UNIT 7 WATER LOGGING AND DRAINAGE

Structure

7.1 Introduction

Objectives

7.2 Quality of Irrigation Water

7.3 Soil Classification Based on EC, ESP and pH Value

7.4 Water Logging

7.5 Land Drainage

7.6 Summary

7.7 Key Words

7.8 Answers to SAQs

7.1 INTRODUCTION

Water is a scarce commodity; quality water is rare. Just as any water is not fit for human consumption similarly any water is not suitable for plant growth. Water comprising impurities to the extent which are injurious to plant growth, is not suitable for irrigation, and is called the unsatisfactory. Water whatever may be the source of water, surface water sources like river, canal, tank or ground water sources like open well or tube well, some soluble salts are always dissolved in it. The main soluble constituent in water is calcium, magnesium sodium and potassium as cation and sulphides, bicarbonates and sometimes carbonates as anion. The above soluble constituents along with boron are of prime importance in determining the quality of irrigation water and its suitability for irrigation purpose. However, the quality of irrigation water is much influenced by the constituents of soil, its texture, structure, drainage characteristics, nature of crop grown and climatical conditions. A particular water may be harmful for irrigation on a particular soil, but the same water may be tolerable or even useful for irrigation in some other soil conditions. . Thus, the suitability of water for irrigation will be determined by the amount and kind of salt present. Keeping in view the extent of ground water and surface water pollution in India, it becomes imperative to find out techniques and methods to arrest water pollution and make arrangement to mitigate its adverse effect on crop. Plants need air as well as moisture in their root zones for their survival. Excess irrigation farm water is free to move into the underground tile drains, if provided. This water, if not removed, retards the plant growth, because it fills the soil voids and restricts proper aeration. Surface drains are, therefore, needed for removing the excess farm water, for most of the cultivated crops on flat or undulating topography. Sub-surface drains, on the other hand, are required for soils with poor internal drainage and a high water table. If no impervious layer occurs below the farm land and the water table is lower than about 3 m from the ground, internal soil drainage may be sufficient and no tile drains needed. But, many a times natural drainage is not adequate and water table is high so much so it enters root zone, under these circumstances proper drainage system is must for maximum crop productivity.

Objectives

After studying this unit, you should be able to

- understand various types of impurities in water their classification and remedies,
- classify soil based on impurities,
- learn causes and effect of water logging and suggest remedies,
- explain need and importance of surface and sub-surface drainage, and
- learn ways of maintenance of drainage.

7.2 QUALITY OF IRRIGATION WATER

Quality of irrigation water is a major concern world over due to possible threat of non-point contamination of ground water and mixing of impurities in surface water due to poor management of domestic and industrial waste. It is imperative to learn different types of impurities and suggest ways and means to save crop from adverse effect.

7.2.1 Various Type of Impurities

The various type of impurities which make water unsuitable for irrigation are :

(a) Sediment concentration in water.

(b) Total concentration of soluble salts in water.

(c) Proportion of sodium ions to other cations.

(d) Concentration of potentially toxic elements present in water.

(e) Bicarbonate concentration as related to the concentration of calcium plus magnesium.

(f) Bacterial contamination.

These impurities affect crops to different degree depending upon the soil conditions and crop type. The effects of these impurities are discussed below :

Sediment

Run off water from basins carry with it a lot of sediments. Water loaded with sediment creates problem in irrigation canal as it increases their siltation resulting into frequent floods, increased maintenance cost and other maintenance related problems. As for as crop land is concerned, the effect depends upon type of irrigated land. For example, when fine sediment from impure water is deposited on sandy soil, it enhances fertility. In contrast, if the sediment is derived from erodible land it adversely affects fertility and permeability. Normally ground water or surface water from reservoirs do not cause serious problem in irrigation as it does not have sufficient sediment.

The effect of sediment present in the irrigation water depends upon the type of irrigated land. When fine sediment from water is deposited on sandy soils, the fertility is improved. On the other hand, if the sediment has been derived from the eroded areas, it may reduce the fertility or decrease the soil permeability. Sediment water creates troubles in irrigation canals, as it increases.

Remedies

As such this is beyond the control of use. However, care may be taken in selecting sources of water. In general, ground water or surface water from reservoirs, etc. does not have sufficient sediment to cause any serious problems in irrigation.

Total Concentration of Soluble Salts

Soluble salts are main culprit in impure irrigation water. Salts of calcium, magnesium sodium and potassium, present in the irrigation water may prove injurious to plants if present in large quantities. Their excess quantity may reduce the osmotic activities of the plants, and may create problem in adequate aeration, causing injuries to plant growth. The adverse effects of salts on the plant growth depend upon the concentration of salts left in the soil.

The concentration of salts in water, may not appear to be harmful to the plants. But the concentration of salts which remain in the soil after the saline water is used up by the plants is much more than the first, and may prove to be harmful. So it is possible that at the beginning of irrigation with undesirable water, no harm may be evident, but over a period of time, the salt concentration in the soil may increase to a harmful level, as the soil solution gets concentrated by evaporation. Hence, the effects of salts on plant growth depend largely upon the total amount of salts present in the soil solution.

Salinity Concentration of Soil

The salinity concentration of the soil solution (C_j) after the consumptive water (Cu) has been extracted from the soil, is given by :

$$C_i = \frac{C\phi}{[\phi - (C_u - P_{\text{eff}})]}$$

where, C_j = Salinity concentration,

Φ = The quantity of water applied,

C_u = Consumptive use of water,

P_{eff} = Useful rainfall,

$C_u - P_{\text{eff}}$ = Used up irrigation water,

C = Concentration of salt in water, and

$C\,\Phi$ = Total salt applied to soil with Φ amount of irrigation water.

