UNIVERSITI PUTRA MALAYSIA

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By

LAMIN SANYANG

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfillment of the Requirement for the Degree of Master of Science

September 2013

DEDICATION

This thesis is specially dedicated to my beloved mum (Nyima Ceesay) and my unique sweetheart (Ummu Hamza Mariyama Jawara)

Abstract of the thesis presented to the Senate of Universiti Putra Malaysia in fulfillment of the requirement for the degree of Master of Science

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September 2013

Chairman: **Associate Professor Wan Azlina bt Wan Ab Karim Ghani, PhD**

Faculty: **Engineering**

Arsenic and zinc contaminated water is an environmental issue due to their toxicity. Acute arsenic poisoning has claimed the lives of many and causes adverse health risk to millions of people (i.e. Bangladesh, India, China etc.). Although, zinc is a vital element for human growth but its excessive intake may pose harm to the environment and public health. Effective removal of these contaminants can be obtained by adsorbing them onto low cost adsorbents. In this study, hydrogel-biochar composite (HBC-RH) was prepared using acrylamide (AAm) as monomer, with N.N'-methylenebisacrylamide (MBA) as crosslinker, ammonium persulfate (APS) as initiator and rice husk biochar (RHB). The synthesized hydrogel-biochar composites were characterized (swelling behavior, surface morphology, functional group, surface area and porosity) and utilized for the removal of arsenic and zinc from aqueous media. Batch equilibrium and kinetic studies were conducted to investigate the potential of the hydrogel-biochar composites on arsenic and zinc removal. The optimum experimental conditions for this study were determined by

evaluating the effect of solution pH (4 – 10), adsorbent dosage (0.167 – 10g/L), adsorbate initial concentration (1 – 150mg/L) and contact time (0 – 48hrs).

From the experimental results obtained, HBC-RH equilibrium swelling percent (S_{eq} %) and equilibrium water content percent (EWC %) were 1008 % and 90.97 %, respectively. The infrared spectrum of HBC-RH manifested significant functional groups such as hydroxyl (OH), carboxyl (COOH) and carbonyl group amide ($CONH_2$) which strongly favor metal ion removal from aqueous solutions. The optimum solution pH value was 6.0 (0.84 mg/g) for arsenic and 8.0 (23.73 mg/g) for zinc. The increase of HBC-RH dosage from 0.167 to 10 g/L boosted up the removal of arsenic and zinc from 10.30 to 60.01 % and 48.30 to 95.32 %, respectively. Increase in arsenic uptake from 0.42 to 27.56 mg/g and zinc uptake from 7.81 to 32.69 mg/g were observed as the initial metal ion concentrations were varied from 1 to 150 mg/L at 28 ˚C and 1 g/L of HBC-RH. A quick HBC-RH sorption of arsenic and zinc were realized within the initial 30 mins which was later followed by a slower sorption rate until equilibrium was achieved after 48 hrs for arsenic and 24 hrs for zinc. Langmuir isotherm best fitted the HBC-RH sorption of both metal contaminants and the maximum monolayer sorption capacity for arsenic and zinc were 41.32 mg/g and 32.47 mg/g, respectively. The kinetic data were best described by pseudo second-order.

In light of the above results, HBC-RH can be considered a promising environmental-friendly adsorbent for the removal of arsenic and zinc from aqueous media.

Abstrak tesis ini dikemukakan kepada Senat Universiti Putra Malaysia
sebagai memenuh ikeperluan untuk ijazah Master Sains

