	AGRICULTURAL TVET COLLEGE	

MODEL TTLM

SMALL SCALE IRRIGATION DEVELOPMENT LEVEL-IV

Learning Guide- 05

Unit of competency: Manage salinity of irrigated land

Module title: Managing salinity of irrigated land

LG code: AGR SSI4M 05LO1-LO3

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Nominal duration: 25 Hrs

Instruction sheet	Learning guide- 03

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:–

- Investigate salinity prone areas
- Practice salinity prevention techniques
- Practice techniques for management of salt affected irrigated lands

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, you will be able to

- Investigate salinity prone areas
- Checking soils for primary salinity
- Understand basic laboratory techniques of soil and water quality analyze
- Check quality of water source for irrigation
- Investigate ground water level of project area and checking salt content
- Practice salinity prevention techniques
- Monitor and controlling ground water rise periodically
- Optimizing application of water based on crop, soil and time.
- Assessing irrigation water quality
- Plan appropriate field water distribution
- Perform periodical soil test for salinity
- Intercrop deep rooted perennial crops
- Understand agro-forestry practices
- Avoid excess seepage from canals
- Practice techniques for management of salt affected irrigated lands.
- Estimate leaching requirement
- Leach excess salt from root zone according to environmental issues
- Plan and installing appropriate drainage facility
- Determine irrigation scheduling for crops on the saline land
- Identify and cropping salt loving crops according to nutrition
- Recommend chemical amendment for sodic, saline and saline-sodic soils

- Look for optimal soil and water management practices

Learning Activities

1. Read the specific objectives of this Learning Guide.
2. Read the information written in the “Information Sheets.
3. Accomplish the “Self-check” at the end of each learning outcomes.
4. Ifyouearnedasatisfactoryevaluationproceedtothenext“InformationSheet”.However, if you acting is unsatisfactory, see your teacher for further instructions or go back to the Learning Activity.
5. Submit your accomplished Self-check. This will form part of your training portfolio

Information sheet -1	Investigate salinity prone areas

INTRODUCTION

Background facts about salinity what is salinity? The term salinity refers to the presence of soluble salts in water and soil systems. The presence of salinity in the plant root zone can have a major impact on the performance of a crop and is arguably the biggest threat to irrigated agriculture. The sources of soluble salts that can accumulate in the soil water beneath include;

- Salt imported to a field via irrigation water,
- Saline ground water/water tables,
- Weathering of soil minerals, organic materials and the underlying rock
- Ocean-derived salts blown inland and carried to ground in rain and/or dust,
- Soluble nutrients and ameliorants such as fertilizers and gypsum that are applied to soil, and
- Cleaning agents added to drip irrigation systems (eg. the use of sodium hypochlorite is a source of chloride that adds to the salt load of the irrigation water).

1.1. Checking soils for primary salinity

Primary salinity are salinity that occurs naturally in soils and waters. Secondary salinity refers to salting that result from human activities, usually land development and agriculture. (Salting, also called salinisation, is the process and result of soluble salts accumulating in soils or waters.) The division between primary and secondary salinity is useful for separating areas where human activities do not appear to be affecting salinity processes (primary salinity) from areas where salinity is clearly influenced by human activities (secondary salinity), frequently associated with quite rapid changes in the environment. However, it is often difficult to categories salting outbreaks as one or the other type because secondary salinity is often primary salinity accelerated by human activity. Many areas that now exhibit secondary salinity show considerable evidence of having been affected by primary salinity in the past. Primary salinity appears as naturally occurring saline areas and saline soils. Salt lakes, salt pans, salt marshes and salt flats are all examples of naturally occurring saline areas .Secondary salinity can be divided into **three** groups on the basis of the processes contributing to salting:

- **Water table salting**: is a concentration of salts associated with evaporation of water from a shallow water table (that is, the upper surface of the groundwater). This process contributes to salinity in both irrigated and dry land (non-irrigated) areas. Seepage salting is a type of water table salting that occurs when groundwater seeps at the ground
- **Irrigation water salting**: is salting associated with the accumulation of salts from irrigation water in the soil and the effect of the water composition on soil properties. The sodi city of irrigation water and the properties of irrigated soils are important components of irrigation water salting.
- **Erosion scalding**: is salting primarily caused by erosion processes. This occurs when surface soils are eroded by surface water flow or wind, exposing saline and/or sodic sub soils. This handbook will deal mostly with the first two types of secondary salinity, water table salting and irrigation water salting, and with sodi city. Naturally occurring saline and sodic soils The distribution of naturally occurring saline soils in Australia is closely related to the occurrence of geomorphic basins with closed drainage and low hydraulic gradients. About 5.3% of the land area of Australia is naturally saline (Northcote & Skene 1972).

Salinity origin Soil salinity may be primary or secondary in origin. Primary salinity Primary salinity occurs naturally in the landscape. Examples of primary salinity are salt marshes, salt lakes, tidal swamps or natural salt scalds . Primary salinity is sometimes called inherent salinity. Secondary salinity Secondary salinity occurs in the landscape due to human activity. In Australia this is typically human activity post European settlement. Examples of secondary salinity are salinization of soil, surface water or groundwater due to urbanization and agriculture (irrigated and dry land). If the water table is within three meters of the soil surface in clay soils, (less distance in sands) groundwater can rise by capillary action to the soil surface. The water then evaporates from the surface, leaving the salt behind. This produces a salt bulge at the soil surface. If this soil is relocated by wind or water, it often carries the concentrated salt with it. Thus salt can be Salinity processesv Secondary salinity occurs where salt is mobilized and redistributed closer to the soil surface and/or into waterways. This can occur due to:

- rising saline groundwater (dry land agriculture processes)
- rising saline groundwater (irrigation agriculture induced)
- rising saline groundwater (urban development induced)
- use of saline irrigation water (pumped groundwater) and
- cyclic and Aeolian processes (salt redistributed).

Soil and water become saline when salts are brought to the soil surface. This usually occurs when water moves/leaks past the plant root zone, enters the groundwater system, fills the spaces within the soil and rocks, and causes the water table to rise. As water tables rise, salts found naturally in rocks and soils are dissolved in the groundwater and are carried by it toward the soil surface. Salts are also moved up the soil profile by capillary action. This process draws groundwater from the water table up through the soil.

1.2. Understanding basic laboratory techniques of soil and water quality analyze

Soil salinity a range of direct and indirect laboratory and field methods are used to measure soil salinity.

Field method this method is appropriate for quick field tests. Field test results will differ from **laboratory** results because soil drying, shaking and settling times are not standardized in the field. However, to simply identify the order of magnitude of a salinity problem, these factors can be ignored. Most of these criteria were developed to provide rough practical guidelines for interpreting soil salinity data. Most soil processes and values occur on a continuum, so criteria which suggest sharp class boundaries should be applied with some flexibility.

Salinity measurement The original way to measure soil salinity was to take a known weight of dry soil, leach it thoroughly to extract all the salt, and evaporate the solution to dryness. When the water evaporates, it leaves the salt behind just as it does on the soil surface. So the remaining dry salt could be weighed to give Total Dissolved Salts (TDS) by evaporation by weight. This was obviously a tedious process, so a quicker method was developed that relies on measuring the

Electrical Conductivity (EC) of the saline solution in equilibrium with the soil, then calculating with reasonable accuracy, the TDS. The more salt is dissolved, the more the solution will conduct electricity. EC and TDS (calculated) are related by a constant (0.34) for most Australian soils and saline waters as follows: TDS as g salt/100 g of dry soil (%) = 0.34 x EC1:5 (dS/m) Total Dissolved Salts (TDS) is the same as Total Soluble Salts (TSS). Laboratory tests that may be requested on saline soils include: • salinity (as EC and Total Dissolved Salts (TDS)) • specific anions (chloride, sulphate, bicarbonate and carbonate) • Exchangeable Sodium Percentage (ESP).

Table.1. Soil test

Method	Lab or field	Advantages	Disadvantages/limitations	Use
1:5 soil water suspension	lab or field	fast, routine	too dilute, particularly in sandy soils (up to 40 times more dilute than field water contents); sparingly soluble salts cause problems of over-estimation of salinity	fast field and lab survey
Saturation extract	lab	closer to field water content— 2 to 3 times more dilute	tedious preparation	quantitative evaluation of salinity, comparison across soils
Electromagnetic induction	field	very fast	non-linear depth integration; soil properties and water content have some effect	initial broad area survey
Time domain reflectometry	lab and field	measures soil EC at field water content, also measures field water content	expensive; technique not yet sufficiently tested problems with signal strength in high CEC, soils; not as good for salt as for water content	research, monitoring
Soil solution extraction	field	measures soil EC at field water content	tedious preparation; not for heavy clay soils degassed sample; high spatial variability;	research for evaluating leaching and deep drainage, monitoring
Soil solution displacement	lab	accurate at field water content	very tedious; poor solution yield	research
Ceramic salinity sensors	field	measure soil EC at field water content	very slow response; drift in calibration	research, monitoring

Water quality

Water quality is a term used to describe the chemical, physical, and biological characteristics of water, usually in respect to its suitability for an intended purpose. These characteristics are controlled and influenced by substances, which are either dissolved or suspended in water. Although scientific measurements are used to define the quality of water, it's not a simple thing to say that " this water is good," or " this water is bad ". The quality of water that is required to wash a car is not the same quality that is required for drinking water. Therefore, when we speak of water quality, we usually want to know if the water is good enough for its intended use, be it for domestic, farming, mining or industrial purposes, or its suitability to maintain a healthy ecosystem. Water quality is changed and affected by both natural processes and human activities. Generally natural water quality varies from place to place, depending on seasonal changes, climatic changes and with the types of soils, rocks and surfaces through which it moves. A variety of human activities can potentially significantly alter the quality of natural waters, Water quality for agricultural use can be evaluated using field and laboratory analyses. The electrical conductivity of, and other simple tests on, samples of irrigation water can be measured in the field using portable conductivity bridges, pH meters and testing kits. For example, having tools-of-the-trade for the testing of groundwater in wells obviates the need for transporting water samples. Local analyses of carbonate, bicarbonate and nitrate may be required where storage of samples may lead to chemical changes and inaccurate results.

