



THE Consulting Engineer

A Four-Monthly Publication of The Association for Consulting Engineering in Nigeria (ACEN)

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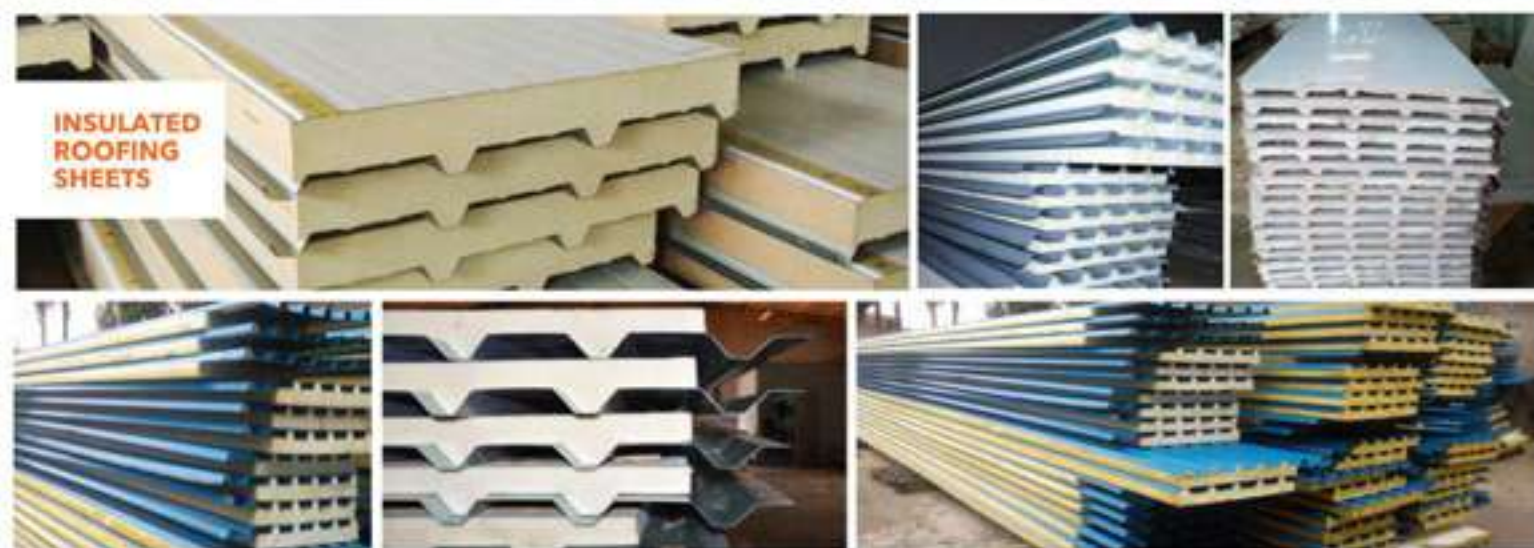
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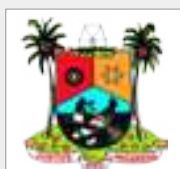
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FROM THE EDITORIAL SUITE

Over the years, “The Consulting Engineer” magazine has served as a rich repertoire of information for teeming readers across Nigeria, particularly engineers and related professionals. This edition is also very rich in content and is based on the theme “Environmental Engineering Services”.



Engr. Ademola Adeboya, MNSE

The impact of the environment on the health of living things in the ecosystem is of great concern to engineers and relevant stakeholders. This edition examines the subject in various ramifications to provide insight on how to safeguard the environment to the benefit of man and other living things. It can only be deemed wise on the part of this generation to safeguard the environment for the future generation.

The first article is on “Remediation Techniques for Crude Oil Spills” by Dr. Reuben N. Okparanma (Associate Professor, Environmental Diagnostics & Remediation, Department of Agricultural & Environmental Engineering, Rivers State University, Port-Harcourt). This material is very educative and serves as a scholarly comprehensive review of remediation techniques currently available in any open access literature. This material should prompt the interest of relevant government agencies in Nigeria towards implementing workable solutions to the degradation of the environment caused by crude oil spills in oil producing communities.

Environmental impact assessment (EIA) is an important prerequisite in the development and execution of projects. The applicable policy and actionable activities on EIA are well enunciated in this edition by Dr. Abbass Suleiman (Director of Environmental Impact Assessment, Federal Ministry of Environment) as they pertain to Nigeria. Engineering consultants and contracting firms need to be very familiar with EIA policy.

Another presentation is on “Salvaging the Environment through Eko Clean Air” by Mrs. Bola Ajao (Head, Public Affairs, Lagos State Environmental Protection Agency – LASEPA). The Lagos State Government, through LASEPA, took

the bull by the horn by embarking on “Eko Clean Air Initiative”. The details of the activities in the context of this initiative are presented in this edition. LASEPA has also presented an article on “E-Waste Management”. LASEPA has shown a good example of its laudable drive in ensuring the use of modern and safe approach to e-waste management.

Other articles in this edition are:

- Process Safety Implications to Health and Environmental Protection by Engr. Wilson Dadet, FNSChE, Lead Process Engineer, Nigeria LNG Limited
- Environmental Control of Highway Construction by Engr. Henry Okpala, FNSE, FNICE, FNHITE, FIMC, KGS, Principal Consultant, HECON Consultants

The special supplement section carries a feature on Coastal and Reclamation Engineering Services Limited. This is a highly reputable firm with footprints in several countries of the world. The firm operates with reliable technical and management expertise using its world-class approaches in service delivery.

“The Consulting Engineer” Personality in this edition is Engr. Lanre Sagaya, Jr, MNSE, Director, YOLAS Consultants Ltd. His achievements as a rising icon in engineering consultancy should prompt younger engineers to aim at excellence in practice of the profession.

ACEN’s first Business Evening event in 2023 is recorded in memorable pictures in this edition. The Tit-Bits section has a write-up by the columnist, Engr. Enefiok Ubom, FNSChE on “Waste to Electric Power”. This material should serve as an eye opener to the government in various tiers in Nigeria in the quest to improve electricity supply while simultaneously turning waste to wealth.

Finally, we are deeply grateful to all those who contributed to the successful publication of this edition.

Engr. Ademola Adeboya, MNSE
(Chairman, Editorial Board)

ACEN PRESIDENT'S MESSAGE

Engineering continues to be the forerunner for the development and progress of any society. It is involved in solving the real-world problems of society, as opposed to science, which is led by curiosity and research.

The various disciplines and diverse specializations of engineering create solutions for different areas of human life. Therefore, the engineer serves a very crucial role in the society.



Engr. F. Ajibade Oke, FNSE

The vision of our founding fathers was to create an environment for consulting engineers to achieve global standards while taking into consideration our local conditions and constraints.

The Association for Consulting Engineering in Nigeria (ACEN) has evolved from the early 1960s and 1970s when the majority of the owners of consulting engineering companies that make up ACEN were working under colonial and expatriate consulting engineering firms in the country.

These engineers are now business owners handling various buildings and infrastructural projects all over the country. ACEN members continue to perform well in various aspects of engineering

and it is anticipated that the enacted Engineers Registration Amendment Act 2019 will provide a good platform for ACEN members to be at the forefront of infrastructural development in Nigeria.

I congratulate the Council and the Local Organising Committee of ACEN for the successful hosting of the FIDIC Africa Infrastructure Conference in Lagos during May 2022.

The decision to open up the space for participation of all of ACEN's seven (7) zones in the hosting of its activities is already yielding very good results. ACEN will continue to collaborate with the National Assembly, relevant Ministries, Departments and Agencies of Government (MDAs) at the Federal and State levels; foster its relationship with Nigerian Association of Chambers of Commerce, Industry, Mines and Agriculture ((NACCIMA), Council for Regulation of Engineering in Nigeria (COREN) and the Nigerian Society of Engineers (NSE). ACEN is a Council member of COREN as stipulated in the assented Engineers (Registration, etc.) Amendment Act 2019.

"The Consulting Engineer" magazine is published thrice a year, each publication has a theme and articles that bear relationship with the theme. It continues to play its role in informing and educating members on new developments in science and technology, it also shares engineering principles and practice with the MDAs and the public.

The themes for this year are Environmental Engineering Services; Electrical Engineering Services and Climate Change and I have no doubt that we will serve you with good publications.

I wish you good fortune this year and beyond.

Engr. F. Ajibade Oke, FNSE
President

"Engineering continues to be the forerunner for the development and progress of any society. It is involved in solving the real-world problems of society, as opposed to science, which is led by curiosity and research."

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THE ASSOCIATION FOR CONSULTING ENGINEERING IN NIGERIA (ACEN)

The Association for Consulting Engineering in Nigeria, ACEN, was founded in 1971 and registered in 1979. ACEN is a body of registered independent private engineering consultancy firms and the voice of the profession in Nigeria.

MISSION STATEMENT

“ACEN shall build a strong membership that fosters equal opportunities, creates competitive advantage through increased visibility with strategic partners, and improves the standards of consulting engineering in line with international best practice.”

VISION STATEMENT

“To remain the ultimate reference business association of choice for organisations providing professional engineering consultancy services in Nigeria.”

FUNDAMENTAL OBJECTIVES

- Ensure that the highest level of technical competence and business ethics are brought to bear on the practice of the profession in Nigeria.
- Ensure that every State has the highest level of Consulting Engineering practice by having members in every state of the federation and the federal capital.
- Increase the number of engineering firms in the country relative to the size of the nation.
- Ensure that stakeholders in the built environment get maximum value for their investments by monitoring standards of practice within the industry.
- Grow the industry by promoting the growth of large consulting engineering firms.

ACEN MEMBERSHIP

Prior to December 2007, ACEN membership was open to individual and firm members, who possessed the required experience and professional integrity. At the 2007 AGM, a motion was passed limiting ACEN membership to firms. This was to further emphasize the business nature and focus of the association. Membership is therefore now open to Consulting Engineering firms with the adequate experience and commitment to continuous improvement in technical and business integrity. Today, ACEN's member firms numbering about 300 are located in the 6 geo-political zones and the FCT.



ACEN & COREN

The Council for the Regulation of Engineering in Nigeria is the statutory body responsible for the regulation of all Engineering activities in Nigeria. It is empowered to keep a register of all Engineering craftsmen, technicians, technologists, Engineers and Consulting Engineering Firms who wish to practice in the country. No individual or organization is allowed to practice Engineering in Nigeria without the approval of COREN. Thus all member firms of ACEN must be registered with COREN and the members of such firms must also be individually registered by COREN. ACEN has just recently been mandated by COREN to register on its behalf all consulting engineering firms in the country. Furthermore, ACEN President now seats on the Council of COREN. Thus, ACEN is now better positioned within the built industry.



ACEN & NSE

The Nigerian Society of Engineers is the umbrella association of all graduate Engineers in Nigeria and all Engineers employed in ACEN member firms are members of NSE. Conversely, most members of NSE with an interest in Consulting Engineering practice are members of ACEN. ACEN focuses only on the business interest of Consulting Engineering Firms and her interest is, therefore, specific and complementary to the scope of COREN and NSE.



ACEN & FIDIC

The International Federation of Consulting Engineers is a 100-member organisation that provides the strongest platform for our international activities. FIDIC is the voice of Consulting Engineering all over the world, and this it does through seven major focus areas: Representation, Business Practice, Ethics/Integrity, Image, Sustainability, Globalization and Quality.

FIDIC is perhaps best known for its contract documents, which are used all over the world, especially for international projects in the third world. The documents are used extensively by the Nigerian Federal Ministry of Works. In addition, FIDIC has Manuals on a Guide to Practice that teaches best practice in Consulting Engineering, Business Integrity Management, and Quality Management amongst several others.

Two (2) ACEN members, Engr. J.I. Folayan and Engr. Bayo Adeola have served on the FIDIC Executive Committee, the highest level of the organization. Other ACEN members have served on committees and task forces of the organization, and members attend the yearly annual conferences in large numbers regularly.



ACEN & FIDIC Africa

FIDIC Africa is the FIDIC Group of African Member Associations which addresses specifically, African concerns. FIDIC Africa currently has 14 members, holds regular annual conferences and AGMs, and promotes networking among its members. Nigeria played a very active role in the formation of FIDIC Africa and has continued to be very active in the Association.

ACEN Past President, Engr. (Mrs.) Mayen Adetiba, was once Chairman of FIDIC Africa while several ACEN members have served on the Executive Committee including ACEN's Past President, Engr. Charles 'Yele Akindayomi and the Immediate Past

President (IPP), Engr. George C. Okoroma, who are members, presently, of the FIDIC Africa Executive Committee.

ACEN ACTIVITIES

ACEN provides a series of activities tailored to deliver service and benefits to our members in these key areas:

- Training through the ACEN School of Consulting Engineering.
- AGM & EGM for effective dissemination of information to members.
- Attending International Conferences.
- Membership / Certifying Standards.
- Advocacy.
- Quarterly Business Evening meetings to discuss topical issues affecting members.
- The Young Professionals Forum.
- Triannual publication of "The Consulting Engineer" magazine.
- Monitoring and follow-up on policies and bills relating to matters of engineering practice.
- Legal retainership program to advise members on legal issues.
- Advancing the practice of consulting engineering for favourable business environment for members.
- Setting up of Special Task Forces on:
The collapse of buildings, conditions of engagement/ scale of consultancy remunerations, quackery, Industry study, formation of built industry transparency initiative, local content for the construction industry, etc.

CHALLENGES OF ACEN

Despite the fact that ACEN has been in existence for fifty-two (52) years, some of the challenges leading to its formation have remained while new ones have emerged. The most notable current challenges are as follows:

- Unfavourable Government procurement policies especially in the states.
- Private sector perception.
- Loss of Engineers to other sectors due to low remunerations.
- Number, size and scope of ACEN Member firms.
- Delayed payments to members.
- Limited awareness and knowledge of the savings consultants contribute to the overall cost of projects if employed by governments and entrepreneurs.
- Inadequate corporate sponsorship to enhance smooth operations of the organisation.



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- Water Studies and Boreholes Services:
- Supply of Laboratory and Drilling Equipment with their Accessories
- Material Testing (Quality Control and Quality Assurance)
- Pile Foundations Construction
- Mineral Survey and Exploration
- Structural Testing (destructive and NDT testing on concrete)
- Geotechnical Training Services for Personnel

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Registration Unit CAC:
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REMEDICATION TECHNIQUES FOR CRUDE OIL SPILLS

BY DR. REUBEN OKPARANMA

ABSTRACT

A broader understanding of remediation techniques for crude oil spills is essential for informed and effective management of the risk of exposure to potentially carcinogenic petroleum hydrocarbons which find their way into the environment when crude oil is spilled. Spillage of crude oil and its allied products has largely been attributed to equipment failure or human error as well as the wilful destruction of production facilities by vandals. Over the years, the most effective method of managing oil spills has been by remediation with the sole aim of reducing or controlling the risks associated with one or more pollutant linkages. With the abundance of remediation techniques currently in use, it is difficult (if not impossible) to find all the remediation techniques described in one piece of literature. This paper reviews as many of the remediation techniques as never done previously in any open access literature, accentuates their advantages and disadvantages and compares them in terms of costs and clean-up time for informed decision making.

KEYWORDS: *Bioremediation, Environmental Engineering, Environmental Pollution, Land Contamination, Land Reclamation*

1.0 INTRODUCTION

Crude oil spills, almost always, release petroleum hydrocarbon contaminants into the environment above a target value (screening level). Screening level is the contaminant concentration at which there is no unacceptable risk to a specified target (USEPA, 1996). Some petroleum hydrocarbon contaminants include benzene, toluene, ethylbenzene, xylene (BTEX), total petroleum hydrocarbon (TPH) and polycyclic aromatic hydrocarbons (PAH).

In crude oil-producing countries, available records (such as recorded in Okparanma, 2013; SPDC, 2022) show staggering levels of oil spill incidence. This is particularly the case in developing countries where extant environmental laws are ignored by the oil companies due to lack of proper enforcement by the



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Port-Harcourt)

local regulatory authorities (Okparanma et al., 2010). This disregard for laws intended to protect ecological health and the failure of the oil and gas industry watchdogs to enforce the laws have been responsible for the widely documented negative environmental impacts of crude oil spills in these developing countries.

Restoration of the impacted environment to its pristine conditions has been the main focus of remediation. However, in practice, restoring impacted environmental medium to its pristine conditions is an uphill task. Thus, the best practice has been to ensure that

site-specific remediation objectives that relate to remediation target values for contaminants are achieved. Achieving the remediation target values for contaminants can depend on the type/nature of contaminants, length of time the remediation has gone on for, type of remediation technique adopted and prevailing environmental conditions, among others. To drive home the essence of this review, further discussion would be focused on the types of remediation techniques used to tackle crude oil spills.

2.0 CLASSIFICATIONS OF REMEDIATION TECHNIQUES

Fig. 1 shows the broad classifications of remediation techniques. Based on development status, the established techniques are the traditional methods that have been in use for a long period of time while the innovative techniques are the relatively new methods of remediation. The established techniques are further categorized into biological and non-biological methods. The biological remediation (bioremediation) techniques are those that rely on biochemical processes of biological organisms (bacteria, fungi, earthworms, plants, etc.) to decontaminate impacted environmental media. The non-biological techniques are those that rely on physical, chemical and thermal processes to render impacted media harmless. Since the innovative techniques are not fully developed, their applications are still confined to the laboratory due to health and safety concerns as well as regulatory issues.

Remediation techniques can also be classified based on the type of application. Relative to the pollution hotspot, remediation can be applied either in-situ or ex-situ. In-situ techniques are applied onsite once the hotspots have been identified. If the contamination is on land, no excavation is required. In-situ application depends on a number of factors including type/nature of contaminant, depth of contamination, size of the site and technology application cost. On the other hand, ex-situ application can be done either onsite or offsite. Onsite ex-situ application is when the remediation is carried out within the contaminated site, but distances away from the hotspot while offsite ex-situ application is when the remediation is done somewhere different from the contaminated site. Onsite/offsite ex-situ application depends on the size of the site (because of space for plant/treatment area), neighbours/planning restrictions, client's preference and distance to treatment, storage and disposal (TSD) facility due to haulage cost.

The processes involved in the detoxification of crude oil contaminated environment can be used to classify remediation techniques. These include thermal, physical, chemical and biological processes. Thermal processes use heat to increase the propensity to burn, desorb, destroy or melt the contaminants. Physical/chemical treatment uses the physical and/or chemical properties of the contaminants or of the contaminated medium to destroy (i.e., chemically convert), separate or contain the contamination. In physical processes, phase transfer of pollutants from the matrix is induced. In chemical processes, the chemical structure as well as the behaviour of pollutants is changed through chemical reactions to produce less toxic or better separable compounds from the matrix. In biological process, contaminants are transformed or degraded into harmless substances including carbon dioxide, water, fatty acids and biomass through microbial metabolism.

The effects of the different remediation techniques on contaminants differ significantly and can be used to classify them. These effects may involve contaminant destruction as a result of a complete biological and/or physicochemical degradation (e.g., incineration), contaminant removal

through phase transfer/mobilisation, recapture (e.g., leaching and sorption), concentration and recovery / harvesting (e.g., by physical separation) or combination (e.g., through hyper-accumulator plants). Other effects are enhancing the recycling of the treated matrix, stabilisation, containment and immobilisation. Stabilisation is when a contaminant remains in-situ but is rendered less mobile and/or less toxic by some combinations of biological,

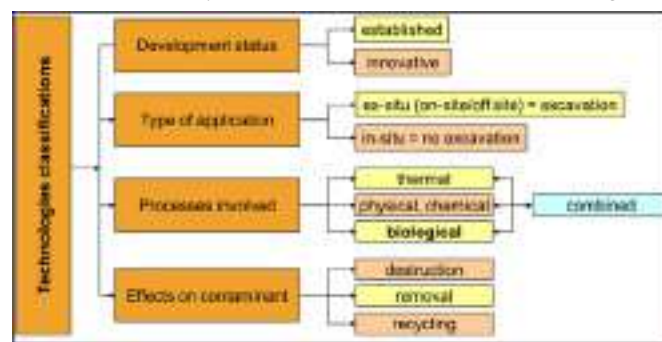


Fig. 1: The broad classifications of remediation techniques for contaminated land and groundwater (Adapted from Coulon, 2012)

chemical or physical processes. Containment prevents exposure of the surrounding environment. Immobilisation changes contaminants into less available constituents by some transport process or by adding immobilizing agents.

