1.0 The Environment

1.1 Definition: Is all of the external factors affecting an organism. These factors may be other living organisms (biotic factors) or non-living variables (abiotic factors such as temperature, rainfall, day length, wind and ocean currents. The interactions of organisms with biotic and abiotic factors form an ecosystem. Ecosystem refer to organisms living in a particular environment such as forest or a coral reef and the physical parts of the environment that affect them.

1.2 Major Component

The major components of the environment are:

1. The lithosphere i.e. the worlds of rock
2. The atmosphere i.e. the air
3. The hydrosphere, i.e. region occupied by water
4. Biosphere i.e. the living things
5. Pedosphere i.e. the soil

Note: Environment where all of those worlds interact are often the most complex and productive on earth, i.e. the soil.

2.0 Soil as Environmental Interface

The importance of soil as a natural body derives in large part from its role as an interface between the worlds of rock, air, water and biosphere.

The concept of the soil as interface means different things at different scales. **At the scale of kilometres**, soil channel waters from rain to rivers and transfer mineral elements from rocks to the oceans. They also run over and supply vast amount of atmospheric gases substantially influencing the global balance of methane and CO_2. **At a scale of few meters**, soil forms the transition zone between hard rock and air, holding both liquid water and O_2 gas often used by plant roots. It transfers mineral elements from the earths' crust to its vegetation. It processes or stores the organic remains of terrestrial plants animals and man. **At a scale of few millimetres,** soil provides diverse microhabitats for air-breathing and aquatic organism, channels water and nutrients to plant roots and provides surface and solution vessels for thousands of biochemical reactions. Finally, **at a scale of a few micrometers and less**, soil provides ordered and complex surfaces, both mineral and organic that acts as templates for chemical reactions and interacts with water and solutes. Also, at this scale its tiniest mineral particles form micro-zones of electromagnetic charge that attract everything from bacterial cell wall to proteins to conglomerates of water molecules

3.0 Factors Threatening the Environment

1. Population Growth
2. Global Warming
3. Depletion of the Ozone layer
4. Habitat destruction and species extinction
5. Air pollution
6. Water pollution

7. Ground water depletion and contamination

8. Chemical risks- Toxic substances that humans encounter regularly which poses health risks.

9. Environmental Racism- Studies have shown that not all individual are equally exposed to pollution

10. Energy production- Typical example i.e. environmental effects of the fossil fuel age. NOTE: There are a lot of international treaties to combat these global problems

4.0 The Concept of Environmentalism

Environmental quality seems to be a new topic when in fact; the current emphasis on environmental quality is a renewed interest in an old topic. We are becoming increasingly aware that exposure to various substances may cause human health problems ranging from death to subclinical effects such as attention deficit syndrome. The natural tendency is to eliminate or reduce our exposure to substances that we suspect may adversely affect human health.

An environmentalist is a person who works towards solving environmental problems and environmentalism is an attitude by a group of individuals, perhaps the whole society that the environment takes a high priority in the decision-making process. A more philosophical approach categorizes an individual's attitude about the environment into one of the three groups, namely:

1. Egocentric- In which an individual in an individual's action are guided solely by concern for him or herself

2. Homocentric- meaning concern for the human species

3. Ecocentric- meaning an overall concern for the environment.

Society as a whole and most individual have progressed slowly from egocentric attitudes towards more ecocentric attitudes.

5.0 SOIL QUALITY AND FUNCTIONS OF SOIL

Introduction

As compared to the environment of compartments air and water, soil is an extremely complex system. This is due to a huge variety of soil properties and chemical, physical and biological system conditions. The combination of these makes the development of general rules for quantitative evaluation of soil quality impossible. This is because soils have a much higher buffering capacity than air and water. This property (buffering capacity) is the capacity to allow contents of compounds, once present at optimum level, to increase without actual occurrence at negative effects.

5.1 Soil Quality in Relation to Soil Functions

The quality of soil is adversely influenced by contamination (pollution) of the system. The concepts of “contamination” and “pollution” of soil are used in a comparable way as they reflect only a difference in degree of drainage to the soil system. Any addition to soil, i.e contaminants- meaning the compounds that may exert adverse effect on soil functioning. It can be defined as soil contamination. Because most soils do have a certain buffering capacity, it usually takes some time before the negative effects become apparent. Once this situation occur, the soil can be considered as polluted, which for all practical purposes means that malfunctioning or dysfunctioning of the soil is apparent due to abundant pressure or availability of the compounds.

Such malfunctioning may refer to one specific function in a particular but sometimes also in combination of different functions are:

1) The bearing function: For instance as playground for children and for building of houses/structures.

