APRIL 2021

THE FLOW OF WATER THROUGH THE SOIL IN A CONTEXT OF RESIDENTIAL AUTONOMOUS WASTEWATER TREATMENT

The flow of water through the soil is difficult to observe in the field, but an understanding of how it behaves through the different layers of material that make up a treatment or leaching unit could help us make better decisions when preparing plans and specifications of a septic system, all the while complying with applicable local laws and regulations.

Following our recent collaboration with Alexandre Cabral, P. Eng., Ph. D., Université de Sherbrooke professor in the Engineering Department and an expert in soil mechanics and environmental geotechnics, we are sharing with you some of our observations from the research conducted on the flow of water through different types of soil, within the context of decentralized wastewater treatment with infiltration.

HYDRAULIC LOADING RATE

The hydraulic loading rate of soil is a very important parameter when designing a septic system with infiltration. In the majority of cases, this parameter, called K, is really a simplification of its counterpart in saturated conditions, Ksat. This parameter represents the hydraulic loading rate of the soil when it is saturated. Moreover, it represents the condition of the soil when it demonstrates the greatest water permeability. **Contrary to what one might believe, a material's water permeability is not a constant, but rather a function of suction.**

The figure below shows the water permeability of different materials according to its water suction, called capillarity. A near-zero water suction level indicates a saturated soil. It is at this value that we find the Ksat parameter.

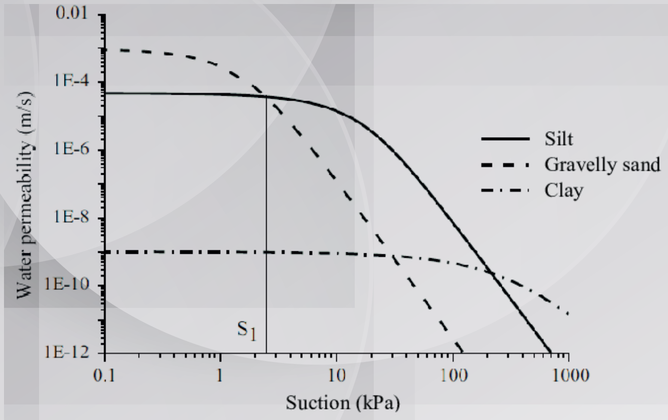

Figure 1. Water permeability as a function of suction for different materials

CAPILLARY ACTION

The capillarity is caused by the surface tension that develops between materials when humidity is present (Holtz et al.). Forces of attraction are present and create capillary bridges between the grains of the material (Figure 2).

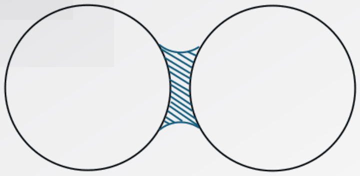

Figure 2. Capillary bridge between two grains (wikipedia)

It is thanks to this phenomenon that humid sand can maintain a specific structure. This allows, among other things, for the creation of sand castles! However, when this same material becomes completely inundated or completely dry, these forces of attraction become negligible, resulting in a material that has no capacity to maintain a structure; the sand castle crumbles (Figure 3).

Figure 3. Impact on the capillarity of the sand (realsimple.com)

As presented in the first figure, the suction is a fundamental element in the hydraulic loading rate of a material. In a soil that is minimally humid, as the material dries, the suction generated by the few water particles and the air increases: the grains are trying to hold this water. This means that water will flow with difficulty through the grains, which explains the low hydraulic loading rate of the material. As the soil gets more humid, the suction reduces thanks to the pores filling up, allowing a faster flow of water. When saturated, the pores can no longer contain an extra quantity of water, which explains the fast flow of excess molecules through the material (Figure 4).

Still looking at Figure 1, an interesting phenomenon can be observed when the hydraulic loading rates of sand and clay are compared. While it is well known that clay is much less water permeable than sand, it is no longer the case past a certain suction. This can be explained by the great capacity of clay to retain its water, which means that at strong suction rates, the pores in the clay remain completely saturated with water.

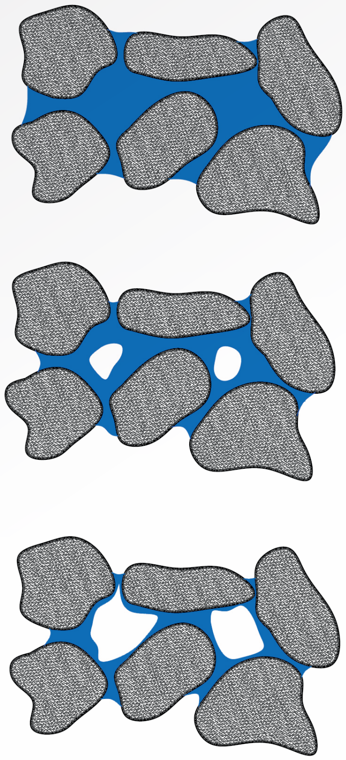

Figure 4. Condition of pores relative to their water retention

UNSATURATED FLOW

As it happens, most water flow takes place in unsaturated conditions. A hydraulic loading rate determined directly in the field has a different score from a hydraulic loading rate established in a laboratory, since true saturation is rarely achieved in the field. We refer to a field saturated hydraulic loading rate (Kfs) relative to a real saturated hydraulic loading rate (Ksat).

This is important since water flow in unsaturated conditions can lead to very interesting phenomena, such as capillary barriers.

CAPILLARY BARRIERS

Capillary barriers occur when the water flows from one permeability condition to higher permeability conditions. Imagine that a humid system sand draws the water towards very permeable native soil. If this native soil is much less humid, its hydraulic loading rate could be lower than the humid system sand, as we saw with the example of sand and clay above. This, then, is a capillary barrier, water that spreads on the surface of a native soil that is technically more permeable, rather than infiltrate. However, as the native soil saturates, its hydraulic loading rate increases, reversing the phenomenon.

Crushed Stone

The crushed stone used in practically all systems with infiltration into the soil is very permeable, but we do not really observe an interruption in the flow of water when it reaches the stone surface. Although the same phenomenon is present, it is rapidly broken as soon as a small quantity of water goes through. In the context of a septic system, the crushed stone remains effective at spreading water on a surface, without restrictions.

TO CONCLUDE

The hydraulic loading rate of the material used is often calculated in saturated conditions, while what happens in reality is quite different. Although these concepts are not generally applied in designing septic systems, understanding how water flows is a fundamental element in defining standards, regulations and best practices. This information can also help guide decisions when special situations are encountered in the field.