3.0 TYPES OF REMEDIATION TECHNIQUES

Remediation techniques for crude oil spills may be broadly categorized into three namely, thermal, physicochemical and biological treatment (bioremediation) methods.

3.1 THERMAL TREATMENTS

Thermal treatments involve high temperature heating of the contaminated soil to volatilise, melt, decompose or destroy contaminants. In addition to microwave-assisted heating, thermal treatment techniques in use are shown in Fig. 2.

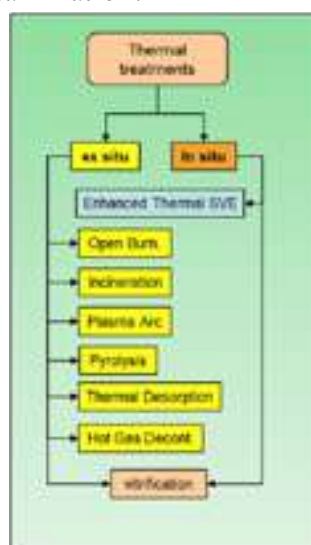


Fig. 2: The thermal treatment techniques currently available for crude oil-contaminated land and groundwater (Adapted from Coulon, 2012)

i. Microwave-Assisted Heating: In microwave-assisted heating of materials, energy is transferred directly to substances. This causes every single element in the material to be heated instantly through molecular or ionic vibrations under the effect of an oscillating magnetic or electric field (Mutyala et al.,

2010). Although microwave-assisted heating technology is not applicable to every material, it is becoming increasingly attractive in the treatment of oilfield drill cuttings (Robinson et al., 2009) which is a waste stream consisting of soil, crude oil, drilling mud and other drilling mud additives. Generally, microwave heating method has not been commercialized on a large scale as yet due to the huge financial implications for initial setup; only few small-scale commercial applications of the technology have been reported in the literature (Mutyalu et al., 2010).

ii. **Enhanced Thermal Soil Vapour Extraction (SVE):** In soil vapour extraction (SVE) shown in Fig. 3, vacuum is applied to the soil to induce the controlled flow of air and remove volatile organic compounds (VOCs) and semi-volatile organic compounds (SVOCs) from the unsaturated (vadose) zone. Vacuum is applied through extraction wells. SVE is also known as in-situ soil venting, in-situ volatilization, enhanced volatilization or soil vacuum extraction.

iii. **Plasma Arc:** A plasma torch is a device that converts electrical energy into thermal energy. The plasma arc creates a “flame” that has temperatures in the range of 4,000 to 7,000 °C. It is

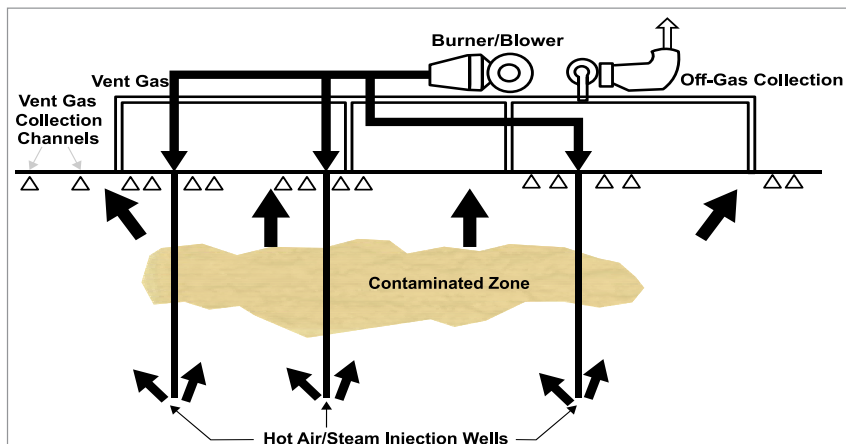


Fig. 3: A schematic of enhanced thermal soil vapour extraction (Source: Coulon, 2012)

different from incineration because it uses energy from plasma to thermally convert organic waste from a solid or liquid to a gas through controlled pyrolysis or controlled gasification (See Fig. 4).

iv. **Pyrolysis:** Pyrolysis is a form of treatment that chemically decomposes organics in contaminated media by heat in limited amount of oxygen.

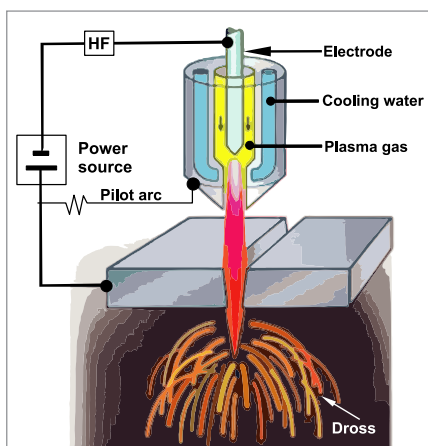


Fig. 4: A schematic of plasma arc technology (Source: Coulon, 2012)

It typically occurs under pressure and at operating temperatures above 430°C (800°F). Typical application of pyrolysis in the remediation of hydrocarbon-contaminated soil is



Fig. 5: An application of pyrolysis in the remediation of hydrocarbon-contaminated soil (Source: Coulon, 2012)

shown in Fig. 5.

v. **Thermal Desorption and Incineration:** Thermal desorption refers to the indirect heating of contaminated soil/sediments to vapourize volatile and semi-volatile compounds without incinerating the soil/sediments. Thermal desorption seeks to recover contaminated soil/sediment without necessarily converting them to ash. Low-temperature thermal desorption units (250 to 350°C) are used to remove light aliphatics and aromatics (e.g., BTEX) while high-temperature thermal desorption units (up to 520°C) are used to remove heavier aromatics such as PAHs (Owens et al., 1993). On the other hand, incineration destroys contaminated soil/sediments and converts them to ash. The thermal desorption process and incineration are shown in Fig. 6. The advantages and limitations of the thermal treatment process are shown in Table 1 while Table 2 compares the treatment technologies.

3.2 PHYSICOCHEMICAL TREATMENTS

In physical treatments, physical properties of the contaminants or the contaminated medium are used. Phase

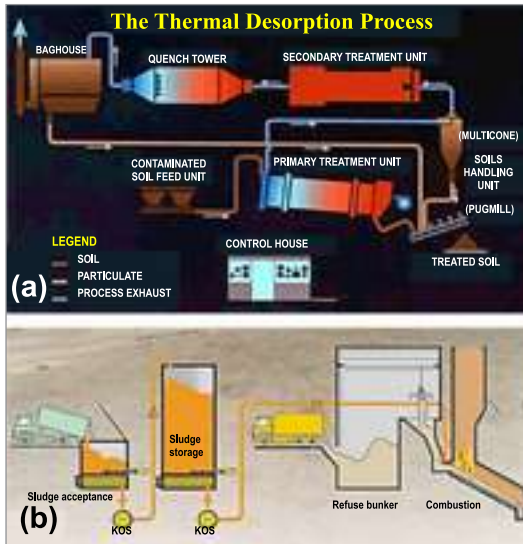


Fig. 6: (a) A thermal desorption process at Fort Edward, NY, USA, and (b) incineration process.

Advantages	Limitations
Fast treatments	Not applicable to inorganics
Applicable to organics	Not applicable to liquid or gaseous media
Applicable to solid media	Efficiency controlled by the contaminants
Significant reduction of volume	Expensive and fugitive dust emission
	High carbon footprint
	Destroy solids (e.g., HTTDUs for drill cuttings)

HTTDUs, High Temperature Thermal Desorption Units

Table 1: The advantages and limitations of thermal treatments

Technologies	Cost (€/ton)	Clean-up time (months)*
Combustion	220 - 6000	< 6
Pyrolysis	300	< 6
Plasma arc systems	750 - 1900	6 - 12
Vitrification	300 - 400	6 - 12
Thermal desorption	40 - 300	6 - 12

*Data from (Lodolo, 2005) cited in Coulon (2012). Time referred to a standard mass of 20,000 tons

Table 2: Comparison Among Thermal Treatment Methods

transfer of contaminants is induced by means of a physical mechanism. No modification of the chemical structure of contaminants occurs. On the other hand, in chemical treatments, the chemical structure (and then the behaviour) of the pollutant is changed by means of chemical reactions. The physico-chemical treatment techniques currently available for crude oil-contaminated land and groundwater are shown in Fig. 7.

i. **Containment Barriers:** The barriers are installed around the contaminated soil in order to avoid the possible spreading of contaminants to water sources close to the site (See Fig. 8).



Fig. 8: In-situ containment barriers for surface oil spills (Source: Coulon, 2012)

Sub-surface barriers consist of vertically excavated trenches filled with slurry.

The slurry, usually a mixture of bentonite and water, hydraulically shores the trench to prevent collapse and retards groundwater flow. The barrier is non-reactive, treating no particular target group of contaminants (See Fig. 9).

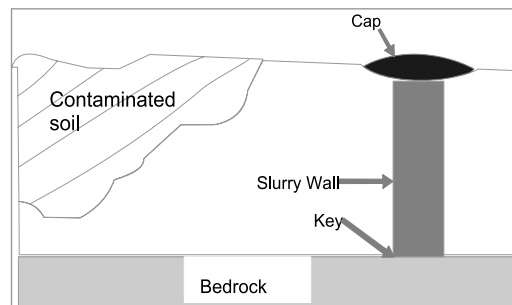


Fig. 9: In-ground containment barrier for subsurface oil spills (Source: Coulon, 2012).

The pH is kept neutral by mixing cathode and anode solutions (See Fig. 10).

iii. **Sediment/Soil Washing:** Soil washing is a water-based process for scrubbing soils ex-situ to remove contaminants. This is achieved by:

- Dissolving or suspending them in the wash solution which can be sustained by chemical manipulation of pH for a period of time
- Concentrating them into a smaller volume of soil through particle

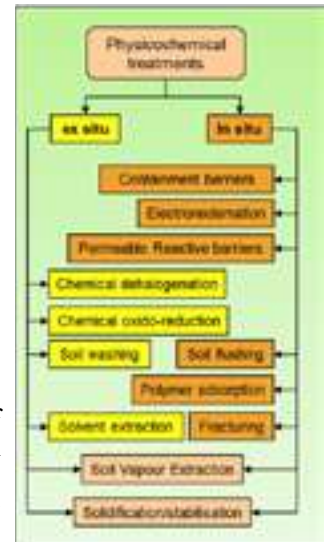


Fig. 7: Physical treatment techniques currently available for crude oil-contaminated land and groundwater (Adapted from Coulon, 2012)

ii. **Electro-Reclamation:** In electro(bio)reclamation, nutrients are added through the electrode wells and electro-kinetic processes are used to disperse these materials to the bacteria already

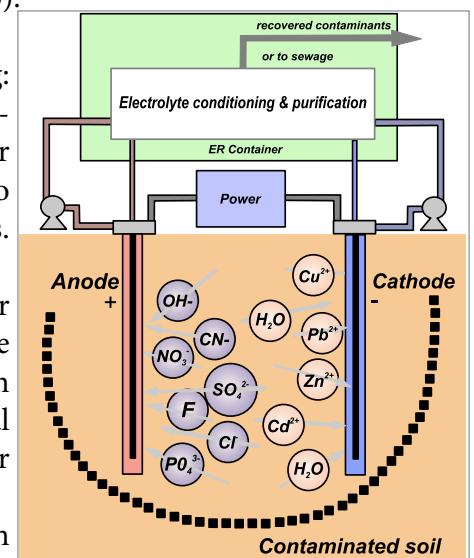


Fig. 10: Schematic of in-situ electro(bio)reclamation process (Source: Coulon, 2012).

Advantages	Limitations
Fast treatments	Often do not treat but only transfer contaminants
Treat a wide range and type of contaminants	Residuals need further treatment
Applicable to various media	Limited by site characteristics
Low relative cost	
Low site characterisation required	

Table 3: Advantages and limitations of physical treatments

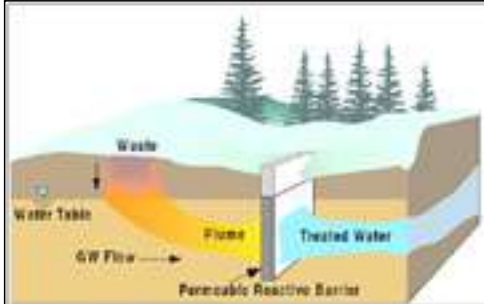


Fig. 11: In-ground permeable reactive barrier for remediation of contaminated groundwater (Source: Coulon, 2012)

size separation, gravity separation and attrition scrubbing. The advantages and limitations of the physical methods of remediation are shown in Table 3.

- iv. Permeable Reactive Barrier:** Permeable reactive barrier (PRB) is a developing technology for in-situ groundwater remediation (See Fig. 11). The barrier allows some, but not all, contaminants to pass through it. A typical example is activated carbon. The primary removal methods include:
- Sorption and precipitation
 - Chemical reaction
 - Reactions involving biological mechanisms

- v. Soil Flushing:** Soil flushing is the extraction of contaminants from the soil with water or other suitable aqueous solutions. Water, or water containing an additive to enhance contaminant solubility, is applied to the soil or injected into the groundwater to raise the water table into the contaminated soil zone. Contaminants are leached into the groundwater followed by extraction and treatment.

- vi. Solidification and Stabilization:** Contaminants are physically bound or encapsulated within a stabilized matrix (solidification), or chemical reactions are induced between the stabilizing agent and contaminants to reduce their mobility (stabilization) (See Fig. 12). A leachability test is typically performed to measure the immobilization of contaminants.

The advantages and limitations of the chemical methods of remediation are shown in Table 4 while Table 5 compares the technologies.

3.3 BIOLOGICAL TREATMENTS (BIOREMEDIATION)

Metabolic microbial activity is key to the biodegradation of non-conservative contaminants like hydrocarbons during bio-remediation. Usually, there is partial degradation in both aerobic and anaerobic environments which explains why the biodegradation curve of non-conservative contaminants is asymptotic (Okparanma et al., 2017). Unaided bioremediation is very slow. Thus, several methods are employed to expedite the process. These methods include, but not limited to, bio-stimulation and bio-augmentation. There are a number of bio-remediation strategies in common use as shown in Fig. 13.

- i. Bio-Piling (Engineered Bio-Pile):** Contaminated soil is placed in an engineered bio-pile (See Fig. 14) and treated with a blend of selected chemicals and microorganisms that naturally break the toxins down into less harmful compounds. After treatment, treated soils can be safely backfilled, landfilled or taken offsite for other forms of applications

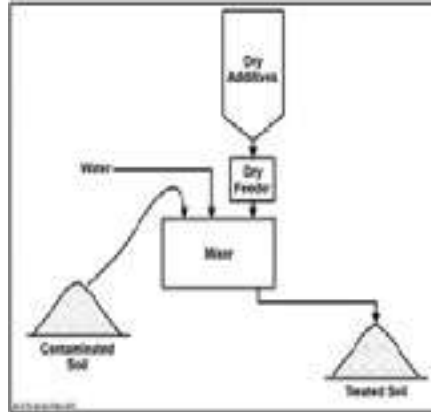


Fig. 12: Schematic of solidification/stabilization process (Source: Coulon, 2012).

Advantages	Limitations
Fast treatments	Require extensive site characterisation
Treat a wide range and type of contaminants	Residuals need further treatment
Applicable to various media	Limited by site characteristics

Table 4: Advantages and limitations of chemical treatments

Technologies	Cost (€/ton)	Clean-up time (months)*
Soil washing	140 - 400	6 - 12
Supercritical Water Oxidation	150 - 300	< 6
Solvent Extraction	150 - 450	6 - 12
Solvated Electron	300 - 500	< 6
Chemical Dehalogenation	200 - 500	< 6
Soil Flushing	75 - 210	6 - 12
Electrokinetic	65 - 195	6 - 12
Landfill Caps	N.A.	N.A.
Solidification/Stabilisation	75 - 200	6 - 12 or greater
Soil Vapour Extraction	20 - 130	6 - 12 or greater

*Data from (Lodolo, 2005) cited in Coulon (2012). Time referred to a standard mass of 20,000 tons.

Table 5: Comparison Among Physicochemical Technologies.

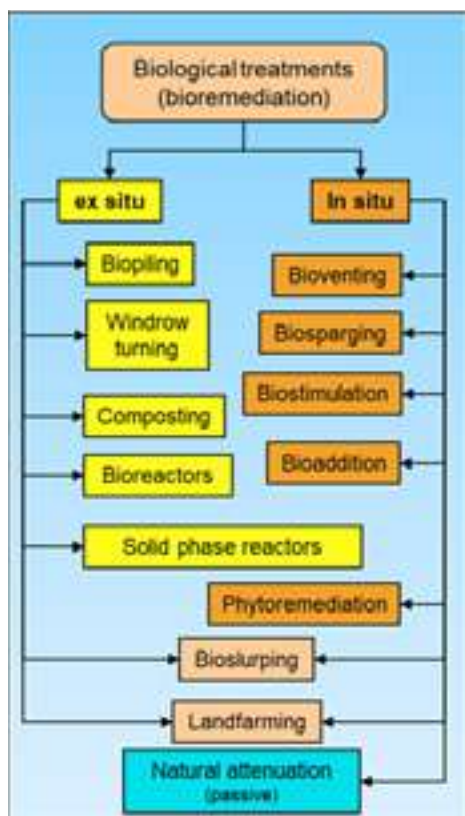


Fig. 13: Biological treatment techniques currently available for crude oil-contaminated land and groundwater (Adapted from Coulon, 2012).

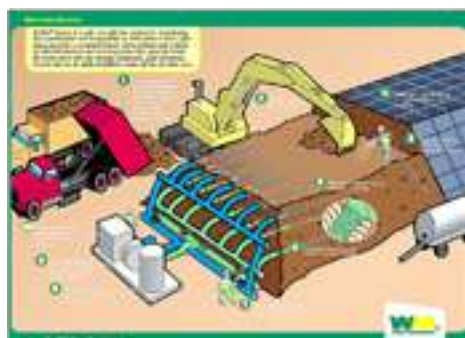


Fig. 14: Schematic of an engineered bio-pile system (Source: Coulon, 2012).



Fig. 15: A mini semi-engineered bio-pile system at Ogoniland, Niger Delta region, Nigeria.

- ii. **Bio-Piling (Semi-engineered Bio-Pile):** In contrast to engineered bio-pile, most agro-technical operations in the semi-engineered bio-pile system like tilling of soil for proper mixing of added nutrients and irrigation of bio-pile are done manually to enhance aeration (See Fig. 15).

- iii. **Composting (Bio-Pile and /Windrows):** Composting involves the addition of organic matter like woodchips, straw and/or sawdust as bulking agents to a contaminated medium either in static bio-piles, windrows or in-vessel systems and allowing the matrix to stay for some time for biodegradation to occur naturally (See Fig. 16). The added organic matter increases microbial diversity enhances complex contaminants' breakdown under a good temperature, aeration and nutrient level.

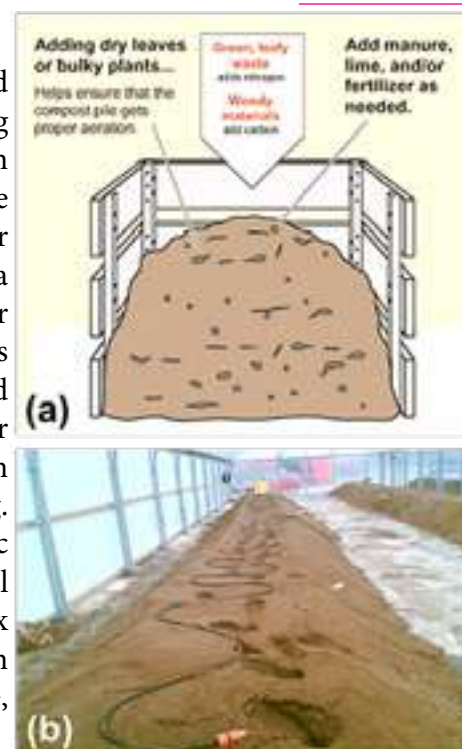


Fig. 16: Composting with decomposing organic materials in (a) Bio-Piles and (b) Windrows (Source: Coulon et al., 2010).

- iv. **Bio-Stimulation / Bio-Augmentation:** The use of amendments to stimulate the indigenous microbial community to enhance biodegradation is known as bio-stimulation. According to a recent review (Goswami et al., 2018), several amendments have been used for bio-stimulation targeting various hydrocarbon contaminants. Currently, the Nigerian Content Development and Monitoring Board (NCDMB) is funding the field trial of an indigenously formulated amendment, Solpawa®-SBX, at one of the HYPREP's sites in Ogoniland, Niger Delta, Nigeria (See Fig. 17)..

