Environmental Science

(CE 155)

LECTURE NOTES

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Environmental Science

An interdisciplinary field that includes both scientific and social aspects of human impact on the world. It involves an understanding of the scientific principles and impacts, economic influences and political actions.

A common adage by the naturalist John Muir – 'Tug on anything at all and you will find it connected to everything else on the universe'.

Eg. In the forest behind the college of Engineering laboratories formerly used to harbour a number of trees, shrubs, biennials, etc with reptiles like snakes – python, cobras etc, mice, frogs, insects, different species of the birds, squirrels, etc. Since the start of the development of new structures to house business.

Environmental Science

school certain reptiles like the python have either been killed or chased away. In addition small scale farmers have been cultivating vegetables in some portions of the land.

This development have led to increase in population of mice in the forest thereby attracting animals like owls and hawks to the area, a situation which hitherto was not existing.

The water in the stream in the valley is gradually decreasing in the volume because of the felling of the trees and exposition of the stream surface to the harsh dry climatic conditions thus increasing the rate of the evaporation.

Environmental Ethics

The Ethics is a branch of philosophy that seeks to define what is right and what is wrong. Most of the issues discussed in this course will involve much of ethical dimensions.

The laws of any nation should match the ethical commitment of those living there. Not every action that is ethically right can have a law supporting it. E.g. 1) There is no law that you have to help your elderly neighbour to unload her groceries from the car. But even without a law this still must be the ethical right thing to do. 2) It is ethically right that after Eating snack you do not throw or litter around with the Polythene bag that was used to bag your snack.

The goal of environmental ethics is not just to convince us to be concerned about the environment but rather to focus on

Environmental Ethics

the moral foundation of environmental responsibility and how far this responsibility extends. Three primary theories have been put forward on moral responsibility regarding the environment. They include:

1) Anthropocentrism or human centred ethics
2) Biocentrism or life centred environmental ethics
3) Ecocentrism

Anthropocentrism has the view that all environmental responsibility is derived from human interest alone. It assumes that only humans are morally significant and have direct moral standing. In this view the adage is ‘protect when it benefits humans’. This view is flawed in the sense that we must ensure that the Earth remains environmentally hospitable for supporting human life and even that it remains

Environmental Ethics

a pleasant place for humans to live now and for the future.

Biocentrism or life centred environmental ethics
According to this theory all forms of life (humans, animals, Plants, microorganisms etc.) have an inherent right to life.

Ecocentrism
This approach / theory maintains that the entire environment deserves direct moral consideration and not consideration that is derived merely from human or animal interests. In this regard everything existing on the Earth or mother Earth should have the same right to life as any other mother.

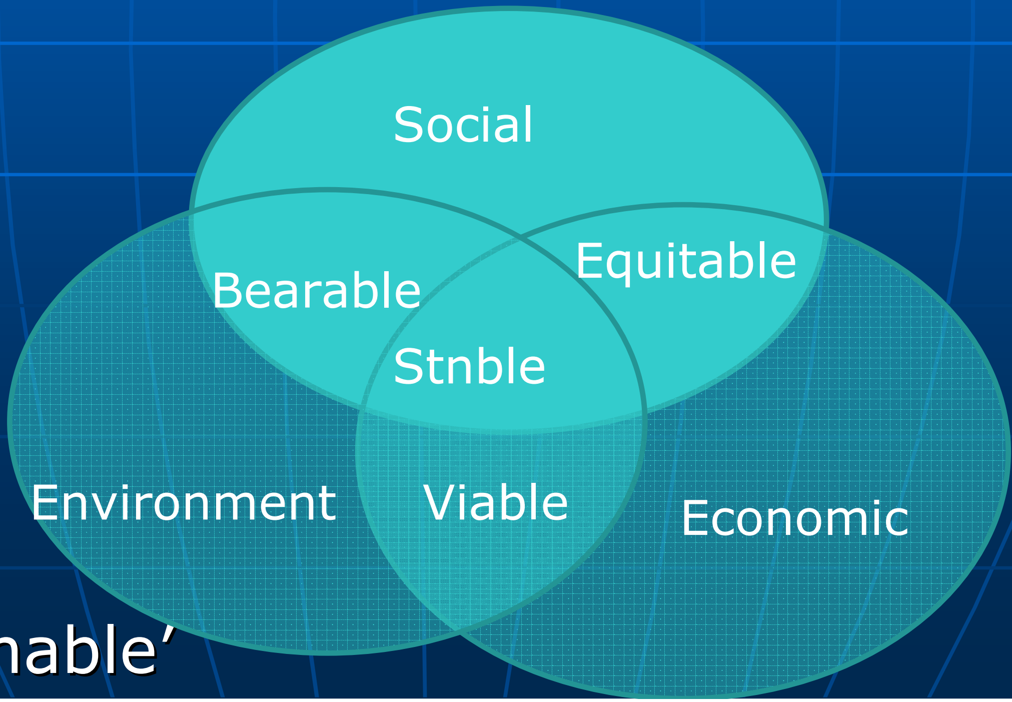
Environmental Ethics and Sustainable Development

Generally our attitudes or approaches to the environment must evolve round development, preservation and conservation.

In order to preserve and conserve our environment, our development should be sustainable. Sustainable development (SD) is often defined as 'meeting the needs of current generations without compromising the ability of future generations to meet theirs'. SD focuses on the promotion of appropriate development to alleviate poverty while still preserving the ecological health of the landscape. SD hinges on three pillars namely: economic development, social development and environmental protection. At times consideration is given to cultural development as well.

Ecosystems

The United Nations Conference on Environment and Development in 1992 in Rio de Janerio, Brazil set out a roadmap for sustainable development. In a follow up conference in South Africa in 2002, many observers questioned why there had been such a lack of international progress in alleviating poverty and protecting the environment.



Stnble – Sustainable'

ENVIRONMENTAL SCIENCE AND ENERGY PRINCIPLES

In environmental science information is provided on the environment especially the resources occurring within our environment and how human activities affect the quality, composition, constitution of these resources.

What is a resource?

Resource

Any physical or virtual entity of limited availability or anything used to help one earn a living.

There are two broad divisions of resources

- Natural Resources
- Human Resources

Natural Resources

These are basically derived from the environment.

Natural Resources

Natural resources may be classified based upon

- **Origin**
- **Stage of development**
- **Renewability**

Origin

Biotic and Abiotic

Biotic – living e.g. Forest, animals, birds and their products

Abiotic – land, water, air, minerals etc.

Stage of development

Potential resources

Actual resources

Potential resources are those that exist and may be used in the future

Actual resources are the type of resources that have been surveyed. Their quantity and quality have been determined and are being put to use in the present times.

Renewability

Renewable and the non-renewable resources

Renewable – are inexhaustible resources e.g.. the sun, plants and animals, fresh air, fertile soil, fresh water, energy from the sun and wind tides.

Non renewable sources:

Can be depleted after a period of time of exploitation. Recovery may be expensive and may be impossible e.g..

metallic minerals e.g. gold, iron, copper, tin etc.

Non-metallic e.g. fossil fuel, clay, sand, salt phosphates etc.

Renewable and Non-renewable

Renewable resources can become non - renewable resources if they are used at a faster rate than they can be replenished. Some animal and plant spp. have become extinct because the rate at which they are being utilised is faster than what the sedentary phosphorus cycle can maintain.

The world is running out of resources e.g..
Fossil fuels - 50 yrs
Pb, Sn, Cu, Ag, Hg – 2000 – 2040. etc

Mitigation Measures

Recycle

Reuse

Reduction in consumption

Recovery

More devised technologies to recover more minerals from used ores; alternative method or alternative materials for same purpose that a mineral or a particular resource is used.

THE ENVIRONMENT

The sum total of external conditions and influences affecting the development and life of an organism. In addition it is the aggregate of all natural and operational conditions that affects the performance of an equipment or its components and determine the behaviour of a physical system.

The Environmental setting:

- Physico-chemical: Water, air, soil, noise, radiations
- Biological: terrestrial and aquatic lives
- Cultural: history (beliefs), attitudes and practices,
- Socio-economic: population, economy, infrastructure

Environmental Engineering

Basically the application of theories of science and material forces to confront ecological and socio-economic problems so as to reduce pollution, contamination and deterioration of the surroundings in which humans live.

Environmental Engineering involves control of water, soil and atmospheric pollution and the social and environmental impact of planned projects.

Ecological Concepts

Ecology – study of the relationship between living organisms and with their environment.

Ecosystem is a self-sustaining and self regulating community of organisms with their environment.

Population is a group of plant or animal species in a given locality.

Community is a group of plant and animal populations living and interacting in a given locality

Ecosystems

Ecosystem does not only include the community of organisms but also organisms and their biotic environment, which involves the movement of energy and materials through the communities. Ecosystems have no definite boundaries. They are self regulating and normally have a continuous input of energy to retain its stability. The only significant source of energy for most ecosystems is sunlight. Producers in an ecosystem are the only ~~animals~~ that could trap the sun’s energy through the process of photosynthesis and make it available to the ecosystem

The ecosystem functions through the operation of some natural laws. It operates through the recycling of matter in accordance with the law of conservation of matter and the one way energy flow is in accordance with the first and second law of energy.

HABITAT AND NICHE

Organisms interact with their surroundings in many ways. Certain factors may be critical for the existence of a particular species. A shortage or absence of a particular factor can restrict the success of the species. Such factors are known as limiting factors. The factors could be biotic or abiotic. E.g. Many plants are limited by scarcity of water, light, specific soil nutrients such as nitrogen, phosphorus etc. Climatic factors such as temperature range, humidity, periods of drought or length of winter are often limiting factors.

It is impossible to understand an organism apart from its environment. The habitat of an organism is the space that the organism inhabits, the place where it lives.

The Niche of an organism is the functional role it has in its surroundings (its profession). An organism s niche includes all the ways it affects the organisms with which it interacts as well as how it modifies its physical surroundings. In addition the description of a niche includes all of the things that happens to the organism.

KINDS OF ORGANISM INTERACTIONS

<u>Predation</u>: a kind of interaction where one organism – the predator, kills and eats another (known as prey). To succeed many predators employ several strategies including strength, speed and snares to overpower their prey. Obviously for the prey to survive, they need to and do breed more else they become extinct. Normally the prey that is healthier, quicker and better – adapted are likely to survive.

<u>Competition</u>: in this kind of interaction two organisms strive to obtain the same limited resource. Two kinds of competition exist – Intraspecific and Interspecific competition. Competition among members of the same species is intraspecific while competition between members of different species is referred to as interspecific competition.

KINDS OF ORGANISM INTERACTIONS

Competition among members of the same spp. is a major force in shaping the evolution of a specie. When resources are limited, less well –adapted individuals are more likely to die or be denied mating privileges. Because the most successful organisms are likely to have larger numbers of offspring, each succeeding generation will contain more of the genetic characteristics that are favourable for survival of the species in that particular environment. Since individuals of the same species have similar needs, competition among them is usually very intense. A slight advantage on the part of the individual may mean the difference between survival and death.

Competitive Exclusion Principle

Is the concept that no two species can occupy the same ecological niche in the same place at the same time. The more similar two species are, the more intense will be the competition between them. If one of the two is better adapted to live in the area than the other, the less –fit species must evolve into a slightly different niche, migrate to a different geographic area or become extinct.

Symbiosis is a close long lasting physical relationship between two different species where at least one of them derives some sort of benefits from the contact / interaction. Three types of symbiotic relationships exist: Parasitism, Commensalism and mutualism.

Parasitism:- a relationship in which one organism known as the parasite lives in or on another organism known as the host from which it derives some form of benefit e.g. Nourishment. Parasites are normally smaller than the host. The host generally is harmed, it is generally not killed immediately.

KINDS OF ORGANISM INTERACTIONS

Two kinds of parasites occur – endoparasites and ectoparasites

Commensalism:- a relationship between two organisms in which one organism benefits while the other is not affected. Many commensal relationships are rather opportunistic and may not involve a long-term physical contact.

Mutualism:- a relationship that benefits both specie involved. In most mutualistic relationships the relationship is obligatory; the species cannot live without each other. In others the species can exist separately but are more successful when they are involved in a mutualistic relationship. E.g. Many kinds of plants such as legumes (beans, peanuts, clover etc) have bacteria that live in their roots in little nodules. The roots for nodules when they are infected with certain kinds of bacteria. The bacteria do not cause disease but provide the plants with

KINDS OF ORGANISM INTERACTIONS

nitrogen-containing molecules that the plant can use for growth. Similarly, many kinds of fungi form an association with the roots of plants. The root-fungus associations are called mycorrhizae.

ROLES OF ORGANISMS IN ECOSYSTEMSS

Producers: are organisms that are able to use simple inorganic substances in their environment together with sunlight to produce / make complex organic molecules.

Consumers: are organisms that require organic matter as a source of food. They consume the organic matter to provide themselves with energy and the organic molecules necessary to build their own bodies. They break down the organic matter to simple inorganic molecules through the process of respiration. Based upon the way they obtain their food and the kinds of things they eat, consumers can be classified as either primary consumers or secondary consumers

Primary consumers (herbivores) are animals that eat producers (plants and phytoplanktons) as a source of food.

Secondary Consumers (carnivore) are animals that eat other animals.

Omnivores :- Animals that eat both plants and other animals.

Decomposers:- organisms that use non-living organic matter as a source of energy and raw materials to build their bodies. Whenever an organism sheds a part of itself, excretes waste products or dies, it provides a source of food for decomposers. Decomposers are extremely important in recycling matter by converting organic matter to inorganic material.

Scavengers:- these animals eat carcasses.

Trophic Levels and energy flow in Ecosystems

Each step in the flow of energy through an ecosystem is known as a trophic level. Producers normally constitute the first trophic level and herbivores for the second trophic level. Carnivores that eat herbivores are the third trophic level followed by carnivores that eat other carnivores as occupants of the fourth trophic level. Omnivores, parasites and scavengers occupy different trophic levels depending upon what they happen to be eating at the time.

In ecosystems there is always the transfer of energy. The transfer occurs in accordance with the second law of thermodynamics. As energy flows through an ecosystem, it passes through several levels know as trophic levels. Each trophic level contains a certain amount of energy. Each time

Trophic Levels and energy flow in Ecosystems

useful energy is lost, usually as heat to the surroundings. Therefore, in most ecosystems useful energy is lost, usually as heat to the surroundings. Therefore, in most ecosystems higher trophic levels contain less energy and fewer organisms.

