# UNIT 4 INTERCEPTION, DEPRESSION STORAGE AND INFILTRATION

## Structure



## 4.1 INTRODUCTION

Some amount of total precipitation is caught or intercepted by vegetation cover or by the surface of buildings and other structures, and from there it is evaporated back into the atmosphere. You have learnt about the process of evaporation and evapotranspiration in Unit 3. That part of the precipitation which ultimately reaches the ground surface may then follow one of the three available courses. It may, first, remain on the surface as depression storage in the form of pools, puddles and surface moisture, and which is eventually evaporated back into the atmosphere. Secondly, it may infiltrate through the ground surface to join existing soil moisture. Thirdly, it may flood over the surface as runoff.

Interception, depression storage, evaporation, evapotranspiration and infiltration may be considered as losses because these are not available as surface runoff and direct harnessing by man. In terms of ground water, however, infiltration is a gain. In this unit, you will learn about these processes: interception, depression slorage and infiltration. You will also learn about various methods to estimate these losses.

### Objectives

After completing this unit you should be able to:

- explain the processes: interception, 'depression storage and infiltration,
- understand the influences of various factors on these processes,
- estimate these losses for a given area,
- estimate excess rainfall from a given storm, and
- describe hydrologic water balance for a given catchment.

## 4.2 INTERCEPTION

Interception is that portion of total precipitation which, while falling on the surface of the earth, is intercepted by the surfaces of buildings, etc., and subsequently lost by evaporation. In the study of major storm events and floods, the interception loss is generally neglected, However, it may be a very significant factor in overall water balance studies. This section explains the interception process, factors effecting interception loss, and estimation of interception loss.

### 4.2.1 Interception: A Process

**Vegetation cover on the ground, and buildings, roads and pavements intercept part of the falling precipitation, and temporarilystore It on their respective surfaces.** This intercepted water is either evaporated back into the atmosphere or mostly falls down to the ground. The three main components of interception by vegetal cover are defined below.

**Interception Loss**

Water which is retained on a surface, as mentioned above, and which is later evaporated away.

**Through Fall**

Water which drips through, comes down from the leaves, etc. onto the ground surface.

**Stem Flow**

Water which trickles along the twigs and branches and finally down the main trunk onto the ground surface.

Thus, it is only the interception loss that does not reach the ground surface ; and it may be regarded as a primary water loss.

In most urban areas, interception by vegetation is comparatively unimportant. A significant percentage of precipitation may, however, be held and evaporated from the surface of buildings; however, reliable experimental data in this regard are virtually non-exislent. Normally, water from the roof of a building is led into a drainage system or into the subsoil via sewers and storms drains. Only that amount of precipitation which is required for wetting of any surface is ultimately lost to the atmosphere as evaporation.

### 4.2.2 Factors affecting Interception Loss from Vegetation

Interception loss is invariably, greatest at the beginning of a storm, and then reduces with time. The most important factor, affecting interception loss, is the **interception capacity** of the vegetation cover, i.e., the ability of the vegetation to collect and retain the falling precipitation. At first, when all the leaves and twigs or stems are dry, interception is quite high, and so a very large percentage of precipitation is prevented from reaching the ground. As the leaves become wetter the weight of water on them eventually overcomes the surface tension forces by which it is held there, and, thereafter further additions (from rainfall) are almost entirely offset by the water droplets falling from the lower edges of leaves.

The duration of rainfall is a secondary factor: during long continued rains the interception loss may be closely related to the rate of evaporation. While rain is actually falling, however, conditions are seldom conducive to high rates of evaporation and in these circumstances wind speed tends to be the only meteorological factor of decisive importance. Data collected by Horton and others show that interception loss increases with the duration of rainfall, but only gradually so that the relative importance of interception decreases with time. Further, obviously, the relative importance of interception losses tends to decrease as lhe amount of rainfall increases.

Rainfall frequency is of considerably greater significance than either the duration or the amount of rainfall. When Lhe annual total precipitation is made up of many similar short sl-lowers, separated by periods of clear weather, interception loss may represent 35 to 50 per cent of the annual total. If, on the other hand, equivalent amounts of rain occur during prolonged falls on vegetation surfaces, which for much of the time are thoroughly wetted, total interception loss will be much smaller.

Interception loss may also be affected by the type of precipitation and particularly by the contrast between rain and snow. Evidence concerning the interception of snow does not lead to any firm conclusions. It has been argued that snow reaches the floor of a forest more easily than rain. Other investigations, however, have indicated that the interception of snow and rains are quantitatively much the same.