In arid and semi-arid areas it will be necessary to predict the salt balance and the water balance for a project area to evaluate leaching requirements, and the drainage needed to maintain the land in a productive condition. In rehabilitation projects, water samples may be analyzed at different points of the network.

Water for drip irrigation and for other techniques where there is a potential clogging problem can be evaluated on the basis of measurements of the suspended solids and chemical or biological properties of the water.

1.3 Checking quality of water source for irrigation

Water Quality Consideration for Irrigation

- ✓ pH
- ✓ Conductivity
- ✓ Sodium & Potassium
- ✓ Nutrients
- ✓ Specific compounds

The increasing demand placed on water supplies throughout will mean that irrigated agriculture faces the challenge of using less and/ or poorer quality water to maintain production. An increased reliance on ground waters and reuse of surface waters means that water quality will be ‘poorer’ than surface water or rainwater. The salinity and sodi city levels of these waters will be higher than surface water supplies and irrigation management will need to be modified to enable sustainable use of these poorer quality waters. Irrigation water quality criteria depend on soil properties, climate (rainfall in particular), plant species and management practices. Since these factors interact to define acceptable quality in a given situation, water composition alone provides only a rough guide under average conditions. A number of irrigation water assessment guidelines have been developed over the years.

In increased salinity levels as more salt is added with each application of irrigation water. The extent of this problem is difficult to assess and can be partly controlled by choice of salt-tolerant crops and water management strategies. Where supplementary irrigation (irrigation at levels less than annual rainfall) is the norm, salinity is of less concern than sodi city because salt levels can be reduced dramatically by wet season rainfall. Inherent in the philosophy of many of the water quality guidelines for irrigation is the control of soil salinity by leaching with increasing levels of water application. For clay soils, leaching is strongly influenced by the salinity and sodicity of the irrigation water. Thus, threshold values are needed which define the boundary between stable permeability and decreasing permeability for combinations of irrigation water salinity (EC) and SAR. Decreasing permeability is generally the result of increased soil surface dispersion due to insufficient salt content within the surface layers to flocculate the soil. This problem is obvious with rainfall events after irrigation with sodic waters. In rainfall periods, the total salt content in the surface soil solution is lowered by leaching. The ESP will not be reduced as much because in a given volume of soil the number of exchangeable ions (that is, ions held on exchange sites on soil particles) is generally 50 to 500 times greater than the number of ions in the soil solution. Consequently, the number of calcium and magnesium ions available in the soil solution is much lower than the number needed to replace exchangeable sodium. If EC becomes too low to counteract the effects of exchangeable sodium, clay swelling and dispersion occurs, resulting in reduced infiltration rates and soil permeability. Irrigation water salinity and sodicity classification Irrigation salinity can develop from water table salting, or from the use of poor quality irrigation water. Salting from the use of poor quality irrigation water occurs in irrigated soils where there is insufficient leaching to remove salts from the root zone, resulting Plant response to saline irrigation water when assessing water quality for irrigation, the recommended approach is to assess water quality parameters and soil properties. With this information, leaching fraction can be determined, from which soil root zone salinity and plant response can be determined Other factors such as climate, crop type and irrigation management are also important when making recommendations on water suitability.

Table. 2. Irrigation water quality

Irrigation water quality (assume LF = 0.15)		Water salinity rating	Plant salt-tolerance grouping
EC (dS/m)	Chloride (mg/L)		
< 0.65	< 220	very low	sensitive crops
0.65–1.3	220–440	low	moderately sensitive crops
1.3–2.9	440–800	medium	moderately tolerant crops
2.9–5.2	800–1500	high	tolerant crops
5.2–8.1	1500–2500	very high	very tolerant crops
> 8.1	> 2 500	extreme	generally too saline

1.4. Investigating ground water level of project area and checking salt content

Depth to the water table The depth to the water table can be measured using a plopper or other indicating device attached to a tape measure that can be lowered down a bore. A plopper is simply a device that makes a plopping sound when it strikes the water surface. Old valves from internal combustion engines (preferably with concave faces) and brass plugs with concave faces make serviceable ploppers. A plopper can also be constructed from a 20–25 mm pipe with a cork or stopper blocking the inside of the pipe about 5 mm from the bottom end. Whistles and electrical devices can also be used. It is important to record the reference point used for measurement; this is usually either ground level or the top of the bore. For salinity investigations, it is preferable to measure from the water table to ground level.

The following steps should ensure an accurate measure:

- Measure the distance from the bottom of the plopper to the end of the tape where it is attached to the plopper. Add on this amount each time a measurement is taken.
- Lower the plopper into the bore until the plopper enters the groundwater. Pull up the tape slowly, jiggling the plopper up and down over a depth of about 50 mm until a plopping sound is heard every time the plopper is lowered. Obtain an accurate reading from the water table to the top of the bore casing or piezometer by jiggling the tape less and less. Using this method, it is possible to accurately measure the depth to the water table to within 5 mm.
- To correct for the height of the bore or piezometer casing, hold the tape at the top of the inner edge of the casing, and then pull the tape down to ground level (Figure 42). Now read the measurement on the tape at the top inner edge of the bore casing or top of piezo meter.
- Add the distance between the end of the plopper and the beginning of the tape to the measure at the top of the bore casing. This will be an accurate measure of the depth to the water table corrected for the height of the bore casing.

How to measure groundwater level

1.Unlock the protective metal bore casing if present.

2. Remove the PVC monitoring bore cap at the top of the pipe.

3. When measuring groundwater levels, take the reading BEFORE baling out the bore. Low yielding bores may take several days to reach equilibrium and the reading taken after 24 hours may be incorrect. Baling is only necessary when water quality samples are being taken and is described later in this chapter.

4. Use a plopper (a weight tied to the end of a tape measure that 'plops' upon hitting the watertable), fox whistle (shaped metal tied to the end of a tape measure which whistles upon reaching the water table), or electronic sensor with a read out window to detect the water level.

5. Lower the tape measure down the PVC pipe. The plopper, whistle or electronic readout indicate when the end of the tape reaches the top of the water in the monitoring bore.

6. Measure the depth of the water from the top of the PVC casing with the tape. Subtract the height of the bore above ground level from the readings. (for further information see ‘Determining groundwater level’ – next section). This gives you the depth of the water table from the surface and is called the Standing Water Level (SWL).

7. Record the water table depth and monitor bore number together with rainfall and irrigation information date (where applicable) on a chart.

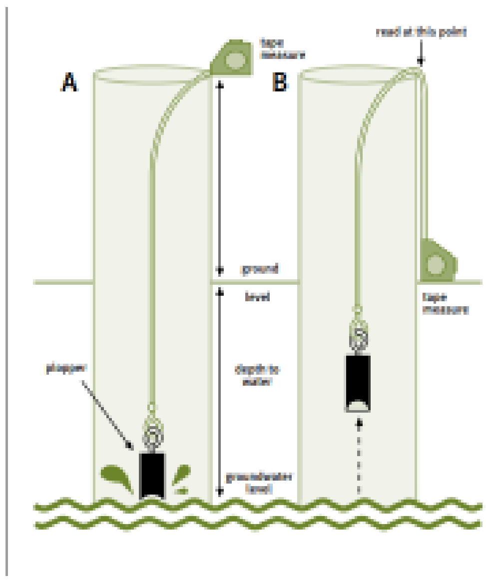

Fig.1. Using a plopper to measure depth to the water table

Piezo meters

Use of Piezo meters are very useful for assessing depth to the water table, changes in water level with time and rainfall events, elevation of the water table above a datum and hence the gradient of flow, estimated flow capacity of the aquifer material, chemistry of the water, and long-term monitoring of changes associated with land use. To assess flow regimes and the interrelationships of aquifers, hydraulic head (the pressure of the groundwater) needs to be assessed. This is usually done using piezo meters. By definition, a water table level will not exceed ground level, whereas the hydraulic head associated with water in a confined aquifer (such as the Great Artesian Basin) may be many meters above ground level. Piezo meters measure pressure. The open well is a specialized type of piezo meter which indicates the free water height of the water table. Because water tends to flow from areas of high potentio metric potential to areas of low potential, water levels in piezo meters are useful for indicating the direction of water flow. The chemistry of dissolved salts in waters drawn from piezo meters is useful for indicating the origins of the water and the chemical processes involved in determining the composition of the water. Trilinear diagrams (described in Interpretation using trilinear diagrams page 76) can be used to graph chemical information for interpreting water sources and processes. Information on the installation of the piezometers can be used in conjunction with water level information to determine aquifer hydraulic conductivity, using, for example, the bail test of Bouwer and Rice (1976). Other information is needed to obtain a comprehensive interpretation of the water level and chemistry information obtained from piezo meters.

