

EMT 307: ENVIRONMENTAL POLLUTION STUDIES (2 UNITS)

Lecturer: Professor O. Bamgbose

SYNOPSIS

The environment and its interaction concept of elementary cycles, characteristics of the atmosphere, styles and effects of environmental pollution. Land pollution and methods of waste disposal. Air pollution and its effects on man, plants and materials. Water pollution and treatment of waste waters, Nuclear pollution, Noise pollution and global environmental problems, green house effect, global warming, Ozone layer depletion, nuclear winter, acid rain.

Pre-requisite CHM 305

LECTURE CONTENT

The environment

For people who live in industrialised societies can be unaware of the present concern about the predicament of the environment. Much has been written about the fate which awaits mankind the advice of the more pessimistic ecologists be ignored, in fact some say that the end of our civilisation is so close that little can be done to prevent catastrophe. The more optimistic commentators have emphasised that man's awakening to the dangers and the adaptability of technology will enable civilisation to continue, it is because of this that the study of the environment is therefore necessary and crucial to man's existence.

Environmental can be divided into 5 major zones, the lithosphere, hydrosphere, biosphere, atmosphere and exosphere.

Environmental chemistry is the study of the chemical composition of these zones and of the chemical processes occurring in them and even more important is the interfacial regions that mark their boundaries. The biosphere of which use are pent of comes between the hydrosphere and the atmosphere and serves as the core of the environment. The earth or lithosphere is covered by two interpenetrating thin films; the hydrosphere and biosphere, which in turn is enveloped by the earth's gaseous mantle, the atmosphere which gradually tails into the exosphere.

Interactions

Land, water and air interacts with each other in their natural forms. Interactions is reflected in the composition of mineral waters and pure waters in sediments. Mineral waters and pure waters in sediments. Mineral waters contain dissolved substance from the lithosphere and on the of these waters into the lithosphere.

No single component of the environment exist alone with interaction with any of the other components waterfalls as rain, hail or snow and flows through the land into

streams and lakes and finally into the sea where it is exposed to continuous evaporation back into the atmosphere also the interaction of the 3 components air, soil and water could also be shown by the carbon, O₂ and N₂ cycles. For example plants draw CO₂ from air, water and soil, sun energy converts the CO₂ to form carbohydrate and O₂ which is released to the atmosphere which is latter used for decaying and breathing by other living things.

While in humans the carbohydrate is used up and converted to a CO₂ and water, which is latter used by plants.

Components

soil is the pdt of physical/ chemical erosion and weathering combined with biological weathering. Soil contain mostly organic matter. In our environment only the viable biosphere exceeds soil in complexity. This soils are exceedingly variable.

Three region develop from weathering

- 1) The decyest horizon is the zone of slightly weathered plant material which may be bed rock, allumial or glacial.
- 2) Extensively leached
- 3) Extensively eroded.

As one proceeds from rock to soil there is generally a decrease of more soluble elements – Ca, Mg, Na and K to lesser Al and Fe and a relative increase in silicon and organic matter. The dark coloured Organic matter in human is faro red from decomposition of plant and to a far lesser degree animal matter. Gases in the soil and the atmosphere have more CO₂ and less of O₂.

Air

The atmospheric air consist of O₂, CO₂ and N₂ water vapour and rare gases noth N₂ accurting for about 78% and O₂ 21%. N₂ is involved in some complex and huphly important in our environment N- Cycle. CO₂ is chrely related to O₂. Amount of CO₂ in atmosphere is constent and is replervish by the death of animals.

Man's activities leading to pollution

Man as a living creature has altered his environment very much to his advantage and disadvantage exceeding natural sedimentation, thus man's activities continue to consume or dirty the environment since the first industrial revolution.

In general technological advances which increases wealth and make available resources for the other uses have a potential beneficial effect on the environment. However a balance must be struck between the demands of society for consumption of goods, and foods made so abundantly by modern equipment to that for good towns country side.

Man's activities in the sphere of population growth, agriculture, transportation, health and industrial growth continuously lead to environmental pollutions. Man removes quantities of materials, metals, minerals and fossils from the environment and at the same time dumps them as solid wastes raving from abandoned automobile to building rubbles cans and plastics into the ocean at a rate.

Pollution

Pollution may be defined as the introduction by man into the environment of substances or energy to cause hazards to human health, harm to living resources and ecological

systems, damage to structures or amenity or interference to legitimate use of the environment.

The important concept in this definition are:

1. Pollution is caused by substance or energy
2. It has a source or sources and we are created by man – natural inputs of the same substance are excluded. Thus pollution is an meccament added by man to bioshe.
3. Pollution acts on the environment, as a result leading to exposure of structures or organisms
4. The significant of pollution is related to its effects on a range of targets including man, the resources and ecological systems he depends.
5. Pollution is fudged by is impact on the environmental components if there is damage to structures or interference with legitimate uses of the environment, the substance causing te effect are by definition pollution.

Quantification of the scale of the hazard or damage or interference is important and the basic questions is one of acceptability of the consequences of the release of the substances or energy.

:- simply put pollution is something in the wrong place at the wrong time in the wrong quantity.

The above definition on pollutants exclude potentially hazardous materials caused by people on themselves like cosmetics, food additives pharmaceuticals and the notorious tobacco smoke. The exclusion of these materials has a consequence of great importance. Recent evidence suggest that a high proportion of cancers – perhaps as many as 60-80% maybe provoked by environmental factors rather than result from genetic defects and biochemical instabilities.

Land Pollution

Sources of land pollution can be attributed to the following

- a) Domestic wastes
- b) Agricultural wastes
- c) Industrial wastes.

Domestic wastes

Individual house holders in cities and communities generate a waste amount of solid and communities generate a vast amount of solid wastes including paper food, metals, glass, mood, plastics, clothes, rags rubber, leather and dirt. Disposal has been largely into open dumps, with a fraction going into sanitary land fills and another fraction burned in inamoratos. The remaining small proportion is flushed, composted or salvaged.

Open dumps burn, contributing to air pollution, breed rats a severe health hazard, pollute water sources and are offensive eyesores. These however is still the most important method of waste disposal in the less development countries for waste

disposal include control tipping or sanitary landfill pulverisation, composting and incineration.

Control tipping or Sanitary land fill

Dumping of refuse on land is a disposal method used from time immemorial. Even as of today over 70% of the waste generated in the whole world is disposed of by filling of clay pits, coastal wet lands, valleys and in fact virtually any hole or depression.

The control tipping is the disposal of refuse in layers, followed by compaction and covering of layer with inert material.

1. Length of haul:- this is usually a major factor in disposal cost estimates, however with rear at hand sites being exhausted for many cities hauls of up to 50 miles may still be economical e.g in Ibadan the ring road refuse depot has been cancelled and the refuse depot moved to Alkaran road which is about 40km from the town centre.
2. Distance from housing:- the tip must be at least 200metres from any housing to minimise nuisance.
3. Prevention of water pollution:- the site should not contain static water as the decaying refuse and water combination produce extremely offensive smells and encourage the breeding of the . running water should not be present, neither should the site connect with the aquifer as contamination of water supplies can result and jeopardise public health.

Availability of covering material

A properly run tip has the refuse in compacted layers not more than 1.8m deep and these layers must be covered with at least 20cm of inert material such as soil or ashes or thoroughly composted refuse. This prevents or controls the ingress of flies, rats, and other forms of bird, insect and animal farm. The covering of the refuse layers is an essential part of the operation and neglect of this aspect can cause the tip to degenerate into a major public nuisance.

