Soil Pores

By Alfred R. Conklin, Jr.

The inorganic particles in soil are sand silt and clay. The organic particles are humus. These particles do not however act independently of each other. They are cemented together to form secondary structures called peds. The formation of peds results in the development of pores in soil. Water may move into and through soil pores by mass flow while components dissolved in water may move by mass flow or by diffusion. A first step in understanding soil pores is to compare them to glass capillaries. However, soil pores have very little in common with glass or other capillaries.

As can be seen in the table, soil pores can be divided into three groups. The macropores drain readily and are important in the exchange of soil air with atmospheric air. Some mesopores drain readily and some retain water when the soil dries. When water is added, these pores fill and retain water when the soil drains. They subsequently lose water to the soil atmosphere and to plant roots. Micropores hold water against the pull of gravity. They also retain water under the most severe drying conditions. This water is not available to plants and movement of material into and out of these pores is by diffusion.

Cementing primary soil particles together is done by clay, organic matter, iron and microbial gums. The resulting peds are different in different parts of a soil profile. They have different sizes and shapes. In the upper part of a soil profile, the A horizon, the peds are small and are said to be granular. In the lower B horizons, the peds are larger and called either blocky or prismatic. One other type of structure called platy, thin plate-like peds, can be found in any horizon and may be produced as remnants of parent material or from working the soil, particularly plowing.

Soil pore space can be measured by determining a soil's bulk density. A common method is to insert a brass ring of known weight and volume into the soil. The ring is inserted using an instrument designed to prevent compaction during insertion. The ring plus soil is removed and dried in an oven at 105°C for 24 hours. The sample is weighted and the weight of the ring subtracted from the total weight to give the weight of dry soil. Dividing the soil weight by its volume gives its bulk density in Mg/m^3 (equivalent to g/cc). In most soils, the bulk density is between 1 and 1.3 Mg/m^3. Soils with bulk densities lower than 1 are either organic or have a large amount of organic matter in them. Soils with bulk densities above 1.65 are considered to be compacted. When compacted the macro- and mesopores are lost, leaving only micropores.

Soil pores are different from glass capillaries in two significant ways. First, soil pores are not straight. They represent tortuous paths or openings through the soil. Secondly, they do not have a constant diameter. The internal volume increases and decreases from one end to the other. The movement of water and other components into and out of soil pores is controlled by the diameter of the mouth, or by points of restriction in the interior of the pore.

On the other hand, there is one way in which soil pores are similar to glass capillaries. Water will not move from small capillaries into large capillaries. It will, however, move from large capillaries to smaller capillaries. Surface tension causes water to be more strongly held in small diameter than large diameter pores. Thus, it takes energy to move water out of the small pores and into the larger pores.

This is very important when looking at or predicting water movement in soil. Water will stop moving down a soil profile when it encounters a layer which has larger pores. It will only move into and through the large pore layer after the overlaying layer is saturated with water. The water in the