This information includes:

- the bore log
- installation information, including depth, position and length of the slotted section of the tube and the sealing material
- rainfall records for the area (essential)
- elevation of each piezo meter, preferably above Height Datum or otherwise some arbitrary height reference
- any information from deep bores in the surrounding catchment
- observations of stream or spring flow, including water composition
- Observations on land clearing or other human activities, such as dams, roads etc.
- Water table salting Appearance Salting associated with a rising or shallow water table can become apparent in the following ways:
- The ground surface may become permanently or seasonally damp or waterlogged, or remain damp for extended periods after rain. Previously ephemeral gullies and streamlines may begin to flow continuously or for longer periods.
- Vegetation in low-lying areas may fail to germinate or grow, or may die off over a period of time.

- Pasture composition and diversity may change over time so that couch grass or other salt-tolerant species dominate.
- In residential areas, buildings may suffer from rising damp.
- Groundwater quality may deteriorate.

An area severely affected by water table salting typically consists of a bare area, perhaps with a salt-encrusted soil surface, fringed by salt-tolerant vegetation, with groundwater underlying or seeping through the soil surface. In a seepage area, the ground will appear wet or shiny. If the salting is not severe, the seepage area itself may be lightly vegetated with salt- and water-tolerant species but the surrounding area may be bare. In some situations, the groundwater does not rise near the soil surface because a deep creek or gully in the vicinity intersects the water table and acts as a drain. The base flow in such a drain may be poor quality, saline water. Capillary action draws water from the water table upwards through the soil. This water evaporates or is used by vegetation. Salts which were dissolved in the water accumulate at the soil surface or in the root zone when the water is removed. Salt concentration can increase to a level at which vegetation can no longer survive.

Seepage salting, a form of water table salting, occurs when the water table is at the soil surface, permanently or seasonally, and groundwater seeps through the soil surface. Seepage can reduce salt accumulation in the soil by moving salt to the soil surface and flushing it away. However, salt can accumulate in the area surrounding a seepage as a result of capillary action from the shallow water table. Where water table salting occurs, the groundwater itself is often, but not necessarily, saline. Water table salting can occur in irrigated areas as well as dry land areas. When ground waters are used for irrigation, water table rise is rarely a problem because there is no net increase in the amount of water entering the catchment; excess water draining below the root zone is effectively cycled from the groundwater to the irrigation water and back to the groundwater. Water table rise is more likely to occur when surface waters are used for irrigation because this increases the water inputs to the system—amounting to a 200 to 600 mm/yr effective increase in rainfall, doubling rainfall input in some irrigation areas. In dry land areas, water table salting usually occurs after vegetation clearing and subsequent development reduces water use and thus the ability of the system to maintain the water table at an adequate depth below the soil surface. Groundwater irrigation cycles water within the system, but irrigation with surface water increases water inputs to the system, increasing the likelihood of water table rise

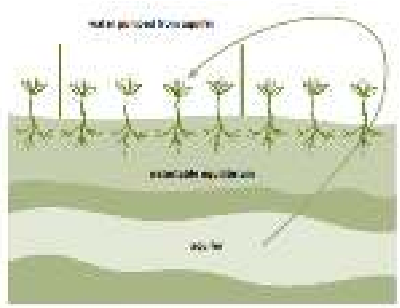

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Fig .2. Groundwater irrigation cycles water

Self-Check 1	Written Test

Name: ___________________________ Date: ________________

Directions: Answer all the questions listed below.

1. What are the main Water Quality Consideration for Irrigation water?(6pt)
2. What are the essential information used to measure ground water level by using piezo meter (7pt)
3. What is the difference between primary and secondary salinity ?(6pt)
4. How to measure soil Salinity? write the correct procedures to measure soil salinity?(6pt)
5. List the types of secondary salinity?(5pt)

Note: Satisfactory rating – 15 points above Unsatisfactory - below 15 points

You can ask you teacher for the copy of the correct answers.

Information Sheet-2	Practice salinity prevention techniques

2.1. Monitoring and controlling ground water rise periodically

Ground water is the water that seeps through rocks and soil and is stored below the ground. The rocks in which ground water is stored are called aquifers. Aquifers are typically made up of gravel, sand, sandstone or limestone. Water moves through these rocks because they have large connected spaces that make them permeable. The area where water fills the aquifer is called the saturated zone. The depth from the surface at which ground water is found is called the water table. The water table can be as shallow as a foot below the ground or it can be a few hundred meters deep. Heavy rains can cause the water table to rise and conversely, continuous extraction of ground water can cause the level to fall.

Groundwater Monitoring Systems by Function

Table1. Showing Groundwater Monitoring Systems by Function

SYSTEM	BASIC FUNCTION	WELL LOCATIONS
Primary (Reference) Monitoring	evaluation of general groundwater behaviour, e.g.: trends resulting from land-use change + climatic variation processes such as recharge, flow and diffuse contamination	in areas with uniform hydrogeology and land use.
Secondary (Protection) Monitoring	protection against potential impacts to: strategic groundwater resource well-fields/springheads for public WS urban infrastructure from land subsidence archaeological sites against rising WT groundwater-dependent ecosystems	around facilities/areas/ features requiring Protection.

Tertiary (Pollution containment) Monitoring	early warning of groundwater impacts from: • intensive agricultural land use • industrial sites • solid waste landfills • land reclamation areas • quarries and mines	immediately down + up-gradient from hazard

Effectiveness of groundwater monitoring is improved by careful attention to:

- Network design
- System implementation
- Data interpretation
- Data storage from past monitoring activities
- Accessibility of monitoring stations...
- Participatory monitoring amongst water users
- Interpretation and use of data to formulate management actions

Ways to Protect and Conserve Groundwater

Go Native: Use native plants in your landscape. They look great, and don't need much water or fertilizer. Also choose grass varieties for your lawn that are adapted for your region's climate, reducing the need for extensive watering or chemical applications.

Reduce Chemical Use: Use fewer chemicals around your home and yard, and make sure to dispose of them properly - don't dump them on the ground!

Manage Waste: Properly dispose of potentially toxic substances like unused chemicals, pharmaceuticals, paint, motor oil, and other substances. Many communities hold household hazardous waste collections or sites - contact your local health department to find one near you.

Don't Let It Run: Shut off the water when you brush your teeth or shaving, and don't let it run while waiting for it to get cold. Keep a pitcher of cold water in the fridge instead.

Fix the Drip: Check all the faucets, fixtures, toilets, and taps in your home for leaks and fix them right away, or install water conserving models.

Wash Smarter: Limit yourself to just a five minute shower, and challenge your family members to do the same! Also, make sure to only run full loads in the dish and clothes washer.

Water Wisely: Water the lawn and plants during the coolest parts of the day and only when they truly need it. Make sure you, your family, and your neighbors obey any watering restrictions during dry periods.

Reduce, Reuse, and Recycle: Reduce the amount of "stuff" you use and reuse what you can. Recycle paper, plastic, cardboard, glass, aluminum and other materials.

Natural Alternatives: Use all natural/nontoxic household cleaners whenever possible. Materials such as lemon juice, baking soda, and vinegar make great cleaning products, are inexpensive, and environmentally-friendly.

Learn and Do More!: Get involved in water education! Learn more about groundwater and share your knowledge with others.

2.2. Optimizing application of water based on crop, soil and time.

Different crops need different type of soils, different types and amounts of nutrients, and different types and amounts of water. The amount of water required by the plant is also dependent on the growing season and the climate where it is grown. By selecting the right crop for the given soil conditions and climate, one can optimize yields and save water requirements for irrigation.

Alluvial Soils: This type of soil is common in delta regions. Alluvial soils are deposited by rivers and are rich in some nutrients (particularly potash and humus), but are lacking in nitrogen and phosphorous. They tend to be sandier and quicker-draining than many other soils. Rice, wheat, sugarcane, cotton and jute all grow well in these soils.

Black Soils: Black soil gets its color from various salts or from humus. It contains a large amount of clay, but is sandy as well in hillier regions. This soil contains moderate amounts of phosphorous but is poor in nitrogen. This type of soil is also used for rice, wheat, sugarcane and cotton. It is additionally used to grow groundnut, millet and oilseeds.

Laterite Soils: These soils are found in areas with heavy rainfall, particularly near the coasts. It is an acidic soil and is rich in iron, which gives the soil a somewhat red appearance. It is used to grow more tropical crops such as cashew, rubber, coconut, tea and coffee.

Mountain Soils: These soils are found in the Himalayas and contain significant amounts of organic matter. They are somewhat acidic, but suitable for growing tea, coffee, spices and many types of tropical fruits.

Red and Yellow Soils: Red and yellow soils get their names from the very large amounts of iron oxide present in them. They are sandy and somewhat acidic, and are also low in nitrogen and phosphorous. Despite this, red and yellow soils are used to grow rice, wheat, sugarcane, millet, groundnut, ragi and potato.

