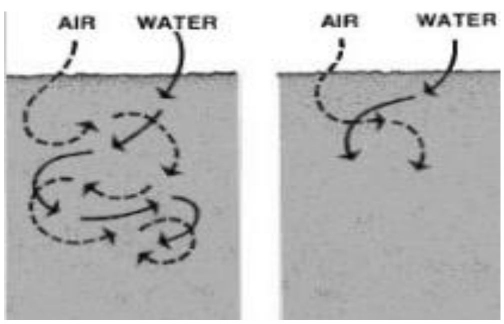
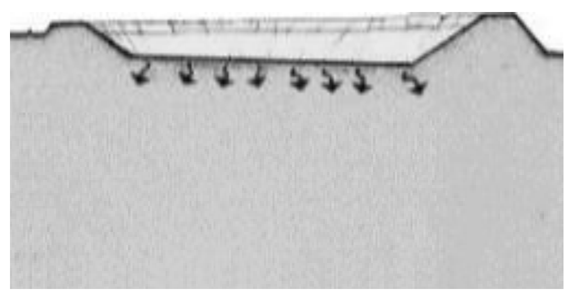
SOIL PERMEABILITY

- A material is permeable if it contains continuous voids.
- All materials such as rocks, concrete, soils etc. are permeable. The flow of water through all of them obeys approximately the same laws. Hence, the difference between the flow of water through rock or concrete is one of degree.
- The permeability of soils has a decisive effect on the stability of foundations, seepage loss through embankments of reservoirs, drainage of subgrades, excavation of open cuts in water bearing sand, rate of flow of water into wells and many others.

Why is it important to determine soil permeability?

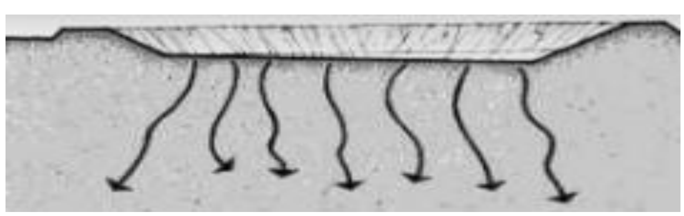
Soil permeability is the property of the soil to transmit water and air and is one of the most important qualities to consider for fish culture.





Impermeable Soil Looses More Water

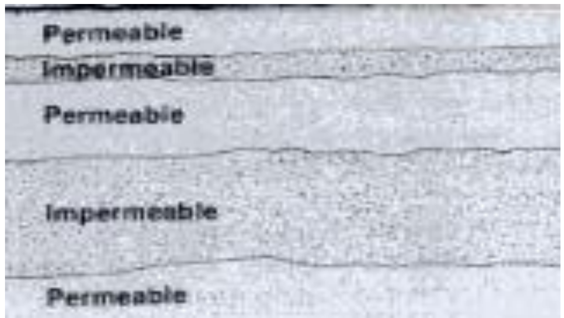
A small pond built in impermeable soil will lose little water through seepage.



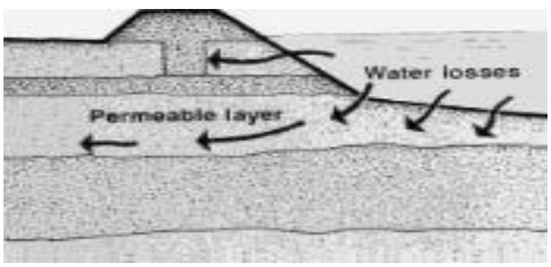
Permeable Soil loses too much water

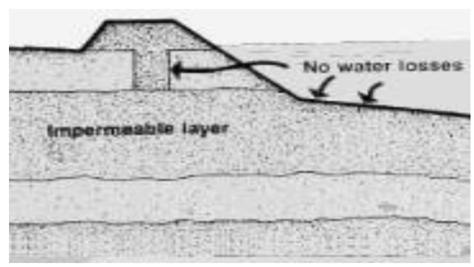
The more **permeable the soil**, the greater the **seepage**.

Some soil is so permeable and seepage so great that is not possible to build a pond without special construction techniques.



Soils are generally made up of layers and soil quality often varies 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 good water retention.

Again, soil quality will have to be checked with this in mind.

Which factors affect soil permeability?

There are factors that can 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, mottling, layering, visible pores and depth to impermeable layers such as bedrock and clay pan form the basis for deciding if permeability measurements are likely to be representative.

