LECTURE NOTES

Irrigation and Hydraulic Structures

Semester: 6^{th}, B.Tech

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CHAPTER-6

WATERLOGGING

Waterlogging

Introduction:

Waterlogging occurs when the soil is saturated with water. The agricultural land becomes waterlogged when the soil pores within the root zone of the crops get saturated and the normal conditions circulation of air is cutoff. The waterlogging affects the productivity of the land and leads to a reduction in the crop yield. Waterlogging generally occurs because of over-irrigation, high water table and the poor water management.

Due to the presence of water at or near the land surface, evaporation takes place continuously. Because of evaporation, there is a continuous upward flow of water from the water table if it is high because of the capillary action. Water brings salts with it and when the water evaporates, these salts get accumulated on the surface. These salts affect the fertility of the soil, and the soil may become alkaline. Waterlogging can be prevented to a large extent by providing an effective drainage system.

Causes of waterlogging:

Waterlogging of the land occurs when the water table rises and the soil in the root zone of the plants gets saturated and the air circulation is stopped. Waterlogging general ly occurs because of intensive irrigation and inadequate drainage of the irrigated land. Waterlogging affects the productivity and the fertility of the land and causes a reduction in the crop yield. The causes of waterlogging are:

1. Over-Irrigation: The main cause of waterlogging is over-irrigation of the land. The excess water applied to the land percolates deep into the ground and joins the water table. As the ground water storage is augmented, the water table rises. As soon as the water table comes close to the land surface, waterlogging occurs.

2. Inadequate surface drainage: Waterlogging usually occurs when there is inadequate surface drainage of the irrigated land. Heavy precipitation along with inadequate surface drainage causes flooding of the land. The prolonged flooding (or inundation) results in heavy percolation of water into the ground, which causes a rise of the water table and hence waterlogging.

3. Obstruction of natural surface drainage: If a natural drainage (stream) near the irrigated area is obstructed by constructing an embankment for a road, canal, etc., the flooding of the area may occur leading to waterlogging.

4. Obliteration of a natural drainage: If an existing natural drainage is destroyed, it results in stoppage of natural flow and hence waterlogging.

5. Obstruction of natural subsurface drainage: If there is an impermeable stratum below the land surface at a relatively low depth, it prevents natural downward movement of water into the subsoil which may result in the formation of perched water table that can cause waterlogging.

6. Impervious top layer: If the top layer of the land is impervious, it obstructs the flow in the downward direction. Such land is prone to waterlogging due to irrigation.

7. Seepage from canals: Water Seeps from the bed and sides of an unlined canal. It adds to the ground water reservoir and there is a general rise in the water table, which may lead to waterlogging.

8. Construction of a reservoir: If a large reservoir is constructed in the region, there is an increase in the water level on the upstream of the dam. Consequently, there is an increase in the inflow to the groundwater storage and a decrease in the outflow from the groundwater as base flow of the river. The adjoining area may get waterlogged.

9. Defective methods of cultivation: If the defective methods of cultivation are used, there may be ponding up of water on the land surface which may cause waterlogging. The defective methods of cultivation include construction of high levees (bunds) which obstruct the natural drainage, inadequate preparation of land, failure to smoothen the field after tillage, improper disposal of spoil earth, improper selection or crops and growing crop which require excessive watering.

10. Defective irrigation practice: Waterlogging may also occur due to detective irrigation practice, such as adopting high intensity of irrigation, applying high depth of water and using detective method of application of water like wild flooding.

Ill effects of waterlogging:

1. Reduction in growth of plants: Because of waterlogging, there is absence of aeration in the roots of plants due to which the plant growth is reduced.

2. Difficulty in cultivation: For optimum results in crop production, the land has to be prepared. The preparation of land in wet condition is difficult and expensive. As a result, cultivation may be delayed and the crop yield adversely affected.