It is normally difficult to actually measure the amount of energy contained in each trophic level. One of the ways to estimate the amount of energy is to quantify the biomass. The biomass is the weight of living material in a trophic level. For a simple ecosystem it is often easy to collect and weigh all the producers, herbivores and carnivores. The weights often show the same 90% loss from one trophic level to the next as happens with the amount of energy.

FOOD CHAINS AND FOOD WEBS

Food Chain:- a series of organisms occupying different trophic levels through which energy passes as a result of one organism consuming another. Some food chains rely on a constant supply of small pieces of dead organic material coming from situations where photosynthesis is taking place. The small bits of non-living orgainc materials are called detritus. The floor of a forest can be a perfect example of a detritus food chain.

The forest floor receives fallen leaves that serve as detritus food chain. Initially the leaves will be colonized by bacteria and fungi. If an earthworm is eaten by a bird, it becomes part of a larger food chain that includes material from both a detritus food chain and a photosynthesis – driven food chain. When several food chains overlap and intersect, they make up a food web.

1^{st} and 2^{nd} Laws of Energy

1. Energy is neither created nor destroyed but merely changed from one form into another.

2. This law states that whenever energy is changed from one form to the other, some of the useful energy is lost. The energy that cannot be used to do useful work is called entropy. The entropy of the universe is increasing. Normally the quality of the energy available for useful work will always be lower in quality than the initial energy. We can recycle matter but we cannot recycle energy for all practical purposes.

1^{st} and 2^{nd} Laws of Energy

All machines and living things that manipulate energy release heat. Organized matter tends to become more disordered unless an external source of energy is available to maintain the ordered arrangement. The chemical reaction that causes rust release heat. The chemical reaction that causes rust releases heat. Ultimately, orderly arrangements of matter, such as clothing automobiles, or living organisms, become disordered. There is an increase in entropy.

Eventually, nonliving objects wear out and living things die and decompose. This process of becoming more disordered coincides with the constant flow of energy toward a dilute form of heat. This dissipated, low quality heat has little value to us, since we are unable to use it.

It is important to understand that energy that is of low quality from our point of view may still have significance to the world in which we live. For example the distribution of heat energy in the ocean tends to moderate the temperature of the coastal climates. It is important to recognize that we can sometimes figure new ways to convert low quality energy to high quality energy. Eg. Low quality wind energy to high quality electricity.

An unfortunate consequence of energy conversion is pollution. The heat lost from most energy conversions is a pollutant. The wear of the brakes used to stop cars results in pollution. The emissions from power plants pollutes.

Environmental Crisis

The laws of energy give keys to understanding the environmental crisis currently challenging the world.

Environmental Crisis	
Global warming,	Ozone layer depletion
Floods	Air pollution
Polluted water supply	Waste disposal
Land degradation	Destruction of rainforest
Desertification	Rapid population growth etc

Environmental Crisis
Structure of Earth's atmosphere

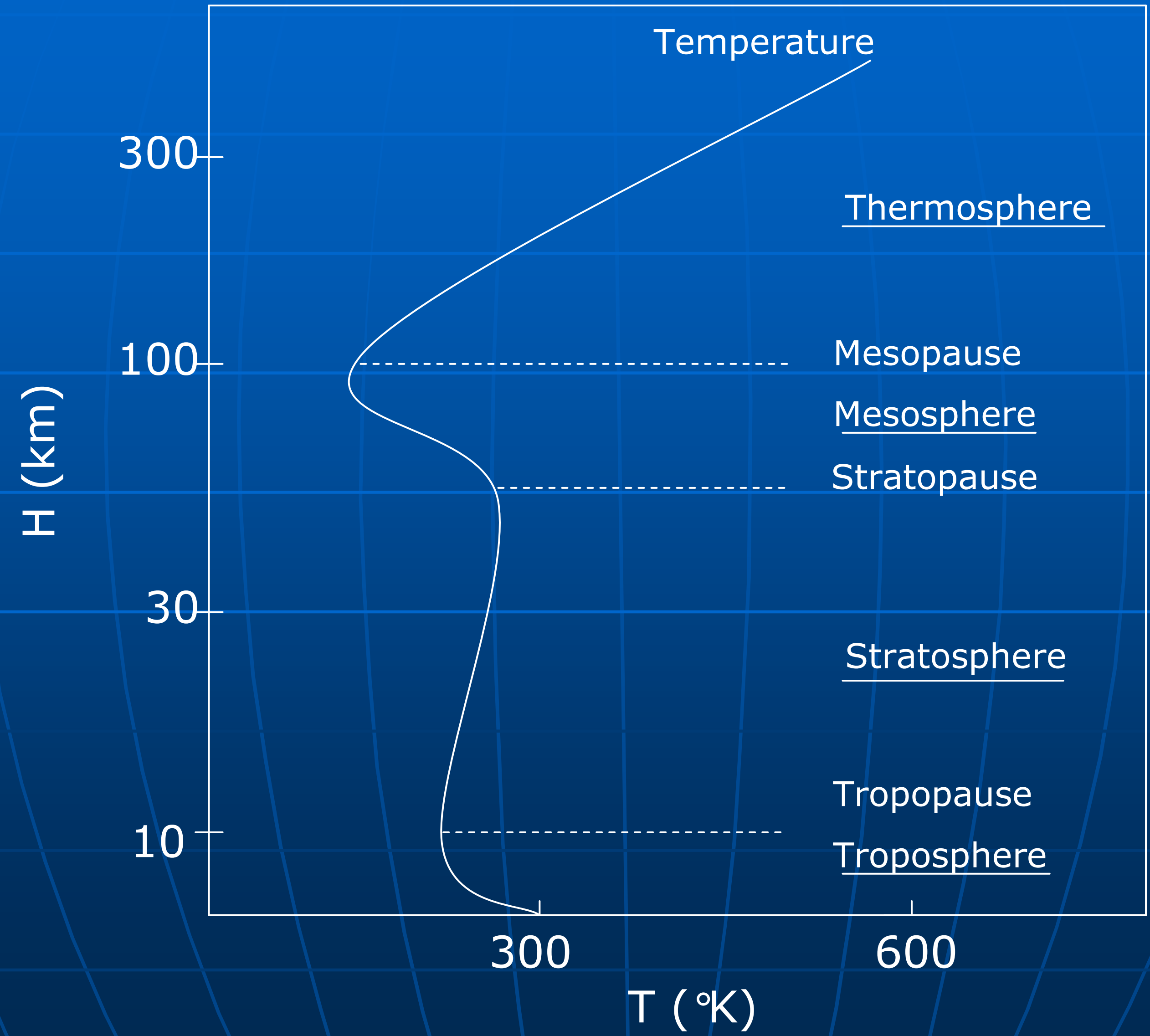
The thin film of gas that surrounds the earth varies in structure as the distance increases outward from the surface. The earth's atmosphere is divided into regions based primarily on considerations of temperature as shown in the figure on the next slide. The temperature at the earth's surface varies from sub-zero ℃ (i.e. temperatures beneath zero; so it is a term normally used for negative number – temperature) in the polar regions and high mountains areas to highs of about 70℃ in the arid desert regions.

The corresponding air temperatures close to the earth's surface (within a few metres) are lows of sub-zero and highs of about 50℃. In very warm areas, the air temperature is typically 10 to 20℃ cooler than the hot surface temperatures. Typically, at mid latitudes the temperature falls with increasing altitude in the troposphere. This is known as positive lapse rate.

The increase continues to an altitude known as the tropopause, above which the temperature increases again in the region known as stratosphere. The height of the troposphere is about 10km above the earth's surface, while the stratosphere extends a further 20 to 30 km.

The lower 0 to 2 km of the troposphere can be further divided into several regions. This entire region (0 to 2 km) is called the atmospheric boundary layer (ABL). The ABL is that region where the wind velocity is affected by the shear resistance of the earth's surface. The ABL is shallowest over oceans or large inland waterways, where its height is about 500 m.

The depth of the ABL may be up to 2 km in urban areas with many tall structures. In typical rural areas, the ABL depth is about 1 km. At the earth's surface, the wind velocity is lowest, and increases gradually (non linearly) to the top of the ABL.


Temperature
300
Thermosphere
100
Mesopause
Mesosphere
Stratopause
H (km)
30
Stratosphere
Tropopause
10
Troposphere
300
600
T (°K)

Above the ABL, the wind velocity is approximately constant, being unaffected by the shear resistance of the earth's surface. The region of most interest for atmospheric pollution is that within the ABL, though higher regions within the troposphere are of interest to large scale air circulation behaviour and global climate circulation modelling. A region close to the earth's surface, called the sub-layer of the ABL, is affected by local roughness and is characterized by high turbulence and strong mixing.

Within the ABL the average percentage chemical composition of the air is as follows:

	%
Nitrogen (N_2)	78
Oxygen (O_2)	21
Argon (Ar)	0.9
Carbon dioxide (CO_2)	0.03
Neon (Ne)	0.0018
Helium (He)	0.00052
CH_4	0.00022
Krypton (Kr)	0.0001
Di-nitrogen oxide (N_2O)	0.0001
Hydrogen (H_2)	5.0×10^{-5}
Xenon (Xe)	8.0×10^{-6}
Ozone (O_3)	2.0×10^{-6}
Ammonia (NH_3)	6.0×10^{-7}
Nitrogen dioxide (NO_2)	1.0×10^{-7}
Nitrous oxide (NO)	6.0×10^{-8}
Sulphur dioxide (SO_2)	2.0×10^{-8}
Hydrogen sulphide (H_2S)	2.0×10^{-8}

OZONE

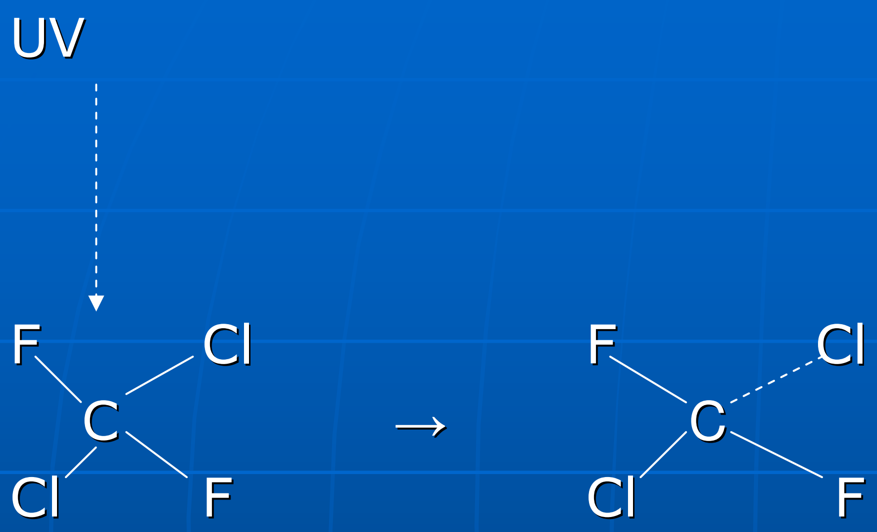
The proliferation of ozone is one of the most widespread environmental problems and one of the most difficult to manage. Just about every major urban area of the country exceeds the health protective limits for ozone established by the various EPA. Ozone is a colorless gas with a pungent odor, and the chief component of smog. Chemically it is a form of oxygen with three oxygen atoms instead of the two normally found in oxygen. It is very reactive. Ozone levels high enough to cause health problems for people are also high enough to damage crops and vegetation. Ozone can also damage the lungs of man, building materials and cultural treasures (monuments). Ozone could exist in the troposphere or the stratosphere.

Ozone is produced in the atmosphere (troposphere) when sunlight triggers certain chemical reactions. The precurssors, or chemicals that are initially needed for this reaction to take place include volatile organic compounds (VOCs) and nitrogen oxides (NOx). VOCs are released into the air when petroleum products are combusted, handled or processed. NOx are also produced by combustion. Sunlight provide energy to fuel the reactions between the VOCs and the NOx and naturally occurring atmospheric gases, resulting in the production of ozone and eventual generation of smog. Recent findings indicate that some pollutants especially ozone are more harmful in lower concentrations than previously thought because they could cause life long, permanent health damage. Ozone is the most serious threat to vegetation. It attacks leaves causing them to yellow, develop dead spots and drop early. It can reduce plant's growth, fruit yield and increase susceptibility to insect attack and interferes with photosynthesis.

OZONE IN STRATOSPHERE

The ozone layer in the stratosphere filters out some of the u.v. light from the sun. Destruction of the ozone layer allows more of the sun's UV rays to penetrate to us. Increased UV can lead to greater incidence of skin cancer, Cataracts, reduction in populations of certain fish larvae and plankton. It also reduces the useful life of outdoor paints and plastics. Chlorofluoro-carbons (CFC) are compounds that consist of Cl, F and C and used as coolants for refrigerators, air conditions, propellants for aerosol sprays agents for producing plastic foam and cleansers for electrical parts. CFCs do not degrade easily in the first layer of the atmosphere (troposphere) and so rises into the stratosphere. CFCs are broken down by UV light in the stratosphere. The chlorine atoms released react with the ozone layer to convert it into two molecules of oxygen and chloride.

OZONE



$+ \quad O_3 \rightarrow O_2 + Cl\text{-}O \rightarrow$

$O + Cl\text{-}O \rightarrow O_2 + Cl$

OZONE

The Halons are also industrially produced group of chemicals that contain bromine. Halons destroy ozone in a manner similar to chlorine. Halons are used primarily in fire extinguishing foam.

Green house gases and Global warming

Green house effect is a natural phenomenon caused predominantly by water vapour, NO_2, O_3, CO_2 and CH_4 (methane) and other gases in the atmosphere. Their effect on the earth is comparable to that of the glass in a green house. Greenhouse gases greatly affect the temperature of the Earth; without them, Earth's surface would be on average about 33 ℃ (59 ℉) colder than at present.

Global Warming

Visible light passes through the atmosphere to the earth's surface. When the light is absorbed by the earth, it is converted to heat. Some heat escapes, CO_2 and other gases in the troposphere trap the rest, warming the earth. This allows the earth to maintain a warm temperature and support life. If there is no green house effect, the earth will be much colder. In recent years, activities of man have generated a lot of CO_2 and many people have become concerned about human activity causing the earth to become too warm. It is important to recognize that there is a great deal of disagreement among scientists about weather global warming is actually occurring.

Causes of global warming

- Certain types of air pollutants may be producing long-term and perhaps irreversible changes to the global atmosphere.
- Industrial growth since the mid-nineteenth century has released large amounts of CO_2 into the troposphere.

