

# **WATER POLLUTION AND SUSTAINABLE DEVELOPMENT: CAUSES, EFFECTS AND INNOVATIVE SOLUTIONS**

A paper presented by

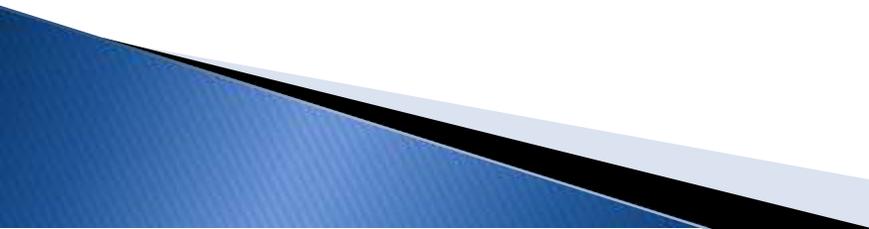
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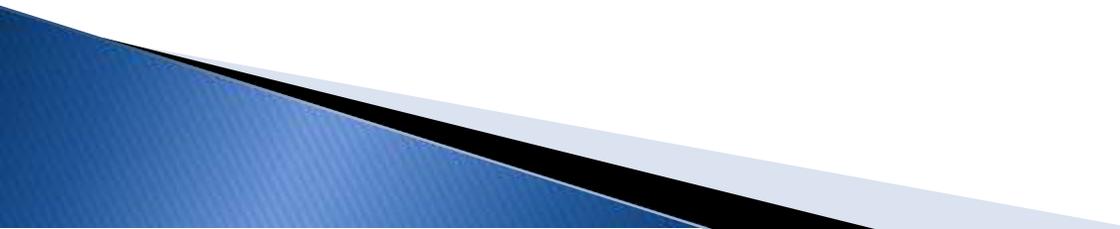
At the  
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ABUJA

# BACKGROUND

- ▶ Mankind is ever faced with challenges.
  - ▶ Some are natural but most are anthropogenic.
  - ▶ The anthropogenic challenges, which mostly defy the natural 'challenge absorbance system', are of great concern.
  - ▶ These anthropogenic challenges, such as pollution of various forms, are usually the result of man's developmental efforts.
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# Background (cont.)

- ▶ These developments leave the ecosystem, atmosphere, biosphere and hydrosphere degraded to various extents and render such developments unsustainable.
  - ▶ As a result, the millennium development goals were formulated (MDGs) (Sachs, 2012)
  - ▶ The MDGs captured some pressing needs of man and set out plans to meet them by 2015 but they appeared streamlined.
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- ▶ Thus, the **sustainable development goals (SDGs)**, designed to overcome these observed shortfalls of MDGs, were published by United Nations in 2015 (Assembly, 2014; Sachs, 2012)
  - ▶ **Sustainable development (SD)** is defined as the kind of development achieved with less adverse effects on the ecosystem with a view to allowing future developments at ease (Carley and Christie, 2017; Assembly, 2014; Lele, 1991).
  - ▶ Fundamentally, SD globally embraces development bearing the eventual wellbeing of man in mind.
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- ▶ This is so critical now that it is so obvious that the earth's life support ability is rapidly slipping away as a result of man's actions, with impending grave consequences,
  - ▶ Sustainable development (SD) has become the most popular catchphrase requiring a major paradigm shift in the area of development globally (Lele, 1991)
  - ▶ The Sustainable Development Goals captured 17 areas of man's endeavours put forward to handle all the major challenges of man in a most sustainable manner.
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# **SUSTAINABLE DEVELOPMENT GOALS**

- ▶ One of the SGDs (no. 6) is the provision of clean water and sanitation.
  - ▶ Provision of clean water is therefore a major index in the assessment of development of any UN member country including Nigeria.
  - ▶ Clean water has been declared a fundamental human right by the World Health Organisation.
  - ▶ This is as a result of the high relevance of water to man. Water must be in enough supply for an area to develop.
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# Sustainable development goals (Contd)

- ▶ Access to this essential potable water is severely threatened by numerous anthropogenic activities with consequences.
- ▶ Water pollution is a major challenge to the provision of clean water in this era and has further reduced the much desired freshwater sources (Ezbakhe, 2018; Huang and Xia, 2001).
- ▶ Water pollution is the introduction of substances or energy that can be hazardous to organisms into water sources by anthropogenic activities, directly or indirectly

- ▶ Numerous public health challenges have been linked to water pollution (Chigor *et al.*, 2019)
- ▶ With our poor environmental practices in Nigeria, pollution of water sources has thinned down our available water resources appreciable.
- ▶ For instance, open defecation, oil spillage, poor disposal of household and industrial wastes have left fresh and marine water resources so polluted that they are not even fit for animal consumption (Ado *et al.*, 2015)



Clearly polluted River in Nigeria  
(Source: Legit.ng)

