WHAT INSIDE THE SOIL?

Mrs. Suhada K.M.

Assistant Professor, PG Department of Chemistry, KAHM Unity Women's College, Manjeri, Kerala-676122, India

E-mail: kmsuhada591989@gmail.com

Soil chemistry is the study of soil's chemical properties. Mineral composition, organic matter, and environmental conditions all influence soil chemistry. J. Thomas Way, a consulting chemist for the Royal Agricultural Society in England, conducted numerous tests on how soils exchange ions in the early 1850s and he is considered the father of soil chemistry.

Soil chemistry was primarily concerned with chemical processes in the soil that contribute to pedogenesis or effect plant growth until the late 1960s. Concerns regarding environmental pollution, organic and inorganic soil contamination, and potential ecological and environmental health problems have developed since then. As a result, in soil chemistry, the focus has changed from pedology and agricultural soil science to environmental soil science.

Environmental soil chemistry

Predicting the fate of pollutants and the methods by which they are initially introduced into the soil requires a thorough understanding of environmental soil chemistry. When a chemical is exposed to the soil environment, it can undergo a variety of chemical reactions that might increase or decrease the toxicity of the contaminant. Adsorption/desorption, precipitation, polymerization, dissolution, complexation, and oxidation/reduction are examples of these processes. Scientists and engineers working on environmental restoration frequently overlook these effects. Understanding these processes allows us to more accurately forecast the fate and toxicity of contaminants, as well as build scientifically sound and cost-effective remediation techniques.

Soils transport and move water, house thousands of bacteria and other animals, and contain a variety of worn rock and mineral combinations. The chemical makeup of soil changes as soils and minerals weather over time. Humans, on the other hand, affect the chemistry of soils faster than anything else.

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Ion Exchange

The flow of cations (positively charged elements such as calcium, magnesium, and sodium) and anions (negatively charged elements such as chloride and compounds such as nitrate) through soils is known as ion exchange. Cation exchange is far more widespread in the United States.

Cation exchange is the process of a cation in a water solution around a soil particle exchanging with another cation adhered to the clay surface. The number of cations in the soil water solution is significantly less than the number connected to soil particles.

The cation exchange capacity

The cation exchange capacity is the total quantity of positive charges that the soil can absorb (CEC). The rate at which nutrients travel through the profile is influenced by CEC. A soil with a low CEC is substantially less fruitful than one with a high CEC since it can't hold as many nutrients and has fewer clays. It's crucial to apply fertiliser in small amounts if your soil has a low CEC so that it doesn't permeate into the groundwater. A soil with a low CEC is less able to hold spilt chemicals.

Soil pH

The pH of the soil is a measurement of its acidity or alkalinity. pH levels range from 1 to 14, with acidic values ranging from 0 to 7 and alkaline values ranging from 7 to 14. Soils are normally rated from 4 to 10 on a scale of one to ten. Understanding how quickly reactions occur in the soil, as well as the pH, is one of the most critical properties involved in plant growth. The element iron, for example, becomes less accessible to plants when the pH rises. This leads to iron shortage issues. Crops like values of 5.5-8, but the value varies depending on the crop. The pH of soil is determined by the parent material used in its development, although people can alter it to better suit plant growth. Soil pH also affects organisms.

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Sorption and Precipitation

Different nutrients and ions can be captured by soil particles. Sorption is the process through which one substance absorbs or retains the properties of another. Soils with high sorption might hold a lot of extra environmental toxins, such as phosphorus, on the particles in this situation. When a nutrient or chemical in the soil solution (water around soil particles) turns into a solid, soil precipitation occurs. If the soils are extremely saline, this is critical. Soil chemists investigate the speed of these reactions under a variety of circumstances.

Soil Organic Matter Interactions

Soil chemists also study soil **organic matter** (OM), which are materials derived from the decay of plants and animals. They contain many hydrogen and carbon compounds. The arrangement and formation of these compounds influence a soils ability to handle spilt chemicals and other pollutants.

Soil structure

Soil structure refers to the way soil is arranged in the solid portions of the soil as well as the pore space between them. The arrangement of soil pores between individual soil granules is governed by how they clump, bind together, and aggregate. Water and air circulation, biological activity, root growth, and seedling emergence are all influenced by soil. Soil structures come in a variety of shapes and sizes. It is a dynamic and complicated system that is influenced by a variety of circumstances.

The arrangement of the solid parts of the soil and the pore spaces between them is referred to as soil structure. Aggregation occurs when soil particles interact through rearrangement, flocculation, and cementation. Precipitation of oxides, hydroxides, carbonates, and silicates; biological activity products (such as biofilms, fungal hyphae, and glycoproteins); multivalent cation ionic bridging between negatively charged particles (both clay minerals and organic compounds); and interactions between organic compounds are all beneficial (hydrogen bonding and hydrophobic bonding).

