UNIVERSITY OF PORT HARCOURT

SCIENCE AND SUSTAINABILITY: PIONEERING A GREENER FUTURE

An Inaugural Lecture

By

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ORDER OF PROCEEDINGS

2.45 pm. Guests are seated

3.00pm. Academic Procession begins

The Procession shall enter the CBN Centre of Excellence auditorium, University Park, and the Congregation shall stand as the Procession enters the hall in the following order:

Academic Officer
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Dean, School of Graduate Studies
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Lecturer
University Librarian
Registrar
Deputy Vice Chancellor Research and Development
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Deputy Vice Chancellor Administration
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After the Vice Chancellor has ascended the dais, the Congregation shall remain standing for the University of Port Harcourt Anthem.

The Congregation shall thereafter resume their seats.

THE VICE CHANCELLOR'S OPENING REMARKS.

The Registrar shall rise, cap, invite the Vice Chancellor to make his opening remarks and introduce the Lecturer.
The Lecturer shall remain standing during the Introduction.

THE INAUGURAL LECTURE

The Lecturer shall step on the rostrum, cap and deliver his Inaugural Lecture. After the lecture, she shall step towards the Vice Chancellor, cap and deliver a copy of the Inaugural Lecture to the Vice Chancellor and resume her seat. The Vice Chancellor shall present the document to the Registrar.

CLOSING

The Registrar shall rise, cap and invite the Vice Chancellor to make his Closing Remarks.

The Vice Chancellor's Closing Remarks.

The Vice Chancellor shall then rise, cap and make his Closing Remarks. The Congregation shall rise for the University of Port Harcourt Anthem and remain standing as the Academic [Honour] Procession retreats in the following order:

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Registrar
University Librarian
Lecturer
Provost, College of Health Sciences
Dean, School of Graduate Studies
Deans of Faculties/School
Professors
Academic Officer

DEDICATION

In loving memory of my father, late Sir Donatus Okeahialam Nwaichi, a guiding light whose wisdom and values of excellence have shaped my journey. This Inaugural Lecture is dedicated to the man whose legacy continues to inspire and illuminate my path. Your teachings live on in every pursuit of excellence. Forever in my heart!

ACKNOWLEDGMENTS

A very good afternoon. It is with immense joy and gratitude that I stand before you today to deliver my professorial inaugural lecture. I am deeply humbled by the opportunity to share my knowledge and insights with such a distinguished audience.

First and foremost, I would like to express my heartfelt appreciation to our great and unique University of Port Harcourt, for bestowing upon me this esteemed title of professor. It is a privilege and a responsibility that I do not take lightly. I am honoured to be a part of this esteemed institution and its rich academic tradition.

I would like to extend my sincere gratitude to the phenomenal Vice Chancellor of the University of Port Harcourt, Prof. Owunari Abraham Georgewill, for his unwavering support, guidance, and belief in my pursuit of academic excellence. Even before ascending to the esteemed office of Vice Chancellor, your commitment to my work was evident through your dedicated attendance and enthusiastic support at my events, which illuminated my resolve to continue pursuing greater developmental efforts. Your personal dedication, coupled with your leadership and vision, has been instrumental in fostering an environment that encourages inclusivity, intellectual growth, and scholarly achievements. For this, I am deeply grateful.Thank you for your invaluable contributions to our university and for gracing this occasion with your prized presence. I express gratitude for the distinguished contributions of the Principal Officers in our esteemed institution, including the Deputy Vice-Chancellor (Administration) – Prof. Clifford Ofurum, Deputy Vice-Chancellor (Academic) – Prof. Kingsley Owete, Deputy Vice-

Chancellor (Research & Development) – Prof. Iyeopu Siminialayi, Registrar – Dr. Gloria Chindah, Ag. Bursar – Dr. Godspower W. Obah, and Librarian – Prof. Helen Emasealu.

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To the Inaugural Lecture Committee and all those involved in planning this momentous event, thank you for your professionalism and tireless efforts in making this lecture a reality. Your dedication and commitment to academic excellence are evident in the seamless execution of this event.

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To my ever-patient family, I extend profound gratitude. My foremost supporter and incredible husband, Mr. Chucks Raphael, and my brilliant twins, Francis Munachimso Raphael and Claire Somtochukwu Raphael, have showered me with immeasurable love, support, and understanding throughout my academic journey. Thank you Chinyere, for your support.

In remembrance, my late but enduring father, Ezeji Sir. Donatus O. Nwaichi, and my dear mother, Lady Ezinne Eunice A. Nwaichi, provided the wings for me to soar without perching. Their words of wisdom continue to fuel my journey.
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To the Triune God, my Creator, who comprehends the intricacies of our existence—what am I that You are mindful of me? My cherished name, Eucharia, fashioned after the Holy Eucharist, signifies thanksgiving and sharing. You have never allowed my pipeline to run dry, ensuring I always have something to give. May Your glory continue to shine in my life!

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PREAMBLE

My profound journey into the realm of science, environmental stewardship, and sustainability finds its roots in the formative years spent at Madonna Senior Secondary School for Science in Etiti, Imo State, Nigeria. This unique educational institution, characterized by a commitment to excellence, nurtured my early fascination with the intricate wonders of the scientific world.

During my time at Madonna, I engaged in debate contests with fellow secondary schools, passionately advocating for the environment. Little did I realize at the time, my dedication to defending Mother Earth was just beginning. I was privileged to thrive in an extraordinary learning environment, where cutting-edge laboratories exceeded the standards I would encounter in my undergraduate studies. Inspired by the school's compelling motto, "Semper Eligere Optimum" (Always Choose the Best), I internalized a commitment to both environmental stewardship and excellence, values that have since guided my academic path.

This formative phase wasn't just about academic pursuits; it was a holistic immersion into a culture of excellence. The tradition of receiving an additional "first" branded dress during Christmas, a practice instilled by my late father for securing the first position throughout my Primary School years, has significantly influenced my capacity to recognize and celebrate excellence in every aspect of my life.

A defining chapter in my professional journey unfolded during my internship at Eleme Petrochemicals Company Ltd (EPCL), a subsidiary of the Nigerian National Petroleum Corporation (NNPC). Under the guidance of Mr. El-Idris Ibrahim in the Petroleum Products & Quality Control (PPQC) Department, my immersion in the intricate realm of the Water Lab became a crucible for structured learning.

My responsibilities included the meticulous monitoring of effluent, process water, and potable water. This hands-on experience not only deepened my understanding of environmental systems but also underscored the critical importance of rigorous scientific practices in maintaining water quality standards. It was within these industrial corridors that my commitment to environmental stewardship and sustainability solidified.

As I embark on this Inaugural Lecture, titled "Science and Sustainability: Pioneering a Greener Future," I reflect on these foundational experiences that have shaped my academic trajectory. The journey from Madonna's enriched laboratories to the industrious landscapes of EPCL has intricately woven together the threads of my passion for science, environmental advocacy, and the pursuit of sustainable solutions.

Join me in this introspective voyage as we unravel the threads connecting my early educational endeavors to the impactful strides in environmental research and sustainability that define my academic odyssey. Together, let us explore the boundless possibilities at the confluence of science and sustainability, envisioning a future where our collective endeavors harmonize with the natural world for the greater good. Semper Eligere Optimum—Always Choose the Best.

INAUGURAL LECTURE

For the records, this lecture will mark the ninth inaugural lecture from the Department of Biochemistry, Faculty of Science at the University of Port Harcourt. The series from the Department began with the inaugural lecture titled 'In Praise of

Enzymes,' delivered by the late Prof. E. O. Anosike. Following that, the late Prof. G. I. Ekeke presented the second, 'Blood is Thicker than Water,' while Prof. B. W. Abbey delivered the third, titled 'Bridging the Protein Gap with What You Have.' Prof. E. N. Onyeike presented the fourth lecture, titled 'Food, Nutrition, and Toxicology: Is Your Life in Your Hands?'

The fifth lecture, titled 'Continuing the Praise of Enzymes,' was delivered by Prof. M. O. Monanu. 'Food, Your Friend or Foe' became the sixth inaugural lecture from the Department of Biochemistry, delivered by Prof. J. O. Akaninwor. The seventh lecture, titled 'Managing the Scourge of Sickle Cell Haemoglobinopathy: Which Way Forward?' was presented by Prof. A. A. Uwakwe. The eighth and the last from the Department, titled 'The Power of Food,' was delivered by Prof. M. O. Wegwu in 2019, marking the 163rd in the University series.

It is worth of mentioning that by this Lecture, I have become the 3rd after Prof. Victor Chikezie Uchendu (1st) and Prof Donatus Ikechi Igbokwe (2nd) to present an Inaugural Lecture in my town of birth, Nsirimo Umuahia in Abia State of Nigeria.

I've been fortunate to deliver two public lectures. The initial one, titled 'Metal Removal and Soil Enzyme Interactions: A Green Approach,' took place at the Institute of Agrophysics in Lublin, Poland, in 2013. The second, 'Unseen Dangers on Our Plates: Exploring the World of Contaminants and Food Toxicology,' was presented at the University of Cordoba, Cordoba, Spain, in 2023. These experiences have significantly enriched my professional journey.

INTRODUCTION

The Vice Chancellor, ladies and gentlemen, esteemed colleagues, honored guests, and members of the academic community, I stand before you today with immense gratitude and a profound sense of responsibility as we embark on a journey of exploration and discovery. In the realm of academia, this inaugural lecture serves as a pivotal moment, marking not just the culmination of my academic journey but also the commencement of a new chapter dedicated to advancing knowledge and addressing critical issues facing our world.

Our planet, our shared home, is currently at a crossroads, grappling with the consequences of industrialization and the relentless exploitation of natural resources. As we witness unprecedented environmental challenges, it becomes imperative for us to delve into the heart of this intersection between science and sustainability.

With expertise in Environmental Biochemistry and Toxicology, my academic journey has taken me to explore the Niger Delta, a region of utmost significance due to its environmental importance and the urgent demand for sustainable solutions.

The accelerating pace of industrialization has undoubtedly propelled our societies forward, ushering in an era of progress and innovation. However, this progress has come at a cost—a cost borne by our environment. The delicate balance within ecosystems has been disrupted, leading to environmental degradation, loss of biodiversity, and the looming threat of climate change.

In this inaugural lecture, we will navigate the intricate web of challenges stemming from over-exploitation and the ramifications of man's relentless quest for industrial advancement. Our exploration will extend to the forefront of sustainable solutions, focusing on the groundbreaking potential of bioremediation and phytoremediation as nature-inspired correctives to environmental degradation. Phytoremediation, variant of bioremediation is a process that uses various plants to remove, degrade, or contain contaminants in soil, water, or air. Through this natural approach, plants can absorb pollutants from the environment or facilitate the breakdown of contaminants into less harmful substances.

I have screened and submitted many locally available plant candidates for this technology and secured a patent for it.

Bioremediation and phytoremediation stand as beacons of hope, showcasing the resilience and healing power of nature. Through these green solutions, we aim not only to remediate contaminated sites but also to redefine our relationship with the environment. Nature, in its inherent wisdom, provides us with tools to reverse the damages we've inflicted upon the Earth.

Moreover, this lecture will underscore the pivotal role of humanity in fostering ecosystem sustainability. As stewards of the Earth, it is our collective responsibility to cultivate a harmonious coexistence with nature, acknowledging that our actions today shape the world we bequeath to future generations.

Together, we will embark on a journey of exploration, seeking pioneering solutions for a greener future. I invite you to join me in this endeavor, as we plunge into the intricate tapestry of science and sustainability, unraveling the threads that connect us to our planet and charting a course towards a more sustainable and resilient world.

SETTING THE STAGE: SCIENCE AND SUSTAINABILITY NEXUS

A. Science and Sustainability

Science is a systematic and organized body of knowledge that is derived through observation, experimentation, and analysis. As it studies the natural world, its phenomena, and the governing principles, science aims to understand, explain, and predict various aspects of the universe, and is driven by curiosity, inquiry, and the quest for knowledge.

Green science, also known as sustainable science or environmental science, refers to the field of scientific research and application focused on developing solutions that minimize environmental impact, promote conservation, and foster sustainable development. It encompasses various disciplines such as ecology, renewable energy, waste management, pollution control, sustainable agriculture, and green technology. The aim of green science is to address pressing environmental challenges while ensuring the long-term well-being of ecosystems and human society.

Sustainability, on the other hand, refers to the ability to meet the needs of the present generation without compromising the ability of future generations to meet their own needs. It includes responsible and balanced use of resources, the preservation of ecosystems and biodiversity, and the promotion of social well-being. Sustainability focuses on finding harmonious solutions that address environmental, economic, and social challenges, ensuring the long-term viability and resilience of our planet and its inhabitants.

When science and sustainability intersect, it involves applying scientific principles, methods, and knowledge to achieve sustainable development. This entails using scientific insights and innovations to address environmental issues, reduce ecological footprint, promote renewable energy sources, mitigate climate change, protect biodiversity, and create sustainable systems and practices across various sectors of society. By embracing the principles of science and sustainability, we can strive towards a future that is environmentally sound, economically viable, and socially equitable for current and future generations (Ahmed et al., 2022; Nwaichi & Osuoha, 2021).

Environment according to Osuoha and Nwaichi (2020) in an ecological sense, refers to natural surroundings, including all living and non-living things, that an organism interacts with. Wearing a global lens, it includes the sum of all external conditions affecting the life, development, and survival of an organism, society, or planet Earth. Examples of global environmental issues include climate change, pollution, and biodiversity loss, as they impact the entire planet.

B. The interconnectedness of science and sustainability in addressing environmental issues

The nexus between science and sustainability in addressing environmental issues is fundamental to developing effective solutions for the challenges our planet faces. Illustration of how science and sustainability work hand in hand include:

a) Scientific Understanding:

Science provides a framework for studying and understanding the intricate workings of the environment. Through scientific research, we can assess the impacts of human activities on ecosystems, measure pollution levels, study climate patterns, and analyze biodiversity loss. This scientific understanding forms the basis for identifying environmental issues and their causes.

Nwaichi at al. (2020) delved into the health profile of individuals exposed to particulate matter (Black) soot in Choba and Mgbuoba localities of Port Harcourt. The findings reveal that concentrations of these air pollutants are notably higher in the early morning and decrease as the day progresses. Consequently, residents in these areas may face elevated exposure risk to these air pollutants from 6 am to 8 am.

