

Signature of Faculty In-charge

Experiment No.13

Date-----

Measurement of irrigation water by volume and velocity-area method and measurement of irrigation water by measuring devices

Aim

To study about different water measuring devices and irrigation water

Irrigation water is an expensive and limiting unit of crop production and therefore, proper quantity should be applied to a crop as per edaphic conditions. Excess supply of irrigation water is as harmful as water stress for crop growth. Therefore, effort should be made to apply the right amount of water as and when required. This is only possible by application of measured amount of irrigation water.

Objectives

1. To know the exact area that can be irrigated with a particular volume of water.
2. To avoid over and under irrigation.
3. To economize the use of irrigation water.
4. To save the crop from excess water application.
5. The excess water application leads to deep percolation losses and leaching of nutrients.
6. To save the crops and soil from the ill effects of excess water application (poor drainage situation).

Hectometer

Hectometer is the volume of water necessary to cover an area of hectare to a depth of one meter. Generally, two situations occur in irrigation water management:

- (i) Measurement of flow through open channels (Velocity and area method).

(ii) Measurement of flow through pipes (Direct discharge method).

Velocity and area method

In this method the velocity of water flow in channel is measured and water discharge is calculated by the formula given below:

$$Q = A \times V$$

Where, Q Discharge of water,

A=Cross section of the flow area,

V=Velocity of flow of water.

This includes the following method

(a) Float method: In this method a straight section of irrigation channel (25-50 Mt. Long) is selected and a light floating body is allowed to float along with water and the time taken to cover the distance is recorded. An average velocity of channel often takes to be 0.8 the surface velocity as obtained with the float. Though the factors may be reduced if the channel is narrow, irregular and rough. It is a cheapest and simplest method of water discharge measurement but not so accurate.

(b) Current meter

Current meters are used for measuring the velocity in channels, streams and long rivers. The water velocity is measured by noting the time taken for certain revolutions and using the meter calibration curve that relates the meter speed caused due to water flowing velocity. Water meters show the discharge of water directly in gallons or liters. They are the most reliable and standard devices for measuring discharge of water. (c) Tracer method

The principle involved in this method is that a substance which dissolve in water but does not react with it, is introduced into the flow, and its concentration is measured at two points. Assuming that the substance completely mixes with water and there is no loss of water between

the points of mixing and measurement. In this method common salt or dye (salt dilution method) or radioisotopes are mixed with water and salt concentration or isotopes count is measured at downstream.

Materials required

- Weirs
- Orifices
- Scale
- Spade

Introduction

Measurement of irrigation stream is essential for the studies on soil-water-plant relations and for judicious management of water on the farm to obtain high efficiency in irrigation. Irrigation water is generally measured under two conditions:

- i) At rest: Measured in units of volume such as liter, cubic meter, hectare centimeter (ha cm) and hectare meter (ha-m)
- ii) In motion: Expressed in rate of flow units such as litres per second, liters per hour, cubic meters per second, hectare centimeters per hour and hectare meters per day.

Units of volume:

- i) **Liter:** It is a volume equal to 1/1000 cubic meter (1000 cm^3)
- ii) **Cubic-meter:** It is a volume to that of a 1 meter long, 1 meter wide and 1 meter deep container (1 cubic meter = 1000 liters)
- iii) **Hectare centimeter (ha cm):** It is a volume of water necessary to cover an area of 1 hectare to a depth of 1 cm (100 cubic meters = 100,000 liters)
- iv) **Hectare meter (ha m):** A volume necessary to cover an area of 1 hectare to a depth of 1 meter (10,000 cubic meters = 10 million liters)

Units of flow:

- i) **Litre per second:** A continuous flow amounting to 1 litre passing through a point each second. It is generally used to denote the discharge of a pump, small stream or pipe line.
- ii) **Cubic- metre pre second:** A flow of water equivalent to a stream 1 metre wide and 1 m deep, flowing at a velocity of 1 metre per second.

Working principle

The velocity of water in a stream or river may be measured directly with a current meter and the discharge estimated by multiplying the mean velocity of water by the area of cross section of the stream. When mean velocity of a stream is determined with current meter the cross section of flow is divided into a number of sub-areas and separate measurements are made for each sub area. It has been found that the average of readings taken at 0.2 and 0.8 of the depth below the surface is an accurate estimate of the mean velocity in a vertical plane

Procedure

Measuring structures

In farm irrigation practice, the most commonly used devices for measuring water are weirs, parshall flumes, orifices, siphons and water meters. In these devices the rate of flow is measured directly by making a reading on a scale which is a part of the instrument and computing the discharge rate from standard formula. The discharge rate can also be obtained from ready reckoners prepared for the instrument.

A. Weirs

A weir is a notch of regular form through which water may flow. Notch may be rectangular, trapezoidal or triangular (90° -V). Rectangular and 90° V-notch weirs are commonly used on the farm.

i) Rectangular weir

It is used to measure comparatively large discharges. The length of a rectangular weir may be equal to the width of the channel (suppressed rectangular weir) or less (contracted rectangular weir). The discharge through a rectangular weir may be calculated by the following equation:

Suppressed rectangular weir:

$$Q = 0.0184 LH^{3/2}$$

Where, Q = Discharge (litres/sec.)