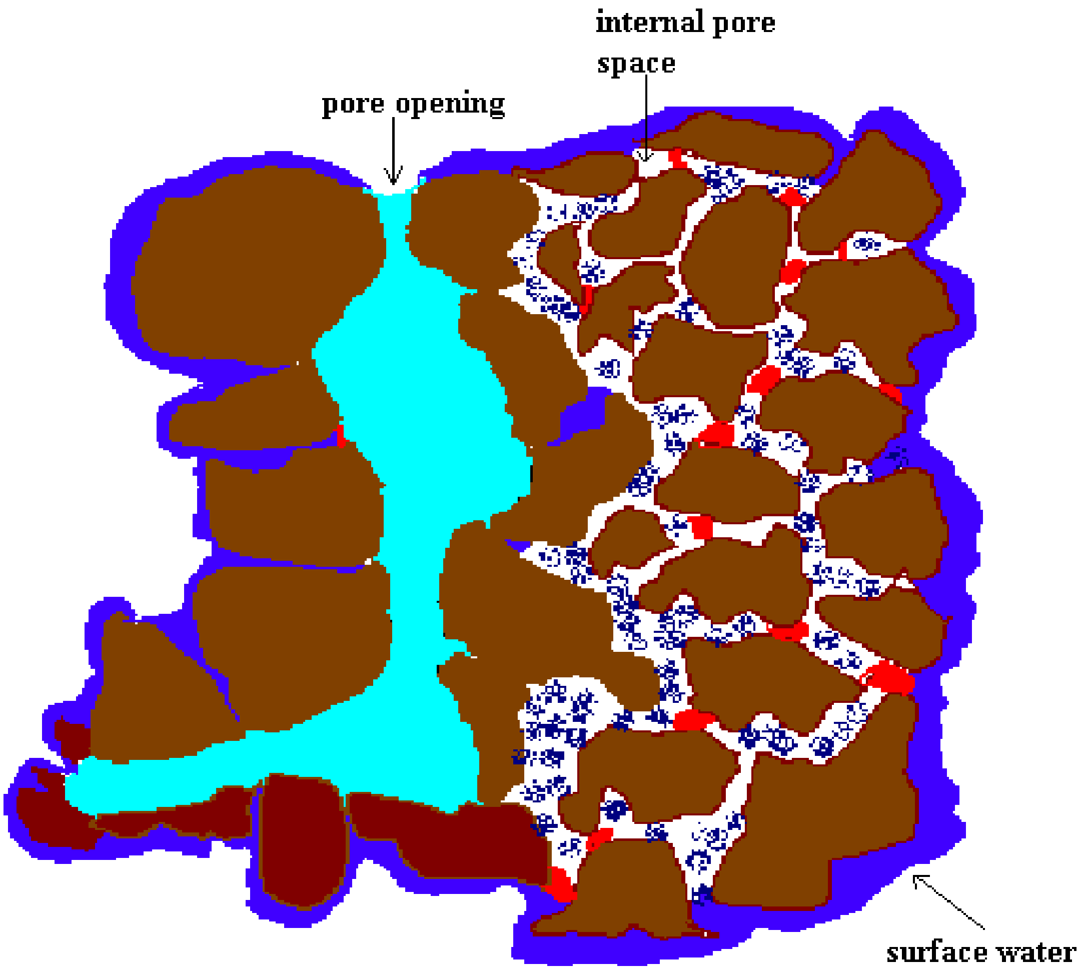
Types of Pores	
Pore	Average diameter range
Macropores	0.2mm and larger
Mesopores	0.2 to 0.02 mm
Micropores	0.02 and smaller

Table 1.

overlying layer provides the pressure needed to move water out of small pores and into the larger pores. Discontinuities between layers of soil tend to result in the occurrence of macropores and these impede the movement of water.

There is also another extremely important consequence of the restricted movement caused by small pores. Pollutants which enter soil will initially be attracted to surfaces. Given time they will also diffuse into pores. An initial simple extraction extracts material from the surface and indicates that some of the material has perhaps been lost. A subsequent extraction removes an additional small amount of material not extracted the first time. This can occur because after the initial extraction some of the material that had diffused into soil pores diffuses back out and is available for extraction.

It can easily be shown that soil will attract gaseous contaminants and these can also be attracted to surfaces and diffuse into pores.



Soil pore - entrance and exit control drainage - movement in

Figure 1. Soil pore - entrance and exit control drainage - movement in and out is controlled by diffusion.

The longer the time between pollution spill and the initial clean up activity, the more material will have diffused into pores. This means that clean up will take longer and will be more expensive. Keep in mind that diffusion into pores is not the only mechanism by which a soil contaminant is "lost" or attenuated. Contaminants will also undergo both chemical and biological reactions, which break them down.

At this point, the answer to removing material, which has diffused into small pores, might seem to be to treat soil in such a way that all the water in pores is removed. Thus, this source of continuing low level contamination is removed. Such a strategy will result in precipitation in capillaries, coating capillary walls, bonding and decomposition of pollutant(s). In all of these cases, the material will not be any easer to remove and may become unremoveable.

To maintain pores, keep traffic off the soil and avoid working it when it is either very wet or very dry. Large amounts of traffic, even if the vehicles are lightweight, will compact soil under any condition. Working soil when it is very dry or very wet also causes lose of macro- and mesopores. Pores can be maintained or increased by adding organic matter to soil and by growing a dense sod (grass) crops on it.

Maintaining or increasing the meso- and macropores in soil is very important in any soil cleanup effort. Larger pores are needed for procedures, which require movement of a fluid through soil. In addition, plant roots and microorganisms need both oxygen and water. Thus, for both bioremediation and phytoremediation meso- and macropores are important.

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