### 4.2.3 Estimation of Interception Loss

Assuming sufficient rainfall to satisfy the interception - storage capacity, the usual expression for total storm interception is given by:

$$I = S_v + R \times E \times t_r \qquad \text{...(4.1)}$$

where, I is the total interception for the projected canopy area in units of length, $S_v$ is the storage capacity (usually 0.025-0.13 cm) per unit of projected area, R is the ratio of vegetal surface area to its projected area, $E$ is the evaporation rate during the storm from plant surfaces, and $t_r$ is the duration of rainfall.

Some investigators have observed that normally storage increases with increasing rainfall; and to account for that behaviour, of the basin, the following equation can be used:

$$I = (S_v + RE\, t_r)\,(I - e^{-kP}) \qquad ...(4.2)$$

where, P is the .totalprecipitalion in consistent units with $S_v$, and k is equal to $\frac{1}{(S_r + RE\, t_r)}$.

In general, interception, during a storm, is also expressed by equations of the form given below:

$$I = a + b\left(\frac{P}{25.4}\right)^n \qquad ...(4.3)$$

where, I and P are in millimeters.

Table 4.1 gives typical values of a, b and n for different types of vegetal cover described by Equation (4.3)

**Table 4.1 : Constants a, b and *n* in the Interception**

| Vegetal Cover | Interception (mm) | | |
|---|---|---|---|
| | a | b | n |
| Orchards | 1.016 | 4.572 | 1.0 |
| Ash in woods | 0.508 | 4.572 | 1.0 |
| Beech in woods | 1.016 | 4.572 | 1.0 |
| Oak in wood | 1.27 | 4.572 | 1.0 |
| Maple in woods | 1.016 | 4.572 | 1.0 |
| Willow, shrubs | 0.508 | 10.16 | 1.0 |
| Hemlock and pine woods | 1.27 | 5.08 | 0.5 |
| Bean, potatoes, cabbage and other small crops grown on hills | 0.017h | 0.125h | 1 |
| Clover and meadow grass | 0.004h | 0.066h | 1 |
| Forage, alfalfa, vetch, millet etc. | 0.008h | 0.083h | 1 |
| Small grains, rye, wheat barely | 0.004h | 0.042h | 1 |
| Corn | 0.004h | 0.004h | 1 |

The symbol *h* referes to the height of plant in cm. (Source: Gray (1973) in Bras 1990).

It should be obvious that the knowledge of interception loss is highly empirical. The reader is referred to Branson et al (1981) for a more extensive discussion of interception in general.

## SAQ 1

i) Why is interception loss generally neglected in the studies of major storm events and Bloods ?

ii) Interception losses inclues :

a) evaporation through flow and stream flow.

b) only evaporation loss.

c) evaporation and transpiration losses.

d) only stream flow.

iii) State 'true' or 'false' and give brief explanations:

a) Through fall and stem flow are prevented from reaching the ground surface, and therefore are part of interception loss.

b) Interception loss in a season is much higher if seasonal total precipitation consists of several short showers separated by periods of clear weather.

c) Interception loss in urban areas is equal to that amount of precipitation which is required only for wetting of roof of the buildings.

## 4.3 DEPRESSION STORAGE

Process of interception and also depression storage provide an opportunity for increased evaporation from a basin. Depression storage, later on, is lost partly through the process of evapotranspiration and partly through infiltration into the ground. Land surface contains depressions if various sizes ranging from small puddles to lakes. Rainfall held in these depressions does not contribute to surface runoff unless these are filled to capacity. Hence, depression storage is considered as an initial loss. The first good shower is sufficient to fill the slorage that is characteristic to the basin, comprising interception **by** vegetation and local depressions.

### 4.3.1 The Process

**Depression storage** is also known as **surface storage.** It comprises water retained in the hollows and depressions that exist on the ground surface, during and after precipitation. This water is either evaporated directly, or is used by vegetation for its growth, or else infiltrates into the soil so that nothing of it appears as surface runoff during or immediately after the storm. Depression storage is, therefore, an aspecl of total water loss which is closely allied to interception loss. Depression storage must by differentiated from **surface detention** which is essentially the temporary storage of precipitation on the ground surface occurring before the beginning of overland flow and surface runoff. When the rate of precipitation exceeds the rate at which soil can absorb ( infiltrate) the precipitation, the hollows and depressions on the ground surface begin to fill up. As soon as all the surface storage capacity is filled, further additions of precipitation lead to a continuous movement of water over the ground surface towards the stream channels. Although depression storage is commonly thought of as a small scale phenomenon related to minor depressions and puddles, it may also assume a considerable importance on a large scale where topographical conditions are particularly favourable.

