FACULTY OF ENGINEERING

DEPARTMENT OF WATER RESOURCES AND MINING ENGINEERING

FINAL YEAR PROJECT REPORT

MODELLING AND OPTIMIZATION OF THE USE OF GREEN GRAPHENE OXIDE IN THE REMOVAL OF LEAD (II) IONS FROM WASTEWATER USING RSM-CCD

CASE STUDY: UGANDA BATTERIES LIMITED.

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This report is submitted to the Department of Mining and Water Resources Engineering in partial fulfilment of the requirements for the award of a Bachelor of Science in Water Resources Engineering of Busitema University.

ABSTRACT

Background: The discharge of wastewater containing heavy metals into streams, lakes, ground water and rivers is increasing rapidly. Lead is one of the most toxic heavy metals, which is generated by a number of industries. Among the various removal technologies of heavy metals from wastewater, adsorption has gained great importance as a purification and separation technique in industrial scales.

Methods: Green Graphene oxide (GGO) was synthesized by modified Hummer's method. Its application as an excellent adsorbent for lead (II) removal was also demonstrated using response surface methodology (RSM) using Central composite design (CCD). The effects of five independent variables; adsorbent dose, initial lead ion concentration, and temperature and contact time on the lead (II) removal efficiency were investigated and the process was optimized using RSM. Using central composite design (CCD), 52 experiments were carried out and the process response was modeled using a quadratic equation as function of the variables.

Results: The optimum values of the variables were found to be 1.2879g/l, 147.2727ppm, 59.6465 minutes, 34.5455^0C and 6.5253 for adsorbent dosage, lead (II) initial concentration, contact time, temperature and pH, respectively. Using RSM-CCD approach, a quadratic regression model was generated to demonstrate the relationship between removal efficiency (RE) and factors of Adsorbent dose (A), initial ion concentration (B), contact time (C), temperature (D)and pH (E).

Conclusions: The significance of each of the model term was evaluated using the probability of error value (P values) and R-sq. P-values less than 0.050 showed that the terms were significant. The model was adequate with 0.8066 R-sq. and 0.000 P-value.

Recommendations: The synthesized GO desires characterization with respect to functional groups, structure and morphology. Adsorption isotherms and kinetics studies need to be further conducted to understand the adsorption mechanism. Use of other optimization techniques like artificial intelligence and Taguchi methods need to be compared with RSM-CCD. The possibility of using blended sugarcane bagasse and rice straw to enhance efficiency should be investigated.

Keywords: Green Graphene oxide, Adsorption, Lead (II) ions, Modelling, Optimization, Response Surface Methodology and Central composite design

DECLARATION

I KIHEMBO RABECCA hereby declare to the best of my knowledge that this is my true and original piece of work and has never been submitted to any university or institution of higher learning for any academic award.

Signature: ………………….

Date: ………………………

APPROVAL

This research report has been submitted to the Faculty of Engineering for examination with the approval of my supervisor.

Supervisor

Mr. TIGALANA DAN

Signature: ……………………

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Acronyms and Abbreviation

AAS	Atomic Absorption Spectroscopy
CR	Contribution Ratio
RSM	Rough Surface Methodology
CCD	Central Composite Design
BBD	Box-Behnken design
UBL	Uganda Batteries Limited
GGO	Green Graphene Oxide
rGO	reduced Graphene Oxide
RSB	Rice-Straw Biomass
RSBB	Rice Straw Biomass Biochar
APE	Absolute percentage error
UBL	Uganda Batteries Limited
SDGs	Sustainable Development Goals
Pb	Lead
RE	removal efficiency
AC	adsorption capacity
CR	contribution ratio

1 CHAPTER ONE:

1.1 Background

Along with the acceleration of industrialization and urbanization, the discharge of wastewater containing heavy metals into streams, lakes, ground water and rivers is increasing rapidly (El-naggar, Hamouda, Mousa, Abdel-hamid, & Rabei, 2018)(X. Zhang et al., 2013). Heavy metal ions such as Cu, Pb , Hg, Zn and Cr in the aqueous environment mainly originate from industrial wastewater (Lata, 2016)(Duru, Ege, & Kamali, 2016). Lead is one of the most toxic heavy metals, which is generated by mining, electroplating, dyeing, battery, textile, explosive, and other industries (Lata, 2016). These ions cause many toxic effects on the environment and human health due to their toxicity, non-biodegradability carcinogenicity and long half-life (Taylor et al., 2014).

Long-term drinking of water polluted by lead causes serious health risks (Wang, Chen, & Yang, 2015) to the brain, kidney, liver, blood, nervous and reproductive systems, causing effects like learning disabilities (decreased IQ), anemia, chronic headache, dysentery and amentia (Guo, Bulin, Li, & Zhang, 2018)(Taylor et al., 2014). For the sake of ecological stability and public safety, it is necessary to eliminate Pb(II) from wastewater (Zhao et al., 2011) in a simple, efficient, and environmentally friendly approach (Guo et al., 2018).

Various separation technologies which include precipitation, reverse osmosis, ion exchange, membrane separation, flocculation, electrolysis, and adsorption (Linbo Li, Zhao, & Tian, 2020)(Guo et al., 2018)(K. Zhang, Kemp, & Chandra, 2012)(Leilei Li, Luo, Li, Duan, & Wang, 2014)(Sophia et al., 2016) have been employed to remove heavy metals from wastewater. Among these methods, adsorption has gained great importance as a purification and separation technique in industrial scales (Tabrizi & Zamani, 2016) and become an attractive option for industrial water treatment because of its safe, simple operation, fast response, relatively low cost and high efficiency (Nuji & Habuda-stani, n.d.)(W. Fu & Huang, 2018). However, the other methods have several disadvantages such as generation of toxic waste products, ineffectiveness at lower concentrations of metal ions and low selectivity (El-naggar et al., 2018)(Duru et al., 2016).

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