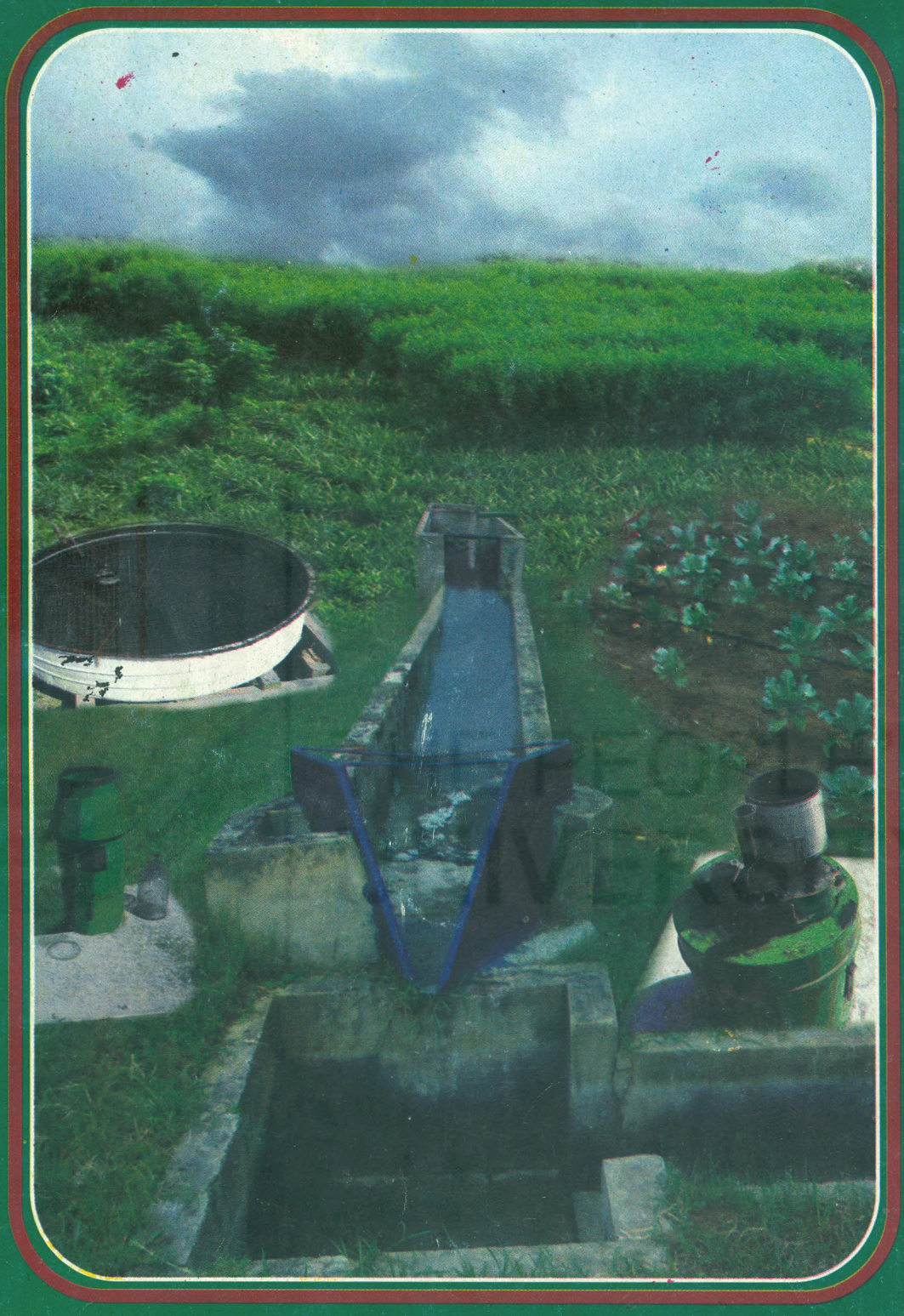
Indira Gandhi National Open University
School of Agriculture

ONRL-001

Practical Training at Water Harvesting Agency



PRACTICAL MANUAL 1

"शिक्षा मानव को बन्धनों से मुक्त करती है और आज के युग में तो यह लोकतंत्र की भावना का आधार भी है। जन्म तथा अन्य कारणों से उत्पन्न जाति एवं वर्गगत विषमताओं को दूर करते हुए मनुष्य को इन सबसे ऊपर उठाती है।"

— इन्दिरा गांधी

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"Education is a liberating force, and in our age it is also a democratising force, cutting across the barriers of caste and class, smoothing out inequalities imposed by birth and other circumstances."

– Indira Gandhi

Indira Gandhi
National Open University
School of Agriculture

ONRL-001
Practical Training at Water Harvesting Agency

PRACTICAL MANUAL

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ONRL-001 PRACTICAL EXERCISES

During the programme, students have been exposed to various aspects of water harvesting and management in general and roof water harvesting in particular. Keeping in view, the importance of managing limited water resources which includes harvesting, conserving and utilization, watershed/water harvesting projects need trained manpower well equipped with theory and practical aspects. Therefore, a considerable emphasis has been laid on practical hands-on exercises. Practical exercises of vital importance for water harvesting projects include exercises on water storage and measurement structures, roof water harvesting from a household and group housing society, discharge measurement, measurement of rainfall, water level and soil moisture.

Objectives

After going through the Practical Manual and conducting practical exercises, you should be able to:

- calculate the volume of water harvested from individual households as well as group housing societies;
- calculate the storage capacity of water storage structures;
- measure the discharge of a tube well and a water course;
- measure rainfall from non-recording and recording rain gauges;
- measure evaporation from U.S. Class 'A' Pan;
- measure ground water level;
- determine soil bulk density (apparent specific gravity);
- measure soil moisture; and
- study the status of various water storage and measurement structures used for rainwater harvesting, type of catchments for water harvesting and storage; and working of roof water harvesting system during field visit.

Study Guide

The Practical Course involves 15 days' practical training at a water harvesting agency. During the practical training, the guided and unguided experiments will be performed by the students.

The practicals will be evaluated under two components: (i) guided experiments and (ii) unguided experiments. The guided experiments will be performed under the guidance of the counsellors. The unguided experiments shall be undertaken by the students on their own. For unguided experiments, students will not be provided guidance during conduct of experiments.

Both the components will be evaluated. 70% weightage will be assigned to guided experiments and 30% to unguided experiments. Each experiment performed by the

students would be evaluated. The performance of the students would be assessed by the counsellors based on manipulative skills, observation and their understanding of the basic concepts related to the experiments.

For successful completion of the programme, a participant is required to have a minimum of 75% attendance in the Practical Training sessions at the identified Water Harvesting Agencies. A student will not be eligible to appear in Term End Practical Examination, if the percentage of attendance in Practical Training sessions falls below 75%. He/she, however, may appear for theory papers.

We would advice the students to critically go through the study material related to the particular experiment before conducting it in the field/laboratory.

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EXPERIMENT 1 ROOF TOP WATER HARVESTING FROM A HOUSEHOLD

Structure

1.0 Objective

1.1 Introduction

1.2 Experiment

- 1.2.1 Principle
- 1.2.2 Requirements
- 1.2.3 Procedure

1.3 Observations and Calculations

1.4 Results

1.0 OBJECTIVE

After completing this practical exercise, you should be able to calculate the volume of water harvested from individual household.

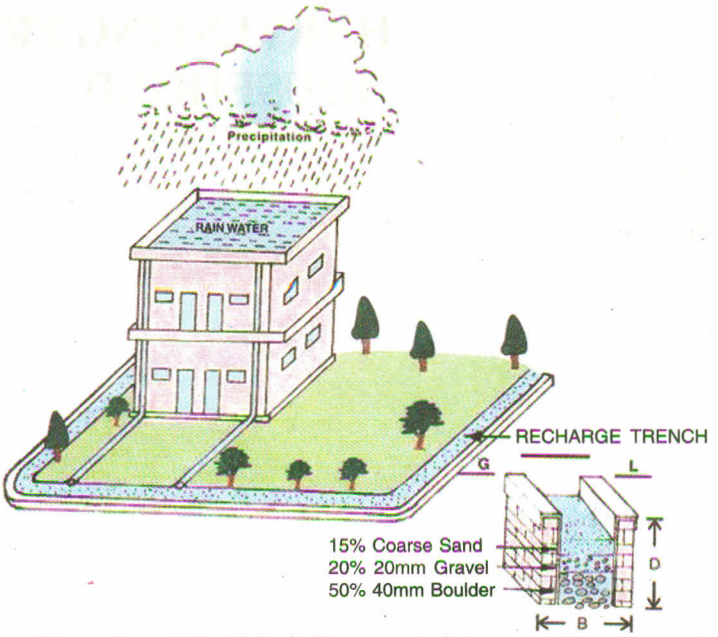
1.1 INTRODUCTION

Rainwater harvesting is the technique of collection of precious natural resource i.e. rainwater. The rainwater harvesting from roof of an individual house (Fig. 1.1) as well as cluster of houses can help in storing rainwater for its subsequent domestic use during lean season and recharging ground water in declining water table areas. The rainwater harvested on house roof is collected through rain pipe and stored in a tank or in ground water structure. In order to design water storage/ground water structure it is of utmost importance to estimate the volume of water in response to different intensities and duration of rainfall. This practical exercise will help the students to determine the volume of rainwater harvested from roof of a house or cluster of houses (Fig. 1.1).

1.2 EXPERIMENT

1.2.1 Principle

To collect and save every drop of precious rainwater before it is lost as runoff or evaporated back to atmosphere.



