RIVERS STATE UNIVERSITY, PORT HARCOURT

ENVIRONMENTAL POLLUTION: SAW QUALITY MONITORING AS PLATFORM FOR POLLUTION CONTROL AND MANAGEMENT

AN INAUGURAL LECTURE

By

PROFESSOR TUBONIMI JOSEPH KIO IDERIAH

BSc. (UPH), MPhil. & PhD. (RSUST), (MNES, MCSN, MSPAC, MSTAN)

Professor of Environmental & Analytical Chemistry

SERIES NO. 76

Wednesday, 27th April, 2022

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The Dean, School of Postgraduate Studies

Deans of Faculties/Student Affairs

Directors of Centres/Institutes

Heads of Departments

Distinguished Professors and other members of Senate

All Academic, Administrative and Technical Staff

The Chairman & Members of Council

Respected Chiefs & Ministers of God

Students of this Great University

Respected Guests, Friends, Admirers, Associates and Well Wishers

Gentlemen of the Press

Distinguished Ladies and Gentlemen

1.0 PREAMBLE

This is my story; this is my song, praising my Saviour all thy day long!

Vice Chancellor Sir, I am greatly pleased with joy and ecstasy to be given the privilege to present the 76th Inaugural lecture of this great University today.

Vice Chancellor sir, it is disheartening that I was appraised for the rank of Research Reader in 2009 but my promotion was only announced in a mass release in 2015 although appropriately back dated to October 2010. Therefore, rather than assessment for full Professor in 2013, it was done in 2015. I thank the former Vice Chancellor, Prof. Blessing Chimezie Didia for the transparency, justice and impartial processes of assessment and timely announcement of promotions. He indeed manifested his name as a 'God sent VC.

From 2009 to 2015 there were at least nine (21) A&PC meetings, minimum of three (3) per year but at each meeting my case was stepped down for reasons not known or mentioned. Someone saw me in UBA on campus after an A&PC meeting and after greetings he called me back and asked ***"Do you have problem or quarrel with anybody in your office***", I said No and he said ***"I am surprised"***!, and then walked away.

Unfortunately no other member, not even the Chairman of A&PC then asked why; as you caringly, usually do.

This caused prolonged period of delay and anxious waiting. However, I continued to take solace in the word of God in *Hab. 2:3-*

For the vision is yet for an appointed time, but at the end it shall speak, and not lie: though it tarry, wait for it; because it will surely come, it will not tarry.

And the prophetic word ***"At the end it shall speak"***

1Thess. 5:18-

In every thing give thanks: for this is the will of God in Christ Jesus concerning you.

I give God all the glory. I remember my friend and colleague Professor Akuro E. Gobo used to say ***"And it came to pass"*** but I say now and always ***"AT THE END IT SHALL SPEAK"*** and according to Bishop David Oyedepo ***"THERE ARE NO CHAMPIONS WITHOUT CHALLENGES".***

We thank God, today the system has changed for the best. I specially thank you Vice Chancellor Sir for not allowing the spirit to quench ***(1 Thes. 5:19:- Quench not the Spirit.)*** but putting smiles on the faces of staff. God bless you Sir.

Sir, my inaugural lecture was initially scheduled for April 2020 but was suspended as a result of the "lockdown" which started on March 20, 2020 due to the Covid-19 pandemic. Also on resumption of inaugural lectures new time table was made. These led to my inaugural lecture taking place today. I give God all the glory.

I am indeed excited today because this is the first inaugural lecture by a resident staff of the Institute of Pollution Studies, the first centre for excellence in Environmental Studies for the peculiar problems of the Niger Delta. Also I am the ***first Professor of Environmental and Analytical Chemistry*** in this Great University, in Rivers State and indeed, the Niger Delta region. Vice Chancellor Sir, to the best of my knowledge, in Nigeria.

"AT THE END IT SHALL SPEAK".

2.0 INTRODUCTION

Inaugural lecture provides opportunity for academics to share their achievements in research, innovation, engagement and teaching activities before an audience or members of the University community and the general public. Colleagues and others thereby can hear about researches that are done or ongoing in the University.

Vice Chancellor Sir, let me unveil the title of my Inaugural lecture. This lecture is centered on Environmental Quality Monitoring as the Platform for Pollution Control and Management. The word 'SAW' in the title refers to Soil, Air and Water. This word could also be 'WAS' which refers to Water, Air and Soil. In either SAW or WAS the alphabet/letter, A (representing Air) appears to be central. Thus the lecture is focused more on Air quality monitoring and less of soil and water quality monitoring (to save your time). Furthermore, SAW is the past tense of SEE implying that we SAW the recent environmental problems such as soot.

According to Catlow and Thirlwall (1976), "Take away the cause and the effect will fizzle away". In the same vein I say "Take away the source and the impact will fade away". Environmental pollution issues may be likened to the Plantain tree which when cut, the the stem and saplings continue to grow to maturity but will die off if uprooted.

Effects and impacts may be synonymous but there are interpretations relating to timing and value judgments.

EFFECTS are the physical and natural changes resulting directly or indirectly from an action or development.

IMPACTS are the consequences or end products of those effects represented by attributes of the environment on which we can place an objective or subjective value.

However Magnitude (Size) of impact does not always equate with significance (importance for decision-making) of the impact.

2.1 Environmental - Analytical Chemistry

This field of study has two main disciplines:

(1) Environmental Chemistry deals with investigation of the effects of chemical compounds in nature (air, water, soil, food chains and organisms).

(2) Analytical Chemistry deals with the development of analytical methods to be used to quantify and solve problems in environmental chemistry, such as environmental monitoring, studies of the quality of water, air, soil, pollutants contents of effluents, etc.

The work or intention of the Environmental-Analytical chemist (as I am) is to combine these two disciplines for research projects.

2.2 The Role of Chemistry in Pollution Studies

Whether a contaminant is harmful or not depends solely on its chemical make-up e.g. liquid mercury (Hg) may be swallowed without harmful effects but as little as 0.001mg of mercury (II) sulphate, chloride or nitrate will cause a disease called minamata (which may cause mental derangement, disorders of the central nervous system, crippling or death).

A contaminant may have been produced by some chemical process or a reaction and if it is to be disposed of it will certainly require another chemical process or reaction. ***Thus the generation of pollutants, the damage they cause and their removal all involve chemical processes.***

Chemistry involves the study of matter, its compositions, behaviour, properties, transformations from one form to another and the disposal of these transformations. Thus, the principles of chemistry are needed for clear understanding of the nature of every form of matter, whether natural or man-made, of environmental significance or not e.g. metals, petroleum products, drugs, foods, water, the earth crust, plastics, radio-active materials and the human brain cell all have properties determined by chemical principles. The science of chemistry is central to environmental problems, and their controls.

Every environmental problem which we face daily has chemical basis. Problems such as air pollution, water pollution, groundwater contamination, toxic wastes, acid rain, ozone depletion, greenhouse effect, etc require understanding of basic chemical concepts.

2.3 Man, Technology and the Environment

Technology Developments in Man's History

The word "technology" is a broad term and does not simply refer to high-tech inventions or computerization. ***Technology comprises the crafting of materials and transforming them into implements that allow man to control or manipulate natural resources in order to meet his needs.*** The cavemen learned how to make fire that provided them heat, light and protection against the wild animals that attacked them. ***The cavemen's first technological tools were stone, axes and spears which were used as protection and hunting implements.*** The impact of technology on the environment back then was not too significant because it was mainly utilized to improve the supply of man's basic needs.

As years passed, technological advancement was no longer confined to the mere purpose of meeting man's needs for food, clothing, and shelter. ***It started from Stone Age and was elevated to the Bronze Age and finally reached the Iron Age, which brought technological advancements in weaponry.*** Since the industrial revolution in the 1800s, the impact of human activities has drastically increased due to increased population, industrial manufacturing and agricultural practices.

As trade and commerce grew, the more it heightened the impact of technology on natural environment wherein air, land and water reached certain degrees of contamination, pollution and degradation.

Thus, the negative impact of technology on the environment began to surface as more of the Earth's natural resources and ecological habitats were being depleted or disrupted.

Greenhouse Gas Emissions

Greenhouse gas emissions have brought us global warming, melting glaciers, rising sea levels, air pollution, ocean acidification, disrupted marine and wildlife, biodiversity loss, groundwater contamination, soil depletion and a host of other adverse effects that stem from other technological innovations that were conceptualized without considering the consequences. Nations continue to increase the use of technology in warfare and they produce weapons that make use of metals, chemicals and microorganisms that have far greater negative effects.

Green Technology and the Aim to Reverse the Negative Impacts

New technology brought about what will be known in man's history as the Computer Age. Green technology has come up with better solutions of generating heat and energy. The sun's powerful UV rays are being harnessed through solar panels instead of the wood burning process. The kinetic powers of wind and water currents are being utilized to produce electricity that can lessen the demands for coal and fossil fuels.

Technology as a Cause of Environmental Problems

The production of non-returnable soft-drink bottles had increased by 53,000 per cent, synthetic fibres by 5980 per cent, and mercury used for chloride production by 3930 per cent. During that same period, the production of food, textiles, clothes and metals had only increased at similar rates to population growth (42 percent); and cotton fibre, wool and soap manufacture had decreased.

Plate 1: Technology of Bottling/Canning of Fruit Drinks

Plate 2: Plastic wastes blocking the drain

Plate 3: Plastics and Debris Pollution of the Seashore

The new production technologies had a far greater environmental impact than the ones they replaced.

1. The traditional fertilizing system of farms
2, Replacement of soaps by detergents. The burning of fuel and high-temperature reactions needed during manufacture of detergents added to air pollution.
3. Textile production
4. The new technologies also used more electric power and other forms of energy than those they replaced.

2.4 Definition of Some Key Words, Terms/ Phrase(s)

Monitoring: This is the systematic process of collecting, analyzing and using information to track a programme's progress toward reaching its objectives and to guide management decisions.

Environmental monitoring: This refers to the tools and techniques designed to observe an environment, characterize its quality, and establish environmental parameters, for the purpose of accurately quantifying the impact of an activity on the environment.

Environment: The sum total of all surroundings of a living organism including natural forces and other living things which provide conditions for development and growth as well as of danger and damage.

Pollution: The gross contamination of an environment causing harmful or potentially harmful effects to human life or other life forms in the total ecological community.

Contamination: The introduction of a substance into an environment that may cause impairment to it.

Air Pollution: The presence of substances in the air that are present either in an environment where they don't belong or present at levels greater than they should be and with harmful potential.

Particulate Matter: is the sum of all solid and liquid particles suspended in air, many of which are hazardous. Particles in air such as dust, dirt, soot, smoke cause health problems, pollen, liquid droplets.

PM2.5: Very small particles less than 2.5μm in width (fine particulate matter). They are less than 1/30th the width of a

human hair. They are small enough to be inhaled deep into the lungs and affect the heart, blood vessels and lungs.

Soot: This is the common term for a type of particle pollution called PM2.5 i.e. particulate matter that is 2.5μm in diameter or smaller. Soot comprises a variety of pollutants including chemical, acid, metals, solutions and dust. It can come in solid, liquid or gaseous (aerosols) states.

$PM_{2.5}$ = Soot particle, PM_{10} = Dust particle,
PM_{50} – 70 = Human air, PM_{90} = Fine beach sand.

Environmental Impact Assessment (EIA): An assessment of the impact of a planned activity on the environment.

Mitigation: The introduction of measures to avoid, reduce, remedy or compensate for any significant adverse impacts.

2.5 Importance of the Atmosphere

1. The atmosphere is a protective blanket which nurtures life on the earth and protects it from the hostile environment of outer space.
2. It is the source of CO_2 for plant photosynthesis and O_2 for respiration.
3. It provides nitrogen needed to produce chemically-bound nitrogen essential for life.
4. It transports water from the oceans to land thereby acting as condenser.
5. The atmosphere is also used as a dumping ground for many pollutant materials ranging from sulphur dioxide to refrigerant Freon. This causes damage to vegetation and materials, shortens human life and alters the characteristics of the atmosphere.

6. The atmosphere absorbs most cosmic rays from outer space and protects organisms from their effects.

7. It absorbs most of the electromagnetic radiation from the sun, allowing transmission of significant amounts of radiation only in the region of 300 - 2,500 nm (near-ultraviolet, visible and near infrared radiation) and 0.01- 40 m (radio waves). By absorbing electromagnetic radiation below 300 nm the atmosphere filters out damaging ultraviolet radiation that would be very harmful to living organisms.

In order to understand Atmospheric Chemistry and air pollution it is important to appreciate the atmosphere, its composition and physical characteristic.

Stratification of the Atmosphere

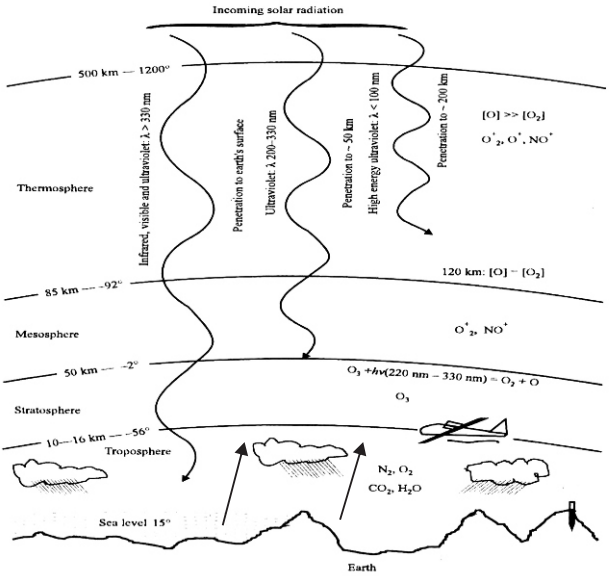


Fig. 1: Major regions of the atmosphere (not to scale) Source: Bhatia (2003)

Troposphere: From sea level to an altitude of 10 -16km. A homogeneous composition of major gases other than water and decreasing temperature with increasing altitude from the heat radiating surface of the earth.

Stratosphere: Here the temperature rises to a maximum of about -2°C with increasing altitude due to the presence of ozone which may reach a level of about 10ppm by volume in the mid range of the stratosphere.

Mesosphere: The absence of high levels of radiation absorbing species in this layer results in a further temperature decrease to about – 92°C at an altitude around 85km . The upper regions of the mesosphere and higher is call **exosphere** from which molecules and ions can completely escape the atmosphere.

Thermosphere: The far outer reaches of the atmosphere in which gases reach temperatures as high as 1200°C by the absorption of very energetic radiation of wavelengths less than 200nm by gas species in this region.

2.6 The Best way to measure Air Pollution

How much particulates or nitrogen dioxide are there in the air at a certain location? This is something that is recorded by different persons at measurement stations located in urban and rural environments. However, the measurement stations should be located at the right place and the instruments used should be approved. Researchers should make sure that the measurements meet the requirements. There are rules for how the measurement should be done and my role has been to ensure that the requirements are met.

For instance;

1. The distance to a major intersection should be at least 25 meters, so that the measurement station represents

the entire street and not just the intersection where the cars often start and stop.

2. The height of the intake should not be placed more than 4 meters from the ground.

3. The measurement station should be placed at least half a meter away from a facade so that it is not too protected.

2.7 Passive and Active Sampling Methodologies for measurement of Air Quality

In 1974, World Health Organisation (WHO) and United Nations Environment Programme (UNEP) jointly established a programme, known as GEMS/AIR, to monitor and assess urban air quality on a global scale. GEMS/AIR is a component of the United Nations Global Environment Monitoring System.

The initial objectives of GEMS/AIR were to:

1, Assist participating countries in their efforts to develop air monitoring systems.

2. Increase the comparability, compatibility and validity of urban air quality data on a global scale.

3. foster the international exchange of information on the levels and trends of air pollution.

4. Provide comprehensive assessments relevant to urban air quality and associated issues.

Although specialized instrument servicing skills may be difficult to obtain, good laboratory skills are often available.

(a) In these circumstances, state-of-the-art automatic equipment may not be the best means of obtaining reliable monitoring data, as under some local conditions it may not be possible to meet the demands of these techniques in the long term.

(b) Although GEMS/AIR has developed special programmes which include technical support to involve and assist some developing countries, it is recognised that the choice of air quality monitoring methodologies needs to pay particular attention to local circumstances.

c) In recent years, relatively simple and inexpensive methods have been developed as potentially credible alternatives to the more demanding automatic monitoring systems.

Four major methods for monitoring have evolved (UNEP/ WHO, 1994). These are, in increasing order of expense and complexity:

i. **Passive sampling:** A sampling integrated over exposure time is collected by diffusion to the sampler.

ii. **Active sampling:** A sampling integrated over exposure time is collected by pumping the pollutant into the sampler.

iii. **Automated monitoring:** The sample is analysed on-line and in real-time.

iv. **Remote sensing:** A sample integrated along a path between a light source and a detector is analysed in real-time.

Automated methods tend to be much more complex, expensive and technically demanding than the passive and active sampling technologies, which are often prohibitive. In circumstances where the state-of-the-art automatic equipment cannot always be supported with resources, the use of other technologies such as passive and active samplers may provide a means of obtaining reliable data which can be more easily maintained. Equally, such technologies offer a useful means of performing wide-scale surveys, for examples screening and

baseline studies, or for initial surveys to assist in site selection or determine site representivity.

(A) A passive sampler for gaseous species is a device which is capable of taking samples of gas or vapour pollutants from the atmosphere at a rate controlled by a physical process such as diffusion through a static layer or permeation through a membrane, but which does not involve the active movement of air through the sampler (Brown *et al.,* 1981).

Passive samplers involve the collection of air pollutants using an absorbing material without the use of pumps, and so they require no power supply. This makes such samplers very easy to deploy. Moreover, passive samplers are inexpensive and, since all analysis can be performed centrally, highly skilled personnel are not required on-site. ***They can also have advantages in uniformity, quality assurance and quality control.***

The development and use of passive samplers originated in the field of occupational exposure monitoring. In recent years, however, diffusion sampling techniques have been further developed and proven for ambient air quality monitoring (UNEP/WHO, 1994).

(B) Active samplers use pumps to draw air through the absorbing material. Active samplers have been widely used for decades, and are probably the most widely used as pollution monitoring techniques world-wide (UNEP/WHO, 1994). They also represent the most common method of monitoring in GEMS/AIR (UNEP/WHO, 1988). The items of equipment needed for active sampling and analysis of several air pollutants are readily available, and are manufactured and serviced in many developing countries.

Active sampler systems for air quality monitoring require electrical power to draw air through a chemical or physical collection medium. Collection can be made via absorption, adsorption, impaction, filtration, diffusion, reaction or combinations of these processes. The samples collected are subsequently analysed to determine the concentration of the pollutant(s) of interest. The volume of sampled air can be varied and sufficient volumes of air are sampled to allow daily or hourly average concentrations to be measured.

Active samplers are relatively simple, inexpensive manual methods which have been used widely for determining SO_2, NO_x, O_3, etc. These methods involve both absorption and chemical reaction in an absorbing solution, or collection on chemically impregnated filters. Other active sampler methods are either much more expensive or more technically demanding and hence not widely used for routine monitoring.

2.8 My Contribution to Measurements

Vice Chancellor Sir, in view of the fact that the use of passive samplers originated in the field of occupational exposure, I conducted a comparative study between passive and active sampling methods. The results shown in Table 1 speak volume and their differences in Table 2.

Table 1: Concentrations of some Air Pollutants measured with Passive (Digital handheld) samplers and Active samplers

Type of sampler	Sample No.	SPM (µg/m^3)	NO_2 (ppm)	CO (ppm)
Digital samplers	1	152.8	0.050	0
	2	101.3	0.010	0
Active samplers	1	789.5	0.015	2.0
	2	476.2	0.014	1.0

Table 2.- Advantages and Disadvantages of Active and Passive (Digital) Air Monitors

Digital Samplers	Active Samplers
High cost	Low cost
Portable	Non portable
No skill needed	Need skill
High calibration issues	No calibration issues

NOTE: Till date the active method using glass fibre filters remains the only means to determine heavy metals in the air.

2.9 Basic Concepts of Suspended Particulate Matter (SPM)

Airborne particulate matter is an ensemble of solid and liquid particles suspended and dispersed in air. The properties of these particles vary in terms of chemical composition, morphology (size/shape), optical parameters (colour/light scattering), and electrical characteristics (charge, resistance). Particles, which in general are non-spherical, are classified in terms of their aerodynamic diameter which is the diameter of a sphere of unit density (i.e. 1 g/cm^3, equivalent to that of water) with the same terminal velocity due to gravitational force in calm air as the particle in question, under the prevailing conditions of temperature, pressure and relative humidity.

For particles of aerodynamic diameter less than 0.5 μm, the particle diffusion diameter is used instead of the particle aerodynamic diameter, i.e. the diameter of a sphere with the same diffusion coefficient as the particle under the prevailing conditions of temperature, pressure and relative humidity.

In ambient air, SPM has a bimodal mass distribution with respect to size whose shape depends on the predominant physical and chemical formation processes of the particles. The size range extends from some tens of nanometers (nm) to some hundreds of micrometers (μm).

As a rule, most of the fine mode originates from anthropogenic activities and comprises, for example, primary carbonaceous aerosol (soot) resulting from incomplete combustion, and secondary aerosol (e.g. sulphate/nitrate/ammonium), resulting from chemical transformations followed by condensation processes.

There is a wide variation from one person to another in probability of particle inhalation, deposition, reaction to deposition and clearance.

The International Organization for Standardization (ISO) defined the following fractions of suspended particulate matter (ISO, 1991):

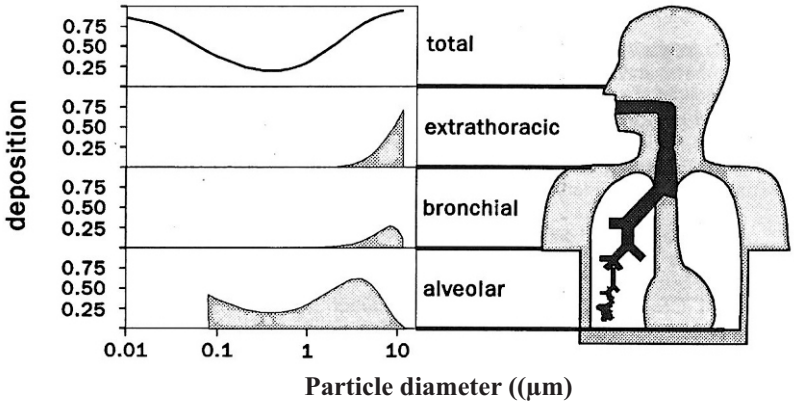


Fig. 2: Typical values for regional deposition of artificially prepared aerosol particles (spheres of unit density) in the human respiratory tract during mouth breathing at rest, as a fraction of the inhaled particles.

Source: UNEP/WHO (1994).

1. Total airborne particles.
2. Inhalable fraction.
3. Extrathoracic fraction.

4. Thoracic fraction.
5. Tracheobronchial fraction (The mass fraction of inhaled particles which penetrates beyond the larynx but which fails to penetrate the unciliated airways is termed the tracheobronchial fraction).
6. Respirable fraction (the mass fraction of inhaled particles which penetrates to the unciliated airways (formerly also called the alveolar fraction).

3.0 EFFECTS (IMPACTS) OF AIR POLLUTANTS

3.1 Impacts on Humans

According to World Health Organization, health is a complete state of physical, mental and social wellbeing and not merely the absence of disease or infirmity. Thus worker's health is the complete state of physical mental and social wellbeing of a worker and not merely the absence of disease or infirmity in the worker (WHO, 1999).

The effects may be short-term or long-term

(i) Short-Term Effects

These may show up shortly after a single exposure or repeated exposures to a pollutant include:

Irritation of eyes, nose, and throat (ENT), Headaches, Dizziness, Fatigue, Asthma, Age, Pre-existing medical conditions. In some cases, whether a person reacts to a pollutant depends on individual sensitivity, which varies tremendously from person to person.

(ii) Long-Term Effects

Some health effects may show up either years after exposure has occurred or only after long or repeated periods of exposure. These effects that can be severely fatal include: Respiratory diseases , Heart disease, Cancer. It is prudent to try to improve the indoor air quality in your home even if symptoms are not noticeable.

Indoor air pollution causes non-communicable diseases including stroke, ischaemic heart disease, chronic obstructive pulmonary disease (COPD) and lung cancer; Close to half of deaths due to pneumonia among children under 5 years of age are caused by particulate matter (soot) inhaled from indoor air pollution. The health effects attributed to indoor air pollution include:

i Acute lower respiratory infections in children, particularly pneumonia.

ii. Chronic obstructive pulmonary disease (COPD)

iii. Lung cancer

iv. Low Birth weight

v. Asthma

vi. Naso-pharyngeal and laryngeal cancer

vii. Cataract in adults

viii. Tuberculosis (TB)

3.1.1 Problems of Particle Pollution Exposure

People with heart or lung diseases, children, and older adults are the most likely to be affected by particle pollution exposure.

Most effects of SPM on human health result from inhalation, although other routes of uptake such as the alimentary tract (children ingesting dust, food contamination, etc.) may be of interest in certain cases, for example lead and some highly toxic organic compounds (xenobiotics). The exposure problems may be listed as follows:

i Premature death in people with heart or lung disease

ii. Nonfatal heart attacks

iii. Irregular heartbeat

iv. Aggravated asthma

v. Decreased lung function

vi. Increased respiratory symptoms, such as irritation of the airways, coughing or difficulty breathing.

Exposure to respirable particles may result in any of the following:

1. pulmonary function changes,
2. changes in the defence capacity of the lung,
3. occurrence of respiratory disorders;
4. aggravation of existing respiratory and cardiovascular disease;
5. increased susceptibility to respiratory infection;
6. morphological changes of the respiratory tract;
7. carcinogenesis;
8. mortality (Prins *et al*., 1984; WHO/ECOTOX, 1992).

According to Prins *et al*. (1984) Respirable particulate matter may cause effects by three different mechanisms:

1. a direct mechanical (irritation) effect on the respiratory tract;
2. a direct (systemic) toxic effect;
3. an indirect effect as carrier of toxic compounds.

Two types of effects are generally considered:

(a) **Acute effects**, resulting from short-term exposures to temporary high concentrations of pollutants,

(b) **Chronic effects,** resulting from long-term exposure to lower-levels of pollutants (and/or repeated exposure to peak levels).

Both acute and chronic effects can be reflected in excess mortality rates, increased respiratory disease and reduced lung function.

The type of health effect observed depends largely on the location of deposition of the particles, which is itself dependent on both breathing pattern and particle size. The chemical composition of the particle is also of importance. Thus, both the physical and chemical characteristics of the particles are important for evaluating potential health impacts.

3.1.2 Impact of Indoor Air Pollution on Worker Productivity

Worker productivity is the real output per hour of work (Steindel & Stiroh, 2001). When the health of a worker is affected, invariably his productivity will drop. Poor indoor air quality in buildings can decrease productivity by about 6-9% in addition to causing visitors to express dissatisfaction (Wyon, 2004).

Odour has been found to influence cognitive processes that affect creative task performance, as well as personal memories and moods. Eventually the air we breathed affects our thinking and concentration (Clements-Croome, 2008).

3.1.3 Factors that Affect Comfort and Productivity

Odours, Temperature - too hot or cold, Air velocity and movement - too drafty or stuffy, Heat or glare from sunlight, Glare from ceiling lights especially on monitor screens, Furniture crowding, Stress in the workplace or

home, Feelings about physical aspects of the workplace: location, work environment, availability of natural light and the aesthetics of office design, such as colour and style.

Work space ergonomics, including height/ location of computer/keyboards adjustability and desk chairs, Noise and vibration levels, Selection, location / use of office equipment.

3.2 Impacts on the Environment

The environmental impacts of SPM in relation to particle morphology have not been as extensively investigated as for health. The following effects can be recognized:

(1) soiling of buildings and material degradation (cultural monuments, etc.);

(2) terrestrial effects resulting from deposition (acidification);

(3) clogging of leaf stomata;

(4) reduction of visibility. In most cases, particles responsible for these effects belong to all size classes.

3.3 Impacts of individual Pollutants

Suspended Particulate Matter

Most effects of TSP (or SPM) on human health result from inhalation, although other routes of uptake such as the alimentary tract (children ingesting dust, food contamination, etc) may be of interest in certain cases, for example lead and some highly toxic organic compounds.

Suspended Particulate Matter may be chemically inert but can absorb chemically active materials. The effects of SPM depend on its chemical composition and physical characteristics.

(Concawe, 1999). (1) It can soil painted surfaces, (2) corrode metals, (3) reduce visibility, (4) aggravate respiratory (bronchi) and cardiovascular diseases and (5) cause premature mortality. (6) Settling aerosols containing hydrocarbon vapours can also stain materials. (7) Suspended particulate matter also contributes to green house effect in the atmosphere by absorbing infra red radiation from the earth. Continuous emission of SPM reduces the general aesthetics of the environment.

Respirable particulate matter may cause effects by three different mechanisms (UNEP/WHO, 1994): (1) a direct mechanical (irritation) effect on the respiratory tract; (2) a direct (systemic) toxic effect; and (3) an indirect effect as carrier of toxic compounds.

Exposure to respirable particles may result in any of the following: (1) pulmonary function changes, (2) changes in the defense capacity of the lung, and occurrence of respiratory disorders; (3) aggravation of existing respiratory and cardiovascular disease; (4) increased susceptibility to respiratory infection; (5) morphological changes of the respiratory tract; (6) carcinogenesis; and (7) mortality (UNEP/WHO, 1994).

Asthmatics and patients with chronic obstructive pulmonary disease (COPD) are said by WHO to be "clearly more susceptive" for reductions in lung function, increased airway responsiveness, and symptoms than are healthy persons.

Nitrogen dioxide

The oxides of nitrogen (NOx) are mainly nitrogen monoxide (NO), dinitrogen oxide (N_2O) and nitrogen dioxide (NO_2). All these are formed in all types of combustion taking place at high temperature.

$$N_2 + 2O_2 \longrightarrow 2NO_2$$

Nitrogen dioxide is one of the most active photochemical species found in a polluted atmosphere and is an essential participant in the smog – formation process. In NO_2 polluted air, O_3 which is an eye irritant could be produced as a secondary pollutant.

Nitrogen dioxide can combine with sulphur dioxide and water vapour to form acid rain. In combination with hydrocarbon in the atmosphere oxide of nitrogen may form photochemical oxidants, which irritate the eyes and respiratory tracts and impair human health.

Volatile Organic Compounds

High levels of VOC could stain materials. In particular, ethylene can inhibit plant growth while polynuclear aromatic hydrocarbons are carcinogenic.

Volatile organic compounds and nitrogen oxides, once emitted, undergo chemical transformation in the atmosphere in the presence of sunlight to form ozone. Sulphur dioxide and nitrogen oxides undergo chemical transformation in the atmosphere and occur as sulphur, nitrate, and hydrogen ions when dissolved in precipitation.