Other Soils; Saline and alkaline soils are too low in nutrients and too high in salt for productive agriculture. Marsh soils are likewise unfit, but mainly because of their high acidity.

Sandy soils have a low water storage capacity and a high infiltration rate. They therefore need frequent but small irrigation applications, in particular when the sandy soil is also shallow. Under these circumstances, sprinkler or drip irrigation are more suitable than surface irrigation. On loam or clay soils all three irrigation methods can be used, but surface irrigation is more commonly found. Clay soils with low infiltration rates are ideally suited to surface irrigation.

For irrigation purposes, it is important to remember water is absorbed and moves **slowly** through **clay soils**, but once wet, they retain significant amounts of moisture. Water is absorbed and moves **quickly** through **sandy soils**, but they retain very little. This means water applied quickly to clay soil has a tendency to run off rather than move into the soil. Therefore, when irrigating clay soils, water should be applied slowly over a long period but then the site may not need irrigation for several days. Irrigation on sandy soils should be applied quickly but for short periods. Irrigation times on sandy sites should be shorter, otherwise water moves beyond the root zone, becoming unavailable to the plant and contributing to soil leaching. For efficient water use under certain weather conditions, sandy sites may need daily irrigation for short periods. Clay soils have greater capillary (sideways and upward) movement than do sandy soils (Fig 2.2). Quick water application on sandy soils will contribute to a broader wetting area, providing more soil volume for roots to exploit.

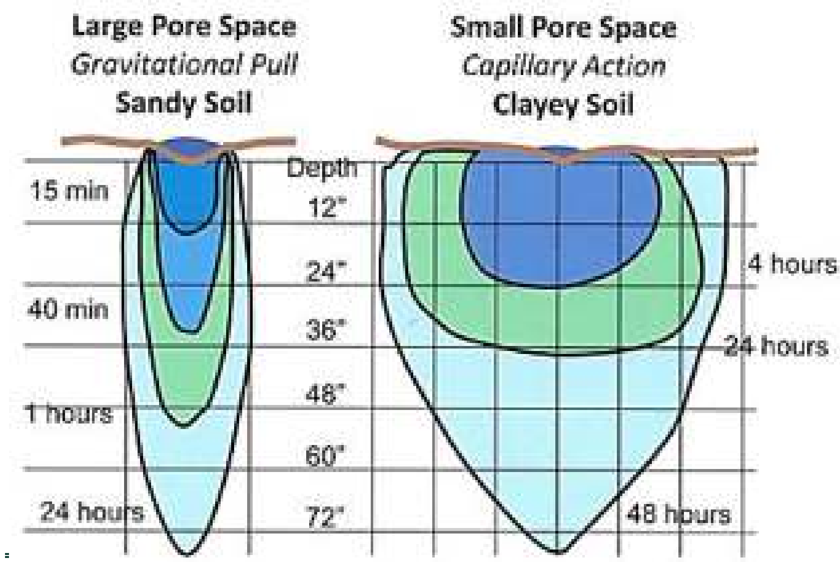

Fig 2.1 water spread and penetration time and distance in sandy and clay soils

When a variety of different soil types is found within one irrigation scheme, sprinkler or drip irrigation are recommended as they will ensure a more even water distribution. Different types of crop need different types of soils and the relations can shown as follow

Plants for clay and silt soils

Plants for clay and silt soils	Plant Type	Suitable for acid soils	Suitable for alkaline soils	Suitable for neutral soils	Extra features
Acer (Japanese Maple)	Tree	✓		✓	
Crab Apple	Tree	✓	✓	✓	
Laburnum	Tree				
Magnolia	Tree	✓	✓	✓	
Sorbus (Rowan)	Tree	✓		✓	
Berberis	Shrub	✓		✓	
Camellia	Shrub				
Hydrangea	Shrub	✓	✓	✓	
Lilac (Syringa)	Shrub	✓		✓	
Mahonia	Shrub	✓		✓	
Pyracantha	Shrub				
Rose	Shrub		✓	✓	
Sambucus	Shrub				
Vitis (Grape Vine)	Shrub				
Weigela	Shrub	✓	✓	✓	
Aconitum	Perennial	✓	✓	✓	
Aster novi-belgii	Perennial				
Astilbe	Perennial	✓	✓	✓	
Astrantia	Perennial		✓	✓	
Bluebells	Perennial				
Calamagrostis	Perennial				
Carex elata	Perennial	✓	✓	✓	
Deschampsia	Perennial	✓	✓	✓	
Filipendula	Perennial	✓	✓	✓	
Foxglove	Perennial				
Hosta	Perennial	✓	✓	✓	
Ophiopogon	Perennial				
Peony	Perennial	✓	✓	✓	
Rodgersia	Perennial	✓	✓	✓	
Rudbeckia	Perennial				
Solidago	Perennial	✓	✓	✓	
Prem Baboo					

Plants for sandy soils

Plants for sandy soils	Plant Type	Suitable for acid soils	Suitable for alkaline soils	Suitable for neutral soils	Extra features
Eucalyptus	Tree	✔		✔	
Hamamelis (Witch Hazel)	Tree	✔		✔	
Juniper	Tree				
Pinus (Pine)	Tree	✔	✔	✔	
Acacia (Mimosa)	Tree	✔	✔	✔	
Buddleja	Shrub	✔		✔	
Cotoneaster	Shrub				
Erica carnea	Shrub	✔	✔	✔	
Helianthemum	Shrub	✔	✔	✔	
Lavender	Shrub	✔		✔	
Perovskia	Shrub				
Pieris	Shrub		✔	✔	
Rhododendron	Shrub				
Rosemary	Shrub	✔	✔	✔	
Achillea	Perennial				
Allium	Perennial	✔	✔	✔	
Anthemis	Perennial	✔			
Dianthus	Perennial				
Echinops	Perennial	✔			
Eryngium	Perennial				
Festuca glauca	Perennial	✔	✔	✔	
Gaillardia	Perennial	✔	✔	✔	
Iris	Perennial				
Leymus arenarius	Perennial	✔	✔	✔	
Oenothera	Perennial	✔	✔	✔	
Osteospermum	Perennial		✔	✔	
Poppy	Perennial	✔	✔	✔	
Red Hot Poker	Perennial	✔	✔	✔	
Sage	Perennial	✔	✔	✔	
Salvia	Perennial	✔	✔	✔	
Sedum	Perennial				
Stipa	Perennial	✔		✔	
Thyme	Perennial				
Verbascum	Perennial	✔	✔	✔	
Wallflower	Perennial	✔	✔	✔	
Prem Baboo					

Soil texture

Increasing clay content in the soil profile is associated with greater water holding capacity. However, this does not mean more water is available for plants to use, as the clay helps create a complex soil matrix of smaller pores which hold water at greater suction pressures.

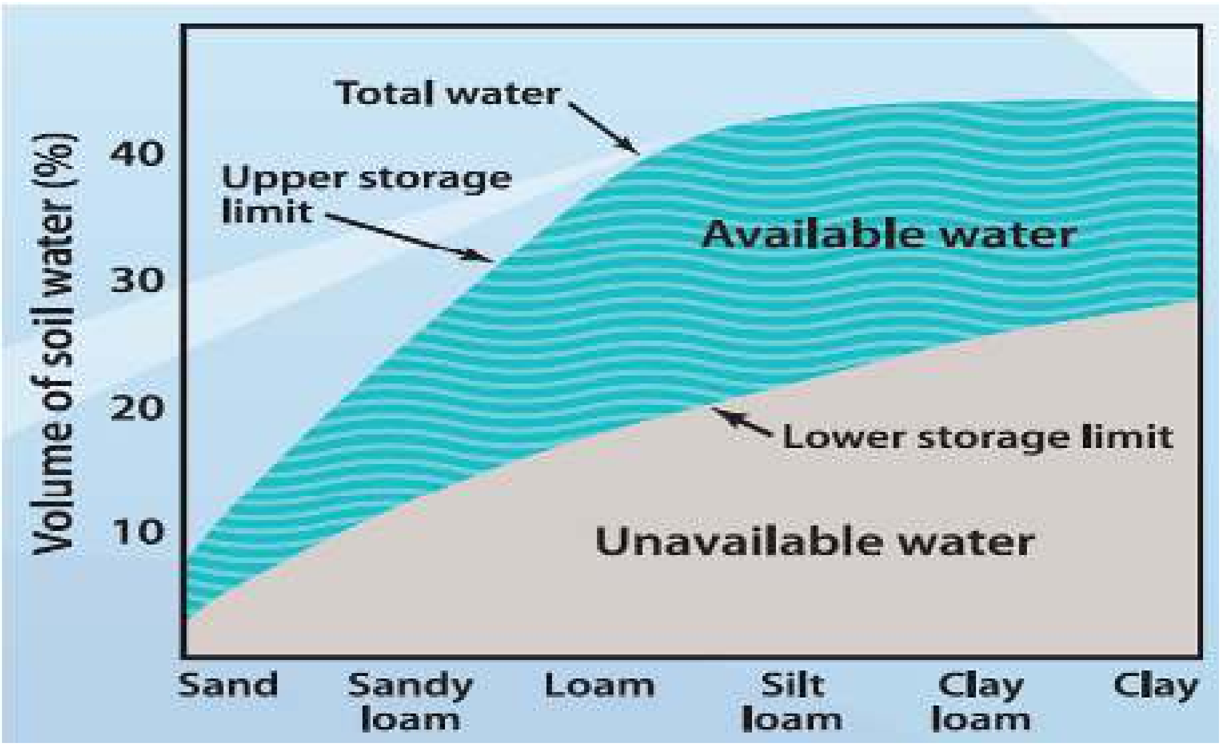

Figure 2.2: The relative amounts of water available and unavailable for plant growth in soils with textures from sand to clay (from Kramer 1983).