### 4.3.2 Estimation of Depression Storage

We are generally interested in knowing the amount of water that is retained during a storm event in the surface irregularities of the given basin. Its total volume is expressed as:

$$V = S_d\left[1 - e^{-(P_e/S_d)}\right]$$

$$= S_d\left[1 - e^{-kP_e}\right] \qquad ...(4.4)$$

where, V is the volume of water stored , $S_d$ is the maximum storage capacity of the depressions, and $P_e$ is the volume of precipitation in excess of interception and infiltration (gross precipitation minus infiltration).

Therefore, rate of depression storage (v) is given by: .

$$= \frac{dV}{dt} = (e)^{-kP_e} \qquad ...(4.5)$$

where, $\frac{dP_e}{dt}$ is the precipitation rate (i) minus infiltration rate ($f$). Therefore, we have:

$$\frac{dV}{dt} = (1-f).e^{-k.P_e} \qquad ...(4.6)$$

The overland flow supply rate ($\sigma$) can be expressed as:

$$\sigma = 1 - f - v$$

$$\sigma = (i - f) - (1 - f).e^{-kP_e}$$

$$\sigma = (i - f) - \left(1 - e^{-kP_e}\right) \qquad ...(4.7)$$

The **overland supply rate** is the net result after subtraction of infiltration and depression storage from the gross rainfall. This overland flow supply rate becomes runoff and is routed through overland and stream segments resulting in the stream flow hydrograph (discussed in Unit 5)

SAQ 2

i) Bring out the difference between depression storage and surface detention?

ii) Choose the relevant word to make the statement correct:

a) Natural lake provides depression/temporary storage.

b) Depressions begin lo fill only after the rate of infiltration/evaporation/interception loss is greater/smaller than the rate of rainfall.

c) Depression storage is part of initial/continuing loss during a storm period.

iii) Relate the rate of depression storage to the rate of rainfall and rate of infiltration.

## 4.4 INFILTRATION

The phenomena of infiltration deserves a special place in hydrologic study as the understanding of the same enables us to estimate excess rainfall and resulting runoff, soil moisture, and ground water recharge. During a major storm, capable of producing a flood, evapotranspiration loss is generally negligible arid losses by interception and depression storage are small compared to infiltration, whereas interception loss and depression storage are considered as an **internal loss;** infiltration continues as long as there is a supply of water at the soil surface either by direct precipitation or by a flowing sheet of water.

### 4.4.1 Infiltration: A Process

Transfer of water from the atmosphere to the soil is called **infiltration.** It is the process whereby water soaks into or is absorbed by the soil, A distinction is to be made between the terms infiltration and **percolation,** the latter being used to describe lhe downward flow of water through the zone of aeration towards the water table, the former being restricted to the entry of water through the surface layers of the soil,

**Infiltration capacity** was defined **by** Horton as the maximum rate at which rain can be absorbed by a soil in a **given** condition. It is the relationship between rainfall intensity and the infiltration capacity which determines how much of the falling rain will flow directly over the ground surface into streams and rivers, and how much will enter the soil to be retained as net moisture storage for some period of time before being either passed downwards as percolation or returned to the atmosphere by the processes of evaporation and transpiration. Maximum amount of water that a soil can retain against the force of gravity is called field capacity.

### 4.4.2 Factors affecting Infiltration

The infiltration process is affected by a large number of factors as discussed below. Some of these factors cause infiltration capacity to vary geographically, while others cause its variation with time, and a third group (a sizable number of factors) causes variations both .

geographically as well as temporally.

**Rainfall** Characteristics

The actual rate of infiltration, $f$, at a given time can be expressed as:

$$f = f_c, \text{ when } i > f_c$$

and, $$f = i, \text{ when } i < f_c \qquad ...(4.8)$$

where, $i$ is intensity of rainfall and $f_c$ is the infiltration capacity at a given time; $i$, $f$ and $f_c$ are expressed in cm/hr or mm/minute. The infiltration capacity ($f_c$) of a soil is high at the beginning of a storm and has an exponential decay as the time elapses.

Increase in rainfall intensity is reflected in an increase in the size of raindrops, and consequently in an increase in their compacting force while the drops strike the ground surface. Thus, an inverse relationship between infiltration and rainfall intensity may occur under such conditions.

