UNIVERSITY OF ILORIN

THE TWO HUNDRED AND NINETY-SECOND (292ND) INAUGURAL LECTURE

"LEVERAGING THE EXPERTISE OF CHEMISTS IN ENVIRONMENTAL MANAGEMENT: A FOCUS ON ANALYTICAL, ENVIRONMENTAL, AND MATERIAL FIELDS"

By

PROFESSOR HUSSEIN KEHINDE OKORO
B.Sc. Industrial Chemistry, Cert., Computer, M.Sc. (Ilorin); Ph.D. (Cape Town, South Africa), PGDE, Dip. (HRM) (Ilorin), ***FICCON, FCSN***

DEPARTMENT OF INDUSTRIAL CHEMISTRY,
FACULTY OF PHYSICAL SCIENCES,
UNIVERSITY OF ILORIN, NIGERIA

THURSDAY, 6TH NOVEMBER, 2025

This 292nd Inaugural Lecture was delivered under the Chairmanship of:

The Vice-Chancellor

Professor Wahab Olasupo Egbewole, SAN
LL.B (Hons) (Ife); B.L (Lagos); LL.M (Ife); Ph.D. (Ilorin); FCArb; Fspsp

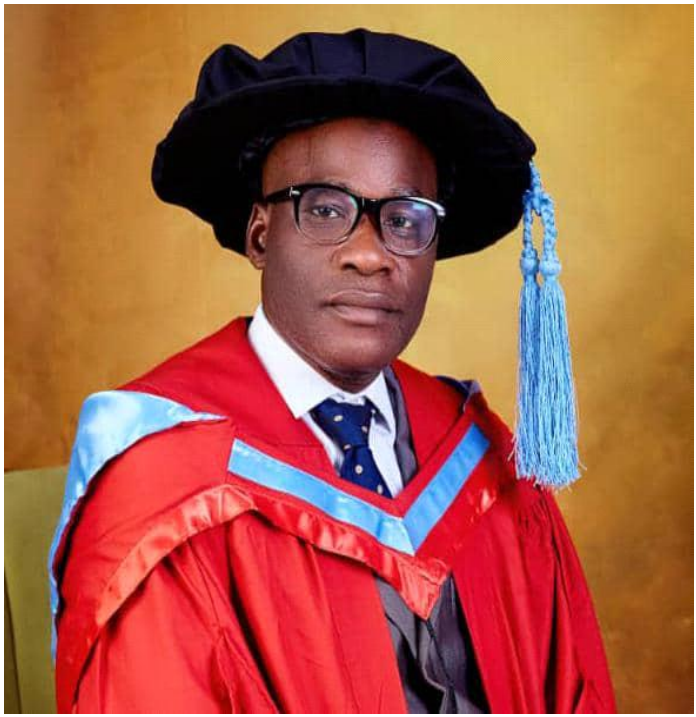
6th November, 2025

ISBN: 978-978-699-469-7

Published by:

The Library and Publications Committee,
University of Ilorin, Ilorin, Nigeria

Printed by
Unilorin Press, Ilorin, Nigeria



PROFESSOR HUSSEIN KEHINDE OKORO

B.Sc. Industrial Chemistry, Cert., Computer, M.Sc. (Ilorin); Ph.D. (Cape Town, South Africa), PGDE, Dip. (HRM) (Ilorin), *FICCON, FCSN*

PROFESSOR OF ANALYTICAL AND ENVIRONMENTAL CHEMISTRY, DEPARTMENT OF INDUSTRIAL CHEMISTRY, FACULTY OF PHYSICAL SCIENCES, UNIVERSITY OF ILORIN, NIGERIA

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Academic and Non-Teaching Staff of the University,
My Lords Spiritual and Temporal,
Distinguished Invited Guests,
Gentlemen of the Press,
Students of Industrial Chemistry and Chemistry and other students here present,
Greatest students of the University of Ilorin,
Distinguished Ladies and Gentlemen.

Preamble

Praise be to Allah, who created all things and beautified them with some of what He created. He created the heavens and adorned them with the Throne and the Kursiy. He created the earths and beautified them with the Kaaba and the Maqam of Ibrahim. He created mankind and beautified them with our beloved, our master, the master of mankind, the most beautiful of them, the best of them, the kindest of them, the most refined and perfected of them, he who brought humanity to the worship of the Lord of mankind. So, all praise is due to Allah, Lord of all worlds. I seek refuge in Allah against devil the accursed and I commence this presentation in the name of Almighty Allah, the

most Gracious, the most Beneficent and the most Merciful. Allah is the first and the last, the beginning and the end, the one without equal. Allah is first without any reference point and He is the last without any point of termination. I thank the Almighty Allah wholeheartedly for sparing my life right from birth to date.

It is with immense gratitude to the Almighty Allah that I stand before this distinguished audience to fulfill my dream. Today's lecture is the 292nd in the series of Inaugural Lecture in the University of Ilorin, the 12th in the Faculty of Physical Sciences and the 2nd from the Department of Industrial Chemistry. It is the 2nd from the Analytical-Environmental Chemistry Unit, 1st from Nanotechnology Research area. The 1st Professor from Makun Adeola Okoro Clan of Owo. The 1st Professor of Analytical Environmental & Material Chemistry from Round Table of Academic Mentors, University of Ilorin.

Mr. Vice Chancellor, permit me to inform this audience that today marks my birthday anniversary. Alihamuduliah Robi Lia Lamina for sparing my life till today. Before I delve into the focus of the lecture let me say that I was born to the family of Makun Adeola Okoro Dynasty in Owo, Ondo State, Nigeria. I finished my elementary education at Government Primary School, Owo, in 1987 after completing my basic Quranic School in 1985 under the mentorship of Sheikh Imam Jamiu A. Okoro. After my secondary school, I obtained UME form in 1994 and I chose University of Ilorin to study Medicine. I eventually got offer for admission to study Industrial Chemistry at the University of Ilorin, where I graduated in 2002. After the one-year compulsory National Youth Service Corp (NYSC) programme, my School Principal then, Mr. Ben Ezike, advised us to go for Master degree while we were searching for job to keep us busy in the meantime. I went to FUTA to obtain an MTech form but was advised by Prof. (Mrs.) Elleta to continue my educational pursuit with the University of Ilorin. After finishing, I started my doctorate right away under our erudite scholar and mentor, Prof. F.A. Adekola, who is the Chair of Analytical Environmental Chemistry.

My Ph.D. research was first centered on the Environmental Monitoring of Oyun River However, an erudite Professor of Analytical and Environmental Chemistry; Prof. O.S. Fatoki, on the advice of Prof. Adekola, facilitated the changing of my Ph.D. programme to Cape Peninsula University of Technology, Cape Town (CPUT). The University of Ilorin and CPUT subsequently used the opportunity to draw up an MoU between the two institutions. This MoU has given birth to the U6+ Consortium of African Universities with me appointed as the Desk Officer last year, and also nominated by the Vice-Chancellor to serve as the Editor-in-Chief for U6+ 2024 Conference Proceedings. In addition, I was appointed by the Vice-Chancellors of the U6+ Consortium of African Universities as the Pioneer Editor in-Chief for the U6+ Multidisciplinary Journal for African Development. Upon the commencement of my doctoral study at the proposal writing stage, I was able to come up with three review articles in relation to my research work. One article was published in *Review of Environmental Contamination and Toxicology* (*RECT*), Springer, with a total citation of 113 as at October 2025 (**Okoro,** *et al*., 2012), while the second was published in *Asian Journal of Chemistry* (**Okoro** *et al*., 2011**)** with a total citation of 80 according to google scholar. I went ahead to write the third one on A Review of Sequential extraction of heavy metals and that has a total of 200 citations according to google scholar on 2nd October, 2025. Again, at the tail end of my doctoral program I was invited to contribute a chapter on "Organotin Compounds" in Encyclopedia of Toxicology published by Elsevier Science Direct, with a total of 15 Citations.

Mr. Vice-Chancellor, I must let this august gathering know that I encountered a big challenge too during my doctoral work. This first challenge had to do with funding since I missed the ETF scholarship grant before my departure from Nigeria, by Allah mercy the CPUT Management appointed me as a Research Assistant in the Department of Chemistry on the agreement that the salary will cater for my upkeep and school fees, thank God first challenge resolved. The second challenge I faced had to do

with the sampling I obtained from Cape Town Harbour (Atlantic Ocean) with a boat equipped with CSIR crews. Each time I was going to take samples, I used to pray and fast because I have a phobia for water and so seeing different wild animals like sea lions, sharks, crocodiles etc., was scary to me. I can recall that I used to call my supervisor before I enter the harbour for sampling, Prof used to say Hussein good luck and best wishes. Alhamudulilah for my safety throughout my sampling periods, second challenge overcome.

Vice-Chancellor, Sir, I am glad to inform you that fifteen (15) research publications published in high impact international Scopus journal outlets emanated from my Ph.D. thesis alone. I was also able to present my Ph.D. work in five different international conferences held in South Africa, Kenya, Nigeria, Ghana, Boston and Long Beach, California, USA. I won the Global Excellence and Stature Scholarship which provided me the opportunity to do my postdoctoral research at the Department of Applied Chemistry now Chemical Science Department, University of Johannesburg. I can recall that I used to write Prof. HKO at the back of my school notes while I was in Secondary School. Alhamudulilah the dream has come true. Today, A Professor of Analytical- Environmental Chemistry is standing before you to present an inaugural lecture.

Introduction

Vice-Chancellor Sir, Chemistry is the study of the composition, structure, and properties of matter. It is often called the "central science," because it combines Physics, Mathematics, Biology, and even Environmental Science. As a central science, owing to its relevance to all fields of human endeavors, it draws on the ideas and techniques of Analytical Chemistry, which occupies a central position. Thus, this inaugural lecture hereby aimed at leveraging the expertise of Chemists in Environmental Management, with a focus on Analytical, Environmental, and Materials Fields. Its main objective focuses on providing different methods in understanding and addressing environmental problems thereby contributing to the protection of

both ecosystems and human health. The significance of this inaugural lecture includes understanding and monitoring pollution; developing new analytical methods for pollutants' removal; formulation of environmental regulations and policies; environmental impact assessment; and identifying pollutants to include the use of analytical techniques like chromatography, spectroscopy, and mass spectrometry, which allow for the detection and identification of pollutants in various environmental matrices (water, air, soil).