Due consideration of the above factors can make controlled tipping a very acceptable method of refuse disposal especially if the refuse is treated by pulverisation before hand to aid compaction. This method of disposal will continue in dominance for many years as its costs are normally well below those of incineration or other disposal processes.

Pulverisation

Pulverisation covers a variety of refuse processes which result to a homogeneously sized mix.

Pulverisation it is claimed gives a very homogeneously material with a higher initial density than crude refuse (904kg/m^3 compared with 598kg/m^3). Compaction is

enhanced and less cover material is required. Pulverisation may be carried out in the wet or dry state wet machines are usually horizontally perforated rotating drums. The perforation size, speed and time spent in the drum control the particle size. Water is sprayed into the drum to assist the disintegration of the refuse.

Dry pulverisation is usually accompanied by hammer mills. The impact of the hammers effect the material reduction. The hammers may be free to swing on a rotating shaft or shafts or simply fixed to the shaft hammer mills give more accurate size control of the end product compared with the horizontal drum wet process.

Composting

Composting is a method of handling and processing municipal refuse which produces as end products (a) a humus like material which may be used as a soil conditioner or top dressing for a controlled tipper and (b) rejected matter such as salvage and non-combustible material. Technically composting is a biological process of decomposition carried out under controlled conditions of ventilation, temperature and moisture by organisms in the wastes themselves.

The process rate is influenced and aeration. Refuse composting is characterised by extensive materials handling and separation. After composting 50 – 60% of the original volume of refuse remains to be disposed of either by sale or tipping. However the compost produced does not have a ready market as fertiliser because of its high carbon-nitrogen ratio (30:1) that is its fertilizer content is minimal. This is done to the composition of refuse as nitrogenous compound are almost non-existent.

Thus all the compost does is to provide a coarse form of humus unless enriched – it is noted that heavy metals can be a problem in its agricultural use.

Incineration

Incineration is the term used for the combustion of municipal refuse. In a properly designed and operated incineration there is a substantial reduction in the volume of waste material to be disposed of by tipping.

The process is extremely hygienic and many problems associated with controlled tipping, such as wind blown refuse, rodents and flies e.t.c are completely eliminated. Properly incinerated refuse becomes a sterile ash with minimal carbon or fat content and thus can be safely tipped in almost any location. Incineration take place in three stages, namely evaporation, distillation and combustion. Evaporation takes place in the furnace from both radiant and convective heat exchange and as more heat is added to the refuse, volatile hydrocarbon gases are released with ignition taking place around 700⁰c. On further heating (and supplying the requisite amount of O₂) the fixed carbon is consumed and converted to CO₂. The inert non- combustible matter which remains is discharge to the ash hopper for disposal. Major problem nith incineration and in fact nay refuse disposal process are caused by refuse heterogeneity e.g plastics and aerosol/ canister .

Both produce acids such as HCL and trichloro fluoromethere which decomposes on incineration to produce fluorides which corrode incineration.

Agricultural Solid wastes

Agricultural wastes and mineral wastes, principally from mining, make up a very large proportion of the total solid wastes in all countries but constitute a proportionately less harmful pollutant because they are spread over wide areas, not concentrated as are most residential and industrial wastes. This largest single source of solid waste includes animal manures and wastes from slaughter houses and from all forms of crop harvesting. Food animals, principally cattle, dogs, sheep and chickens generate 1,000 times more manure than does the total human population. In the past nutrients were returned to the soil by the livestock in pastures or on range land. Modern feedlots, with increasing numbers of food animals, concentrate these quantities, however corrective measures are to spread the waste pollution.

Sediment from soil erosion is another factor in the deterioration of the land and the adding of turbidity to the waters. Sediment production is an increasing problem from poorly managed forest range lands and agricultural crops. (mining operations and construction add to the sediment bulk).

Fertilizer salts on the land also contribute to eutrophication of water, either when more fertilizer are applied to the land than the crops can take up or when the rains wash off the salts. White fertilizer is essential to the growing of food, its side effects increase with increase of population.

Pesticides (including insecticides, nematocides, herbicides and fungicides) contain hundreds of major chemicals (particularly the DDT groups of compounds used for as control of water diseases), their impact on soil and water contamination is great and as such residue of these substances have been found in both crops and animals. To feed a rising population, pesticide usage is not likely to decrease. Their persistence and levels of tolerance in man, animals and plants have been of great concern to scientist over the years. They have been known to cause convulsions, are carcinogenic, tetragonal and even death.

Mineral wastes

Mineral solid wastes are mostly from mining of minerals and fossil fuels and the associated milling and processing industries. Strip mining causes a particularly difficult form of pollution streams and destroy watersheds but also leaves huge scars on the land. Efforts to repair scars on the country side have been attempted by some comprise but are expensive.

Land pollution control

Recycling, recovery and reuse

These have been referred to as the secondary materials industry growing rapidly in the 190s. The metals that are reused to the greatest extent are iron and steel, followed by copper, zinc and aluminium. Reclaimed rubber constitutes an important fraction of total consumption. The growing reuse and recovery industry is hampered, however by the lack of economy of scale.

Three basic steps are involved : collection, separation and processing. The significance of recycling in the future from both the pollution control and conservation view point

has been pointed out as one of the advantages of the new city concept. Such experimental cities built from scratch can plan all type of pollution control far better than can old established cities and extensive recycling can be economically realized. There is hope for waste management resource recovery by recycling. Such comprehensive approach envisages the separation of the wastes so that some may be either converted to find or burned directly as fuel, some may be transformed by chemical processing into new products, while other may be reused or recycled in their original form. Paper a major constituent of most municipal waste is an excellent candidate for recycling.

Japan recovers and reuses half of all the paper it consumes. Similarly glass production, principally beverage bottles have been reused.

Attempts have been made to recycle some waste that constitute eye sores in the environment e.g Junked automobiles and tyres.

Junked automobiles the disastrous aesthetic impact of automobiles grave yards makes this component of solid waste conspicuous in the public eye, but most automobiles were being scrap processed for recycling in the early 70's in the development countries. In the third world countries the automobiles grave yards are scattered all over environment.

Similarly a considerable proportion of tyres in developed countries discarded annually can be reclaimed, but most are unfit for reclamation and constitute a disposal problem they may be incorporated into asphalt for paving.

AIR POLLUTION

Pollutants and their sources

Five major classes of pollutants are discharged into the air normally carbon monoxide, particulates, sulphur oxides, hydrocarbons and nitrogen oxides. In addition to the automobile, other major sources are from combustion of fuel in electric power plants, industrial processes and space heating from the combustion in solid waste disposal, coal waste fires and agricultural burning.

Carbon monoxide

Carbon monoxide is a colourless, odourless, poisonous gas. Slightly lighter than air. The only significant source of carbon monoxide is the combustion process when the carbon in fuel is burned incompletely, with the carbon partly oxidized to carbon monoxide instead of fully to carbon dioxide. The largest single source of carbon monoxide is the internal combustion engine.

PARTICULATES

These include particles of solid or liquid substances in a number of sizes ranging from those that are visible as soot and smoke to particles too small to detect except under an electron microscope. Particulates are produced primarily by stationary fuel combustion and industrial processes, Forest fires account for a small percentage.

