ENVIRONMENTAL, PHYSICO-CHEMICAL AND HYDROGEOPHYSICAL INVESTIGATION OF A WETLAND DUMPSITE IN LAGOS STATE, NIGERIA

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CERTIFICATION

This is to certify that this research project was carried out by **ORAKWE Linus Obinna (REG NO. SCP11/12/H/1335)** under our supervision, at the Institute of Ecology and Environmental Studies.

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DEDICATION

This thesis is dedicated to the Almighty God, and my late father, Mr. Joseph Orakwe who was transited to glory during the course of this research work, for their immeasurable support.

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LIST OF ABBREVIATIONS AND ACRONYMS

Acronyms		**Description**
B/D	-	Bulk Density
BH	-	Borehole
BOD	-	Biological Oxygen Demand
Cc	-	Coefficient of Conformity
CPS	-	Coastal Plains Sands
CS	-	Coarse Sand
D/D	-	Dry Density
DEC	-	Dokay Engineering Consultancy
DEFRA	-	Department for Environment Food and Rural Affairs
Df	-	Degree of Freedom
DO_2	-	Dissolved Oxygen
DSWL	-	Depth to Static Water Level
DSWL	-	Depth to Static Water Level
EC	-	Electric Conductivity
ECE	-	European Commission Environment
EGL	-	Elevation of the Ground Level
EIONET	-	European Information and Observation Network

FS	-	Fine Sand
GHG	-	Green House Gases
GHH	-	Groundwater hydraulic head
GW	-	Ground water
GWC	-	Groundwater Controlled sample
GPS	-	Global Positioning System
HH	-	Hydraulic Head
HP	-	Horizontal Profiling
HH	-	Hydraulic Head
ITRC	-	Interstate Technology & Regulatory Council
LAWMA	-	Lagos Waste Management Authority
LGA	-	Local Government Area
MBT	-	Mechanical and Biological Treatment
MRF	-	Material Recovery Facility
MS	-	Medium Sand
MSW	-	Municipal Solid Waste
NES	-	Nigerian Environmental Society
NMC	-	Natural Moisture Content
OWMC	-	Ontario Waste Management Corporation's
PC	-	Productivity Commission
PCMS	-	Prakriti, Centre for Management Studies

SG	-	Specific Gravity
SPSS	-	Statistical Package for Social Sciences
SW	-	Surface Water
SWC	-	Surface Water Control Sample
SWM	-	Solid Waste Management
TC	-	Total Coliform
TDS	-	Total Dissolved Solids
TEM	-	Transient Electromagnetic
TH	-	Total Hardness
THB	-	Total Heterogeneous Bacteria
TR	-	Traverse
TSS	-	Total Suspended Solids
USCS	-	Unified Soil Classification System
USDER	-	United State Department of Environmental Resources
USEPA	-	United State Environmental Protection Agency
VES	-	Vertical Electric Soundings
VR	-	Void Ratio
WHO	-	World Health Organisation
2D	-	Two Dimension

ABSTRACT

Engineering geological, physicochemical and hydrogeophysical investigations were carried out on a wetland dumpsite in Epe, Lagos State, Nigeria. This was with a view to investigating the impact of the dumpsite leachate on the physicochemical properties of surface and groundwater in the typical wetland environment.

2-D Dipole-Dipole profiling and 1-D Vertical Electrical Sounding (VES) techniques were carried out along five traverses established within the study area. The 2-D imaging adopted 10 m inter-electrode spacing and expansion factor (n) varying from 1-5. The data acquired were inverted into 2-D resistivity structures using the DIPRO for window V. 4.0 software. The VES were conducted with the Schlumberger array. The depth sounding curves were interpreted quantitatively using the partial curve matching technique and computer assisted 1-D forward modeling with the RESIST software. Geoelectric sections were generated from the VES interpretation results. Eighteen (18) soil profile samples were collected from four (4) boreholes. These samples were analyzed for hydraulic/geotechnical properties using standard methods. Forty (40) water samples were collected from 10 stations (including 2 controls) comprising 5 each of surface and groundwater sources during the rainy and dry seasons of 2014 and 2015. The samples were analysed for physicochemical and bacteriological parameters using relevant reagents and equipments including colorimeter, turbidity meter, UV-Visible Spectrophotometer, and Atomic absorption Spectrophotometer.

The lithological log revealed that the study area was underlain by intercalations of sand and clayey sand. The subsoil was characterised by low bulk density (mean of 1.89±0.162 g/cm^3);

moderate porosity and permeability (mean of 37.84±8.42% and 3.0 x 10^{-4}± 1.1 x 10^{-4} cm/sec); low moisture content (mean of 17.57±15.18%); and fine to medium grained texture. The coefficient of uniformity value of < 6 was recorded for these samples. AK and KQ type curves with increasing layer resistivities at shallow depth were observed within virgin areas while the H, QH and HA with decreasing layer resistivities within the upper two to three geoeletric layers were observed in the premises of the dumpsite. VES interpretation results delineated 3 – 4 subsurface layers. 2-D images also delineated two geologic layers with resistivity values 212 to 2165 Ωm. These values generally decrease towards the waste dump and unreclaimed wetland portion. South - southwestward groundwater flow direction from the waste dump was established. The overall mean and standard deviation of physical parameters were Temperature 27.6±1.4°C; Turbidity 21.0±17.0 NTU; Conductivity 905.8±1038.6 µS/cm; TDS 463.6±523.5 mg/L; and TSS 30.2±39.4 mg/L. Chemical parameters were pH 6.2±0.6; Acidity 169.0±181.4 mg/L; Hardness 645.2±782.5 mg/L; DO 2.1±0.8 mg/L; and BOD 212.0±83.8 mg/L. Mean values for major ions in mg/L were Na^{+}62.1±32.2; K^{+} 11.7±4.6; Ca^{2+} 279.3±352.9; Mg^{2+} 103.1±127.1; NO_3^{-} 42.3±29.8; SO_4^{2+}129.8±107.9; PO_4^{2-} 29.8±26.2; and Cl^{-} 285.5±279.2. Mean heavy metals concentrations in mg/L were Cr 0.8±0.8; Fe 1.8±2.0; Pb 0.3±0.3; Ni 0.1±0.1; Mn 3.7±6.3; Cd 0.0±0.0; Co1.0±0.8; Cu 0.3±0.3 and Zn 8.8±5.7. Bacteriological parameters in cfu/ml were THB 2664500.0±1811930.0 and TC 4477.4±7081.0.