In a uniform, coarse-textured soil (e.g. deep sand, sandy earth) low amounts of clay or silt result in poor soil aggregation and a free draining profile. This results in low storage capacity for either water or nutrients in the root zone. These soil types can also be water repellent due to the build-up of waxes on the surface of sand particles, restricting the rate of water infiltration into soil and resulting in greater surface water losses. In soils where there is a sharp change in soil texture in the subsoil (e.g. sand over clay duplex soils) the amount of water available for plants, depends on the texture of the surface soil, depth to subsoil and the nature/texture of the subsoil and its interface with the surface soil. Due to its clay content, this soil type can store a lot of water but the availability of this water will be determined by infiltration patterns and rooting depth.

Soil structure

Soil aggregates create pores which store water for plants to access. A poor or non-existent soil structure with high clay content will have a reduced volume of soil pores. The pores that are present are smaller so water is held at higher suction pressures, making the plant exert more energy to extract the water, rather than using that energy for yield. Coarser textured soils will generally have larger pore sizes and little soil structure, resulting in rapid water drainage. A lack of soil structure can also mean poor infiltration and sometimes a compacted subsurface which can result in water logging in the root zone. Increasing soil organic matter content helps create and stabilize soil structure.

Rooting depth

The large variation in the maximum rooting depth of different crops and the tolerance of plant species to different soil conditions, in addition to depth of soil, determines the capacity of a plant to access available water on many soils (Van Gool et al., 2005). In many agricultural soils there are subsoil barriers which prohibit plant roots from accessing available water:

Physical barrier: subsurface compaction which may allow the movement of water and nutrients, but restrict root growth.

Chemical barrier: factors like subsoil acidity and salinity prevents the plant roots from accessing the whole soil profile.

Management options

Apart from claying sandy soils, there are few options to influence soil texture to improve water holding capacity. However, improving soil structure and removing barriers to plant growth can improve both the storage capacity of the soil itself and increase the area/depth of soil which plant roots may utilize for exploration. Potential management options:

- Deep ripping compacted subsoil (see Subsurface Compaction fact sheet).
- Liming to ameliorate soil acidity (see Soil Acidity fact sheet).
- Increase organic matter to improve water infiltration.

2.3. Assessing irrigation water quality

The term "water quality" describes the physical, chemical, and biological components of water and has been extensively examined and reported for drinking water (Chapman, 1996; Walker & Moore, 2003). Irrigation water quality may impact the health and productivity of plants, soils, and the surrounding ecosystems receiving drainage water (Sanchez & Silver tooth, 1996).

Reclaimed irrigation water may have higher salt content than municipal, potable water sources (Devitt, Morris, Baghzouz, & Lockett, 2005). Poor quality irrigation water can also reduce pesticide efficacy and alter the physical structure of soils (Sanchez & Silver tooth, 1996).

Monitor irrigation water quality throughout the growing season and over time (years), and adjust management actions (e.g., fertilization, soil amendment, drainage development, and irrigation volume) to maximize plant health while protecting natural resources (Lockett, Devitt, & Morris, 2008).

In assessing the suitability of waters for irrigation use, water quality characteristics that affect agricultural production, catchment condition, and downstream water quality need to be evaluated.

The parameters that determine irrigation water quality are divided into three categories:

- Chemical
- Physical
- Biological.

Water Quality Concerns

- Alkalinity -- pH, carbonates
- Sodium
- Salinity
- Specificions -- Cl, B, Fe

PH: Measure of acidity (H+) and alkalinity (OH-) in solution ranges from 0-14

  - 7 = neutral (H+ ions = OH- ions)
  - >7 = alkaline
  - <7 = acidic

- Influences soil pH and nutrient availability
- Reliable indicator of other water quality issues
  - Plant and soil management problems
  - Damaged irrigation equipment
  - Reduced pesticide efficacy

Salinity

- Measure of the soluble salts content in a water source, reported as:

- Lab - Total dissolved salts (TDS; expressed in ppm or mg/L)
- Field - Electrical conductivity (EC; expressed in dS/m or mmhos/cm)

➢ Highly saline irrigation water:

- Reduces seed germination, rooting, growth, establishment, and fruiting of plants (Hillel, 2000)
- Lowers the osmotic potential of the soil solution, reducing plant available water (Duncan, Carrow, & Huck, 2009)

SAR

Assesses the sodium (Na) status and permeability hazard of irrigation water Relationship between soluble Na and soluble calcium (Ca) and magnesium (Mg) used to predict the exchangeable Na fraction of soil equilibrated with a given solution (Leinauer & Devitt, 2013)

Elevated SAR values in irrigation water applied to clay soils can cause:

➢ Dispersion of soil colloids

➢ Reduced infiltration and hydraulic conductivity

Better estimate than SAR of potential irrigation management issues when:

➢ bicarbonate concentrations ≥ 120 ppm

➢ bicarbonate-rich water applied to alkaline soils

Does not require any additional analysis – uses commonly reported parameters

Bicarbonates

Produced by dissolving carbon dioxide in water Expressed as ppm or meq/L

High levels of bicarbonates in irrigation water can:

➢ Cause unsightly foliar deposits on leaf tissue

➢ Precipitate salts

➢ Clog drip emitters and soil pores

➢ Form complexes with Mg and Ca – reducing Ca and Mg for plant uptake and colloidal dispersion (Leinauer & Devitt, 2013)

➢ Increase soil pH if the buffering capacity of the soil (resistance to pH change) is low

Residual Sodium Carbonate

Determines if excess Ca and Mg in irrigation water after Ca and Mg ions precipitate with carbonates

- Expressed as meq/L
- Useful when determining
- Irrigation water management
- Soil amendment needs

2.4. Planning appropriate field water distribution

The purpose of distribution system is to deliver water to consumer. The term distribution system is used to describe collectively the facilities used to supply water with appropriate quality, quantity and pressure from source to the point of usage. Water quality should not be requirements of good distribution system. It should be capable of get deteriorated in the distribution pipes. Supplying water at all the intended places with sufficient pressure it should be capable of supplying the requisite amount of water head.

The layout/plan should be such that:

- No consumer would be without water.
- Distribution pipes should be preferably laid one meter away or above the ground.
- It should be fairly water-tight as to keep losses due to sewer lines.
- Leakage to the minimum.
- The distribution pipes are generally laid below the road pavements

Advantages:

- It gives quick service calculations of pipe sizes is easy.
- Due too many pressure easier due to less number of valves
- It is suitable for cities with rectangular Grid Iron System layout, where the water mains and branches are laid in rectangles.

Disadvantages

- Sizes of pipes are not possible due to provision of valves on all branches.
- Dead ends, stagnation of water occur in pipes
- The first task of the WSP team is to fully describe the water supply system in order to support the subsequent risk assessment process.

Describing the water supply system involves the following steps:

- Gathering information on the system;

- Preparing a flow chart from source to consumer and including the elements described below;
- Inspecting the system to verify that the flow chart is accurate and
- Identifying potential water quality problems.

The description of the distribution system provides the foundation for development of the WSP. It will assist the WSP team in identifying where the system is vulnerable to hazardous events, relevant types of hazards and control measures.

Water transmission or distribution system usually, treated water is conveyed to service reservoirs for distribution to consumers. In urban systems, a water transmission system may also be necessary to convey water from a treatment plant to a number of service reservoirs located at different convenient points in the city. Both water transmission systems and water distribution systems are networks of pipes. However, water transmission systems have a tree-like configuration, whereas water distribution systems usually have loops.

2.5. Performing periodical soil test for salinity

Soil sampling or testing for salinity analysis is often used as a diagnostic tool to identify the existence of saline soils. However, its use in assessing the cause of vine growth decline should be treated with care. The problem with using a soil analysis is that the soil samples taken do not necessarily represent the root zone in which the vine is growing. In some instances, especially in drip irrigated vineyards, areas in the soil profile can develop significantly high salinity levels but only represent a small portion of the soil volume accessed by the vine roots.

Field tests for waters

Field tests are useful as a preliminary survey of the extent and distribution of salinity in a catchment or area. Water samples can be obtained from existing water access points (streams, wells, bores, irrigation channels, dams), but the accuracy of the survey will be limited by the spatial distribution of these points. Ideally, sampling points should be selected to represent a range of local geomorphologic features (including soils and aquifers) and land uses. Sources of information as well as directly sampling surface waters and ground waters. The Salt watch program has resulted in the collation of a substantial database on the salinity of surface waters and ground waters.

Salinity and chemical composition

Salinity in water samples can be determined on-site using an EC meter, or samples can be forwarded to a laboratory for testing of salinity and chemical composition. Samples for laboratory analysis should be forwarded as quickly as possible. Delays and high temperatures will result in salts precipitating out of solution, changing the chemical composition of the water.

