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Efficiency of Biochar from Agricultural Waste to Remove Heavy Metals in Water

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Abstract. The aim of this study was to investigate the efficiency of biochar from agricultural waste to remove heavy metals in drinking water. Biochar in the study was chosen from three plant species are including; cat-tail (Typha angustifolia L.), bamboo (Bambusa bambos (L.) Voss.), and water hyacinth (Eichhornia crassipes (C. Mart. Solms.). Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES) wad used to determine of heavy metal (Cu, Pb, and Fe) in water. Result was show that all amounts of biochar from cat-tail and bamboo could be reduce the concentration of Cu (98-100%), Pb (14.0-97.7%) and Fe (8.3-95.7%), respectively. Water hyacinth biochar 10 gram is excluded because it does not absorb Cu. However, the study found that the adsorption cat tail biochar 10 grams could absorb the highest Cu. Biochar can be applying to reduce a risk of harm by heavy metal from water to become a tool for rural areas to be without water supplied system.

Keywords: Biochar, Agricultural waste, Heavy metals, Drinking water.

1. Introduction

In Thailand, water consumption in rural areas is scarce because there is no water supply system. It relies on natural water sources or wells, sometimes water might be contaminated by the accumulation of toxins and pathogens. In recent years, the contamination of water supplies by organic and inorganic chemicals has continued to attract significant global attention from the general public [1], [2]. The contamination of heavy metals has become a worldwide problem because activist who human actions, such as mining, agriculture, industry. Many heavy metal compounds are persistent or can be biodegraded into recalcitrant products that survive conventional water treatment processes. Although, the heavy metals compound are essential element for human [3]. Because of elements has served as the reaction of the enzyme and the metabolism of glucose and lipids. On the other hand, there were some heavy metals that are highly toxic and carcinogenic contaminants in the environment and can enter the human body [4], [5]. Therefore, monitoring of heavy metals in environmental samples is essential in soil, plants and water [6]. Nowadays, biochar material has been extensively researched for its ability to use in the environment management and has shown promise as an adsorbent certain environmental contaminants, including heavy metals [7], [8]. Biochar is a carbon-rich solid obtained by heating biomass, such as wood, manure. It's produced by thermal decomposition of organic material under limited supply of oxygen (O_2), and at relatively low temperatures (<700 ℃) [9]. There has been a growing on the application of biochar in water treatment [10], [11]. This research will study the efficiency to removal three types of heavy metals included copper, lead, and iron and compare in different types of biochar from agricultural waste are cat-tail, bamboo, and water hyacinth.

2. Material and Methods

2.1. Standards and Biochar Preparation

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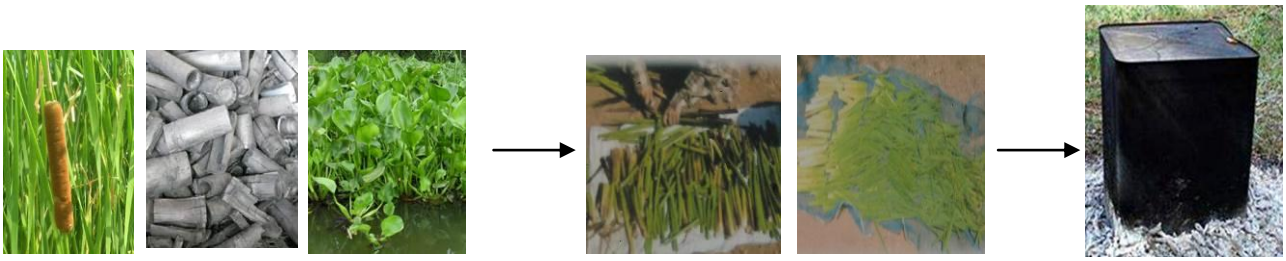
In the current experiment, the calibrations were prepared with multi element standard solution (1,000 mg/l) containing all analyzes (Cu, Pb, Fe). Five different liner concentration standards were prepared in ranging 0.2, 0.4, 0.6, 0.8 and 1.0 mg/l. All metals having good linear graph with correlation coefficient > 0.998 were observed in the preparation standard curve. Agricultural wastes for preparation to biochar in the study are cat-tail, bamboo, and water hyacinth (Table 1). After harvested, make a similar size cut approximately 30 cm for fit in the bucket, after that drying by air. Burned in the close bucket temperature about 250oC (Fig. 1). All experiment work was performed at Science Center, Valaya Alongkorn Rajabhat University under the Royal Patronage, Pathumtanee Province. The experiment design was 10, 20 and 30 g of Biochar contain in simple trap water filtration using in rural household areas.