The study concluded that shallow water table and thick column of unconsolidated sandy formation typical of wetland condition influenced waste dissolution and migration of leachate thereby seriously polluting water resources around the investigated dumpsite.

CHAPTER ONE

INTRODUCTION

1.2. Background to the Study

One of the major challenges of many emerging cites of the world is how to develop an effective and sustainable Municipal Solid Waste (MSW) Management System. Developing such systems have become topical and constitute major financial budgets of metropolitan cities and nations. If adequately implemented to comprise resource recovery and other associated safety measures, these systems will help to minimize negative impacts resulting from MSW on natural resource, esthetic value, land space, human health and environmental status (Productivity Commission, 2006).

In line with the goals of sustainable development, providing sustainable waste management system entails systematic process of meeting the needs of today in a manner that supports waste minimization, resource recovery for reuse or recycling and sanitary disposal of residual components in order to protect the environment for the future generations. This concept is globally accepted and enforced by different governments and non-governmental organizations. It promotes increasing standard of living and strikes a proper balance between development and quality environmental status; such that a quality environment in-turn sustains biodiversity and socio-economic activities (NES, 2006; Zimmerman, 2008).

As an important component of sustainable waste management system, providing adequate disposal arrangement is necessary for waste fractions not captured by available resource recovery facilities. Landfill, though occupying the bottom position in waste management hierarchy, is one of such disposal facility that is indispensable, because most technologies used in the waste management sector produce residual components that must be contained in final repository facilities like sanitary landfills. Therefore, till today, adopting best practice in landfill system has remained important; especially in nations where such unrecovered waste components are still disposed in non-engineered dumpsites, thereby constituting problems to human health and the environment.

Nigeria, like most developing nations witness problems of uncontrolled dumping of solid waste in all States of the Federation. These problems include degradation of esthetic value of cities, leachate contamination of underground and nearby surface water resources, increase in population of insects and rodents, offensive odour and flooding due to blocked canals. The foregoing problems are poorly addressed at all levels, by placing emphasis on the removal and transportation of solid waste from sites where they pose ugly sights or blocked drainage channels to remote areas where they cannot be seen nor their associated odour perceived.

Lagos State, the economic and financial capital of Nigeria, is one of the most populous States in the country. According to Ojo and Bowen (2014), although Lagos State is the smallest state in Nigeria, with an areal extent of 356,861 hectares of land mass, about one-fifth (75,755 hectares) are wetlands. It has a population of about 12.2 million inhabitants, estimated from the 2006 population figure using an annual growth rate of 3.06% for the State (Okafor *et al.*, 2007). According to the Lagos Waste Management Authority (LAWMA) 2014, the State generates over 9,000 metric tons (MT) of solid waste per day. Providing efficient and sustainable management system to contain this amount of waste is a big challenge to the State Government and other stakeholders of waste management in the State. One of such challenges is in the area of securing landmass to locate new waste management facilities, especially landfills.

Preliminary investigations showed at least seven different dumpsites (Solous 1 - 4, Abulegba, Ewuelepe and Olushosun) in Lagos State. These dumpsites are mainly located on the upland part of Lagos State, until February 12th, 2009 when the State through LAWMA considered locating new landfills on low lying wetlands of Epe and Badagry Local Government Areas (LAWMA, 2011). Though it was planned that these new landfills will be engineered, with adequate attention paid to the geology of the area where they will be located, the Epe Landfill has started receiving waste with no such consideration or construction of leachate control system; hence, the need to understand the peculiarities of these ***wetlands*** viz-a-viz solid waste disposal operations in Lagos State.

Wetlands being land areas permanently or seasonally saturated with water are distinct ecosystem with peculiar characteristics. They are distinguished from other land forms or water bodies by their characteristic vegetation of aquatic plants, adapted to its unique hydric soil (Wikipedia, 2015). The Epe Wetland, like other wetlands across the world is vital to environmental sustainability and green infrastructural development. According to Acquavella (2006), wetlands are the worst type of ecosystems for dumping of refuse; as the result could be devastating to both people that live near these dump sites as well as the rare and narrow-niched ecosystems they habour.

1.2 Statement of Research Problem /Justification of Study

Until recent when a dumpsite was established on low lying wetland, refuse dumping in Lagos State had been upland. The paradigm shift has been a source of concern, because the policy violates classical criteria in landfill location. According to USEPA's code of Federal regulations, landfills should not be built near locations that are not geologically suitable, including faults, flood plains, ***wetlands***, or any other restricted area (USEPA, 2014). Standards and Regulations of British Columbia in Canada also stipulated that landfills should never be built on wetlands and that such