# TYPES AND SOURCES OF WATER POLLUTION

- ▶ A. BASED ON THE WATER SOURCE AFFECTED BY THE POLLUTION, WATER POLLUTION IS CLASSIFIED INTO:
  - Freshwater (Surface water and Ground water) pollution
  - Marine water pollution

# FRESHWATER POLLUTION

- ▶ Freshwater includes all inland waters, all naturally occurring water bodies except seawater and brackish waters (Water Pollution, 2019)
  - ▶ The surface freshwater bodies, which are more at the receiving end of contaminants, are so easily polluted.
  - ▶ For a very long period of time, various untreated wastes were dumped directly into surface water bodies with the impression that they will be diluted into harmless levels.
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Discharge of untreated industrial waste into water sources (Source: The Guardian)

## Fresh water pollution (contd)

- ▶ Surface water pollution has also been made worse by certain natural phenomena such as flooding and landslides.
  - ▶ Most surface water sources are quite accessible and are heavily polluted presently (Water Pollution, 2019)
  - ▶ The most common pollutants of surface water are runoffs, though they remain vulnerable to pollutants discharged out of pipes and from precipitation.
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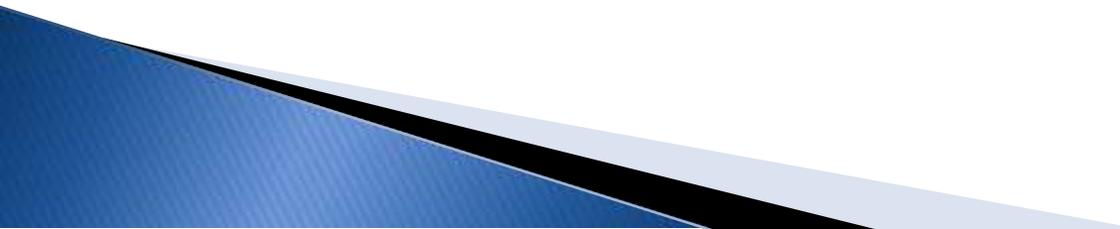
# MARINE WATER POLLUTION

- ▶ Marine waters represent all water bodies that are salty waters.
- ▶ Waste disposal into marine environment usually assumes that the water body is so large that the effect will never be felt. This went on for so long until 1975 when USA made efforts to control it (Howard, 2019).



Pollution of a marine environment in Niger Delta Nigeria  
(Source: Jenny Howard, National Geographic)

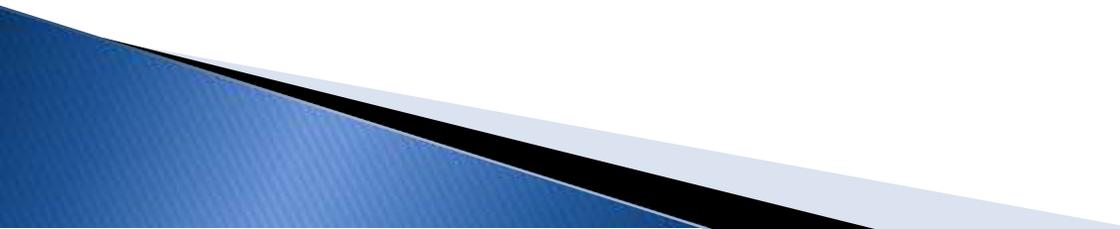
# Marine Water Pollution (Contd.)

- ▶ Common marine pollution has been grouped into **chemical, light, noise and plastic pollutions**.
  - ▶ **Chemical Pollution** explains the presence of all man made contaminants that are emptied into marine water sources.
  - ▶ Some common chemical contaminants include pesticides, herbicides, fertilizers, detergents, oil, industrial effluents and sewage (Howard, 2019)
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- ▶ **Light Pollution** is another important pollutant in the vast marine ecosystem.
- ▶ This is based on the ability of artificial light sources to penetrate the marine ecosystem with a possibility of upsetting the natural circadian rhythm which controls many life processes of the biota such as mating, migration etc.
- ▶ **Noise Pollution** is also critical once the natural noise in the marine environment is altered
- ▶ However, the introduction of unnatural noise could upset the normal communication system. This noise pollution may be introduced by ships, oil rigs and sonar devices (Howard, 2019; Hildebrand, 2004)

**Plastic Pollution** of marine environment is quite obvious and with severe consequences. Anthropogenic use and discard of plastic into the marine environment has been on the increase since the 1960s (Howard, 2019). This has accounted for the presence of plastics covering as much as 620,000 square meters in the oceans. Ocean animals have ingested these plastic pollutants leading to their death (Law, 2017).

