Soil structure (constituents)

In our study of soil composition, we will start from general composition of soils in terms of soil profiles and gradually approach the particulars of mineral composition. We will therefore conveniently subdivide the problem, in sequential order of scale from macroscopic to microscopic, into the following categories:

1. Soil formation and macroscopic composition in terms of soil profiles
2. Phase composition in terms of solid, liquid, organic, and gas phases
Present in the soil mass
3. Solids composition and classification in terms of the relative sizes of particles
4. Mineral composition in terms of basic elements

1- **Inorganic Components of Soil**

The inorganic components are subdivided into crystalline and non-crystalline types. Inorganic matter typically constitutes the majority of the soil's components. The inorganic portion of soil consists largely of aluminosilicates. Typically, feldspar minerals comprise 60% of an average inorganic rock.
Inorganic minerals are classified as A) primary minerals (derived from weathering of rock) and B) secondary minerals (transformed as fine particles). Primary minerals comprise a major portion of the sand and silt fraction

2- **Organic Components of Soil**

Soil organic matter consists of nonhumic and humic substances. The nonhumic substances include polysaccharides, proteins, fats and low molecular weight organic acids. Humic substances represent most of the organic matter in soil. On the basis of their different solubility in acid or base, humic substances are differentiated into fluvic acids, humic acids, and humins

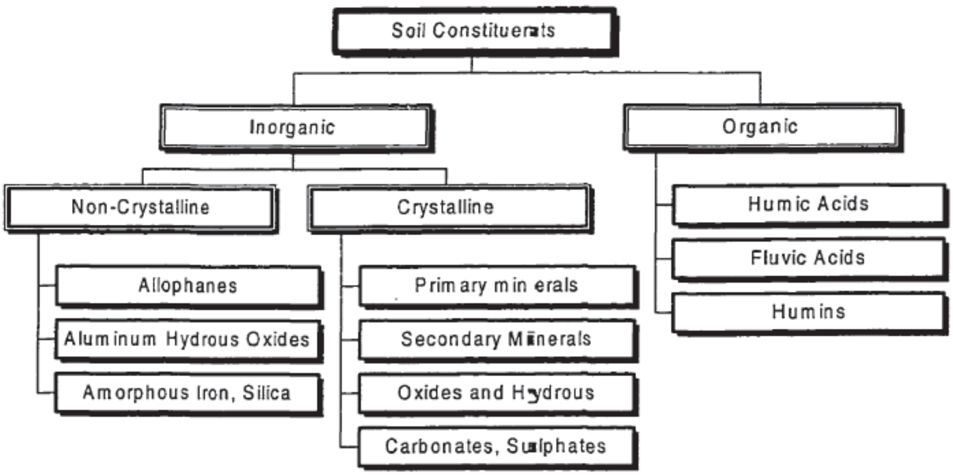


Figure 2.1 Natural soil constituents (focus on solid phase)

Soil Composition

Soils are complex media composed of solids, liquid, and gaseous phase. Soil, whether saturated or unsaturated, are not completely mixed as most aquatic system are, so soil and ground contamination tends to be heterogeneous. Important soil properties that relate to hazardous waste management include the 1) Soil textural class 2) Soil mineralogy 3) bulk density 4) porosity 5) organic carbon content.

Soils are composed of four major components:
An inorganic (or mineral) fraction, organic matter, water, and water, and air. The proportion of each of four components, with some typical ranges is shown in figure.

For example: water saturated soils of wet lands contain less air but more water, and forest soils contain higher levels of organic matter compared to desert soils.

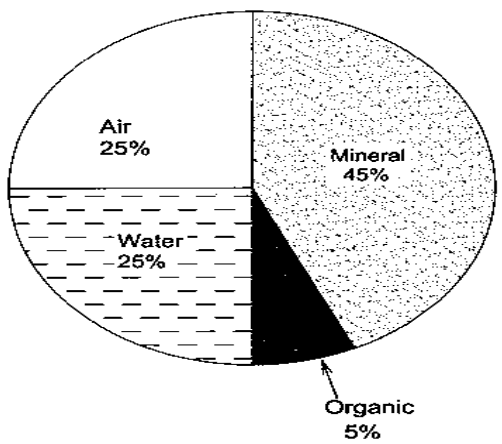


Figure 2: Typical volumetric composition of the four components of soil (proportions of water and air are highly variable)

DIFFERENT SCALES OF SOIL STRUCTURE

Soil scientists whose primary focus is the root growth, tillage, and erosion in topsoil's term the visible clods of the topsoil's as aggregates. These aggregates range in size from millimeters to several centimeters. The U.S. Department of Agriculture (USDA) arrived at a scheme to classify the structure of aggregates based on their size and shape. This classification

Sources of Soil Contamination

Soils may become contaminated by the accumulation on heavy metals and metalloids through emissions from the rapidly expanding industrial areas, mine tailings, disposal of high metal wastes, leaded gasoline and paints, land application of fertilizers, animal manures, sewage sludge, pesticides, wastewater irrigation, coal combustion residues, spillage of petrochemicals, and atmospheric deposition [1, 2].

Heavy metals constitute an ill-defined group of inorganic chemical hazards, and those most commonly found at contaminated sites are lead (Pb), chromium (Cr), arsenic (As), zinc (Zn), cadmium (Cd), copper (Cu), mercury (Hg), and nickel (Ni).
All contaminants subdivided into :

A: Natural
• Atmospheric fallout

• Volcanic eruption

• Minerals leaching

• Land erosion etc.

