Problems of Irrigation Lands

6.1. Definition of Salinity and Water-logging

An agricultural land is said to be water-logged, when its productivity gets affected by the high watertable. The productivity of land infact, gets affected when the root zone of the plants gets flooded with water, and thus become ill-aerated. Ill aeration reduces crop yield, as explained below :

The life of a plant, infact, 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, many other problems are created by water-logging, as discussed below :

(*i*) 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.

(*ii*) Certain water loving plants like grasses, weeds, etc. grow profusely and luxuriantly in water-logged lands, thus affecting and interfering with the growth of the crops.

(*iii*) Water-logging also leads to salinity, as explained below :

If the watertable has risen up, or if the plant roots happen to come within the capillary fringe, water is continuously evaporated by capillarity. Thus, a continuous upward flow of water from the watertable to the land-surface, gets established. With this upward flow, the salts which are 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 present 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, and the plant ultimately fades away. Such soils are called saline soils. From the above discussion, it becomes evident that the water-logging ultimately leads to salinity, the result of which is, the reduced crop yield. For this reason, salinity and water-logging are treated as a twin problem; under the head 'salinity and water-logging'. *Whenever there is water-logging, salinity is a must.*

6.2. Causes of Water-logging

Water-logging is the rise of watertable, which may occur due to the following factors :

(i) **Over and Intensive Irrigation.** When a policy of intensive irrigation is adopted, then, 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 watertable. For this reason, to avoid water-logging, a policy of *extensive irrigation* (*i.e.* irrigation spread over wider regions) should supersede the policy of *intensive* irrigation.

(ii) **Seepage of Water from the Adjoining High Lands.** Water from the adjoining high lands may seep into the sub-soil of the affected land and may raise the watertable.

(iii) **Seepage of Water through the Canals.** Water may seep through the beds and sides of the adjoining canals, reservoirs, etc., situated at a higher level than the affected land; resulting in high watertable. This seepage is excessive, when soil at the site of canals, reservoirs, etc. is very pervious.

(iv) **Impervious Obstruction.** Water seeping below the soil moves horizontally (*i.e.* laterally) but may find an impervious obstruction, causing the rise of watertable on the upstream side of the obstruction. Similarly, an impervious stratum may occur below the top layers of pervious soils. In such cases, water seeping through the pervious soils will not be able to go deep, and hence, quickly resulting in high watertable.

(v) **Inadequate Natural Drainage.** Soils having less permeable sub-stratum (such as clay) below the top layers of pervious soils, will not be able to drain the water deep into the ground, and hence, resulting in high water level in the affected soil.

(vi) **Inadequate Surface Drainage.** Storm water falling over the land and the excess irrigation water should be removed and should not be allowed to percolate below. If proper drainage is not provided, the water will constantly percolate and will raise the level of the underground reservoir.

(vii) **Excessive Rains.** Excessive rainfall may create temporary water-logging, and in the absence of good drainage, it may lead to continued water-logging.

(viii) **Submergence due to Floods.** If a land continuously remains submerged by floods, water loving plants like grasses, weeds, etc. may grow, which obstruct the natural surface drainage of the soil, and thus, increasing the chances of water-logging.

(ix) **Irregular or Flat Topography.** In steep terrain, the water is drained out quickly. On flat or irregular terrain having depressions, etc., the drainage is very poor. All these factors lead to greater detention of water on the land, causing more percolation and raised watertable.

6.3. Water-logging Control

It is evident that water-logging can be controlled only if the quantity of water into the soil below is checked and reduced. To achieve this, the inflow of water into the underground reservoir should be reduced and the outflow from this reservoir should be increased, as to keep the highest position of water-table at least about 3m below the ground surface. The various measures adopted for controlling water-logging are enumerated below:

(1) **Lining of Canals and Water Courses.** Attempts should be made to reduce the seepage of water from the canals and water courses. This can be achieved by *lining* them. It is a very effective method to control water-logging.

(2) **Reducing the Intensity of Irrigation.** In areas where there is a possibility of water-logging, intensity of irrigation should be reduced. Only a small portion of irrigable land should receive canal water in one particular season. The remaining areas can receive water in the next season, by rotation.

(3) **By Introducing Crop-rotation.** 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, and then by one requiring almost no water. Rice may be followed by wheat, and wheat may be followed by a dry crop such as cotton.

(4) **By Optimum Use of Water.** It is a known fact that only a certain fixed amount of irrigation water gives best productivity. Less than that and more than that, reduces the yield. But most of our cultivators are unaware of these technicalities, and they feel that by using more water they can increase crop yield. Therefore, they try to use more and more water. This can be checked by educating the cultivators by proper propaganda. Moreover, 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. A strict watch should also be kept at the outlet, in order to stop undue tapping.

(5) **By Providing Intercepting Drains.** Intercepting drains along the canals should be constructed, wherever necessary. These drains can intercept and prevent the seeping canal water from reaching the area likely to be water-logged.