## B. WATER POLLUTION CLASSIFIED BASED ON POLLUTION SOURCES

- ▶ Specifically, this classification has recognised two types of pollution types;
    - Point Source Pollutions
    - Non-Point Source Pollutions
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# POINT SOURCE POLLUTION

- ▶ **Point Source Pollution** is used to describe water pollution when the contaminant is introduced from defined, single identifiable source such as pipes and drains.
- ▶ **Common point sources of water pollution** include sewage/ waste water from water treatment plants and other industries such as oil refineries, paper and pulp mills, chemical, automobile and electronics manufacturers and factories.
- ▶ Point source pollution is easier to manage
- ▶ This ease of managing point source pollutions is due to the identifiable sources and as such regulations could be made.

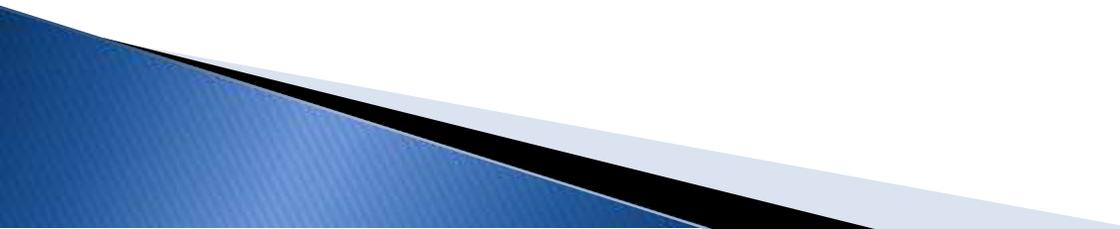
# NON-POINT SOURCE POLLUTION

- ▶ **Non-Point source pollution**, also called *diffuse diffusion*, represents all contaminant introductions and impacts taking place across a wide area and which cannot be easily attributed to a single source.
- ▶ Because of the challenge of establishing the source of these pollutions, it is more difficult to manage the resultant effects.
- ▶ Unlike point source pollutions, they are usually attributed to given land use including

urban, agricultural or forestry land use (EPA, 2019).

**Urban land use** contamination is due to urban runoff or storm water following rainfalls. The storm water washes a lot of contaminants off the streets of these urban centres into water bodies.

Some contaminants of the storm water include car oil, dust and the faeces of animals including man. The issue of faecal contamination is made worse in nations like Nigeria where open defecation is still widely practiced. Other storm water contaminants include soil and sediment run off from construction sites and toxicants and chemicals from industrial areas.



**Agricultural land use** pose a severe non-point contamination source for water pollution especially in countries like Nigeria where fertilizers, pesticides and animal manures are utilized without due consideration on their possible adverse effects on water sources. A major challenge here is the fact that livestock are given access to water sources. This practice is common and has led to increased rate of erosion and fouling of water sources (Law, 2017).

The effects of **Forestry land use** is similar to that of agriculture based on disturbed soils that could hasten erosion as well as sediment runoff.

## C. TYPES OF WATER POLLUTION BASED ON NATURE OF POLLUTANTS

- ▶ Based on the pollutant that is the cause of pollution, water pollution may be one of the following types:
- ❑ **Chemical pollution** is caused by release of chemicals into the atmosphere by wastewater and steam leading to the presence of unusual levels of these pollutants in the environment (Elliot *et al*, 2019). These include herbicides, pesticides and fertilizers, pharmaceuticals etc and they pose severe health risks.
- ❑ **Sewage/Waste Water Treatment Plant Pollution**: This has remained very important in the pollution of water sources (Balkhair and Ashraf, 2016; Tahir and Visaria, 2017). Despite the global reduction in water resources and advocacies against the disposal of untreated sewage into water bodies, the practice has continued.

**Faecal contamination** is a key indicator considered in water quality studies (Aboh *et al*, 2015). Studies still indicate presence of these indicators in water bodies as a result of continued discharge of untreated sewage/waste water into waters as well as open defecation, which is so common in Nigeria. The presence of these in uncontrolled levels result in severe consequences. These defile the acceptable water qualities and make water unsafe for use. The water environment is often left upset with consequences that include algal bloom and eutrophication.



People seen defecating into a water channel (Source: Kogi Reports, 2019)

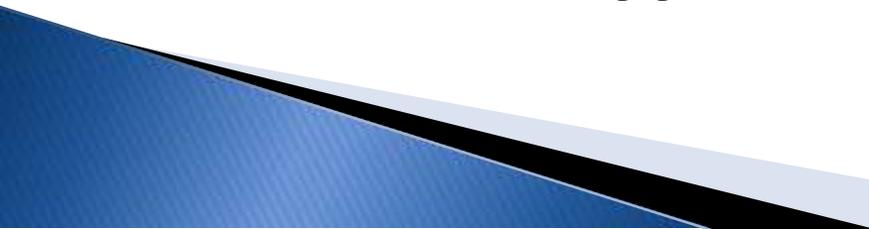
❑ **Crude Oil pollution** has ravaged numerous water resources across the world particularly in Nigeria. Due to unsustainable exploration practices, the Niger Delta aquatic environment has been identified as one of the most devastated ecosystems in the world (Ichor *et al.*, 2016). This has led to a sharp drop in the available water sources in this region. It is very worrisome considering the fact that most of Nigeria's water sources are located in this region. In fact, crude oil pollution is the leading pollution issue faced in Nigeria. These pollutants release their constituent contaminants, including polycyclic aromatic hydrocarbons, heavy metals, benzene, toluene, ethylbenzene etc, making the water bodies toxic and no longer potable for use (Ite *et al.*, 2018).

