Special Issue for International Conference of Advanced Materials Engineering and Technology (ICAMET 2013), 28-29 November 2013, Bandung Indonesia

Advances in Environmental Biology, 7(12) October Special Issue 2013, Pages: 3580-3586

AENSI Journals

Advances in Environmental Biology

AENSI

Journal home page: http://www.aensiweb.com/aeb.html

A E B

Study on Ferum (Fe) and Zinc (Zn) Removal by using Rice Bran at Sungai Pelepah, Kota Tinggi, Johor

[1,2]Aeslina Abdul Kadir, [2]Alida Abdullah, [1]Lee Kah Wai

[1]*Faculty of Civil and Environmental Engineering, UniversitiTun Hussein Onn Malaysia, 86400 Parit Raja, Batu Pahat, Johor Darul Takzim, Malaysia.*
[2]*Center of Excellence Geopolymer and Green Technology (CEGeoGTech), School of Materials Engineering, Universiti Malaysia Perlis (UniMAP), P.O Box 77, d/a Pejabat Pos Besar, 01000 Kangar, Perlis, Malaysia*

ARTICLE INFO

Article history:
Received 11 September 2013
Received in revised form 21 November 2013
Accepted 25 November 2013
Available online 5 December 2013

Key words:
Heavy metals, Adsoption, Agricultural waste, Water pollution.

ABSTRACT

Water pollution due to heavy metals is currently occurring at Sungai Pelepah, Kota Tinggi. Adsorption method is one of the most low cost effective methods to overcome this pollution problem compared to the other available methods for example, duckweed, orange peels, tea leaves, coconut shell and many more in heavy metals removal. In this study, rice bran was used as a low cost adsorbent. Rice bran is the outer layer of a grain of rice. Rice bran is an agricultural waste material generated in rice producing during milling process. It is an economical product and could easily to be obtained. Therefore, three objectives were selected for this study which is to determine the possibility of using rice bran as an adsorbent in heavy metals removal, to determine the characteristics of rice bran as an adsorbent and to identify the water quality of Sungai Pelepah after the treatment. The water samples were collected at Sungai Pelepah and the rice bran was collected at rice-milling factory. Three batch reactors consist of Reactor A (water sample with common activated carbon as adsorbent), Reactor B (water sample with rice bran as adsorbent) and Reactor C (control reactor). The batch reactors were conducted in the environmental laboratory, UTHM. As expected that rice bran could remove the heavy metals from the water sample as well as other adsorbents. The largest removal of Zinc (Zn) is 91.1% at 90 minutes and the largest Iron (Fe) removal is 73.0% with duration 90 minutes. As a conclusion, rice bran could be one of the low cost and effective adsorbent to be used in large amount operation of water treatment.

To Cite This Article: Aeslina Abdul Kadir, Alida Abdullah, Lee Kah Wai., Study on Ferum (Fe) and Zinc (Zn) Removal by using Rice Bran at Sungai Pelepah, Kota Tinggi, Johor. ***Adv. Environ. Biol., 7(12), 3580-3586, 2013***

INTRODUCTION

River is an important part of the natural environment due to the human and wildlife habitats. Nevertheless, it seems that river pollution problems are practically happening every day. The overall water quality of rivers could be reduced by several sources of water pollution which is including industry and agriculture discharge liquid waste. River containing heavy metals are generated by a wide variety of industries, such as, the mining of ore, manufacturing factories and many more. Furthermore, the contamination of heavy metals such as lead, cobalt, chromium and many more have commonly caused the river to be polluted. Therefore, heavy metals should be prevented before it reaches to the natural environments because of its toxicity [2].

