INVESTIGATION OF ZINC REMOVAL CAPACITIES OF DIFFERENT SORBENT MATERIALS TO BE USED IN CONSTRUCTED WETLANDS

MASTER OF SCIENCE

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December 2010
Declaration

I hereby declare that this submission is my own work and that to the best of my knowledge and belief, it contains neither materials previously published or written by another person, nor material, which to a substantial extent has been accepted for the award of any other degree or diploma of an university or other institute of higher studies, except where an acknowledgement is made in the text.

W.A.U. Witharana
Date:

This is to certify that this thesis submitted by W.A.U. Witharana is a record of candidate's own work carried out by her under our supervision. The matter embodied in this thesis is original and has not been submitted for the award of any other degree.

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Decayed is this body, a frail nest of diseases. This foul mass breaks up. Indeed, the life ends in death.

Dedication
To
All teachers
who have profoundly changed
the our lives
Acknowledgement

I owe my deepest gratitude to all the teachers who have guided me towards the success of my academic achievements.

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Abstract

There is an increasing demand for better water quality in order to safeguard public health, the social security and accomplish environmental integrity. It has been found over the past couple of years that health hazards associated with heavy metal have been on the rise, particularly the chronic health problems due to the ingestion or consumption of even low doses of heavy metal-rich waters. Accumulation of such metals is reported mainly due to non-treatment or poor treatment of industrial wastewaters. Lack of tertiary treatment may have attributed to this growing problem and hence the environmental pollution. Constructed wetlands have therefore received great attention in the recent past as a tertiary treatment method or a polishing technique due to low construction and operation costs, minimum maintenance and also as an environmental friendly system. However, finding a low-cost sorbent material which can be used as an alternative to activated carbon has been a problem for decades in wastewater treatment industry, especially in developing countries. Therefore, the present study focuses on the applicability of low-cost sorbent materials that can be used in constructed wetlands as a filter medium. The focus was on four sorbent materials: tile, brick, saw dust and rice husks, which were selected based on their local availability. Laboratory-scale experiments were performed to investigate their maximum adsorption capacity and removal efficiency with a synthetic Zinc solution. The Results revealed that tile material has the highest adsorption capacity (47.6 mg/g) and removal efficiency, (98%) while brick (37.0 mg/g, 86%), sawdust (20.4 mg/g, 80%) and rice husks (15.8 mg/g, 64%) have relatively low adsorption capacities and removal efficiencies, respectively. The percentage removal of Zinc by all the four sorbent materials increased with an increase of contact time. The kinetics of adsorption were relatively fast for all tested low-cost materials. The equilibrium data were correlated with both Langmuir and Freundlich isotherms. Adsorption isotherms are well-described by Langmuir isotherms. The separation factor of equilibrium ($R_L$) indicates favourable isotherms ($0 < R_L > 1$) for all tested materials. Characterization of four sorbent materials was done by undertaking SEM, XRD and FTIR analyses. It can be concluded from the results that, the low-cost sorbent materials that were tested can be an attractive substitute for activated carbon in removing Zn from industrial wastewaters.

Keywords: adsorption isotherms, constructed wetlands, sorbent material, Zinc
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Abbreviations and Acronyms

AAS                Atomic Adsorption Spectrometer
BOD                Biological Oxygen Demand
BOI                Board of Investment of Sri Lanka
CAC                Commercially available Activated Carbon
CEA                Central Environmental Authority
CEC                Cation Exchange Capacity
CWs                Constructed Wetlands
FIAM               Free Ion Activity Model
FTIR               Fourier Transformation Infra-Red
FWS CWs            Free Water Surface Constructed Wetlands
FWS                Free Water Surface
HSSF               Horizontal Subsurface Flow
IAA                Indole Acetic Acid
IDB                Industrial Development Board
MoID               Ministry of Industrial Development
NEA                National Environment Act
N                  Nitrogen
P                  Phosphorus
SEM                Scanning Electron Microscope
SSHF CWs           Subsurface Horizontal Flow Constructed Wetlands
SSVF CWs           Sub-Surface Vertical Flow Constructed Wetlands
TOC                Total Organic Carbon
TON                Total Organic Nitrogen
TRP                Total Reactive Phosphorus
TSS                Total Suspended Solids
XRD                X-Ray Diffraction