A wide range of EC meters is available, ranging from small pocket meters costing around $80, to small field meters with temperature compensation costing about $250, to multi-function extended range EC meters costing upwards of $300. Mid-range meters with built-in temperature compensation are appropriate for most salinity investigations. Generally we are expected to perform periodic soil salinity tests in the soils which are found in irrigation areas.

2.6. Intercropping deep rooted perennial crops

Intercropping is a long-established farming technique of cultivating two or more crops in the same space at the same time, is an important component of agricultural production systems in most developing countries. The advantages of intercropping include higher overall productivity, better utilization of land and resources, and the establishment of soil microbial diversity

Perennial crops are crops that last two or more seasons. Perennial plantings serve as a foundation for your school garden and can have various purposes such as:

- Attracting wildlife and providing habitat for beneficial insects (pollinators and predators) both of which connect to science content
- Food production (herbs, fruit trees, shrubs, and vines)
- Medicinal uses (teas, tinctures, salves, and balms)
- Ornamental uses (dried floral crafts, cut flowers)
- Providing year round color and foliage
- Providing year round plant material for studying and projects

Perennial plants are usually easier to maintain than annual vegetable crops and, once planted, perennials provide a place of beauty and interest for years to come.

2.6.1. Understanding agro-forestry practices

Agro forestry is a land-use system in which trees or shrubs are grown in association with agricultural crops, pastures or livestock. This integration of trees and shrubs in the land-use system can be either a spatial arrangement, e.g. trees growing in a field at the same time as the crop, or in a time sequence, e.g. shrubs grown on a fallow for restoration of soil fertility. Or a collective name for land-use systems and technologies in which woody perennials (trees, shrubs, palms, bamboos, etc.) are deliberately combined on the same land management unit with herbaceous crops and/or animals, either in some form of spatial arrangement or temporal sequence.

There are both ecological and economic interactions among the different components recently come into international prominence as a potential source of solutions to many interrelated problems of production & conservation troubling land use systems in the tropical and subtropical regions of the world today

Good agro forestry should fulfill:

Productivity:

- Increased output of tree products
- Improved yield of associated crops
- Reduction of cropping inputs
- Increased labor efficiency
- Diversification of production
- Satisfaction of basic needs
- Other economic efficiency
- Achievement of biological potential

Sustainability:

- Achieve conservation goals while appealing to needs of low income farmers

Adoptability:

- It is imperative for the AF to be adopted
- Fit socio-cultural, environmental and farming system character

Overcoming High Alkalinity

- Don't over water
- Acidic fertilizers/amendments
- Acidify irrigation water
- Residue - irrigate in eve., less frequent
- Use buffer in spray tank

Sodium adsorption ratio

- Ratio of sodium to calcium and magnesium

- Salinity of water should also be considered
- sodium has greater effect at low salinity than high salinity

2.7. Avoiding excess seepage from canals

Excessive seepage from irrigation canals can highly affect irrigation efficiency in other words it can affect irrigated crops highly, So that we are expected to remove or avoid it early. There are several designed structures for avoiding excess seepage from canals. The major ones are:

- **Canal escapes**

These are structures meant to release excess water from a canal, which could be main canal, branch canal, distributaries, minors etc. Though usually an irrigation system suffers from deficit supply in later years of its life, situations that might suddenly lead to accumulation of excess water in a certain reach of a canal network may occur due to the following reasons:

- Wrong operation of head works in trying to regulate flow in a long channel resulting in release of excess water than the total demand in the canal system downstream. Version 2 CE IIT, Kharagpur
- Excessive rainfall in the command area leading to reduced demand and consequent closure of downstream gates.
- Sudden closure of control gates due to a canal bank breach.

The excess water in a canal results in the water level rising above the full supply level which, if allowed to overtop the canal banks, may cause erosion and subsequent breaches. Hence, canal escapes help in releasing the excess water from a canal at times of emergency. Moreover, when a canal is required to be emptied for repair works, the water may be let off through the escapes. Escapes as also built at the tail end of minors at the far ends of a canal network. These are required to maintain the required full supply level at the tail end of the canal branch. The construction feature of escapes allows it to be classified in to two types, as described below.

- **Weir or surface escapes**

These are constructed in the form of weirs, without any gate or shutter and spills over when the water level of the canal goes above its crest level Version 2 CE IIT, Kharagpur 3.9.8.2 Sluice or surplus escapes these are gated escapes with a very low crest height. Hence, these sluices can empty the canal much below its full supply level and at a very fast rate. In some cases, these escapes act as scouring sluices to facilitate removal of sediment. The locations for providing escapes are often determined on the availability of suitable drains, depressions or rivers with their bed level at or below the canal bed level so that any surplus water may be released quickly disposed through these natural outlets. Escapes may be necessary upstream of points where canals takeoff from a main canal branch. Escape upstream of major aqueducts is usually provided. Canal escapes may be provided at intervals of 15 to 20km for main canal and at 10 to 15km intervals for other canals. The capacity of an escape channel should be large enough to carry maximum escape discharge. These should be proper energy dissipation arrangements to later for all flow conditions.

Self-check-2	**Written test**

Name: ___________________________ Date: ________________

Directions: Answer the following questions.

1. What is ground water? Briefly explain the ways of monitoring ground water (6pts)
2. What is the need of assessing the quality of irrigation water? Explain the factors that affect quality of water (6pts)
3. Explain the ways how can we protect and conserve our ground water? (4pts)
4. What is distribution system? How can we plan an appropriate distribution system? (6pts)
5. What is the objective of testing soils? Briefly explain the procedure (4pt)

Note: Satisfactory rating – 13 points and above Unsatisfactory - below 13 points

You can ask you teacher for the copy of the correct answers.

Information Sheet-3	**Practice techniques for management of salt affected irrigation lands**

The management of salinity is often considered to be an irrigation issue related to water quality and leaching requirements. However, there a number of other factors such as design of the irrigation system that should be considered for effective control of salinity.

3.1. Estimating Leaching requirements and excess salt leached

Leaching of salts from the root-zone remains the most effective technique for salt management. Irrigation scheduling strategies such as 'regulated deficit irrigation' and 'partial root-zone drying' minimize deep leaching and tend to accumulate imported salts in the root-zone. The leaching fraction refers to the amount of water that needs to be applied in excess of vine evapotranspiration requirements to flush out accumulated salt. The extra water applied can come from irrigation or by rainfall. Low leaching fractions, caused by little rainfall or low irrigation allocations, increases the net salinity retained in the root zone leading to a potential requirement to use salt tolerant rootstocks (Appendix A). The application of leaching irrigation events has commonly been associated with the management of salt in the root zone. The common suggestion was that leaching of salts can be done either as part of each irrigation, or it can be achieved via a single large irrigation soon after harvest. The use of leaching events during periods of high transpiration demand is less effective and efficient as leaching events during low transpiration demand. Best leaching of salts from the topsoil occurs when the soil profile is near saturation and the water applied has little salt and water is applied slowly and evenly, either by rainfall or irrigation.

Table 3.1 shows the importance of rainfall in the salt leaching process. As rainfall increases (e.g. moving from the langhome Creek region to the Adelaide Hills), there is a decrease in the number of leaching irrigation events that need to be applied to prevent salt build-up in the root zone of grapevines.

The effectiveness of rainfall assumes that rainfall enters the soil rather than runs off, hence the term 'effective rainfall'. This table also assumes that the water entering the soil is 100% effective in leaching salts.

Table 3.1. Leaching requirements (the extra irrigation water required in %) to maintain average root zone salinity less than 2 dS/m (grapevine tolerance), where the total irrigation for the season is 0.5 and 2 megalitres1, for a range of effective annual rainfall totals. (Source: Tanji and Kielen 2002)

Water quality, dS/m	**0.5Ml**				**0.2Ml**			
	Effective annual rainfall, mm							
	0	200	400	600	0	200	400	600

1	11%	12%	1%	1%	11%	5%	3%	3%
2	25%	4%	2%	2%	25%	11%	7%	5%
3	43%	6%	3%	2%	43%	18%	11%	8%
4	67%	9%	5%	3%	67%	25%	15%	11%

Assumes that the amount of irrigation applied equates to the water demand of the vineyard

Recent research has shown that the leaching process is not always completely efficient. This is thought to be due to the presence of preferred pathways of water movement through the soil, which results in salt build-up in other parts of the root-zone. In some situations where shrinkage cracks form in saline clay soil, salt crystals form on the crack faces in response to evaporation losses. If runoff water can be directed down these cracks before they close up, substantial amounts of salt can be leached quickly and deeply. Application of leaching fractions is only effective if the water table is deep enough to receive the extra water without adversely affecting vine growth. Hence, monitoring the water table using test wells and/or piezometers is recommended. Subsoil drains may have to be installed if the water table is high enough to adversely affect vine performance.

A common practice in determining the depth of irrigation for leaching purposes is through soil water monitoring. Water monitoring allows objective measurement of factors such as depth of penetration of rainwater or flood water – a key factor when assessing the effectiveness of salt leaching programs in vineyards. Salinity is usually monitored in conjunction with soil water content using devises such as capacitance probes and neutron probes.