The awareness of preventing pollution has been rising recently. Generally, there are many different methods used. Recently, the heavy metals adsorption process is being widely used by various researchers for the removal of heavy metals from waste streams and activated carbon has been frequently used as an adsorbent. Despite its extensive use of the water and wastewater treatment industries, activated carbon remains as an expensive material. Activated carbon is carbon which produced from carbonaceous source materials such as nut shells, peat, wood, coir, lignite, coal, and petroleum pitch. Activated carbon is widely used in air purify industry, drinking water treatment, and metal plated industry. Current researchers are more focusing an alternative low cost adsorbents for example seaweed, orange peels, and many more [7,9]. In the other hand, A studied of heavy

Corresponding Author: Aeslina Abdul Kadir, Faculty of Civil and Environmental Engineering, UniversitiTun Hussein Onn Malaysia, 86400 Parit Raja, Batu Pahat, Johor Darul Takzim, Malaysia.
E-mail: aeslina@uthm.edu.my

metals removal by using seashell was carried out by Kohler S. *et al* [4]. But, these adsorbents have to be maintained the value of pH to prevent the sample of water remaining toxins.

By the way, big amount of natural wastes was disposed in a year without treating nicely. While the natural wastes are quite useful if those are recycled and treated as an adsorbent in used in the water treatment industry. Recently a lot of natural wastes have been used as an adsorbent. Potential natural adsorbent wastes are quite useful if it can be recycled and use as an adsorbent. The advantages of adsorbent used included low cost, high efficiency, minimization of sludge. Therefore, in this study, the usage of rice bran as a natural adsorbent to remove heavy metals was investigated.

Literature Review:

Nowadays, in the world, water pollution is an important environmental concern, and there are many sources of chemicals in the environment such as industrial pollution, managed landfills or pesticide runoff. However, industrial wastewater is the major point source of water contamination [1].

The heavy metals contained in the rivers such as chromium, lead, cadmium, copper, zinc, cobalt and many more. Most of the heavy metals will cause water pollution in the river and cause a lot of effects and harmful to human or wildlife. For example, heavy metals will cause skin irritation, kidney and liver damage and a lot of healthy damaged. Thus, heavy metals have to be prevented before those pollutants affect human and wildlife.

There are few types of processes that have been used for the treatment of water and wastewaters, including microbial degradation, chemical oxidation, chemical precipitation, ion exchange, membrane filtration, chemical reduction electrodepositing, reverse osmosis and adsorption. These technologies are frequently ineffective or too expensive. The adsorption process is being widely used by various researchers for the removal of heavy metals from waste streams and activated carbon has been frequently used as an adsorbent. Activated carbon has been widely used in the sorption of heavy metals from aqueous solutions as a versatile adsorbent with optimal sorption properties [5,12,11]. However, production and regeneration of commercial activated carbons are still expensive and cost effective alternative adsorbents have been the target of recent research for environmental protection. Natural materials, such as rice bran, coffee grounds, tea leaves, and many more are available in large quantities and easily to be obtained. Besides that, certain waste products from industrial or agricultural processes have been investigated [3,6].

Heavy Metal:

Heavy metal is defined as referring to any metal component which has a relatively high density and is toxic or poisonous at lower concentrations. Heavy metals are natural elements of the earth's crust and a small extent; they enter our bodies via food, drinking water and air. Our bodies will be harmed by a lot of heavy metals, which cannot be digested, such as, copper, lead, mercury, and others. Heavy metals can represent a common type of chemical pollution in water. They can be found naturally in bedrock and sediment or they might be introduced into water from industrial sources and household chemicals. Heavy metals can be harmful to human life whether through direct ingestion of contaminated water or through accumulation in the tissue of other organisms eaten by humans. There are some common heavy metals that can be found in water such as mercury (Hg), lead (Pb), cadmium (Cd), arsenic (As) and aluminium (Al).

There are five sources which are basically contributing to the water pollution: geological weathering, which provides the background level; industrial processing of ores and metals, the use of metal and metal compounds, such as chromium salts in tanneries, copper compound in agriculture, and tetraethyl lead as an anti-knock agent in gasoline. The existing metals that are released in the air is from automobiles, fuel burning and industrial process emissions may settle on land ultimately run off to surface waters.