Acid Rain

Acid rains is mainly attributable to the strong mineral acids – Sulphuric and nitric acids that are derived from oxidation of SO_2 and NOx respectively. Pollutant emission of the strong acids - nitric and sulphuric are slight but atmospheric oxidation NO_2 and SO_2 causes formation of these acids. They are removed from the air in rainfall then known as acid rain (acid fog, acid snow and acid dust). Winds carry air pollutants hundreds of miles from their points of origin. These transported air pollutants can damage aquatic ecosystems, crops and forest and may pose risks to human health. One of the pollutants is called acid deposition (or more commonly – acid rain).

Acid rain, which results from the reaction of pollutant gases and moisture in the atmosphere has irreversibly damaged the environment in many parts of the world. The process of acid deposition begins with emissions of sulfur dioxide (primarily form coal burning power plants) and nitrogen oxides (primarily from motor

Acid Rain

vehicles and coal burning power plants). These pollutants interact with sunlight and water vapor in the upper atmosphere to form acidic compounds (sulfuric acid and nitric acid). These compounds often fall to earth as acid rain or snow but the compounds can also join dust or other dry airborne particles and fall as dry deposition.

Effects:

- The extent of damage caused by acid rain depends on the total acidity deposited in a particular area and the sensitivity of the area receiving it. Areas with acid neutralising compounds in the soil can experience years of acid deposition without problems.
- Since surface waters have less buffering capacity than soils, acid precipitation problems are usually noticed in aquatic ecosystems before they are noticed in terrestrial ecosystems.

- Burning fossil fuels such as coal, oil and natural gas also release large amounts of CO_2.
- Clearing of rain forests by burning the wood contributes CO_2 and other green house gases to the atmosphere. Also the clearing means less CO_2 is removed from the air by plants.

EFFECTS

- Recent studies and computer models indicate that by increasing the amount of CO_2 in the atmosphere, we may have initiated a warming trend that may raise, average global temperature between 2℉ (-16.7℃) to 8℉ (-13.3℃) by the year 2050.
- Global warming may change weather patterns and regional climates
- Natural important agricultural areas could become less productive
- Natural ecosystems would also be affected.
- Leads to rising sea levels of one foot in the next 30 to 40 years and two to seven feet by the year 2100. This inundate 50 to 80% of the US, coastal wetlands, erode all recreational beached and increase salinity of estuaries and groundwater.

Acid Rain

- Increased acidity of surface waters so much that it reduces or eliminates their ability to sustain aquatic life.
- Forest and agricultural crops are vulnerable because acid deposition can leach nutrients from the ground
- Can hamper micro-organisms that nourish plants (rhizobium, etc)
- Release toxic metals that would normally be tied up in the soil at higher pH.
- The pollutants that cause acid rain can also make the air hazy or foggy affecting the enjoyable views of vacationers and potentially affecting communication and navigation.

Acid Rain

Control:

- Power plants burning coal with high sulfur content are considered major cause of acid rain. Coal from e.g. Midwest (U.S.A) has a much higher sulphur content than Western coal. These oxides of N and S released from Midwestern power plants, are carried by winds toward the eastern seaboard and Canada.

  Power plants have to reduce release of SO_2. Total SO_2 released should be permanently limited to the low levels set.
- Stiff penalties for plants that release more pollution
- Bonus allowance to be given to power plants that install clean coal technology designed to reduce SO_2 release or for using renewable energy sources such as solar or wind.
- New cars and utility boilers that releases lesser NO_x emmissions to be designed.

POLLUTION

Pollution can be defined as an undesirable change in the physical, chemical or biological characteristics of the air, water or land that can harmfully affect health, survival, or activities of humans or other living organisms. Under this definition, pollution does not necessarily have to cause physical harm. It may merely interfere with human activities, e.g. a lake may be considered polluted if it cannot be used for boating activities.

The term 'undesirable change', requires value judgements. An alteration may be judged favourable by some; or the undesirable effect may be considered acceptable when compared with the favourable effect e.g. an affluent country may ban the use of DDT as a pesticide because of a judgement that the risks (especially to non-human organisms) outweigh the benefits. At the same time, a country with insufficient food production or a country where malaria affects much of the population may decide that the advantages of using DDT to kill crop pests or malaria-carrying mosquitoes outweigh the risks of its undesirable effects.

Types of Pollution

Classification of pollutants

One classification of pollutants put pollutants into three divisions. The first type of pollutants include those substances that occur in nature, but as a result of human activity are found in unusually large concentrations e.g. CO_2.

The second type of pollutants are the toxic compounds that released into the environment as a result of anthropogenic activities. These compounds are not found naturally in the environment e.g. mercury, zinc, arsenic, selenium etc.

The third type of pollutants occur when substances which are not themselves toxic but are released into the environment as a result of human activity.

Types of Pollution

Another classification of the pollutants is given based upon the pollutants susceptibility to degradation.

Two Types of pollutants

- **Degradable Pollutants**
- **Non-degradable Pollutants**

Degradable Pollutants

These are the pollutants that can be decomposed, removed, consumed and thus reduced to acceptable levels either by natural processes or by human-engineered systems.

<u>**Two classes of degradable pollutants**</u>

Rapidly degradable pollutants – decomposes faster e.g. human sewage, animal and crop wastes.

Slowly degradable pollutants – decompose slowly but eventually are either broken down completely or reduced to harmless levels, e.g. DDT, radioactive materials (strontium-90, plutonium-239 etc.).

Non-degradable Pollutants

- These are pollutants not broken down by natural processes. E.g. lead, mercury, some plastics etc.

Air Pollution

Air pollution refers to the accumulation of substances in the atmosphere that can cause harmful health effects to living things or can negatively affect the public welfare. Negative effects of public welfare include the economic impact of damage to crops or property, such as buildings or works of arts. Air pollution is the result of human activities as well as naturally occurring phenomenon. Transportation, power and heat generation, industrial processes and the burning of solid wastes are the major sources of pollution due to human activities. Volcanic eruptions and naturally occurring fires such as those caused by lightning storms are natural causes of air pollution.

For anyone living in a crowed city it’s hard to envision a world without smog. The word smog is a relatively recent term describing a type of pollution associated with urban settings and smokestack industries. Smog is a blend of the two words smoke and fog and it was first used by the French physician, Dr. H. A. des Voeux.

One of the greatest risk to human health and the environment is air pollution. The list of health problems brought on or aggravated by air pollution includes: lung diseases, such as chronic bronchitis and pulmonary enphysema; cancer, particularly lung cancer; neural disorders including brain damage; bronchial asthma and the common cold which are most persistent in places with highly polluted air and eye irritation.

Environmental problems range from damage to crops and vegetation to acid rain which eventually increases the acidity of some lakes and making them not conducive for the survival of fish and other aquatic life to global warming and destruction of the stratospheric ozone layer which can potentially have devastating effects on our planet.

Air Pollution

- In addition to ozone, common pollutants that were among the first to be regulated throughout the country include: carbon monoxide, airborne particulates, sulfur dioxide, lead, nitrogen oxides, asbestos, beryllium, mercury, vinyl chloride, arsenic, radionuclides, benzene and coke oven emissions.

Carbon monoxide – ordorless gas produced from incomplete combustions

Sulfur dioxide – produced from combustion of coal, fuel oil and diesel fuel.

Nitrogen dioxide – Produced from combustions, motor vehicles, industrial boilers and heaters.

Particulate matter – produced from diesel soot and smoke produced from wood burning. Can also be produced from photochemical reactions among polluting gases, primarily sulfur oxides and nitrogen oxides resulting in corrosive sulfate or nitrate ions.

Common Air Pollutants	Health concern
Ozone (0.12 ppm)	Respiratory tract problems, asthma, eye irritation, nasal congestion, premature aging of lung tissue
Particulate matter (150 µg/m^3)	Eye and throat irritation, bronchitis, lung damage
Carbon monoxide (10 mg/m^3)	Cardiovascular, nervous and pulmonary problems,
Sulfur Dioxide (0.03 ppm)	Respiratory tract problems, permanent lung damage
Lead (1.5 µg/m^3)	Retardation and brain damage
Nitrogen Dioxide (100 µg/m^3)	Respiratory illness and lung damage
Hazardous Air Pollutants	
Asbestos (-)	Variety of lung disease especially lung cancer
Beryllium	Primary lung disease; affects liver, spleen, etc.
Mercury	Damages brain, kidneys and bowels
Vinyl chloride (26 µg/m^3)*	Lung and liver cancer
Arsenic	Causes cancer
Radionuclides	Causes cancer
Benzene	Leukemia
Coke Oven Emissions	Respiratory Cancer
Values quoted in the brackets represent the guideline values – California, USA	

SOIL FORMATION, PROPERTIES AND PROFILE

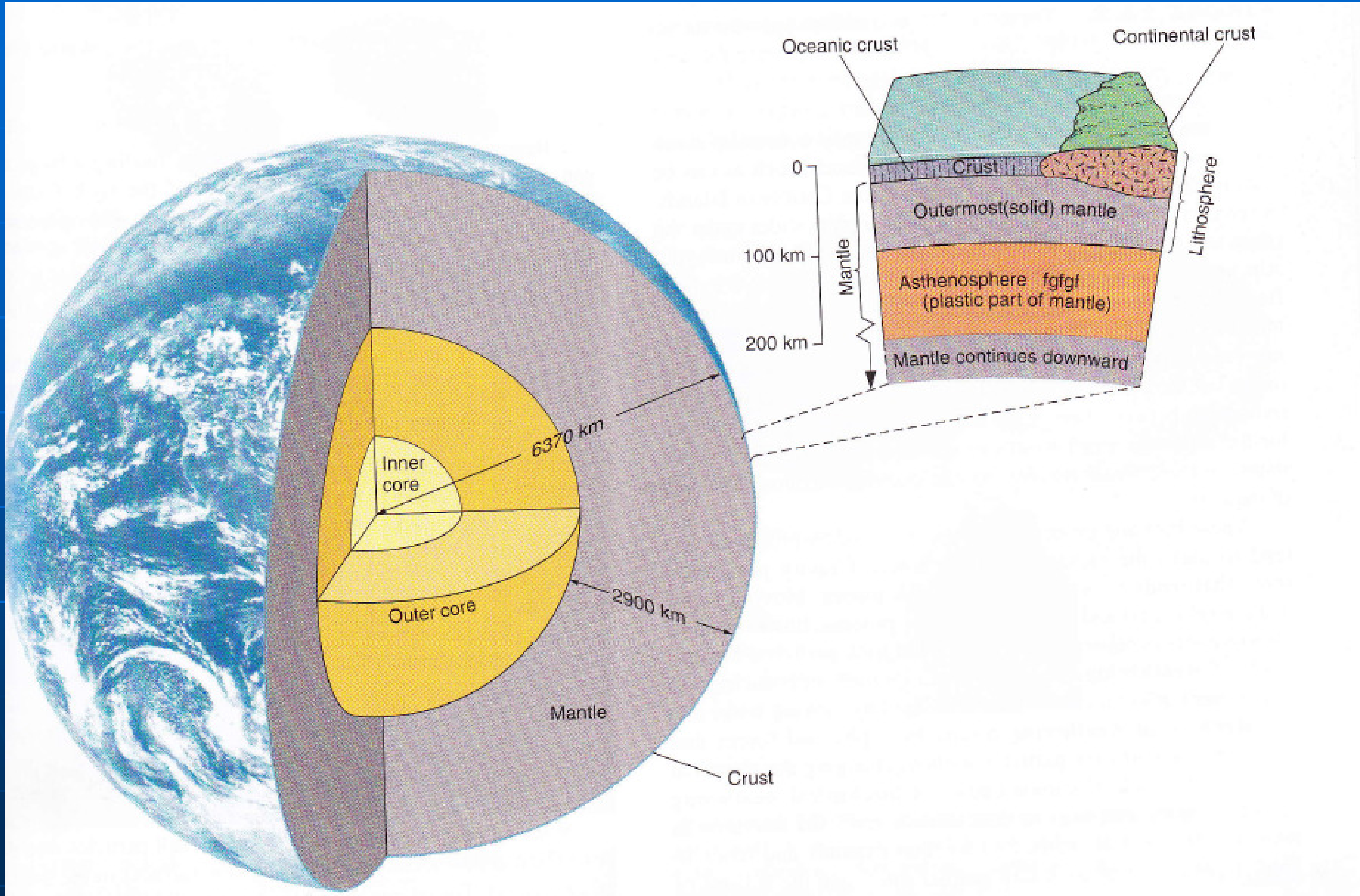
OBJECTIVES

a.) Geologic process
b). physical, chemical and biological factors involved in soil formation
c). Soil texture and structure
d). Layers in the soil profile
e). Human activities and impact on soil

Geologic Processes

Formerly the earth was thought of to be a stable unchanging mass but recent findings and research has shown that activities such as earthquakes, floods, tsunamis, volcanic eruptions and windstorms have been changing the surface of the places we live. Much of these activities cause large portions of the Earth surface (known as plates) to shift. The Earth comprise the crust, the mantle, inner and outer core. The crust is the outermost and superficial less dense but thin layer that covers a thick underlying layer called the mantle.