# Crude Oil Pollution



Polluted water in Ogoni land (Source: The Baifra Times)

**Plastic and Microplastic Pollution** of water sources is a global issue especially in the aquatic environments (Liu *et al*, 2016). These pollutants get incorporated into trophic levels and are easily bioaccumulated. These may be transferred to man by various routes including dietary intake. Obviously, most plastics and microplastics pollution is sourced from human activities and more use have been found for plastic materials, such as in packaging (Geyer *et al*, 2017)). Unfortunately, they are discarded after use without caution and end up in water bodies. The water sources soon become clogged and unfit for use.



## **Pollution of water sources by Industrial Waste**

**water** is a very important pollution source globally (Ozaki *et al*, 2019) and is worse in Nigeria due to no legislations or poor enforcement of legislations meant to protect the environment from such harmful practices. Industrial waste is any waste that results from industrial or manufacturing processes (SWDF, 2019) and they contain specific and easily identifiable chemical compounds classified as toxic wastes or organic pollutants. Industrial waste water is quite important in water pollution as they easily seep into environments.

Matters are made worse as most industries in Nigeria are small scale and don't have the resources to treat their wastes. The effects of these pollutants are severe to all life forms as well as the environment. Of particular interest in Nigeria are industrial waste waters from laundry and embalmment services which contain perchlorethylene, suspected to be carcinogenic.

**Thermal Pollution from power plants** give rise to sudden temperature changes that occur in the aquatic environment due to temperature regulation in different plants (Yavari and Qaderi, 2018; Oribhabor, 2016). Usually, various plants including power plants source water from the water bodies as a way of keeping the needed temperature. This results in sudden change in the temperature of the water bodies with consequent change in the physicochemical parameters. These physicochemical parameters such as oxygen, in turn affect the ecosystem biota, leaving imbalanced and polluted water sources. Other processes that have led to thermal pollution of water sources include soil erosion, deforestation, runoff of paved surfaces and natural processes like volcanoes (Conserve Energy Feature, 2019).

**Radioactive Substances Pollution is** another important pollutant in the water environment. It is physical pollution of the water environment or indeed any other environment or organisms due to the release of nuclear substances (Posudin, 2014). This contamination due to radioactive substances is because of the presence of radioactive materials in nature and other artificial nucleotides (Bonavigo *et al*, 2009). These result from anthropogenic processes including nuclear power plants, nuclear weapons testing and manufacture and use of radioactive sources. Radioactive pollution of water sources occur as radionucleotides which may be uranium, thorium and actinium (Posudin, 2014). Natural radioactive contaminants of water also include radium, uranium as well as the radioactive gas, radon. The radioactive elements have been associated with severe health issues, including cancers.

# HOW CLIMATE CHANGE IS AIDING WATER POLLUTION AND INCREASING WATER INSECURITY

- ▶ The issue of climate change is a global challenge that is encompassing in terms of its effects on the ecosystem.
- ▶ Climate change may be the result of natural or anthropogenic processes.
- ▶ The recent chaos around climate change is due to anthropogenic release of greenhouse gases such as carbon (IV) oxide (Akpodigaga and Odjugo, 2010; Moser, 2010)

## (Contd.)

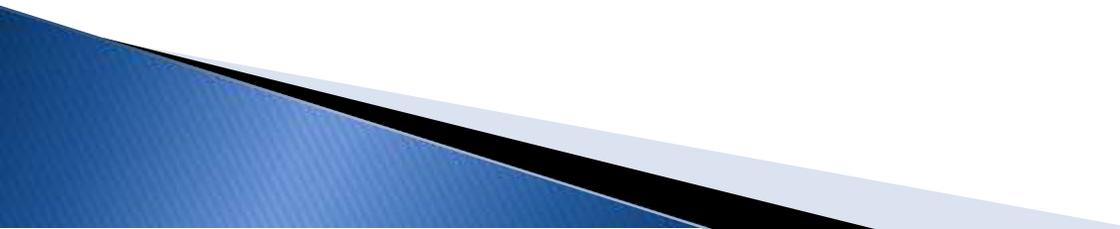
- ▶ This increased release in greenhouse gases, manifesting in climate change, has contributed to water pollution in the following ways;
  - ❑ **Increased precipitation**: A notable consequence of climate change is increased precipitation or rainfall leading to frequent flooding in many countries including Nigeria.
  - ❑ **Rising carbon dioxide emissions** which increases ocean temperatures and acidity.
  - ❑ **High surface water temperatures and increased nutrients** which give rise to harmful algal blooms.

