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Treatment of Heavy Metals in Groundwater by the Carbonization of Lemon Peels and Coconut Shells

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Abstract: Groundwater can be one of the sources for the fresh water that can be utilized for various purposes. The presence of heavy metals (iron and copper) caused by the anthropogenic activities does affect the quality of the groundwater. This study is focusing on the properties of groundwater in Universiti Tun Hussein Onn Malaysia (UTHM) and the method that can remove or reduce the concentration of heavy metals such as iron and copper in the groundwater. Activated carbon from coconut shells and lemon peels as the natural adsorbents were studied and the efficiency of both materials were compared. The scope of this study was based primarily on a comprehensive literature review to gather comprehensive information on the activated carbon used, as well as expectations for its usage on groundwater samples in RECESS UTHM. The groundwater data was obtained from the previous research papers. The best values for each parameter from both activated carbons was selected based on the nearest values to the values from previous research journals. The average optimum dosage for coconut shells activated carbon was 0.77g were capable of removing 92.4% of heavy metal presents in the groundwater. The lemon peels were 1.28g with 91.88% percentage removal. The optimum contact time for lemon peels was at 83 minutes with 81.46% percentage removal. Meanwhile, the optimum contact time for coconut shells activated carbon was at 100 minutes with 89.01% percentage of removal. The finding of this study will contribute to the benefit of the society in advancement of knowledge on the properties of groundwater. The groundwater quality can be improved and can be used as a source of freshwater for domestic purposes.

Keywords: Groundwater, Heavy Metals, Iron, Copper

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1. Introduction

Groundwater is becoming the main source of freshwater for domestic, agricultural and other human activities in many places, particularly in coastal area [1]. Groundwater is a valuable resource of fresh water and comprises about two-thirds of the world's freshwater supplies [2]. The use of groundwater as a source for domestic, municipal, agricultural and industrial activities continues to increase mainly due to the heavy capital outlay and maintenance of the production of surface water through dams, particularly in developing countries [3]. Groundwater shall be used for agricultural, industrial and domestic purposes. It accounts for about 50 percent of livestock and irrigation use, and just fewer than 40 percent of water sources, while 98 percent of household water use in rural areas comes from groundwater [4].

Referring to the National Groundwater Monitoring Program in 2018, the parameters of the groundwater should comply or meet the requirement with the National Guidelines for Raw Drinking Water Quality which established by the Ministry of Health in order to determine the quality or the standard of the groundwater. Basically, the quality of the groundwater itself could be affected by the presence of heavy metals. The presence of the heavy metals in the groundwater may cause by the industrial and also agricultural activities as well. These heavy metals should be removed from the groundwater content to ensure the quality of the water to be consumed for domestic purposes.

Focusing on treating the contamination in the groundwater, there are many ways to make this happen. In order to remove toxic heavy metals from water systems, conventional methods have been used such as chemical precipitation, coagulation, ion exchange, electrochemical treatments, filtration, electro dialysis, membrane methods and biological methods [5]. Adsorption of heavy metals on conventional adsorbents such as activated carbon has been widely used in many applications as an effective adsorbent, and the activated carbon produced by carbonizing organic materials is the most widely used adsorbent [6]. Activated carbon is a material used to filter out contaminated water and air from harmful chemicals. It is composed of coal, wood, nutshells or other carbon-rich materials with black granules. The pollutants sorb (stick) to the surface of the granules when polluted water or air flows by activated carbon, and are separated from water or air. Lemon peels and coconut shells is chosen as the materials for granular activated carbon or “GAC” which have the benefit to treat a wide range of contaminant vapors including radon and contaminants dissolved in groundwater, such as fuel oil, solvents, polychlorinated biphenyls (PCBs), dioxins, and other industrial chemicals, as well as radon and other radioactive materials. It even removes low levels of some types of metals from groundwater.

Hence, this review study aimed to support the ability of lemon peels and coconut shells as an adsorbent agent to improve groundwater quality in Malaysia by implementing adsorption method.