Carbon monoxide

Carbon monoxide has high affinity of CO for haemoglobin and other important haem containing proteins (eg. cytochromes). Carbon monoxide is a poisonous gas having a lifetime of two to four months in the atmosphere. The toxic effects of CO on human beings and animals arise from its irreversible combination with haemoglobin (Hb) in the blood, affecting its oxygen-carrying capacity and result to death.

$$Hb + O_2 \longrightarrow HbO_2$$

$$HbO_2 + CO \longrightarrow HbCO + O_2$$

Carboxyhaemoglobin (COHb) complex reduces the oxygen carrying capacity of the blood cells so that less oxygen is available to the body cells and organs, especially the brain, leading to various physical disabilities. Also HbCO reduces the dissociation of Oxyhaemoglobin (HbO_2) into haemoglobin and oxygen. Carbon monoxide ties up about 220 times more Hb than does O_2. As much as 2000mg/m^3 CO could kill instantly and 250mg/m^3 CO will cause loss of consciousness. The upper limit of CO for industrial exposure to healthy workers is 100mg/m^3. At this level, many people experience dizziness, headache and lassitude. An amount, as low as 10mg/m^3 has effect on the central nervous system. (Concawe, 1999).

Hydrogen sulphide

Hydrogen sulphide emissions result in damage to human health. It also causes irritation of the respiratory tract and damage to the central nervous system. At high concentrations it destroys immature plant tissue (Manahan, 1979). The major source of hydrogen sulphide is the microbial decay of organic matter and the reduction of sulphate ion (Manahan, 1979).

$$SO_4^{2-} + 2(CH_2O) + 2H^+ \longrightarrow H_2S + 2CO_2 + 2H_2O$$

Hydrogen Sulphide at levels well above ambient concentrations irritates respiratory tract and damage central nervous system (Manahan, 1979). Hydrogen Sulphide could cause death at levels as low as 0.25mg/m^3. Higher concentrations above 0.25mg/m^3 have the ability of deadening the odour cells of the olfactory lobes, so that the victim may not be sensitive to the impending danger of death. Hydrogen Sulphide can be oxidized by atmospheric molecular oxygen (O_2) and Ozone (O_3) in the following reactions:

$$2H_2S + 3O_2 \longrightarrow 2SO_2 + 2H_2O$$

$$H_2S + O_3 \longrightarrow SO_2 + H_2O$$

Further oxidation of SO_2 by O, O_2 and O_3 will give;

$$SO_2 + O \longrightarrow SO_3$$

$$2SO_2 + O_2 \longrightarrow 2SO_3$$

$$SO_2 + O_3 \longrightarrow SO_3 + O_2$$

Sulphur dioxide

Sulphur dioxide is corrosive and an eye irritant. Inhalation of $0.2mg/m^3$ SO_2 could result in death. Sulphur dioxide is the most corrosive of the sulphur oxides while SO_3 and SO_2 could react with atmospheric water vapour to produce sulphuric acid, which can be precipitated as acid rain.

$$SO_2 + H_2O \longrightarrow H_2SO_3$$

$$H_2SO_3 + \tfrac{1}{2} O_2 \longrightarrow H_2SO_4$$

$$SO_3 + H_2O \longrightarrow H_2SO_4$$

Ammonia

Ammonia in polluted atmosphere reacts readily with acid materials such as sulphuric acid aerosol droplets to form ammonium salts.

$$NH_3 + H_2SO_4 \longrightarrow NH_4HSO_4$$

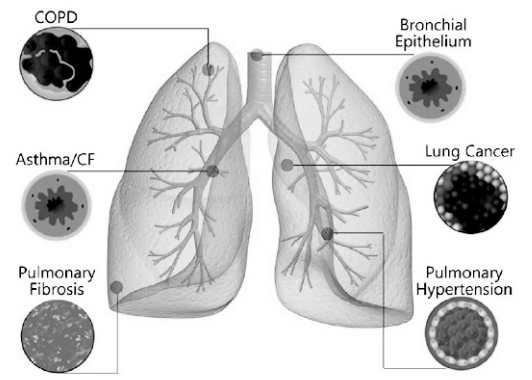


Plate 4: Pulmonary function changes
https://www.creative-biolabs.com/drug-

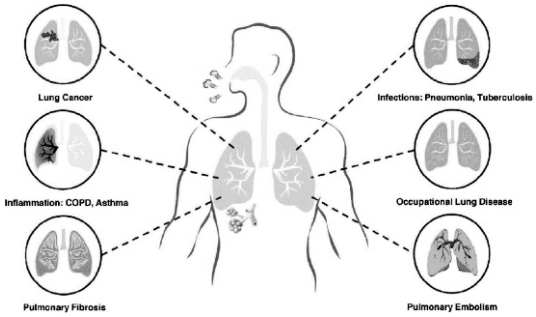


Plate 5: Respiratory Disorders
https://www.researchgate.net/figure/

https://www.deccanherald.com/dh-galleries/photos/10-common-diseases-caused-by-air-pollution-in-pics-1047812

Plate 6: Diseases caused by Air Pollution

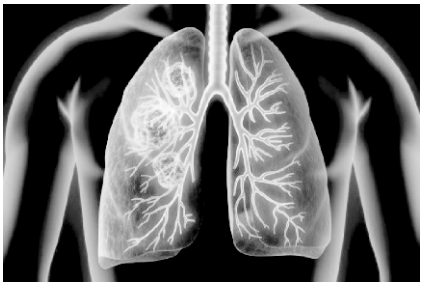


Plate 7: Lung Cancer

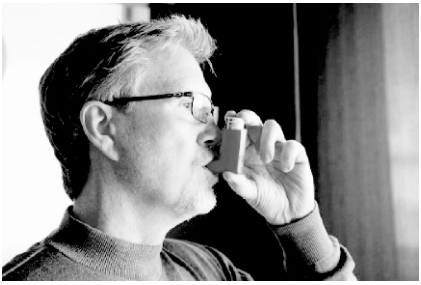


Plate 8: Asthma Attacks

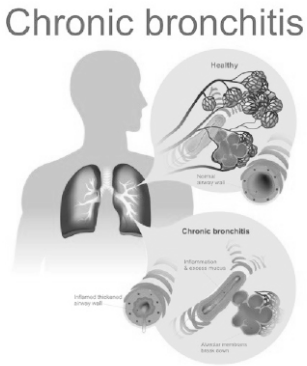


Plate 9: Chronic Bronchitis

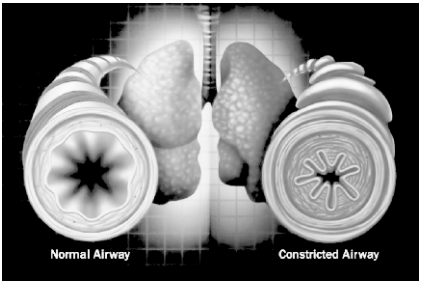


Plate 10: COPD

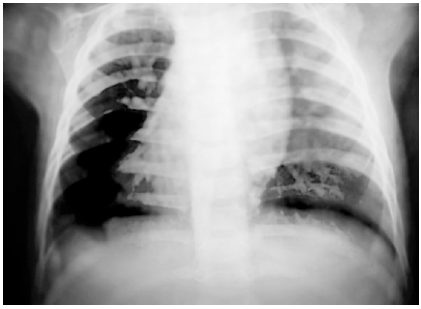


Plate 11: Pneumonia

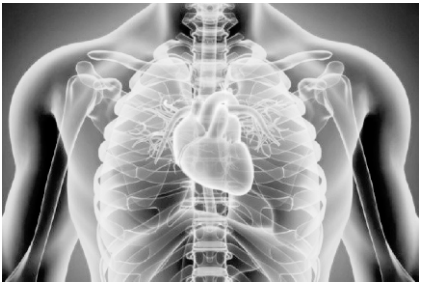


Plate 12: Heart Disease

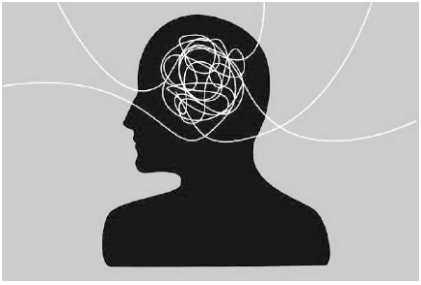


Plate 13: Mental Illness

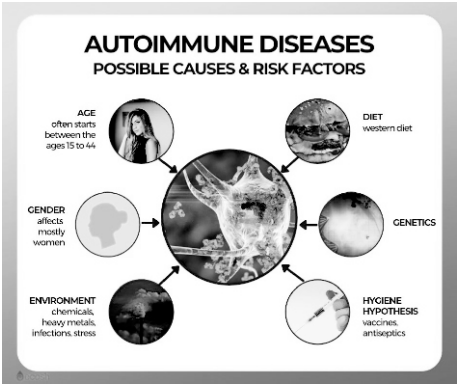


Plate 14: Autoimmune Conditions

Plate 15: Miscarriage

Plate 16: Premature Birth

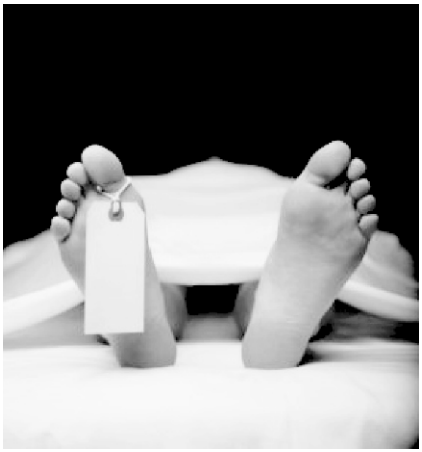


Plate 17: Premature Death

Plate 18: Learning and Memory Problems

Plate 19: Eye and Nose Irritation

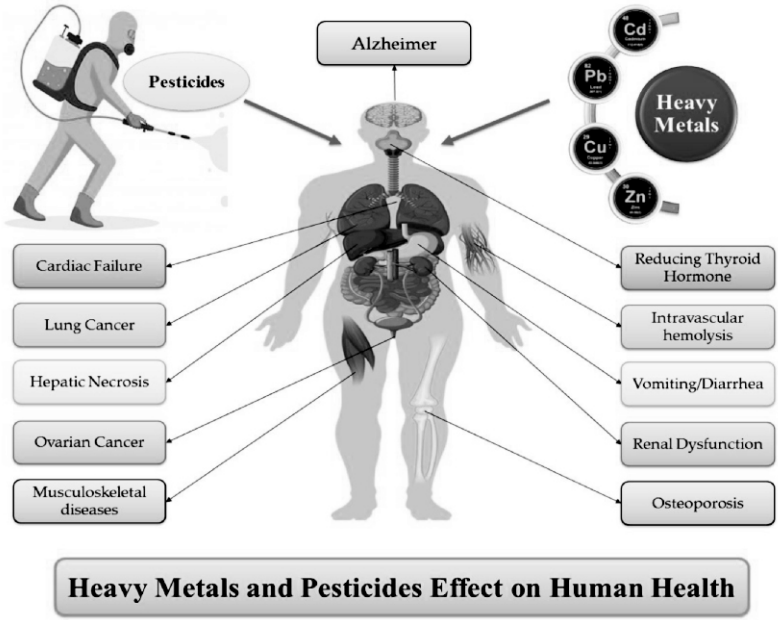


Plate 20: Heavy and Pesticides Effects on Human Health

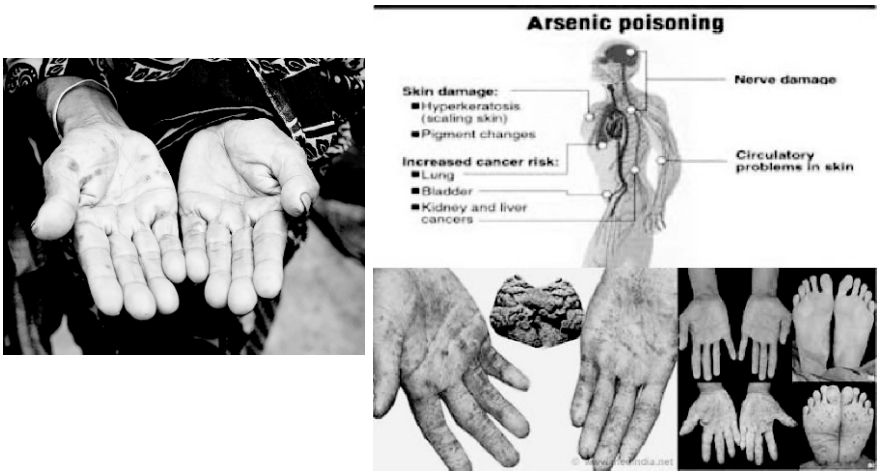
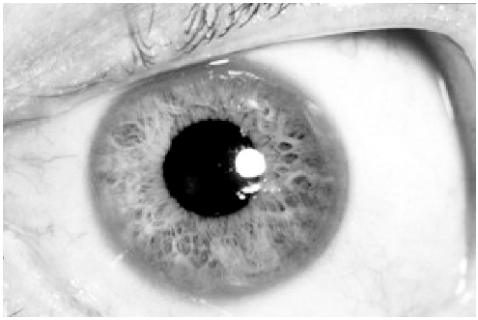


Plate 21: Arsenic Poisoning

Copper toxicity



A Kayser-Fleischer ring, copper deposits found in the cornea, is an indication the body is not metabolizing copper properly.

Plate 22: Copper Toxicity

Cadmium

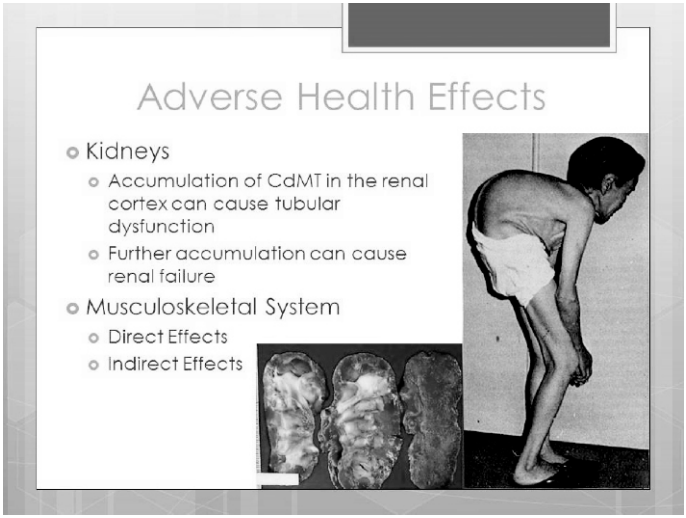


Plate 23: Cadmium Poisoning

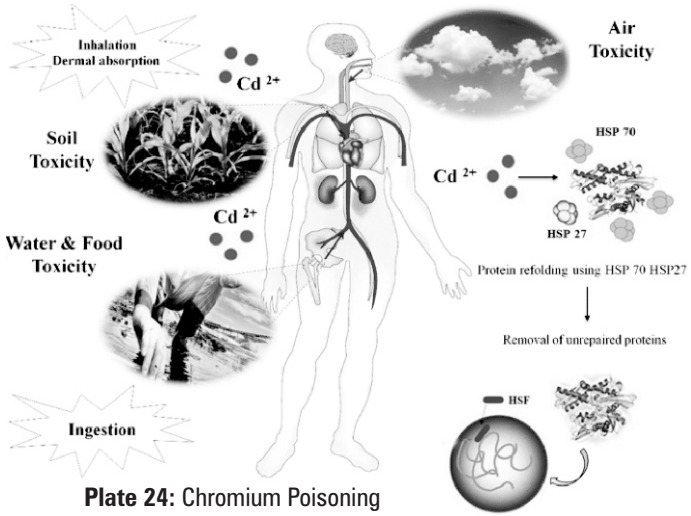


Plate 24: Chromium Poisoning

Chromium

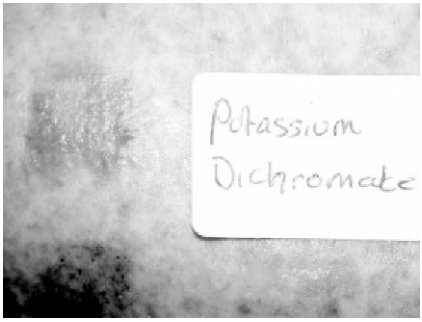


Plate 25: Chromium Poisoning

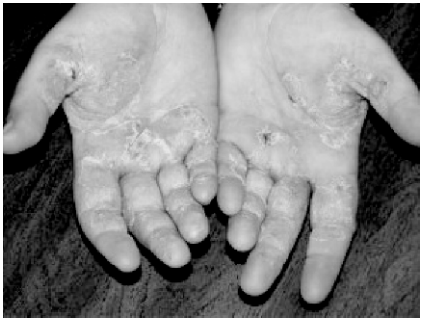
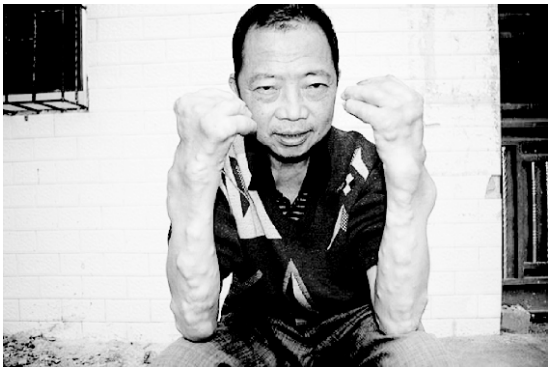


Plate 26: Chromium Poisoning



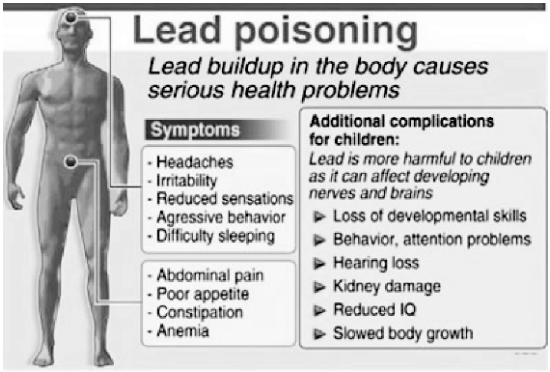
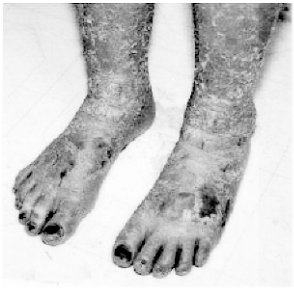


Plate 27:
Lead Poisoning

Mercury Poisoning

Exposure: High toxicity: mercurialism



Acrodynia ('Pink Disease')
-Pain
-Pink discolouration

-Impairment of speech & hearing

Plate 28:
Mercury Poisoning

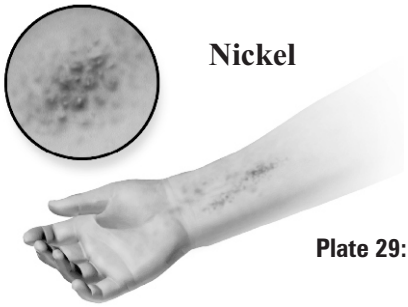


Plate 29: Nickel Poisoning

3.4 SPM MEASUREMENT METHODS

The monitoring objectives, choice of measurement and analysis methods are key elements to be considered in the measurement of air pollution.

(i) Monitoring objectives

Before considering the choice of sampling and analysis method, and the monitoring strategy (number and location of sampling stations, period of sampling, etc.), it is necessary first to consider what the objectives are. This is to answer the question 'Why monitor?'.

Monitoring objectives include to:

(1) Determine potential effects on human health,

(2) Determine effects on the environment,

(3) Determine compliance with regulations,

(4) Identify sources of pollution,

(5) Provide exposure data for use in epidemiological studies,

(6) Identify trends as a result of introduction of regulations or changes in social or economic behaviour, etc.

(7) Provide a part of the basic data needed to develop a rational programme for air quality management.

Once the objective is defined, it is possible to determine which particle size range is of most interest and thus which is the preferred method of sampling and which type of physical or chemical characterization will be necessary.

(ii) Choice of Method

Measurement for research purposes aimed at defining a problem requires different strategy than routine monitoring to determine compliance with standards and regulations. Research applications are likely to require more sophisticated and expensive equipment, covering a much wider range of factors and locations.

Over the years, I have been primarily concerned with routine monitoring, both for compliance with standards and to provide a basis for identification of sources and development of control strategies.

3.5 Chemical and Physical (Size) Characterization of Particulate Matter

Chemical and physical analysis of the particulate matter collected on filters is commonly performed to determine the presence of specific components like metals (e.g. lead) or specific air contaminants (e.g. Benzo[a]pyrene (BaP). This compositional characterization can be important for assessing potential health and environmental effects, as well as for investigating the contribution of different sources of particles to Total Suspended Particulates (TSP). In general, multielemental techniques such as X-ray - fluorescence (XRF), neutron activation analysis (NAA), particle induced X-ray emission (PIXE) and inductively coupled plasma atomic emission spectrometry (ICP-AES) are used as they offer the advantage of providing a more complete chemical characterization of the particles.

3.6 Particle Morphology

(i) As a rule light microscopy is used to analyse coarse particles (soil dust, tyre dust, pollen, powders, and fibrous aerosol such as man-made mineral fibers).

(ii) Electron microscopy is used to perform detailed morphological analyses of the submicron aerosol below 1 μm (cigarette smoke, asbestos, fine mode SPM), and may also be used for elemental analysis (by means of electron dispersive x-ray microanalysis).

3.7 Instrumental Analytical Techniques for Elemental Analysis

During the past three decades there has been an ever-increasing interest in the determination of trace elements in the atmosphere. This interest relates to various issues including environmental health-related issues and epidemiological

studies, visibility degradation, compliance with regulatory laws and the study of atmospheric transport. There are essentially seven analytical techniques available for trace element characterisation of airborne particulate matter:

1. X-ray fluorescence (XRF)
2. Neutron activation analysis (NAA)
3. Particle induced X-ray emission (PIXE)
4. Atomic absorption spectrometry (AAS)
5. Inductively coupled plasma atomic emission spectrometry (ICP-AES)
6. Inductively coupled plasma mass spectrometry (ICP-MS)
7. Ion chromatography (IC)

Techniques 1 – 3 (XRF, NAA, and PIXE) are all multielement, non-destructive and nuclear and/or atomic based and have been used extensively for many years.

Methods 4-6 are all destructive. ICP-AES and ICP-MS are also multielemental, whereas AAS is usually only capable of single element determinations.

The last method, ion chromatography, can be used to determine a wide range of anions (e.g. S-compounds, NO_3^-, Cl^-, Br^-, F^-, I^-, etc and cations (e.g. NH_4^+, Na^+, K^+, Ca^{2+}, Mg^{2+}, etc) down to sub parts per billion levels. It is usually used for the determination of halides, sulphur compounds, NH_4^+, and NO_3^- and not usually considered when analysing particulate matter for heavy metals. As with AES or AAS, the IC technique is destructive requiring specific treatment of the sample.

Plate 30: x-ray FlorescencePlate
https://highpressure.ethz.ch/

31: Neutron activation analysis (NAA)
https://serc.carleton.edu/research_education/

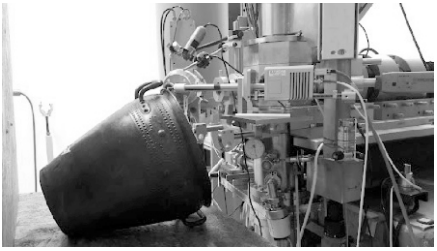


Plate 32: Particle induced X-ray emission (PIXE)
http://www.iperionch.eu/project/pixe-

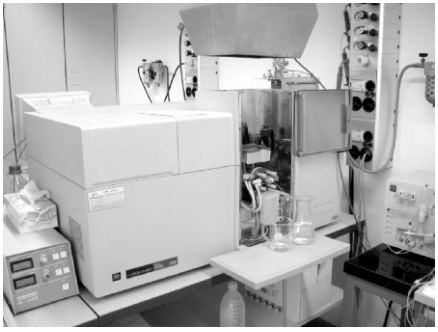


Plate 33: Atomic absorption spectrometry (AAS)
https://en.wikipedia.org/wiki/Atomic_

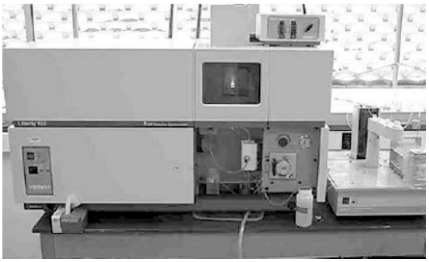


Plate 34: Inductively coupled plasma atomic emission spectrometry (ICP-AE
https://www.researchgate.net/figure/Inductively-Coupled-Plasma-Atomic-Emission-

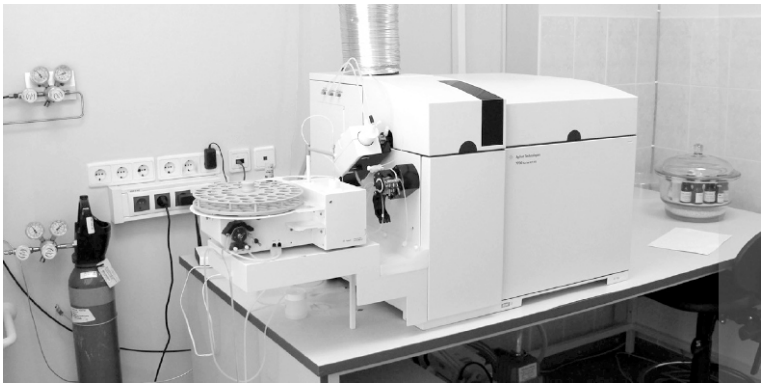


Plate 35: Inductively coupled plasma mass spectrometry (ICP-MS)
https://scientificservices.eu/item/inductively-coupled-plasma-mass-spectrometer-icp-ms/1325

Plate 36: Ion chromatography (IC)Plate
https://www.chromatographytoday.com/

37: Gas chromatography-mass spectroscopy
https://en.wikipedia.org/wiki/Gas

Plate 38: Gas chromatography-mass spectrometer
https://m.made-in-china.com/product/Gcms-Gas-Chromatography-Instrument-Mass

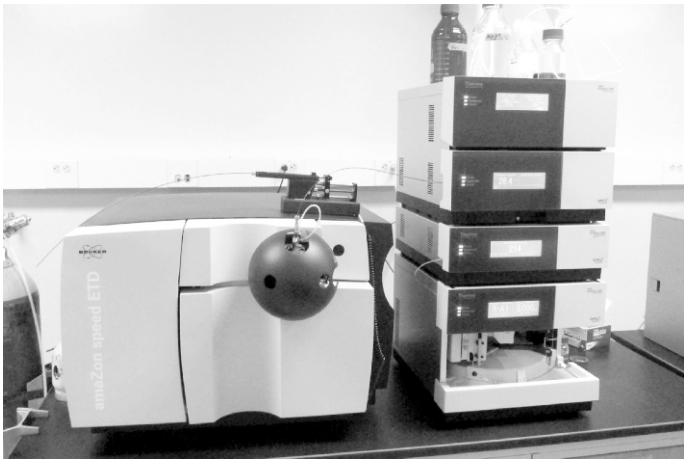


Plate 39: Liquid chromatography-mass spectroscopy
https://en.wikipedia.org/wiki/Liquid_chromatography%E2%80%93mass_spectrometry

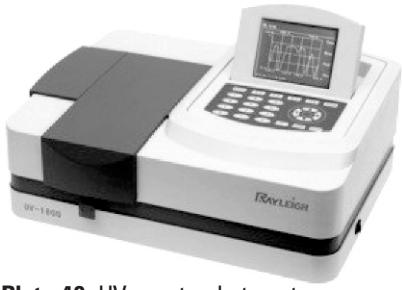


Plate 40: UV spectrophotometer
https://www.pharmaguideline.com/2015/09/principle-of-uv-spectrophotometer.html

Plate 41: Field Data Recording at a Riverside Community

Plate 42:
Sampling and Recording at Riverbank

Plate 43: Water Quality Insitu Measuring meters

Plate 44: IPS Water Quality Study Team at ISS in RSU

4.0 AIR QUALITY PARAMETERS AND FIELD MEASUREMENT EQUIPMENT

4.1 Common Air Quality Parameters (Pollutants)

The parameters measured include:

1. **Particulates:** PM_1, $PM_{2.5}$, PM_7, PM_{10}, TSP/SPM
2. **Gases:** Carbon oxides (CO, CO_2), Nitrogen (iv) Oxide (NO_2), Sulphur (IV) oxide (SO_2), methane (CH_4), organics (VOC, THC), Hydrogen Sulphide (H_2S), Ammonia (NH_3), Ozone (O_3),

3. **Trace metals:** Pb, Cr, Cu, Cd, Ni, etc.
4. **Meteorology:** Relative humidity, ambient temperature, wind speed and wind direction,
5. **Others:** noise

The common air pollutants can be classified into three groups:

(1) Biological

Typically these pollutants are present where water is found to support growth of bacteria, viruses, and fungi. Common biological pollutants can be dust mites, animal dander, legionella, and pollen. Inadequate maintenance and house-keeping of building ventilation systems can compound the issue.

(2) Chemical

Sources of chemical pollutants (gases and vapors) come from five main categories: (1) products used in the building, (2) products that can get pulled into the HVAC system from outside the building, (3) accidental spills, (4) products used during construction activities, and (5) byproducts of combustion such as carbon monoxide, formaldehyde, and nitrogen dioxide.

(3) Particles

These are described as solid or liquid, non-biological that can be suspended in air, creating respiratory hazard. This is most often dirt and dust drawn into the building ventilation system. Another source can be construction activities in the building resulting in suspended particles, such as drywall dust, wood dust, and silica from cutting, drilling, or sanding of concrete.

Some Indoor Air Pollutants

Asbestos, Bacteria and viruses, Building and paint products, Carbon monoxide, Carpets, Cleaning supplies and household chemicals, Cockroaches, Dust mites and dust, Floods and water damage, Formaldehyde, Lead, Mold and dampness, Nitrogen dioxide, Pet dander, Radon, Residential wood burning, Secondhand smoke, Volatile Organic Compounds.

4.2 FIELD MEASUREMENT EQUIPMENT

(A) Portable Digital Hand-held Monitors

i. Aeroqual Gas Monitors,

ii. MET One Aerosol instrument,

iii. Multi RAE PLUS (PGM - 50),

(B) Extech Combination (Hydrothermo-anemometer),

(C) High Volume Sampler

(D) Impinger (Gas bubbler device)

(E) Draeger Tubes

Table 3: Air Pollutants Measurement Methods (Classical and Instrumental)

S/n	Pollutant	Method of Measurement
1.	Suspended particulate matter	Modified EPA gravimetric method (High Volume Sampler)
2.	Nitrogen dioxide	Saltzman
3.	Sulphur dioxide	Pararosaniline (West-Gaeke)
4.	Hydrogen sulphide	Iodimetric
5.	Carbon monoxide	Non-dispersive infra-red
6	Hydrocarbon	Gas chromatography.