Most types of cultivation degrade soil structure because the related mechanical mixing compacts and shears aggregates and fills pore spaces, as well as exposing organic materials to

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a faster rate of decomposition and oxidation. A further consequence of continued cultivation and traffic is the development of compacted, impermeable layers or 'pans' within the profile.

The disintegration of aggregates and dispersion of clay material as a result of fast soaking is frequently linked to the degradation of soil structure during irrigation. This is especially true if the soils are sodic, meaning the cations bonded to the clays have a high exchangeable sodium percentage (ESP). When particles are wet, high sodium levels (in comparison to high calcium levels) lead them to reject one another, causing aggregates to disaggregate and disperse. If irrigation allows saline water (even at low concentrations) to enter the soil, the ESP will rise.

To protect and improve soil structure, a variety of treatments are used. Increase organic content by incorporating pasture phases into cropping rotations; reduce or eliminate tillage and cultivation in cropping and pasture activities; avoid soil disturbance during periods of excessive dry or wet when soils may tend to shatter or smear; and ensure sufficient ground cover to protect the soil from raindrop impact, according to the NSW Department of Land and Water Conservation. It may be advised in irrigated agriculture to use gypsum (calcium sulphate) to replace sodium cations with calcium and so reduce ESP or sodicity, avoid quick wetting, and avoid disturbing soils when they are too wet or dry.

Grades of soil structure

The degree of aggregation, or grade of structure, is defined as the difference between cohesion* inside aggregates and adhesion* between aggregates. Because these properties change depending on the moisture content of the soil, the grade of building should be decided when the soil is neither too moist nor excessively dry. The following are the four major structure grades, ranging from 0 to 3.

0 Structureless has no observable aggregation or no definite orderly arrangement of natural lines of weakness, such as:

- Massive structure (coherent) where the entire soil horizon appears cemented in one great mass;
- Single-grain structure (non-coherent) where the individual soil particles show no tendency to cling together, such as pure sand;

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1. Weak structure is made up of indistinct aggregates that are difficult to see in place. When the soil material is removed from the profile, it is broken down into a mixture of relatively few whole aggregates, many fractured aggregates, and a lot of unaggregated material;
2. In undisturbed soil, moderate structure is well developed from discrete aggregates that are somewhat durable and visible but not distinct. The soil material breaks down into a mixture of numerous distinct whole aggregates, some fragmented aggregates, and minimal unaggregated material when taken from the profile;
3. Strong structure is made up of discrete aggregates that are long-lasting and visible in undisturbed soil.When removed from the profile, the soil material consists very largely of entire aggregates and includes few broken ones and little or no non-aggregated material.

Classes and types of soil structure

By definition, class of structure describes the average size of individual aggregates. Usually, five distinct classes may be recognized in relation to the type of soil structure from which they come. They are:

- Very fine or very thin;
- Fine or thin;
- Medium;
- Coarse or thick;
- Very coarse or very thick.

By definition, type of structure describes the form or shape of individual aggregates. Generally, soil technicians recognize seven types of soil structure, but here only four types are used. They are rated from 1 to 4 as follows:

1. Granular and crumb structures are individual particles of sand, silt and clay grouped together in small, nearly spherical grains. Water circulates very easily through such soils. They are commonly found in

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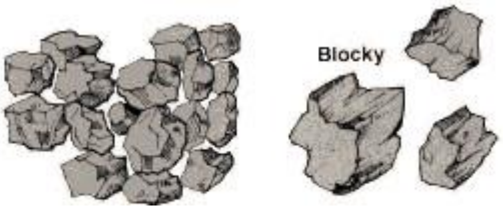
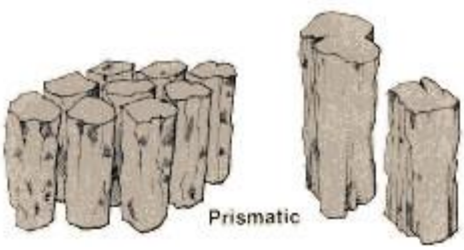
the A-horizon of the soil profile;

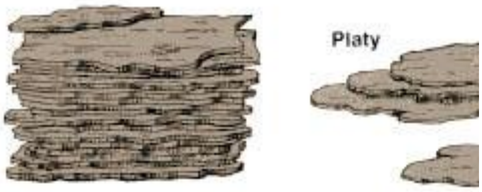
2. Blockyand subangular blocky structures aresoil particles that cling together in nearly square or angular blocks having more or less sharp edges. Relatively large blocks indicate that the soil resists penetration and movement of water. They are commonly found in the B-horizon where clay has accumulated;



3. Prismatic andcolumnar structures are soil particles which have formed into vertical columns or pillars separated by miniature, but definite, vertical cracks. Water circulates with greater difficulty and drainage is poor. They are commonly found in the B-horizon where clay has accumulated;



4. Platy structure is made up of soil particles aggregated in thin plates or sheets piled horizontally on one another. Plates often overlap, greatly impairing water circulation. It is commonly found in forest soils, in part of the A- horizon, and in claypan* soils.