3. Accumulation of salts: As a result of high water table in waterlogged areas, there is an upward capillary flow of water to the land surface where water gets evaporated. The upward moving water brings with it soluble salts from the salty soil layers well below the surface. These soluble salts carried by the upward moving water are left behind in the root zone when this water evaporates. The accumulation of these salts in the root zone of the soil may affect the crop yield considerably.

4. Weed growth: There are certain types of plants and grasses which grow rapidly in marshy lands. In waterlogged lands, these plants compete with the desired useful crop. Thus, the yield of the desired useful crop is adversely affected.

5. Increase in plant diseases: Because of waterlogging, various diseases occur in the plants, which decrease their growth.

6. Lowering of soil temperature: The presence of excessive moisture content lowers the temperature of the soil. In low temperature the bacteriological activities are retarded which affects the crop growth badly.

7. Increase in incidence of malaria: The waterlogged land becomes a breeding place for mosquitoes which may cause malaria. Moreover, the climate becomes damp which may affect the health of community.

Measures for prevention of waterlogging:

The main cause of waterlogging in an area is the introduction of canal irrigation in the area. It is; therefore, better to plan an irrigation scheme in such a way that the land is prevented from getting waterlogged. The following measures are usually adopted for prevention of waterlogging or relieving the area, which are waterlogged.

1. Limiting the intensity of irrigation: In regions where there is a possibility of waterlogging, the annual intensity of irrigation should be kept low, not more than 40 to 60%.

2. Providing a drainage system: Waterlogging can be prevented by providing a properly designed drainage system.

3. Lining the canal section: When the canal section is made fairly watertight by providing lining, the seepage loss is reduced to quite a good extent.

4. By lowering the FSL of the canal: Loss may be due to percolation or absorption but when FSL is lowered the loss is reduced to sufficient extent. The canal should be designed such that its FSL is as low as possible, consistent with the requirements of flow irrigation for the commanded area.

5. Improving the natural drainage of the area: Improving the natural drainage involves removing obstruction to the flow such as weeds, bushes and other vegetations from the stream section. Straightening of the streams and canalizing them into shallow wide reaches improves the natural drainage. Increasing the bed slopes of the streams also improves the drainage. The chances of waterlogging are considerably reduced if the natural drainage of the area is good.

6. Provision of intercepting drains: These are generally constructed parallel to the canal. The water seeping from the unlined canal can be intercepted by providing intercepting. They give exceptionally good results for the reach where the canal runs in high embankments.

7. Increasing outflow from the groundwater reservoir: If the well irrigation is adopted in the area, the water table goes down and the chances of waterlogging are considerably less. In fact, a judicious combination of the canal irrigation and the well irrigation in the same area is an ideal solution for the waterlogging problems.

8. Changing the crop pattern: In regions susceptible to waterlogging, the crop pattern should be changed so that the crop requiring heavy irrigation should be avoided and those requiring light irrigation is encouraged.

9. Prevention of seepage from reservoir: The seepage from small reservoirs can be reduced by lining the surface of the reservoirs. Also suitably designed filters should be provided so that seepage from the reservoirs is discharged into streams.

10. Changing the assessment method: lf the water supplied to the cultivators is assessed on area basis; the cultivators have a tendency to use excess water which causes waterlogging. By adopting the volumetric assessment of water, the excess use of water is controlled and the chances of waterlogging are reduced.

11. Adopting better methods of application of water: By adopting efficient methods of application of water, such as Sprinkler irrigation and drip irrigation, waterlogging can be prevented.