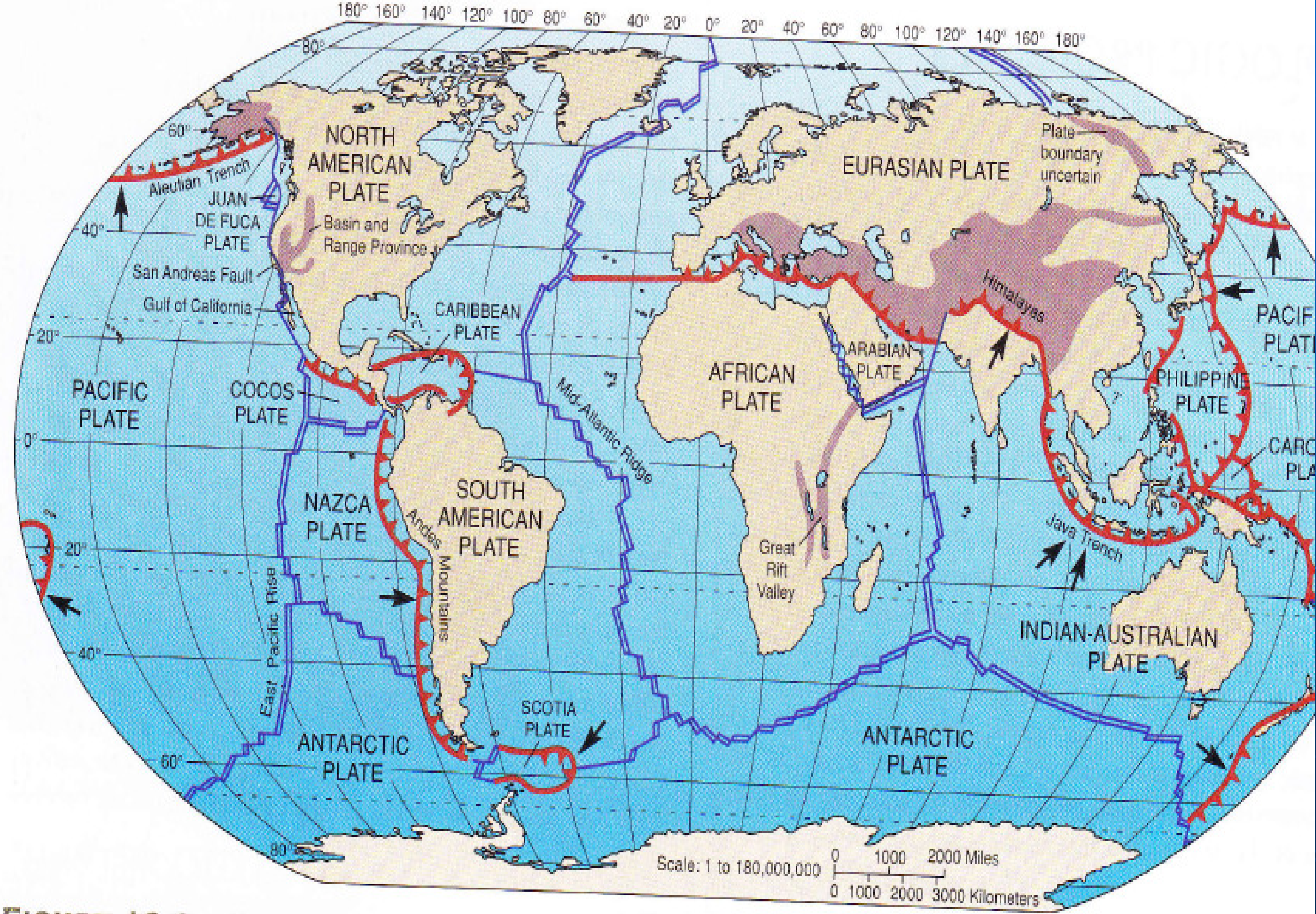
The mantle consist of an inner part and an outer portion that is adjacent to the crust. The crust together with the outer mantle is referred to as lithosphere. The inner mantle portion is a relatively thin layer known as asthenosphere. The asthenosphere is capable of plastic flow. Below the asthenosphere is a solid mass that forms the remaining part of the mantle. The central core consists primarily of iron and nickel and has a solid centre and liquid outer region.



Oceanic crust
Continental crust
Crust
0
Outermost(solid) mantle
Lithosphere
100 km
Mantle
Asthenosphere fgfgf
(plastic part of mantle)
200 km
Mantle continues downward
6370 km
Inner
core
Outer core
2900 km
Mantle
Crust

Plate Tectonics

The concept of plate tectonics indicates that the outer surface of the Earth consist of large plates composed of the crust the outer portion of the mantle and that these plates are slowly moving over the surface of the liquid outer mantle. The movements of the plates on the plastic outer layer of the mantle are independent of each other. Therefore, some of the plates are pulling apart from one another, while others are colliding. Where the plates are pulling apart form one another, the liquid mantle moves upward to fill the gap and solidifies. Thus new crust is formed from the liquid mantle. Approximately half of the Earth surface has been formed in this way in the past 200 million years. The bottom of the Atlantic and Pacific Oceans and Rift Valley and Red Sea of Africa are areas where this is occurring. Where



180° 160° 140° 120° 100° 80° 60° 40° 20° 0° 20° 40° 60° 80° 100° 120° 140° 160° 180°
NORTH AMERICAN PLATE
EURASIAN PLATE
Plate boundary uncertain
Aleutian Trench
JUAN DE FUCA PLATE
Basin and Range Province
San Andreas Fault
Gulf of California
CARIBBEAN PLATE
Himalayas
ARABIAN PLATE
AFRICAN PLATE
PACIFIC PLATE
COCOS PLATE
PHILIPPINE PLATE
Mid-Atlantic Ridge
NAZCA PLATE
SOUTH AMERICAN PLATE
Andes Mountains
East Pacific Rise
Great Rift Valley
Java Trench
INDIAN-AUSTRALIAN PLATE
SCOTIA PLATE
ANTARCTIC PLATE
ANTARCTIC PLATE
Scale: 1 to 180,000,000
0 1000 2000 Miles
0 1000 2000 3000 Kilometers

plates are pulling apart on one portion of the Earth, they must be colliding elsewhere. Where plates collide, several other things can happen. Often one of the plates slide under the other and is melted. Often when this occurs, some of the liquid mantle makes its way to the surface and volcanoes are formed that results in the formation of mountains. Volcanic activities add new material to the crust. When a collision occurs between two plates under the ocean, the volcanoes may eventually reach the surface and form a chain of volcanic islands, such as can be seen in the Caribbean Islands. Most of these movements are associated with earthquakes. The movements of the plates are not slow and steady sliding movements but tend to occur in small jumps.

These building processes are counteracted by processes that tend to make the elevated surfaces lower. Gravity provides a force that tends to wear down the high places.

Moving water, ice and wind assist in the process, however their effectiveness is related to the size of the rock particles.

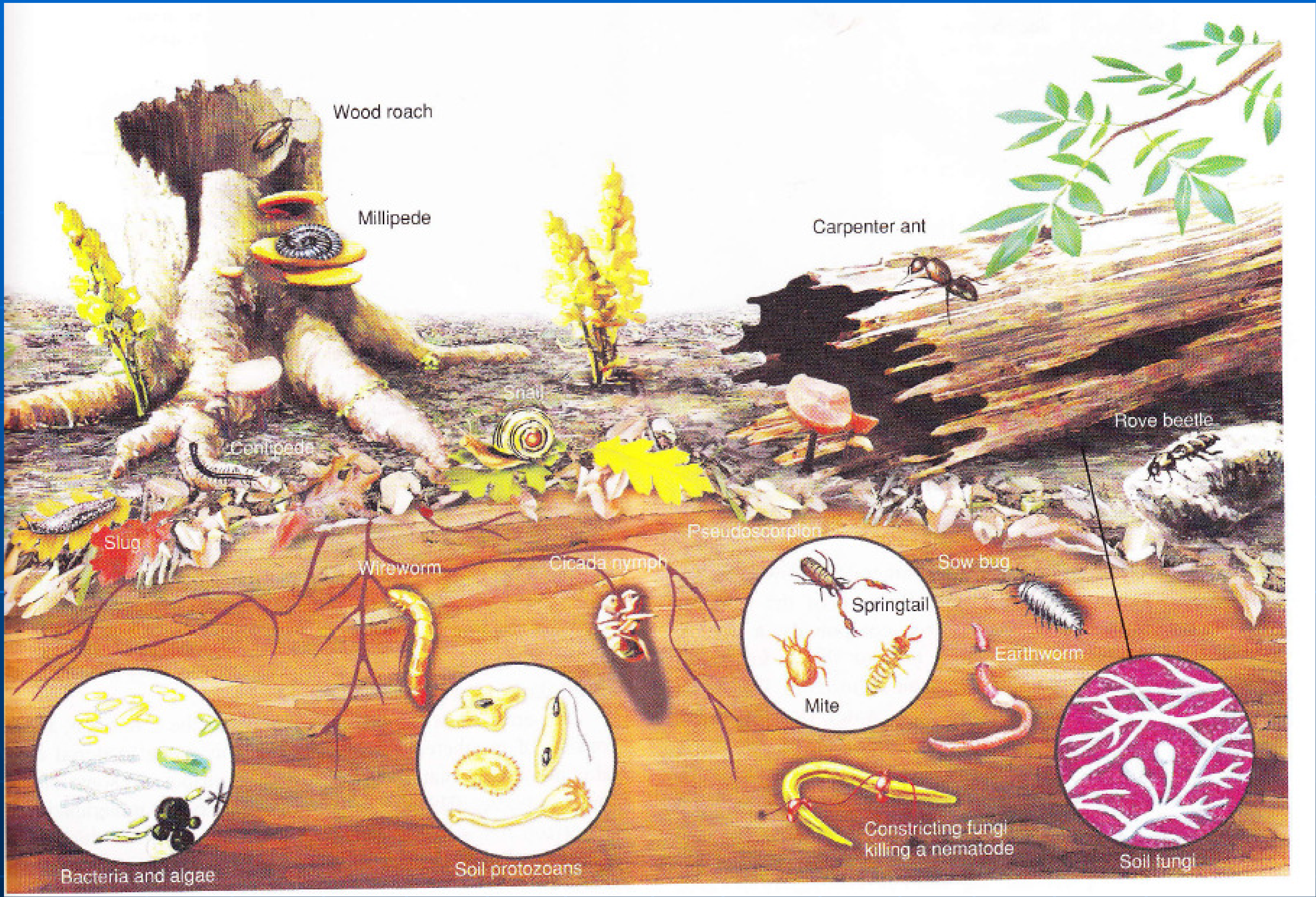
Mechanical weathering results from physical forces that reduce the size or rock particles without changing the chemical nature of the rock. Common causes of mechanical weathering are changes in temperature that tend to result in fractures in rock, the freezing of water into ice that expands and tends to split larger pieces of rock into smaller ones, and the actions of plants and animals. Because rock does not expand evenly, heating a large rock can cause it to fracture so that pieces of the rock flake off. These pieces can be further reduced in size by other processes, such as the repeated freezing of water and thawing of ice. Water that has seeped into rock cracks and crevices expands as it freezes, causing the cracks to widen. Subsequent thawing allows more water to fill the widened cracks, which are enlarged further by another period of freezing. Alternating freezing and thawing breaks large rock pieces into smaller ones. Other activities that bring about the breaking of rocks include the following:

The roots of plants growing

Wind and moving water

Activities of organism like worms and rats burrowing

Chemical weathering



Wood roach
Millipede
Carpenter ant
Snail
Rove beetle
Centipede
Slug
Pseudoscorpion
Wireworm
Cicada nymph
Sow bug
Springtail
Mite
Earthworm
Bacteria and algae
Soil protozoans
Constricting fungi killing a nematode
Soil fungi

Chemical weathering

The chemical alteration of rock eg when rocks are exposed to the atmosphere they may undergo oxidation or hydrolysis by combining with atmospheric oxygen and/or water (acid rain), in so doing get chemically changed into different compounds.

A combination of physical, chemical and biological events acting over time is responsible for the formation of soil.

LAND AND SOIL

Land is the part of the world not covered by the oceans. Soil is the thin covering over the land consisting of a mixture of minerals, organic material, living organisms, air and water that together support the growth of plant life. The proportions of the soil components vary with different types of soils, but a typical 'good' agricultural soil is about 45% mineral, 25% air, 25% water and 5% organic matter. This combination provides good drainage, aeration and organic matter. The organic material resulting from the decay of plant and animal remains is known as humus.

Humus accumulates on the surface and ultimately becomes mixed with the top layers of mineral particles. This material contains nutrients that are taken up by plants from the soil. Humus also increases the water holding capacity and the acidity of the soil so that inorganic nutrients which are more soluble under acidic conditions, become available to plants. Humus also tends to stick other soil particles together and helps to create a loose, crumbly soil that allows water to soak in and permits air to be incorporated into the soil. Compact soils have few pore spaces, so they are poorly aerated and water has difficulty penetrating, so it runs off.

SOIL PROPERTIES

Soil properties include soil texture, structure, atmosphere, moisture, biotic content and chemical composition. Soil texture is determined by the size of the mineral particles within the soil. The largest soil particles are gravl, which consists of fragments larger than 2.0 millimeters in diameter. Particles between 0.05 adn 2 mm are classified as sand. Silt particles range from 0.002 to 0.05mm in diameter adn the smallest particles are clay particles, which are less than 0.002 mm in diameter. Clay particles tend to be flat and are easily packed together to form layers that greatly reduce the movement of water through them. Such soils are poorly aerated and do not drain well. Clay soils ten stay moist for longer periods of time and do not easily lose minerals to percolating water.

Soil Properties

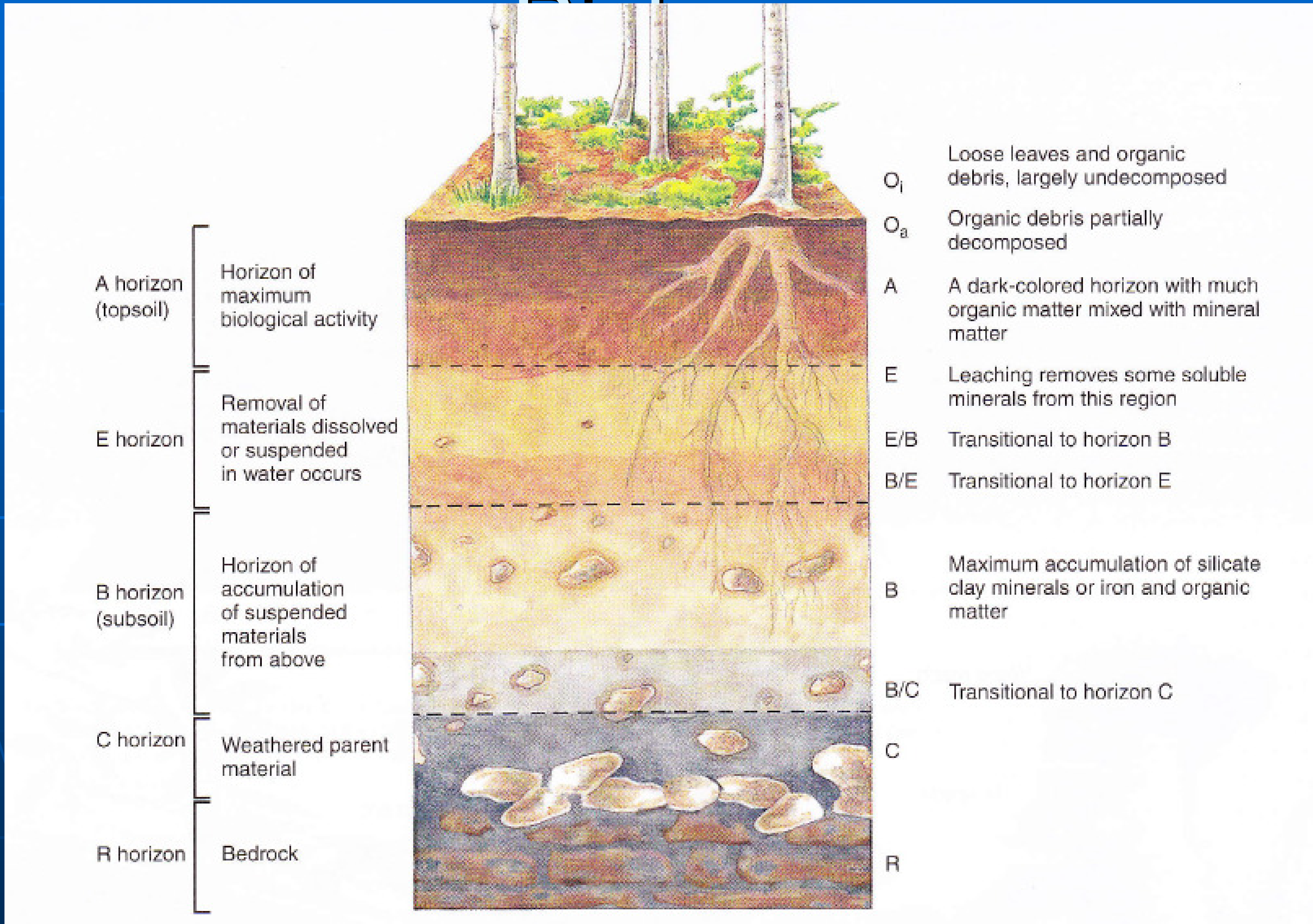
An ideal soil for agriculture use is a loam, which combines the good aeration and drainage properties of large particles of large particles with the nutrient – retention and water holding ability of clay particles.