SULPHUR OXIDES

Are acrid, corrosive, poisonous gases produced when fuel containing sulphur is burned. Most of the sulphur oxides come from utility and industrial plants that burn coal and oil which contain sulphur as an impurity (i.e the Nigeria coal and Bonny light oil are ranked one of the world's best because of their low sulphur content). The burning of coal produces about 60% of the sulphur oxides emitted annually. Oil burning and industrial processes that use sulphur are major producers of sulphur oxides, usually concentrated in urban areas.

HYDROCARBONS

Like carbon monoxide, represent unburned and wasted fuel. Unlike carbon monoxide gaseous hydrocarbons at concentrations normally found in the atmosphere are not toxic; they are a major pollutant however, because of their role in forming photo chemical smog. Sources of airborne hydrocarbons include incineration evaporation of industrial solvents and combustion of coal and wood.

But the leading contribution is gasoline emitted by evaporation and by the internal combustion engine. Other hydrocarbon emission comes from miscellaneous burning and industrial processes. About 60% is produced in urban areas with their high concentrations of automobiles.

NITROGEN OXIDES

Are produced when fuel is burned at high temperatures. The major sources of this pollutant are transportation vehicles and the combustion process as used in electric power plants and industrial boilers (which account for about half of the nitrogen oxide emissions). In combustion the ordinarily inert nitrogen in the air combines with oxygen at high temperatures and tends to stay combined if the exhaust gases are cooled too quickly. Nitrogen oxides combine with hydrocarbons to form a complex variety of secondary pollutants called photochemical oxidants. These oxidants, together with solid and liquid particles in the air make up what is commonly known as smog. Photochemical oxidant pollutants include ozone, NO_2 , peroxyacyl, nitrates, aldehydes and acrolein.

Another common air pollutant in urban areas is lead which comes from manufacturing sources, pesticides, combustion of coal, refuse incineration and leaded gasoline which when burned in automotive engines, is the major source of air borne lead in urban areas. Apart from the pollutants themselves, certain natural factors affect air pollution. The ultraviolet rays in sunshine combine with hydrocarbons and nitrogen oxides to form photo-chemical smog which can result in condition of atmospheric stagnation during temperature inversions, such phenomena occur when temperature increases from ground level up to several hundred feet within the troposphere (lower atmosphere); they are called inversions because temperature usually decreases with altitude. Inversions can impede the rise of the air from below and if the lower air contains pollutants, the inversion acts as a lid to seal them below. If no significant lateral movement of air occurs, the stage is set for an acute air – pollution episode.

EFFECT ON MAN, PLANTS AND MATERIALS

Effects of air pollutants on man are varied. When carbon monoxide is inhaled, it displaces the oxygen in the blood and reduces the amount of oxygen carried to the body tissues. At levels commonly found in city air, mental performances can be dulled or slowed thereby making people more prone to accidents. It is believed to impose an extra burden on those already suffering from various diseases such as anaemia, heart diseases and blood vessels and chronic lung conditions. Sulphur oxides can cause temporary and permanent injuries to the respiratory system, irritating the upper respiratory tract and lung tissue.

Photochemical oxidants result in eye irritations and studies indicate that nitrogen oxides are harmful to human health, specifically increasing children's susceptibility to flu.

Many other pollutants are a growing public health worry even though they may not constitute immediate and direct threats.

Studies suggest that lead levels found in the bodies of urban people may interfere with their ability to produce blood. It is being debated whether the lead levels in the environment are of themselves dangerous to health or whether if further concentrating lead in some food chains leading ultimately to toxic doses for man or other organisms.

Air pollution has inflicted widespread damage on plant life, buildings and materials. Smog in the LA (Los Angeles) area contributed to the show decline of citrus groves south of the city. Air pollution also damages mans most durable products; steel corrodes two to four times faster in urban industrial centres than in rural areas where much less sulphur bearing coal and oil are burned. Sulphur oxides are also accelerates the erosion of stationary & buildings throughout the world, particulate not only settle as dirt but also speed up the corrosive action of other pollutants.

Techniques for air pollution control

Technological capabilities and control devices are available to abate many air pollution problems although some have not become economically feasible. Air pollution is accounted for by three main sources i.e vehicle emissions. Electric power plants, industrial and other sources of air pollution.

Vehicle emission: Developed countries have since the 1960 enacted legislative control of automobile pollution and standards have since the 1970's been to tightened with the most stringent requiring a 90% reduction from 1960's levels of CO₂, hydrocarbon and NO.

The technological controls necessary in order for automobiles to comply with emission standards are varied.

Emission of hydrocarbons from the crank case was largely eliminated by ventilation systems that recycle crank case ventilation air and blow by gases to the engine intake instead of venting them to the atmosphere. For controlling evaporation fuel, techniques have been developed to recycle the vapours to the engine. Evaporative emissions could also be decreased by changing the properties of gasoline.

To meet the early exhaust emission standards for hydrocarbons and carbon monoxide, auto manufacturers developed ways to induce further oxidation and they redesigned cylinders and adjusted the fuel – air ratio and other variables to reduce the amounts of these pollutants in the exhaust.

Motor vehicle pollution is the product of a complex combustion system of engines, fuels and fuel additives. Effective control cannot be achieved solely by redesigning engines and installing control devices but will also depend on improvements in fuel and fuel additives. The key additive in air pollution control is tetraethyl lead in gasoline, which accounts for a significant portion of particulate pollution from cars. Major gasoline companies have introduced how leaded or lead free gasoline (cost of production is higher)

Control devices for vehicle emission pollution and cylinder includes;

1. Optimizing on air fuel ratios, ignition timing and cylinder design.
2. Crank case blow by gases can be recycled into the engine
3. Evaporative losses can be reduced by absorbing the hydrocarbons on charcoal filter
4. Air injection into the manifold by the exhaust pipes to ensure increase oxidation
5. Filters are used in the exhaust system for the removal of particulates.

A more radical alternative to the internal combustion engines is now receiving worldwide attention. The most promising low pollutant power sources are the steam engines and the gas turbines and the electrically powered automobiles. There is also the manifestation of the hybrid car with electric power for in-town driving and an internal combustion engine for long distance travelling i.e Toyota prius, Ford hybrid, and Nissan hybrid. Furthermore, there has been limited production of vehicles that run on H₂ with production of water as the combustion product.

ELECTRIC POWER PLANTS

Electric power plants fired by coal or oil emit sulphur oxides, nitrogen oxides and particulates. In industrialized countries such plant account for over 75% of the total sulphur oxides and since the electric power industry is rapidly proliferating, the potential increase of sulphur oxide emission is tremendous.

A number of alternatives are available to control sulphur oxide pollution.

1. The use of nuclear power for generating electricity (through this has its own problems)
2. The recommendation of the use of low sulphur coal and oils – In many existing power stations, low – sulphur coal cannot be burned without operational difficulties or incurring high capital costs for finance modifications.
3. Removal of sulphur from fuels a) by removing sulphur at refinery b) diluting high sulphur oil with low sulphur oil

4. Chemical processing like oxidation of the SO_2 to sulphur trioxide and the trioxide to sulphuric acid which is removed by addition of activated char (carbonaceous material).

INDUSTRIAL AND OTHER SOURCES OF AIR POLLUTION

Industrial sources generate a range of air pollutants specific to the process involved. Integrated steel mills emit particles, smoke carbon monoxide and fluorides, cement plants produces particles and sulphur compounds. Refineries emit sulphur compounds, hydrocarbons smoke particles and odours.

The major industrial air polluters are inorganic and organic chemical plants iron and steel mills, petroleum refineries pulp and paper mills and non ferrous metal smelters.