1.1 Significant Study

At the end of the study, the finding of this study will contribute to the benefit of the society in advancement of knowledge on the properties of groundwater. The groundwater quality can be improved and can be used as a source of freshwater for domestic purposes. The polluted groundwater can be treated and thus lead to a better environmental condition. As for the researchers, the study will help them to analyze the properties of heavy metals that are present in the groundwater resource based from the result obtained from the analysis.

2. Materials and Methods

Perceiving the objectives of the assessment is imperative before the investigation was done. This can assist with continuing track with the objectives until the completion of the investigation. Furthermore, issue clarifications and the fundamental of the investigation moreover ought to be lit up to prod more concerning the assessment. All data in this study were obtained from all potential sources from electronic databases such as journal articles, thesis, reports, etc. The information was

collected on the basis of the literature and for the objective of seeking results. The results and data obtained from the various published papers were analyzed. The conclusion and recommendation were drawn on the basis of the overall result and the findings.

2.1 Background of Study Area

The research from [7] and [8] consists of extensive batch experimental work. In these experiments, groundwater samples were analysed. For the study, groundwater samples were taken at RECESS (Research Centre for Soft Soil) UTHM (Universiti Tun Hussein Onn Malaysia) in Parit Raja [7][8]. RECESS test area's topography is generally flat, with the original ground elevation ranging from 1.35m to 1.80m above mean sea level. The Center is located on a site with a water table that is 0.5 - 0.65 meters below the ground surface. The land had previously been planted with oil palms, which need adequate drainage. Earth drains with depths ranging from 0.6m to 1.0m were installed in grid formations. The water table at this area varies between 0.5 and 0.63 meters below ground level.

2.2 Location of Water Sampling

An analysis approach requiring the use of current data is secondary research to maximize the overall quality of analysis, current data is summarized and collated. The groundwater sample is collected from RECESS UTHM well and tested in order to identify the heavy metals that presents in the groundwater sample [7][8]. The coordinate of the sampling location is at 1°51’07’’N 103°04’51’’E.

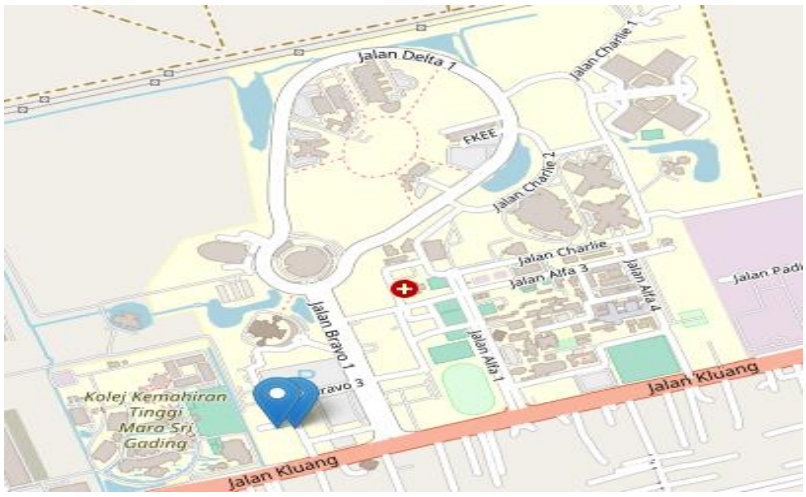

Figure 1: Location of water sampling (Source: UTHM official website)

2.3 Data Analysis

The data collected for this research was obtained from the previous published paper [7][8]. In this review research, the information gathered from the other published article was sorted appropriately.

3. Results and Discussion

This chapter discussed the results and findings collected from the different published research that was reviewed. In this section, the obtained results were analyzed that includes the properties of each adsorbent agent which is coconut shells and lemon peels. The initiative on the groundwater treatment in RECESS Universiti Tun Hussein Onn Malaysia by implementing the adsorption method seems feasible due to the good performance of the adsorbent materials. The implementation of the same experimental procedure and method could be enhanced and improvised in treating the heavy metals contamination in RECESS UTHM groundwater.