Rice Bran:

The outer layer of a grain is called the bran, which is simply the husk of a grain, and is separated during the milling process. There is no an artificial element or chemical synthesis involved during the milling process, making this an all-natural nutrient powerhouse. Bran possesses a great amount of insoluble fiber, which makes it an excellent factor in heavy metals adsorption capacity.

Advances in Environmental Biology, 7(12) October Special Issue 2013, Pages: 3580-3586

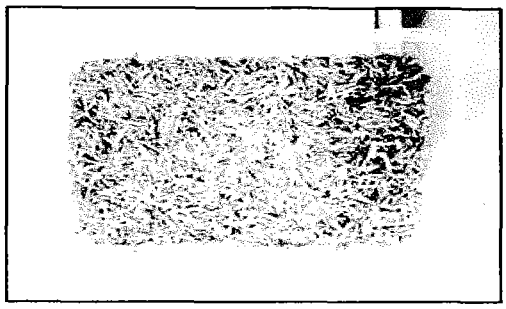

Fig. 1: Rice bran collected from milling factory.

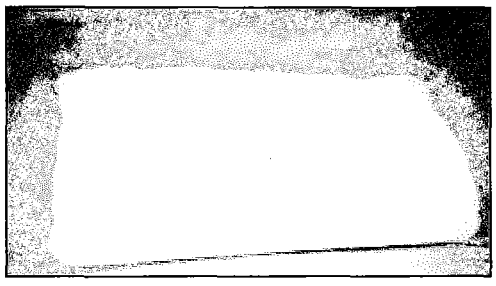

Fig. 2: Rice bran in powder form.

Rice bran is an agricultural waste material generated in rice producing countries, especially in Asia. The annual world rice production is approximately 500 million metric tons, of which 10 to 20% are rice bran. Dry rice bran contains 70 to 85% of organic matter (lignin, cellulose, sugars) and the remainder consists of silica, which is present in the cellular membrane [13]. Although rice bran is a grand quantity of waste material, but rice bran can be produced and used as heavy metals removals to reduce the pollution problems in the environment, Therefore, rice bran is easily obtained and produced as heavy metals removals. The economical and adsorption of rice bran will be better compared with other natural materials.

Methodology:

Three reactors were conducted separately. Two reactors contained water samples and tested with rice bran, and another one will act as a control reactor. Both of three reactors were put on the shaker machine with speed 125 rounds per minute of different times which is 30 minutes, 60 minutes and 90 minutes.

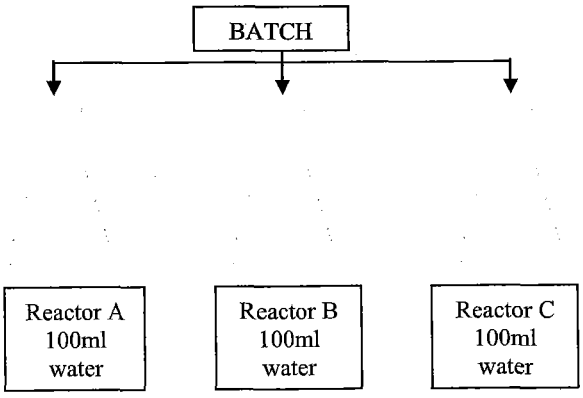

Fig. 3: Three reactors were conducted separately.

RESULTS AND DISCUSSIONS

The water samples that are tested in this study were collected from Sungai Pelepah, Kota Tinggi, Johor. The characteristics of water sample from Sungai Pelepah were determined. By the way, the characteristic of the

adsorbent was determined to verify the component in the adsorbents. Those entire tests were conducted in the laboratory of Faculty of Civil and Environmental Engineering.

This chapter discussed the performance of rice bran in the heavy metals removal from the river based on the laboratory batch reactors. The main parameters related with the batch reactors where the variable contact time to compare the average performance of adsorbent.

Characterizations of Rice Bran:

By using X-Ray Fluorescence Analysis (XRF) that was carried out in Analytical Environmental Laboratory, the characteristic of the adsorbent used in this study had been determined. Table I shows that the characteristic of rice bran. Figure 4 shows that rice bran are viewed by SEM-EDX.

