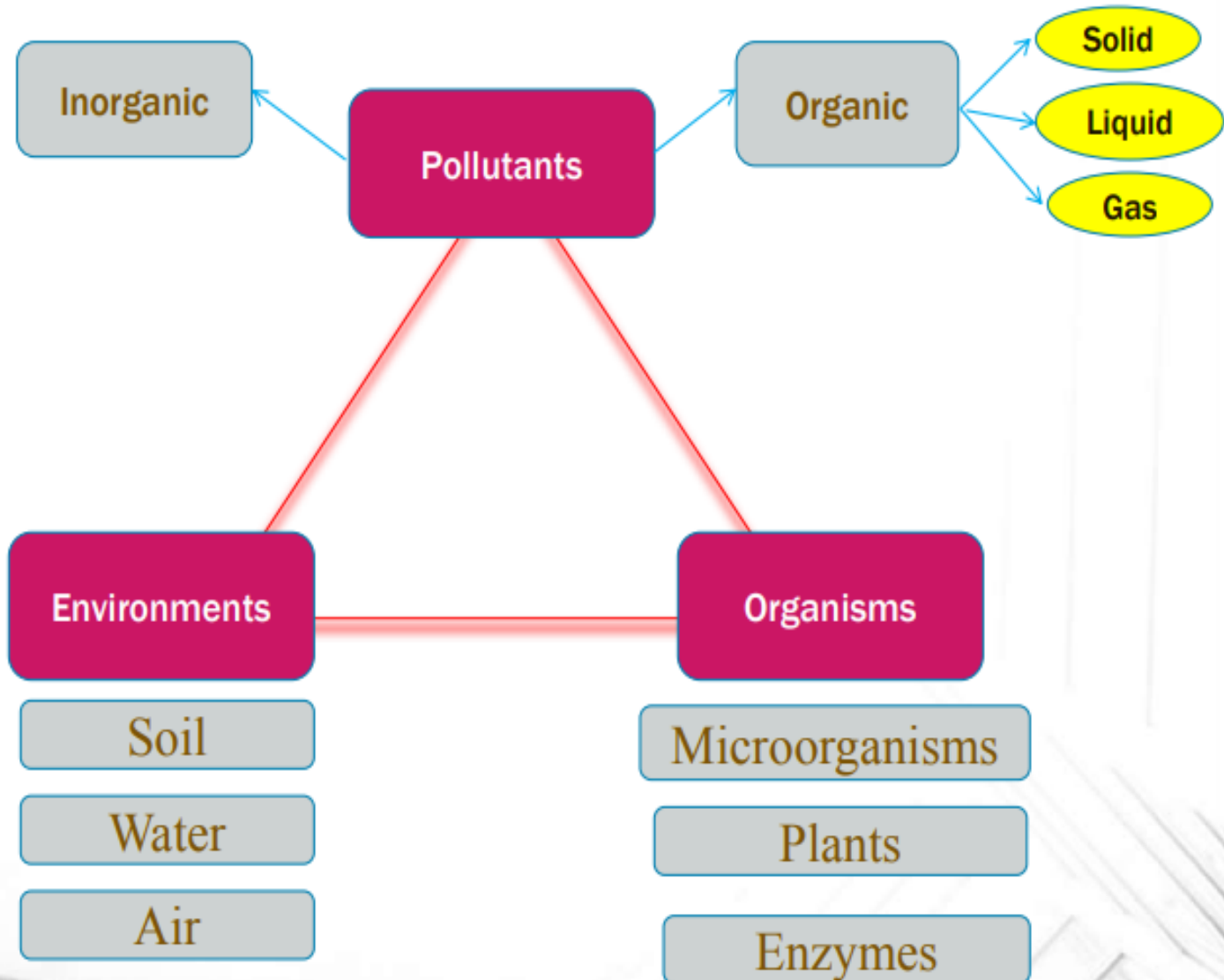


Bioremediation

- “Bioremediate” means to use biological organisms to solve an environmental problem such as contaminated soil or water.
- Bioremediation is a waste management technique that involves the use of organisms to remove or neutralize pollutants from a contaminated site.
- According to the EPA, bioremediation is a “treatment that uses naturally occurring organisms to break down hazardous substances into less toxic or non toxic substances”.