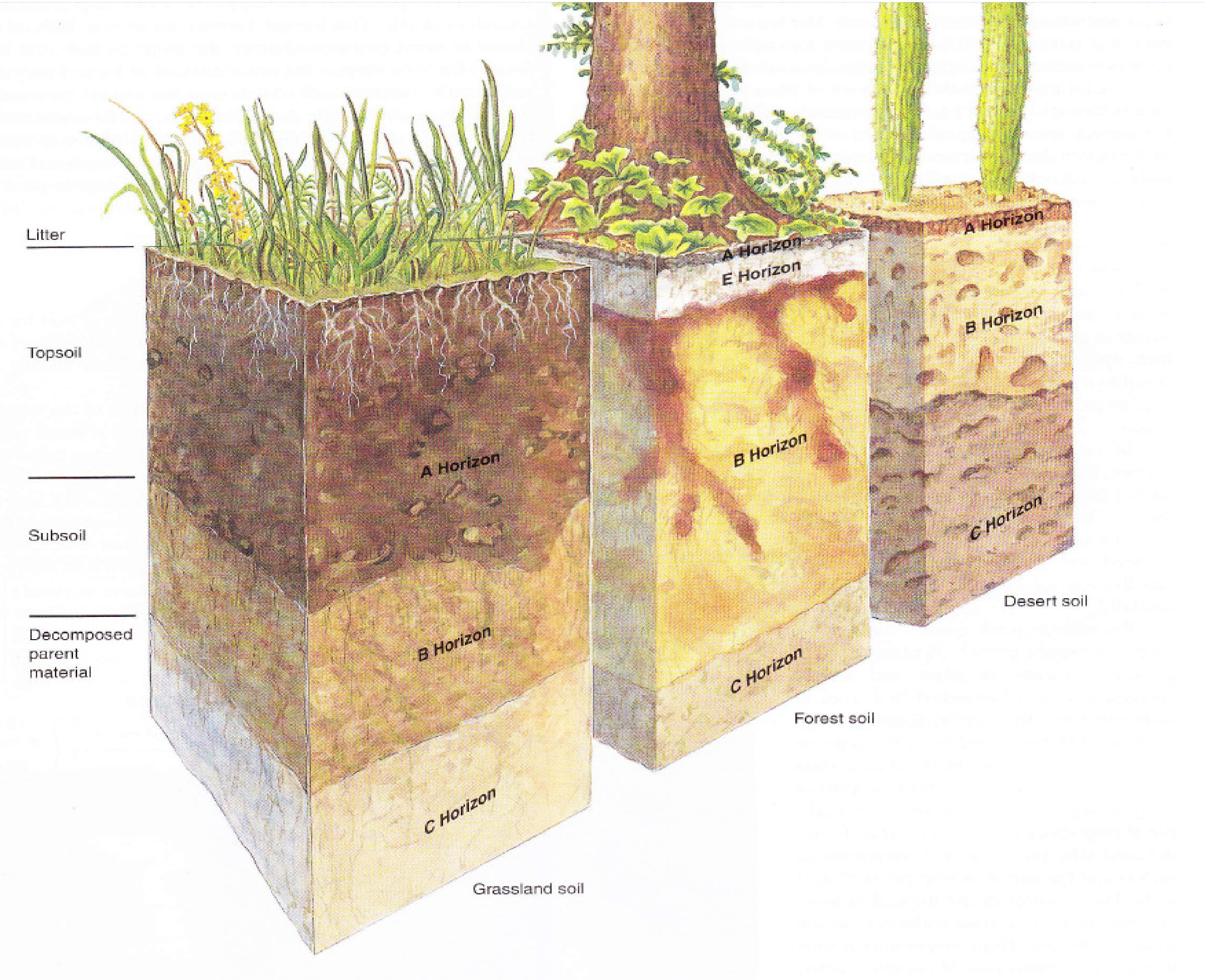
Soil structure is different from its texture. Soil structure refers to the way various soil particles clump together. The particles in sandy soils do not attach to one another; therefore, sandy soils have a granular structure. The particles in clay soils tend to stick to one another to form large aggregates. Other soils that have a mixture of particle sizes tend to form smaller aggregates. A good soil is friable, which means that it crumbles easily. The soil structure and its moisture content determine how friable a soil is.

Soil Profile

The soil profile is a series of horizontal layers in the soil that differ in chemical composition, physical properties, particle size and amount of organic matter. Each recognizable layer is known as a horizon. Several systems exist for describing and classifying the horizons in soils. The uppermost layer of the soil contains more nutrients and organic matter than do the deeper layers. The top layer is known as the A horizon and consist of small mineral particles mixed with orgnaic matter. It's usually dark in color because of the high content of organic matter. If there is a layer of litter (undecomposed or partially decomposed organic matter) on the surface, it is known as the O- horizon. Forest soils typically have an O- horizon. Many agricultural soils do not, since the soil is worked to incorporate surface crop residue. As the organic matter decomposes, it becomes incorporated into the A horizon. The thickness of the A horizon may vary from less than one cm on steep mountain slopes to over a meter deep. Most of the living organisms and nutrients are found in the A – horizon. As water moves down through the A – horizon, it carries dissolved organic matter and minerals to lower layers in a process called leaching. Below the A horizon is a lighter coloured

Layer known as the B – horizon. The B-horizon, often called the subsoil contains less organic material and fewer organisms than the A – horizon. However it contains accumulations of nutrients that were leached from higher levels. B – horizon is a valuable source of nutrients for plants and it normally support a well developed root system. The area below the B-horizon is known as the C-horizon and it consists of weathered parent material. The chemical composition of the minerals of the C- horizon helps to determine the pH of the soil. The characteristics of the parent material in the C horizon may also influence the soil's rate of water absorption and retention.


A horizon
(topsoil)
Horizon of
maximum
biological activity
E horizon
Removal of
materials dissolved
or suspended
in water occurs
B horizon
(subsoil)
Horizon of
accumulation
of suspended
materials
from above
C horizon
Weathered parent
material
R horizon
Bedrock
O_i
Loose leaves and organic
debris, largely undecomposed
O_a
Organic debris partially
decomposed
A
A dark-colored horizon with much
organic matter mixed with mineral
matter
E
Leaching removes some soluble
minerals from this region
E/B
Transitional to horizon B
B/E
Transitional to horizon E
B
Maximum accumulation of silicate
clay minerals or iron and organic
matter
B/C
Transitional to horizon C
C
R



Litter
Topsoil
Subsoil
Decomposed parent material
A Horizon
B Horizon
C Horizon
Grassland soil
A Horizon
E Horizon
B Horizon
C Horizon
Forest soil
A Horizon
B Horizon
C Horizon
Desert soil

Land Pollution

Historically, land has been the recipient of most wastes including those removed from the air and water. Pollution of the land / soil not only threaten the future use of the land but also the quality of the surrounding air, surface water and groundwater. Pollutants on the surface of the land or in the soil frequaently move to the surrounding air and water, particularly groundwater. Sometimes this contamination is the result of a direct application, say of pesticides or fertilizers, onto the land; improper storage, handling or disposal of toxic substances.

Industrial waste, if not properly treated and handled can imperil both public health and the environment. Leaks from underground storage tanks and chemical spills also contribute to contamination of the land and groundwater.

If not properly disposed, common household wastes can cause environmental problems ranging from foul-smelling smoke from burning trash to breeding grounds for rats, flies and mosquitoes. Even at properly run disposal sites, land contamination can contribute to air and water pollution because small quantities of toxic substances may be dumped with other household wastes.

Land Pollution

Rain water seeping through these buried wastes may form leachate. Leachate is the liquid that results when water moves through any non-water media and collects contaminants. Examples would include water as it trickles through either wastes or soils where agricultural pesticides or fertilizers have been applied. This leachate can then percolate down through the soil and may result in contamination of the groundwater.

Other organic wastes such as garbage and paper products decompose and can form explosive methane gas which, because it is lighter than air, tends to rise through the soil and into the atmosphere. Instances of houses near municipal landfills collecting explosive levels of methane gas in crawl spaces or basements have been documented.

The main sources of land pollution are municipal waste disposal, illegal hazardous waste disposal, abandoned hazardous waste sites and underground tanks.

Contaminated stormwater heavily polluting rivers

Environmental Impact Assessment

EIA is a process of assessing environmental impact of a development project to improve decision making on its implementation

Brief History (Before the concept of EIA)

- Project evaluation – formerly prior after the execution of a major project there used to be project evaluation. This was based on technical studies valued in monetary terms (cost benefit analysis).
- Rough evaluation – full of shortcomings and failures
- Efforts to develop new evaluation approach led to EIA. In this Technical, Financial, Economic and Environmental aspects were given their proper weight in the decision making process.

ENVIRONMENTAL IMPACT ASSESSMENT

- 1960 in the USA
- 1962 - First evidence of local application of insecticides had far reaching ecological impacts
- Environmental aspects of projects became a requirement for decision making
- National Environmental Policy Act / Law (NEPA) published in 1970. EIS should be published for major actions significantly affecting quality of human environment.

Some common targets

EIA seeks to identify probable alternatives for project with little or no adverse impacts on the community or environment.

EIS is the assessment report produced after the assessment exercise; it details both the beneficial and adverse impacts anticipated upon completion of a project and the probable impacts that would be experienced during the operational phase of the project.

To perform an EIA about 5 major parties are involved:

- The Proponent or the Initiator e.g. Gov't agency, private personnel, company etc.
- Decision makers – Central or Local gov't agency, provincial official (EPA – Gh)
- Review Commission – EPA, EIA committee – management committee

- Interest group – NGO, General (Univ. staff, Local people, Chiefs, District Assemblies)
- Consultant / Consultancy companies

Purpose of the EIA

- It enables financier/ client to take environmental issues into account
- It seeks to compare the various alternatives which are available for any project. Each alternative will have economic cost and benefit as well as environmental impact. Adverse impacts may be reduced at higher project cost whilst environmental benefits may be enhanced at environmental cost.
- It attempts to weigh the environmental effects on a common basis with economic cost and benefit in the overall project evaluation
- It identifies and forecasts the possible positive and negative impacts to the environment resulting from a proposed project.
- It helps to avoid costs and delays in implementation.

It provides a formal mechanism for direct agency co-ordination to deal with concerns.

- It measures the level of plan implementation and the degree of effectiveness of the above environmental protection provision.

Basic Water microbiology and Public Health

- Introduction: The constituents of wastewater and natural untreated water that often impair the quality and thus make water unwholesome for human consumption include micro-organisms (e.g. bacteria, viruses, algae, fungi etc) and hazardous chemical constituents e.g heavy metals like As, Cd, Hg, etc; some poly-aromatic hydrocarbons like pesticides – DDT, lindane etc. These contaminants has the capacity of adversely affecting the health of consumers. The most important aspect of drinking water is its micro-biological quality. Very important is the types of microoganisms that are pathogenic.

- Microbiological contaminants:

Bacteria - Several types of bacteria including coccus, bacillus, vibrio and spirillum exist and are sized between 0.5 and 5 μm. Bacteria are single-cell organism consisting of a protoplasm enclosed by a unit cell membrane. Within the protoplasm is centrally positioned nuclear region which bears the genetic material known as chromatin. Also present in the cytoplasm are other organelles like mitochondria, ribosomes and vacuoles. The mitochondria helps with the respiration and metabolic activities of the cell to produce chemical energy required for multiplication and other activities. The ribosomes are needed for the production of proteins whiles the vacuoles engage in excretory processes. Most bacteria multiply by binary fission.

Bacteria

Bacteria are the cause of most sanitary problems, because some of them are pathogenic, so they can cause diseases. Their generation time is very short e.g. as short as 20 minutes. In sewage treatment and in some cases of water treatment process (nitrification – nitrosomonas and nitrobacter), some bacteria are advantageous because they can stabilize organic matter.

$$C_5H_7O_2N + 5\ O_2 \rightarrow H_2O + 4\ CO_2 + NH_4^+ + HCO_3^-$$

Bacteria cells can combine to form chains. As in a capsule bacteria cells can be found surrounded by a slime layer consisting of degradation products of the cell wall (polysaccharides). Some have flagella for locomotion.

The major source for pathogenic organisms is fecal matter originating from domestic sewage. The number of organisms, that is present in sewage varies enormously. Normally you don't find in water quality surveys quantitative values for the pathogenic organisms mentioned. We often find values for faecal coliforms, e.g. Escherichia coli or E. coli, sometimes streptococcus faecalis and spores of Clostridium perfringens. Next to these we find values for bacterial counts at 20 and 37°C representing the temperature at which these bacterial / pathogens are cultured.

COLIFORMS AND FECAL COLIFORMS

The organisms which are used as indicators of water pollution are:
Coliform bacteria
Coliform species are regularly found in unpolluted soils and water. The standard test for coliforms cannot be said to indicate specific faecal pollution. Especially in warm polluted waters the coliform number in water can increase quite significantly. The coliforms are commonly rod-shaped bacterium, not thought of as disease causing bacteria. Pathogenic bacteria in wastes and polluted waters are usually much lower in numbers and much more harder to isolate and identify than coliforms which are usually in high numbers in polluted waters. Many coliform bacteria live in the soil and these organisms may be the source of those that appear in water especially surface water.