Characteristics of **Soil**

The type of soil, viz. sand, silt or clay; its texture, and structure, and its permeability and underdrainge capacity are the important characteristics affecting infiltration. A loose permeable sandy soil will have a larger infiltration capacity than a light clayey soil. Clayey soils can be rendered virtually impermeable due to raindrop compaction, whereas clean sandy soils are much less susceptible to rain compaction.

**A** soil with good underdrainage, i.e., the natural facility to transmit the infiltrated water downward to a ground water storage, would obviously have a higher infiltration capacity. When the soils occur in layers (i.e., possess stratification), the transmission capacity of the layers determines the overall infiltration rate. Also, a dry soil can absorb more water than the soil whose pores are already full of water. Therefore, land use has a significant influence on the field capacity of soil as it causes soil compaction and change in the characteristics of soil cover.

Surface Cover

A vegetation cover tends to increase infiltration by:

i) retarding surface flow, and thus allowing more time for water to enter the soil,

ii) shielding the soil surface from direct impact of rain drops, thereby reducing surface compaction, and

iii) encouraging more rapid passage of infiltrating water, because the complex root system of the vegetation makes the soil more permeable.

Spread of buildings and paved surfaces in urban areas effectively reduces the infiltration capacities, of various patches of ground, to zero and thus contributes significantly to the frequency of flood peaks in such areas.

Characteristics **of** Infiltrating Water

Viscosity of water and, therefore, the ease with which it may move through soil pore spaces, varies **with** water temperature. It is therefore, expected that temperature will tend to exert some influence on the rate of infiltration. Scarcely, any evidence exists, however, regarding this relationship.

Water quality is another factor whose influence on infiltration is difficult is delimit quantitatively. Water, infiltrating into soil will have many impurities both in solution and suspension. Turbidity of water especially the clay and colloid content'is an important factor. Suspended particles block the fine pores in the soil and reduce its infiltration capacity. Infiltration rates have also been found to vary when infiltrating water is contaminated by salts, particularly in very alkaline soils, because the salts affect not only the viscosity of water but also the rate of swelling of colloids.

### 4.4.3 Measurement af Infiltration

Infiltration characteristics of soil, at a given location, can be obtained by conducting controlled experiments on small areas. The experimental set-up is called an **infiltrometer.** There are two kinds of infiltrometers:

i) Flooding type infiltrometers, and

ii) Rainfall simulator.

### Flooding Type Infiltrometer

This is a simple instrument consisting essentially of a metal cylinder, 30 cm diameter and 60 cm long, open at both ends. This cylinder is driven into the ground to a depth of 50 cm (Figure 4.1).

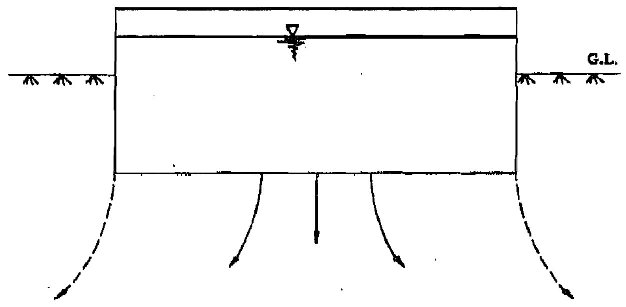


**Figure 4.1: Flooding Type Infiltrometer**

Water is poured into the top part to a depth of 5 cm and a pointer is set to mark the water level. As infiltration proceeds, the volume is made up by adding water from a burette to keep the water level at the tip of the pointer. Knowing the volume of water added at different time intervals, the plot of the infiltration capacity *vs* time is obtained. These experiments are continued till a uniform rate of infiltration is obtained and this may take 2-3 hours. The surface of the soil is usually protected by a perforated disk to prevent formation of turbidity and its setting on the soil surface.

A major objection to this simple infiltrometer, as shown in Figure 4.1, is that the unfiltered water spreads at the outlet from the tube (as shown by dotted lines in the figure), and as such the tube area is not representalive of the area into which infiltration takes place. To overcome this lacuna a ring infiltrometer consisting of a set of two concentric rings (Figure 4.2) is used. In this infiltrometer two concentric rings are inserted into the ground