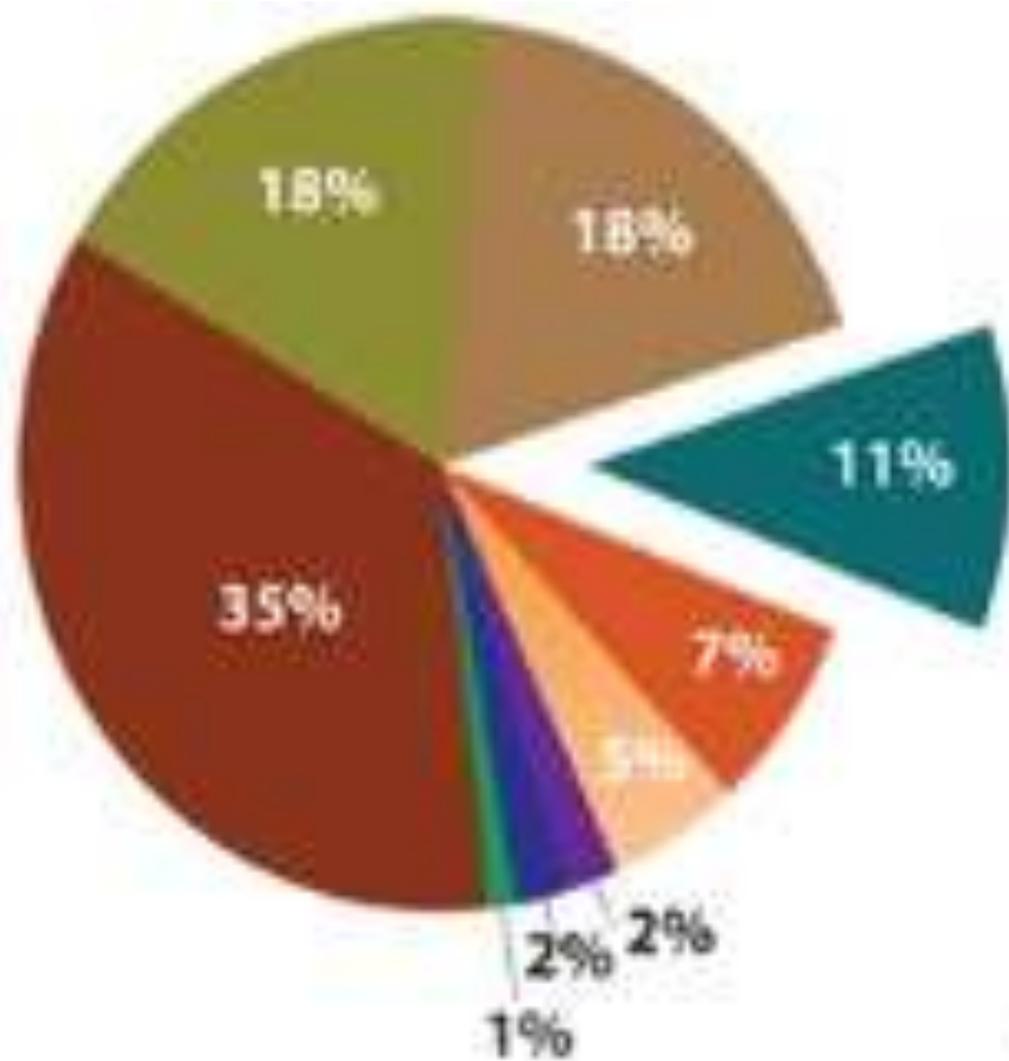
# EFFECTS OF WATER POLLUTION ON THE ENVIRONMENT AND PUBLIC HEALTH

## Effects On the Environment

- ▶ The effects of water pollution on the environment include:
  - ❑ Eutrophication and
  - ❑ Destruction of aquatic life.

# Effects of Water Pollution On Human Health

- ❑ Waterborne disease
  - ❑ Antimicrobial resistance dissemination
  - ❑ Heavy metal-poisoning
- 



- Neonatal causes
- Other
- Pneumonia\*
- **Diarrhea\***
- Malaria
- Injuries
- AIDS
- Meningitis
- Measles

\*Includes neonatal deaths

Source: Liu et al, Lancet 2012

# **INNOVATIVE SOLUTIONS TO WATER POLLUTION TOWARDS SUSTAINABLE DEVELOPMENT**

## **❑ GREEN AGRICULTURE/ ACTIONS TO REDUCE CLIMATE CHANGE**

- ▶ Agriculture is an important source of non-point pollutants in water.
  - ▶ This has resulted from the use of chemicals such as fertilizers to boost yield in order to meet the quantity and quality needs of an ever increasing population.
  - ▶ While there is need to sustain and even improve yield, there is also need to sustain the environment.
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## Green agriculture/ actions to reduce climate change (Contd.)

