WORKSHOP

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Determination of Soil Moisture Characteristics

by
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1.0 Introduction

The planning and execution of hydraulic and land deveopment projects(for example, drainage and irrigation) is almost always preceeded by geohydrological research. This research is partly aimed at acquiring a clear picture of the existing hydrological situation and partly to determine the criteria to be applied to a properly functioning water economy. In general, for any planning and mangement processes to be effective, it require a data base. At present, the hydrologists are provided mainly with rainfall and discharge data which are also based on a very limited number of networks. However, data on soil hydrologic parameters such as, infiltration, hydraulic conductivity, pore characteristics, soil retention characteristics etc. are not available due to limited field and laboratory facilities. There are various methods of field research to determine the soil properties, depending on available material and research requirements. These methods extend from simple augerhole method and the double ring infiltrometers to the most complicated techniques. In the present lecture, various methods and technologies available in our country for the estimation of soil moisture characteristics are discussed.

1.1 Measurement of Soil Hydraulic Properties

1.1.1 Water Content(Gravimetric method)

Measurements of water content are needed in hydrological studies for direct knowledge of the quantity of the available soil water for interpretation of physical and chemical measurements, and for determination of water retention and hydraulic conductivity curves. Soil water content can be expressed as a dimensionless mass or volume ratio. The gravimetric content is mass ratio.

$$\theta_m = M_w/M_s \qquad \text{(Eq.1)}$$

where, θ_m is gravimetric water content, M_w is water mass (mg) , and M_s is dry soil mass (mg) the volumetric water content is based on the volume ratio.

$$\theta = V_w/V \qquad \text{(Eq. 1a)}$$

where θ is volumetric water content, V_w is volume of water(cu. m) V is total soil volume. Gravimetric and Volumetric soil water content are related to each other as

$$\theta = r_s\,\theta_m \qquad \text{(Eq 1b)}$$

where r_s is dry bulk density of the soil (mg/cu. m) soil water content can be measured by direct methods such as oven or microwave dry, or by indirect ones based on neutron thermalisation, gamma ray attenuation or electrical conductivity and capacitance.

1.1.2 Tensiometry

Tensiometers are widely used for measurement of the soil water tension in the field. They consist of a porous ceramic cup and a device to meassure the pressure inside the tensiometer. When the porous cup is buried in the soil, water can move freely through the pores in its walls into the soil and back. As the soil becomes drier, the soil water tension increases and water flows out of the cup into the soil. The prerssure of the water inside the tensiometer is then decreased. As the soil is wetted, soil water tension decreases, water flows from the soil into the cup and the pressure of the water inside the cup will increase. Assuming that soil water is in equilibrium with the water inside the tensiometer. This pressure can be measured with a vacuum gauge, a water or mercury filled manometer or an electrical transducer. Normally, the porous cup is palced at the lower end of the tensiometer and the pressure transducer at the top. The matric potential, h, in the soil around the porous cup is than derived as

$$h = h_T + T \qquad \text{(Eq 1c)}$$

In practice, tensiometers (fig 1) cannot measure soil water tensions higher than about 800 cm. This is caused by air-entry into the pores of the ceramic porous cup and dissolution of dissolved air if the soil water tension increases towards 1000 cm(1 bar). Because standard ceramic tensiometer cups have a conductance of the order of $3 * 10^{-5}$ cm^2/s, response time will be adequate for most field studies.

Soil water tensions higher than about 800 cm can be measured with thermo couple psychrometry. By these method these tensions are derived from measurements of the relative humidity in the soil with tehrmocouple psychrometer. Because the relative humidity of the soil varies only slightly between 0.99 and 1.00, accurate measurements are difficult. Therefore the psychrometer does not have the sensitivity to measure low soil water tension in the suction range of the tensiometer accurately but it is useful instrument in the suction range 2-50 bar.

1.1.3 Neutron Scttering

Neutron scattering has become a widespread method for volumetric water content measurement since commercial equipment became available around 1960. The main advantage of

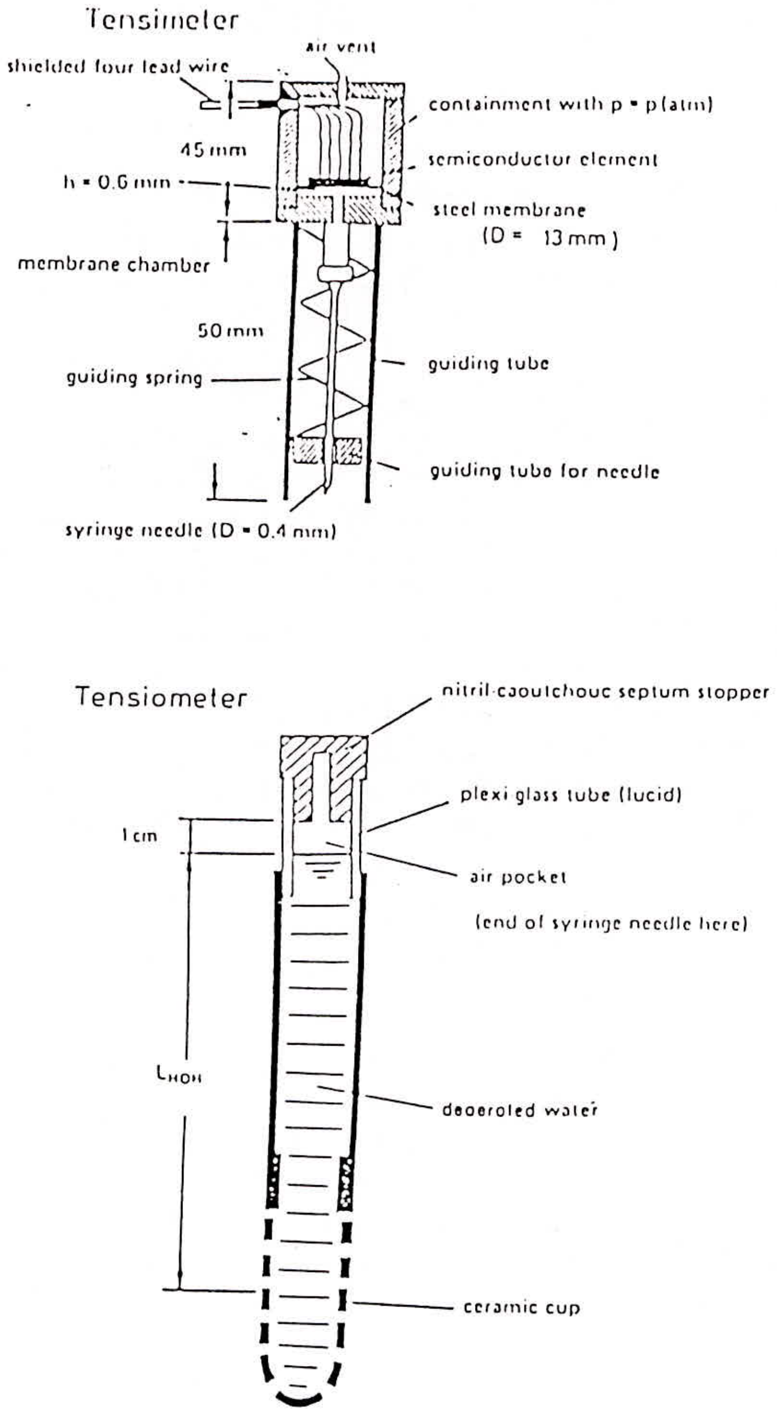


Figure 1. Diagram of tensimeter and a tensiometer with septum stopper (from Marthaler *et al.*, 1983).

this method is that it allows rapid, non-destructive, repeatable measurements of water content at the same locations and depths. Disadvantages are the relatively high cost of the neutron moisture meter, difficulty of measuring water contents near the soil surface and poor detection of sharp changes in water content. In addition, operators should be familiar with safety rules to reduce health hazards associated with exposure to gamma and neutron radiation. Before water content measurements are started, several standard counts(Istd) should be taken while the probe is in the shield.