A wide variety of air pollution control technology is available to industry; filters vapour collectors electrical precipitators cyclones (centrifugal devices for separatory solid material from gases) scrubbers, absorbers and combustion equipment such as after burners and catalytic units.

OTHER SOURCES: - Refuse disposal also contributes to air pollution. Few of the worlds disposal sites on land are sanitary landfills (defined as having daily cover, no open burning and no water pollution problems) and few municipal incinerators have adequate air pollution control devices.

AIR POLLUTION MONITORING

Nearly all types of analytical equipment have been used in the monitoring of air pollutants. The choice of sampling technique depends upon the state of the pollutant that is solid, liquid or gas. Methods available include the sampling of gases in polythene bags, the absorption of liquid aerosols onto collection columns and the use of impingers and filters for the collection of solids. Many simple chemical procedures are available for measuring the common pollutants enabling standardised methods of analysis to be used. Alternatively more sophisticated equipment can be used as required frequently for an automatic monitoring system. Some of the simplified procedures are tabulated below.

POLLUTANT	METHOD
SO_2	Absorption in dilute hydrogen peroxide followed by measurement of total acidity.
H_2S	Measurement of darkness of silver sulphides stain produced on an impregnated filter paper
Ammonia	Absorption in dilute acid followed by use of nessler's method.
Fluorides	Collection in water using a Perspex impinger. This is then determined colorimetrically as the lauthanium alizarin complex

Smoke	Use of reflectometer to measure darkness of stain produced on filter paper
Oxides of Nitrogen	Absorption in a solution of sulphanilic acid conversion to the diazo compound estimated colorimetrically.
Ozone	Absorption in a buffered solution of KI and sodium thiosulphate. Back-titration of excess with iodine.

Sophisticated equipment that has been used includes NDIR analyses analysers for CO₂ Non-dispersive infra-red analysers and the use of flame ionisation techniques – for hydrocarbons. While NO is measured by a new technique of chemiluminescence.

The automatic monitoring of ambient air quality is now becoming an accepted part of public health programmes. There are more problems to this kind of background monitoring than with the monitoring of stack gases for example or vehicles emissions from single sources. The concentrations are generally much lower and a network of analysers rather than an isolated measurement is necessary to obtain data on dispersion and drift patterns.

Eventually computer evaluation of simultaneous analytical meteorological and geographical data will be needed to provide meaningful alarms for potentially dangerous conditions or detect actual high episodes of pollution from single identifiable sources.

WATER POLLUTION

Properties of water

Pure water should have the following properties

Colourless Odourless Boiling point of 100⁰C Tasteless Freezing point of 0⁰C, Density of 1g/cm³.

Any water deviating from these properties is said to be contaminated, however it is usually not possible to even have the most ideal drinking water to possess all the above properties. Water being a universal solvent, even in its natural state contains dissolved materials, carries particles and is the home of living organisms. Although the composition of waste in water varies widely, its main inorganic constituents are sodium, potassium, ammonium, calcium magnesium, chloride, nitrite, bicarbonate, sulphate and phosphate. While the organic compounds are numerous and not well known with the exception of pesticides, detergents, phenolic substances and carboxylic acids.

What is waste water

Water quality depends on the use the water is to be made of and this may range widely for various uses like manufacturing, irrigation, cooling, drinking, food processing, washing and recreation. Pollution of water can therefore be defined as that which renders the use of a water body unsuitable for a specific use. This therefore leads to production of waste water.

Waste water can then be defined as the end product of water after it has been used for a specific purpose. The production of waste water therefore involves the addition of some materials original absent in the water body or an increase of those originally present. The materials added and the sources from which they originate are classified below.

1. Wastes which demand oxygen – dead plants and animals. Animal waste products (urine + faecal matter) industrial wastes from food processing. Plants, slaughter houses, meat packing plants.
2. Agents which cause disease – Bacteria and viruses
3. Plant nutrients – Water running off irrigated lands containing nitrates, PO_4^{3-} & K compounds
4. Synthetic organic compounds – Chlorinated pesticides, detergents dyes
5. Various inorganic chemicals – Acid wastes like HCl, H_2SO_4
6. Sediments – Clay, silt , sand, gravel
7. Heat – Warm water from cooling uses
8. Radioactive minerals – Effluent from mining and processing of radioactive minerals or fall out in test nuclear bombs.

Waste water (water pollution) by nitrates, toxic substances bacteria and viruses affects human health, taste and odours, can be unpleasant even in water not harmful to human health. More subtle are long term changes in the aquatic life of a water body, the decline of sport fish and increase in carp, sludge worms and other life forms tolerant of pollution. Waste water (water pollution) also speeds eutrophication with resultant aging and clogging of lakes. In these ways water pollution degrades the multiple uses of water for human supply, recreation aquatic life and other wildlife, agriculture and industry.

Uses of water

The most essential use of water is for drinking to sustain the fluids necessary for life. However the quantity used for drinking is relatively low (e.g in the US 1 part in 4,000 parts is drunk). Most of the water is consumed by agriculture industry and power generating facilities as shown below

Nature of use	Gallons Used
Irrigation	180 billion
Industry	80 billion
Power generation	110 billion
Municipal wastes	30 billion

From the above it is clear that water is used extensively to bring man is food and fibres, his necessities and luxuries. For example the volumes of water used in producing items essential to existence of man are shown

Items Produced	Water Used (gallon)
Sunday times	200
Wheat for a loaf of bread	300
Tank full of petrol	400
1kg of beet	4,000
A car	50,000
1 ton of synthetic rubber	600,000

Degradable & non- degradable waste

Complex mixtures in water of rivers and lakes include many unknown chemicals and for practical purposes can be divided into degradable and non- degradable waste.

Degradable wastes in water are those that are reduced in quantity by natural processes. These include organic wastes and thermal discharges. The degradation process uses the oxygen in the water and constitute natural self purification. However if the waters are too loaded with organic matter, degradation without sufficient free oxygen produces offensive odours such as H_2S and CH_4 .

Non degradable wastes are salts – soluble in water, soluble gases or particulate matter. These wastes may include a wide range of toxic metals arising from complex manufacturing processes; cadmium ,mercury and lead for examples. Depending on which metal is concentrated, there have been incidences of permanent neurological impairment and death among persons eating fish from waters heavily polluted by mercury.

Water pollution sources can be divided into three

- a) Domestic wastes
- b) Agricultural wastes
- c) Industry waste

Domestic wastes

In virtually all urbanised society, water is used as a means of carrying away the bodily wastes of human population. Water is also used in the home for bathing, food, and washing of utensils, clothes and working surfaces. All the wastes waters from these uses are discharged to a soil drain and this in turn to a "sewer" (underground channel pipeline or construction of brick concrete to carry off sewage from buildings to centres for treatment). The liquid which flows in the sewers is known as "sewage". If this sewage is derived only from the household use of water it is known as domestic sewage.

The composition of a domestic sewage is determined primarily by its ingredients. There is firstly the local tap water which may range in composition from a very soft moorland water (40mg/L DS) to a very hard well water (>500mg/L DS) to which is added during the course of use, such pollutants as urine, faeces, paper, soap, constituents of synthetic detergents, scraps of food, earth, grease, cosmetics and other waste materials. All these are mixed together in the sewer. The turbulence generated by the passage of sewage through the sewage system tends to break up paper and faeces so that the sewage arriving at the treatment works appears as a grey brown suspension. Note that in Nigeria, in general there is no sewage system and in particular sewage treatment farms. All wastes end up in free flowing streams channelled from individuals' gutters.