A Brief History of Chemistry

As a field of study, Chemistry is very fundamental to our world. This is because it does not only play a role in everyone's lives, but also touches almost every aspect of our existence in some way. Chemistry is essential for meeting our basic needs of food, clothing, shelter, health, energy, and clean air, water, and soil. Analytical chemistry is an area in chemistry that focuses on identifying compounds and determining the amount of a compound in a solution or substance. Analytical chemistry is used in many different fields. In forensic science, an analytical chemist can identify and quantify the presence of substance in a sample. In environmental science, analytical chemistry can be used to detect the presence of dangerous heavy metals, such as arsenic. Analytical chemistry can also be involved with the development of new analytical instrumentation. It can play a supporting role in organic and biochemistry by identifying the structure of novel molecules.

Measurement of Substance in Analytical and Environmental Chemistry

Vice-Chancellor Sir, Analytical chemistry is fundamentally a science of measurement that provides the methods and principles for determining the identity (what is it) and quantity (how much of it is there? of a substance in a sample. The Almighty Allah has mentioned the concept of measurement in the Holy Quran. This includes the underlisted verses and Hadith of the Prophet Muhamad, SAW.

وَأَوْفُوا ٱلْكَيْلَ إِذَا كِلْتُمْ وَزِنُوا بِٱلْقِسْطَاسِ ٱلْمُسْتَقِيمِ ۚ ذَٰلِكَ خَيْرٌ وَأَحْسَنُ تَأْوِيلًا

"Give full measure when ye measure, and weigh with a balance that is straight: that is the most fitting and the most advantageous in the final determination". (Quran Chapter 17, Verse 35).

The Holy Prophet صَلَّى اللّٰـهُ عَلَيْهِ وَاٰلِهٖ وَسَلَّمَ also frowned at dishonesty in weighing and measuring at various places:

1. There is a valley in Hell, which is so hot that even a mountain would melt in it, and Hell itself seeks refuge from it; those who are lazy towards Salah and who do not give the full measure when weighing will be imprisoned in it. *(Qurrat-ul-'Uyoon, p. 391 summarised)*

2. On the Day of Judgement, the ones who do not give the full measure of weight, their faces will be disgraced, their tongues will stammer and their eyes will be blue. A scale of fire will be placed on his neck and it will be said, 'Weigh from here to there.' He will be punished in this manner between two mountains for 50,000 years. *(Qurrat-ul-'Uyoon, p. 391 summarised)*

Environmental Chemistry

The practice of green chemistry must be based upon Environmental Chemistry**.** This branch of chemical science is defined as the study of the sources, reactions, transport, effects, and fates of chemical species in water, soil, air, and living environments and the effects of technology thereon. Figure 1 illustrates this definition of environmental chemistry with an important type of environmental chemical Species.

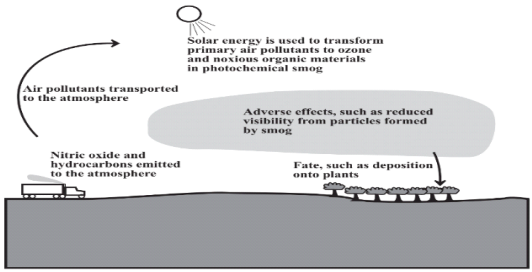


Fig. 1: Nature of Environmental Chemistry

Environmental Pollution

Pollution caused by human activities damages the environment, ecosystems and health. Reducing it is possible, and this is everyone's responsibility. Environmental pollution is the introduction of foreign and potentially harmful elements into the environment. The consequences are particularly important, when they damage ecosystems and human societies, especially with regard to health. Pollution is not a human prerogative; volcanoes, for example, also emit pollutants. It is, however, certain that our species is contributing massively to environmental pollution, and this has increased over the past centuries. There are different types of pollution. The first to be studied were those in which pollutants had physical elements: air pollution, water pollution and land pollution. Some of the major types of environmental pollution are here described.

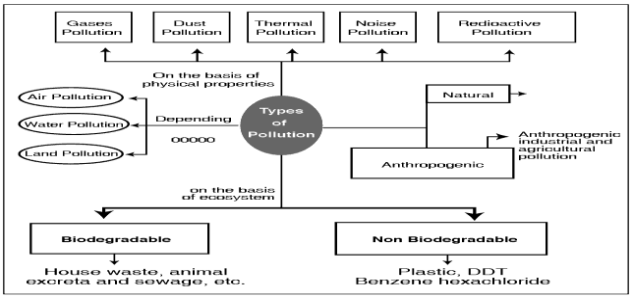


Fig. 2: Types of Pollution

Water Pollution and Material Chemistry

Water pollution now affects virtually all the world's seas, oceans, lakes and rivers. In the sea, the most egregious cases are *oil spills from* shipping disasters, but the problem of *pollution from plastics* and particularly microplastics is becoming increasingly urgent. Fresh water accounts for only 2.5% of all water on Earth; it is the most precious resource for human life. Over 2 billion people live in countries with high levels of water stress, meaning the amount of water available is

less than the amount required. Around 700 million people do not have basic drinking water services. Water pollution is worsening at all stages of the water cycle. The following are some negative ways water pollution can directly affect human health; Ingesting microplastics and drinking water containing chemical waste.

Given that the phrase "materials chemistry," although coined only recently, has become so popular within the chemical community, it is pertinent to ask how materials chemistry should be defined, what it is and (perhaps more importantly) what it is not. Materials chemistry comprises the application of chemistry to the design, synthesis, characterisation, processing, understanding, and utilisation of materials, particularly those with useful, or potentially useful, physical properties. It may be agreed that simply synthesizing a new chemical substance in nano- or macroscopic form is not materials chemistry, but just chemical synthesis. For it to be considered materials chemistry, an element of application, function, or design needs to be present. For example, in the case of "nanomaterials," there should be some indication of special or potentially useful properties that result directly or indirectly from the small size or exceptionally high surface-to-volume ratio of the substance (Peter Day *et al*., 2009).

My Research Focus

Vice-Chancellor Sir, in the course of my career as a teacher of Analytical-Environmental and Materials Chemistry, I contributed both at home and abroad to the existing knowledge in different aspects of analytical-environmental and materials chemistry, with focus on such areas as water quality monitoring, including speciation analysis; investigations and monitoring of organic compounds and heavy metals pollutants in water, soil, sediments and biological tissues; biomonitoring of pollutants, development of an analytical method for the analyses of organic and inorganic compounds; remediation of organics and heavy metals from environmental samples using different approaches; membrane nanotechnology for water filtration research; risk

assessments of environmental data; and environmental toxicology with over 15 years of cognate experience.

For the purpose of this lecture, I have chosen to talk about my contributions in the field of water quality monitoring with emphasis on heavy metals, organic compounds and biotas samples analyses in different media and their associated risk assessments, biomonitoring, membrane nanotechnology for water filtration, research on the remediation of organics, and heavy metals from environmental samples using different approaches.

Determination of Organic and Inorganic Pollutants in Water Samples from Surface, Ground and Marine Water

Vice-Chancellor, Sir, permit me to give an account of several research that we have carried out on water both at home and abroad. What we did was to use the knowledge of analytical chemistry to investigate the presence of these toxic organic and inorganic contaminants in different matrixes, assess their possible risks and used synthesized materials to remove these contaminants from the environment and these translate to leveraging the expertise of Analytical-Environmental and Material Chemist in Environmental Management. In developing nations like Nigeria, the consequences of not having access to safe drinking water are far more severe for human health (Adeniyi *et al.*, 2022; **Okoro** *et al.*, 2024). I have been able established pollution status and was able to generate bankable data on the following rivers: Asa, Oyun and Okun Rivers in Kwara State; Olonkoro River in Oyo State; In addition, I also worked on Pharmaceutical Effluents in Ilorin Metropolis; Groundwater Pollution in Ilorin, Cape Town and Lagos Harbour; Use of Membrane for Water Filtration; Preparation of Biomass for Pollutant Removal; and Testing of Physicochemical Properties of Water.

Monitoring of Organotin Compounds in Cape Town and Lagos Harbours

During my research sojourn in CPUT, Cape Town, South Africa, H.K Okoro carried out research on environmental assessment of endocrine disruptive chemicals such as organotin compounds and heavy metals in the harbour *vis-à-vis* the development of novel analytical methods for organotin analysis in water and sediment in Cape Town harbour and then investigate the use of biomarker to test for the toxicity of these compounds using mussel (*Mytilus galloprovincialis)* (**Okoro** *et al*., 2011; **Okoro** *et al*., 2012a & b). Vice Chancellor, sir, I wish to let you know that this study was the first to be conducted in the whole of South Africa according to available literature. The results show that Organotins have high toxicity towards aquatic organisms (**Okoro** *et al.*, 2011; **Okoro** *et al*., 2012; **Okoro** *et al*., 2015, **Okoro** *et al*., 2016). We used biomarker assays to assess the toxicity of this compound. The results revealed that those organotin compounds are toxic (**Okoro** *et al*., 2015).

Fig. 3: Pictorial View during Sampling from Cape Town Harbour with CSIR Sampling Crew

As a result of dearth of data on the levels of organotin compounds on the West African coast including Lagos harbour, a study was undertaken by Adekola, AbdusSalam, Basheer and **Okoro** (2020), to profile organotin compounds at Lagos Dockyard Harbour, Nigeria. The sediment and water samples were collected for two years (2016–2018) covering both the dry

and wet seasons. Higher values of OTCs were recorded during the wet season than the dry season and this was attributed to the dredging of the harbour and remobilization of organotin compounds from sediments into the water compartment. More so, the study showed that the degradation of these organotin compounds into their metabolites was governed by the influence of specific microorganisms. Therefore, regular monitoring of harbour was recommended for public safety.

Characterisation of Potentially Toxic-Elements in the Environment

Vice-Chancellor Sir, among the different contaminants, potential toxic elements have posed major concerns for environmental and human health on account of their non-biodegradability. Potentially-toxic elements (PTEs), otherwise known as heavy metals have been characterized as potential toxic elements in the Cape Town Harbour in different matrices (water, sediments and biota samples). The mobility patterns, fractionation, risk assessments of PTEs on Cape Town and Lagos Habour were carried out (Fatoki…. & **Okoro** 2012; **Okoro** *et al.*, 2013a&b; **Okoro** *et al.*, 2014b). The determination of PTEs in coal samples in Ewekoro were carried out. The result shows that the selected heavy metals Chromium, Manganese, Nickel, and Lead were present at a high level when compared with heavy metals as determined in coal samples from the literature. There is need for a constant monitoring of the heavy metals and trace elements concentration in coal and minimisation of the use of these materials is necessary (**Okoro** *et al.*, 2017a).