S/n	Pollutant	Method of Measurement
7	Trace metals	Trace metals in the atmosphere are collected on glass fibre filter, digested and analyzed by atomic absorption spectrometric (AAS) method.
8	Precipitation samples	Precipitation samples are collected in rain guage and plastic containers and the constituents analysed by titrimetric, UV spectrophotometric, AAS and flame photometric methods (APHA, 1975)
9	Ammonia	Phenate

Plate 45: High Volume Air Sampler (SPM)

Plate 46: Impinger (Bubbler Device - Gases)

Plate 47: Kanomax 3900 Particle Counter and High Volume Sampler

Plate 48: Holdpeak 50800 $PM_{2.5}$

Plate 49: Aeroqual Series 500 Air Quality Mete

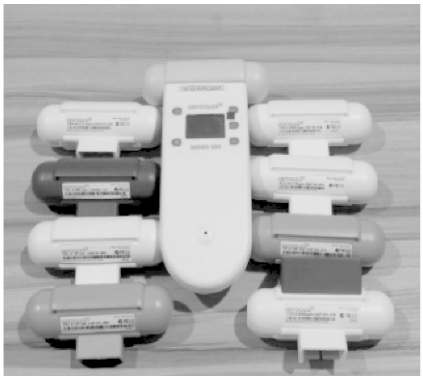


Plate 50: Aeroqual Series 500 Air Quality Meter with Cartridge for Various Pollutant Parameters

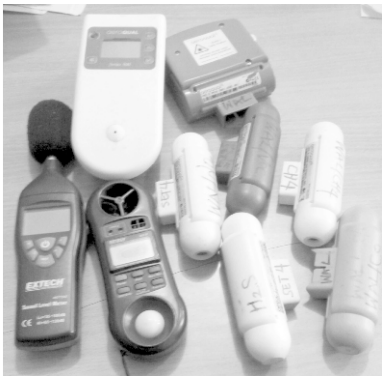


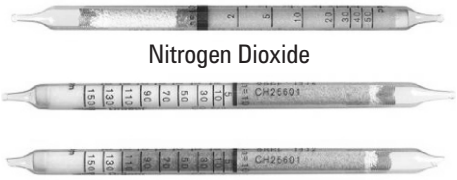
Plate 51: PM_{10} Airborne Particulate Meter.

Plate 52: Testo 250-Xl for Gaseous Emission Monitoring

Plate 53: Ambient Weather WM-4

Plate 54: Kestrel 5500 Weather Meter

Plate 55:
Draeger accuro pump



Nitrogen Dioxide

Carbon monoxide

Plate 56: Dräger Short-Term Detector Tubes

Plate 57: Field Measurements in Mangrove forest at Robert Kiri near Soku

Plate 58: Field Measurement on the River / Sea

Plate 59: Air Monitoring (Sampling) on Land

Plate 60: Data Recording on Land

5.0 MY CONTRIBUTION TO ANALYSIS

5.1 A Comparison of Methods of Analysis for Lead in Environmental Samples (Ideriah et. al., 2011)

Vice Chancellor Sir, on my employment into this University as a Research Assistant I was admitted for MPhil (Environmental Chemistry) program as the first Post Graduate student in the Chemistry Department of this University (with Mr. Enyi of College of Arts & Science, Rumuola who withdrew after the first year). Being worried of the huge cost of analysis of heavy metals with Atomic Absorption Spectrophotometer, I decided to develop the cost effective Colorimetrc method for the determination of heavy

metals as a project. My supervisors then, now of blessed memory, Dr. Solomon Amabara Braide and Dr. Welford A. Lolo Izonfuo expressed doubts about the feasibility of the project and therefore were not willing to supervise. However when they saw the series of data I generated from my preliminary test analysis they became impressed, interested and decided to supervise the project.

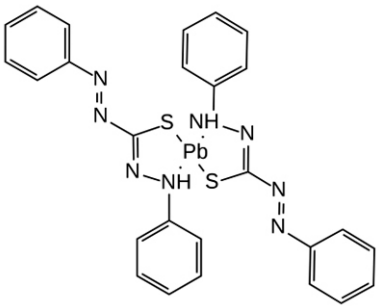


Fig. 3: Lead Dithizone

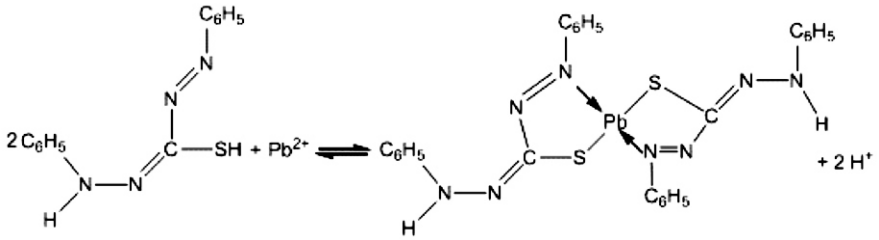


Fig. 4: Reaction of complex formation of dithizone with Pb^{2+}

Lead concentrations in soil, leaves and crop samples along selected roadsides in Port Harcourt were determined with Atomic Absorption spectrophotometric and Diphenylthiocarbazone (Dithizone) colorimetric methods. Results for lead concentrations as determined by the two methods were linear, yielding the regression equation: y = 2.2096+1.0345x, where y was the concentration of lead determined by the AAS method and x was that determined with the Dithizone

colorimetric method. Both methods proved to be good as the correlation (r = 0.9939) and squared correlation coefficient (R2 = 0.9879) between lead levels obtained by the two methods were high. The instrumental method has proven to be fast and simple. However, the Dithizone colorimetric method produced satisfactory result and is sensitive, less expensive and recommended for the analysis of heavy metals in environmental samples.

It is reported in APHA (1995) that the AAS method is subject to interference in the flame mode and required an extraction procedure for low concentrations; the dithizone method is more sensitive and is preferred by some analysts for low concentrations.

In developing countries like Nigeria, the huge cost of instrumental analysis makes it difficult for researchers and students to carry out work involving heavy metal analysis. Consequently, a less expensive but sensitive and accurate method is needed for the determination of heavy metals concentrations, in particular lead in environmental samples. In the present report, lead concentrations in soil and leaves samples determined by the colorimetric method are compared and correlated with the concentrations determined by the atomic absorption spectroscopic method.

This study showed that colorimetric methods are sensitive, selective, less expensive and very useful for measurement of low metal concentrations. It is therefore economically recommended for analysts especially students who cannot afford the instrumental method for the analysis of heavy metals in environmental samples.

Lead in one set of the replicated samples was directly analyzed with Shimadzu AA-670 Atomic Absorption/ Flame Emission spectrophotometer at a wavelength of 217nm. Lead

in the other set of digested and replicated samples was analyzed using the Dithizone colorimetric method (Bassett, 1978; Christian, 1977) with a Bausch and Lomb spectronic 20 at a wavelength of 540 nm.

The detailed results of lead concentrations in the samples obtained from the two methods of analysis are presented in Figs. 4 and 5.

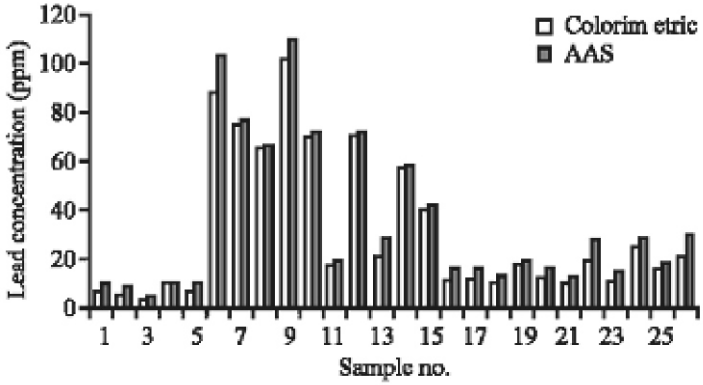


Fig. 5: Concentration if lead (ppm) measured by AAS and Colorirnetric methods

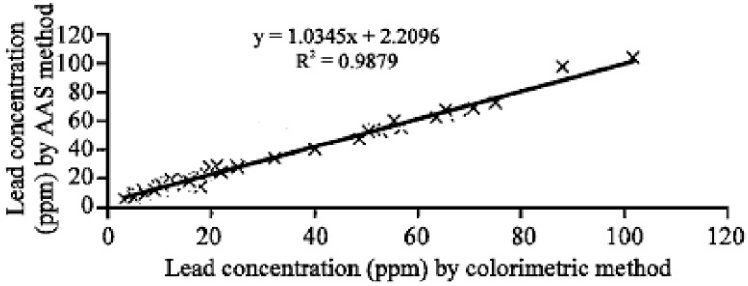


Fig. 6: Variation of lead concentration (ppm) measured by AAS and Dithizone colorimetric methods

6.0 AIR POLLUTION

Air pollution is becoming a major factor in the quality of life of urban and rural dwellers, posing a risk both to human health and to the environment. In order to develop appropriate air quality management plans, however, it is necessary first to have reliable information about the state of pollution. (Ideriah, *et. al*., 2001; Umesi *et. al*., 2009).

The concentration of specific pollutants must be measured over time and space and, of particular importance, the quality of these measurements must be known. Quality assurance and quality control (QA/QC) are thus essential part of all measurement systems (Ideriah, *et. al*., 2001; Umesi *et. al*., 2009).

Air pollution may be indoor or outdoor (ambient). Both outdoor and indoor air quality data represent the true exposure for human beings. Indoor air pollution is one of the pollution problems that are potentially threatening man's health and well-being. Indoor Air Quality (IAQ) is the quality of air within buildings and structures, especially as it relates to the health and comfort of the occupants. Currently , indoor air pollution is ranked by EPA as one of the top five environmental risks to public health (USEPA, 2000).

The quality of air inside homes, offices, health care facilities and other private and public buildings where people spend a large part (80-90%) of their time is an essential determinant of healthy life and well-being (USEPA, 2000)..

In public residential buildings, air contaminants can originate within the building or can be drawn from the outdoor environment. Activities of people living within the indoor environment such as, fuel combustion, tobacco smoking, use of kerosene and gas stoves and emissions from garage exhaust fumes are the principal factors responsible for the presence of most indoor air pollutants (Samuel & Abayneh, 2014).

Assessment of the health effects of indoor air pollution is scarce compared to that on outdoor air pollution due to the fact that policy development in the air pollution field has focused on out-door air pollution as a result of the correctly perceived need to deal with the high levels of outdoor air pollutants associated with both coal, smoke and photochemical smog.

Presently there is growing awareness in Nigeria of the potential adverse effects of industrial operations on the quality of air. The World Health organization (WHO), in 1967 initiated a program on air pollution monitoring and published guidelines for the air quality. Air quality studies in Nigeria and particularly the Niger Delta is still in its infant stage and with several challenges. According to Ideriah *et. al.* (2001 and 2007), Trinya and Ideriah (2015) air pollution studies in Rivers State and indeed Nigeria are few and independently carried out. The same authors also indicated that ***government is not involved in systematic and consistent air quality assessment programmes.***

There is the problem of insecurity and difficulty in terrain that militates against most community based air sampling initiatives. Other obvious and prominent drawbacks include lack of emissions inventory/database due to lack of consistent and systematic measurements, lack of Green House Gas (GHG) monitoring stations, collaboration between key regulatory authorities and laxity in the enforcement of emission regulations.

The success of air pollution control depends on the ability to determine accurately the nature and levels of pollutants in the atmosphere and from emission sources. Therefore, good analytical methodology is essential to the study and alleviation of air pollution (Manahan, 1979).

Airborne particulate matter, also called suspended particulate matter (SPM) or total suspended particulates (TSP) can be found in ambient air in the form of dust, smoke, or other aerosols. SPM may be of anthropogenic and/ or natural origin. Direct sources of SPM includeburning of fossil fuels (coal, oil and wood) for power

heating and transportation: construction and industrial activities; as well as soil erosion (wind blown dust), forest fires, volcanic eruption, and pollen. SPM can occur as a secondary aerosol resulting from atmospheric transformation of gaseous pollutants emitted from combustion sources (e.g. power plants and automobiles) or natural sources such as forests. Particles can also result from condensation of volatile elements and species in the atmosphere to form very small participles or absorbed on the surface of already formed, finely divided particles.

Various sampling and analysis methods may be employed to assess airborne particle concentrations. The simplest methods involve measurement of "total suspended mass" and/or black smoke, which may be appropriate for many monitoring situations.

Carbon Monoxide (CO) is emitted into the atmosphere mainly as a product of the incomplete combustion of carbonaceous material. The major sources of CO exposure for the general, non-smoking population are exhaust emissions from combustion and the burning of fossil fuels. Smoking provides an addition to source of CO for the non-smoking public. In addition to these exogenous sources, CO is generated endogenously mainly from the breakdown of proteins. Healthy individuals can tolerate low-level exposures to CO but it can be hazardous at higher concentrations and even at low concentrations for those with unusual susceptibility.

The sources of H_2S are microbial decay of organic matter and reduction of sulphate ion as represented in the equation:

$$SO_4^{2-} + 2(CH_2O) + 2H^+ \rightarrow H_2S + 2CO_2 + 2H_2O.$$

High concentrations of sulphate ion in seawater cause bacterially mediated formation of H_2S; which causes pollution problems in some coastal areas and is a major source of atmospheric sulphur.

Smith (1992) reported that hydrogen sulphide emission is currently regulated under the accidental release provisions of the 1990 clean Air

Act. Because H_2S at sufficiently high concentrations is reported to have dangerous health effects, the WHO Regional office for Europe has given a guidance value for H_2S of 150 $\mu g/m^2$ for a 24 hour average time. In the US, a number of states have established standards or guidelines for H_2S. These state standards do not reflect any Federal recommendations and vary considerably from state to state (Smith 1992). Neither FEPA nor DPR has any guidelines for H_2S.

The Federal Government of Nigeria established the Federal Environmental Protection Agency (FEPA) now known as Federal Ministry of Environment (FMEnv,1991), through Decree 58 of 1988 as amended by Decree 59 of 1992 to formulate standards and guidelines for environmental pollutants. In recognition of the fact that we live in a global village and environmental issues are trans-boundary, the levels of pollutants are usually compared with relevant international environmental standards.

Nigeria flares about 1.2 billion m^3 of associated natural gas per year in conjunction with the exploration of crude oil in the Niger Delta (GGFR, 2002). The figure is on the increase due to discovery and exploitation of more oil reserves. The wasted energy resource through flaring in Nigeria is about 45% of the energy requirements of France, the world's fourth largest economy (Ashton *et al.,* 1999).

Nigeria wastes 16% of the world's total associated gas through flaring (GGFR, 2002). According to World Bank estimate, about 10% global CO_2 emission comes from flaring. Nigerian gas flaring alone accounts for 35 million tons of CO_2 and 12 million tons of CH_4, which has a higher warming potential than CO_2 (Manby, 1999; Watts, 2001).

The current practice of gas flaring in Nigeria is not only a depletion of the nation's non-renewable resource base, but also a significant source of polluting water, air, and soil in the Niger Delta of Nigeria. O' Rourke and Connolly (2003) stated that oil exploration and exploitation processes create environmental, health and social

problems in local communities hosting oil producing fields in the Niger Delta.

Three environmental impacts are associated with flaring: air pollution, noise and thermal radiation. The air pollutants of principal concern with regard to human health and phytotoxicity are oxides of nitrogen and sulphur, particulate matter, hydrocarbons, carbon monoxide, etc.

Pollutants usually exit a stack in the form of a plume and are carried upwards by natural buoyancy. To a rough approximation, the plumes are usually cone shaped. The pollutants get carried along by the wind and diluted by turbulence.

The effects of gas flaring are beyond the local environment, as it also contributes to global warming. Kaldany (2001) stated that there has been more attention paid to gas flaring since the issue of global warming has become more high profile in the world. The gas flaring produces enormous amounts of green house gases (GHG) responsible for global warming including carbon dioxide (CO_2), methane (CH_4), and propane (C_3H_8).

6.1 Sources of Indoor Air Pollutants

Table 4: Sources of Indoor Air Pollutants

	Pollutants / Contaminants	Sources	
1	Volatile organic compounds (VOCs)	Perfumes, hairsprays, furniture polish Cleaning solvents Hobby and craft supplies Pesticides Carpet dyes and fibers Glues, adhesives, sealants.	Paints, stains, varnishes, strippers, Wood preservatives Dry cleaned clothes, moth repellents Air fresheners, Stored fuels, and automotive products, Contaminated water, Plastics

	Pollutants / Contaminants	Sources	
2	Formaldehyde	Particleboard, interior-grade plywood Cabinetry, furniture	Urea Formaldehyde foam insulation Carpet, fabrics
3	Pesticides	Insecticides, (including termiticides) Rodenticides	Fungicides, disinfectants Herbicides (from outdoor use)
4	Lead	Lead-based paint	Exterior dust and soil
5	Carbon Monoxide, carbon dioxide, nitrogen dioxide	Improperly operating gas or oil furnace/ hot water heater, fireplace, wood stove	Unvented gas heater/ kerosene heater
6	Sulphur Dioxide	Combustion of sulfur-containing fuels (primarily kerosene heaters)	
7	RSP (respirable particulates)	Fireplace, woodstove Unvented gas heater	Tobacco products Unvented kerosene heater
8	Environmental Tobacco Smoke (ETS)	Tobacco products	
9	Biological contaminants	Plants, animals, birds, humans Pillows, bedding, house dust Wet or damp materials	Standing water Humidifiers, evaporative coolers Hot water tank
10	Asbestos	Pipe and furnace insulation Ceiling and floor tiles	Decorative sprays Shingles and siding
11	Radon	Soil and rock Some building materials	Water

6.2 Typical Houses and Activities that could be seen in the Niger Delta Urban and Rural settings:

Plate 61: Urban Metropolis

Plate 62: Urban Slum

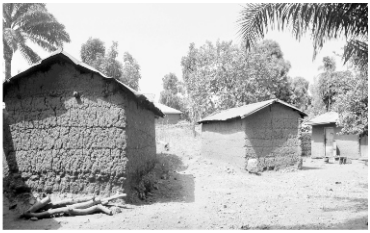


Plate 63: Rural Settlements

Plate 64: Rural Settlements

Plate 65: Cooking with Wood

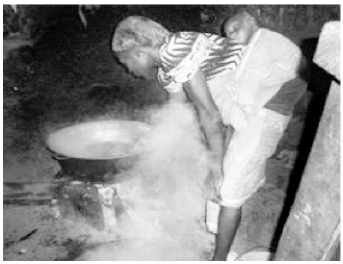


Plate 66. Exposure of Mother and Child

Source: Oluwole et al. (2013)

Plate 67: Fungi on wall & ceiling of a typical indoor environment

Black Soot around Port Harcourt Air Basin

Plate 68: Smoke plume viewed from RSU

Plate 69: Black soot on classroom fans

Plate 70: Horizontal Flare

Plate 7: Vertical Flares

Plate 72
Smoke from Vehicle exhaust

Plate 73.
Smoke plume from destroyed illegal Refinery

Plate 74: Burning of seized petroleum products (www.Icirnigeria.org)

Plate 75: Vegetation burning resulting from Oil Pipeline vandalism.

Plate 76

Plate 77

Burning of illegal refinery (sweetcrudereports.com)

Plate 78 Collection and burning of used tyres

Plate 79

Plate 80

Burning of illegal refinery (sweetcrudereports.com)

Plate 81

Plate 82

Burning of a boat carrying crude oil at Bodo Creek and Combustion of a sabotaged oil pipeline

7.0 MY CONTRIBUTIONS TO ENVIRONMENTAL MONITORING

7.1 Air Quality Monitoring

7.1.1 Main problems of sampling air are:

- Number of sampling stations required,
- Location of the stations,
- Sampling time and
- Frequency of sampling.

7.1.2 Factors affecting concentrations of pollutants at any point on the ground:

- the quantity of emissions,
- wind direction, wind speed and level of turbulence.
- The time over which the samples are averaged (the averaging time) is crucially important and should always be mentioned alongside measurements of atmospheric concentrations (Concawe, 1994).

Averaging times vary depending on their purpose for example outdoor air quality is assessed using hourly, daily or yearly averages. Shorter averaging time have higher standard value (Concawe, 1994).

The World Health Organisation (WHO) has selected methods for analyzing air pollutants. These methods are based on those adapted by the United States Environmental Protection Agency (USEPA), EEC, etc (WHO, 1996).

The Federal Environmental Protection Agency (FEPA), now Federal Ministry of Environment (FMEnv.) in Nigeria has adopted these methods for the purpose of surveillance and monitoring of air pollutants pending the development of her standard methods. The methods adopted in this study were influenced partly by local circumstances and partly by the guidelines of the Department for Petroleum Resources (DPR) and FMEnv.. In general, the choice of analytical procedures is based on sensitivity, stability, repeatability and capability for calibrations.

7.2 Determination of Indoor and Outdoor Concentrations of Suspended Particulate Matter in South-Eastern Nigeria (Ideriah *et. al.,* 2001)

The day and night indoor and outdoor concentrations of suspended particulate matter (SPM) in Iko, Obrikom, Port Harcourt, Ogbo and Ugbele communities in southern Nigeria were determined using a Hi-volume sampler with low resistance (glass fibre) filter. The samples were analysed by gravimetric method, using microbalance techniques. The results (Tables 5 and 6) showed that in most communities the indoor night SPM concentrations were higher than the indoor day and outdoor day SPM concentrations. The study also revealed that mud wall with thatch roof buildings had higher SPM values than cement wall with zinc roof buildings. The observed differences are not significant ($p>0.05$). Furthermore, the findings generally showed that the SPM concentrations in the rural communities were higher than those in the urban communities. Most of the results were found to exceed international and national guideline values.

Table 5: Concentration of SPM ($\mu g/m^3$) from five communities in southern Nigeria

Community	*Station*	*Indoor*						*Outdoor Day*			*Indoor/ Outdoor ratio*
		Day Sample number			*Night Sample number*			*Sample number*			
		1	*2*	*3*	*1*	*2*	*3*	*1*	*2*	*3*	
Iko	1	130.6	87.7	33.2	184.3	147.9	48.4	44.8	354.3	300.0	0.36
	2	152.6	52.6	131.2	1037.2	980.9	703.9	537.9	431.0	450.5	0.24
Obrikom	1	455.8	847.1	794.5	631.0	1293.9	1271.0	517.5	784.1	700.0	1.05
	2	251.3	180.0	200.0	104.0	177.3	175.5	139.4	518.5	380.1	0.61
Port	1	191.5	230.6	667.3	309.6	378.8	510.4	158.2	193.6	788.2	0.96
Harcourt	2	243.1	182.6	245.6	155.7	238.4	240.0	1057.0	275.7	229.6	0.43
Ogbo	1	677.9	650.1	590.9	450.2	816.7	767.5	755.3	1419.2	1280.5	0.56
	2	1123.7	1117.0	1020.7	1076.4	425.4	550.0	1233.4	1677.9	1560.7	0.73
Ugbele	1	47.9	73.9	50.6	34.4	117.3	106.5	19.0	24.3	28.4	2.40
	2	50.6	72.9	34.2	105.5	132.5	120.3	20.5	22.1	21.8	2.45

Table 6: Concentrations of indoor SPM (g/m3) collected from thatch and zinc roof houses at Iko town

Station	*Indoor Day*		*Indoor Night*	
	Thatch	*Zinc*	*Thatch*	*Zinc*
1	130.6	87.7	184.3	48.4
2	152.6	52.6	1037.2	703.9

Air Quality Index (AQI)

Air quality index is a scale from 0 to 500 used to show how polluted the air is, along with the risks associated with each rating. An AQI is calculated using established standards based on medical research for the acceptable levels of major air pollutants (USEPA, 2016).

An air quality index (AQI) translates numerical data into a descriptive rating scale and makes it easier for citizens of all ages to understand the level of pollution in the air they breathe.

Air quality indexes serve two main purposes:

1. To inform the public about air quality in a comprehensible manner so that they may take action to protect their health.
2. To help countries develop and assess policies for better air quality.

The higher the AQI value, the higher the level of air pollution and the more severe the health concern. This allows for a direct comparison of each of the pollutants used in the AQI. These pollutants are ozone, particulate matter, carbon monoxide, sulphur dioxide, and nitrogen dioxide. AQI values equal to or less than 100 are generally considered as satisfactory. When AQI values are above 100, air quality is

unhealthy: at first for certain sensitive groups of people, then for everyone as AQI values get higher.

The AQI is divided into six categories each with a specific colour. Each category corresponds to a different level of health concern. The colour makes it easy for people to quickly determine whether air quality is reaching unhealthy levels in their environment (communities, location or office).

Table 7. Air Quality Index Scale as defined by the USEPA NAAQS/DPR/FMEnv Standard

Air Quality Index V alues (AQI)	Air Pollution Level	Health Implications	Colors
0 to 50	Good	Air quality is considered satisfactory, and air pollution poses little or no risk	Green
51 to 100	Moderate	Air quality is acceptable; however for some pollutants, there may be a moderate health concern for a very small number of people who are unusually sensitive to air pollution	Yellow
101 to 150	Unhealthy for sensitive group	Members of sensitive groups may experience health effects. The general public is not likely to be affected	Orange
151 to 200	Unhealthy	Everyone may begin to experience health effects; members of sensitive groups may experience more serious health effects	Red
201 to 300	Very Unhealthy	Health warnings of emergency conditions. The entire population is more likely to be affected	Purple
301 to 500	Hazardous	Health alert: everyone may experience more serious health effects	Maroon

Table 8. AQI Based on SPM from Southern Nigeria

Community	*Station*	*Indoor Day Sample number*			*Night Sample number*			*Outdoor Day Sample number*		
		1	*2*	*3*	*1*	*2*	*3*	*1*	*2*	*3*
Iko	1	88	66	30	115	95	44	41	200	173
	2	99	48	88	500	500	500	433	308	332
Obrikom	1	339	500	500	500	500	500	413	500	500
	2	148	113	123	75	111	110	92	414	236
Port Harcourt	1	118	138	500	177	234	405	102	119	500
	2	144	114	145	100	142	143	500	160	137
Ogbo	1	500	500	486	332	500	500	500	500	500
	2	500	500	500	500	301	445	500	500	500
Ugbele	1	44	59	46	31	81	76	17	22	26
	2	46	59	31	75	89	83	19	20	20

Table 9 AQI Based on SPM in five communities in thatch and zinc roof houses at Iko town

Station	*Indoor Day*		*Indoor Night*	
	Thatch	*Zinc*	*Thatch*	*Zinc*
1	88	66	115	44

7.2.1 Indoor and Outdoor Air Quality in some Riverine Communities in Bayelsa and Rivers States

(Ideriah, 2003)

Air quality measurements were made at fourteen communities. Two samples, indoor and outdoor were collected at each station. The parameters measured are Suspended Particulate Matter (SPM), Nitrogen dioxide (NO_2), Sulphur dioxide (SO_2), Hydrogen Sulphide (H_2S), Ammonia (NH_3), Total Hydrocarbon (THC) and Carbon monoxide (CO). The instruments used include a high volume sampler, a train of impingers fitted with bubbler devices and an automatic gas monitor. The quality assurance and control (QA/QC) measures employed include sampling at approximately 1.5m above ground and away from buildings; impingers were covered with aluminum foil and replicated

analysis. The results of measurements made at the various stations are shown in Table 10.

Table 10: Concentrations of Air Pollutants measured at the Study Areas

Stations		SPM µg/m³	NO_2 µg/m³	SO_2 µg/m³	NH_3 µg/m³	VOC µg/m³	H_2S µg/m³	CO ppm
Basambiri	Indoor	206.5	16.4	<6.0	1.5	24.6	<0.5	1.0
	Outdoor	105.3	10.5	<6.0	1.5	54.3	0.5	1.5
Ogboloma-biri	Indoor	160.5	18.9	<6.0	1.5	14.9	<0.5	1.0
	Outdoor	131.6	10.9	<6.0	1.5	20.4	0.5	1.5
Rowka (Mile 2)	Indoor	264.5	20.4	<6.0	1.5	10.0	<0.5	1.0
	Outdoor	224.3	15.0	<6.0	1.5	13.0	0.5	1.5
Fantuo	Indoor	90.4	25.0	<6.0	1.5	11.0	<0.5	1.0
	Outdoor	67.5	14.6	<6.0	1.5	15.0	0.5	1.5
Ibidi (Brass LGA)1	Indoor	100.0	18.5	<6.0	1.5	11.0	<0.5	1.0
	Outdoor	74.4	12.5	<6.0	1.5	14.0	0.5	1.5
Obioku (Brass LGA)	Indoor	98.8	17.8	<6.0	1.5	12.4	<0.5	1.0
	Outdoor	84.6	11.0	<6.0	1.5	20.5	0.5	1.0
Abonnema	Indoor	110.6	29.2	<6.0	1.5	60.0	<0.5	1.5
	Outdoor	100.4	16.6	<6.0	1.5	93.7	0.5	1.0
Kula	Indoor	100.0	30.5	<6.0	1.5	30.6	<0.5	2.0
	Outdoor	75.6	21.3	<6.0	1.5	59.2	0.5	1.5
Idama	Indoor	192.5	26.0	<6.0	1.5	85.4	<0.5	1.5
	Outdoor	88.4	20.6	<6.0	1.5	202.3	0.5	1.0
Bille	Indoor	99.4	19.8	<6.0	1.5	56.5	<0.5	1.5
	Outdoor	8870.6	10.0	<6.0	1.5	83.9	0.5	1.0
Ke	Indoor	100.0	22.5	<6.0	1.5	48.0	<0.5	1.5
	Outdoor	786.5	12.8	<6.0	1.5	62.5	0.5	1.0
Harry's town	Indoor	92.3	31.5	<6.0	1.5	24.6	<0.5	1.0
	Outdoor	80.6	28.8	<6.0	1.5	44.4	0.5	1.0
Bakana	Indoor	90.4	26.0	<6.0	1.5	12.3	<0.5	1.5
	Outdoor	78.5	14.6	<6.0	1.5	19.7	0.5	1.0
Abalama	Indoor	75.0	18.5	<6.0	1.5	16.3	<0.5	1.0
	Outdoor	64.0	12.4	<6.0	1.5	25.0	0.5	1.0
FMEnv.		250	75	260	200	160	8	10

Table 11. Air Quality Index for Pollutants in R]

Stations		SPM µg/m^3	NO_2 µg/m^3	SO_2 µg/m^3	CO ppm
Basambiri	Indoor	126	15		11
	Outdoor	75	10		17
Ogbolomabiri	Indoor	103	18		11
	Outdoor	88	10		17
Rowka (Mile 2)	Indoor	155	19		11
	Outdoor	135	14		17
Fantuo	Indoor	68	23		11
	Outdoor	56	14		17
Ibidi (Brass LGA)1	Indoor	73	17		11
	Outdoor	60	12		17
Obioku(Brass LGA)	Indoor	72	16		11
	Outdoor	65	10		11
Abonnema	Indoor	78	27		17
	Outdoor	73	15		11
Kula	Indoor	73	28		22
	Outdoor	60	20		17
Idama	Indoor	119	24		17
	Outdoor	67	20		11
Bille	Indoor	72	24		17
	Outdoor	500	19		11
Ke	Indoor	73	18		17
	Outdoor	500	9		11
Harry's town	Indoor	69	21		11
	Outdoor	63	12		11
Bakana	Indoor	68	29		17
	Outdoor	62	27		11
Abalama	Indoor	60	17		11
	Outdoor	55	11		11

The indoor concentrations of SPM and NO2 in all the stations and CO in most stations were higher than the outdoor concentrations. This observation could be attributed to emission from domestic activities and poor ventilation. On the other hand the outdoor concentrations of VOC were higher than the indoor concentrations probably due to fugitive emissions from pipeline, outboard engines and other automobiles.

The results were compared with permissible limits recommended by the Federal Ministry of Environment (FMEnv. 1991). The concentrations of SPM at Basambiri (indoor) 206.5 and Rowka (indoor, 264.5; outdoor, 224.3) were high enough to cause concern. VOC at Idama exceeded the permissible limits. These levels could be attributed to the activities of the flow station, engine boats and automobiles in the communities.

