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COURSE CODE: CVE208 SOIL MECHANICS

TOPIC: A TERM PAPER ON SOIL CAPILLARITY AND SOIL PERMEABILITY

Capillary action (sometimes **capillarity**, **capillary motion**, **capillary effect**, or **wicking**) is the ability of a liquid to flow in narrow spaces without the assistance of, or even in opposition to, external forces like gravity. The effect can be seen in the drawing up of liquids between the hairs of a paint-brush, in a thin tube, in porous materials such as paper and plaster, in some non-porous materials such as sand and liquefied carbon fiber, or in a biological cell. It occurs because of intermolecular forces between the liquid and surrounding solid surfaces. If the diameter of the tube is sufficiently small, then the combination of surface tension(which is caused by cohesion within the liquid) and adhesive forces between the liquid and container wall act to propel the liquid.

- Capillary Action:

- Capillary action, also referred to as capillary motion or capillarity, is a combination of cohesion/adhesion and surface tension forces.
- Capillary action is demonstrated by the upward movement of water through a narrow tube against the force of gravity.
- Capillary action occurs when the adhesive intermolecular forces between a liquid, such as water, and the solid surface of the tube are stronger than the cohesive intermolecular forces between water molecules.
- As the result of capillarity, a concave meniscus (or curved, U-shaped surface) forms where the liquid is in contact with a vertical surface.

Capillary rise is the height to which the water rises within the tube, and decreases as the width of the tube increases. Thus, the narrower the tube, the water will rise to a greater height.Capillary rise in tubes of varied widths.

Capillary action is the same effect that causes porous materials, such as sponges, to soak up liquids.

- Capillarity is the primary force that enables the soil to retain water, as well as to regulate its movement.
    - The phenomenon of capillarity also occurs in the soil. In the same way that water moves upwards through a tube against the force of gravity; water moves upwards through soil pores, or the spaces between soil particles.
    - The height to which the water rises is dependent upon pore size. As a result, the smaller the soil pores, the higher the capillary rise.
    - Finely-textured soils, like in Maui, typically have smaller pores than coarsely-textured soils. Therefore, finely-textured soils have a greater ability to hold and retain water in the soil in the inter-particle spaces. We refer to the pores between small clay particles as micropores. In contrast, the larger pore spacing between lager particles, such as sand, are called macropores.

In addition to water retention, capillarity in soil also enables the upward and horizontal movement of water within the soil profile, as opposed to downward movement caused by gravity. This upward and horizontal movement occurs when lower soil layers

have more moisture than the upper soil layers and is important because it may be absorbed by roots.

Clay soil has the highest capillarity, followed by **loam**and then **sandy soil**.

Capillary penetration in porous media shares its dynamic mechanism with flow in hollow tubes, as both processes are resisted by viscous forces.[23]Consequently, a common apparatus used to demonstrate the phenomenon is the *capillary tube*. When the lower end of a glass tube is placed in a liquid, such as water, a concave meniscus forms. Adhesion occurs between the fluid and the solid inner wall pulling the liquid column along until there is a sufficient mass of liquid for gravitational forcesto overcome these intermolecular forces. The contact length (around the edge) between the top of the liquid column and the tube is proportional to the radius of the tube, while the weight of the liquid column is proportional to the square of the tube's radius. So, a narrow tube will draw a liquid column along further than a wider tube will, given that the inner water molecules cohere sufficiently to the outer ones.

The amount of water in the soil is dependent upon two factors:

- First, soil water is intimately related to the climate, or the long term precipitation patterns, of an area.
- Secondly, the amount of water in the soil depends upon how much water a soil may hold.

Soil water holding capacity

Before we discuss the capacity of soils to hold water, we must understand the concept of capillarity.