Table 1: Characteristic of rice bran.

Formula	Concentration (%)
CO_2	0.1
SiO_2	90.7
K_2O	2.06
Cl	1.72
CaO	1.6
SO_3	1.09
P_2O_5	0.59
Na_2O	0.56
Fe_2O_3	0.49
Al_2O_3	0.41
MgO	0.31
Mn	0 < LLD
Mo	0 < LLD

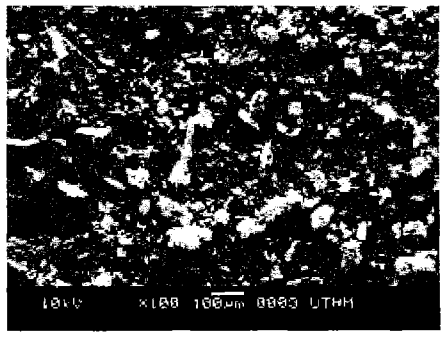

Fig. 4: Rice Bran in 100 x larger by SEM-EDX.

From the Table 1, we can determine that the most containing of elements in rice bran are Silicon Dioxide (SiO_2), known as silica, which is about 90.7%. This component is the mainly component in the rice bran. Besides that this component is widely used to be manufactured as an absorbent to absorb water in the industrial sector. Furthermore, rice bran also contained Potassium Oxide (K_2O) with 2.06%, Chlorine (Cl) with 1.72%, Calcium Oxide (CaO) with 1.6% and others components in the minority. Therefore, with the great amount of Silicon Dioxide (SiO_2) component, rice bran is one of the potential adsorbents to remove heavy metals in water samples.

Iron (Fe) and Zinc (Zn) in Water Sample:

The characterization of water sample was carried out using Atomic Absorption Spectroscopy (AAS) method in the Analytical Environmental Laboratory to determine the most significant heavy metals which are iron (Fe) and zinc (Zn). The results are recorded in Table 2.

Table 2: Concentration Heavy Metals In Water Sample.

Containing	Concentration (mg/l)	Standard for Drinking Water Quality (mg/l)
Iron (Fe)	0.124	3.0
Zinc (Zn)	0.101	0.3

Batch Experiments:

From the Table II, the heavy metals that were chosen from the river characterization were Iron (Fe) and Zinc (Zn). Heavy metals such as Fe contained in the river due to the mining ore are at the top of that river.

Therefore, the water treatment has to be conducted to reduce the containing heavy metals in the river. The result shows that rice bran is a very good adsorbent in this study.

Iron (Fe) Removal:

From the initial characterization of the water sample,it shows that the initial concentration of Iron (Fe) is 0.124 mg/l with the initial pH of 5 to 6. Table III shows that the result of the experiment.

Table 3: The percentage iron (fe) removed.

Time (mins)	Reactor A (mg/l)	Water sample (mg/l)		Average (mg/l)	Percentage removed (%)
		Reactor B	Reactor C		
30	0.054	0.043	0.045	0.044	64.5
60	0.056	0.039	0.039	0.039	68.5
90	0.056	0.034	0.033	0.034	73.0

According to the Table 3 the results shown that the concentration Iron (Fe) in water sample reduced because of the adsorption by rice bran. The reduction of Iron (Fe) can be different between the control batch reactor and water sample batch reactors. The water samples reactors are duplicable sample, the average of two reactors is determined. From Figure 5, it shows the percentage of Iron (Fe) removal is increasing from 64.5 % in 30 minutes to 68.5 % at 60 minutes, and then increasing to 73.0 % at 90 minutes. Therefore, the largest removal of Iron (Fe) is 73.0 % at 90 minutes and the line graph shown that, the percentage of Iron (Fe) removal is directly proportional to the duration. The result shown that, the capability of rice bran could absorb the iron in the water sample effectively.