This investigation establishes the impact of human activities such as artisanal refining as air-borne pollutants peak during the early morning hours, and factors such as specific meteorological conditions and anthropogenic activities likely contribute to the increased concentrations of TSPM, PM_{10}, and $PM_{2.5}$ in Choba and Mgbuoba communities in Rivers State.

Reducing emissions is a critical component of mitigating climate change and preventing its worst impacts. Efforts focus on transitioning to renewable energy sources, improving energy efficiency, protecting and restoring forests, and adopting sustainable practices (Onyejekwe et al., 2019) in various sectors. Nwaichi and Uzazobona (2011) posited that human activities, such as burning fossil fuels (coal, oil, and natural gas), deforestation, and industrial processes, release large amounts of greenhouse gases into the atmosphere (Figure 1). This increases the concentration of these gases, enhancing the natural greenhouse effect.

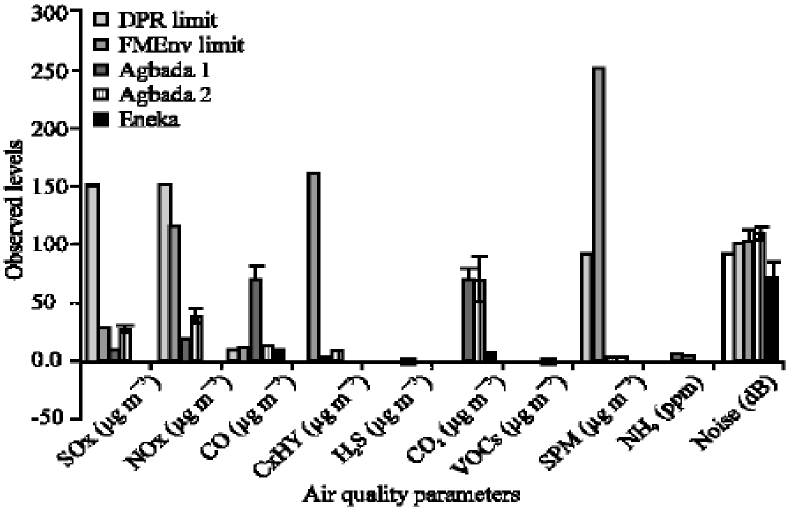

Figure 1: Mean levels of air quality parameters monitored. Data represent mean ± SE at $p \leq 0.05$ The warming of the Earth's surface disrupts climate patterns and has far-reaching effects on ecosystems, weather patterns, sea levels, and more. This results in events like more frequent and severe heatwaves, changes in precipitation patterns, rising sea levels, and disruptions to ecosystems.

b) **Innovative Technologies:**

Science plays a crucial role in developing innovative technologies that promote sustainability. Researchers and scientists work towards finding alternative energy sources, improving energy efficiency, developing clean technologies, and designing sustainable infrastructure. These advancements help reduce environmental impacts, such as greenhouse gas emissions and resource depletion, while promoting a more sustainable way of living. The biomass (Figure 2) generated during phytoremediation, containing contaminants absorbed by plants, can be harvested and used for energy production through processes like biomass incineration or biogas generation (Nwaichi and Colin, 2017).

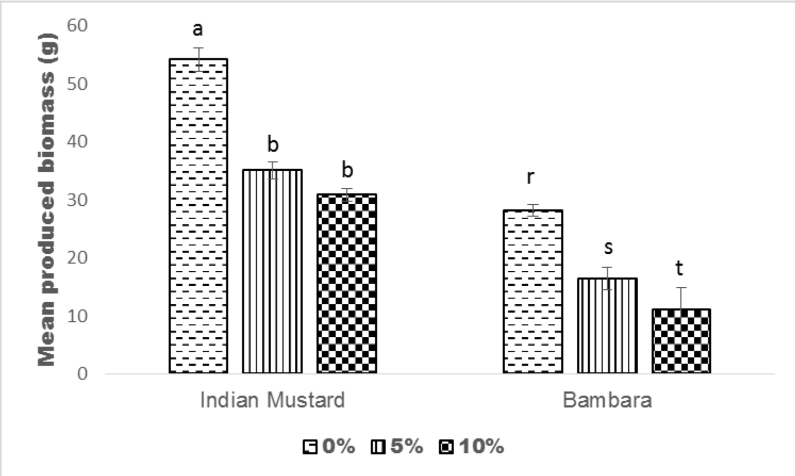

Figure 2: Produced biomass recorded for Indian mustard and Bambara plants. Values are means ±SE (n = 3); 0%, 5% and 10% represents different crude oil spiking percentages. Means with different alphabets within a cluster are significantly different at 95% confidence level.

c) Data Collection and Analysis: Science provides tools and methods for collecting and analyzing data related to environmental issues. Through monitoring systems, field studies, and modelling techniques, scientists gather valuable data on air and water quality, deforestation rates, species population, and climate trends. Such data helps in understanding the extent and impact of environmental issues and supports evidence-based decision-making.

Bioremediation is a process where living organisms, like bacteria or plants, are used to clean up or break down pollutants in the environment (Nwaichi et al., 2010; Nwaichi &Wegwu, 2010). Essentially, it's like nature's way of cleaning up pollution by using living organisms to remove or neutralize harmful substances from environmental cores namely soil, water, or air. Microorganisms, like bacteria, are really good at breaking down oil spills in the environment. They're seen as a safe and eco-friendly way to clean up pollution. In environmental cleanup, scientists use models to understand how fast these bacteria grow and remove pollutants. This helps them predict and control the cleanup process and see how the bacteria react to different environmental conditions (Agbaji, Nwaichi & Abu, 2021). Microorganisms used in this study, *Achromobacter agilis, Pseudomonas fluorescens*, *Bacillus thuringiensis, Staphylococcus lentus*were mined bacterial isolates from Plant and their rhizosphere soil from an aged oil-polluted soil site in B-dere, Gokana of Ogoni, Rivers State of Nigeria (36^{o} 4’N and 15^{o} 7’E). The strains were isolated in the environmental biotechnology laboratory of the Department of Microbiology of the University of Port Harcourt, Rivers State, Nigeria.

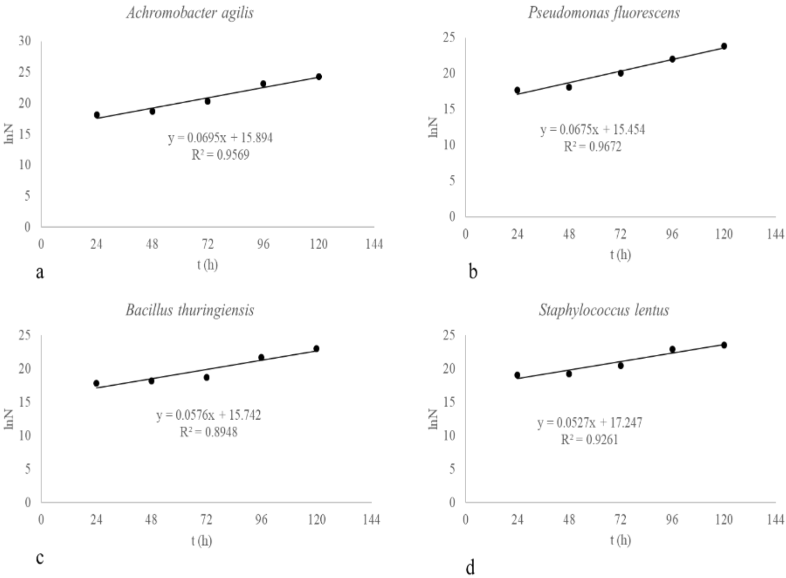

Figure 3: shows the natural log vs time of the exponential growth of (a)*Achromobacter agilis,* (b) *Pseudomonas fluorescens,* (c) *Bacillus thuringiensis,* and (d) *Staphylococcus lentus.* The slope of the line is equal to the specific growth rate (μ).

From the linearized plot (Figure 3) of the growth model, the specific growth rate μ, of each isolate is equal to the slope of the linear equation of each growth model. Then applying equation 3, using the specific growth rate, the generation time was computed, and results were summarized in Table 1. Also, summarized in Table 1 are the results of the lag time λ and asymptote (A) from Figure 1 semi-log plot. The summarized results from table 1, shows that the specific growth rate of the bacterial isolates in Bonny light crude oil is in the order of *Achromobacter agilis*>*Pseudomonas fluorescens*>*Bacillus thuringiensis*>*Staphylococcus lentus*. This order is also consistent with generation time for the isolates. However, *Pseudomonas fluorescens* has the least lag time, followed by *Achromobacter agilis*, *Bacillus thuringiensis*, *Staphylococcus lentus* in this order. In terms of the asymptote, the stationary phase where bacteria are at the maximum biomass, *Achromobacter agilis* has the highest biomass, followed by *Pseudomonas fluorescens*, the *Staphylococcus lentus* and *Bacillus thuringiensis.*

Table 1: Estimated maximum specific growth rate (μ_m) and substrate utilization constant (K_S) for bacterial utilization of poultry droppings as phosphorus nutrient source

Phosphorus Substrate Poultry Droppings	μ_m h^{-1}	K_S g	R^2 Value
Achromobacter agilis	0.092	0.043	0.995
Pseudomonas fluorescens	0.070	0.010	0.859
Bacillus thuringiensis	0.070	0.010	0.990
Staphylococcus lentus	0.074	0.028	0.991

From the kinetic studies it is concluded that the *Achromobacter agilis, Pseudomonas fluorescens, Bacillus thuringiensis,* and *Staphylococcus lentus* isolated from the rhizosphere of plant in aged oil-polluted soil were all high degraders of hydrocarbon and all have high affinity for corn chaff, and poultry droppings and low affinity for corn steep liquor to stimulate their growth rate with high biomass in order to efficiently bioremediate hydrocarbon pollutant as evident in the μ, μm, and KS (specific growth rate, maximum specific growth rate and substrate utilization constant respectively) values obtained (Table 1). The study also offers concentration range and inoculum size range for optimization studies that will offer the optimal concentration values for bioremediation applications. One of the key findings is that corn steep liquor at high liquor concentration could be inhibitory to bacteria growth rate and biomass production, therefore when used in bioremediation cocktail at high concentration could reduce the efficiency of such bioremediation agent. The concentration range of 10 to 20 ml dL-1 was optimum for the formulation of a bioremediation cocktail to treat polluted hydrocarbon soil in a bioremediation study. It, therefore, can be concluded that knowledge of bacterial growth kinetics, bacterial numbers in a culture medium and substrate utilization is important for both research and commercial purposes. It is a recommended tool in environmental biotechnology for the formulation of the optimal bioremediation agent for oil spill cleanup.

d) Policy Development:

The insights and findings from scientific research inform the development of environmental policies and regulations. Scientific evidence guides policymakers in setting emission standards, establishing protected areas, implementing sustainable practices, and promoting conservation efforts. Integrating science into policy formulation ensures that environmental decisions are based on reliable information and are aligned with long-term sustainability goals. Policy Brief is a concise summary presenting research or project findings that addresses an urgent or relevant problem and offers evidence-based recommendations. It is practical, stakeholder-specific, 2 to 8 pages in length, written in accessible language, sometimes has infographics to visually communicate evidence, and should not take more than 5 minutes to read.

I led an Evidence-Use Project funded through AFIDEP, by Hewlett & Packard Foundation and the following six (6) Policy Briefs were innovatively developed:

1. Adopt Safe, Natural Methods for Land Restoration – E. O. Nwaichi (UniPort)
2. Strengthening Climate Change Adaptation Capacity of Farmers in Nigeria: Path to Attaining Agriculture

Promotion Policy (APP) and Nation's Food Security Agenda – C. C. Ifeanyi-obi (UniPort)
3. Baseline Quality Control of Herbal Medicine for Improved Healthcare Delivery in Nigeria – E. Chimezie (Nigeria Natural Medicine Development Agency, NNMDA)
4. Utilizing Local Plant Bioresources to Enhance National Health and Economic Fortune – C. Mbaoji (NNMDA)
5. Improving Participation of Private Health Facilities in Integrated Disease Surveillance and Response (IDSR) Reporting – U. A. Okengwu (UniPort)
6. Engaging the Informal Sector in Improving the Productivity of the Nigerian Economy – L. U. Oghenekaro (UniPort)

Policy tools like Policy Briefs have shown to be the most useful type to achieve desired behavioural change that leads to policy development and the eventual implementation.

e) Education and Awareness:
In the realm of environmental sustainability, education and awareness serve as powerful tools harnessed by science to instigate positive change. Science plays a pivotal role in the dissemination of knowledge, empowering individuals to make informed decisions and take proactive measures in safeguarding the environment. Through science-based educational programs and public outreach initiatives, a heightened sense of environmental stewardship is cultivated, fostering sustainable practices within communities and among individuals.

In my extensive engagement within the Niger Delta, my team and I have undertaken various training sessions and awareness campaigns targeting community leaders, including Chiefs, Youth, Children, Men and Women groups (refer to Figures 4 and 5). These initiatives aim to establish joint ownership and commitment towards environmental protection.

Figure 4: My research consisting of undergraduate and postgraduate students

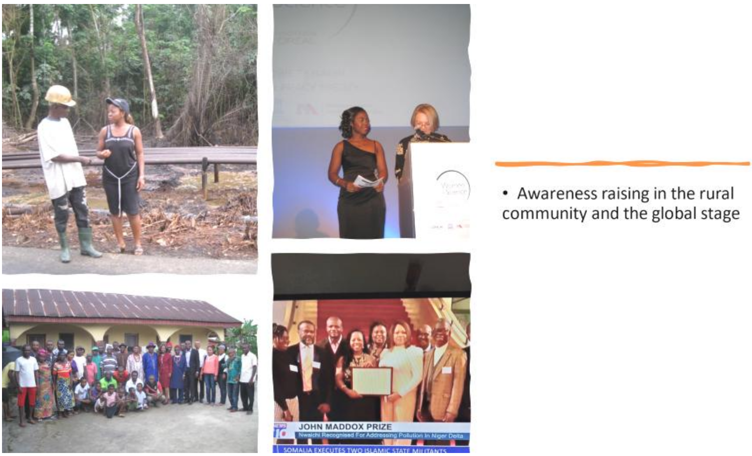

Figure 5:Awareness and education happening locally and globally

On the global stage, leveraging platforms such as the UNESCO LO'real FWIS 2013 in Paris and the John Maddox Prize in London (Figure 5), I have addressed international audiences, shedding light on the merits and risks associated with my research outputs. Furthermore, my research team, comprising both undergraduate and graduate students, has actively developed their science communication skills, contributing to the wider dissemination of knowledge.