The neutron moisture meter consists of a source of fast neutrons(usually americium-241/beryllium), a detector for slow neutrons, a protective shield composed of lead(for gamma ray absorption) and polyethylene or paraffin(for neutron absorption) which serve also as reference standard, and a scalarto count the flux of slow neutrons scattered by the soil. The neutron-scattering method depends upon the interaction of fast neutrons with main soil constituents. To use the neutron moisture meter a thin wall alumimium, steel or plastic access tube must be installed. Because an air gap between the probe and tube wall affects detection of slow neutrons, the diameter of the access tube should be consistent with the probe size. For the same reason, cavities between the tube wall and the soil should be avoided. Therefore, it is advisable to auger the access hole through the access tube, gradually sinking the tube as the hole deepens. After installation, the tube is sealed at the bottom to prevent flooding during epriods with high groundwater tables and is covered with an empty can or stopper to keep rainwater and debris out. Then the meter is placed over the tube, the probe is lowered to a selected depth and one or more counts(I) are made. These counts are converted to volumetric water contents, can be approximated by a linear empirical equation

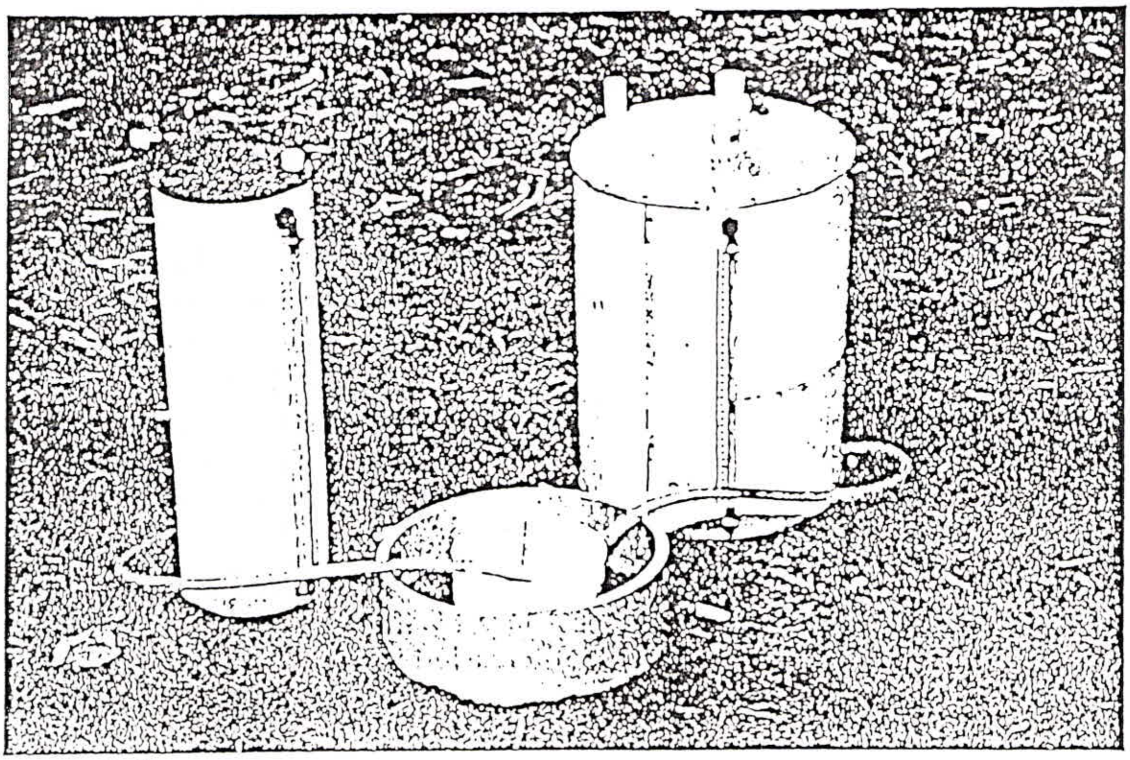
$$\theta = a + bf \qquad \text{(Eq 1d)}$$

where f is thew count ratio, I/Istd, and a and b are parameters which depend upon soil characteristics and the standard count when the probe is in the shield.

1.2 Determination of Infiltration Characteristics

1.2.1 Double Ring Infiltrometers

Double ring infiltrometers are used for determining infiltration capacity curve in selected locations of the study area. Two rings made up of cast iron with a height of about 1 m and a diameter of 27.5 – 30 cm (inner ring) and 40—45 cm (outer ring). The inner ring is used for the measurement of infiltration depth and the outer ring is used as a buffer ring which will saturate the surrounding soil layer. Both the rings are inserted into the ground upto a depth 40 – 45 cm (fig 2). Initially the outer ring (the space between inner and outer ring)is filled with water till the soil layer gets saturated. Inner ring area is also filled with water and head should be maintained equal in both the rings. A float is attached to maintain head in both the rings. The depth infiltration may be measured by fixing scale to the rings. Initially the water infiltrates very fast and latter on it reaches the steady state. With time depth a graph can be drawn which will give the infiltration capacity of the soils.



2-a

Figuro 2a. Ring infiltrometer with a Mariotte hydraulic head device.

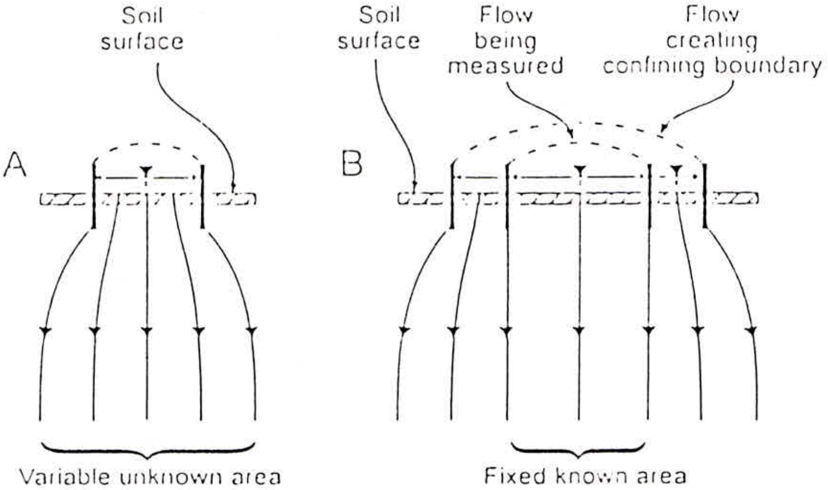


Figure 2 . Divergence of streamlines during infiltration buffered by using a double ring infiltrometer.

1.2.2 Disc Permeameter

The disc permeameter has become a popular apparatus for measuring in situ the soptivity,S, and hydraulic conductivity, K, of the soil at some prescribed potential. Measurements of sorptivity, S, and hydraulic conductivity, K, are important for predicting how water will enter, redistribute within., and drain from soils. Methods that can rapidly and accurately measure S and K are valuable. The disc permeameter (Perroux and White 1988) is a relatively new method that has gained popularity because of its simplicity, the speed at which measurements can be made, and because it does not greatly disturb the soil surface being measured. (White and Sully 1987;) White and Perroux 1987 and 1989; Smettem and Clothier 1989; Ankeny et al 1991). Different methods have been devised for calculating S and K are compared using same set of data. These methods are all based on the approximate , but usefully accurate, solution of flow from a disc source found by Wooding (1968). This linearized solution uses a hydraulic conductivity (K) function of the exponential form (Gardner 1958):

$$K = Ks \exp(\psi / \lambda_c) \qquad \text{(Eq.3)}$$

where Ks is the saturated hydraulic conductivity (m s-1), λ_c is the macroscopic capillary length scale (m) and ψ is the matric potential (m).

