PERMEABILITY

Definitions: ***Permeability (r_s)*** is defined as the flow of water at 60^0F in gallons/day through a medium having 1^2 ft cross - sectional area under a hydraulic gradient of 1ft/ft. ***Hydraulic Conductivity*** (Coefficient of permeability, ***K***) of a medium is unit when it will transmit a unit volume of groundwater in unit time at the prevailing kinematic viscosity through a cross-section of unit area. The ***field co-efficient of permeability (Kf)*** is defined as the flow of water in gallons per day through a cross section of aquifer one feet thick and one mile wide under a hydraulic gradient of 1 feet / mile at field temperature ***Transmissivity (T)*** is defined as the rate at which water of prevailing kinematic viscosity is transmitted through a unit width of aquifer under a unit hydraulic gradient. Therefore,

T = Kb in m^2/day, where 'K' is the hydraulic conductivity and 'b' is the saturated thickness of the aquifer.

Determination of Hydraulic Conductivity

A. Laboratory methods:

Several methods have been developed for determination of permeability from small samples of aquifers. It is known that when unconsolidated samples are disturbed and repacked, the porosities, packing and grain orientation in remarkably changed, hence affecting the permeability. Even then with great precaution the permeability can be measured in laboratory, which resembles to the values obtained by field methods.

There are two broad kinds of measurements. (1) Discharging type and (2) Non discharging type

Discharging type

Constant head method: The constant head permeameter can be used to measure permeabilities of consolidated or unconsolidated sediments under low heads. Water enters the medium cylinder from the bottom and is collected as overflow after passing upward through the material as shown in figure 1. From Darcy's law it follows that permeability can be determined from

$$K = \frac{Vl}{Ath}$$

It is important that medium be thoroughly saturated to remove entrapped air. Several different heads in a series of tests provide a reliable permeability measurement.

Falling head method: Here water is added to the tall column, it flows upward through the medium cylinder and is collected as overflow. The test consists of noting times at which the water level lowers to various graduations on the tube. The hydraulic conductivity can be measured by the equation,

$$K = \frac{dt^2L}{Dc^2t} \ln \frac{ho}{h}$$

Where A, L , dt, dc, h and ho are shown in the figure 2 and 'the' is the time interval for the water level in the tube to fall from 'ho' to 'h'. Both consolidated and unconsolidated samples can be tested in this manner

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Non- discharging type. For measurements of permeability of unconsolidated formation under very low heads, a nondischarging permeameter may be used. A long U tube containing the medium is connected to supply and receiving reservoirs at the top. The entire instrument is submerged in a constant temperature chamber, while the top is covered to avoid evaporation losses from the reservoirs. The permeability is derived similar to that above, giving

$$K = \frac{Al}{2at} \ln \frac{ho}{h}$$

where A, L, and a are identified in figure 3, ho is the head at t= and h, is the head at later time t.

2. Field methods:

Tracer Method: By introducing tracer one can calculate the ground water velocity. Tracer kept in up one experimental well A is sampled for in the observation well B as shown in the figure. The hydraulic conductivity is then given by,

$$K = \frac{aL^2}{ht}$$

Where a is the porosity of the medium, ‘the’ is the time taken for tracer to reach the distance and L and h are as shown in the figure 4.

Auger Hole Method: Natural permeabilities at shallow depths intersected by water table can be measured directly by auger hole method. A cylindrical cavity is formed to below the water table and water is pumped out rapidly. Test involves pumping to lower the water level and then observing the rate of rise, or adding water and observing its rate of fall. From these information the permeability co - efficient can be measured by means the formula.

$$K = \frac{Cdy}{864dt}$$

Where dy/dt is the rate of rise/fall in cm/sec and the factor 864 yields K value in meters/day. C is a dimensionless constant and governed by the variables shown in figure 5. This method is simple and cheap.

The most reliable method is pumping test with wells. Based on observations of water level in connection with pumping, an integrated permeability value of over a sizable aquifer section can be obtained. Then, because the aquifer is not disturbed, the reliability of such determination is superior to laboratory methods.