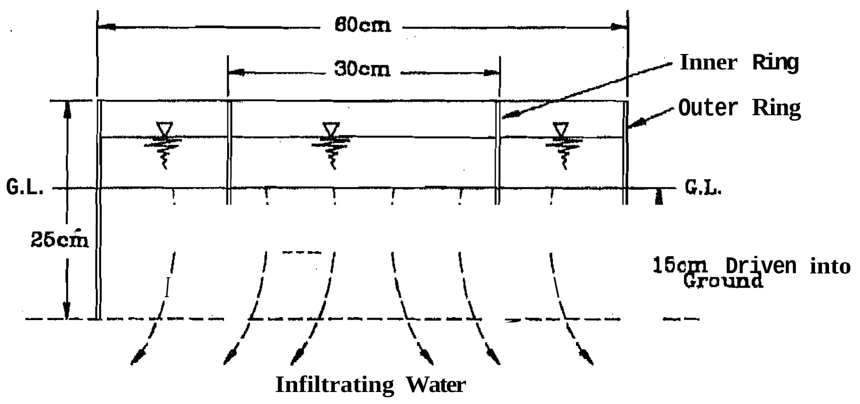


**Figure 4.2: Ring Infiltrometer**

and the water depth is maintained on the soil surface as discussed above, in both the rings, to a common fixed level. The outer ring provides a water jacket to the infiltering water of the inner ring, and hence prevent, to a large extent, the spreading out of the infiltering water with respect to the inner tube. The measurement of water volume is done for the inner ring only.

The main disadvantages of a flooding type infiltrometer are:

i) the raindrop-impact effect is not simulated,

ii) the driving of the tube or rings disturbs the soil structure, and

iii) the results of the infiltrometer experimentation depend to some extent on its size, with the larger instruments giving less rates than the smaller ones; this happens due to the border effect.

### Rainfall Simulator

Here, a small plot of land, of about 2 m x 4 m size is provided with a series of nozzles on the longer side, with arrangements to collect and measure the surface runoff rate. The specially designed nozzles produce raindrops falling from a height of 2 m, and are also capable of producing various intensities of rainfall. Experiments are conducted under controlled conditions with various combinations of intensity and duration, and the consequent surface runoff is measured in each case. Using the water-budget equation involving the volume of rainfall, infiltration and runoff, the infiltration rate and its variation with time is calculated. If the rainfall intensity is higher than the infiltration rate, infiltration-capacity values are obtained.

Rainfall simulator type infiltrometers give lower values than the flooding type infiltrometers. This is due to the effect of rainfall impact and turbidity of the surface water present in the former.

## 4.5 EMPIRICAL INFILTRATION EQUATIONS

Under given soil type and antecedent moisture conditions, there will be an initial i ltration rate, $f_o$. This rate will decrease as more water gets infiltrated, finally achieving aconstant rate, $f_c$, **i.e, ultimate Infiltration capacity.** This infiltration capacity rate prevails when the soil is saturated. Under a steady state (i.e, with storage change), it will be equal or less than the rate at which water percolates and flows into the deep ground water systems (aquifers). The parameters $f_o$, $f_c$ and the decay of infiltration capacity are functions of the soil moisture conditions, vegetation, rainfall, intensity and soil surface conditions. For example, the behaviour of a given soil may be different under different storms because of surface sealing or crushing caused by the impact of raindrops.

Several empirical equations incorporating the above mentioned factors, affecting the behaviour of the soil have been proposed. These formulae can be listed as :

a) Green-Ampt Model (1911)

b) Horton Infiltration Equation (1939-40)

c) Huggins-Monka Equation (1966)

d) Soil Conservation Service Practice (1968)

e) Antecedent Precipitation Method (1969)

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(Reader should refer to Bras (1990) for details about these methods). Horton infiltration equation, as an example, is discussed herein. It lakes the form,

$$f = f_c + (f_o - f_c)\, e^{-\alpha t} \qquad ...(4.9)$$

where, in practice, $f_o$, $f_c$ and $\alpha$ (a constant) are parameters to be estimated from the given data; $e$ is the napierian base and $\alpha$ is a constant and $t$ is the time from the beginning of