1.2.2 Principles of Operation

When a source of water, such as a wet circular disc or shallow pond , is placed on the soil surface, the initial stages of flow into the soil are dominated by the soil's capillary properties. As time progresses, both the size or geometry of the water source and the force of gravity influence the water flow rate. For uniform soils a time is eventually reached where the flow rate from the source becomes steady. This steady state flow rate is governed by capillarity, gravity, the size of the disc and the pressure at which water is supplied to the soil surface.

In this technique we make use of both the initial and steady-state flow rates to separate the capillarity and gravity contributions to soil water flow. In addition, by selecting the water supply pressure we can dictate the sizes of pore sequences or fissures which participate in the flow process.

1.2.3 Hydraulic conductivity and Sorptivity

The method for determining soil hydraulic properties from disc permeameter measurements in the field is based on an analysis of the three-dimensional flow from a shallow circular pond or surface disc. The situation is illustrated in fig.3.

For a pond or disc of radius r_0 , on a homogeneous soil , Wooding showed that when water is supplied at a potential of ψ_0 the steady state volumetric flow rate q is

$$q = \pi r_0^2 (K_0 - K_n) + 4 r_0 \varphi \qquad \text{(Eq.4)}$$

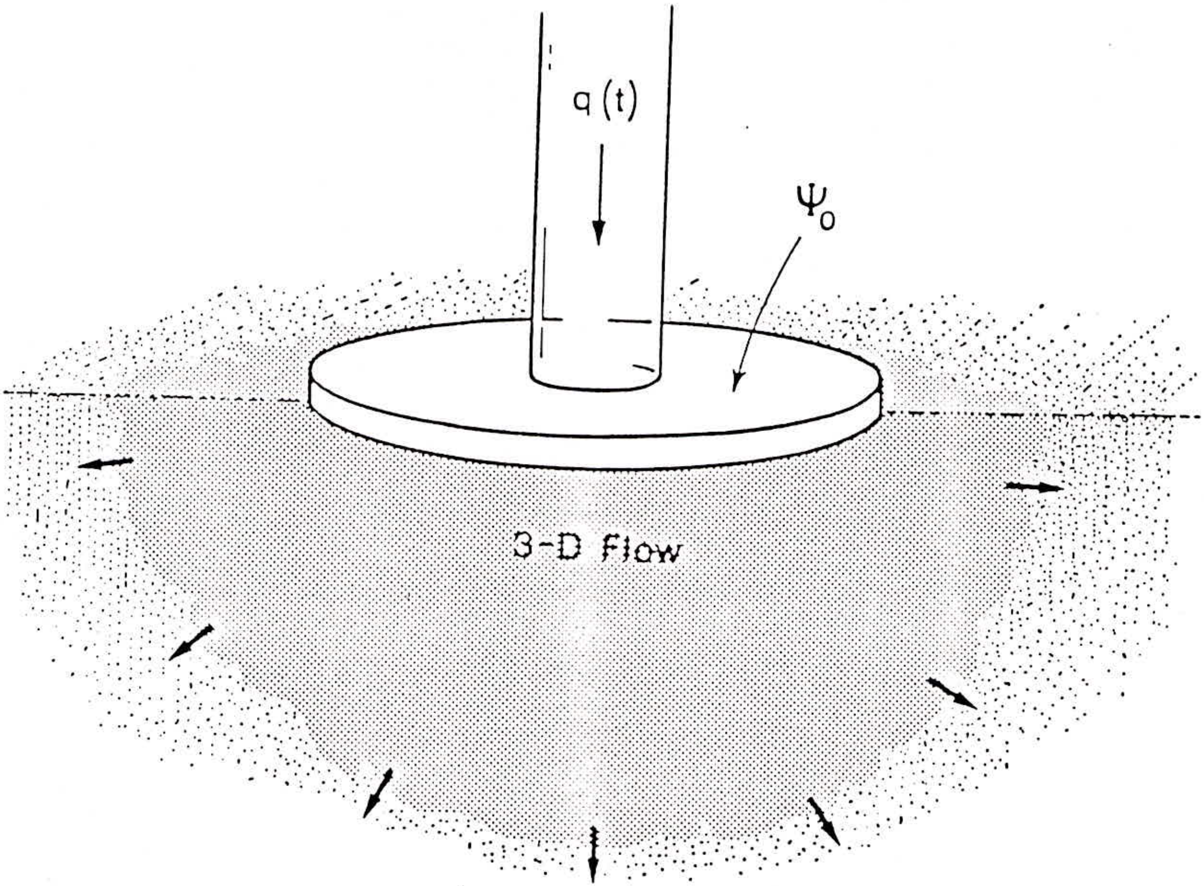


Fig. .3.Three-dimensional flow from a shallow circular pond or surface disc.

The first term on the right essentially represents the contribution of gravity to the total flow from the surface disc and the second term contains the contribution due to capillarity. In the gravity term K_0 is the hydraulic conductivity at the supply potential o_0, and K_n is the hydraulic conductivity at the initial soil water potential φ_n . For relatively dry materials K_n is much smaller than K_0 and we can safely ignore its effect . The capillarity term contains the matric flux potential , which is related to the conductivity by $\varphi = K_0 \lambda_c$

The macroscopic capillary length λ_c is related to the sorptivity, S_0, and the hydraulic conductivity (White and Sully, 1987),

$$\lambda c = bSo^2/(\theta o - \theta n) \qquad \text{(Eq 5)}$$

is the initial moisture content at θn is the moisture content at φ_n, θo is the moisture content at the supply potential, φ_0, So is the sorptivity at φ_n with supply potential o_0 and `b' is a dimensionless constant whose value lies between 1/2 and $\pi/4$. For field soils a good mean value for b is 0.55. With simplification and, dividing by the area of the disc, we find the steady-state flow rate per unit area

$$\frac{q}{\Pi r_0^2} = K_0 + \frac{4b\, S_0^2}{\Pi r_0(\theta_0 - \theta_n)} \qquad \text{(Eq. 6)}$$

Rearranging (Eq.6) to find the conductivity, we have

$$K_0 = \frac{q}{\Pi r_0^2} - \frac{4b\, S_0^2}{\theta_s - \theta_r} \qquad \text{(Eq.7)}$$

During the early stages of flow from the disc, capillarity domiantes flows irrespective of the disc. At short infiltration times the system behaves as if it were one-dimensional. In this case the cumulative infiltration is given by (Philip, 1969). where Q is the total volume of water infiltrated and t is time from the commencement of infiltration. Sorptivity, then is the Slope of the cumulative infiltration vs $t^{1/2}$ plot.

To calculate the hydraulic conductivity from (4), the measurements required are the sorptivity, the steady state flow rate, the initial volumetric moisture content at the supply potential.

1.2.4 Macroscopioc Capillary Length and Characteristic Mean Pore Size

The macroscopic capillary length, is a scaling length which simplifies the treatment of multidimensional soil-water flows (Philip, 1985). Two simple methods can be used for estimating λc in the field. In the first we can use the following equation as suggested by White and Sully, (1987),

That is

$$\lambda_c = bS_0^2 /[(\theta_0 - \theta_n)K_0] \qquad \text{(Eq.8)}$$

In the second we make use of paired measurements of sorptivity at positive, S−, and negative, S-, supply pressures:

$$\lambda_c = 2b\Delta\Psi / [(S_{-}/S_{-})^2 - 1] \qquad \text{(Eq.9)}$$

where ΔΨ = Ψ+ - Ψ- is the difference in supply pressures, and S+ and S- are measured conveniently with the disc permeameter. For pure water at 20 C (6) becomes

$\lambda_m = 7.4/\lambda_c$ where λ_m and λ_c are in mm.