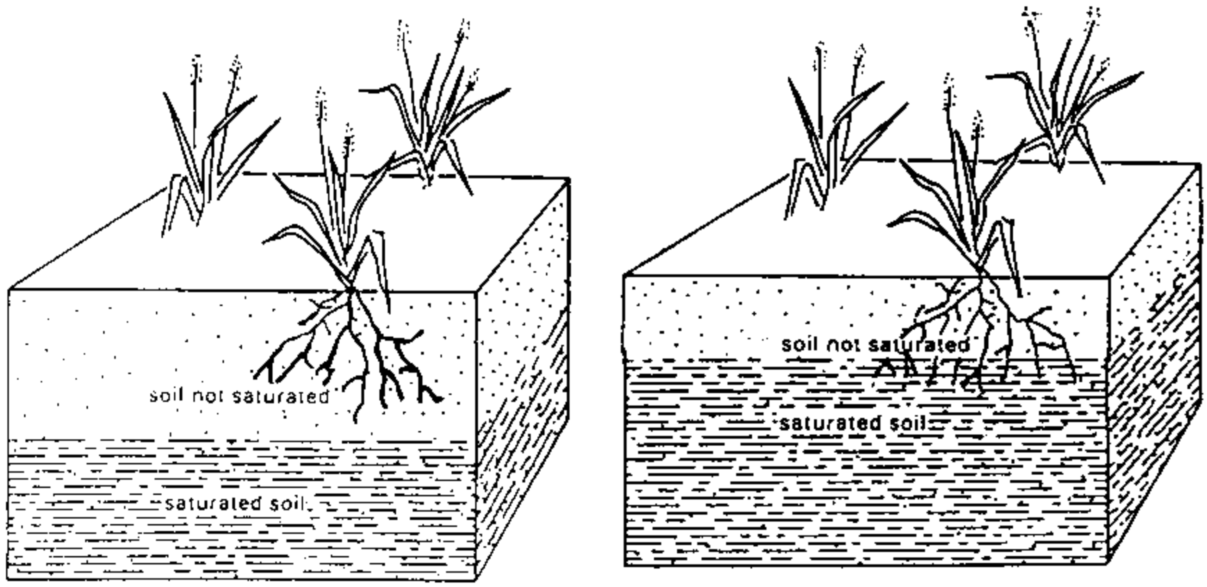
12. Educating the cultivators to use water economically: The cultivators should be apprised of ill effects of waterlogging. They should be trained to use water economically and avoid wasteful use of water.

Drainage of Irrigated lands:

Need for drainage: During rain or irrigation, the fields become wet. The water infiltrates into the soil and is stored in its pores. When all the pores are filled with water, the soil is said to be saturated and no more water can be absorbed; when rain or irrigation continues, pools may form on the soil surface.

Part of the water present in the saturated upper soil layers flows downward into deeper layers and is replaced by water infiltrating from the surface pools. When there is no more water left on the soil surface, the downward flow continues for a while and air re-enters in the pores of the soil. This soil is not saturated anymore. However, saturation may have lasted too long for the plant health. Plant roots require air as well as water and most plants cannot withstand saturated soil for long periods.

Besides damage to the crop, a very wet soil makes the use of machinery difficult, if not impossible. The water flowing from the saturated soil downward to deeper layers, feeds the groundwater reservoir. As a result, the groundwater level (often called groundwater table or simply water table) rises. Following heavy rainfall or continuous over-irrigation, the groundwater table may even reach and saturate part of the root zone (Fig. 1). Again, if this situation lasts too long, the plants may suffer. Measures to control the rise of the water table are thus necessary.



(a) Before Irrigation **(b) After Irrigation**

Figure 1. Groundwater table before and after irrigation

The removal of excess water either from the ground surface or from the root zone is called drainage. Excess water may be caused by rainfall or by using too much irrigation water, but may also have other origins such as canal seepage or floods. In very dry areas there is often accumulation of salts in the soil. Most crops do not grow well on salty soil. Salts can be washed out by percolating irrigation water through the root zone of the crops. To achieve sufficient percolation, farmers will apply more water to the field than the crops need. But the salty percolation water will cause the water table to rise. Drainage to control the water table, therefore, also serves to control the salinity of the soil.