Orosun…and **Okoro** (2023) worked on heavy metal contamination of selected mining fields in North-Central Nigeria. Seventy-two (72) soil samples were collected from the mining fields with 36 samples each from Ifelodun beryllium mining field and Moro gold mining field. Deterministic and stochastic approaches were explored to examine the human health risks. The evaluated Hazard Indices (HI) for the investigated mining locations are < 1, the recommended

threshold provided by the United States Environmental Protection Agency (USEPA) for acceptable non-cancer risk. The estimated cancer risk level for the mining locations exceeds the acceptable range of 1.00E-6 and 1.00E-4. Thus, the mining is making significant contribution to HMs pollution, which is dangerous to human health. However, the Monte Carlo Simulation (MCS) revealed that the 95th, 50th and 5th percentiles of the cumulative probability of the cancer risks are within the acceptable range (Orosun…. & **Okoro**, 2023).

In 2019, El-Imam (The current Commissioner for Health Kwara State) and Okoro moved research to Igbeti, Oyo State, where a study was conducted to investigate heavy metals (As, Cd, Cr, Co, Pb and Ni) concentration of the abandoned marble quarry pond surface water and sediment in Igbeti, Oyo State, the study centered on the physicochemical *properties, heavy metal composition, and metal resistant microorganisms associated with gold mine tailings in Jebba, Nigeria.* The HMs detected include Arsenic (As), Mercury (Hg), Cadmium (Cd), and Lead (Pb). Twenty-one HMRB were isolated with the presence and levels of HMs elucidating the high risk of cancerous and non-cancerous effects borne by artisan gold miners (El-Imam…. *&* **Okoro**, 2023).

Concentrations of these PTEs were also evaluated in vegetable samples, irrigation water, food safety has become a serious global concern because of the accumulation of potentially toxic metals (PTMs) in crops cultivated on contaminated agricultural soils. Amongst these toxic elements, arsenic (As), cadmium (Cd), chromium (Cr), and lead (Pb) receive worldwide attention because of their ability to cause deleterious health effects. Thus, an assessment of these toxic metals in the soils, irrigation waters, and the most widely-consumed vegetables in Nigeria such as; Spinach (*Amaranthus hybridus*), and Cabbage (*Brassica oleracea*) was evaluated using inductively-coupled.

Thus, an assessment of these toxic metals in the soils, irrigation waters, and the most widely-consumed vegetables in Nigeria; Spinach (*Amaranthus hybridus*), and Cabbage (*Brassica*

oleracea) was evaluated using inductively-coupled plasma-optical emission spectroscopy (ICP-OES). The mean concentration (measured in mg kg^{-1} of the PTMs in the soils was in the sequence Cr (81.77) > Pb (19.91) > As (13.23) > Cd (3.25), exceeding the WHO recommended values in all cases.

The concentration of the toxic metals was higher in spinach than in cabbage, which may be due to the redistribution of the greater proportion of the metals above the ground tissue, caused by the bioavailability of metals in the aqueous phase. Expectedly, the hazard index (HI) and carcinogenic risk values of spinach were higher than that of cabbage. This implies that spinach poses potentially higher health risks. Similarly, the Monte Carlo simulation results revealed that the 5th percentile, 95th percentile, and 50th percentile of the cumulative probability of cancer risks due to the consumption of these vegetables exceed the acceptable range of 1.00E−6 and 1.00E−4. Thus, the probable risk of a cancerous effect is high, and necessary remedial actions are recommended (Orosun…& **Okoro, 2023)**.

Adsorption Study using Metal Organic Framework

Mr. Vice-Chancellor, I am delighted to inform you that I belong to many research groups, and we have carried out many remediation studies on organic and heavy metals pollutants removal from the environment. Metal organic framework (MOF) was used to carry out adsorption studies to remove both organic and heavy metals pollutants from the environment. Availability of hazardous contaminants such as heavy metals in both terrestrial and aquatic environments especially in certain solid particulates like soils and sediments has come to the limelight owing to sundry pollution and contamination challenges principally in terms of their ability to make it one way or another into the human body system (**Okoro** *et al*., 2017b).

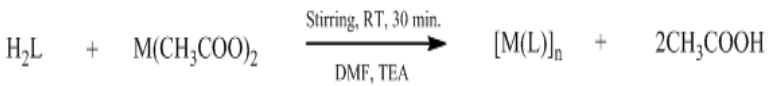
MOFs were discovered in the past years and its excellent features, for example, as high surface area and tune-able pore size, among others, has made them to be useful in the remediation of pollutants from the environment (**Okoro** *et al.*, 2018). Different methods have been used widely in the synthesis

of MOFs, these includes solvothermal methods that is variation of some parameters such as temperature, the concentration, pH and ligand (Tella…& **Okoro,** 2017a).

During the course of this study, we were able to synthesize the zinc (II) and copper (II) metal-organic frameworks (Benzene 1,4-Dicarboxylic acid; BDC) and apply them to remove some 3d metals from aqueous solution and in the adsorption of PAH from wastewater. Resultant metal-organic frameworks characterisation was done with the aid of X-ray Diffraction (XRD), Fourier Transform Infrared Spectrophotometry (FT-IR), Energy Dispersive X-ray (EDS) spectroscopy, Scanning Electron Microscopy (SEM), Transmission Electron Micrograph (TEM) and pH point of zero charge (PZC). The adsorptive procedure employed to test the kinetic, equilibrium characters and thermodynamics behavior was the batch process.

The data showed that for copper; the metal-organic frameworks have an adsorptive capacity of 157.316 mg/g and 134.643 mg/g for Cu-BDC and Zn-BDC while the MOFs have an adsorption capacity of 145.144 mg/g and 138.158 mg/g for Cu-BDC and Zn-BDC when tested with zinc. The experimental data of the synthesised MOFs clearly indicated that they have great potential in remediating the subject metals in aqueous medium. The result of the re-usability test of the MOFs suggested that the MOFs have excellent recovery and re-usability capacity (**Okoro** *et al.,* 2018; **Okoro** *et al.,* 2019a, 2019b; **Okoro** *et al*., 2020; **Okoro** *et al.,* 2021a; Tella…& **Okoro,** 2022).

Ligand Metal ions Metal ions on the MOFs



(H_2L – Terephthalic acid; M – Zn or Cu)

Scheme 1: Scheme showing the reaction of the synthesis of the zinc and copper Metal Organic Frameworks (MOFs).

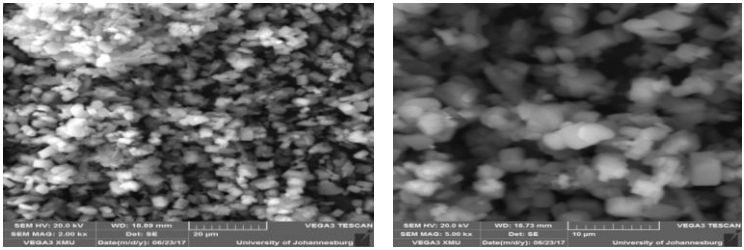


Fig. 4a & 4b: Scanning electron microscopy (SEM) image for Cu-BDC at a magnification of 5.00 Kx and 2.00 Kx

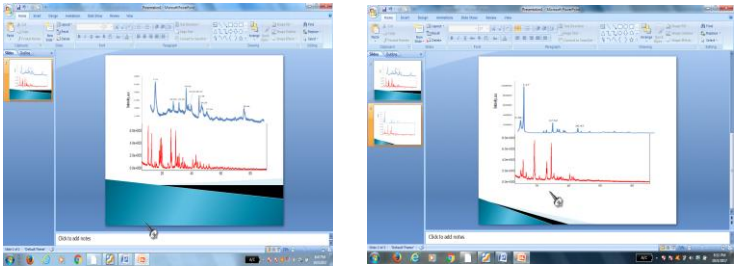


Fig. 5a & 5b: X-ray Diffraction plot for Cu-BDC (red) compared with CCDC standard (blue)

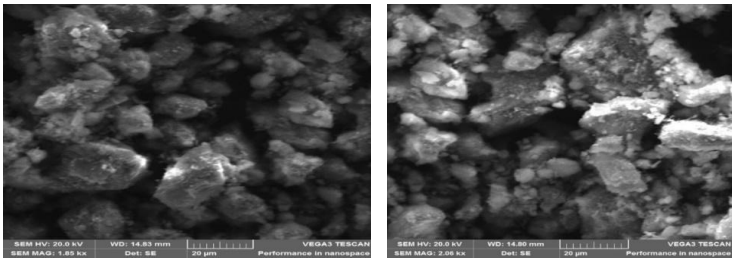


Fig. 6a & 6b: Transmission electron micrograph of ZnBDC at a magnification of 2.06 kx and 1.85kx

Over the years, highly ordered structured inorganic porous materials have been employed in separation and catalysis. In Nigeria, the utilisation of these materials has been channeled basically at combating toxic materials released in our

environment. Notable among these toxins are the polycyclic aromatic hydrocarbons (PAHs), which are typical pollutant from the oil and gas industries. This research employed the application of metal organic frameworks (MOFs) of zinc and copper-based materials in the removal of naphthalene and anthracene. Naphthalene and anthracene adsorption was investigated with both Zinc Benzene 1,4-Dicarboxylic (Zn-BDC) and Copper Benzene 1,4-Dicarboxylic (Cu-BDC) MOFs. Ninety-seven percent (97%) and 50% removal were recorded for naphthalene and anthracene, respectively.