Table 1: Name of plants for produce biochar

Scientific Name	Family	Other Name	Thai name
Eichhornia crassipes (C. Mart.) Solms[1]	PONTEDERIACEAE	Water hyacinth	Phak top chawa
Typha angustifolia L.[2]	TYPHACEAE	Cat-tail, Elephant Grass, Lesser Reedmace, Narrow-leaved Cat-tail	Thub rau si
Bambusa bambos (L.) Voss[1]	POACEAE (GRAMINEAE)	Bamboo	Phi

2.2. Analysis of Heavy Metal in Water

Heavy metal element content of water sample was analyzed using by inductively coupled plasma with optical emission spectrometry (ICP-OES method) (Y238 Untrace Ultimate, JY Jobin Yvon, Horiba). Briefly, a mixed heavy metal standard was added in each sample. The wavelengths of element : Cu (324.754 nm) Pb (220.353 nm) and Fe (259.940 nm)



Three type of agricultural wast

Materials cutting and drying by air

Burned in the close bucket ≈250°C

Cat-tail biochar Bamboo biochar Water hyacinth biochar

Fig. 1: Preparation of biochar from agricultural residues

3. Results

3.1. Concentration of Heavy Metals Removal

Results of concentration of heavy metals removal from water with a biochar produce from three type of agricultural waste and compared in three doses. Concentration of Cu, Pb, and Fe content in water was due to biochar adsorption, as shown in Table 1.

In bamboo and water hyacinth biochar have been a reflection to heavy metal in water were decreased with increasing biochar dose. The amount of cat tail biochar was increase did not affect to remove heavy metal.

In cat tail biochar, the ability to remove using at 10, 20 and 30 grams are Cu (1.000, 0.987 ±0.006 and 0.980 ± 0.010 mg/l, respectively), Pb (0.973±0.006, 0.977 ±0.006 and 0.970 mg/l, respectively) and Fe (0.957±0.006, 0.957±0.006 and 0.953±0.006 mg/l, respectively)

In bamboo biochar, the ability to remove using at 10, 20 and 30 grams are Cu (0.393 ±0.006, 0.933 ±0.006 and 0.967 ± 0.006 mg/l, respectively), Pb (0.770, 0.980 ±0.010and 0.930mg/l, respectively) and Fe (0.333±0.006, 0.733±0.012 and 0.930, respectively)

The ability of water hyacinth biochar to remove heavy metals at 10, 20 and 30 grams are Cu (0.063 ±0.006, 0.127 ±0.012 and 0.163 ± 0.006 mg/l, respectively), Pb (0.140±0.017, 0.203 ±0.015 and 0.263±0.015 mg/l, respectively) and Fe (0, 0.090 and 0.083±0.06 mg/l, respectively.

Table 2: Mean concentration and standard deviation of heavy metal removal (n=3)

Dose	Biochar	Cu	Pb	Fe
10g	Cat-tail	1.000±0.000	0.973±0.006	0.957±0.006
	Bamboo	0.393±0.006	0.770±0.000	0.333±0.006
	Water hyacinth	0.063±0.006	0.140±0.017	0.000
20g	Cat-tail	0.987±0.006	0.977±0.006	0.957±0.006
	Bamboo	0.933±0.006	0.980±0.010	0.733±0.012
	Water hyacinth	0.127±0.012	0.203±0.015	0.090±0.000
30g	Cat-tail	0.980±0.010	0.970±0.000	0.953±0.006
	Bamboo	0.967±0.006	0.973±0.006	0.930±0.000
	Water hyacinth	0.163±0.006	0.263±0.015	0.083±0.006