In recent years coliform bacteria are replaced in water analysis by faecal coliform. Fecal coliforms are more specific and live in the intestinal track of humans and many other animals. E. Coli is exclusively faecal and constitutes over 90% of the coliform flora of human intestine. E. coli are the main part of faecal coliform; more time- consuming to detect. The faecal coliforms e.g. the E.coli must still be taken as the most sensitive and specific indicator of faecal pollution at present available. Faecal Streptococci are occassionally used as indicator organisms especially when confirmation of dubious E.coli results is required. Animals generally excrete much more high numbers of faecal streptococci than human, hence the ratio of faecal coliforms to faecal streptococci, can indicate whether pollution is derived from animal or human source (ratio of more than 4 = human source pollution).

Spores of Clostridium perfringens : - spore of C. perfringens is some

times used for detection of intermittent pollution. Indicator organisms are present in large numbers in the faeces of man. The presence of these organism in water may be interpreted to mean that such a water has been contaminated with faecal matter, possibly coming from carriers of diseases / pathogenic organisms.

- E.coli $10^5 - 10^6$ / ml
- Streptococcus faecalis $10^3 - 10^5$ / ml
- Spores of clostridium perfringens $10^2 - 10^4$ / ml

Organisms which might be injurious to health are in general always present in smaller numbers than E. coli. This implies that E.coli (and faecal coliforms) is a good indicator for the probable presence of harmful organisms. Organisms which are a hazard to health mostly originate from excrements.

E. Coli itself belongs to the coliform group and is harmless. Besides E.coli, the bacteria of the coliform group are used as well in order to simplify the examinations in the laboratory.

Fungi

Fungi are microscopic plants, multicellular, lacking in chlorophyll, which is a photosynthetic pigmen which permits the conversion of sunlight energy into chemical energy. Fungi are found in biological treatment plants and polluted water utilizing organic matter. They can be responsible for tastes and odours in water.

Algae

Algae are microscopic plants, multicellular, lacking definite stems and leaves as is the case of higher plants. They are present normally in surface water (river, lake, reservoirs) because they need sunlight. Algae utilize CO_2 (HCO_3^-), NH_4 (NO_2^-, NO_3^-), PO_4^{3-} and elements in minor amounts to produce cells and oxygen.

Algae can carry out photosynthesis (utilization of sunlight energy) and don’t depend on oxidation of organic matter to survive. Algae produce oxygen in the presence of light converting inorganic materials in water into organic matter.

In absence of light the algae exert oxygen demand.

Different Classes Of Algae

- Blue-green algae – (cyanophyceae or myxophyceae)
  e.g. microcystis anabaena, aphanizomenon, oscilatoria.
- Green algae (chlorophyceae) e.g. chlorella, palmella, scenedesmus.
- Diatoms (bacillariophyceae) e.g. asterionella, melosira, synedra, tabellaria.
- Flagellates (chrysophyceae, euglenophyceae) e.g. chlamydomonas, euglena, pandorina,

The importance of algae for water quality is large because of

- Their formation of taste and odour compounds, toxic substances
- Their influence on the oxygen balance of the water (supersaturation of O_2; anaerobic conditions)
- Their contribution to the organic matter content of the water and the turbidity (clogging of filters).

Virus

- A virus particle (viron) consists of nucleic acid, DNA or RNA covered by a protein coat called a capsid. The combined nucleic acid and capsid called the nucleocapsid can either be naked and enclosed by a membrane. Among the enclosed virus are the influenza virus and herpes. Virus are extremely host-specific and within a given host also tissue – and cell-specific. The virus differ from micro-organisms in the ff properties.

1. They may contain only one kind of nucleic acid RNA or DNA (note: there has been discovered however virons with both nucleic acid).
2. Only the nucleic acid is necessary (but not sufficient) for their reproduction.
3. They are unable to reproduce outside living cells. Reproduction occurs within the host cell since they depend on the host cell for the replication of its nucleic acid and synthesis of its protein coat. This process usually leads to the death of the host cell. Plants, animals and micro-organism e.g. bacteria are host for viruses size about 100 nm in length. In using a bacteria as a host the virus is known as phage

Reproduction: - Following adsorption, the phage injects its DNA into the host cell. In phage T2, the nucleic acid penetrates the host cell, the protein coat remaining on the exterior. The injected phage DNA causes an immediate change in metabolism of infected cell.

The synthesis of bacteria DNA ceases but the total protein content continues to increase and DNA synthesis is resumed at higher rate. Phage DNA is synthesised at the expense of degraded bacterial DNA. New protein coat are then synthesised for the new phages. Matured phages then cause the bacterial cell to lyse through secretion of lysozyme to release the new phages. Viral infections in general are currently among the most prominent infectious diseases. This is easily explained by the fact that bacteria offer a variety of targets for therapeutic agents to inhibit their growth.

The multiplication of viruses on the other hand is intimate coupled to essential metabolic processes of the host cell, such as nucleic acid synthesis. It is therefore extremely difficult to inhibit intracellular viral growth without serious damage to the host cell metabolism. The development of anti-viral therapeutics has therefore met with little success so far and the old- fashioned methods for dealing with the common cold for instance still seems the best.

Public significance of diseases associated with excreta and water related diseases

Classification of water and related diseases

Disease		**Disease**	
Cholera Infectious hepatitis Paratyphoid Typhoid	Waterborne	Guinea worm Schistosoma (Bilharzia)	Water-based
Amoebic dysentery Bacillary dysentery Gastroenteritis	Waterborne or water – washed	Malaria Onchocerciasis Yellow fever Sleeping sickness	Water related insect vector
Ascaris Conjuctivitis Diarrhoea diseases Leprosy Scabies	Water - washed		

Water quality and health

Water washed disease- Water washed diseases are caused by water scarcity where people cannot wash themselves, their clothes or home regularly.

Trachoma is the main cause of preventable blindness in the developing world, with four million sufferers, an estimated 500 million at risk and six million permanently blinded. It is common in areas that are hot, dry and dusty and where there is not enough water for people to wash regularly. Trachoma is spread, especially among young children, by flies, fingers and clothing coming into contact with infected eyes, spreading the infection to other people's eyes.

Effect on health: The infection causes a sticky eye discharge with soreness and swelling of the eyelids. After repeated infections scarring of the inner eyelids occurs which can lead to trichiasis where the eyelashes turn inwards. These then rub on the eye, scarring the cornea and causing blindness.
Prevention: Trachoma can be prevented through regular hand and face washing with a good supply of clean water, along with hygiene education to help prevent flies from breeding.

Water quality and health

Scabies occurs in areas where there is a lack of water and people are unable to wash themselves,

their clothes, bedclothes or houses regularly.

It is caused by the scabies mite which infests the surface layer of the skin. The mite can spread

from one person to another through personal contact.

Effect on health: Scabies causes itchy sores and lesions mainly between the fingers, wrists, elbows,

breasts and pubic areas.

In younger sufferers more areas, including baby's feet and the head, can be infected. Because

sufferers often scratch the sores and lesions they become prone to other infections.

Prevention: Washing regularly with soap and keeping clothes, bedclothes and houses clean

prevents scabies.

Water quality and health

Waterborne disease- Diseases spread by contamination of water (or hands) by human feaces or urine. With this type of disease, infection occurs in a manner as shown in the scheme below:

Infected person → Pathogens in excreta→ contaminated water source

Susceptible person ← consumption of untreated water

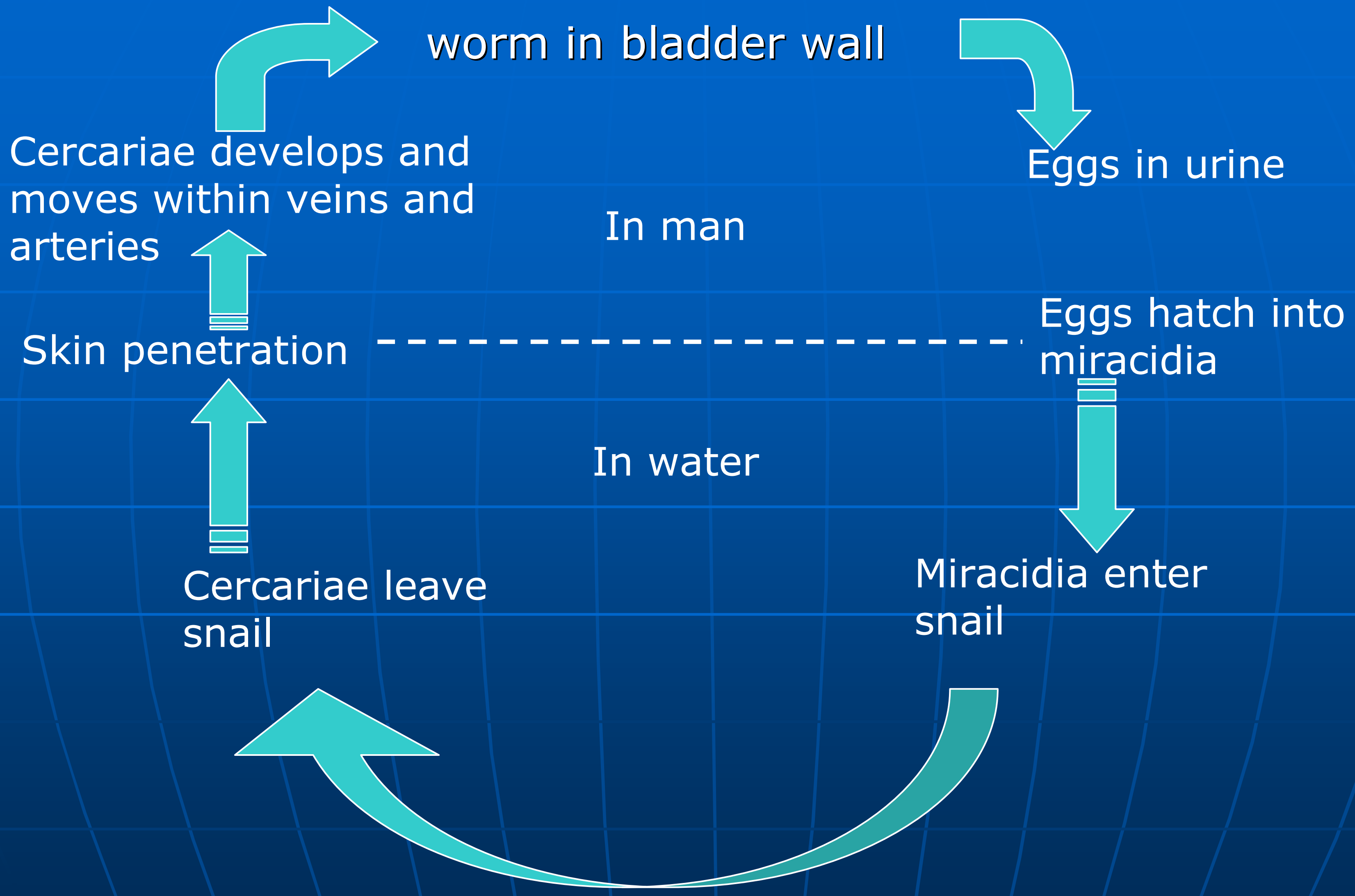
Preventive measures: Improve quality of drinking water. Prevent casual use of untreated or unimproved sources

Water based disease- Diseases whose causative pathogen spend part of its life cycle in aquatic animals such as water snails. The most well known example is schistosomiasis. Its pattern of disease transmission includes a part of the pathogen (worm) life cycle in an intermediate host (as eggs in snails). After the eggs of the worm have penetrated a snail the hatch inside the snail. These larvae can only survive for 48 hours in water.

The larvae can however, penetrate the skin of human beings and they can then migrate through the body, where they can multiply. It is unfortunate that schitosomiasis is often spread by irrigation schemes which tend to provide suitable habitats for the snail host as wells as increasing the likelihood of contact with the water by agricultural workers.

The scheme of development of the pathogen is given as follows:

Water quality and health



Infectious cycle of schistosomiasis

Water quality and health

Preventive measures: Desist form the use of or contact with any water resource known to have the infection. Control snail population and prevent people or inhabitants from defecating in surface waters.

Water – related insect vector diseases

Diseases spread by insects that breed or feed near open surface waters eg. malaria.

Preventive measures: include avoiding suitable habitats for insect like shallow stagnant water pools, regions around the edges of lakes and irrigation canals. Control by the use of insecticides, although this measure has the possibility of creating some water quality problems. Biological control measure like the introduction of fish species that prey on the larvae of the insect could be adopted.

Water Quality

Aim

To provide you with information on what parameters are considered when defining the quality of water

To offer you a survey of situations and conditions in which the quality of water changes

contents

- Water resources, use and consumption
- Water quality parameters
- Water quality and public health
- Raw water quality and pollution
- Raw water quality and application requirements

Water resources, use and consumption

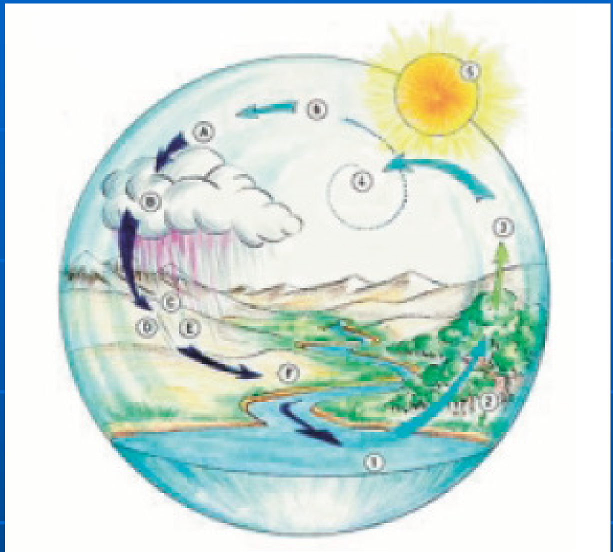
- Water resouces

  surfaces waters, groundwater, rain water, sea / ocean, moisture,

  water reuse

Hydrological cycle

The Water Cycle



Water travels on the surface of the earth, underground and in the atmosphere in a cycle – the Water Cycle.

• Clouds provide precipitation in the form of rain, snow and hail.

•Water runs on the surface. Part is used by the vegetation; part flows to the water bodies or infiltrates the soil to form the underground water bodies.