The addition of hydrocarbon-degrading micro-organisms to enhance biodegradation is known as bio-addition or bio-augmentation (See Fig. 18). This practice is usually adopted in the event of a deficiency of competent indigenous microbes. Some of these specialized microbes can occur naturally while others can be synthesized in the laboratory.

- v. **Bio-Venting/Bio-Sparging:** In bio-venting, oxygen is delivered to contaminated unsaturated soils by forced air movement (applying either extraction or injection of air) to increase oxygen concentrations and stimulate biodegradation (See Fig. 19a). In bio-sparging, air (or oxygen) and nutrients (if needed) are injected into the saturated zone to increase the biological activity of the indigenous microorganisms (See Fig. 19b).



Fig. 17: Irrigating crude oil-contaminated soil after the application of Solpawa® bioremediation products in a mini semi-engineered biocell at Ogoniland, Niger Delta, Nigeria.

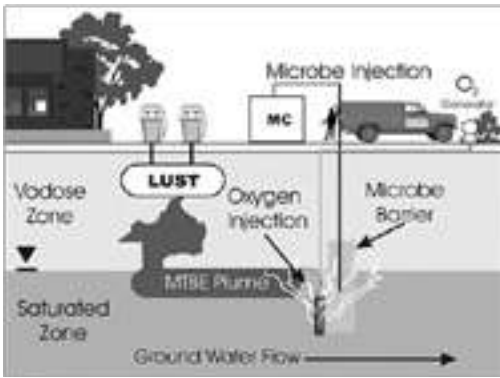


Fig. 18: Schematic of an on-site treatment of hydrocarbon-contaminated soil by bio-augmentation
(Source: Coulon, 2012)

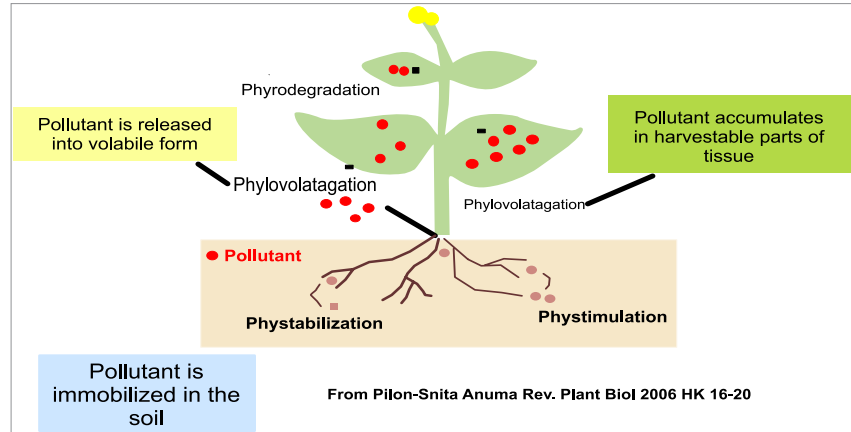


Fig. 20: Processes involved in the phyto-remediation of contaminated soil
(Source: Coulon, 2012).

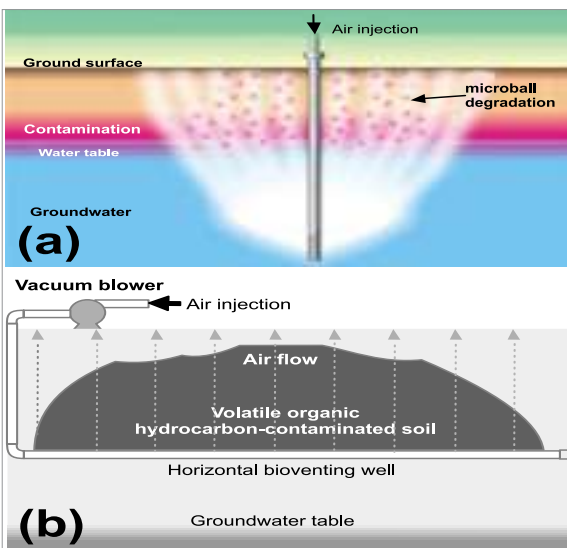


Fig. 19: Schematic of the application of bio-venting (a) and (b) bio-sparging
(b) (Source: Coulon, 2012).

vi. **Phyto-Remediation:** The direct application of green plants for in-situ removal or degradation of contaminants in environmental media is known as phyto-remediation. The contaminants are removed by one or more of many phyto-remediation processes including phyto-degradation, phyto-stabilization, phyto-volatilization and phyto-extraction as shown in Fig. 20 (Thijs et al., 2017). Some dicotyledonous plants including spear grass, guinea grass, elephant grass, gamba grass, corn and elephant grass have been reported to have the potential to remediate contaminated soil. In a recent

study, costus afer plant has also been reported to remediate contaminated soil (Emeka et al., 2023).

vii. **Natural Attenuation:** Natural attenuation is a process which may be physical, chemical or biological that, under favourable conditions, acts without human intervention to reduce the mass, toxicity, mobility, volume or concentration of contaminants in soil or groundwater. Usually, when it is enhanced by bio-stimulation and/or bio-augmentation with the application of some agro-technical methods like tilling in windrows, it is referred to as remediation by enhanced natural attenuation (RENA). RENA is widely used in the Niger Delta, Nigeria for the remediation of crude oil-contaminated soils (Ebuehi et al., 2005). The advantages and limitations of the biological

Advantages	Limitations
Generate little or no residues	Not generally applicable to inorganics
Treat a wide range of organics	Slow treatment (30 days to 2 years)
Offer flexibility in system design	Require extensive site characterisation
Versatile alternatives with low carbon footprint	Limited by site characteristics
Cost less than other technologies	
Applicable to various media	

Table 6: Advantages and limitations of biological treatments.

Technologies	Cost (€/ton)	Clean-up time (months)*
Biopiles	25 - 75	< 6 - 12
Bioslurping	230 - 270	6 - 12
Landfarming	90 - 100	6 - 12 or greater
Composting	250 - 300	6 - 12 or greater
Natural Attenuation	10 000/year	> 12
Bioventing	15 - 80	< 6
Biostimulation / Bioaugmentation	25 - 100	6 - 12 or greater
Phytoremediation	50 - 100	> 12

*Data: (Lodolo, 2005) cited in Coulon (2012). Time referred to a standard mass of 20,000 tons.

Table 7: Comparison among biological technologies.

treatment methods are shown in Table 6 and the comparison is in Table 7.

viii. **Genetically Engineered Microorganisms (GEM):** The enhancement of bioremediation through genetic engineering is increasingly becoming attractive in recent times. This is because recombinant DNA techniques are known to improve the degradation of

hazardous wastes under laboratory conditions (Menn et al., 2008). Recombinant bacteria can be obtained by genetic engineering techniques. There are at least four principal approaches to GEM development for bioremediation applications. These include:

- a. Modification of enzyme specificity and affinity
- b. Pathway construction and regulation
- c. Bioprocess development, monitoring, and control
- d. Bio-affinity bio-reporter sensor applications for chemical sensing, toxicity reduction and endpoint analysis

Some GEMs that have been used for bioremediation include *Pseudomonas* sp. B13, *P. putida*, and *E. coli* FM5/pKY287 (Menn et al., 2008). Up until now, though, the application of GEM in bioremediation is still confined to the laboratory due to ecological and environmental concerns and regulatory constraints.

4.0 CONCLUSION

Remediation techniques currently available for crude oil spills were reviewed in this paper. Some techniques are well-developed and have gained wide recognition and public acceptance while a few others are still at the laboratory stage. This category is yet to be accorded recognition and public acceptance due to some constraints. The thermal techniques appear to be comparatively faster but more expensive and less environmentally friendly while the biological techniques are relatively cheap and more ecologically safe but take a longer time to achieve desired results. As it turns out, no particular method fixes it all. Consequently, there will always be room for more innovations in trying to improve existing techniques by scientists and engineers, including the fact that some techniques would complement others.

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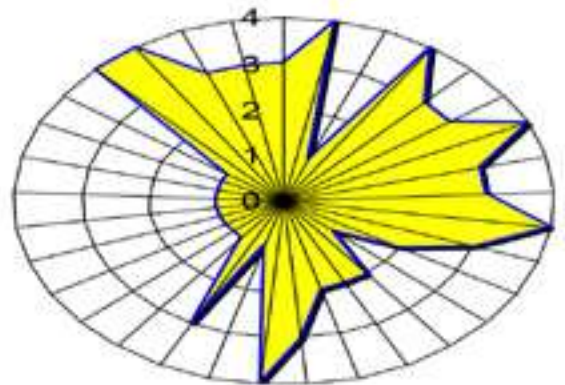
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ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT POLICY & IMPLEMENTATION IN NIGERIA

BY DR. ABBASS SULEIMAN

1.0 INTRODUCTION

In the early 1960s, some laws and regulations were put in place specifically to protect the environment. The essential linkages between development and the environment started gaining more currency especially after the Stockholm Conference on the Human Environment in 1972. Following the dumping of toxic wastes in Koko in 1988, environmental issues in Nigeria assumed a new dimension and importance. The Harmful Waste Decree No 42 of 1988 which prohibits the importation and use of toxic wastes was promulgated to deal with the specific mandate of protecting the Nigerian environment. On 10th December 1992, the mandate of Federal Environmental Protection Board was enlarged by the amended Federal Environmental Protection Agency (FEPA) Decree of 1992 vide EIA decree No 86 of 1992.

2.0 ENVIRONMENTAL IMPACT ASSESSMENT ACT

The Federal Government of Nigeria enacted the Environmental Impact Assessment (EIA) Act No. 86 of 1992 as a demonstration of her commitment to the Rio Declaration of Principles (United Nations Conference on Environment & Development, UNCED, Rio de Janeiro Brazil, 1992). Article 17 in the Rio Declaration states inter alia “Environmental impact assessment, as a national instrument, shall be undertaken for proposed activities that are likely to have a significant adverse impact on the environment and are subject to a decision of a competent national authority.”

3.0 CREATION OF FEDERAL MINISTRY OF ENVIRONMENT

In 1999, the Federal Ministry of Environment was created and FEPA became part of the Ministry now known as the Department of Environmental Assessment. The Department is charged with the responsibility of ensuring that all developmental projects are carried out in compliance with relevant environmental laws and regulations in order to ensure environmental sustainability [www.ead.gov.ng/about-us].

Specifically, Section 1 of the EIA Act states that the objectives of any environmental impact assessment shall be: (a) To establish, before a decision



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is taken by any person, authority, corporate body or unincorporated body including the Government of the Federation, State or Local Government intending to undertake or authorize the undertaking of any activity that may likely or to a significant extent affect the environment or have environmental effects on those activities shall first be taken into account; (b) to promote the implementation of appropriate policy in all Federal Lands (however acquired) States and Local Government Areas consistent with all laws and decision making processes through which the goal and objective in paragraph (a) of this section may be realised; (c) to encourage the development of procedures for information exchange, notification and consultation between organs and persons when proposed activities are likely to have significant environmental effects on boundary or trans-state or on the environment of bordering towns and villages [EIA Act CAP E12, LFN 2004].

4.0 ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT (ESIA)

Environmental and Social Impact Assessment (ESIA) policy and implementation in Nigeria is a crucial topic, given the country's diverse ecosystems, cultural heritage and social dynamics. The Nigerian government recognizes the need to balance economic growth with environmental and social sustainability. As a policy implementation strategy, the three tiers of Government, namely Federal, State and the Local Governments, are charged with clearly defined responsibilities.

The Federal Government is involved in quality control and assurance of baseline information, Public Display of EIA reports, public announcement of Panel Review meetings and mobilization of stakeholders for Panel Review meetings. The two

tiers of Government apart from statutorily serving as Panel members in the Technical and Panel Review meetings of EIA reports of projects located in their respective territories or geographical boundaries, they are also involved in the initial environmental examination of proposed project sites as well as in EIA follow-up program. This arrangement is to ensure adequate consultations and hence, understanding and inter-governmental and community co-operation in the EIA process and project implementation.

5.0 IMPLEMENTATION OF ENVIRONMENTAL IMPACT ASSESSMENT

The Environmental Impact Assessment (EIA) Division of the Environmental Assessment Department is divided into three branches (Registration & Verification, Evaluation & Analysis and Impact Mitigation Monitoring) for easy implementation of EIA in Nigeria.



Fig. 1: EIA Process initiation



Fig. 2: EIA Evaluation & analysis



Fig. 3: EIA Impact mitigation monitoring

The EIA Act of 1992 established the legal framework for environmental impact assessment in Nigeria. The law requires that any proposed project that may have a significant impact on the environment must undergo an environmental impact assessment before approval. The NESREA Act of 2007 established NESREA, a regulatory body responsible for enforcing environmental standards and regulations in Nigeria. The EIA Procedures and Charges Regulations, 2021 provide guidelines for the conduct of Environmental Impact Assessments in Nigeria.

The ESIA process in Nigeria involves four main stages: screening, scoping, impact assessment and reporting. See Figs. 1, 2, 3 & 4. The screening stage determines whether a proposed project requires an environmental and social impact assessment. Projects that are likely to have a significant impact

on the environment or social well-being must undergo an impact assessment. The scoping stage identifies the potential impacts of the project and establishes the scope of the assessment. The impact assessment stage evaluates the potential impacts of the project on the environment and social well-being. The reporting stage involves the preparation of a report that summarizes the findings of the assessment and makes

“...the implementation of the EIA process in Nigeria is an important step towards promoting sustainable development and protecting the environment and local communities.”

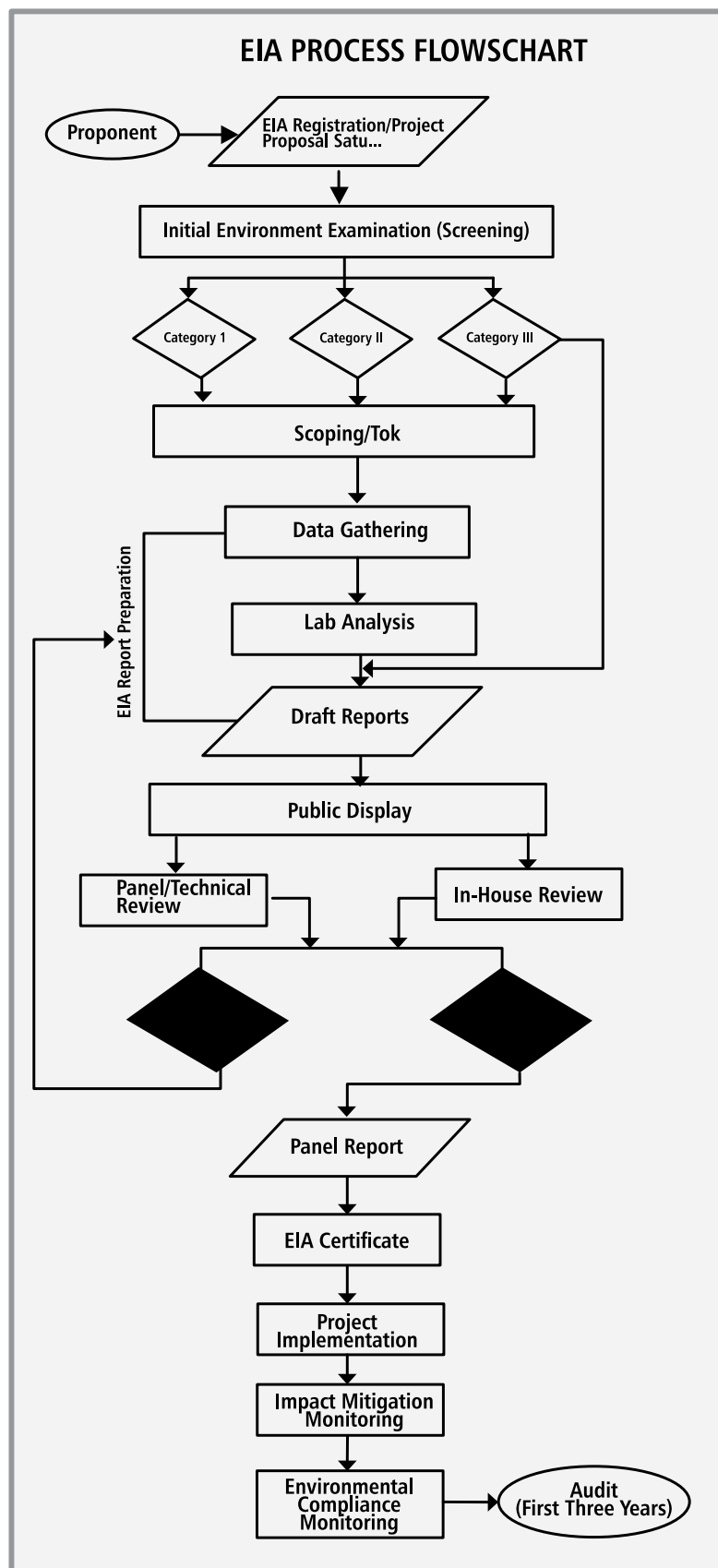


Fig. 4: EIA Process flowchart

recommendations for mitigating any adverse impacts.

6.0 CONCLUSION

In conclusion, the implementation of the EIA process in Nigeria is an important step towards promoting sustainable development and protecting the environment and local communities. EIA policy and implementation in Nigeria are critical for promoting sustainable development, protecting the environment and ensuring social well-being.

The legal framework, including the EIA Act of 1992 codified as EIA Act Cap E12 LFN, 2004, the NESREA Act of 2007 and the EIA Procedures and Charges Regulations, 2021 provides the foundation for EIA in Nigeria. Efforts are being made to enhance the capacity of stakeholders and regulatory agencies, improve transparency and accountability in decision-making and monitor compliance with the EIA process. Engineering consultants are critical stakeholders in the EIA process. They have a critical role to play in promoting the effective implementation of the EIA process to ensure that development projects are sustainable, environmentally responsible and meet the needs of all stakeholders.

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SALVAGING THE ENVIRONMENT THROUGH 'EKO CLEAN AIR'

BY MRS. BOLA AJAO

1.0 INTRODUCTION

Lagos, Africa's largest megacity, with over 22 million inhabitants, is confronted with myriads of environmental challenges largely caused by human activities. The most significant challenge, within the perspective of human existence, is air pollution. Some of the identified contributors to this phenomenon in Lagos State, Nigeria include transportation, power, industrial activities and urbanization, among others.

Global attention is on climate change as a result of human actions on the environment. These human actions, particularly in mega cities, prompted the World Bank study on Lagos environment in 2017 which clearly reiterated the need for urgent action to save the earth for future generations.

2.0 BASIS FOR 'EKO CLEAN AIR' (ECA) INITIATIVE

Breathing clean air is a basic human necessity and the more we take care of our environment, the less we spend on healthcare. With this understanding, there is a determination to rid Lagos State of all forms of pollution and bequeath a clean, safe and healthy environment to future generations.

The United Nations report also revealed that air pollution is the greatest environmental threat to global public health and accounts for an estimated 7 million premature deaths every year. Nigeria has the largest number of deaths due to air pollution in Africa and ranks fourth for air pollution across the globe. Lagos, with a growing population, has lost its serenity and tranquility to urbanization and industrialization. These developments have exposed the inhabitants to myriads of pollution with attendant consequences on health and the environment.

3.0 COMPLIMENTARY INITIATIVES TO ACHIEVE ECA OBJECTIVES

In an effort to restore clean air in Lagos State, robust initiatives such as the introduction of the Bus Rapid Transport (BRT) system, Vehicular Emission Test by Lagos State Vehicle Inspection Service (LACVIS)

Tree planting, Dumpsite improvement, blue line light rail mass transit, Water transportation, advocacy and public education have been implemented with continuous improvement.

4.0 AIR QUALITY MONITORING

LASEPA has also taken other measures to ensure clean air availability. These are: the provision and installation of air quality monitoring stations in six locations across the state between 2020 and 2021 (Alausa, Ikorodu, Abesan-Ipaja, Akoka, Lekki and Jankara-Lagos island), development of climate action plan, industrial monitoring to ensure compliance to regulations, guidelines and standards and the review of existing laws and policies, etc.

5.0 IDENTIFYING WITH THE GLOBAL COMMUNITY

At the 26th Conference of Parties, COP26, of the United Nations Framework Convention on Climate Change, UNFCCC, held in Glasgow, Scotland, the General Manager of LASEPA, Dr. Dolapo Fasawe made a case for achieving Net-zero emissions and commitment of government to focus on monitoring emissions and overall air quality of Lagos State.