In addition to purely domestic sources is the inflow of storm (rain) water which collects rapidly in volumes too great for treatment plants to handle. This intensifies the disposal problem. In the usual combined sewer system the waste water cannot be separated from the large volume of rain H₂O. Therefore when total flow exceeds the capacity of the system, most of the waste water is included in the bypass flow that is discharged directly into the outlet- river or stream.

Agricultural waste

While agricultural wastes contribute considerably to water pollution through the run-off from pesticides, herbicides and fertilizers, they are generally less concentrated and have less aggravating effects on industrial and domestic waste originating in or near cities. Where the land is available, the wastes from farm animals, many times greater in volume in nearly all countries than that of the human population are best disposed of by field constructed near feedlots.

Industrial wastes

Water using, industrial plants add pollutants that have a variety of effects. Four major industries account for a large portion of waste water discharge:- paper, chemical, petroleum and steel. In addition great amounts of waste heat are discharged into water by power generation.

Because industrial wastes are generated in bulk at the plants, they can more easily be controlled and much has been done at the source either to change production to minimize waste or to treat waste.

In view of the diversity of industries a rigid classification is impossible but some of the more important classes can be grouped together as

Food and drink manufacture

Effluent from such establishments such as slaughter houses, breweries, canneries, sugar factories and distilleries contain high concentrations of organic matter of natural origin and are usually amenable to treatment by the same methods as domestic sewage. They may thus be treated in special plants or in admixture with sewage at the sewage plants.

Textile

The effluent contain substances derived from the washing of raw materials (wool, cotton etc) together with materials used in processing such as detergents, lubricants, dyeing auxiliaries and dyestuffs. They may be difficult to treat biologically but are commonly discharged to sewers for treatment with domestic sewage.

Metal finishing industries

Articles made of metals are often subject to many operations before they are considered saleable or fitted for their purpose. These finishing operation are often conducted in many small widely distributed establishments and involve the production of large volumes of effluents containing rather toxic materials e.g Al, Pb Cd. These are normally removed from source by precipitation, the precipitate so formed is removed by sedimentation.

Waste heat (thermal pollution)

Industry also uses huge amount of water for cooling. The largest such user is the electric power industry. Steam generating plants which draw water from a natural source to cool their condensers, discharge it back at an average of about 7°C higher temperature (13°F).

Nuclear plants require 50% more water than equivalent fossil plants; and with the growth of the electric power industry, the cooling of power generation plants is clearly becoming a major pollution problem. Such thermal pollution as it has been termed accelerates biological and chemical reactions and aggravates biological and chemicals reactions and aggravates the diminution of dissolved oxygen. Water temperature may rise above the level tolerable for the fish and at the same time promote the growth of undesirable algae, adding to the effects of other pollutants; excess nutrients, detergents, fertilizers and human waste. Waste heat, therefore speeds up the eutrophication of lakes.

Effects of pollution on natural waters

Pollution of water can be in form of physical pollution (discharge of suspended matter), biological pollution (discharge of pathogenic bacteria, viruses and other organism and chemical pollution whose effect is more readily felt. The three most important from of chemical pollution are O₂ deficiency, toxicity and eutrophication .

Oxygen deficiency

All natural waters contain micro – organism when require organic matter for growth and O₂ for respiration. The oxygen is obtained as dissolved oxygen – 10mg/ at 11°C. In an unpolluted stream the bacteria are low in number and as such O₂ level is maintained at or near saturation by entry if O₂ from the atmosphere through the water surface. When biodegradable organic substances are added as in for example a polluting discharge ,the numbers of microorganisms and their respiration rates are increased; resulting in a lowering of the O₂ concentration in the water. The O₂ concentration determines the character of a stream i.e. whether it will be life supporting or not. Most

fish require about 3mg/L of oxygen. Even when the O₂ level is above this minimum level, the toxicity of other poisons may be increased. When the O₂ level falls to zero some bacteria derive their oxygen by reduction of nitrate and as a last resort from reduction of sulphate yielding H₂S. A river in this condition will be nearly lifeless, black and evil smelling. If however the degree of pollution is not too severe the oxygen demand of the organic matter will be met by the resources of the stream (dissolved O₂ supplemented by re-aeration) and as the water continues to flow it will be restored to a condition approximating to that above the polluting discharge.

Toxicity to fish

The appearance of dead fish in a river is an obvious manifestation of pollution. Toxicity can be chronic or acute. Chronic toxicity is usually not evident, but is the resultant effect of accumulation of toxic chemicals over a period of time. While acute toxicity is the immediate manifestation of absorption of high amount of toxic material with deleterious effect. i.e chronic toxicity is more dangerous than acute toxicity in that steps can be taken to arrest acute toxicity whereas for chronic toxicity a whole generation could have been affected.

Many factors affect the toxicity of a substance to fish and these include.

- a) Species, age, degree of acclimatisation of the fish
- b) Temperature, DO content, hardness and pH value of water.
- c) Industry effects of the pollutant on the properties of the water (e.g transparency) or on organism serving as food for the fish.

Toxicity is usually expressed as the concentration which (under specified conditions) will cause death of half a population in a given time. If for example the time is 48hrs, the concentration is referred to as 48h LC₅₀. In mixtures of poisons the effects are often additive, e half an LC₅₀ of one poison plus half a LC₅₀ of another giving a LC₅₀ of the mixture.

Eutrophication

This is the enrichment of water by plant nutrients. With the passage of time many lakes which normally had supported a sparse but varied population gradually passes into the eutrophic state because of erosion and decomposition processes which increases the content of nutrients and therefore become highly biologically active. This is manifested by periodic blooms of algae which render the water unsightly and may cause oxygen deficiency on decay.

This natural progress of eutrophication is accelerated by pollution and much research has been devoted to the elucidation of the controlling factors of which N and P appear

to aid the process, and for this reason, processes for their removal have been developed. This does not indicate that other nutrients are also not responsible.

Water pollution monitoring

In general two factors determine the water quality that is the organoleptic factors and the physio-chemical properties.

The organoleptic factors ask that good water must be odours less, colourless and free of any turbidity. While the physio-chemical properties are in actual fact field parameters. And these are pH, conductivity, hardness, Alkalinity, chloride, sulphate and Nitrate.

Those parameters that give pollution are

Gross pollution parameters – BOD, COD NH₃, (TOC (total organic carbon)) what parameters monitored depends on the use the water is to be made. i.e engineer (pH) if water is too acidic for piping, then to know the amount of lime to be added.

A biologist to know if it will support organic life, industrialist might be interested in hardness – problems of boilers, in food processing and detergent industries.

Fisheries officer might be interested in turbidity i.e. amount of light penetration.

Sampling & sample storage/ preservation.

Sample is taken from the free flowing part of the stream preferably mid – stream where the water is thoroughly mixed. If water is shallow the bed should not be disturbed. Normally it is usual to dip a container into the stream and once the sampling is done it is necessary to store or preserve the samples; there and then on the field the dissolved oxygen must be measured either by using an oxygen probe or fixing the oxygen by the winkler's method. The samples are stored in cooler filled with ice on the field and transferred to freezers at the laboratory.

