



FACULTY OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF WATER RESOURCES ENGINEERING

FINAL YEAR REPORT

**EFFECT OF ZINC IONS ON THE REMOVAL EFFICIENCY OF LEAD (II) IONS
FROM WASTEWATER USING ACID-MODIFIED BIOCHAR**

CASE STUDY: ROOFING ROLLING MILLS

By

BASALIRWA DORCUS GLORIA

BU/UG/2021/0087

This final year project report is submitted to the Faculty of Engineering and Technology in partial fulfilment of the requirement for the award of the Degree of Bachelor of Science in Water Resources Engineering of Busitema University

MAY 2025

ABSTRACT

This paper investigates the impact of Zn ions on the adsorption performance of acid-modified biochar in removing Pb II ions from wastewater. The adsorption efficiency of biochar in a single metal ion condition was 99.99% for both Pb and Zn ions. In a multi-ion system, the adsorption efficiency for Zn ranged from 95% to 100%, whereas for Pb II ions, it was between 88% and 99%. Batch experiments were conducted to assess the influence of pH, contact time, and dose on the adsorption process. The results demonstrated that metal removal was high with pH (6.5-7), a contact time of 63 minutes, and a dose of 11-20g. Furthermore, interaction graphs were created to illustrate the combined effects of key parameters such as pH and dose, pH and contact time, and dose and contact time. The study concludes that while biochar exhibits promising potential for Pb (II) ion removal, its effectiveness may be limited in complex water systems with competing ions. These findings provide critical insights into optimizing biochar application in wastewater treatment systems for enhanced heavy metal remediation.

DECLARATION

I, the undersigned declare that this research is my original work, except where due acknowledgment has been made. I declare that this work has never been submitted to this University or any other institution for funding/partial fulfilment for any award.

Student name: BASALIRWA DORCUS GLORIA

Registration Number: BU/UG/2021/0087

Signature: 

Date: 15/05/2025

APPROVAL

I hereby certify that this report is the original report of BASALIRWA DORCUS GLORIA, BU/UG/2021/0087. It has been done under my supervision and is ready for submission to the Department of Water Resources Engineering.

SUPERVISOR'S NAME: Mr. Bagoole Christopher

SIGNATURE: 

DATE: 15/05/21

ACKNOWLEDGMENT

First of all, I would like to thank the Almighty God for enabling me to write this report in good health. I want to thank Dr. Ddumba Joseph Lwanyaga, Mr. Bagoole Christopher, Mr. Bendicto S. Maseruka, Mr. Tigalana Dan, Mr. Marcel Engiro, and Mr. Okinyi for their vital contributions. Their insights and expertise enabled me to seamlessly integrate the research findings into this report, culminating in the successful completion of my proposal. I thank the Department of Water Resources Engineering for the assistance and cooperation. Your support has been vital to my project's progress.

I would also like to thank the manager of National Water Quality Reference Laboratories, Mr. Katumba Geoffrey, and Mr. Lubega Michael, for supporting me in my research by allowing me to use their laboratories.

I would like to acknowledge my parents for their financial and emotional support during the process of compiling this report.

Lastly, I acknowledge the encouragement and constructive criticism given by my peers, your support has fostered a stimulating learning environment.

Table of Contents

ABSTRACT.....	i
ACKNOWLEDGMENT.....	iv
List of figures.....	viii
List of tables.....	viii
ABBREVIATIONS	ix
CHAPTER ONE: INTRODUCTION.....	1
1.1 BACKGROUND	1
1.2 PROBLEM STATEMENT	2
1.3 OBJECTIVES	2
1.3.1 Main objective	2
1.3.2 Specific objectives	2
1.4 JUSTIFICATION	2
1.5 SIGNIFICANCE.....	2
1.6 SCOPE OF STUDY.....	3
CHAPTER TWO: LITERATURE REVIEW.....	4
2.0 Introduction.....	4
2.1 Impact of Steel and iron industries waste water	4
2.1.1 Co-existing ions in industrial wastewater	4
2.2 Biochar as an adsorbent	5
2.2.1 Biochar modification	5

