Peels as Efficient Adsorbent. Environmental Nanotechnology, Monitoring & Management, 57-63.

[11] Thuraiya M., Dumaran J., Geetha M., Nageswara L. & S. Feroz. (2015). Treatment of Dairy Wastewater using Orange and Banana Peels. Journal of Chemical and Pharmaceutical Reseacrh, 1385-1391.

[12] F. Baharudin, M. M. (2018). Removal of Iron and Manganese in Groundwater using Natural Biosorbent. IOP Conf. Series: Earth and Environmental Science 140 012046.

[13] El-Din GA, Ameer AA, Malsh G & Hussein M. (2017). Study on The Use of Banana Peels For Oil Spill Removal. Alexandria Engineering Journal, 1-8.

[14] Koninika T. & Abedin M.Z. (2015). Adsorption Of Methylene Blue From Aqueous Solution By Pomelo (Citrus Maxima) Peel. International Journal of Scientific & Technology Research, 230-232.