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

<table>
<tr><th colspan="2">STRUCTURE TYPE</th><th>PERMEABILITY</th></tr>
<tr><td rowspan="2">Platy</td><td>-Greatly Overlapping</td><td rowspan="5">From very slow to very rapid</td></tr>
<tr><td>-Slightly Overlapping</td></tr>
<tr><td colspan="2">Blocky</td></tr>
<tr><td colspan="2">Prismatic</td></tr>
<tr><td colspan="2">Granular</td></tr>
</table>

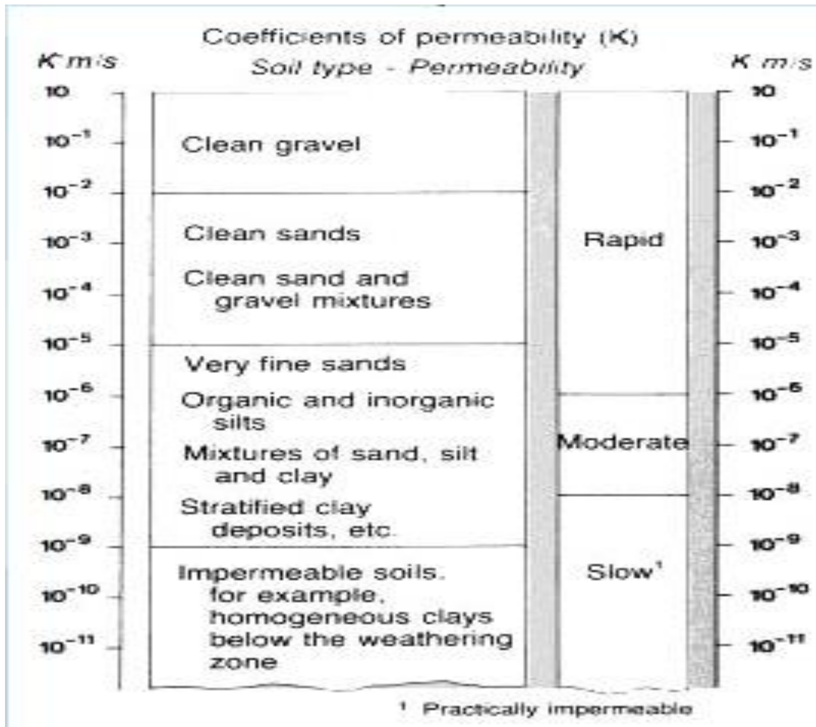
Table-1

Table-1: 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 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 centimeters per hour (cm/hr), millimeters per hour (mm/hr), or centimeters per day (cm/day), or as a **coefficient of permeability** k in meters per second (m/sec) or in centimeters per second (cm/sec).

Measurements of soil permeability in the laboratory

When you take an undisturbed sample to a testing laboratory, to measure permeability, a column of soil is placed under specific conditions such as water saturation and constant head of water.

SOIL PERMEABILITY CLASSES FOR AGRICULTURE AND CONSERVATIONS

Soil Permeability Classes	**Permeability Rates**	
	cm/hour	**cm/day**
Very Slow	Less than 0.13	Less than 3
Slow	0.13-0.3	3-12
Moderately Slow	0.5-2.0	12-48
Moderate	2.0-6.3	48-151
Rapid	12.7-25	305-600
Very Rapid	More than 25	More than 600

TABLE - 2

PERMEABILITY RATE

SOIL PERMEABILITY CLASSES FOR CIVIL ENGINEERING

Soil Permeability Classes	**Coefficient of Permeability (K in m/sec)**	
	LOWER LIMIT	**UPPER LIMIT**
Permeable	$\mathbf{2 \times 10^{-7}}$	$\mathbf{2 \times 10^{-1}}$
Semi-permeable	$\mathbf{1 \times 10^{-11}}$	$\mathbf{1 \times 10^{-5}}$
Impermeable	$\mathbf{1 \times 10^{-11}}$	$\mathbf{5 \times 10^{-7}}$

TABLE - 3

COEFFICIENT OF PERMEABILITY

MEASUREMENTS OF SOIL PERMEABILITY IN THE FIELD

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 VISUAL EVALUATION OF THE PERMEABILITY RATE OF SOIL HORIZONS

The permeability of individual soil horizons may be evaluated by the visual study of particular soil characteristics which have been shown by soil scientists to be closely related to permeability classes.

The most significant factor in evaluating permeability is structure: its type, grade, and aggregation characteristics, such as the relationship between the length of horizontal and vertical axes of the aggregates and the direction and amount of overlap.

Although neither soil texture no **color mottling** alone are reliable clues, these soil properties may help to estimate permeability when considered together with the structural characteristics.

