HYDRAULIC PROPERTIES AND WATER-REPELLENCY OF ORGANOSILANE-TREATED SOIL AS AN ALTERNATIVE MATERIAL UTILISED IN A LANDFILL LINER SYSTEM

EPELLE, PROMISE SOKARI
(14CI016680)

SEPTEMBER, 2022

HYDRAULIC PROPERTIES AND WATER-REPELLENCY OF ORGANOSILANE-TREATED SOIL AS AN ALTERNATIVE MATERIAL UTILISED IN A LANDFILL LINER SYSTEM

BY

EPELLE, PROMISE SOKARI
(14CI016680)
B.Eng. Civil Engineering, Covenant University, Ota

A DISSERTATION SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF ENGINEERING (M.Eng.) DEGREE IN CIVIL ENGINEERING IN THE DEPARTMENT OF CIVIL ENGINEERING, COLLEGE OF ENGINEERING, COVENANT UNIVERSITY, OTA, OGUN STATE, NIGERIA

SEPTEMBER, 2022

ACCEPTANCE

This is to attest that this dissertation was accepted in partial fulfilment of the requirements for the award of Master of Engineering (M.Eng.) degree in Civil Engineering, Department of Civil Engineering, College of Engineering, Covenant University, Ota.

Mr. Taiwo B. Erewunmi
(Secretary, School of Postgraduate Studies) **Signature and Date**

Prof. Akan B. Williams
(Dean, School of Postgraduate Studies) **Signature and Date**

DECLARATION

I, **EPELLE, PROMISE SOKARI (14CI016680)** declares that this research work was carried out by me under the supervision of Dr. Isaac I. Akinwumi of the Department of Civil Engineering, Covenant University. I also solemnly declare that to the best of my knowledge, no part of this report wholly or partially has been submitted here in Covenant University or elsewhere in a previous application for award of a degree. All sources of data and scholarly publications have been duly acknowledged.

EPELLE, PROMISE SOKARI

Signature and Date

CERTIFICATION

We certify that this dissertation titled **"HYDRAULIC PROPERTIES AND WATER-REPELLENCY OF ORGANOSILANE-TREATED SOIL AS AN ALTERNATIVE MATERIAL UTILISED IN A LANDFILL LINER SYSTEM"** is an original research work carried out by **EPELLE, PROMISE SOKARI (14CI016680)** in the Department of Civil Engineering, College of Engineering, Covenant University, Ota, Ogun State, Nigeria under the supervison of Dr. Isaac I. Akinwumi. We have examined and found this work acceptable as part of the requirements for the award of Master of Engineering (M.Eng.) in Civil Engineering.

Dr. Isaac I. Akinwumi
(Supervisor) **Signature and Date**

Prof. Anthony N. Ede
(Head of Department) **Signature and Date**

Prof. Gbenga M. Ayininuola
(External Examiner) **Signature and Date**

Prof. Akan B. Williams
(Dean, School of Postgraduate Studies) **Signature and Date**

DEDICATION

This research is dedicated to God Almighty for His grace upon my life throughout the course of this project.

ACKNOWLEDGEMENTS

I want to thank God firstly, because all that I have or is connected to me comes from Him. I am deeply grateful to Him for His constant love, mercy, and grace. I thank Him for the beautiful opportunities and for being more than a friend.

To the Chancellor, Covenant University, Dr. David O. Oyedepo and Vice Chancellor, Prof. Abiodun H. Adebayo. God bless you for your impactful leadership over the years. I also wish to appreciate the Dean School of Postgraduate Studies, Prof. Akan B. Williams.

I want to appreciate the management of civil engineering department, under the leadership of Prof. Anthony N. Ede also the PG coordinator, Dr. Gideon O. Bamigboye. You have been a blessing to the civil engineering department of Covenant University.

To my gracious supervisor, Dr. Isaac I. Akinwumi, the degree of impact you have had in my life cannot be over-emphasized. May God continue to bless you and may you attain greater heights.

I also acknowledge Prof. Vincent O. Ogunro and the Fulbright Scholarship programme for all the support in making sure this research work ran without a hitch.

Also, to my parents, the foundation of my discipline and source of my joy, Arc. and Mrs. Epelle. I cannot thank you enough for your love, care and support. May you live long and eat the fruit of your labour, Amen. My beloved sister, Rhoda Epelle who has been a steppingstone for me to make progress in life and has been an arm of support for me in times of need. I am forever grateful, and I love you.

To my friends turned brothers; Victor Ajayi, Moses Ichado, David Ijie and Wisdom Folorunsho for your support and the experiences we have had along the way, I love you brothers.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS AND SYMBOLS

Σ	-	Summation
BOD	-	Biological Oxygen Demand
C&D	-	Construction and Demolition
CBR	-	California Bearing Ratio
CCL	-	Compacted Clay Liner
COD	-	Chemical Oxygen Demand
DAS	-	Diaminesilane
EPA	-	Environmental Protection Agency
GCL	-	Geosynthetic Clay Liner
GM	-	Geomembrane
HDPE	-	High Density Polyethylene
HDTMS	-	Hexadecyltrimethoxysilane
HM	-	Heavy Metal
ICP	-	Inductively Coupled Plasma
ISWA	-	International Solid Waste
LGA	-	Local Government Area
MDD	-	Maximum Dry Density
MOC	-	Magnesium Oxychloride Cement
MRF	-	Material Recovery Facilities
MSW	-	Municipal Solid Waste
OES	-	Optical Emission Spectroscopy
OM	-	Organic Matter
OMC	-	Optimum Moisture Content
P123	-	Polyethylene oxide-polypropylene oxide-polyethylene oxide triblock copolymer
PERI	-	Potential Ecological Risk Index
PVC	-	Polyvinyl Chloride
SDM	-	Sessile Drop Method
SI-C	-	Silicon-Carbon Link
SSC	-	Sewage Sludge Compost

TKN	-	Total Kjeldahl Nitrogen
TSF	-	Tailings Storage Facilities
UCS	-	Unconfined Compressive Strength
VOC	-	Volatile Organic Compound
VS	-	Vinyltrimethoxysilane
WDPT	-	Water Drop Penetration Time
XRD	-	X-ray Diffraction
XRF	-	X-ray Flourescence

ABSTRACT

In developing countries, where cost and availability of geomaterials utilised in the design and construction of landfills is an issue, cost-effective options are urgently needed. This work focuses on the issue of waste management, landfills, and a more economical alternative for a landfill liner system. It assesses the hydraulic properties and water-repellency of organosilane-treated soil as an alternative material utilised in a landfill liner system. Hydraulic conductivity test and water droplet penetration tests were carried out on the untreated and treated soil at variations; 1:1000, 1:500, 1:100, 1:80 and 1:50. These variations were done by mass with respect to an organosilane to soil correlation. The hydraulic conductivity of the natural soil at 1.74×10^{-5} cm/s reduced to 5.03×10^{-6} cm/s, 4.54×10^{-6} cm/s, 1.77×10^{-6} cm/s, 7.78×10^{-7} cm/s and 6.36×10^{-8} cm/s at 1:1000, 1:500, 1:100, 1:80 and 1:50 respectively. This reduction indicated that higher organosilane content in the soil causes lower hydraulic conductivity. From the tests on hydraulic characteristics, it was concluded that only 1:50 met the requirement for a liner material with the value being less than 1×10^{-7}cm/s. Also, the water droplet penetration time using precision pipette and a stopwatch was carried out to determine its degree of water-repellency. It was observed from the tests that the water droplet penetration time for the untreated soil at zero seconds increased to 300, 1140, 6210, 7800 and 9450 seconds at 1:1000, 1:500, 1:100, 1:80 and 1:50 respectively. This increment in time indicated that an increase in organosilane content increases the time it takes for water to penetrate into the soil fabric. Mix ratio 1:1000 came out as strongly repellent, 1:500 was severely repellent while 1:100, 1:80 and 1:50 were extremely water repellent samples. From these analyses, it was concluded that organosilane-treatment causes the soil structure to become compact causing higher packing density, and low porosity in the microstructure. Hence, an organosilane-treated layer in a composite liner system is a promising replacement for geomembrane in a landfill.

Keywords: Geomembrane, Hydraulic Conductivity, Landfill, Organosilane, Waste Management.