Source: *Central Ground Water Board, Faridabad (Haryana –India)*

Fig. 1.1 Rainwater harvested from a household

1.2.2 Requirements

- Rainfall data
- Measuring tape

1.2.3 Procedure

1) Collect rainfall depth data for a particular event.
2) Estimate effective rainfall by multiplying rainfall depth with coefficient k generally value of $k = 0.8$.
3) Measure length and width of the roof of a house.
4) Calculate area of the house roof by multiplying length and width.
5) Calculate the volume of water harvested from individual household and cluster of households by multiplying effective rainfall with area of a household. Alternatively, volume of harvested water can be determined by using the following table:

Ready Reckoner to Determine the Volume of Harvested Water from Roof Top (assuming value of coefficient k = 0.8)

Rain-fall, mm / Roof top area, m^2	Volume of Harvested Water, m^3												
	100	**200**	**300**	**400**	**500**	**600**	**800**	**1000**	**1200**	**1400**	**1600**	**1800**	**2000**
20	1.6	3.2	4.8	6.4	8	9.6	12.8	16	19.2	22.4	25.6	28.8	32
50	4	8	12	16	20	24	32	40	48	56	64	72	80
100	8	16	24	32	40	48	64	80	96	112	128	144	160
500	40	80	120	160	200	240	320	400	480	560	640	720	800

Source: *Central Ground Water Board, Faridabad (Haryana – India)*

1.3 OBSERVATIONS AND CALCULATIONS

Example

1) Effective rainfall (mm) = Rainfall (mm) × 0.8

2) Roof area (m^2) = Length (m) × width (m)

3) Volume of rainfall (m^3) = Effective rainfall (mm) × roof area (m^2)

Rainfall = 200 mm

Roof top area = 150 m^2

Effective rainfall for water harvest = 200mm × 0.8

= 160 mm

Volume of rainwater harvested = $\frac{160mm \times 150m^2}{1000}$

= 24 m^3

Depth of water harvested = $\frac{24m^3}{150m^2}$

= 0.16 m or 16 cm

Water harvested (% of rainfall) = $\frac{16}{20} \times 100$

= 80%

Exercise

Rainfall depth, mm	
Length of roof, m	
Width of roof, m	

Rainfall =

Roof top area =

Effective rainfall for water harvest =

Volume of rainwater harvested =

Depth of water harvested =

Water harvested (% of rainfall) =

1.4 RESULTS

Depth of water harvested = ... mm

Water harvested (% of rainfall) = ... %

EXPERIMENT 2 ROOF TOP WATER HARVESTING – GROUP HOUSING SOCIETIES

Structure

2.0 Objective

2.1 Introduction

2.2 Experiment

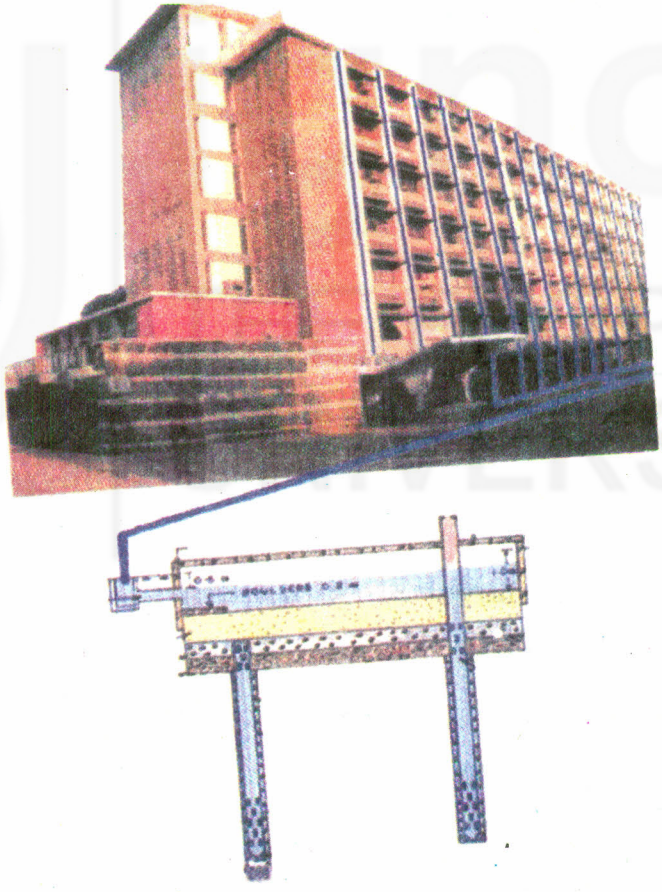
- 2.2.1 Principle
- 2.2.2 Requirements
- 2.2.3 Procedure

2.3 Observations and Calculations

2.4 Results

2.0 OBJECTIVE

After completing this practical exercise, you should be able to calculate the volume of water harvested from a cluster of houses in a society.



Source: *Central Ground Water Board, Faridabad (Haryana –India)*

Fig. 2.1: Rainwater Harvested from a Group Housing Society

2.1 INTRODUCTION

Water demand is increasing on account of high population in the cities due to significant migration from the rural areas. In almost all big cities of India, there is great shortage of potable water for domestic use.In cities, big housing societies are coming up at very fast rate. It will further worsen the situation of water availability. Now, rainwater harvesting has been made mandatory for all the group housing societies (Fig. 2.1). The harvested water can either be stored or used for recharging ground water through bore wells.

2.2 EXPERIMENT

2.2.1 Principle

To collect and save every drop of precious rainwater before it is lost as runoff or evaporated back to atmosphere.

2.2.2 Requirements

- Rainfall data
- Measuring tape
- k coefficient (generally 0.8 for concrete roof)

2.2.3 · Procedure

1) Collect rainfall depth data for a particular event.
2) Estimate effective rainfall by multiplying rainfall depth with coefficient?
3) Measure length and width of the roof of a cluster of houses in group housing society.
4) Calculate area of roof of cluster of houses by multiplying length and width?
5) Calculate the volume of water harvested from cluster of households by multiplying effective rainfall with area of cluster of houses?

2.3 OBSERVATIONS AND CALCULATIONS

Example

1) Effective rainfall (mm) = Rainfall (mm) × 0.8
2) Roof area (m^2) = Length (m) × width (m)
3) Volume of rainfall (m^3) = Effective rainfall (mm) × roof area (m^2) × $\frac{1}{1000}$

Rainfall = 200 mm

Roof top area = 1200 m^2

Effective rainfall for water harvest = 200 mm × 0.8

= 160 mm

Volume of rainwater harvested $= \frac{160\text{mm} \times 1200\text{m}^2}{1000}$

$= 192\ \text{m}^3$

Depth of water harvested $= \frac{192\text{m}^3}{1200\text{m}^2}$

$= 16\ \text{cm}$

Water harvested (% of rainfall) $= \frac{16\text{cm}}{20\text{cm}} \times 100$

$= 80\%$

Exercise

Rainfall depth, mm	
Length of roof, m	
Width of roof, m	

Rainfall =

Roof top area =

Effective rainfall for water harvest =

Volume of rainwater harvested =

Depth of water harvested =

Water harvested (% of rainfall) =

2.4 RESULTS

Depth of water harvested = ... mm

Water harvested (% of rainfall) = ... %

EXPERIMENT 3 STORAGE CAPACITY OF WATER STORAGE STRUCTURES

Structure

3.0 Objective

3.1 Introduction

3.2 Experiment

- 3.2.1 Requirements
- 3.2.2 Procedure

3.3 Observations and Calculations

3.4 Results

3.0 OBJECTIVE

After completing this practical exercise, you should be able to calculate the storage capacity of water storage structures.

3.1 INTRODUCTION

Different types of storage structures of different cross-sections, i.e. cylindrical, rectangular, square are used for storing roof top rainwater as shown in figure given below. The cylindrical shape structures are considered most appropriate. The size of the storage structure depends on the amount of rainfall, purpose, per capita water use, number of persons in a household or a group housing society and period of water scarcity. The correct estimation of storage capacity is of vital importance from cost of storage tank and future planning considerations.



Fig. 3.1 : Cylindrical tanks



Fig. 3.2 : Rectangular tanks

3.2 EXPERIMENT

3.2.1 Requirements

- Measuring tape
- Calculator

3.2.2 Procedure

1) Measure the dimensions of tank

   i) Cylindrical tank (Fig. 3.1): diameter (D) and depth (H).

   ii) Rectangular tank (Fig. 3.2): length (L), breadth (B) and depth (H).

2) Measure area of cross-section of tank.

   i) Rectangular tank: Area (A) = $L \times B$

   ii) Cylindrical tank: Area (A) = $\frac{\pi}{4} D^2$

3) Calculate storage capacity (volume) of a tank (V) = $A \times H$

3.3 OBSERVATIONS AND CALCULATIONS

Example

Storage capacity of different shapes of tank

Rectangular

L = 2.8 m

B = 1.0 m

H = 0.8 m

A = 2.8 m^2

V = 2.24 m^3

= 2240 litre

Cylindrical

D = 1.0 m

H = 1.28 m

A = 0.785 m^2

V = 1.0 m^3

= 1000 litre

Exercise

Determine the storage capacity of rectangular and cylindrical tanks

Storage capacity of different shapes of tank

Rectangular

L =

B =

H =

A =

V =

=

Cylindrical

D =

H =

A =

V =

=

3.4 RESULTS

Storage capacity of different shapes of tank

i) Rectangular = ...m^3

= .....litre

ii) Cylindrical = ...m^3

=.....litre

EXPERIMENT 4 DISCHARGE MEASUREMENT

Structure

4.0 Objectives

4.1 Introduction

4.2 Experiment

- 4.2.1 Principle
- 4.2.2 Requirements
- 4.2.3 Procedure

4.3 Observations and Calculations

4.4 Results

4.0 OBJECTIVES

After completing this practical exercise, you should be able to:

- measure the discharge of a tube well; and
- measure the discharge of a water course.

4.1 INTRODUCTION

Water is the most valuable source for enhancing agriculture production. Accurate discharge measurement will lead to economic and efficient utilisation. Precise estimate of discharge is required to determine the volume of water to be applied during each irrigation to meet water requirement of a particular crop. The water is applied through a tube well or a water course.

4.2 EXPERIMENT

4.2.1 Principle

Precise discharge measurement leads to efficient utilisation of scarce water resource.

4.2.2 Requirements

- Storage tank
- Open channel
- Measuring tape
- Watch
- Float
- Calculator

4.2.3 Procedure

i) Open channel or water course

Float Method (Velocity Area Method)

This is the easiest and simplest method for fairly accurate estimate of discharge in an open channel/water course linked to the canal system. A floating body (block of wood or bottle partially filled with water) is used to measure the velocity of flow of water. The velocity is multiply by area of the channel to determine discharge and the brief procedure for discharge measurement is given below.

