Soil Formation

1. Soil structure defined in the field “is often expressed as the degree of stability of aggregates” (Bronick 2004). The structure of a soil affects the quality of the animal and plant life that use it as means of survival. It helps in maintaining water quality and promotes sequestration of carbon. The aggregates in soil are formed through natural processes that are dependent on the amount of organic carbon present, the presence of animal and plant life, and amount of clay and carbonates, texture, moisture, and ion exchange. Soil structure can also be defined by the “size, shape and arrangement of solids and voids, continuity of pores and voids, their capacity to retain and transmit fluids and organic and inorganic substances, and the ability to support rigorous root growth and development” (Bronick 2004)

The aggregates that make up the structure of the soil are classified by; macro and microaggregates which are dependent on the amount of carbon and nitrogen, and their particular binding agents. The structure of the soil influences the environment of the organisms that use it as their home. It affects how plants root and their ability to retain water and nutrients. Good soil structure will cause increase in water storage, oxygen, and reduces the need for fertilizer. When soil is disturbed its balance is destroyed which can cause a decrease in nutrients, water, and oxygen for plants and other organisms (Bronick 2004).

Soil structure plays an important role in sustaining the environment that we live in. Today’s agricultural practices are the leading cause of soil degradation. In order to
maintain soil structure more sustainable means of agriculture should be addressed to help stop soil erosion, carbon emission, and loss of nutrients. This could be done through composting, planting crops with higher biomass, and increasing diversity (Bronick 2004).

2. Formation of aggregates occurs through two types of processes: physical-chemical and biological. Each process plays a more dominant roll at different levels of aggregation; physical-chemical at the primary particle and submicroaggregate, stages and biological in the macroaggregate, microaggregate, and to a lesser extent, the submicroaggregate stages. Aggregation begins, in most cases, when platelets of clay bond together with the aid of cations to form clay domains. Either end of the positively charged cations in the soil attract negatively charged clay particles binding them together and resulting in the “stacking” of clay platelets known as flocculation. Once formed the clay domains bond with organic particles and polyvalent cations to form submicroaggregates to microaggregates. The greater amount of precipitated hydroxides, carbonates, and phosphates in a soil the more likely it is for aggregates to form because the cations released will act as bonding agents. Roots and fungal hyphae secrete organic matter, such as carbohydrates and polysaccharides, which also act as bonding agents and are most useful in the formation of macroaggregates. Because of this, more organic carbon in the soil means more aggregates will be likely form. Macroaggregates form through the bonding of several microaggregates together or, occasionally, around a center of particulate organic matter.

3. Soil formation is strongly regulated by the interaction of texture, organic matter, and climate. Clay (particles <0.002 mm) has the strongest influence on aggregation in
multiple ways. Clay particles can bind with each other forming bridges between larger particles. They can also coat particulate organic matter slowing decomposition. Different chemical composition of clay influences aggregate stability. Clays get dispersed during flooded conditions, filling the gaps in between larger particles. As the soil dries, the clays form tight bonds to each other and larger particles, creating bridges. Non-swelling clays form tight cation bonds that result in stable aggregates. Swelling clays decrease aggregate stability. These clays expand when wet causing them to detach from each other and other particles, resulting in less aggregation. Thus the type of clay is more important in aggregation, than quantity of clay.

Organic matter in the soil can be divided into groups: particulate organic matter, carbohydrates, polysaccharides, phenols, lignin, lipids, and humic substances. Particulate organic matter (POM) are relatively large (.25 mm to 2.0 mm) particles of decomposing plant and animal debris. POM can form the basis of macroaggregates as other particles bind to the outside. As the POM are decomposed by microbial activities, they produce polysaccharides as a waste product that acts as an aggregate glue. Phenolic compounds increase aggregation by forming cationic bridges. Lignins are not easily decomposed, resulting in more particulate organic matter, therefore increasing aggregation. Lipids and humic substances reduce clay dispersion resulting in more stability of aggregates.

Climate has a dramatic effect on soil aggregate formation. Wet-dry cycles can either increase or decrease aggregation depending on whether the type of clay swells or not. The wet-dry cycle causes aggregates to form. Temperature also has a strong influence on aggregation. Warmer humid climates have increased decomposition rates
which results in less POM but also more biological waste products that act as glue. In frigid climates the decomposition rates are lower, which causes increased particulate organic matter, which can form the nucleus of macroaggregates. In arid climates carbonates, earthworms, and crusting can increase aggregation. The less soil moisture can result in decreased aggregation resulting in more erosion and increased run off.

Sources:
