UNIVERSITY OF ILORIN

THE TWO HUNDRED AND TWENTY-SIX (226TH)
INAUGURAL LECTURE

"POLLUTION: A CURSE OR A NECESSITY, THE CHOICE IS YOURS".

By

PROFESSOR NASIRU ABDUS-SALAM(FCSN)
B.Sc, M.Sc., Ph.D. (Ilorin)

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

THURSDAY, 2ND FEBRUARY, 2023

This 226th 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

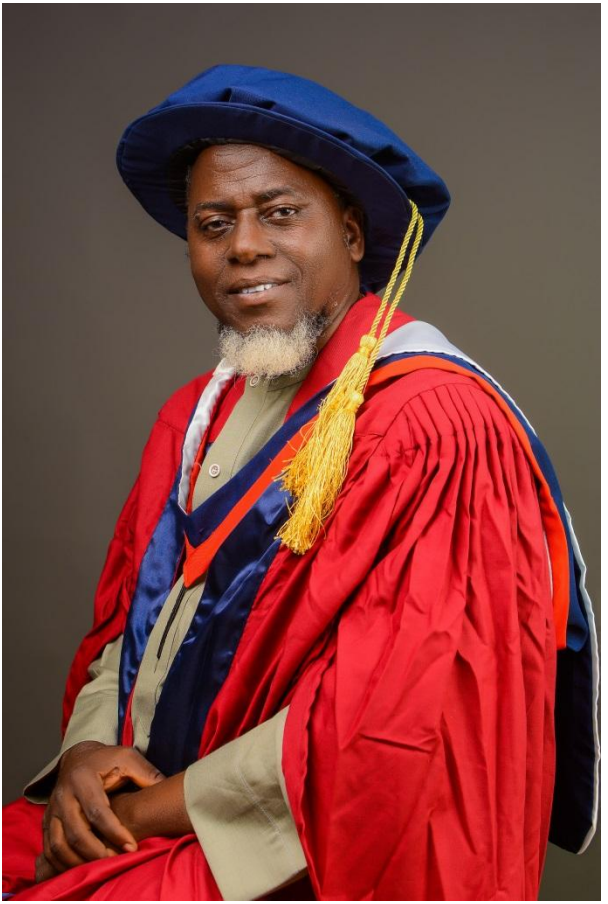
2nd February, 2023

ISBN: 978-978-8556-15-2

Published by:

The Library and Publication Committee,
University of Ilorin, Ilorin, Nigeria.

Printed by
Unilorin Press,Ilorin, Nigeria.



PROFESSOR NASIRU ABDUS-SALAM(FCSN)
B.Sc, M.Sc., Ph.D. (Ilorin)

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

BLANK

Courtesies

The Vice-Chancellor
Deputy Vice-Chancellor (Academic)
Deputy Vice-Chancellor (Management Services)
Deputy Vice-Chancellor (Research, Technology and Innovation)
The Registrar
The University Bursar
The University Librarian
Provost, College of Health Sciences
Deans of the Faculty of Physical Sciences
Deans of other Faculties, Postgraduate School and Students Affairs
Professors and other members of the Senate
Chairman and members of the Governing Council
Directors of Centers and Units
Heads of Departments of Chemistry and Industrial Chemistry
Heads of other Departments and Units
All other Academic Colleagues
All Non-Teaching Staff
My Lord Spiritual and Temporal
Distinguished Students of Chemistry and Industrial Chemistry
Gentlemen of the Print and Electronic Media
Distinguished Invited Guests
Great Unilorites
Ladies and Gentlemen

Preamble

I seek refuge in Allah against the devil and I begin this delivery in the name of Allah, the Beneficent the Merciful. Allah, you are the first without any reference point of starting and you will be the last without any point of termination to your existence. With gratitude to the Almighty Allah, I stand before this distinguished audience to deliver the 226th inaugural lecture of the "Better by Far" University and the 10th from the Department of Chemistry. The University's 32nd inaugural lecture was the first from the Department of Chemistry and was

delivered by Professor Moses O. Fagbule with the title "Colour for A Colourless World: A Chemist's Modest Contribution" on the 15th of December 1988. The 75th inaugural lecture and the second from the Department of Chemistry was delivered by Professor Joshua A. Obaleye on the 29th of July, 2004 with the title "Marriageology of Chemical Nature: Drug-Metal Complexes Perspective". The 82nd inaugural lecture and the third from the Department of Chemistry was delivered by Professor Sulyman A. AbdulKareem with the title "Making Stuffs, Hot Stuffs: The Power of Mind over Matter" on the 10th of May 2007. Professor Samuel A. Ibiyemi delivered the 84th inaugural lecture and the fourth from the Department of Chemistry with the title "*THEVETIA* Plant Economic Potential: Chemistry's Key Position" on the 28th of June 2007.

The 88th inaugural lecture and the fifth from the Department of Chemistry was delivered by Professor Gabriel A. Olatunji on the 12th of February, 2009 and it was entitled "Journey to the Promised Land: The Travails of an Organic Chemist". The 125th inaugural lecture and the sixth from the Department of Chemistry entitled "My Adventure with Polymers" was delivered by Professor David S. Ogunniyi on the 21st of March 2013. My mentor, Professor Folahan A. Adekola, delivered the 130th inaugural lecture and the seventh from the Department of Chemistry with the title "The Heart of Science in the Service of Man" on the 25th of April 2013. The 138th inaugural lecture, and which was the 8th from the Department of Chemistry, was delivered by Professor Ezekiel O. Odebunmi on the 21st of November 2013 with the title "Catalysis and Chemical Industry Development: A Fruitful Wedlock". The 165th inaugural lecture, which was the 9th from the Department of Chemistry entitled "In Search of the Answers to Questions Unknown", was delivered by Professor Basil U. Eke on the 24th of November 2018.

An inaugural lecture is a significant event in the life of a University through which the University Administration brings Town and Gown together for the purpose of sharing ideas or

knowledge that has been generated. The event allows Professors to share their professional accomplishments as well as to inform colleagues and the general public about their current and future research goals. It is also an opportunity for Professors to engage with the campus community and the general public in their field of expertise, forms new collaborations, strengthens existing relationships with co-researchers, and make practical suggestions that will influence the work of related industries, the general public, and policymakers.

Today, I am privileged to stand before you to deliver the 226th Inaugural lecture, the 10th from the Department of Chemistry and 2nd from the Analytical and Environmental Unit of the Department with the title **"Pollution: A Curse or a Necessity, the Choice is Yours".** I am greatly indebted to the Vice-Chancellor, Prof Wahab O. Egbewole and the University Administration for the rare opportunity I am being given today to deliver the 226th inaugural lecture.

Introduction: My Venture to Chemistry

For reasons best known to my parents, I was enrolled in Quranic School in Ilala, Kwara State, rather than allowing me to begin my earlier education with Western Primary Education, even though my elder and younger siblings were allowed to have both Western and Islamic Education. Later, I attended Darul Islam Arabic School, Oshodi, Lagos (1967-1971), Darul 'Ulum, Ilala (1971-1973), and Arabic and Islamic Advanced School, Omupo, Kwara State (1973-1976), all in pursuit of pure Islamic Education because my father's vision for me was to be like my teacher and mentor, Dr. Yusuf KolawoleJumu'ah Al-Ilala (**a.k. Ayyuha**). Then Dr. Y.K. Jumu'ah was a young and vibrant Arabic and Islamic scholar, whom every parent of that time aspired to and took as a model for their children. Therefore, my father, the late Alfa (Alhaj) Salami Afolabi, wanted a replica of Dr. Y.K. Jumu'ah in me and thought the best way to achieve his goal for me was to focus on Arabic Education. But later on, with the honest advice from Dr. Yusuf, whom he wanted me to be like, I began Western Education in 1976, from Form Two, after

the mid-term break of the second term, without Primary Education. Dr. Y.K. Jumu'ah advised my father that, having acquired more than the fundamentals of Arabic Education, I should begin to complement Arabic Education with Western Education, particularly because acquiring Western Education has a time and age range or limit within which it can be acquired.

This marked the beginning of my sojourn into Western Education. Learning how to use and speak the English Language was initially tough and rough but within the first year Allah brought out the potential in me. Initially, I employed the service of a friend as an interpreter to explain most subjects to me, after which I committed to memory everything I read in notes before tests and examinations. The practice of **"La cram la pour"** was fully employed, and it really paid off for me. In 1980, I won the highest number of prizes at graduation in the Mock Examinations results, one of which was in Chemistry. Although my ambition was to be a Medical Doctor, I was not admitted for that and I accepted Allah's decision as being the best for me. I have no regret about being a Chemist today. My journey to the promised land began with my admission into the Chemistry programme at the University of Ilorin after my HSC A' Level (Cambridge) in 1982. I waited for a year to work so as to raise funds to support my parents for my degree education. Therefore, my admission into the Chemistry programme commenced in 1983 and I obtained B.Sc. (Hons) in Chemistry in 1986, M.Sc. (Chemistry) in 1991, and Ph.D. (Chemistry) in 2005 from the same institution. So, I am an undiluted chemist per excellence and an alumnus of the "Better by Far" University.

Mr. Vice-Chancellor sir, my parents wanted me to grow into a spiritual personality while my mentor wanted me to acquire Western Education in addition to Islamic Education to make me a completely unique person. Alhamdulillah, Almighty Allah has accepted and actualised my father's and mentor's wishes. With all sense of humility, it is on record today that I am the current Chief Imam, the spiritual leader of the University of Ilorin Muslim Community, and a Professor of Chemistry, which

is the zenith of the academic profession. This is not my making, all praises and adoration belong to ALLAH my creator, cherisher, and sustainer who made it possible for me to attain both the spiritual and academic heights. “Which of the favour of my Lord will I deny?” فَبِاَيِّ اٰلَآءِ رَبِّكُمَا تُكَذِّبٰنِ

Analytical Chemistry

Modern Analytical Chemistry can be defined as a science that is concerned with the development of general approaches, methods, and tools for the study of chemical compositions of substances and analysis of objects while chemical analysis is restricted to the acquisition of information about chemical compositions of substances. Analytical chemistry can also be described as a branch of chemistry that is involved in identifying, separating, and quantifying chemical compounds by using methods or techniques that are sensitive to the detection, identification, characterization, and quantification of chemical components of matter. Analytical Chemistry is central to many branches of science and applied science-related disciplines. This central position is depicted in Figure 1.

Fig.1: The Central Nature of Analytical Chemistry

Mr. Vice-Chancellor, sir! Our Lord created everything in the universe for the benefit of man. Man takes what benefits him from the universe and returns what he dislikes back to it. Allah declared

أَلَمْ تَرَوْا أَنَّ اللَّهَ سَخَّرَ لَكُم مَّا فِي السَّمَاوَاتِ وَمَا فِي الْأَرْضِ وَأَسْبَغَ عَلَيْكُمْ نِعَمَهُ ظَاهِرَةً وَبَاطِنَةً

“Do ye not see that Allah has subjected to your (use) all things in the heavens and on earth, and has made his bounties flow to you in exceeding measure, (both) seen and unseen?” (Q31: 20).

The same Lord warned us against abuse and mismanagement of the resources at our disposal because of its grievous consequences. He said:

وَلَا تُفْسِدُوا فِي الْأَرْضِ بَعْدَ إِصْلَاحِهَا

“Hence, do not spread corruption on earth after it has been so well ordered” (Q7:56).

In the teaching and practice of Prophet Muhammad, we were instructed to preserve nature. Please permit me to quote two of such inspirational sayings of the Holy Prophet that enjoined us in this regard:

مَنْ قَتَلَ صَغِيرًا، أَوْ كَبِيرًا، أَوْ أَحْرَقَ نَخْلًا، أَوْ قَطَعَ شَجَرَةً مُثْمِرَةً، أَوْ ذَبَحَ شَاةً لَاهَابِهَا، لَمْ يَرْجِعْ كَفَافًا

“Whoever kills a young or old, or burns palm trees, or cuts down a fruitful tree, or slaughters a sheep for its flames, does not return sufficiently”.

عَنْ مُعَاذِ بْنِ جَبَلٍ، قَالَ قَالَ رَسُولُ اللَّهِ ﷺ "اتَّقُوا الْمَلَاعِنَ الثَّلَاثَ الْبَرَازَ فِي الْمَوَارِدِ وَقَارِعَةِ الطَّرِيقِ وَالظِّلِّ " (رواه أبو داود).

