Biodegradation

**Biodegradation**

‘’A process by which microbial organisms transform or alter (through metabolic or enzymatic action) the structure of chemicals introduced into the environment’’

**FACTORS AFFECTING CONTAMINANT BIODEGRADATION**

Biological Factors

Rates of contaminant degradation

The rate of contaminant degradation is dependent on the concentration of the contaminant and the amount of “catalyst” present. The amount of “catalyst” present represents the number of organisms able to metabolize the contaminant as well as the amount of enzyme(s) produced by each cell. Any factor that affects concentration of contaminant, the number of microorganisms present or the expression of specific enzymes by the cells can increase or decrease the rate of contaminant degradation.

**Extent of contaminant degradation**

The extent to which contaminants are metabolized is largely a function of the specific enzymes involved and their ‘’affinity” for the contaminant and the availability of the contaminant. The “affinity” of an enzyme is an inherent property of the enzyme that is determined by its structure. This “affinity” varies among different enzymes and even among enzymes with identical functions produced by different populations of microorganism.

**General indicators and microbial physiology**

Carbon: nitrogen: phosphorus (C:N:P) ratios Microbial cells are comprised of carbon (C), nitrogen (N) and phosphorus (P) at an average C:N:P ratio of 50:14:3. Sufficient amounts of these nutrients must be available in a usable form and in proper proportions for unrestricted microbial growth to occur.

Nutrient availability Organic compounds serve as sources of carbon and estimated based on concentrations of total organic carbon (TOC). TOC tends to overestimate the carbon available to microorganisms. In general, the total number of organisms present is proportional to the amount of carbon available.

The total amount of nitrogen available to microorganisms in the form of organic nitrogen, ammonia (NH4+), nitrate (NO3–), and nitrite (NO2–) significantly influence the rate of contaminant degradation. A C: N ratio of less than 40 suggests that adequate nitrogen is present.

Microorganisms utilize both soluble inorganic (orthophosphate) and organic forms of phosphorus. Phosphorus limitation occur when the C: P ratio is more than 120:1 and a C: N: P ratio of 100:10:1 is considered optimal. High concentrations of calcium (Ca) and magnesium (Mg) precipitate phosphates reducing the amount available for microbial metabolism.

Terminal electron acceptors

Table: A wide range of organic and inorganic compounds used as terminal electron acceptors by microorganisms.

Electron acceptor Chemical symbol Process

Oxygen O2 Aerobic respiration

Nitrate and nitrite NO3 & NO2 Aerobic respiration (denitrification)

Ferric iron Fe+3 Anaerobic respiration Manganese Mn+4 & Mn+2 Anaerobic respiration

Sulfate SO4–2, S2O3–2 & SO3–2 Anaerobic respiration (sulfate reduction) Organic compounds Many Fermentation Carbon dioxide CO2 Methanogenesis

In aerobic processes, oxygen is the terminal electron acceptor. The rate of contaminant degradation by aerobic processes is often limited by the availability of oxygen, which is supplied by diffusion from the atmosphere or dissolved in and transported by water. The diffusion of oxygen from the atmosphere into soil and water is slow and the solubility of oxygen in water is low as oxygen is depleted, other organic and inorganic compounds are used as terminal electron acceptor.

**Temperature**

Temperature directly influences the rate of biodegradation by controlling the rates of enzyme catalyzed reactions. The rate of biodegradation is decreased one-half for each 10oC decrease in temperature. Rates of biodegradation are generally exceedingly low at 0oC. higher soil temperatures result in higher microbial metabolic activity and higher rates of biodegradation up to a maximum of about 65oC.

**Moisture**

Moisture (water) influences the rate of contaminant metabolism because it influences the kind and amount of soluble materials that are available as well as the osmotic pressure and pH of terrestrial and aquatic systems. soil moisture content should be between 25–85% of the water holding capacity, and a range of 50–80% is optimal for biodegradation.

**pH**

Soil pH is a measure of the acidity or alkalinity of water. Biodegradation occur under a wide-range of pH; however, a pH of 6.5 to 8.5 is optimal for biodegradation in most aquatic and terrestrial systems .Soil pH affect the availability of nutrients. For example, the solubility of phosphorus, an important nutrient in biological systems, is maximal at a pH value of 6.5 and decreases at pHs that are either higher or lower than this value.

**Environmental Factors**

Geologic and hydrogeologic factors

**Adsorption and absorption**: The binding of an organic compound to the surface of a solid is called adsorption. The extent of adsorption that occurs is determined by the relative affinity of the compound for a solid matrix, the surface area of the matrix and the volatility or solubility of the compound in water.

Absorption is an analogous process wherein a contaminant penetrates into the bulk mass of the soil matrix.

Both adsorption and absorption reduce the availability of the contaminant to most microorganisms and the rate at which the chemical is metabolized is proportionately reduced.

Contaminant migration in groundwater:

Contaminant migration within an aquifer is controlled by many chemical and physical properties of the contaminants, and of the hydrogeologic setting in which they are found. Hydraulic conductivity is one of the primary aquifer characteristics. Particle size and rock type affect hydraulic conductivity, with smaller particle size, or increasing density of rock, resulting in lower rates of hydraulic conductivity. Typically, hydraulic conductivities for soils in the range of 10-5– 10-3cm/ sec is convenient for biodegradation process.

Other factors are dispersion and diffusion of contaminants. Dispersion is the mechanical mixing and spreading of the contaminants that occurs within the aquifer and includes diffusion, the movement of contaminants along a concentration gradient due to their kinetic energy.