3.1 Characteristic of Groundwater in RECESS UTHM

RECESS UTHM groundwater tested shows a result of average iron concentration before treatment which is 2.37 mg/L exceeds the allowable value for iron (1.0 mg/L) as stated by National Water Quality Index [7]. The high abundance of iron in groundwater is often associated to the anaerobic dissolution of iron-bearing rocks and minerals, primarily oxides (hematite, magnetite, limonite), sulphides, carbonates, and silicates in the presence of reducing agents such as organic waste and hydrogen sulphide [9]. On the other hand, the groundwater data obtained shows that the range value of iron and copper concentration varies with different samples. For iron concentration, the values recorded were in the range from 0.08 mg/L – 0.085mg/L. As for copper, the values recorded in the study were in the range from 0.143 mg/L to 0.496 mg/L [8]. All data of iron and copper metal found in the groundwater in RECESS UTHM from the previous research papers were tabulated in Table 1.

Table 1: Iron and copper metal concentration found in RECESS UTHM groundwater

Heavy Metals	Musa et al, (2013)	Kadir et al, (2012)
Iron (mg/L)	Sample 1 (0.080) Sample 2 (0.082) Sample 3 (0.085)	2.37
Copper (mg/L)	Sample 1 (0.496) Sample 2 (0.143) Sample 3 (0.143)	-

3.2 Analysis of Efficiency of Adsorption Method by Activated Carbon from Coconut Shells and Lemon Peels

The implementation of adsorption method approach was applied to the data from the previous research papers in treating iron and copper metal concentration in the RECESS UTHM groundwater [7][8]. The secondary data was analyzed on the basis of the optimum contact time and adsorbent dosage acquired which uses coconut shells and lemon peels as the natural adsorbents [10][11]. By analyzing the percentage removal of adsorbate with the usage of natural adsorbent which is coconut shells and lemon peels as activated carbon associated with the influence of contact time and amount of dosage based on secondary data obtained from the previous research, the findings obtained were used to prove the applicability of the adsorption method to treat iron and copper metal that presents in the groundwater. The optimum value of contact time and adsorbent dosage was derived from the average value obtained. The mathematical equation to calculate the average value are as the following equation.

$$Average\ value\ = \frac{\sum_{i=1}^{n} Xi}{n}$$

$$\sum_{i=1}^{n} Xi\ = X_1 + X_2 + X_3 + \ldots\ldots X_n \qquad Eq.\ 1$$

$$n = total\ number\ of\ terms$$

The percentage of removal efficiency for both activated carbon; coconut shells and lemon peels were also determined with the influence of optimum adsorbent dosage and contact time in order to derive the average percentage of removal for iron and copper metal presents in RECESS UTHM groundwater. Based on all calculated data, the average optimum value of adsorbent dosage and

contact time for coconut shells activated carbon are 0.77g and 100 minutes respectively. As for lemon peels activated carbon, the average optimum adsorbent dosage and contact time are 1.28g and 83 minutes respectively. These average values are implemented to derive the efficiency on iron and copper metal presents in RECESS UTHM groundwater.

3.3 The Implementation of Optimum Adsorbent Dosage and Contact Time for Iron and Copper Removal in RECESS UTHM Groundwater

For adsorbent dosage, the coconut shells activated carbon (0.77g) with efficiency of percentage removal 92.4% was selected because the required amount was much less than lemon peels activated carbon (1.28g) with efficiency of percentage removal 91.88%. As for the contact time, the lemon peels activated carbon was selected because it reaches the equilibrium of adsorption faster at 83 minutes with the efficiency of percentage removal 81.46 % where else coconut shells activated carbon reached the equilibrium at 100 minutes with the efficiency of percentage removal 89.01 %. The implementation of optimum values was calculated for iron and copper metal removal based on the percentage of removal efficiency of coconut shells and lemon peels activated carbon as shown in Table 2, Table 3.