(6) **By Provision of an 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 (described in details a little later).

(7) **By Improving the Natural Drainage of the Area.** To reduce the percolation, the water should not be allowed to stand for a longer period. 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, jungles, forests, etc. and improving the slopes of the natural drainage lines.

(8) **By Adopting Consumptive Use of Surface and Subsurface Water.** 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. *Hence, the ground water should also be used in conjunction with canal water for irrigation,* as the continuous use of ground water will not allow any appreciable rise in the level of water-table, due to continuous seepage of canal water.

This combined use of subsurface water (ground water) and the surface water (canal water) in a judicious manner, as to derive maximum benefits, called conjunctive use, should hence be adopted to control water-logging.

6.4. Reclamation of Saline and Alkaline Lands

Land reclamation is a process by which an unculturable land is made fit for cultivation. Saline and water logged lands give very less crop yields, and are, therefore, almost unfit for cultivation, unless they are reclaimed. Before summarising the remedies for reclaiming such lands, we shall first review the process, whereby, a land becomes, 'saline' or in extreme cases 'alkaline'.

Every agricultural soil contains certain mineral salts in it. Some of these salts are beneficial for plants as they provide the plant foods, while certain others prove injurious to plant growth. These injurious salts are called <u>*alkali salts*</u> and their common examples are Na_2CO_3, Na_2SO_4, and NaCl. Na_2CO_3 or black alkali* is the most harmful; and NaCl is the least harmful. These salts are soluble in water. If the watertable rises up, or if the plant's roots happen to come within the capillary fringe, water from the watertable starts flowing upward. The soluble alkali salts also move up with water and get deposited in the soil within the plant roots as well as on the surface of the land. *This phenomenon of salts coming up in solution and forming a thin (5 to 7.5 cm) crust on the surface, after the evaporation of water, is called effeorescence.* Land affected by effeorescence is called *saline soil*. The salty water surrounding the roots of the plants reduces the osmotic activity of the plants, as explained below :

Since the plant roots act as semi-permeable membranes, so we have almost pure water on one side of the membrane (*i.e.* the water already extracted by the roots) and highly concentrated salt solution on the other side. Now, from the knowledge of physical chemistry, we can conclude that pure water from within the roots will start flowing out of the roots by 'osmosis' towards the salt solution, until the pressure on pure water side becomes equal to the osmotic pressure of the salt solution. The plant will, hence, die due to lack of water, as shown in Fig. 6.1.

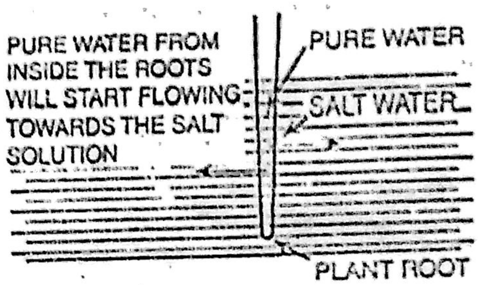

Fig. 6.1

Such a salt affected soil is unproductive and is known as "saline soil". If the salt effeorescence continues for a longer period, a base exchange reaction sets up, particularly if the soil is clayey, thus *sodiumising the clay*, making it impermeable and, therefore, ill-aerated and highly unproductive. Such soils are called *alkaline soils*. The reclamation of alkaline lands is more difficult.

Reclamation of salt affected lands. It is evident from the above discussion that effeorescence can be avoided if the watertable is maintained sufficiently (about 3m) below the roots, so that the capillary water is not able to reach the root zone of the plant. *Hence, all those measures which were suggested for preventing water-logging hold good for preventing salinity of lands also.* An efficient drainage system consisting of surface drains as well as sub-surface drains (explained in the next article) must be provided in order to control and lower the watertable in saline lands. After the high watertable has been lowered by suitable drainage, the soil is freed from the existing salts by a process, called *Leaching*.

6.4.1. Leaching. In this process, the land is flooded with adequate depth of water. The alkali salts present in the soil, get dissolved in this water, which percolate down to join the watertable or drained away by surface and sub-surface drains. The process is repeated till the salts in the top layer of the land are reduced to such as extent that some salt resistant crop can be grown. This process is known as leaching. High salt resistant crops like fodder, berseem, bajra etc., are now grown on this leached land for one or two seasons or till the salinity is reduced to such an extent that an ordinary crop like wheat, cotton, citrus garden crops, etc. can be grown. The land is then said to have been reclaimed.

* It is known as black alkali because it dissolves some organic constituents of soil, which when in solution with it, appear black. The ground, therefore, gets spotted with patches of black stain.

When sodium carbonate (Na_2CO_3) is present in the saline soil, gypsum ($CaSO_4$) is generally added to the soil before leaching and thoroughly mixed with water. Na_2CO_3 reacts with $CaSO_4$ forming Na_2SO_4, which can be leached out as explained earlier.