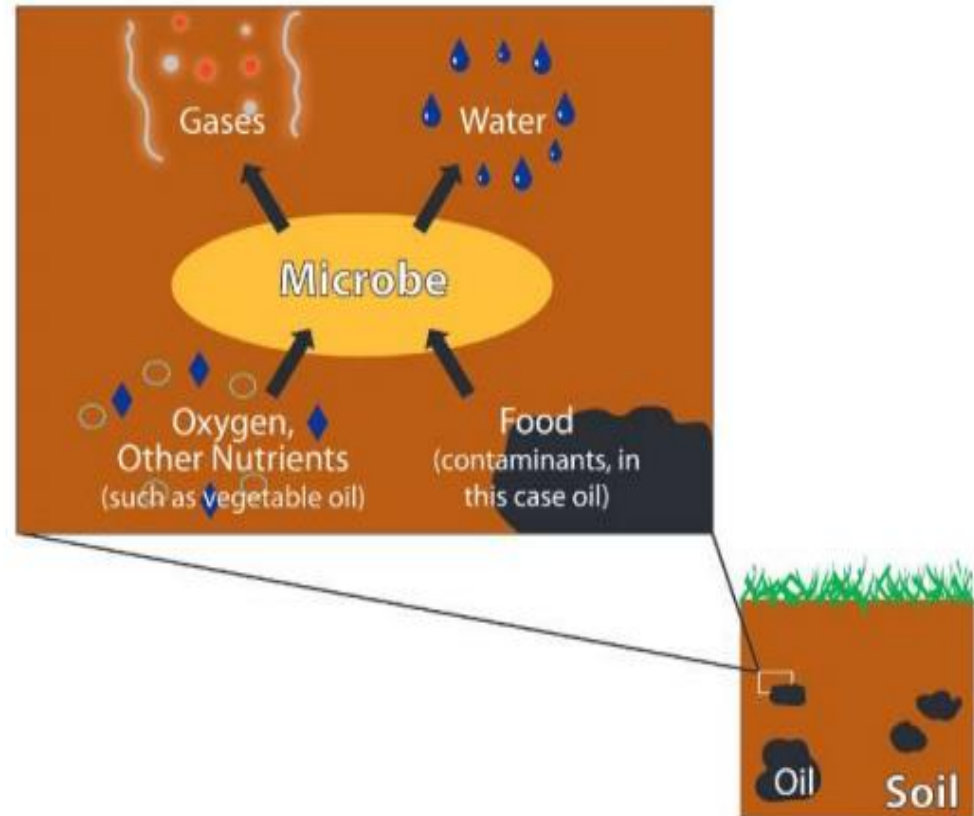
- Bioremediation is the a biological degrading processes for the treatment of contaminated soils, groundwater and/or sediments, relying on microorganisms including bacteria and/or fungi to use the contaminant(s) as a food source with resulting degradation of the contaminant.
- Microorganisms used to perform the function of bioremediation are known as **bioremediators**.
- Bioremediation is one of the most economic remedial techniques presently available for treating most organic fuel based contaminants such as coal tars and liquors, petroleum and other carcinogenic hydrocarbons such as benzene and naphthalene, and some inorganics.

BIOREMEDIATION IS A TRIPLE-CORNERS PROCESS



How Does It Work?

- Waste material is examined & certain bacteria are isolated based on their efficacy at digesting and converting the waste.
- Indigenous or local bacteria is to be used!
- The bacteria then go through several steps of cultures and process for performance testing.
- The suitable bacteria are placed back in the waste environment.
- They grow & thrive & in the process digest & convert the waste into Carbon dioxide & water.
- The right temperature, nutrients, and food also must be present.
- Conditions may be improved by adding “amendments.”



Microbe takes in oil, oxygen, and nutrients and releases gases and water.

ESSENTIAL FACTORS FOR MICROBIAL BIOREMEDIATION

Factor

Desired Conditions

Microbial population

Suitable kinds of organisms that can biodegrade all of the contaminants

Oxygen

Enough to support aerobic [biodegradation](#) (about 2% oxygen in the gas phase or 0.4 mg/liter in the soil water)

Water

Soil moisture should be from 50–70% of the water holding capacity of the soil

Nutrients

Nitrogen, phosphorus, [sulfur](#), and other nutrients to support good microbial growth