3.2. Planning and installing appropriate drainage facility

Drainage can be an attractive option in situations where recharge areas are not under the control of the landholder with the salinity problem and groundwater quality is good. Extensive hydrological investigations may be required to determine whether drainage is a viable option under local conditions and to predict its likely effectiveness. When investigating drainage as a salinity management option, these factors need to be considered:

- ✓ Effective drainage requires a height difference between the water table and the drain outlet. To drain flat or insufficiently sloping areas, pumps may be required, increasing the cost of implementation.

- ✓ The hydraulic conductivity of the soil dictates drain spacing. To be effective in clay soils, drains may need to be positioned so close together that this form of management becomes impractical. A minimum workable spacing for drains is considered to be about 80 m.
- ✓ Drainage effluent requires disposal. If the groundwater is saline, the effluent may be too salty to be released into local waterways (except possibly during times of flood). However, it may be possible to dilute the effluent with channel water for use downstream or in irrigation areas. This can be a particularly sensitive issue in some areas where drainage water, in addition to being saline, may also carry high levels of nutrients and chemicals.

When drainage is being designed, future extensions, improvements and the drainage of adjacent areas need to be taken into account. Local extension officers (specializing in soil conservation or water resources) offer a comprehensive service for designing and installing surface and subsurface farm drainage systems.

3.2.1. Planning appropriate drainage facility

Preliminary investigations are necessary to determine the best point(s) for groundwater extraction. To select sites for preliminary investigations, the best sources of information are local knowledge, data on hydrogeology, and results of previous drilling in the area. This information will provide a guide to the likely depth to which bores will have to be sunk, and thus the likely cost of drilling. Other information that should be obtained before carrying out preliminary investigations includes whether a licence is needed to drill, the type of drill rig most suited to the job, and the means of constructing the bore(s).

Once a bore has been constructed, a pump test is useful for determining the characteristics of the aquifer at that site. This involves pumping the bore for 24 hours and measuring the change in water level over time in the bore and the volume of water being extracted at regular time intervals.

The success of a bore for groundwater extraction will depend on factors such as the extent of the aquifer, the ability of the aquifer to drain water freely, the diameter and design of the bore, and pumping interference from other bores in the vicinity. An analysis of results from preliminary investigations will determine the effect of these factors and provide an indication of the maximum capacity of the bore, optimum pump inlet level, long-term reliability of the bore and stability of the aquifer.

If the transmissivity of the groundwater aquifer is low, multiple bores may need to be installed to obtain the required quantity of water. Supplying pumps and energy sources to each of these bores would quickly make such a system uneconomical. One option is to use smaller diameter (and thus less costly) bores and manifold these together to make a single inlet for a large surface-mounted pump. However, if one bore breaks suction, the whole system will fail. Because of the limits on suction lift of a surface-mounted pump, depth to the water table and distance between the bores will be limiting factors in this type of system.

A multiple bore system is more likely to have an even drawdown of the groundwater than a single pumped bore. As a result, a multiple bore system will provide better results when the water is being extracted near to the area affected by the high water table.

3.2.2. Installing Drainage system

Drainage water disposal

Any proposal to dispose of pumped or drained water requires a permit from the appropriate authority. Appropriate permits, licences, easements and so on must be arranged for any effluent disposal, regardless of the quality of the water. Outlets must be designed to prevent damage to the receiving watercourse, and the disposal of poor quality water must be managed to prevent adverse effects on other lands and water supplies.

- **Surface drainage**

Surface drains are used to route floodwaters, subsurface drain outflows, irrigation tail waters and any other excess surface water away from problem areas. This may reduce recharge, erosion and prolonged waterlogging and ponding, as well as providing an opportunity for reusing excess water.

- **Subsurface drainage**

Subsurface drainage can be used to prevent waterlogging in two ways:

- ✓ **Relief drainage** is used where there is already a high water table to lower the water table below the root zone of the crop.
- ✓ **Interception drainage** is used to prevent waterlogging and high water tables on lower ground by intercepting seepage and transmission of groundwater from higher ground.

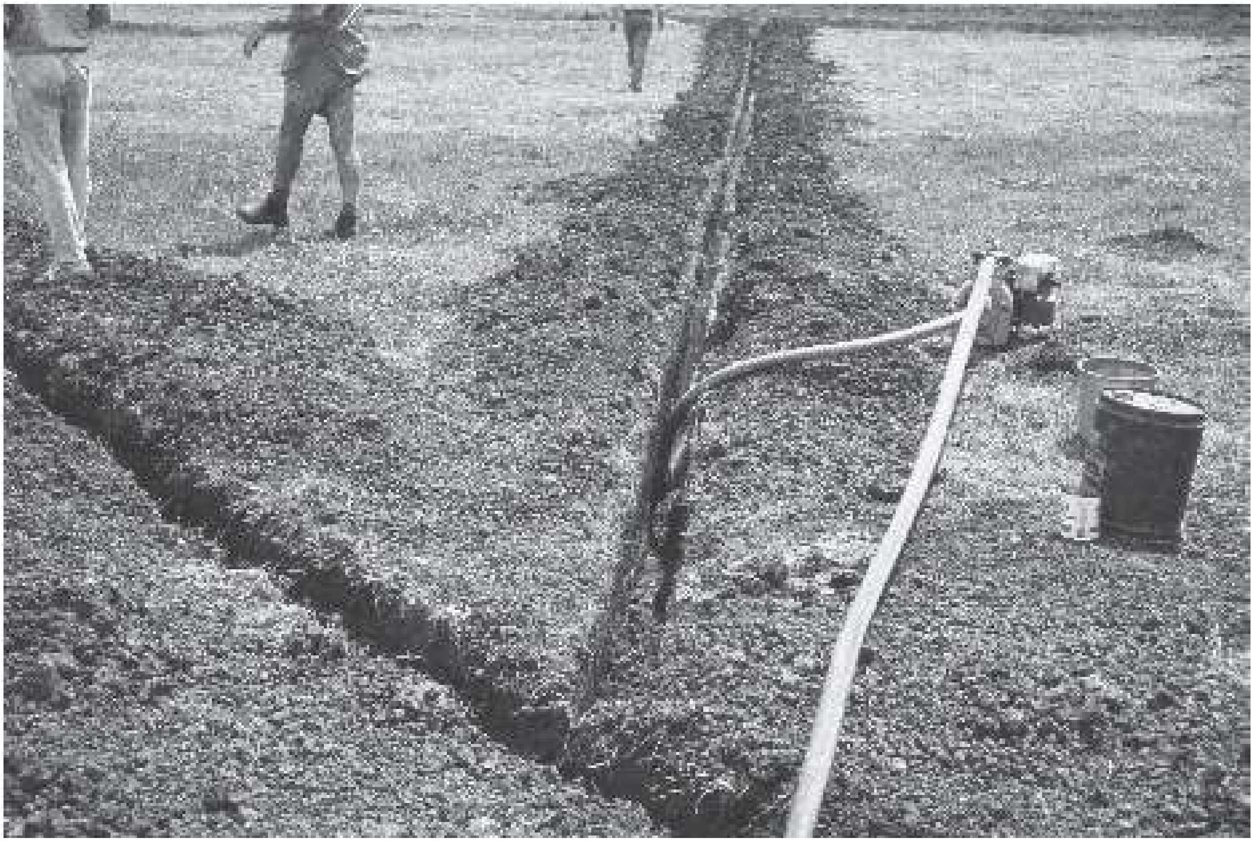

Figure 3.1. Installation of subsurface drainage into a salt affected drainage line.

Many subsurface drainage systems rely on buried slotted agricultural pipe or slotted PVC pipe drains with non-slotted pipe taking the water to the discharge point. Clay pipes (tile drains) or rubble drains have also been used, but these are difficult to install and maintain. Most types of pipes tend to become blocked by plant roots after a period of time.

In suitable soils, mole drains can be used to enhance flow into collector drains. Mole drains are created by dragging a 'plug' through the soil to create a tunnel for water to flow into and along to some type of outfall. The amount and type of clay and the ESP level of the soil will determine the stability and useable life of mole drains. The quality of the drainage water will also affect the dispensability of the soil and thus the stability of the drain.

The optimal depth for drains depends on soil type and crop. The aim is to maintain the water table below the root zone of the crop for relief drainage, and to intercept as much seepage as possible for interception drainage.

- ✓ **Interception trenches**

Groundwater interception trenches at right angles to the hydraulic gradient (direction of flow) can be used to intercept groundwater. Large trenches can provide water storage and can be pumped with conventional pumping equipment. This engineering option will only be effective in areas where the groundwater can be accessed fairly close to the surface (1.5 to 5 m depth).

Trenches which are located above breaks-of-slope, toe slopes or wetter areas upslope of some subsurface barrier to water movement will act as surface storages, being constantly recharged by the groundwater seepage.

Trenches can be pump-tested in a similar manner to bores. The volume of initial storage needs to be taken into account together with the number of trenches when determining the volume of available water. Water quality and potential uses also need to be considered before trenches are constructed.

Figure 3.2. A groundwater interception trench

- ✓ **Groundwater pumping**

To determine whether groundwater pumping is a viable option for managing salinity, the following need to be determined:

- ✓ the volume of water that needs to be pumped to reclaim the affected area
- ✓ how efficiently this volume can be extracted, method of extraction and cost

- ✓ the quality of the water to be pumped
- ✓ Options for using and disposing of water of this quality, and possible benefits and consequences of its use.