Narrated Mu'adhibnJabal: The Messenger of Allah (ﷺ) said: Be on your guard against three things which provoke cursing: urinating/defecating in the watering places and on the thoroughfares, and in the shade (of the tree) [Abu Daud].

Environmental Chemistry

Environmental Chemistry is the branch of Chemistry that deals with chemical processes that occur in water, air, terrestrial and living environments, and the effects of human activities on them. It includes niche areas such as astrochemistry, atmospheric chemistry, environmental modeling, geochemistry, water chemistry, and pollution remediation. In other words,

Environmental Chemistry is the study of the chemical and biochemical phenomena that occur in nature. It involves understanding how the uncontaminated environment works; which of the naturally occurring chemicals are present, in what concentrations, and with what effects?

Environmental pollution, however, is the undesirable transformation of the environment as a result of direct or indirect activities of man through changes in the energy patterns, level of radiation, physicochemical compositions, and species richness. It is a global issue affecting developed and developing nations and is threatening the survival of humans, animals, and vegetation. The emergence of globalization, occasioned by the rapid increase in industrialization and technological advancement with the consequences of the discharge of toxic solid, liquid, and gaseous substances into the environment at a rate higher than it could be converted to harmless substances by nature, is the major cause of environmental pollution. Pollution is an integral part of development and both are inseparable but can be managed for healthy living on this planet.

Industrialization and technological advancement process some components of the environment into new products of better benefits. In the process, undesirable or poorly-processed products are generated as pollutants in the environment because there is no 100% efficiency of any system. Wastes are generated through natural and anthropogenic (man-made) sources in the environment. However, nature has a mechanism by which it removes the pollutants that are bad components. For instance, the food byproducts include gaseous matter, urine, and faeces, which are pollutants if retained in the body. They are carefully removed and safely eliminated for the betterment of man. If dead human bodies are not interred into the earth, the decay will cause serious environmental pollution. Nature taught man how to safely keep decaying bodies from polluting the environment. Therefore, pollution is a natural phenomenon associated with every aspect of the environment which equally has a mechanism for eliminating its negative consequences. Because pollution

originating from natural sources is eliminated by natural mechanisms, therefore, such pollution is just a necessity inherent in natural processes.

Fig. 2: Basic Types of Pollution

Water, air, and soil pollution are the basic types of pollution as depicted in Fig. 2.

Water, air, and soil pollution are the basic types of pollution as depicted in Fig. 2. The 1972 Stockholm Conference organised by United Nations on the Human Environment is 50 years old in 2022. The conference led to the creation of the United Nations Environment Programme (UNEP) and June 5 of every year is designated as World Environmental Day. September of every year marks Environmental Awareness Month, a commemorative day for raising awareness about environmental issues that need the world's attention. Such issues include global warming, pollution, and the conservation of natural resources. Sweden hosts 2023 Environment Day in partnership with the United Nations Environment Programme (UNEP) with the theme – "Only One Earth", which highlighted the possibilities of shifting to more sustainable, greener lifestyles.

Mr. Vice-Chancellor Sir, about 70% of the earth's surface is covered by water and only 2.5% of the total universal water volume is freshwater, representing the useful volume to man. Around 70% of industrial waste is dumped into this little volume of water while 80% of water pollution is caused due to indiscriminate discharge of domestic and industrial wastes. More

than 6 billion pounds of garbage, mainly plastic, end up in the oceans every year.

Water pollution is the presence of chemical, physical, or biological components or factors producing a condition resulting in the impairment of some beneficial uses of a given body of water. The level of contamination necessary to impair a water body is highly dependent on the type of water body, its location, and the beneficial uses it supports. Water deemed unfit for drinking by humans may be suitable for other uses, such as aquatic habitat, irrigation, or recreation. Although certain natural events can cause water pollution, nature has a mechanism for ameliorating its effects. Therefore, I will focus herein on the anthropogenic sources of pollution, that is, pollution arising from humans (Schweitzer &Noblet, 2018).

Sustainable Development Goal 6.1 aims at universal and equitable access to safe and affordable drinking water. The indicator of this goal is **"safely managed drinking water services"**. This is to say that the goal aims at making available to the world population drinking water from an improved water source that is located on-premises, that is available when needed, and which is free from faecal and priority chemical contamination.

Although microbial agents are the largest cause of waterborne diseases worldwide, chemical contaminants in drinking water have been associated with a broad array of adverse health effects, including cancer, cardiovascular disease, neurological disease, and miscarriage. Some contaminants enter the water through leaching, accidental spills, runoff, and atmospheric deposition. Others, such as disinfection by-products and lead, are introduced during treatment or even at the tap (Barrett, 2014). About 15 million children under the age of five years die every year from diseases caused by drinking contaminated water.

Man-made organic chemicals have been found in drinking water for many years. Their numbers and varieties increase as our analytical capabilities improve. Many organic

chemicals are carcinogenic or mutagenic. Chlorinated compounds have been found in untreated well water at levels up to 21,300 micrograms/L and are generally present at higher levels in chlorine-treated water than in untreated water.

Contamination of the environment with different inorganic and organic compounds, such as pesticides, pharmaceuticals, and metals, represents one of the main environmental challenges brought about by human activities. There is a continuous build-up of the chemical industry due to globalization and industrialization's demand resulting in an increase in the production and release of chemicals in the environment at a rate faster than environmental interventions and remediation systems can be implemented. Similarly, the concept of urbanization has increased the chemical build-up in most cities with attendant unhealthy consequences on vegetation, and human and animal health (Saaristo et al., 2018).

Drinking water contaminants include several chemicals such as arsenic, aluminium, lead, fluoride, disinfection by-products, radon, and pesticides (Table 1). Their health effects range from cancer, cardiovascular diseases, adverse reproductive outcomes, and neurological diseases. Currie et al. (2013) showed that the consumption of chemically contaminated water by mothers, specifically those who are less educated, has significant effects on the gestation of infants and the birth weight of the baby (Currie et al., 2013).

Mr. Vice-Chancellor Sir, although food is a necessity, it is better to imagine than experience what the health situation of man would have been if the by-products of the metabolism of food, the faeces and urine are not efficiently removed from the body or the obnoxious gases such as carbon monoxide (a silent killer), nitrogen and carbon dioxide, either generated by cells or inhaled, are not eliminated from cells and tissues. The sources of these by-products and toxic gases cannot be avoided because of the great benefits derivable from them and the efficient removal mechanism put in place by Allah to deal with the by-products (the pollutants) has made the entire process a necessity rather

than a curse. The handling of pollution, which can make it a curse or a necessity, informed the title of this inaugural lecture – **"Pollution: A Curse or a Necessity, the Choice is Yours"**. I have chosen this title to disabuse the minds of many who consider pollution or pollutants as a curse rather than an unavoidable necessity. What is your thought on the myriad of problems associated with oil exploration in the Niger Delta region of Nigeria? Is the exploration a curse on the region or an unavoidable necessity? The handling of the pollution determines where to place it.

Table 1: Some Inorganic contaminants in water and their effects (Rather et al., 2017).

Chemical contaminants	Diseases/health effects caused	References
Aluminum, arsenic	Skin, bladder, and prostate cancers, Alzheimer's and peripheral neuropathy, reproductive, cardiovascular, immunological, and neurological diseases	Barnaby et al., 2017; de Meyer et al., 2017
Disinfection by-products (trihalomethanes and dichloroacetic acid)	Leukemia, reproductive diseases, bladder, and colon cancers	Jeong et al., 2017; Villanueva et al., 2017
Fluoride	Osteosarcoma, skeletal fluorosis	Guissouma et al., 2017; Walia et al., 2017
Lead	Occupational cancers, haemoprotein degradation, intellectual disability, anti-social behavior, high blood pressure, heart disease, kidney disease, and reduced fertility	Rosen et al., 2017; Tirima et al., in press
Nitrate	Stomach, esophagus, bladder, brain, colon, rectum, pancreas, ovarian, and kidney cancers, adverse pregnancy outcomes, diabetes and thyroid disorders	Espejo-Herrera et al., 2015; Schullehner et al., in press
Pesticide residues (2, 4-D, malathion, diazinon, and fenpropimorph)	Leukemia, reproductive, immunological, and neurological cancers	Mekonen et al., 2016; Shi et al., 2018
Radon	Lung cancer	Gunnarsdottir et al., 2016; Jobbágy et al., 2017
Sulfate (gypsum, anhydrite, barite, and celestine)	Diarrhea, laxative effect	Călinescu et al., 2016; Song et al., 2017

Mr. Vice-Chancellor, sir, what follows are my research contributions to the field of Analytical and Environmental Chemistry. Let me quickly add that the reports I shall render here are outcomes of the research endeavours with my research team consisting of my B.Sc., M.Sc., and Ph.D. research students on one part and with my research collaborators from within and outside the University of Ilorin. Many of the members of my

team as well as the collaborators are among this great audience today.

Water Research

A recent UNICEF report revealed that 2.2 billion people lack access to safe drinking water; more than half of the global population does not have access to safe sanitation and 673 million people practice open defecation (UNICEF, 2019). Nearly one-third of Nigerian children do not have enough water to meet their daily needs and one in five children globally does not have enough water to meet their everyday needs (UNICEF, 2021). Globally, at least 2 billion people use a drinking water source contaminated with faeces.

Anthropogenic activities are identified as the main source of the increasing amounts of heavy metals found in aquatic environments (Zamora-Ledezma, et al., 2021). Heavy metal toxicity can cause mental and central nervous system damage, as well as lower energy levels and damage to the blood, lungs, kidneys, liver, and other essential organs. Long-term exposure may imitate Alzheimer's disease, Parkinson's disease, muscular dystrophy, and multiple sclerosis by causing slow-moving physical, muscular, and neurological degenerative processes. Allergies are prevalent, and prolonged exposure to certain metals or their compounds can lead to cancer (Verma and Dwivedi, 2013).

Some researchers analysed the trends, health risks, and sources of eight dissolved heavy metal species in river and lake water across five continents (Africa, Asia, Europe, North America, and South America) from 1970 to 2017 and identified mining and industries as the major contributors of metal pollution. Heavy metal sources, on the other hand, varied significantly by continent, with waste discharge and rock weathering dominating in Africa, mining and manufacturing dominating in Asia and South America, fertilizer and pesticide use dominating in North America, and mining and manufacturing, waste discharge, and rock weathering dominating in Europe (Li, 2020). The report concluded that, globally, the

water system showed increasing trends for Cd, Cr, Cu, Ni, Mn, and Fe and decreasing trends for Pb and Zn. It would be recalled that in 2010, there was a lead (Pb) poisoning epidemic in Zamfara State. Investigation from the village revealed the disappearance of Duck from the community before the symptom manifested in humans. The source was traced to massive environmental contamination from the informal processing of lead-rich ore to extract gold. The team of experts revealed that in all villages, including in family homes and compounds, soil lead concentrations exceeded 100,000 ppm, far above the internationally accepted standard of 400 ppm for residential areas (CDC, 2016). It is clear knowledge that the diversification of Nigeria's economy favours legal and illegal mining operations. Therefore, my initial interest was to understand the quality of the freshwater, which formed the bulk of water available for man's activities. I was then later inspired to examine what we have been doing in Nigeria to manage our water system.

Oyun River

This is the longest river in Kwara State traversing 6 local government Areas. Agricultural activities, small-scale industries, institutions, and some local dams are sited along the course of this river. Rural settlements along the river course depend on it for domestic and other uses. Thus, to study the quality of water in this river, water and sediment samples were collected from seven (7) different locations along the course of the river between Offa in the Offa Local Government Area and OdoAwon in the Moro Local Government Area. The samples were treated using standard analytical procedures and tools (Adekola*et al.*, 2003). Generally, the concentrations of Zn, Pb, and Cd in the sediments were higher than the concentrations in the water samples. Meanwhile, the concentrations of these metals in the river are within both the WHO maximum permissible limits for potable water and the Canadian regulatory limits for irrigation purposes. The levels of heavy metals in sediments were within the United States Environmental Protection Agency (USEPA)

standards for dredged sediments. Regular monitoring of the river was therefore recommended.