To evaluate visually the permeability of soil horizons:

1. Examine a fresh soil profile in an open pit;
2. Determine the soil horizons present;
3. Using the Table – 4, evaluate the permeability class to which each horizon belongs; carefully studying the structural characteristics of the soil;
4. Confirm your results through the other soil properties in Table – 5;
5. Ranges of permeability rates may then be found in Table – 2.

Permeability class (Table 15)	*Structure, type and class (Sec 73) (1)*	*Structure, grade and consistency (Secs 72 + 80) (2)*	*Relationship of horizontal and vertical axes, overlap, cleavage, and its direction (3)*	*Porosity channels and cracks (4)*
Very slow permeability	Massive	Very strong		Without visible pores.
	Irregular blocky; often assuming a columnar structure	Clods are very strong and cannot be broken by hand. More force is required to break the blocks vertically than horizontally. Horizontal breakage is usually along the block faces and in some instances the small irregular angular blocks can be flaked off horizontally.	Where the irregular blocky structure dominates, the irregular fragments are very firmly developed with a longer horizontal than vertical axis and with sharp angles. These are meshed shingle-fashion with about 50 percent horizontal overlap. Under proper moisture conditions, the medium to coarse irregular angular blocks break along definite cleavage to fine irregular, angular blocky structure, the arrangement remaining the same regardless of size.	The individual blocks have no visible pores, but some tortuous vertical channels that seem to follow block faces are discernible, usually at 2- to 5-cm intervals which seldom extend more than 5-8 cm without a horizontal jog.
	Structureless	It is usually difficult to break into the mass, but once broken in, the small indurated lumps pulverize easily.		
Slow permeability	Fine to medium irregular blocky	More force is required to break the blocks along the vertical than the horizontal axis. The broken faces tend to assume a saw-toothed appearance.	The irregular angular blocks have sharp angles and the horizontal axes are longer than the vertical. The blocks are generally meshed shingle-fashion with about 40 percent horizontal overlap.	There are very few small pores discernible. The apparent vertical cracks which follow the block surfaces seldom extend more than a few cm before jogs of 2-5 cm appear.
	Usually platy, sometimes structureless	Plates broken horizontally fracture along straight smooth lines, the laminated layers seeming to be made of small flattish "chips" that can be easily removed by tweezers.	Horizontal bedding can be easily detected in "chip" form, generally lying in shingle-fashion with horizontal overlap of 40-50 percent or more. Sometimes the thin, laminated layers are continuous.	Only a few very fine vertical pores are visible. Flow of water follows apparently tortuous lines around the main chips.
Moderately slow permeability	Medium to fine irregular blocky, fragmental	The blocks (clods) and fragments are less firm and stable than those of the slower permeability classes. They can be more easily broken along the vertical axes.	The angle of the blocks and fragments is not sharp and often very slightly rounded. The horizontal axis is only slightly longer than the vertical. The structural fragments overlap 20-25 percent. If the overlap is oblique, the size of fragments may be larger and the overlap more than 25 percent.	Pores are fine but moderately numerous. The oblique overlap is indicative of freer air and water movement. Root penetration is noticeable.
Moderate permeability	Fine to medium subangular blocky (nut-like), partially rounded, some obtuse angles	Cohesion of soil materials is moderate and clods are easily broken by hand, but seldom fractured unless broken individually.	The clods or blocks overlap only slightly and many vertical fractures are almost straight. Cleavage generally occurs along the faces of the nuciform aggregates.	Pores are medium to fine and numerous.
Moderately rapid permeability	Medium subangular blocky (nuciform) coarse granular or crumb structure	The structural aggregates are not firmly developed and the cohesion of soil material is moderately weak.	Vertical cleavage is nearly always along aggregate faces and follows approximately straight vertical or oblique lines, with only occasional slight overlap of structural aggregates.	Pores in the aggregate are large and numerous.
Rapid permeability	Crumb structure (sometimes ranging toward a single-grain condition)	Consistency ranges from slightly plastic when wet to friable or crumbly when dry.		Pore space is large.
Very rapid permeability	Single-grain structure	Consistency ranges from non-plastic when wet to incoherent when moist or dry.		