2.3 Adsorption mechanisms.....	6
2.3.1 Factors affecting the adsorption performance of biochar	7
2.3.2 Adsorption isotherms	8
2.4 Summary of literature review	8
CHAPTER THREE: METHODOLOGY	9
3.0 Study area.....	9
3.1 Sample collection.....	9
3.1.2 Sample analysis.....	9
3.1.3 Biochar preparation.....	9
3.1.4 Biochar characterization	9
3.2 Experimental design.....	10
3.2.1 Batch experiment setup.....	11
3.2.3 Heavy metal concentration measurement	12
3.2.4 Removal efficiency	12
3.3 Adsorption capacity	12
3.4 Removal efficiency of Pb II ions and Zinc ions in mono-ion environment.....	12
CHAPTER FOUR: RESULTS AND DISCUSSION	13
4.1 Introduction.....	13
4.2 Biochar characterization	13
4.3 Wastewater characterisation.....	14
4.4.1 Removal efficiency of Pb II ions and Zn ions after the adsorption process	16

4.4.2 Effect of Dose, pH, and contact time on the removal efficiency of Zinc ions.....	16
4.4.3 Effect of pH, dose and contact time on Pb II ions removal efficiency	17
4.5.5 Effect of two-way interaction of factors affecting the removal efficiency of zinc ions.....	18
4.5 Adsorption capacity of the AMB	18
4.7 Observations from mono-ion solutions.....	20
CHAPTER FIVE: CONCLUSIONS AND RECOMMENDATIONS	21
5.1 Conclusions.....	21
5.2 Recommendations.....	21
References.....	22
Appendices.....	27

List of figures

Figure 1 shows various methods of BC modification SOURCE: Advancements in application of modified biochar as a green and low-cost adsorbent for wastewater remediation from organic dye.....	6
Figure 2 shows the various mechanisms of Biochar adsorption processes SOURCE: Biochar for Wastewater Treatment—Conversion Technologies and Applications	7
Figure 3 shows biochar made from rice husks.....	10
Figure 4 (A) shows a person using an electric weighing scale, (B) shows a Ph probe in use, (C) shows a magnetic stirrer, (D) shows an ICP-OES	11
Figure 5 shows FTIR spectra for untreated biochar(left), SEM image (right)	13
Figure 6 shows FTIR spectra for AMB(left), SEM image(right)	14
Figure 7 a) shows effect of dose, b) effect of contact time, c) shows effect of pH, ...	17
Figure 8 e) shows the effect of pH, f) shows the effect of dose, and g) shows the effect of contact time on response	17
Figure 9 show the interaction of factors on their effect on the response	18
Figure 10 shows the removal efficiencies of Pb, Zn over time	20
<i>Figure 11 show the interaction of factors on their effect on the response</i>	<i>34</i>

List of tables

Table 1 showing the factors and their levels to be used for DOE using RSM	10
Table 2 summarises the initial concentrations of the metals existing in the wastewater.....	14
Table 3 Results of final concentration after adsorption process	14
Table 4 shows the results of the removal efficiency of Zn and Pb	16
Table 5 shows the adsorption capacity of the biochar	18
Table 6 shows the removal efficiencies, adsorption capacities of Pb and Zn ions in mono-ion systems.....	20

ABREVIATIONS

AAS	Atomic Absorption Spectrometer
CCD	Central Composite Design
DOE	Design of experiments
FTIR	Fourier Transform Infrared
ICP-OES	Inductively Coupled Plasma Optical Emission spectroscopy
NDP	National Development Plan
NWQRL	National Water Quality Reference Laboratory
Pb	Lead
RSM	Real Surface Method
SDG	Sustainable Development Goal
SEM	Scanning Electron Microscopy