**Dr. Dolapo Fasawe, M.B.Ch.B.,
MPH, IHC (General Manager,
LASEPA)**

6.0 IMPLEMENTATION OF ‘EKO CLEAN AIR’ INITIATIVE AS AN ADVOCACY TOOL

On August 27, 2022, the state in collaboration with some development partners, embarked on the laudable “Eko Clean Air” (ECA) initiative at Itedo Community in Eti-Osa LGA to address air pollution, promote circular economy and further empower the vulnerable members of the community through waste to wealth. This program was geared towards achieving sustainable development.

The campaign is part of actualizing the THEMES Agenda of the present administration of Mr. Babajide Sanwo-Olu, Governor of Lagos State, under the Health and Environment Pillar targeted at reducing health inequality, proper waste sorting and promotion of clean environmental practices. THEME Agenda refers to: T – Traffic Management & Transportation, H – Health & Environment, E – Education & Technology, M – Making Lagos a 21st Century economy, E – Entertainment & Tourism, S – Security & Governance.

ECA was strategically designed as an advocacy tool and behavioral remodeling drive leveraging a pan-stakeholder, pro-action and purposeful collaboration with relevant stakeholders to effectively monitor and mitigate air pollution in Lagos. The initiative, which is already making measurable impact, is to be replicated in the 20 Local Government Areas and 37 Local Council Development Areas (LCDAs) of Lagos State. It has been implemented in areas like

Itedo Community (Eti-Osa), Ibeshe in Oriade LCDA, Ikorodu and recently Isale Eko (Lagos Island) with over 10 thousand beneficiaries to date. See Figs. 1.

LASEPA has been engaging residents through outreaches by providing branded gas cylinders for households and communities as alternatives to firewood/charcoal/kerosene stoves for cooking. This is to reduce emissions and ensure cleaner air with a view to increasing life expectancy of the residents of Lagos.

7.0 SOME PRE-ECA ACTIVITIES

Prior to the intervention, ‘Knowledge, Attitude and Practice (KAP) Study of the Environment’ was carried out as well as ‘Baseline Air Quality Assessment’. Thereafter, there was a post intervention assessment to measure impact.

Provision of drinkable water was embarked upon in some communities that lacked access to clean water. School advocacy program was launched to enable youths imbibe environmental activism. Some of the students were decorated as ‘Environmental Ambassadors’. Eco-friendly materials such as multiple use bottles and bags as well as rechargeable lamps were also distributed to discourage the use of single-use plastics and lanterns respectively. The aim is to improve quality of life and encourage green lifestyles.

Nigeria generates over 5 million tons of waste yearly and most Nigerians burn their waste or have them



Fig. 1: ‘Eko Clean Air’ sensitization campaign.



Fig. 2: *Trash for cash campaign*



Fig. 3: *Participants in 'Trash for Cash' program.*

dumped at landfills, contributing more to the pollution of the environment. As part of addressing this menace, LASEPA embarked on waste-to-wealth drive, specifically tagged 'Trash for Cash', where residents exchange wastes such as pet bottles, used electrical-electronic items and waste oil for cash rewards, food produce, health insurance, cowry cards for transportation and gas cylinders, among others. See Figs. 2 & 3.

'Sanwo Switch To Gas' (SS2G) is an offshoot of the 'Eko Clean Air' Initiative. It focuses more on grassroots participation to encourage attitudinal change and transition from the use of wood, charcoal and kerosene stoves to cleaner energy. See Figs. 4, 5 & 6.

LASEPA has also used advocacy walk, media appearances, jingles and educational activities such as poetry, graphics by students and drama presentation by popular Nigerian actors, the Prince Jide Kosoko drama group. These activities were adopted to champion the sensitization campaign for cleaner energy as a pathway to deepen the use of renewable energy and enhance pollution prevention.

LASEPA has also engaged sustainability advocates such as Dr. (Mrs.) Ibijoke Claudiana Sanwo-Olu, the former Acting Consular to the US Mission, Mr. Brandon Hudspeth, the HIS Towers, Lagos Waste Management Authority (LAWMA), Lagos State Signage & Advertising Agency (LASAA), Federal Road Safety Commission (FRSC), Ministry of Health, Ministry of Transportation, Lagos State Health Scheme (LASHMA) and the Touch and Pay Technologies Ltd (TAP) for the Cowry cards, etc.

Others are the Ministry of the Environment & Water Resources (MOE&WR), Lagos State Parks & Gardens Agency (LASPARK), Lagos State Coconut Development Authority (LASCODA), Lagos State Lotteries & Gaming Authority (LSLGA) and Lagos Ferry Services (LAGFERRY), among others.



Fig. 4: The wife of Lagos State Governor, Dr. Mrs. Ibijoke Claudina Sanwo-Olu (middle) speaking at the ‘Sanwo Switch to Gas’ advocacy campaign in Elegbata, Isale Eko, Lagos Island



Fig. 5: A ‘Sanwo Switch to Gas’ advocacy presentation

8.0 ACHIEVING LASEPA’S GOALS WITHIN ENABLING LAWS

The goal of LASEPA is to create a changed mindset to promote sustainable environmental management

practices in the state and further use the provisions of the Law on violators in accordance with Section 182(1) of the Lagos State Environmental Management and Protection Law, 2017 which



Fig. 6: A 'Sanwo Switch to Gas' advocacy campaign.

“All emissions from vehicles, plants and equipment including generating plants in residential, commercial and industrial areas within the state shall meet air emission standards proscribed by the Agency”.

states that: “All emissions from vehicles, plants and equipment including generating plants in residential, commercial and industrial areas within the state shall meet air emission standards proscribed by the Agency”. Also, section 182 (2) of the Lagos State Environmental Management and Protection Law, 2017 states that: “As from the commencement of this Part, a person who sells or maintains any plant and equipment including electricity generating plants and other plants with an emission level above agreed emission standards subject to the provisions provided in the regulation to this Part, shall apply for a permit to the Agency which shall be granted with or without any condition.”

9.0 CONCLUSION

The ECA advocacy will continue so as to educate the residents in the state on the need to ensure a clean and healthy environment through attitudinal change across the various LGAs/LCDAs.



George Hotel, Lagos



CICC, Calabar



Zenith Bank, Accra



Lake Point Tower, Lagos



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E-WASTE MANAGEMENT IN LAGOS

BY MRS. BOLA AJAO



1.0 INTRODUCTION

Lagos State Environmental Protection Agency (LASEPA) is the authorized agency responsible for all issues pertaining to the management of e-waste in Lagos State.

E-waste is any electrical or electronic equipment/product that is unwanted, obsolete, not working and whose useful life is imminent or has actually come to an end. Computers, cell phones, television sets, refrigerators, stereos, copiers and fax machines are examples of everyday electronic products that are being discarded, thrown away as garbage or dumped into landfills. Those who engage in these unwholesome practices are, unfortunately, unmindful of the dangers inherent in improper handling or management of the “digital rubbish” otherwise known as e-waste.

2.0 E-WASTE MANAGEMENT MEASURES

In recent times, e-waste has become a major contributor to environmental pollution across the globe. This is due to the rapid pace of technological advancement and the rush for ownership and replacement of a wide range of old devices for more sophisticated electronic machines and devices by rural

and urban dwellers across the globe. Most of these devices have turned out to be more of enemies of the environment than friend.

Lagos State, being the commercial nerve center of Nigeria, is not exempted from the influx of a wide range of electronic devices, such as computers, smart phones, television sets and other electronic appliances that may contain hazardous materials. Measures such as distribution of informative/educative materials, encouragement of green procurement practices (purchasing equipment or devices or products and services that cause minimal adverse environmental impacts) are put in place to effectively handle and manage e-waste for the health benefits of all residents of the state.

Governments around the world have taken steps to address the inherent problem of e-waste, implement policies and regulations to reduce the negative impacts and promote responsible e-waste management.

Lagos has taken the bull by the horn to halt the indiscriminate dumping of Tokunboh (imported fairly used items) devices at Lagos markets through holistic measures in line with global best practices. In order to halt the e-waste menace, LASEPA responded by embarking upon aggressive sensitization, accreditation of collectors, monitoring/evaluation and enforcement of e-waste policy such that requires manufacturers to take back their products that have reached their end of life. This is in accordance with the National Environmental Regulations on Electrical and Electronic sector 2022. Section 8 subsection 2. See Fig. 1.



Fig. 1: E-waste sensitization campaign

This has helped in reducing the amount of e-waste ending up in landfills and informal scrap yards. Also, a series of town hall meetings have been organized with relevant stakeholders to ensure that e-wastes are disposed in an environmental-friendly manner through appropriate channels.

In line with the objective of the state to promote healthy living and safeguard environmental quality that is consistent with social and economic needs of the people, the state has been collaborating with relevant stakeholders at the international, national and state levels. These stakeholders include the United Nations Environment Program (UNEP), National Environmental Standards Regulations & Enforcement Agency (NESREA) and Lagos State Waste Management Agency (LAWMA). The aim is to implement the Global Environmental Facility (GEF) funded circular economy approach for electronics sector and creation of 30 e-waste collection centers across the 20 LGAs to test-run the scheme in Nigeria.

In recognition of the need to sanitize the unwholesome management of e-waste and further protect the people and environment from unhealthy situations associated with constant exposure and haphazard disposal of waste, LASEPA continuously organizes workshops, trainings and seminars for both the formal and informal sector so as to keep them abreast of new trends in the handling and management of e-waste.

“Trash for Cash”, an incentivized circular economy and sustainability series, with the primary aim of driving a waste-to-value narrative, has drastically reduced the indiscriminate dumping and littering of wastes on roads, water channels and drainages in Lagos State. This initiative has also raised more awareness on the importance and value of proper recycling and responsible disposals of e-waste. See Fig. 2.



Fig. 2: ‘Trash for Cash’ campaign

In order to ensure that e-waste/scrap are properly disposed to accredited e-waste collectors, the agency has been involved in monitoring of scrap yards to determine compliance and level of impact on the environment by carrying out laboratory analysis), granting authorization, registration and issuance of permit to collectors and recyclers.

The agency also encourages citizens’ participation in all phases of the e-waste management planning along the value chain and electrical/electronic equipment (EEE) lifecycle to gain community awareness input. Concerted efforts are also being made to join forces with progressive partners (formal/informal) at all tiers, levels, private and corporate organizations to phase out Ozone-depleting substances and the need to preserve nature and comply with environmental guidelines while also ensuring that technicians operate in an eco-friendly manner.

E-waste contains a variety of hazardous materials, such as lead, cadmium, mercury and flame retardants, that can pose a serious threat to human health and the environment. If not properly managed, these hazardous materials can leach into the soil and groundwater, contaminating the environment and posing a risk to mother earth. It is important to also note that everybody has a role to play in reducing e-waste and promoting responsible e-waste management. By working together, we can create a cleaner, healthier and more sustainable future for everyone.

“E-waste contains a variety of hazardous materials...that can pose a serious threat to human health and the environment.”



Fig. 3: Sensitization campaign to mark the year 2022 World Ozone Day.

3.0 IDENTIFICATION WITH THE INTERNATIONAL COMMUNITY

To reaffirm the commitment of the government to the holistic cause, periodical meetings are held with the executives of the relevant associations in addition to annual celebration of relevant international days (World Ozone Day, International E- Waste Day and World Environment Day) to serve as a forum for intellectual exercise to forge partnerships and develop global cooperation to achieve the global goal of preventing further depletion of the ozone layer. See Figs. 3 & 4.



Fig. 4: A sensitization team of the year 2022 World Ozone Day

4.0 COLLABORATION WITH NAFDAC

Last year, a feat recorded by the agency in collaboration with the National Agency for Food and Drug Administration Control (NAFDAC), was the discovery of an illegal scrap yard and three containers each of 40 feet in length with large volumes of hazardous chemical, used medical consumables, electronic/electrical waste and operating recycling plant within a residential area without relevant state permits or environmental controls. See Fig. 5 & Fig. 6.

5.0 ENABLING LAWS FOR E-WASTE MANAGEMENT

The following are relevant laws guiding the operation of the agency and the appropriate sanction on violators respectively; The National Environmental (Electrical and Electronic sector) Regulations 2022, Section 8 Subsection 2 which states that; Where a person generates or handles waste, such person shall be responsible for collection, treatment, transportation and final disposal of the waste in line with specified standards and guidelines. Section 12 Subsection 1 also specifies that a person who imports, exports, manufactures, assembles, distributes or retails various brands of EEE shall subscribe to the Extended Producer Responsibility



Fig. 5: NAFDAC & LASEPA closed down an illegal scrap yard

Program and the Buy Back Policy as provided in the Eighth Schedule to these Regulations.

A person who also manufactures, imports, distributes or retails EEE shall take back the end-of-life EEE and set up a collection point or centre.

While the Lagos State Environmental Management and Protection Law, 2017; Section 181 (a) (b) states

that: A person shall not:

(a) Dispose of, dump, bury or (b) allow to be buried, dumped in or over any water within the State any solid or liquid, hazardous or radioactive substance or waste as may be designated without the participation of the Agency and in line with the Agency's Regulations and guidelines.



Fig. 6: NAFDAC & LASEPA closed down an illegal containerized waste dump.



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Our work has won us a strong reputation for cost effective, pragmatic environmental engineering and management consultancy within Nigeria and across West Africa.

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COASTAL AND RECLAMATION ENGINEERING SERVICES LTD

International Head Office: St. Gallen, Switzerland

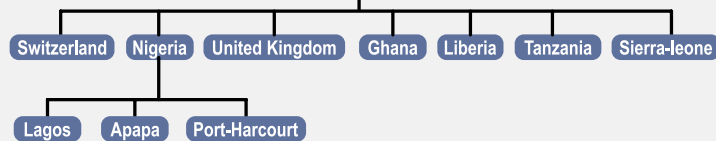
Regional Head Office: 3, Ademola Street, Ikoyi, Lagos, Ng

CARES Global Presence

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CARES Global Presence

Office Locations



CARES PROFILE

Coastal and Reclamation Engineering Services (CARES) is an international, multi-disciplinary engineering, environmental, water resources management and maritime consultancy that brings together a team of highly experienced individuals, many of whom have had over 30 years of practice in the industry. We are experienced at addressing a large variety of challenges and providing high-quality environmental and engineering consultancy and associated support services. Our local presence ensures our advice is appropriate and cost-effective. Our team consists of various COREN accredited Chartered Engineers, Master Mariners, Society of Environment (SoE) UK Chartered Environmentalists, Global Reporting Initiative (GRI) accredited Sustainability Practitioners, NEBOSH accredited Occupational Health and Safety personnel and ISO 14001 Environmental Management Systems (EMS) Lead Auditors.

CARES Limited was established in the UK in 2002 and quickly diversified and expanded to an international business with a focus on 'Local Presence'. We operate in several countries around the world and apply a model unique in the consulting industry: 'Global Expertise and Local Presence'. We believe that in establishing offices in the countries

CARES 
Global Expertise Local Presence

in which we work and engaging and training consultants to internationally recognized standards have enabled us to serve our clients in a manner which is appropriate, sustainable and cost-effective.

CARES Operating Bases

- CARES UK: Registration No. 4565517, with several industry and professional accreditations
- CARES Head Office is in St. Gallen, Switzerland
- CARES Nigeria: Certificate of Incorporation No. RC 495390, based in Lagos with satellite offices in Apapa and Port-Harcourt
- CARES Ghana: Certificate of Incorporation No. CS128552016, based in Accra
- CARES Consultants Liberia: Registration No. 051797965, based in Monrovia
- CARES Tanzania: Certificate of Incorporation No. 122046, based in Dar es Salaam
- CARES Sierra Leone: Registration No. GBR251016COAST00018



CARES Nigeria

CARES Nigeria is a fully incorporated Nigerian company, established in 2003 with a staff strength of approximately 60 persons. CARES has the benefit of being able to draw upon the technical support and expertise provided by our Regional Head Office in Ikoyi, Lagos. We also operate from three satellite offices: two in Apapa, Lagos and one in Port-Harcourt, River's State.

TECHNICAL CAPABILITY AND MANAGEMENT CAPABILITY

CARES places environmental and social management at the heart of all its services. As consultants, we help our clients to achieve environmental and social

compliance with applicable environmental and social reviews and studies including pre-acquisition audits, hydro-geological assessments, water resources management, intrusive site investigation, contaminated land assessment and remediation. These are all provided to reduce our clients' exposure to environmental risk and liabilities.

CARES Consultancy has achieved certification for Quality Assurance under ISO 9001:2015 and for Environmental Management Systems (EMS) under ISO 14001:2015 both of which, provide the framework within which work will be undertaken in an intelligent, logical and orderly manner.

AREAS OF SPECIALIZATION

CARES offers a range of environmental, engineering, maritime management and water resource management services to a wide range of clients in different sectors. Our key areas of specialization are

ENVIRONMENT	ENGINEERING	WATER RESOURCES	MARITIME MANAGEMENT
- Environmental and Social Impact Assessments (ESIA)/ - Environmental Baseline Surveys - Environmental and Social Management Plans (ESMPs); - Strategic Environmental Assessments (SEA) ; - Municipal Waste Management Advisory Services; - Environmental and Social Due Diligence; - Environmental, Social and Governance Audits; - Occupational Health & Safety Compliance Audits; - Environmental Baseline Surveys; - Land Quality Assessments; - Resettlement Action Plans (RAP); and - Site Investigations - ESG and Sustainability Reporting - Capacity Building	- Infrastructure Engineering. - Quality Control of Construction. - Coastal Protection. - Channel Design. - Construction Supervision and Contract Administration - Foundation Design. - Feasibility Studies; - Flood Protection System. - Marine Access Studies; - Dredging Auditing and Project Management. - Pollution Control Structures. - Dredging and Reclamation Design; and - Design of Marine Structures.	- Irrigation Design, Operation and Maintenance - Project Management - Hydraulic Modelling - Dam and Barrage Design - Spillage Design - Water Resources Studies - Flood Determination and Protection Systems. - Hydrogeological Studies - Wastewater Treatment and Outfall - Geotechnical Instrumentation - Construction Supervision & Contract Administration - Hydrogeological Studies - Wastewater Treatment & Outfalls - Surveys, Monitoring & Evaluation	- Training Delivery - Navigation Simulation Studies - Aids to Navigation regimes and implementation - eCMIID Surveys - Operational Management Analysis and Structures - Risk Management - Formal Safety Assessments - Vessel Traffic System and Services - International Ship & Ports Facility Security (ISPS) Audit - Safety of Navigation (IMO) desk level studies - International Safety Management Audits - Suitability/Condition Surveys - Safety of Life at Sea (SOLAS) - Harbour Design - Port Design - Security Assessment - Maritime Emergency Planning - Contingency Planning

Fig. 1: CARES key consultancy services

SOME FLAGSHIP PROJECTS EXECUTED BY CARES

Some of our ongoing projects in each of our key consultancy services are shown below:



PTOL Quay Studies-February 2022-August 2022.



Construction Supervision of the Development of the Liberia Inland Storage and Distribution Facility (Oct 2022 till date).



Construction Supervision of a Modern Hospital Complex, May 2018-August 2018.



Port Quay Wall Survey: September 2018-January 2018



Baseline Noise Assessment-June 2021



Resettlement Action Plan for Dredging of Odaw Drainage Basin: September 2021-till date.



Identifying a new site for the disposal of dredged material: June 2019 till date.



Environmental Health Safety and Legal Compliance Audit (February 2023)



Environmental and Social Due Diligence for Aker Energy: January 2022-March 2023.

SOME FLAGSHIP PROJECTS



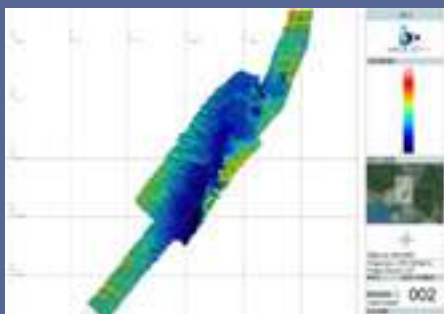
Promoting Climate Adaptation by Upscaling Solar Irrigation Technology options for Smallholder famers in Ghana: September 2022-February 2024



Opportunity Assessment and Feasibility study of rainwater harvesting for agriculture in the Kwahu Afram plain-Feb. 2021 till date.



Technical Assistance for Upscaling lowland rice production to improve food security through solar powered irrigation practices: November 2021-February 2023.