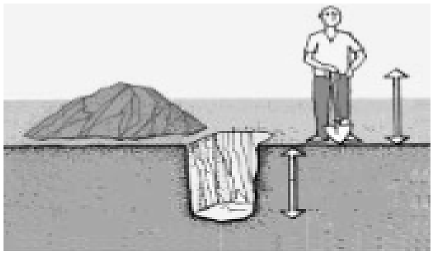
Table - 4

Permeability class (Table 15)	*Texture and profile*	*Physical behaviour*	*Colour and mottling*
Very slow permeability	Claypans, heavy clay, or in presence of very slowly permeable substratum	Soil cracks severely on drying with exception of hardpan or indurated layers which do not crack or fracture.	Generally mottled.
	Hardpan as distinguished from claypan	The hardpan layers associated with this class often consist of highly indurated layers of sand or sand and gravel. These usually give out a ringing sound when struck with a spade.	High degree of mottling.
Slow permeability	Clay or silty clay, claypans, moderately indurated layers	Shrinkage and cracking are less pronounced than in the very slowly permeable class.	Mottling is moderately strong.
	Silt, "siltpan"		Moderately strong mottling and greyish colour are indications of this type of structure.
Moderately slow permeability	Moderately fine-textured horizons, showing a small amount of granulation or a slight dispersion of particles	Shrinkage is usually not very pronounced and cracks are neither large nor numerous.	Mottling is moderate, but the colour is brighter than for the slow permeability class.
Moderate permeability	Moderately fine textures, slightly plastic when wet and moderately hard when dry		Mottling is generally slight.
Moderately rapid permeability	Moderately fine to medium-textured soils		Occasional mottling. Colour is generally moderately bright yellow.
Rapid permeability	Medium or moderately coarse-textured soils		There are no mottlings unless water-table is high. Colour is generally very bright. Organic matter content is usually moderate or low.
Very rapid permeability	Coarse-textured or gravelly soils		Colour is bright unless the water-table is high.

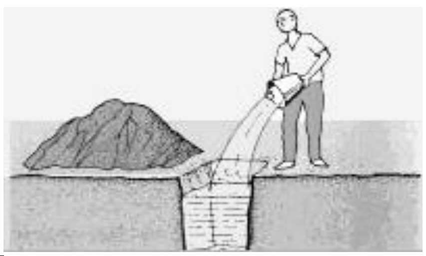
Table - 5

SIMPLE FIELD TEST FOR ESTIMATING SOIL PERMEABILITY

Step 1: Dig a Hole as deep as your waist

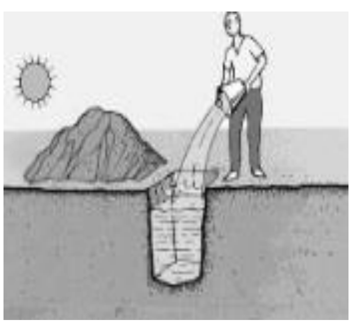


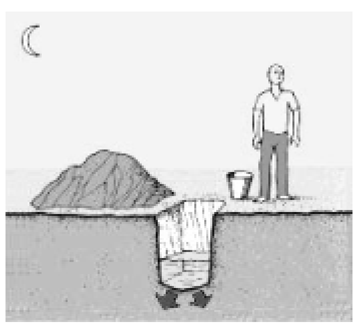
Step 2: Fill the hole with water to the top again, and cover it with boards.

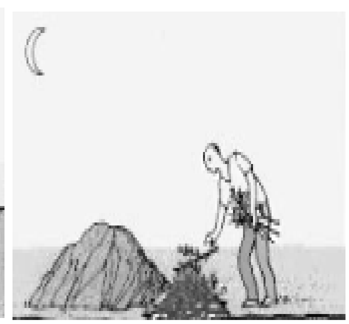


Step 3: If most of the water is still in the hole the next morning, the soil permeability is suitable to build a fish-pond here;

Step 4: Early in the morning, fill it with water to the top;

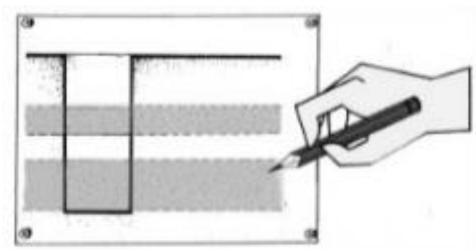
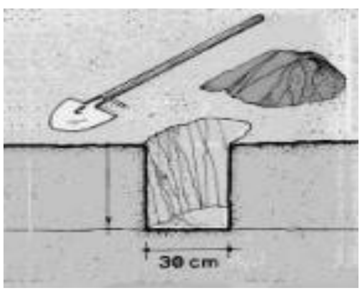


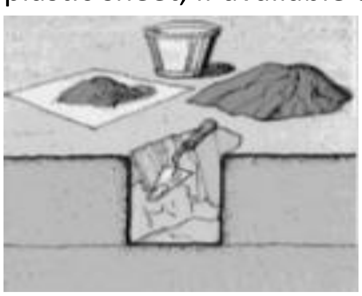




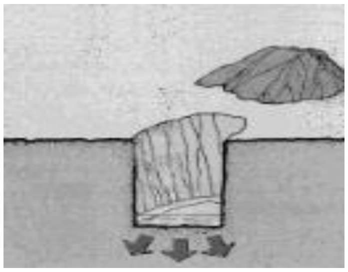
Step 5: Repeat this test in several other locations as many times as necessary, according to the soil quality.