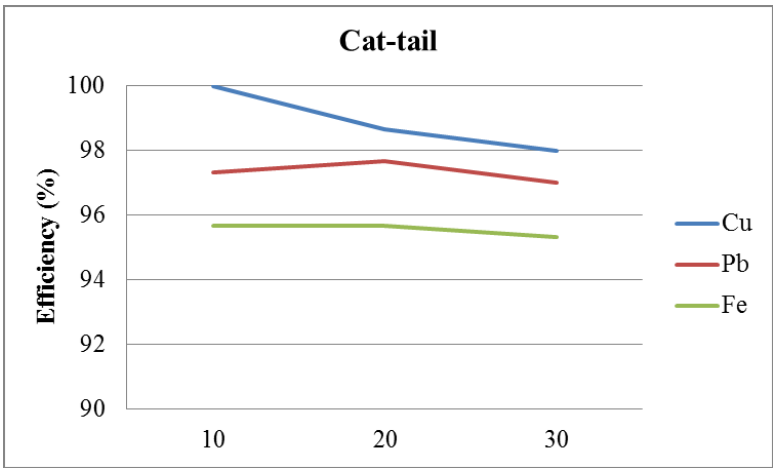
3.2. Comparison of Heavy Metals Removal

In Table 2, Comparison of biochar as a percentage of the dose found to remove the most compared to the other is a cat-tail 10 grams to 100%. Nevertheless, 10gram of water hyacinth biochar cannot absorb Fe. The bamboo biochar showed the 20grams effectively absorbs most at 98%. In water hyacinth biochar that effectively absorbs most of 30grams (26.3%).

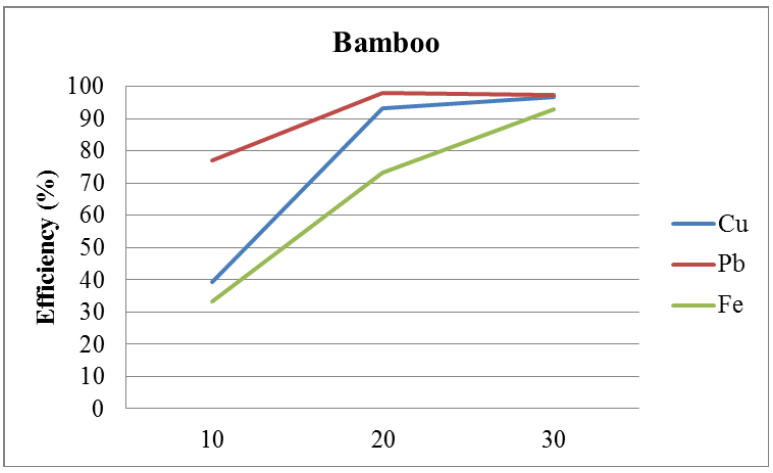
Table 3: Percentage of heavy metal removal

Dose	biochar	Cu	Pb	Fe
10g	Cat-tail	100.0	97.3	95.7
	Bamboo	39.3	77.0	33.3
	Water hyacinth	6.3	14.0	0.0
20g	Cat-tail	98.7	97.7	95.7
	Bamboo	93.3	98.0	73.3
	Water hyacinth	12.7	20.3	9.0
30g	Cat-tail	98.0	97.0	95.3
	Bamboo	96.7	97.3	93.0
	Water hyacinth	16.3	26.3	8.3

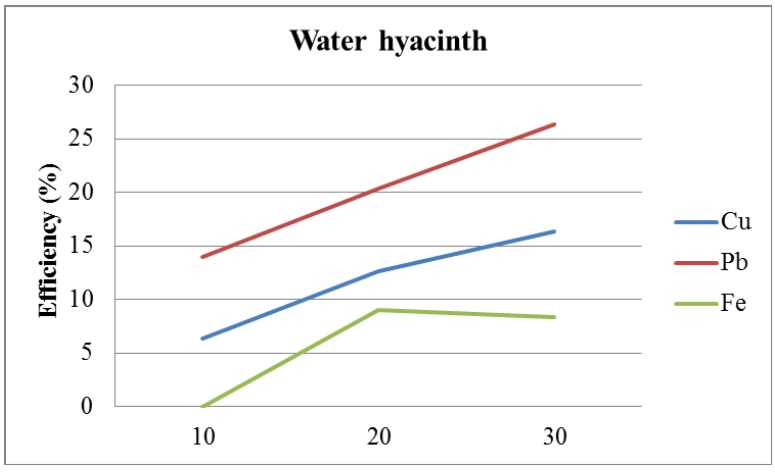
Comparing performance tends to absorb heavy metals compared to the type of agricultural waste are shown in Fig. 2. The trend of cat-tail is different from other materials because of an increase in the amount of biochar, but we found that the ability to absorb the decline Fig. 2(a). The trend of cat-tail biochar is tending to absorb the amount of 30grams effective in absorbing heavy metals as possible in a range of 95.3% (Fe) to 100% (Cu).