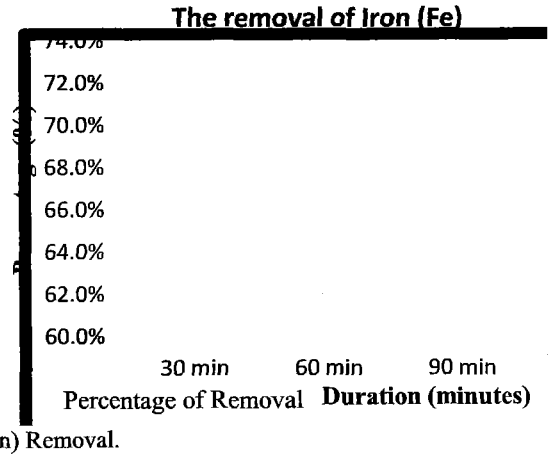

Fig. 5: Percentage of Zinc (Zn) Removal.

Zinc (Zn) Removal:

From the initial characterization of the water sample, it shows that the initial concentration is 0.101 mg/l with the initial pH of 5 to 6. Table IV shows that the results of the Zinc (Zn) removal.

Based on the Table 4, it shows that the result of Zinc (Zn) concentration in water samples is dropped because of the adsorption by rice bran. The decreased of Zinc (Zn) concentration can be clearly differentiated between the before and after treatment of water sample. In the Figure 6, the percentage of the Zinc (Zn) removal can be determined uprising which is about 86.1% in 30 minutes increasing to 90.1% at 60 minutes, then rising again to 91.1% in 90 minutes. With this data, the graph can be concluded that the percentage of Zinc (Zn) removal is directly proportional to the duration of the treatment. The result shown that, the capability of rice bran could effectively absorb the iron in the water sample.

The largest Iron (Fe) removal was shown in the result which is 73.0% with duration of 90 minutes. By the way, the biggest Zinc (Zn) removal obtained in the experiment is 91.1% at 90 minutes. Therefore, the results proved that the rice bran could adsorb the Iron (Fe) and Zinc (Zn) effectively in the treatment. Rice bran could be acted as an economic adsorbent and widely used for heavy metal treatment.

Table 4: Result of the experiment.

Time (mins)	Reactor A (mg/l)	Water sample (mg/l)		Average (mg/l)	Percentage of Removal (%)
		Reactor B	Reactor C		
30	0.044	0.013	0.014	0.014	86.1
60	0.044	0.010	0.009	0.010	90.1
90	0.045	0.009	0.009	0.009	91.1

Advances in Environmental Biology, 7(12) October Special Issue 2013, Pages: 3580-3586

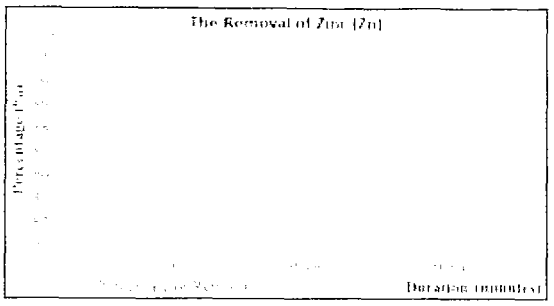

Fig. 6: Percentage of Zinc (Zn) Removal.

Conclusions:

The objectives of the study were achieved. Firstly, the characteristics of rice bran had been determined by using X-Ray Fluorescence Analysis (XRF) and Scanning Electron Microscope (SEM EDX) which had found that the majority component in the rice bran is Silicon Dioxide (SiO2) with 90.7%. This great amount of silica available has been made rice bran act as adsorption material.

Heavy metals containing of Sungai Pelepah before and after treatment had been determined by using Atomic Absorption Spectrometer (AAS) method. The results had shown that the containing of heavy metals after treatment is obviously reduced compared to before treatment. This has proved that the objective of the study was achieved. The method which is called Atomic Absorption Spectrometer used in this study, is quite sensitive to the sample. This means the data that carried out by this method are not definite, so the test method had to be repeated to ensure the data that's collected are almost similar and precise.