L = Length of crest (cm)

H = Head over the crest (cm)

Contracted rectangular weir:

$$Q = 0.0184 (L-0.2H) H^{3/2}$$

Where, Q = Discharge (litres/sec.)

L = Length of crest (cm)

H = Head over the crest (cm)

ii) Trapezoidal or cipolletti weir

The discharge of water through this type of weir may be computed by the formula given below:

$$Q = 0.0186 LH^{3/2}$$

Where, Q = Discharge (litres/sec.)

L = Length of crest (cm)

H = Head over the crest (cm)

iii) 90° V-Notch weir

It is commonly used to measure small and medium sized streams. The advantage of the V-notch weir is its ability to measure small flow accurately. The discharge through a 90° V-notch weir may be computed by the following formula:

$$Q = 0.0138 H^{5/2}$$

Where, Q = Discharge (litres/sec.)

H = Head over the crest (cm)

B. Orifices

Orifice plates can be used to measure comparatively small streams like flow into border strips, furrows or check basins. It consists of iron, steel or aluminium plate that contains accurately circular opening usually ranging from 2.5 cm to 7.5 cm in diameter. A plastic scale may be fixed directly on the upstream face of the orifice plate with its zero reading coinciding with center of the orifice.

The discharge through an orifice is calculated by the formula:

$$Q = 0.61 \times 10^{-3} \times a \sqrt{2gH}$$

Where, Q = Discharge through orifice, liters /sec.

a = Area of cross section of the orifice, cm²

g = Acceleration due to gravity, cm /sec² (981 cm/sec²)

H = Depth of water over the center of the orifice, cm.

C. Parshall flume

Parshall has developed a device to measure the flow in which the discharge rate of water is obtained by measuring the drop in head. It is a self-cleaning device. It is suitable for measuring a wide range of stream sizes, from a few litres/sec. to several cubic metres/sec. It can be used in relatively shallow channels like irrigation furrows. It may also be used to measure the flow of large streams. The Parshall flume consists of a metal or concrete channel structure having three principal sections:

1. Converging section at upstream end
2. Constricted section or throat.
3. Diverging or expanding section at downward.

The size of the flume is determined by the width of the throat of the flume. The flumes of about 7.5, 15.0 and 22.5 cm sizes are used in field measurements.

Discharge through the flume can occur under the following conditions:

1. **Free flow:** When elevation of the water surface near the downstream end of the throat section is not high enough to cause any retardation of the flow due to a back flow of water is termed as free flow. Under this condition, only one measurement of the head or

water level (H_a) in the converging section is required to estimate the rate of flow.

2. **Submerged flow:** When the elevation of the water surface downstream from the flume is high enough to retard the rate of discharge, the flow is said to be submerged flow. The important point in Parshall flumes is the ratio between the reading at H_b and H_a heads. This ratio should not exceed 0.6 for 7.5, 15.0 and 22.5 cm size flumes. If the ratio exceeds 0.6, it is termed as submerged flow. To determine this ratio, H_a and H_b are provided at the upstream and downstream sections of the flume. In this case a correction is subtracted from free flow conditions to obtain the correct rate of flow.

D. Syphons

These are generally used to irrigate the field from canals and channels. Syphons are the pipes usually made of rubber or plastic or aluminum. Following formula can be used to measure the discharge rate of syphons:

$$Q = 0.61 \times 10^{-3} \times A \sqrt{2gh}$$

Where, Q = Discharge rate of water (l /sec.)

g = Acceleration due to gravity (981 cm/ sec.²)

h = Height of water (cm)

A = Cross sectional area of the water in the syphon (cm²).

Calculation

1. Calculate the discharge rate of water of a suppressed rectangular weir 50 cm long with a head of 15 cm.

$$Q = 0.0184 LH^{3/2}$$

$$= 0.0184 \times 50 \times 15^{3/2}$$

$$= 0.0184 \times 50 \times 58.095$$

$$= 53.45 \text{ L/S}$$

2. Calculate the discharge rate of water of a contracted rectangular weir 40 cm long with a head of 10 cm?

$$Q = 0.0184 (L - 0.2H) H^{3/2}$$

3. Calculate the discharge rate of water of a 90° V-notch with a head of 12 cm.

$$Q = 0.0138 H^{5/2}$$

Precautions

- From rust
- Handle properly after using it

Practical significance

A weir or flumes low head dam is a barrier across the width of a river that alters the flow characteristics of water and usually results in a change in the height of the river level. There are many designs of weir, but commonly water flows freely over the top of the weir crest before

cascading down to a lower level.

The Parshall flume is an economical and accurate way of measuring the flow of water in open channels and non-full pipes. The flume was originally developed to measure surface waters, water rights apportionment, and irrigation flows, but its use has expanded to include measuring the flow of sewage (both in pipe and treatment plants), industrial discharges, and seepage from dams.

Conclusion

Signature of Faculty In-charge