The great success recorded for Naphthalene has been attributed to the tighter fitting between the pores of the MOFs materials and naphthalene, as naphthalene molecules are less sterically-hindered as compared to anthracene. Desorption and reusability result showed that both MOFs materials demonstrate high regeneration capacity, and the reuse of the materials proved effective for three batch adsorption process (**Okoro** *et al.,* 2018; **Okoro** *et al*., 2019a, 2019b; **Okoro** *et al.,* 2020; **Okoro** *et al*., 2021a; Tella… & **Okoro**, 2022**).**

Remediation of Water Contaminants using Biomass

Okoro and Adeniyi (2023) worked on the use of different biomass such as: Cassava peels, lime-peels, sugarcane barggass, plantain peels, teak leaves, Malaina leaves, bamboo leaves and so on to mention but a few to produce biochar and clay impregnated biochar and their applications in wastewater treatment, aquaculture and pharmaceutical effluents. Applications of biomass materials as natural adsorbents for water contaminants were explored. The study found that modifying the adsorbents enhances their capacity, with K_2CO_3-activated bean pods. Challenges and opportunities in using bean pods, husks and other biomass materials for water purification were carried out (Emenike….& **Okoro**, 2023; Emenike….& **Okoro**, 2024; Emenike…& **Okoro**, 2025; Iwuozor…. & **Okoro** 2024a&b; **Okoro** *et al.,* 2024; **Okoro** *et al.,* 2025). Our research group also explored the efficacy of sugarcane bagasse-derived materials in a packed bed system for remediating aquaculture wastewater, with the goal of ensuring environmentally safe discharge. This study

examines the effectiveness of sugarcane bagasse-based materials as a cost-effective and green alternative for industrial wastewater treatment (**Okoro** *et al.*, 2025).

Okoro, Adeniyi and Iwuozor (2025), also explored the efficacy of sugarcane bagasse-derived materials in a packed bed system for remediating aquaculture wastewater, with the goal of ensuring environmentally safe discharge. The bagasse fibres (SCB) were mercerised with sodium hydroxide (NaOH-SCB) and carbonized into biochar (SCB). Characterization techniques revealed significant chemical and physical changes in the modified bagasse, including changes in elemental composition, surface area, and thermal stability. The modified materials exhibited increased surface area and reduced pore size, and SCBB being the most thermally stable. The effect of contact times (30 min, followed by 1, 2, and 24 h) was studied on the treatment of fishpond effluent with bagasse-based materials. Physico-chemical parameters measured were temperature, pH, total dissolved solids, total suspended solids, electrical conductivity, dissolved oxygen, chemical oxygen demand, biological oxygen demand, and colour. The concentrations of metals (iron, magnesium, manganese, and copper) were also analysed.

The treatment with the filter materials was effective in positively regulating various physico-chemical parameters of the effluent; however, it had a negative effect on the electrical conductivity and total dissolved solids. Among the materials, SCBB was the most effective for improving physico-chemical parameters, while NaOH-SCB was more effective for reducing the concentration of metals in the effluent. The optimum contact time for the treatment was observed to be 24 h for SCB, 2 h for NaOH-SCB, and either30 min or one hour for SCBB. This study examines the effectiveness of sugarcane bagasse-based materials as a cost-effective and green alternative for industrial wastewater treatment.

Nanoremediation Studies

Cadmium contamination of agricultural soils is a serious problem due to its toxic effects on health and yield of crop

plants. Ogunkunle and **Okoro** (2020b) investigated the potential of low-dose nano-TiO_2 as soil nano-remediation on Cd toxicity in cowpea plants. The study concluded that soil application of nano-TiO_2 could be a green alternative to ameliorate soil Cd toxicity in cowpea plants. **Okoro** and Lawal (2020) at the University of Johannesburg, South Africa carried out adsorption of pharmaceuticals using graphene oxides (GO) functionalized with ionic liquids (IL) in 2017. Pseudo-second-order and Langmuir models best explained the kinetics and adsorption isotherm, respectively. Graphene Oxide- Ionic Liquid (GO−IL) showed superior adsorption efficiency for the selected pharmaceuticals when compared to graphene oxide GO.

Membrane Nanotechnology Research for Water Filtration

Before I started working on membrane nanotechnology research. I received training from Prof. J.C. Ngila during my Postdoctoral Fellowship under her supervision at the Department of Applied Chemistry, Faculty of Science, University of Johannesburg, South Africa. My first research in this area focused on using membrane for water filtration (**Okoro** *et al.*, 2017) Various technologies have been employed for wastewater treatment. These include chemical precipitation, coagulation-flocculation, ion-exchange, adsorption, evaporation, biosorption, and membrane filtration. There are many advantages of membrane technology over other techniques and these include high separation efficiency, no phase changed involved, eco-friendly, ease of operation, and scale up, energy saving. The introduction of polymeric membrane technology has been useful in solving problems related to wastewater treatment. The advantages of membrane technology include cost, less chemical consumption, and small footprints, among others. However, polymers widely used in the preparation of polymeric membranes such as polyvinylidene difluoride (PVDF) and PES possess notably hydrophobic properties.

This study reports a simple fabrication of polyethersulfone (PES)-based membranes, their characterisation, and application. These membranes are modified with hyperbranched polyethyleneimine (HPEI) and -silver (nAg)-

decorated HPEI., These were then compared for filtration, organic fouling, antifouling, and antibacterial properties against the neat PES membrane. The fabricated membranes were characterised for their chemistry using attenuated transmission reflectance-equipped Fourier transform infrared spectroscopy (ATR-FTIR) and x-ray photoelectron spectroscopy (XPS). As such, the presence of HPEI interactions between the nAg and HPEI in the membranes was confirmed. An energy-dispersive x-ray detector coupled scanning electron microscopy (SEM-EDS) and atomic force microscopy (AFM) were used to study morphological, compositional, topographical, and topological changes to the membrane owing to the modifications. A thermogravimetric analyzer (TGA) was also utilised to evaluate the effect of modification on thermal stability of the resulting membranes.

The results of the BSA rejection for the HPEI/PES membranes were a maximum of 98% while those of the nAg@HPEI/PES ranged between 30-87%. The membranes possessed high flux recoveries, indicating great potential for the membranes for antifouling applications in water treatment. Extensive antibacterial studies were carried out on the membranes to probe bioactivity. Enhanced activity was recorded (except for neat PES) with zone inhibitions of up to 7 mm against five bacterial strains including *E. Coli* and *K. Pneumoniae* as found in several wastewater streams. The antibacterial properties of these membranes mean they can prolong membrane operational lifetime by mitigating bio-filming during water treatment (**Okoro** *et al.*, 2017; **Okoro** *et al.*, 2021b).

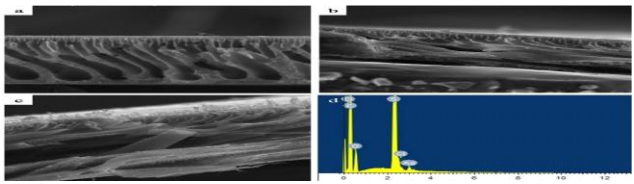


Fig. 7: SEM cross-sectional membrane micrographs of neat PES (a), nAg@1% HPEI/PES, and nAg@3%HPEI/PES, and the EDS spectrum of nAg@3%HPEI/PES

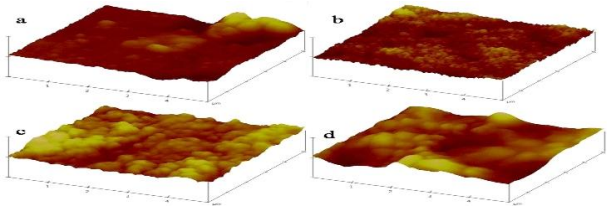


Fig. 8: AFM 3D Micrographs for the Fabricated Membranes with increasing Modification

Heavy Metals in Water Samples from Different Groundwater Locations

Vice-Chancellor Sir, heavy metals analyses of groundwater samples collected from the central industrial district of Ilorin, Kwara State was carried out to assess the suitability of the water for human consumption and domestic purposes. The result reflects probable pollution from the industrial effluent which is often released into storm water channels without further treatment (**Okoro** *et al*., 2012). Another study was carried out as a follow-up on the assessment of ground water in Iloffa community. It was observed that most of the polluted waters are those located close to dumpsites. Therefore, it is necessary to consider the industrial activities and other activities in areas to dig wells or boreholes (**Okoro** *et al.,* 2017b). Orosun and **Okoro** (2024b) evaluated the sources and potential health hazards of heavy metals in groundwater samples from Ilorin, Nigeria. In the children's population, the highest cancer risk (ILCR) was 5.83 for Cd in location 1 (Oke-Ose). The cancer risk of Cd and Cr for both children and adults were found to be higher than the permissible limit, potentially leading to a rise in the number of incidences of carcinogenic health consequences among the local population. This study was undertaken to also emphasize the mutuality between water pollution and the 2030 Agenda for Sustainable Development Goals (SDGs).

Organic and Inorganic Contaminants in Water and Sediment Samples from Asa, Oyun and Okun Rivers

Evaluation of the levels of polycyclic aromatic hydrocarbons (PAHs) in water samples collected from Asa and Oyun River within Ilorin in Kwara State. Gas Chromatography-Mass spectrometry has been used for the analytical determination. A total of 52 hydrocarbons were found to be present in the water samples. These two rivers can be said to be contaminated with PAHs. The pollution can be attributed to both anthropogenic and natural sources. The water needs to be adequately treated and regularly monitored. Future evaluation of human health risk assessments, seasonal monitoring of PAHs in the rivers and possible remediation studies are recommended. (Adekola…& **Okoro**, 2015).

Potentially toxic elements (PTEs) are widely released into the environment as a result of increased urban and industrial development in recent years. The bulk of PTEs are cancer-causing and harm human health by producing free radicals. As a result, it is crucial to monitor, evaluate, and limit the effects of the elements on human health. **Okoro** and Orosun (2024b) carried out health and ecological risk assessments levels of PTEs (As, Cr, Cd, Ni, Co, and Pb) in pharmaceutical effluents discharged into the Asa River around the Ilorin metropolis and their seasonal variations were evaluated. As, Cd, Pb, Cr, Ni, and Co had mean PTE values in the effluents (both seasons) of 0.0258, 0.0233, 0.00193, 0.0176, and 0.0164 mg/L, respectively, with As and Pb surpassing the WHO standard. The average values of the metals in the human risk assessment for carcinogenicity were As > Cd > Pb > Cr > Ni > Co, with As above the recommended threshold in several locations. However, all of the metal hazard indices were < 1, indicating that the waters were suitable for domestic purposes. Nonetheless, the relevant authorities should mandate that pharmaceutical effluents be treated before being released into bodies of water. However, the incremental lifetime cancer risk for arsenic and nickel was high and required attention. The ecological risk assessment

showed that lead and arsenic were the major PTEs pollutants in all locations. The study identifies PTEs profiles in sediments and emphasizes the necessity of continual monitoring and action to stop long-term negative impacts on the local environment and public health.