Supervision of Fatale River Hydrographic surveys in Guinea-December 2019-February 2020



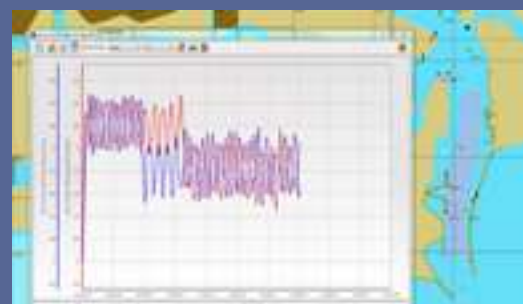
Engineering Survey Works of Lowland Irrigation Systems: Zleli



Port Training Institute Navigation Simulation Facility: November 2018 till date.



Onne Port Formal Safety Assessment-November 2022-till date.



Maritime Consultancy Services for ship vertical motion study: March 2022-June 2022.

Navigation Simulation Studies for Lekki deep sea port: November 2022-December 2022

CARES has established a significant footprint across Nigeria and beyond. We have the depth and breadth of expertise to respond to the most challenging project types across the country. Our national footprint is highlighted in Fig. 2.

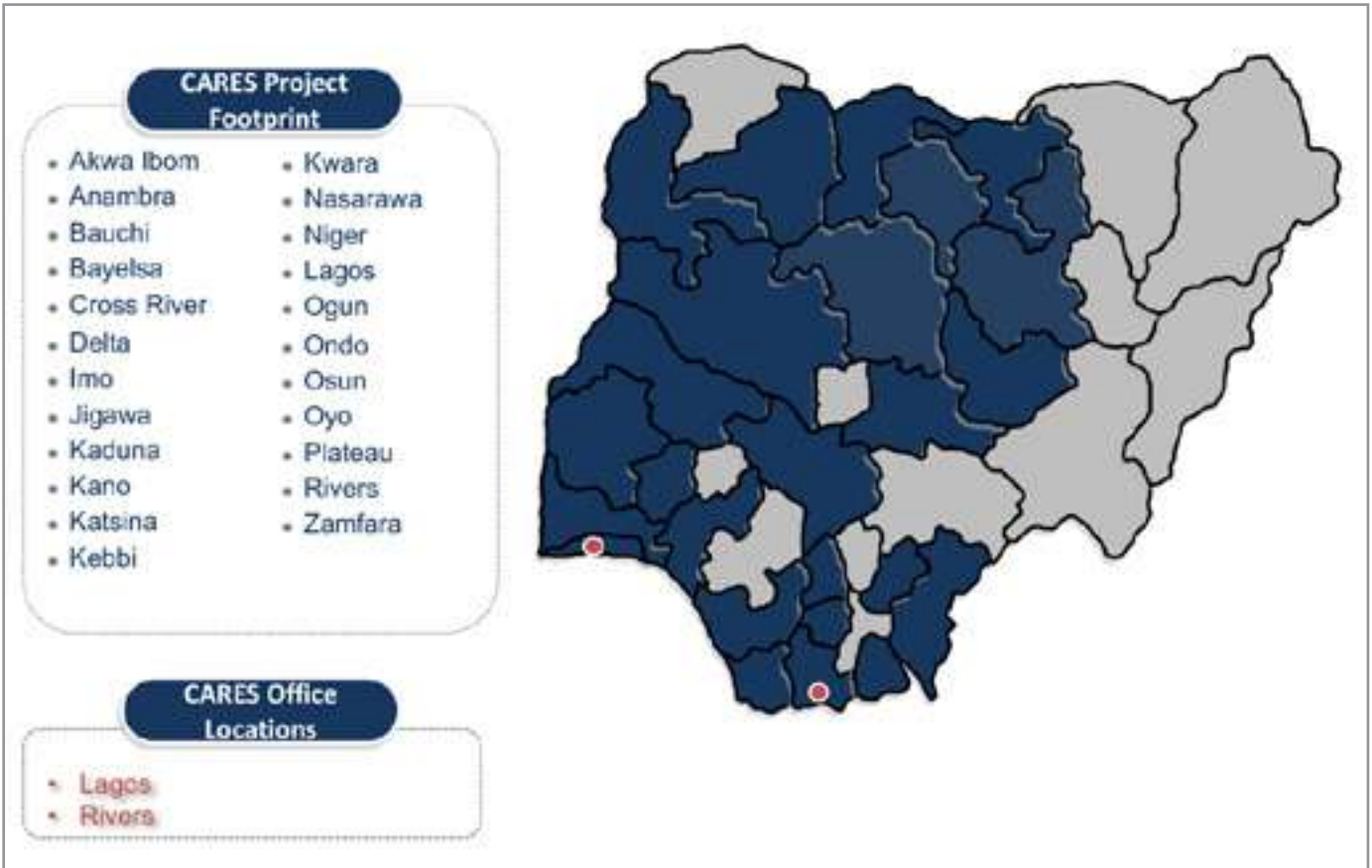


Fig. 2: CARES personnel footprint across Africa.

CARES has accumulated work experience with different types of organizations including international organizations, public institutions, cooperation agencies, NGOs and

civil society entities, private sector companies and other consulting firms. The following layout provides a collage of some of our clients.



Professional Association Memberships and Statutory Registrations

CARES Nigeria has the following applicable international professional association memberships



CARES: NIGERIA-CASE STUDY

Identification of a new site for the disposal of dredged material in the Bonny River from a number of surveys including a sediment tracer study.

CARES has executed various projects where biophysical and socioeconomic environmental issues have been thoroughly assessed to determine a developmental project's environmental and economical sustainability. The necessity for a new disposal site for dredge spoils associated with capital and maintenance dredging on the Bonny River was established, following studies conducted by various subject matter experts including CARES' in-house maritime personnel. This case study highlights the specific biophysical and metocean studies conducted which should adequately inform the selection of an ideal new disposal site within the Bonny River.

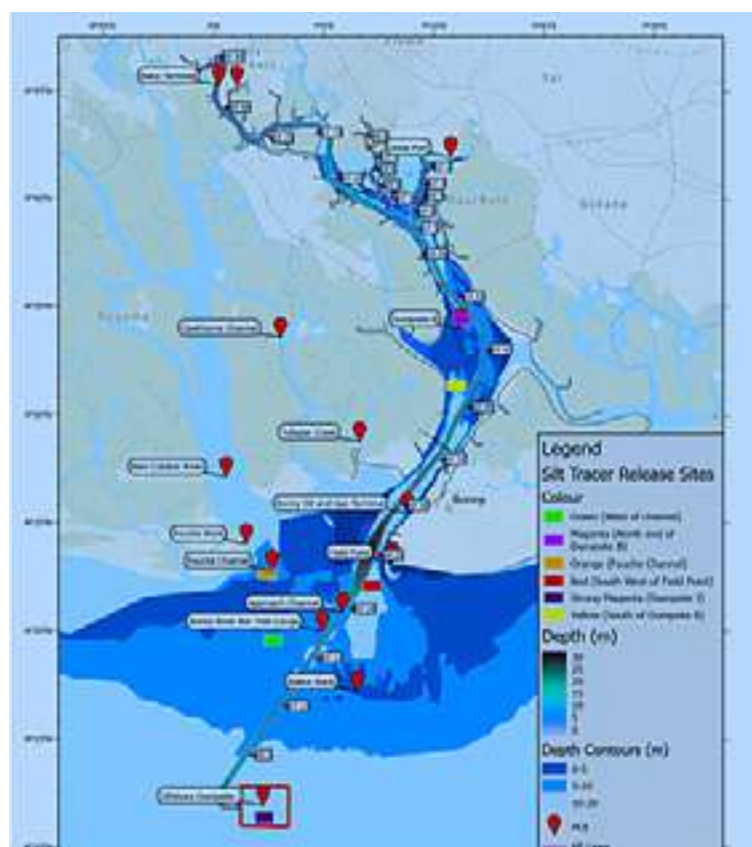
CARES had previously divulged its concerns with identifying a new in-river dredge placement such as the corresponding increase in dredge volumes and potentially higher costs. An earlier review of prior measurement and modelling studies conducted on the Bonny River, also disclosed some uncertainty regarding key metocean processes, overall

circulation and sediment dynamics of the estuarine system of the Bonny River. A common theme from many of these studies has been to look at the sources of sediment that causes siltation, recommend ways to mitigate this and to optimise dredging and disposal operations.

To identify possible disposal sites for consideration, CARES collated and reviewed historical data (including quarterly bathymetric surveys); deployed, collected, and analysed MetOcean data from sensors installed on buoys and other port infrastructure;

completed boat-based Conductivity Temperature and Depth (CTD) profiling surveys; and obtained and analysed over 1,000 sediment samples collected during the surveys.

CARES also released multiple different coloured silt tracers from six locations across the river to track silt movement, deposition, and secondary transport within a wide area, over several weeks, to understand the sediment transport



pathways and corresponding processes vis a vis dredging and disposal operations. This was to provide an improvement in the overall understanding of the estuary to identify disposal options, and to determine the final locations of dredged material.

CARES personnel conducted fieldwork for this study between November 2020 and October 2022 which comprised; background sampling to assess any background fluorescence present within the study area that may interfere with the detection of the fluorescent tracer particles; tracer release exercise to assess the fate of fine sediments placed at the disposal sites, sediment sampling collection and laboratory analyses of 1273 samples, and Conductivity Temperature and Depth (CTD) deployment and profiling.

Analysis of the outcomes of these studies are currently ongoing, and will inform a selection of options for a new in-river dredging disposal location. A report with our findings will be documented and submitted to BCC's part of steps to determine the feasibility of the proposed locations, CARES will also assess the impacts

the disposal sites may have on its biophysical and socioeconomic environment. The assessment will also include the cumulative impacts that the new proposed disposal site will have vis a vis other operations within the Bonny estuary.



An environmental impact assessment (EIA) for approval of the proposed disposal site will also be conducted in alignment with the Federal Ministry of the Environment EIA Act. The EIA will commit to identifying and evaluating significant potential and actual impacts such as noise levels, water quality, soil, vegetation, health, safety and socioeconomics. As part of the EIA report, CARES will also recommend key mitigation measures / principles to be employed in order to reduce the negative effects of the project including the use of best available technology as well as the use of pre-mobbed and regularly maintained equipment, machines and vehicles.



A detailed environmental and social management plan (ESMP) will be developed for the project to be efficiently implemented by BCC. The Environmental Social Management Plan (ESMP) provides the mechanism for implementing mitigation measures that have been developed to reduce the effects of 'medium' and 'high' significant impacts to as low as reasonably possible, prior to, and throughout the lifecycle of the proposed project.

A few of the benefits for this project include reduced vessel sailing times, overall haul distance and reduced cost of dredging which overall is vital to the oil and gas economy.

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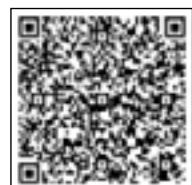


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ACEN BUSINESS EVENING



The President, Engr. F. Ajibade Oke, giving a welcome address at the 1st ACEN Business Evening.



The Guest Speaker at the 1st Business Evening, Permanent Secretary (General Administration), Office of the Governor of Oyo State, Tpl Dayo Ayorinde.



Cross-section of participants at the event.

 *Honourable Council Member, Engr. Wale Lagunju, making a contribution at the event.*



Esteemed Member, Engr. Olayinka Alli, making a contribution to the event.



L-R: The President, Engr. F. Ajibade Oke, presenting a plaque to the Guest Speaker, Tpl Dayo Ayorinde.



L-R: The President, Engr. F. Ajibade Oke; Guest Speaker, Tpl, Dayo Ayorinde and ACEN Zone 7 Coordinator, Engr. Bola Olowe at the event.



The President, Engr. F. Ajibade Oke (3rd left) flanked to the right by the Guest Speaker, Tpl Dayo Ayorinde, and (L- R) the Managing Director, Engr. Kalejaiye Sunday, Engr. Wale Lagunju, Engr. Bola Olowe and Engr. Olayinka Alli at the event.

“THE CONSULTING ENGINEER” PERSONALITY
ENGR. LANRE SAGAYA, JR. MNSE
(DIRECTOR, YOLAS CONSULTANTS LIMITED)

Engr. Lanre Sagaya, Jr. is a civil engineer, specializing in transportation engineering with over 15 years consultancy experience; in design, construction supervision and project management in the USA and Nigeria. He is currently a director and works in the transportation engineering division of Yolas Consultants Ltd., based at the Lagos office. Yolas Consultants is an indigenous firm, established in 1980 and has been in continuous existence for over 40 years.

Engr. Sagaya, Jr. attended Adesoye College in Offa, Kwara State for his WAEC and ‘A’ Levels. He holds a Bachelor of Science (BSc.) degree in Civil Engineering from Birmingham University, UK where he graduated in 1999. He also holds a Master of Engineering (MEng.) degree in Transportation Infrastructure from Virginia Polytechnic and State University (Virginia Tech), USA (2003).

He worked in the USA for Sheladia Associates Inc., in Washington DC as an intern while completing his Masters program and as a Staff Engineer after graduation. There, he mainly performed bridge structural analysis and design; supervised bridge and roadway construction and performed bridge condition inspections. He then switched companies and worked with Stanley Consultants Inc. in Phoenix, Arizona as a Transportation Engineer. There, he prepared roadway construction plans; was involved in various aspects of highway and municipal roadway design as well as construction cost estimation.

“He worked in the USA for Sheladia Associates Inc., in Washington DC...”

“...a civil engineer, specializing in transportation engineering with over 15 years...experience...”





“...Sagaya, Jr. completed a Master of Science (MSc.) program in International Development Studies from the Bartlett School...UK...”

“Some recent projects include the Bus Rapid Transit (BRT) Improvement Design & Construction Supervision, Ketu to CMS in Lagos; Sango-Ota to Owode Road Rehabilitation Design in Ogun State; Warri Port Terminal “C” Reconstruction Supervision, Modandola’s Creek Road Multipurpose Jetty (Apapa) Reconstruction & Expansion Design; and Lagos-Ibadan Expressway Expansion Design (Traffic Studies).

He is registered with the Council for the Regulation of Engineering in Nigeria, COREN and he is a Member of the Nigerian Society of Engineers...”

Before returning to Nigeria in 2009, Engr. Lanre Sagaya, Jr. completed a Master of Science (MSc.) program in International Development Studies from the Bartlett School of the Built Environment at the University College London (UCL), UK in 2008. He is a 2011 graduate of the International Federation of Consulting Engineers (FIDIC) Young Professionals Management Training Program. He was a delegate at the 2013 FIDIC Centenary Conference; and a speaker at the 2023 FIDIC-Africa Conference held in Livingstone, Zambia.

Since 2009, he has been working at Yolas Consultants Ltd in the company’s Lagos office. Here, over the years, he has worked in various capacities including;

- Project Management
- Transportation (Roadway and Marine) Engineering Design
- Prepared Technical and Financial Proposals
- Client Relations and Project Coordination
- Construction Supervision and Management

Some recent projects include the Bus Rapid Transit (BRT) Improvement Design & Construction Supervision, Ketu to CMS in Lagos; Sango-Ota to Owode Road Rehabilitation Design in Ogun State; Warri Port Terminal “C” Reconstruction Supervision, Modandola’s Creek Road Multipurpose Jetty (Apapa) Reconstruction & Expansion Design; and Lagos-Ibadan Expressway Expansion Design (Traffic Studies).

He is registered with the Council for the Regulation of Engineering in Nigeria, COREN and he is a Member of the Nigerian Society of Engineers, NSE. He is a regular contributor of articles to the Association of Consulting Engineers (ACEN) four-monthly magazine, “The Consulting Engineer”.

A WORD FOR YOUNG ENGINEERS

BY ENGR. LANRE SAGAYA

The 'YOUTH QUESTION' permeates all professions. In the case of young engineers, there are issues peculiar to them. I, therefore, feel privileged to share my experiences and thoughts which I believe will be of benefit to the group we call 'Young Engineers'.

Youth in Nigeria includes citizens of the Federal Republic of Nigeria between the ages of 18 to 29 years according to the New Youth Policy, 2019. However, the African Youth

Charter recognizes youth as people aged between 18 to 35 years. In some schools of thought, it is defined as the state of mind or mind set of an individual. In general, it is seen as the period between childhood and adulthood (maturity). For the purposes of this presentation, we would classify young engineers as those recent graduates from an approved tertiary institution, engineers in youth service and engineers in relevant employment not exceeding 5 years.

Young engineers are usually very resourceful, full of physical strength and they do exhibit changes in physical, social and emotional make-up and youthful enthusiasm. These characteristics, if well harnessed, can lead to a great future. At this juncture, let me share my thoughts on how young engineers can achieve a great future.

i. Self-Orientation and Self-Discovery: Having graduated as a young engineer, you need to orientate yourself mentally to the next phase which is practice of engineering. Seek employment and learn in humility under the guidance of a more experienced engineer. Seek to discover the real YOU, that is how you will have competences and the opportunity to excel. This attitude has helped me in my entire career and at YOLAS Consultants Limited where I currently work. Here, I have been nurtured and I keep growing in practical knowledge and competence.



Engr. Lanre Sagaya, Jr., MNSE

ii. Application of ICT Tools: This is the Information & Communications Technology age, the Fourth Industrial Revolution, the Internet of Things. This age is further strengthened by the emerging of a sub-discipline called 'Artificial Intelligence' (AI). There is need to learn fast, keep up to date and correctly apply these tools in engineering practice. Interestingly, youths are quicker in innovating and inventing modern ways of doing things. There is, however, a need

to share the technologies with dependable mentors to avoid costly mistakes in practice because ultimately, software is a set of tools to increase productivity without compromising engineering fundamentals. In my own case in YOLAS Consultants Ltd, I have been well guided by purposeful leadership.

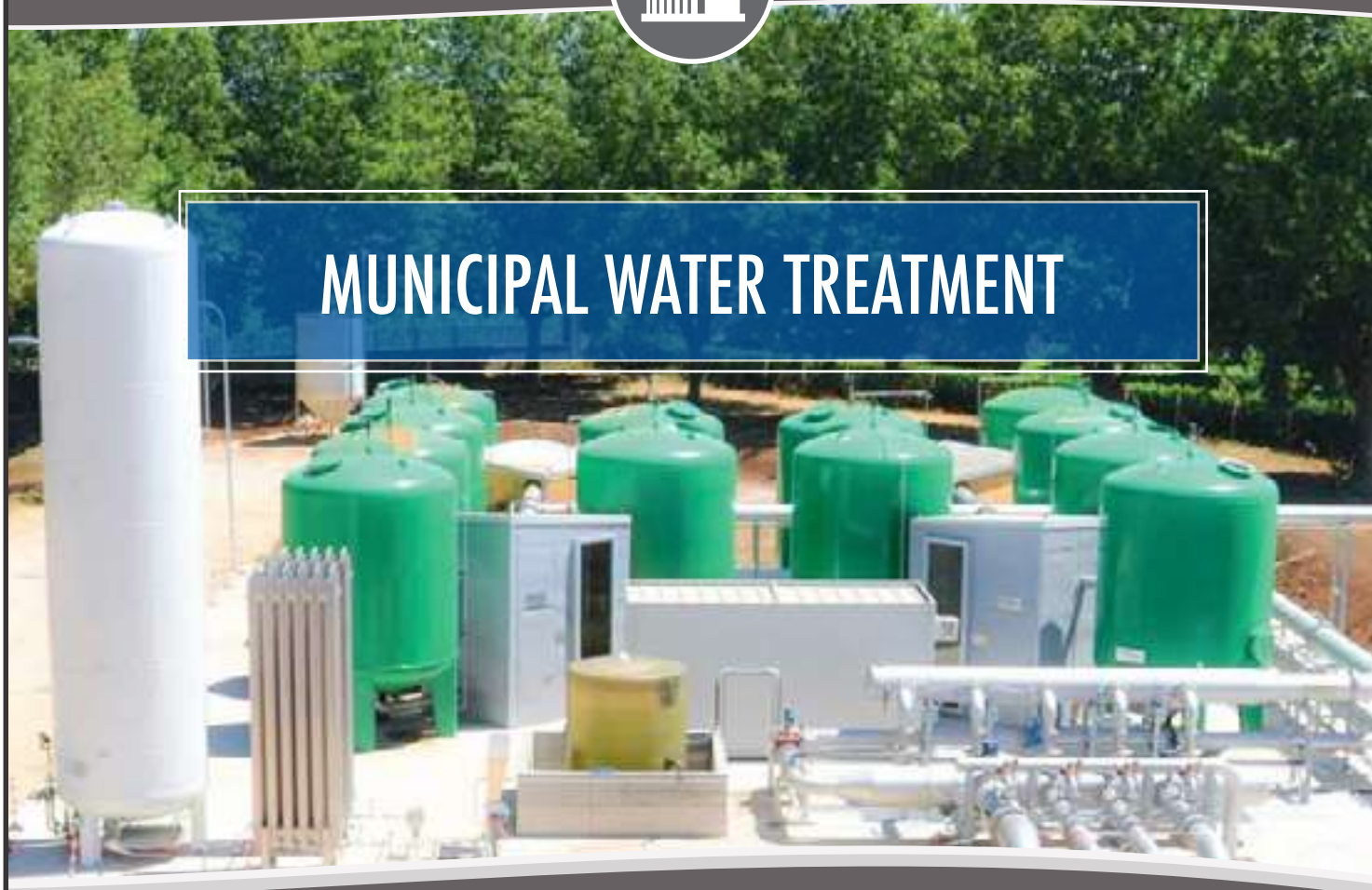
iii. Professional Development: Endeavour to enroll in a professional society. For engineers, we have the Nigerian Society of Engineers (NSE), division of NSE such as Nigerian Institution of Civil Engineers (NICE) or Nigerian Institution of Electrical & Electronics Engineers (NIEEE) or Nigerian Society of Chemical Engineers (NSChE), among others depending on your discipline. It is also important to apply and get registered by the Council for Regulation of Engineering in Nigeria (COREN). Your membership provides a veritable platform to interact with professional colleagues.

iv. Integrity: In order to stand the test of time in practice, the young engineer must insist on morality and ethics. Young engineers must ensure they contribute to creating the right culture for dependable professional practice in their organizations.