1) Select 30 m long straight and uniform cross-section of flowing water course.
2) Place the float on water surface and note the time (t) to cover the above distance.
3) Calculate the surface velocity (v) of flow by dividing the distance (30 m) with time (t).
4) Multiply v by 0.85 to get average velocity (v_a)
5) Calculate the area of cross-section of a channel
   a) Rectangular channel (Fig. 4.1) : Area (a) = $b \times d$

      Where

      b = bottom width

      d = depth of flow

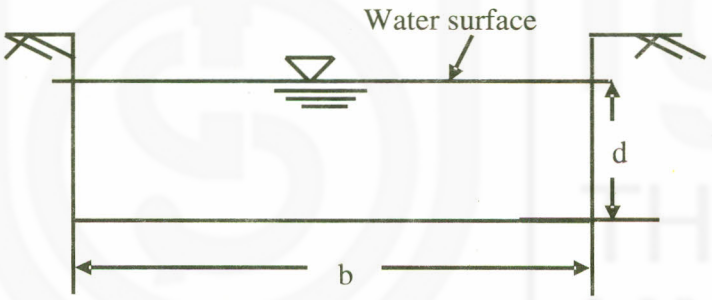




Fig. 4.1 : Rectangular channel

   b) Trapezoidal channel (Fig. 4.2) : Area (a) = $(b + d \times s) \times d$

      Where

      b = bottom width

      d = depth of flow

      s = side slope (generally $s = 1$, for loose soil $s = 2$, for stiff clay $s = 0.5$)

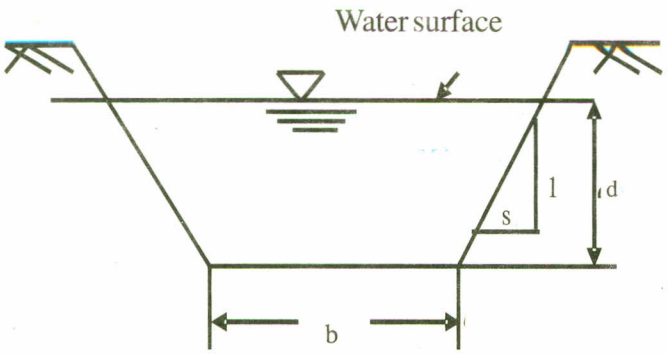




Fig. 4.2 : Trapezoidal channel

6) Calculate the discharge (Q) = $v_a \times a$

ii) Tube well

1) Measure the dimensions of storage tank

   i) Rectangular tank: length (L), breadth (B)

   ii) Cylindrical tank: diameter (D)

2) Measure area of cross-section of tank.

   i) Rectangular tank: Area (a) = $L \times B$

   ii) Cylindrical tank: Area (a) = $\frac{\pi}{4} D^2$

3) Note the time (t) to fill tube well water up to a certain depth H

4) Calculate volume of water of a tank (V) = $a \times H$

5) Calculate the discharge of tube well by dividing V with t

Discharge rate, litre/sec = $\frac{Volume\ of\ tan\ k\ (litre)}{Time\ requried\ to\ fill\ (sec)}$

4.3 OBSERVATIONS AND CALCULATIONS

Example 1

i) Discharge measurement of a water course

Distance = 30 m

t = 40 sec

v = 0.75 m/sec

v_a = 0.64 m/sec

Rectangular channel

b = 0.45 m

d = 0.30 m

a = 0.048 m^2

Q = 0.03 m^3/sec

= 30 litre/sec (1 m^3 = 1000 litre)

Trapezoidal channel

b = 0.20 m

d = 0.20 m

s = 1

a = 0.08 m^2

Q = 0.0512 m^3/sec

= 51.2 litre/sec

Example 2

ii) Discharge measurement of a tube well

Rectangular

L = 2.8 m

B = 1.0 m

H = 0.8 m

t = 150 sec

A = 2.8 m^2

V = 2.24 m^3

Q = 0.0152 m^3/sec

= 15.2 litre/sec

Cylindrical

D = 1.0 m

H = 1.28 m

A = 0.785 m^2

t = 75 sec

V = 1.0 m^3

Q = 0.0133 m^3/sec

= 13.3 litre/sec

Exercise 1

i) Discharge measurement of a water course

Distance =

t =

v =

v_a =

Rectangular channel

b =

d =

a =

Q =

=

Trapezoidal channel

b =

d =

s =

a =

Q =

=

Exercise 2

Discharge measurement of a tube well

Rectangular

L =

B =

H =

t =

A =

V =

Q =

=

Cylindrical

D =

H =

A =

t =

V =

Q =

=

4.4 RESULTS

1) Discharge of water course

i) Rectangular channel = ……m^3/sec

= ……litre/sec

ii) Trapezoidal channel = ……m^3/sec

= ……litre/sec

2) Discharge of tube well

i) Rectangular = ……m^3/sec

= ……litre/sec

ii) Cylindrical = ……m^3/sec

=……litre/sec

EXPERIMENT 5 RAINFALL MEASUREMENT

Structure

5.0 Objective

5.1 Introduction

5.2 Experiment

5.2.1 Requirements

5.2.2 Procedure

5.3 Observations and Calculations

5.4 Results

5.0 OBJECTIVE

After completing this practical exercise, you should be able to measure rainfall from non-recording and recording rain gauges.

5.1 INTRODUCTION

Rainfall is an important natural resource which provides water for different usages such as public health, industry and agriculture. Accurate measurement of rainfall helps in conserving and managing water resources efficiently. Harvesting, conservation and utilisation of rainwater holds the key for undertaking agriculture and other allied activities in order to achieve socio-economic development of watersheds. Rainfall can be measured by non-recording and recording type (automatic) rain gauges. Non-recording rain gauges record periodic readings of the accumulated rainfall (24 hours). Large capacity rain gauges are used for measuring rainfall only a few times at the remote sites. Recording type rain gauges continuously record rainfall and thus rainfall depth can be obtained for any period. It enables to determine rainfall characteristics such as intensity, frequency, duration and amount of rainfall influencing rate and amount of runoff.

5.2 EXPERIMENT

5.2.1 Requirements

- Non-recording rain gauge
- Recording rain gauge

5.2.2 Procedure

i) Non-recording rain gauge

The rainwater is received in a plastic bottle covered with funnel (Fig. 5.1). The depth of rainfall received in 24 hours is measured by glass cylinder provided by the manufacturer. The rainfall is measured at 8 am.

Precautions

- Rain gauge should be kept on a hard compact platform and height of rim be kept 30 cm above the ground level;
- Ensure that rain gauge is leakproof; and
- Measuring cylinder should be kept clean and leaves and other foreign particles should have been removed from the receiver.



Fig. 5.1 : Non-recording rain gauge

ii) Recording rain gauge

It consists of a cylinder with a funnel top, circular inner brass tube, recording mechanism of a clock driven drum carrying the record sheet on which a pen draws the graph of rainfall against time (Fig. 5.2). The clock mechanism completes one rotation in 24 hours. The X-axis of the chart (graph) is the rainfall (mm) with accuracy of 1 mm and Y-axis represents time. The recording sheet is replaced once in 24 hours. The recording pen is fixed on a rod connected to a float in the inner cylinder. As the rainwater accumulates in the cylinder, the float rises along with the pan which records the rainfall. When the cylinder is full, the connection is established with the inner cylinder and siphon tube and the entire water gets drained and pen drops to the zero position. The depth of rainfall recorded on the graph sheet is read for every half an hour to determine the variation in rainfall intensity for different durations of the storms.

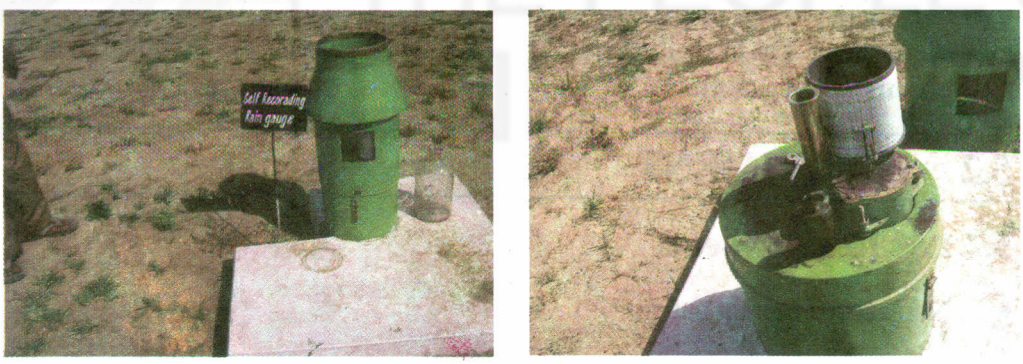


Fig. 5.2: Recording rain gauge

Precautions

- Change the chart every day between 8.30 - 9.00 am;
- Ensure that there is sufficient ink in the pen; and
- Instrument should be kept clean and free from leaves and other foreign particles.

5.3 OBSERVATIONS AND CALCULATIONS

(i) Non-recording rain gauge

Amount of rainfall measured by glass cylinder provided by the manufacturer at 8 am. = ... cm

(ii) Recording rain gauge

Determine the depth of rainfall for each hour = ... cm

Calculate the intensity of rainfall = ...cm/hr

5.4 RESULTS

(i) Non-recording rain gauge

Depth of rainfall = ...cm

(ii) Recording rain gauge

Average depth of rainfall = ...cm

Intensity of rainfall = ...cm/hr

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EXPERIMENT 6 PAN EVAPORATION

Structure

6.0 Objective

6.1 Introduction

6.2 Experiment

6.2.1 Requirements

6.2.2 Procedure

6.3 Observations and Calculations

6.4 Results

6.5 Precautions

6.0 OBJECTIVE

After completing this practical exercise, you should be able to measure evaporation from U.S. Class 'A' Pan.

6.1 INTRODUCTION

Evaporation is an important process of the hydrologic cycle. Approximately, 75% of the total annual precipitation is returned to the atmosphere by evaporation and transpiration. In hot climates, the loss of water by evaporation from rivers, canals and open-water storages as evaporation is quite significant. Most of the water withdrawn for beneficial uses ultimately returns to streams and aquifers and becomes available for reuse, while the loss of water due to evaporation is entirely lost from the usable supply. Even in humid areas, evaporation loss is significant. High evaporation loss in relation to the usable yield is characteristic of river systems in the country due to the climate, character of stream flow, and the great seasonal variations and pattern of runoff. Storage reservoirs are a major source of water loss through evaporation as they are exposed to wide surfaces.

Evaporation is measured using evaporation pans. There are a number of standardized pans for measuring evaporation and the U.S. Class 'A' pan is probably the most commonly used (Fig. 6.1). The pan is circular with a diameter of 1.21 m and depth of 25.5 cm. The basin is put on a 15 cm high wooden frame due to air circulation around the basin. The water level is kept about 5 cm below the rim, due to allowance of percolation and the need of water. The water level is measured every day. Due to heating of metallic pan sides, the measured evaporation is higher than the actual evaporation. To correct this value, pan evaporation is multiplied by a pan coefficient which depends on the climatic region. An average value of pan coefficient is taken as 0.70 with a range of 0.60-0.80. Maximum evaporation from water surface takes place in summer after the water temperature gets relatively raised and at times when, with low relative humidity, air temperature is low.