Ilaje River, Ondo State

The water quality within five different communities of Ilaje local government area of the Ondo state of Nigeria sharing the same river was examined for some physicochemical parameters and heavy metals burden. The solids, water temperature, pH, some ionic radicals, and heavy metals were examined and compared with WHO guidelines on drinkable water in order to express the degree of natural and anthropogenic input to the pollution burden. The trend in the physicochemical parameters was such that it indicated how negatively the water regime was stressed by pollutants generated from domestic, agricultural, and industrial activities as well as the effect of the oil spill. Some heavy metals and anionic radicals were examined and were found to occur at threatening concentrations that call for environmental/health concerns. The water bodies from the various communities examined were found generally to be unsafe for domestic and agricultural activities, which are the mainstay of the economy of the inhabitants. It was recommended that proper education, monitoring, and clean-up procedures, in case of oil spillage, be carried out promptly at these five different communities of Ilaje LGA, Ondo State (Abdus-Salam *et al.*, 2010).

Mr. Vice Chancellor, sir, my research team investigated the impact of dry season farming using polluted water for irrigation. The health risk was high as vegetables were found to bioaccumulate toxic metals in their leaves which would bio-magnify in higher species of the food web (Dosumu et al., 2003); We also carried out the assessment of the impact of petroleum depot effluents on a nearby river quality (Abdus-Salam*et al.*, 2017).

Lagos Lagoon

There is growing evidence that some endocrine substances are linked to human health issues such as breast cancer, infertility, poor sperm counts, genital abnormalities,

early menstruation, diabetes, and obesity among others. Endocrine-disrupting chemicals (EDCs) are hormone-mimicking substances that are extremely toxic, and some of them have been demonstrated to act as female or male hormones. Endocrine-disrupting substances have been shown to transform male frogs into female frogs and he-fish into she-fishes. Heavy metals and organotin compounds (trimethyl tin, tributyltin, triphenyltin) are examples of endocrine-disrupting chemicals (Okoro et al., 2011). Our research team determined the distribution, concentration, and mobility of potentially toxic elements in the sediment of Lagos harbour. The continuous discharge of metallic waste into the Lagos lagoon in various forms could have an adverse impact on the harbour and its environ.

The sediments of the lagoon were sampled from six different locations between November 2016 and July 2018. A modified sequential Tessier procedure was used for the metal extraction. The distribution of the metals across the four phases followed the decreasing order: metals in organic fraction > metals in reduced form > Exchangeable and carbonate fraction > metals in residue form. Furthermore, the risk assessment codes showed that there is a tendency for these metals to move from low to high risk which could pose a threat to the aquatic environment. Hence, there is a need for close monitoring and preventive measures against the discharge of untreated waste into the lagoon (Kazeem*et al.*, 2021).

Our research group also investigated the application of organotin-based antifouling compounds in the harbour during the repairing and painting of ships at the maintenance wing of the dockyard. These antifouling chemicals are extremely toxic to aquatic life and despite restrictions on the use of these organotin-containing antifouling paints by the international communities, the organotin contaminants were still detected in almost all the locations considered for sampling in a significant amount.

Sediment and water samples were collected for two years (2016–2018) covering both the dry and wet seasons. A cold extraction technique by ultrasonication was used for collected sediments,

and a liquid-liquid separation technique was applied to water samples and later cleaned up using a silica gel-based packed column. Higher values of OTCs were recorded during the wet season than in the dry season, and this was attributed to the dredging of harbour and remobilisation of organotin compounds from sediments into the water compartment. These high values obtained for degradation indices implied that apart from the historical source of TBT and TPhT, which were predominantly from the use of antifouling paint, there were non-historical terrestrial pollutants that contained organotin compounds that were from the sewage sludge and wastewater treatment as well as fertiliser applications that had run off into the Lagos lagoon as results of inputs from multi-national companies within the Lagos metropolis. The Principal Component Analysis (PCAs), Cluster Analysis (CA) and correlation analysis provided evidence for the interaction among these contaminants and possible sources of the contaminants. Moreover, 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 (Kazeem*et al.*, 2020).

Mr. Vice-Chancellor, sir, our other published research on water and sediment which were undertaken to understand the fate of toxic metals in the environment include, Sequential extraction of trace metals and particle size distribution studies of Kainji lake sediment, Nigeria (Adekola*et al.*, 2010); Assessment of Pollution Status of Asa River and Okun Stream in Ilorin Metropolis (Usman et al., 2010); Source Identification of Fe and Mn Pollution of University of Ilorin Dam (Adekola et al., 2015); Assessment of the Impact of Industrial Discharge on the Quality of Water around Lafarge Cement WAPCO, Ewekoro, Nigeria (Abdus-Salam and Adeoye, 2019); The impact of water distribution system on eventual quality: A case study of the University of Ilorin water system (Adekola*et al.*, 2013).

Quality of Some Dams in Kwara and Osun States

Potable water is becoming progressively scarce due to anthropogenic pollution and it has necessitated monitoring of the water quality of rivers and dams as a subject of ongoing concern and research. To this end, we conducted a study to assess the quality of water collected from Agba in Ilorin South, Igbaja in Ifelodun, Oloru in Moro, and Omu-Aran in Irepodun dams of Kwara State, Nigeria, using standard procedures. Water and sediment samples were collected from three different spatial locations on the dams. The average values of most physicochemical parameters such as pH, temperature, DO, BOD, TDS, Total Hardness, Alkalinity and some nutrients, such as chloride (Cl^-), sulphate (SO_4^{2-}), phosphate (PO_4^{3-}), nitrate (NO_3^-) and some heavy metals, such as Cu, Zn, in the dams had values that were within WHO guidelines for drinking water. However, Cd and Fe concentrations were observed to be much higher than WHO guidelines for drinking water. This could be a result of anthropogenic input. The dams' sediments analysed for heavy metals showed that Mn, Zn, and Cd were high in the dams, which could have been easily washed into the water body through leaching, thereby causing a detrimental effect on the consumers (Abdus-Salam, *et al.*, 2016).

The Owalla Dam water and sediment qualities were determined by using appropriate analytical techniques. The average values of most physical-chemical parameterswere within World Health Organization (WHO) and United State Environmental Protection Agency (USEPA) guidelines for drinking water. Toxic trace elements including Cd and Pb occurred in very minor to insignificant concentrations with Igeo (index of geo-accumulation) values classifying the sediments as unpolluted. The sediments were also characterised by variably-high CIA (chemical index of alteration) values (av. 60) which was an indication that their derivation was from moderate to high tropical weathered source areas (Abdus-Salam, *et al.*, 2013).

Mr. Vice Chancellor sir, I am happy to report to this audience that after the commissioning of Unilorin Dam and before it became operational, its water developed an unpleasant

colouration. The University authority contacted Professor F.A. Adekola, the Unit Head of Analytical and Environmental Chemistry, to determine the cause of the unusual colour. I worked with him and an interim report was submitted. This report necessitated the formation of a multi-disciplinary research group, led by Prof. F.A. Adekola, to determine the remote causes of Mn that were not noticed until after the commissioning of the Dam. I was one of the six (6) man technical members of the research group that was funded under the University of Ilorin Senate Research Grant.

In the 50-page study report that we submitted, we established the high content of manganese (Mn) and iron (Fe) in the geological basement of Unilorin Dam. Under anaerobic or limited oxygen conditions, these metals are in their soluble forms but when the water containing the dissolved metals is exposed sufficiently to the atmosphere (aerobic condition), they are oxidized into fine metal oxides. These oxides impart unsightly colour to the dam water. We also established the nature of the soil structure of the river banks as sandy-loamy with characteristic acidic pH. The sandy nature supported the easy washing of Mn and Fe into the feed water (Oyunriver) and the dam while the pH condition enhanced the bioavailability of manganese and iron. The report concluded that the source of Mn was natural and was from the geological basement of the river and the soil of the river banks (Adekola*et al.*, 2008). An additional ion exchange component was recommended to be added to the water treatment unit to remove dissolved Mn in the water. The recommendation was implemented and the problem was permanently resolved.

Dumpsites and Soil Pollution

Mr. Vice Chancellor, sir, the followings are my contributions to the understanding of the quality of polluted soil through unguided or planned but unscientific creations of dumpsites. Dumpsites are commonly located within the vicinity of living communities and wetlands. The dumpsites are often not lined and their basements are not usually prepared for selective

adsorption of toxic substances. Therefore, they are prone to release pollutants to nearby water and the air through leachates and dumpsite gases respectively.

LokojaDumpsits: Soil samples from six (6) dumpsites located indiscriminately within Lokoja, Kogi State, were collected with the aid of a soil auger at the depth of about 30 cm below the earth's surface. The speciation pattern of heavy metals (Zn, Mn, Cd, Pb, and Fe) from dumpsite was investigated, using Tessier's five steps sequential extraction procedures. Metals associated with geochemical fractions were used to predict the fate and mobility of these metals in the soil environment. The possible impact of the dumpsites on the surrounding hydrosphere (water bodies) was studied on the leachates, which were collected within 20 m reach of the dumpsites. The research concluded that the dumpsites posed a potential pollution danger to nearby groundwater due to the high mobility of the heavy metals.The high per cent bioavailability was an indication of poor retention in the residual geochemical form partly due to saturation and/or old age of the dumpsites (Abdus-Salam *et al.*, 2011).

Ilorin Dumpsites: Speciation and distribution of heavy metals in soil control the degree to which metals and their compounds are mobile, extractable, and available to plants. Eight (8) strategically located dumpsites in the Ilorin metropolis were chosen for the study of the dumpsites-soil characteristic. Both the estimated total and potentially available metals were studied, using EPA 1311 and Tessier et al., (1979) methods respectively. It was observed that the groundwater was vulnerable to contamination as no treated basement to adsorb toxic metals was provided for in the sites. About 70% of Mn, Fe, Zn, Cd, and Pb were found in the exchangeable bound to carbonate and bound to iron/manganese oxide fractions. These fractions represent the mobile and lethal portion of the total metals in the ecosystem. We concluded that the dumpsites in Ilorin posed negative consequences on the soil and groundwater environment. (Abdus-Salam, 2009).

In follow-up research conducted by our research group about eight years later on the dumpsites in the Ilorin metropolis and on the University of Ilorin's dumpsite, we observed similar trends of metal bioavailability in the dumpsites (Shaibu*et al.*, 2015).

Other investigated and published reports of our careful studies on pollution emanating from poor management of dumpsites and soils include the bioremediation of heavy metals in contaminated soil from abandoned Asa dam road dumpsite (Abdus-Salam *et al.*, 2017); Biological monitoring of chromium, copper, iron, manganese, and zinc in Ibadan Province, Nigeria (Giwa*et al.*, 2007); Some heavy metals in urban and rural topsoils of Ibadan, Nigeria. (Giwa*et al.*, 2009).

Atmospheric Pollution

The physicochemical quality of rainwater in the atmospheric environment of Ilorin, was evaluated. Rainwater samples were collected on every rainy day between March and October 2008. Samples were analysed for pH, conductivity, and water-soluble cations and anions. Generally, the ionic abundance in precipitation (µg L^{-1}) showed the general trend: NO_3^->Cl^-> SO_4^{2-}> PO_4^{3-} for anions and Ca^{2+}> K^+> Na^+> Fe^{2+}> Mg^{2+}> Pb^{2+} for cations. The statistical analysis of physicochemical parameters revealed a strong correlation ($p < 0.01$ and $p < 0.05$) among some sites and this was an indication of a common source of inputs for these parameters. In summary, both natural and anthropogenic inputs into the atmosphere influenced the changes in the chemical compositions of wet precipitation (Abdus-Salam*et al.*, 2014).

In another study of urban air pollution, the needle leaves samples of Scots pine (*Pinussytveslris L.*), a bio-indicator plant, were collected from nineteen trees of uniform growth. The pine needle trees from twelve locations in Ibadan and seven locations in Ilorin were sampled. The results showed that there was no significant difference between the concentrations of sulphur in the two cities at a 95% probability level. The levels of Zinc in the two cities were also lower than 100 ppm, which is the

established concentration for unpolluted sites. Cadmium concentration in all samples was generally below the detection level of 0.0I ppm. We concluded that both cadmium and Zinappeared not to pose any threat to the ambient environment of these cities (Adekola*et al.*, 2002).

Remediation Studies

Mr. Vice-Chancellor, sir, **"Pollution: A Curse or a Necessity, the Choice is Yours"** presupposes that pollution is problematic, but if one makes it an untouchable monster, then it will, in turn, be a curse. But if it is considered a necessity that is associated with the benefits of industrialization and globalization, then a remediation strategy must be put in place to checkmate the pollution components. The latter consideration is my approach to pollution issues. The presentation so far was on my concerted research efforts and that of my research team for over two decades on identifying the pollution problems and quantifying them using the instrumentation of analytical chemistry. The second aspect of my research is on environmental pollution remediation, which utilized the combination of synthetic and analytical chemistry to solve environmental problems.