2) The Plant growth function: This may refer to natural vegetation and the production of crops for animal and human consumption

3) The filtering function of water: Ground water as well as surface water

4) The ecological function of soil: With its contribution to element cycling as an important aspect

Proper functioning of soil as stated above imposes a wide variety of quality criterion. This strongly hampers the introduction of a quality assessment methodology with general applicability and validity. At first sight, the bearing function would probably be the least demanding, at least once certain physical requirements are met. However, experience has shown that for building of houses, some minimal requirements of chemical conditions in the soil are needed; and a combination of use of the same site for waste disposal and later for urban expansion ie not always without problems.

Methods to assess health risks for people living in an area where there is unconscious combination of soil usages or in polluted areas, requires insight in the quantitative relationships between pollutant exposure of the organism under consideration on one side and the resulting effects to be expected from the exposure on the other side.

In the case of human, the exposure pathways are:

1) Soil ingestion, especially for children

2) Inhalation of air ,containing volatile polluting compounds

3) Drinking water

4) Food in the form of plant products and animal products

5) Radiation exposure

As a result of the adverse effects of heavy metals and other contaminants, environmental agencies proposed critical levels in soil above which toxicity is considered to be possible. For example the Table below shows the normal range and critical total concentrations of heavy metals for soil (Kabata-Pendias and Pendias, 1984).

Elements	Normal range in soil(mg/kg)	Critical soil total conc(mg/kg)
Cd	0.01-2.0	3-8
Co	0.5-6.5	25-50
Cr	5-1500	75-100
Hg	0.01-0.5	60-125
Pb	2-300	100-400
Ni	2-750	100

6.0 POLLUTION AND CONTAMINATION

6.1 *Preface:* The term contaminant is often used synonymously with pollutant, although difference in the definitions would indicate that these terms are not interchangeable. Contaminant implies concentration of a substance is higher than would naturally occur but does not necessarily mean that the substance is causing any harm. However, pollution refers to a situation in which the concentration of a substance in which the concentration of a substance is higher than would naturally occur but also indicate that the substance is causing harm of some type. Therefore, a soil could be contaminated but not polluted. Pollution is often broadly categorized according to its source:

Point-source pollution: As the name implies, is pollution with a clearly identifiable point of discharge. E.g. waste water treatment plant etc

Nonpoint-source pollution: Is pollution without an obvious single point of discharge. E.g. Surface runoff of a commonly used lawn herbicide.

6.2 *Classification of Potential Pollutants*

Pollutant	Examples
Nutrients	N and P in commercial fertilizers, manures, biosolids
	Waste water treatment effluent
Agrochemicals	Insecticides ,herbicides, fungicides etc
Hazardous organic chemicals	Strong acids and bases
Acidification	Acid precipitation, acid mine drainage

Salinity or Sodicity	Saline irrigation water, salt water intrusion
Trace elements	Heavy metals, elements normally present at low Concentration in soil and plant
Sediments	Eroded soil in surface waters
Particulates	Dust (from wind erosion),volcanic dust ash
Greenhouse gases	CO2,CH4 and other relatively active gases
Smog form of compounds	Ozone, secondary products of fuel combustion

6.3 Mechanism of Pollution Transport through soil

6.3.1 Contaminant Fate and Transport

FATE: The environment plays a key role in the ultimate fate and transport of contaminants. The specific fate of contaminant following their release into the environment, depends on their chemical structure which is highly variable, abiotic factors within the receiving environment (e.g. organic carbon ,ph ,surface water) and interaction with the biotic environment which can result in degradation, transformation or bioconcentration of the contaminants. Once contaminants also reach the soil, they move in one of these directions:

1) Vapourized into the atmosphere without chemical change

2) Absorbed by soils, move downward through the soil in liquid or solution form and can be lost from the soil by leaching.

3) Undergo chemical reactions within or on the surface of the soil

4) Broken down by soil micro-organisms

5) Washed into streams and rivers in surface run-off

6) Taken up by plants or soil animal and move up the food chain

Transport Mechanisms

Channels or contaminants are transported through soil principally by 3 mechanisms:

1. Massflow of dissolved chemicals within moving solution

2. Liquid diffusion within soil solution

3. Gaseous diffusion within soil air voids.

1. Massflow: Refers to the passive transport of dissolved solution within moving soil water which is approximated as the product of the volume flux of water times the dissolved solute concentration.