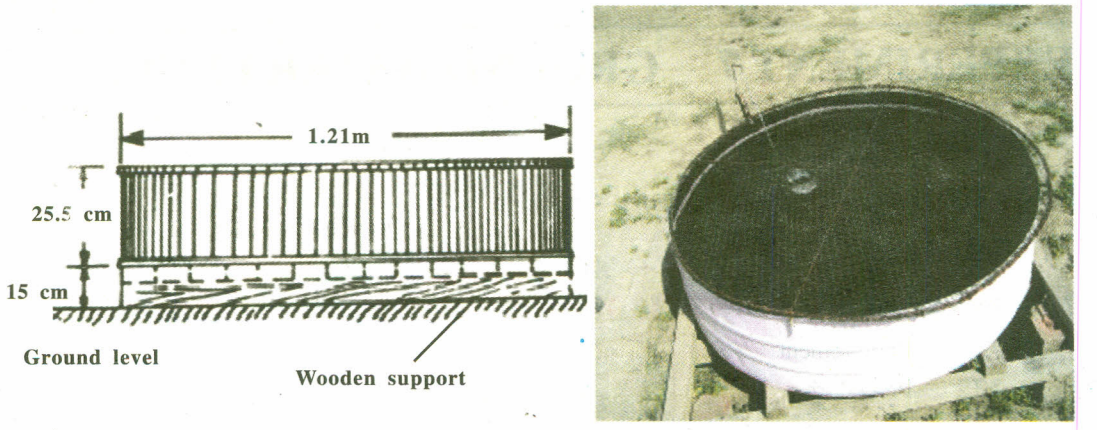


Fig. 6.1: U.S. Class 'A' Pan

6.2 EXPERIMENT

6.2.1 Requirements

- U.S. Class 'A' Pan
- Scale

6.2.2 Procedure

- Measure amount of water evaporated in previous 24 hours every day in the morning using hook gauge.
- After measurement, fill water in the Pan to the original level.
- Repeat the process the next day.
- Calculate actual evaporation by multiplying pan evaporation with pan factor (0.8).

$$\text{Actual evaporation} = \text{Pan evaporation} \times 0.8$$

6.3 OBSERVATIONS AND CALCULATIONS

Pan evaporation = ... mm

Actual evaporation = Pan evaporation × 0.8

Actual evaporation = ... mm

6.4 RESULTS

Pan evaporation = ... mm

Actual evaporation = ... mm

6.5 PRECAUTIONS

- There should not be any leakage of water from the pan.
- Pan should be always placed 10 cm above the ground surface.
- The pan should be painted white once in a year.

EXPERIMENT 7 GROUND WATER LEVEL

Structure

7.0 Objective

7.1 Introduction

7.2 Experiment

7.2.1 Requirement

7.2.2 Procedure

7.3 Observations and Calculations

7.4 Results

7.5 Precautions

7.0 OBJECTIVE

After completing this practical exercise, you should be able to measure water table or water level at different locations and times.

7.1 INTRODUCTION

Water in the zone of saturation is known as ground water as shown in the Fig. 7.1. When the ground water partly fills an aquifer (a permeable layer), the upper surface of the saturated zone called water table is free to rise or fall. The ground water in such a layer considered to be unconfined or under pheratic or water table conditions. Measurement of ground water level or water table is important to determine water table fluctuation in response to rainfall/irrigation or drought at different locations and times. This helps in adopting corrective measures under both the situations. The depth of water table is of crucial importance for installation of tube wells and to estimate ground water contribution to the crop water requirement.

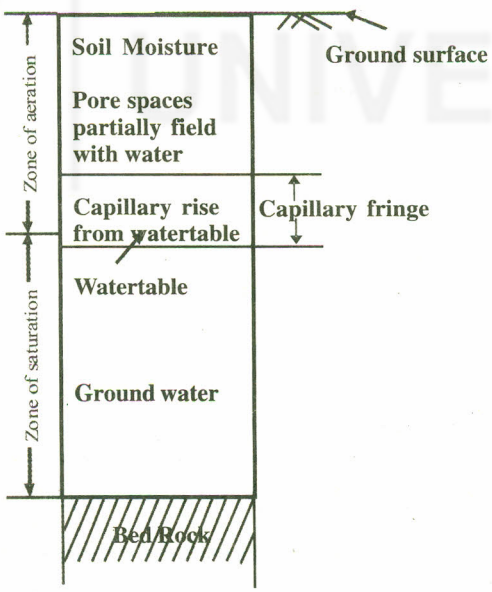


Fig. 7.1 : Ground water and zone of saturation

7.2 EXPERIMENT

7.2.1 Requirement

- Measuring tape

7.2.2 Procedure

i) Wetted tape method

A chain or metallic or steel tape is used to measure the water level in a open well or a metallic tube as shown in Fig. 7.2(A). The tape is attached with a weight so that it is lowered vertically below the water level. The lowered length of the tape from the reference level is noted. The depth of water level from the reference level is determined by subtracting wetted length from the lowered length of the tape. The water level from ground surfaced can then be estimated by subtracting distance between reference level and ground surface.

ii) Mechanical sounder

A weight consisting of a small piece of metal is connected to the lower end of the tape (Fig. 7.2(B)). As soon as the tape with weight touches the water surface in a well or pipe, it produces a sound. The depth to water level can be directly read from the tape from reference level. The water level depth from ground surface can be determined as explained above.

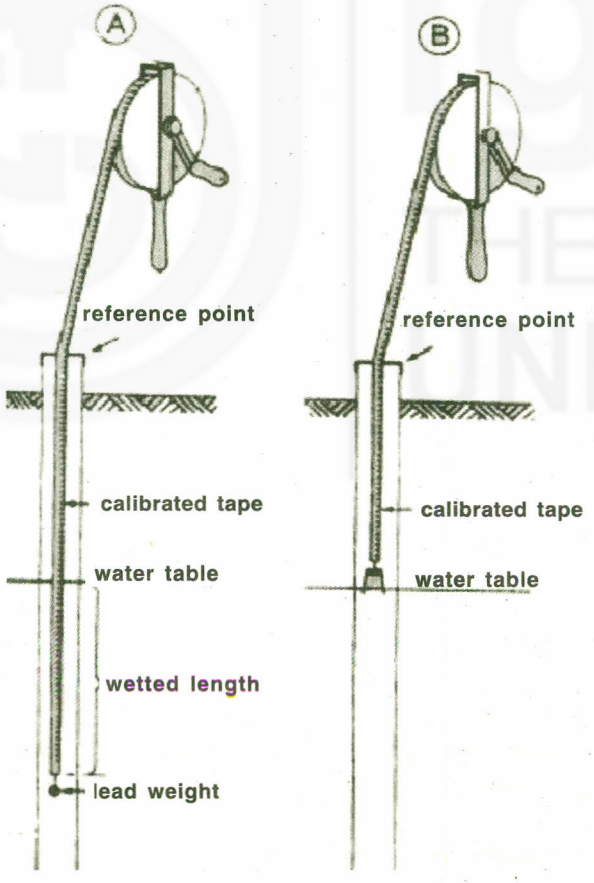


Fig. 7.2 : Water level measurement by (A) wetted tape and (B) mechanical sounder methods

7.3 OBSERVATIONS AND CALCULATIONS

Example

Method

Wetted tape method

Lowered length of tape from reference level	=	3.6 m
Wetted length of tape from reference level	=	0.3 m
Water level from reference level	=	3.6m–0.3 m
	=	3.3 m
Difference between reference level and ground surface	=	0.4 m
Water level from ground surface	=	3.3m–0.4m
	=	2.9 m

Mechanical sounder

Lowered length of tape up to water level from reference level	=	3.3 m
Difference between reference level and ground surface	=	0.4 m
Water level from ground surface	=	3.3m–0.4m
	=	2.9 m

Exercise

Method

Wetted tape method

Lowered length of tape from reference level	=
Wetted length of tape from reference level	=
Water level from reference level	=
Difference between reference level and ground surface	=
Water level from ground surface	=

Mechanical sounder

Lowered length of tape up to water level from reference level	=
Difference between reference level and ground surface	=
Water level from ground surface	=

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7.4 RESULTS

Water level from reference level = ... m

Water level from ground surface (water table) = ... m

7.5 PRECAUTIONS

Following precautions need to be taken for correct and representative measurement of water level at different locations and times.

- Bore well pipes used for water level measurement need to be protected by providing a cap plug properly tightened so that they are not tampered by putting soil or stone pieces;
- Water should not remain stagnant in the vicinity of open well or bore well; other-wise the water level measured under such a condition will not reflect the actual water table at that particular point;
- Measuring tape should be in good condition (straight with no bends) and the markings should be clearly visible;
- Lowered length and wetted length of tape, difference between reference and ground surface should be clearly read and noted.

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EXPERIMENT 8 BULK DENSITY OF SOIL

Structure

8.0 Objective

8.1 Introduction

8.2 Experiment

8.2.1 Requirements

8.2.2 Procedure

8.3 Observations and Calculations

8.4 Results

8.0 OBJECTIVE

After completing this practical exercise, you should be able to determine soil bulk density (apparent specific gravity).

8.1 INTRODUCTION

The soil moisture is generally measured on dry weight basis. To determine soil moisture on volume basis bulk density plays an important role. The soil moisture on dry weight basis is multiplied by bulk density to determine soil moisture on volume basis.

Dry Bulk Density (BD) of soil is the ratio of dry soil to the total volume of soil (including particles and pores).

$$BD = \frac{W_s}{V_t} = \frac{W_s}{V_s + V_a + V_w} \qquad (8.1)$$

Where,

BD = bulk density, gm/cc

W_s = dry weight of soil, gm

V_t = total volume of soil, cc

V_s = volume of soil solids, cc

V_a = volume of air, cc

V_w = volume of water, cc

Its value ranges between 1 gm/cc for clays and 1.8 gm/cc for sand and the average value of medium soil is generally of order of 1.5 gm/cc.

8.2 EXPERIMENT

8.2.1 Requirements

- Core soil sampler

- Moisture boxes
- Measuring tape
- Balance for weighing
- Oven

8.2.2 Procedure

Bulk density is determined by taking un-compacted soil sample of known volume by using following procedure:

- Measure the weight of core cylinder, kg
- Measure the diameter of core cylinder (d), cm
- Measure the depth of core cylinder (h), cm
- Calculate the area (A) of cross-section of the core cylinder, cm^2

$$A = \frac{\pi d^2}{4}$$

- Calculate the volume (V) of the core cylinder (same as volume of soil) by multiplying area of cross-section with core depth, cm^3

  $V = A \times h$

- Drive cutting edge of cylinder of core sampler into the soil and obtain un-compacted soil core within the tube.
- Trim sample carefully at both ends of the core cylinders.
- Place the soil sample in the oven for drying for about 24 hours.
- Weigh the soil sample after drying.
- Divide weight of soil sample by volume of soil by using relationship given in eq. 8.1.