•Surface water bodies evaporates under the effect of the sun and finds itself in a gaseous form in the atmosphere.

•Water vapour condenses in contact with cold air masses, which then creates clouds and comes down as rain.

Invisible phenomena

Evaporation, absorption, water vapour and transport by winds – sun energy required for process

Visible phenomena – condensation, precipitation, snow, runoff, infiltration, superficial and underground flow.

Water Quality

- As precipitated water encounters the atmosphere and the environment, its quality changes through interactions with:

  - Gases in the air
  - soil and rock– contaminants
  - anthropogenic activities eg mining, agriculture and irrigation, industries e.g. dyeing and tannin

Water use

- About 66% of the human body is made up of water
- Depending on the human body needs about 3 – 10 litres of water / day is required for normal functioning.
- Uses – cooking, recreation, laundry, drinking gardening, transportation, waste disposal, fire fighting, industrial applications etc.
- Influences: Cultural habits, pattern and standard of living, utility fee for water, quality of water, proximity of water source.

In the selection of the type of water supply / source, finance, location, size of community, geographical conditions and the available water source are normally the major considerations.

Water consumption

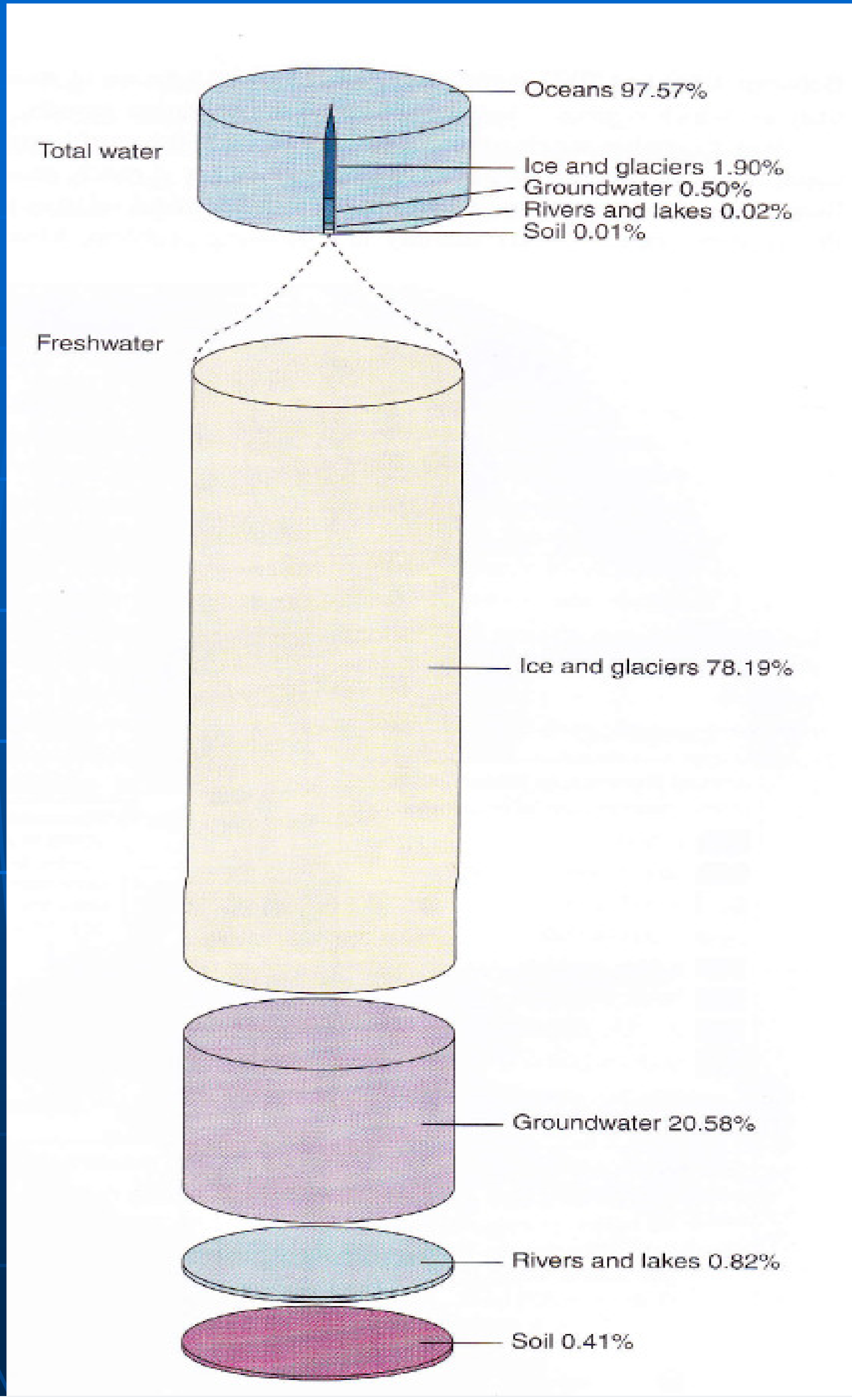
- Water use and consumption are normally expressed in litres per capita(head) per day (l.c.d).

  l.c.d is useful for making rough estimates of a community's water demand

Typical Domestic Water Usage

Type of water supply	Typical water consumption (l.c.d)	Range (l.c.d)
Communal water point		
(e.g. village well, public stand-post)		
- at considerable dist. (>1000 m)	7	5 - 10
- at medium dist.(500 – 1000m)	12	10 - 15
Village well		
walking distance < 250m	20	15 - 25
Communal standpipe		
walking distance < 250m	30	20 - 50
Yard connection		
(tap placed in house-yard)	40	20 - 80
House connection		
- single tap	50	30 - 60
- multiple taps	150	70 - 250

Water incidence	10^3 km^3	Amount of water % of total water	% of fresh water
World oceans	1 300 000	97 .220	-
Salt lakes and inland seas	100	0.008	-
Icebergs and polar ice	28 500	2.136	77.63
Water in the atmos.	13	0.001	0.035
Water in plts and liv.org.	1.13	0.0001	0.003
Fresh water lakes	120.3	0.009	0.335
Water courses	1.34	0.0001	0.003
Soil and subsurface water	67	0.005	0.178
Groundwater	8290	0.62	21.800
Total Fresh water	36,700	2.77	100


Total water
Oceans 97.57%
Ice and glaciers 1.90%
Groundwater 0.50%
Rivers and lakes 0.02%
Soil 0.01%
Freshwater
Ice and glaciers 78.19%
Groundwater 20.58%
Rivers and lakes 0.82%
Soil 0.41%

Water and Wastewater Quality parameters

- Important properties of water focused on when considering water quality include, the bpt., Melting pt., vapour pressure, surface tension, solvent, density, heat capacity.

- The very notion of water quality is linked to the intended use of the water: swimming, drinking and cooking, irrigation, industrial process water etc. Whatever we use it for, its quality must be preserved. As the natural content varies considerably. We must define average conditions for natural and safe waters. Above a predestined threshold, water will be declared polluted.

- Water pollution is a harmful modification of water caused by the addition of substances likely to modify its quality, aesthetic aspect and use for human purposes. The polluting agent may be physical, chemical or biological in nature and cause discomfort, nuisance or contamination

Water and Waste water Quality parameters

Parameter	WHO	GH std bd	GH EPA
pH	8.5	5.5 – 8.5	6.9 (ww)
Temperature			
Turbidity (NTU)	5	5	
DO			
Colour (mg Pt/l); (TCU)	15	15	
TSS		0	
TDS (mg/l)	1000	1000	
BOD_5			50 (ww)
COD			
VS			
Coliform (No. /100ml)	0	0	
Fecal coliform(No./100ml)	0	0	
Samonella	0	0	
Heavy metals			
Fe (mg/l)	0.3*	0.3*	
Mn(mg/l)	0.4		
As (µg/l)	10		
Ca (mmol/l)	2.5(EU)		
Mg (mg/l)	30 (EU)		
Cr (mg/l)	0.05		
Zn	5		
Na	200		
Pb (mg/l)	0.05		
Se (mg/l)	0.01		

Water and waste water Quality parameters

Parameter	WHO	GH std bd	GH EPA
Pesticides			
Chloride (mg/l)	250	250	
Alkalinity			
Total hardness(mmol/l)	5		
Total hardness(mg/l)	500	500	
(mg/l as $CaCO_3$)	500		
SO_4^{2-}		250	
Eutrophic compds			
NH_4^+ (mg/l)	0.5*(EPA)		
NO_3^-	45	10	
NO_2^-		0.1	
PO_4^{3-}			
SiO_2			
Organic compds			
$KMnO_4$			
PAH			
Odour			
colour			

Hardness

- Carbonate hardness (temporal hardness)
- Non- carbonate hardness (permanent hardness)

The most abundant multivalent metallic ions in natural water normally responsible for hardness are Ca and Mg. Other cations like Fe^{2+}, Mn^{2+}, Sr^{2+} and Al^{3+} also contribute to the hardness but to a little extent.

The carbonate hardness is sensitive to heat and precipitates readily

$$Ca(HCO_3)_2 \rightarrow CaCO_3 + CO_2 + H_2O$$

The impact of hardness, is that it wastes soap. In solution the lathering does not occur untill all of the hardness ions are precipitated thereby softening the soap.

e.g. $2\ NaCOOC_{17}H_{33} + Ca^{2+} \rightarrow Ca^{2+}(COOC_{17}H_{33})_2 + 2Na^+$

The precipitate formed adheres and stains dishwashers, clothes, tubs, dishes and may remain in the pores of the skin making the skin feel rough and uncomfortable.

Changes in pH in the water distribution may result in deposits of precipitates. HCO_3 begin to convert to the less soluble carbonates at pH above 9.

Unit of measurement: mg/L as $CaCO_3$

Ranges of hardness

Soft	: < 50 mg/l as $CaCO_3$
Moderately hard	: 50 – 150 mg/L as $CaCO_3$
Hard	: 150 – 300 mg/L as $CaCO_3$
Very Hard	: > 300 mg/L as $CaCO_3$

IRON AND MANGANESE

- **Consumer complaints – dark brown to black precipitates, stain laundry and porcelain fixtures**

  Coating and darkening of filters in treatment plant

  Concentration as low as 0.02 mg/l could form coating in distribution mains, service lines, meters

  chronic exposure to manganese concentration beyond 0.5mg/l could give rise to a disease condition similar to Parkinsonism.

- **WHO health based guideline for manganese occurrence in drinking water is pegged at 0.4 mg/l (WHO guideline 2004).**
  WHO guideline value of 0.1 mg/l has been recommended for Mn for drinking water sources

ARSENIC

- Long term exposure to drinking water with [As] > 10 μg/l
- Can cause cancer of the skin, lungs, urinary bladder, kidney, etc
- Skin pigmentation,
- Hardening, thickening of skin and laceration of sole of feet.
- Retardation in the intelligence of children.
- Nausea, vomiting, stomach pain, numbness of hands and feet etc.
- In Ghana – upsurge in the incidence of cancer especially breast, meanwhile patronage groundwater as drinking water source is on the increase.

ARSENIC

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FLUORIDE

- Inorganic anion

Allerged to be impact benefits to humans.

Recent finds – controversy

WHO – Europe – Rate of decrease of cavities in teeth of

childn in regions with / without – same.

The claim of F^- being beneficial has not held up

independent scientific scrutiny.

High [F^-] → more brittle and fragile bones, increased bone mass density but reduce strength of the bone at the same time due to F- caused defects in the bone structure.

F- + Al in drinking water → accumulates in brain → neurotoxic morphological changes.

A study in China has shown that even accepted levels in F- in water (0.88 mg/l) may affect children's intelligence

High F- is also a contributing factor to a bone cancer condition of osteosarcoma.

May cause elevation in blood sugar possibly exacerbating diabetes.

Fluoride defects

Navi Kaki of Chhapra village

Kpugi—Gushegu

Wunjuga—Saboba/Cheriponi

LEAD

Anaemia, mental retardation,

SO_2

Bronchitis

Acid rain – precipitation causes corrosion of monuments and materials.

Changes acidity of water bodies and can cause death of fish

Impedes photosynthesis

DISSOLVED OXYGEN

1. Biodegradable organic matter, mostly of domestic origin, removes DO. This is because the micro-organisms present in water consume the organics as food (substrate) and utilize oxygen to accomplish respiration. The more the organics present, the larger the demand on oxygen.

2. Aquatic animals, including organisms in sediment remove DO.

3. Plants add DO during the day via photosynthesis but remove it at night by respiration. Dying and decaying plants diminish Do.

4. In summer periods in temperate countries and tropical countries, the increased water temperature reduces DO solubility.

5. Tributaries draining into or waste water discharging into a river bring their own oxygen supplies that affect DO of the river on mixing.

6. Low river flows slow the rate of oxygen transfer into the water from the atmosphere.

PUBLIC HEALTH

Toxic Chemical compounds and their extent of toxicity

In toxicology the adverse effects of chemicals (pollutants) on living organisms is studied and the probability of these effects occurring upon consumption of the pollutant is considered.

The toxicity of a pollutant is described using various terminologies:

Lethal dosage, ADI, MAC etc.

The toxicity of a chemical substance in water depends upon several factors other than the actual concentration. Some substances, which are highly toxic, are unstable in water and break down into innocuous by-products. The degree of toxicity also has to be assessed on the daily intake from sources other than water, for example lead pollution in air.