7.3 Air Quality around some Cement Industries in Port Harcourt, Nigeria

(Ideriah and Stanley, 2008)

The quality of air around some cement industries operating in Port Harcourt Nigeria was assessed using WHO recommended methods involving a high volume sampler, a train of impingers fitted with bubbler devices and digital gas monitors.

The results showed low levels of gaseous pollutants. The concentrations of SPM and NO2 varied between 678.9 and 996.2 μg/m3 and 7.8 μg/m3 and 20.0 μg/m3 respectively at Atlas cement and were lower than 607.7 and 23,198.5 μg/m3 and 27.45 and 140.7 μg/m3 respectively at Eagle cement area. Statistical analysis showed significant difference ($P<0.05$) between the indoor and outdoor mean concentrations of SPM at the cement industries. The concentrations of SPM in all the stations and NO2 at station 1 at Eagle cement exceeded guideline values. These imply serious environmental and health concern.

This study showed that cement dust in form of SPM arising from cement unloading, transfer, bagging, loading on to trucks is a major problem in the cement industry and bagging of cement in an open area as in Atlas cement company is better than enclosed factory. This implies that workers at Eagle cement and those in similar enclosed places are at higher risk.

Table 12: Comparison of Concentrations of Air Pollutants with Federal Ministry on Environment Guidelines

Pollutants	Mean Concentrations								FMEny
	Station 1		Station 2		Station 3		Station 4		
	Eagle	Atlas	Eagle	Atlas	Eagle	Atlas	Eagle	Atlas	
SPM ($\mu g/m^3$)	23190.8	996.2	1239.6	827.1	1856.8	909.8	617.1	678.9	600
NO_2 ($\mu g/m^3$)	141.1	20.0	53.0	7.8	45.8	19.4	27.8	13.8	75
SO_2 ($\mu g/m^3$)	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	260
NH_3 ($\mu g/m^3$)	39.4	0.5	0.5	0.5	0.8	0.5	0.5	0,5	200
THC ($\mu g/m^3$)	50.6	48.5	9.6	15.3	39.4	27.5	7.0	39.5	160
CO (ppm)	5.0	2.0	2.0	2.0	3.5	1.0	3.0	1.0	10

Table 13. AQI around Atlas Cement Company

Stn no.	Pollutants			
	SPM ($\mu g/m^3$)	NO_2 ($\mu g/m^3$)	SO_2 ($\mu g/m^3$)	CO (ppm)
Loading / bagging bay	500	500	35	22
Sack factory/ bagging ship	500	500	35	22
Company premises	500	500	35	11
Jetty (control)	500	500	35	11

Table 14. AQI around Eagle Cement Company

Stn no.	Pollutants				
	Sample No.	SPM ($\mu g/m^3$)	NO_2 ($\mu g/m^3$)	SO_2 ($\mu g/m^3$)	CO (ppm)
Loading / bagging bay (1)	1	500	500	35	55
	2	500	500	35	55
Sack factory/ bagging ship (2)	1	500	500	35	22
	2	500	500	35	22
Company premises (3)	1	500	500	35	33
	2	500	500	35	39
Jetty (control) (4)	1	500	500	35	33
	2	500	500	35	33

Table 15: Comparison of AQI at Eagle and Atlas Cement Company

Pollutants	Mean Concentrations							
	Station 1		Station 2		Station 3		Station 4	
	Eagle	Atlas	Eagle	Atlas	Eagle	Atlas	Eagle	Atlas
SPM ($\mu g/m^3$)	500	500	500	500	500	500	500	500
NO_2 ($\mu g/m^3$)	500	500	500	500	500	500	500	500
SO ($\mu g/m^3$)	35	35	35	35	35	35	35	35
CO (ppm)	55	22	22	22	29	11	33	11

A similar assessment of air quality was done in the indoor of a Chemical Fertilizer Company at Onne, Nigeria (Ideriah *et. al.*, 2007).

The indoor air quality of a nitrogenous fertilizer company was assessed using high volume sampler, impingers and noetox gas monitor. The parameters determined were suspended particulate matter, ammonia and carbon monoxide. The results showed that the highest levels of suspended particulate matter were 2,460.4μgm^{-3} at the study sites and 42.5μgm^{-3} at the control site. The highest values of ammonia 805.2±53.9μgm^{-3} at the sites and 51.4±4.5μgm^{-3} at the control site. The highest value of Carbon dioxide were 4.65 ±7.93 ppm. The differences between the mean values of suspended particulate matter and ammonia at the study sites and control (Training house) were significant ($p<0.05$). The study showed that the levels of suspended particulate matter and ammonia at indoors of the selected sites present a health hazard, indicating that the factory workers are at high risk.

7.4 Effect of Naked Lamp on Levels of Air Pollutants in Port Harcourt, Nigeria

(Ideriah *et. al.*, 2008)

Vice Chancelor Sir, one of the air pollution issues especially in the Niger Delta is the issue of night markets which take place in the evenings and last till late in the night, as late as 10.00pm. As a result of lack of street lights and epileptic electric power supply, traders mostly women and children use naked lanterns or kerosene stoves. These local lanterns emit clouds of smoke that consists of carbon monoxide mainly.

We investigated the effect of naked kerosene lamps on the concentrations of some air pollutants in order to create awareness on those who use them indoors and in the night markets. In general, we found out that the use of naked lamps adversely affects the quality of air and is detrimental to human health. We recommended that the use of naked lamps should discouraged and the quality of air in areas where it is used should be regularly monitored to create awareness among the populace.

The effect of burning naked lamp on the levels of air pollutants, SPM, NO_2, SO_2, THC and CO was determined in Diobu area of Port Harcourt metropolis, Nigeria using active sampling methods involving a high volume sampler, a train of impingers and a digital gas monitor. The concentrations of SPM ranged between 10.7 and 682.8 $\mu g/m^3$, NO_2, ranged between 35 and 180.8 $\mu g/m^3$ THC ranged between 9.1 and 10.9 $\mu g/m^3$, CO ranged 1.0 and 3.5 ppm while SO_2 (<6.5 $\mu g/m^3$) did not vary. The levels of pollutants measured during burning naked kerosene lamps were higher than those measured without the naked lamp. In particular the differences in the levels of SPM and NO_2 between the burning naked lamp measurements and without the naked lamp measurements

were found to be significant ($p<0.05$). The levels of SPM and NO_2 measured during the burning naked lamp exceeded their permissible limits recommended by local and international agencies. The regular use of naked lamps in homes and night markets were therefore discouraged.

The real health effects of air pollution depend on the concentrations experienced by people rather than those recorded by stationary air quality monitors located out-doors. Two key features of people which strongly influence their exposure are their mobility and the time spent indoors. Recent estimates suggest that the average proportion of time spent indoors by the population in developed countries is about 90%, with considerable variation between individuals (GB Parliament House of Commons Environment Committee, 1991; Dimitroulopoulou *et al.*, 2001).

Kaladumo (1996) reported aggravation of asthma, increased hospital admission for respiratory conditions, to long term responses such a chronic lung diseases, bronchitis and accelerated ageing of the lungs as being associated with the petroleum industry in the Niger Delta region.

Table 16: Concentrations of air pollutants measured during the experiment

		Pollutants				
		SPM	NO_2 µg/m^3	SO_2 µg/m^3	THC	CO ppm
Experiment		µg/m^3			µg/m^3	
1	With lamp	664.2	152.7	<6.5	10.0	3.5
2		655.0	167.5	<6.5	10.6	3.0
3		682.8	180.8	<6.5	10.9	3.0
4	Without lamp	12.5	37.5	<6.5	9.1	1.0
5		10.7	35.0	<6.5	9.8	1.0
6		13.6	39.4	<6.5	10.1	1.0

Table 17. AQI Based on Pollutants detected during the experiment

Experiment	Pollutants			
	SPM ($\mu g/m^3$)	NO_2 ($\mu g/m^3$)	SO_2 ($\mu g/m^3$)	CO (ppm)
1 With lamp	500	500	<3	39
2	500	500	<3	33
3	500	500	<3	33
4 Without lamp	11	500	<3	11
5	10	500	<3	11
6	1	500	<3	11

Common complaints of traders in night markets include irritation and redness of the eyes by smoke, irritation of nostrils and impairment of breathing. Studies of the human health effects of air pollution carried out in China showed that air pollution suppresses the immunological function, decreases lung function and increases respiratory symptoms as well as respiratory disease (Yin, 1993).

7.5 Distribution of Ambient Suspended Particulates and Volatile Organic Carbon in a Fast Developing Metropolis in the Niger Delta, Nigeria (Emerhi, *et. al.*, 2012)

The concentrations of various sizes of suspended particulates and volatile organic carbons along selected roadsides and control sites in the fast developing city of Port Harcourt in the Niger Delta were determined at 0 m and 50m from roads during the dry and rainy seasons. The results showed highest concentrations of PM_1 (0.004mg/m^3), $PM_{2.5}$ (0.19 mg/m^3), PM_7 (0.715 mg/m^3), PM_{10} (0.829 mg/m^3), TSP (0.946 mg/m^3) and VOC (4.2ppm) in the dry season and PM_1 (0.004mg/m^3), $PM_{2.5}$ (0.28 mg/m^3), PM_7 (0.226 mg/m^3), PM_{10} (0.109 mg/m^3), TSP (0.129 mg/m^3) and VOC (1.2ppm) in the rainy season. The

differences between the dry and rainy season values were significant at $P \geqslant 0.05$. The concentrations of the pollutants measured at the high density areas were generally higher than the concentrations measured at low density areas; however PM_1, $PM_{2.5}$, PM_{10} and VOC showed significant differences with traffic density at $P \geqslant 0.05$. There was no significant difference between the mean concentrations measured at 0m and 50m. The results showed very strong relationship between PM_{10} and TSP in both season, PM_7 and TSP in the dry season as well as PM_1 with $PM_{2.5}$ and PM_7 in the rainy season implying similarity in sources of the particulates. The pollutants in the study area do not originate from the same sources as the correlations between $PM_{2.5}$ and other fractions as well as between the suspended particulates and VOC were very low with decreasing mean r = 0.2174PM_1, 0.2052 $PM_{2.5}$, 0.0591 PM_7, 0.0386 PM_{10} and 0.0209 TSP. The levels of VOC call for serious environmental concern as their concentrations at the high density stations exceeded permissible limit recommended by the Federal Environmental Protection Agency of Nigeria and United States. The levels of the pollutants were influenced by traffic density, seasonal variations and distances from major roads, therefore farming activities and consumption of exposed foodstuffs should be discouraged in the study areas.

Table 18: Mean Concentrations of Particulate Matter Measured at the Study stations

	Mean concentrations of Particulate Matters (mg/m^3)				
	PM_1	$PM_{2.5}$	PM_7	PM_{10}	TSP
Dry Season	0.0013^a	0.0922^a	0.0921^a	0.1109^a	0.1316^a
Wet Season	0.0007^b	0.0054^b	0.0350^a	0.0273^b	0.0359^b
High Density	0.0040^c	0.0267^c	0.2557^c	0.2313^c	0.0282^c
Low Density	0.0008^d	0.0067^d	0.0400^d	0.0683^d	0.0707^c
Distance (0m)	0.0011^e	0.0086^e	0.0686^e	0.0702^e	0.086^d
Distance (50m)	0.0016^f	0.0062^e	0.0548^e	0.0681^e	0.0816^d

Means with different superscript within columns are significantly different at $P \leqslant 0.05$ using DMRT

Table 19.AIR QUALITY INDEX (AQI)around Port Harcourt (Dry and Rainy season)

Station No	Station Code	Distance (m)	$PM_{2.5}$		PM_{10}	
			Dry	Wet	Dry	Wet
1	AR/GJ	0	52	69	55	61
		50	59	13	57	6
2	TA/PZ	0	50	17	44	19
		50	52	17	45	42
3	AR/EJ	0	63	84	58	35
		50	65	21	59	25
4	EW/EJ	0	63	84	58	35
		50	65	21	59	25
5	EW/RU	0	13	0	500	68
		50	17	13	500	6
6	IR/M3	0	50	13	24	15
		50	46	25	25	11
7	UST/F	0	13	4	51	3
		50	13	4	52	4
8	UST/E	0	25	21	17	28
		50	25	4	19	6
9	RR/EC	0	25	13	88	7
		50	29	13	89	8
10	LS/DB	0	38	1	35	7
		50	38	0	35	77
11	MP/DL	0	25	17	21	17
		50	29	21	22	19
12	GCSS	0	17	4	31	21
		50	17	4	33	3
13	EB/RA	0	21	4	22	17
		50	21	4	21	14

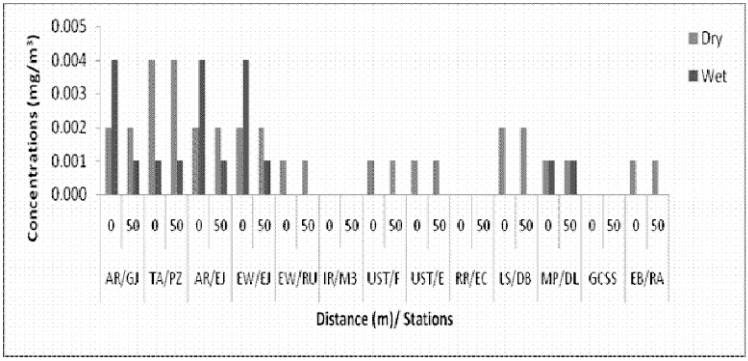


Fig. 7: Variations in concentrations of PM_1 with seasons, stations and distance

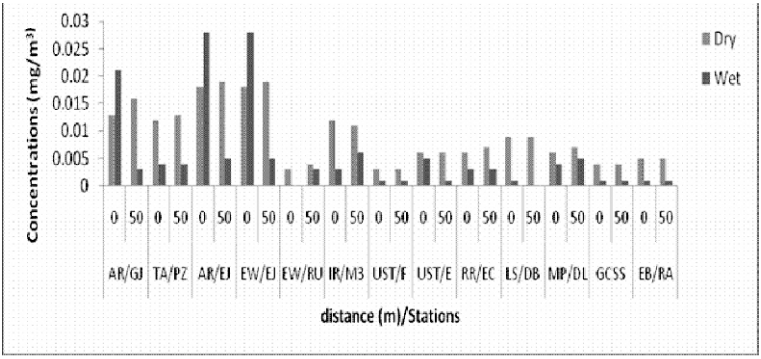


Fig. 8: Variations in concentrations of $PM_{2.5}$ with seasons, stations and distance

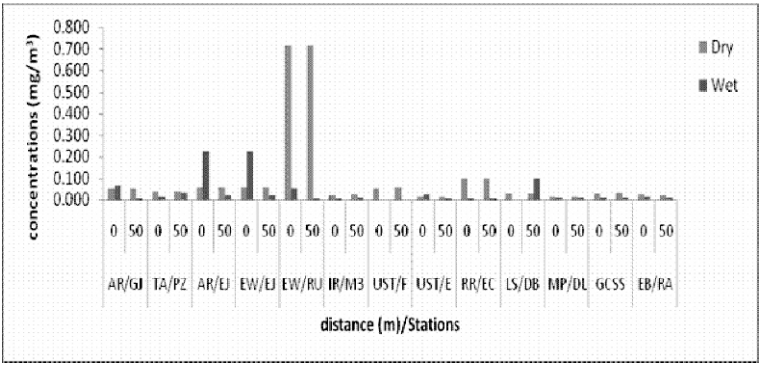


Fig. 9: Variations in concentrations of PM_7 with seasons, stations and distance

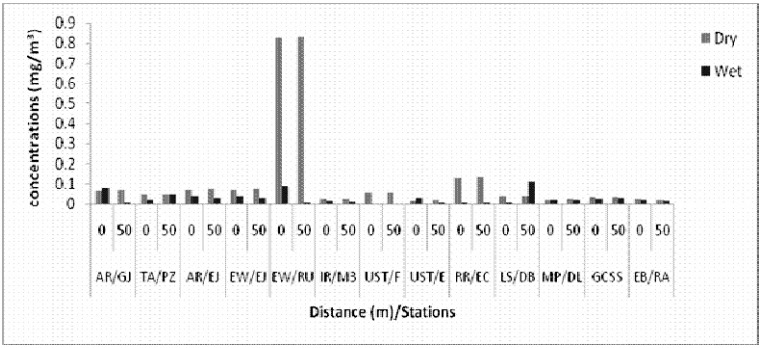


Fig. 10: Variations in concentrations of PM_{10} with seasons, stations and distance

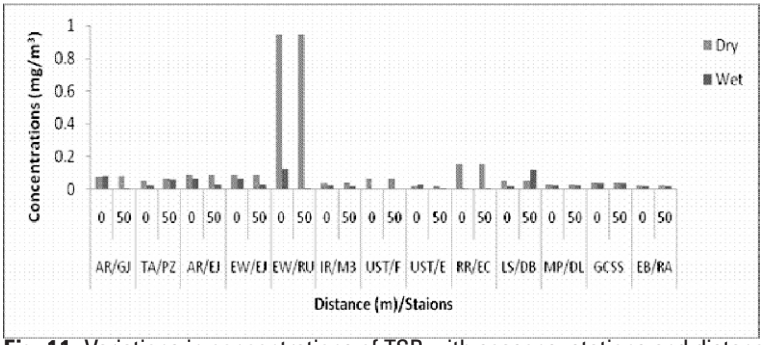


Fig. 11: Variations in concentrations of TSP with seasons, stations and distance

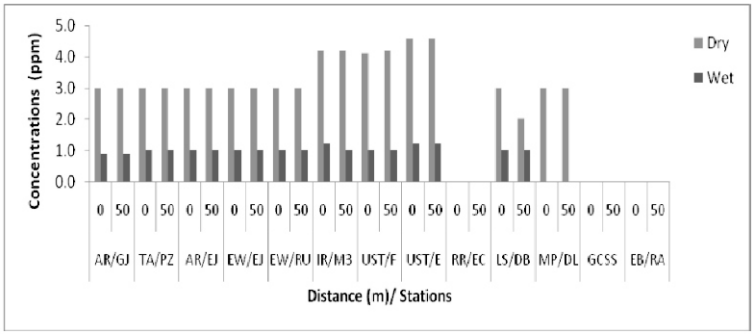


Fig. 12: Variations in concentrations of VOC with seasons, stations and distance

7.6 Ambient Air Quality Assessment of Rivers State University of Science and Technology Campus Air Basin Port Harcourt

(Ubong *et al.*, 2015)

Vice Chancellor Sir, in 2013 while discussing with the Commissioner for Environment in Rivers State concerning Environmental Impact Assessment (EIA) of FADAMA III project asked why we do not carry out EIA on the various structures springing up within the University but are always after other projects outside. We took it as a challenge and conducted EIA studies on Air, Boreholes water and Epidemiology within this University. This effort was supported by the University management in 2013. Sir, a similar proposal for monitoring is ready for submission to you for consideration. It is said **"Charity begins at home"**.

The measurement of air quality was done within Rivers State University of Science and Technology (RSUST) campus, Nigeria, to document levels of air pollutants and also ascertain the degree of alteration of fresh air on campus, which may to some extent, interfere with comfortable work and learning activities. The parameters measured within the University Campus were Sulphur dioxide (SO_2), Nitrogen dioxide (NO_2), Ammonia (NH_3), Carbon Monoxide (CO), Hydrogen Sulphide (H_2S), Methane (CH_4), Volatile Organic Compounds (VOCs), Respirable Particulate Matter (PM10, PM7, PM2.5, PM1) and Total Suspended Particulates (TSP).

The Shopping Complex air shed had the highest concentration of Particulate Matter (PM1 - 10 and TSP) while PM1 and TSP did not exceed allowable limits but PM2.5, PM7 & PM10 showed exceedances over international permissible limits.

Table 20: Particulate distribution at selected sites on RSUST campus in April, 2014, Port Harcourt

S/No	Stations	Coordinates	Suspended Particulate Matter fractions ($\mu g/m^3$)						$PM_{2.5}/PM_{10}$ Ratios	Ratio remarks
			Time pm	PM_1	$PM_{2.5}$	PM_7	PM_{10}	TSP		
1	Shopping Centre	04° 47′.493N	4.31	5	23	49	52	57	0.44	Outside range
		06° 58′ .918E		15	38	54	57	61	0.67	Within range
2	Main Gate	4° 48′ .229 N	4.54	1	6	18	23	27	0.26	Outside range
		06° 59′ .197E		2	7	31	43	54	0.16	Outside range
3	Main Library	04° 4′ .043 N	5.1	<1.0	5	22	23	24	0.22	Outside range
		06° 58′ .691E		<1.0	6	23	25	31	0.24	Outside range
4	Tech/Science Faculty	04° 47′.250N	5.3	<1.0	6	20	27	30	0.22	Outside range
		06° 58′ .892E		<1.0	6	20	26	31	0.23	Outside range
	Standards			**25.0***	**25.0***	**50.0***	**50.0***	**250****	**0.50.8**	**0.50.8***

Observed in other places ** National Standard * International WHO Standard

Table 21: Gaseous distribution at selected sites on RSUST campus in April, 2014, Port Harcourt (Concentrations in mg/m^3)

S/No	Stations	Coordinates	Concentrations in mg/m^3							Noise dB(A)	R/H (%)	Wind Speed (m/s)	Temp T. (℃)	Direction
			NO_2	SO_2	VOC	H_2S	CO	NH_3	CH_4					
1.	Shopping Centre	04° 47′ .493 N	0.167	0.38	35.0	0.01	4.58	0.27	4.0	74.5	65.7	0.1	31.0	N
		6° 58′ .918 E	0.169	0.38	35.4	0.02	4.59	0.27	4.0	75.6				
2	Main Gate	04° 48′ .229 N	0.164	0.46	32.2	0.01	6.56	0.27	3.0	73.4	67.2	0.3	31.0	NE
		06° 59′ .197 E												
3.	Main Library	04° 48′ .043 N	0.105	0.12	18.3	ND	0.26	ND	1.0	70.2	68.9	0.8	30.0	NE
		06° 58′ .691 E	0.105	0.13	19.4	ND	0.27	ND	1.0	70.3				
4.	Technical & Science	04° 47′ .250 N	0.145	ND	12.5	ND	0.16	ND	2.0	68.8	69.9	1.1	29.7	N
		06° 58′ .892 E	0.151	ND	12.6	ND	0.16	ND	2.0	67.7				

ND = Not Detectable

Table 22. AQI Based on Pollutants Measured within RSUST CAMPUS

Stations		$PM_{2.5}$	PM_{10}	NO_2	SO_2	CO
Shopping Centre	Northerly	73	47	87	0	19
	Easterly	106	51	88	0	19
Main Gate	Northerly	25	21	85	0	28
	Easterly	29	39	86	0	28
Main Library	Northerly	21	21	52	0	1
	Easterly	25	23	52	0	1
Tech./Science Faculty	Northerly	25	25	74	0	1
	Easterly	25	25	78	0	1

7.7 Air Quality Assessment around Selected Gas Flare Sites in Rivers State Nigeria

(Ideriah & Yusuf, 2017)

The quality of air around some gas flare sites in Rivers State, Nigeria was determined by measuring major air pollutants at different distances from the flare. Programmable Multi Gas Monitors, Gas Detection Tubes, Aerosol Mass Monitor Digital Anemometer and Compass were used. Five gas flare sites were selected for the assessment. The choice of the flare sites and sampling points were based on factors such as accessibility, wind direction, availability of open space, attitude of host communities, etc.

The highest concentrations of some pollutants such as TSP, NO_2, SO_2, H_2S and C_6H_6 exceeded Federal Ministry of Environment and United State EPA permissible limits. It was concluded that the quality of air around the flare sites is poor and gas flaring contributed to the levels of pollutants measured. Thus, there is need for regular monitoring.

The results of mean concentrations of air pollutants and AQI in the ambient environment of the various gas flare sites are presented in Tables 23 and 24 respectively.

Table 23: Mean Concentrations of Air Pollutants around some Gas Flares Sites in Rivers State

Location	TSP µg/m^3	PM_{10} µg/m^3	NO_2 ppm	SO_2 ppm	H_2S ppm	CO ppm	VOC ppm	C_6H_6 ppm
Oshie`	155.7 ± 78.9	47.4 ± 2.6	<0.1 ± 0	<0.1 ± 0	<0.2 ± 0	0.15± 0.06	<0.01± 0	<0.5 ± 0
Idama	156 ± 39.4	65.2± 16.4	<0.1 ± 0	<0.1 ± 0	<0.2 ± 0	0.15± 0.07	0.3 ± 0.3	<0.5 ± 0
Idu	163 ± 65.3	67.95± 27.2	<0.1 ± 0	0.15± 0.1	<0.2 ± 0	<0.1 ± 0	<0.1 ± 0	<0.5 ± 0
Obagi	109.2 ± 7.1	45.5 ± 3.0	0.15± 0.1	0.2± 0.14	<0.2 ± 0	0.2 ± 0.14	0.45± 0.5	<0.5 ± 0
Rumuekpe	166.1 + 90.3	69.2 + 37.6	<0.1 + 0	<0.1 + 0	<0.2 + 0	<0.1 + 0	<0.1 + 0	<0.15+ 0
FMEnv	250	250	0.04	0.01	0.0052	10	-	0.25
USEPA/ WHO*	150	*150	0.053	0.14/*0.5	*0.005	9	*2	*0.003

Table 24. AQI Based on Pollutants around some Gas Flares Sites in Rivers State

Location	PM_{10} µg/m^3	NO_2 ppm	SO_2 ppm	CO ppm
Oshie`	43	<46	0	2
Idama	55	<46	0	2
Idu	56	<46	0	1
Obagi	41	78	0	2
Rumuekpe	57	<46	0	1

7.8 Monitoring Ambient Particulate Matter in Eleme and Gokana Local Government Areas in Rivers State (Ideriah, 2018)

Vice Chancellor Sir, in 2018 and 2019 the levels and distribution of $PM_{2.5}$ and PM_{10} in six communities in Eleme and Gokana Local Government Areas were monitored. Particulate Matter ($PM_{2.5}$ and PM_{10}), micro meteorological parameters such as wind speed, wind direction, relative humidity, temperature and pressure were measured for twenty four hours (24hrs.) at two hours (2hrs.) intervals.The instruments used for sampling include Aeroqual digital hand held monitors and anemometer.

The study revealed that the highest and mean values of $PM_{2.5}$ as well as highest PM_{10} concentrations of the particulate pollutants measured in the ambient environment of the communities exceeded both the daily and annual recommended standard permissible limits.

Within the limits of the methods used, it was inferred that gas flaring, domestic and vehicular activities as well as illegal fossil fuel burning in the areas contributed to the levels of the particulate pollutants measured.

Mogho and Agbonchia communities were found to be more polluted with $PM_{2.5}$ and PM_{10}, Agbonchia having the highest particulates. The concentrations of PM_{10} were generally higher than those of $PM_{2.5}$ in all the locations.