PRECISE FIELD TEST FOR MEASURING PERMEABILITY RATES:

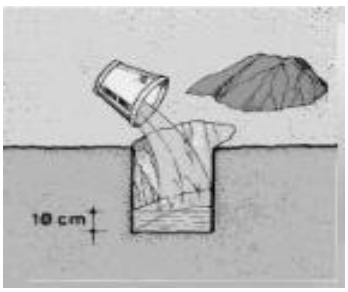
1. Carefully examine the drawings you have made when studying your soil profiles; You can use the Tables-4 and Tables-5 to estimate permeability.
2. Mark the soil horizons on your drawings which seem to have the slowest permeability. Use a colored pencil;
   Note: Water seeps into the soil both horizontally and vertically, but you need only be concerned with the water seepage because this is mainly what happens in ponds.
3. On the basis of texture and structure, determine which soil horizons seem to have the slowest permeability;
   
4. Dig a hole approximately 30cm. in diameter until you reach the uppermost least permeable horizon;
   

5. Thoroughly smear the sides of the hole with heavy wet clay or line them with a plastic sheet, if available to make them waterproof;
   

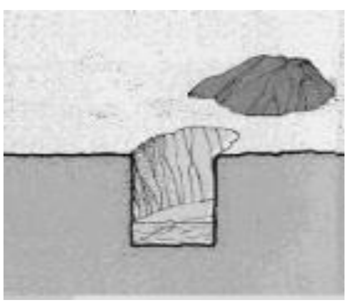
6. At first, the water will seep down rather quickly, and you will have to refill as it disappears.



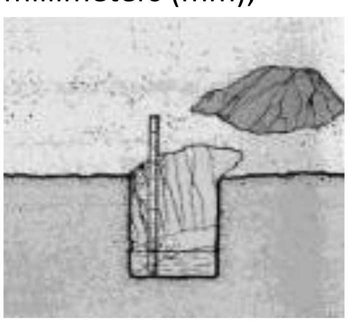
7. Make sure that the water in hole is about 10cm deep as before. If it is not, add water to reach that level;



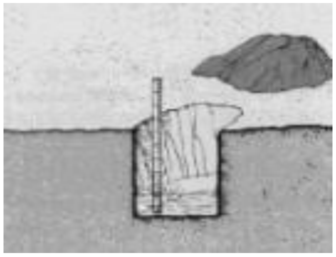
8. When the pores of the soil are full of water, seepage will slow down. You are then ready to measure the permeability of the soil horizon at the bottom of the hole.



9. Put a measuring stick into the water and record the exact water depth, in millimeters (mm);

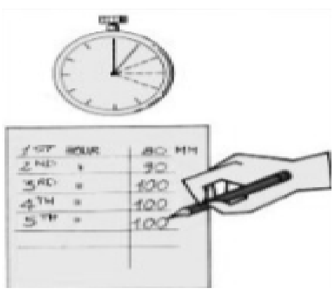


10. Check the water level in the hole every hour for several hours. Record the rate of seepage for each hourly period. If the water disappears too rapidly, add water to bring the level up to 10cm. again. Measure the water depth very carefully;



11. When your hourly measurements become nearly the same, the rate of permeability is constant and you may stop measuring.

12. If there are great differences in seepage each hour, continue pouring water into the hole to keep the level at 10cm. until the rate of seepage remains nearly the same.



NOTE: A soil horizon with suitable permeability for a pond bottom should also be at least 0.7-1m, thick unless lower horizons exist with suitable permeability and thickness.

13. Lastly, now compare your results with the following values.

PERMEABILITY RATE IN mm/hr.	**Suitability of horizon for a pond bottom**
Slower than 2	Acceptable seepage: soil suitable
2-5	Fast seepage: soil suitable ONLY if seepage due to soil which will disappear when pond is filled.
5-20	Excessive seepage soil unsuitable unless seepage can be reduced as described below.

If the permeability rate is faster than **5mm/hr**., this may be owing to a strongly developed structure in the soil. In such cases, you try to reduce the permeability rate by destroying the structure, as follows:

a. Puddle the bottom soil of the hole as deep as you can.
b. Repeat the more precise permeability test until you can measure a nearly constant value for seepage.