Types of drainage:

Drainage can be either natural or artificial. Many areas have some natural drainage; this means that excess water flows from the farmers' fields to swamps or to lakes and rivers. Natural drainage, however, is often inadequate and artificial or man-made drainage is required. There are two types of artificial drainage:

1. Surface drainage

2. Subsurface drainage

1. Surface drainage: Surface drainage is the removal of excess water from the surface of the land. This is normally accomplished by shallow ditches, also called open drains. The shallow ditches discharge into larger and deeper collector drains. In order to facilitate the flow of excess water towards the drains, the field is given an artificial slope by means of land grading (Fig. 2).

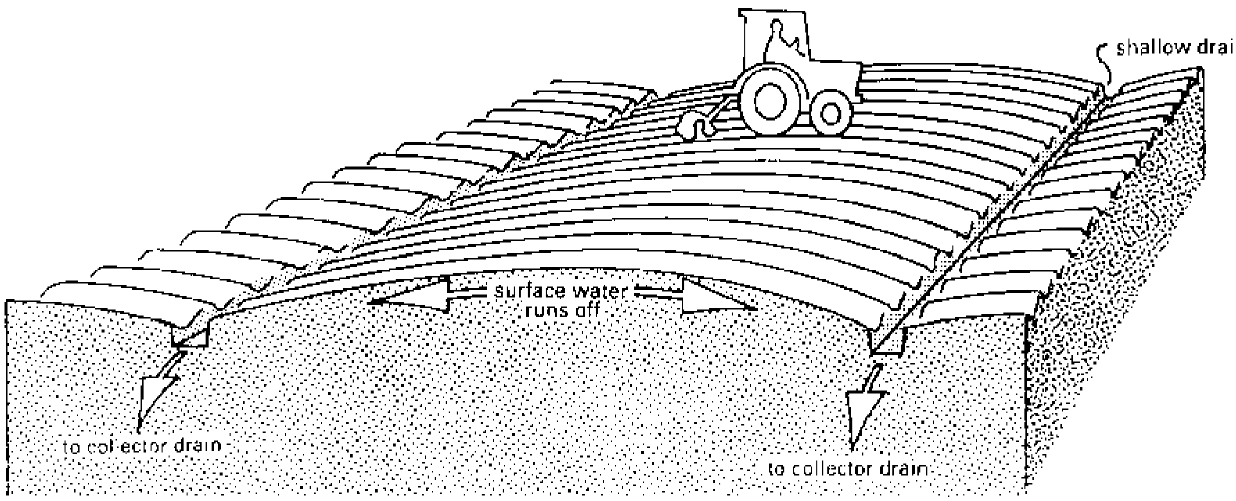


Figure 2. Surface drainage- The field is given artificial slope to facilitate drainage

2. Subsurface drainage: Subsurface drainage is the removal of water from the root zone. It is accomplished by deep open drains or buried pipe drains.

i. <u>Deep open drains</u>

The excess water from the root zone flows into the open drains (Fig. 3). The disadvantage of this type of subsurface drainage is that it makes the use of machinery difficult. Open drains use land that otherwise could be used for crops. They restrict the use of machines. They also require a large number of bridges and culverts for road crossings and access to the fields. Open drains require frequent maintenance (weed control, repairs, etc.).