The containing of heavy metals in water samples from Sungai Pelepah before and after treatment was determined by using Atomic Absorption Spectrometer (AAS) method. The results shown that the containing heavy metals, which are iron (Fe) and zinc (Zn), after treatment are obviously declined compared to before treatment. These results strongly proposed that adding rice bran as an adsorbent in the treatment of heavy metals removal are effective. From the study, rice bran was removing the containing iron (Fe) and zinc (Zn) successfully from water sample. However, the progress of the treatment has to be improved further by further study. Therefore, this rice bran was verified as a good adsorbent in the heavy metal removal treatment.

Recommendations:

There are few recommendations was suggested to improve the future study due to the heavy metals removal by using rice bran. Firstly, the apparatus used in the experiment must be ensured in good condition because the errors could be avoided during the experiment. Besides that, the dosage used of rice bran must be measured due to the requirement of experiment before adding into reactors because the quantity of adsorbent will be affected the results obtained. The contact time and the speed of the shaker have to be ensured that is according to the requirement of the experiment. It is because contact time and the speed of the shaker will affect the reaction between rice bran and water sample in the experiment

ACKNOWLEDGMENT

We greatly acknowledge UTHM Laboratories for providing facilities, support and assistance throughout the project.

REFERENCES

[1] Daifullah, A.A.M., N.S. Awwas and S.A. Reefy, 2004. "Purification of wet phosphoric acid from ferric ions using modified rice husk," Chemical Engineering Process, 43: 193-201.

[2] Jameel M. Dhabab, 2011. Removal of some heavy metal ions from their aqueous Solutions by duckweed, Al-Mustunsiyria University, Iraq.

[3] Wong, K.K., C.K. Lee, K.S. Low, M.J. Haron, 2003. Removal of Cu(II) and Pb(II) by tartaric acid modified rice husk from aqueous solutions, U.K.

[4] Kohler, S., *et al.*, 2009. Using Sea Shells to Remove Heavy Metals from Water, The Graz University of Technology, Austria.

[5] Mohan, D. and C.U.J. Pittman, 2006. "*Activated carbons and low cost adsorbents for remediation of tri- and hexavalent chromium from water*," Journal of Hazardous Materials, B137: 762-811.

[6] Mohan, S. and G. Sreelakshmi, 2007. Fixed bed column study for heavy metal removal using phosphate treated rice husk, Indian Institute of Technology Madras, India.

[7] Nasim, A.K., S. Ibrahim and S. Piarapakaran, 2004. Elimination of Heavy Metals from Wastewater Using Agricultural Wastes as Adsorbents, University Malaya, Malaysia.

[8] Nur Azreen Bt Fuadi, Ahmmed Saadi Ibrahim, Kamriah Nor Ismail, 2012. "*Review study for activated carbon from palm shell used for treatment of waste water,*" ISSN: 2232-1179.

[9] Park, H.J., S.W. Jeong and J.K. Yang, 2007. Removal of heavy metals using waste eggshell, Kwang Woon University, Seoul, Korea.

[10] Rodríguez Reinoso, F. and A. Linares Solano, 1988. "*Microporous Structure of Activated Carbons as Revealed by Adsorption Methods, in Chemistry and Physics of Carbon*," Thrower, P. A., Editor. Marcel Dekker, Inc: New York.

[11] Rodríguez Reinoso, F., 1997. "*Activated Carbon: Structure, Characterization, Preparation and Applications, in Introduction to Carbon Technologies,*" Rodríguez Reinoso, F, Editor. Secretariado de publicaciones universidad de Alicante: Alicante, pp: 35.

[12] Suzuki, R.M., A.D. Andrade, J.C. Sousa and M.C. Rollemberg, 2006. Preparation and characterization of activated carbon from rice bran, University Estadual de Maringá, Brazil.

[13] Vempati, R.K., S.C. Musthyala, Y.A. Molleh and D.L. Cocke, 1995. Surface Analyses of Pyrolysed Rice Husk using Scanning Force Microscopy. *Fuel*, 74(11): 1722-1725.