Improving soil structure

Reduced erosion due to increased soil aggregate strength and decreased overland flow; improved root penetration and access to soil moisture and nutrients; improved emergence of

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seedlings due to reduced crusting of the surface; and increased water infiltration, retention, and availability due to improved porosity are just a few of the advantages of improving soil structure for plant growth, particularly in an agricultural setting.

In horticulture, productivity from irrigated no-tillage or minimum-tillage soil management declines with time owing to soil structure degradation, which inhibits root growth and water retention. There are a few outliers; it is uncertain why such unique fields preserve structure, but it is linked to high organic matter levels. In these situations, improving soil structure can greatly boost production. Wheat yields in cropping systems can be boosted by 10 kg/ha for every extra millimetre of rain that can enter owing to soil structure, according to the NSW Department of Land and Water Conservation.

Minerals

The mineral components of soil come from the parent rocks, often known as regolith. Minerals account for around 90% of the overall weight of the soil. O, Fe, Si, Al, N, P, K, Ca, Mg, C, H, and other significant elements found in compound form include O, Fe, Si, Al, N, P, K, Ca, Mg, C, H, and others. The creation of primary and secondary minerals can help identify which minerals are present in a rock.

Soil Pores

The interactions of the soil's micropores and macropores are crucial to soil chemistry because they allow water and gaseous components to flow into the soil and into the surrounding atmosphere. Macropores assist in the movement of molecules and substances into and out of micropores. The aggregates themselves are made up of micropores.

Soil Water

Water is necessary for organisms in the soil profile, and in an ideal soil, it partially fills the macropores.

Water moves ions deeper into the lower soil layers, causing the soil to become more Oxidized in other soil horizons, causing leaching of the soil.

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Water can also go from a greater water potential to a lower water potential, which can cause capillarity activity and gravitational force due to water adhesion to the soil surface and cohesion among the water molecules.

Air

The three major gases in the atmosphere are oxygen, carbon dioxide, and nitrogen. By volume, oxygen makes up 20% of the atmosphere, nitrogen makes up 79 percent, and CO2 makes from 0.15 to 0.65 percent. Because of the breakdown of stored organic matter and the quantity of plant roots, CO2 levels rise as soil depth increases. The presence of oxygen in the soil is beneficial because it aids in the transformation of insoluble stony mass into soluble minerals and organic humification. The air in the soil is made up of the same elements as in the atmosphere, but in different amounts. Chemical processes in bacteria are aided by these gases. Soluble nutrients build up in the soil, making it more productive.

Soil Texture

The ability of the soil to keep its structure, the restriction of water flow, and the contents of the particles in the soil are all influenced by soil texture. Soil texture takes into account all particle kinds, and a soil texture triangle is a diagram that may be used to compute the percentages of each particle type that sum up to 100% for the entire soil profile. These soil divides range not only in size, but also in how they affect some of the most critical aspects determining plant growth, such as soil aeration, workability, water and nutrient transport and availability.

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Sand

Sand particles range in size (about 0.05mm-2mm).[4] Sand is the most coarse of the particle groups. Sand has the largest pores and soil particles of the particle groups. It also drains the most easily. These particles become more involved in chemical reactions when coated with clay.

Silt

Silt particles range in size (about 0.002mm-0.5mm). Silt pores are considered a medium in size compared with the other particle groups. Silt has a texture consistency of flour. Silt particles allow water and air to pass readily, yet retain moisture for crop growth. Silty soil contains sufficient quantities of nutrients both organic and inorganic.

Clay

Clay has particles smallest in size (about<0.002mm) of the particle groups. Clay also has the smallest pores which give it a greater porosity and it does not drain well. Clay has a sticky texture when wet. Some kinds can grow and dissipate or in other words shrink and swell.

Loam

A combination of sand, silt and clay that encompasses soils. It can be named based on the primary particles in the soil composition, ex. sandy loam , clay loam , silt loam, etc.

Soil chemistry is the study of how elements and their compounds are distributed between and within the soil's three main phases: solid, liquid, and gaseous. We want to understand Chemistry of soil and its classification based on its structure. Cation exchange is an important and unifying concept in soil science because it affects the flocculation and dispersion of soils and suspended sediments, the availability and transport of nutrient and contaminant cations, and the management of soil pH.

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