Finally, be industrious because hard work is the key to success as you are the future leaders of the profession.



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PROCESS SAFETY IMPLICATIONS TO HEALTH & ENVIRONMENTAL PROTECTION

BY ENGR. WILSON DADET

1.0 INTRODUCTION

Process safety generally refers to the prevention of unintentional releases of chemicals, energy or other potentially dangerous materials to the environment. It can also be said to be the management of risks associated with the operation of industrial processes such as the handling of hazardous materials or the use of complex machinery. The goal of process safety is to prevent accidents and incidents that could result in harm to workers, the public or the environment.



Engr. Wilson Dadet, FNSChE
(Lead Process Engineer, Nigeria
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Process safety Incident typically involves an unexpected mechanical integrity failure in a pipeline system or processing facility, sometimes including a fire, explosion, rupture or hazardous chemical leak. These occurrences are always accompanied with negative consequences to the environment and health. For example, releases of toxic chemicals to the environment pose serious health challenges.

Process safety management (PSM) standards are established to prevent

Process safety has significant implications for health and environmental protection. This is so because industrial accidents arising from unsafe processes have the potential of catastrophic impact on the ecosystem. For example, chemical spills or explosions can release toxic substances into the air or water causing illness or death. Pollution from industrial activities can contaminate air, water and soil thereby causing harm to human health and ecosystem. Process safety, health and environmental protection go hand in hand.

The primary goal of process safety management is to eliminate process safety incidents and potential catastrophic impacts upon people, environment, equipment and production. Process safety management involves planning, organizing, directing and controlling processes to achieve safe operations of the system.

workplace incidents caused by hazardous chemicals. However, the benefits of PSM extend to many industries—not just those that deal with chemical production. Having a proactive approach to hazard management can be the difference between a localized incident and a large-scale catastrophe with considerable impact on the environment. Building inherently safer processes and improving training and competency for those running the processes are two of the most effective ways to reduce hazards. Businesses which take these steps have a net positive impact on the planet.

2.0 THE DEEPWATER HORIZON OIL SPILL IN THE GULF OF MEXICO IN 2010

One example of a case study on process safety implications to health and environmental protection is the Deepwater Horizon oil spill in the Gulf of Mexico in 2010. This disaster occurred when a deepwater drilling rig (the Deepwater Horizon) exploded and caught fire resulting in the release of millions of barrels of oil into the ocean.

The incident highlighted the importance of process safety in preventing accidents that can have significant impacts on human health and the environment. In this case, inadequate safety measures and inadequate emergency response plans contributed to the

“Deepwater Horizon oil spill in the Gulf of Mexico in 2010. This disaster occurred when a deepwater drilling rig exploded and caught fire resulting in the release of millions of barrels of oil into the ocean.”

“Process safety metrics are critical indicators for evaluating a process safety system’s management performance. Serious process safety incidents involving loss of life, serious injury or property damage...”

disaster, resulting in the deaths of 11 workers and the contamination of thousands of square miles of ocean water.

The response to the Deepwater Horizon oil spill also demonstrated the challenges of implementing effective process safety measures in complex and dynamic industrial settings. Despite the deployment of significant resources and expertise, the spill was not fully contained for several months, causing ongoing damage to marine life and the coastal environment.

In retrospect, the Deepwater Horizon oil spill provides a powerful example of the consequences of inadequate process safety management and the importance of addressing process safety risks to protect both human health and the environment.

3.0 PROCESS SAFETY MANAGEMENT SYSTEMS

The identification and mitigation of potential risks to health and the environment constitute essential elements in process safety management (PSM). PSM keeps employees safe and healthy at work, especially as it pertains to the release of hazardous chemicals. Process safety management systems, such as risk assessments and hazard and operability (HAZOP) studies, are used in identifying and addressing potential risks to health and the environment by providing a systematic and structured approach to analysing industrial processes.

HAZOP studies, for example, are process safety management tools that involve a team of experts who systematically review an industrial process and identify potential hazards and operability issues. This may include analysing process design and operating procedures, identifying potential sources of error or failure and evaluating the effectiveness of existing safety measures.

HAZOP studies enhance the prevention of incidents that could harm human health or the environment.

Additionally, other process safety management systems may include risk assessment tools, safety audits, HAZIDS and incident investigation procedures, all of which can help in identifying and addressing potential

risks to health and the environment.

4.0 MITIGATING THE ENVIRONMENTAL IMPACT OF INDUSTRIAL ACTIVITIES

The role of process safety in mitigating the environmental impact of industrial activities is to prevent accidents and incidents that could release pollutants or other harmful substances into the air or water. By ensuring the safe and reliable operation of industrial processes, process safety can help prevent the accidental release of pollutants that can contaminate air, water, soil, and harm human health and the environment.

For example, process safety measures do prevent chemical spills or leaks that could contaminate water sources such as rivers, lakes or groundwater. Similarly, process safety measures do prevent the release of toxic gases or other pollutants into the air which can harm human health and damage ecosystems.

In addition to preventing accidents and incidents, process safety reduces the overall environmental impact of industrial activities by promoting the use of sustainable and environmentally friendly technologies and processes. For example, process safety management systems are used in identifying opportunities to reduce waste or opportunities for efficient use of resources which result in the reduction of environmental footprint of industrial operations.

5.0 PROCESS SAFETY MANAGEMENT METRICS

Process safety metrics are critical indicators for evaluating a process safety system’s management performance. Serious process safety incidents involving loss of life, serious injury or property damage are often preceded by less serious or near

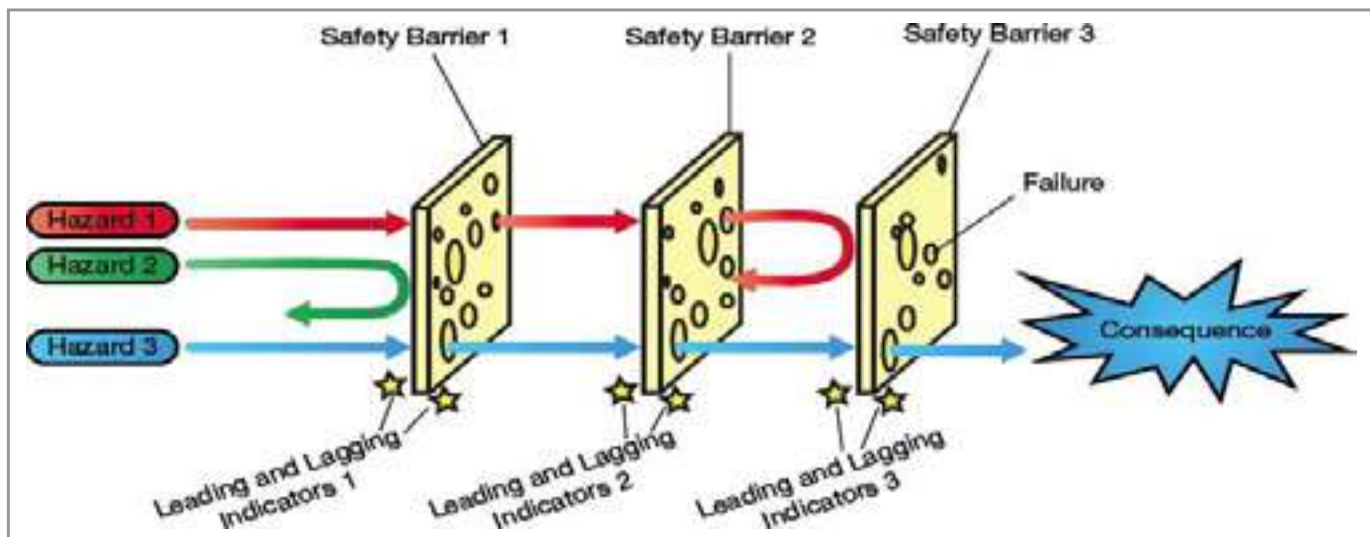


Fig. 1: The barrier-based approach based on the Swiss cheese model (Source: CEP February 2016)

misses as well as unsafe behaviours. Process safety metrics are established, collected and acted upon by industries to improve their performance by identifying problems, failures and lapses that can lead to process safety incidents or events as well as to track performance over time.

A vital aspect of process safety management is ‘Safety Leading Indicators’ which are proactive measures that measure prevention efforts and can be observed and recorded prior to an injury. On the other hand, ‘Safety Lagging Indicators’ are reactive measures that track only negative outcomes such as an injury once it has already occurred.

Leading indicators can play a vital role in preventing worker fatalities, injuries and illnesses as well as strengthening other safety and health outcomes in the workplace. Leading indicators are proactive and preventive measures that can shed light on the effectiveness of safety and health activities. They reveal potential problems in a safety and health program.

An effective PSPI program provides predictive signals that warn of deterioration in critical systems. This enables organizations to take pre-emptive corrective actions. PSPIs can be used to benchmark process safety performance across an organization’s production facilities or to compare facilities owned by different companies.

The key to an effective PSPI program is selecting the right PSPIs. Various organizations have developed practices or standards that give guidance on PSPI programs. There are the barrier-based and tier-based approaches for selecting PSPIs.

i. **Barrier-based vs. tier-based approach**

The barrier-based approach is based on the widely used Swiss Cheese Model (See Fig. 1). It shows how a series of safety barriers (i.e., risk control systems [RCSs]) can break down and allow hazards to propagate to loss events. Barriers are represented by slices of Swiss cheese with the holes representing failures in the barrier. If an initiating event occurs and the holes in the barriers align, a loss event will occur.

“A vital aspect of process safety management is ‘Safety Leading Indicators’ which are proactive measures...”

Process safety performance indicators (PSPIs) are key performance metrics that indicate when a process safety accident is most likely to occur. PSPIs can be categorized as either leading or lagging indicators. A leading PSPI is an active indicator of process safety performance; a lagging PSPI is a reactive indicator of process safety performance.

The barrier-based approach is based on the Swiss Cheese Mode. Multiple safety barriers prevent hazards but failures in the barriers may allow a hazard to occur. Leading and lagging PSPIs are defined around each safety barrier.

The tier-based approach is based on the safety pyramid (See Fig. 2). Safety accidents are placed on the pyramid according to their severity — high-consequence incidents are placed at the top of the pyramid, low-consequence incidents at the bottom. Tier-based PSPI programs recognize that lower-consequence incidents occur before incidents with higher consequences. If, for example, low-consequence events begin to occur more frequently, that might be an indicator that a higher-consequence event is imminent.

The tier-based approach is based on the safety pyramid where consequences increase in severity from the bottom to the top of the pyramid. Tier 3 and Tier 4 events are considered leading PSPIs and Tier 1 and Tier 2 events are considered lagging PSPIs.

The pyramid is divided into four tiers of severity:

a. Tier 1: Major process safety incidents

“Multiple safety barriers prevent hazards but failures in the barriers may allow a hazard to occur. Leading and lagging PSPIs are defined around each safety barrier.”

- b. Tier 2: Less-severe process safety incidents
- c. Tier 3: Challenges to safety systems
- d. Tier 4: Lack of operating discipline (e.g., unsafe behaviours)

Each approach defines leading and lagging indicators differently. The barrier-based approach defines leading and lagging indicators around each of the safety barriers. Lagging indicators provide reactive monitoring of the barriers through incident investigation, near-misses and weaknesses discovered in the system. Leading indicators provide active monitoring of the barriers and ensure the barrier's continued effectiveness at reducing process safety risks.

For example, a generic leading indicator of staff competence is the percent of employees involved in hazardous operations who have received training and have proven their competency. A lagging indicator of staff competence is the number of process safety incidents, including near misses, caused by a lack of staff competence.

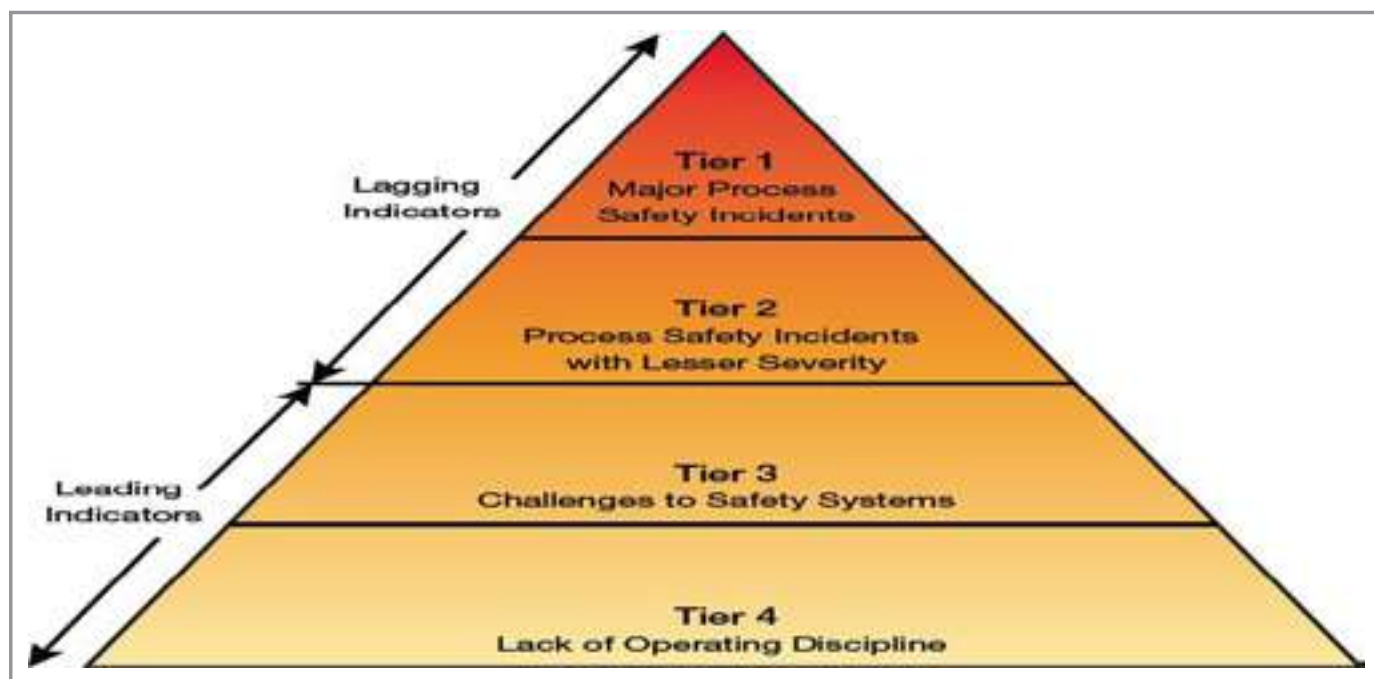


Fig. 2: The tier-based approach is based on the safety pyramid (Source: CEP February 2016)

“The concept of “inherently safer design” (ISD) proposes that it is more effective to reduce hazards...”

The tier-based approach uses the safety pyramid to define leading and lagging indicators. Tier 1 and Tier 2 events are deemed lagging indicators while Tier 3 and Tier 4 events are deemed leading indicators.

As earlier mentioned, leading indicators are proactive, preventive and predictive measures that provide information about the effective performance of the firm's safety and health activities. They measure events leading up to injuries, illnesses and other incidents and reveal potential problems in the firm's safety and health program. In contrast, lagging indicators measure the occurrence and frequency of events that occurred in the past, such as the number or rate of injuries, illnesses and fatalities. While lagging indicators can alert you to a failure in an area of your safety and health program or to the existence of a hazard, leading indicators allow you to take preventive action to address that failure or hazard before it turns into an incident.

A good program uses leading indicators to drive change and lagging indicators to measure effectiveness. For example, one good leading indicator might be the amount of time it takes to respond to a safety hazard report. A decrease in the response time may demonstrate an increased awareness in safety and managers' commitment to workplace safety. Conversely, an increase in response time could signal a lack of management concern, which could mean that hazards are likely to remain uncontrolled and incidents are more likely to occur. Furthermore, workers may decide to discontinue reporting hazards if they feel that management is not being responsive to their concerns. This can affect morale which can have broad implications for the workplace.

A comprehensive process safety strategy can transform important leading indicators such as:

- Near misses
- Participation in site safety programs and initiatives
- Employee engagement in safety topics
- Safety regulations compliance
- Safety training completion rates

But to do this, facilities must integrate safety measures with their overall process design. It is not enough to make minor corrections here and there. After all, a site can only go through the management

of change (MOC) process so many times before doing a complete overhaul.

6.0 DESIGN AND STANDARDS

The concept of “inherently safer design” (ISD) proposes that it is more effective to reduce hazards than to control them.

This approach can transform a process from the inside out. But it is not always easy to adopt ISD. Many companies turn to less environmentally friendly processes and practices.

One example of this is the dumping of hazardous mine waste into water systems. Some suggestions for solving this problem are rooted in the principles of inherently safer design.

An example of ‘Inherently Safer Design’:

“Produce less waste. In some cases, a mining company may prefer to build an open pit mine that produces a large quantity of waste but could instead build an underground mine that targets the ore more precisely and produces less waste that can be more responsibly managed.”

This is an example of the “minimize” category of ISD. By reducing the size of the work area, the company can also reduce its environmental impact. This is just one illustration of how process safety and environmental protection intersect. These concepts span a variety of industries and regions, multiplying their impact exponentially.

It should be noted that, evolution of technical standards and practices is a natural consequence of continuous improvement and it is important that advantage is taken of new technology where this is seen to be of benefit both to health and the environment. Retrospective application of new standards is always controversial mostly attributed to cost implications and it must be remembered that older processes were designed to sets of related standards and codes which together created a safe design. However, attention needs to be paid to changes in engineering standards where they are based on lessons learnt to ensure adherence to contemporary standards and codes.