Guidelines for Disk Permeameter Operation

(i) Warning

Be sure the "O" rings are in place before assembling the disc.

(ii) Calibration

Prior to use each reservoir must be calibrated. Remove the reservoir from the disc, turn it upside down, and secure it vertically in a stand on a balance. Add a volume of water and record the scale readings and the change in mass. Repeat several times over the length of the reservoir. Using an approximate water density of 1.00 g cm-3, calculate an average calibration of volume per scale distance for the entire length of the scale.

(iii) Initial Water Content and Bulk density

The initial water content and the bulk density are needed to calculate to hydraulic conductivity . At least two measurements should be made for each infiltration measurement. Measurements are made on cores taken approximately 250 mm from the centre of the disc measurement surface. Use metal cylinders of diameter 50 mm and height 50 mm sharpened at one end. Drive the cylinder into the soil and carefully excavate it. Trim off the ends and place the core in an air-tight container for weighing and oven drying. Place the air-tight container in a plastic bag and seal it for transportation.

1.2.4. Ponded Permeameter Measurements

(i) Setting the Potential

The potential for the ponded permeameter is adjusted by means of the height adjusting screws on the base of the disc. The potential at the soil surface is the distnace from the bottom of the air entry tube to the soil surface (fig 4)

(ii) Side tube volume

After a potential is chosen, the pond volume can be calculated by multiplying the distance from the bottom of the disc to the soil surface by the ring area. Calibrate the side tube by finding the volume of water per unit of height in the tube. Divide the pond volume by this number to obtain the height of water necessary in the side tube to fill the pond. Measure this height from the top of the disc plate and mark the side tube.

(iii) Site Preparation

The amount of site preparation depends on the surface and the potential used. These factors will determine the amount of clearance between the bottom of the permeameter and the surface. The usual supply potential for ponded infiltration is +10 mm.

1. Clear a thin band on the soil surface where the edge of the steel ring will be in contact with the soil. It may be necessary to remove stones or clip vegetation along the outside circumference of the ring . Remove from the centre of the ring any large stones that would interfere with the disc and clip the vegetation to a height below the level of the bottom of the disc.

2. Insert the ring about 4 mm into the soil surface by placing a cover plate over the ring until the cover plate contacts the spacer. Note that the depth of insertion must be constant as it affects the supply potential . Remove the cover plate and spacer and seal the ring on the outside with a bentonite or local clay paste.

3. Set the empty permeameter on the ring and check that the permeameter is as level as possible and that the supply potential is properly adjusted.

4. Remove the permeameter from the ring and place in a bucket of water. Fill the side tube to the required volume . Fill the reservoir tube with water being certain that the one-way valve has been wetted to insure an air-tight seal. Check to make certain that the water level in the supply reservoir does not fall. If it does, the stop-cock or one way valve is leaking.

1.2.5 Infiltration measurements

Carefully place the permeameter on the ring. To begin the measurement, open the stopcock on the side of the tube. Start the stop watch when the side tube empties. It is essential

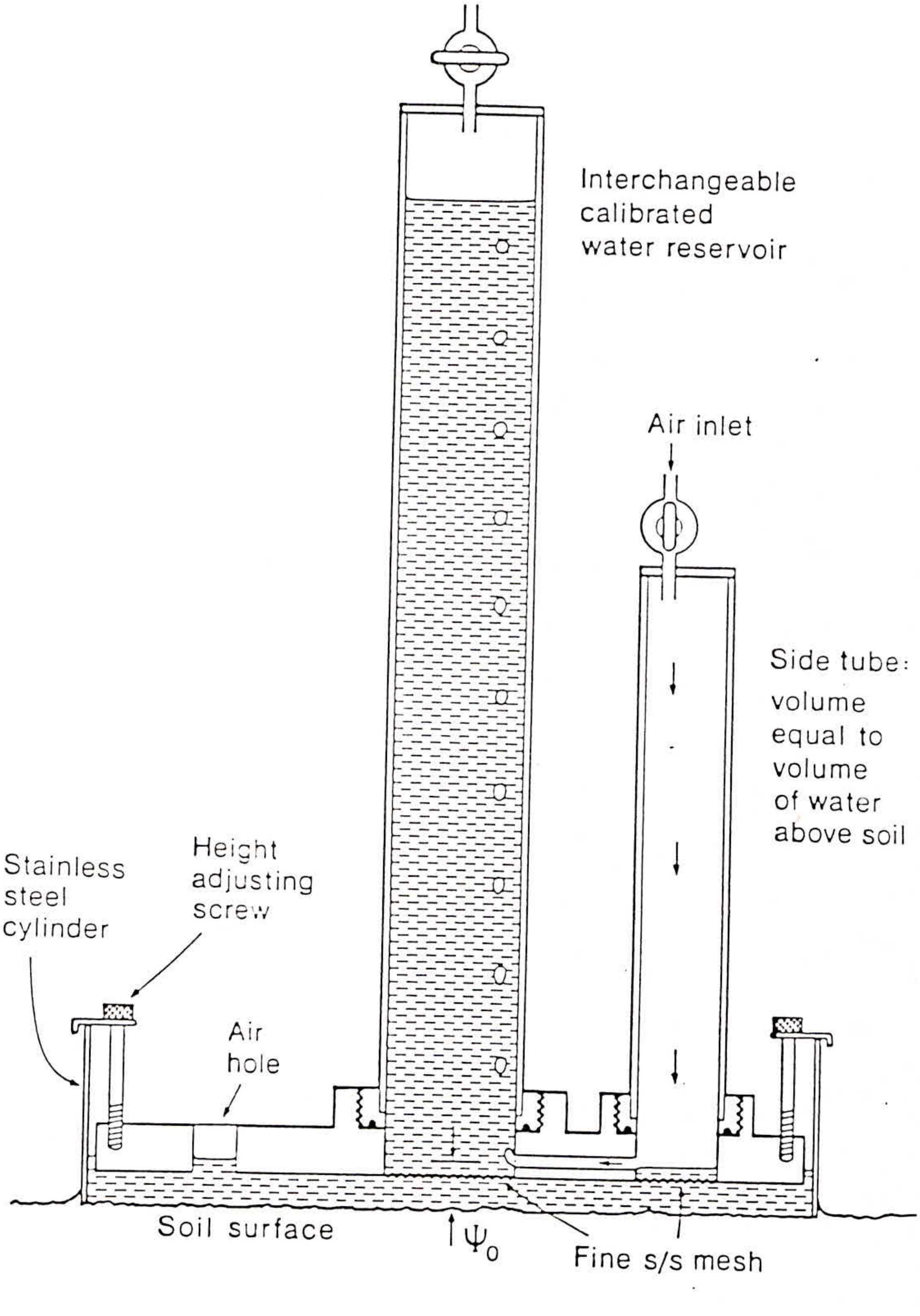


Fig.4 .The disc permeameter for ponded measurements.

that the seal on the outside of the ring does not leak. Check for leaks periodically but especially at the outset.

With recording stopwatch , record times at constant predetermined scale increments on the reservoir tube, usually 5 or 10 mm. It is important to record as many accurate measurements as possible during the early stages of flow. The scale increment used depends on the soil and is best determined by experience. We find that 5 mm increments for the early time data is satisfactory for most soils except sands. For sands increments of 10 mm or more may be required. After the early stages, measurements can be recorded continuously or interrupted until flow approaches steady state before recording again. In the latter case, when approximately one-half the reservoir volume has been infiltrated into the soil, begin recording again. In the latter case, when approximately one-half the reservoir volume has been infiltrated into the soil , begin recording again. Continue recording until flow appears to be steady (i..e., the time taken for equal scale increment does not change). For the steady state flow we use a scale increment of 10 mm. At least 10 measurements should be taken to insure that an accurate value for steady state flow is obtained. In some soils several reservoir volumes are required before steady state flow is reached.