Temperature

Appropriate temperatures for microbial growth (0–40 °C)

pH

Best range is from 6.5 to 7.5

Types of bioremediation

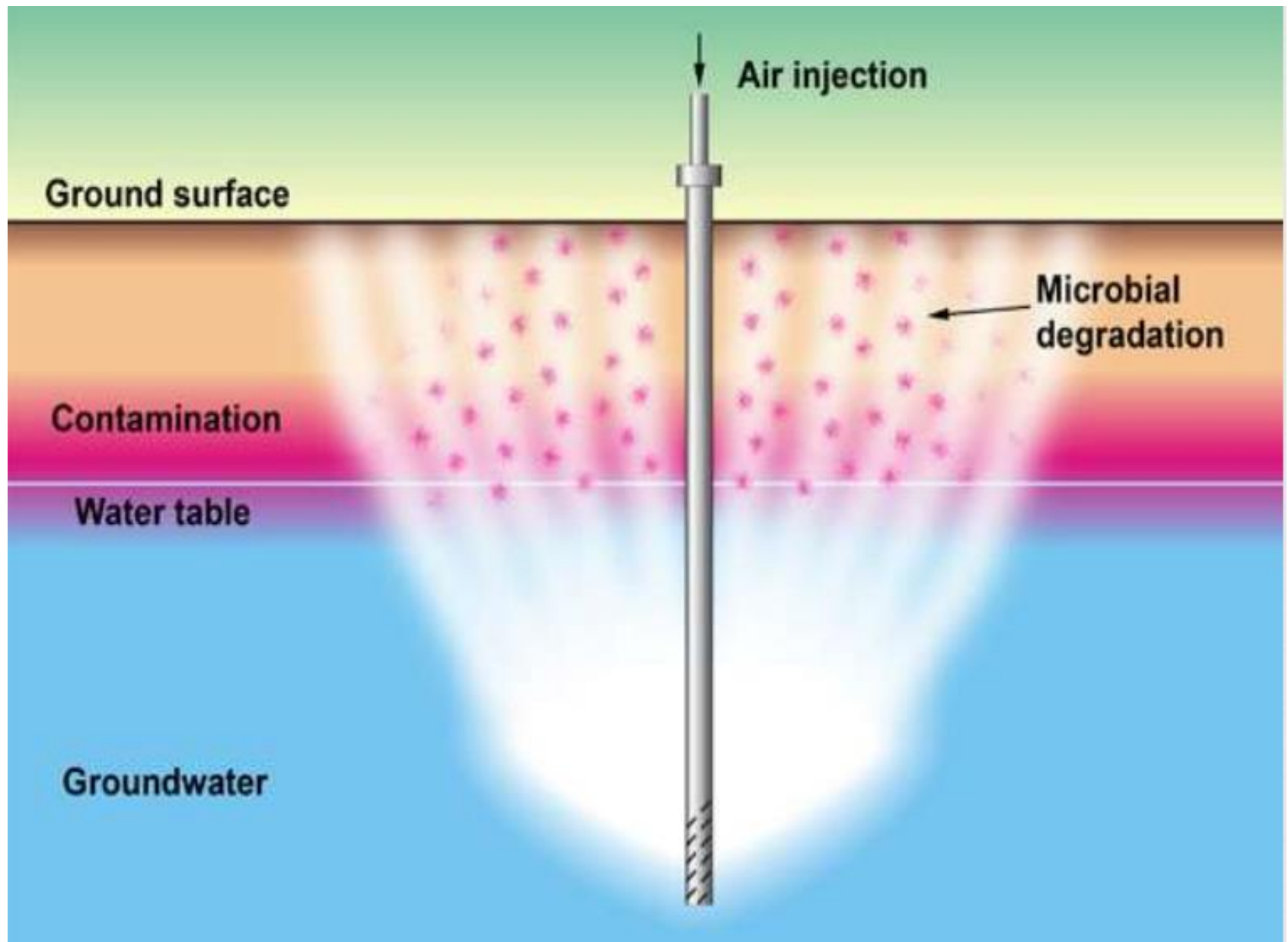
- Two types :
 1. In – situ bioremediation Cleaning up of contamination at the site where it occurred.
 2. Ex – situ bioremediation Cleaning up of contamination out of site.

In – situ bioremediation

- There are two main types of in situ bioremediation:
- intrinsic bioremediation and accelerated bioremediation.
- Intrinsic bioremediation uses microorganisms already present in the environment to biodegrade harmful contaminant.
- In accelerated bioremediation, either substrate or nutrients are added to the environment to help break down the toxic spill by making the microorganisms grow more rapidly.