8.3 OBSERVATIONS AND CALCULATIONS

Example

Weight of core cylinder	=	1.72 kg
Diameter of core cylinder (d)	=	7.5 cm
Depth of core cylinder (h)	=	15 cm
Area of cross-section of core cylinder (A)	=	44.2 cm^2
Volume of core cylinder (V)	=	662.3 cc
Weight of dry soil sample with core cylinder	=	2.7 kg
Weight of dry soil sample	=	2.7 kg−1.72 kg

= 0.98 kg

= 980 gm

Bulk density (*BD*) = $\frac{980 \text{ gm}}{662.3\text{cc}}$

= 1.47 gm/cc

Exercise

Weight of core cylinder =

Diameter of core cylinder (*d*) =

Depth of core cylinder (*h*) =

Area of cross-section of core cylinder (*A*) =

Volume of core cylinder (*V*) =

Weight of dry soil sample with core cylinder =

Weight of dry soil sample =

=

=

Bulk density (*BD*) =

Weight of core cylinder =

8.4 RESULTS

Bulk density of soil = gm/cc

EXPERIMENT 9 SOIL MOISTURE

Structure

9.0 Objective

9.1 Introduction

9.2 Experiment

9.2.1 Requirements

9.2.2 Procedure

9.3 Observations and Calculations

9.4 Results

9.0 OBJECTIVE

After completing this practical exercise, you should be able to measure soil moisture at different soil depths.

9.1 INTRODUCTION

Soil moisture measurements are important to estimate the depth of irrigation to be applied at different stages of the crop as well as optimum irrigation scheduling. Measurement of soil moisture change is also necessary to estimate evapotranspiration.

Depending on the soil texture, soil moisture is held in soil pores by soil moisture suction or tension. The amount of moisture a soil holds at various tensions indicates the ease or difficulty with which moisture can be removed from a soil. In light soils, soil moisture can be taken up by plants by exerting less suction whereas in clay soils more tension have to be applied to extract the same amount of water. The clay soil can store much higher amount of soil moisture as compared to sandy soil. However, release of water from a sandy soil is much easier than that from clay soil.

9.2 EXPERIMENT

9.2.1 Requirements

- Auger for soil sampling (Fig.9.1)
- Moisture boxes
- Measuring tape
- Balance for weighing
- Oven

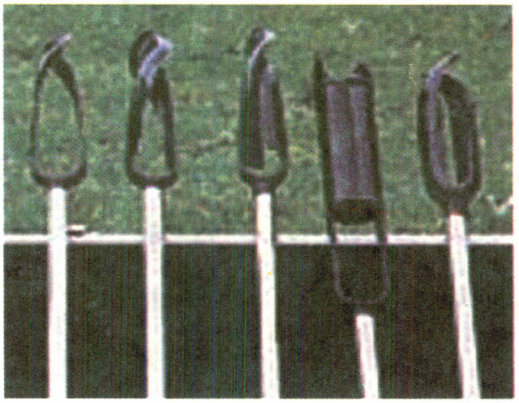


Fig. 9.1: Soil augers

9.2.2 Procedure

There are a number of methods to determine soil moisture at different depths of soil profile. Some of the methods needing sophisticated instrumentation have very limited application and are generally used for research purposes. The gravimetric method as described below is the easiest and cheapest method and gives fairly accurate estimate of soil moisture.

- Weigh the moisture box alone (W_1), gm
- Take soil samples with soil auger from pre-determined depths below ground surface and put them in moisture boxes.
- Weigh each soil sample (about 100 gm) along with moisture box (W_2), gm
- Place soil samples with box in the oven for 24 hours
- Weigh the dry soil sample with box (W_3), gm
- Estimate soil moisture content on weight basis (MC_w), per cent

$$MC_w = \frac{[(W_2 - W_1) - (W_3 - W_1)]}{W_3 - W_1} \times 100$$

- Determine the soil moisture content on volume basis (MC_v), per cent by multiplying MC_w with dry Bulk Density (BD) of soil

$$MC_v = MC_w \times BD$$

9.3 OBSERVATIONS AND CALCULATIONS

Example

Weight of box + moist soil	= 180 gm
Weight of box + dry soil	= 165 gm
Weight of empty box	= 45 gm
Weight of moisture	= 180 gm – 165 gm
	= 15 gm
Weight of dry soil	= 165 gm – 45 gm
	= 120 gm
MC_w	$= \frac{15}{135} \times 100$
	= 11.1%
Bulk density of soil	= 1.5 gm/cc
MC_v	= 11.1 × 1.5
	= 16.65 %

Exercise

Weight of box + moist soil = gm

Weight of box + dry soil = gm

Weight of empty box = gm

Weight of moisture =

= gm

Weight of dry soil =

= gm

MC_w =

= %

Bulk density of soil = gm/cc

MC_v =

= %

9.4 RESULTS

Moisture content on dry weight basis (MC_w) = %

Moisture content on volume basis (MC_v) = %

EXPERIMENT 10 FIELD VISIT

Structure

10.0 Objectives

10.1 Introduction

10.2 Procedure

10.3 Observations

10.4 Conclusions

10.0 OBJECTIVES

After completing the field visit, you should be able to:

- provide the status of various water storage and measurement structures used for rainwater harvesting;
- list the type of catchments for water harvesting and storage; and
- study the working of roof water harvesting system.

10.1 INTRODUCTION

During the programme, students have been exposed to various aspects of water harvesting in general and roof water harvesting in particular. Keeping in view, the importance of managing limited water resources which includes harvesting, conserving and utilisation, watershed/water harvesting projects need trained manpower well equipped with theory and practical aspects. Therefore, a considerable emphasis has been laid on practical hands-on exercises. Different practical exercises of vital importance for water harvesting projects include exercises on water storage and measurement structures, roofwater harvesting from a household and group housing society, discharge measurement, measurement of rainfall, water level and soil moisture.

10.2 PROCEDURE

Students will be divided into small groups for field visit. Each group will study different water harvesting and measuring structures and their components. They will also visit a group housing society and study the working of roofwater harvesting system. On the basis of visits, each group will compile a report covering all the aspects in detail.

10.3 OBSERVATIONS

Detailed description of different systems needs to be given.

10.4 CONCLUSIONS

It will include positive and negative points of water harvesting systems and structure as observed during field visit.

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EXPERIMENT 1 ROOF TOP WATER HARVESTING FROM A HOUSEHOLD

Structure

1.0 Objective

1.1 Introduction

1.2 Experiment

- 1.2.1 Principle
- 1.2.2 Requirements
- 1.2.3 Procedure

1.3 Observations and Calculations

1.4 Results

1.0 OBJECTIVE

After completing this practical exercise, you should be able to calculate the volume of water harvested from individual household.

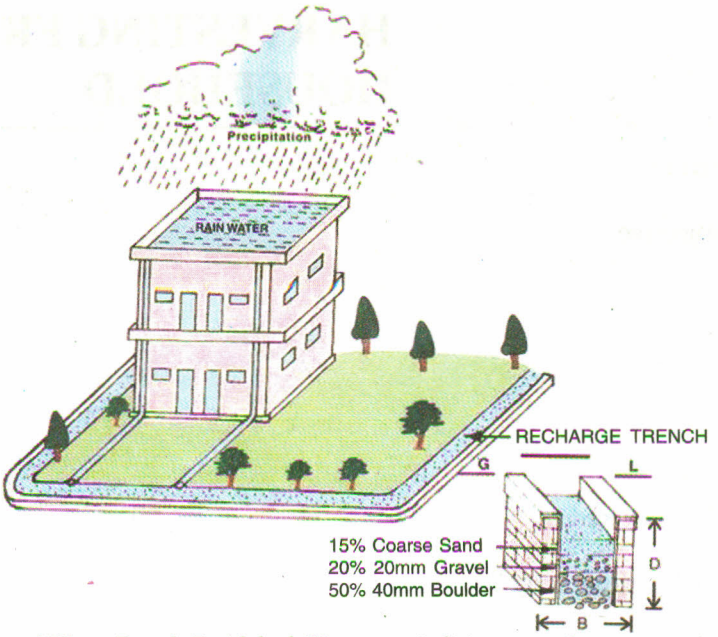
1.1 INTRODUCTION

Rainwater harvesting is the technique of collection of precious natural resource i.e. rainwater. The rainwater harvesting from roof of an individual house (Fig. 1.1) as well as cluster of houses can help in storing rainwater for its subsequent domestic use during lean season and recharging ground water in declining water table areas. The rainwater harvested on house roof is collected through rain pipe and stored in a tank or in ground water structure. In order to design water storage/ground water structure it is of utmost importance to estimate the volume of water in response to different intensities and duration of rainfall. This practical exercise will help the students to determine the volume of rainwater harvested from roof of a house or cluster of houses (Fig. 1.1).

1.2 EXPERIMENT

1.2.1 Principle

To collect and save every drop of precious rainwater before it is lost as runoff or evaporated back to atmosphere.