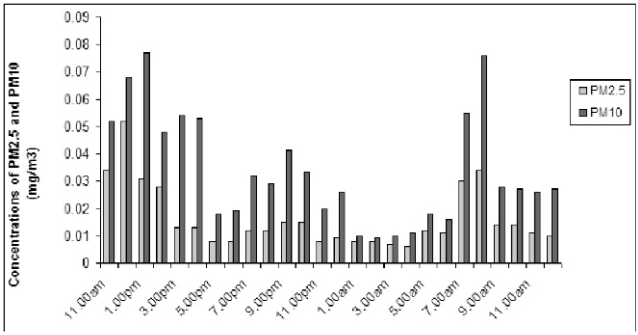


Fig. 13: Variations of Particulate Matter with Time at Bodo

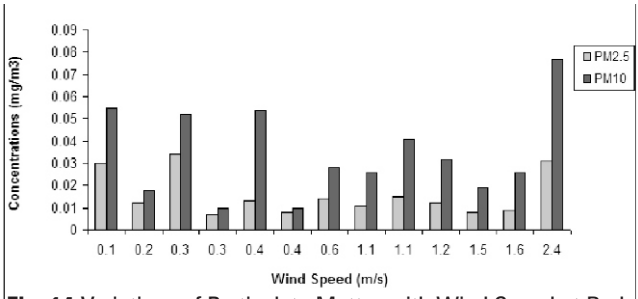


Fig. 14: Variations of Particulate Matter with Wind Speed at Bodo

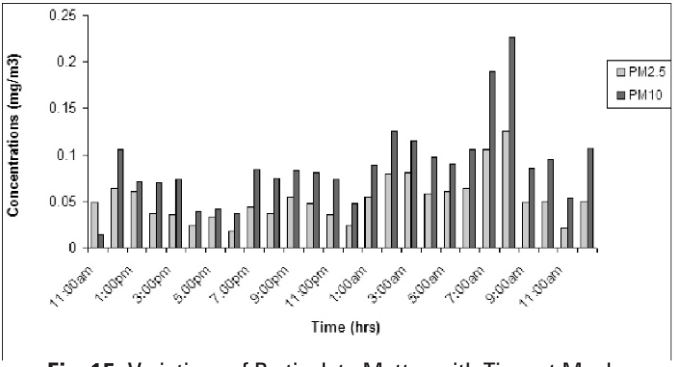


Fig. 15: Variations of Particulate Matter with Time at Mogho

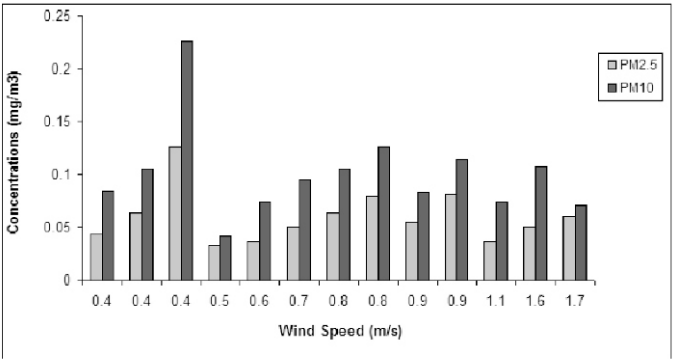


Fig. 16:Variations of Particulate Matter with Wind Speed at Mogho

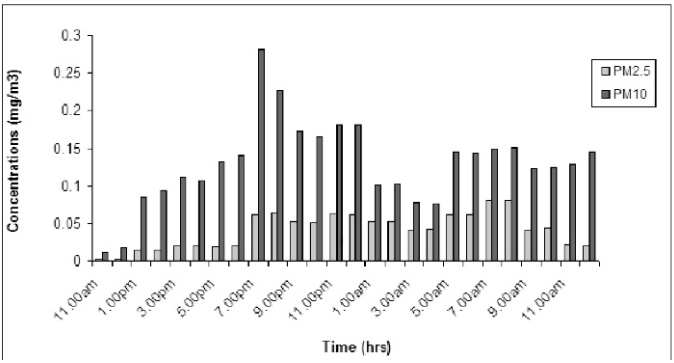


Fig. 17: Variations of Particulate Matter with Time at Onne

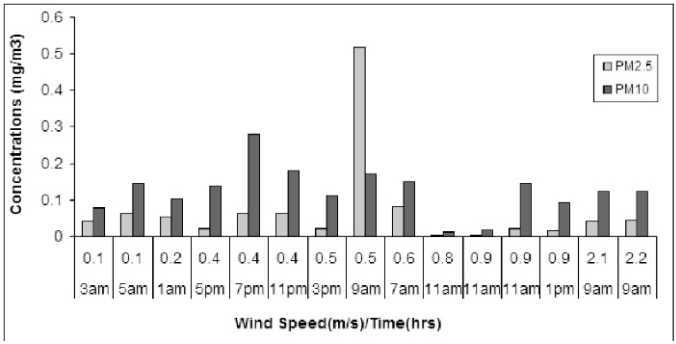


Fig. 18:Variations of Particulate Matter with Wind Speed and Time

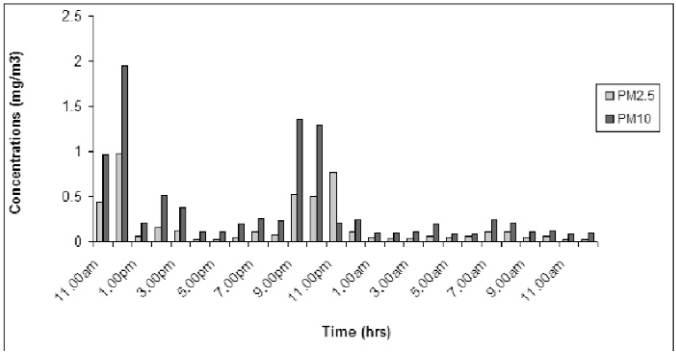


Fig. 19: Variations of Particulate Matter with Time at Agbonchia

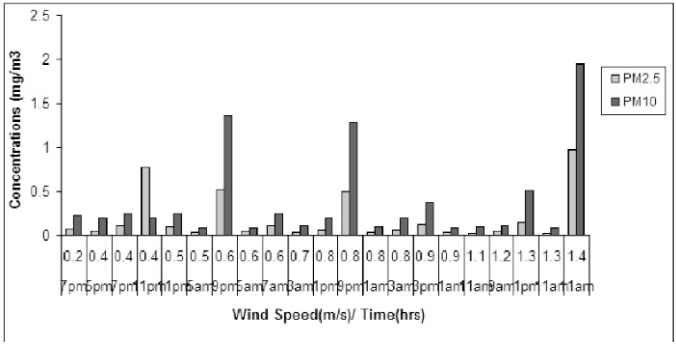


Fig. 20: Variations of Particulate Matter with Wind Speed/Time

AQI at BODO

S/no		
	$PM_{2.5}$	PM_{10}
1	97	47
	141	
2	90	61
	84	44
3	52	49
	52	48
4	33	16
	33	17
5	50	29
	50	26
6	56	37
	56	30
7	33	18
	38	24
8	33	9
	29	8
9	25	9
	50	10
10	46	16
	63	15
11	88	50
	97	61
12	54	25
	54	25
13	46	24
	42	25

AQI at Mogho

S/no		
	$PM_{2.5}$	PM_{10}
1	134	13
	154	75
2	152	58
	104	58
3	101	60
	76	35
4	95	38
	63	34
5	121	65
	104	60
6	149	64
	129	63
7	101	60
	76	43
8	146	67
	162	86
9	163	80
	151	71
10	152	68
	154	75
11	177	117
	187	136
12	131	65
	136	70
13	69	48
	136	76

AQI at Onne

S/no		
	$PM_{2.5}$	PM_{10}
1	13	10
	13	16
2	54	65
	56	69
3	67	78
	69	76
4	65	88
	67	93
5	153	163
	154	136
6	141	109
	139	105
7	154	114
	153	113
8	144	73
	141	74
9	114	61
	116	61
10	153	95
	153	94
11	163	98
	163	98
12	114	84
	121	85
13	71	87
	69	95

AQI at AGBONCHIA

S/no		
	$PM_{2.5}$	PM_{10}
1	456	500
	500	500
2	151	125
	206	406
3	187	233
	82	80
4	76	77
	144	121
5	177	150
	161	136
6	500	500
	500	500
7	500	124
	176	148
8	119	74
	111	69
9	106	77
	156	121
10	119	67
	149	66
11	176	146
	179	127
12	139	77
	156	83
13	71	68
	71	70

AQI at Deyor

S/no		
	$PM_{2.5}$	PM_{10}
1	4	2
	4	1
2	4	1
	4	1
3	4	1
	0	1
4	8	1
	4	0
5	13	2
	13	1
6	21	1
	13	6
7	13	6
	17	9
8	8	11
	4	10
9	8	13
	8	11
10	4	11
	4	8
11	21	10
	21	13
12	29	13
	38	8
13	38	8
	46	6
14	42	6
	46	1
15	33	1
	46	1
16	42	10
	42	1
17	29	1
	29	1
18	25	1
	21	1
19	8	1
	8	1
20	8	1
	8	1
21	4	1
	4	1
22	4	1
	4	1
23	8	1
	4	1
24	4	1
	4	1

AQI at Oghale

TIME	$PM_{2.5}$	PM_{10}
2.00pm	42	76
3.00pm	29	52
4.00pm	42	95
5.00pm	25	63
6.00pm	38	71
7.00pm	29	59
8.00pm	33	50
9.00pm	29	59
10.00pm	33	56
11.00pm	46	61
12.00am	52	63
01.00am	52	67
2.00am	63	78
03.00am	63	90
04.00am	67	95
05.00am	86	114
06.00am	61	109
07.00am	78	101
08.00am	46	69
09.00am	38	50
10.00am	25	56
11.00am	50	76
12.00pm	52	61
01.00pm	56	76
02.00pm	50	56

7.9 Assessment of Air Quality around Okrika Communities Rivers State Nigeria

(Gobo et. al., 2012)

The quality of air around Okirika communities in Rivers State were determined using portable hand held air monitors for air pollutants and anemometer for meteorological parameters. The parameters measured were suspended particulate matter, nitrogen dioxide, sulphur dioxide, hydrogen sulphide, ammonia, carbon monoxide, methane and volatile organic carbon, temperature, wind speed, wind direction and relative humidity. The dry season concentrations of air pollutants were higher than the rainy season concentrations. The observed differences in mean concentrations of the air pollutants between the two seasons were not significant in case of TSP ($P<0.05$) but were significant ($P<0.05$) in other pollutants. The highest mean concentrations of the gaseous pollutants exceeded permissible limits and therefore pose environmental and health concern for the inhabitants of the area. The quality of air in the area is poor and need to be regularly monitored. The AQI of the area are shown in Tables 26 and 27 for Dry and Rainy seasons respectively.

Table 25. Air Quality Index at Okrika Communities (Dry season)

	Suspended particulate matter (mg/m3)				
Station	$PM_{2.5}$	PM_{10}	NO_2 (ppm)	SO_2 (ppm)	CO (ppm)
Refinery	97	324	413	156	98
LG. council	65	53	28	398	113
Sec school	69	233	99	500	103
George Ama	93	116	99	156	92
Kalio Ama	76	67	119	198	153
A.T.C	56	74	119	156	120
oloma	61	55	99	156	11
Ibaka	88	58	119	398	26
Ogbogbo	101	29	9	156	19
Kiri Ama (control)	42	29	23	42	6

Table 26. Air Quality Index at Okrika Communities (Rainy season)

Station	Pollutants				
	$PM_{2.5}$ (mg/m^3)	PM_{10} (mg/m^3)	NO_2 (ppm)	SO_2 (ppm)	CO (ppm)
Refinery	25	50	99	111	19
LG. council	15	16	99	111	1
Sec. school	11	20	99	42	1
George Ama	15	18	99	111	1
Kalio Ama	33	56	99	111	1
A.T.C	8	28	99	111	1
Ogoloma	25	38	99	111	1
Ibaka	25	49	99	111	1
Ogbogbo	33	52	99	111	1
Kiri Ama (control)	4	9	99	36	0

A similar monitoring of the air quality at Bonny River Terminal (BRT) showed that all particulate and gaseous pollutants concentrations were below permissible limits while some trace elements exceeded limits as shown in Tables 28 and 29.

7.10 Air Quality at Bonny River Terminal

Table 27: Hourly mean concentrations of Air Pollutants measured around Mobil BRT in September 1998

Location	Pollutants							
	SPM $\mu g/m^3$	NO_2 g/m^3	SO_2 $\mu g/m^3$	NH_3 $\mu g/m^3$	H_2S $\mu g/m$	THC $\mu g/m^3$	CO ppm	CO_2 ppm
BRT	81.1 ± 0.03	11.7± 0.01	ND	26.4± 0.03	ND	7.3± 0.03	2.0± 0.02	310± 0
Kalaibiama	164.8 ± 0.05	7.8 ± 0.04	ND	ND	0.3± 0.01	9.6± 0.03	7.0± 0.03	315± 0.01
Peterside	235.6 ± 0.01	14.9± 0.02	ND	ND	ND	4.1± 0.03	7.5± 0.03	318± 0.02
Near Finima	111.5 ± 0.02	0.8 ± 0.03	ND	ND	ND	2.9± 0.03	1.0± 0.02	310± 0.01
Girls Sec. School Bonny	75.2 ± 0.03	16.4± 0.03	ND	ND	ND	4.3± 0.03	2.0± 0.04	325± 0.01
Bonny L.G.C	122.2 ± 0.02	36.0± 0.01	ND	ND	ND	7.6± 0.03	3.0± 0.02	325± 0.03
FMEnv.	250	75	260	200	8	160	10	325

ND = Not Detected

Table 28: Trace Elements concentrations in Air measured around Mobil Bonny River Terminal

Station No.	Trace Elements (ppm)								
	Fe	As	Ba	Cd	Cu	Hg	Cr	Zn	Pb
1.	5.02 0	BDL	BDL	0.008	0.18 9	BDL	0.004	92.24 0	0.005
3	2.71 0	BDL	BDL	0.008	0.106	BDL	0.005	57.8 00	0.006
4	5.49 0	BDL	BDL	0.010	0.101	BDL	0.006	93.44 0	0.080
5	7.43 0	BDL	BDL	0.012	0.161	BDL	0.014	187.14 0	0.069
6	9.217	BDL	BDL	0.017	0.220	BDL	0.016	121.14 0	0.135

BDL = Below Detection Limit

Simbi-Wellington and Ideriah (2020) assessed the effects of gas flaring at Awoba Flow Station on the air quality around mangrove forest ecosystem in Bille, Rivers State and reported high concentrations of NO_2, VOC, CO and CH_4. The quality of the air in the area is poor with respect to NO_2, VOC & NH3 that exceeded their WHO recommended limits. They recommended that the use of flaring to dispose unwanted gas should be discouraged and regular monitory of the pollutants should be encouraged.

Oweisana *et al,.*(2021) monitored the air quality around Omoku and Obrikun. They concluded that the communities were exposed to moderate to high concentrations of gaseous and particulate matter pollutants which may adversely affect the health of the people under prolonged exposure. They recommended regular monitoring, minimized gas flaring and health impact assessment of the pollutants.

Table 29: Air Quality Index for $PM_{2.5}$ from April 2019 to March 2020 at the Study Area

AQI (PM2.5) _USEPA NAAQS / DPR / FMEnv.

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	154	65.9	37.1	30.8	28.3	25.0	24.2	21.7	40.0	79.2	58.4	59.4
2	165	78.3	17.5	38.3	29.2	31.3	29.6	26.3	36.3	97.1	53.5	62.1
3	159	135	65.3	59.6	52.5	48.3	45.4	37.5	64.5	120	91.4	107
4	103	76.7	13.8	20.0	16.7	14.2	13.8	12.9	22.9	35.4	59.0	58.8
5	142	107	20.0	26.7	22.9	20.4	18.3	20.0	29.2	22.9	70.1	59.4
6	105	72.7	20.0	31.7	25.0	19.6	23.3	21.3	38.8	23.8	57.7	62.1
7	143	85.7	33.3	34.2	29.6	22.9	20.0	17.1	30.4	19.6	57.7	59.4
8	85.7	68.2	26.3	18.3	17.9	59.6	15.0	14.2	20.0	14.6	61.7	60.5

Table 30: Air Quality Index for PM_{10} from April 2019 to March 2020 at the Study Area

AQI (PM_{10}) _USEPA NAAQS / DPR / FMEnv.

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	103	31.3	14.9	10.2	10.1	9.44	9.17	13.4	15.8	10.9	23.1	26.4
2	116	31.7	7.96	13.6	11.9	11.1	11.1	13.1	16.4	16.5	19.3	28.1
3	137	77.2	54.1	32.1	31.1	27.8	28.1	34.9	53.0	28.4	107	119
4	72.8	29.1	5.19	8.80	8.89	7.78	7.50	7.13	8.61	10.7	23.2	28.3
5	76.2	33.7	12.8	10.5	10.6	8.89	8.33	7.22	11.8	18.1	30.0	26.3
6	60.8	28.5	14.0	16.2	16.8	11.8	10.6	12.8	15.5	7.04	21.6	28.1
7	63.4	29.3	13.2	11.4	11.0	11.4	10.2	8.89	12.4	5.28	19.2	28.7
8	63.4	28.9	7.50	6.57	6.85	6.48	6.48	5.65	4.54	5.93	25.6	27.0

Table 31: Air Quality Index for NO_2 from April 2019 to March 2020 at the Study Area

AQI (NO_2) _USEPA NAAQS / DPR / FMEnv

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	63.8	68.0	13.2	19.8	9.43	7.55	9.43	21.7	27.4	36.8	8.49	14.2
2	60.6	58.5	13.2	20.8	14.2	12.3	9.4	29.2	33.0	38.7	12.3	27.4
3	49.1	55.3	16.0	21.7	22.6	30.2	17.0	23.6	25.5	58.5	37.7	32.1
4	25.5	23.6	16.0	18.9	13.2	23.6	20.8	17.9	13.2	24.5	6.60	15.1
5	52.1	40.6	20.8	23.6	17.9	16.0	12.3	37.7	53.1	10.4	12.3	32.1
6	39.6	33.0	16.0	17.0	16.0	13.2	14.2	17.9	22.6	7.55	24.5	29.2
7	29.2	26.4	25.5	17.9	16.0	11.3	13.2	16.98	27.4	24.5	15.1	19.8
8	16.0	14.2	9.43	6.60	7.55	4.72	1.89	5.66	6.60	4.72	9.43	11.3

Table 32: Air Quality Index for SO_2 from April 2019 to March 2020 at the Study Area

AQI (SO_2) _USEPA NAAQS / DPR / FMEnv.

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	116	14.3	14.3	14.3	14.3	14.3	14.3	14.3	14.3	81.2	56.0	81.2
2	121	42.9	14.3	14.3	14.3	14.3	14.3	14.3	14.3	81.2	28.6	42.9
3	226	246	81.2	68.6	81.2	93.7	223	68.6	612	190	239.1	116
4	93.7	42.9	14.3	14.3	14.3	14.3	14.3	14.3	14.3	81.2	28.6	69
5	93.7	112	14.3	14.3	14.3	14.3	14.3	14.3	14.3	42.9	14.3	103
6	93.7	14.3	14.3	14.3	14.3	14.3	14.3	14.3	14.3	28.6	14.3	14.3
7	56.0	28.6	14.3	14.3	14.3	14.3	14.3	14.29	14.3	56.0	14.3	14.3
8	42.9	42.9	14.3	14.3	14.3	14.3	14.3	14.29	14.3	56.0	14.3	56.0

Table 33: Air Quality Index for CO from April 2019 to March 2020 at the Study Area

AQI (CO) _USEPA NAAQS / DPR / FMEnv.

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0.114	0.114	0.114	0.114	0.114	0.114	0.114	0.114	0.114	0.114	0.114	0.114
2	0.114	0.114	0.114	0.114	0.114	0.114	0.114	0.114	0.114	0.114	3.86	0.114
3	138	86.6	43.1	80.0	81.3	64.0	58.3	37.2	37.2	50.6	51.5	138
4	0.114	0.114	0.114	40.5	43.4	19.2	8.98	0.114	0.114	72.8	98.7	0.114
5	0.114	0.114	0.114	44.2	33.6	21.1	16.1	9.20	9.20	52.3	58.3	0.114
6	0.114	0.114	3.98	0.114	0.114	0.114	0.114	0.114	0.114	11.70	13.30	0.114
7	3.86	8.41	0.114	0.227	0.455	0.455	0.341	0.114	0.114	0.114	0.114	3.86
8	37.8	22.0	0.114	0.114	0.114	0.114	0.114	0.114	0.114	0.114	0.114	37.8

Table 34: Air Quality Index for O_3 from April 2019 to March 2020 at the Study Area

AQI (O_3) _USEPA NAAQS / DPR / FMEnv.

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5
2	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5
3	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5
4	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5
5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5
6	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5
7	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5
8	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5

8.0 MY CONTRIBUTION TO SOIL QUALITY MONITORING

8.1 The Concept of Soil Testing

Soil is a loose and friable material in which plants may or may not find a foothold and nourishment as well as other conditions of growth. It is composed of mineral matter, organic matter (both living and dead), water and air.

Soil testing can be likened to the use of thermometer in the medical profession. It aids in the diagnosis of production problems related to soil fertility and soil acidity.

In general, soil testing is the chemical or physical measurement/ analyses made on soil to assess the available nutrient status of the soil.

The objectives of soil testing are:

(1) to accurately determine the available nutrient status of soils.

(2) to clearly indicate to the farmer the seriousness of any deficiency in terms of various crops.

((3) to form the basis on which fertilizer needs are determined and

(4) to express the results in such a way that they permit an economic evaluation of the suggested fertilizer recommendations.

The chemical method and sampling techniques can be transferred from country to country but the research background required for valid interpretations and sound judgment usually cannot. Thus the success of a soil testing program is directly proportional to its research backing.

Soil testing program may be divided into six phases:

(1) Collecting the soil samples

(2) Extracting and determining the available nutrients

(3) Interpreting the analytical results

(4) Making fertilizer recommendations

(5) Evaluation of soil quality to determine the pollution status

(6) Monitoring remediation or clean-up measures where pollution occurred and remediating or treatment action taken

Therefore the success of a soil testing program depends as much on good individual judgment as it does on accurate chemical analyses.

8.2 SOIL QUALITY MONITORING

8.2.1 Heavy Metal Contamination of Soils along Roadsides in Port Harcourt Metropolis, Nigeria

(Ideriah et. al. 2004)

The results showing ranges and mean concentrations of the heavy metals are presented in Table 30. The concentrations of the heavy metals are higher at the road junctions than at the control stations. The concentrations of metals at the urban control are higher than those at the rural controls. This indicate the contributions of heavy metals by auto emissions from motor vehicles and other industrial emissions which are not available at the rural area where samples were collected. It is assumed that the amount of metals introduced from atmospheric fallout at the control stations is insignificant and is not likely to influence the

result substantially. In all the stations the concentrations of Pb were higher than those of the other metals. Pb is used as an anti knock compound (tetraethyl lead) in gasoline.

The distribution patterns were similar for all the metals except at stations located in residential and automobile workshop areas where high concentrations of metals, in particular Cu, Ni and Zn were found. This is as a result of identical sources of input. The concentrations of heavy metals generally decreased with increasing distance away from the road junctions. Linear regression analysis showed negative correlation ($r = -0.9577$) between metal concentrations in soil and distance. This shows that the major effect of traffic is limited to a narrow zone from the road. The heavy metal concentrations from high traffic density areas are higher than those from low traffic density areas. Linear regression analysis showed positive correlation ($r = 0.9162$) and t - test showed significant difference ($P<0.05$) between the metal concentrations from high and low traffic density areas. This shows the contributions of emissions from automobiles to metal concentrations in the samples. The results obtained from soils along roadsides in Port Harcourt are differentiated according to the traffic density and compared with estimated background levels on Table 30.

The mean, concentrations of Cu and Ni at the heavy traffic density areas were above the background levels. It is also shown that the mean Metal concentrations decreased with decreasing traffic density. Although the concentrations of most metals are highest at the heavy traffic density areas the levels of metals obtained in the

low density and urban control areas indicate that in addition to auto emissions, metal parts and domestic wastes contributed to the distribution of the metals.

Table 35. Heavy metals concentrations (ppm) in roadside soils along different traffic density areas in Port Harcourt

Metal	Heavy density	Low density	Control	Estimated background level
Cu range	10.8 - 88.7	3.6 - 18.4	1.7 – 6.9	29
Mean	37.23 ± 15.88	11.97 ± 2.48	3.34± 1.25	
Cr range	18.7 - 95.7	3.0 - 25.6	1.1 - 7.2	88
Mean	44.24 ± 17.29	12.51 ± 3.90	3.58 ± 2.22	
Ni range	6.7 - 45.5	2.1 - 13.8	0.6 - 5.4	6
Mean	23.63 ± 8.06	7.10 ± 1.93	2.29 ± 1.90	
Pb range	15.9 169.5	7.5 39.5	1.4 10.4	83
Mean	60.63 ± 29.58	18.96 ± 4.11	4.0 ± 3.22	
Zn range	13.8 - 93.8	5.3 - 50.3	4.7 - 22.5	42
Mean	40.10 ± 15.86	27.87 ± 13.37	14.05 ± 6.03	

8.2.2 Soil Quality around a Solid Waste Dumpsite in Port Harcourt, Nigeria (Ideriah *et. al.* 2006)

This study carried out at Eastern By pass near Marine Base in Port Harcourt showed that waste dumps contribute to the concentrations of nutrients, heavy metals and other soil parameters. The accumulation of nutrients results in the luxuriant growth of plants/crops on the waste dump. The increased moisture content of the soils in the wet season increased microbial activities, which probably resulted in increased nutrients and hence increased organic matter as possible chelating agents. Tilling of the soils by farmers and addition of fresh dumps influenced the variations in particle sizes. Large quantities of decomposed organic materials and agricultural activities significantly

influenced the texture of soils around the waste dumpsite. The presence of liming materials and activities of micro-organisms on the waste dump probably increased the pH of the soils while the formation of organic acids as a result of high decomposition of plant residues outside the main dump lowered the pH values. The concentrations of potassium increased in the wet season, probably as a result of farming activities on the waste dump. The low values of C/N ratios show high decomposition and efficient mineralization process in the area. The texture of soils, high levels of organic matter, available phosphorus, total nitrogen and pH probably influenced the availability and mobility of the metals. Metal concentrations in soil increased with distance from the major traffic road. Thus, road traffic is not the major source of lead around the waste dump.

Table 36. Variations of soil parameters and heavy metals at Eastern by-pass waste dumpsite (dry season)

	Parameters										
Sample code	pH	Org.M (%)	K (meq per 100g)	ECEC (meq per 100 g)	TN (%)	Av.P (pg g^{-1})	C/N	Cd (pg C^{l})	Ni (pg	(pg g^{-1}) Pb	Textural class
EBNS1	6.0	6.21	1.92	27.41	0.10	28.42	36	0.56	3.50	23.00	Sand
EBNS2	8.4	4.00	2.00	28.50	0.03	11.25	35	1.30	4.50	27.00	Loamy sand
EBNS3	9.4	2.00	2.21	25.00	0.02	5.00	40	1.90	5.50	87.00	Loamy sand
EBNS4	9.1	5.45	2.00	22.30	0.05	7.20	45	1.50	3.50	17.00	Loamy sand
EBNS5	7.9	5.40	1.10	22.50	0.04	7.55	43	2.46	8.00	58.50	Loamy sand
EBNS6	8.9	5.50	2.18	28.38	0.08	12.10	40	0.56	3.50	22.00	Loamy sand
EBNS7	8.4	5.83	1.41	44.76	0.09	19.45	38	1.50	3.50	43.00	Loamy sand
EBNS8	8.5	6.00	1.28	45.50	0.15	19.65	35	0.56	2.00	56.00	Loamy san
EBNS9	6.5	6.55	1.00	46.00	0.17	20.00	37	0.76	3.50	27.50	Loamy sand
EBNS10	5.1	5.85	0.86	44.50	0.19	20.50	38	2.26	3.50	27.50	Loamy sand
EBSS1	5.7	1.43	0.15	3.50	0.02	10.25	42	0.06	0.50	6.00	Sand
EBSS2	6.3	3.00	1.32	20.00	0.03	8.50	60	0.40	5.50	25.00	Loamy sand
EBSSd1	6.3	0.78	1.10	12.56	0.02	12.85	23	0.50	2.50	4.00	Sand
EBSSd2	8.1	0.30	0.72	10.00	0.01	8.00	42	0.06	0.50	7.50	Loamy sand
UCS1	4.7	0.50	3.58	10.50	0.03	8.50	27	88.00	8.00	4.00	Loamy sand

Org.M= organic matter; ECEC= effective cation exchange capacity; TN= total nitrogen; Av.P= available phosphorus

Table 37. Variations of soil parameters and heavy metals at the Eastern by-pass waste dumpsite (wet season)

Sample code	Parameters										
	pH	Org.M (%)	K (meq per 100 g)	ECEC (meq per 100 g)	TN (%)	Av.P (pg g^{-1})	*C/N*	Cd (pg g^{-1})	Ni (pg g^{-1})	Pb (pg g^{-1})	Textural class
EBNS1	8.1	5.53	2.31	31.26	0.06	15.00	54	1.30	3.50	12.50	Sandy loam
EBNS2	7.4	4.55	2.40	29.78	0.04	12.15	48	0.55	4.00	105.00	Sandy loam
EBNS3	7.9	2.10	2.56	28.88	0.03	5.30	41	1.90	4.00	105.00	Sandy loam
EBNS4	6.5	6.33	1.65	24.00	0.09	7.78	46	4.90	22.00	105.00	Sandy loam
EBNS5	7.1	6.22	2.34	24.65	0.08	8.20	44	1.70	16.00	27.50	Loamy sand
EBNS6	7.9	5.19	2.44	21.29	0.07	7.25	43	2.05	20.00	72.50	Loamy sand
EBNS7	8.0	5.05	3.97	33.19	0.09	8.45	33	1.70	9.50	52.50	Sand
EBNS8	7.6	6.40	2.50	35.25	0.12	8.99	35	0.95	10.50	*25.00*	Sand
EBNS9	7.4	6.75	3.77	35.84	0.17	9.35	37	1.15	7.00	17.50	Loamy sand
EBNS10	7.4	6.50	3.97	34.90	0.20	9.68	38	0.95	53.00	12.50	Loamy sand
EBSS1	6.3	2.17	0.29	13.32	0.02	12.30	63	0.55	1.00	0.50	Sand
EBSS2	7.8	4.83	2,69	25.59	0.03	10.13	93	4.70	9.00	245.00	Loamy sand
EBSSd1	8.25	0.39	0.05	10.24	0.01	8.57	26	0.40	2.00	2.50	Loamy sand
EBSSd2	4.0	4.03	0.15	20.26	0.05	12.25	47	0.40	2.00	2.50	Sand
UCS1	6.1	3.50	1.03	25.45	0.03	0.85	45	85.00	9.00	6.00	Loamy sand

Org.M= organic matter; ECEC= effective cation exchange capacity;
TN= total nitrogen; Av.P= available phosphorus.

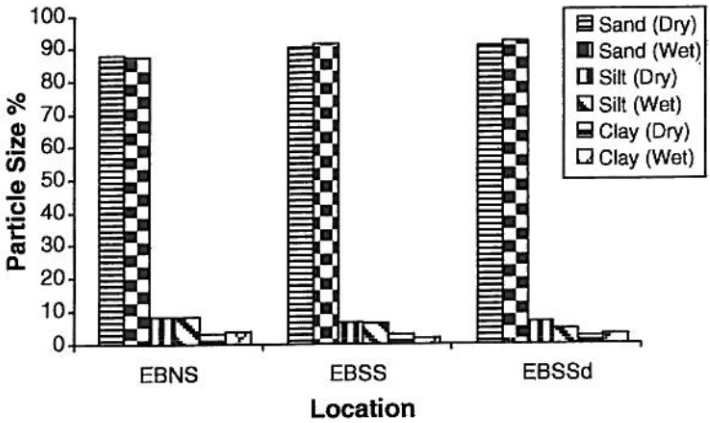
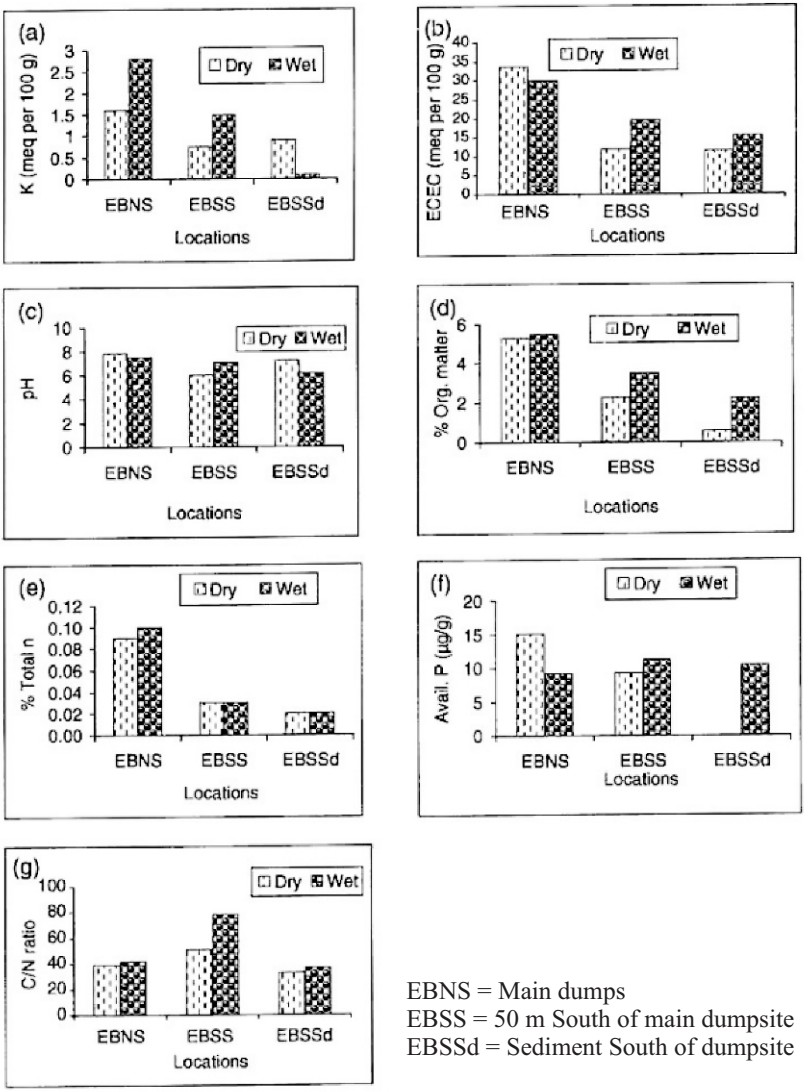


Fig. 21: Seasonal variations in particle size at Eastern by-pass dumpsite.



EBNS = Main dumps
EBSS = 50 m South of main dumpsite
EBSSd = Sediment South of dumpsite

Fig. 22: (a—g) Seasonal variations in concentrations of soil properties at Eastern by-pass dumpsite

A similar study on heavy metals contamination of soils around municipal solid wastes dumps in Port Harcourt, Nigeria by Ideriah et. al.(2005) noted that Port Harcourt waste dump (disposal) sites are situated on agricultural lands, open spaces, burrow pits and close to rivers or water bodies and untreated wastes from all sources are dumped at the same site. They concluded that wastes contributed to the levels of metals, road traffic is not the major source of lead around the dump sites and the concentrations of cadmium copper exceeded permissible limits and could adversely influence human health since vegetables and crops luxuriantly growing on the waste dump are continuously consumed.