Okoro *et al.* (2015) carried out determination of concentrations, , bioavailability and mobility of priority metals in sediments of Oyun River, Sango, Ilorin, Nigeria. The result obtained clearly indicates that with the exception of Cu, the metals are highly bioavailable leading to it having a higher impact on its target system, subsequently leading to contamination of the water. The high percent bioavailability is an indication of poor retention in the residual geochemical form partly due to saturation of the sediment (river). The high percentage of Mn, Cd and Pb in the bioavailable forms suggested the need to keep close surveillance on these metals because of their high toxicity (Okoro *et al*., 2015). Similarly, Iyiola and **Okoro** (2016) carried out a study on bioaccumulation of heavy metals and cytogenotoxic effects that could result from exposure of fish to heavy metals in the Asa River, Ilorin, Nigeria. The three different fish species, **Redbelly tilapia** (*Tilapia zilli), **Nile tilapia** (Oreochromis niloticus)* and **Mango tilapia** (*Sarotherodon galilaeus)* were obtained from the Asa River and the fourth species, **African catfish** (*Clarias gariepinus)* was cultured in the laboratory to serve as control. The fish organs; bone, gills, kidney and liver from the four fish species were carefully dissected for the determination of some heavy metals. Genotoxicity results in this study showed that the Asa River water contains genotoxic metals, which may be responsible for the micronucleus and nuclear abnormalities observed in the aquatic environment.

In a similar dimension, assessment and the distribution of four phenolic compounds in Asa River were investigated. This study provided information about the quality of water and sediment collected from the river. The major findings of this research showed the presence of phenol and 2-chlorophenol in

water and sediment from some locations. The discharge of industrial and domestic waste in addition in relation to the unprecedented levels of inflow to the historical input run off of pesticides residue into the Asa River has contributed greatly to the high concentration of phenols and its derivatives in some locations. Also, the result of hazard quotient HQ (non-carcinogenic risk) showed that continuous exposure to phenol and 2-chlorophenol by adults and children through various activities could have serious health implications. Our study revealed that there is need to invest more in water research development. Plastic usage should also be eliminated as much as possible as it favors the persistency of phenolic compounds in the environment. It is also important to create awareness by spreading the message about how important aquatic life is and why we need to protect it (**Okoro** *et al*., 2024c).

Okun river in Ilorin caters for diverse needs as a result of rapid industrialisation and urbanisation, the quality of the river is significantly affected. The study of impact of discharged industrial wastewaters into Okun River was carried out. The mean concentrations of heavy metals and the physicochemical parameters determined were compared with standards and tolerance limit. Cr was not detected in all the samples while Mn, Fe, Cu, Zn and Cd concentrations varied from 0.10-3.47 mg/L, 2.64-9.65 mg/L,0.37-3.79 mg/L, 0.22-1.53 mg/L and 0.00-0.03 mg/L respectively. The principal component analysis confirmed the heavy metals to be from anthropogenic and industrial origin (**Okoro** *et al.,* 2019c).

Heavy Metals Analysis in Sediment Samples from Olonkoro River and Ureje Rivers

Research attention and interest also got to Oyo and Ekiti States on the Rivers Olonkoro and Ureje River, respectively. The study focused on the fractionation profile, mobility patterns and correlations of heavy metals in estuary sediments from Olonkoro River, in Tede catchment area of the South-West region, Nigeria. In general, the total metal concentrations were in the order: Fe > Zn > Mn > Cu > Pb > Cd in sediment samples and for Tessier's

sequential fractionation, manganese was found to be more in the exchangeable phase, Fe in the Residual, Zn in carbonate-bound metal while Pb was greater in the exchangeable form and Cu was found to be more concentrated in the organic phase. Percent of bioavailable and non-bioavailable proportions of heavy metals for Mn, Fe, Cu, Zn, Pb, and Cd in the sediment samples varied between 12.92-87.08, 11.57-88.43, 0.29-99.71, 10.76-89.24, ND-100 and ND, respectively. The high percent bioavailability is an indication of poor retention in the residual geochemical form partly due to saturation of the sediment in the river. The high percentage of Mn, Cd and Pb in the bioavailable forms suggested the need to keep close surveillance on these metals because of their high toxicity (**Okoro** *et al*., 2017).

On the Ureje river, this study investigated the level of contamination of four heavy metals (chromium, cadmium, nickel, lead) in the sediment collected from the river located in Ado-Ekiti, Nigeria from the river located in Ado-Ekiti, Nigeria. Ado Ekiti, Nigeria and compared their seasonal variations during the wet and dry seasons. Comparing the two seasons, the concentration of chromium was observed to be lower than that of lead in the dry season while the reverse was the case during the wet season. Although the concentration of the metals is unlikely to pose any risk, the presence of chromium and lead in the area calls for proper monitoring to safeguard the health of human and aquatic lives around the area (**Okoro** *et al.,* 2015b).

Microchemical Analysis of Endocrine Disruptive Chemicals in Water and Sediment Samples from Oyun, Asa and Cape Town Harbour, South Africa

With the aim of working on the bad aspects in the environment as one of the roles of an analytical and environmental chemist, comprehensive studies were carried out on the endocrine disruptive chemicals owing to their toxicity and harmful effects in the environment. Endocrine disruption refers to the ability of chemicals or substances at a certain dose to interfere with hormonal systems in the body (**Okoro** *et al*., 2017c). The contamination of the environment by organic

pollutants is a major risk factor, particularly for developing countries. In 2022, H.K Okoro and research group wrote a comprehensive review article published in Emerging contaminants, *Elsevier Science Direct Journal on the Selected Organic Pollutants* (SOPs) like the phenolic compounds, polyaromatic hydrocarbons (PAHs), pesticides, and herbicides (**Okoro** *et al*., 2022a).

Based on the above observations on the EDCs and emerging contaminants we decided to check the following EDCs in our environment: Phthalate, Phenols, Polyaromatic Hydrocarbons (PAHs), Organotin compounds and Pesticides. a Yoruba adage says: "***ile ni ati nko eso rode"*** "meaning charity begins at home'' "but don't end it there" H.K. Okoro, M.M. Orosun, A. Muhaliyu (University of Ilorin); Saheed AbdulGaniy King Fahd University of Petroleum and Saheeed Abiodun Popoola, University of Medinah, Saudi Arabia, investigated Ecological risk assessment and phthalate ester concentrations in sediment samples from Ilorin metropolis, North-central, Nigeria. Ecological risk assessment revealed that only DEP likely posed a minimal risk. While the findings indicate that the phthalates pose minimal or no risk, there is a need for comprehensive phthalate monitoring in these locations to minimize the influx of these substances. This proactive measure is essential to prevent potential disruptions to the delicate equilibrium of the ecosystem, which could result in a catastrophic loss of biodiversity (**Okoro** *et al*., 2017; **Okoro** *et al.*, 2022a; **Okoro** *et al.*, 2024c). The analysis was carried out in Saudi Arabia in conjunction with my research collaborators there.

A pilot study on the determination of phenolic compounds in four different locations along the Oyun River, in North-central, Nigeria. Analysis was carried out using HPLC technique. Samples were collected from the upper, middle and lower stream from each of the sampling stations. The collected samples were extracted, pre-concentrated and analysed by HPLC technique. Among the phenolic compound studied, chlorophenol has the highest concentration of 13.01 ppm at location 4, while

2,4dinitrophenol has the lowest concentration of 2.036 ppm at location 1. The study revealed the presence of phenols compounds in Oyun River. Conclusively, it is pertinent to continue with the constant monitoring of the river because high levels of these endocrine pollutants could pose dangerous health effects to human and aquatic lives. More attention is needed in curbing the rate of pollution in our rivers. However, United Nations Sustainable Development Goals (UN-SDGs) must be our core priority and target to achieve better living (**Okoro** *et al*., 2022b).

In the spirit of research collaboration **Okoro** and Adetitun (2019) investigated levels of some PAHs, and capacity of microbes isolated from soil contaminated with diesel utilizing hexadecane. Bacteria and fungi were isolated and identified using standard microbiological methods. Identification and quantification of PAH, metal was accomplished using standard methods. A total of fifteen fungal species were isolated and identified. The results showed that six of the USEPA targets PAH assayed were detected. In both the Cape Town and Lagos Harbours as reported in our previous studies (**Okoro** *et al*., 2012; **Okoro** *et al.,* 2015; **Okoro** *et al.,* 2016; Basheeru…& **Okoro**, 2020), Mr. Vice- Chancellor, I must let you know that the paper we published on the Lagos harbour research was achieved during the lockdown period in 2020 in one of the high impact factors journals: *International Journal of Environmental Analytical Chemistry* published by Taylor and Francis.

I am glad to let you that apart from research articles, we have written review articles and book chapters and many international conference presentations from our findings about this endocrine disruptive chemical called organotin compounds (**Okoro** *et al.,* 2011a; **Okoro** *et al.,* 2011b; **Okoro** *et al.,* 2014; **Okoro** *et al*., 2015; **Okoro** *et al.,* 2016; Basheeru…. & **Okoro**, 2020). The study on the analysis of pesticides in carbonated soft drinks was carried out to determine the levels of pesticide contamination in the samples. It can be deduced that the presence of organochlorine pesticides in the samples were from

the use of fruit extracts prepared as flavors in soft drinks and fruit-based drinks. The use of chemical pesticides by farmers and industries should be replaced with organic pesticides (**Okoro** *et al.*, 2018).

Method Development for the Determination of Organotin and Phenolic Compounds in Water and Sediments Samples Collected from Surface and Marine Water

Mr. Vice-Chancellor, I am glad to inform you that my research groups were able to contribute significantly in this regard because many researchers have been adopting the method we developed on organotin and phenolic compounds analysis in different sample media using gas chromatography-flame photometry detector (GC-FPD) and high-performance liquid chromatography (HPLC) techniques respectively. The first method development we did was on the use of gas chromatography-flame photometry detector (GC-FPD) (**Okoro** *et al.*, 2012). Analytical methods for speciation of targeted organotin compounds (TBT and TPT) in water samples using SPE cartridge and liquid-liquid extraction. Also, sediment analysis using methanol - acid digestion and acid-sonication extraction methods were also developed. Different parameters affecting extraction and peak resolution were optimized. Also, three derivatisation procedures were optimised.