Source: *Central Ground Water Board, Faridabad (Haryana –India)*

Fig. 1.1 Rainwater harvested from a household

1.2.2 Requirements

- Rainfall data
- Measuring tape

1.2.3 Procedure

1) Collect rainfall depth data for a particular event.
2) Estimate effective rainfall by multiplying rainfall depth with coefficient k generally value of $k = 0.8$.
3) Measure length and width of the roof of a house.
4) Calculate area of the house roof by multiplying length and width.
5) Calculate the volume of water harvested from individual household and cluster of households by multiplying effective rainfall with area of a household. Alternatively, volume of harvested water can be determined by using the following table:

Ready Reckoner to Determine the Volume of Harvested Water from Roof Top (assuming value of coefficient k = 0.8)

Rain-fall, mm / Roof top area, m^2	Volume of Harvested Water, m^3												
	100	**200**	**300**	**400**	**500**	**600**	**800**	**1000**	**1200**	**1400**	**1600**	**1800**	**2000**
20	1.6	3.2	4.8	6.4	8	9.6	12.8	16	19.2	22.4	25.6	28.8	32
50	4	8	12	16	20	24	32	40	48	56	64	72	80
100	8	16	24	32	40	48	64	80	96	112	128	144	160
500	40	80	120	160	200	240	320	400	480	560	640	720	800

Source: *Central Ground Water Board, Faridabad (Haryana – India)*

1.3 OBSERVATIONS AND CALCULATIONS

Example

1) Effective rainfall (mm) = Rainfall (mm) × 0.8

2) Roof area (m^2) = Length (m) × width (m)

3) Volume of rainfall (m^3) = Effective rainfall (mm) × roof area (m^2)

Rainfall = 200 mm

Roof top area = 150 m^2

Effective rainfall for water harvest = 200mm × 0.8

= 160 mm

Volume of rainwater harvested = $\frac{160mm \times 150m^2}{1000}$

= 24 m^3

Depth of water harvested = $\frac{24m^3}{150m^2}$

= 0.16 m or 16 cm

Water harvested (% of rainfall) = $\frac{16}{20} \times 100$

= 80%

Exercise

Rainfall depth, mm	
Length of roof, m	
Width of roof, m	

Rainfall =

Roof top area =

Effective rainfall for water harvest =

Volume of rainwater harvested =

Depth of water harvested =

Water harvested (% of rainfall) =

1.4 RESULTS

Depth of water harvested = ... mm

Water harvested (% of rainfall) = ... %

EXPERIMENT 2 ROOF TOP WATER HARVESTING – GROUP HOUSING SOCIETIES

Structure

2.0 Objective

2.1 Introduction

2.2 Experiment

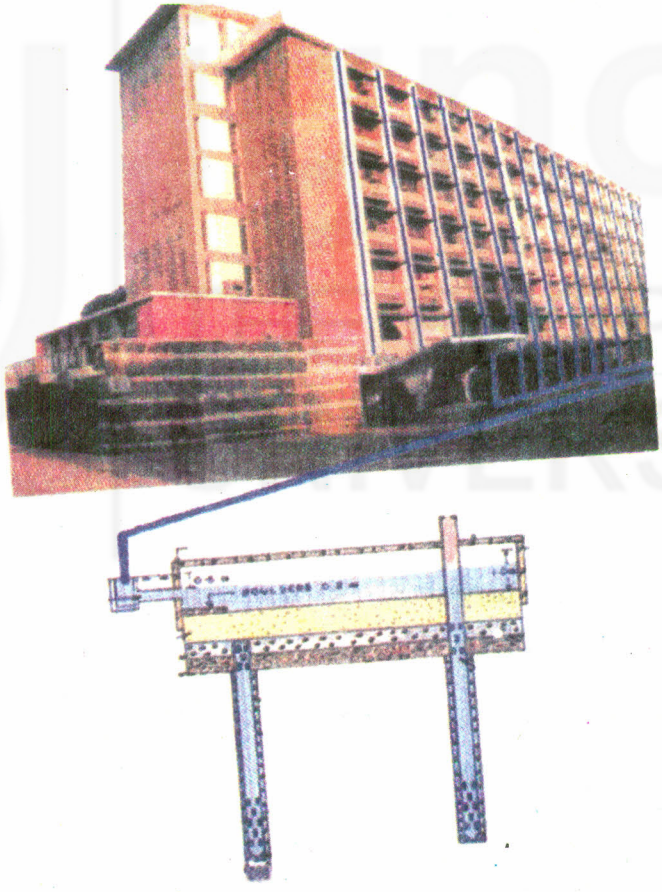
- 2.2.1 Principle
- 2.2.2 Requirements
- 2.2.3 Procedure

2.3 Observations and Calculations

2.4 Results

2.0 OBJECTIVE

After completing this practical exercise, you should be able to calculate the volume of water harvested from a cluster of houses in a society.



Source: *Central Ground Water Board, Faridabad (Haryana –India)*

Fig. 2.1: Rainwater Harvested from a Group Housing Society

2.1 INTRODUCTION

Water demand is increasing on account of high population in the cities due to significant migration from the rural areas. In almost all big cities of India, there is great shortage of potable water for domestic use.In cities, big housing societies are coming up at very fast rate. It will further worsen the situation of water availability. Now, rainwater harvesting has been made mandatory for all the group housing societies (Fig. 2.1). The harvested water can either be stored or used for recharging ground water through bore wells.

2.2 EXPERIMENT

2.2.1 Principle

To collect and save every drop of precious rainwater before it is lost as runoff or evaporated back to atmosphere.

2.2.2 Requirements

- Rainfall data
- Measuring tape
- k coefficient (generally 0.8 for concrete roof)

2.2.3 · Procedure

1) Collect rainfall depth data for a particular event.
2) Estimate effective rainfall by multiplying rainfall depth with coefficient?
3) Measure length and width of the roof of a cluster of houses in group housing society.
4) Calculate area of roof of cluster of houses by multiplying length and width?
5) Calculate the volume of water harvested from cluster of households by multiplying effective rainfall with area of cluster of houses?

2.3 OBSERVATIONS AND CALCULATIONS

Example

1) Effective rainfall (mm) = Rainfall (mm) × 0.8
2) Roof area (m^2) = Length (m) × width (m)
3) Volume of rainfall (m^3) = Effective rainfall (mm) × roof area (m^2) × $\frac{1}{1000}$

Rainfall = 200 mm

Roof top area = 1200 m^2

Effective rainfall for water harvest = 200 mm × 0.8

= 160 mm

Volume of rainwater harvested $= \frac{160\text{mm} \times 1200\text{m}^2}{1000}$

$= 192\ \text{m}^3$

Depth of water harvested $= \frac{192\text{m}^3}{1200\text{m}^2}$

$= 16\ \text{cm}$

Water harvested (% of rainfall) $= \frac{16\text{cm}}{20\text{cm}} \times 100$

$= 80\%$

Exercise

Rainfall depth, mm	
Length of roof, m	
Width of roof, m	

Rainfall =

Roof top area =

Effective rainfall for water harvest =

Volume of rainwater harvested =

Depth of water harvested =

Water harvested (% of rainfall) =

2.4 RESULTS

Depth of water harvested = ... mm

Water harvested (% of rainfall) = ... %

EXPERIMENT 3 STORAGE CAPACITY OF WATER STORAGE STRUCTURES

Structure

3.0 Objective

3.1 Introduction

3.2 Experiment

- 3.2.1 Requirements
- 3.2.2 Procedure

3.3 Observations and Calculations

3.4 Results

3.0 OBJECTIVE

After completing this practical exercise, you should be able to calculate the storage capacity of water storage structures.

3.1 INTRODUCTION

Different types of storage structures of different cross-sections, i.e. cylindrical, rectangular, square are used for storing roof top rainwater as shown in figure given below. The cylindrical shape structures are considered most appropriate. The size of the storage structure depends on the amount of rainfall, purpose, per capita water use, number of persons in a household or a group housing society and period of water scarcity. The correct estimation of storage capacity is of vital importance from cost of storage tank and future planning considerations.



Fig. 3.1 : Cylindrical tanks



Fig. 3.2 : Rectangular tanks

3.2 EXPERIMENT

3.2.1 Requirements

- Measuring tape
- Calculator

3.2.2 Procedure

1) Measure the dimensions of tank

   i) Cylindrical tank (Fig. 3.1): diameter (D) and depth (H).

   ii) Rectangular tank (Fig. 3.2): length (L), breadth (B) and depth (H).

2) Measure area of cross-section of tank.

   i) Rectangular tank: Area (A) = $L \times B$

   ii) Cylindrical tank: Area (A) = $\frac{\pi}{4} D^2$

3) Calculate storage capacity (volume) of a tank (V) = $A \times H$

3.3 OBSERVATIONS AND CALCULATIONS

Example

Storage capacity of different shapes of tank

Rectangular

L = 2.8 m

B = 1.0 m

H = 0.8 m

A = 2.8 m^2

V = 2.24 m^3

= 2240 litre

Cylindrical

D = 1.0 m

H = 1.28 m

A = 0.785 m^2

V = 1.0 m^3

= 1000 litre

Exercise

Determine the storage capacity of rectangular and cylindrical tanks

Storage capacity of different shapes of tank

Rectangular

L =

B =

H =

A =

V =

=

Cylindrical

D =

H =

A =

V =

=

3.4 RESULTS

Storage capacity of different shapes of tank

i) Rectangular = ...m^3

= .....litre

ii) Cylindrical = ...m^3

=.....litre

EXPERIMENT 4 DISCHARGE MEASUREMENT

Structure

4.0 Objectives

4.1 Introduction

4.2 Experiment

- 4.2.1 Principle
- 4.2.2 Requirements
- 4.2.3 Procedure

4.3 Observations and Calculations

4.4 Results

4.0 OBJECTIVES

After completing this practical exercise, you should be able to:

- measure the discharge of a tube well; and
- measure the discharge of a water course.

4.1 INTRODUCTION

Water is the most valuable source for enhancing agriculture production. Accurate discharge measurement will lead to economic and efficient utilisation. Precise estimate of discharge is required to determine the volume of water to be applied during each irrigation to meet water requirement of a particular crop. The water is applied through a tube well or a water course.

4.2 EXPERIMENT

4.2.1 Principle

Precise discharge measurement leads to efficient utilisation of scarce water resource.

4.2.2 Requirements

- Storage tank
- Open channel
- Measuring tape
- Watch
- Float
- Calculator

4.2.3 Procedure

i) Open channel or water course

Float Method (Velocity Area Method)

This is the easiest and simplest method for fairly accurate estimate of discharge in an open channel/water course linked to the canal system. A floating body (block of wood or bottle partially filled with water) is used to measure the velocity of flow of water. The velocity is multiply by area of the channel to determine discharge and the brief procedure for discharge measurement is given below.