2. Liquid diffusion: Refers to the transport of the dissolved solutes within solution by intermolecular collision which moves the solutes from regions of higher solute density to lower solute density(concentration)

$$q_c = Ddc/dx$$

3. Vapour diffusion- Chemical Vapour

Molecules in the soil air spaces also undergo molecular collision and spread out by vapour diffusion which is expressed as the product of the vapour density or concentration gradient and a proportionality coefficient called the soil vapour diffusion coefficient

6.4 LOSS PATHWAYS OF CONTAMINANTS IN SOIL

Contaminants added to a soil from the surface may leave the zone of incorporation by one of these three loss pathways.

1. Leaching takes place principally by mass flow and refers to the downward movement of the contaminants

2. Volatilization: Refers to the loss of contaminants in vapour form to the atmosphere through the soil surface

3. Degradation: Refers to the biological or chemical transformation of the contaminant to a different form with properties distinct from those of the contam inant prior to transformation.

(Subsurface) Transformation Processes

Transformation processes change the chemical structure of a compound which might result in one or more of the following

1. Detoxification: An irreversible change in a substance from a toxic to non-toxic form. This occurs most commonly when an organic substance breaks down into its inorganic constituents with water and CO2 being the main by-products

2. Transtoxification: Inverse the conversion of one toxic compound to another toxic compound. In the process, toxicity may remain the same, increase or reduce

3. Toxification: Is the conversion of non-toxic compound to a toxic substance

6.5 TOXIC ELEMENTS IN THE ENVIRONMENT

Included among the toxic elements are heavy metals such as Ag, Cd, Cr, Co, Cu, Fe, Hg, Mo, Ni, Pb, Sn, Zn as well as lighter elements such as Al, Ag and Sc.

Under certain environmental conditions, these elements may accumulate to a toxic concentration and cause ecological drainage.

6.5.1 MAJOR SOURCES

1. Naturally occurring contaminations, natural emissions of toxic elements to the atmosphere can take place by volcanic outputs or outgassing, and by vapour-phase of relative volatile elements such as As, Hg and Se. We can have contamination from metalliferous sites.

2. Anthropogenic sources of toxic elements

Agricultural practice: From long-term use of pesticides sewage sludge (ie by-product of secondary treatments of municipal sewage)

Pollution from (metal) mining and processing: Pollution from toxic elements is association with various aspects of minig and processing industries. Mining produces ore as a product along with a considerable amount of metal-contaminated wastes pollution around mines is caused by dumping of contaminated overburden, excavating wastes etc

Oil pollution: The contaminations of soil and ground water with mineral oils, hydrocarbons or mineral oil-based products are among the most common negative effect of the industrial society.

7.0 MAJOR CONSEQUENCES OF CHEMICALLY DEGRADED SOILS

1. Environmental pollution / contamination

2. Bioaccumulation in plants and animals tissue

3. Accumulation of heavy metals

    a) Narrow Concentration Range – The margin between beneficial and harmful is narrow

    b) Food Chain – Plants, animals and humans

    4. Eutrophication

Prevention of Inorganic Chemical Contamination

1. Reduce the application to soil

2. Immobilize the toxins – maintain pH$\geq$ 7.0

3. Removal of toxins – Remediation (“Clean up”)

Physical Remediation

1. Incineration

2. Vacuum Extraction

3. Soil washing / Flushing

4. Leaching

5. Heating

Biological Remediation (Bioremediation)

1. Microbial Action

2. Phytoremediation

    i) Phyto Extraction - *Hyperaccumulation*

    ii) Enhanced Rhizosphere Phytoremediation

    iii) Phytostabilization

    iv) Phytodegradation

    v) Phytovolatilization

Greenhouse Gas Emissions and Mitigation

What are greenhouse gases (GHGs)?

- Gases that create a greenhouse effect over the earth surface, thereby increasing the temperature of the earth.

- The principal GHGs are carbon dioxide (CO_2), Nitrous oxide (N_2O), and methane (CH_4). Other GHGs include chlorofluorocarbons.

Causes of GHG Emissions

1. Fossil fuel combustion

2. Land use change i.e. deforestation, biomass burning

3. Agricultural sources of carbon (CO_2):

- Operation of farm machinery
- Fertilizers and agricultural lime
- Pesticides
- Irrigation
- Seed production

Impact on global climate change

Increased temperatures

2. Severe droughts

3. Floods

4. Sea level rise

Mitigation

One major way of reducing GHGs emission is *Soil Carbon Sequestration*.

Carbon Sequestration is the process of carbon storage in soils. Consequently soils could act as carbon "sinks".

"Sinks" - Forest soils, grassland soils, ocean, agricultural land

Effects of Global Warming

The resultant effect of greenhouse gases

emissions is largely seen in global warming.

- Weather - climate change
- Ice/glacier melt
- Sea level
- Agriculture
- Plants and Animals

  Human health