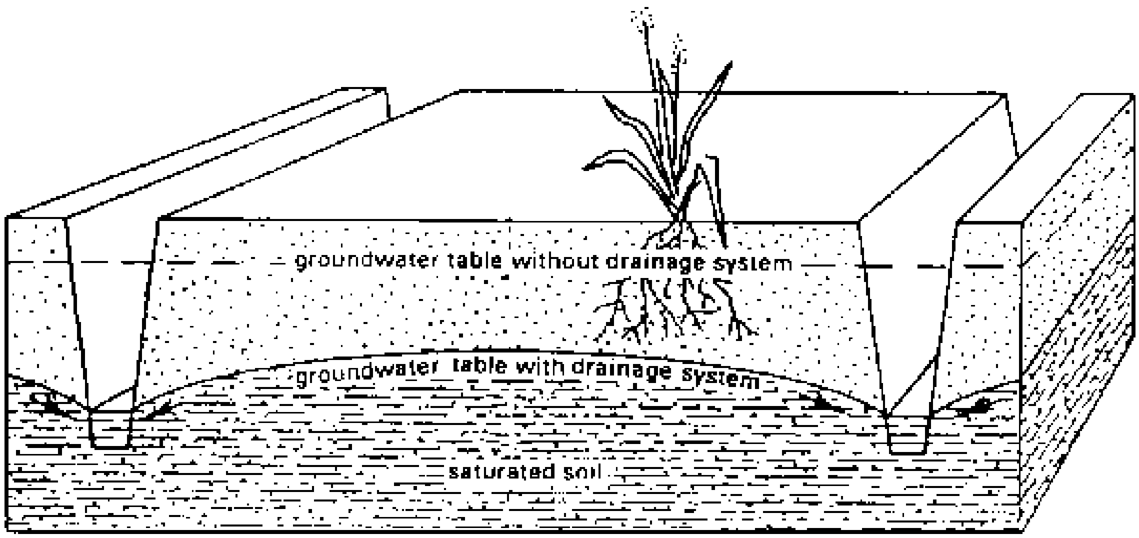


Figure 3. Deep open drains

ii. Pipe drains

Pipe drains are buried pipes with openings through which the soil water can enter. The pipes convey the water to a collector drain (Fig. 4).

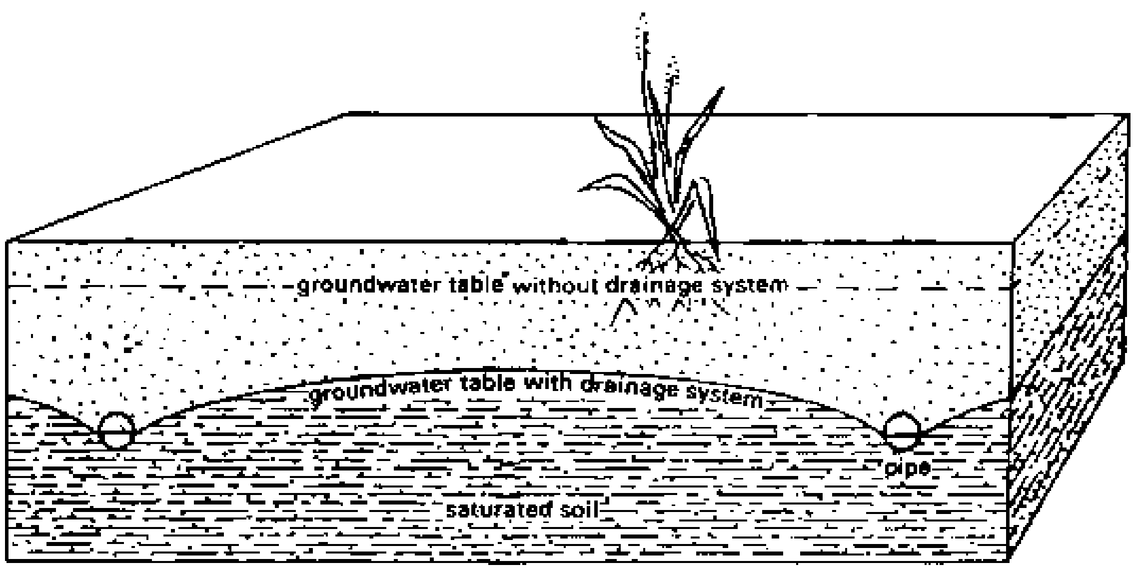


Figure 4. Pipe drains

Drain pipes are made of clay, concrete or plastic. They are usually placed in trenches by machines. In clay and concrete pipes (usually 30 cm long and 5 -10 cm in diameter) drainage water enters the pipes through the joints. Flexible plastic drains are much longer (up to 200 m) and the water enters through perforations distributed over the entire length of the pipe. In contrast to open drains, buried pipes cause no loss of cultivable land and maintenance requirements are very limited. The installation costs, however, may be higher due to the materials, the equipment and the skilled manpower involved.