Internationally, my commitment to education and awareness took on a new dimension. Funded initiatives led to Public Lectures in Poland, collaborative presentations with my Polish team at the National Science Festival, and engagements with high schools and primary school equivalents as a National Expert Visitor under the UNESCO L’Oreal FWIS. These efforts aimed to inspire young minds to pursue careers in STEMM disciplines (Figure 6).

Figure 6: Leveraging customised formats to raise awareness

Regionally, in Morocco, Zambia and Kenya, I aligned with the American Chemical Society to present research evidence, raising awareness and educating chemistry professionals on the potential hazards of dual-use chemicals (Figure 7).

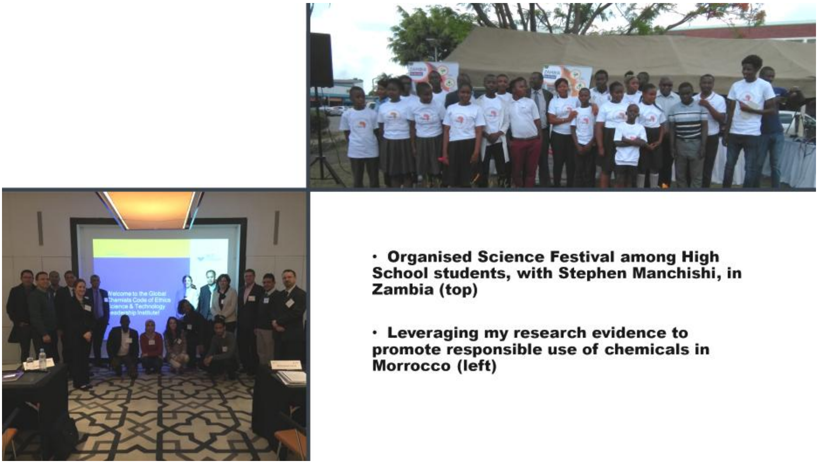

Figure 7: Awareness and education was taken regionally too

Closer to home, within my university community, I orchestrated gatherings of professionals and practitioners from diverse departments and stakeholders. These events, involving experts from Chemistry, Biochemistry, Pharmacy, Science Laboratory Technology, Anatomy, Physiology, Chemical Engineering, Petroleum Engineering, Environmental Engineering, as well as representatives from Government, Media, and Industry, showcased research evidence addressing ethical considerations in the practice of chemistry. Many of those who benefited from these initiatives are present here today, underscoring the impact of science-driven education and awareness in building a sustainable future.

Figure 8: My immediate community feels my impact

f) Collaborative Approach:
Collaboration stands as the cornerstone in addressing the multifaceted environmental challenges we encounter today. As emphasized by Nwaichi et al. (2020), forging partnerships between scientists, policymakers, businesses, and communities is paramount for devising holistic and effective solutions. In my role leading the University-wide Bioremediation team, we engaged in impactful collaborations with the Nigeria Navy, community leaders, and academia, exemplifying the power of teamwork.

This collaborative approach extended beyond academic boundaries, culminating in a comprehensive assessment of the Andoni coastal community. Our partnership facilitated the integration of diverse perspectives, ensuring a well-rounded understanding of the environmental issues at hand (Figure 9). The collaborative effort not only streamlined access to limited resources but also fostered knowledge exchange and innovative ideation, ultimately contributing to robust evidence gathering.

Through this collaborative initiative, we uncovered critical insights into the challenges faced by the Andoni community, ranging from environmental degradation to infrastructural deficiencies. Our findings underscored the urgent need for shore protection, intervention in the degraded mangrove area, revival of a moribund poultry project, enhancement of healthcare facilities, and capacity building for the local populace. The visible oil sheen on the water body (Figure 10) highlighted the pressing need for targeted bioremediation efforts in the oil-impacted mangrove and mudflat ecosystems.
Recommendations stemming from our collaborative efforts included the implementation of bioremediation measures to restore biodiversity, alternative income sources to sustain the community during the restoration period, and training programs for the locals in aquaculture management, traditional birthing practices, and security protocols. We also proposed the use of permeable and impermeable groynes to protect vulnerable shores and ensure the sustainable flow of water.

Furthermore, our collaborative strategy recognized the importance of potable water supply to safeguard the community from using contaminated water, thereby preventing potential disease outbreaks. The engagement with diverse stakeholders exemplifies the transformative impact that collaborative, interdisciplinary approaches can have on addressing environmental challenges and building a more sustainable future.

Figure 9: Our team was multidisciplinary in composition to unravel complex problems

Figure 10: Significant findings from a collaborative project at Ataba community

The value of a multidisciplinary research team (Figure 11) in addressing sustainability challenges lies in its ability to bring together diverse expertise, perspectives, and approaches, enabling a comprehensive understanding of complex problems and fostering innovative solutions that consider social, economic, and environmental dimensions. In 2014, our multidisciplinary and international team activated Science Diplomacy by providing scientific advice and evidence to inform and support decision-making by EU over boundary dispute between Poland and Czech Republic.

Figure 11: An effective collaboration that drove science diplomacy

The escalating production of sewage sludge from wastewater treatment plants exerts substantial pressure on effective management and disposal practices (Nwaichi and Warigbani, 2013). Wastewater treatment facilities generate substantial volumes of sludge that necessitate proper treatment, either for reuse or environmentally conscious disposal, to ensure optimal benefits (Frac et al., 2014; Łagód et al., 2012). In Europe, the average dry weight production of sewage sludge is estimated at 90 g per person per day, a consequence of primary, secondary, and tertiary treatment processes. A global perspective anticipates a gradual increase in sludge output in the coming decades, driven by the forces of urbanization and industrialization (Frac et al., 2014).

Our study aimed to evaluate the impact of municipal sewage sludge accumulation during landfill storage on the functional diversity of soil microbial communities. Soil samples were collected from a municipal sewage sludge (SS) and from a sewage sludge landfill located 3 meters from the SS landfill (SS3), with comparisons made against an undisturbed reference soil (Table 2). While the sewage solids exhibited higher individual carbon (C) and nitrogen (N) content, the C/N ratio was lower than that of the control soil, suggesting potential limitations for supporting crop growth and microbial health. BiologEcoPlates™, inoculated with a soil suspension, were analyzed for Average Well Color Development (AWCD), Richness (R), and Shannon-Weaver index (H) to interpret the results.

Fungi isolated from the sewage sludge were identified through comparative rDNA sequencing of the LSU D2 region, employing MicroSEQ® ID software to assess raw sequence files, perform sequence matching to the MicroSEQ® ID-validated reference database, and construct Neighbor-Joining trees. The findings of this investigation shed light on the intricate dynamics between municipal sewage sludge, soil microbial functional diversity, and the potential implications for environmental and agricultural ecosystems.

Table 2 Sludge and Soil Characteristics

Parameter	Values	
	Soil	Sewage Sludge
pH	7.5	7.5
EC (ms m^{-1})	14.58	33.50
TOC %	0.845	30.00
N (g 100 g^{-1})	0.068	5.70
P (mg kg^{-1})	373.00	600.00
K (mg kg^{-1})	223.00	469.10
C/N	12.50	5.26
Ca (g kg^{-1})	6.38	2.52
Mg (g kg^{-1})	1.39	1.09
Na (g kg^{-1})	0.19	-
Zn (mg kg^{-1})	43.06	326.00
Cu (mg kg^{-1})	5.85	46.40
Cd (mg kg^{-1})	0.16	-
Cr (mg kg^{-1})	15.99	33.00
Pb (mg kg^{-1})	11.51	21.00

Notes: EC—electric conductivity, TOC—total organic carbon.

The alterations in fungal composition (data not shown) likely ensued from the enhanced conditions favoring fungal growth. As the utilization or storage of non-stabilized sludge on land poses potential hygienic challenges, understanding the fungal compositions associated with sludge becomes crucial from a practical standpoint. Fungi, being opportunistic organisms, harbor potential pathogenic properties for humans, animals, and plants. However, the pathogenicity of fungi varies, necessitating the monitoring of mycological quality in municipal sewage sludge to mitigate the risk of human infections.

This study underscores the significance of community-level physiological profiling using BiologEcoPlates™ as a sensitive and effective indicator for assessing microbial functional diversity and microbial communities amid sewage sludge accumulation. These parameters prove valuable in monitoring the soil microbial status subsequent to sewage sludge application, providing insights into the potential impacts on environmental and agricultural ecosystems.

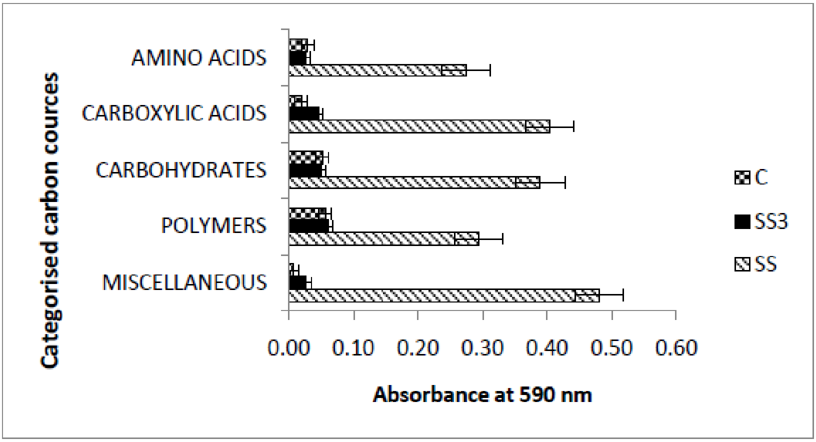

Figure 12: Categorized substrate utilization patterns by the microbial communities from the soil after 48 h of incubation. Errors bars indicate the standard errors of the mean (n = 3).

Significant distinctions were identified in the substrate utilization patterns of microbial communities across the three soil samples (Figure 12). Notably, carboxylic acids, carbohydrates, and miscellaneous groups exhibited heightened metabolic activities, particularly in the soil impacted by sewage sludge accumulation.

Municipal sewage sludge stands out for its abundance of molds and yeasts, known as fungal plant pathogens. A majority of the fungi recovered in this investigation possess characteristics indicative of potential pathogens. Consequently, individuals engaged in sewage sludge research and accumulation must exercise caution to prevent mycotic infections, and production processes should be tailored to control the dissemination of pathogenic fungi into the environment.

Furthermore, it is worth highlighting that the insights and expertise gained through this collaboration have laid the foundation for my patent aimed at remediating acidic petroleum-impacted soil. This innovation underscores the practical applications arising from research efforts in addressing environmental challenges.

C. The reciprocal relationship between sustainability challenges and scientific research

The interconnectedness between sustainability challenges and scientific research is intricate and dynamic. Sustainability issues, including climate change, biodiversity loss, resource depletion, and pollution, prompt scientific research to comprehend their origins, impacts, and potential remedies. Concurrently, scientific research plays a pivotal role in recognizing and tackling these sustainability challenges (Elegbede et al., 2023), thereby advancing the overarching objective of attaining a more sustainable future.

Figure 13: Assessment of a Niger Delta coastal community revealed loss of biodiversity

Scientific research establishes the groundwork for understanding the intricate and interrelated nature of sustainability challenges. Through rigorous investigation and analysis, researchers unravel the fundamental causes, patterns, and processes contributing to these challenges. For instance, studies have unveiled the effects of pollution on ecosystems and human health (Nwaichi et al., 2010; Nwaichi &Ayalogu, 2011). Our 28-day feeding study's hazard characterization disclosed negative impacts of potentially toxic BTEX and PAH on organ weight, optimum digestibility, and animal growth rate (Figure 14).

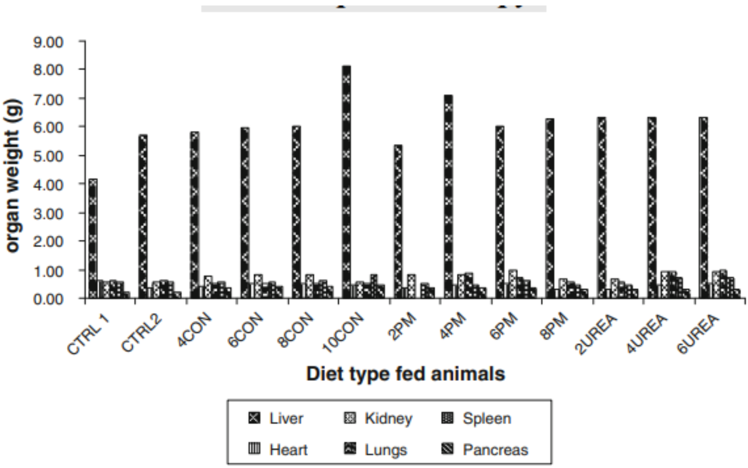

Figure 14: Observed organ weight (g) of animals fed different diets after 28 days. CTRL 1 = Group fed commercial feed only, CTRL 2 = Group Fed commercial feed + beans from control experiment i.e. beans harvested from plants grown on un-spiked soil; PM = Group Fed commercial feed + beans harvested from Poultry manure-amended treatment; UREA = Group Fed commercial feed + beans harvested from Urea-amended treatment; CON = Group Fed commercial feed + beans harvested from spiked un-amended treatment; 2, 4, 6, 8, and 10 added to CON, UREA and PM represent different % spill concentrations (v/w) simulated (Nwaichi et al., 2010).

Sleep time decreased with rising hydrocarbon concentrations, likely due to increased liver enzyme activity. The phytotoxic responses observed in common edible species in Nigeria were relatively severe, as depicted in various phytotoxic responses (Figure 15). This knowledge is vital for formulating effective strategies and policies to mitigate and adapt to these challenges.