Units and Critical Limits of Concentration

The salt concentration is generally expressed by ppm (parts per million) or by mg/l (milligram per litre), both units being equal. The critical salt concentration in the irrigation water depends upon many factors, yet however, amounts in excess of 700 ppm are harmful to some plants, and more than 2000 ppm are injurious to all crops.

The salt concentration is generally measured by determining the electrical conductivity of water as both are directly proportional to each other. Electrical conductivity is expressed in micro mhos per centimetre.

Classification of Water Based on Salinity

Low Conductivity Water (C1)

When conductivity value is up to 250 micro mhos/cm at 25°C, it is called low conductivity water.

Medium Conductivity Water (C2)

When its value is between 250 to 750, it is called *medium conductivity water.*

High Conductivity Water (C3)

When its value is between 750 to 2250, it is called *high conductivity water.*

Very High Conductivity Water (C4)

When the conductivity value is above 2250, the saline water is classified as *very high conductivity water.*

Suitability of Saline Water for Irrigation Purpose

The suitabilities of above four types of waters for irrigation supplies are presented in Table 7.1. This classification is based on U.S.D.A. Handbook No. 60 (1954). Engineers are advised to follow these recommendations while working in the field.

Table 7.1 : Extent of Salinity and Use of Water

Sl. No.	Type of Water	Use in Irrigation
1.	Low salinity water (C1). Conductivity between 100 to 250 micro mhos/cm at 25°C.	Such water can be used for irrigation for almost all crops and for almost all kinds of soils. Very little salinity may develop, which may require slight leaching; but it is permissible under normal irrigation practices except in soils of extremely low permeabilities.
2.	Medium salinity water (C2). Conductivity between 250 to 750 micro mhos/cm at 25°C	Such water can be used, provided that a moderate amount of leaching occurs. However, normal salt-tolerant plants can be grown without much salinity control.
3.	High salinity water (C3) conductivity between 750 to 2250 micro mhos/cm at 25°C.	Such water cannot be used on soils with insufficient drainage. Special precautions and measures are necessary for salinity control and only high-salt tolerant plants can be grown.
4.	Very high salinity water (C4). Conductivity more than 2250 micro mhos/cm at 25°C.	Such water is harmful and generally not suitable for irrigation. Use as irrigation water must not be allowed.

Remedies

Care may be taken in selecting sources of water. The recommendation given in the Table 7.1 may be adhered to for safe use of saline water.

Proportion of Sodium Ions to Other Cations

Salt cations are common in many soils. Their percentage varies depending upon location. Sodium ion availability defines soil characteristics. Normally it is available in small quantity. Most of the soils contain calcium and magnesium ions and small quantities of sodium ions. *The percentage of the sodium ions is generally less than 5% of the total exchangeable cations.* If this percentage increases to about 10% or more, it affects soil structure. The aggregation of soil grains breaks down. The soil becomes less permeable and of poorer tilth. It starts crusting when dry and its pH increases towards that of an alkaline soil.It has been observed that high sodium soils are plastic, sticky when wet and are prone to form clods, and tend to make crust on drying.

Sodium-Absorption Ratio (SAR)

The proportion of sodium ions present in the soils is generally measured by a factor called *Sodium-Absorption Ratio* (SAR).It represents the sodium hazards of water.

SAR is defined as :

$$SAR = \frac{Na^+}{\sqrt{\frac{(Ca^{++} + Mg^{++})}{2}}}$$

Where, Na^+, Ca^{++} and Mg^{++} are concentration of the respective ions in equivalent per million. The epm is determined by directly atomic weight the salts by their respective values. The SAR value can be reduced by adding gypsum to the water or to the soil.

Classification of Water Based on Sodium Hazard

Low Sodium Water (S1)

When the value of SAR lies between 0 to 10, it is called *Low Sodium Water* (S1).

Medium Sodium Water (S2)

When SAR lies between 10 to 18, it is called *Medium Sodium Water* (S2).

High Sodium Water (S3)

When SAR lies between 18 to 26, it is called *High Sodium Water* (S3).

Very High Sodium Water (S4)

When values of SAR are more than 26, it is called *Very high sodium water.*

Suitability for Irrigation

The suitabilities of these four kinds of water for irrigation is presented in Table 7.2.

Table 7.2 : SAR Value and Recommended Use of Water

Sl. No.	Type of water	Use in irrigation
1.	Low sodium water (S1). SAR value lying between 0 to 10.	This type of water can be used for irrigation on almost all soils and for almost all crops. However, crop which are highly sensitive to sodium, such as stone-fruit tree may not be irrigated with such water.
2.	Medium sodium water (S2). SAR value lying between 10 to 18	This type of water is appreciably hazardous in fine textured soils, which may require gypsum treatment. However, it may be used on coarse-textured or with good humus soils with good permeability.
3.	High sodium water' (S3). SAR value lying between 18 to 26.	Such water may prove harmful on almost all the soils, and do require good drainage, high leaching and gypsum addition for proper irrigation.
4.	Very high sodium water (S4). SAR value above 26.	Very harmful to crops. Generally, not suitable for irrigation.

Remedies and Care

Care may be taken in selecting sources of water. The recommendation given in the Table 7.2 may be adhered to for safe use of water high sodium concentration.

Concentration of Potentially Toxic Elements

A large number of elements such as boron, selenium, etc. may be toxic to plants. Traces of *Boron* are essential to plant growth, but its concentrations above 0.3 ppm may prove toxic to certain plants. The concentration above 0.5 ppm is dangerous to nuts, citrus fruits and *deciduous* fruits. Cotton, Cereals and certain other crops are moderately tolerant to boron, while Dates, Beets, Asparagus', etc. are quite tolerant. Even for the most tolerant crops, the boron concentration should not exceed 4 ppm.

Remedies and Care

The waste water containing soap, etc. should not be used with great care in irrigation. Selenium, even in low concentration, is toxic, and must be avoided.