8.2.3 Evaluation of Soil Quality in Parts of Israel and Nigeria (Ideriah, 2019)

Vice Chancellor Sir, I had the privilege to be in Israel on pilgrimage in 2010 and while on tour of historic sites the tour guide talked about the Keybuts who are farmers in the area. I was surprised but interested at the luxuriant growth of plants especially vegetables on the type of dry, patchy and reddish soils. As an Environmentalist I was inspired to compare their soils with soils in my home country Nigeria, Rivers State in particular and found amazing results. Thus I referred to the trip as both Spiritual and Environmental Knowledge gains.

Thus I referred to the trip as both **Spiritual and Environmental Knowledge gains**

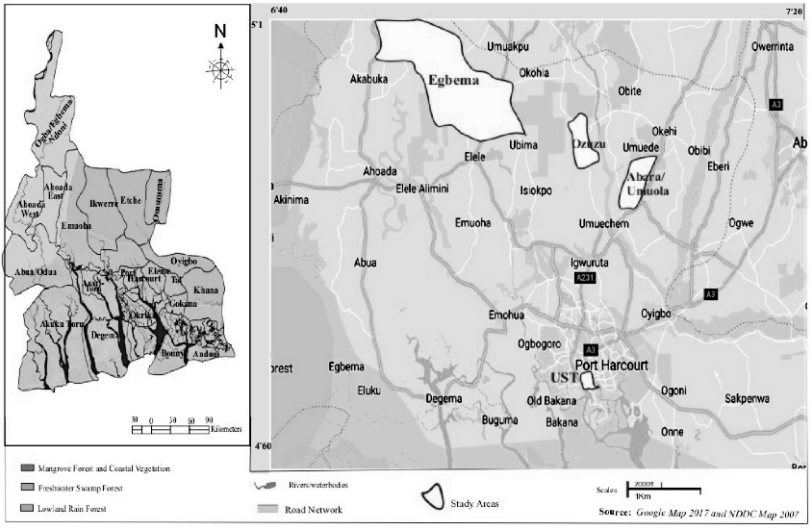


Fig. 23: Map of Rivers State Nigeria showing the Study Areas

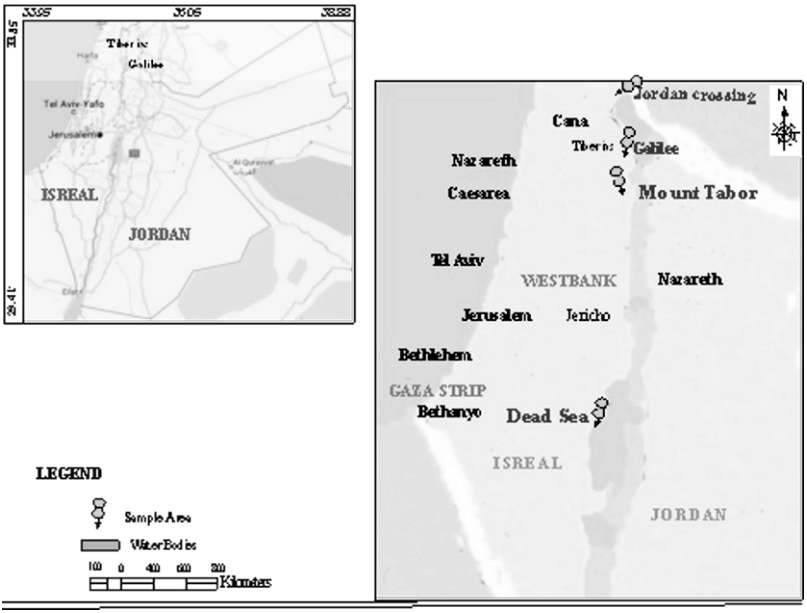


Fig. 24: Map of Israel showing Study Areas

The levels of physiochemical parameters and some heavy metals in top soil and sediment from parts of Israel and Nigeria were determined using standard methods and AAS by GBC 2.0.

The findings from this study have shown that the soils in Nigeria are acidic and nutrient-deficient as most of the values were below permissible limits while soils from Israel are alkaline. The observed soil pH can influence nutrient absorption and plant growth through its influence on nutrient availability and the presence of toxic ions. The concentrations of heavy metals especially the high Fe and Mn values obtained show that the acidic condition of the soils increased the solubility and availability of these metals.

The soils in Nigeria need application of land amendment materials such as organic wastes (from plants and animals) than soils in Israel as the soil physicochemical properties show that all the soils of the study areas in Nigeria are acidic and low in Organic Matter, Total Nitrogen, Available Phosphorus and Exchangeable Bases while those in Galilee and Mt. Tabor in Israel are moderate. The levels of exchangeable bases, exchangeable acidity and ECEC were higher in soils from Israel than Nigeria and highest in Dead Sea sediment than soil from both countries.

Soil Metal Index

The soil pollution level and its variation along the station were determined using soil metal index (SMI) which compares the pollution status of the different stations.

The soil metal index (SMI) for each sampling station was calculated by dividing the ratio of the heavy metal

concentration in the soil sample to the standard value of the metal for each metal.

The sum of the value obtained was divided with the number of metals investigated. The result was multiplied by 100.

$$SMI = \frac{\left(\frac{C_1}{S_1} + \frac{C_2}{S_2} + \cdots + \frac{C_n}{S_n}\right)}{n} \quad (1)$$

Where C in mg/kg is the concentration of the metal at a station and S in mg/kg is the standard (reference) concentration of the metal and n is the number of metals determined.

The SMI >100% indicates polluted soils while the SMI<100% indicates unpolluted soils.

Enrichment Factor (EF)

The enrichment factor (EF) of metals is a useful indicator of the station and degree of the environmental contamination (Feng et. al., 2004). The EF compares each value with a given standard level. The EF was calculated using the method of Sinex & Helz (1981) shown below.

$$\text{Enrichment Factor (EF)} = \frac{\left(\frac{\text{Me}}{\text{Fe}}\right)_{\text{sample}}}{\left(\frac{\text{Me}}{\text{Fe}}\right)_{\text{standard}}} \quad (2)$$

Where (Me/Fe)sample is the metal to Fe ratio in the sample of interest; (Me/Fe)standard is the permissible value of the metal to Fe ratio. Iron is used for normalization because natural sources (1.5%) greatly dominated its input.

Where EF < 2 is deficiency to minimal enrichment; EF = 2-5 is moderate enrichment; EF = 5-20 is significant and EF > 40 is extremely high enrichment (Mmollawa et. al., 2011).

Table 38: Mean Concentrations of Physicochemical Parameters in Soils and Sediment in Israel and Nigeria.

Parameters	Jordan	Mt. Tabor	Galilee	Deadsea sediment	Umuola	Ozuzu	Egbema	Port Harcourt
pH	7.30±0.2	7.30±0.03	8.08±0.001	5.78±0.4	6.40±00.1	6.70±0.2	5.4±0.32	5.3 ± 0.1
Organic carbon(%)	1.61±0.1	2.54±0.02	7.83±0.02	0.02±0.3	0.64±0.6	1.12±0.5	1.56±0./4	1.25 ±0.07
Organic matter %)	2.78±0.2	4.39±0.01	13.49±0.03	0.04±0.09	1.10±0.7	1.93±0.8	2.69±0.9	2.16±0.2
Total N. (%)	0.03±0.01	0.96±0.1	0.12±0.04	0.05±0.08	0.05±0.7	0.10±0.6	0.14±0.2	0.09 ± 0.02
C:N Ratio	53.67±0.3	2.65±0.2	65.25±0.05	0.4±0.07	12.8±0.8	11.2±0.9	11.14±0.1	13.89±0.5
Available P. (ppm)	3.51±0.1	14.04± 0.3	70.18±0.06	1.40±0.06	14.04±0.3	64.6±0.2	14.0±0.1	58.74±7
Mg (meq/100g)	2.40±0.4	16.60±0.4	9.80±0.07	67.60±0.05	1.80±0.4	1.60±0.5	1.56±0.6	0.76 ± 0.20
Ca (meq/100g)	14.20±0.5	40.20±0.5	32.60±0.08	50.80±0.04	3.20±0.9	4.80±0.8	5.42±0.7	3.44 ± 0.08
Na (meq/100g)	1.09±0.02	2.17±0.6	2.72±0.09	39.35±0.03	1.35±0.01	1.09±0.02	1.10±0.03	0.43 ± 0.03
K (meq/100g)	0.64±0.6	2.05±0.7	2.31±0.1	5.74±0.02	0.07±0.06	0.07±0.05	0.08±0.04	0.06 ± 0.00
Ex.Acidity(cmd/kg)	0.24±0.02	0.72±0.8	0.32±0.2	0.80±0.01	0.40±0.03	0.32±0.02	0.36±0.01	0.55± 0.05
Ex.Al (cmol/kg)	0.11±0.5	0.35±0.9	0.16±0.3	0.40±0.1	0.16±0.4	0.08±0.3	0.12±0.2	0.20±0.1
ECEC (cmol/kg)	19.82±0.7	61.71±0.01	48.16±0.4	164.29±0.2	6.90±0.5	7.88±0.6	3.64±0.7	5.32±0.8
BS (%)	98.73±0.3	98.33±0.02	99.34±0.5	99.86±0.3	93.04±0.1	95.94±0.3	94.62±0.7	91.86±0.9
Cl^- (ppm)	47.61±0.1	156.13±0.03	121.82±0.6	9798.00±0.4	22.64±0.5	82.52±0.1	43.41±0.9	116.34±0.5
SO_4^{2-} (ppm)	1.96±0.03	0.410±0.04	5.0±0.7	184.61±0.5	1.54±0.2	0.912±0.1	0.542±0.6	8.48 ± 0.0
NO_3^- (ppm)	0.062±0.04	0.212±0.05	0.160±0.8	14.00±0.6	0.08±0.3	0.150±0.4	0.112±0.5	0.03 ± 0.0
Silt (%)	1.28±0.05	19.15±0.06	15.28±0.9	4.52±0.7	12.0±0.8	4.0±0.7	3.0±0.6	3.8 ± 0.0
Clay (%)	2.48±0.06	22.42±0.07	22.48±0.09	5.2±0.8	13.20±0.2	3.2±0.3	12.0±0.4	7.8 ± 0.0
Sand (%)	96.24±0.07	60.43±0.08	62.24±0.07	90.28±0.9	74.80±0.8	92.8±0.7	85.0±0.6	88.4±0.5
Textural class	S	CL	SCL	S	LS	S	LS	S

S=Sand, CL=Clay Loam, SCL=Sandy Clay Loam, LS=Loamy Sand.

Table 39: Heavy Metal Concentrations (ppm) in Soils and Sediment in Israel and Nigeria.

Parameters	Jordan	Mt. Tabor	Galilee	Dead sea Sediment	Umuola	Ozuzu	Egbema	Port Harcourt	Standards
Mn	20.77	25.06	23.91	31.69	8.970	170.40	0.01	19.25 ± 0.60	2000
Cr	1.65	1.62	2.74	1.46	0.18	0.29	0.24	0.16 ± 0.06	100
Fe	214.33	286.34	816.75	78.28	26.74	1.07	402.37	2.05	50000
Ni	2.95	2.09	3.05	0.93	0.06	0.08	0.03	0.35 ± 0.23	50
Cd	1.13	0.04	0.94	0.09	0.01	0.01	0.02	0.72 ± 0.20	3
Pb	7.78	0.09	7.54	0.05	9.37	12.30	0.01	3.15 ± 2.56	100
Zn	2.69	1.95	5.05	2.05	23.92	35.30	1.80	32.63 ± 0.54	300
Cu	0.58	0.85	0.75	0.52	12.60	8.76	0.90	6.42 ± 0.32	100
SMI	0.0698	0.0132	0.06617	0.01643	0.0417	0.05262	0.00402	0.0578	

TABLE 40: Enrichment Factor Values of Heavy Metals at the Study Areas

Para-meters	Jordan	Mt Tabor	Galilee	Dead sea Sediment	Umuola	Ozuzu	Egbema	Port Harcourt
Mn	2.423	2.188	0.732	10.121	8.386	3981.308	0.00062	234.7561
Cr	3.849	2.829	1.677	9.325	3.366	135.514	0.298	39.0244
Ni	13.773	7.299	3.734	11.88	2.244	74.766	0.075	170.7317
Cd	87.871	2.328	19.182	19.162	49.863	155.763	0.828	5,853.66
Pb	18.15	0.157	4.616	0.319	175.21	5747.66	0.0124	768.293
Zn	2.092	1.135	1.031	4.365	149.09	5498.44	0.746	2652.845
Cu	1.3531	1.484	0.459	3.321	235.612	4093.458	1.118	1565.854

TABLE 41: Soil Metal Index (x 100) of Heavy Metals at the Study Areas

Parameters	Jordan	Mt Tabor	Galilee	Deadsea Sediment	Umuola	Ozuzu	Egbema	Port Harcourt
Mn	0.010	0.013	0.012	0.016	0.004	0.085	0.000	0.010
Cr	0.016	0.016	0.027	0.015	0.018	0.003	0.002	0.002
Fe	0.004	0.006	0.016	0.002	0.001	0.000	0.008	0.000
Ni	0.059	0.042	0.061	0.019	0.001	0.002	0.001	0.007
Cd	0.376	0.013	0.313	0.030	0.026	0.003	0.006	0.240
Pb	0.078	0.001	0.075	0.001	0.094	0.123	0.000	0.032
Zn	0.009	0.007	0.017	0.007	0.080	0.118	0.006	0.109
Cu	0.006	0.009	0.008	0.005	0.126	0.088	0.009	0.064
TOTAL SMI	0.070	0.013	0.066	0.016	0.042	0.052	0.004	0.058

The textural classes of the soils and sediment were sand at Jordan and Dead sea in Israel and Ozuzu and Port Harcourt in Nigeria while soils at Umuola and Egbema in Nigeria were loamy sand. The soils at Mt.Tabor and Galilee were found to be clay loam and sandy clay loam respectively. This indicate that the soils and sediment from Jordan, Dead sea in Israel and Ozuzu and Port Harcourt in Nigeria have low fertility, permeable and high nutrient leaching. The soils from Mt. Tabor, Galilee, Umuola and Egbema could be rated more fertile with high nutrient holding capacity. The light and/or pale colour of the soils and sediment from Jordan, Dead sea,

Ozuzu and Port Harcourt could be responsible for their high sand contents while the soils at Galilee, Mt. Tabor and Egbema have shades of red due to their clay and iron contents.

The C:N ratio ranged from 2.65 – 65.25 with a mean of 40.52±19.23 in soils and 0.4 in Deadsea sediment in Israel while it ranged from 11.2 – 13.89 with a mean of 12.26±0.67 in Nigeria. Carbon to Nitrogen ratio is an indicator of nitrogen mineralization and accumulation in soils. Ideriah *et. al*. (2005); Ideriah & Ideriah, (2006) reported low range of C:N ratios for soils in the Niger Delta region of Nigeria. According to Brady & Weil (1996), C/N ratio in the Topsoil is commonly between 10 and 12 in humid regions. The low range in Nigeria implies high decomposition and mineralization in the area. If the ratio is below 20, mineralization will be higher than immobilization (Brady & Weil (1996).

A t-test showed significant difference ($p<0.05$) in the mean levels of the parameters measured between Israel and Nigeria.

Generally the SMI values obtained were below 100% suggesting that the soils of the study areas though contaminated are unpolluted with heavy metals. The spatial variation of SMI reflects effect of anthropogenic activities in the enrichment of heavy metals.

The enrichment factor (EF) was used to quantify the level of the potential anthropogenic effects in soils from the study areas. The EF values increase with the contributions of anthropogenic sources (Emad & Abdelaal, 2015). The EF > 1 indicates that the abundance of the heavy metals in the soil may not come from the local soil background but other natural and/or anthropogenic sources such as vehicle emissions, industrial emissions, etc (Thornton, 1991). The EF < 5 though not significant, indicates metal accumulation while EF > 5 indicate soil contamination for related metals.

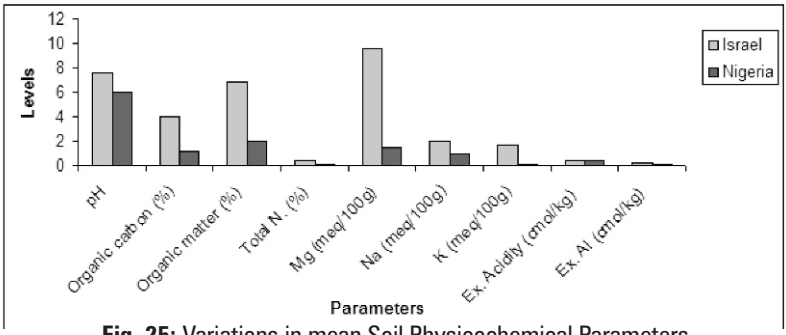


Fig. 25: Variations in mean Soil Physicochemical Parameters

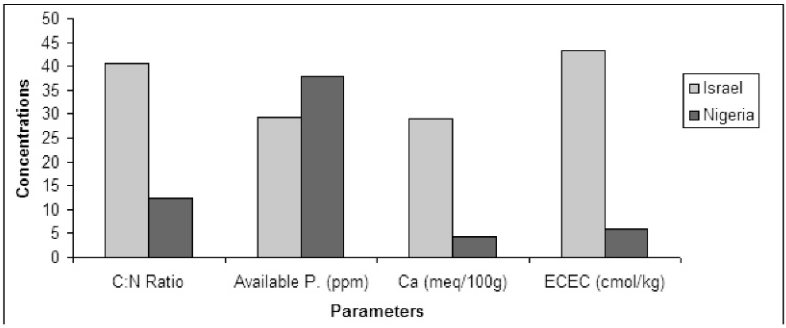


Fig. 26: Variations in mean Soil Physicochemical Parameters

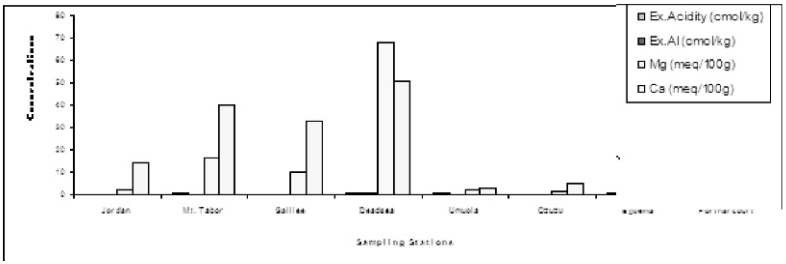


Fig. 27: Variations of Physicochemical Parameters with Stations

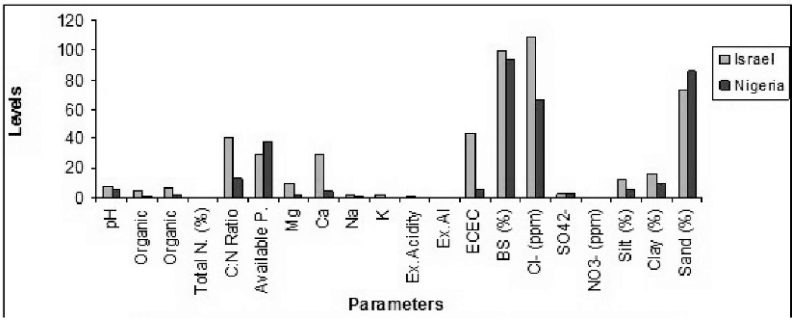


Fig. 28: Comparison of Mean Levels of Physicochemical Parameters from Israel and Nigeria

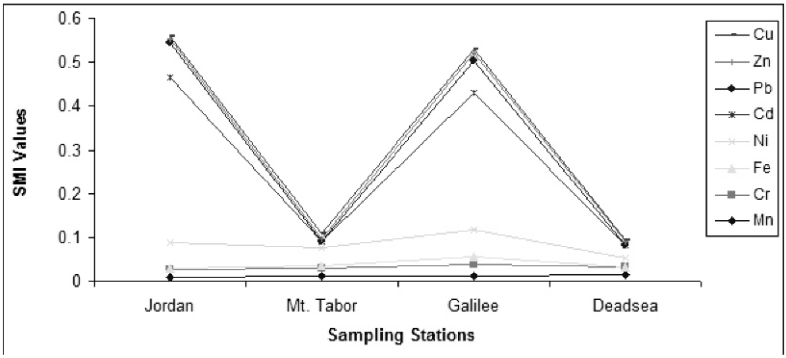


Fig. 29: Variations of SMI Values with Stations in Israel

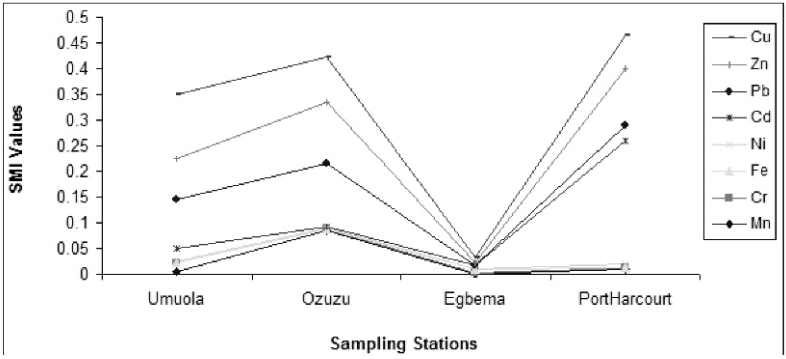


Fig. 30: Variations of SMI Values with Stations in Nigeria

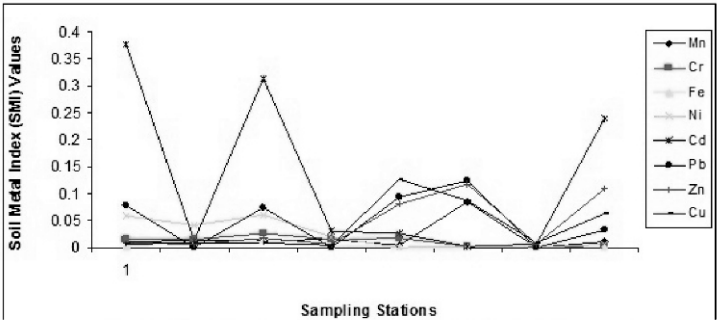


Fig. 31: Variations of Soil Metal Index (SMI) at the Study Areas

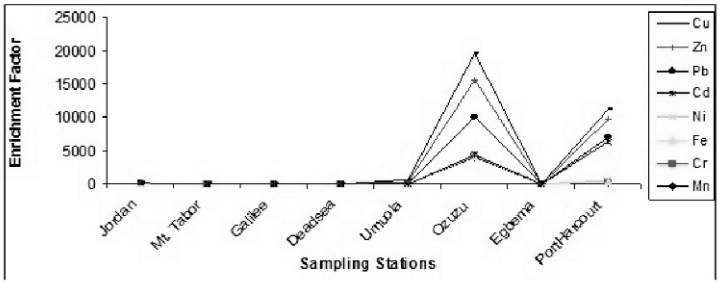


Fig. 32: Variations of Enrichment Factor of Heavy Metals in Soils from the Study Areas

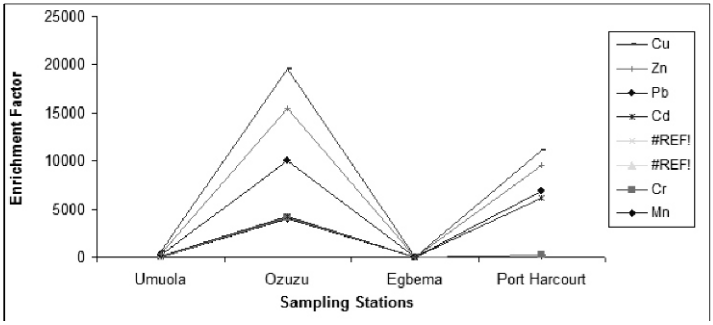


Fig. 33: Variations of Enrichment Factor in Nigeria

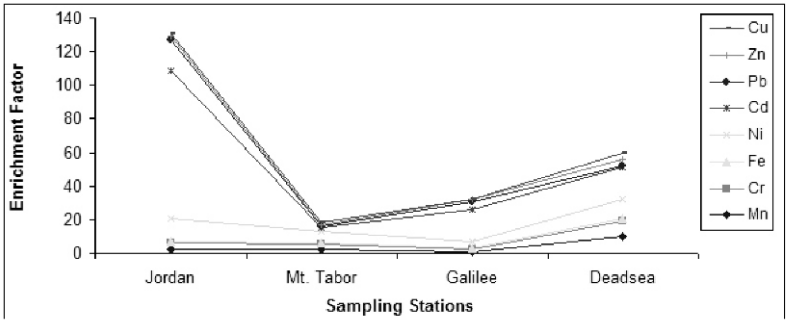


Fig. 34: Variations of Enrichment Factor of Heavy Metals in Israel

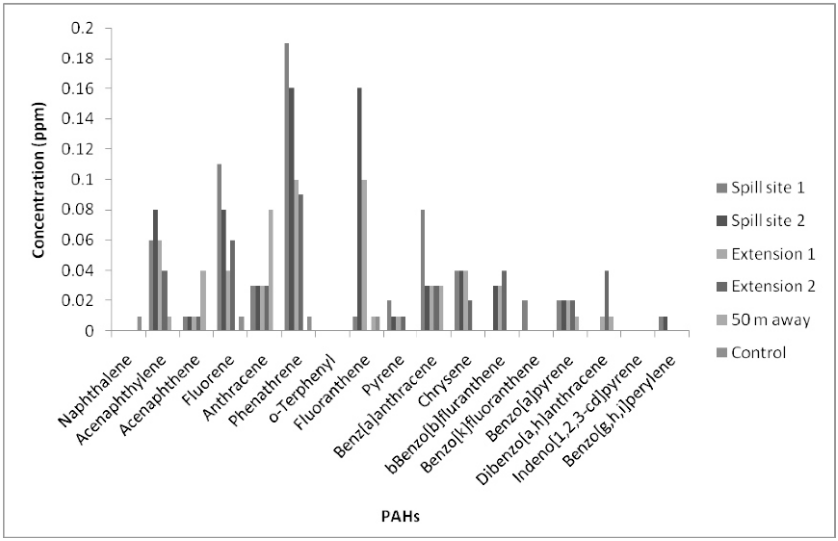


Fig. 35: Variations of concentrations of PAHs in soil at study sites (15-30 cm)

9.0 WATER QUALITY MONITORING

9.1 Distribution of Heavy Metals in Water and Sediment along Abonnema Shoreline, Nigeria. (Ideriah *et. al.,* 2012)

This study determined the levels and distribution of the toxic heavy metals lead (Pb), copper (Cu), Cadmium (Cd), Chromium (Cr) and zinc (Zn) in water and sediment of Sombriero river at the shoreline of Abonnema in the Akuku- Toru Local Government Area of Rivers State, Nigeria with a view to create awareness and establish baseline data on the present status of the river. The concentrations of the metals were determined using GBC Avanta flame Atomic Absorption Spectrophotometer version 2.02.

The findings of this study showed that sediment is the ultimate sink for heavy metals in the aquatic system. The water body surrounding Abonnema island is contaminated with heavy metals especially Zn, Cr, Cu and Cd which can contaminate sea foods and hence humans. The MPI values indicate that the sediment and Zn in water from the river are critically contaminated with respect to heavy metals and therefore pose serious environmental concern. Abandoned metals parts and effluents from industrial and commercial activities such as fishing (nets, hooks, etc) shipping, timber processing and outboard engine boats influenced the levels of metals along the Sombriero River axis of Abonnema while domestic activities (such as building materials, solid wastes), run offs, tidal and wave actions influenced the metal levels along the Abonnema creek. The area is contaminated with heavy metals and requires creation of awareness, periodic monitoring and evaluation of sea foods since most communities along the Sombriero River depend on sea foods and use the water for salt production after crystallization.

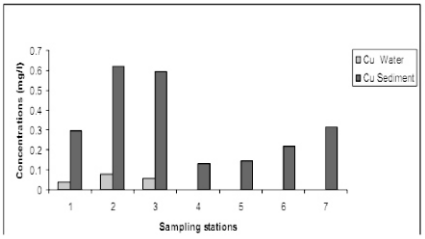


Fig. 36: Variations in concentrations of Cu in water and sediment

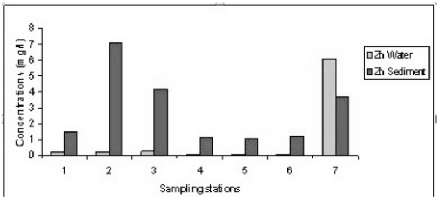


Fig. 37: Variations in co**ncentrations of Zn in water and sediment**

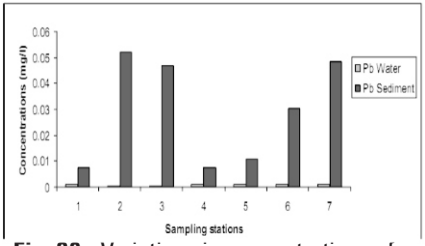


Fig. 38: Variations in concentrations of Pb in water and sediment

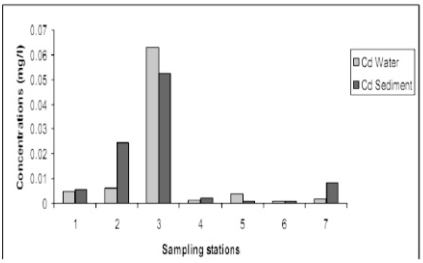


Fig. 39: Variations in concentrations of Cd in water and sediment

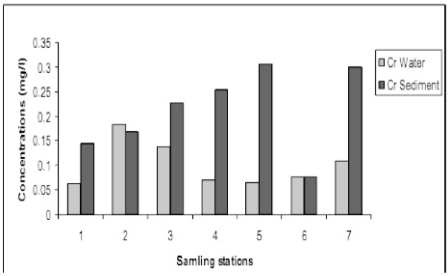


Fig. 40: Variations in concentrations of Cr in water and sediment

There were variations in the concentrations of heavy metals between the high activity (Sombriero River, stations 1-5) and low activity (Abonnema creek, stations 6 and 7) areas. This could be attributed to wave actions and tidal effects which drifted heavy metals to the low activity stations. In addition the lower volume of water (Shallow) and width of the creek could have influenced the high concentrations of some metals measured at the low activity area.

The presence of metal Jetties for boats and ships at stations 1 and 2 respectively greatly influenced the concentrations of metals measured there.