Natural Goethite

Osogbo Goethite: An investigation was carried out on the potential of locally-sourced goethite for the removal of cadmium ions from aqueous solutions, using the batch equilibration technique. Identified α-FeO.OH (goethite) sample was obtained from the Geological Survey Department of the Federal Ministry of Solid Mineral, Osogbo, Nigeria. Both IR and XRD techniques provided evidence for cadmium fixation on the surface of the goethite. The adsorption kinetics appeared to be rapid as equilibrium was attained within 1 hour. The sorption mechanism appeared to follow the Langmuir adsorption isotherm model. It proceeded through physical adsorption onto the goethite surface. It was concluded that the natural goethite structure did not collapse under the experimental conditions because there was no release of Fe in the analysed solution after

Cd-adsorption. This is a good characteristic for an eventual industrial application (Salami and Adekola, 2002).

Kaduna Goethite: we also studied other experimental conditions that would enhance the adsorption capacity of natural goethite. Adsorption characteristics of Pb and Cd were conducted on natural goethite from Kaduna (Nigeria) and compared same with synthetic goethite. Adsorption efficiency was greatly governed by pH with nearly 100% adsorption of Pb occurring at initial pH of 5. Generally, Pb was adsorbed more strongly with increasing pH from 3 to 5 than Cd and thus posed a less environmental threat. The adsorption behaviour was essentially the same, although, synthetic goethite adsorbed a little more metal ion than natural goethite. The higher performance was attributed to the higher purity of synthetic goethite than natural goethite per unit mass of sample rather than the greater chemical reactivity of the synthetic goethite (Abdus-Salam and Adekola, 2005). We concluded that natural goethite can compete favourably with synthetic goethite for decontamination of Pb or Zn from polluted effluents. The following equilibria can represent the reaction scheme for the adsorption process of the goethite,

$$M^{2+} + SOH \rightleftharpoons SOM^{+} + H^{+}$$

$$M^{2+} + SOH + H_2O \rightleftharpoons SOMOH + 2H^{+}$$

where M represents Cd, Pb or Zn while OH represents the surface hydroxyl group on goethite, S is the goethite as the adsorbent.

Mr. Vice-Chancellor sir, the structural stability of goethite as an adsorbent was investigated using two Nigerian goethites (Osogbo and Kaduna) dissolution patterns in HCI and HNO_3 similar to industrial effluent conditions. The rate of dissolution was found to be slightly faster in HCl than in HNO_3 under the same experimental conditions. The higher rate of dissolution in HCl could be attributed to the complexing ability of Cl^- in addition to the H^+ effect while the lowering effect by NO_3 was attributed to the adsorption of NO_3 onto the goethite surface. Mononuclear complexes, especially bidentate of

oxyanion, are found to accelerate dissolution as opposed to binuclear complexes. A binuclear bidentate surface complex formation between NO_3 and Fe^{3+} was therefore proposed to account for the inhibition observed. The possible formation of Fe—Cl reduces both the surface positive charge and the repulsion between the oxide surface and protons in the solution. This produced accelerated proton dissolution. The effect of temperature on the initial dissolution rate fits into the Arrhenius equation, with Kaduna goethite exhibiting a higher rate than the Osogbo type in both acids. We concluded that in case these acids are needed for regeneration or desorption experiments, the concentrations used are mild enough and will produce minimal loss of goethite samples based on the percentage of Fe^{3+} dissolved per g- goethite (Abdus-Salam and Adekola, 2006).

Synthetic Hematite: A Hematite sample was synthesized, using the precipitation method, and it was characterized, using a combination of analytical techniques such as FTIR, XRD and AAS. The hematite was then studied for its potential to remove chromate ions from an aqueous solution. The experimental results were finally analysed, using Langmuir, Freundlich and Temkin isotherms. The Temkin isotherm was found to have the most satisfactory fitting for the sorption data (Bodunde*et al.*, 2013).

Adsorbents from Agricultural Wastes

Mr. Vice-Chancellor, sir, our curiosity in cleaning the environment from a large volume of annually generated agricultural garbage directed my research focus on how to convert the readily available waste into useful biomass adsorbent. Moreover, the cost of available imported adsorbent is usually expensive and it is a contributing factor to the evasion of effluent treatment by many industries. An adsorbent from readily available agricultural waste with comparative efficiency with imported activated carbon will conserve our foreign reserve, boost our economy and clean our environment of pollutants. We realised from this effort that nothing is a waste and whatever you

throw away because it has no value to you is a valuable raw material for a new product, if only you know.

Activated Carbon from Date Palm Seed

Activated carbon was prepared from date palm seed, using one-step process of carbonization and activation with 56.54 % efficiency. The adsorbent was characterised by FTIR and XRF for surface functionality and elemental composition respectively. Kinetic studies showed good regression coefficients for pseudo-first and pseudo-second-order kinetic models. The adsorption data fitted well into Langmuir isotherm than Freundlich isotherms with regression coefficient (R^2) very close to unity. The thermodynamic quantities, such as ΔG, ΔH and ΔS were evaluated and indicated that the adsorption process was spontaneous and endothermic. We, therefore, concluded that DPA can be considered as alternative biomass for the removal of a single dye solution of alizarin and fluorescein since it was found to be effective, low cost, abundant, and can be sourced locally (Abdus-Salam and Buhari, 2016).

Activated carbon from mango seeds (MGA): MGA was prepared using a one-step procedure with 62.27% yield and was characterised using standard analytical procedures. The adsorptions of Alizarin and Fluorescein dyes were rapid at the first 15 min of agitation with 86.90% and 85.75% removal respectively. The regression coefficient (R^2) values for pseudo-first order and pseudo-second order kinetic models were 0.938 and 0.999 respectively. The adsorption data for Alizarin and Fluorescein dyes on MGA fitted well into Langmuir isotherm with regression coefficient (R^2) very close to unity and Langmuir maximum adsorption constant, q_m of 1.00. The evaluated thermodynamic quantities revealed negative values of ΔG, positive ΔH and ΔS, which indicated that the adsorption of these dyes was spontaneous, endothermic and increasingly random at the aqueous-MGA interface during adsorption. Therefore, we concluded that MGA can be considered as alternative biomass for the removal of the single dye solution of Alizarin and Fluorescein dyes since it was not only effective but abundant;

and it can be sourced locally at low cost (Abdus-Salam and Buhari, 2014).

Jatrophacurcusis a drought-resistant perennial species that grows well in marginal or poor soil. In our quest for adsorbents from local agricultural waste that will have comparative performance with imported activated carbon, we investigated the preparation of adsorbents by pyrolysis and modification of physic nut plant stem (MDS), root (MDR) and coat (MDC) while the carbonized samples were labelled ACS, ACR and ACC respectively. The preparations of a number of adsorbents were therefore performed on a laboratory scale by activation with activating agents such as $ZnCl_2$, H_3PO_4, and NaOH. They were also characterized, using standard methods including SEM and iodine number, which is a relative indicator of porosity in a carbonaceous material and may be used as an approximation of surface area for some types of carbon. Higher iodine numbers reflected the better development of the microporous structure and higher adsorption abilities for low-molar-mass solutes. The characterization data obtained indicated that the adsorbents with favourable physicochemical properties were produced using several methods. The adsorbents (MDS, MDR, MDC, ACS, ACR, ACC) in this study had shown to have excellent physicochemical properties and the SEM showed they had well-defined or organized surface morphology structures (Fig. 3). The iodine number of the adsorbents is in the range of 208.5 - 244.9, which is in agreement with the result obtained in Jatropha Husk activation with H_3PO_4 (Kumar et al., 2009). These showed that they could be used as effective adsorbents for the removal of contaminants from water. As the raw material of the carbons is disposed off as waste, applications of the MDS, MDR, MDC, ACS, ACR, ACC adsorbents to the water treatments are expected to be low cost and effective (Elelu et al., 2019).

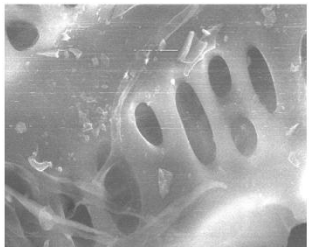


Fig. 3: SEM of Activated Carbon of Stem (ACS) x 2000 Magnification

Composite Formation between Inorganic and Biomass Adsorbents

Mr. Vice-Chancellor sir, our success in the preparation of adsorbents from waste agricultural materials (Biomass) challenged us on the need to improve on their adsorptive characteristics to be competitive with high-performing inorganic adsorbents. This directed my research focus again to how we could re-engineer the structure of the low-cost biomass adsorbents through composite formation between our biomass and good-performing inorganic adsorbents. The composites are of better structural properties than the precursors (the biomass and inorganic) adsorbents. This usually confers higher adsorption efficiency on the composites than the precursors under the same experimental conditions. The composite is cheaper because an equal mass of both (biomass and inorganic) will contain no more than half of the inorganic adsorbent plus biomass. Furthermore, composites with the right proportions of precursors are usually more efficient than inorganic adsorbents alone.

Magnetite and Baobab Composite: Magnetite (MG) was synthesised, Baobab fruit shell (BB) adsorbent was prepared and the composite between the two adsorbents (MB) was prepared in situ. The three adsorbents were characterized and separately applied for the removal of zinc from synthetic wastewater. The adsorbents' performance was investigated from the effects of initial metal ion concentration, adsorbent dose, contact time, temperature, and pH, which are high determinant

factors for pollutants removal from aqueous solutions. The adsorption data obtained were fitted into Langmuir, Freundlich and Temkin isotherm models and the Freundlich isotherm fitted the experimental data best with a regression coefficient (R^2) value close to unity. The pseudo-second-order kinetic model best described the adsorption of Zn(II) on the adsorbents with an R^2 value close to unity suggesting a covalently bonded chemical process. Thermodynamic studies showed that the adsorption processes were endothermic and mostly spontaneous for Zn(II). We concluded that the Baobab-magnetite composite (MB) had greater efficiency than the precursors (Fig. 4). Desorption experiments were conducted on the spent adsorbent to determine the economy of reusability potential of the adsorbents. The three adsorbents were found to have high efficiency for reuse at low concentrations of HClleachant. which suggested a good regenerative potential for the adsorbents' usage (Abdus-Salam and Adekola, 2018).

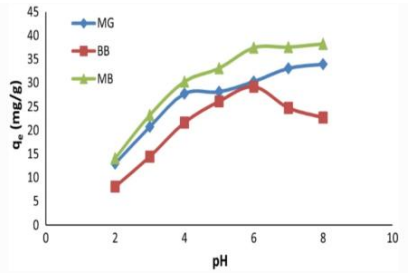


Fig. 4: Effect of pH on the Adsorption of Zn

Goethite and Date palm Composite: Goethite was chemically synthesized (GT) through the air oxidation method of precursors, Date palm (*Phoenix dactylifera*) seed (RDS) was prepared as adsorbent while the composite (COM) of the two was prepared in-situ. The three adsorbents were characterized, using FTIR for the surface functional groups; SEM for the shapes and morphology of both samples; XRF to obtain the elemental composition; BET surface area determination and particle nano-sizer to determine the size of the particles. The results obtained

showed that pHpzc values were 8 and 7 for goethite and composite respectively. We concluded that on the basis of the characterization results obtained, the synthesized GT and the prepared COM would find applications in ion exchange, chromatographic methods and adsorption processes (**Abdus-Salam** and Ikudayisi, 2017).

Remediation of Dye Pollution

Textiles, paper and pulp manufacturing, leather treatment, printing, and food products industries make use of dyes for different purposes. These dyes are toxic, carcinogenic or mutagenic and can pose a severe hazard to health when ingested by aquatic organisms and man. It is a major source of pollution in the water environment and a major concern to environmentalists. Our research efforts in pollution remediation were directed towards the "process development" of treatment procedures that will yield comparative efficiency if not better than what is currently available and more cost-effective. Our effort is yielding positive results.

Mr. Vice-Chancellor sir, the menace of dye pollution is worrisome because a little quantity of it in water can spread fast and wide and can create aesthetic problems in addition to its carcinogenic effect. Several methods of removing pollutants from wastewater were studied and reported by various researchers [Abdus-Salam &Buhari, 2016]. Adsorption unlike ion exchange, coagulation, ultra-filtration, membrane filtration, and chemical precipitation for removing pollutants from wastewater, has more advantages in terms of cost, operation, and design. Various studies have shown that the adsorption method can be applied in removing dyes from wastewater by the application of metal oxides or their composites.