Bicarbonate Concentration as Related to Concentration of Calcium Plus Magnesium

High concentration of bicarbonate ions may result in precipitation of calcium and magnesium bicarbonates from the soil-solution, increasing the relative proportion of sodium ions and causing sodium hazards.

Bacterial Contamination

Bacterial contamination of irrigation water is not a serious problem, unless the crops irrigated with highly contaminated water are directly eaten, without being cooked. Cash crops like cotton, nursery stock, etc. which are processed after harvesting, can, therefore, use contaminated waste waters, without any trouble.

7.3 SOIL CLASSIFICATION BASED ON EC, ESP AND pH VALUE

Based on the different chemical properties soil can be classified in different categories. These problem soul needs treatment for amending their characteristics to make them usable. A large chunk of land in India is under these categories and different techniques have been evolved to counter their effect on plant growth.

Depending upon the *Electrical conductivity EC* (representing salt content) of water, the *exchangeable sodium percentage ESP* (representing percentage of sodium w.r.t. total exchangeable cations), and the pH value of the soil, the soils are classified as :

(a) Saline or white alkali soil

(b) Alkaline or Sodic soil

(c) Saline- alkali

The limits of three different parameters is furnished in the Table 7.3 below.

Table 7.3 : Classification of Soil Based on EC, ESP and pH Value

Sl. No.	Classification	Electrical Conductivity (EC) in Micro-mho/cm	Exchangeable Sodium Percentage (ESP)	pH Value
1.	Saline soil or white alkali	> 4000	< 15	8.5
2.	Alkaline soil or Non-saline alkali or Sodic soil or Black alkali	< 4000	> 15	8.5 to 10.0
3.	Saline-alkali soil	> 4000	> 15	< 8.5

Remedies

Different remedial measures are available for reclaiming saline alkaline and saline alkaline soil. The important one are listed below :

(a) For reducing SAR, i.e. alkalinity addition of gypsum to the water or to the soil work well.

(b) For controlling soil salinity leaching works well.

(c) Providing adequate drainage facility, including bio-drainage.

(d) Selection of suitable crops and their variety tolerant to sodic and saline conditions.

Example 7.1

What is the SAR value of irrigation water having the characteristics as concentration of Na, Ca and Mg are 22, 3 and 1.5 milliequivalents per litre respectively?

Classify the water if electrical conductivity is 200 mhos per cm at 25°C.

Solution

$$SAR = \frac{Na^+}{\sqrt{\frac{(Ca^{++} + Mg^{++})}{2}}} = \frac{22}{\sqrt{\frac{3 + 1.5}{2}}} = 14.67$$

Putting the values of concentrations of Na, Ca and Mg as 22, 3 and 1.5 in the above equation the SAR = 14.67.

Thus, this is medium Sodium water (S2).

If electrical conductivity is 200 micromhos per cm the water is C1 water.

Hence, the given water is classified as C1-S2 water.

SAQ 1

(a) What are the various impurties present in water?

(b) Explain EC, SAR and ESP.

7.4 WATER LOGGING

An agricultural land is said to be water-logged, when its productivity gets affected by the high water table. The productivity of land in fact, gets affected when the root zone of the plants gets flooded with water, and thus become ill aerated. Inadequate aeration reduces crop yield.

7.4.1 Effect of Water Logging

Hampering the Nitrification

The life of a plant, in fact, depends upon the nutrients like nitrates, and the form in which the nitrates are consumed by the plants is produced by the bacteria, under a process called nitrification. These bacteria need oxygen for their survival. The supply of oxygen gets cutoff when the land becomes ill aerated, resulting in the death of these bacteria, and fall in the production of plant's food (i.e. nitrates) and consequent reduction in the plant growth, which reduces the crop yield. Apart from ill aeration of the plants, water logging creates many other problems.

Delayed Cultural Practices

The normal cultivation operations, such as tilling, ploughing, etc. cannot be easily carried out in wet soils. In extreme cases, the free water may rise above the surface of the land, making the cultivation operations impossible. In ordinary language, such a land is called a swampy land. In general, this leads to excessive delay in cultural practices and delayed sowing of crop, less or very poor yield.

Overgrowth of Weeds

Certain water loving plants like grasses, weeds, etc. grow profusely and luxuriantly in waterlogged lands, thus affecting and interfering with the growth of the crops.

A Major Cause of Salinity

With the rise of the water table, the plant roots happen to come within the capillary fringe, and water get continuously evaporated by capillarity. Thus, a continuous upward flow of water from the water table to the land-surface gets established. Due to this upward flow of water, the salts, present in the water, also rise towards the surface, resulting in the deposition of salts in the root zone of the crops. The concentration of these alkali salts in the root zone of the crops has a corroding effect on the roots, which reduces the osmotic activity of the plants and checks the plant growth. The plant ultimately fades away. Such soils are called saline soils. Thus, water logging ultimately leads to salinity, resulting into reduced crop yield. Salinity and water logging are treated as a twin problem as salinity and water logging occurs together. Water logging is followed by salinity.

7.4.2 Causes of Water Logging

Basically, water logging is the rise of water table unto root zone level leading to various problem to crop growth. This may occur due to the following reasons.

Over and Intensive Irrigation

Under the practice of intensive irrigation, the maximum irrigable area of a small region is irrigated. This leads to, too much of irrigation, in that region, resulting in heavy percolation and subsequent rise of water table. This can be overcome by a policy of *extensive irrigation*, i.e. irrigation spread over wider regions. Thus, to avoid water logging extensive irrigation should supersede the policy of *intensive* irrigation.

Seepage of Water from Nearby Areas

Water from the adjoining high lands may seep into the sub-soil of the affected land and may raise the water table. This occurs generally when land surface is not flat and adjoining area is moisture rich.

Seepage of Water Through the Canals/Reservoirs

This is major cause of water logging in canal command areas. This has reached an arming stage in many areas. Water may seep through the beds and sides of the adjoining canals, reservoirs, situated at a higher level than the affected land. This results into high water table in the affected area. This seepage is many a times excessive particularly when soil at the site of canals and reservoirs is very pervious.