(a) Cat-tail biochar



(b) Bamboo biochar



(c) Water hyacinth biochar

Fig. 2: Comparison in different types of biochar products

The trend of bamboo biochar is tending to absorb the amount of 10 grams effective in absorbing heavy metals as possible in a range of 93.0 % (Fe) to 97.3% (Pb), shown in Fig. 2(b).

In Fig. 2(c), was show tend to absorb the quantity of water hyacinth biochar at 30grams potential to absorb heavy metals in the PB and Cu. However, except for the best Fe dose20grams.

In addition, Fig. 3 show an efficiency of biochar to remove heavy metal separated by compounds (Cu, Pb and Fe) found cat-tail biochar was remove Cu > Pb > Fe, respectively, the higher performance than other types. Trend of bamboo and water hyacinth biochar were remove Pb > Cu > Fe, respectively

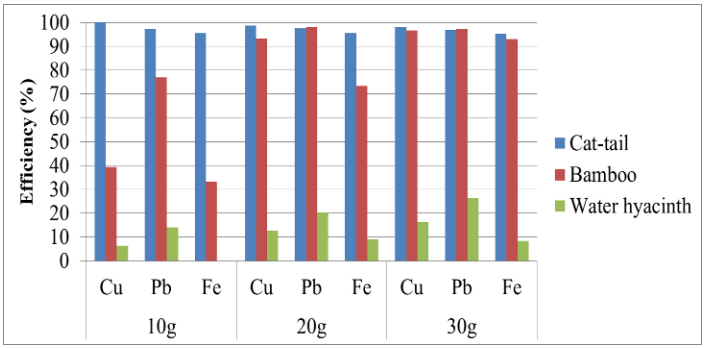


Fig. 3: Comparison in different types of biochar products

Efficiency of cat tail biochar, the ability to remove using at 10, 20 and 30 grams are Cu (100, 97.3 and 95.7%, respectively), Pb (97.3, 97.7 and 97.0 %, respectively) and Fe (95.7, 95.7 and 95.3 %, respectively)

In bamboo biochar, the ability to remove using at 10, 20 and 30 grams are Pb (77.0, 98.0 and 97.3 %, respectively), Cu (39.3, 93.3 and 96.7%, respectively), and Fe (33.3, 73.3 and 93.0, respectively)

In water hyacinth biochar, the ability to remove using at 10, 20 and 30 grams are Pb (14.0, 20.3 and 26.3%, respectively) Cu (6.3, 12.7 and 16.3 %, respectively), and Fe (0, 9.0, 83%, respectively)

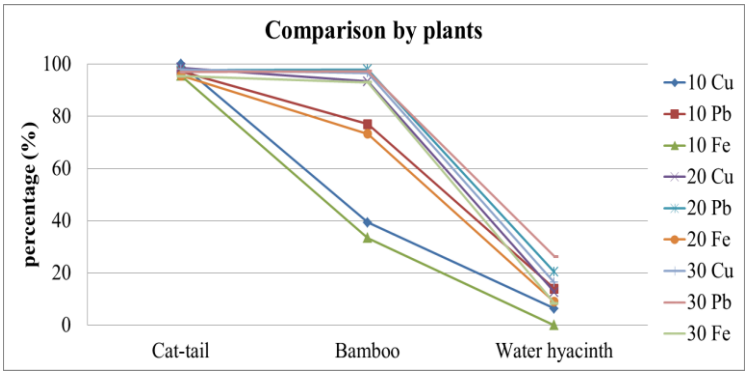


Fig. 4: Comparison in different types of biochar products for application

Therefore, it was concluded that the introduction of biochar has the suitable to use to remove heavy metal from water used for consumption. Fig. 4 shows, the graph shows the performance of cat-tail. Biochar can adsorb three heavy metals in water by over 90 percent in every dose.

4. Conclusions

The conclusion of this study was analysis of heavy metals in water, through different types of biochar by ICP-OES. Cat-tail biochar is a good choice, because in addition to the already powerful ingredients and simple preparation. For the different characteristics of agricultural waste affect absorption after burning the material texture is different. For water hyacinth, after burned characteristics also found that the toughness of fiber and pore width, which can cause poor absorption. Cat-tail was burned and blender to a fine powder that can be effective in absorbing heavy metals as well.

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6. References

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