The adsorption of Rhodamine B (RB) on ZnO-NPs was investigated by my research team at varied solution pH (2–10), concentration (10–60 mg/L), adsorbent mass (0.05–0.25 g), temperature (293–315 K), and contact time (5–240 min). The optimum adsorption was established at pH 6 in 150 min, while the maximum adsorption capacity of RB on ZnO-NPs was 24.41

mg/g at pH 4 in 180 min, using 50 mg/L RB at 313 K. The Langmuir isotherm model fitted adsorption data well while the adsorption process followed pseudo-second-order kinetics with $R^2 = 0.987$. The change in Gibbs free energy (ΔG^o) obtained was negative, signifying the spontaneity of the adsorption process, while the positive values of ΔH^o (+5.35 kJ/mol) and ΔS^o (+0.02 kJ/mol) for RB adsorption on ZnO-NPs indicated endothermic adsorption and randomness at the ZnO-NPs-aqueous interface respectively. Therefore, it was concluded that the nanoscaleZnO-adsorbent is efficient for the removal of RB from wastewater. Our results were compared with similar research efforts in literature (Table 2) (Godwin *et al.*, 2022a).

Table 2: Comparison of Adsorption Capacities of Rhodamine B on Various Adsorbents with ZnO-NPs.

Adsorbent	% Removal	Reference
ZnO-NPs	**97.70**	**Present work**
Acid-treated banana peel	89.80	Oyekanni*et al.* [2019]
MgO supported on Fe-Co-Mn	92.20	Rahdar et al. [2019]
Moringaoliefera	92.00	Ramuthal*et al.* [2009]
Natural Moroccan clay with CTAB	90.1	Damiyine et al. [2017a]
Expanded perlite from aqueous solution	82.00	Damiyine et al. [2017b]
Acid activated carbon	85.00	Mitra et al. [2018]
Iron impregnated in activated carbon	85.00	Menderes *et al.* [2014]
Natural diatomite	85.50	Musale et al. [2017]
Carbon powder of *polyalthialongifolia* seed	93.00	Husari et al. [2013]

The adsorption of Methylene Blue (MB) onto Raw Date-palm Seeds (RDS), Thermally Activated Carbon (TAC), Chemically Activated Carbon (CAC), Goethite (GT) and their Composite (COM) were studied, using batch equilibrium technique and optimisation of dependable variables. The

combined results of isotherm, kinetics, and thermodynamic studies suggested a combined physio-chemisorption process. Also, the kinetic modeling suggested that intra-particle and film diffusions occurred simultaneously and/or in combination with other processes in the mechanism of adsorption (Abdus-Salam*et al.*, 2021a).

In another separate application, these adsorbents were applied to the removal of an acid dye- eosin yellow (EY) in a batch equilibrium experiment. The effects of initial concentration, pH, adsorbent dosage, agitation time and temperature were optimized. The obtained thermodynamic parameters revealed that the adsorption processes were exothermic (- ΔH), feasible, and spontaneous (- ΔG except for RDS) (**Abdus-Salam et al.**, 2021b).

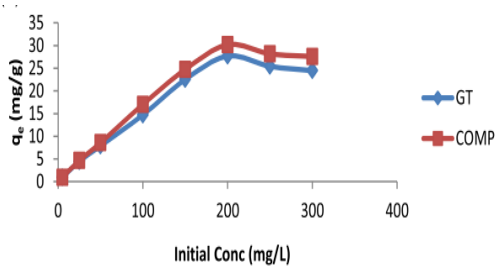


Fig. 5: Comparative Effect of Initial Concentration on Adsorption of Eosin Yellow (EY) on MG and Composite

Nanotechnology

Mr. Vice-Chancellor sir, over the years, metal oxide design and fabrication at the nanoscale range has received great attention with the advent of nanotechnology. The field of nanotechnology is a fast-growing and promising area that offers improved, innovative, and cost-effective solutions to solving environmental problems in terms of the design of nanomaterials (Chen and Gao, 2021). My research group ventured into the synthesis of pure nano-sized adsorbents for the decontamination of polluted water bodies. In the beginning, the nano-size range was not easily attainable as our initial synthetic products were

particle sizes outside the nano range (>100 nm). With strong determination and careful manipulation of variable parameters, we have made tremendous progress. Some of our successes are reported below:

Zinc Oxide nanoparticle (ZnO-NPs): The ZnO-NPs were synthesized and characterized, using XRD, SEM, and TEM to determine the composition, crystallinity, and morphology of the nanomaterial respectively, while the bonds and functional groups were determined by FTIR method. Pure ZnO-NPs were synthesized since there were no other characteristic peaks observed other than that of ZnO. The synthesized ZnO-NPs had a specific area BET of 70.13 m^2/g, pore volume of 0.45 cm^3/g, and pore size of 15.66 m^2/g. The DLS results for nanoparticle sizing showed that synthesized ZnO-NPs had an **average particle size of 52.76 nm** and therefore, ZnO-NPs adsorbent contained mainly mesopores. The EDX showed that it contained zinc and oxygen only; the pHpzc was found to be 6.53; careful observation of the TEM images confirmed hexagonal structures, while the SAED image showed that the nanomaterial was within the nano-range (Godwin *et al.*, 2022).

Goethite nanoparticles (α-FeOOH): α-FeOOH nanoparticles were synthesized by the hydrothermal-assisted method and characterised, using XRD, FTIR, SEM, TEM, and DLS methods. The XRD results showed that single-crystalline orthorhombic α-FeOOH was formed, while SEM and TEM images showed that the synthesized α-FeOOH nanoparticles were rod-like in shape. The EDAX result gave a good composition of the respective elements of the synthesized nanomaterial, while the Dynamic Light Scattering (DLS) study gave average **nanoparticle sizes of 58.24 nm**. The mechanism of batch adsorption of Pb(II) and Indigo carmine (IDC) onto α-FeOOH nanoparticles was studied at various conditions of solution pH, adsorbate concentration, adsorbent dose, temperature, and time of agitation. The optimum adsorption capacity of Pb(II) and IDC at pH 4 and 10 were estimated as 18.99 and 287.98 mg/g at 318 and 313 K respectively.

The Langmuir isotherm model fitted well with the regression coefficient, R^2 = 0.9898 and 0.9966 for Pb(II) and IDC respectively. The pseudo-second-order kinetics, with R^2 = 0.9974 and 0.9861 for adsorption of Pb(II) and IDC respectively, best described the adsorption process. However, intraparticle diffusion and pore-filling mechanism were found to control the adsorption rates. The change in Gibbs free energy (ΔG°) obtained was negative, which revealed spontaneous adsorption processes, while the positive values of ΔH (+107.08 and +102.15 KJ/mol) and ΔS (+0.361 and +0.341 KJ/mol) for Pb(II) and IDC respectively showed an endothermic and randomness of the adsorption processes. The activation energy showed that the adsorption onto α-FeOOH NPs adsorbent was a physical process with external diffusion as the rate-determining step. (Godwin *et al.*, 2022).

Hematite (α-Fe_2O_3): In another research work, we designed an easy and simple hydrothermal approach for synthesising pure rod-like Hematite (α-Fe_2O_3) in an alkaline medium, using a hydrated salt of iron without any hard template or surfactants. Rod-like α-Fe_2O_3 obtained by the hydrothermal method was characterised, using XRD, FTIR, FESEM, EDX, TEM, and DLS methods. The XRD analysis showed that the single-crystalline sample indexed as the pure rhombohedra α- Fe_2O_3 material was formed, while the DLS and zeta potential analysis indicated an average particle diameter and particle size of about 1300.9 nm and 31.20 mV with less aggregation respectively. The FESEM and TEM analyses showed that the synthesized α- Fe_2O_3 minerals were rod-like in shape, while EDX analysis gave a good composition of the elements with only peaks of iron (Fe) and oxygen (O_2) in the absence of other impurities in the synthesized rod-like α- Fe_2O_3. Therefore, this method may be applied to synthesize other forms of iron minerals or other inorganic materials at an industrial scale level, especially when rod-like materials are needed (Abdus-Salam *et al.*, 2020).

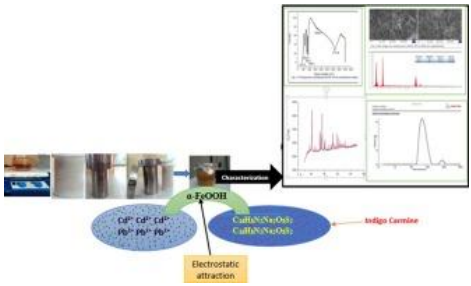


Fig. 6: Hydrothermal Synthesis of α-Fe_2O_3

Mr. Vice-Chancellor, Sir, ZNPs adsorbent was synthesised through a carefully designed procedure involving progressions of the chemical reactions and final calcination of co-precipitated hydroxide of zinc at 500 ^{O}C (Fig. 7). This reaction scheme involved five (5) stages of reactions depicted by the following equations:

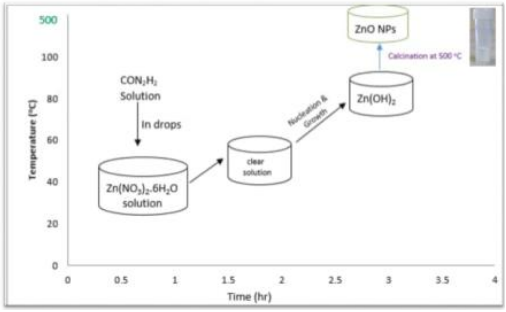


Fig. 7: Schematic Procedure for the Synthesis of ZnNPs.

Step I: Dissolution of urea in water to produce ammonia (Eqn. 1);

$$CO(NH_2)_2(s) + 3H_2O(l) \rightarrow CO_2(g) + 2NH_3(g) + 2H_2O(l) \quad (1)$$

Step II: Generation of ammonium ions from ammonia to enhance pH required to grow Zn nanocrystals (ZNPs) (Eqn. 2);

$$CO_2(g) + 2NH_3(g) + 2H_2O(l) + e^- \rightarrow OH^-(aq) + (HCO_3)^{2-}(aq) + 2NH_4^+(aq) \quad (2)$$

Step III: Dissolution of Zinc nitrate to produce Zn^{2+} ions (Eqn. 3);

$Zn(NO_3)_2(s) + H_2O(l) \rightarrow Zn^{2+}(aq) + 2NO_3^-(aq) + H_2O(l)$ (3)

Step IV: Reaction of aqueous products of steps II and III to produce the hydrated zinc species and hydroxide ions (Eqn. 4);

$5(CO_3)^{2-}(aq) + 4Zn^{2+}(aq) + 6OH^-(aq) + H_2O(l) \rightarrow Zn_4CO_3(OH)_6(s) + H_2O(l) + 5e^-$ (4)

Step V: Decomposition of hydrated zinc species on heating to produce ZNPs (Eqn. 5)

$Zn_4CO_3(OH)_6.H_2O(s) \rightarrow 4ZnO(s) + 4H_2O(s) + CO_2(g)$ (5)

Zinc oxide nanoparticles (ZNPs) were prepared from $Zn(NO_3)_2.6H_2O$ and CON_2H_4. Multiple analytical tools including X-ray Diffraction (XRD), Scanning Electron Microscopy (SEM), Energy Dispersion Atomic X-ray (EDAX), Transmission Electron Microscopy (TEM), and Thermogravimetric-Differential Thermal Analysis (TGA/DTA) were utilized for determination of the composition, morphology, elemental analysis, crystallinity, and thermal stability respectively, while Fourier-Transform Infrared Spectroscopy (FTIR) method was used to determine the functional groups present in the ZNPs. The Debye-Scherer equation ($K = 0.9/\beta\cos\theta$) was used to estimate the average crystal size of the synthesized ZNPs and obtained **35.69 nm**- where the particle shape factor was taken to be 0.9, λ is the wavelength of the CuKα radiation, and β the Full Width at Half Maximum (FWHM) of the diffraction peak in radian, which corresponds to the Bragg diffraction angle (2θ). However, the DLS results of ZNPs for particle sizing revealed that the synthesised material had an average particle size of **52.76 nm** (Godwin et al., 2022).