Encounter of Impervious Obstruction

We know that water seeping below the soil moves horizontally or laterally. This may encounter an impervious obstruction, causing the rise of water table on the upstream side of the obstruction. This may lead to water logging. Similarly, in ceratin cases it is possible that an impervious stratum may occur below the top layers of pervious soils. In this case also, water seeping through the pervious soils will not be able to go deep, and hence, quickly results in high water table rise.

Lack of Natural Drainage System

If sufficient availability of natural drainage is not there in form of slope, soils having less permeable sub-stratum such as clay lying below the top layers of pervious soils, will not be able to drain the water deep into the ground. This may lead to rise in water level to the extent that it can affect the root zone and the crop cultivation.

Inadequate Surface Drainage

Surface drainage system is common passage way for run off water. It becomes necessary to ensure that storm water falling over the land and the excess irrigation water should be removed from the area. It should not be allowed to percolate below. In absence of proper surface drainage, the water will constantly percolate and will raise the level of the water table leading to water logging.

Excessively High Rain Fall

This is common source water logging is cities. Even in farm land heavy down pouring may cause water logging. However, excessive rainfall may create temporary water logging, but in the absence of good drainage, it may lead to continued water logging over the area.

Overgrowth of Weeds and Aquatic Plant

During rainy seasons weeds and grasses grow excessively obstructing the passage of water in natural waterways. If a land is continuously submerged by floods, aquatic plants like hyacinths, grasses and weed may grow. They may obstruct the natural surface drainage of the soil, and thus, increasing the chances of water logging.

Irregular or Flat Topography

Topography also affects natural drainage and thus lead to water logging. In steep terrain, the water is drained out quickly. On flat or irregular terrain having depressions, the drainage is very poor. These factors lead to greater detention of water on the land, causing more percolation and water logging, if infiltration of soil is not proper.

7.4.3 Control Measures of Water Logging

It is evident that water logging can be controlled only if the passage and quantity of water into the sub soil below the surface is controlled and reduced. For this first of all, the inflow of water into the underground reservoir should be reduced and the outflow from this reservoir should be increased simultaneously. It is necessary to keep the highest position of water-table at least about 3 m below the ground surface. The various measures adopted for controlling water logging are given below.

Lining of Canals and Water Courses

Control measures must try to check the causes of water logging. As seepage is one of the main culprits of rise of water table, attempts should be made to reduce the seepage of water from the canals and watercourses. This can be achieved by lining them. It is a very effective method of controlling water logging.

Reduced Intensity of Irrigation

The areas where there is a possibility of water logging, intensity of irrigation should be reduced. Efficient water supply should be ensured. Only a specific portion of irrigable land should receive canal water in one particular season. The remaining areas can receive water in the next season, by rotation. This can be achieved by crop rotation. This would help controlling water logging in the region.

Crop-rotation

Crop rotation is also an effective means of controlling water supply to sub surface zone. As certain crops require more water and others require less water. If a field is always sown with a crop requiring more water, the chances of water logging are more. In order to avoid this, a high water requiring crop should be followed by one requiring less water. We may choose next crop one requiring almost no water. For example, rice may be followed by wheat, and a dry crop such as cotton may follow wheat. This will ensure break in continuous excess irrigation.

Optimum Use of Water

Excess of anything is harmful we know that only a certain fixed amount of irrigation water is required for best productivity. Any major deviation reduces the yield and empties the pocket of the farmer. But there is ignorance in some areas that using more water can increase crop yield. This happens more in the areas where water charges are less or where there is uncertain supply of canal water and electricity in case of tube well irrigation. Educating the farmers by proper extension method can bring improvement. As a policy matter, the revenue should not be charged on the basis of irrigated area but should be charged on the basis of the quantity of water utilised.

Intercepting Drains

These drains are to check the canal water seepage. Intercepting drains along the canals should be constructed, wherever necessary. They would help intercepting seepage water and prevent the water from reaching the area and thus water logging may be prevented.

Improved Natural Drainage

The worn out natural drainage systems in the cropped area should be revived. This would reduce the percolation by, not allowing water to stand for a longer period. At community level, some relief in this direction can be obtained by removing the obstructions from the path of natural flow. This can be achieved by removing bushes and other obstructions and improving the slopes of the natural drainage lines.

Efficient Drainage System

An efficient drainage system should be provided in order to drain away the storm water and the excess irrigation water. A good drainage system consists of surface drains as well as sub-surface drains.

Consumptive Use of Surface and Subsurface Water

Conjunctive use is a combined use of sub-surface water or ground water and the surface water or canal water in a judicious manner to derive maximum benefits. The introduction of lift irrigation to utilize ground water helps in lowering the water table in a canal irrigated area, where water table tends to go up. This system ensures use of the ground water in conjunction with canal water for irrigation. The continuous use of ground water will not allow any appreciable rise in the level of water table, even due to continuous seepage of canal water. Thus, consumptive use should be adopted to control water logging.

SAQ 2

(a) Discuss the effect and causes of water logging.

(b) What are the remedial measures of water logging?

7.5 LAND DRAINAGE

Irrigation and drainage are two face of the same coin. Surface irrigation is a boon only if it is practiced with great care. As stated earlier, only optimum amount of water should be applied to the crop, as per the requirement of the crop and the properties of the soil., In fact, the root zone of the soil fails to absorb excess water which may percolate and help in raising the water table. If this gravity water encounter an impervious stratum and is not drained up properly. This excess water is harmful to crop yield. It becomes necessary to remove excess water by draining it out from below the soil. The drained water may be discharged back either into a river or a canal or some other safe place. Hence, while designing a canal irrigation network, it is desirable to provide a suitable drainage system, for removing the excess irrigation water. Thus irrigation and drainage go together. Drainage system is also required for draining out the rain water and ensure its easy disposal to prevent its percolation.

