L.2. Stimulation of indigenous microbial growth:

The biodegradation of organic compounds including hydrocarbons is associated with microbial growth and metabolism and three fore any of the factors affecting microbial growth will influence degradation. If the m.o cannot use the pollutants as their sole source of energy and carbon skeletons, some other growth substrate will be needed. The mo. may also require supplementation with nitrogen and phosphorus as demonstrated in marine situations.

The following factors can affect the growth of m.o:-

- Presence of other biodegradable organic material.
- Presence of nitrogen and phosphorus-containing inorganic compounds.
- Oxygen levels,
- Temperature * Ph * of water, soil moisture.
- Number and type of m.o present, and * presence of heavy metals or salt.

The aerobic degradation of hydrocarbons is faster than the anaerobic process, so that a supply of oxygen will be needed to maintain aerobic conditions if rapid degradation is required. A soil with an open structure will encourage oxygen transfer and a waterlogged soil will have the reverse effect.

The temperature affects microbial growth, at low temp.

Threat of degradation will be slow. Nutrient addition to soils at temp. Of 4-10 c^{o} has been shown to have little effect as the low temp. Reduces growth to such a low level. The addition of nitrogen- and phosphate- containing fertilizer greatly increases the degradation of contaminants and hydrocarbons. The PH of the soil will affect both the growth and the solubility of the compound to be degraded.

In some cases hydrocarbon contamination may also be associated with high levels of heavy metals, which may inhibit microbial growth deepen- ding on the concentration and type of metals.

The rate of degradation of xenobiotic in soil and water is also dependent on the presence of mo. with the enzymatic capability to degrade the polluting molecules.

Bioaugmentation: Is the addition of selected organisms to contaminated sites in order to supplement the indigenous microbial population and speed up degradation. In general, introduced bacteria decline rapidly after introduction and their growth is poor. This decline in introduced bacteria is probably due to their failure to compete with the indigenous population.

Bioaugmentation has been considered for crude oil removal for some time, Bioaugmentation can be effective in the laboratory but in the field, this may not be true.

The fate of introduced organisms has been followed in the environment using molecular techniques such as DGGE and TGGE analysis of 16S rDNA fragments. Other possible causes for bio augmentation failing are.

- Rarely, a limiting population of micro-organisms,
- The concentration of the contaminate not sufficient to support growth,
- The environment may contain substances that inhibit growth,
- Predation by protozoa,
- The added micro-organisms may use some other substrate in the environment, and
- The introduced micro-organisms may not be able to penetrate the soil to get to contaminant.

More recently, bioaugmentation has had more success using activated soil rather than pure culture. The activated soil are those containing indigenous microbial populations recently exposed to the contaminant. The technique has the advantages that it introduces naturally developed populations not cultured outside the soil, and that it is a mixed population. This technique shown to enhance the degradation of pentachlorophenol, atrazine, and chlorobenzoate.

Bacteria are not the only micro-organisms used for bioaugmentation, fungi have also been used as they can grow under low-water condition, are present in both soil and water, and the hyphae can penetrate the soil, making the pollutant available.

A Number of fungal inoculate have been used to bio augment soils contaminated with PCP and this removed 80-90% with 4 week.

A selected strain of *Methylosinus trichosporium* was used in afield study where the organism was selected for its high trichloroethylene (TCE) transformation rate under low-copper conditions. Once injected 50% of the cells attached to the soil, forming a biofilter that was efficient for the trans formation of TCE.

A fungus Absidia Cylindrospora has been used to degrade fluorine, and *Cladophialophora* sp. Strain TI degraded BTEX.

Phytoremediation: Is the use of plants for the removal of contaminants and metals from soil and water or to render them harmless. The use of plants for bioremediation provides an aesthetically pleasing option, has minimal disruption to topsoil, is effective with low levels of mixed contamination, offers the possibility of recovery of metals, and is inexpensive, some so 50-80% less than alternatives.

The disadvantages are that the process can be slower than other bioremediation methods, taking a number of growing season, the contaminants may reduce the plant growth considerably, and that the plants, which a accumulate pollutants, constitute a hazard to wildlife and food chains.

A plant used for phytoremediation needs, to be tolerant of the pollutant grow rapidly with a high yield per hectare, accumulate the metal in harvestable parts, have a profuse root system, and have a high bioconversion factor.

The bioconversion factor is the concentration of pollutant in the plant concentration of pollutant in the plant compared with that in the environment.

- ❖ Most plants have a bioconversion factor of less than 1.
- ❖ The plants that cumulate high concentrations of metals are known as hyper accumulators and can accumulate 50-100 times more metal than normal plants.