Toxic Chemical compounds and their extent of toxicity

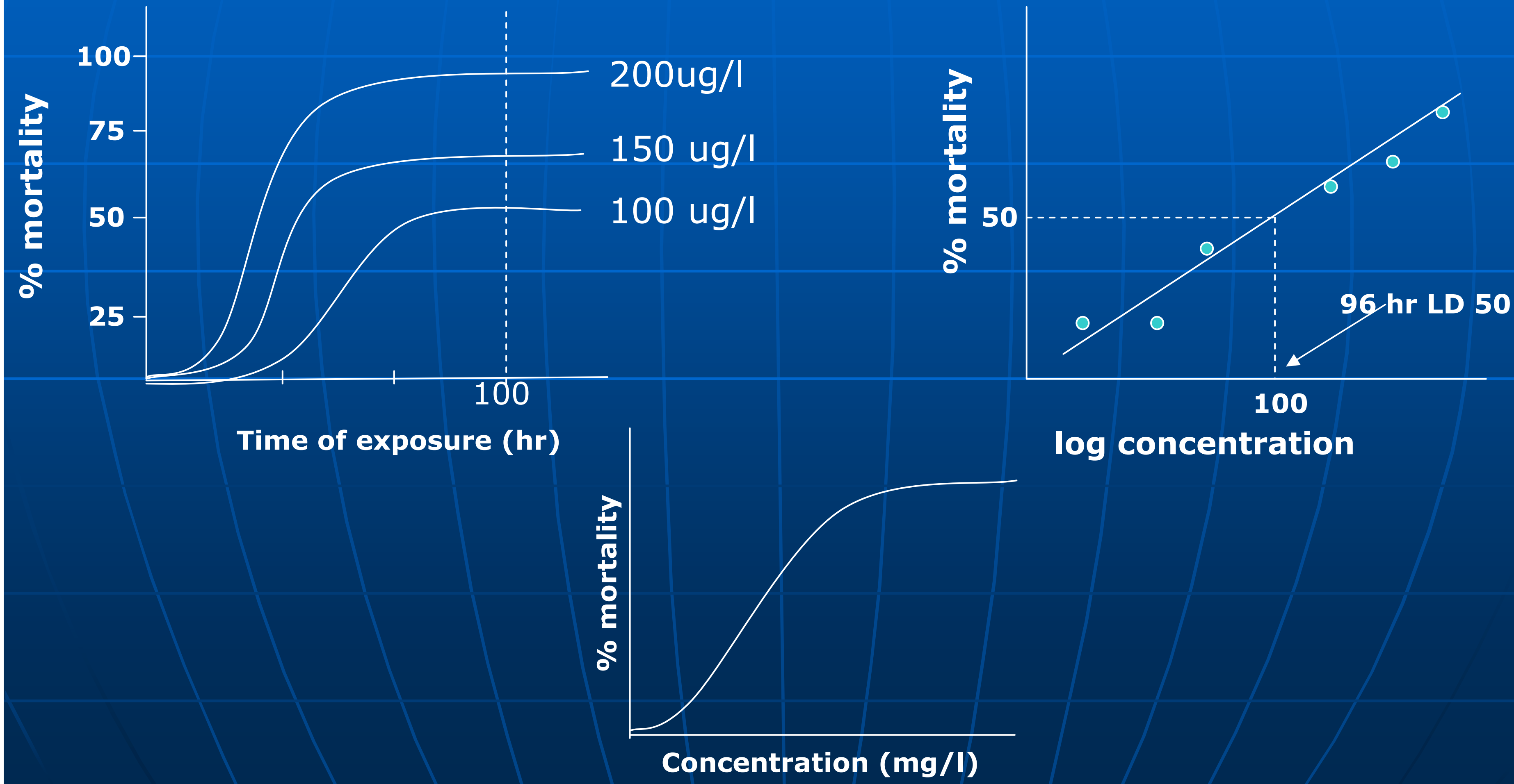
Toxicity – i) Acute toxicity, ii) Sub-acute toxicity iii) Chronic toxicity,

Acute toxicity – The health effects is expressed within a few days.

Expressed as LD-50. LD-50 is the quantity of a compound ingested at once that results in the dead of 50% of the consumers (animals or human beings) in a few days. Generally the measuement of acute toxicity is determined within 4 days (i.e. 96 hours) of exposure.

Toxic Chemical compounds and their extent of toxicity

Determination of the LD50



Toxic Chemical compounds and their extent of toxicity

Class	LD 50 range	category
1	1 mg/kg	Extremely toxic
2	1 – 50 mg/kg	Very toxic
3	50 – 500 mg/kg	Moderately toxic
4	0.5 – 5 g/kg	Slightly toxic
5	5 – 15 g/kg	Hardly toxic
6	15 g/kg	Non – toxic

Toxic Chemical compounds and their extent of toxicity

- Sub-acute toxicity

This is often expressed using the no observed effect level or no observed adverse effect level (NOAEL)

The NOAEL is the highest dose or concentration of a substance that causes no detectable health effect. (Based on long term studies)

In some cases LOAEL may be used. LOAEL refers to the lowest observed dose or concentration of a substance at which there is a detectable adverse health effect.

Toxic Chemical compounds and their extent of toxicity

TDI – is the amount of a substance, expressed on a body weight (e.g. mg/kg of body weight of a person) that can be ingested daily with e.g. food, air, water without appreciable health risk (TDI – Tolerable Daily intake)

The TDI can be derived as follows:

$$\text{TDI} = \frac{(C)(GV)}{(bw)(P)}$$

$$\text{GV} = \frac{\text{TDI. bw. P}}{C}$$

where:

bw = body weight (60 kg for adults, 10 kg for children, 5 kg for infants

P = Fraction of the TDI allocated to drinking water

C = daily consumption of drinking-water (2 L for adults, 1 L for children, (1.75 for infants)

GV = Guideline value

Toxic Chemical compounds and their extent of toxicity

- Guideline Value

GV represents the concentration that does not result in any significant risk to health of the consumer over a lifetime of consumption; With GV, the quality parameter defined is suitable for human and for all domestic purposes including personal hygiene

- Chronic toxicity

The measurement of chronic toxicity has generally been held as monitoring over periods of 30 – 60 days for which there are no adverse effects on life. Concerns over potential cancers, tumors and birth defects are real and difficult to quantify into acceptable water quality criteria.

- Acceptable (ADI)

It has been the practice to use 'safety factors' commonly of 100 to bring down the no- effect level to the safe ADI level.

RAW WATER QUALITY AND APPLICATION REQUIRMENTS

Algae

Gross photosynthesis (limitation)

$$\sum P_{gross} = \mu_{max} * \frac{F(i) * f}{E_w + C * E_c} * C$$

Where:

C: algae concentration

μ_{max} = the maximum photosynthesis rate at optimum light (per unit of biomass)

f: photoperiod of the day

E_w: light extinction coefficient of water

E_c: specific extinction coefficient (per unit of biomass)

F(i): dimensionless function of light intensity (integrated over depth)

Net Growth $= \sum P_{gross} - \sum R$

Adverse effects of algae

- Occurrence of very turbid and coloured water.
- Give rise unstable oxygen conditions by photosynthesis and respiration of algae
- Can cause overstrained oxygen economy due to degradation of dead algae, leading to anaerobic conditions at the sediment – water interface
- Production of organic compound with chelating properties. Other algae can for gels which can clog rapid sand filters
- Blue green algae if prevalent are capable of forming toxins.

Adverse effects of algae especially for the water supply

- Increase of coagulant demand
- Flotation of flocs in settling basins
- Clogging and passage of filter
- Bacterial aftergrowth in distribution system

Adverse effects of aquatic weeds

•Clogging of intake screens for water supply or hydropower production

•High evapo-transpiration

•Interferences with transportation

•Interference with fisheries:

fish population and harvesting of fish

Eutrophication

Eutrophication – the enrichment of water bodies (lakes, rivers, reservoirs) with nutrients usually phosphates (mainly) and at times nitrogen compounds, (silicates to a lesser extent) resulting in increased plant biomass (algal blooms, macrophytes or floating aquatic weeds).

Eutrophication is a natural process but can be accelerated by human influence (- Cultural eutrophication)

Degree of Eutrophication	Level of nutrients
Oligotrophic	low
mesotrophic	moderate
eutrophic	high
hypertrophic	very high

Eutrophication

Trophic	[P]	[Chl]	secchi
	μg/l	μg/l	m
Oligo	< 10	< 2.5	> 6
Meso	10 – 35	2.5 – 8	3 – 6
Eu	35 – 100	8 – 25	1.5 – 3
Hyper	> 100	> 25	< 1.5

INDUSTRIAL WATER

Maximum conc. Of constituents in raw waters for various industrial operations (mg/l)

Characteristic	Boiler water	Cooling water	Textile Plants	Pulp and paper	Chemical industry	Petroleum
Silica	150	50	-	50	-	85
Aluminum	3	3	-	-	-	-
Iron	80	14	0.3	2.6	10	15
Manganese	10	2.5	1.0	-	2	-
Calcium	-	500	-	-	250	220
Magnesium	-	-	-	-	100	85
Ammonia	-	-	-	-	-	40
Bicarbonate	600	600	-	-	600	480
Sulfate	1400	680	-	-	850	900
Chloride	19000	600	-	200	500	1600
Nitrate	-	-	-	-	-	8
Dissolved solids	35000	1000	150	1080	2500	3500
Suspended solids	15000	5000	1000	-	10000	5000
Hardness	5000	850	120	475	1000	900
Alkalinity	500	500	-	-	500	500
Color	1200	-	-	360	500	25

Agriculture Water

- Water Quality for irrigation (tropical conditions)

TDS

- < 400 mg/l – poor drainage
  saline soil
  inadequate water supply

< 1000 mg/l – good drainage
- proper irrigation management

< 2000 mg/l – salt resistant crops
- good drainage
- low sodium adsorption ration (S.A.R.)

E.C. < 100 mS/m (25˚C)

SAR < 10 - poor drainage

< 18 - good drainage

Agriculture Water

Water Quality for irrigation (tropical conditions)

Boron < 1.25 mg/l - sensitive crops

< 4 mg/l – tolerant crops

Coliforms < 100 per 100 ml if water is to be used for unrestricted irrigation

$$SAR\ (meq/l) = \frac{[Na^+]}{\sqrt{\dfrac{[Ca^{2+}] + [Mg^{2+}]}{2}}}$$

The porosity of Na – clay is lower than for Ca – clay. This means that the permeability for air and water is lower.

Quality requirements for fishing in tropical streams

CO_2	<12	mg/l
pH	6.5 – 8.5	
NH_3	<1	
Heavy metals	<1	
Copper	<0.02	
As	<1	
Pb	<0.1	
Selenium	<0.1	
Hg	<0.01	
Cyanides	<0.012	
Detergents	<0.2	
DO	>2	

<u>Pesticides</u>

DDT	<0.002
Endrin	<0.004
Methylparathion	<0.21
Malathion	<0.16

CATTLE BREEDING

Purposes of water use

- Consumption (drinking, fodder preparation etc)
- Washing & cleaning and waste transport
- For processing dairy products at the farm (cheese, cleaning equipment

Water demand for livestock and poultry breeding

Species	Average Water requirement	Max. requirment	Excrement – liquid(l/day
Livestock under fattening	10 - 40	60	10
Milk cows	15 – 60	140	20
Calves	15	20	2
Horses	48	60	
Sheep	8	10	
lambs	4	6	
Poultry and small animals			
Hens	0.23 – 2.75	1.5	
Turkeys	0.5	0.9	
Rabbits	3	5	

The Facts

- Global water: 97% seawater, 3% freshwater. Of the freshwater 87% not accessible, 13% accessible (0.4% of total).
- Today more than 2 billion people are affected by water shortages in over 40 countries.
- 263 river basins are shared by two or more nations;
- 2 million tonnes per day of human waste are deposited in water courses
- Half the population of the developing world are exposed to polluted sources of water that increase disease incidence.
- 90% of natural disasters in the 1990s were water related.
- The increase in numbers of people from 6 billion to 9 billion will be the main driver of water resources management for the next 50 years.

Integrated Water Resource Management

Integrated management means that all the different users of Water resources are considered together. Water allocations and management decisions consider the effects of each use on the others. They are able to take account of overall social and economic goals, including the achievement of sustainable development.

- Within this IWRM principle, it is vital to recognise first the basic right of all human beings to have access to clean water and sanitation at an affordable price.

- **Water has a value as an economic good as well as a social good.**
- Many past failures in water resources management are attributable to the fact that the full value of water has not been recognised and has led to wasteful and environmentally damaging uses of the resource.

- **Allocation**
- Treating water as an economic good is an important means for decision making on the allocation of water. This is particularly important when extending supply is no longer a feasible option.

- Agriculture
- Water supply & wastewater
- Mining, industry
- Environment
- Fisheries
- Tourism
- Energy
- Transport
- Each of the water uses identified above has valuable positive impacts.

Most also have negative impacts which may be made worse by poor management practices, lack of regulation or lack of motivation due to the water governance regimes in place. Water management within government structures is distributed across many agencies and tends to be dominated by sectoral interests.

Fresh water is a finite and vulnerable resource, essential to sustain life, development and the environment.

Water development and management should be based on a participatory approach, involving users, planners and policymakers at all levels.

Women play a central part in the provision, management and safeguarding of water.

Water has an economic value in all its competing uses and should be recognised as an economic good.

The participatory approach involves raising awareness of the importance of water among policy-makers and the general public. It means that decisions are taken at the lowest appropriate level, with full public consultation and involvement of users in the planning and implementation of water projects

SOME ACTIVITIES TO EMBARK UPON FOR INTEGRATED ENVIRONMENTAL RESOURCES MANAGEMENT

1. Awareness creation
2. Solid and Liquid Waste management
3. Creation of buffer zones for water bodies
4. Development of woodlots
5. Appropriate farming (both crops, fishing and animal farming) practices
6. Water Abstraction, Use and Drilling license
7. Creation of Game reserves

MILLENIUM DEVELOPMENT GOALS

1. Eradicate extreme poverty and hunger
2. Achieve universal primary education for all
3. Gender equality
4. Child health
5. Maternal health
6. Combat HIV/AIDS
7. Ensure environmental sustainability
8. Global partnership

GOAL 7
ENSURE ENVIRONMENTAL SUSTAINABILITY

Target 1

Integrate the principles of sustainable development into country policies and programmes and reverse the loss of environmental resources.

Target 2

Reduce biodiversity loss; achieving by 2010, a significant reduction in the rate of loss

Target 3

Halve, by 2015, the proportion of the population without sustainable access to safe drinking water and basic sanitation

Target 4

By 2020 to have achieved a significant improvement in the lives of at least 100 million slum dwellers

Target 1
Integrate the principles of sustainable development into country policies and programmes and reverse the loss of environmental resources.

- Immediate action is needed to contain rising green house gas emission.
- Success in limiting ozone depleting substances is also helping to mitigate climate change

Target 2
Reduce biodiversity loss; achieving by 2010, a significant reduction in the rate of loss

Marine areas and land conservation need greater attention

Deforestation slows and more forests are designated for biodiversity conservation

The number of species threatened with extinction is rising rapidly

Fish stocks require improved fisheries management to reduce depletion

Target 3
Halve, by 2015, the proportion of the population without sustainable access to safe drinking water and basic sanitation

Almost half of the world’s population face a scarcity of water

More people are using improved sanitation facilities, but meeting the target will acquire a redoubling of efforts

In developing regions, nearly one in four uses no form of sanitation

Though access to improved drinking water has expanded, nearly one billion people do without

Women shoulder the largest burden in collecting water

Target 4
By 2020 to have achieved a significant improvement in the lives of at least 100 million slum dwellers

Simple, low – cost interventions could significantly improve the lives of many slum dwellers