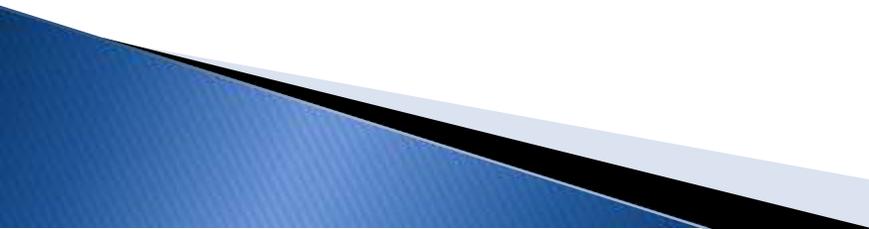
- ▶ Green Agriculture is promoted globally and has been practiced in places like China, United States of America and Germany (Dou and Zhao, 2019)
- ▶ Specifically, laws restricting the use of fertilizers, pesticides and other agrochemicals have been instituted
- ▶ Further, use of water resources in agriculture is strictly regulated to protect and restore water resources (Dou and Zhao, 2019; Koohafkan *et al.*, 2012)

- ▶ The **use of such technologies** would reduce the level of runoff due to disturbed soil particles.
  - ▶ Technological/computerised farming including drip irrigation and using of devices such as GPS and GIS, have been used to perfect the use of fertilizers and other agrochemicals in order to reduce the adverse effects.
  - ▶ Controlling the discharge of untreated animal wastes and droppings is also important in order to reduce their contamination of water sources.
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# PLASTIC WASTE REDUCTION

- ▶ Plastic waste is a major pollutant of Nigerian water sources.
  - ▶ There is need for the reduction of plastic wastes as a way of reducing water pollution towards sustainable development.
  - ▶ The **reduce, reuse and recycle (3R) policy** as used in developed and developing countries will go a long way
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# Plastic Waste Management

- ▶ Plastic waste management may involve biodegradation, landfilling, incineration and recycling (Panyakapo and Panyakapo, 2008)
  - ▶ Proper management of plastic wastes as well as use will remove them from the ecosystems and protect waters from pollution.
  - ▶ We need a legislation to this effect in Nigeria.
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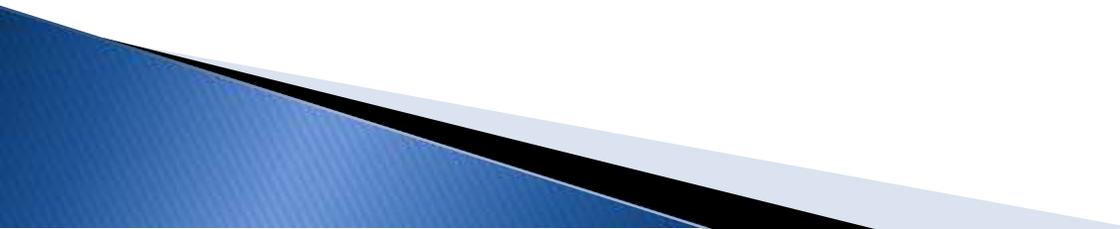
# Wastewater Treatment

- ▶ The challenges of disposal of untreated wastewater into water sources is quite notable.
- ▶ Treatment of wastewaters will rid them of key pollutants such as heavy metals.
- ▶ Central sewage system as found in parts of the world should be encouraged
- ▶ This will allow the collection of all municipal wastewater and treatment in treatment plants.
- ▶ Properly treated wastewater could be recycled for use, thereby increasing the available water resources

# Storm Water Management: Filter Runoff/Artificial Lakes

- ▶ Storm water management geared towards managing the effect of storms on the ecosystem should be encouraged.
  - ▶ Storm water management looks at efforts to control/reduce runoff of rain water directly into the environment and attempts to improve the quality of water (EEC Environmental, 2019)
  - ▶ It could be done with artificial lakes, ponds and other facilities aimed at filtering runoff.
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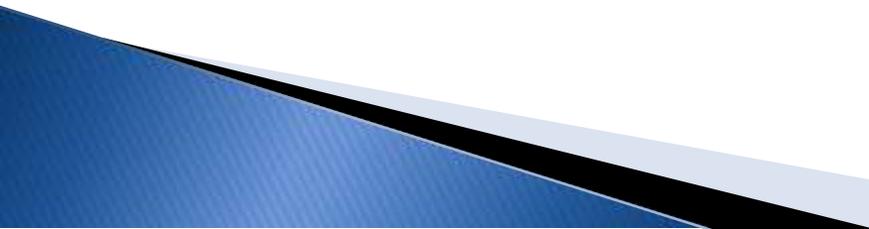
# Storm Water Management (Contd.)