Drainage Coefficient (D. C.)

The rate at which the water is removed by a drain is called the *drainage coefficient.* It is expressed as the depth of water in cm or metres, to be removed in 24 hours from the drainage area. The drainage coefficient largely depends upon the rainfall but varies with the soil type, crop, and degree of surface drainage. Its recommended value is 1 % of the average annual rainfall to be removed per day.

Values of Drainage Coefficient

A suitable value of drainage coefficient (DC) may be taken for the calculations, depending upon the local recommendations. Values of 1 to 2.5 cm/day for mineral soils and 1.25 to 10 cm/day for organic soils for different crops, have been suggested for humid regions, by U.S. Soil Conservation Service.

Example 7.2

A drainage channel discharge 0.5 cubic meters of water per second and drains 300 hectares. What is drainage coefficient of this land.

Solution

Drainage coefficient is depth of water intended to be removed from drainage area in a 24 hour period.

Total water discharge from channel in 24 hours = $0.5 \times 60 \times 60 \times 24 \text{ m}^3$

Total area = 3 ha = $300 \times 104 \text{ m}^2$

$$\text{Drainage coefficient} = \frac{0.5 \times 60 \times 60 \times 24}{3.0 \times 10^6} = 0.0144 \text{ m} = 14.4 \text{ mm}$$

7.5.1 Types of Drainage System

Drainage system can be classified as :

(a) Surface drainage

(b) Sub-surface drainage

Surface drainage is also called open drainage system while sub-surface drainage as tile- drainage or underground drainage.

Surface Drainage or Open Drainage

Surface drainage is the removal of excess rainwater falling on the fields or the excess irrigation water applied to the fields, by constructing open ditches, field drains, and other related structures. In this process the land is sloped towards these ditches or drains, as to make the excess water flow in to these drains. In fact, land grading, which results in a continuous land slope towards the field drains, is an important part of a surface drainage system. Land grading or land leveling is also necessary for surface irrigation

Types of Surface Drain

Surface drains are needed for removing the storm water and excess farm water, for most of the cultivated crops on flat or undulating topography However, if no impervious layer occurs below the farm land and the water table is sufficiently lower, internal soil drainage are sufficient and no additional drainage facility is required. But for maximum productivity of most of the crops drainage facility becomes essential, particularly in waterlogged areas. Surface drains are two types shallow and deep surface drains.

Shallow Surface Drains

The open drains, which are constructed to remove the excess irrigation water collected in the depressions on the fields, as well as the storm (rain) water, are broad and shallow, and are called shallow surface drains. These drains carry the runoff to the outlet drains. They are trapezoidal in cross-section. If designed properly, they should carry the normal storm water from the fields, plus the excess irrigation water. Many a times, the excess irrigation water is neglected and these drains are designed only for the runoff resulting from the average storms which is neither economical nor desirable. Manning's equations may be used to obtain design velocity of these drains, keeping the velocity within the critical velocity, and thereby avoiding silting or scouring. Proper shape is selected based on available information. Manning's equation may however be used for the design of shallow as well as deep surface drains.

Deep Surface Drains

The drains, which are large enough to carry the flood water of the catchment area from the shallow surface drains, and are of sufficient depths to provide outlets even for the underground tile drains, if provided are called deep surface drains. These drains carry the storm water discharge, drains, shallow surface drains, and the seepage water coming from the underground tile drains. They are, therefore, designed for the combined discharge of the shallow surface drains as well as that of the tile drains. Sub-surface drains are required for soils with poor internal drainage and a high water table Generally, a cunnette of about 0.6 m depth with steeper slope is provided in the center of the drain bed, so as to carry the seepage water of the underground tile drains. Cunnette is lined so as to withstand higher flow velocities. The full section of drain is used only during the rainy season when the cunnette is not able to handle the flow will Manning's equation may be used for estimating velocity and based on that flow capacity can be determined while designing of deep surface drains. Different forms of sub-surface drains are described below.

Surface Inlet

A surface inlet is intake structure constructed to carry the pit water into the sub-surface or tile drain. A cast iron pipe or a manhole constructed of brick or monolithic concrete, is sufficient and satisfactory. Basically, it is the facility to remove the surface water from the pot holes depressions, road ditches, farmstead. This may also be accomplished by connecting them with the shallow surface drains called random field drains

French Drain

When the quantity of water to be removed from the pits or depression is small, a blind inlet may be installed over the tile drain which is also called French drain. These are constructed by back filling the trench of the tile drain with graded materials, such as gravel and coarse sand, or with corn cobs, straw and similar substances, as shown in Figure 7.1.

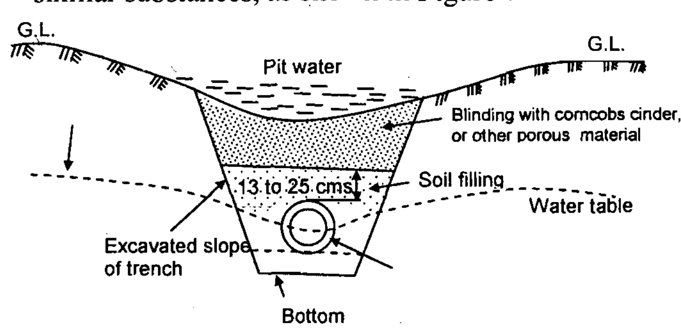

Figure 7.1 : French Drain

Such inlets are not permanently effective. The voids in the backfill of the blind inlet become filled up with the passage of time, thereby reducing its effectiveness. Even though they are not permanently effective, they are economical to be installed and do not interfere with the farming operations.