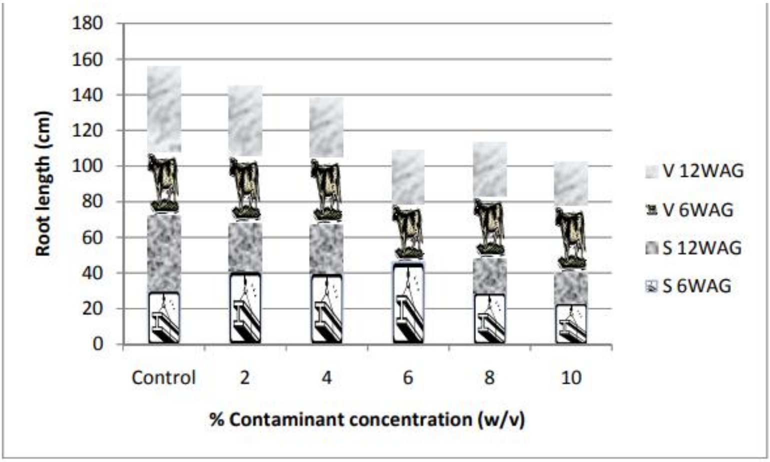

Figure 15: Observed Root length at 6 and 12 weeks after germination (WAG) for *S. stenocarpa* (S) and *V. subterranean* (V) (Nwaichi &Ayalogu, 2011).

Conversely, sustainability challenges act as catalysts for scientific research. As the urgency and magnitude of these challenges become increasingly evident, there is a growing demand for scientific knowledge and innovation to develop sustainable solutions. Researchers are motivated to explore new technologies, methodologies, and approaches contributing to sustainable development. This leads to the emergence of interdisciplinary fields such as sustainability science, integrating knowledge from various scientific disciplines to address complex sustainability issues.

Furthermore, scientific research is instrumental in informing policy and decision-making processes related to sustainability. Policymakers rely on scientific evidence to develop and implement effective strategies for environmental conservation, resource management, and climate action. Scientific findings provide the necessary foundation for policy discussions, international agreements, and the formulation of regulations aimed at promoting sustainability.

In turn, addressing sustainability challenges often requires interdisciplinary collaboration and a holistic approach. Scientific research encourages the integration of different fields of knowledge, fostering collaboration between scientists, policymakers, industry experts, and community stakeholders. This collaborative effort allows for a comprehensive understanding of sustainability challenges and the development of innovative solutions considering social, economic, and environmental dimensions.

Overall, the reciprocal relationship between sustainability challenges and scientific research is vital and symbiotic. Sustainability challenges drive scientific research by emphasizing the urgent need for knowledge and solutions, while scientific research contributes to addressing these challenges through evidence-based understanding, innovation, and policy guidance. Recognizing and fostering this reciprocal relationship can accelerate progress towards a more sustainable and resilient future.

D. The Urgency and Significance of Addressing Environmental Challenges

As stewards of this planet, it is our moral and intellectual duty to understand and mitigate the pressing environmental challenges we face today for the well-being of current and future generations.

i) Global scale

The world is currently facing an unprecedented environmental crisis characterized by climate change, biodiversity loss, pollution, deforestation, and resource depletion. These challenges are interconnected and pose severe threats to ecosystems, human health, and socio-economic stability on a global scale.

ii) Impact on human

Addressing environmental challenges is essential to secure a sustainable and flourishing future for humanity. The direct impact of environmental degradation on human well-being, including the loss of clean air and water, heightened vulnerability to natural disasters, compromised food security, and the emergence of diseases, necessitates immediate action. It is imperative that we take urgent steps to preserve our natural resources and protect the health and livelihoods of people worldwide.

One prevalent environmental issue is pollution caused by petroleum and its derivatives, drawing global attention to oil spills. Notable incidents, such as the spills on January 12, 1998, at Mobil Unlimited Idoho platform (45,000 barrels), and July 1979, at the West of Shell operated forcados terminal storage facility (560,000 barrels), have resulted in significant environmental damage along the Atlantic coastal line in Nigeria. Anthropogenic activities in coastal areas, including the use of creosote-treated wood in aquaculture, bush burning, industrial effluent discharge, dense vehicular emissions, and artisanal refining of petroleum products in the Niger Delta, contribute to the contamination of coastal environments with Polycyclic Aromatic Hydrocarbons (PAHs).

PAHs pose a major concern due to their persistence and mutagenic and carcinogenic properties. These pollutants, containing two or more fused benzene rings, are widespread in marine and terrestrial environments. Their inclusion in the priority pollutant lists of the EU and USEPA underscores their hazardous nature. The predominant exposure route is dietary, with the potential for bioaccumulation in aquatic organisms due to the chemical stability and lipophilic nature of PAHs.

I spearheaded the Environmental Management of the critical Sea Eagle FPSO (Floating Production Storage and Offloading) operations, uncovering concerning pollution stemming from ballast water and emissions from associated activities. My report sparked impactful discussions with significant policy implications. This initiative underscores the imperative that environmental degradation knows no boundaries.

The study conducted by Nwaichi and Ntorgbo (2016) examined the levels of sixteen PAHs in 30 edible tissues of frequently-consumed fish and seafood collected from three coastal waters of the Niger Delta—Sime, Kporghor, and Iko. This investigation, focusing on the Urgency and Significance of Addressing Environmental Challenges, sheds light on the impact of PAH contamination on human health. The assessment focused on changes in the physical, chemical, and biological components of the ecosystem, emphasizing the urgency of addressing environmental challenges to safeguard human health.

Table 3:PAHs levels (μg kg^{-1} wet wt.) for *Littorina littorea* from the study areas

PAHs	Sime Tai	Kpoghor	Iko
Naphthalene	<0.0001	<0.0001	<0.0001
Acenaphthylene	<0.0001	<0.0001	<0.0001
Acenaphthene	<0.0001	<0.0001	<0.0001
Fluorene	<0.0001	0.04±0.004	<0.0001
Phenanthrene	0.03±0.004	0.01*±0.002	0.02±0.003
Anthracene	0.02±0.002	0.01*±0.000	0.02±0.003
Fluoranthene	0.01±0.000	0.03±0.004	0.03±0.004
Pyrene	0.03±0.004	0.04±0.004	0.04±0.003
Benzo[a]anthracene	0.05±0.004	0.002*±0.004	0.08±0.004
Chrysene	0.08*±0.004	<0.0001	0.01*±0.002
Benzo[b]fluoranthene	4.24*±0.01	13.3±0.03	16.8±0.04
Benzo[k]fluoranthene	0.004.001	<0.0001	0.04*±0.004
Benzo[a]pyrene	0.01*±0.00	0.01*±0.00	0.02*±0.003
Indeno[1,2,3-cd]pyrene	2.65*±0.01	22.4*±0.05	13.1*±0.02
Dibenzo[a,h]anthracene	0.01*±0.002	0.002±0.00	0.002±0.00
Benzo[g,h,i]perylene	0.02*±0.002	0.01±0.002	0.01±0.002
Total	7.15*±0.04	35.8*±0.100	30.1*h±0.09
LMW-PAH/HMW-PAH	0.01*±0.001	0.002*±0.000	0.001*±0.000
BaA/(BaA+Chry)	0.38±0.001	1.000*±0.003	0.89±0.001

Means with superindices across rows are significantly different (P < 0.05), values are mean±S.E.M (n=10).

Table 4:PAHs levels (μg kg^{-1} wet wt.) for *Crassostrea virginica* from the study areas

PAHs	Sime Tai	Kpoghor	Iko
Naphthalene	<0.0001	<0.0001	<0.0001
Acenaphthylene	<0.0001	0.002±0.00	0.01±0.002
Acenaphthene	<0.0001	0.003±0.00	0.06±0.004
Fluorene	<0.0001	0.04±0.004	0.12±0.01
Phenanthrene	0.06*±0.004	0.01*±0.00	0.13*±0.01
Anthracene	0.05±0.01	0.05±0.004	0.02±0.002
Fluoranthene	0.09*±0.004	0.49±0.01	0.23±0.01
Pyrene	0.05±0.01	0.03±0.002	0.05±0.004
Benzo[a]anthracene	0.03*±0.003	0.003*±0.00	0.01*±0.002
Chrysene	0.03±0.003	<0.0001	0.09±0.004
Benzo[b]fluoranthene	2.72*±0.01	87.4*±0.03	63.9*±0.004
Benzo[k]fluoranthene	0.02±0.002	0.01±0.000	0.06*±0.01
Benzo[a]pyrene	0.07±0.004	0.01*±0.002	0.02±0.002
Indeno[1,2,3-cd]pyrene	0.01*±0.002	16.9*±0.03	32.1*±0.02
Dibenzo[a,h]anthracene	0.49*±0.004	0.05*±0.004	0.17*±0.01
Benzo[g,h,i]perylene	0.05±0.01	0.02±0.002	0.18*±0.004
TOTAL	3.67*±0.05	105±0.09	97.2±0.09
LMW-PAH/HMW-PAH	0.50±0.002	0.01±0.000	0.004*±0.000
BaA/(BaA+Chry)	0.50*±0.01	0.03*±0.001	0.10*±0.002

Means with superindices across rows are significantly different (P < 0.05), values are mean±S.E.M (n=10).

Table5: PAHs levels (μg kg^{-1} wet wt.) in *Periophthalmuskoeleuteri* from the study areas

PAHs	Sime Tai	Kpoghor	Iko
Naphthalene	<0.0001	<0.0001	<0.0001
Acenaphthylene	<0.0001	0.002±0.000	<0.0001
Acenaphthene	<0.0001	0.001±0.000	<0.0001
Fluorene	0.01±0.000	0.003±0.000	<0.0001
Phenanthrene	0.03±0.004	0.24^{*}±0.04	<0.0001
Anthracene	<0.0001	0.04±0.003	<0.0001
Fluoranthene	0.06^{*}±0.004	2.46^{*}±0.01	0.01^{*}±0.002
Pyrene	0.05±0.01	0.09±0.004	0.01±0.000
Benzo[a]anthracene	0.003^{*}±0.000	0.002^{*}±0.00	0.03^{*}±0.01
Chrysene	<0.0001	<0.0001	0.09±0.004
Benzo[b]fluoranthene	0.86^{*}±0.004	10.4^{*}±0.04	49.3^{*}±0.05
Benzo[k]fluoranthene	0.001±0.00	0.001±0.00	0.001±0.002
Benzo[a]pyrene	<0.0001	<0.0001	0.002±0.000
Indeno[1,2,3-cd]pyrene	171^{*}±0.43	32.7^{*}±0.03	3.67^{*}±0.01
Dibenzo[a,h]anthracene	0.002±0.000	<0.0001	0.001±0.002
Benzo[g,h,i]perylene	0.001±0.00	<0.0001	0.004±0.000
TOTAL	171.9^{*}±0.45	45.9±0.12	53.1±0.07
LMW-PAH/HMW-PAH	0.00x±0.000	0.01^{*}±0.000	5.31^{*}±0.09
BaA/(BaA+Chry)	0.10^{*}±0.004	1.00^{*}±0.02	0.43^{*}±0.05

Means with superindices across rows are significantly different (P < 0.05), values are mean±S.E.M (n=10).

Gas chromatographic analysis was employed for PAHs determination. Observed mean PAHs levels in the samples ranged from below detection limit of 0.0001 to 22.4 ± 0.05 μgkg-1 wet wt. in L. littorea, 0.0001 to 87.4 ± 0.03 μgkg-1 wet wt. in C. virginica and from 0.0001 to 171 ± 0.43 μgkg-1 wet wt. in P. koeleuteri. The highest average concentration of 171 ± 0.43 μgkg-1 wet wt. was recorded for Indeno [1,2,3-cd]pyrene from Sime water. High molecular weight PAHs (HMW-PAHs) were generally predominant compared to low molecular weight PAHs (LMW-PAHs). The LMW- PAH/HMW-PAH ratio was <1 for all species, indicating anthropogenic origin of PAHs in the coastal waters of Niger Delta environment. Moreover, the study of the PAHs fingerprints, using specific ratios, suggests the predominance of a pyrolytic origin for observed PAHs.

iii) Climate Change and Its Consequences

Climate change is perhaps the most urgent environmental challenge we face. Rising temperatures, sea-level rise, extreme weather events, and shifting climate patterns pose immense threats to ecosystems and human societies. The need to transition to low-carbon economies, reduce greenhouse gas emissions, and adapt to the changing climate cannot be overstated.

Climate change is closely related to contaminants in the air or dust through the intricate dynamics of the Earth's atmosphere. Human activities release greenhouse gases, such as carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O), into the atmosphere, contributing to the greenhouse effect. This effect traps heat, leading to a rise in global temperatures and contributing to climate change.

Simultaneously, various pollutants and contaminants are released into the air through industrial processes, vehicle emissions, and other anthropogenic activities. These pollutants include particulate matter, heavy metals, volatile organic compounds (VOCs), and other airborne contaminants (Nwaichi and James, 2012). Some of these substances can directly influence climate change by altering atmospheric composition and affecting regional climate patterns.

The interplay between climate change and contaminants in the air or dust involves a complex web of interactions where human-induced emissions contribute to both global warming and the release of pollutants that, in turn, can further impact climate patterns and environmental health.

Heavy metals have been identified as significant indoor dust pollutants, prompting a health risk assessment of heavy metal contents in dust collected from the corners of classrooms in randomly selected public primary schools in Rivers State (Figure 16). The study by Olua et al. (2018) focused on lead (Pb), cadmium (Cd), chromium (Cr), and arsenic (As) levels, analyzed using Atomic Absorption Spectrophotometer (AAS, GF, Flame HVG). Results indicated that the maximum levels for Pb and Cd were observed in location E at 25.39±0.09 and 3.52±0.23 mg kg-1, respectively, while Cr and As maximum levels were found in location H at 45.24±0.02 and 1.53±0.06 mg kg-1. Minimum levels were observed at location E.

The Average Daily Intake Dose (ADD) considering ingestion, dermal contact, and inhalation, along with the corresponding Target Hazard Quotients, revealed oral ingestion as the primary exposure pathway. While there was no evidence of non-carcinogenic risk or Hazard Index (HI), children in the population were found to be more exposed to Lifetime Cancer Risks (TLCR), except at location F. It is strongly recommended that a similar risk assessment be conducted on agricultural products harvested from primary school farms and borehole water within these regions (Olua et al., 2018).

