2016

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http://dspace.nm-aist.ac.tz/handle/123456789/330

한국물환경학회·대한상하수도학회
2016년 공동학술발표회
물환경 재도약의 원년 2016

A-5

Comparative Study of Pb^{2+} Removals and Isotherms by Physically - and Chemically - Modified Agro - Wastes from Tanzania

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1. Introduction

Biosorption, in the present study, refers to the application of either dead or living biomass to sequester environmental pollutants (Gadd, 2009). Handling and processing of dead biomass for biosorption purposes is simpler and less time-consuming compared to processes that involve living-cell biosorbents. Consequently, the use agro-industrial wastes and by-products (AIWBPs) for biosorption of water contaminants is referred to as an economic and eco-friendly option (Abdolali et al., 2014). Availability and abundance of AIWBPs are other aspects of low-cost biosorption worth considering. To be economic, AIWBPs have to be readily available and accessible, easily fabricated, and highly abundant. Cost-effectiveness, however, is not the only advantage of using AIWBPs in water treatment systems. Other advantages include, but are not limited to: resource reuse and recycle, high removal efficiencies at low pollutant concentration, sorbent regeneration, and precious metal recovery (Volesky, 2007). In this study, we investigate the applicability of raw, physically- and chemically-modified agro-wastes collected from Tanzania to remove Pb^{2+} from aqueous solution.

2. Materials and Methods

Raw corn and rice husk were washed several times using DIW to remove extraneous dirt and contaminants. The husks were then dried at 110 ºC overnight to remove moisture. Dried husks were then ground and sieved only using the 35 mesh fraction. The ground husks were pyrolyzed into biochars. The biochars were in turn treated with either $ZnCl_2$ or KOH. Biosorbents were characterized by BET, FTIR, SEM, pHPZC and CEC. Biosorption experiments were conducted using ground husks, biochars, and chemically-modified biochars. Equilibrium modeling was carried out using Langmuir, Freundlich, D-R, and Temkin models.

3. Results and Discussion

As indicated in Table 1, the surface area of biochars was higher than that of raw husks. Treatment with $ZnCl_2$/KOH resulted into a significantly higher surface area. Pyrolysis and subsequent treatment of husks with chemicals increased their CECs. The pHPZC was between 3.04 and 6.55. pH values above these values favor Pb^{2+} sorption.

Table 1. Characteristics of the biosorbents

Parameter	Biosorbent^a							
	HUSK1	HUSK2	CHAR1	CHAR2	ZCHAR1	ZCHAR2	KCHAR1	KCHAR2
BET surface area (m^2 g^{-1})	0.33	0.47	0.82	2.58	84.75	203.62	108.58	165.17
Cation Exchange Capacity (cmolkg^{-1})	2.76	2.16	23.71	22.77	44.35	37.68	45.07	61.06
Point of zero charge (pHPZC)	5.53	5.65	3.04	3.04	4.32	4.60	6.50	4.56

^{a}HUSK1/2=corn/rice husk, CHAR1/2=corn/rice husk biochar, ZCHAR1/2=$ZnCl_2$-treated corn/rice husk biochar, CHAR1/2=KOH-treated corn/rice biochar

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Fig. 1 indicates that treatment of husks with heat to make biochars followed by chemical treatment with $ZnCl_2$/KOH enhanced the surface micropores on the biosorbents. Raw husks (HUSK1/HUSK2) do not have well-defined pore structure but biochars (CHAR1/CHAR2) and chemically-treated biochars (ZCHAR and KCHAR) have a network of pores on the surface. Fig. 2 indicates that sorption efficiencies for modified biosorbents were better than those for unmodified biosorbents. However, all biosorbents attained Pb^{2+} removal efficiencies higher than 80%. Modeling results (not shown here) indicate that modified biosorbents had higher sorption capacities than raw biosorbents and that treatment with $ZnCl_2$ greatly enhanced the surface characteristics and Pb^{2+} removal efficiencies.

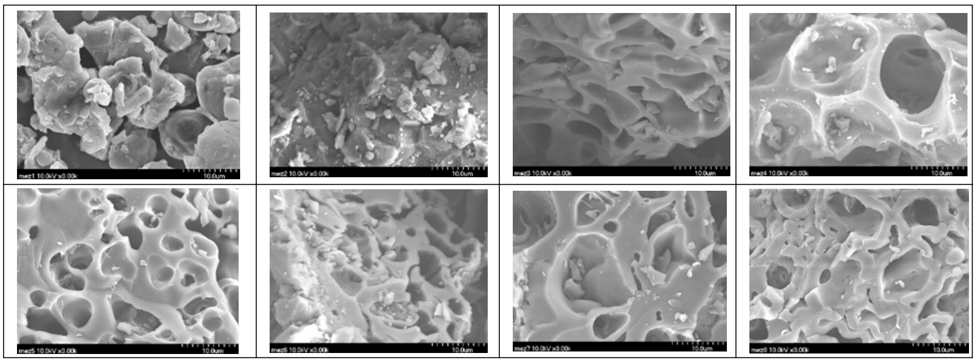

Fig. 1. SEM micrographs of HUSK1, HUSK2, CHAR, CHAR2 (upper row) ; ZCHAR1, ZCHAR2, KCHAR1 and KCHAR2 (lower row)

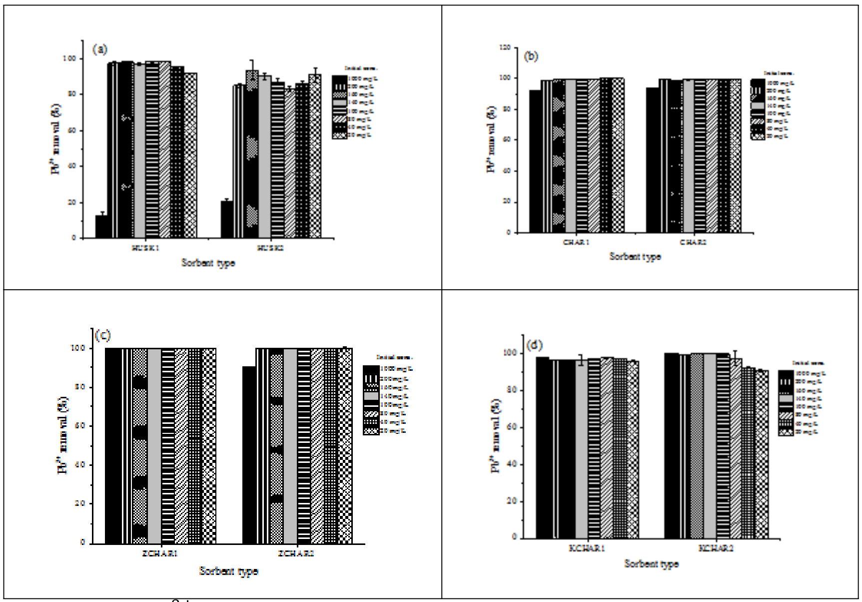

Fig. 2. Pb^{2+} biosorption efficiency results: (a) HUSK1 and HUSK2, (b) CHAR1 and CHAR2, c) ZCHAR1 and ZCHAR2, (d) KCHAR1 and KCHAR2

4. Conclusion

1) Biochars remove Pb^{2+} more efficiently than raw husks
2) Chemical modification of biochars increase their surface area and sorption capacities

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