Bedding

Bedding is a method of surface drainage which makes use of dead furrows, as shown in Figure 7.2 The area between the two adjacent furrows is known as a bed. The depth of the bed depends on the soil characteristics and tillage practices. In the bedded area, the direction of fanning may be parallel or normal to dead furrows. Tillage practices, parallel to the beds, retard water movement to the dead furrows.

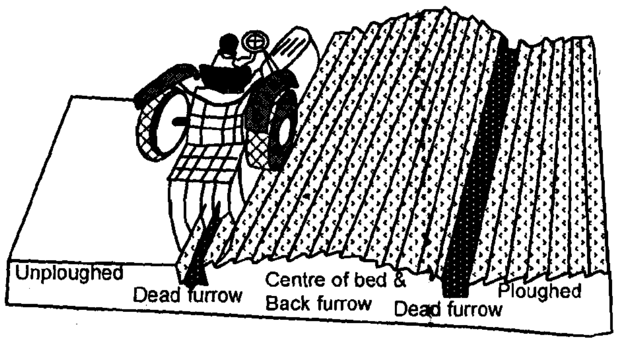

Figure 7.2 : Bedding

Ploughing is always parallel to the dead furrows. Bedding is most practicable on flat slopes of less than 15%, where the soils are slowly permeable and the drainage IS not economical.

Sub-surface Drainage or Tile Drainage

Tile drains are required for high water table conditions in the areas where the soils are having poor internal drainage ability. If no impervious layer occurs below the farm land and the water table is low (lower than about 3m from the ground), internal soil drainage may be sufficient and no tile drains needed. For maximum productivity of most of the crops, both surface as well as sub-surface drains may sometimes, however, become, essential, particularly in areas of higher water table.

Advantages of Tile Drains

Tile drainage helps in increasing crop yields by draining the water or by lowering the water table in the following manner :

(a) Removes the free gravity water, not available directly to the plants, thus, increases the volume of root zone soil from which roots can obtain nutrient.

(b) Increases air circulation *and* bacterial activity in the soil, thus improving soil structure and making the plant food more readily available.

(c) Reduces soil erosion as a well drained soil has more capacity to hold rainfall, resulting in reduced runoff and soil erosion.

(d) Helps removing toxic substances such as sodium, their excess amount may retard plant growth.

(e) Lowering the water table during rainy seasons thus checking water logging and salinity and other soil and water problems.

(f) Easy and timely cultural practices.

Limitations

(a) Providing underground tile drains is a costly affair and may be required only in areas of high water table, and where the ground soil has a poor internal drainage capacity. In other words where it is absolutely desired.

(b) Without proper maintenance and care it becomes un-functional.

Laying Tile Drains

Tile drains are usually, pipe drains made up of porous earthenware and are circular in section. The diameters may vary from 10 to 30 cm or so. These drains are laid below the ground level, butting each other with open joints. The trenches in which they are laid are back filled with sand and excavated material to form an envelop.

Envelope Filters

It facilitates flow of drained water to tile drainage system Tile drains are laid below the ground level in the trenches. The trenches in which they are laid are back filled with porous material, as shown in Figure 7.3. As far as possible, the tile drains should not be placed below less pervious strata without envelop filter as the water will not be able to reach the drain. Thus, in absence of filter they may remain dry even though the land above the impervious strata may be waterlogged.

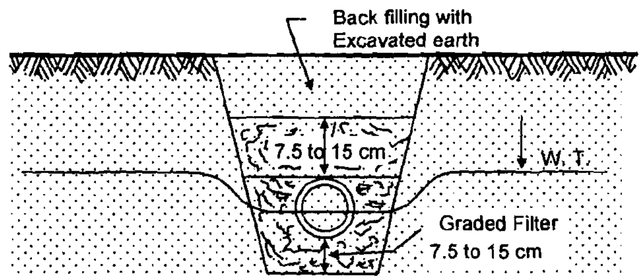

Figure 7.3 : Envelop Filter

Formation and Functions of Envelop Filters

When tile drains are placed in less pervious soils, they are generally surrounded by graded gravel filters, called envelope filters The filter consists of different gradations, such as gravel, coarse sand, bajri, and other coarse material. The coarsest material is placed immediately over the tile, and the size is gradually reduced towards the surface. The minimum thickness of the filter is about 7.5 cm. The graded filter may sometimes be substituted by a single gradation, depending upon the availability and cost considerations. Corrugated metal pipe with a flap shutter to prevent entry of rodents and back flow from the outlet into the tile drain, is generally provided at the outfall point, as shown in Figure 7.4.

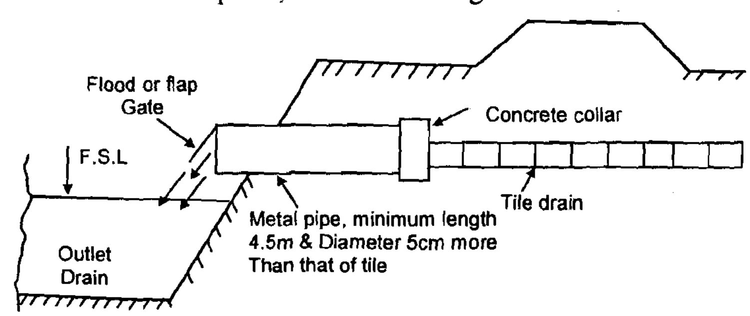

Figure 7.4 : Laying tile Drains

We can summarise the function of envelop filters as follows :

(a) It prevents the inflow of the soil into the drain.

(b) It increases the effective tile diameter, and thus increases the inflow rate.

Provision of Pump Outlet

A pump outlet system needs to be installed, if the bed level of the outlet drain is higher than that of the discharging tile drain. It consists of an automatic controlled pump with a small sump for storage as shown in Figure 7.5. However, pump outlets are costly and require technical expertise in installation and operation. We should collate the cost of deepening the outlet drain with the cost of installing and maintaining a pump outlet before finally deciding the course of action.