This assessment underscores the importance of understanding and mitigating the impact of heavy metal exposure, not only for immediate health concerns but also in the broader context of environmental and climate-related implications. Continued research and risk assessments are essential for developing strategies that address both local health risks and broader environmental challenges, contributing to a more sustainable and climate-resilient future.

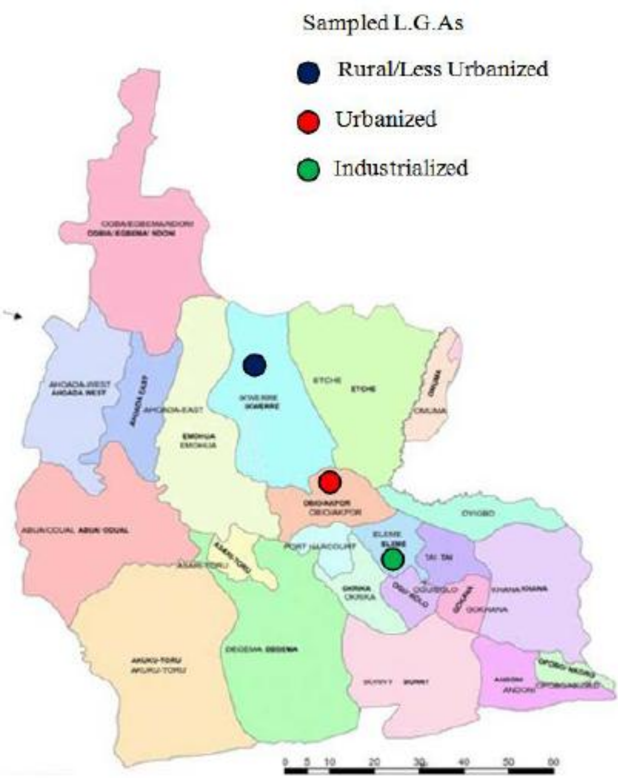

Figure 16: Map of Rivers State showing sampling sites

iv) Biodiversity Loss and Ecological Imbalance

The rapid loss of biodiversity and the degradation of ecosystems have far-reaching consequences. Biodiversity loss disrupts critical ecosystem functions such as pollination, nutrient cycling, and water purification, leading to decreased resilience and stability. Preserving biodiversity and protecting fragile ecosystems are vital for sustaining life on Earth and maintaining the delicate balance of our planet.

Due to humanity's inevitable reliance on water, whether directly or indirectly, and considering the delicate nature of

Africa's largest river Delta, this study focused on assessing the groundwater quality from three operational boreholes in Gokana, Ogale, and Trans-Amadi communities in Rivers State, Nigeria. The aim was to evaluate the suitability of the water samples for end-users. The study utilized conventional field and laboratory techniques to analyze hydrochemistry, physical properties, and microbial load.

The results revealed significant variations in various water characteristics, attributed to factors such as petroleum production, artisanal refining, illegal tapping, and industrial activities. Physicochemical properties, including TSS, DO, NH3, Acidity, color, and pH levels, exceeded set limits defined by the Department of Petroleum Resources (DPR) and Nigerian Standards for Drinking Water Quality (NSDWQ) for all locations. Notably, these findings were comparable to the recent report by the United Nations Environment Programme (UNEP, 2011) on Ogoniland and its surroundings (Figure 17).

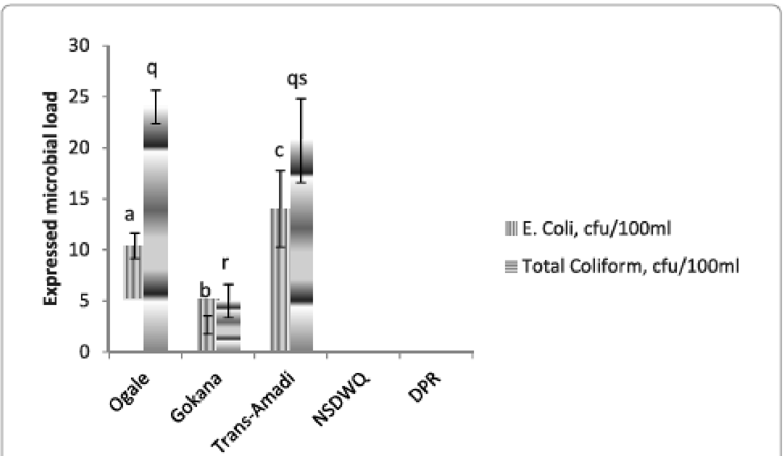

Figure 17a: Mean values of some biological parameters

Furthermore, at a significance level of $p \leq 0.05$, elevated levels of the carcinogen Benzene were observed in Ogale water samples. Although the expressed microbial load did not meet standards for all locations, there was no statistically significant difference ($p \leq 0.05$) among the different locations.

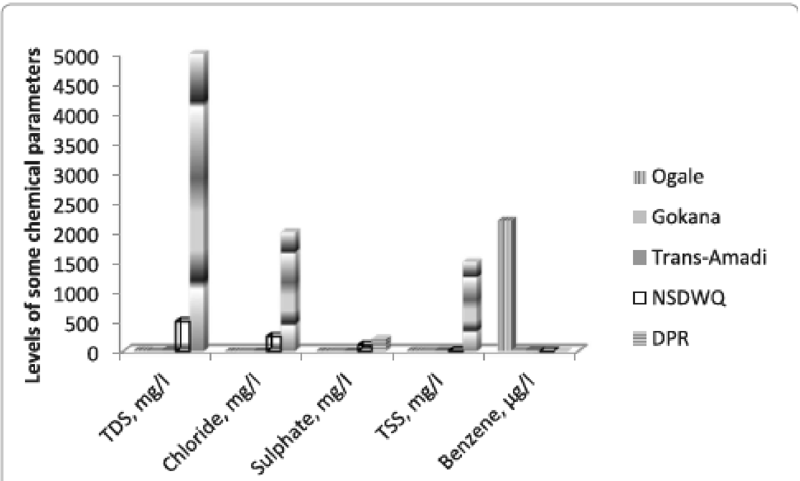

Figure 17b: Mean values of some chemical parameters

These findings suggest groundwater pollution, with potential interrelationships with social and health implications.

In my endeavor to communicate my research findings to a prominent regulatory body in Nigeria regarding prevalent remedial practices and their potential impact on biodiversity and ecological equilibrium, I encountered the response that the current regulatory framework did not account for my technology. This revelation underscored the necessity for updated regulations, as many existing ones were formulated in a pre-biotechnology era. The call for new regulations becomes imperative to delineate desired outcomes in crucial domains such as environmental health, equity, and fairness, while explicitly outlining those outcomes deemed undesirable.

But avoiding harm shouldn’t be just a priority for society. It also needs to be a priority for each innovator. As technologists, we have a responsibility to understand the implications of our research and innovate in ways that are beneficial. Traditionally, many technologists adopted the attitude that the shape technology takes is inevitable and there’s nothing we can do about it, so we might as well innovate freely. But we know that’s not true.

SCIENTIFIC INNOVATIONS FOR A SUSTAINABLE FUTURE

A. Showcasing Cutting-Edge Scientific Technologies and Research Areas

i) The Imperative of Sustainable Agriculture

The imperative of sustainable agriculture is paramount in addressing the formidable challenges of feeding a growing global population, mitigating environmental degradation, and ensuring the resilience of agricultural systems.

In my pursuit of tackling complex sustainability challenges in impacted farmlands, my interdisciplinary research has not only deepened our understanding but also yielded practical solutions seamlessly integrating social, economic, and environmental dimensions.

An indispensable step in evaluating soil quality is the estimation of soil organic matter (SOM), a crucial component included in minimum data sets used to assess the world's soils. In a groundbreaking study, soil organic matter status and turnover evaluations were conducted on disturbed, biologically reclaimed, and undisturbed agricultural soils. Nwaichi & Essien (2016) and Nwaichi et al. (2015) presented recent findings on indicators of SOM, utilizing cellulose breakdown as measured by β-glucosidase activity and CO2 release as gauged by respiratory activity. This innovative biological estimation of SOM, especially in stressed soils, represents a significant contribution to our understanding. The results underscore the potential benefits of minimizing synthetic farm inputs, promoting resource conservation, and enhancing biodiversity—a cornerstone of sustainable agriculture that seeks to optimize productivity while safeguarding our planet.

In another investigation, Nwaichi & Frac (2015) explored the impact of petroleum pollution on a vulnerable Niger Delta ecosystem, assessing interactions in a first-generation phytoremediation site of a freshly-spilled crude oil in agricultural soil. Employing a community-level approach to assess patterns of sole carbon-source utilization by mixed microbial samples, the study differentiated spatial and temporal changes in soil microbial communities. Genetic diversity and phenotypic expressions were measured for a more holistic perspective. The 5’-terminal restriction fragments generated after Csp digestion of the 16S rRNA gene correlated with observed DNA concentrations in the community profile, revealing a loss of diversity with pollution. Crude oil pollution significantly reduced phosphomonoesterases and respiratory activities, and these values were pH dependent. Notably, there were no expressed dehydrogenases activity in the initial spill site, but these were enhanced with phytoremediation. Factor analysis of predictors and independent variables indicated that respiratory, alkaline phosphatase, and β-glucosidase activities could be used to explain underlying factors (Figure 18). The study observed positive soil-microbes-plant interactions, demonstrating the potential for remediation efforts.

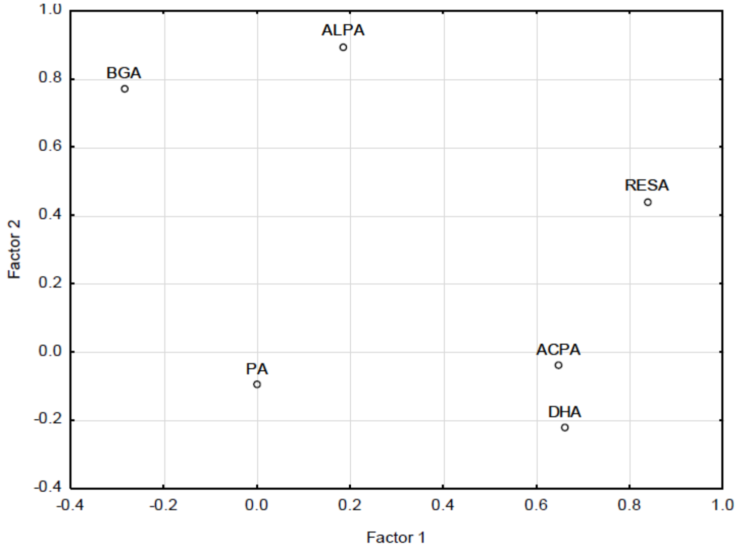

Figure 18: Factor analysis of predictors and independent variables for biochemical parameters. PA, DHA, ACPA, BGA, ALPA and RESA denote protease, dehydrogenase, acid phosphatase, β-glucosidase, alkaline phosphatase and respiratory activities respectively.

In summary, the imperative of sustainable agriculture is not just a theoretical concept but a practical necessity addressed through cutting-edge scientific technologies and research. The exploration of soil organic matter dynamics and the intricate response of microbial communities to petroleum pollution exemplify the commitment to advancing our understanding and application of sustainable agricultural practices. This journey underscores the transformative potential of scientific endeavors in shaping the future of agriculture under the sub-theme "Showcasing Cutting-Edge Scientific Technologies and

Research Areas" in my inaugural lecture. Together, let us delve into these innovations and pave the way for a sustainable and resilient agricultural future.

ii)Sustainable Intensification and Agroecology

Sustainable intensification stands as a pivotal strategy, seeking to optimize agricultural productivity while minimizing adverse environmental impacts. This approach underscores the integration of ecological principles into farming practices, championing methodologies like crop rotation, agroforestry, and organic farming. Agroecology emerges as a transformative force, endorsing biodiversity, soil health, and natural pest control—fostering resilient and sustainable food systems. Nwaichi and Ayalogu (2010) observed allelopathic suppression on crops by *Mucuna pruriens*(Figure 19). Allelopathic chemicals persisted in some neighbouring plants asthose planted in succession. Although produced allelochemicals acted as natural herbicides, it may also haveundesirable effects on non-target species thus the need for prior ecological studies.

Figure 19: *Mucuna pruriens* var. pruriens showed allelopathic potential

In response to a heightened interest in management practices aimed at reducing phytotoxicity during phytoremediation experiments, soil polluted by crude oil and its variants from conditioner-aided phytoremediation experiments underwent terminal restriction fragment polymorphism (t-RFLP) analysis. This process aimed to evaluate the biodiversity of the bacterial microflora within the polluted soil and amended conditions. Genetic fingerprinting revealed that hydrocarbon-induced stress led to a depletion of the genetic resources within the soil microflora, resulting in a radical change in its qualitative composition. Remarkably, the amended stressed soils not only exhibited a greater number of species but also showcased a clear improvement with the application of conditioners (Figure 20). Positive associations were observed between conditioners and attempts at phyto-assisted clean-up, demonstrating the potential efficacy of these interventions.

The diversity (Figure 20) and evenness (data not shown) of species in this study showed wide distortions due to contamination and plant type and were higher in communities from control planted soils closely followed by those of *H. brasilensis* and *F. littoralis* in polluted soils. It is worthy to mention that the two latter plants grow naturally in the polluted community, where test was sourced.

The exploration of sustainable intensification and agroecology delves into cutting-edge scientific technologies and research areas. By integrating ecological principles and innovative soil management practices, we aim to not only enhance agricultural productivity but also contribute to resilient and sustainable food systems. The intricate analysis of bacterial microflora in polluted soils underlines the transformative potential of these approaches, providing insights into the dynamics of biodiversity and soil health.