Table 42. Metal Pollution Index values for heavy metals in water and sediment around Abonnema

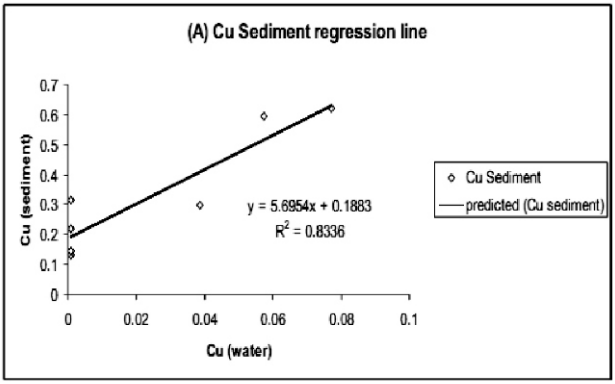
Area	Sample type	Cu	Zn	Pb	Cd	Cr	Mean
High Activity (Sombriero river; Akuku Toru),	Water	0.011	0.169	0.001	0.006	0.094	0.0562± 0.033
	Sediment	0.291	2.241	0.017	0.007	0.212	0.5536± 0.425
	Mean ±S.E	0.151± 0.140	1.205± 110.36	0.009± 0.008	0.007± 0.0005	0.153± 0.059	
Low Activity (Abonnema Creek; Okolobio)	Water	0.001	0.860	0.001	0.001	0.092	0.191± 0.1682
	Sediment	0.263	2.095	0.038	0.003	0.151	0.51± 0.3989
	Mean ±S.E	0.132± 0.131	1.478± 0.6175	0.020± 0.0185	0.002± 0.001	0.122± 0.0295	

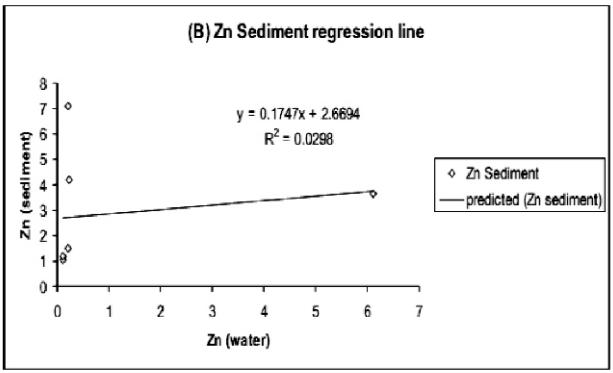
The correlation between the concentrations of metals in water and sediment fitted a linear regression equation (3) of the form:

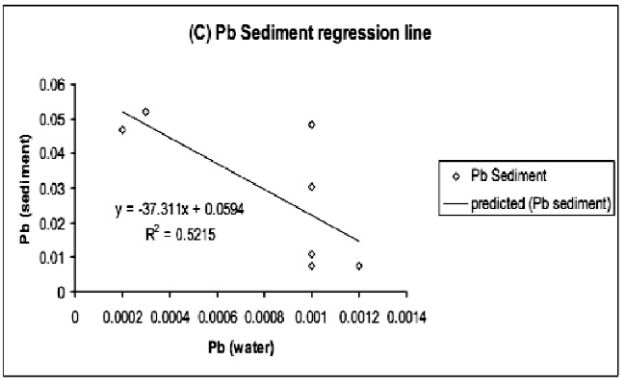
$$y = m\,x + c \qquad (3)$$

Where y = concentrations of metals in sediment,
x = concentrations of metals in water;

m and c = coefficients corresponding to the slope and intercept on y axis respectively (Figures 41 A-E).


(A) Cu Sediment regression line
Cu (sediment)
Cu (water)
y = 5.6954x + 0.1883
R2 = 0.8336
Cu Sediment
predicted (Cu sediment)


(B) Zn Sediment regression line
Zn (sediment)
Zn (water)
y = 0.1747x + 2.6694
R2 = 0.0298
Zn Sediment
predicted (Zn sediment)


(C) Pb Sediment regression line
Pb (sediment)
Pb (water)
y = -37.311x + 0.0594
R2 = 0.5215
Pb Sediment
predicted (Pb sediment)

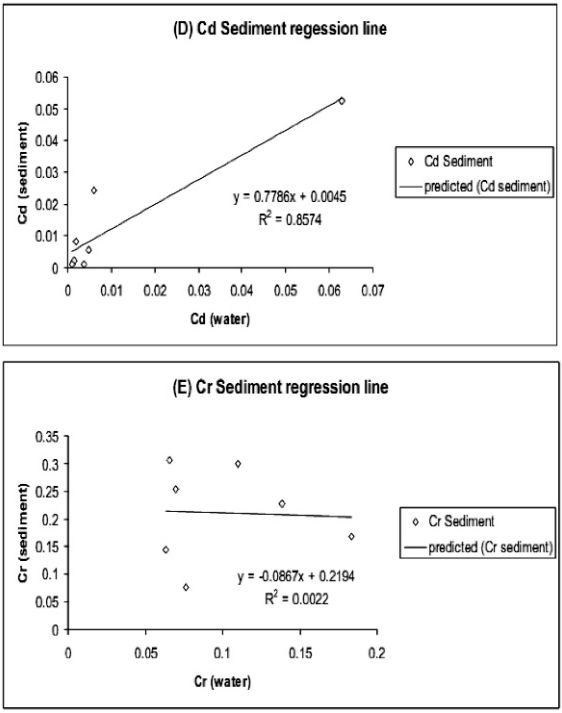


Fig. 41 (A-E). Regression plots showing the relationship between metals in sediment and water

Heavy metals especially Zn, Cr, Cu and Cd which can contaminate sea foods and hence humans. The MPI values indicate that the sediment and Zn in water from the river are critically contaminated with respect to heavy metals and therefore pose serious environmental concern. Abandoned metals parts and effluents from industrial and commercial activities such as fishing (nets, hooks, etc) shipping, timber processing and outboard engine boats influenced the levels of metals along the Sombriero River axis of Abonnema while domestic activities (such as building materials, solid, etc.).

$$MPI = (Cf_1 \text{ x } Cf_2 \text{ x } \text{----------} \ Cf_n)^{1/n} \qquad (4)$$

Where Cf_1 = concentration of metal in water/sediment for sampling stations 1 – n and n = number of stations the samples were collected. The MPI is a very useful tool in evaluating overall pollution of water bodies with respect to heavy metals (Usero *et. al*., 1996; Prasad & Kumari, 2008). The critical pollution index value above which the overall pollution level should be considered on acceptable is 100 (Prasad & Kumari, 2008).

At the two activity areas (High and low) the MPI values of the metals in sediment were higher than those in water (Table 37). The difference between them was not significant ($P > 0.05$). The correlation coefficient for metals in water and sediment at high and low activity areas $r = 0.8777$ and 0.9905 respectively while between high and low activity areas, $r = 0.9043$ for water and 0.9996 for sediment. This observation agrees with the earlier report that sediment is a depository of metals in the aquatic system (Chindah & Braide, 2003; Ideriah *et. al*., 2010; AMA, 1992). The mean MPI values for Cu, Cd and Cr at the high activity area were higher than those at the low activity area (Table 37). The reverse was the case for Zn and Pb. Zinc was the most prevalent metal in the study area since it had the highest MPI value at both locations. This is attributed to the fact that until recently, Zn was the only roofing sheet used in the study area. The higher MPI values of Zn and Pb at the low activity area (Okolobio, Creek) could be attributed to closeness of most metal scraps and waste dumps, all rounds (up and down) Zn buildings (huts), topography of the area, leaching and run off of rain water which scavenges automobile emissions into the creek. In addition, metals such as Pb from engine boats and other sources on the high activity Somebriero River drift and settle on the mangrove swamp and sediment at the low activity area during tidal and wave actions. The levels of Cu, Cd and Cr in the sediment were mainly contributed by deposits of abandoned metals parts during Timber processing

and shipping activities. The MPI at the high activity area followed the order of Zn > Cr > Cu > Pb > Cd which is in line with the order of intercept in the regression plots while the order of Zn > Cu > Cr > Pb > Cd was observed at the low activity area.

9.2 Hydrogeochemical Characteristics and Quality Assessment of Groundwater in Rivers State University of Science and Technology Port Harcourt (Ideriah & Ikoro, 2015)

Vice Chancellor Sir, in 2013 we commenced the monitoring of Boreholes water quality in this University which was supported by the management. The monitoring was later sponsored by TeTFund in 2016.

The quality and suitability of boreholes water quality in the Rivers State University of Science and Technology were assessed for potability and irrigation purposes by analyzing the water for physico-chemical parameters, microbial contents, hydrogeochemical faces and irrigation indices using standard methods. The results obtained were compared with permissible limits for drinking water provided by World Health Organization, NAFDAC and Standard Organization of Nigeria.

Based on the findings of this study the tap water within RSUST is fresh and soft with low to moderate dissolved solids. All the borehole water quality on Campus are not potable due to low pH; in addition, borehole water at Council Unit (Convocation Arena), ISS, UWA and Institute of Education had high microbial count and therefore not suitable for drinking. The use of the water in its present state for aqua-culture might be detrimental to fishes. The water is suitable for irrigation and other purposes except drinking. There is need to urgently

commence treatment of water supplied within the University community and create awareness to educate people on the need to boil and/or filter the water prior to consumption.

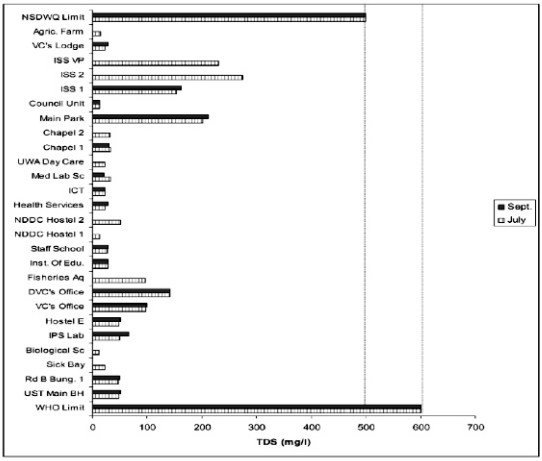


Fig. 42: The pH of groundwater in RSUST in July and September 2013.

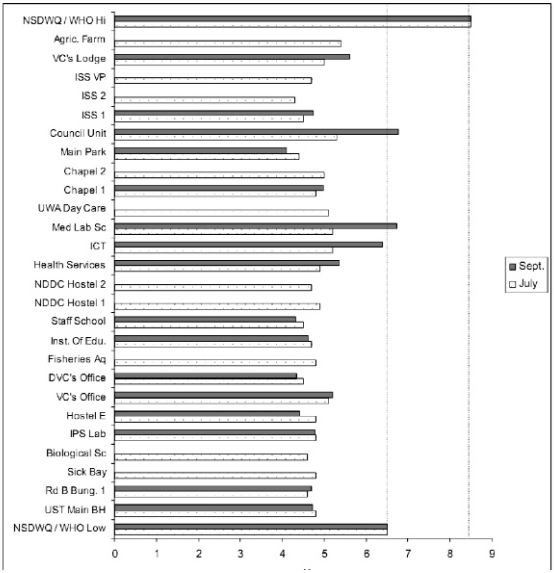


Fig. 43: TDS levels of RSUST groundwater in July and September 2013

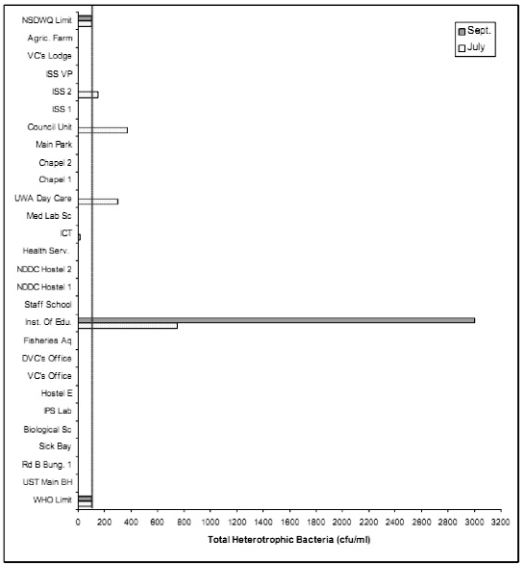


Fig. 44: Total Heterotrophic Bacteria levels in RSUST groundwater July/Sept. 2013.

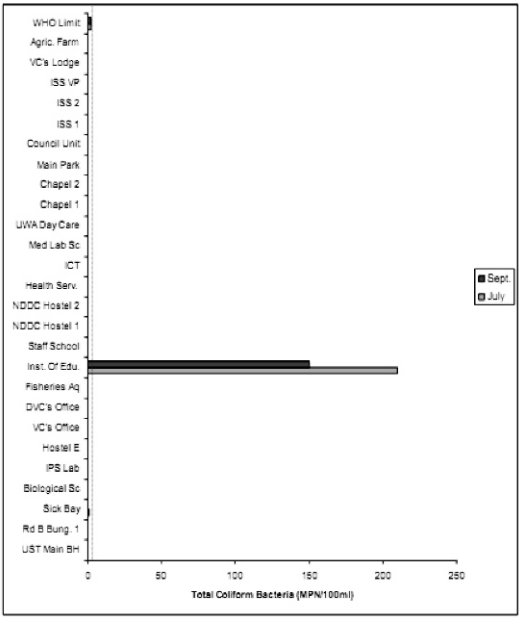


Fig. 45: Total Coliform Bacteria levels in RSUST groundwater July/Sept. 2013

9.2.1 Water Characterization

The groundwater in Rivers State University of Science and Technology has been classified based on the hydro-geochemical characteristics obtained in the Piper's diagram (Fig. 50).

There are five water types characterizing the aquifer and they include:

There are five water types characterizing the aquifer and they include: Ca – HCO_3–, Na - Cl, Ca - Mg - Cl-, Ca - Na - HCO_3– and Na - HCO_3– types. The order of occurrence were: Na - Cl- type (57.7%), Na - Ca - HCO_3– type (17.3%), HCO_3– type (13.5%), Na - HCO_3– type (7.7%) and Ca - Mg - Cl- type (3.8%). The Ca - Cl type was not observed in this study.

9.2.2 Irrigation Suitability

The suitability of the groundwater for irrigation purposes was determined using six computed water quality parameters namely (1) Sodium Adsorption Ratio` (SAR), (2) Soluble Sodium Percentage (SSP), (3) Magnesium Adoption Ratio (MAR), (4) Kelly's Ratio (KR). These indices were calculated for each of the 22 sampling locations. The result for all the parameters of the borehole water samples in the study area revealed that 100% of them were suitable for irrigation.

Sodium gets to the aquifer from rainwater in coastal areas and / or dissolution of rock as rainwater percolates and the groundwater flows through the aquifer. As a result of effects of sodium on soil and plants; it is considered one major factor that governs the use of groundwater in irrigation (USDA, 1954, Offodili,

2002). The suitability of groundwater for agricultural purposes (such as irrigation) is based on its Sodium Adsorption Ratio (SAR). The SAR was calculated using the formula by Richards (1954):

$$SAR = \frac{Na^{+}}{\sqrt{\{1/2[(Ca^{2+})+(Mg^{2+})]\}}} \quad (5)$$

Where, Ca^{2+}, Mg^{2+} and Na+ are in mili-equivalent per litre (meq/l) concentration of the metals in the groundwater. There are four sodium hazard classifications (Richards, 1954): low/S1 (SAR <10), medium/S2 (SAR 10 - 18), high/S3 (SAR 18 - 26) and very high/S4 (SAR >26).

Soluble sodium percent (SSP) is another parameter used to indicate water that is suitable for irrigation. It was calculated from the formula:

$$SSP = [Na^{+}/(Ca^{+2} + Mg^{+2} + Na^{+})] \times 100 \quad (6)$$

Where, Ca^{2+}, Mg^{2+} and Na^{+} are concentrations in meq/l. SSP values less or equal to 50 indicates good quality water while values greater than 50 are contrary and unsuitable for irrigation. The SAR and SSP values obtained for RSUST water samples are in Table 38

Table 43. SAR and SSP values and status of RSUST water samples (2013).

S/No.	Station / Location	SAR	SAR Status	SSP	SSP Status
1.	UST Main BH	1.903	Excellent	60.616	Unsuitable
2.	Road B Bungalow 1	1.392	Excellent	49.734	Good
3.	Sick Bay	0.536	Excellent	49.734	Good
4.	Biological Sc	1.079	Excellent	50.755	Unsuitable
5.	IPS Lab	2.448	Excellent	50.094	Fair
6.	Hostel E	1.430	Excellent	44.531	Good
7.	VC's Office	1.078	Excellent	50.094	Fair
8.	DVC's Office	1.164	Excellent	33.417	Good
9.	Fisheries Aq	2.911	Excellent	49.734	Good
10.	Inst. Of Education	0.466	Excellent	50.094	Fair
11.	Staff School	1.759	Excellent	50.755	Unsuitable
12.	NDDC Hostel 1	0.533	Excellent	50.755	Unsuitable
13.	NDDC Hostel 2	1.011	Excellent	49.734	Good
14.	Health Services	0.268	Excellent	49.734	Good
15.	ICT	3.686	Excellent	50.094	Fair
16.	Med Lab Sc	0.648	Excellent	32.376	Good
17.	UWA Day Care	2.432	Excellent	50.755	Unsuitable
18.	Chapel 1	0.535	Excellent	49.734	Good
19.	Chapel 2	0.757	Excellent	49.734	Good
20.	Main Park	2.640	Excellent	28.922	Good
21.	Council Unit	0.002	Excellent	49.734	Good
22.	ISS 1	4.246	Excellent	49.734	Good
23.	ISS 2	4.325	Excellent	59.831	Unsuitable
24.	ISS VP	5.074	Excellent	67.625	Unsuitable
25.	VC's Lodge	1.558	Excellent	50.755	Unsuitable

Magnesium Adsorption Ratio (MAR) also known as magnesium hazard (MH) was calculated using the equation by Raghunath (1987).

$$MAR = \frac{Mg^{2+}}{Ca^{2+}+Mg^{2+}} \times 100 \quad (7)$$

Kelly Ratio (KR) was calculated using a formula by Kelly (1940)

$$KR = \frac{Na^{+}}{Ca^{2+} + Mg^{2+}} \quad (8)$$

"Where, Ca^{2+}, Mg^{2+} and Na^{+} concentrations in mili-equivalent per litre (meq/L)"

9.2.3 Water Quality Index (WQI)

Groundwater chemistry is very important in the identification of drinking water quality (Edmunds *et al.*, 2002; Rao, 2006). The WQI is helpful to evaluate the quality of groundwater and its usage for drinking (Avvannavar and Shrihari, 2008; Gupta et al., 2015)

The WQI is computed in four steps, calculated using the equations below adopted from Sener *et al.* (2017).

Assign a weight (w_i) to each parameter according to its importance in drinking water purposes (8)

Step 1: Compute the Relative Weight (W_i) for each parameter using the equation:

$$W_i = \frac{w_i}{\sum_{i=1}^{n} w_i} \quad (9)$$

Step 2: Assign a quality rating scale (qi) for each parameter by dividing its determined concentration (ci) in each sample by its respective guideline value (si); multiplied by 100 (WHO, 2011).

$$q_i = (\frac{C_i}{S_i}) \times 100 \quad (10)$$

Step 3: Determine the sub index (SIi) for each parameter using equation (3.15)

$$SI_i = W_i \times q_i \quad (11)$$

Step 4: Sum all sub indices to get the WQI

$$WQI = \sum_{i=1}^{n} SI_i \quad (12)$$

"Where SI_i represents the sub-index of the ith indicator, W_i is the relative weight, q_i represents the quality rating for each chemical indicator, w_i is the weight of each element". The WQI classifies the water quality as "Excellent (WQI < 50), Good (WQI = 50 -100), Poor (WQI = 100 - 200); Very Poor (WQI = 200 - 300) and Unsuitable for Drinking (WQI > 300)" (Ramakrishnaiah *et al.*, 2009; Batabyal and Chakraborty, 2015).

The water quality index of groundwater in the study area ranged from 49.10 to 65.89. The WQI values in the study fell within the bad (6%) to medium (94%) quality.

9.2.4 Hydrogeochemistry

Groundwater quality is also dependent on nature of bedrock, topography, geology, soils, climate, atmospheric precipitation and quality of the recharged water in addition to anthropogenic pollution sources in terms of agricultural and industrial activities. Further, groundwater quality could be affected by means of subsurface geochemical reactions such as weathering, dissolution, precipitation, ion exchange and various biological processes. Gaining a clear understanding of the main factors governing groundwater chemistry is important for managing groundwater resources. The plots of the Piper, Durov and Gibbs Diagrams are used to investigate the hydrogeochemical properties of the water.

The hydrogeochemical facies of groundwater type to distinguish the groundwater differs in their compositions and chemical properties (Mahlnect et al. 2004). Dependent on lithology, water flow patterns and indigenous time physicochemical properties of groundwater differ (Domenico 1972).

9.2.4a Piper Trilinear Diagram

Plotting of samples on the Piper Trilinear Diagram reveals the composition of the water in the different sampling stations, indicating the water type (Piper, 1944). The milliequivalents of the various anions and cations are used and plotted in two different triangular graphs. The points of these anions and cations on the x, y and z axes of the triangular graphs are extrapolated to determine the dominant ion types. The extrapolated points on the triangular graphs are further projected onto the diamond graph to determine the water type.

9.2.4b Durov's Diagram

Durov diagram is a useful graphical tool that is widely used to identify the chemical relationship and evolution of groundwater samples (Chen et al, 2019), and helps in the interpretation of the evolutionary trends and the hydrochemical processes occurring in the groundwater system. Like the piper diagram, milliequivalents of cations and anions are plotted on the triangular graphs and the extrapolated points are projected onto the square plot to determine the hydrogeochemical process.

9.2.4c Gibbs Diagram

The Gibbs diagram is widely used to establish the relationship of water composition and lithological characteristics of an aquifer (Gibbs, 1970). According to the relationship between TDS versus [Na^+/ (Na^+ + Ca^{2+})] and TDS vs [Cl^-/ (Cl^- + HCO_3^-)], groundwater formation mechanisms are classified in three distinct fields such as Precipitation Dominance, Evaporation Dominance and Rock–Water Interaction Dominance areas. The hydrogeochemical arrangement of groundwater describes the rock-water interaction (Elango and Kannan, 2007).

9.2.5 Heavy Metal Health Risk Assessment

The health risk assessment for heavy metals gave HI values < 1 in both children and adults revealing that there is no risk of exposure either through ingestion or dermal contact of the borehole water.

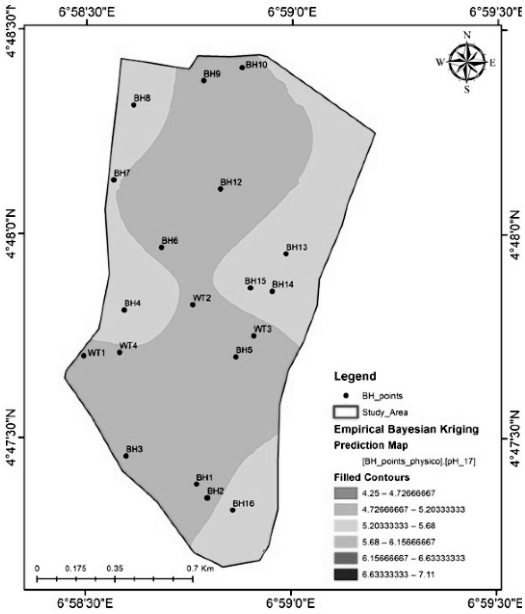


Fig. 46:
pH prediction Map

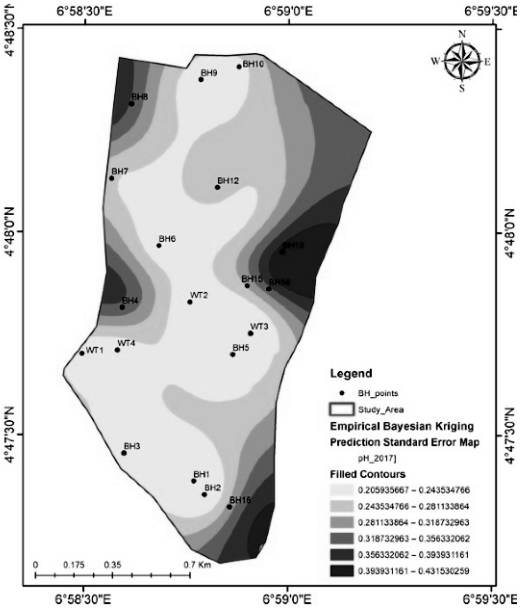


Fig. 47:
pH Prediction Standard
Error Map

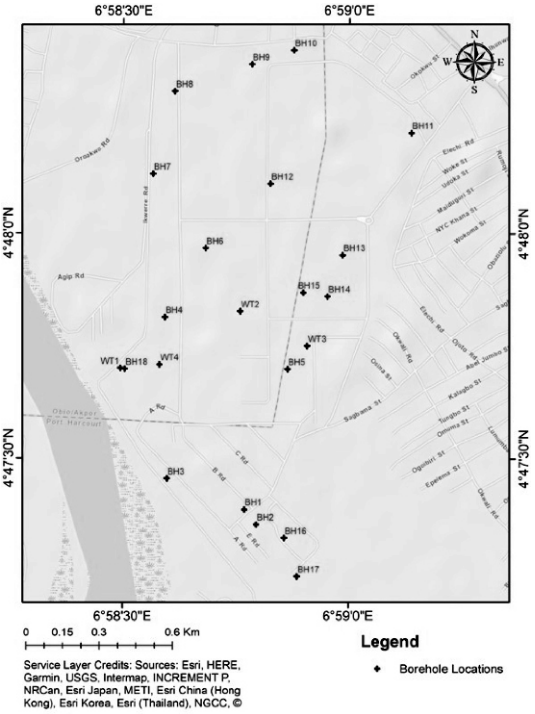


Fig. 48:
Map showing Boreholes Location

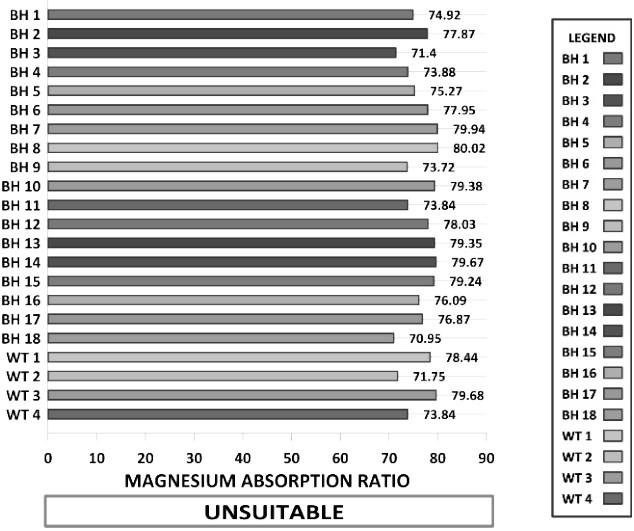


Fig. 49:
Magnesium Ratio (MAR) Values and Ratings for Boreholes in the Study Area

MAR RATING:
< 50 = Suitable,
> 50 = Unsuitable

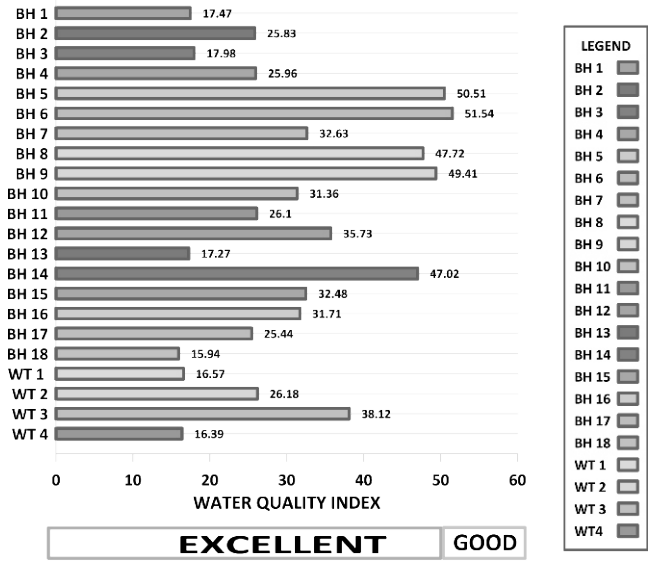


Fig. 50: Water Quality Index (WQI) Values and Ratings for Boreholes in the Study Area

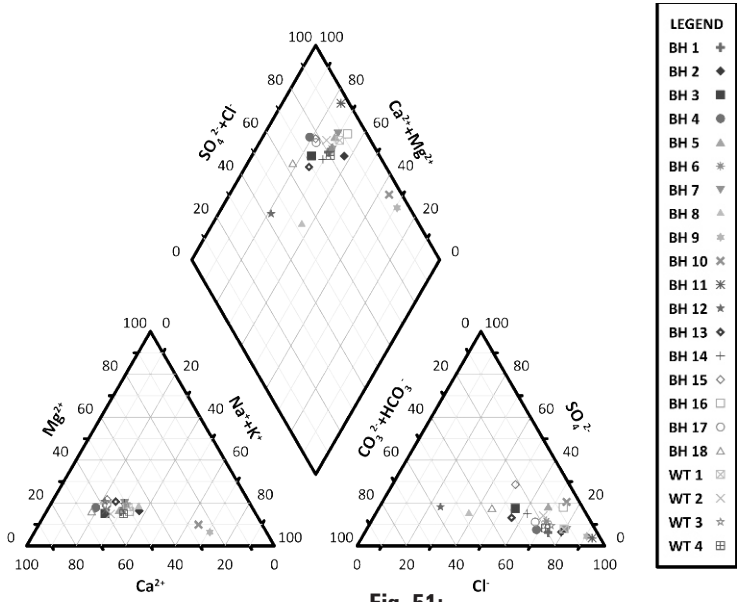


Fig. 51:

Piper Trilinear Diagram Showing the Classification of Water in the Hydrological Facies

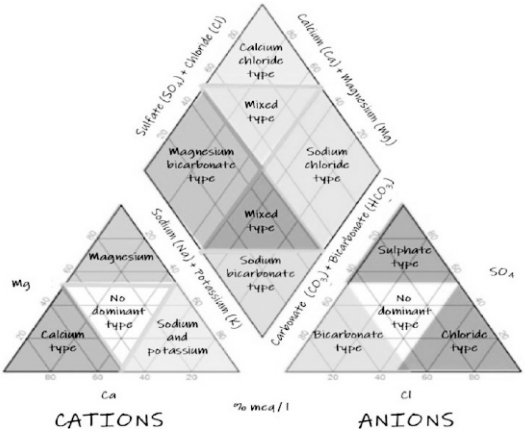


Fig. 51: cont.