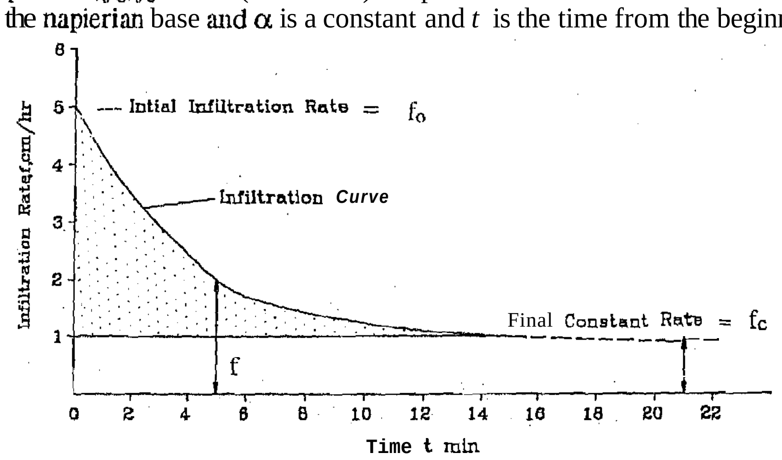


Figure 4.3: Infiltration Cnpacity vs Time

rainfall; $F$ is defined in Figure (4.3). The initial infiltration capacity and the decay rate depend on soil and antecedent conditions. Horton found that infiltration-capacity curves approximate the form given by Equation (4.9).

The equation is applicable only when rainfall less by retention (i.e., supply rate) is greater than or equal to $f$ .

Figure 4.4 shows the Horton infiltration equation as applied to a given rainfall event. It may be said that at a point $t_1$ (in time domain), where rainfall for the first time exceeds the infiltration, the actual infiltration rate will be larger than that given by $f_1$ in the Figure: this is

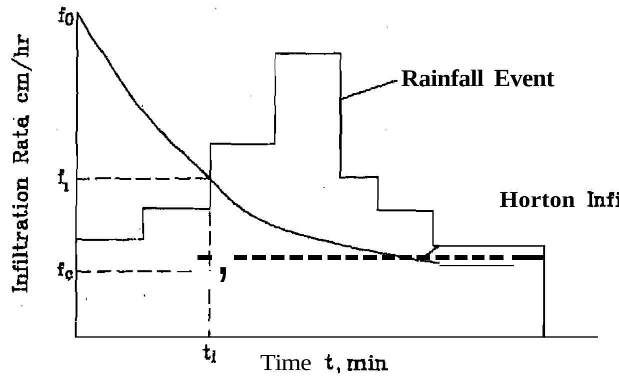


**Figure 4.4: Horton Infiltration Curve vs Rainfall Event**

so because $f_1$ implies that the infiltration rate has decayed down from $f_o$ as a consequence of increased soil moishue, which is given by the area under $f$-curve between time 0 and $t_1$. This inconsistency crops up because the Horton, like the Philip's equation assumes that the surface is saturated all the time, hence there is an unlimited supply of moisture.

To account for this discrepancy, the procedure indicated in Figure 4.5 is commonly used

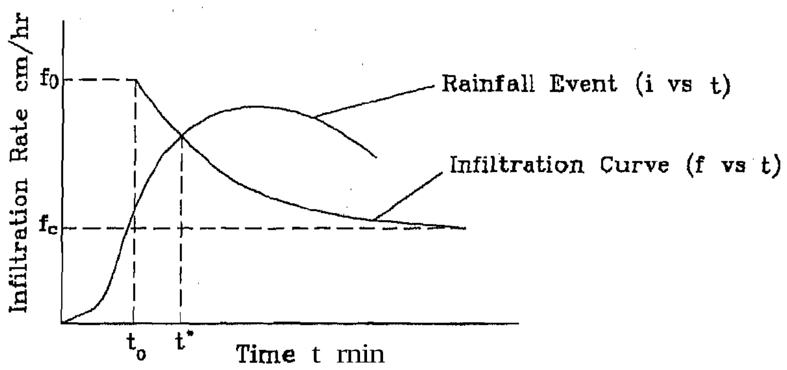


**Figure 4.5: Coucept of Ponding Time *in the* Process of Infiltration**

with the Horton and any other time dependent infiltration equation. The following two equations in this context, namely:

$$\int_{t^*}^{t_o} f(t)\, dt = \int_{0}^{t_o} i(t)\, dt \qquad ...(4.10)$$

and,

$$f(t^*) = i(t^*) \qquad ...(4.11)$$

would be solved simultaneously for the time shift $t^*$ to $t_o$ (see Figure 4.5), the time, $t^*$, being commonly called the **ponding time.**

The above procedure would need to be repeated every time for i < $f$. Nevertheless, this is rarely done in practice except for the initial time shift.