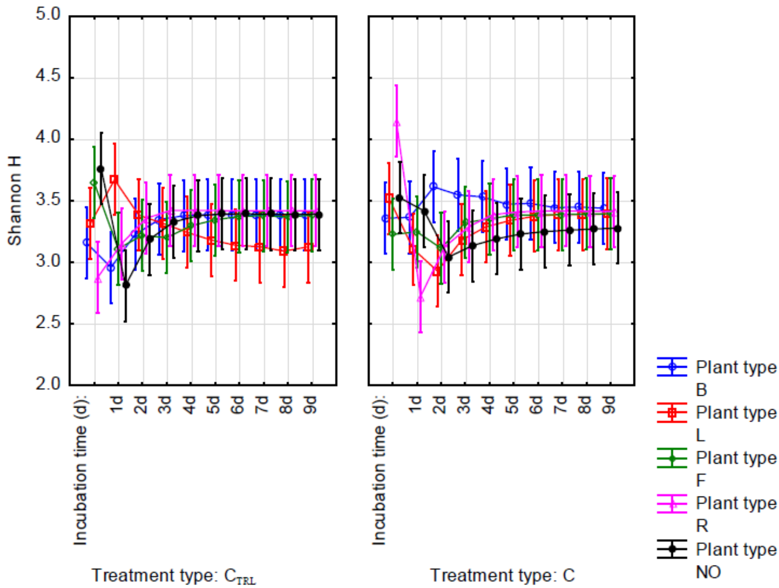

Figure 20: Species diversity characterization in observed community. B, L, F, R, and NO denote Bambara, Lemon grass, Fimbristylis, Rubber, and unplanted regimes respectively.

iii) Climate-Smart Agriculture and Resilience

Environmental sustainability stands as a critical concern in today's world, where the challenges posed by climate change have far-reaching consequences. Agriculture, as a primary driver of environmental change, both contributes to and is impacted by climate change. Thus, it becomes imperative to adopt agricultural practices that are not only productive and efficient but also environmentally sustainable. Our team, when deploying phyremediation, collaborated with farmers to optimize the use and management of natural resources, employing efficient methods tailored to their land and climate conditions. This collaborative effort aimed at finding improved crop varieties and diversification strategies for remediating complex lands, ensuring safer and bountiful harvests. Co-created initiatives, such as soil management, minimal or no-till practices, and wetland preservation, emerged through co-learning with local communities, drawing on indigenous knowledge.

Climate-Smart Agriculture (CSA) is a holistic approach that addresses these challenges by integrating three core principles: increasing agricultural productivity, enhancing resilience to climate change, and reducing greenhouse gas emissions. This approach recognizes the interlinkages between climate change, food security, and sustainable development.

CSA focuses on enhancing the resilience of agricultural systems to climate change, acknowledging the risks posed by climate variability and extreme weather events. For example, a weed in the cocoyam family provided shield for interest species from extreme weather conditions. Resilient farming practices, including agroforestry, conservation agriculture, and integrated pest management, help farmers adapt to changing climatic conditions by conserving soil moisture, preventing erosion, and building natural pest and disease control mechanisms.

Additionally, climate-smart agriculture emphasizes the importance of reducing greenhouse gas emissions from the agricultural sector (Nwaichi et al., 2014; Daniel et al., 2020). Agriculture significantly contributes to global emissions, primarily through methane and nitrous oxide released from livestock and fertilizers. Adopting climate-smart practices, such as improved manure management, optimized fertilizer application, and livestock breed selection, can mitigate these emissions, contributing to climate change mitigation efforts.

By adopting climate-smart agriculture and resilience-building practices, we achieved a range of environmental and socio-economic benefits. This includes ensuring food security, conserving biodiversity and natural resources through sustainable land management, and fostering more sustainable livelihoods, particularly for smallholder farmers who are often the most vulnerable to climate change impacts.

To effectively implement climate-smart agriculture, collaboration among various stakeholders is crucial. Policymakers, researchers, farmers, and civil society organizations need to work together to develop and disseminate appropriate technologies, provide access to finance and markets, and facilitate knowledge sharing and capacity building.

B. Exploring the Sustainable Development Goals (SDGs): The Role of Science and My Contribution

The Vice Chancellor, ladies and gentlemen, I am humbled to address this critical topic of global sustainability. I would like to shed light on the Sustainable Development Goals (SDGs) as a transformative framework that guides our journey towards a sustainable future for all. The SDGs, adopted by the United Nations, provide us with a comprehensive roadmap to address the interconnected challenges of poverty, inequality, environmental degradation, and climate change. These 17 goals encapsulate our collective aspirations for a better world by 2030. What a privilege and unique opportunity I have as an academic and researcher, to contribute to this global movement for positive change. By aligning my research, teaching, and outreach efforts with the SDGs, I have fostered innovation (the third mission of university), collaboration, and knowledge exchange to advance sustainability at local, national, and global levels. The SDGs serve as a powerful framework to guide our academic endeavours, empowering us to contribute meaningfully to the achievement of these ambitious goals. Society has a deep interest in the fruits of innovation and that is a good reason to approach innovation with optimism posits Ng (2023).

The Vice Chancellor, ladies and gentlemen, esteemed colleagues, and honored guests, as we progress on this journey that not only delves into the intricacies of environmental science but also resonates profoundly with the United Nations Sustainable Development Goals (SDGs). Our exploration at the intersection of science and sustainability not only sheds light on critical environmental challenges but also pioneers solutions that align with a greener future. Join me examine how our research addresses and touches upon several key SDGs (1, 2, 3, 4, 5, 6, 7, 9, 11, 13, 14, 15, and 17).

1. No Poverty (SDG 1): Our work directly impacts SDG 1 by addressing environmental degradation's role in poverty reduction. Preserving natural resources ensures sustainable livelihoods, mitigating the adverse effects of environmental decline on vulnerable communities.

2. Zero Hunger (SDG 2): Through our research, we contribute to SDG 2 by examining the impact of environmental factors on food security. Our findings aim to enhance agricultural practices and minimize pollutants, thus fostering a sustainable and secure food supply.

3. Good Health and Well-being (SDG 3): The connection between environmental degradation and human health is a focal point of our study. By understanding and mitigating the health risks posed by environmental pollutants, we contribute to SDG 3, promoting well-being for present and future generations.

4. Quality Education (SDG 4): Our research contributes to knowledge dissemination and awareness, aligning with SDG 4. By understanding the intricate links between the environment and human health, we empower communities and policymakers to make informed decisions for a sustainable future.

5. Gender Equality (SDG 5): Environmental challenges often disproportionately affect women. By exploring these intersections, our research addresses SDG 5, striving for gender equality by recognizing and mitigating gender-specific vulnerabilities linked to environmental issues.

6. Clean Water and Sanitation (SDG 6): Our study directly addresses water quality concerns arising from environmental degradation. By identifying and mitigating pollutants, we contribute to SDG 6, ensuring clean water access for all.

7. Affordable and Clean Energy (SDG 7): Our research acknowledges the impact of environmental pollution on energy sources. By exploring sustainable alternatives, like biogas from produced biomass, and mitigating pollution, we align with SDG 7, promoting affordable and clean energy solutions.

9. Industry, Innovation, and Infrastructure (SDG 9): We pioneer solutions that align with SDG 9, emphasizing sustainable practices and innovations to address environmental challenges. Our work contributes to building resilient infrastructure, that patronises reduce, reuse and recycle, and fostering sustainable industrialization.

11. Sustainable Cities and Communities (SDG 11): Environmental challenges often manifest in urban settings. Our research informs strategies for sustainable urban development, aligning with SDG 11 and promoting resilient, inclusive, and sustainable cities.

13. Climate Action (SDG 13): Our study significantly contributes to SDG 13 by addressing the impacts of pollution and environmental degradation, key factors in climate change. By pioneering sustainable solutions, we actively engage in climate action.

14. Life Below Water (SDG 14): The focus on coastal environments and marine life in our research aligns with SDG 14, aiming to conserve and sustainably use marine resources. We explore solutions to mitigate the impact of pollutants on aquatic ecosystems.

15. Life on Land (SDG 15): Our examination of terrestrial environments and ecosystems aligns with SDG 15, promoting the sustainable use and conservation of land resources. By addressing anthropogenic activities, we contribute to the preservation of biodiversity.

17. Partnerships for the Goals (SDG 17): Lastly, our research fosters collaboration and partnerships across disciplines and sectors. By exploring the intersection of science and sustainability, we actively contribute to SDG 17, recognizing the need for collective efforts to achieve the broader sustainability agenda.

In all, our stands as a testament to the profound connections between environmental science and the UN SDGs. By pioneering solutions for a greener future, we strive to make meaningful contributions to global sustainability, addressing complex challenges that transcend disciplinary boundaries. Together, let us embark on a journey towards a more sustainable and resilient world.

COLLABORATIVE PARTNERSHIPS AND POLICY IMPLICATIONS

The Vice Chancellor, ladies and gentlemen, distinguished colleagues, and esteemed guests,

As an academic, my responsibilities primarily revolve around teaching and research, with additional services outlined in my appointment letter. In the context of collaborative partnerships, I find that my diverse and unique sets of students, both past and present, are my foremost collaborators. This realization struck me as I reflected on the impactful journey I've shared with these individuals. Notably, Dr. Victor Olua, an ex-student, presented me with the flourishing tree depicted in Figure 21. This symbolic gesture resonates with my commitment to contribute to the broader mandate mentioned earlier. It underscores the significant role my students play as essential collaborators, forming an integral part of every research team I assemble. Their diverse perspectives and contributions enhance the collaborative nature of my work.

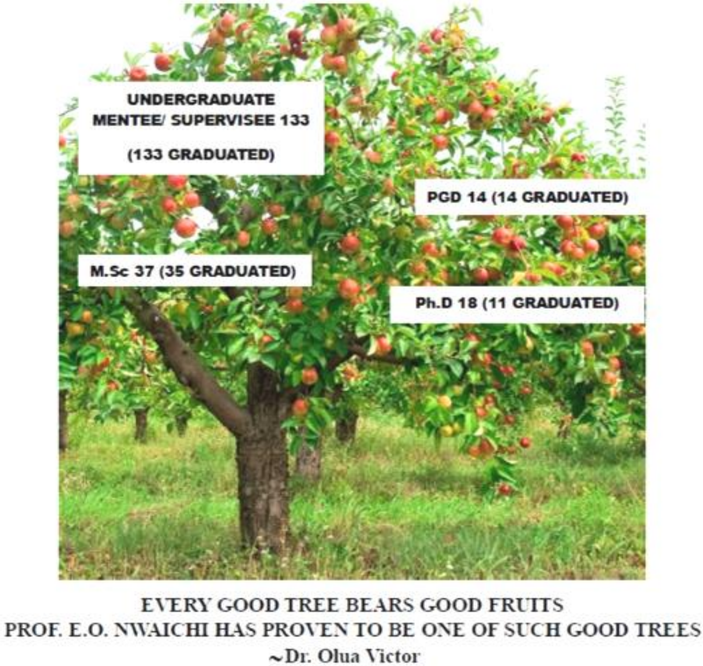

Figure 21: A symbolic presentation by my assigned collaborator

Through active engagement with policymakers, industry leaders, and communities, the findings of our research are translated into actionable policies, technologies, and practices that champion sustainable development.

Recognizing the critical role of innovation in today's dynamic world, I sought to implement change by securing a grant to institutionalize evidence-informed decision-making in a government agency. The pronounced discrepancy between research outputs and their execution in real-world practice prompted this initiative, emphasizing the crucial need for Evidence-Informed Decision-Making (EIDM) in both research and policy spaces.

A meticulous study of a selected government agency in the Health sector and a research institution laid the groundwork for a strategic partnership aimed at increasing the number of experts in government and education sectors. The establishment of a 28-member Evidence Leaders in Africa (ELA) team, comprising policymakers and researchers, formed the backbone of this initiative. Through capacity-building training and workshop sessions, the project facilitated heightened interactions among researchers, policymakers, and stakeholders, leading to increased research uptake for decision-making.

The socio-demographic characteristics of the respondents, comprising individuals from various governmental and non-governmental organizations, revealed a cross-section of age groups and work experiences. Surprisingly, a significant percentage of respondents were not familiar with Evidence-Informed Decision-Making (EIDM) at the project's inception. However, the initiative successfully built awareness and interest, resulting in the development and launch of Guidelines for Evidence Use in the participating government agency (Figure 22).

In a testament to the success of the project, the debut edition of the Guidelines for Evidence Use was so well-received that it prompted a revised edition sponsored by the government, complete with an ISBN. Furthermore, the project has given rise to a vibrant local and regional Community of Practice (CoP), consisting of experts (Figure 22) from both government and academia, fostering ongoing collaboration and knowledge exchange.

Figure 22: Developed Guidelines for Evidence Use, Community of Practice and associated Awards

To solidify and institutionalize this collaboration, a Memorandum of Understanding (MoU) was later sealed between the lead researcher's institution, the University of Port Harcourt, and the participating government agency, NNMDA (National Nutrition and Microbiology Development Agency). This MoU signifies a structured institutional relationship aimed at fostering continued collaboration and mutual growth in the realm of evidence-informed decision-making.

The project's impact has not only been recognized locally but has also received international acclaim. I am honored to share that I have been awarded by African Institute for Development Policy (AFIDEP) Kenya (Figure 22), an accolade primarily linked to the success and innovations stemming from this project. This additional recognition underscores the project's global significance in advancing evidence-informed decision-making and sustainable practices.

The multi-faceted outcomes of the project have not only contributed to the advancement of evidence-informed decision-making but have also garnered recognition on an international scale. In August 2022, I was honored with the prestigious "Winner, Evidence Leader Africa (Producer Category)" award in Pretoria, South Africa (Figure 22), a testament to the project's significant impact and innovative contributions to the field.

It is noteworthy to state that this collaborative journey exemplifies the power of interdisciplinary research, strategic partnerships, and evidence-informed decision-making in shaping a greener future. Remember, a mono-economy is not sustainable, and through collaborative partnerships and evidence-informed policy, we pave the way for a more sustainable and resilient future.

CASE STUDIES: PIONEERING SOLUTIONS

The Vice Chancellor, ladies and gentlemen, distinguished colleagues, and esteemed guests,

The management of crude oil-impacted vegetation arising from oil spills poses a significant challenge during cleanup efforts (Figure 23). Conventionally, this waste is either incinerated or subjected to open burning, contributing to global carbon emissions. To address this environmental concern, our team embraced an innovative approach by introducing composting as an eco-friendly waste management solution. Composting not only facilitates the safe disposal of impacted vegetation but also produces nutrient-rich compost teeming with diverse microbes, crucial for soil remediation. This local composting initiative stands as an alternative to foreign-made remediation products.