Capillarity

- Water molecules behave in two ways:
    - Cohesion Force: Because of cohesion forces, water molecules are attracted to one another. Cohesion causes water molecules to stick to one another and form water droplets.
    - Adhesion Force: This force is responsible for the attraction between water and solid surfaces. For example, a drop of water can stick to a glass surface as the result of adhesion.
- Water also exhibits a property of surface tension:

- Water surfaces behave in an unusual way because of cohesion. Since water molecules are more attracted to other water molecules as opposed to air particles, water surfaces behave like expandable films. This phenomenon is what makes it possible for certain insects to walk along water surfaces.
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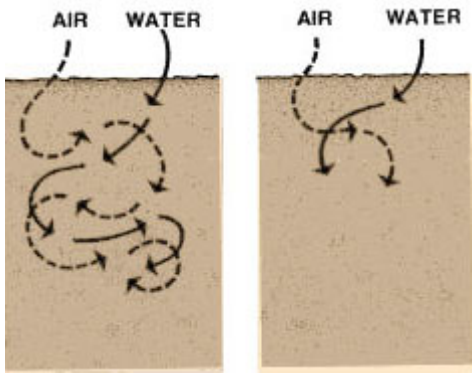
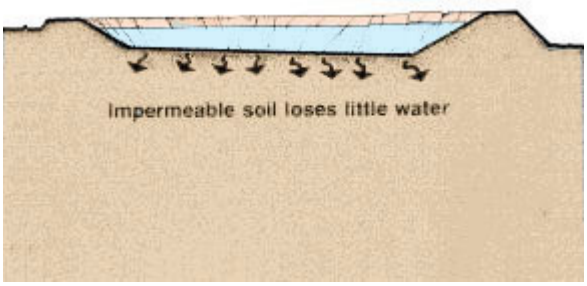
2. SOIL PERMEABILITY

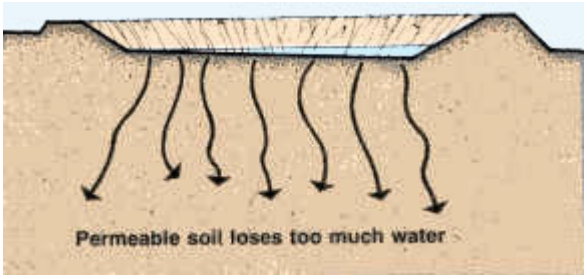
Soil permeability is the property of the soil to transmit water and air and is one of the most important qualities to consider for fish culture.



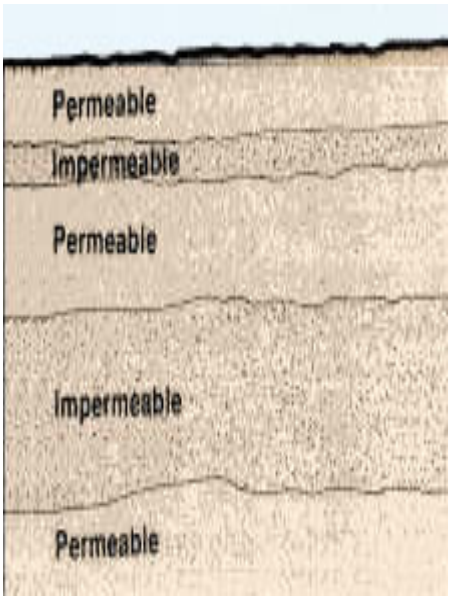
A pond built in impermeable soil will lose little water through seepage.



The more permeable the soil, the greater the seepage. Some soil is so permeable and seepage so great that it is not possible to build a pond without special construction techniques. You will learn about these techniques in a later volume in this series.



Soils are generally made up of **layers** and soil quality often varies greatly from one layer to another. Before pond construction, it is important to determine the relative position of the permeable and impermeable layers. The



design of a pond should be planned to avoid having a permeable layer at the **bottom** to prevent excessive water loss into the subsoil by seepage.

Many factors affect soil permeability. Sometimes they are extremely localized, such as cracks and holes, and it is difficult to calculate representative values of permeability from actual measurements. A good study of soil profiles provides an essential check on such measurements. Observations on soil texture, structure, consistency, colour/mottling, layering, visible pores and depth to impermeable layers such as bedrock and **claypan*** form the basis for deciding if permeability measurements are likely to be representative.The size of the soil pores is of great importance with regard to the rate of **infiltration** (movement of water into the soil) and to the rate of **percolation** (movement of water through the soil). Pore size and the number of pores closely relate to soil texture and structure, and also influence soil permeability.

To measure soil permeability in the field, you can use one of the following tests:

- The visual evaluation of the permeability rate of soil horizons;
- A simple field test for estimating soil permeability;

A more precise field test measuring permeability rates. The number of factors affect the permeability of soils, from particle size, impurities in the water, void ratio, the degree of saturation, and adsorbed water, to entrapped air and organic material

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