1.2.6 Supply surface water content

At the end of infiltration measurements , close the stopcock and remove the permeameter. Watch the water level in the ring closely and skim a soil sample off the surface (2-3 mm) with a spatula as soon as the free water disappears from the surface. Place the sample in an air-tight container for weighing. Seal the air-tight container in a plastic bag for transportation.

It is important to take the sample as close to the surface as possible, when the excess water has just disappeared from the surface. Sample taken too deep or too late will give incorrect, low values of soil moisture.

Unsaturated permeameter

(i) Setting the Potential

The potential is set by altering the water level in the bubbling tower as shown in fig . The water potential at the membrane is $Z_2 - Z_1$. The value of Z2 is fixed for each disc so that the potential is varied by altering Z1, the height of the water above the bottom of the air-inlet tube (fig 5).

A plastic syringe with a length of thin tubing attached is used to add or withdraw water from the bubbling tower. When checking the water level, make sure that the air-inlet tube is completely air filled by forcing air into the air-inlet tube until it is empty of water.

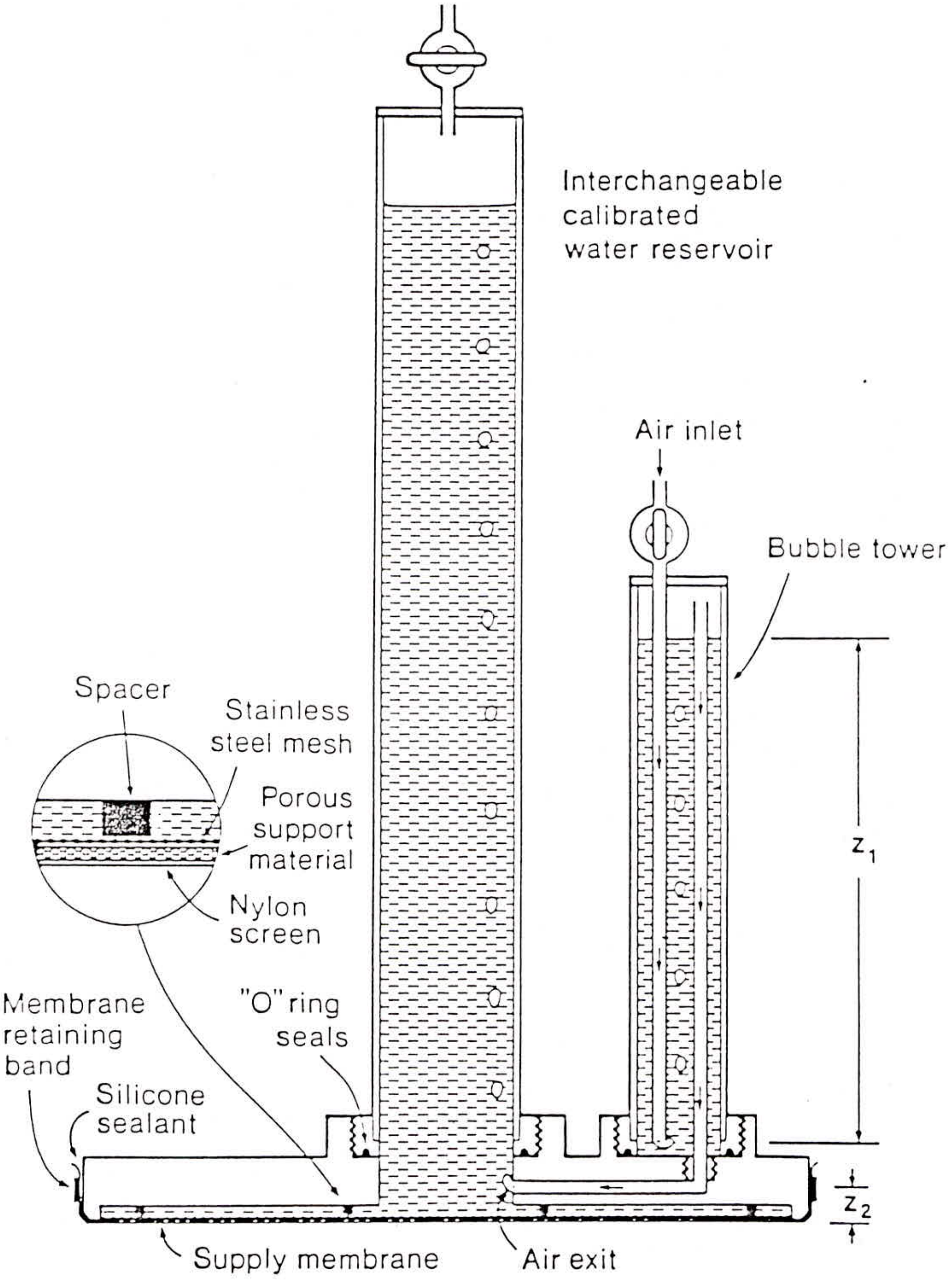


Fig. 5. The disc permeameter for unsaturated measurements.

(ii) Testing the membrane seal

The unsaturated permeameters are not air-tight unless the disc is soaked in water for several hours prior to the measurements. Proper operation can be checked by setting the potential in the bubble tower, filling the reservoir and holding the disc level, placing absorbent material in contact with the disc. The bubbling tower should begin to bubble but no bubbles should form in the reservoir above the membrane. To test for air leakage, move the towel around the circumference of the disc.

(iii) Site Preparation

If the soil is not bare and flat (usually only sandy soils), then it will be necessary to prepare a cap of contact material . Clean an area about 100 mm larger in diameter than the disc by clipping any vegetation down as low as possible (< 3 mm) and removing any large stones from the surface. Place the 3 mm high ring on the surface and fill with a suitable contact material , such as fine sand. Tamp down the sand lightly and smooth the by drawing a steel rule across the top of the ring. Carefully remove the ring. Infiltration measurements should be made as soon as possible to prevent the contact material surface from drying. Fill the disc reservoir and make the following checks.

1. One-way valve should be wetted (stopcock doesnot leak)

2. Level of water in the bubbling tower should be set properly;

3. No air bubbles should be present in the disc section.

(iv) Infiltration measurement

The same scale increments are used for the unsaturated measurements as are used for the ponded measurements. When placing the disc directly on the soil surface, begin until the wetting front has moved through the cap. The time taken depends on the cap material, the thickness and the value of the water potential set by the bubbling tower. It is better to begin timing too early rather than too late.

Record times as often as possible during the early stages of infiltration. As with the ponded measurements, recording may be interrupted until the flow rate approaches steady state. When the reservoir is about half empty, begin recording again. Continue making measurements until the flow rate is constant. Ten or more measurements constant to within sampling error are required.

(v) Supply surface water content

At the completion of infiltration remove the disc and quickly scrape aside a portion of the contact material cap. Sample the top 2 – 3 mm of soil with a spatula. Place the sample in an air-tight container for weighing. The sample must be taken from lower than 5 mm below the soil surface.

(vi) Required Measurement Times

Both the duration of the sorptive phase and the time of approach to steady state depend on the soil. The duration of the sorptivity-dominated phase can range from 0.02 to 1 hour. The time required to approach steady-state flow ranges from 0.2 to 6 hrs.