The accuracy of the extraction procedure was also verified on certified reference material (BCR - 462) certified for TBT (54 ± 15 µg/kg) and DBT (68 ± 12 µg/kg). Good recoveries were obtained with methanol - acid digestion. The results were validated by analysing the real water and sediment samples collected from the Cape Town harbour and the compounds were detected in both water and sediment samples at substantial concentration, respectively (**Okoro** *et al.*, 2012; **Okoro** *et al.*, 2016). Research on phenolic compounds is of current interest since they have important biological and pharmacological properties. HPLC is one of the advanced techniques for routine analysis of phenolic compounds. In our method development on HPLC, the experimental results

demonstrated that the HPLC method offers excellent recoveries and could be employed for environmental sample analysis. In view of its rapidity, simplicity, environment-friendly nature, the optimised method was an excellent alternative detection technology for phenol analysis and can be widely employed in environmental and other related fields (**Okoro** *et al.*, 2019).

Contributions to Manpower Development in Nigeria and Globally

- I have supervised more than ninety (90) undergraduate research project students at the University of Ilorin, Ilorin, Nigeria and I have equally supervised five (5)) undergraduate research projects at Cape Peninsula University of Technology, Cape Town, South Africa. I have successfully supervised fifteen (15) M.Sc. students for their Master degree Dissertations in Industrial Chemistry. In addition, I am currently supervising three (3) Master students.
- I am currently supervising seven (7) Ph.D. students in Industrial Chemistry with a focus on the area of Analytica-Environmental and Materials Chemistry.
- Vice-Chancellor Sir, it is my pleasure to mention some of my mentees: Assoc. Prof. Saheed AbdulGaniy, Chemistry Department, King Fahd University of Petroleum & Minerals; Dr. Wasiu Afolabi, Technology Portfolio Manager, King Abdullah University of Science and Technology, Saudi Arabia; Dr. Mujeebah is working as a forensic drug analyst in a forensic company in the United States of America; Mr. Julius Ige, Principal Scientific with Raw Materials Research and Development; Mr. Seyi Ayika, Assistant Lecturer, Kogi State University, Kaaba; Mr. Seun Ajibola, Lecturer 2, Federal University of Allied Health Sciences, Enugu; Mr. Kingsley Iwuozor, Head, Factory Operations Department, Nigeria Sugar Institute, Ilorin; Mr. Usman Umaru, Lecturer I, Federal University of Education

Kontagora; Mrs. U.O Imam Aliagan, Assistant Lecturer Kwara State University, Malete; Mrs. Omisola Oluwakemi Ruth Administrative Assistant Universal Elysium Consortium (Concessionaire of Onitsha Port, Anambra State), Mr. Adekola Adebayo, Product Manager, Infiniti Venture Laboratory. Ms. Ogunbire Victoria Abosede (Quality Assurance Officer, Ayo-Ayodele Pharmaceutical Chemist Nigeria Limited), Ms. Oderinde Oluwadamilola (Sales Rep, Seven-up bottling company).

Community Service

Vice-Chancellor Sir, some of my major community services include:

A. University of Ilorin Assignments

- Faculty Representative, UNILORIN Sugar Research Institute (2025- Date)
- Board Member, University of Ilorin Apiary Board Management (2023-2024)
- Ag. Head of Department, Department of Industrial Chemistry (2021-2023)
- Deputy-Director (Training): Centre for Research Development and In-house Training (2020-2023)
- Deputy-Editor-in-Chief Ilorin Journal of Science (2019-2021)
- Faculty of Physical Science Representative, Junior Staff Appointment and Promotion Committee (2021-2025)
- Faculty of Physical Science Representative, Faculty of Environmental Sciences, University of Ilorin, Nigeria (2018-2020)
- Secretary, University of Ilorin Water Monitoring Committee (2020-2023)
- Assistant Postgraduate Coordinator, Department of Industrial Chemistry (2019-2021)
- Examination Officer, Department of Industrial Chemistry (2017-2018)

- Academic Level Adviser, Department of Chemistry & Industrial Chemistry (2013-2018)

B. National Assignments

- External Assessors, Promotion of Academic Staff Member to Professor in some Universities inside the country: Federal University of Oye-Ekiti (FUOYE) (2025-Date)
- Supervisor, Joint Admission and Matriculation Board (JAMB) (2018-Date)
- Resident/Collation Officer, Independence National Electoral Commission for the 2019 General Elections: ASA Local Government Area, Asa, Kwara State

C. Regional and International Assignments

- Pioneer Editor In-Chief for the U6+ Multidisciplinary Journal for African Development (2025-Date)
- International External Assessors, Promotion of Academic Staff Member to Professor in some Universities outside the country: King AbdulAzeez University, Jeddah, Saudi Arabia (2024-Date)
- International External Examiner of Master Dissertations and Ph.D. Research theses, University of Pretoria, South Africa (2024); University of Venda, South Africa (2024). At the National Levels: External Examiner for PhD Thesis at Federal University of Technology, Minna.
- Chairman, Technical Sub-Committee for the 2024 AfricaLics (LOC) Conference held at the University of Ilorin (November, 13-15, 2024)
- Editor-in-Chief for the Editorial Board of 2024 U6+ Consortium of African Universities International Conference held at Cape Peninsula University of Technology, Cape Town, South Africa (September, 9 - 12, 2024)
- Desk Officer, Signing and implementation of Memorandum of Understanding (MoU) between University of Ilorin and Cape Peninsula University of

Technology, Cape Town, South Africa (13th December 2023 – Date)

- Coordinator/Facilitator, University of Ilorin Academic and Non-Academic Staff Training on Digital Learning Africa, organised by International Business and Economic Forum Conference, 2022.
- Editorial Board Member, *Annals of Applied Science Journal* (2021-Date)
- Review Editor, Frontier in Environmental Chemistry (2022-Date)
- Reviewer to many International Journals of high impact factors.
- Coordinator and Data Manager, World Time Higher Education, World University Ranking (2021).
- Duties "Entering of University Data, Validation of Data and Subject offered" at University of Ilorin, Nigeria (2021-2023)
- Amir, Cape Town Duah Forum, Cape Town, South Africa (2010-2013)
- Research Assistant, Chemistry Department, Faculty of Applied Sciences, Cape Peninsula University of Technology, Cape Town, South Africa (July, 2010 - Jan. 2013)
- Part-Time Lecturer, Department of Chemistry & Chemical Engineering, Cape Peninsula University of Technology, Cape Town, Republic of South Africa (Jan. - June, 2010).

D. Other Community Services

- Secretary-General, Chemical Society of Nigeria, Kwara State Chapter (2020-2023)
- Assistant Secretary and Secretary-General, *The Companion*, Kwara District (2013-2021)
- Ushra Coordinator, *The Companion,* Kwara District (2021-2024)

Conclusion

Vice-Chancellor Sir, environmental pollution is a major global issue for both developed and developing economies and it is increasing gradually, with impact on living organisms, including humans. The condition has worsened in recent times, as various authorities have postulated several control measures to combat water pollution. It is, therefore, very important that we prevent pollution rather than treat symptoms of pollution. Experience has shown that remedial actions to clean up polluted sites and water bodies are generally much more expensive than applying measures to prevent pollution from occurring.

From this lecture, it has been established that the sources of bad substances in the environment are not limited to industrialisation, urbanisation, agriculture, oil, air and soil pollution, wastes from commercial and house garbage. It is, therefore, necessary to let us know that several creatures survive underground. Disrupting the harmony of the environment by improper waste disposal, is disrupting their habitat. This has led to several creatures reaching the endangered status. We walk and survive on land. It is literally the base of our ecosystem. It is in our good interest to manage our environment and nurture it. It is also necessary that we identify the presence of pollutants and good substances that we can use as a control measure, as reflected in this lecture.

Recommendations

Vice-Chancellor Sir, it is pertinent to make the following recommendations to checkmate, reduce and prevent the vast increase in environmental pollution. The ban on the use of antifouling agents has been enforced in European and other developed countries but this is not the case in Africa.

1. The Federal Government should put in place legislation banning the importation and use of ships coated with antifouling agent in our marine ecosystem. if this law is put in place, the level of organotin pollution will be minimised.

2. The Federal Government agencies such as the National Environmental Standards and Regulations Enforcement Agency (NESREA); National Water Research Institute (NWRI); Federal Ministry of Environment to step up the regular monitoring of these endocrine-disrupting chemicals and other potential toxic chemicals presents within the surface, marine and groundwater bodies of our dear nation.

3. The Federal and State Governments through their Ministry of Environment need to put in place adequate control measures to ensure compliance with national and international regulations on the protection of water systems; There is also a need for adequate surface, groundwater and marine water and sediment quality guidelines for Nigeria as a nation.

4. Nigerian government should provide state-of-the-art facilities in our universities to avoid eradication of this type of subject in our tertiary institutions owing to lack of facilities.

5. Universities Management should support the graduate and undergraduate students through the provision of University Research Fund as it applies in other climes such as South Africa, India and other European countries.

6. The Federal and State Government through the Ministries of Water Resources should build wastewater treatment plant (WWTP). This must be designed and planned properly to ensure the safety and health of our communities and protect our environment from water pollution. When planning a WWTP, we need to consider some factors such as: population density, projected growth, water usage, regulations and available treatment technologies. Although wastewater treatment facilities have been installed and improved upon over the years in many countries, the reverse is the case in our country, Nigeria.

7. The Federal Government should establish major and well-equipped research laboratories with state-of-the-art facilities in different geopolitical zones. This will ease the problems and challenges being faced by researchers when they need to analyse their samples. Majority of our doctoral students, who are in the area of Analytical-Environmental Chemistry find it difficult to recognise not to talk of operating analytical instruments because these are not provided. They rather send samples abroad for analysis after their sample preparations. This is a big problem our stakeholders need to handle and address urgently to prevent the crash of our education system.

8. The Federal Government should make the laws flexible to allow researchers to place order for chemicals they needed for their research and charge relevant organizations such as the Standard Organization of Nigeria (SON), Institute of Charted Chemists of Nigeria, Chemical Society of Nigeria to champion this course.

9. The Federal and State Governments should not neglect the postgraduate students because they are the heartbeats of any university in terms of research outputs. Bursary/Scholarships should be made available to

support postgraduate students to reduce the *Japa* syndrome that are facing today.

10. Government agency like TETFUND should create the idea of rewarding researchers who publish their research findings with high impact journals. This practice has started here in *our better by far university,* University of Ilorin. I implore the university management not to relent because it motivates researchers to do more.

ACKNOWLEDGEMENTS

Vice Chancellor Sir, First and foremost, I would like to acknowledge the Almighty Allah, the Lord of the Universe and the All-knowing for seeing me through to this enviable position and the zenith of my academic career *Alhamudulilah Robi Li Alaminah.* Praise be to Allah, the Cherisher and Sustainer of the Worlds.