COMPOSITE HDROGEL-BIOCHAR UNTUK PENYERAPAN ARSENIK DAN ZINK DARIPADA MEDIA BERAIR

Oleh

LAMIN SANYANG

September 2013

Pengerusi: Associate Professor Wan Azlina bt Wan Ab Karim Ghani, PhD

Fakulti: Kejuruteraan

Air yang dicemari logam arsenik dan zink merupakan isu alam sekitar kerana ketoksik annya. Keracunan arsenik akut telah meragut nyawa ramai penduduk dunia dan menyebabkan risiko kesihatan yang buruk kepada berjuta-juta orang (seperti di Bangladesh, India, China). Walaupun zink adalah elemen penting untuk tumbesaran manusia, pengambilan yang berlebihan boleh menimbulkan mudarat kepada alam sekitar dan juga kesihatan awam. Penyingkiran yang berkesan bahan cemar boleh dilakukan ke atas bahan penjerap berkos rendah. Dalam kajian ini, hidrogel-biochar komposit (HBC-RH) disediakan dengan menggunakan akrilamid (AAm) sebagai monomer, N.N'-metilenabisakrilamid (MBA) sebagai perangkai silang, amonium persulfat (APS) sebagai pemula dan sekam padi bio-arang (RHB). Komposit hidrogel-biochar yang disediakan dianalisis (ciri pembengkakan, SEM, FTIR, luas permukaan-BET dan keliangan) dan digunakan untuk menyingkir arsenik dan zink dari media akueus. Keseimbangan pukal dan kajian kinetik telah dijalankan untuk menyiasat kebolehgunaan

komposit hidrogel-biochar untuk menyingkir arsenik dan zink. Keadaan optimum untuk kajian ini telah dikaji dengan menilai kesan pH larutan (4 - 10), dos penjerap (0.167 – 10 g/L), kepekatan awal bahan penjerap (1 – 150 mg/L) dan masa kontak (0 - 48 jam).

Daripada keputusan ujikaji yang diperolehi, HBC-RH mempunyai keseimbangan peratusan bengkak (S_{eq}%) dan peratus kandungan air (EWC%) sebanyak masing-masing 1008% dan 90.97%. Spektrum inframerah HBC-RH menunjukkan kumpulan berfungsi utama seperti OH, COOH dan $CONH_2$ yang cenderung untuk menyingkir ion logam daripada larutan akueus. Nilai pH yang paling optimum adalah 6.0 (0.84 mg/g) untuk arsenik dan 8.0 (23.73 mg/g) untuk zink. Peningkatan dos HBC-RH dari 0.167 kepada 10.0 g/L telah meningkatkan penyingkiran arsenik dan zink masing-masing dari 10.30 ke 60.01% dan 48.30 ke 95.32%. Peningkatan dalam pengambilan arsenik dari 0.42 kepada 27.56 mg/g dan penyerapan zink dari 7.81 kepada 32.69 mg/g diperhatikan apabila kepekatan awal ion logam diubah daripada 1 hingga 150 mg/L pada 28˚C dengan mengguna 1.0 g/L HBC-RH. Penyerapan pantas arsenik dan zink oleh HBC-RH berlaku dalam 30 minit pertama dan kemudiannya diikuti dengan kadar penyerapan yang perlahan sehingga keseimbangan dicapai selepas 48 jam untuk arsenik dan 24 jam untuk zink. Isoterma Langmuir dipasang terbaik bagi penyerapn HBC-RH bagi kedua-dua logam dan kapasiti maksimum lapisan mono bagi arsenik dan zink msing-masing adalah 41.32 mg/g dan 32.47 mg/g. Data kinetik menunjukkan proses penjerapan mengikuti isoterma pseudo-kedua order.

Dari keputusan ujikaji, HBC-RH dikenalpasti sesuai digunakan sebagai penjerap mesra alam dan berpotensi tinggi untuk penyingkiran arsenik dan zink daripada media akueus.

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I certify that a Thesis Examination Committee has met on 2 September 2013 to conduct the final examination of Lamin Sanyang on his thesis entitled "Hydrogel-Biochar Composite for Sorption of Arsenic and Zinc from Aqueous Media" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Master of Science.

Members of the Thesis Examination Committee were as follows:

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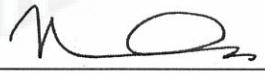

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Date: 19 December 2013

This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfillment of the requirement for the degree of Master of Science. The members of the Supervisory Committee were as follows:

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DECLARATION

I declare that the thesis is my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously, and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or at any other institutions.

LAMIN SANYANG

Date: 2nd September 2013

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