Methods involved in In – situ bioremediation

- **BIOSPARGING :**
- Biosparging involves the injection of air under pressure below the water table to increase groundwater oxygen concentrations and enhance the rate of biological degradation of contaminants by naturally occurring bacteria.



Biostimulation

- Involves supplying oxygen and nutrients by circulating aqueous solutions through contaminated soils to stimulate naturally occurring bacteria to degrade organic contaminants.

Bioventing

Bioventing is the most common in situ treatment and involves supplying air and nutrients through wells to contaminated soil to stimulate the indigenous bacteria.

Bioaugmentation

- Bioaugmentation is another Bioremediation method which frequently involves the addition of microorganisms indigenous or exogenous to the contaminated sites.

Ex – situ bioremediation

- Ex situ bioremediation is only used when necessary because it's expensive and damaging to the area, since the contaminated land is physically removed.
- **Landfarming** is a simple technique in which contaminated soil is excavated and spread over a prepared bed and periodically tilled until pollutants are degraded.

- **Composting** is a technique that involves combining contaminated soil with non-hazardous organic compounds such as agricultural wastes. The presence of these organic materials supports the development of a rich microbial population and elevated temperature characteristic of composting

Bioremediation of heavy metals

- Heavy metals cannot be destroyed by microbes.
- But can be transformed from one oxidation or organic state to another.
- This may result in either of the following result (i) more water soluble , (ii) inherently less toxic, (iii) less water soluble , or (iv) volatilized

- **Bioleaching :**

- Some micro organisms can produce metal leaching organic acids. E.g. : Thiobacillus sp. are capable of producing sulphuric acid which can form metal chelates.
- Many microorganisms produce siderophores, iron complexing molecules, some of which have high affinity for heavy metals and form metal chelates. e.g. : Pseudomonas aeruginosa for Cu and Zn

- **Biosorption :**

- Metabolism – independent sorption of heavy metals to biomass.
- Can use low cost waste biomass sources such as spent brewery yeast.
- Some bacteria (e.g. : *Alcaligenes eutrophus*) can also adsorb metals like Cd and Zn.

- **Bioimmobilization :**

- Immobilize metals by precipitation.
- Microbes precipitate heavy metals by changing their valence.
- The process is called Enzyme - Catalyzed Transformation.
- E.g. : U (VI) is highly soluble.
- But U (IV) formed through enzymatic reduction is highly insoluble.
- Also include formation of insoluble metal phosphates and sulphates (biomineralization).

Bioremediation of pesticides

- Pesticides are Persistent Organic Pollutants (POPs).
- Several methods are employed in bioremediation of pesticides.
- **Degradation by microbes :**
- Some pesticides are readily degraded by microbes.
- They use the organic chemicals in pesticides for growth and reproduction.
- E.g. : genera of Flavobacterium, Pseudomonas, Rhodococcus

- **Biotransformation :**

- Oxidation or reduction, hydrolysis etc. of pesticide by enzymes present in different bacteria, fungi, plants can transform it into less or non – toxic compounds.

- **Leaching :**

- Since many of the pesticides can be solubilised are soluble , they can be removed via leaching.

- **Phytoaccumulation and phytoextraction :**
- Crop plants like Brinjal, spinach, radish , rice can bio accumulate pesticides like DDT and benzene hexachloride.
- **Bioremediation of oil spills:**
- Oil spills threaten public health and safety by contaminating drinking water, causing fire and explosion hazards, diminishing air and water quality, wasting nonrenewable resources.

Methods involved in bioremediation of oil spills are:

- **Seeding with naturally occurring microbes –**
- Many microbial genera like *Nocardia*, *Bacillus*, *Streptomyces*, *Coryniforms* and 70 others are known to contain species that can degrade petroleum components.
- **Environmental modifications –**
- Factors like oxygen supply , nutrient concentration, temperature, pH, pressure, salinity etc. of the contaminated area is modified in favor to the activity of degrading microbes.

Bioremediation of plastics

- **Degradation using endophytes:**
- Several plastics contain the same chemical bond that are found in natural plant polymers.
- Endophytes , organisms that symbiotically grows inside plants, can degrade these similar bonds in plastics.
- e.g. : Endophytic fungus *Pestalotiopsis* microspore can degrade plastic polyester polyurethane.

- **Degradation by microbes :**

- Many microbes can degrade plastics and use it as energy or carbon source.