- ▶ In Nigeria, where poor environmental practices such as poor waste disposal practices, open defecation and others are common, storm water is an important challenge to providing clean water.
  - ▶ Water pollution could be reduced appreciable if storm water management is put in place.
  - ▶ NESREA should explore collaboration with NEWMAP in this direction.
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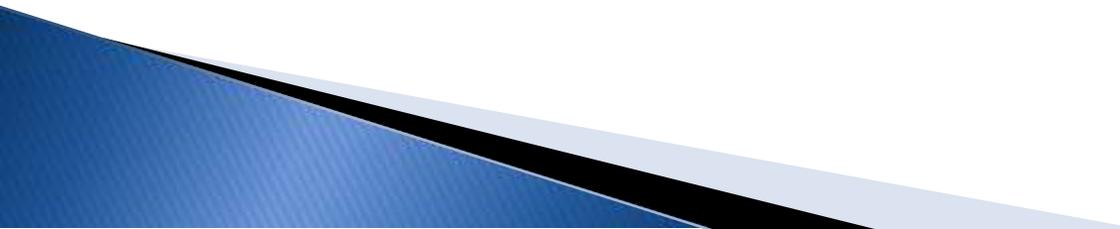
# Preventing Oil spills and Air Pollution/Acid Rain Prevention

- ▶ Pollution in all aspects of the ecosystem eventually end up in the hydrosphere/water.
  - ▶ Oil spillage and release of polycyclic aromatic hydrocarbons among other air pollutants have rendered numerous water bodies unfit for use in Nigeria.
  - ▶ Prevention of oil spillage is only possible if we maintain recommended best practices in the oil industry.
  - ▶ It is of great concern that many years after the global ban on gas flaring, Nigeria still allows this unhealthy practice.
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# Preventing Oil spills and Air Pollution/Acid Rain Prevention (Contd.)

- ▶ There is need for strict monitoring of the installations to reduce crude oil pollutions.
  - ▶ Ships, boats and other water transport vessels that ply our waters must be monitored closely and subjected to integrity tests to reduce the amount of oil pollution, noise and heat they introduce into our waters,
  - ▶ Air pollution is mainly from release of gases into the atmosphere.
  - ▶ A key route is the combustion of fuels either fossil or otherwise.
  - ▶ This has led to acid rain with severe consequences.
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## **Preventing Oil spills and Air Pollution/Acid Rain Prevention (Contd.)**

- ▶ A reduction in air pollution will noticeably reduce water pollution and increase access to clean water by all Nigerians.
  - ▶ The introduction of carbon emission taxes, invention of hybrid vehicles and battery-powered vehicles are notable interventions worthy of emulation in the Nigerian case
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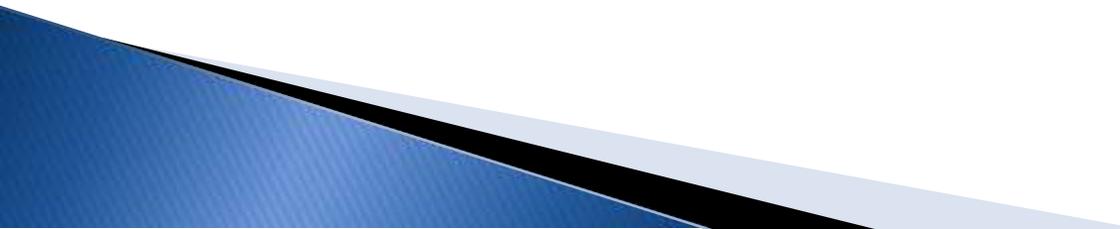
# BIOREMEDIATION OF POLLUTED AQUATIC ENVIRONMENTS

- ▶ Oil exploration and other processes have left the aquatic environment highly degraded.
  - ▶ These polluted environments require remediation and reclamation.
  - ▶ Biodegradation involves the use of living organisms in the degradation of contaminants and restoration of such ecosystems.
  - ▶ This method is preferred as cheap, efficient and quite environmental friendly
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# EFFECTIVE COMPLIANCE MONITORING AND ENFORCEMENT

- ▶ The water safety plan (WSP) was recommended by the world health organisation and has been adopted by member countries including Nigeria.
- ▶ This plan charts the systematic supply of water from source to the end users in a way that will be safe and acceptable.
- ▶ In the Nigerian context, the WSP is covered by the Nigeria Standard of Drinking Water Quality 2007.
- ▶ This documents mandates all water service providers to develop a Water Safety Plan.