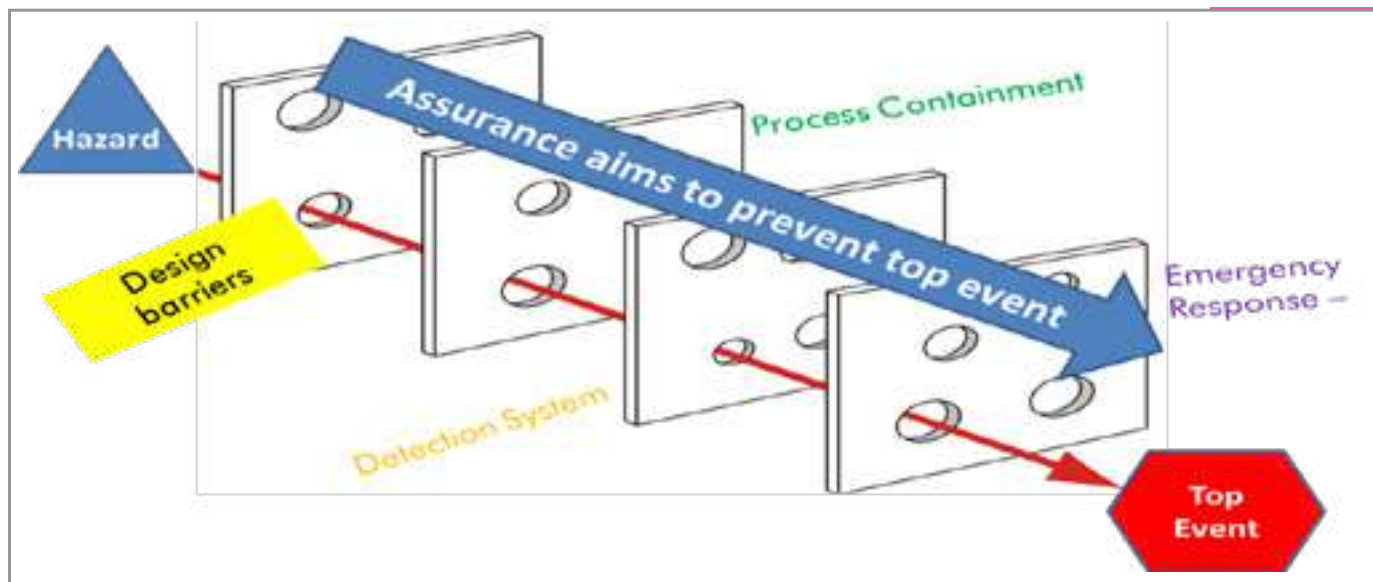


Fig. 3: Relationship between hazards, design barriers and top event.

7.0 INSPECTION, MAINTENANCE AND ASSURANCE

Many incidents have resulted from maintenance and inspection not being carried out correctly or not carried out at all. Experience has shown that some managers have taken the short-term view to continue operation and take a chance that nothing could go wrong until it is more 'convenient' to carry out essential maintenance and inspection. When this leads to disaster, the consequences for everybody involved and the environment can be considerable.

In this respect, planning and execution of maintenance activities should be considered critical to safe operations and environmental protection. In addition, there are predictive tools that can be used to develop an accurate picture of how deterioration processes are impacting process integrity over time and thus allow the development of maintenance and inspection regime that will circumvent the occurrence of incidence harmful to health and the environment.

Hazards which can potentially result in a top event are ubiquitous around us. Barriers are essential in safeguarding people and the environment. Assurance is essential across the board towards barrier quality and effectiveness in hazard prevention. Assured barriers are required in all spheres of engineering practice. Fig. 3 depicts the relationship between hazards, design barriers and top event. When barriers are assured, hazards are disconnected from resulting to top events. Assured barriers are essential in safeguarding people, plant and process

9.0 PROCESS SAFETY CULTURE

This is the combination of group values and behaviours that determines the manner in which process safety is managed. A sound process safety culture refers to attitudes and behaviours that support the goal of safer process operations.

More succinct definitions include, "How we do things around here", "What we expect here" and "How we behave when no one is watching". In an especially sound culture, deeply held values are reflected in the group's actions and newcomers are expected to endorse these values in order to remain part of the group.

Investigations of catastrophic events have identified common process safety culture weaknesses that are often factors in other serious incidents. The values of the group (e.g., corporation, facility, shift team) can shape the attitudes of the individual which in turn play a significant role in determining individual behaviours. A sound culture provides its members with the values necessary for understanding why strict adherence to procedures is the right thing to do.

Everyone in the organization has a role in process safety culture. The leadership of an organization has the primary responsibility for identifying the need for, and fostering, cultural change and for sustaining a sound culture once it is established. The responsibility for fostering and maintaining a sound culture should cascade down through the organization. Successful cultural change requires that expectations of new attitudes and

behaviours be communicated and reinforced. These new attitudes and behaviours demonstrate successful results for which the members of the organization recognize and appreciate.

“The implications of process safety infringements on health and environment can be greatly reduced if the commitment to process safety is the cornerstone...”

Acceptable behaviours must be modelled at all levels of the organization through leadership by example. The rationale for, and anticipated benefits of, expected behaviours must be made evident to all.

8.0 FUEL TANKER INCIDENTS

Petrol tanker accidents are becoming rampant and common occurrences on Nigerian highways. In many instances, they claim the lives of innocent people and damage to the environment.

In January 2022, there was a fire incident involving a tanker explosion and in February and March of the same year, there were fire incidents at Iddo Train Terminus and Otedola Bridge, respectively. The Otedola Bridge incident involved a tanker that exploded and caught fire.

The integrity of petrol tanker, human factor (drivers), bad road, among others, are responsible in aggravating the menace of tanker accidents. In the light of the foregoing, preventing fuel tanker accidents requires a combination of goal-oriented strategies which incorporate managerial, technical, training, policy reviews, staff motivation and involvement of relevant agencies such as Federal Road Safety Corps, Standard Organisation of Nigeria, Nigerian Midstream and Downstream Petroleum Regulatory Authority, etc as an all-inclusive safety management approach.

9.0 CONCLUSION

The implications of process safety infringements on health and environment can be greatly reduced if the commitment to process safety is the cornerstone of process safety excellence. In this light, organizations generally do not improve without strong leadership and strong management commitment. For process safety, management needs to recognize that process safety is not the same as personal safety and move beyond established personal safety programs.

One can learn if the management of a company is committed to process safety by its actions.

Organizations that understand hazards and risk are better able to allocate limited resources in the most effective manner. Industrial experience has demonstrated that businesses using hazard and risk information to plan, develop and deploy stable, lower-risk operations are much more likely to enjoy long-term success.

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ENVIRONMENTAL CONTROL OF HIGHWAYS USING DRAINAGE SYSTEMS

BY ENGR. HENRY CHUKWUDI OKPALA

1.0 INTRODUCTION

The main purpose of a drainage system as part of highway infrastructure is for highway durability. The concrete or asphalt pavement will last longer based on the designed life span.

With the provision of lined drain on highways, we are assured of

- Longer life span
- Durability and stability of the carriage way
- No short term structural failure of the pavement
- The subgrade will not easily be exposed to thermal changes due to varying weather conditions.
- No side way sliding of earth subgrade thereby leading to pavement collapse.

Highway drainage system is designed to effectively collect and divert all rain water that gathered around the road and also harvest large part of runoff from the catchment uphill of the road and transmit same to outlet point. The removal of the water from the road surface will prevent ingress of water into the road pavement thereby not undermining the subgrade which can eventually lead to pavement collapse.

2.0 BASIS OF HIGHWAY DRAINAGE DESIGN

The design for drainage structure in highway is based on the science of GIS mapping/topographic survey, hydrology, hydraulics and structural engineering. GIS mapping/survey topography deals with the catchment area of the drainage basin, etc. Hydrology deals with the occurrence and form of water in nature (environment). While hydraulics deal with the science of the law of motion of water, liquid and of their practical applications. Structural engineering deals with the strength and stability of the hydraulic structure. Finally, before



Engr. Henry C. Okpala, FNSE, FNICE, FNIHTE, FIMC, KGS (Principal Consultant Hecon Consultants)

the execution of the designed project takes off, priced BEME and working document should be ready in order to achieve an effective project execution.

3.0 TYPES OF HIGHWAY DRAINAGE SYSTEMS

These include 'Surface Drainage Systems' and 'Sub-surface Drainage system'

i. Surface Drainage System: This system removes excess water from the land surface using channels, ditches, P.V.C piping and lined drains while the lining of the lined drains could be concrete, rock,

gabion or grass. They may be other structures such as chutes, energy dissipators, pipe and box culverts associated with the drainage system.

ii. Sub-surface Drainage system: This is not included in the scope of this design presented in this treatise.

4.0 METHODS OF ESTIMATING PEAK FLOOD DRAINAGE

There are several methods for computing peak flood discharge. These comprise:

- Empirical or Exponential formula
- Rational method
- Modified rational method
- Unit hydrograph method
- Frequency analysis, etc.

Method 1

By using one of the empirical or exponential formulae applicable to the region.

$$\text{e.g. } Q = a A^m$$

Where:

Q = The average flow from the basin having a drainage area equal to A .

a and m are coefficients determined by the factors than the size of the drainage area.

This is also known as regression analysis method.

Method 2

By using a rational method involving the rainfall and other characteristics for the area.

$$Q = \frac{CIA}{360} \text{ (Metric)}$$

Where:

Q = Maximum flood discharge in m³/second.

A = Catchment area in Ha for small watershed < 100 acres (40.47 Ha)

I = Peak intensity of rainfall in mm/hr.

C = Runoff coefficient – unitless.

Note: These few conversions

1 Ha = 104m²;

1 Acre = 0.4047Ha

1 Acre = 4047m² (4000m²)

5.0 THE DESIGN SEQUENCE

This is Itemized below:

5.1 (i) GIS mapping to produce map of catchment area to be used to compute hydrological parameters needed to compute the peak flood; land use maps needed for estimation of runoff coefficient; rainfall-frequency analysis and preparation of rainfall intensity duration frequency (IDF) curves for the area.

5.1 (ii) Topographic survey to determine the plan, profile, alignment and gradient of the drain

5.2 Hydrological studies and computation of peak flood by the rational formula

5.3 Hydraulic design

5.4 Structural design

5.5 Execution of drainage system for highway

5.1 (i) GIS mapping to produce map of catchment area

(ii) Topographic survey to determine the plan

Sketch of a drainage basin showing systematic layout illustrating a lined drain for design and artificial field drains/collectors to accelerate surface runoff and finally peak runoff computation is shown in Fig. 1. (Total Estimated Catchment Area: 4.40Ha)

From the Fig. 1 diagrammatic illustration, our main duty is to design for the main drain. The drainage basin is divided into three major components.

- Field drainage systems with collector drains that carry runoff into the main drain
- Main drainage system that receives all runoff from the illustrated watershed or catchment area
- An outlet where the storm-water or runoff discharges into the region/area that is not captured by the GIS mapping/survey topography has its slope and contour lines towards another catchment area/watershed.

Finally, runoff is influenced by rainfall that flows over paved and unpaved, pervious and impervious land/soil characteristics.

Using GIS mapping and topographic survey of

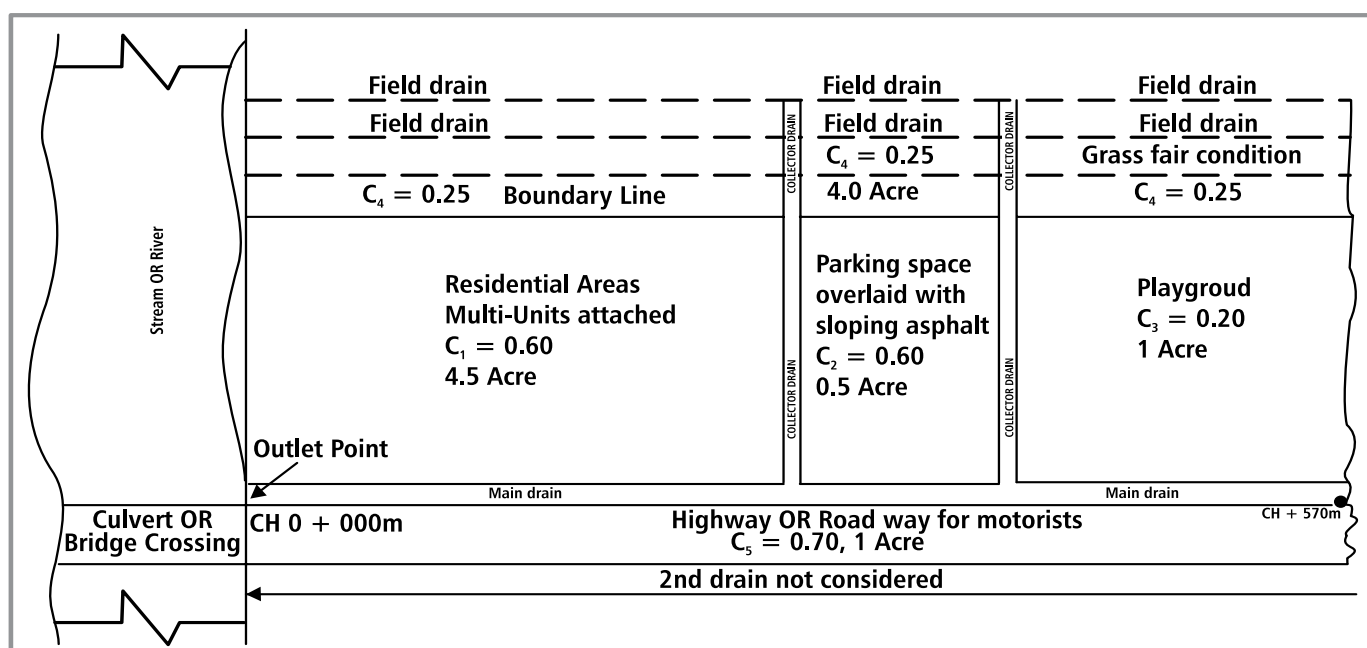


Fig. 1: Sketch of drainage basin

the watershed/catchment area billed for runoff calculation, different values of runoff coefficients were selected based on the land/soil characteristics say C1, C2, C3 etc. The associated corresponding sizes or areas were obtained say A1, A2, A3, etc. Then the recorded results were used to generate the weighed value of the overall runoff coefficient C for the catchment area with the formula:

$$C = \frac{A_1 C_1 + A_2 C_2 + A_3 C_3 + A_4 C_4 + \dots}{A_1 + A_2 + A_3 + A_4 + \dots}$$

See sample table shown in Table 1.

TYPICAL RUNOFF COEFFICIENT TABLE		
RURAL LAND USE	LOWER BOUNDS	UPPER BOUNDS
Cultivated land, sand & gravel soils	0.25	0.35
Cultivated land, sandy & loamy soils	0.20	0.52
Cultivated land, clay & silt loam soils	0.40	0.72
Cultivated land, tight clay soils	0.50	0.82
Pasture, sandy loam soils	0.10	0.22
Pasture, clay & silt loam soils	0.30	0.42
Pasture tight clay soils	0.40	0.60
Meadow	0.10	0.50
Woodland, sandy loam soils	0.10	0.30
Woodland, clay & silt loam soils	0.30	0.50
Woodland tight clay soils	0.40	0.60
Bare rock	0.82	0.94
Desert	0.30	0.55
URBAN LAND USE	LOWER BOUNDS	UPPER BOUNDS
Parking	0.85	0.96
Commercial	0.71	0.89
Streets	0.70	0.91
Industrial	0.67	0.86
Residential lots, high density	0.25	0.54
Residential lots, medium density	0.19	0.50
Residential lots, low density	0.14	0.46
Railway yards	0.20	0.35
Playgrounds	0.20	0.30
Sports fields	0.20	0.35
Parks	0.10	0.25
Cemetaries	0.10	0.25
MAN-MADE SURFACES	LOWER BOUNDS	UPPER BOUNDS
Roofs, steeply sloping	0.90	0.95
Roofs, small flat	0.90	0.95
Roofs, large flat	0.75	0.95
Asphalt	0.70	0.95
Pervious Asphalt	0.55	0.80
Concrete	0.70	0.95
Pervious concrete	0.60	0.80
Concrete blocks, uncemented joints	0.50	0.70
Concrete blocks, cemented joints	0.70	0.85
Gravel	0.50	0.60
Earth	0.50	0.50
Grass, poor condition	0.32	0.62
Grass, fair condition	0.25	0.60
Grass, good condition	0.21	0.58
Turf block	0.15	0.30

Table 1: Typical runoff coefficients

5.2 Hydrological Studies and Computation of Peak Flood by the Rational Formula

To estimate the maximum quantity of runoff water expected to reach the main drain under consideration, we use the following equation:

$$Q = \frac{CIA}{360}$$

Where, minimum time of concentration is 10mins from the Umudike graph shown in Chart 1.

Duration of rainfall is 1hr 30secs.

Designed return period is 25 years.

Then, intensity of rainfall I is obtained from the IDF curve. (intensity duration frequency) curve.

The diagrammatic illustration as in Fig. 1 is not a case study but given as a guide to enable the reader appreciate the sequence of the designer's procedure. By studying the diagram in Fig. 1 using these presentations with typical runoff coefficient table and IDF curve, you can generate any required data of a symbol using available equations/formulae. An illustrative example is given below:

Design data after field work.

$$I = 97.5 \text{ mm/hr}$$

$$A = 4.4 \text{ Ha}$$

$$C = \text{Coefficient of Runoff } 0.65$$

$$Q = \frac{CIA}{360} \dots \dots \dots \text{Equ D - 1}$$

$$Q = \frac{0.65 \times 97.5 \times 4.4}{360}$$

$$= \frac{0.77 \text{ m}^3}{\text{s}} \text{ (27.3cfs)}$$

$$\text{For cfs unit} = Q = C \times \text{in/}$$

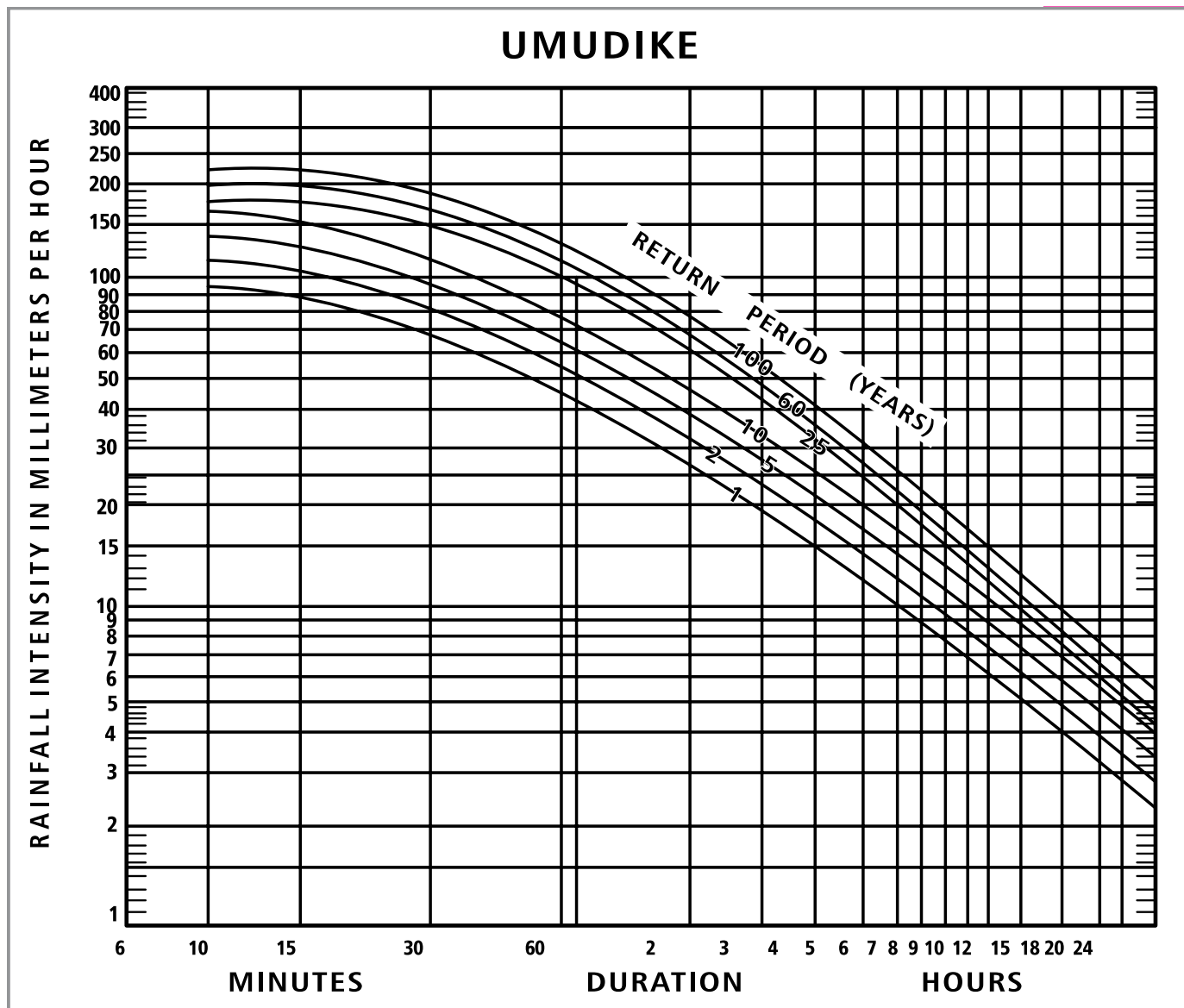


Chart 1: Intensity Duration Frequency (IDF) Curve for Umudike

hr x Acres

Discharge Conversion = $1 \text{ m}^3/\text{s} = 35.40 \text{ cfs}$

5.3 Hydraulic Design of Channel

The hydraulic design of the channel is a combination of equation of continuity and Manning's formula.