1.3 Guelph Permeameter apparatus

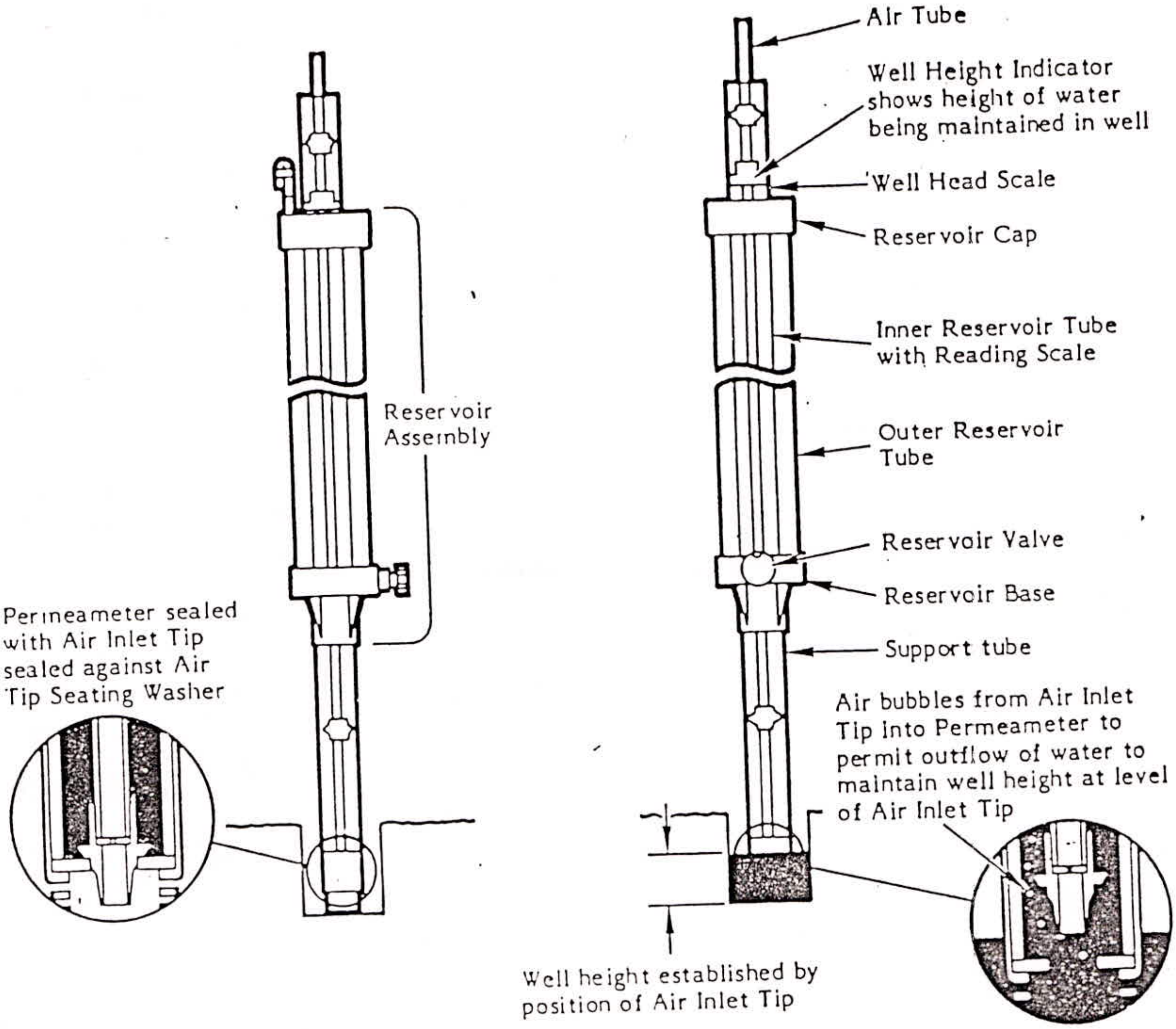
The Guelph permeameter is essentially an `in hole' Mariotte bottle constructed of concentric transparent plastic tubes. The apparatus comprises the following sections:

i) Tripod Assembly
ii) Support tubes and lower air tube fittings
iii) Reservoir assembly
iv) Well Head scale and upper air tube fittings
v) Auxialiary tools

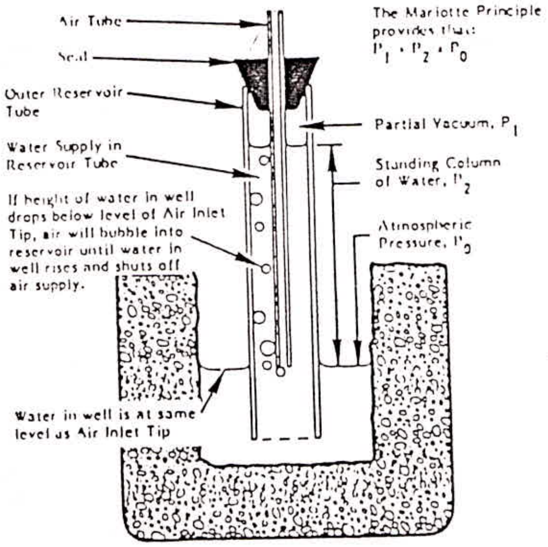
The Guelph permeameter method (Reynold et al. 1985) measure the steady state liquid recharge Q, necessary to maintain a constant depth of liquid H in an uncased cylindrical well of radius `a' finished above the water table. Constant head level in the well hole is established and maintained by regulating the level of the bottom of the air tube which is located in the centre of the permeameter . As the water level in the reservoir falls , a vacuum is created in the air space above water. When the permeameter is operating , an equilibrium is established.

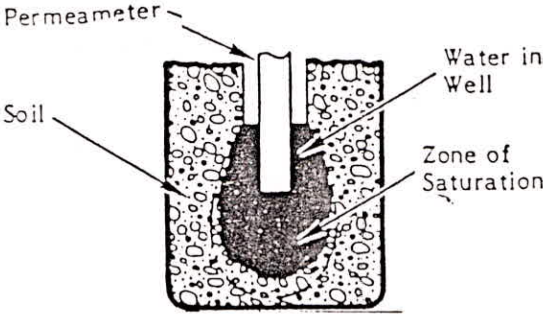
When a constant well height of water is established in a cored hole in a soil, a bulb of saturated soil with specific dimension is rather quickly established as shown in figure 6. The bulb is very stable and its shape depends on the type of soil, the radius of the well and the head of water in the well. The shape of the bulb is numerically described by the C factor used in the calculations. Once the bulb shape is established , the outflow of water from the well reaches a steady state flow rate which can be measured. The rate of this constant outflow of water, together with the diameter of the well and height of water in the well can be used to determine the field saturated hydraulic conductivity of the soil.

The Richard analysis of steady state discharge from a cylindrical well in unsaturated soil, as measured by the Guelph permeameter technique accounts for all the forces that contribute to three dimensional flow of water into soils, the hydraulic push of water into soil, the gravitational pull of liquid out through bottom of the well and the capillary pull o water out of the well into the surrounding soil. The Richard analysis is the basis for the calculation of field saturated hydraulic conductivity. The C factor is a numerically derived shape factor which is dependent on the well radius `a' and head `H' of water in the well. The flow chart of procedure for measurement of saturated hydraulic conductivity and permeameter placement are shown in figure 7a & 7b.



Details of reservoir assembly (A) closed or sealed state with air inlet tip sealed against air tip washer (B) when air tube is uplifted permitting of flow of water.





Permeameter in operation (A) Equilibrium is established (B) A view of bulb in zone of saturation

Fig. 6. Guelph Permeameter Reservoir assembly.