## 4.6 RELATION OF INFILTRATION TO RUNOFF

During a major storm, capable of producing flood conditions in a river basin, evapotranspiration losses are negligible and losses by interception and depression storage are small compared to the amount of infiltration, because infiltration continues as long as there is supply of water onto the soil either by direct precipitation or by a flowing sheet of water **(overland flow).** Too low a rate of infiltration causes high runoff **and** too high a rate of infiltration results in low runoff. Infiltration reduces floods **and** soil erosion and furnishes stream flow during the periods of dry weather, and also provides water for the growth of plants as well as recharges the ground water reservoir.

In hydrological calculations involving floods it is found convenient to use a constant valve of infiltration rate for the duration of the storm. The average infiltration rate is **called infiltration index** and two types of indices, in this regards, are in common use. The $\varphi$ - index is the average rainfall above which the rainfall volume is equal to the runoff volume.

The φ - index is derived from the rainfall hyetograph with the knowledge of the resulting runoff volume. The initial loss is also considered as a part of infiltration. The φ–value is found by treating this value as a constant infiltration capacity. If the rainfall intensity is less than φ then the infiltration rate is equal to the rainfall intensity (Figure 4.6). Thus, **φ - index** is that rate of rainfall above which the rainfall volume equals the runoff volume. The amount of rainfall in excess of the index is called **rainfall excess.** The φ-index thus accounts for the total abstraction and enables runoff magnitudes to be estimated for a given rainfall **hyetograph.** The other index is termed **W-index.** It is the average infiltration rate during the time rainfall intensity exceeds the capacity rate. The W-index, thus, essentially is φ–index less by the average rate of retention by interception and depression

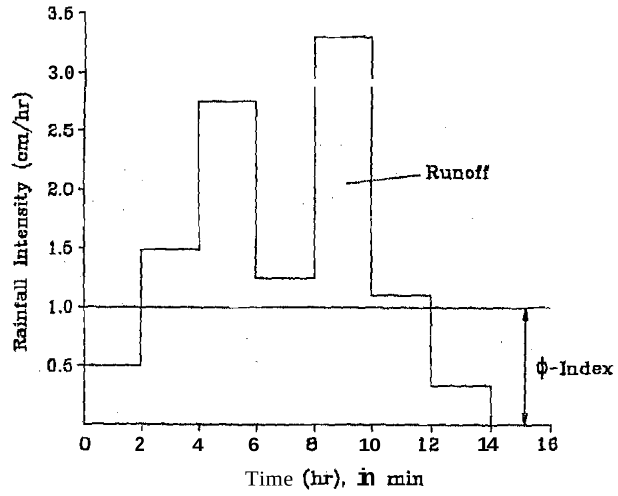


**Figure 4.6 : Infiltration Loss by φ - Index**

storage.

It is obvious that in an attempt to refine the φ–index the initial losses are separated from the total obstructions and an average value of infiltration rate the (W-index) is quantitatively put as:

$$W = \frac{\text{Total infiltration}}{t_e} = \frac{P - R - I_a}{t_e} \quad ..(4.12)$$

where,

P = total storm precipitation (cm) corresponding to $t_e$,

R = total storm runoff (cm) i.e., surface runoff,

$I_a$ = initial losses (cm) i.e., effective surface retention,

$t_e$ = duration of the rainfall excess, i.e., the total time during which the rainfall intensity is greater than infiltration capacity (hours), and

W = average rate of infiltration (cm/h) during the time rainfall intensity exceeds the capacity rate.

Since $I_a$ values are difficult to obtain, the accurate estimation of the W–index is rather difficult. The minimum value of the W–index obtained under very wet soil conditions, representing the constant minimum rate of infiltration of the catchment is known as $W_{min}$. Both the W–index φ- index vary from storm to storm.

The φ–index during a storm for a catchment depends in general upon the soil type, vegetal cover, initial moisture condition, storm duration and intensity. To obtain complete information on the interrelationship between these factors, a detailed and extensive study of a given catchment is necessary. For practical purposes concerning the estimation of flood magnitudes, due to critical storms, a simplified relationship for φ is adopted. As the maximum flood peaks are invariably produced due to long-duration storms and usually in the wet season, the initial losses are assumed to be negligibly small. Further, only the soil type and rainfall are found to be critical in the estimation of the φ- index for maximum flood-producing storms,

On the basis of rainfall and runoff correlation, CWC has found the fallowing relationship relevant to the estimation of φ- index pertaining to flood producing storms and soil conditions prevalent in India: .

$$R = \alpha I^{1.2} \qquad ...(4.13)$$

and,

$$\varphi = \frac{I - R}{24} \qquad ...(4.14)$$

where, R = runoff in cm from a 24-h rainfall of intensity I cm/day, and $\alpha$ = a runoff coefficient which depends on the soil type as shown below:

Table 4.2: Runoff Coefficient ($\alpha$)

| Sl.No | Type of Soil | Coefficient |
|---|---|---|
| 1) | Sandy soil and sandy loam | 0.17 to 0.25 |
| 2) | Coastal alluvium and silty loam | 0.25 to 0.34 |
| 3) | Red soils, clayey loam, grey and brown alluvium | 0.42 |
| 4) | Black-cotton and clayey soils | 0.42 to 0.46 |
| 5) | Hilly soils | 0.46 to 0.50 |

In estimating the maximum floods for design purposes, in the absence of any other data, a $\varphi$– index value of 0.10 cm/h can be assumed.

SAQ 3

i) What is the importance of infiltration in hydrologic cycle?

ii) Explain the typical shape of an infiltration capacity curve.

iii) Discuss the practical importance of $\varphi$ - index.

## 4.7 SUMMARY

Interception losses are essentially evaporation losses in nature. These occur in urban areas through wetting of surfaces of buildings for which experimental data is virtually non-existent. Several factors affect interception by vegetation, most important being the ability of the vegetation surfaces to collect and retain falling precipitation. Surface storage comprises water retained in hollows and depressions which is either evaporated or is used by vegetation or else infiltrates into the soil.

Infiltration is the link between surface and subsurface flows. Empirical infiltration equations calibrated to local conditions are used in the estimation of infiltration capacity. Surface runoff occurs when the rate of rainfall exceeds infiltralion capacity of a given watershed.

Estimation of interception, depression storage and infiltration are needed to relate runoff to the amount of rainfall during a storm period or during a season.

## 4.8 KEY WORDS

Abstractions (or losses) : These constitute the difference between the observed total rainfall hyetograph and the excess rainfall hyetograph. Losses are primarily caused by infiltration with some allowance for interception and surface storage.

**Index Loss** : Losses which occur in the initial period of a storm, rainfall.

Infiltration : Transfer of water from the atmosphere, after precipitating onto the ground, to the soil.

Infiltration **Capacity** : Maximum rate at which infiltration can occur under given conditions.

| | | |
|---|---|---|
| **Infiltrometer** | : | An experimental set-up used to obtain infiltration characteristics of the soil for a given area. |
| **Infiltration Index** | : | The assumed average infiltration rate such that rainfall in excess of this index is equal to the direct surface runoff. |
| **Interception** | : | Part of the storm precipitation that is intercepted by vegetation and other forms of cover on the drainage area. |
| **Surface Cover:** | : | Cover over the land surface provided by vegetation, roads, pavements, building, etc. |

## 4.9 ANSWERS TO SAQs

**SAQ 1**

i) Interception is a loss of precipitation (rain) that is interrupted from falling onto the ground; the loss takes place through the process of evaporation. Since the process of evaporation is slower compared to the process of rainfall runoff, and the amount of interception loss is relatively much smaller during the period of a major storm; therefore, the interception loss is generally neglected in the studies of major storm events.

ii) Interception loss consists of only evaporation loss.

iii)

a) False — Through fall and stream flow are those parts of rainfall that are intercepted from rainfall, but ultimately reach the ground. Therefore, these are not considered as loss.

b) True — Due to intermittent rains separated by clear– weather periods, leaves and stems become dry frequently. This increases the ability of vegetation to collect and retain more of the falling precipitation, (i.e., interception) as compared to the condition when rain occurrs over a prolonged period.

c) True — Rainfall in excess of the amount required for wetting the surfaces appears as surface runoff.

**SAQ 2**

i) Depression storage is a loss as it does not contribute to the direct runoff, i.e., water occupying depressions is not connected to flow channels. Surface detention is a temporary storage of precipitation on the ground surface occurring before the beginning of overload flow and surface runoff.

ii)

a) Depression, if there is no outlet of the lake.

b) Infiltration, smaller.

c) Initial.

where,.(

$$v = \frac{dV}{dt} = (e)^{-kP_e} \times \frac{dP_e}{dt}$$

$$P_e = \text{rainfall (i)} - \text{infiltration } (f)$$

or,

$$= \frac{dV}{dt} = e^{-kP_e} \left( \frac{di}{dt} - \frac{df}{dt} \right)$$

Therefore, higher the rate of rainfall, higher is the rate of depression storage; and, higher the rate of infiltration lower is the rate of depression storage (which could be negative as well).

**SAQ 3**

Refer to the preceding text for answers.

## FURTHER READING


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