B: Artificial
• Industry

• Landfills

• Land exploration (oil, gas etc.)

• Development (industrial & domestic)

• Hospitals

• Domestic usage

<u>Contamination of Soil with metals (for example)</u>

Once metals contaminate the soil and bring metal concentration above the permissible level it is toxic to plants and animals.

Toxicity may disperse by food chain.

In general, metals represent potential long-term source for continued soil contamination.

Bioaccumulation may enhance the hazards associated with these metals and necessitate the removal from environment (Nemec et al. 2001).

The heavy metals essentially become contaminants in the soil environments because:
(i) their rates of generation via man made cycles are more rapid relative to natural ones,
(ii) they become transferred from mines to random environmental locations where higher potentials of direct exposure occur,

(iii) the concentrations of the metals in discarded products are relatively high compared to those in the receiving environment, and

(iv) the chemical form (species) in which a metal is found in the receiving environmental system may it more bioavailable.

The fate and transport of a heavy metal in soil depends significantly on the chemical form and speciation of the metal. Once in the soil, heavy metals are adsorbed by initial fast reactions (minutes, hours), followed by slow adsorption reactions (days, years) and are, therefore, redistributed into different chemical forms with varying bioavailability, mobility, and toxicity. This distribution is believed to be controlled by reactions of heavy metals in soils such as:

(i) Mineral precipitation and dissolution,
(ii) ion exchange, adsorption, and desorption,
(iii) aqueous complexation,
(iv) biological immobilization and mobilization, and
(v) Plant uptake .

The disintegration process of rocks leading to the formation of soils is called weathering. It is caused by natural agents, primarily wind and water

The specific processes responsible for weathering of rocks are:

1. Erosion by the forces of wind, water, or glaciers جليد, and alternate freezing and dissolved of the rock material

2. Chemical processes, caused by the presence of water. These include:

(a) hydrolysis التحلل (reaction between H^+ and OH^- ions of water and the ions of the rock minerals),

(b) chelation (complexation and removal of metal ions),

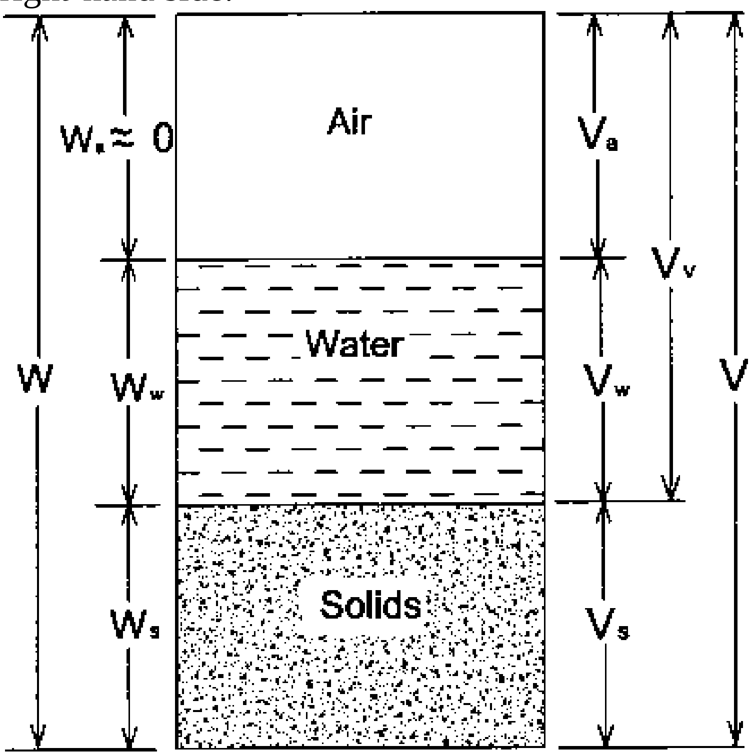
(c) cation exchange between the rock mineral surface and the surrounding medium,

(d) oxidation and reduction reactions تفاعل الاكسدة والاختزال,

(e) carbonation of the mineral surface because of the presence of atmospheric CO2.

3. Biological processes which, through the presence of organic compounds, affect the weathering process either directly or indirectly.

The relative proportions of water and air are usually of primary importance in engineering practice. These phases are both spatially and temporally variable in a given soil mass. The relative proportions of these fluid phases control to a great extent the contaminant transporting capacities of soils. The two phases interact continuously with the solid phase and participate in the mutualالمتبادلة exchange of contaminants. We will define below the terms that are used to express quantitatively the relative proportions of the solid, water, and air phases. In accordance with common practice, we will not make a distinction between the mineral matter and the organic matter in the solid phase. Figure below shows a schematic representation of the three phases with their weights indicated on the left-hand side and the corresponding volumes indicated on the right-hand side.



VT = Va + Vw + Vs
WT = Ww + Ws

Wa ; weight of air
Ww : weight of water
Ws : weight of solid
WT : Total weight
Va : volume of air
Vw : volume of water
Vs : volume of solid
VT : Total volume
Vv : volume of void

The volume-based indicators of phase composition are:

Void ratio, e, defined as the ratio of volume of void space (occupied by both water and air) to volume of solids.

Porosity, n, defined as the ratio of volume of void space to total volume of soil mass.

Degree of saturation, S, defined as the ratio of volume of water to volume of void space,