Table 2: The initial and final concentration of iron and copper with the influence of dosage

Reference		Musa et al, (2013)	
Heavy Metals	Sample	Initial	Final
Iron (mg/L)	1	0.080	6.08×10^{-3}
	2	0.082	6.23 x 10-3
	3	0.085	6.46 x 10-3
Copper (mg/L)	1	0.496	0.038
	2	0.143	0.011
	3	0.143	0.011
Reference		Kadir et al, (2012)	
Heavy Metals	Sample	Initial	Final
Iron (mg/L)	1	2.37	0.18

Table 3: The initial and final concentration of iron and copper with the influence of contact time

Reference		Musa et al, (2013)	
Heavy Metals	Sample	Initial	Final
Iron (mg/L)	1	0.080	0.015
	2	0.082	0.015
	3	0.085	0.015
Copper (mg/L)	1	0.496	0.092
	2	0.143	0.027
	3	0.143	0.027
Reference		Kadir et al, (2012)	
Heavy Metals	Sample	Initial	Final
Iron (mg/L)	1	2.37	0.44

The overall value of initial data of iron and copper metal were reduced with the implementation of optimum percentage removal influenced by adsorbent dosage and contact time. The concentration of iron and copper were reduced and followed the National Water Quality Standards which both of the heavy metal concentration should be less than 1.0mg/L.

3.4 Comparison on The Efficiency Between Coconut Shells and Lemon Peels Activated Carbon to Treat the Groundwater in RECESS UTHM

The percentage removal from coconut shells activated carbon with the influence of optimum amount of dosage was higher compared to lemon peels activated carbon. The average optimum dosage for coconut shells activated carbon was 0.77g were capable of removing 92.4% of heavy metal presents in the groundwater. Meanwhile, the lemon peels were 1.28g with 91.88% percentage removal. The coconut shells activated carbon has proven it capability with a high percentage of heavy metals removal at a low utilization of dosage compared to the lemon peels activated carbon that have a higher optimum dosage required which was 1.28g that have an output of 91.88% removal percentage.

As for the optimum contact time basis, the lemon peels activated carbon shows a faster rate of time to reach the equilibrium period of adsorption compared to coconut shells activated carbon. The optimum contact time for lemon peels was at 83 minutes with 81.46% percentage removal. On the other hand, the optimum contact time for coconut shells activated carbon was at 100 minutes with 89.01% percentage of removal. The results show that lemon peels activated carbon has faster rate to reach the maximum adsorption capacity compared to coconut shells activated carbon.

4. Conclusion

To conclude, the objective of the study was achieved by studying the potential of coconut shells and lemon peel as an adsorbent from the prior research. The characteristics of both materials were investigated in order to support the adsorbent's capability to remediate the groundwater contamination in RECESS UTHM. The physiochemical properties of both coconut shells and lemon peels activated carbon indicate a positive performance as a potential and compatible material for adsorption process to reduce iron and copper concentration that presents in the groundwater. The performance and efficiency of coconut shells and lemon peels activated carbon were compared on the basis of optimum contact time and adsorbent dosage. The activated carbon from coconut shells was significantly feasible as an adsorbent agent to treat heavy metals in groundwater. With a low amount of dosage required (0.77g) to achieve the average of 92.4% of removal percentage, the coconut shells activated carbon could serve as a strong natural adsorbent Lemon peels have the high proportion of physiochemical properties such as cellulose, hemicellulose and pectin content making them a promising natural material to be converted as an adsorbent. The average optimum contact time at 83 minutes with 81.46% of percentage removal shows that lemon peels were also an excellent natural adsorbent to treat heavy metals in groundwater. Overall, coconut shells and lemon peels activated carbon are the natural adsorbents that have high potential to treat iron and copper metal that presents in the groundwater. The recommendation for further research is to increase the variability of other natural material to be converted as the bio adsorbent in order to reduce cost of groundwater treatment and also enhance more research and development of the potential natural adsorbents to be utilized as an activated carbon.

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