There are about 400 species that are hyper accumulators and the levels accumulated are 1000 mg/kg for Zn and Mn, 1000/kg for Co, Cu, Ni, and As, and 100 mg/kg for Cd. (Table).

High accumulators must be able to tolerate high levels of in their roots and shoots and this possible by the concentration of the metal in the vacuole or by chelation of the metal. The plant must also be able to take up the metal from the soil at high rates and transfer the metal from the roots to the shoots at high rate.

Hyper accumulation involves quantities of metal can be stored. One of the most studied mechanisms for metal sequestration is by the peptides metallothioneins and phytochelatins. The metal bind to the organic sulphur in cysteine, which makes up most of these peptides.

Phytoremediation can be divided into a number of processes.

- ❖ Phytoremediation (phytoaccumulation): the removal of contaminants and metals from the soil and their storage in the plant.
- ❖ Phytodegradation: the uptake and degradation of organic compounds.
- ❖ Phytovolatilization: the volatilization of pollutants into the atmosphere.
- ❖ Phytostabilization: the transformation of one species of molecule into a less-toxic species (Cr^{6+} to Cr^{3+}) or the reduction of mobility.
- The removal of pollutants from the atmosphere, gaseous contaminants there are a number of related processes which involve aquatic.

Plants or associated micro- organisms. The roots of plants are asocial- acted with a number of micro- organisms, known as the rhizophere.

- Rizofiltration: the uptake of metals or degradation of organic compounds by the micro- organisms making up the rhizosphere.
- Rhizostimulation: the stimulation of plant growth by the rhizosphere by providing better growth conditions or a reduction in toxic compounds.
- Phycoremediation: the use of micro- and macroalgae to remove metals and organic pollutants.

Phytoextraction: is the uptake of metals and organic pollutants by the roots of plants and their storage in root, leaves, and stems. Plant roots constitute a very large area containing high-affinity chemical receptors. Example of pollutants that can be removed are heavy metals, TNT, TCE, and BTEX.

Sunflower roots can concentrate uranium 30000- fold from contaminated water, and fern *Dicropteris Dichotoma* has been shown to accumulate rare earths La, Ce, Pr, and Nd.

Phytodegradation: organic compounds can be degraded by plants or sequestered in the vacuole for degradation later.

In general, organic compounds can undergo a number of change:

Partial transformation into a less-toxic compound, partial degradation and subsequent sequestration, and complete degradation.

The plant degradation of herbicide, pesticides, and the metabolism of TCE, TNT, PCBs and other chlorinated compounds.

Plants contain aliphatic dehalogenases capable of degrading TCE.

Plants can degrade TNT, RDX, and nitroglycerine to carbon dioxide, ammonium and nitrate as they contain nitroreductases, dehalogenaseses and laccases.

Phytovolatilization: some plants can convert metals ions to more volatile species in a process known as phytovolatiliza*tion*, which can reduce toxicity and aid disposal through the stomata.

TCE can be volatilized by poplar, methyl-butyl ether (MTBE) by eucalyptus, selenium converted to dimethylselen-ide in Indian mustard, and methyl mercury converted to mercury vapour by tobacco.

In addition, micro-organisms accociated with plant roots can convert Hg^{2+} into volatile Hg.

Phytostabilization: Green plants used to stabilize soils, prevent dispersion of metal contaminated soil, and reduce metal mobility by rhizosphere adsorption and precipitation. Inadditation heavy metals cannot be degraded but they can be made more water soluble, less toxic, or insoluble so that they precipitate. Certain metals and organic contaminants can be concentrated on orin the root zone with out degradation. For example the toxic Cr^{6+} can be converted by bacteria into the less toxic Cr^{3+}.

Removal of pollutant from the atmosphere: Nitrogen dioxide is an atmospheric pollutant and is one component of the nitrogen oxides, collectively known as NO_x .The Compositae, Mytaceae, Solanacea, and Salicaceae are the texa that appear to take up nitrogen dioxide.

Rhizofiltration: is the removal of contaminants from flowing water by plant roots**,** which can be performed by the roots or the micro-organism associated with the roots (rhizosphere), or the two combined. The contaminants removed can include organic compounds as well as metals.

The use of construicted wetlands has been investigated for nutrient removal, pathogen reduction, and metal uptake and stabilization.

Wetland plants have a large population of micro-organisms associated with their roots and it is this microbial population that is responsible for the sequestration of heavy metals and breakdown of the organic compounds.