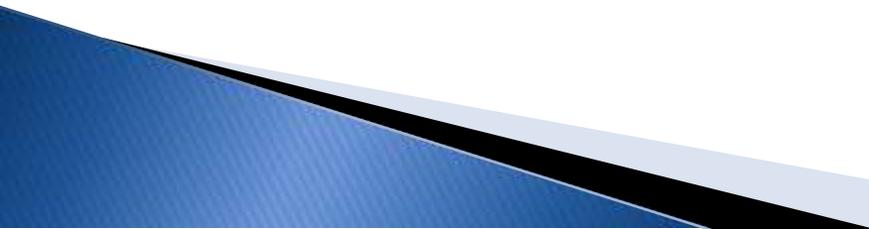
## Effective Compliance Monitoring and Enforcement (Contd.)

- ▶ This is a model of Hazard Analysis Critical Control Point (HACCP) (67). The HACCP concept is a quality assurance tool that monitors every step from source to the final consumption of the water.
  - ▶ There is need to implement and enforce all such regulations in order to protect water sources from pollution. Some of these regulations will also ensure that pollution cases are cleaned immediately they occur to reduce the impacts.
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# WATER EDUCATION AND LITERACY PROMOTION

- ▶ Water education and literacy promotion will make water users more aware of this all important resource.
  - ▶ The WSP captures this as a critical step during its preparation; communication and feedback.
  - ▶ This can be achieved by sensitization and public enlightenment. Increased education and literacy on water resources will reduce some common practices that lead to water pollution.
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Making people aware of the problem is the first step to solving it. In the early 1990s, when surfers in Britain grew tired of catching illnesses from water polluted with sewage, they formed a group called 'Surfers Against Sewage' to force governments and water companies to clean up their act. People who have grown tired of walking the world's polluted beaches often band together to organize community beach-cleaning sessions. Anglers who no longer catch so many fish have campaigned for tougher penalties against factories that pour pollution into our rivers. Greater public awareness can make a positive difference (Woodford, 2019)



## Laws/Legislatures

One of the biggest problems with water pollution is its transboundary nature. Many rivers cross countries, while seas span whole continents. Pollution discharged by factories in one country with poor environmental standards can cause problems in neighboring nations, even when they have tougher laws and higher standards. Environmental laws can make it tougher for people to pollute, but to be really effective they have to operate across national and international borders. This is why we have international laws governing the oceans, such as the 1982 [UN Convention on the Law of the Sea](#) (signed by over 120 nations), the 1972 [London \(Dumping\) Convention](#), the 1978 [MARPOL International](#)

[Convention for the Prevention of Pollution from Ships](#), and The European Union has water-protection laws (known as directives) that apply to all of its member states. They include the [Bathing Water Directive](#) (updated 2006), which seeks to ensure the quality of the waters that people use for recreation. Most countries also have their own water pollution laws. In the USA, there is the 1972 [Clean Water Act](#) and the 1974 [Safe Drinking Water Act](#). NESREA, which is active at national and state levels should extend their presence to local government and community levels for improved monitoring and enforcement. There should also be legislation making it mandatory for governments to provide VIP toilets in communities where there are no water system toilets.

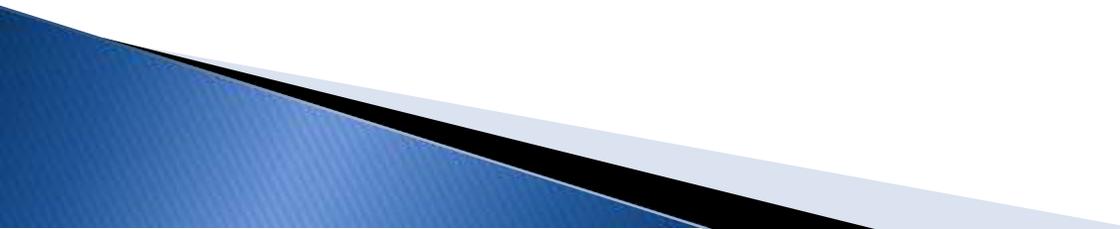
**Economics:** Most environmental experts agree that the best way to tackle pollution is through something called the **polluter pays principle** (Woodford, 2019). This means that whoever causes pollution should have to pay to clean it up, one way or another. Polluter pays principle can operate in all kinds of ways. It could mean that tanker owners should have to take out insurance that covers the cost of oil spill cleanups, for example. It could mean that shoppers should pay for plastic grocery bags as is done in Ireland to encourage [recycling](#) and minimize waste. It could mean that factories that use river water must have their water inlet pipes downstream of their effluent outflow pipes, so if they cause pollution they themselves are the first people to suffer. Ultimately, the polluter pays principle is designed to deter people from polluting by making it less expensive for them to behave in an environmentally responsible way. We should apply this principle to people who openly defecate into water bodies.

# CONCLUSION

- ▶ Water pollution remains a great challenge to sustainable development.
- ▶ . It is important that innovative steps are taken towards combatting this enormous challenge as we look towards achieving the SDGs in the year 2030.

Finally, may I acknowledge the assistance of my colleagues, Dr. V.N. Chigor, Mr. E. Ezeh and Mrs O. Anwara in developing and proof-reading this paper.

Thank you for your Attention!!



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