I thank the Vice-Chancellor, Professor W.O. Egbewole, SAN, for the opportunity given to hold this lecture. I wish to appreciate Professor A. A. Fawole (DVC, Management Services), Professor Mojirade T. Bakare-Odunola (DVC, Academic), Professor M. Etudaiye (DVC, Research, Technology and Innovation), Mr. M.A. Alfanla (The Registrar and Secretary to Council), Professor K.T. Omopupa (The University Librarian), Mr. A. Lawal (The Bursar) and other management staff of this University for this honour.

Special thanks to our amiable, indefatigable, innovative, and ebullient Vice Chancellor, Professor Wahab Olasupo Egbewole, *SAN* whose tenure I was promoted to the rank of Professor in 2023, and for his uncommon leadership quality, steadfastness, dedication and for ensuring we live in a clean and safe environment. Thank you, sir, for the opportunity to complete my tenure as Deputy Director (Training) of Centre for Research, Development and In-House Training (CREDIT) and for approving my second tenure as the Head, Industrial Chemistry Department (the two positions I held simultaneously). I equally acknowledge past Vice Chancellors and Deputy Vice-Chancellors for the role they played in my career path.

My immense appreciation similarly goes to the Chairman, Library and publication Committee and his team, for the final editing, and typesetting of this lecture and for their contributions to its successful presentation of my inaugural lecture. I wish to thank the management of Cape Peninsula University of Technology, Cape Town, South Africa, under the current and able leadership of Prof. Chris Nklapo.

To my family, I want to specially appreciates my parents My father, late Alhaji Imam Zakariyah Adeola Okoro (the former Imam Igboroko Nla Mosque, Owo) and my loving and caring mother, Alhaja Oladutemu Adeola Okoro, for their love, care and unflinching supports that brought me this far, thank you for being wonderful parents. The death of my dad came as a rude shock to me on 3rd November, 2017. May Allah (SWT) enlarge your grave and grant you the best place in *Aljanah Firdaus* To my kind, caring, loving and considerate mother, I thank you for nursing me and for being my pillar, prayer warrior when in need. To my stepmothers, Alhaja Modinah Orente Okoro, Hajia Hamuda Adeola Okoro, thank you so much for being supportive.

I say a big thank you to my siblings, Mr. Kamar Giwa Adeola Okoro, Mr. Munirudeen Idowu Adeola Okoro for your loves, care, support and mutual understanding. Thank you for being a great brother, you are the brother anyone could ask for. To my late sister, Mrs. Falilat Olayinka Olufawoye, whose sudden death came as a rude shock to me while I was away for my doctoral study in South Africa. May your soul rest in peace (Amen). A big thank you to Mr. S.O. Olufawoye for your moral support's sir. Mr. Rasheed Adeola, Mr. Tajudeen Okoro, Hon. Mrs. Musilimat Okoro, Mrs. Serifat Akinyemi, Mrs. Toyiba Adeoye, Mrs. Sidiqat Okoro, Nurat Okoro, Mr. Rashida Okoro, Mr. Musediku Okoro, Mrs. Rafat Abdusallam Okoro, Mr. Haroon Okoro Hafsor Okoro, Sidiqat. May Allah bless you. Thank you all for your support and prayers. To my nephew and niece; Serifah, Hakeem, Taiwo & Kehinde, Lukman Olufawoye AbdulMujeeb, Monsurah Okoro, Funbi, Taofeeq Akinyemi, Jumai Akinyemi, Idris Ekungba, Mrs. Sakeenah Akanbi-Ekungba, Mubashir Ekungba, Nasirulah Ekungba, Dr. Mutmainah Ekungba, Kaothar Ekungba, Fatiu Ekungba.

To my uncles and aunties, Yeye Caroline Okoro, Mr. Samuel Owolabi, Mr. Ahmed Abdul Okoro, Mr. Yahya Abdul Okoro, Mr. Olaniyi Okoro, Mr. Idrees Adeola Okoro, Mr. Azeez Adeola, Mr. Adeyemi Adekambi, Mr. & Mrs. Ige Adekambi,

Mrs. Victoria Adekambi, and Aunt Olawumi, Mr. Sola Okoro. To my *Egbons,* Alhaji Nafiu Okoro, Alhaji Munirudeen Okoro, Bro. Salaudeen Okoro, Mr. Najeeb AbdusSalam (The Seriki Adini of Owo). Bro. Tajudeen Olanitori, Dr. Mustapha Haroon, Late Idowu Adekambi (RIP), Bro. Alaba Adekanmbi, Bro. Monday Okoro. Alhaja Maryam Abdusallam, Barr AbdulRasheed OluwaShina Ekungba, Engr Kazeem Aderbigbe, Late Mr. Ademola Afolayan. I sincerely appreciate brother Kamil Ekungba for your special love towards my family. I must acknowledge my late Uncle Dr. Olufolarin Okoro whose guidance and support made my university dreams a reality. May his legacy live on through my achievement.

To my in-laws, the Dairo, the Alley-Obalokun and Abakun families, I thank you for entrusting your daughter to me as my life partner. I am forever grateful to you for giving me such a wonderful and resourceful wife. *Modupe pupo*. May his legacy live on through my achievement.

To my academic mentors: First of all, my deep appreciation to my Supervisor at the B.Sc. level, Prof. D.S. Ogunniyi, M.Sc. level, Prof. E.O. Odebunmi. I am grateful for the tutelage and work ethics that I received from my Ph.D. Supervisor and Co-Supervisors; Prof. O.S. Fatoki, Late Prof. B.J. Ximba, Prof. R.G. Snyman and my external Co-supervisor, Prof. F.A. Adekola for their invaluable inputs towards the completion of my doctoral study. Prof. Jane Catherine Ngila (University of Johannesburg, South Africa who was my host during my Postdoctoral Fellowship between 2016 and 2017.

High Chief Jamiu Ekungba (The Baba Adini of Owo Muslim Community). As I stand on the threshold of my academic journey, I want to take a moment to express my deepest gratitude to you, sir. You have been instrumental in my undergraduate and postgraduate experience and my appointment as a Lecturer at the University of Ilorin. *Jazakumlah Akheran,* sir for everything you have done for me and my family. Special thanks to Alhaja Risqah Ekungba, I am grateful for your presence in my life, your

selflessness and care have been a blessing to me. Thank you for your unwavering support, hospitality and kindness ma. Alhaja Maryam Ekungba, thank you for your kind supports, loves and care.

Special thanks to Emeritus Prof. Ishaq O. Oloyede (The current JAMB Registrar and the *Kuliyan Sokoto*, Sheu! who appointed me into the service of the University of Ilorin in 2008. Thank you, sir, for your encouragement and mentorship. You are rare gem, great Mentor per excellence and a blessing to humanity. May Allah grant you a long life to reap the fruits of your hard work sir (amen). I also acknowledge Dr. (Mrs.) Raheemah Oloyede for your encouragement and motherly advice.

Special thanks to our immediate Past Vice-Chancellor and my Academic Mentor, Prof. Sulyman Agenjolola AbdulKareem, I thank you for your tutelage, right from my B.Sc. and M.Sc. days. Sir, thank you for the confidence you repose in me by appointing me the Deputy Director of Training at the CREDIT in 2020 and again for appointing me the Head of Department of Industrial Chemistry in 2021. May Allah reward you immensely for being extraordinary educators and mentors. Special thanks to all my teachers right from primary school to the University Level. I appreciate the mentorship of Prof. (Mrs.) Elleta, God bless you ma. I thank the Vice-Chancellor Kwara State University Malete Prof. Sheikh-Lukman Jimoh for granting me sabbatical leave position. You are much appreciated, Sir. I also appreciate the Registrar, KWASU, Dr. (Mrs.) Kikelomo Salley, for your assistant during my sabbatical leave application to your institution.

To my elders, I say a big thank you to Prof. Y.A. Quadri, Prof. M.A. Akanji, and Prof. O.B. Oloyede, Prof. Ola Olu Alli, *SAN*, Prof. L.F. Oladimeji (VC, Al-Hikmah University), I really appreciate your mentorship and encouragement. Each time Prof. Akanji and Prof. Oloyede come for inaugural lectures at the University of Ilorin, they would ask me: ‘’How far have you gone with the planning of your own inaugural lecture?’’ Thank

you for being part of today's success story. Special thanks to Justice Idris Abdulahi Haroon, Alhaja Haleemah Haroon, Alhaji Haroon Abdulah, Dr. Hussein Olanrewaju. To Kabiyesi, The Olowo of Owo, Oba Gbadegesin Ogunoye the 3rd. I appreciate your love, prayers and best wishes always. Kabiyesi, wagbo watoo wajejubae (amin aseeee edumare).

I thank all my friends, and especially members of Al-Ameen Society, Owo, Ondo State, for creating peaceful environment to grow spiritually together. Your physical presence and moral supports mean a lot to me. Special thanks to Cape Town Duah Forum, Kobiowu Central Mosque, Abubakar Sidiq Central Mosque, Al-Sunah Mosque, Ile-Nla Central Mosque, Igboroko Nla Mosque, Owo, Ondo State League of Imams and Alfa's, Owo Muslim Community, The Companions and The Criterion families. I say a big thank you for creating a good atmosphere to grow spiritually. Thank you for your prayers and presence.

I sincerely express my appreciation to my senior and other colleagues from the Department of Industrial Chemistry and Chemistry: Professors F.A. Adekola, O.O. Dosumu, N. AbdulSalam, O.A.A. Eletta, O.O. Oluwaniyi, A.C. Tella, L.A. Usman, F.O. Nwosu, Late G.B. Adebayo (RIP), O.S. Oguntoye, M.F. Zubair, A. Lawal, A.M.O. AbdulRaheem, S.O. Owalude, H.I. Adegoke, G.V. Awolola, F.O. Okeola, A.A. Hamid, M.O. Bamigboye, O. Atolani, O.K. Yusuf, S.E. Eliagwu, A. Rajee, S.A. Adebayo (RIP), Dr. T.O. Abu, H.F. Babamale, A.A. Muhammed, I.K., Ayinla, S.O. Ibrahim, O.D. Saliu, V.O. Adimula, MT. Baker-Arowona, R.O. Ismaeel, M.O. Bello, F.T. Samoh, M.F. Audu. I acknowledge your tremendous contributions to my research endeavors. I also wish to think all our Laboratory and Technical staffs: Mr. S.A. Asala, S.A. Ajala, Late O.K. Balogun (RIP), M.A.B. Adebayo and A.C. Tomilayo; J.F. Odedina, A.A. Ahmed, and S.O. Bello.