1) Select 30 m long straight and uniform cross-section of flowing water course.
2) Place the float on water surface and note the time (t) to cover the above distance.
3) Calculate the surface velocity (v) of flow by dividing the distance (30 m) with time (t).
4) Multiply v by 0.85 to get average velocity (v_a)
5) Calculate the area of cross-section of a channel
   a) Rectangular channel (Fig. 4.1) : Area (a) = $b \times d$

      Where

      b = bottom width

      d = depth of flow

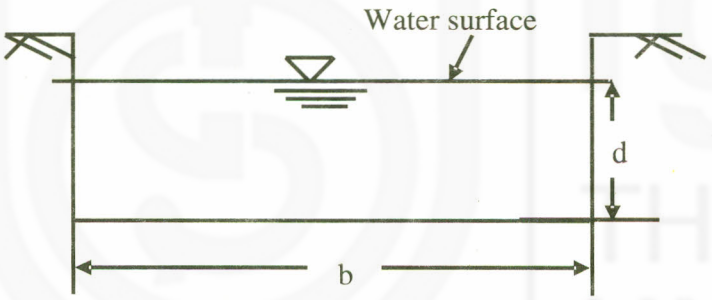




Fig. 4.1 : Rectangular channel

   b) Trapezoidal channel (Fig. 4.2) : Area (a) = $(b + d \times s) \times d$

      Where

      b = bottom width

      d = depth of flow

      s = side slope (generally $s = 1$, for loose soil $s = 2$, for stiff clay $s = 0.5$)

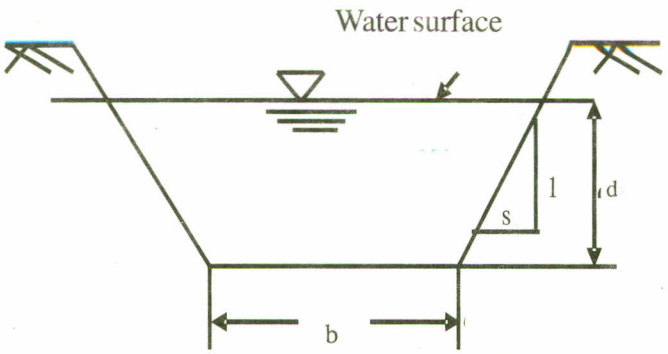




Fig. 4.2 : Trapezoidal channel

6) Calculate the discharge (Q) = $v_a \times a$

ii) Tube well

1) Measure the dimensions of storage tank

   i) Rectangular tank: length (L), breadth (B)

   ii) Cylindrical tank: diameter (D)

2) Measure area of cross-section of tank.

   i) Rectangular tank: Area (a) = $L \times B$

   ii) Cylindrical tank: Area (a) = $\frac{\pi}{4} D^2$

3) Note the time (t) to fill tube well water up to a certain depth H

4) Calculate volume of water of a tank (V) = $a \times H$

5) Calculate the discharge of tube well by dividing V with t

Discharge rate, litre/sec = $\frac{Volume\ of\ tan\ k\ (litre)}{Time\ requried\ to\ fill\ (sec)}$

4.3 OBSERVATIONS AND CALCULATIONS

Example 1

i) Discharge measurement of a water course

Distance = 30 m

t = 40 sec

v = 0.75 m/sec

v_a = 0.64 m/sec

Rectangular channel

b = 0.45 m

d = 0.30 m

a = 0.048 m^2

Q = 0.03 m^3/sec

= 30 litre/sec (1 m^3 = 1000 litre)

Trapezoidal channel

b = 0.20 m

d = 0.20 m

s = 1

a = 0.08 m^2

Q = 0.0512 m^3/sec

= 51.2 litre/sec

Example 2

ii) Discharge measurement of a tube well

Rectangular

L = 2.8 m

B = 1.0 m

H = 0.8 m

t = 150 sec

A = 2.8 m^2

V = 2.24 m^3

Q = 0.0152 m^3/sec

= 15.2 litre/sec

Cylindrical

D = 1.0 m

H = 1.28 m

A = 0.785 m^2

t = 75 sec

V = 1.0 m^3

Q = 0.0133 m^3/sec

= 13.3 litre/sec

Exercise 1

i) Discharge measurement of a water course

Distance =

t =

v =

v_a =

Rectangular channel

b =

d =

a =

Q =

=

Trapezoidal channel

b =

d =

s =

a =

Q =

=

Exercise 2

Discharge measurement of a tube well

Rectangular

L =

B =

H =

t =

A =

V =

Q =

=

Cylindrical

D =

H =

A =

t =

V =

Q =

=

4.4 RESULTS

1) Discharge of water course

i) Rectangular channel = ……m^3/sec

= ……litre/sec

ii) Trapezoidal channel = ……m^3/sec

= ……litre/sec

2) Discharge of tube well

i) Rectangular = ……m^3/sec

= ……litre/sec

ii) Cylindrical = ……m^3/sec

=……litre/sec

EXPERIMENT 5 RAINFALL MEASUREMENT

Structure

5.0 Objective

5.1 Introduction

5.2 Experiment

5.2.1 Requirements

5.2.2 Procedure

5.3 Observations and Calculations

5.4 Results

5.0 OBJECTIVE

After completing this practical exercise, you should be able to measure rainfall from non-recording and recording rain gauges.

5.1 INTRODUCTION

Rainfall is an important natural resource which provides water for different usages such as public health, industry and agriculture. Accurate measurement of rainfall helps in conserving and managing water resources efficiently. Harvesting, conservation and utilisation of rainwater holds the key for undertaking agriculture and other allied activities in order to achieve socio-economic development of watersheds. Rainfall can be measured by non-recording and recording type (automatic) rain gauges. Non-recording rain gauges record periodic readings of the accumulated rainfall (24 hours). Large capacity rain gauges are used for measuring rainfall only a few times at the remote sites. Recording type rain gauges continuously record rainfall and thus rainfall depth can be obtained for any period. It enables to determine rainfall characteristics such as intensity, frequency, duration and amount of rainfall influencing rate and amount of runoff.

5.2 EXPERIMENT

5.2.1 Requirements

- Non-recording rain gauge
- Recording rain gauge

5.2.2 Procedure

i) Non-recording rain gauge

The rainwater is received in a plastic bottle covered with funnel (Fig. 5.1). The depth of rainfall received in 24 hours is measured by glass cylinder provided by the manufacturer. The rainfall is measured at 8 am.

Precautions

- Rain gauge should be kept on a hard compact platform and height of rim be kept 30 cm above the ground level;
- Ensure that rain gauge is leakproof; and
- Measuring cylinder should be kept clean and leaves and other foreign particles should have been removed from the receiver.



Fig. 5.1 : Non-recording rain gauge

ii) Recording rain gauge

It consists of a cylinder with a funnel top, circular inner brass tube, recording mechanism of a clock driven drum carrying the record sheet on which a pen draws the graph of rainfall against time (Fig. 5.2). The clock mechanism completes one rotation in 24 hours. The X-axis of the chart (graph) is the rainfall (mm) with accuracy of 1 mm and Y-axis represents time. The recording sheet is replaced once in 24 hours. The recording pen is fixed on a rod connected to a float in the inner cylinder. As the rainwater accumulates in the cylinder, the float rises along with the pan which records the rainfall. When the cylinder is full, the connection is established with the inner cylinder and siphon tube and the entire water gets drained and pen drops to the zero position. The depth of rainfall recorded on the graph sheet is read for every half an hour to determine the variation in rainfall intensity for different durations of the storms.

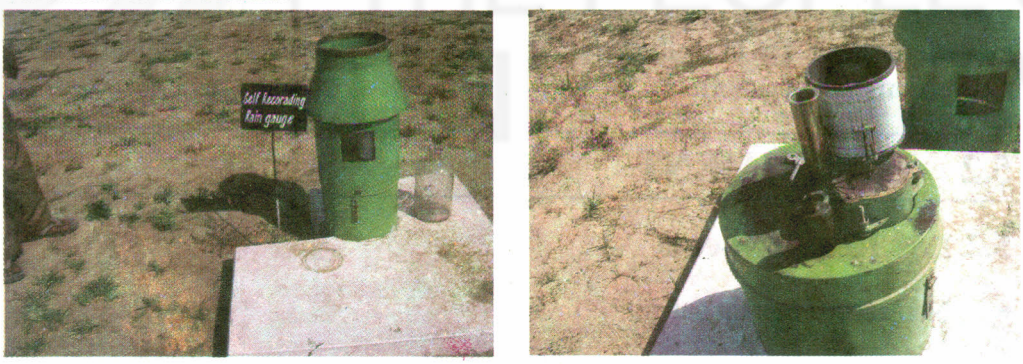


Fig. 5.2: Recording rain gauge

Precautions

- Change the chart every day between 8.30 - 9.00 am;
- Ensure that there is sufficient ink in the pen; and
- Instrument should be kept clean and free from leaves and other foreign particles.

5.3 OBSERVATIONS AND CALCULATIONS

(i) Non-recording rain gauge

Amount of rainfall measured by glass cylinder provided by the manufacturer at 8 am. = ... cm

(ii) Recording rain gauge

Determine the depth of rainfall for each hour = ... cm

Calculate the intensity of rainfall = ...cm/hr

5.4 RESULTS

(i) Non-recording rain gauge

Depth of rainfall = ...cm

(ii) Recording rain gauge

Average depth of rainfall = ...cm

Intensity of rainfall = ...cm/hr

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EXPERIMENT 6 PAN EVAPORATION

Structure

6.0 Objective

6.1 Introduction

6.2 Experiment

6.2.1 Requirements

6.2.2 Procedure

6.3 Observations and Calculations

6.4 Results

6.5 Precautions

6.0 OBJECTIVE

After completing this practical exercise, you should be able to measure evaporation from U.S. Class 'A' Pan.

6.1 INTRODUCTION

Evaporation is an important process of the hydrologic cycle. Approximately, 75% of the total annual precipitation is returned to the atmosphere by evaporation and transpiration. In hot climates, the loss of water by evaporation from rivers, canals and open-water storages as evaporation is quite significant. Most of the water withdrawn for beneficial uses ultimately returns to streams and aquifers and becomes available for reuse, while the loss of water due to evaporation is entirely lost from the usable supply. Even in humid areas, evaporation loss is significant. High evaporation loss in relation to the usable yield is characteristic of river systems in the country due to the climate, character of stream flow, and the great seasonal variations and pattern of runoff. Storage reservoirs are a major source of water loss through evaporation as they are exposed to wide surfaces.

Evaporation is measured using evaporation pans. There are a number of standardized pans for measuring evaporation and the U.S. Class 'A' pan is probably the most commonly used (Fig. 6.1). The pan is circular with a diameter of 1.21 m and depth of 25.5 cm. The basin is put on a 15 cm high wooden frame due to air circulation around the basin. The water level is kept about 5 cm below the rim, due to allowance of percolation and the need of water. The water level is measured every day. Due to heating of metallic pan sides, the measured evaporation is higher than the actual evaporation. To correct this value, pan evaporation is multiplied by a pan coefficient which depends on the climatic region. An average value of pan coefficient is taken as 0.70 with a range of 0.60-0.80. Maximum evaporation from water surface takes place in summer after the water temperature gets relatively raised and at times when, with low relative humidity, air temperature is low.