The quantity of water that needs to be pumped to reclaim a waterlogged or salt-affected discharge area can be roughly estimated by calculating a groundwater balance for the catchment

3.3. Scheduling irrigation on saline land

When growing wine grapes under drip irrigation it is necessary to be mindful of irrigation frequencies to reduce the salt uptake by the vine. Soils should not be allowed to dry out too much, as the salts become concentrated in the soil solution as the soil dries and the vine may take up the salt. This will harm the vine, wine grapes and finally the wine quality. Frequent irrigations in drip will keep the soils close to field capacity and move salts to the edge of the wetted zone away from the bulk of the root system. However, with limited water supply this may not be possible. Where a range of water supplies is available that are of variable quality (i.e. level of salinity), it is desirable that these water resources be scheduled according to phenological stage. Whilst our understanding of variable water quality applications within a growing season is still developing, recent research suggests that chloride accumulation in the grape berries is more related to the environmental conditions leading up to veraison than after veraison. This suggests that it may be best to use the better quality water (e.g. runoff water stored in a dam) early in the season to maintain a low saline soil conditions during the period of rapid cell growth and division and then apply the poorer quality water (eg. from a bore or a salt-affected river) after veraison during fruit development and maturity. This is a topic that requires further research.

3.4. Identifying salt loving crop

Salt tolerance of crops is the maximum salt level a crop tolerates without losing its productivity while it is affected negatively at higher levels. The salt level is often taken as the soil salinity or the salinity of the irrigation water.

Plant species vary in how well they tolerate salt-affected soils. Some plants will tolerate high levels of salinity while others can tolerate little or no salinity. The relative growth of plants in the presence of salinity is termed their salt tolerance.

Salt tolerances are usually given in terms of the stage of plant growth over a range of electrical conductivity (EC) levels. Electrical conductivity is the ability of a solution to transmit an electrical current. To determine soil salinity EC, an electrical current is imposed in a glass cell using two electrodes in a soil extract solution taken from the soil being measured (soil salinity). The units are usually given in deciSiemens per metre (dS/m).

Table 3.2 categorizes salinity into general ranges from sensitive to tolerant saline. These values are used for plant selection for saline soils. Salinity levels vary widely across a saline seep. Salinity also varies from spring to fall. Salinity usually appears on the soil surface just after spring thaw.

A high salt level interferes with the germination of new seeds. Salinity acts like drought on plants, preventing roots from performing their osmotic activity where water and nutrients move from an area of low concentration into an area of high concentration. Therefore, because of the salt levels in the soil, water and nutrients cannot move into the plant roots.

As soil salinity levels increase, the stress on germinating seedlings also increases. Perennial plants seem to handle salinity better than annual plants. In some cases, salinity also has a toxic effect on plants because of the high concentration of certain salts in the soil. Salinity prevents the plants from taking up the proper balance of nutrients they require for healthy growth.

Soil and water salinity can be expressed in various ways. The most common parameter used in soil salinity is the electric conductivity of the extract (ECe) of a saturated soil paste in units of deciSiemens per metre (dS/m) (previously measured in millimhos per centimeter (mmho/cm)). Bernstein presented the following soil classification based on ECe in dS/m:

- ✓ ECe 0–2 non-saline soil
- ✓ ECe 2–4 slightly saline, yield of sensitive crops reduced
- ✓ ECe 4–8 moderately saline, yield reduction of many crops
- ✓ ECe 8–16 saline, normal yield for salt tolerant crops only
- ✓ ECe > 16 reasonable crop yields only for very tolerant crops

Table 3.2 Categories of salinity sensitive to tolerant saline and crop

Sensitivity	Chloride (mg/l)	Sodium (mg/l)	Affected crop
Sensitive	<178	<114	Almond, apricot, citrus, plum
Moderately Sensitive	178–355	114–229	Capsicum, grape, potato, tomato
Moderately tolerant	355–710	229–458	Barley, cucumber, sweetcorn
Tolerant	>710	>458	Cauliflower, cotton, safflower, sesame, sorghum, sunflower

3.5. Recommending chemical amendment for sodic and saline soils

Gypsum is itself a salt, albeit only sparingly soluble. It provides two distinct soil structural benefits when applied to sodic soils:

1. Gypsum provides calcium cations, which replace sodium and magnesium cations associated with the dispersion of negatively charged clay particles.
2. The gypsum also provides a mildly saline soil solution that suppresses dispersion. However, this "electrolyte effect" of dissolved gypsum only persists while a supply of undissolved gypsum is available in the soil. The use of coarse-crystalline mined gypsum (solubility approximately 0.4 dS/m) maintains the electrolyte effect for longer than finely divided gypsum (solubility approximately 1.9 dS/m). Where the soil already is moderately saline, avoid the use of finely divided gypsum that may push up the salinity stress on plants substantially – instead, use a coarse-grade gypsum if a sodic layer requires treatment under these circumstances.

✓ **There are three main ways of applying gypsum to a vineyard soil:**

1. A spreader towed by a tractor is an effective way of adding gypsum to the zones requiring treatment. Mechanical incorporation is not essential – the gypsum will dissolve and travel with the wetting front the next time it rains and/or irrigation water is applied.

2. Gypsum can be applied to a field via an aircraft in situations where the ground is too boggy for ground spreaders and application is required urgently.
4. The gypsum can be dissolved in irrigation water and then be applied through the irrigation system.

3.6. Practicing optimal soil and water management practice are needed

3.6.1 Soil management

The use of soil management practices to control salinity is often not considered. However, there are a number of management practices that can be used to mitigate and control the effects of salinity.

Mulching soil surface

Water dripping onto bare soil is undesirable for several reasons:

- ✓ It is prone to loss by evaporation, particularly when the soil surface is very hot.
- ✓ Surface sealing may occur beneath each dripper, leading to reduced infiltration rates.
- ✓ Surface soil chemical properties tend to become very heterogeneous, with strong salt concentration gradients along the vine rows (mid-way between the drippers tends to be more saline than directly under the drippers). Organic mulches/composts (e.g. Figure 3.3) can overcome these problems:
- ✓ The mulch/compost can act as a wick, which tends to produce a more uniform downward flow of irrigation water and dissolved salts.
- ✓ Burrow-forming soil fauna tend to become active at the soil-compost boundary; this improves soil structure (Figure 3.4), infiltration rates and root zone aeration.
- ✓ Rapid percolation of water into the cool subsoil beneath the protective mulch/ compost reduces the risk of loss by evaporation and encourages the leaching of unwanted salts in the topsoil.

When applying mulch, however, the wine grape grower must know what they are applying. They need to ensure that the imported mulch is free of contaminants and that the nutrient content is taken into account when planning vineyard fertilizer strategies.

Figure 3.3. Compost a) and straw mulch b) applied along the vine rows to improve the physical fertility of a poorly structured topsoil

Figure 3.4. Vertical biopores created by soil fauna beneath straw mulch along vine rows.

3.6.2 Water management practice

Our understanding of different irrigation methods for the control of salinity, particularly in relation to buried drip, is not comprehensive. Table 3.3 describes salinity management issues associated with a range of pressurized irrigation systems. The wetting patterns and rates of flow of irrigation water produced by these contrasting systems are also strongly influenced by soil factors, particularly structure, texture, organic matter content and the degree of water repellence.

Table 3.3 Salinity management issues associated with contrasting irrigation system designs.

Irrigation method	Positive salinity features	Negative salinity features
1. Standard above-ground drip with wide spaced emitters (1.0m)	Less surface area wetted than closely spaced emitters using low output drippers. High output emitters can create continuous wetting patterns and uniform wetting	Where wetting spheres beneath low output emitters do not overlap, salts tend to concentrate on the fringes of the spheres. This salt concentration in zones between the emitters can Create problems for root growth, particularly when mobilized by rainfall.

2. Above-ground drip with closely spaced emitters (0.5m)	Where the wetting spheres beneath each emitter overlap, a continuous wetting front is created that allows a relatively uniform flushing of salts from the root zone.	More expensive than Option 1 Likely to have greater surface evaporation losses than Option 1.
3. Buried drip	Minimal evaporation losses mean that more water is available per unit of applied water. This provides more leaching of unwanted salts from the root zone.	Maintenance can be difficult (e.g. root intrusion, damage by soil fauna); blocked emitters can be difficult to detect. If the irrigation water is saline, substantial amounts of salt can migrate upwards from the drip line and concentrate in harmful concentrations in the topsoil.
4.Microjets or mini sprinklers	A relatively uniform wetting front is created that allows a thorough flushing of salts from the root zone.	Water losses via evaporation tend to be greater with spray systems than with drip systems. The resultant increase in near-ground humidity can encourage vine growth in dry weather, but there may be a greater risk of fungal outbreaks with Sprinklers under moist conditions.

Self-check-3	**Written test**

Name: ___________________________ Date: ________________

Directions: Answer the following questions.

1. How can we determining the depth of irrigation for leaching purposes? (3 pt)
2. What is the advantage of Relief drainage and Interception drainage? (3 pt)
3. What type of crop do you plant on Moderately sensitive areas ?(5pt)
4. Gypsum provides two distinct soil structural benefits what are they?(5pt)

Note: Satisfactory rating – 5.5 points and above Unsatisfactory - below 5.5 points

You can ask you teacher for the copy of the correct answers.

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