Table 3: Comparison of Different Adsorbents used for the Adsorption of Pb Ions and ARS from Aqueous Phases

Adsorbent	**Analyte**	**Quantity adsorbed (mg/g)**	**References**
Activated char from neem	Pb(II)	205.6	Patel, 2020
GWTRs)	Pb(II	92.70	Magdalena *et al*, 2019
Acid activated bentonite	Pb(II)	8.92	Prathiksha, and Balakrishna, 2021
Fe_3O_4/rGO	Pb(II)	65.79	Hoan*et al.*, 2016
$NiFe_2O_4$	Pb(II)	168.0	Andal (2014).
$MgCl_2$-loaded banana straw	Pb(II)	302.0	Li *et al.,* 2020
$MgCl_2$-loaded cassava straw	Pb(II)	200.06	Li *et al.,* 2020
ZNPs-adsorbent	**Pb(II)**	**341.65**	**This work**
CTAB modified alignate bound onto magnetite	ARS	16.89	Vijayalakshmi et al., 2017
Chitosane/ZnO	ARS	8.01	Omnia, and Sahar, 2017
α-$Fe_3O_4^-$ cover composite	ARS	10.74	Omnia, and Sahar, 2017
Olive stone	ARS	10.90	Albadarin, and Mangwandi, 2015
ZNPs-adsorbent	**ARS**	**18.84**	**This work**

The adsorption of Pb(II) and Alizarin Red S (ARS) onto ZNPs obtained was investigated at different solution pH, adsorbate concentration (pollutant), adsorbent mass (ZNPs), working temperature, and contact time between the pollutant and ZNPs. The optimum adsorption capacity of Pb(II) on ZNPs was

341.65 mg/g at pH 10 in 180 minutes at 318 K. A comparison of the adsorption of Pb (II) and ARS on the synthesized nano adsorbent with other adsorbents by other researchers (Table 3) revealed that ZNPs synthesized in this work had higher adsorption capacity for Pb ions and alizarin red S (ARS) than the values obtained by other researchers (Godwin *et al.*, 2022).

My Humble Contributions to Human, Capital and Infrastructural Development

(a) **Supervisees:** All praises and glory belong to Allah who taught man what he knows not. The absolute claim to have trained students belong to Allah but He uses man to facilitate that. I have supervised to completion of about 180 undergraduates, 38 masters, and seven (7) Ph.D. students. Some others are at different stages of completion.

(b) **Administrative Headship:** I was Ag. Head of Department, University of Ilorin (2013 – 2015), Dean, Faculty of Science, Federal University of Kashere, Gombe State (2016 – 2017), Director, General Studies Division, University of Ilorin (2018–2021), Director, Central Research Laboratories, University of Ilorin (2021 to date).

(c) **GNS Administrative Building:** The perennial inadequacy and befitting administrative office space for GNS Division were resolved during my tenure as Director of GNS. The culture of financial discipline, creativity and desire to move the GNS Division to a new level opened the idea of the construction of a new administrative building from the Internally Generated Revenue (IGR) of the Division. The proposal was presented and welcomed by the former Vice-Chancellor, Prof. S.A. Abulkareem who did the other part of the processing of the request till approval was given by the Bureau of Public Procurement (BPP) to carry out the construction by direct labour. A total sum of **twenty-eight million, eight hundred and ninety-eight**

thousand, one hundred and sixty-four naira (₦28,898,164.00) only generated through GNS IGR was expended in the construction of the building.

The GNS textbooks were developed into full courseware and made available to students and lecturers. Furthermore, I midwife the development of GNS lecture materials compatible with modules on Learning Management Systems (LMS) using the already developed courseware. The lecture materials that are currently available to students include courseware and PowerPoint materials as well as video recordings of the lecture deliveries. This was achieved before the University management decided on online lecture delivery occasioned by the COVID-19 pandemic. I acknowledge my predecessor in office, Prof. Wahab O. Egbewole SAN who commenced an online lecture delivery for GNS312.

Conclusion and Recommendations

Mr. Vice-Chancellor Sir, in the course of this presentation, I have carefully discussed my research efforts spanning over two decades in the area of water and land pollution management. In my research efforts, my research team and I examined the pollution index of dams, rivers, boreholes, wells, sediment, and soil using various analytical tools. I have discussed my efforts in process development with the sole aim of establishing ways of decontaminating the water regime. Our latest effort in process development is in the emerging area of nanotechnology in which we have successfully synthesized novel nanoscale adsorbents and applied them with improved results. The main conclusion of my discussion so far is that global pollution problems emanate from poor management of anthropogenic activities. There is a huge investment of human and capital resources into what man gets out of the environment without commensurate attention to the management of the harmful by-products of those processes. Effective and coordinated approaches can resolve the threat of global pollution. Therefore, it is our collective responsibility to make pollution either a mere necessity or a monster of problems which

summarises and encapsulates the title of this Inaugural lecture **"Pollution: A Curse or a Necessity, the Choice is Yours".**

Mr. Vice-Chancellor, sir, Nigeria with a population of about 200 million people with a moderately growing industrial sector, poorly planned urban settlements, and poorly enforced environmental regulations, is bound to face a pollution threat from those sectors. I, therefore, make the following recommendations to avert the negative consequences of pollution:

1. Analytical Chemistry is central to pure science and science-related discipline research. It requires state-of-art equipment to obtain full information about the finite details of research products. These pieces of equipment are seldom available locally and are usually expensive. There cannot be a research breakthrough without qualitative analysis using appropriate and sensitive analytical tools. I call on the government to increase research funding and provide state-of-art equipment to work with.
2. Funding breakthrough scientific research requires huge capital involvement and the government budget alone is grossly inadequate to meet up with the expectations. Corporate bodies' participation in funding research is the best practice globally. I strongly recommend enhanced legislation on participatory funding for science and science-related disciplines by industries and government parastatals with robust internally generated revenues such as the Nigerian Communications Commission (NCC), National Space Research and Development Agency (NASRDA), National Agency for Food, Drug Administration, and Control (NAFDAC), Nigerian National Petroleum Corporation (NNPC), Standard Organization Nigeria (SON) etc.
3. As a matter of urgency, the University Senate Research Grant should not only be reintroduced and maintained, but the value payable to researchers should increase and

be more readily accessible to researchers, particularly, young researchers.

4. The current trend in which related disciplines separately own the same equipment should be discouraged. The proliferation of state-of-art equipment is not economically viable and providing experts to all units and departments to operate them is not cost-effective, particularly in a dwindling economy like Nigeria. Central Research Laboratories in the Universities and Research Centers should be strengthened with these pieces of equipment to serve the larger community.
5. Clean and accessible portable water is one of the critical areas of the UN Sustainable Development Goals and Nigeria can only achieve this through its Ministry of Water Resources. The core mandate of the ministry of water resources is "To develop and implement policies that will make Nigerians have access to clean and safe water at all times". Government policy surmasult is negatively affecting this ministry as a result of its merging, splitting, scrapping, and restructuring, leading to the abandonment of its core mandate. For instance, the ministry at various times has been merged with the Ministry of Agriculture and Rural Development. Government should strengthen this ministry to stabilise and carry out its statutory functions.
6. Freshwater resources (surface and underground water) are critical to a healthy environment and water usability. Presently, these resources are polluted at varying degrees and necessary water standards and regulations must be enforced to ensure portable water quality. Government should challenge relevant agencies such as the National Water Research Institute (NWRI) and the National Environmental Standards and Regulations Enforcement Agency (NESREA) to constantly monitor industrial effluent discharges and enforce necessary regulations.

7. Lagos lagoon is contaminated with organotin compounds and its derivative species, which come from their uses as antifouling agents for ships despite the fact that they are known endocrine disruptors. There must be an effective ban on the use of organotin compounds as antifouling agents. Furthermore, intensive monitoring of the activities taking place in Nigeria harbour must be implemented because the half-life of these OTCs that had locked into the sediment is low and can resurface gradually, most especially in the presence of biotic and abiotic factors.
8. Refuse disposal dumpsites in most urban areas are indiscriminately sited and unscientifically prepared. The geological soil formation, location of water resources, and ability of the dumpsite basement to selectively retain toxic pollutants from percolation into freshwater are necessary factors for consideration for dumpsite locations. For this reason, the government should consider a basement treatment for dumpsites before use.

Acknowledgments

All praises, glorification, and adoration belong to the Creator of the Universe, who taught man what he knows not. Neither my parents nor I envisioned where I am today in spite of their vision for me, but the Merciful Lord has led me to the fountain of grace; ALHAMDULILLAH. Join me in praising HIM if you find anything good in this presentation by saying ALHAMDULILLAH and whatever shortcoming in it is due to imperfection in me, please forgive me. Choosing the right career in life and climbing to the zenith of the career, despite all odds, is not my making, but the choice of HE. Who is this HE? The HE is:

وَهُوَ اللَّهُ لَا إِلَٰهَ إِلَّا هُوَ لَهُ الْحَمْدُ فِي الْأُولَىٰ وَالْآخِرَةِ وَلَهُ الْحُكْمُ وَإِلَيْهِ تُرْجَعُونَ

"And He is Allah; there is no Allah save Him. His is all praise in the former and the latter (state), and His is the command, and unto Him, ye will be brought back (Q28:70).

I thank Allah who has guided me to this path of glory, were it not for HIS guidance, I would not have been rightly guided. Unfortunately for me, my parents who laboured on the farmland during the rainy and sunny days to nurture and educate me did not witness this day- AlhajaMuniratAmope Salami (d. 08/04/2001) and Alhaj (Alfa) AlabiAfolabi Salami (d. 10/12/2019). May their souls be admitted into Al-JannatulFirdaus, aamiin. I acknowledge my numerous paternal uncles and aunts who contributed to my education at one stage or the other: MalamLawalAmoo, Mrs. EgberongbeSanusi, AlhajaMariamoAyerinaSalau, Madam Aisha Muhammad; and maternal aunts Mrs. BilqisOyeyemi, Mrs. HabibatAyinla, and Mrs. HalimatAmoo (all of the blessed memory) and my maternal uncle MalamAlabiShittu. May you live long to reap the fruits of your sacrifice (aamiin). Mr. Rasak O. Lawal is a strong supportive cousin and a pillar in my extended family. The contributions of every one of you to my education formed the solid foundation of my life, and it will continue to yield dividends for you even after your demise.

Unique in my life was my In-laws: (late) Amb. MuhammedPerigroBrimah and (late) AlhajaNusiratBrimah, who trusted the son of a peasant farmer with a precious daughter as my life partner at a time I was obscured and that action of theirs stabilised the rest of my onward life journey. I will forever remain grateful to you. I appreciate my wife's siblings; you are all wonderful.

It is a statement of fact that from the cradle, Allah positioned me on the shoulders of some blessed giant individuals who facilitated my journey to Graceland. My religious teachers are numerous and they are all appreciated for moulding my character and illuminating my heart with the message of Al-Islam. These people include Sheikh (Associate Professor) Yusuf K. Jumu'ah, UstadhAbdulKareemTalabi (late),

AlhajSalaudeenYa'qubOmupo (late), Ustadh Abbas Akinola, AlhajWahabSanusi (Al-Adabiy - late), AlhajiAbdulkadir O. Abdulkareem, Prof. AGAS Oladosu. The other category includes those that I did not learn directly from, but took notes from them on the practical applications of knowledge of Islam to life. They include my mentors in MSSN (Muslim Students' Society of Nigeria), who influenced my thought and actions. They include Prof. Ishaq O. Oloyede, Alhaj Ibrahim Abdullah, Prof. Yusuf O. Badmus, Alhaj Ayo Garba, Alhaj Musa Adelodun, Dr. Muhammad Olukade (late), and a host of others. I appreciate your contributions to my journey in life and may Allah reward you abundantly, JAZAKUMULLAH KHAIRAN.

My teachers on the side of Western Education are no less important to my achievement and the glory of today's inaugural lecture is due to your collective contributions. The following people stood out among others: Principal John Omokan, Mr. Y. Madandola, AlhajaIbiyeye (principal), AlhajAbdulkadir O Abdulkareem, and Mr. Azeez. My supervisors for the three degrees: Prof. G.O. Adediran, Prof M.A. Mesubi, and Prof. Abdulwaheed F.A. Adekola for B.Sc., M.Sc., and Ph.D. respectively. Thank you for the right mentorship. I am grateful to my teachers from Chemistry and Industrial Chemistry Departments: Professors E.O. Odebunmi, J.A. Obaleye, G.A. Olatunji, S.A. Adediran (late), A.A. Owoyale (late), S.A. Ibiyemi, and S.A. Lawani. I remained grateful for the impactful knowledge bequeathed to me.