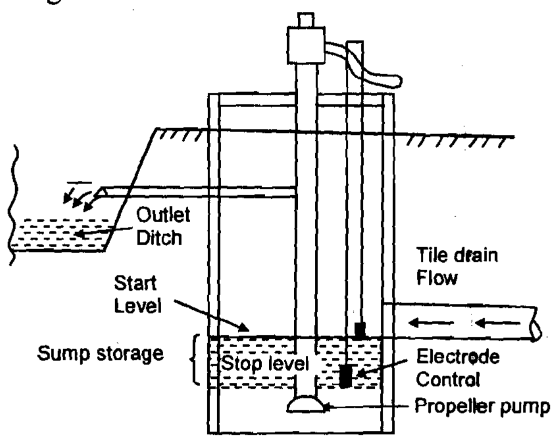

Figure 7.5 : Pump Outlet

Movement of Water into the Tile Drains

After proper installation the tile drains starts removing water movement of water can be summarised as follows :

(a) If soil is fully saturated, water flows into the tile drain along the path shown in Figure 7.6. Water as farther distance has to travel more to get drained.

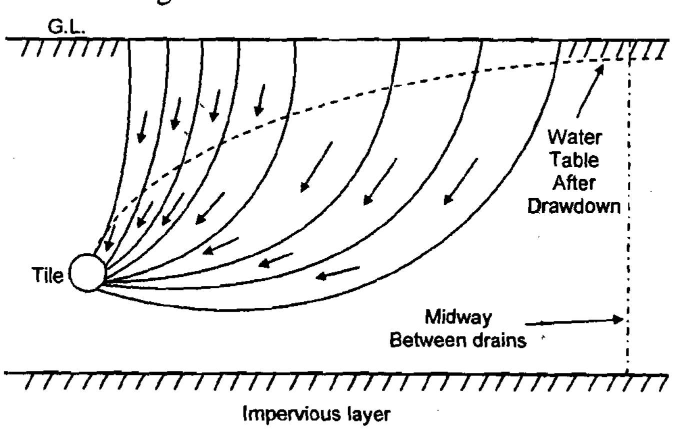

Figure 7.6 : Movement of Water in Fully Saturated Soil

(b) The falling of water table, i.e. draw down will be more near the tile than at the points farther away Since the quantity of water moving between any two flow lines is the same.

(c) Once the saturated soil has drained for a day or two, the resulting water table will be, as shown in Figure 7.7. With the passage of time, the water level goes on lowering down.

(d) With series of tile drains, the sub soil water level directly over the drains, is lower than the level midway between them as shown in Figure 7.7.

(e) When a filter is provided around the tile drains to surround the drains with more pervious soil, then the overall draw down will be more.

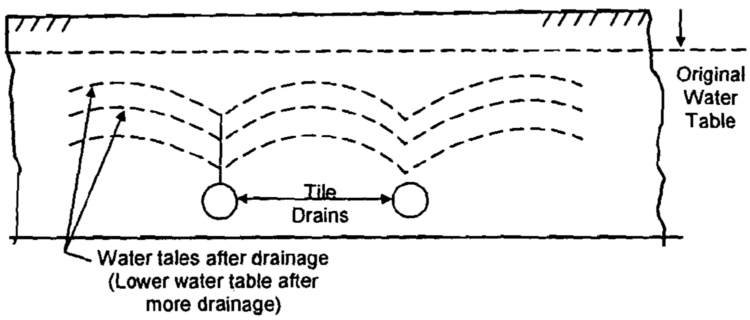

Figure 7.7 : Pattern of the Draw Down

Depth and Spacing of the Tile Drains

The rate of drop of water table mainly depends upon the soil permeability and spacing of the drains. Here, horizontal permeability of the soil is more important as the water has to travel more distance horizontally than vertically before it reaches the drain. As the permeabilities of most of the soils decrease with depth which affects the shape of the flow lines and the rate of the fall of water table.

Consider the Figure 7.8 for determining the tile spacing. Let S be spacing between the drains, and a be the depth of impervious stratum from he centre of the drains, as shown in Figure 7.8. Other parameters areas given.

The tile spacing (S) is given by the following formula :

$$S = \sqrt{\frac{4 \times K\,(b^2 - d_e^2)}{i}}$$

where, K = Hydraulic conductivity,

i = Drainage coefficient m/day,

b = Difference between center of drain and minimum level of water level,

d_e = Equivalent depth of water conducting layer below the drain. It can be determined using Nomograpf given in Figure 7.9, and

b = Height of water table above impervious layer.

The closed drains are generally spaced at such a distance as to be capable of lowering the water table sufficiently below the root zone of the plants. For most of the plants, the top point of the water table must be at least 1.0 to 1.5 metres below the ground level; although this distance may vary from 0.7 to 2.5 m, depending upon the soil and the crop.

The tile drains may be placed at about 0.3 metre below the desired highest level of the water table. A fair idea of the spacing between the tile drains can be obtained based on the above theory as follows :

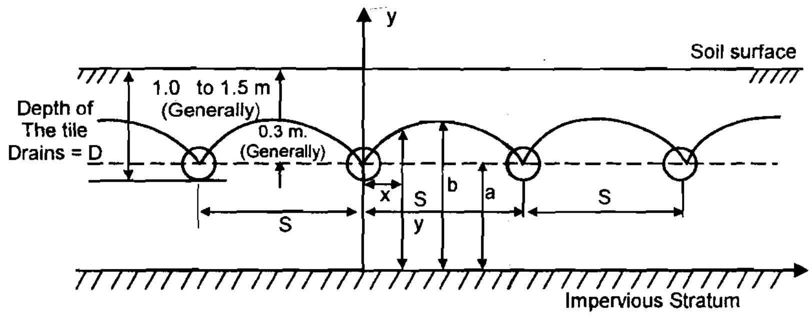

Figure 7.8 : Depth and Spacing of Tile Drains

Example 7.3

Calculate the drain spacing for an irrigated area, assuming the depth to the center of drain is 1.8 m and the minimum depth of the water table is 1.5 m. Given that hydraulic conductivity $K = 0.5$ m/day above an impervious layer at a depth of 6.7 m. The excess irrigation rate if equivalent to drainage coefficient of 1.3 mm/day.