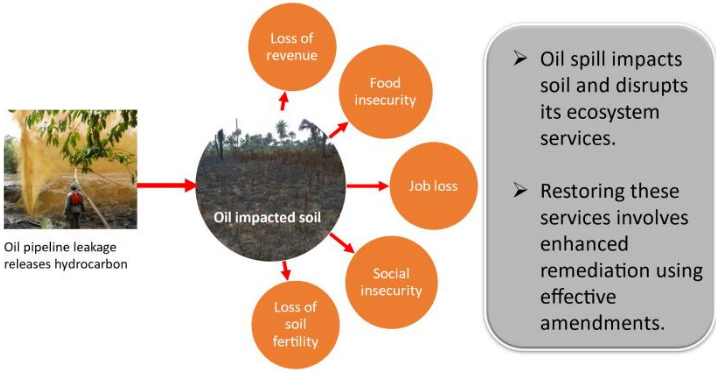

Figure 23: The burden with Oil spill

The transportation of petroleum hydrocarbons through pipelines across various habitats poses a threat to ecosystems, especially when spills occur. Importing fertilizers to address the aftermath of spills incurs substantial costs (Figure 24). Vegetation, covering vast hectares, faces withering or stunted growth due to oil impact. The repercussions extend beyond vegetation to soil, impacting subsoil and groundwater depending on various factors.

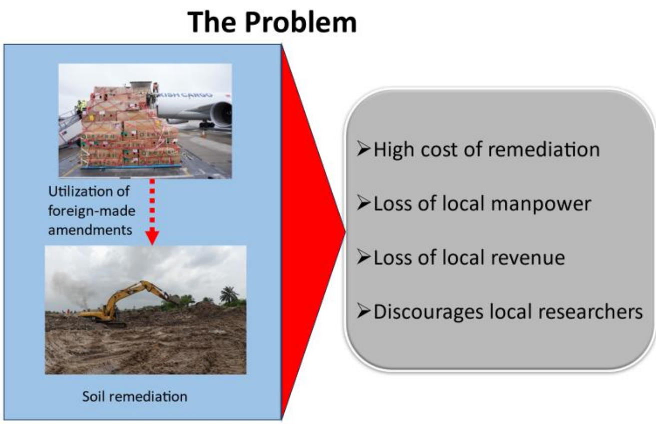

Figure 24: The problem with existing option

In response to the urgent need for greener, available, and affordable fertilizers to combat extensive petroleum spills, we initiated a triple helix model of solution. We secured funding from an oil company and two government agencies, forming a collaborative community-based approach (Figure 25). Our objective was to optimize the composting process, aiming to produce high-quality compost for the remediation of petroleum hydrocarbon-polluted soil. This study specifically explored the potential of producing a soil amendment from composting crude oil-impacted vegetation.

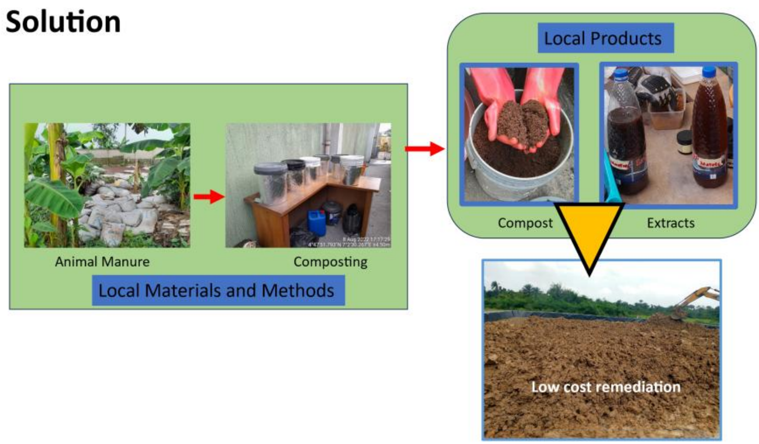

Figure 25: Pioneered solution from the Triple Helix model collaboration

The composting feedstock comprised poultry manure, sawdust, and simulated crude oil-impacted vegetation with a 2% w/w crude oil addition (HC). A control setup without crude oil (C) was established for comparison. The composting process involved turning at 2-day intervals to enhance porosity, with natural ventilation provided through perforated holes on the bins. After a 3-week monitoring period, the HC setup exhibited pH, total nitrogen, available phosphorus, hydrocarbon-utilizing bacteria (HUB), and hydrocarbon-utilizing fungi (HUF) values of 8.27, 1.14%, 0.77%, 1.80 x 10^8 CFU/g, and 17.00 x 10^5 CFU/g, respectively. The corresponding values for the C setup were 8.30, 1.31%, 0.75%, 2.23 x 10^8 CFU/g, and 7.00 x 10^5 CFU/g.

Our compost formulation, combining poultry manure, sawdust, and crude oil-impacted vegetation, proved successful and demonstrated favorable comparisons with existing market products (Figure 26). Notably, the application rate of the product has been established.

Crucially, the inclusion of crude oil did not inhibit the composting process. Concurrent utilization of petrogenic and non-petrogenic carbons was observed, and the presence of crude oil significantly increased hydrocarbon-utilizing bacteria (HUB) and hydrocarbon-utilizing fungi (HUF). Gas Chromatography with Flame Ionization Detection (GC-FID) chromatograms indicated a reduction in both petrogenic and biogenic carbon peaks as composting progressed, affirming that the presence of crude oil did not hinder the composting process.

Justification

Rating	Chemical fertilizer	Foreign-made products	Other organic fertilizers	Our Product
Effectiveness	High	High	High	High
Cost	High	High	Moderate	Low
Environmental friendliness	Low	Moderate	High	High
Production requirements	Complex	Moderate/ Complex	Moderate	Simple
Local content input in production	Low	Absence	Moderate	High

Figure 26: Comparative rating of developed product to existing counterparts

In all, our pioneering solution of recycling crude oil-impacted vegetation through composting offers a sustainable and cost-effective approach to soil remediation. This green remediation strategy not only addresses environmental challenges posed by oil spills but also contributes to the broader goal of fostering a sustainable and resilient future. This case study serves as a beacon of innovative solutions within the framework of my inaugural lecture on pioneering sustainable practices for a greener future.

Conclusion

In concluding, I am pleased to present the following key contributions to knowledge:

1. Science and Sustainability Nexus

My research highlights that the synergy between science and sustainability is crucial in tackling today's environmental crises.

Bioremediation, notably phytoremediation, showcases how scientific ingenuity can revitalize polluted environments using natural processes involving microorganisms and plants. These methods offer sustainable solutions that safeguard and regenerate ecosystems.

My contributions, such as spearheading the Environmental Management Plan of an FPSO, extensive capacity building initiatives, community interventions, advocacy efforts, and ongoing product formulation for environmental clean-up, underscore the necessity of collective stewardship and inclusive strategies for sustainability.

2. Scientific Innovations for a Sustainable Future

By characterizing and identifying ten local plants suitable for phytoremediation, I have contributed to harnessing natural processes for environmental cleanup, offering a sustainable, cost-effective, and eco-friendly solution to pollution challenges.

Innovative approaches like phytoremediation in mixed cropping designs offer climate-smart and resilient solutions to environmental challenges.

These methods underscore the potential of sustainable practices to address environmental degradation and promote a healthier planet, aligning with my commitment to SDGs.

3. Stewardship for a Sustainable Africa I have underscored the importance of collective stewardship for sustainable development in Africa. By advocating for inclusive strategies and overarching policies, I contribute significantly to addressing environmental challenges and promoting resilience across the continent.

4. Collaborative Partnerships and Policy Implications
Collaborative partnerships across academia, industry, government, and local communities are crucial for effective bioremediation and phytoremediation efforts. These partnerships translate scientific innovations into practical applications and influence policy frameworks.

Institutionalizing evidence-informed decision-making within government agencies, as seen in my case, enhances job clarity, bridges gaps between researchers and policymakers, and improves policy document quality. This approach has the potential for widespread adoption among government institutions, fostering sustainable land use practices and healthier ecosystems.

5. Case Studies: Pioneering Solutions

Using locally available materials for environmental cleanups further enhances sustainability efforts by reducing costs and reliance on external resources.

Recycling practices, including the regeneration of solvents in laboratory settings, help minimize waste generation and promote sustainability.

Shared success stories emphasize the need for continued research and implementation of bioremediation technologies to pave the way for a greener future.

6. Triple Helix Collaboration Model Through collaboration among researchers, industry, and government, as exemplified by the Triple Helix model, my research has fostered innovation and societal impact in sustainability-focused endeavors.

7. Interdisciplinary Fields and Sustainability Science I contributed to interdisciplinary fields such as sustainability science by integrating knowledge from diverse scientific disciplines from among my diverse research collaborators to address complex sustainability challenges and advanced environmental solutions for a greener future.

8. The Power of Sustainable Development Goals (SDGs) Lastly, by aligning my research efforts with SDGs 1, 2, 3, 4, 5, 6, 7, 9, 11, 13, 14, 15, and 17, I have demonstrated the transformative potential of the Sustainable Development Goals (SDGs) in guiding global sustainability efforts. By embracing this transformative agenda and working together with partners, I have made significant contributions towards achieving a more equitable, resilient, and sustainable world leveraging my cheap, accessible, long-term, scalable and environmentally friendly solution to healing the soils and wetlands.

Future Direction

Future Direction: Towards Circular Economy and Bioremediation Innovation

Moving ahead, my focus is on upscaling our bioremediation product for field application, advancing the integration of circular economy principles. To achieve this ambitious goal, I am actively engaging with the Founder of Agri-Tech Canada, a pioneer in the patented CRBBP Process. This innovative approach involves utilizing specially cultivated Bio-Crops in a multi-tasking capacity, creating a symbiotic relationship with the environment.

Agri-Tech Canada's strategy encompasses cost-effective practices, such as capturing substantial amounts of CO_2, remediating air, soil, and water. The process culminates in harvesting the Bio-Crops and converting the biomass, enriched with captured carbon, into cost-advantaged Circular-Economy Bio-Products, including Biochar.

My immediate steps involve initiating growth trials for their Bio-Crops and engaging in detailed collaborations with Agri-Tech Canada. Through this partnership, I aim to leverage their proven processes and technologies to enhance our bioremediation efforts, creating a positive environmental impact while contributing to the circular economy paradigm.

In essence, this strategic potential collaboration aligns with my enduring commitment to exploring cutting-edge solutions, integrating sustainable practices, and pioneering advancements that bridge the gap between science and sustainability. The growth trials and engagements with Agri-Tech Canada represent a pivotal step towards realizing a future where bioremediation and circular economy principles converge to address pressing environmental challenges.

Recommendations

Derived from my inaugural lecture, the following actionable recommendations are crafted to guide various stakeholders—government bodies, researchers, academic institutions (specifically my university), industry players, and other stakeholders—in their collective pursuit of sustainable development:

Government Actions:

1. **Strengthen Environmental Governance:**
    - Formulate and implement robust environmental governance frameworks at national, regional, and local levels.
    - Allocate resources for the enhancement of environmental impact assessments and regulatory enforcement.
    - Encourage transparency, accountability, and active stakeholder participation in decision-making processes.

2. **Promote Sustainable Land and Resource Management:**
    - Develop and enforce integrated land-use planning strategies emphasizing sustainable practices.
    - Institute incentives for afforestation, reforestation, and sustainable agricultural practices.
    - Establish policies supporting responsible mining/extraction (of oil) practices and incentivize the sustainable use of natural resources.
    - Invest in programs for land restoration and rehabilitation in areas affected by pollution or degradation.

3. **Climate Change Adaptation and Mitigation:**
   - Formulate region-specific climate change adaptation and mitigation strategies.
   - Allocate funds for the development of climate-resilient infrastructure and the promotion of renewable energy sources.
   - Support and implement nature-based solutions, including coastal protection measures and ecosystem restoration.

4. **Encourage Circular Economy Practices:**
   - Develop and enforce policies promoting the transition to a circular economy.
   - Institute incentives and collaborations (Triple Helix model) involving industries, government agencies, and research institutions for innovative and sustainable practices.

University's Role:

1. **Environmental Education and Research:**
   - Integrate environmental education into formal curricula at all education levels.
   - Establish environmental training programs for professionals and communities.
   - Foster interdisciplinary research collaborations (Triple Helix model) that contribute to sustainable development solutions.

2. **Research and Innovation:**
   - Invest in research infrastructure and promote interdisciplinary research within the university.
   - Facilitate knowledge sharing and technology transfer to address complex environmental challenges.

- Actively encourage collaboration with industry partners for real-world impact.

Industry Engagement:

1. **Circular Economy Implementation:**
    - Actively participate in the transition to a circular economy by minimizing waste generation, promoting recycling and reuse.
    - Collaborate with government agencies and research institutions (Triple Helix model) to implement sustainable consumption and production patterns.
2. **Investment in Sustainable Practices:**
    - Invest in sustainable practices, including responsible resource management and reducing environmental footprints.
    - Collaborate with researchers and government agencies to adopt and implement evidence-based solutions for sustainable development.

Researchers' Responsibilities:

1. **Continuous Learning and Collaboration:**
    - Engage in continuous learning and training programs to enhance Evidence-Informed Decision-Making (EIDM) skills.
    - Actively share best practices in EIDM implementation to facilitate knowledge exchange among various government bodies.

2. Prioritize problem identification and actively engage in solution-oriented research. Avoid following trends without critical examination; be purposeful and independent in your research pursuits.

3. Interdisciplinary Research:
    - Foster interdisciplinary research collaborations (Triple Helix model) to generate innovative solutions for sustainable development.
    - Work closely with industry and government partners to translate research findings into practical applications.

Other Stakeholders:

1. **Community Engagement:**
    - Empower local communities by involving them in decision-making processes.
    - Promote community-led initiatives and recognize indigenous knowledge in sustainable resource management.
    - Foster partnerships between communities, researchers, and policymakers for co-creating and implementing sustainable development solutions.

2. **Advocacy and Awareness:**
    - Advocate for policies and practices aligned with sustainable development goals.
    - Raise awareness among stakeholders about the benefits and importance of adopting sustainable practices.

In embracing these tailored actions, each stakeholder plays a vital role in realizing a future that balances environmental protection, social well-being, and economic prosperity. Collective action, collaboration, and a shared commitment are essential for achieving a sustainable and resilient future.