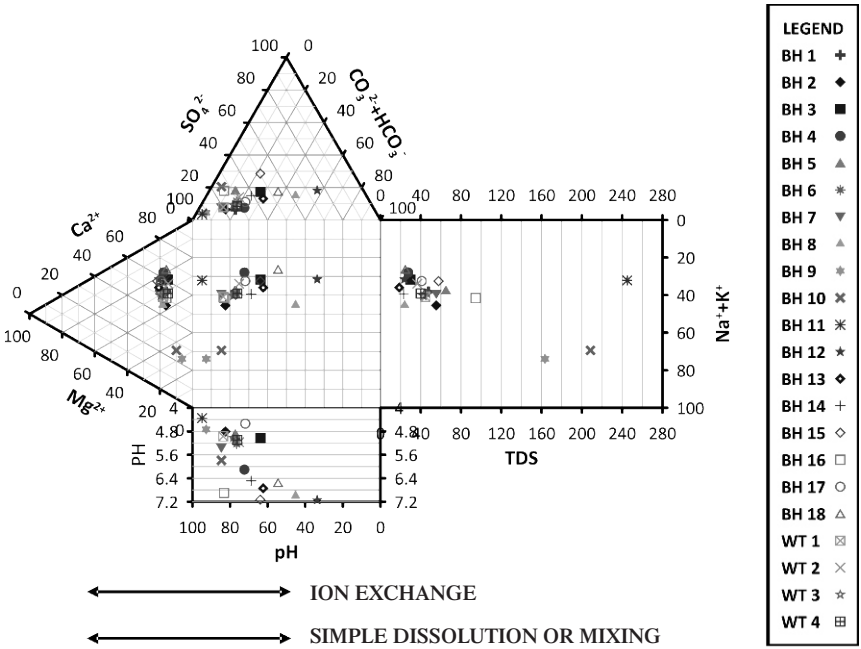


Fig. 52: Extended Durov Diagram Depicting Hydrochemical Processes of Groundwater in the Study Area

Fig. 60: Permeability Index (PI) Values and Ratings for Boreholes in the Study Area

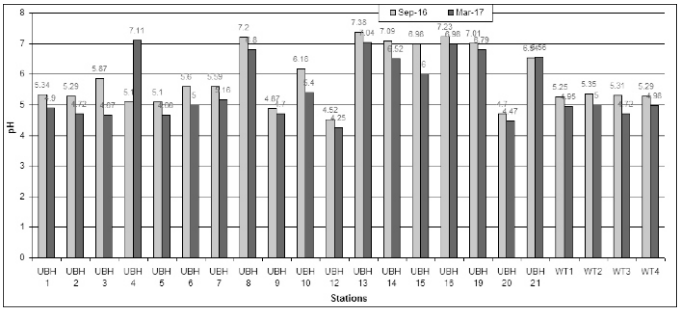


Fig. 53: pH Levels in borehole water samples in 2016 and 2017

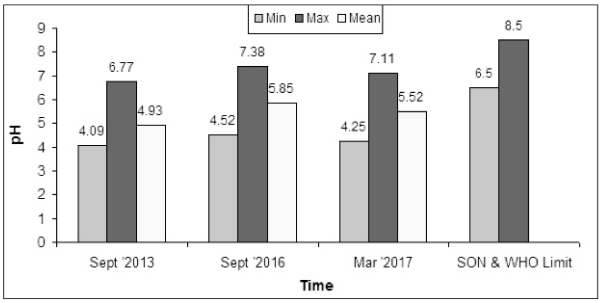


Fig. 54: Mean pH Levels in 2013, 2016 and 2017 Compared to SON and WHO limit

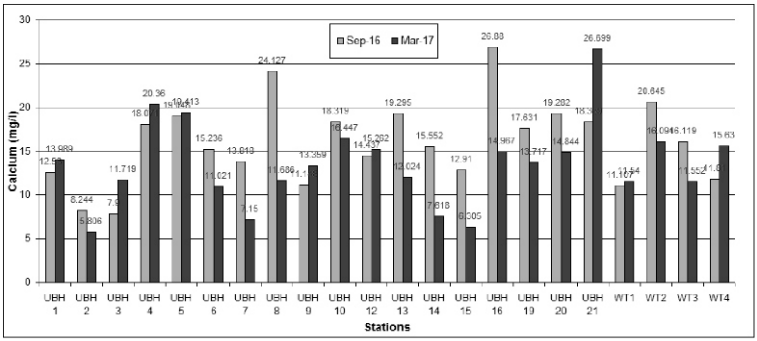


Fig. 55: Calcium Levels in borehole water samples in 2016 and 2017

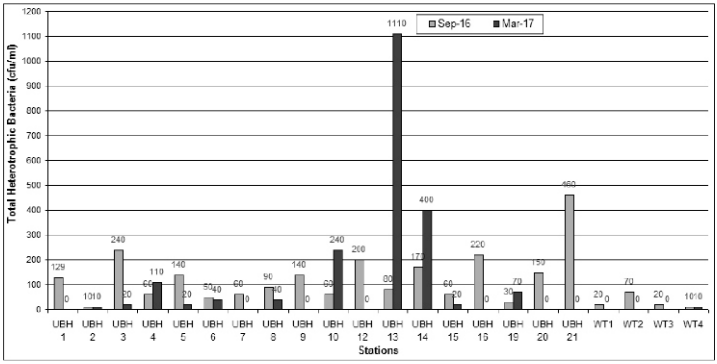


Fig. 56: THB Levels in borehole water samples in 2016 and 2017

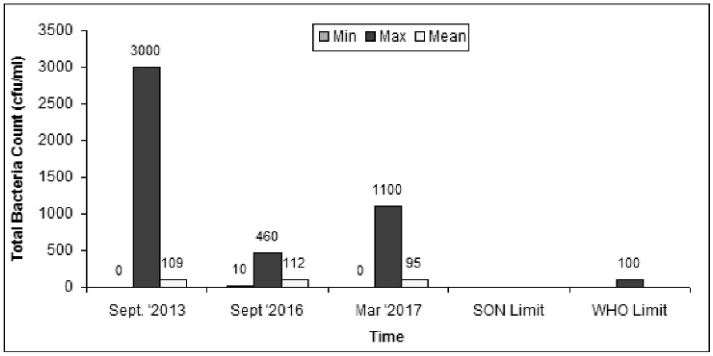


Fig. 57: Mean TBC Levels in 2013, 2016 and 2017 Compared to SON and WHO limit

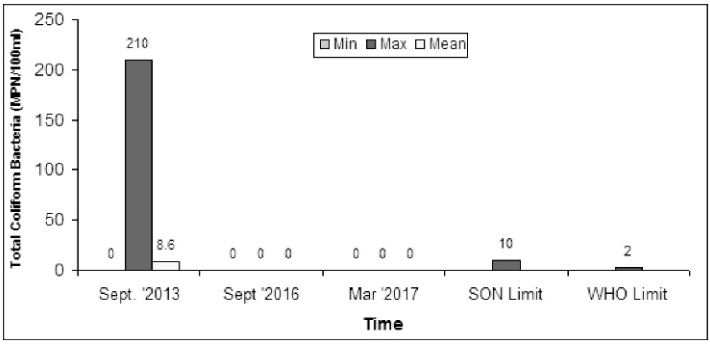


Fig. 58: Mean TCB Levels in 2013, 2016 and 2017 Compared to SON and WHO limit

9.3 QUALITY ASSESSMENT OF SOME SURFACE WATER IN ISRAEL AND NIGERIA FOR MULTIPURPOSE USAGE (Ideriah & Ndubuisi, 2015)

Vice Chancellor Sir, during my pilgrimage to Israel, while in the boat on the Sea of Galilee and the Dead sea (1384 ft below sea level), I was inspired to collect water samples for comparison of the quality with water in my home country, Nigeria.

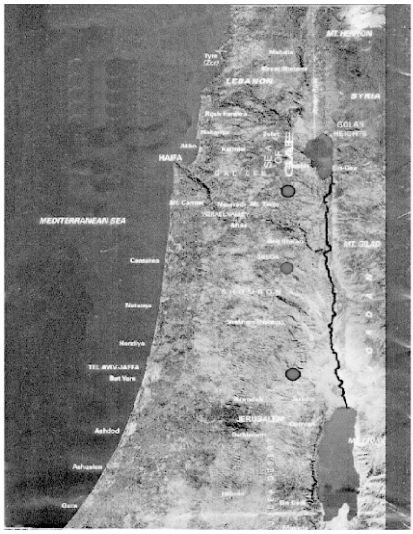


Fig. 59: Sectional Map of Israel showing

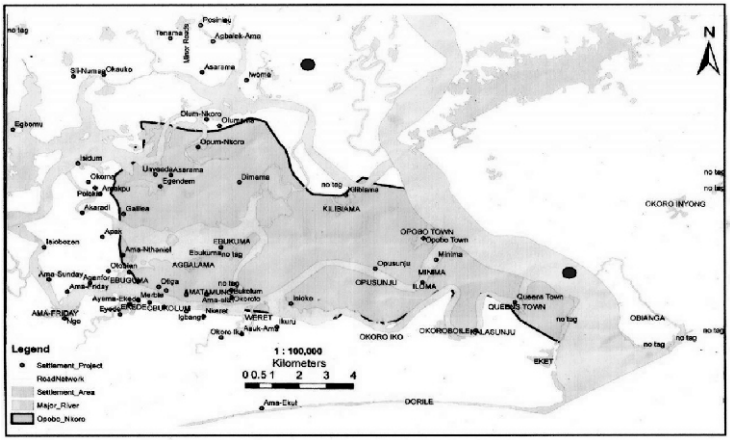


Fig. 60: Map showing Opobo and Asarama Rivers in Rivers State of Nigeria

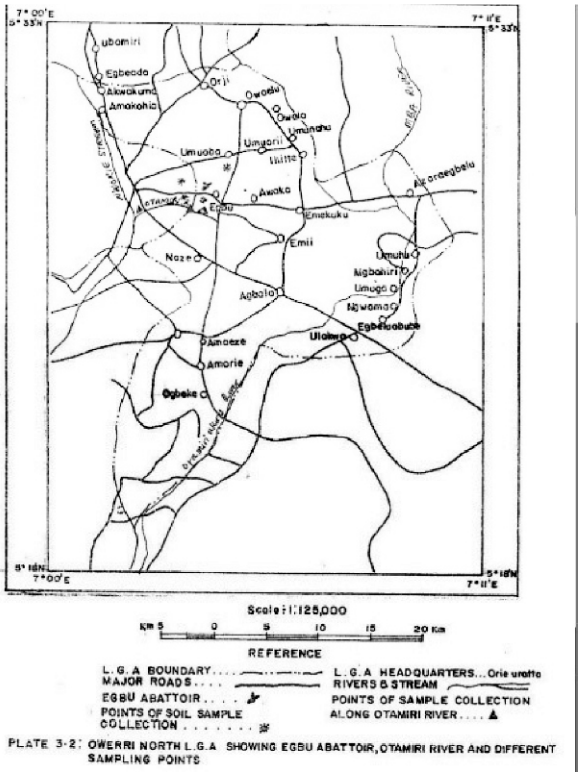


PLATE 3-2: OWERRI NORTH L.G.A SHOWING EGBU ABATTOIR, OTAMIRI RIVER AND DIFFERENT SAMPLING POINTS

Fig. 61: Map showing Otamiri River in Imo State

The quality and suitability of some surface water from Dead sea, Jordan and Galilee in Israel and Opobo, Asarama and Otamiri in Nigeria were assessed for potability and irrigation purposes by analyzing the water for physico-chemical parameters, Mg, Mn, Fe and Pb and irrigation indices using standard methods. The results obtained were compared with standard limits provided by World Health Organization and Standard Organization of Nigeria. The levels of Electrical Conductivity, TDS, Total Hardness and Cl- in all the stations except Otamiri exceeded permissible limits suggesting high mineralization Except for Opobo and Otamiri rivers the concentrations of Ca2+ and Mg2+ exceeded permissible limits. The Total Alkalinity of Dead Sea, Jordan and Galilee exceeded permissible limit. The Turbidity of all the rivers except Opobo river were below permissible limit. The water in Israel had higher concentrations of Mn, Fe and Pb and exceeded permissible limits. The number of parameters that exceeded limits followed the decreasing order: Dead Sea > Galilee. > Jordan > Asarama > Opobo > Otamiri. Irrigation indices showed Soluble Sodium Percent values >50% and Kelly's ratio >1meq/l at Opobo and Otamiri rivers. Also, Sodium Adsorption Ratio of Opobo river was > 26. Thus, Opobo and Otamiri rivers were considered unsuitable for irrigation. The surface water in the study areas especially in Nigeria should be regularly monitored to avoid serious pollution problems.

The findings of this study showed that the surface water in the area had high levels of EC, TDS, SO42-, Cl-, Total Hardness, Ca 2+, Mg2+ and turbidity The contamination of the water can lead to contamination of aquatic lives on which the inhabitants depend. It is therefore concluded that the water in the area is not potable.

Table 44: Physico-Chemical parameters measured in Surface Water around Israel & Nigeria

Parameter	Dead sea	Jordan	Galilee	Opobo	Asarama	Otamiri	WHO	SON
pH	5.70	8.24	7.1	7.44	7.6	8.0	6.5-9 .5	6.5-8.5
Elec. Cond.(μS/cm)	>100,000	3010	2040	16,090	9,000	386.1	1200	1000
Turbidity (NTU)	0	0	4	58.6	4.31	2.10	5.0	5.0
Salinity (mg/l)	>40	1.5	0.9	8.98	11.3	10.8	-	-
TDS (mg/l)	> 70,000	2,107	1,428	14.5	13,300	155.0	1000	500
SO_4^{2-} (mg/l)	96.9	62.0	26.5	215.7	302	285.4	500	100
PO_4^{3-} (mg/l)	0.07	<0.05	<0.05	<0.05	<0.05	0.55	-	-
NO_3^- (mg/l)	0.78	1.21	0.09	1.19	<0.05	3.55	50	10
Total Hardness (mg/l)	259,618	528.8	441.6	1916	1916	0.11	500	100
Total Alkalinity (mg/l)	235	192	167	32	24	27.0	100	100
Cl^- (mg/l)	197,600	647.1	869.4	6,422	6175	19.08	250	100
Ca^{2+} (mg/l)	188536.32	169.3	122.88	6.2	383	0.60	-	75
Mg^{2+} (mg/l)	12130.56	26.1	32.8	3.8	233	0.007	20	0.20
DO (mg/l)	1.6	6.9	7.3	11.4	11.4	23.6	-	-
BOD (mg/l)	0.8	0.4	3.04	1.6	6.1	66.4	-	-
Na (mg/l)	$14.374x10^3$	8.70	9.39	335.91	7.35	5.56	200	
Mn (mg/l)	2.320	0.184	0.746	0.184	0.073	0.052	0.4	0.05
Fe (mg/l)	15.319	3.967	5.747	0.208	0.124	0.084	0.3	0.3
Pb (mg/l)	0.030	0.083	0.163	<0.01	<0.01	<0.01	0.01	0.01
SAR	8.651	0.085	0.194	26.091	0.102	1.955	-	-
KR	0.060	0.004	0.046	23.305	0.016	7.903	-	-
SSP(%)	5.649	5.008	4.394	95.886	1.615	88.768	-	-

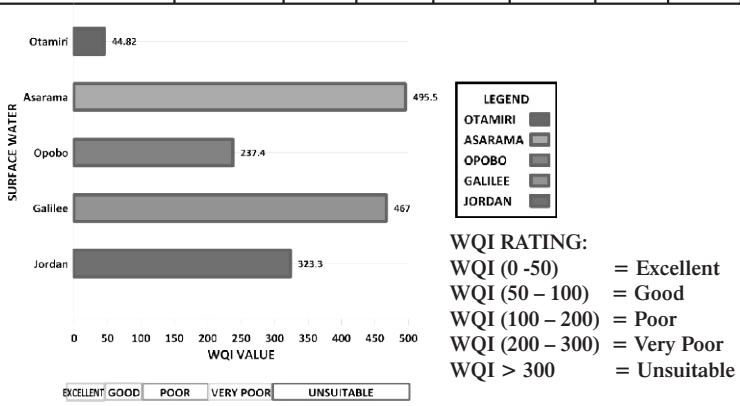


Fig. 62: Water Quality Index (WQI) Values and Ratings for Surface in the Study Area

9.4 Levels of Polycyclic Aromatic Hydrocarbons in Water at Betem Rivers State.

(Ideriah and Nwinaa-ie, 2015)

The levels of Polycyclic Aromatic Hydrocarbons (PAHs) in ground and surface water in parts of Betem community were assessed using Gas Chromatograph, HP 5890 Series II. The results showed that the highest concentrations of carcinogenic PAH in the area were Benz(a)anthracene 0mg/l (in both Ground and surface water), Benzo(a)pyrene 1.280x10-4mg/l (groundwater) and 5.194x10-5mg/l (surface water), Benzo(b)fluoranthene 6.025x10-4mg/l (groundwater) and 1.779x10-4mg/l (surface water), Benzo(k) fluoranthene 8.736x10-4mg/l (groundwater) and 2.930x10-4mg/l (surface water),Chrysene 8.941x10-5mg/l (groundwater) and 2.203x10-5mg/l (surface water), Dibenz(a,h)anthracene 1.254x10-4mg/l (groundwater) and 6.113x10-5mg/l (surface water), Indeno (1,2,3-cd)pyrene 6.480x10-4mg/l (groundwater) and 1.145x10-3mg/l (surface water). The total PAHs in the water from the area exceeded permissible limit. The t-test between the mean concentrations of carcinogenic and non carcinogenic PAHs showed no significant difference ($P>0.05$) in all the sampling stations. The ground water samples were more contaminated than the surface water samples. The concentrations of toxic and carcinogenic PAHs such as Benzo(b)fluoranthene, Benzo(k)fluoranthene and Indeno(1,2,3-c,d) pyrene exceeded their permissible limits in Abude hand dug well, Maakakuru stream and NDDC Borehole. The inhabitants of Betem community are exposed to serious health and environmental effects as they depend on the water from these sources for drinking, agriculture and other domestic purposes. It was recommended that Government should provide better sources of drinking water for the community. Also there should be awareness campaign

and local crude oil refining (bunkering) activities should be discouraged.

Table 45: Carcinogenic and Non- carcinogenic PAHs

	Carcinogenic/	Non carcinogenic PAH
1	Benzo(a)anthracene/	Anthracene
2	Benzo(a)pyrene/	Benzo(g,h,i)perylene
3	Benzo(b)fluoranthene/	Fluoranthene
4	Benzo(k)fluoranthene/	Fluorene
5	Chrysene/	Naphthalene
6	Dibenzo(a,h)anthracene/	2-ethylnaphthalene
7	Indeno(1,2,3-cd)pyrene/	Pyrene

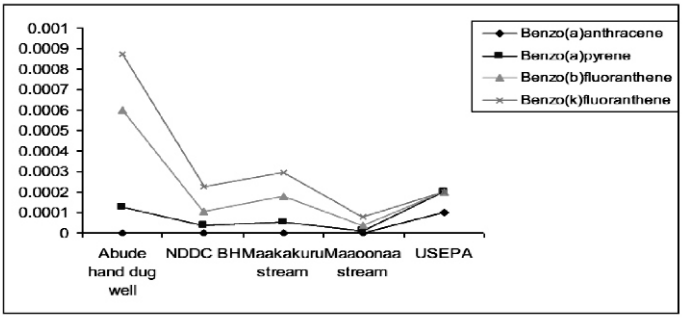


Fig. 63: Variations and Comparison of concentrations of carcinogenic PAH with limits

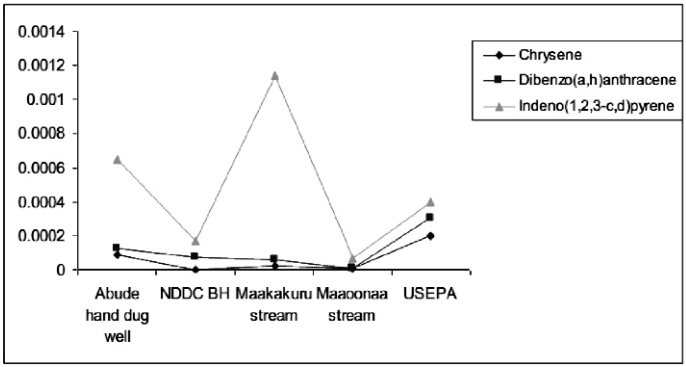


Fig. 64: Variations and Comparison of concentrations of carcinogenic PAH with limits

10.0 CHALLENGES AND RAY OF HOPE

10.1 Challenges to Environmental Monitoring

The monitoring of the different compartments of the environment is a proactive means to prevent or control environmental pollution. The success of this depends on overcoming the following challenges:

- Advent of militancy/kidnapping/youth restiveness, etc.
- Lack of political will and interest by various levels of Government. For instance:

(a) The gas flare project instituted by the Old Rivers State Government (Petroleum Unit in the Military Administrator's office) in 1989 was not concluded as it was stalled abruptly due to lack of funds.

(b) In 2004 the Niger Delta Development Commission (NDDC) contracted Fugro Nigeria Limited to Audit IPS Laboratory and two other laboratories in University of Calabar and Delta State University, Abraka in the bid to equipping them as linkage laboratories. From the Audit Report, the three Laboratories were listed to receive the following:

(1) Atomic Absorption Spectrometer (AAS),

2) Gas Chromatograph-Flame Ionization Detector (GC-FID),

(3) UV-Visible Spectrophotometer and

(4) Other basic laboratory equipment and glass wares.

As prelude to arrival of the instruments and other items; NDDC in 2006 sponsored the Chief Technologists from the three laboratories and two NDDC staff for training on Environmental Laboratory Management at Water, Engineering and Development Centre (WEDC) in Loughborough University, United Kingdom. Vice Chancellor Sir, unfortunately, up till date no equipment has been supplied to any of the three laboratories from the linkage project.

- Lack of funding for the relevant monitoring and analytical equipment.
- Cankerworm of fear of intimidation and the palmerworm of victimization. The case of FADAMA Project EIA in the Rivers State Ministry of Environment in 2013.
- Citizenry ignorance and loss of confidence in governmental and other organizations.

10.2 Ray of Hope

The absence of functional Atomic Absorption Spectrophotometer and Gas Chromatography instruments in most laboratories has been a serious challenge.

Vice Chancellor Sir, the University Management procured an Atomic Absorption Spectrophotometer (AAS) in 2019 for use in the Institute of Pollution Studies.

Also within a year of your Administration, the University Management has procured Agilent Gas Chromatography-Mass Spectrometer with Headspace and a sound proof Alternative Power Supply. These equipment when commissioned will aid research and environmental studies. We commend your developmental efforts.

11.0 CONCLUSION AND RECOMMENDATIONS

11.1 Conclusion

— Earlier studies presented showed poor air quality index at different parts of Rivers State and indeed the Niger Delta region. Though not in the magnitude observed recently.

— The prevailing soot (black carbon) has been aggravated by artisanal refineries prevalent in the region. The burning approach being used to destroy these illegal refineries, has further worsened the situation.

— There are now life threatening human health hazards and environmental degradation problems

11.2 Recommendations

1. Regular awareness campaign (Radio, TV, News papers, etc).
2. Establish monitoring stations in the LGAs of Rivers State for data bank gathering and management.
3. Indoor air quality of offices / classrooms / hostels should be regularly monitored for students' and workers' health and productivity.
4. Create Environmental Research data review unit in the Ministry of Environment.
5. Water from boreholes in this University requires treatment to be potable.
6. Provision of adequate funding for Researches on the Environment.
7. Equipping the Laboratories and Research centres for effective and reliable analyses.
8. The four Refineries in Nigeria should be rehabilitated to full capacity by the Government and if need be grant the establishment of modular refineries.

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My unreserved and sincere appreciation to my perfect, peaceful, gentle and amiable Vice-Chancellor of this great "University of the year 2021", Distinguished Erudite Prof. Nlerum Sunday Okogbule, who in his God fearing and loving disposition did not come to destroy but to build on progressive foundations and for his staff friendly support, gave me the opportunity to present this 76th Inaugural Lecture.

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I specially place on record my depth of gratitude to my colleagues (present and past) in the Institute of Pollution Studies who encouraged me to move on despite unpleasant situations. They include Mr. Udonna Joseph Ikoro, Dr. Ini-Obong Ubong, Mr. Sunny.C. Nleremchi, Late Prof. Solomon Amabaraye Briade, Late Alex Chuks Chindah, Late Dr. Anwaini. Osuamkpe, Chief (Dr.) Akuro Adoki, Dr. Amadi Amadi, Mr. D. O. S. Atemie, Mr. Deinma Tamuno, Late Felix Obene Harry, Mr. Anga Johnbull, Ms. Ebite Ombu, Mr. Godwin Ikeani, Late Mr. Loveday Jonathan, Late Stella Osaji, Late Timi Oyenubi, Late Mrs. Ibiere Orlu,Mr. Hanson Uyi, Hezikiah Oluka Ifiesimama, Nathan Elijah Nario, Mrs. Deborah Eberechi Okachi, Ms. Ndidi Chiorlu, Mrs. Ozhioma Jamabo, Ms. Mary West, Mrs. Confidence Walter. Mrs. Ibiye Hezekiah,Mrs. Maureen Imabim, Mr. Sunday Neeue, Miss Josephine Ideriah, Mr. Chinedu Samuel, Mr. David Ukela .

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PROFILE/ CITATION

PROF. TUBONIMI JOSEPH KIO IDERIAH

Professor Tubonimi Joseph Kio Ideriah was born as the 5th child and 3rd son (representing GRACE and GLORY of GOD) into the humble, loving and God fearing family of Chief Joseph Kio Ideriah (Ideriah 5th) and Mrs. Leah Joseph Ideriah both of Briggs compound Abonnema and of blessed memory.

At birth my parents called me **Nwaditor** which literally means "Child is sweet"; their reason is in the meaning. My baptismal name in the Protestant Church is **Ngoji** which means "Wealth delivery". However, as a child, after Standards 1 and 2; in Elementary 3, with the approval of my parents I changed my name to **Tubonimi** (Kalabari dialect) meaning "Who Knows" and **Robert** (English). In Elementary 5, rather than bearing Robert and Briggs as middle and surnames respectively, I replaced Briggs with my great grandfather's name, **Ideriah** (Compound family name) in compliance with family instruction for the purpose of specificity, peculiarity and global propagation. The meaning of my first name, the global vision of my surname and this occasion today are manifestations of the power in a name.

My father never called me by any of the official names. He specially and fondly called me **Igiri** which means "agile" (implying that I am faster and took lesser time to accomplish same task that took other children long time).

EDUCATIONAL BACKGROUND

Prof. T.J.K. Ideriah started Primary education in Nyemoni State School, Abonnema from 1962-1963 and due to low school fees in Catholic Missionary schools he was transferred to St. Joseph's

Primary School, Abonnema from 1964-1969 where he obtained the First School Leaving Certificate.

Prof. T.J.K. Ideriah attended Nyemoni Grammar School, Abonnema from 1970-1974 where he obtained his West African School Certificate as pioneer of the WAEC May – June examination system. In 1974 he proceeded to the newly established Federal School of Arts and Science (FESAS), Sokoto as a pioneer student where he obtained his A'LEVEL certificate in 1976 and was adjudged the most gentle and amiable Rivers State student.

Prof. T.J.K. Ideriah attended University of Port Harcourt as a pioneer student in 1978 where he obtained his Bachelor of Science degree in Applied Chemistry in 1982. He obtained his Master of Philosophy Degree in Analytical Chemistry and Doctor of Philosophy Degree in Environmental Chemistry from Rivers State University of Science and Technology, Port Harcourt.

WORKING EXPERIENCE/EMPLOYMENT

Prof. T.J.K. Ideriah has work experience within and outside Rivers State. He worked with the Ministry of Health, Port Harcourt from 1976-1978. In 1980, he taught at Lolo Commercial Academy, Port Harcourt as Vacation job. In 1981 he worked at the Port Harcourt Refining Company Alesa, Eleme as Industrial Trainee.

Prof. T.J.K. Ideriah worked at the School of Health Technology Mubi from 1982-1983 during his National Youth Service Scheme. In search for immediate employment, he was employed by Ministry of Education, Kano as a Teacher and taught in GGSS Jogana, GSS Minjibirand GSS Gwamaja Kano from 1984-1989.

Prof. T.J.K. Ideriah was employed by the Rivers State University of Science and Technology Port Harcourt as a Research Assistant in the Institute of Pollution Studies in 1989 he also renders judicious service as an Internal Associate Lecturer in the Departments of CHEMISTRY, CROP/SOIL SCIENCE and INSTITUTE OF GEOSCIENCES AND ENVIRONMENTAL MANAGEMENT.

Prof. T.J.K. Ideriah is presently the **DIRECTOR, Institute of Pollution Studies (IPS)**; the pioneer Center of Excellence for Environmental Pollution Studies in Nigeria.

KINGDOM STEWARDSHIP

The scripture, Prov 22:6 -"Train up a child in the way he should go and when he is old, he will not depart from it" was fulfilled in my life. From childhood I was baptized (infant baptism) and registered in the orthodox church, St. Paul Nyemoni church (now St Paul Lutheran Church) Abonnema. Later I worshiped in "The Light and Life Church" established by my father and was baptized by immersion in a stream. This background endeared me to join the Scripture Union in 1970, my first year in the secondary school and was appointed as Prayer & Bible Secretary. My commitment and dedication in the Scripture Union was rewarded by my divine appointment as Chapel Prefect in my final year after protracted meetings, prayer and fasting of the selection committee.

In 1992, I joined the Pentecostal Church and presently worship/render Kingdom Stewardship in the Living Faith Church (Winners Chapel).

AREAS OF SPECIALIZATION

Environmental Impact Assessment, Strategic Environmental Assessment, Environmental Chemistry, Analytical Chemistry, Environmental Consultancy Services; Hydrogeochemistry, Pollution Control, etc.

ACADEMIC ACTIVITIES/PROFESSIONAL EXPERIENCE:

Prof. T.J.K. Ideriah is vast in Teaching and Research. I have published over 100 papers on Environmental contamination/pollution/control in National and International referenced journals. I am an Editor with many journals including Wilolud journals, British journal of Applied Science & Technology and Journal of Oil and Gas Technology.

I have over28years experience in Environmental studies as consultant with many Technical Reports for both oil and non-oil companies including Shell Petroleum Development Corporation, Agip, Totalfina ELF, Chevron, Mobil, OMPADEC/NDDC and Greater Port Harcourt City Development Authority, etc.

I have attended several Conferences and a member of Learned Societies Activities including (i) Annual General Meeting / Conference of the Nigerian Environmental Society. Lagos, Nigeria 2005 (ii) International Conference on Environmental Audit/Monitoring: Monitoring Pollution in Air, Water, Soil. Lagos, Nigeria 2006; (iii) African Universities Day: The Role of Education in Achieving Sustainable Environmental Management. Port Harcourt, 2006, (iv) Review of Interim Guidelines & Standards on Environmental Pollution Control & Management 2010: Air Quality Guidelines & Standards for Rivers State

(vi) International Conference of Society of Petroleum Engineers: Environmental Desiderata of Gas Flaring in the Emerging Oil & Gas Field of Africa in 21st Century: Lessons from the Niger Delta Region, Nigeria. Kenya, 2014.

Prof. Ideriah is an Environmentalist and well experienced in Teaching and Research. He is the author of the books (1) Basic Principles and Methods of Environmental Chemical Analysis (2) Introduction to Instrumental Methods of Analysis. He also co-authored the following: (1) Environmental Quality Monitoring of Rivers State University of Science and Technology (2) Comprehensive Laboratory Manual for the Institute of Pollution Studies. (3) Interim Guidelines and Standards on Environmental Pollution Control and Management in Rivers State.

MEMBERSHIP OF RELEVANT PROFESSIONAL BODIES

Prof. T.J.K. Ideriah is a member of Chemical Society of Nigeria (CSN) and Nigeria Environmental Society (NES).

EXTRA CURRICULAR ACTIVITIES/HOBBIES

(a) Photography (b) Indoor games (c) Reading.

COMMUNICATION SKILLS

Prof. T.J.K. Ideriah in addition to English language speaks fluently Kalabari (Ijaw), Hausa and Igbo languages.

MARITAL LIFE

Prof. T.J.K. Ideriah is married to Mrs. Eucharia T. Ideriah (Nee Jack) and blessed with joyful, amiable and lovely children – TEMELAYE (LUCKY) and TOMITOMA (JOSEPHINE).

CONCLUSION

Prof. T.J.K. Ideriah is prominent in Research Gate and Google Scholar with over 420 (status 16.7) and 498 (h-index 15) citations respectively.

He has Awards of Excellence by National Body of Students' Chemical Society of Nigeria and Honour by Students Chemical Society of Nigeria, Rivers State University Chapter.

Today, I am Professor Tubonimi Joseph Kio Ideriah, the first **Professor of ENVIRONMENTAL AND ANALYTICAL CHEMISTRY in this great Rivers State University and Niger Delta Region in general.** All Glory to God Almighty.

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