6.4.1.1. Leaching requirement (LR) of a soil. In order to maintain status quo on the salinity of a given soil, and to avoid any further increase in its salinity, it is necessary to apply water to the soil in excess of the consumptive use (*i.e.* the requirement to meet evapotranspiration needs). This excess water will flow down beyond the root zone of the crop to the underground drainage system or to the underground reservoir, washing down the excess salts, which otherwise would have been deposited in the soil to further increase the salinity of the soil.

This excess water, which is required to meet the leaching needs, is generally expressed as the percentage of the total irrigation water applied to the soil (field) to meet the consumptive use as well as the leaching needs. This percentage quantity of water required for maintaining equilibrium in the salt content of the soil, has been computed to be expressed by the following equation :

$$LR\ (\text{Leaching Requirement}) = \frac{D_d}{D_i}$$

$$= \frac{\text{Depth of water drained out per unit area}}{\text{Depth of irrigation water applied per unit of area}} \quad \ldots(6.1)$$

where D_i = Total irrigation water depth applied.

$$= C_u + D_d$$

↓ ↓

Consumptive use + Drained out water depth

$$\therefore \quad L.R. = \frac{D_d}{D_i} = \frac{D_i - C_u}{D_i} \quad \ldots(6.2)$$

For salt equilibrium, the ratio $\frac{D_d}{D_i}$ is found to be equal to $\frac{C_i}{C_d}$; where C_i is the salt content of irrigation water, and C_d is the salt content of drainage or leached water. Since the salt content is directly proportional to the Electrical conductivity* (EC), $\frac{C_i}{C_d}$ will be equal to $\frac{EC_{(i)}}{EC_{(d)}}$ where $EC_{(i)}$ is the *electrical conductivity of irrigation water*; and $EC_{(d)}$ is the *electrical conductivity of drained water* (leached water or leaching water). Hence, equation (6.1) can be written as :

$$L.R. = \frac{D_d}{D_i} = \frac{EC_{(i)}}{EC_{(d)}} \quad \ldots(6.3)$$

The *E.C.* of drainage water, or leaching water, *i.e.* $EC_{(d)}$, may be assumed on the basis of permissible salt tolerance limit of the grown crop, but is generally assumed to

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* Electrical conductivity is a measure of salt content in a given water sample, and is dealt in more details in article 1.7(2).

be twice the E.C. value of the *saturation soil extract** *i.e.*, $E.C._{(e)}$. Hence, eqn. (6.3) can also be written as :

$$L.R. = \frac{D_d}{D_i} = \frac{EC_{(i)}}{EC_{(d)}} = \frac{EC_{(i)}}{2EC_{(e)}} \qquad ...(6.4)$$

Example 6.1. *Estimate the leaching requirement when electrical conductivity (EC) value of a saturated extract of soil is 10 m mho/cm at 25% reduction in the yield of a crop. The EC of irrigation water is 1.2 m.mho/cm. What will be the required depth of water to be applied to the field if the consumptive use requirement of the crop is 80 mm? EC value of the leaching water may be suitably assumed.*

Solution. The given values are :

$EC_{(e)}$ = E.C. value of saturated soil extract = 10 milli mho/cm

$EC_{(i)}$ = E.C. value of irrigation water = 1.2 milli mho/cm

C_u = Consumptive use = 80 mm

The *Leaching Requirement* (LR) is given by the Eqn. (6.3) as :

$$LR = \frac{D_d}{D_i} = \frac{EC_{(i)}}{EC_{(d)}}$$

where $EC_{(d)}$ is the E.C. value of leaching water, which may be assumed to be equal to $2 \cdot EC_{(e)} = 2 \times 10$ m.mho/cm = 20 milli mho/cm

Substituting the above values, we get

$$L.R. = \frac{EC_{(i)}}{EC_{(d)}} = \frac{1.2 \text{ milli mho/cm}}{20 \text{ milli mho/cm}} = \frac{1.2}{20} \times 100\% = 6\%$$

Hence, the Leaching Requirement is 6%. ....Ans. ...(1)

Now using eqn. (6.2), we have

$$LR = \frac{D_d}{D_i} = \frac{D_i - C_u}{D_i} = \frac{D_i - 80 \text{ mm}}{D_i} \times 100\% \qquad ...(2)$$

Equating (1) and (2), we have

$$6 = \left(\frac{D_i - 80 \text{ mm}}{D_i}\right) \times 100$$

or $\quad 6\, D_i = 100\, D_i - 8000$ mm $\quad$ or $\quad 94\, D_i = 8000$ mm

or $\quad D_i = \frac{8000}{94}$ mm = 85.1 mm

Hence, the required water depth for irrigation = 85.1 mm Ans.

LAND DRAINAGE

Surface irrigation is a blessing only if it is practised with great care. Only optimum amount of water should be supplied to the crop, in accordance with the requirement of that crop, and the properties of the soil must be given full consideration. Excess water, which the root zone of the soil fails to absorb, may percolate and help in raising the

* The water solution extracted from a soil at its saturation percentage.