I sincerely appreciate my senior and other colleagues from the Departments of Chemistry and Industrial Chemistry who made the journey interesting to me. You provided me with the necessary motivation to grow on the job. They include Professors U.B. Eke, Dosumu, A.C. Tella, L.A. Usman, A.A. Baba, (Mrs.) O.O. Oluwaniyi, O.S. Oguntoye, A.M.O. Abdulraheem, Drs. Ameen Mubarak, (Mrs.) A. Lawal, S.A. Owalude, M. F. Zubair, H.I. Adegoke, H.K. Okoro, O.F. Okeola, O. Atolani, A.O. Rajee, Ismaeel, Kuranga and M.O. Bello. I thank other senior colleagues who were former staff of the

Chemistry Department: Professors S.A. AbdulKarem, D.S. Ogunniyi, O.A.A. Eletta, and other younger and upcoming colleagues from our departments (CHM & ICH).

I thank our professional colleagues, the past and present technologists in the Departments of Chemistry and Industrial Chemistry, who facilitated most of the reactions cited in this lecture: Messers S.A. Akanji, M.K Idris, S.A. Asala, A.C. Tomilayo, S.A. Ajala, K.F. Olowe, Mrs. A.A. Ahmed among others.

My sincere appreciation goes to my teaming research students consisting of over 180 undergraduates, 38 master's researchers, and 7 completed Ph.D. researchers: Drs. K.A. Basheer, M.O. Bello, D.I. Etong, J. Godwin, R. Oyewumi-Musa, A. Jimoh, and M. Alkali. I appreciate my co-researchers: Professors A.A. Giwa, O.S. Usman, B.C. Tripathy, A.A. Baba, AMO Abdulraheem, and H.I. Adegoke.

I am grateful to my numerous friends, close associates, and their spouses who are good and dependable companions at all times. Some of these peers are Prof M.O. Yusuf, Engr. KamilOlalekan (FNSE), Dr. Lukman Adam, MessersTajudeenShuaib, YakubRahman (Ramasco), Bashir OmolajaBolarinwa (BOB), Said Yusuf, YahyaIyanda, TajudeenAbdulkareem, HabeebBayo, Hamza Mahmud, HamzaSulyman, Isa Lawal (EASE), Muhammad SaniOnire, GaniAlabi, AbdussalamOkunlola, AbdulbakiAbdulraheem (Perm. Sec.), Ibrahim Abdulkadri, Bashir Onikoko, magistrate TajudeenAdeshina, Ustadh Ibrahim Aliu.

I appreciate the contributions of the following to my adventure into an academic career at the University of Ilorin: Prof. Shuaib Oba Abdulraheem (OFR), who signed my appointment letter; MalamAbulbaqiJimoh (then PA to VC); Prof. F.A. Adekola; Prof. M.O. Yusuf and Mr. R.O Mustapha. I appreciate worthy pieces of advice often received from Alhaj M.K. Idris, Prof. O.B. Oloyede, and Prof. M.A. Akanji that have sustained me in this career.

The present and the past leadership as well as members of “The Companion” and “The Criterion” Kwara Districts and the National Executive of the Associations are worthy of appreciation. I grew up among you, and together with you, I rose to this level. I will ever be grateful because you supported every bit of my steps.

Members of the Council of ‘Ulama’u and the University of Ilorin Muslim Community Executives are sincerely appreciated for a healthy relationship with the Imam and for building a strong and united community. Specifically, I am grateful to Professors Ibrahim Katibi, I. Abikan, M.O. Yusuf, A.L. Azeez, A.O. Omotosho, A.A. Alaro, R.O. Adebayo, B.O. Yusuf, A. Imam-Aliagan, Y.O. Imam, A. Abdussalam, M.A. Adedimeji, I. Onireti.

I thank the University of Ilorin community, and particularly the present and past administrations, who created an enabling environment for the growth of staff. I am grateful to all past Vice-Chancellors and particularly to Prof. Shuaib Oba Abdulraheem, who facilitated my employment; Prof. AbdulganiyuAmbali (OON), who processed my elevation to the zenith of my career; and Prof. Sulyman Age Abulkareem, who appointed me the Director, General Studies Division (GNS) and now Director, Central Research Laboratories; and Prof. Y.A. Abdulkareem, who facilitated my appointment as Dean, Faculty of Science, Federal University of Kashere (FUK), Gombe State.

My siblings and their spouses are wonderful companions: Mr. and Mrs. IdrisAbdussalam, Mr. and Mrs. Isa Oyebanji, Mr. and Mrs. H.O. Sulyman, prince and Mrs. RaufAbdussalam. My step sisters and brothers form a constructive pillar in my achievement and I am grateful to them: Mrs. MulikatJimoh, Mrs. TawakaltGaruba, Mrs. HafsatBadmus, AbdulganiyAbdussalam (late), Mrs. KudratOseni, and Mr. IshaqAbdussalam. I thank you all for your supportive roles that will ever remain green in my memory.

This honourable gathering comprising of the physical and virtual audience is highly appreciated for your commitment

to be part of this 226th inaugural lecture. You have made the day a memorable one. May Allah return you safely back to your destinations. Thank you for the honour done to me and my family.

Finally, my nuclear family, consisting of my lovely children: Abdullah Akande, Maryam Folake, Aisha Opeyemi, Muhammad OlayinkaAbdussalam; and my life jacket (هُنَّ لِبَاسٌ لَّكُمْ وَأَنتُمْ لِبَاسٌ لَّهُنَّ), allele, bosom companion, confidant and darling wife, AminaWuraolaAbdussalam (nee Brimah), to whom I have dedicated this lecture in appreciation of her trust in my ability and for standing by me under all circumstances of life. Thank you for the prayers and thank you for the encouragement loaded with "YOU CAN DO IT" and I have done it.

Mr. Vice-Chancellor sir, permit me to conclude this lecture with this inspirational quotation from Q10 verses 9-10.

إِنَّ الَّذِينَ آمَنُوا وَعَمِلُوا الصَّالِحَاتِ يَهْدِيهِمْ رَبُّهُم بِإِيمَانِهِمْ تَجْرِي مِن تَحْتِهِمُ الْأَنْهَارُ فِي جَنَّاتِ النَّعِيمِ

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

Those who believe, and work righteousness, - their Lord will guide them because of their faith: beneath them will flow rivers in gardens of bliss. (This will be) their prayer therein: "Glory to Thee, O Allah!" And "Peace" will be their greeting therein! and the conclusion of their prayer will be: "Praise be to Allah, the Cherisher and Sustainer of the worlds!" (Q10:9-10)

References

Abdus-Salam N.,&Adeoye A. O. (2019). Assessment of impact of industrial discharge on the quality of water around Lafarge cement WAPCO, Ewekoro, Nigeria, *Jewel Journal of Scientific Research*, 4(1&2): 45 -52.

Abdus-Salam, N. &Adekola, F. A. (2005). The influence of pH and adsorbent concentration on adsorption of lead and zinc on a natural goethite.*African Journal of Science and Technology (AJST), Science and Engineering Series* 6(2), 55-66.

Abdus-Salam, N. &Adekola, F. A. (2006). Comparative dissolution of natural goethite samples in HCI and HNO_3, *Journal of Applied Science and Environmental Management* (JASEM), 10 (2), 11-17.

Abdus-Salam, N. &Adekola, S. K. (2018). Adsorption studies of zinc (II) on magnetite, baobab (Adansoniadigitata) and magnetite–baobab composite, *Applied Water Science*, 8, 222 – 232.

Abdus-Salam, N. &Buhari, M (2014). Adsorption of alizarin and fluorescein dyes on Adsorbent prepared from mango seed. *Pacific Journal of Science and Technology*, 15(1),232-234.

Abdus-Salam, N. &Buhari, M (2016). Adsorption of alizarin and fluorescein dyes onto palm seeds activated carbon: Kinetic and thermodynamic studies. *Journal of the Chemical Society of Pakistan*, 38(4), 604 – 614.

Abdus-Salam, N. & Ikudayisi, V. A (2017). Preparation and characterization of synthesized goethite and goethite-date palm seeds charcoal composite. *Ife Journal of Science*, 19(1), 99-107.

Abdus-Salam, N. &Oyede, F. A. (2013). The impact of River on the Water Quality of Nearby Wells: A Case Study of Aluko River, Ilorin, Nigeria. *Chemsearch Journal*, 4(2), 10-20.

Abdus-Salam, N. (2009). Assessment of heavy metals pollution in dumpsites in Ilorin metropolis; *Ethiopian Journal*

of Environmental Studies and Management, 2 (2), 92-99.

Abdus-Salam, N. Ibrahim, M. S. &Fatoyinbo, F. T. (2011). Dumpsites in Lokoja, Nigeria: A silent pollution Zone for underground water. *Waste Management and Bioresource Technology,* 1, 21-30.

Abdus-Salam, N., Adekola, F. A., &Otuyo-Ibrahim, M. (2014).Chemical composition of wet precipitation in ambient environment of Ilorin, north-central Nigeria.*Journal of Saudi Chemical Society,* 18, 528–534.

Abdus-Salam, N., Ademola O. S. &Oyewumi-Musa R. T. (2017).Bioremediation of heavy metals in contaminated soil from abandoned Asa dam road dumpsite. *International Journal of Environment, Agriculture and Biotechnology* (IJEAB), 2 (5), 2516-2523.

Abdus-Salam, N., Ademola, A. S., & Bello, M. (2017).Assessment of the impact of petroleum depot effluents on a nearby river quality. *European Scientific Journal,* 13(36), 396-423.

Abdus-Salam, N., Awoyemi, B. O. & Abdul Raheem, A. M. O. (2016).Comparative studies of water and Sediments qualities of some dams in Kwara State. *Fountain Journal of Natural and Applied Sciences,* 5(1), 38-52.

Abdus-Salam, N., Godwin, J., &Tripathy, B. C. (2020).Hydrothermal synthesis and spectroscopic characterization of one-dimentional rod-like hematite (α-Fe_2O_3) mineral in alkaline medium.*International Journal of Applied Science and Engineering,* 8(1): 11-18, DOI: 10.30954/2322-0465.1.2020.2

Abdus-Salam, N., Ikudayisi-Ugbe, V. A. &Ugbe, F. A. (2021a). Adsorption studies of acid dye– Eosin yellow on date palm seeds, goethite and their composite, *Chemical Data Collections,* 31, 100626.

Abdus-Salam, N., Ikudayisi-Ugbe, V. A. &Ugbe, F. A. (2021b). Adsorptive removal of methylene blue from synthetic wastewater using date palm seeds, goethite and their composite, *ActaScientifica Malaysia*, 5(1), 27-35, DOI: http://doi.org/10.26480/asm.01.2021.27.35

Abdus-Salam. N., Adekola, F. A. &Apata, A. O. (2010): A Physico-chemical assessment of water quality of oil producing areas of Ilaje, Nigeria. *Advance in Natural and Applied Sciences* (ANAS), 4(3), 333-344.

Adekola, F. A., Abdus-Salam, N., Adegoke, H. I. &Majasan, J. O. (2013).The impact of water distribution system on eventual quality: A case study of the University of Ilorin water system. *Analytical Science Journal*, 1(2), 49-61.

Adekola, F. A., Abdus-Salam, N., Bale R. B. &Oladeji, I. O. (2010). Sequential extraction of trace metals and particle size distribution studies of Kainji lake sediment, Nigeria.*Chemical Speciation and Bioavailability*, (2010), 22(1), 43-49.

Adekola, F. A., Bale, R. B., Abdus-Salam, N., Eletta, O. A. A., Olaniyan, J. O and Baba, A. A. (2008). Manganese pollution of the University of Ilorin dam water: Source identification and geochemistry, a Report submitted to Senate Research Grant Committee, University of Ilorin, Nigeria, 50pp.

Adekola, F. A., Salami, N. &Lawal S. O. (2003). Some trace elements determination in surface water and sediments of Oyunriver, Kwara State, Nigeria, *The Nigerian Journal of Pure and Applied Sciences*, 18, 1418-1422.

Adekola, F. A., Salami, N.&Lawal, K. A. (2002). "Assessment of the bioaccumulation capacity of Scots pine (PinusSylvestris L.)needles for zinc, cadmium and sulphur in Ilorin and Ibadan cities (Nigeria)". *The Nigerian Journal of Pure & Applied Sciences*, 17, 1297-1301.