Where:

A = Cross-sectional area of flow in m^2 .

V = Velocity of flow in open channel in m/s .

Q = Discharge that flow in the channel in m^3/s .

R = Hydraulic radius in m.

n = Manning's roughness coefficient - unitless.

s = Friction slope of channel in m/m .

Where as:

y_n = Normal depth of flow.

Q = 27.3 cfs.

n = 0.013 concrete channel coefficient.

b = 1m = bottom width of drain.

b = 1m : 3.281ft = bottom width of drain assumed.

Slope S based on site survey = 0.0005 say
CH 0 + 000m to CH 0 + 570m

$AR^{2/3} = Q \times n$
 $b^{8/3} 1.49 S^{1/2} b^{8/3} \text{ Equ } D - 3$

Ref Art.. 6 – 6B, PP 142

Open channel Hydraulics.

Ven Te Chow.

Now substituting

$y_n/b = 0.960$ Ref. Fig 6-1, PP 130

$y_n = 0.96\text{m}$ Open channel

Hydraulics

Ven Te Chow

The finished height of drain shall be above normal flow depth.

I should design with 1.2m as finished height (y_d).

Now freeboard (FB) is $y_d - y_n = \text{FB}$

$$1.2\text{m} - 0.96\text{m} = 0.24\text{m}$$

Check Velocity

$$\begin{aligned} \text{Water area} &= b y_n \\ &= 1\text{m} \times 0.96\text{m} \\ &= 0.96\text{m}^2 \\ &= 0.8\text{m/s} \end{aligned}$$

OK

Note: $0.45\text{m/s} < 0.8\text{m/s} < 2.5\text{m/s}$.

- Limiting or non scouring velocity for lined concrete drain has maximum of 2.5m/s
- Minimum velocity or self cleansing velocity is 0.45m/s
- Silting velocity is when the velocity is no longer self cleansing or minimum

5.3.1 Using trial and error method (SI metric edition) to get y_n

If the depth of flow be y_n

If the width of channel be $b = 1\text{m}$

$$\begin{aligned} s &= 0.0005 \\ n &= 0.013 \\ Q &= 0.77\text{m}^3/\text{s} \\ A &= b y_n \end{aligned}$$

Substituting in

Using $y_n = 0.96\text{m}$

5.4 STRUCTURAL DESIGN AND DETAILING

The design is considered as earth and water on either side of the lined drain but designed as a cantilever

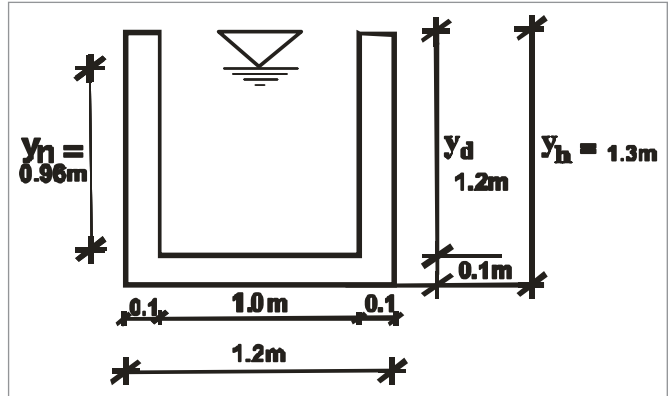


Fig. 2

retaining structure (critical side considered for design). This is illustrated in Fig. 2.

The design is considered as a cantilever retaining wall. Earth on one side and water on the other side. I should quickly consider the critical side that retained earth material and possibly surcharge. The designed diagram adopted is illustrated in Fig. 3. The diagram of forces acting on the lined drain are illustrated in Fig. 4 and Fig. 5.

From Table 17, Table 18 and Table 192 of Reynolds 9th Ed. I selected the following:

$D = 18.9\text{KN/m}^3$ (Unit weight of retained material)
 $K_2 = 0.589$ (frictional coefficient based on angle of repose)

Angle of internal friction or angle of repose 15°

Allowable soil pressure (Bearing Pressure) = 160KN/m^2

Line Drain Wall Design

Load factor to dead weight is 1.4

Load factor to live load which is surcharge is 1.7

Overall height $y_h = 1.3\text{m}$

Note: $2400\text{kg/m}^3 = 24\text{kN/m}^3$ (Density of reinforced concrete)

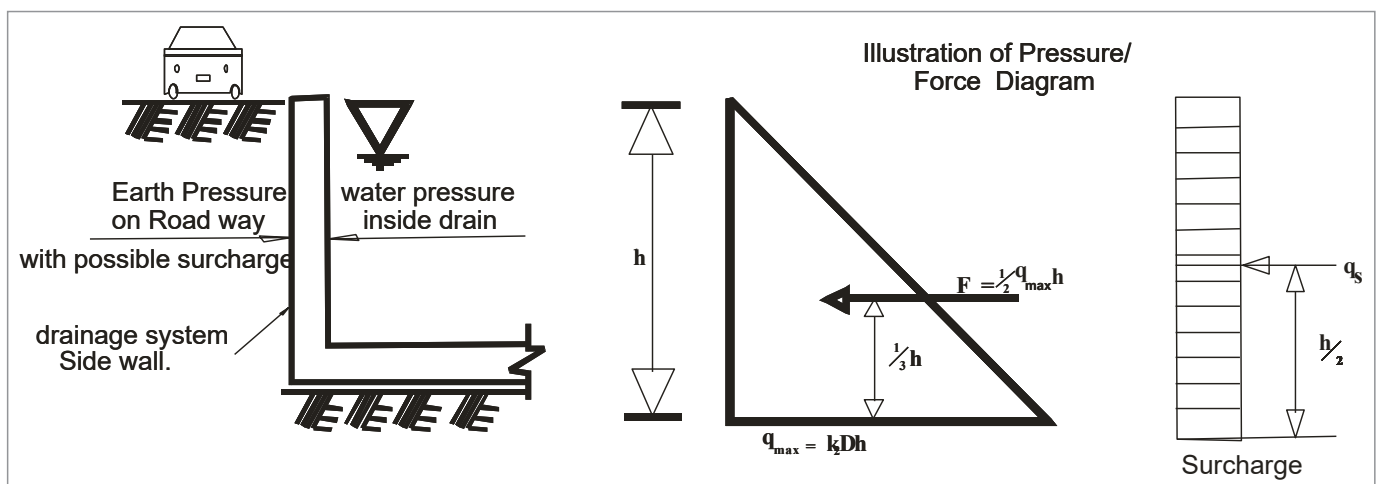


Fig. 3: Cantilever retaining wall

Fig. 4 & Fig. 5: Forces on lined drain.

Dead weight of wall = assumed thickness 0.1m
 $0.1\text{m} \times 24\text{KN/m}^3 = 2.4\text{KN/m}^2$

Dead weight of soil loading = 18.9KN/m^3
 The triangular soil pressure is zero at top q_0 and q_{max} at the bottom
 $q_{\text{max}} = K_2 D h = 0.589 \times 18.9\text{KN/m}^3 \times 1.3\text{m}$
 $= 14.47\text{KN/m}^2$

Total dead weight = $2.4\text{KN/m}^2 + 14.47\text{KN/m}^2 = 16.87\text{KN/m}^2$
 The design load = $16.87\text{KN/m}^2 \times 1.4 = 23.62\text{KN/m}^2$

The force for the triangular shape
 $F_{\text{dead}} = \frac{1}{2} q_{\text{max}} h = 0.5 \times 23.62\text{KN/m}^2 \times 1.3\text{m}$
 $= 15.35\text{KN/m}$

Considering Surcharge:

Maximum load for wheeled vehicle is usually 40 tonnes, while for tracked vehicle = 70 tonnes.
 Wheeled vehicle is considered in this design.

Note: Considered length of long trailer on axle wheel to be 12m while average road width to be 7.3m.
 Take the area of 40tonnes spread to be $12\text{m} \times 7.3\text{m}$
 $= 87.6\text{m}^2$

Applied unit area force due to surcharge q_s

1 tonne = 1000kg

1 kgf = 1kgwt = 9.8N approx. 10N = 0.01KN

0.457tonne = 4.57KN

Load factor for Live Load = 1.7

FINDING MOMENT FOR EARTH PRESSURE AND SURCHARGE (live)

- Earth pressure
- Surcharge (live)

$M_{\text{max}} = M_{\text{dead}} + M_{\text{live}}$
 $= 6.65\text{KNM} + 5.05\text{KNM} = 11.7\text{KNM}$
 (For 1m span of the wall)

FINDING OR CALCULATING THE STEEL REINFORCEMENT USING CP110 DESIGN CODE

Where Z is the lever arm

and $f_y = 425\text{N/mm}^2$ high yield
 Note: exact Z is generated from the equation

Where, $K = \frac{M}{bd^2 f_{cu}}$; $K_{\text{max}} = 0.156$

Assumed bar size is 10mm
 $d = \text{thickness of wall} - \text{cover} - \text{half the reinforcement bar.}$

$Z = d (0.776)$
 $Z = 0.776 \times 55 = 42.68$

Generally, for quick/safe design CP110 allows $0.75d$ for Z

From design table use Y10 at 100mm c/c spacing

$A_{\text{st}} = 785\text{mm}^2/\text{metre run}$

Distribution Steel
 Using CP110 design code.
 $A_{\text{min}} = 0.12 \% bh$ – for high yield

$A_{\text{min}} = 0.12 \times 1000 \times 100 = 120\text{mm}^2/\text{m run}$
 100

From design table use Y8 at 150mm c/c spacing

$A_{\text{st}} = 335\text{mm}^2/\text{metre run}$

The design is considered as a cantilever retaining wall. Earth on one side and water on the other side. I should quickly consider the critical side that retained earth material and possibly surcharge.

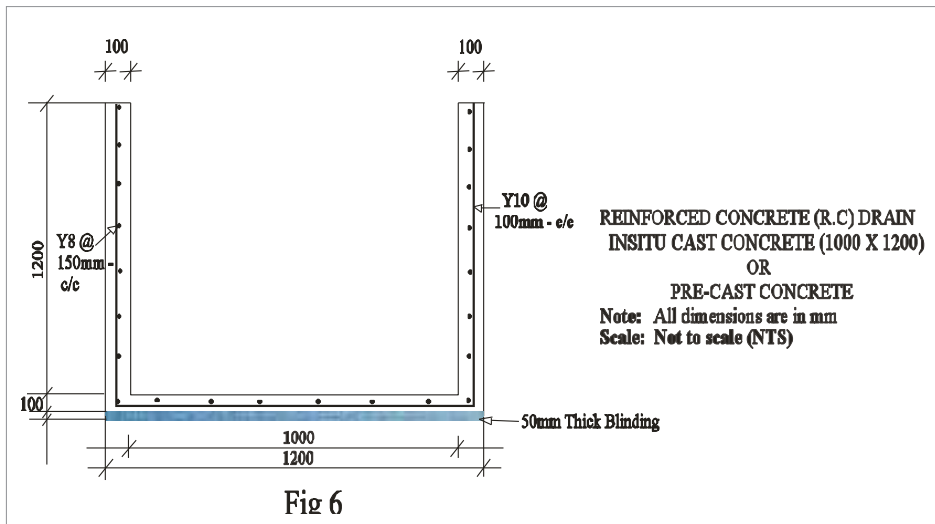


Fig. 6: Details of reinforced lined drain.

Details of the reinforced lined drain are illustrated in Fig. 6..

5.5 EXECUTION OF DRAINAGE SYSTEM FOR HIGHWAYS

5.5.1 Types of Highway Drainage Shapes are shown in Figs. 7.1 – 7.4.

The execution of drainage system is based on the shape designed for any specific highway that is approved/ intended for construction and it varies from rectangular (Fig 7.1), trapezoidal (Fig 7.2), V-shape (Fig 7.3) and circular (Fig 7.4). The most common one which is rectangular drainage system is considered in the presentation shown in Fig 7.1.

There are basically two major modes of execution.

- Pre-cast execution.
- Cast-insitu execution

Pre-Cast Type

The formwork, mould and curing of the pre-cast concrete itself are done in the company's factory yard and stacked until the site is ready for installation.

Cast In-situ Type

This type is executed directly at the roadway site and the casting of concrete is done immediately the blinding, the reinforcement and formwork are ready.

The formwork is removed as soon as the contractor has need for continuous work. The period of curing is allowed before backfilling the side with earth material. Serious compaction is done especially at the side of the roadway to avoid sinking, immediate or consolidated

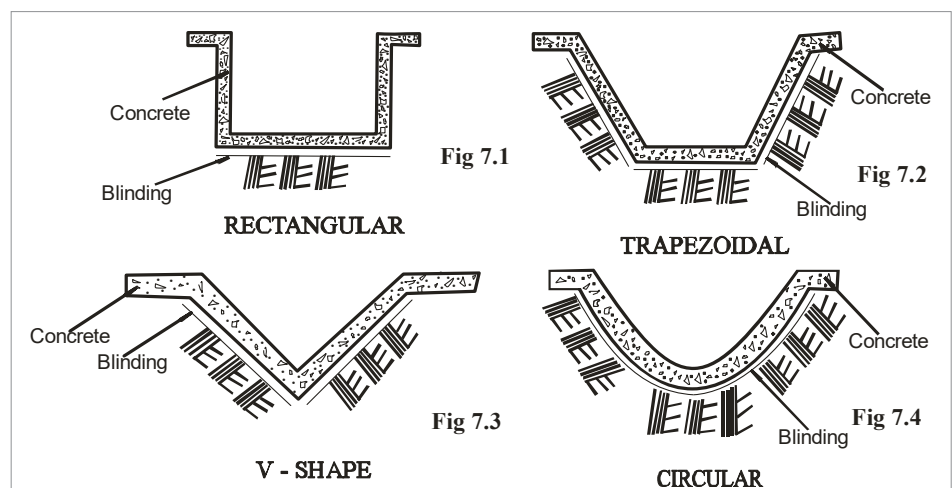
settlement in future.

6.0 CONCLUSION

This treatise is concerned with environmental control of highways with the use of surface drains. Surface drain design method, itself, is presented in details for application as part of the highway infrastructure development. It should, however, be noted that a more enhanced environmental control of highways can be achieved by the use of not only surface drains but also sub-surface drainage system whose design is not covered in this presentation.

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Figs. 7.1 – 7.4: Types of highway drainage shapes.

TIT-BITS ON WASTE TO ELECTRIC POWER

BY ENGR. ENEFIOK
UBOM



Engr. Enefiok Ubom, FNSChE

1.0 INTRODUCTION

Waste material is ordinarily an item which should be thrown away in consideration of being worthless. In many climes where innovative and value-added approaches are adopted in waste management, waste has practically been re-defined as a material with inherent value to be tapped. Turkey is a good example of a country where value is created out of waste instead of allowing waste to be disposed of as waste. This means waste is not wasted. Specifically, we see this in the Istanbul Waste Power Plant operated by Istanbul Environmental Management Company. See Fig. 1.

1.1 DESCRIPTION OF ISTANBUL WASTE FACILITY

Istanbul Waste Power Plant is owned by Istanbul Metropolitan Municipality. The plant was commissioned on November 26, 2021. The plant is a combustion facility and burns 3,000 tons of waste daily, 15% of Istanbul's daily domestic waste. The three incinerators each of 1,000 tons capacity reach about 850–1,100°C. It can generate 78 MWh electrical energy and 175 MWh thermal energy. The generated electricity is equivalent to the needs

of nearly 1.4 million people. A reduction of greenhouse gas emissions amounting to 1.38 million tons can be achieved which is the amount of exhaust gas emission of about 700,000 vehicles. Ninety people are employed in the facility. The capacity of the waste-to-energy plant has since been expanded to cover the electricity needs of 2 million people. Another benefit of this plant is that it saves a waste landfill storage area of 100 ha (250 acres).

1.2 LESSON FOR NIGERIA

Lagos and Abuja are good examples of cities in Nigeria where the State Government and the Federal Capital Development

Authority, respectively, can explore the possibility of setting up viable 'Waste-to-Energy Plant' using the concept operational in Turkey. Nigeria is blessed with experienced professionals who can conduct studies on the feasibility of such plants in Lagos and Abuja. When duly commissioned to conduct such studies, the outcome will form the basis for advice to the government on how the projects can be executed to the benefit of the country particularly as it relates to our topical environmental and electric power issues.



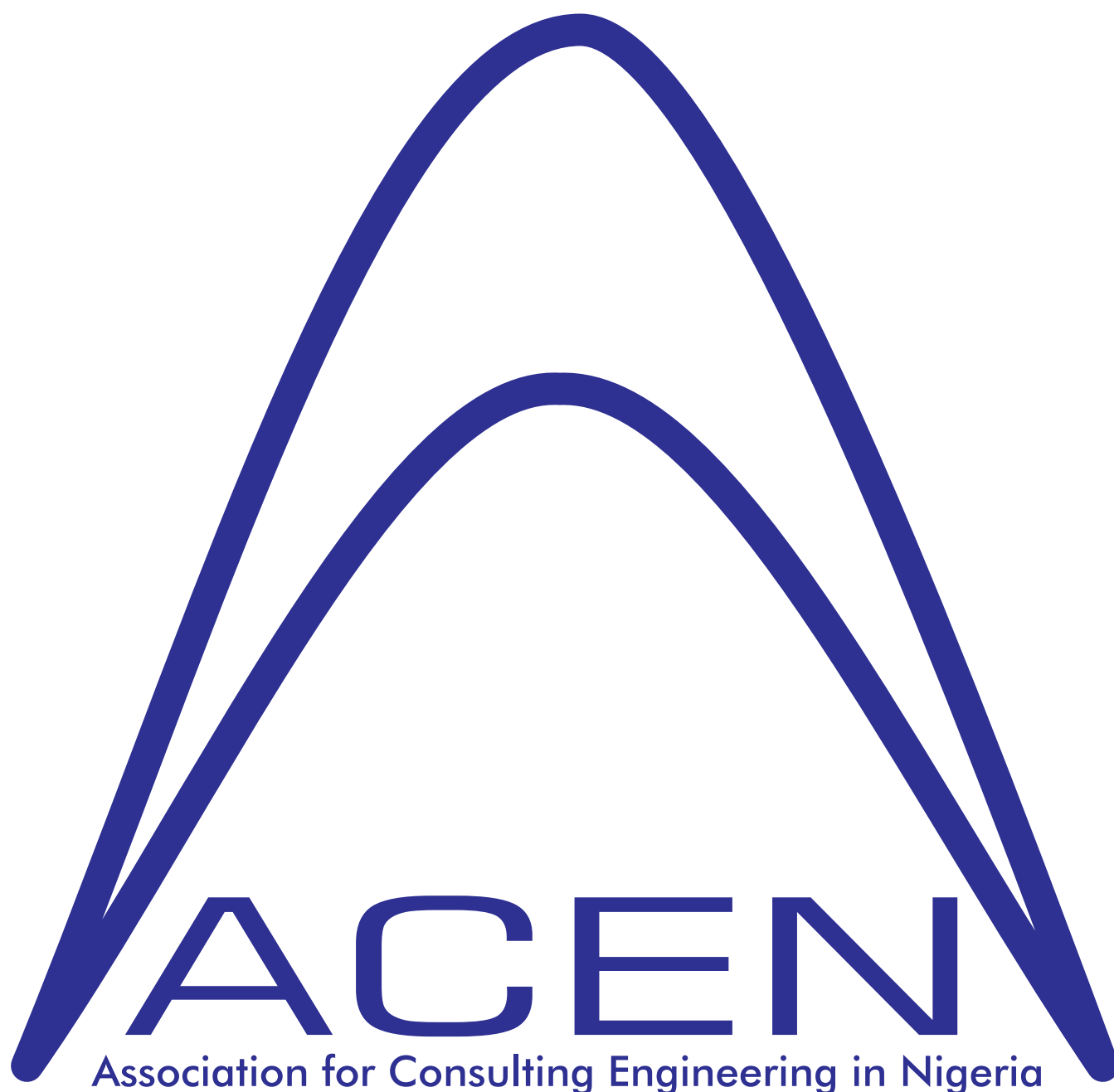
Fig. 1: Istanbul waste power facility. Source: Wikipedia.Org

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