**What is soil permeability?**

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.

The dikes of the pond should be built with soil which will ensure a good water retention. Again, soil quality will have to be checked with this in mind.

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, color/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.

Note: you have already learned that soil is made up of a number of horizons, each of them usually having different physical and chemical properties. To determine the permeability of soil as a whole, each horizon should be studied separately.

Soil permeability relates to soil texture and structure

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.

**Permeability variation according to soil texture**

Usually, the finer the soil texture, the slower the permeability, as shown below:

Example

Average permeability for different soil textures in cm/hour

Sand: 5.0

Sandy loam: 2.5

Loam: 1.3

Clay loam: 0.8

Silty clay: 0.25

Clay: 0.05

**Permeability variation according to soil structure**

Structure may greatly modify the permeability rates shown above, as follows:

Structure type:

Platy (- Greatly overlapping, - Slightly overlapping)

Blocky

Prismatic

Granular

Permeability:

From very slow to very rapid

This may vary according to the degree to which the structure is developed.

It is common practice to alter the soil structure to reduce permeability, for example, in irrigated agriculture through the puddling of rice fields and in civil engineering through the mechanical compaction\* of earthen dams. Similar practices may be applied to fish-ponds to reduce water seepage.

**Soil permeability classes**

Permeability is commonly measured in terms of the rate of water flow through the soil in a given period of time. It is usually expressed either as a permeability rate in centimetres per hour (cm/h), millimetres per hour (mm/h), or centimetres per day (cm/d), or as a coefficient of permeability k in metres per second (m/s) or in centimetres per second (cm/s).

**Factors affecting permeability of soils**

A 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.

**Particle Size:**

It was studied by Allen Hazen that the coefficient of permeability (k) of a soil is directly proportional to the square of the particle size (D). Thus permeability of coarse grained soil is very large as compared to that of fine grained soil. The permeability of coarse sand may be more than one million times as much that of clay.

**Impurities in water:**

the presence of impurities in soil decreases the permeability of soil

**Void ratio (e):**

The coefficient of permeability varies with the void ratio as e/sup>/(1+e). For a given soil, the greater the void ratio, the higher the value of the coefficient of permeability. Here 'e' is the void ratio.

Based on other concepts it has been established that the permeability of a soil varies as e2 or e2/(1+e). Whatever may be the exact relationship, all soils have e versus log k plot as a straight line.

**Degree of Saturation:**

If the soil is not fully saturated, it contains air pockets. The permeability is reduced due to the presence of air which causes a blockage to the passage of water. Consequently, the permeability of a partially saturated soil is considerably smaller than that of fully saturated soil. In fact, Darcy's Law is not strictly applicable to such soils.

**Absorbed water:**

Fine grained soils have a layer of adsorbed water strongly attached to their surface. This adsorbed layer is not free to move under gravity. It causes an obstruction to the flow of water in the pores and hence reduces the permeability of soils. According to Casagrande, it may be taken as the void ratio occupied by absorbed water and the permeability may be roughly assumed to be proportional to the square of the net voids ratio of (e - 0.1)

**Entrapped air and organic matter:**

Air entrapped in the soil and organic matter block the passage of water through soil, hence permeability considerably decreases. In permeability tests, the sample of soil used should be fully saturated to avoid errors.[4]

Permeability of Soil by Constant Head Permeameter – Objectives & Procedure

**How do we determine Soil Permeability?**

**Constant Head Permeability Test:**

The constant head permeability test is a laboratory experiment conducted to determine the permeability of soil. The soils that are suitable for this tests are sand and gravels. Soils with silt content cannot be tested with this method.The test can be employed to test granular soils either reconstituted or disturbed.

Objective and Scope:

The objective of constant head permeability test is to determine the coefficient of permeability of a soil.

Coefficient of permeability helps in solving issues related to:

Yield of water bearing strata

Stability of earthen dams

Embankments of canal bank

Seepage in earthen dams

Settlement Issues

What is Coefficient of Permeability?

The coefficient of permeability, k is defined as the rate of flow of water under laminar flow conditions through a porous medium area of unit cross section under unit hydraulic gradient.

The coefficient of permeability (k) is obtained from the relation

Coeeficient of permeability K=QL/Aht

Where q= discharge, Q=total volume of water, t=time period, h=head causing flow, L= length of specimen, A= cross-sectional area.

Apparatus for Constant Head Permeability Test

Permeameter mould, internal diameter = 100mm, effective height =127.3 mm, capacity = 1000ml.

Detachable collar, 100mm diameter, 60mm height

Dummy plate, 108 mm diameter, 12mm thick,

Drainage base, having porous disc

Drainage cap having porous disc with a spring attached to the top.

Compaction equipment such as Proctor’s rammer or a static compaction equipment, as specified in IS:2720 (Part VII)-1965.

Constant head water supply reservoir

Vacuum pump

Constant head collecting chamber

Stop watch

Large funnel

Thermometer

Weighing balance accuracy 0.1g

Filter paper.

Procedure

Specimen Preparation

Remove the collar of the mould. Measure the internal dimensions of the mould. Weigh the mould with dummy plate to the nearest gram.

Apply a little grease on the inside to the mould. Clamp the mould between the base plate and the extension collar and place the assembly on a solid base.

Take about 2.5kg of the soil sample, from a thoroughly mixed wet soil, in the mould. Compact the soil at the required dry density using a suitable compacting device.

Take a small specimen of the soil in a container for the water content determination.

Remove the collar and base plate. Trim the excess soil level with the top of the mould.

Clean the outside of the mould and the dummy plate. Find the mass of the soil in the mould.

The mould with the sample is now placed over the permeameter. This will have drainage and cap discs properly saturated

Test Procedure

Through the top inlet of the constant head reservoir, the specimen is connected.

The bottom outlet is opened and a steady flow is established

For a particular time interval, the quantity of flow can be collected.

Measure the difference of head (h) in levels between the constant head reservoir and the outlet in the base.

For the same interval, this is repeated three times.

Constant Head Permeability Test

Fig.1: Constant Head Permeabi

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.

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.

Figure 3. Capillary rise in tubes of varied widths. This picture demonstrates the phenomenon of capillary rise. As you can see, the liquid rises to the greatest height in the narrowest tube (at far right), whereas capillary rise is lowest in the widest tube (at far left). Although easily demonstrated by simple experiments using tubes, capillary action occurs in soils. Smaller pores that exist in finely-textured soils have a greater capacity to hold and retain water than coarser soils with larger pores.

Source: http://www.wtamu.edu/~crobinson/SoilWater/capillar.html

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.

Capillarity Experiment

Required materials

Sandy soil sample

Clayey soil sample

Loamy soil sample

3 Glass tubes (open at both ends)

Water

Beaker to hold the glass tubes

Glass wool to plug one end of each of the glass tubes

Estimated Experiment Time

Approximately 10 minutes to set up the apparatus and 1-2 days to carry out the observations

Step-By-Step Procedure

1. Plug one end of the glass tubes using glass wool.

2. Pack 3 long glass tubes tightly with dry sandy, clayey and loamy soil; clearly label each tube.

3. Fill the beaker with water.

4. Immerse the tubes vertically in the beaker with the plugged end towards its base.

5. Make note of the levels of the water as it rises in the glass tubes containing each type of soil

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