Dissolved Oxygen

The determination of DO in water is an important parameter. It is a test that is used in assessing the quality of surface waters. If the value is high then the water body is oxidizing. It is useful in agriculture as the level of DO affect or control the survival of fishes in water. These are two methods

1. Conventional classical method (Winkler's method)
2. Instrumental analytical technique – using selective electrode.

Winkler's method

Sample must be collected carefully taking adequate care not to increase or decrease the O₂ level.

The O₂ is titrated indirectly by converting to the iodine.

MnSO₄, alkaline KI (KOH + KI)

KOH + KI + MnSO₄ to sample

MnSO₄ is converted to Mn(OH)₂, in presence of O₂ the Mn²⁺ is oxidized to Mn⁴⁺

Mn²⁺ + 2OH⁻ => Mn (OH)₂ white Ppt.

Mn (OH)₂ + $\frac{1}{2}$ O₂ => MnO₂ + H₂O – brown ppt of Mn oxide. Precaution cover bottle well to prevent atmospheric oxidation to MnO₂ add H₂SO₄ to neutralise alkaline

condition and give an acidic solution, in acidic medium MnO_2 reacts with I^- added initially.

$\text{MnO}_2 + 2\text{I}^- + 4\text{H}^+ \Rightarrow \text{Mn}^{2+} + \text{I}_2 + 2\text{H}_2\text{O}$. The iodine imparts a brown colour to the solution. The molar amount I_2 produced = to the original molar concentration of O_2 in the sample. The sample is then titrated with sodium thio-sulphate

$2\text{S}_2\text{O}_3^{2-} + \text{I}_2 \Rightarrow \text{S}_4\text{O}_6^{2-} + 2\text{I}^-$ add $\text{S}_2\text{O}_3^{2-}$ until a light yellow colour is obtained then add starch and titrate to colourless end point. The NO_2^- and Fe^{2+} ions interfere in the analysis e.g. $2\text{NO}_2^- + 2\text{I}^- + 2\text{H}^+ \Rightarrow \text{I}_2 + 2\text{NO} + 2\text{OH}^-$ (so during the titration one is monitoring both O_2 & NO_2^- this is removed by addition of sodium azide (NaN_3). In acidic solution, azide releases hydrazoic acid (HN_3) which destroys NO_2^- forming N_2 and N_2O .

$\text{NaN}_3 + \text{H}^+ \Rightarrow \text{HN}_3 + \text{Na}^+$

$\text{HN}_3 + \text{NO}_2^- + \text{H}^+ \Rightarrow \text{N}_2 + \text{N}_2\text{O} + \text{H}_2\text{O}$.

Interference of Fe^{2+} is masked by addition of phosphoric acid.

Biochemical Oxygen Demand BOD 5

Method most commonly used is the dilution method.

Organic matter can be divided into biodegradable organic matter e.g. food nutrients C – CO_2 , N – NH_2 , NO_2 – NO_3 . (oxidation brought about by microorganism) and non-biodegradable matter difficult to degrade by common microorganism e.g. oil and fat – takes an amount of time for the system to produce the microorganism that acts on them.

BOD measures the biodegradable fraction. BOD, BOD_2 ,... BOD_5 indicate the number of days the microorganism is allowed to act. The most commonly used is BOD_5 .

In the trickling filter system, waste water after the solid matter has been screened is sprayed in droplets on aggregation of stones. While in activated sludge, the waste water and air is passed into a tank, then the sludge formed is recirculated into the system.

BOD is measured as $\text{mg O}_2/\text{L}$. If the BOD is high then the amount of biodegradable organic matter is high.

Measurement of BOD 5.

1. Supply plenty dissolved oxygen to the waste water
2. Determine how much DO supplied
3. Incubate and allow microbes to oxidise matter for 5 days at 20°C .
4. Determine DO left.

Practically

Dilution water is prepared.

This contains plenty of oxygen (a jar of water saturated with oxygen). Nutrients are added which induce the growth of microorganism (Mn, Mg, Ca, P, S.). then make sure the microorganism are present e.g. when dealing with sterile sources.

Seeding must be done e.g introduction of waste materials which contain micro organism .

1. Dilution is now done)in carrying out the dilution, a good result is obtained if at the end of the incubation the DO left is about ½ of the DO added in the beginning. A single dilution is done if one has the knowledge of the BOD level. If not a guess is made depending on the randomness of the guess so many number of dilution needed is done.

This is carried out by adding the dilution water to the waste water in the ratio designed

2. Fill two BOD bottles adding dilution water to both in the same ratio
3. Determine the DO in one and incubate one for 5 days
4. The difference in the DO before and after incubation multiplied by the appropriate dilution factor gives the BOD.

$$\text{Calculation: } \text{BOD}_5 = d(X_0 - X_5) - (C_0 - C_5)$$

Where X_0 = oxygen content in the test sample at the start

X_5 " " " " " after 5 days

C_0 " " " " " the reagent blank at the start

C_5 " " " " " after 5days

D= dilution factor

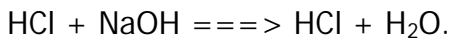
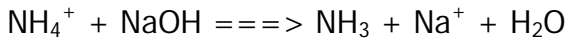
CHEMICAL OXYGEN DEMAND COD

This measures the amount of oxygen necessary or required to destroy gross organic matter. Gross organic matter constitute pollutant in that they consume oxygen which ought to be available to other forms of life. In principle what is done is (i) supply excess oxidizing agent (ii) measure level of oxidizing agent before and after reaction (measure in terms of O_2). Common oxidizing agent used is hot $K_2Cr_2O_7$ in 50% H_2SO_4 in presence of $HgSO_4$ catalyst. In practice a known volume of $K_2Cr_2O_7$ and an equal volume of conc H_2SO_4 to a relatively small volume of the waste water 1- 2mls. Add 1cm^3 of $HgSO_4$. Then reflux for 2hrs at 150°C , cool to room temperature. Fitter to determine dissolved organic matter. If not then determine dissolved total organic matter. Cl^- ion is known to react with dichromate $Cr_2O_7^{2-} + 6Cl^- + 14H^+ \implies 2Cr^{3+} + 3Cl_2 + 7H_2O$ (this can make the COD excessively high, however the addition of $HgSO_4$ takes care of this . $Hg^{2+} + 4Cl^- \implies HgCl_4^{2-}$ which is very stable thereby preventing the rxn. The determine the remaining $K_2Cr_2O_7$ by titrating with standard ferrous Ammonium sulphate solution ($FeSO_4 NH_4SO_4$ in the presence of ferroin indication (1:10 phenanthroline.) colour changes from yellow \implies green \implies dark green \implies red.

Ammonia

In good quality water NH_3 should be less than 0.01mg N/L if higher it indicates presence of organic matter which has been broken down. NH_3 is toxic to fish at about 0.5mg N/L fishes start dying. The state of ammonia depends on the pH e.g if high we have it as NH_3 , if low as NH_4^+ .

The classical method is to distill the sample adjusted to pH 10 with NaOH and collected in acid. Then determine the remains acid by titration. While in the direct method, add excess acid and back titrate with NaOH



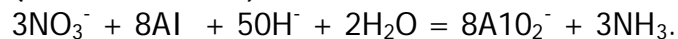
This method is only good if the ammonia level is high. On the other hand if it is very low the Nessler's method is used. (spectrophotometric). Distillation is done and the ammonia is expected as ammonia dissolved in water. Then add Nessler's reagent HgI_4^{2-} . Ammonia forms a complex with the reagent (alkaline solution of potassium tetraiodomercurate ii) $2\text{K}_2[\text{HgI}_4]^- + 2\text{NH}_3 \implies \text{NH}_2\text{Hg}_2\text{I}_3 + 4\text{I}^- + \text{NH}_4\text{I}$ an orange brown colour is formed which is measured at 400nm.