Saline and alkali soils:

Soils are classified as saline or alkaline mainly on the basis of their soluble salt concentration and exchangeable sodium content. Because both these parameters depend upon the moisture content of the soil, it is important to mention the moisture content used in the test. The most commonly used moisture content is the saturation moisture content as determined from a saturated, disturbed soil sample in the laboratory. The soil sample is brought to saturation condition by stirring it in distilled water. When the sample becomes fully saturated, the characteristic end point is reached. The soil glistens and flows slightly without free water standing on the surface. The solution is extracted from the soil in this condition for the test. The solution is called the saturation extract.

On the basis of the soluble salt concentration and exchangeable sodium content, the soils may be classified into 3 types:

1. Saline soils

2. Saline-alkali soils

3. Alkali soils

1. Saline soils: Saline soils are the soils which contain soluble salts in a large quantity such that the growth of the plants is hampered. A normal (non-saline) soil may become saline if the irrigation water contains large quantities of salts. The soil may also become saline by upward movement of ground water due to capillary action when the water table is high. In both these cases, the salts accumulate on the soil surface. The soluble salts in the saline soils are mainly chlorides and sulphates of calcium, magnesium and potassium. Sometimes nitrates of these elements are also found. The saline soils may also contain insoluble salts such as calcium sulphates (gypsum), calcium carbonates and magnesium carbonates. If the saturation extract contains less than 3 gm/l of salt, the soil is said to be non-saline, and if the salt concentration of the saturation extract contains more than 12 gm/l, the soil is said to be highly saline. The electrical conductivity of saline soils is greater than 4000 micromhos per cm at 25°C.

The saline soils can be reclaimed by reducing the soluble salt concentration to acceptable limits by leaching, provided adequate drainage occurs. For that purpose, more water is applied to the field than is required for crop growth. This additional water infiltrates into the soil and percolates through the root zone. During percolation, it washes the salts out of the root zone and takes these along to deeper layers. This is known as leaching.

2. Saline-alkali soils: The saline-alkali soils have characteristics somewhat in-between those of the saline and alkali soils. For such soils the electrical conductivity is greater than 4000 micromhos per cm at 25°C, the exchangeable sodium percentage is greater than 15 and the pH value is about 8.5. Saline-alkali soils can be reclaimed by leaching, but before leaching, it is necessary to replace the exchangeable sodium ions present in the soil by calcium or other suitable ions. If this is not carried out the exchangeable sodium ions will be left after leaching which may deteriorate the soil structure due to dispersion of soil particles. It will result in a decrease in the permeability of the soil.

3. Alkali soils: Alkali soils have electrical conductivity less than 4000 micromhos per cm at 25°C, the exchangeable sodium percentage greater than 15 and the pH value between 8.5 and 10.0. These soils are also called black alkali soils because a black crust is formed on the surface of the soil if organic matter is present. It is very difficult to reclaim alkali soils. Such soils are quite impermeable. It becomes difficult for the water used for leaching to enter the soil and if once entered, it is more difficult to get it out. To replace the sodium ions, chemicals such as gypsum and sulphur are introduced in the soil to increase the concentration of soluble calcium so that it can replace exchangeable sodium. These chemicals are mixed with the soil mechanically. These can also be washed in if intake rate and permeability can be improved.

The permeability of the alkali soil can be improved temporarily by cultivation. The permeability can be improved somewhat permanently by converting the alkali soil to the saline-alkali soil. This is achieved by irrigating the land with saline water. As the soluble salt content is increased, the soil structure is improved and the permeability is increased. After the soil becomes fairly permeable, chemicals such as gypsum can be introduced to replace the sodium. After the exchangeable sodium percentage is decreased, the soil can be reclaimed by controlled leaching and drainage.