

**Defluorination of Water Using Aluminium – Loaded Lemon Peelings Carbon as Modified
Natural Adsorbents**

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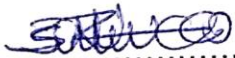
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**A Dissertation Submitted to the Department of Chemistry in Partial Fulfilment of the
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University**

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Declaration

I, Ssekitto Nathan, declare that this research work is my original work and has not been submitted for any award in any University or other institution of higher learning. The information derived from the literature has been fully acknowledged in the text by citation and a list of references provided.

Signature.......... Date.....11/04/2023.....

Approval

This research project report has been submitted for examination with the approval of my supervisor.

Dr Egor Moses

Signature..........Date..... 11 / 04 / 2023

Dedication

I dedicate this project to my mother, Ms. Nagadya Christine for the support given to me throughout my life at secondary school and the university in terms of monetary support, emotional guidance, everlasting care and encouragement. I am eternally grateful for your contributions towards my life and pledge to forever have you at heart for the kindness, sacrifice, commitment and sincere support towards the better version of me.

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I take this opportunity to thank the Almighty God for the gift of life, knowledge, wisdom, basic needs, sound health, guidance and protection since I was born.

List of Acronyms and abbreviations

ALLPC	-	Aluminium Loaded Lemon Peelings Carbon
CDTA	-	Cyclohexanediaminetetraacetic acid
EC	-	Electro-Coagulation
ESI-MS	-	Electrospray Ionisation Mass Spectroscopy
FESEM	-	Field Emission Scanning Electron Microscopy
IQ	-	Intelligence Quotient
ISE	-	Ion Selective Electrode
NEERI	-	National Environmental Engineering Research Institute
NF	-	Nano Filtration
PTFE	-	Polytetrafluoroethylene
PXRD	-	Power X-ray diffraction
TDS	-	Total Dissolved Solids
TISAB	-	Total Ionic Strength Adjustment Buffer
UNBS	-	Uganda National Bureau of Standards
WHO	-	World Health Organisation
XPS	-	X-ray Photoelectron Spectroscopy

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Abstract

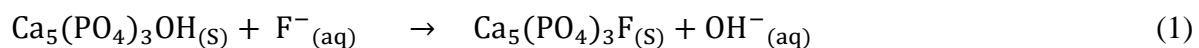
The contamination of groundwater and high concentrations of fluoride ions are major problems worldwide, causing diseases like dental and skeletal fluorosis; in the population that uses this water for their consumption and therefore, its removal from groundwater is a very important issue. This study was aimed at developing an inexpensive and effective adsorbent for removing fluoride ions from drinking water to the safety limit, 1.5 mg/L set by World Health Organization and Uganda National Bureau of Standards. Lemon peelings obtained from Nagongera market, Tororo district were impregnated with aluminium by subsequent carbonization, alkalizing and treatment with aluminium chloride and effectiveness in adsorbing fluoride ions was confirmed by batch adsorption studies. The adsorption data were analyzed by Freundlich and Langmuir isotherms. The adsorption on the aluminium-loaded lemon peelings carbon (ALLPC) obeyed the pseudo second order kinetic model. The adsorption capacity ALLPC was studied with variation in size of adsorbent dose, size particles, pH, adsorbent dose and initial fluoride concentration. The extent of adsorption of fluoride ions by ALLPC adsorbent increased with increase in adsorbent dose, contact time and pH until an optimum value but decreased with the increase in particle size and initial fluoride concentration. In future, the potential ALLPC adsorbent can be used to design a household defluorination unit for effective and economical fluoride removal.

Chapter 1: Introduction

1.1 Background

Chemical contamination of water sources can be either caused naturally or caused by pollution from different sources (man-made). Man-made contamination can hopefully be identified and stopped, but the natural way is not easy and this can put communities into risks (Shorter, 2011). Chemical contamination generally occurs during the water cycle and one of the most well documented naturally occurring contaminants is fluoride which affects drinking water supplies in a number of countries (Jamode, Sapkal, & Jamode, 2004; Kimambo, Bhattacharya, Mtalo, Mtamba, & Ahmad, 2019). When water makes contact regularly with ores, minerals such as fluorite and weathering of rocks (for example shale, basalt, granite) consequently, high fluoride concentration may yield in water (Kimambo et al., 2019). Various industries are also involved in discharging of fluoride in water. These industries include; semiconductor manufacturing factories, pharmaceutical companies, beryllium extraction plants, aluminum smelters, fertilizer manufacturing, and mining industries and others (Paudyal et al., 2013).

Fluoride is the most electronegative and reactive element in the periodic table, occurring primarily as the fluoride ion (F^-) and at the level of 1.0 mg L^{-1} in the body enhances bone development and prevents dental carriers hence the growth and maintenance of healthy bones and teeth by displacing the hydroxide ions from hydroxyapatite, the principal mineral constituent of teeth and bones, to form the fluorapatite, which is harder and tougher than hydroxyapatite.



The maximum tolerance limit of fluoride in drinking water specified by the World Health Organization (WHO) is 1.5 mg L^{-1} , but a lower concentration is recommended for children and even though the highest fluoride concentration in drinking water is 1.5 mg L^{-1} , in many tropical countries, where there is a high sweat loss and a high intake of water due to the hot weather, such an upper limit is unsuitable (Rajkumar et al., 2019) therefore even if the upper limit according to the WHO in the temperate regions is 1.5 mg/L , some areas have their upper limits varying for example, in South Africa, the upper limit is 0.75 mg/L , in India, it is 1 mg/L and in some parts such as Nakuru of Kenya, the upper limit is 3 mg/L and in Uganda, it is 0.6 mg/L .

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