Solution

(a) Depth of impervious layer below the center of tile
$(d) = 6.7 - 1.8 = 4.9$ m.

(b) Compute equivalent depth for the water conducting layer below the drain for $d = 4.9$ m. From Nomograph (Figure 7.9) for equivalent depth $d_e = 2.9$ m.

(c) For tiles flowing half filled, $H = 1.8 - 1.5 = 0.3$ m.

(d) $b = H + d_e = 2.9 + 0.3 = 3.2$ m.

(e) To find the spacing, L

$$L = \sqrt{\frac{4 \times K\,(b^2 - d_e^2)}{i}} = \sqrt{\frac{4 \times 0.5\,(3.2^2 - 2.9^2)}{\frac{1.3}{1000}}}$$

where, $K =$ 0.5 m/day, and

$$i = \text{Drainage coefficient m/day} = \frac{1.3}{1000}$$

Therefore, the design value of spacing of tile drains is 53.06 m.

Maintenance of the Drainage System

For work reliability and long life the drainage system should be periodically maintained. The following need to be done :

(a) In case of surface drainage regular cleaning and removal of weed, etc. must be taken care of. Particularly before start of rainy season special care should be taken.

(b) Any damage to the sidewall should be corrected as and when required.

(c) In case of subsurface drain all different parts should be maintained periodically.

(d) All the damaged components should be replaced as and when required.

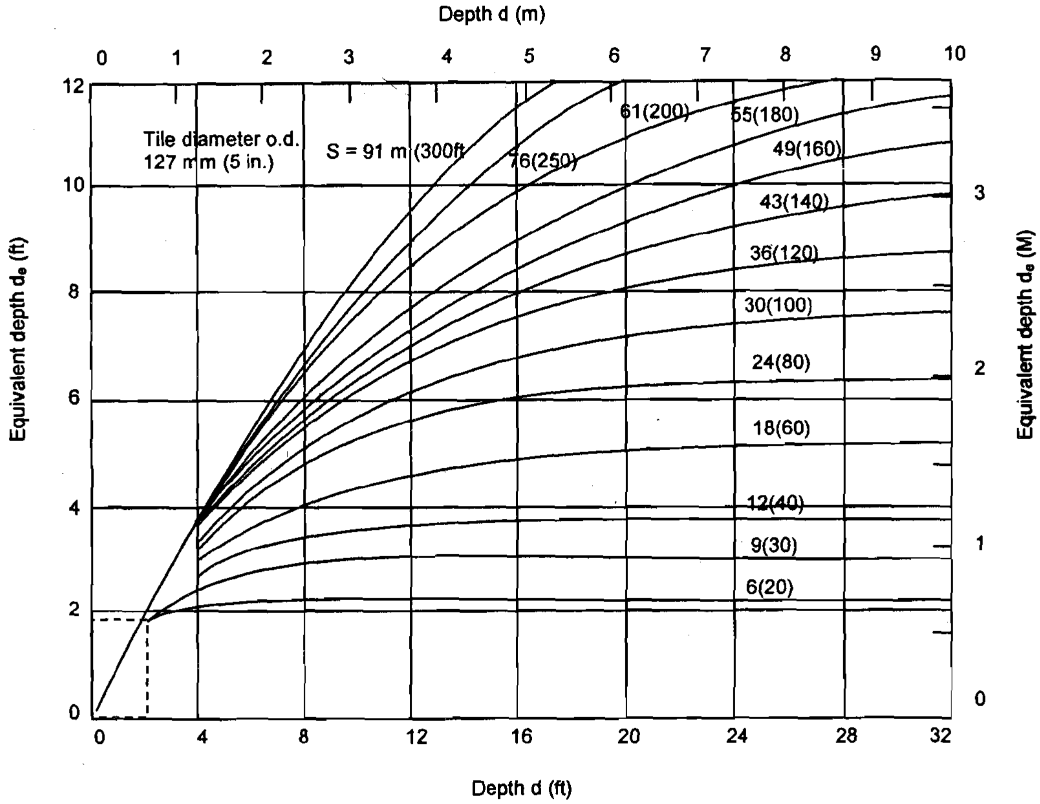

Figure 7.9 : Nomograph for Equivalent Depth (Source : Schwab et. al.)

SAQ 3

(a) Explain various types of drainage system. Discuss the merits and demerits of each.

(b) How are depth and spacing of tile drains are decided.

7.5 SUMMARY

This unit discusses the quality of irrigation water. The various parameters for checking the quality of water are electrical conductivity, sodium absorption ratio, exchangeable sodium percentage, etc. When the productivity of crop is affected due to rise in water table, land is said to be water logged. The effect, causes and remedial measures of water logging are discussed in detail. The types of drainage system are explained with examples.

7.6 KEY WORDS

SAR : Sodium absorption ratio is denoted as

$$SAR = \frac{NA^{+}}{\sqrt{\frac{Ca^{++} + Mg^{++}}{2}}}$$

Water Logging : An agricultural land is said to be water logged when its productivity gets attached by the high water table.

Drainage Coefficient : The rate at which the water is removed by a drain is called the drainage coefficient.

Bedding : It is a method of surface drainage which makes use of dead furrow.

7.8 ANSWERS TO SAQs

SAQ 1

(a) Refer Section 7.2.

(b) Refer Section 7.3.

SAQ 2

(a) Refer Section 7.4.

(b) Refer Section 7.4.

SAQ 3

(a) Refer Section 7.5.

(b) Refer Section 7.5.

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