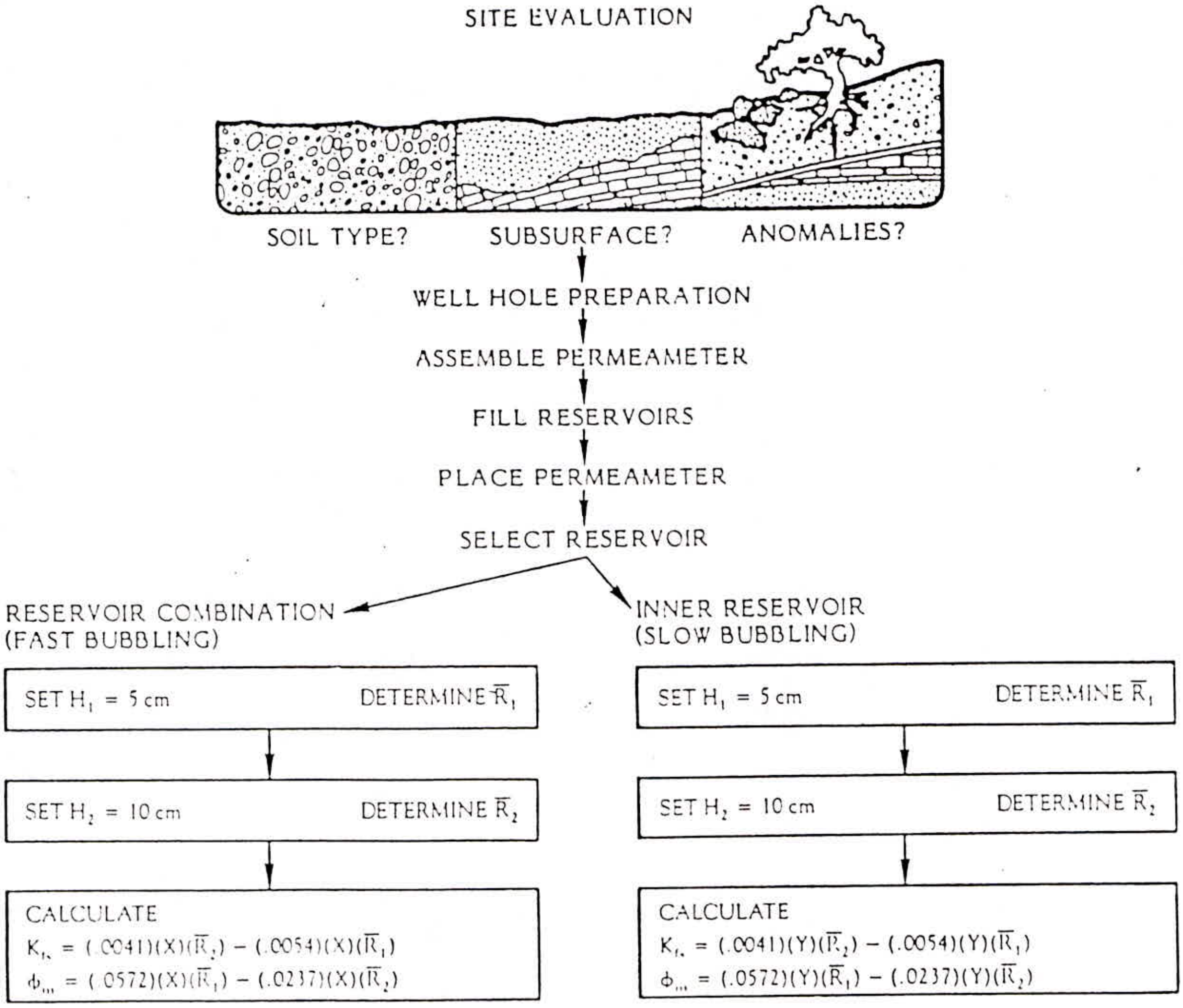


Fig. 7a. Flow chart of procedure for standardized method of measurement using the Guelph Permeameter

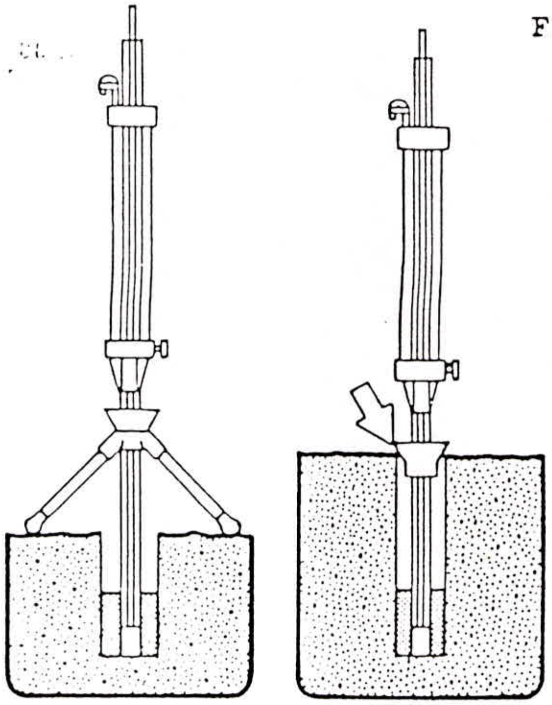


Fig.7b. Placement of permeameter in well hole

(i) Procedure for field use

Before making measurement with the Guelph permeameter in the field , it is necessary to perform a site and soil evaluation, prepare a well hole assemble the permeameter, fill the reservoir, and place permeameter in the well hole.

(ii) Well preparation

A borehole is drilled using soil and sizing auger. The soil auger is used to remove bulk amounts of soil and rock. The sizing auger is used as a finishing tool to produce a proper sized well hole of uniform geometry and to clean debris off the bottom of the well hole. The sizing auger is designed to produce a hole that is uniformly 6 cm in diameter with a flat bottom. Generally, the procedure is to use the soil auger to excavate the well hole last 15 cm can then be excavated using the sizing auger to produce a debris free well hole of uniform geometry .

In the moist soils or in medium to fine textured soils, the process of augering a hole may create a smear layer which can block the natural flow of water out of the well into the surrounding soil. In order to obtain reliable and representative results using the Guelph permeameter, the smear layer must be removed.

(iii) Permeameter placement

Simply centre the Tripod over the well hole and slowly lower the permeameter so that the support tube enters into the well hole. The tripod is used to support the permeameter in well down to approximately 38 cm in depth. For use in wells deeper that 38 cm, the tripod bushing alone provides the functions of centring and stabilising the permeameter. After the permeameter is placed, it can be easily filled with water. The following standard procedure should be followed for making measurements.

(i) verify that both the reservoirs are connected . The reservoirs are connected when the notch on the reservoir valve is pointing up.

(ii) Established 5 cm well Head Height (H1). Slowly raise the air inlet tip to establish the 5 cm well head height. Raising the air tube too quickly can cause turbulence and erosion in the well.

(iii) Observe the rate of fall of the water level in the reservoir. If it is too slow, then turn the reservoir valve so that the notch is pointing down. Water will then be supplied, only from the small diameter inner reservoir which will result in a much greater drop in water level between readings.

(iv) Measure permeameter outflow. This is indicated by the rate of fall of water in the reservoir. Readings shold be made at regular time intervals, usually 2 minute intervals are used. The difference of readings at consecutive interval divided by the time interval equals the rate of fall of water, R1 in the reservoir. Continue monitoring the rate of fall of water in the reservoir untill the rate of fall does not significantly change in three consecutive time intervals. This rate is called R1 and is defined as the "Steady state rate of fall" of water in the reservoir at height H1 which is the first well height established and is always 5 cm in the standardized procedure.

(v) Establish 10 cm Well head height (H2). Slowly raise the air inlet tip to establish the second well head height of 10 cm. Monitor the rate of fall of water, R2, in the reservoir until a stable value of R2 is measure.

