

SOURCES OF CHARGES OF SOIL COLLOIDS

There are two major sources of charges on soil colloids.

✓ **Permanent or constant charges**

The charge produces due to isomorphous substitution and broken edges of clays. This type of charge is known as permanent charge

In case of 2: 1 type clays, the surface charges are balanced by a much larger number of charges emanating from the isomorphous substitution of one cation for another in octahedral and tetrahedral sheets. Since these charges are not dependent on pH, so these are called permanent or constant charges. Isomorphous substitution of one cation for another leads to a charge imbalance in silicate clays that accounts for the ability of clays to attract ions to particle surfaces. The permanent charge is also produced due to broken edge of clay structure.

✓ **Negative charges**

A net negative charge is found in minerals after isomorphous substitution of a lower charged ion (Mg^{2+}) for a higher charged ion (Al^{3+}). Such substitution commonly occurs in aluminum dominated dioctahedral sheets. The substitution of Mg^{2+} for Al^{3+} is an important source of negative charge on smectite, vermiculite and chlorite clay minerals.

A second example is the substitution of Al^{3+} for Si^{4+} in the tetrahedral sheet which also leaves one negative charge unsatisfied. Such a substitution is common in several of the important soil silicate clay minerals such as fine grained micas, vermiculites and some smectite.

✓ **Positive charges**

Isomorphous substitution can also be a source of positive charges if substitution cation has a higher charge than the ion for which it substitutes. In a trioctahedral sheet, there are three magnesium ions surrounded by oxygen and hydroxyl groups and sheet has no charge. However, if an Al^{3+} ion substitutes for one of the Mg^{2+} ions, a positive charge results. Such positive charges are characteristic of trioctahedral sheets of chlorites.

Such isomorphous substitution takes place slowly through past weathering cycles and are not subjected to easy modification. Consequently, these charges are termed as constant or permanent charges because they are related to the chemical composition of the silicate clays.

✓ **Variable or pH dependent charges**

Hydroxyl ions or other functional groups are present on the surfaces of colloidal particles (clay and humus). These functional groups can release or accept hydrogen ions (H^+) and thus produce charge. This type of charge is known as pH dependent or variable charge.

All colloids, organic or inorganic exhibit the surface charges associated with OH^- groups which are largely pH dependent. Most of the charges associated with humus, 1: 1 type clays, oxides of iron & aluminum and allophanes are of this type. There is a second source of charges on some silicate clays and humus. Because these charges are dependent on soil pH, they are called variable or pH dependent. Both negative and positive charges come from this source also and detail of each group of charge is as under:

✓ **Positive charges**

Under moderate to extreme acid soil conditions, some silicate clays as well as iron & aluminum hydrous oxides may have positive charges. Once again, exposed OH^- groups are involved. In this case, however, as soils become more acid, protonation takes place. Since a mixture of humus and several inorganic colloids is usually found in soil, it is not surprising that positive and negative charges may be present at the same time. In some acid soils which are high in iron & aluminum hydroxides, overall net charge may be positive. Humus, kaolinite, allophanes and Fe, Al oxides have mostly variable (pH dependent) negative charges and exhibit modest positive charges at very low pH values.

Protonation

It may be defined as the attachment of protons (H^+ ions) to the exposed OH groups on the surface of soil particles, resulting in an overall positive charge on the particle surface while reverse of this process is called **de-Protonation**

✓ **Negative charges**

It may be said that primary sources of variable charge is due to loss or gain of H^+ from the functional groups on the surfaces of soil colloids. These functional groups include Hydroxyl (OH^-) in organic colloids (clay) and Carboxyl (COOH^-), Phenolic ($\text{C}_6\text{H}_5\text{OH}^-$) and Amine (NH_2^-) in organic colloids (humus).

Some of the pH dependent charges are associated primarily with hydroxyl (OH) groups on the edges and surfaces of inorganic and organic colloids. The OH groups are attached to iron and aluminum in the inorganic colloids. Under moderately acid conditions, there is little or no charge on these particles but as the pH increases, hydrogen dissociates from the colloid OH group and negative charges result. The mechanism of increasing the negative charge is of special importance in soils high in hydrous oxides of iron and aluminum.