Adekola, F.A., Abdus-Salam, N., Bale, R.B., Eletta, O.A.A., Olaniyan, J.O. & Baba, A.A. (2015).Source identification of Fe and Mn pollution of University of Ilorin dam, Nigeria.*Centrepoint Journal* (Science Edition), 21 (2), 18 – 31.

Albadarin, A. B. & Mangwandi, C. (2015). Chemistry mechanism of alizarin red S and methylene B. biosorption onto Olive stone: Equilibrium and kinetics. Paper presented at the third international conference on water, energy and environment (ICWEE), Shayah, UAE.

Andal, V. G. B. (2014). Removal of lead ions by $NiFe_2O_4$ nanoparticles.*International Journal of Research in Engineering and Technology*, 2014; 3(1): 472 – 483.

Barrett, J. R. (2014). Chemical contaminants in drinking water; Where do we go from here? *Environ Health Perspect.* 122(3): A80- doi: 10.1289/ehp.122-A80

Basheeru, K. A., Okoro, H. K., Adekola, F. A. &Abdus-Salam, N. (2021).Mobility and sequential extraction of potentially toxic elements in the sediment of Lagos lagoon.*Chemistry Africa*, 4, 411–427. https://doi.org/10.1007/s42250-020-00218-4

Basheeru, K. A., Okoro, H. K., Adekola, F. A. &Abdus-Salam, N. (2020): Speciation and quantification of organotin compounds in Lagos harbour, Nigeria, *International Journal of Environmental Analytical Chemistry*, DOI: 10.1080/03067319.2020.1849647

Bello, M. O., Abdus-Salam, N. &Adekola, F. A. (2018.Utilization of guinea corn (*Sorghum vulgare*) husk for preparation of bio-based silica and its characterization studies.*International Journal of Environment,Agriculture and Biotechnology* (IJEAB), 3(2), 670-675.

Bodunde, V. T., Adekola, F. A. &Abdus-Salam, N. (2013).Investigation of Sorption of Chromate Ion on

a Synthetic Hematite.*Journal of North Carolina Academy of Science*, 129(1), 24-33.

CDC (Center for Diseases Control and Prevention) (2016). Lead poisoning investigation in Northern Nigeria. Centers for Disease Control and Prevention, National Center for Emerging and Zoonotic Infectious Diseases; https://www.cdc.gov/onehealth/in-action/lead-poisoning.html retrieved on 6/3/2022

Chen, Y. M. &Gao, J. (2021). Synthesis and characterization of ZnO nanoparticles in nhexanol solution, *Mater.Lett.*X. 12, 100106, https://doi.org/10.1016/j. mlblux.2021.100106

Currie, J., Graff Zivin, J., Meckel, K., Neidell, M., &Schlenker, W. (2013). Something in the water: contaminated drinking water and infant health, *Canadian Journal of Economics,* 46(3), 791–810. doi: 10.1111/caje.12039.

Damiyine, B., Guenbour, A., &Boussen, R. (2017a). Adsorption of rhodamine B onto expanded perlite from aqueous solution, kinetics, equilibrium and thermodynamics, *J. Mater.Environ. Sci.* 8(1), 345–355.

Damiyine, B., Guenbour, A., and Boussen, R. (2017b). Rhodamine B adsorption on natural and modified morrocan clay with cetyltrimethyl bromide: kinetics, equilibrium and thermodynamics, *J. Mater. Environ. Sci.,* 8(3), 860–871.

Długosz, O. , and Banach, M. (2021). Continuous synthesis of photocatalytic nanoparticles of pure ZnO and ZnO modified with metal nanoparticles, *J. Nanostruct. Chem.* 11, 601–617, https://doi.org/10.1007/s40097-021-00387-9

Dosumu, O. O., Salami, N. & Adekola, F. A. (2003). Comparative study of trace element levels in some local vegetables varieties and irrigated waters from different locations in Ilorin, Nigeria, *Bulletin of Chemical Society of Ethiopia,* 17 (1), 107-112.

Elelu, S. A., Adebayo, G. B., Abdus-Salam, N. &Iriowen, E. M. (2019).The preparation and characterization of adsorbents from physic nut plant (*JatrophaCurcas L*), *The Chemist* (Journal of American Institute of Chemists), 91(2), 42-49.

Giwa A. A., Abdus-Salam, N., Amuda O. S. & Bello, I. A. (2007).Biological monitoring of chromium, copper, iron, manganese, and zinc in Ibadan Province, Nigeria, *Journal of Biological Science Research,* 2 (1), 133-147.

Giwa, A. A., Bello, L. A., Amuda, O. S., Abdus-Salam, N. &Adelowo, F. E. (2009). Some heavy metals in urban and rural topsoils of Ibadan, Nigeria.*International Journal of Chemical Sciences,* 2 (1), 133-147

Godwin, J., Abdus-Salam, N., Adegoke, H. I., Panda, P. K. Panda, J., &Tripathy, B. C. (2022). Facile synthesis of rod-like α-FeOOH nanoparticles adsorbent and its mechanism of sorption of Pb(II) and indigo carmine in batch operation, *Inorganic Chemistry Communications,*140, 109346 DOI: 10.1016/j.inoche.2022.109346

Godwin, J., Abdus-Salam, N., Panda, P. K., and Tripathy, B. C. (2022). Special crystal growth and nucleation process of zinc oxide nanoparticles from urea solution for efficient removal of Pb(II) ions and alizarin red S, *Research Square,* DOI: https://doi.org/10.21203/rs.3.rs-1625280/v1

Godwin, J., Njimou, J. R., Abdus-Salam, N., Panda, P. K., Tripathy, B. C., Ghosh, M. K. &Basu, S. (2022). NanoscaleZnO-adsorbent carefully designed for the kinetic and thermodynamic studies of rhodamine B, *Inorganic Chemistry Communications*, 138, 109287. DOI: 10.1016/j.inoche.2022.109287

Hoan, N. T., Thu, N. T., Duc, H. V., Cuong, N. D., Khiou, D, Q. &Vien, O. (2016). Fe_3O_4/reduced graphene oxide nanocomposite: synthesis and its application for toxic

of metal ion removal, *Journal of Chemistry,* 2016; Doi.10.1155/2016/2418172.

Husari, F. S., Ali, S. M., Abaziz, A. &Rusop, M. (2013).Special effect of urea as a stabilizer in thermal immersion method to synthesize porous zinc oxide nanostructures, *Journal of Nanomaterials*, 11, 1–7.

Kumar, R. &Chinnaiya, N. (2009). Development and characterization of activated carbon from Jatropha husk, an agro-industrial solid waste, by chemical activation method, *J. Environ. Eng. Manage.,* 19(3), 173-178.

Li, A. Y., Deng, H., Jiang, Y. H., Ye, C. H., Yu, B. G., Zhou, X. L. and Ma, A. Y. (2020). Superefficient removal of heavy metals from wastewater by Mg-loaded biochars: adsorption characteristics and removal mechanisms, *Langmuir,* 36 (31), 9160-9174. https://doi.org/10.1021/acs.langmuir.0c01454

Li, Y., Zhou, Q., Bo Ren, Luo, J., Yuan, J., Ding, Z., Bian, H. & Yao, X. (2020). Trends and health risks of dissolved heavy metal pollution in global river and lake water from 1970 to 2017, *Rev. Environ. Contam. Toxicol.*,251, 1-24.

Magdalena, W., Małgorzata, K., Kaufman, A., Grzegorz, R. & Tomasz, B. (2019). Removal of heavy metals and metalloids from water using drinking water treatment residuals as adsorbents: A review, *Minerals,* 9: 487. doi:10.3390/min9080487.

Menderes, K., &Riza, K. A. (2014).Thermodynamics and adsorption studies of dye (RB) onto natural diatomite, *Physiochemical Probl.Miner.Process.* 50(2), 631–643.

Mitra, S., Muhkerjee, T. (2018).Novel low-cost adsorbent for removal of rhodamine B from wastewater, *International Journal of Engineering Research and Management,* 5(7), 28–32.

Musale, S. S., &Kashalkar, R. V. (2017). Kinetics and thermodynamics studies on the adsorption behaviour of rhodamine B onto carbonized powder of PolyalthiaLongifolia Seed (Ashoka), *International Journal of ChemTech Research*, 10(12), 79–86.

Okoro H. K., Fatoki O. S., Adekola F. A., Ximba B. J. &Snyman R. G. (2011) Sources, environmental levels and toxicity of organotin in marine environment – A review, *Asian Journal of Chemistry*, 23(2), 473-482.

Omnia, A. and Sahar, M. (2-17). Adsorption of copper ions and alizarin red S from aqueous solution onto polymeric nanocomposite in single and binary systems, *Turkish Journal of Chemistry*, 2017; 41: 967 – 986.

Oyekanmi, A. A., Ahmad, A., Hossain, K. &Rafatullah, M. (2019). Adsorption of rhodamine B dye from aqueous solution onto acid treated banana peel: response surface methodology, kinetics and isotherm studies, *PloS One.* 14 (5), e0216878

Patel, H. (2020). Batch and continuous fixed bed adsorption of heavy metals removal using activated charcoal from Neem (AzadirachtaIndica) leaf powder. Scientific Report; 2020; 10:16895. https://doi.org/10.1038/s41598-020-72583-6.

Prathiksha, P. P., &Balakrishna, P. (2021).A Review on removal of heavy metal ions from wastewater using natural/ modified bentonite.MATEC Web of Conferences 144, 02021; https://doi.org/10.1051/matecconf/201814402021.

Rahdar, S., Rahdar, A., Zafar, M. N., Shafqat, S. S. &Ahmadi, S. (2019). Synthesis and characterization of MgO supported Fe–Co–Mn nanoparticles with exceptionally high adsorption capacity for rhodamine B dye, *Journal of Materials Research and Technology*, 8 (5), 3800–3810. https://doi.org/10.1016/j.jmrt.2019.06.041

Ramuthal, S, Nandhakumar, V., Thiruchelvi, M., Arivoli, S., &Vijayakumaran, V. (2009).Rhodamine B adsorption: kinetics, mechanistic and thermodynamic studies, *Environ. J. Chem.* 6 (S1), S363–S373.

Rather, I. A., Koh W. Y., Paek, W. K. & Lim, J. (2017). The sources of chemical contaminants in food and their health implications; *Front Pharmacol.*, 8, 830. DOI: 10.3389/fphar.2017.00830.

Saaristo, M., Brodin, T., Balshine, S., Bertram, M. G., Brooks, B. W., Ehlman, S.M., McCallum, E. S., Sih, A., Sundin, J. Wong, S. B. B., & Arnold, K. E. (2018). Direct and indirect effects of chemical contaminants on the behaviour, ecology and evolution of wildlife, *Proceeding of the Royal Society B* (Biological Sciences), https://royalsocietypublishing.org/doi/10.1098/rspb.2018.1297

Salami, N. &Adekola, F. A. (2002) "A study of sorption of cadmium on goethite in aqueous solution", *Bulletin of Chemical Society of Ethiopia*, 16 (1), 1-7.

Shaibu, S. E., Adekola, F. A., Adegoke, H. I. &Abdus-Salam, N. (2015).Heavy metal speciation patterns of selected dumpsites in Ilorin metropolis, *International Journal of Chemical, Material and Environmental Research*, 2 (1), 1-11.

Török, B. &Dransfield, T., (2018).Green chemistry and inclusive approach, published by Elsevier, Amsterdam, Netherlands, pp 261-290.

Usman, O. A. S., Salami, S. J. &Abdus-Salam, N. (2010).Assessment of pollution status of Asa River and Okun stream in Ilorin metropolis, *Agriculture, Business and Technology Journal*, 8(2), 29 – 35.

Verma, R. and Dwivedi P. (2013). Heavy metal water pollution- A case study, *Recent Research in Science and Technology* 5(5): 98-99.

Vijayalakshmi, K., Mahalakshmi, B., Latha, S., Gomathi, T., Sudha, P. N., Venkesan, J. & Anil, S. (2017). Batch adsorption and desorption studies on the removal Of Pb(II) from aqueous solution using nanochitosan/sodium alginate/Microcrystalline cellulose bead, *International Journal of Biological Macromolecules*, DOI:10.10116/j.ijbiomac.2017.04.120.

WHO (World Health Organization) (2019). Drinking-Water

Zamora-Ledezma, C., Negrete-Bolagay D., Figueroa, F., Zamora-Ledezma, E. Ni, M., Alexis, F., & Guerrero, V. H. (2021). Heavy metal water pollution: A fresh look about hazards, novel and conventional remediation methods, *Environmental Technology & Innovation,* 22, 101504.