(vi) The field saturated hydraulic conductivity, Kfs can be calculated using the following equation:

Kfs=0.0041 .X. R2 - 0.005 .X. R1

where,

X = Reservoir constant, equal to 35.39 when reservoir combination is used.

R2 = Steady, rate of fall of water in the reservoir when second head H2 equal to 10 cm of water is established.
R1 = Steady rate of fall of water in the reservoir when the first head H1 equal to 5 cm of water is established.
Kfs = Field saturated Hydraulic conductivity in cm/sec.

(iv) Strength and Weaknesses of the Various instruments used for field determination of hydrologic properties

1. Disc Permeameter : It is advantageous to use the disc permeameter which disturbs the soil layer very minimum. It is possible to determine both saturated and unsaturated hydraulic conductivities by using the same instrument. In addition to, infiltration and hydraulic conductivity it is possible to calculate sorptivity and pore characteristics. The instrument is quite handy and time required is comparatively very less. Quite suitable in hard rock terrains. Estimates three dimensional flow.

2. However, there are disadvantageous in certain regions like black cotton soils with deep cracks. In some cases it makes overestimation of infiltration rates. Since the depth of penetration of ring is very less it is possible to flow water laterally which cannot be accounted in the calculation. It is very difficault to take initial readings which may mislead the sorptivity values. As the calculation depend on soil moisture, soil moisture estimation brings up errors in infiltration estimate. The value of **`b'** used in the calculation require modification for different types of soils.

3. Double ring infiltrometer is quite is useful in developing infiltration capacity curve. The lateral flow of water is restricted by using double ring, i.e, buffer ring outside. The most difficult part of

this technique is that, it is difficult to transport from place to place. It requires large quantity of water and time consuming. It gives only the rate of infiltration (depth in cm)

4. Guelph permeameter estmates only hydraulic conductivity at a required depth. This is very useful in irrigation water requirement studies. One of the limitation of this instrument is that it cannot be used conveniently in clayey soils.

1.4 Laboratory Determination of Hydraulic Conductivity

Determination of the permeability of undistrubed soil samples is a simple matter. By creating a difference in water pressure on both sides of a well saturated soil sample a water flow passes through the sample. This flow is measured and form together with pressure differences and sample dimensions the essential data for permeability calculations.

The ICW permeameter (fig. 8) works in the following way.

In a closed system circulation pump 1 raises water from storage cistern 2, via filter 3, to the adjustable level regulator 4. To this regular two other pipes are connected: one lead to plastic container 5., the other takes the surplus water back to the storage cistern. The regulator will keep up the required water level in the container, since both regulator and container are part of a communicating vessel system (.e. level in regulator=level in container).

Now a well saturated soil sample is placed into a special ring holder, which is turn placed inside the container. Siphon 7 will lead the water oozing through the sample, via burette 8 and leak basin 9, back to the storage cister, resulting in difference h between the water level inside and outside of the ringholder. In this way a continuous flow of water runs through the sample, which can be measured by collecting this water in a burst and recording it s filling time.
In an open system the water flows directly from the main water supply into the level regulator. The apparatus works as described with the closed system, apart from the surplus and through flow waters, which are not led to a storage cistern but directly into a sewage system.

1.5 Pressure Plate Apparatus

This is a standard method for obtaining the soil moisture retention curve. Pressure plate apparatus consists of a pressure chamber in which a saturated soil sample is placed on a porous ceramic plate through which the soil solution passes but no soil particle or air can pass. The soil solution which passes through the membrane is in contact with atmospheric pressure. As soon as the air pressure inside the chambers are raised above the atmospheric it takes excess water from the soil out of the chamber through the membrane outlet. Soil water will flow out from the soil sample until the metric potential of the unsaturated flow is same as the applied air pressure.The air pressure is then released and the moisture content of the soil is gravimetrically determined.

During a run, soil moisture will flow from around from each of the soil particle and out through the ceramic plate until such time as the effective curvature of the water film through out

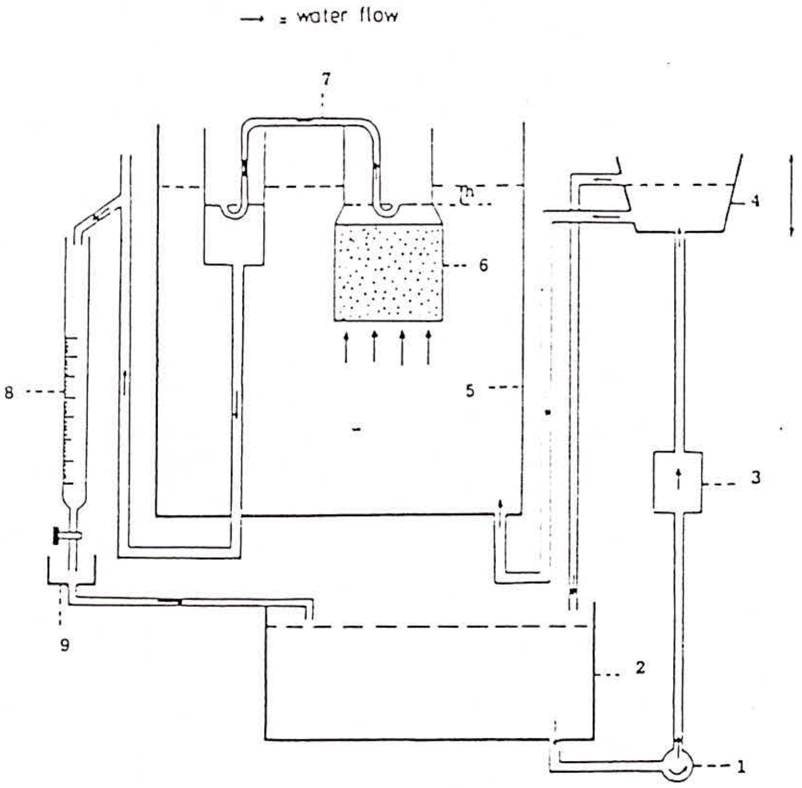


Fig.8; Principle of the laboratory permeameter.

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the soil are the same as at the pores in the plates. When this occurs an equilibrium is reached and the flow of moisture ceases. When air pressure in the chamber is increased, flow of water from the samples starts again and continue until a new equilibrium is reached. A source of regulated gas pressure is required for all extraction work. Compressed air from a compressor is the most efficient source of supply.

The ceramic plates are available in different range. Each ceramic pressure plate cell consists of a porous ceramic plate, covered on one side by a thin neoprne diaphragm sealed to the edges of the ceramic plate. An internal screen between the plate and diaphragm provides a passage for flow of water. An outlet stem running through the plates connects this passage to an outflow tube fitting which to the atmosphere outside of the extractor. To use the ceramic pressure plate cell, one or more soil samples are placed on the porous ceramic surface held in placce by retainingrings of appropriate height. The soil samples together with the porous ceramic plate are then saturated with water. This is usually done by allowing an excess of water to stand on the surface jof the cell for several hours. When the saturation is complete, the cell can be mounted intothe pressure vessel. Air pressure is used to effect extraction of moisture from the soil samples under controlled conditions. The 1 bar ceramic plates are ideal for the routine determination of the 1/10 bar and 1/3 bar range of the soil suction. The 3 bar pressure plate cells are used in the range of 0 - 3 bars. The 15 bar ceramic cells are commonly used for measurement of soil moisture suction in the range of 5 - 15 bars of soil suction.

The moisture retention curve of a soil sample can generally be determined by equilibrateing a soil sammple at a succession is known tension value and each time determining the amount of moisutre. The graph is plotted between the tension and corresponding soil moisture value to obtain the soil moisture retention curve. Different types of soil yields different retention curves.

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