An ammonia probe (gas sensitive electrode) can also be used. The membrane allows only NH_3 to pass through. Has a wide range 10,000ppm – 0.01ppm. To the waste water plenty of NaOH is added to raise the pH, then introduce the electrode system can be standardized using NH_4Cl .

CHLORIDE

If dealing with brackish water i.e salty water with the Cl^- level high. Then it can be determined by mohr's method i.e AgNO_3 titration. For lower levels i.e trace HgNO_3 is the reagent. Medium should be pH2 – pH3 and the indicator is diphenyl carbazone which forms blue –violet complex with HgII ions $\text{Hg}^{2+} + 2\text{Cl}^- \implies \text{HgCl}_2$.

This is so stable that it can be formed if the Cl is 1-2 ppm colorimetric titration can then be done with $\text{Hg}(\text{SCN})_2 + \text{Cl}^- \implies \text{HgCl} + 2\text{SCN}^-$ this is carried out in dioxane/ water mixture saturated with $\text{Hg}(\text{SCN})_2$ Cl^- will displace SCN^- then SCN^- complexes with Fe^{3+} , this is then measured at 480nm, a bright red colour. $\text{Fe}^{3+} + 2\text{SCN}^- \implies \text{Fe}(\text{SCN})_2^-$ (indirect chloride).



Nitrate

Nitrates are reduced to ammonia by means of aluminium, zinc or Davarda's alloy (50% Cu, 45%Al, 5% Zn) in strongly alkaline medium. Since NO_3^- is present in trace level, then we use spectrophotometric method.

First reduce the NO_3^- to NO_2^- , then pass over $\text{Cd}(\text{HS})$ use Na_2CO_3 to adjust pH to 10. Then diazotise with sulphanilic acid and cleave reagent measure the azo-dye colour.

pH

This is by using a pH meter, first standardize with a buffer 4.01 (0.05MkHP) other buffers include phosphate buffer (6.85), borax buffer 9.18). if sample has a lot of suspended particles, then you may need to filter.

Total solids, suspended solids, dissolved solids

The determination of these parameters is important in order to know the kind of pre-treatment that must be carried out. Total solid is the amount of solid in the waste body. Determination is based on gravimetry, in all cases shake the solution vigorously and thoroughly before measuring out 100cm³ of the aliquot with a measuring cylinder.

Total solids

Measure 100cm³ of the aliquot into a clean dry weighed evaporating dish, then evaporate to dryness in a moisture extracting oven (105⁰c) for 2hrs cool and reweigh. Then determine total solids (mg/L).

Has not much importance as it offer no selectivity. Does not convey any specific meaning.

Suspended solids

Centrifuge 100ml aliquot and this will separate the bulk of non soluble material from the soluble materials. This can also be done by filtrations. Separate the non soluble on the filter paper, dry and weigh.

Dissolved solid

To the filtrate evaporate to dryness and weigh Express as mg/L. This gives the dissolved solid. The concentration of suspended solid in waste water is of importance in assessing the cost or mode of treatment.

Settleable solid

Wash and measure 100cm³ of the sample and allow to settled for 1hr. Siphon off the supernatant as carefully as possible so that the settled solid is not disturbed. What is left is filtered and dried.

Alkalinity

There are two types of alkalinity, phenolphthalein and total alkalinity.

CO₃²⁻ is responsible for phenol – alkalinity and both CO₃²⁻ and HCO₃⁻ for total alkalinity.

In unusual situation caustic alkalinity can be present i.e when pH > 10. PH > 9.6 < 10 pH < 9.6.

This is determined by titration with 0.01M HCl. To 100ml of sample is added phenolphthalein, then titrate to a colourless end point. To this sample then add methyl orange indicator and titrate to colour change. Assuming first titre value to be a = phenolphthalein alkalinity assuming second value titre value to be b = total alkalinity.

b-2a = HCO₃⁻ alkalinity results are expressed in mg CaCO₃/dm³.

Hardness

This is the tendency of water not to lather easily with soap. It is caused by the presence of Ca^{2+} and Mg^{2+} in water but many other cations Fe^{2+} , Fe^{3+} , Zn^{2+} also give hardness reactions. Only the alkali metals and the heavy alkali earth metals do not give hardness reaction. Hardness is usually determined by titration using EDTA since Ca^{2+} and Mg^{2+} are to be titrated other interfering cations are masked. This is done by adding Na_2S to an Aliquot of the sample and triethylamine to mask Fe^{3+} if in large amount. The pH is adjusted with ammonium buffer (57cm^3 of concentration NH_3 solution + I made up to 100cm^3). Titrate with 0.02M EDTA using solochrome black T as indicators. Then calculate total hardness expressed in $\text{mg CaCO}_3/\text{dm}^3$. For Ca only buffer it at pH 12 with NaOH (1M) at this pH Mg^{2+} is masked, then use murexide indicator and titrate as Ca^{2+} ONLY.

WASTE WATER TREATMENT

Industries use huge quantities of the nations waters and are the major factor in the continental increase of water pollution. In fact in terms of BOD the waste generated by industry is equivalent to that generated by a population of over 360 million of people. Pollutants discharged include metals like chromium, nickel, acids like sulphuric acid, HCl , petroleum wastes, phenols, cyanide etc. These wastes degrade the quality of receiving waters by imparting tastes, odours, and colour and through excess mineralization, salinity, hardness and corrosion. The variety of the inorganic and organic compound present a serious liquid waste water treatment control problem because of its pollution and toxicity effects. Conventional waste water treatment technology which is often barely adequate for existing waste types offer less promise of providing the type and degree of treatment which is needed in the near future, therefore industrial pollution control technology must be developed to achieve effective and economical control of pollution from varied industries.

Technically it is feasible to return the wastes involved in the transport of domestic and industrial waste to almost any desired level or purity. The desired or required level of purity of treated waste water should be determined by possible dilution in receiving waters and uses that are to be made of these waters, but practically at the present level of development of waste water technology, economic consideration limits the treatment of wastes to levels of purity below those desirable and technically attainable. Waste water treatment is usually accomplished in a series of more or less discrete stages. These stages are referred to as preliminary a) primary, b) secondary and Tertiary treatment.

Preliminary treatment

This involves the removal of most of the floating debris such as rags, paper, and wood. The sewage flows through a screen. The screen may vary from coarse to fine, consisting of parallel steel or iron bars with opening of about 2-4 inches to smaller opening. Some treatment plants use comminutors which catch and cut or shred the heavy solid material. After the sewage has been screened it passes into a grit chamber where sand, grit, cinders and some stones are allowed to settle out.

Primary treatment: after the preliminary treatment there are still some suspended solids, these are minute particles of matter and are removed by passage of the screened waters through a sedimentation tank having a retention period of several hrs in which much of the suspended matter settles out forming the primary sludge. At this point, the sludge free effluent can be chlorinated to remove or kill harmful bacteria before it is discharged into streams.

Secondary treatment

Secondary treatment refers to the removal of most of the colloidal and dissolved organic material present in the waste. The principle of biological oxidation and flocculation are used in which the activated sludge or biological filtration can be done (trickling filter or bacterial beds)

Activated sludge process.