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CITATION

PROF. EUCHARIA OLUCHI NWAICHI

B.Sc., MSc. & PhD (UPH)

FWASLP, FISEST, FNEF, AFAAS, FCommonwealth, FUNESCO LO'real, FASI

Eucharia Oluchi Nwaichi: A Trailblazing Scientist and Academic Leader *Personal, Academic Journey and Professional Background:*

Eucharia Oluchi Nwaichi holds the distinguished position of Professor of Environmental Biochemistry and Toxicology in the Department of Biochemistry at the University of Port Harcourt. Her educational journey began at Community Primary School, Nsirimo Umuahia, her place of birth. She later attended the renowned Madonna Senior Secondary School for Science, whose motto, "Sempre eligere optimum" (Always choose the best), aligns seamlessly with her entrepreneurial spirit as a scientist.

She earned her Bachelor's degree in Biochemistry, followed by Master's and Doctoral degrees specializing in Environmental

Biochemistry and Toxicology, all from the University of Port Harcourt, Nigeria. Accumulating over 14 years of university experience, she has emerged as a prominent figure in teaching, research, and community service.

Her academic trajectory is characterized by a strong foundation in science communication, evidence-based practices, policy communication, research management, gender and science, engagement and outreach, and translation of research into policy.

Before joining the University of Port Harcourt, Prof. Nwaichi accumulated more than six years of industry experience. Her transition to academia did not mark the end of her engagement with the corporate world; she is a consultant to notable organizations and owns a modest company dedicated to capacity building in sustainable environmental practices.

International Exposure and Research Contributions:
Prof. Nwaichi's global influence is apparent through her extensive travels to 29 countries namely USA, United Kingdom, South Africa, Germany, Canada, Italy, France, Netherlands, Switzerland, South Korea, Poland, Czech Republic, Ghana, Gambia, Botswana, Senegal, Qatar, Holy See, Egypt, Sudan, Zambia, Morocco, Kenya, Ethiopia, Rwanda, UAE, Spain, China, and Brasil. Specializing in phytoremediation, her work tackles crucial challenges in environmental science, offering valuable contributions to sustainable solutions for polluted soils. Notably, she holds a patent for the Phytoremediation Process for Crude Oil Impacted Acidic Soil, underscoring her dedication to innovative environmental solutions.

Eucharia served as a PhD External Examiner internationally at Mangalore University in Karnataka state, India, and the University of Ghana in Accra.

Her research excellence is evident through the publication of 104 peer-reviewed articles in reputable journals, 12 well-indexed books or book chapters, a monograph, and 89 conference papers. Eucharia has actively engaged in 76professional workshops and training sessions.

She has adeptly secured grants from a diverse array of esteemed institutions, demonstrating a commitment to addressing societal challenges. These include Fundacion Mujeres por Africa Spain, Commonwealth Scholarship Commission, BW Offshore, UNESCO-L'ORÉAL International Fellowships, William & Flora Hewlett Foundation, The Royal Society, Africa Evidence Network South Africa, Association of Commonwealth Universities, African Academy of Sciences (AAS), African Institute for Development Policy (AFIDEP), Royal Society of Chemistry UK, American Chemical Society, Poland-Czech Republic Cross-Border Operational Programme, UNICEF, Phyto Scholar Grant Oregon USA, Society for Environmental Toxicology and Chemistry, and the Petroleum Technology Development Fund (PTDF).

Professional Affiliations and Editorial Contributions:
Prof. Nwaichi is actively involved in various professional societies, including the African Academy of Sciences, American Chemical Society, International Phytotechnology Society, Society for Environmental Toxicology and Chemistry, Nigerian Society for Biochemistry and Molecular Biology, Organization for Women in Science in the Developing World (OWSD), and more. As an editor in two and a reviewer in twelve scholarly and reputable journals, she actively

contributes to the advancement and dissemination of scientific knowledge.

Humanitarian and Social Advocacy:

Beyond her academic and research achievements, Prof. Nwaichi is deeply engaged in humanitarian efforts and social advocacy. Her involvement in the UNICEF-funded project to monitor and protect children during Nigerian elections showcases her commitment to societal well-being. Additionally, she has used her platform on the popular WAZOBIA FM radio to anchor a talk show on 'Engendering a Protective Environment for Children' (EPEC) during election periods.

Harnessing the power of the National Television Authority (NTA), Prof. Eucharia Oluchi Nwaichi strategically utilizes the platform to disseminate research findings and shape policy discussions. Through a research grant from the William & Flora Hewlett Foundation and facilitated by the African Institute for Development Policy, she not only conducted impactful research but also spearheaded the development of Guidelines for Evidence Use in the Nigeria Natural Medicine Development Agency (NNMDA). This initiative culminated in a public launch chaired by the Hon. Minister of Science & Technology, amplifying the reach and impact of evidence-informed policies in the public domain.

Administrative services

Eucharia currently serves as the Director of the Academic Planning, Research & Control Unit at the University of Port Harcourt. She is a Member of the Governing Council of Hillside University, Okemisi, an active Member of the University of Port Harcourt Senate and holds roles in various key committees, including the Senate Committee on Academic

Programmes and Policies (SCAPP), Committee of Provosts and Deans, University of Port Harcourt Research Ethics Committee, University of Port Harcourt Degree Results Verification Committee, University of Port Harcourt Project Proposal Writing Committee, University of Port Harcourt Graduate School Journals Take-off Committee, and University of Port Harcourt Graduate School Results Verification Committee. She serves as a member of the Technical Planning Committee tasked with establishing the Centre of Excellence for Environmental Remediation under the Federal Ministry of Environment's Hydrocarbon Pollution Remediation Project, HYPREP.

Beyond her university responsibilities, Eucharia contributes to international initiatives, serving on the Steering Committee for the Network of Women Scientists Innovating in Africa (N.O.W. I.S. in AFRICA) in Spain. She also sits on the Reviewers Board of the American Association of University Women (AAUW)'s International Fellowships and Grants. Furthermore, she plays a crucial role in the academic and promotion central committee and serves on the Technical Sub-Committee (TSC) advising on the development of the First Draft of Good Research Management Practice (GRMP) Standard powered by The African Academy of Science (AAS). Additionally, she is part of the Environment Research Technical Committee of Affiliates of the African Academy of Science in Kenya.

Prof. Eucharia Nwaichi recently concluded her role as the Director of Exchange and Linkage Programmes Unit at the University of Port Harcourt. Notably, she spearheaded the coordination of the University of Port Harcourt Students' Debate, clinching the All-Nigeria Universities Debate Championship Trophy in 2022. Her impactful leadership extended to the OWSD, where she served as the National Vice President and the President of the University of Port Harcourt Branch. Under her guidance, the organization achieved significant milestones, including the publication of two books with Springer Publishers, heightened capacity, and enhanced capacity and visibility among members.

In addition, Eucharia chaired the Planning Committee responsible for the successful organization of the highly rated 6th Biennial International Conference of OWSD at the University of Port Harcourt, which Proceedings have been published with Atlantis Springer Nature. Her extensive service record includes roles as a Member of the School of Graduate Studies University of Port Harcourt Academic Board, Academic Board of the Institute of Petroleum Studies (an Affiliate of IFP School France), the Committee tasked with drafting the Memorandum for the 18th meeting of the National Council on Science and Technology (NCST), the Credentials Review Committee for Awka Nigeria National Delegate Council of the Academic Staff Union of Universities (ASUU), the Special Senate Committee on Anti-Plagiarism, the School of Graduate Studies 169th PhD Seminar Assessment Committee, FLAIR Grant 2021 Assessors Panel, The Queen's Commonwealth Essay Competition Jury in the UK, and the American Association of University Women (AAUW)'s International Fellowships and Grants Panel.

Further, she contributed to the Faculty of Science Seminar Series Committee, the Committee tasked with reviewing Students' handbook and Staff Condition of Service by ASUU UNIPORT Chapter, and the Vice Chancellor's Committee on Remuneration of Staff from Non-NUC (Nigerian Universities Commission) funded programs at the University of Port Harcourt in 2013. Additionally, she served on the Faculty of

Sciences Business Committee, was a Departmental Timetable Officer, Exam Officer and Graduate Seminar Coordinator.

Additionally, she assumed the role of Chairman for the Gender Committee at ASUU UniPort, chaired the Communique Drafting Committee for the West African Research and Innovation Management Association (WARIMA) 12th International Conference and Workshop, and contributed to the Departmental Accreditation Sub-Committee focused on the collation of examination materials.

Eucharia has been actively involved in various roles and responsibilities, including serving as the Convener for the Student's Quiz Competition both at the 2024 National Conference of Nigerian Society for Biochemistry & Molecular Biology, NSBMB, where UniPort won, and for the 3rd South-South Zonal Annual Conference of the NSBMB.

Her contributions extend to diverse areas, such as being the Representative for the National Delegate Council of ASUU, Secretary for the Local Organizing Committee of the 28th Annual Conference and General Meeting of the Polymer Institute of Nigeria, Trainer for the Protect Our Future Peace Camp organized by the Centre for Social Transformation and Human Development in collaboration with Konrad Adenauer Stiftung Germany, and Resource Person for the Federal University of Petroleum Research Effurun's Management Retreat.

Furthermore, Eucharia has played pivotal roles as the Organizer/Resource Person for the Global Chemists' Code of Ethics (GCCE), Technical Coordinator for the University of Port Harcourt-wide committee on Bioremediation projects, Staff Adviser for the National Association of Biochemistry

Students, Research Liaison Officer for the Office of the Deputy Vice-Chancellor (R & D) in 2015, Exam Timetable Officer in the Department of Biochemistry, Secretary of the Strategic Plan Document Review Committee for ASUU UniPort, Coordinator of the Postgraduate Studies Seminar in Biochemistry, Secretary for the Departmental Welfare Committee, Book Reviewer for 'Rising to the Pinnacle' by J. A. Ogbolosingha, and Guest Facilitator co-facilitating Scientific Writing Courses for AuthorAID INASP UK.

Inspiring the Next Generation and Mentorship:

She serves as an inspiration to the next generation through her exemplary lifestyle, actively organizing and facilitating enriching events focused on empowering the girl-child, STEMM girls, and youths, all at no cost to the beneficiaries. Prof. Nwaichi's commitment to mentorship shines through her role as a Mentor for the Ignite 2020 Mentorship Scheme, a dynamic initiative powered by Guzakuza for Women Agripreneurs. Her influence isn't confined to this specific program; she also plays a pivotal role as a mentor within the academic sphere, guiding numerous researchers and offering reverse-mentoring to others.

Literary Contributions and Fundraising:

Her inspiring story, crafted into booklets, is being utilized by VOKAL, a South African organization, to fundraise for African women. This initiative not only underscores the power of her narrative but also contributes to meaningful causes for women empowerment.

Global and local Recognition and Awards:

Prof. Eucharia Nwaichi exudes an inspiring mindset of boundless optimism and unwavering ambition, underscoring her remarkably diverse expertise. Her noteworthy contributions have garnered international acclaim, marking her as a Fellow of the Science by Women Foundation, Fundacion Mujeres por Africa, Spain (April 2023).

In 2001, she received the Late Omogbai Memorial Subject Prize for Best Graduating Student in Biochemistry for the 1999/2000 session. Additionally, she was honored with the Dean of Faculty of Science Award for Best Graduating Student in Biochemistry for the same session.

Prof. Eucharia Nwaichi earned the State Governor's Award for Outstanding Corps Member (NYSC) in Akwa Ibom State, Nigeria, in December 2002, in recognition of her exceptional contributions to the state's development.

Eucharia became a Fellow of the African Scientific Institute in 2013 and received an international recognition as a Fellow of UNESCO-L'ORÉAL Paris France in 2013.

Further recognition comes from the National Association of Science Students and National Association of Biochemistry Students, UniPort Chapter, which bestowed upon her the Most Student-Friendly Lecturer award (2013) and Teacher/Student Performance award (2014) for her landmark contributions to the associations' growth.

She was also honored with the Teacher/Student Performance award by the Students Union Government (SUG) University of Port Harcourt Chapter in August 2014, recognizing her significant contributions to students' growth and well-being.

Her accolades include the 2015 University of Port Harcourt Distinguished Merit Award, received in June 2015, in acknowledgment of her diligent and meritorious service to the university.

Eucharia became an International Fellow of the Commonwealth, United Kingdom in 2015.

Eucharia became an Affiliate Member of the African Academy of Science in 2016 and earned a place in the esteemed Hall of Fame by the Faculty of Science at the University of Port Harcourt, a distinction awarded on 29th July 2016.

Her commitment to fostering educational opportunities is evident in securing 10 undergraduate scholarships into British University in Egypt in 2018, with one University of Port Harcourt student successfully graduating with a B.Pharm in November 2023.

Further adding to her accolades, in 2020, her position as an Evidence Leader garnered recognition from both the African Academy of Sciences (AAS) and the African Institute for Development Policy (AFIDEP) in Kenya. During the same year, she was also honored as a Fellow of the Next Einstein Forum in Kigali, Rwanda.

In 2022, she was honored as the Winner of the Professor Kayode Adebowale National Young Scientists' Prize for Women in Chemical Sciences, organized by the Nigerian Young Academy. Further adding to her accolades, she clinched the Africa Evidence Leadership Award (South Africa) in the same year, emphasizing her significant impact in evidence-based practices.

In 2022, she made history as the first and only African recipient of the prestigious John Maddox Prize (United

Kingdom), recognized for her innovative approaches and courageous engagement with conflict-ridden communities to research solutions to pollution in the oil fields of the Niger Delta.

Eucharia has garnered widespread recognition as a Research Icon by the University of Port Harcourt for her impactful research efforts that have elevated the university's profile both locally and internationally, as of January 2023.

Eucharia's dedication to advancing science and education is truly exemplary, and her contributions continue to shape the landscape of environmental research and academia.

The Vice Chancellor, ladies & Gentlemen, introducing Prof. Eucharia Oluchi Nwaichi, a luminary in the scientific community, renowned for her multifaceted contributions to academia, research, innovation, mentorship, and social advocacy. An inspiring figure for aspiring scientists, particularly women, she stands as a dedicated crusader addressing environmental challenges, working towards the creation of a sustainable future!