I also wish to appreciate the Dean, the Sub-Dean and all staff of the Faculty of Physical Sciences. To my senior and colleagues in the faculty: Prof. Bisi Adekeye, Prof. A.S Adimula, Prof. B.L

Adeleke, Prof. K.J Oyewumi, Prof. O.A Oladipo, Prof Olatunji, Prof. Kamil Rauf, Prof. W.B. Yahya, Prof. K.O. Babalola, Prof. (Mrs.) Aderinto, Prof. A. Alabi, Prof. Falaye, Prof. Adewara, Prof. Adejumo, Prof. Abiodun, Prof. Abidoye, Prof. Oyeyemi, Prof. O.S. Idowu, Prof. Titiloye, Prof. (Mrs.) Fadipe-Joseph, Prof. M.O..Ibrahim, Dr. Jos Abubakar, Dr. Job, Dr. Ismail Folorunsho, Dr. Taofeeq Lawal, Dr. Ajibola. To my senior and colleagues from other faculties: Prof. (Mrs.) S.O. Malomo, Prof. Y.O. Imam, Prof. S.F Ambali, Prof. O.A., Omotesho, Prof. A. A. Adeoye, Prof. M.O., Nafiu, Prof. M.O., Salau, Prof. Sule, Prof. A.A. AbdulRahman, Prof. M.T. Yakubu, Prof. Mikhail Buhari, Prof. Jamiu Adeniran, Engr. Dr. A. S. Aremu (former M.D Lower Niger River Basin) and Dr. H. U. Hambali.

To the staff of Pure Chemistry and Industrial Chemistry Department, Kwara State University, Malete under the headship of Prof. A.O. Mustapha, I say a very big thank you for the warm reception you accorded me during my one-year sabbatical leave with you. Thank you for making my stay a memorable one. To my family at the Pure Chemistry and Industrial Chemistry Department, Ladoke Akintola University of Technology (LAUTECH); Chemical Science department, Al-Hikmah University and Landmark University. I say a very big thank you. To the members of the Chemical Society of Nigeria, we are one big family. Thank you so much for all that we have been doing together.

I want to specially thank the ICH Alumni family for your immense cooperation. To my CREDIT family, under the leadership of Prof. K.W. Wahab, who had served as a Director at the Centre, Prof. Christiana Abikoye (Deputy Director, Research), Prof Y.O. Imam I say thank you. To our administrative staff: Mr. Adegboyega, Mrs. Ari, Mrs. Yusuf. Thank you all for the enabling environment and the peaceful moment we had spent together at CREDIT that made our tenure a huge success.

The CPUT, South Africa Alumna 2012/2013 set, UNILORIN Faculty of Science, Chemistry and Industrial Chemistry Alumna, 2002 set. El-Adabiyah School for Arabic and Islamic Studies, Owo, 1990 set, Government Primary School II Alumna, 1986/1987 set, Owo High School Alumna, 1993, set. I thank you all for your understanding and mutual love.

To my wonderful neighbors at Gaa-Akanbi: Engr. Mikail Raji Adegoke, Mr. Shittu, Late Mr. Elelu, Mr. & Mrs. Taofeeq Ibrahim, To the Aleniboro Community under our able and dynamic Magaji Alhaji Jamiu Anu-Oluwa; my neighbors Mr. and Mrs. Yinka Obembe, Mr. & Mrs. Ajibowu, Mr. & Mrs. Owolabi, Mr. & Mrs. Adewale, Mr. & Mrs. Adetunji, Engr. Tijani, Imam Tajudeen Okuta Agidi, Umu Nusrah, Chairman and the entire Aleniboro community. I thank you all for cooperation, peaceful co-existence and your presence here is much appreciated.

To the Roundtable of Academic Mentors here present as well as those online, thank you for believing so much in me and creating the enabling environment for our career development. To my *Aburos*, Dr. Taofiqah O Amoloye-Abu, Dr. Titi Musa-Oyewumi, Professor A.A. Oloyede Junior, Dr. Alli-AbdulMusawir Oluwafuyi, Dr. Lateefah Oloyede, Barr. Taiye Hussein, Dr. Kehinde Hassan Oloyede, Dr. Fahm AbdulGafar, Dr. Biliqis Lawal, Dr. (Mrs.) Oladele Jumoke. Mr. Toyib Abdusallam, Mrs. Tawakalit AbdulSalam, Assoc. Prof. Saheed Adewale (King Fahd University of Petroleum, Saudi Arabia), Dr. Sulyman Okoro.

I say thank you. to the members of my family in South Africa, special thanks go to Dr. & Mrs. Toyin AbdulRaheem, Dr. and Dr. Mrs. Ikhile, Dr. and Mrs. Raji for your hospitality and for making my stay in Cape Town and Johannesburg a memorable one. To our friends and their families, Engr. Mikail Raji Adegoke, Prof. Mrs. Haleemah Adegoke; Prof. Sidikat Aderinoye-Abdulwahab, Col. Abdulwahab, Dr. Kazeem Basheer (University of Lagos), Alhaji Mubaraq Olupona (AAUA

Akungba), Prof. Oluyinka Iyiola, Dr. M.K. Garba, Dr. George Adeniyi, Mr. Yinka Obembe, Mr. Adewale, Mr. Haroon AbdulRahman, Mr. Taofeeq Ibrahim. Dr. Mudathir AbdulSalaam (FIRS, Lagos). Prof. Olushola Oladipo, Dr. (Mrs.) Omotola Oladipo, Dr. Adisa Jamiu. Prof. Sola James & family. Prof. Wasiu Raji & family, and Dr. Olaremu Abimbola.

Special thanks to my postgraduate colleagues during my doctoral study at CPUT; Erick O. Jondicko, Prof. Rasheeda Toefy and Prof. Van Schalkwyk for the assistance you rendered in my statistical analysis. I also thank Dr. Olatunde Olatunji, Prof. Mrs. Beatrice Opeolu, Prof. Ajuwon, Prof. Ayeleso and my postgraduate colleagues: Prof. Lanre Olujimi, Dr. Daso Peter, Mr. Akinsoji Olatunbosun and Prof. Ayanda Sola, for your useful advice. God bless you all. My acknowledgement also goes to the technical staff of the Chemistry Department, CPUT, namely: Zandile Mthembu, Gillian Fennessy Yon, Dr. Nohako Khayinsa for their cooperation and for being there for me always. My thanks go to all academic and non-academic staff of the Chemistry Department, CPUT. I specially thank Michelle Yvonne Slabber of Ecotoxicology lab, CPUT, for helping me in sampling and for her assistance at all times during my toxicology experiments.

To my research collaborators, I say a big thank you to Prof. Jane C. Ngila, Prof. Z. Caliphs (University of Johannesburg, South Africa) Prof. S.A. Iwarere (University of Pretoria, South Africa), Prof. S. Pandey (India), Dr. Adewale George, Dr. M.M. Orosun, Prof. O.A. Iyiola, Dr. Aminat El-Imam, Dr. Clement Ogunkunle and Prof. Haleemah I. Adegoke (University of Ilorin). Associate Profs. Saheed AbdulGaniy King Fahd University of Petroleum and Associate Prof Saheeed Abiodun Popoola, University of Medinah, Saudi Arabia. I thank you all for the collaboration we shared together.

I thank you all, my mentees, my current Ph.D. students: Mr. Seyi Ayika, Mr. Ajibola Seun, Mr. Usman, Mr. Idris and Mrs. Umu Alkhary Alliagan. Mr. Kingsley Iwuozor. Mr. Ismail Akande,

Mr. Stephen Utum. All staff and students of the University of Ilorin present here physically or online. May God bless you all. I am indeed grateful. Special thank you to all the LOC members for my Inaugural Lecture under the able Chairman and Co-Chair, Drs. G.O. Adeniyi and M.K. Garba. Thank you so much for proper planning of this lecture.

My special and deep thanks go to the Tertiary Education Trust Funds (TETFUND) for the research and travel grants I have enjoyed in the past. Acknowledgements also go to Global Excellence and Stature (GES) for the scholarship I used for my Postdoctoral Research Fellowship at the Applied Chemistry Department, University of Johannesburg, South Africa. My thanks also go to Mr. Sebastian Brown, Alistair Aldonis and Ashley Davids of CSIR, South Africa, for being part of the sampling team during the course of my research on Cape Town Harbour, South Africa.

I cannot appreciate my children enough for their cooperation, understanding and total support during my career advancement. You are blessed and your successes, accomplishments and achievements shall have no bound they shall be greater than me. Lateefah Ayodeji Okoro (Our barrister lawyer in the making), AbduLateef Abidemi Okoro (who was born in my absence during my research work in South Africa), AbdulMuizz Olalekan Okoro and Muhammad Olanrewaju Onaopemipo Okoro. Thank you for your patience, tolerance and total support. Daddy loves you all.

Lastly, but not the least, egun la ti nkeyin igbale. my darling wife, who started the journey with me by following me the penultimate Monday after our wedding to pick up my appointment. Honey, I thank you specially and especially for your understanding and full support towards the success of my academic journey. I could not have done all these without you; you give the best of advice. Indeed, our kids are fortunate to have you as their mother. I am proud of you and I am forever thankful to have met you. You are my breath and my light.

Thank you for being an amazing, beautiful, strong, intelligent, kind, supportive, caring, thoughtful and loving wife. My Director Home Affairs, I love you very much and I will continue to do so. I thank you all for your patience and your kind attention. May Allah (SWT) reward you abundantly. Aamin.

I appreciate everyone who is here today to attend this great occasion. My appreciation also goes to all those, who cannot make it physically owing to one reason or another but who are online listening to my inaugural lecture. Owing to space limitation, I may not be able to mention all your names but I sincerely appreciate you all immensely. Your great support and motivation made this occasion possible for me.

I say Jazakallahu Khairan and wish everyone safe journey to your various destination.

Vice-Chancellor sir, kindly permit me to end this lecture by reading this verse of the Holy Quran.

﴿ دَعْوَاهُمْ فِيهَا سُبْحَانَكَ اللَّهُمَّ وَتَحِيَّتُهُمْ فِيهَا سَلَامٌ ۚ وَآخِرُ دَعْوَاهُمْ أَنِ الْحَمْدُ لِلَّهِ رَبِّ الْعَالَمِينَ﴾

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