In this process the settled sewage is mixed with flocculent suspension of micro-organisms (activated sludge) and aerated in a tank for several hrs. During this time most of the organic matter is removed from the sewage by flocculation, adsorption or oxidation. The sludge which increases in amount by 5 to 10% during the aeration stage is removed from the purified effluent in another [a further] sedimentation tank. Most of the sludge is returned to the inlet of the aeration tank, the excess being disposed of by returning it to the inlet of the primary sedimentation tank.

Biological filtration:-In this process the settled sewage is distributed over the surface of a bed of suitable medium. They are essentially beds of stones provided with apparatus for distributing the wastes over the surface and with a drainage system for ventilation and effluent removal. The beds are usually circular in shape making the distribution of the waste over the surface possible by means of simple rotatory devices powered by motors. The depth of the bed is about 6ft. The effluent from the filtration will contain suspended organic matter which is removed by sedimentation. The effluent is comparable in quality with that produced by the activated sludge treatment. Because of its simplicity this method is preferred for smaller sewage works while the activated sludge process which occupies less space and more amenable to control is used in larger works.

Tertiary treatment

This is more or less the chemical treatment of the waste waters and involves the addition of some chemicals with the aim of removing phosphorous, organic, and nitrogen. However a disadvantage of addition is the increase in total dissolved solids. The chemicals commonly used are Alum. $\text{Al}_2(\text{SO}_4)_3 \cdot 18\text{H}_2\text{O}$. $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$. hydrated lime $\text{Ca}[\text{OH}]_2$, ferric chloride and ferric sulphate $\text{Fe}_2(\text{SO}_4)_3$. The addition of aluminium sulphate to the effluent from the activated sludge process precipitate the phosphate. The resulting precipitate is flocculated by gentle stirring and removal in a final sedimentation tank. In this way the phosphate content of the effluent may be reduced to less than 1mg/L. Also the alum floc removes some of the residual suspended and dissolved organic matter reducing the BOD of the final effluent to about 1mg/L.

Large amount of lime may also be added to remove phosphate as the hydroxyapatite $\text{Ca}_5\text{OH}(\text{PO}_4)_3$. The lime can also be use in removing ammonia, it raises the pH – to about 10.5 and aids the removal of ammonia by air stripping.

Sludge treatment

Of the organic matter entering the sewage works about half is converted to sludge, the disposal of which represents one of the major problems in sewage disposal as at presently practised. In the past sludge was spread on drained beds of sand until dry enough to be lifted manually and carted away. This process which needs a considerable area of land depends to a large extent on weather conditions and can be offensive. Sludge is increasingly being disposed by chemical engineering method such as filtration in a press or rotary drum filter, followed by incineration. Sludge may be treated at high temperature and pressure ($220 - 360^\circ\text{C} \times 100\text{atm}$) to yield a readily dewatered sludge but also a highly polluting liquid which must be given further treatment is produced. The use of anaerobic digestion process has been used, this involves maintaining the sludge at about 30°C for about 30 days during which time about half the organic matter is converted to methane. The resulting thin sludge is odourless and can be disposed of by direct application to grassland or dried on drained beds. The methane has been used in some plants for fuel in diesel engines to generate electrical power need to operate the works.

It has also been suggested that sewage sludge should be returned to land as fertilizers, this has been done in some countries however as sludge many contain toxic materials or certain organisms pathogenic to man or to animals, the use of sewage sludge as a fertilizer must always be viewed with some reservation.

Water reclamation

Effluent from sewage works is subjected to several further stages of treatment (including storage, chemical treatment and carbon adsorption) and is used to supplement the water obtained from a river source the proportion of reclaimed water being about 1/3

These problems are of particular significance with the direct reuse of sewage effluent for domestic purpose.

- A Viruses: at most water works chlorination is employed to ensure absence of pathogenic bacteria.
- B However the best solution is to remove as much organic matter as possible i.e passage through regular activated carbon columns.
- C Organic matter – lack of detailed knowledge of the long term effects of ingesting organic matter contained in sewage effluent provides a further reason for removing a large proportion of such materials

Inorganic constituents:- while the suspended and dissolved organic matter in sewage is of paramount importance, it must be noted that in the course of use, inorganic materials also are added to the water and many of these are not removed or are incompletely removed in the course of sewage treatment. Removal of these inorganic ions would require processes of the kind developed for desalination of sea water e.g. electro dialysis, reverse osmosis or even distillation.

Nuclear energy irradiation

Radioactive materials emit α -, β and gamma rays. Low level man-made radiation comes from X-rays, radioactive materials and electronic devices including television sets. Medical uses constitute 94% of all man made radiation and 30% of all radiation to which the average individual is exposed. High doses of radiation have been shown to be related to incidence of leukemia and other cancers, and low level radiation may cause genetic damage and increase natural mutation.

Nearly all the of the radio nuclides escaping into the environment do so at the site of nuclear fuel reprocessing for example the long island incident in American and the Chernobyl/nuclear disaster in the USSR. The significant effluent discharged are krypton 85 and tritium which move into the air and water system.

Radioactive waste is divided into low level and high level wastes. Materials with low levels of radioactivity are the gaseous, liquid and solid wastes from reactors and other nuclear facilities. These are packaged and buried in licensed burying grounds. High level wastes, the by products of reprocessing of used fuel elements from nuclear reactions will become an increasing problem uses of radiation sources. Technology has been developed to reduce the high level liquid waste to solid from thereby reducing the final volume to one-tenth of the original liquid material. Nevertheless, dumping in the sea, storing in salt mines and other methods of disposal all carry with them hazards because of the radioactive materials very long half life.

A case worth of mention is the waste dumped as at Koko in Bendel state. In which Italians collected waste from industries at a profitable price (the industries in the disposal in their country) and dumped this waste in Nigeria without any regard to the environment consequence and hazard. The unfortunate incident is that even the Nigerian government has no law prohibiting the unregulated disposal of the waste materials and as such by law all people connected with the incident can not be prosecuted.

Noise pollution

Noise, unwanted sound is one form of environmental contamination that disappears when the same is turned off. Yet it is a form of environmental degradation and has implications for health that may be as serious as air or water pollution. It can change man's physiological state by speeding up pulse and respiratory rates, and it can impart hearing either permanently or temporarily. There is medical evidence that noises can cause heart attack in individuals with existing cardiac injury and the continued exposure to loud noises could cause chronic effects as hypertension or nuclear. Noise is measured in decibels in range from barely audible to shatteringly loud. The rapid growth of air transportation and development of jets has created a major noise problem

millions of people living near enough to air ports are subject to intense aircraft noise. Another one noise that cannot be eliminated is the sonic boom, created by planes flying faster than the speed of sound. Sonic boom is a sudden pressure disturbance or shock wave in the air. These have been known to shatter glass, twist metal window frames and cause rock slides.

Developed countries have legislation limiting noise pollution. Curfew provision often certain particular noise making activities or operation during certain days or hours. An inferring source of noise pollution in Nigeria is the unlimited and unpaid for music that is imposed on people in the market place and the unsolicited from man made alarm clocks in the mane of churches and mosque with their attendant vigil practices.

Technological methods for reducing industrial and city noises include machines much lower noise that can cut through asphalt and concrete than conventional tack hammers, sound absorbing materials on plant ceilings and walls, and sound absorbing partitions around noise equipment. For high level noise work situations, personal protective devices include plastic-form earmuffs and ear plugs made of rubber, plastic or disposable materials such as wax – impregnated cotton.