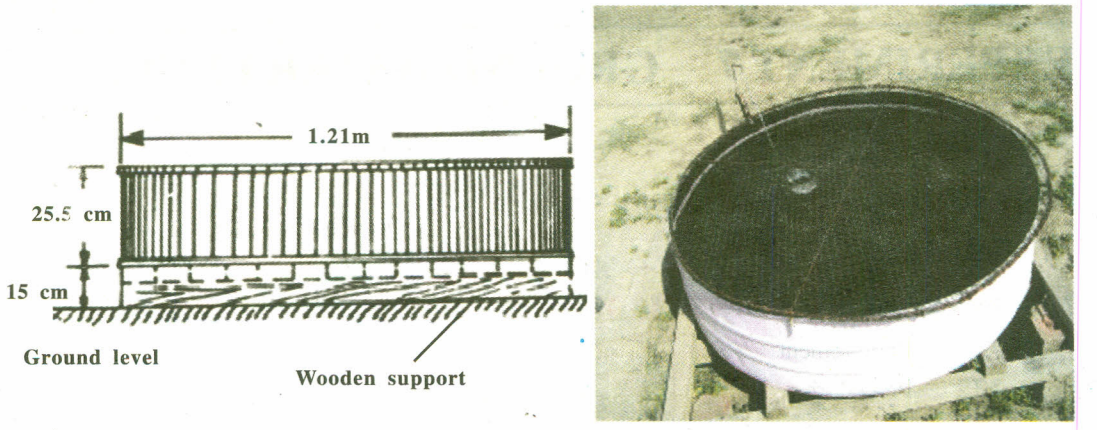


Fig. 6.1: U.S. Class 'A' Pan

6.2 EXPERIMENT

6.2.1 Requirements

- U.S. Class 'A' Pan
- Scale

6.2.2 Procedure

- Measure amount of water evaporated in previous 24 hours every day in the morning using hook gauge.
- After measurement, fill water in the Pan to the original level.
- Repeat the process the next day.
- Calculate actual evaporation by multiplying pan evaporation with pan factor (0.8).

$$\text{Actual evaporation} = \text{Pan evaporation} \times 0.8$$

6.3 OBSERVATIONS AND CALCULATIONS

Pan evaporation = ... mm

Actual evaporation = Pan evaporation × 0.8

Actual evaporation = ... mm

6.4 RESULTS

Pan evaporation = ... mm

Actual evaporation = ... mm

6.5 PRECAUTIONS

- There should not be any leakage of water from the pan.
- Pan should be always placed 10 cm above the ground surface.
- The pan should be painted white once in a year.

EXPERIMENT 7 GROUND WATER LEVEL

Structure

7.0 Objective

7.1 Introduction

7.2 Experiment

7.2.1 Requirement

7.2.2 Procedure

7.3 Observations and Calculations

7.4 Results

7.5 Precautions

7.0 OBJECTIVE

After completing this practical exercise, you should be able to measure water table or water level at different locations and times.

7.1 INTRODUCTION

Water in the zone of saturation is known as ground water as shown in the Fig. 7.1. When the ground water partly fills an aquifer (a permeable layer), the upper surface of the saturated zone called water table is free to rise or fall. The ground water in such a layer considered to be unconfined or under pheratic or water table conditions. Measurement of ground water level or water table is important to determine water table fluctuation in response to rainfall/irrigation or drought at different locations and times. This helps in adopting corrective measures under both the situations. The depth of water table is of crucial importance for installation of tube wells and to estimate ground water contribution to the crop water requirement.

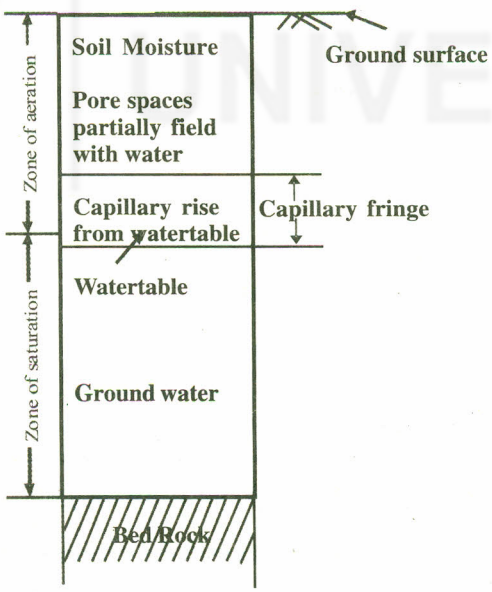


Fig. 7.1 : Ground water and zone of saturation

7.2 EXPERIMENT

7.2.1 Requirement

- Measuring tape

7.2.2 Procedure

i) Wetted tape method

A chain or metallic or steel tape is used to measure the water level in a open well or a metallic tube as shown in Fig. 7.2(A). The tape is attached with a weight so that it is lowered vertically below the water level. The lowered length of the tape from the reference level is noted. The depth of water level from the reference level is determined by subtracting wetted length from the lowered length of the tape. The water level from ground surfaced can then be estimated by subtracting distance between reference level and ground surface.

ii) Mechanical sounder

A weight consisting of a small piece of metal is connected to the lower end of the tape (Fig. 7.2(B)). As soon as the tape with weight touches the water surface in a well or pipe, it produces a sound. The depth to water level can be directly read from the tape from reference level. The water level depth from ground surface can be determined as explained above.

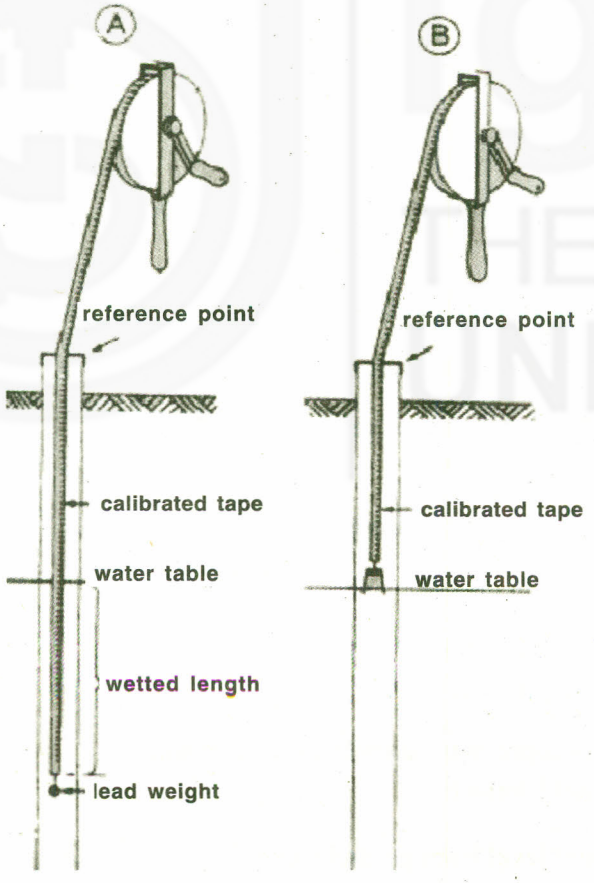


Fig. 7.2 : Water level measurement by (A) wetted tape and (B) mechanical sounder methods

7.3 OBSERVATIONS AND CALCULATIONS

Example

Method

Wetted tape method

Lowered length of tape from reference level	=	3.6 m
Wetted length of tape from reference level	=	0.3 m
Water level from reference level	=	3.6m–0.3 m
	=	3.3 m
Difference between reference level and ground surface	=	0.4 m
Water level from ground surface	=	3.3m–0.4m
	=	2.9 m

Mechanical sounder

Lowered length of tape up to water level from reference level	=	3.3 m
Difference between reference level and ground surface	=	0.4 m
Water level from ground surface	=	3.3m–0.4m
	=	2.9 m

Exercise

Method

Wetted tape method

Lowered length of tape from reference level	=
Wetted length of tape from reference level	=
Water level from reference level	=
Difference between reference level and ground surface	=
Water level from ground surface	=

Mechanical sounder

Lowered length of tape up to water level from reference level	=
Difference between reference level and ground surface	=
Water level from ground surface	=

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7.4 RESULTS

Water level from reference level = ... m

Water level from ground surface (water table) = ... m

7.5 PRECAUTIONS

Following precautions need to be taken for correct and representative measurement of water level at different locations and times.

- Bore well pipes used for water level measurement need to be protected by providing a cap plug properly tightened so that they are not tampered by putting soil or stone pieces;
- Water should not remain stagnant in the vicinity of open well or bore well; other-wise the water level measured under such a condition will not reflect the actual water table at that particular point;
- Measuring tape should be in good condition (straight with no bends) and the markings should be clearly visible;
- Lowered length and wetted length of tape, difference between reference and ground surface should be clearly read and noted.

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EXPERIMENT 8 BULK DENSITY OF SOIL

Structure

8.0 Objective

8.1 Introduction

8.2 Experiment

8.2.1 Requirements

8.2.2 Procedure

8.3 Observations and Calculations

8.4 Results

8.0 OBJECTIVE

After completing this practical exercise, you should be able to determine soil bulk density (apparent specific gravity).

8.1 INTRODUCTION

The soil moisture is generally measured on dry weight basis. To determine soil moisture on volume basis bulk density plays an important role. The soil moisture on dry weight basis is multiplied by bulk density to determine soil moisture on volume basis.

Dry Bulk Density (BD) of soil is the ratio of dry soil to the total volume of soil (including particles and pores).

$$BD = \frac{W_s}{V_t} = \frac{W_s}{V_s + V_a + V_w} \qquad (8.1)$$

Where,

BD = bulk density, gm/cc

W_s = dry weight of soil, gm

V_t = total volume of soil, cc

V_s = volume of soil solids, cc

V_a = volume of air, cc

V_w = volume of water, cc

Its value ranges between 1 gm/cc for clays and 1.8 gm/cc for sand and the average value of medium soil is generally of order of 1.5 gm/cc.

8.2 EXPERIMENT

8.2.1 Requirements

- Core soil sampler

- Moisture boxes
- Measuring tape
- Balance for weighing
- Oven

8.2.2 Procedure

Bulk density is determined by taking un-compacted soil sample of known volume by using following procedure:

- Measure the weight of core cylinder, kg
- Measure the diameter of core cylinder (d), cm
- Measure the depth of core cylinder (h), cm
- Calculate the area (A) of cross-section of the core cylinder, cm^2

$$A = \frac{\pi d^2}{4}$$

- Calculate the volume (V) of the core cylinder (same as volume of soil) by multiplying area of cross-section with core depth, cm^3

  $V = A \times h$

- Drive cutting edge of cylinder of core sampler into the soil and obtain un-compacted soil core within the tube.
- Trim sample carefully at both ends of the core cylinders.
- Place the soil sample in the oven for drying for about 24 hours.
- Weigh the soil sample after drying.
- Divide weight of soil sample by volume of soil by using relationship given in eq. 8.1.

8.3 OBSERVATIONS AND CALCULATIONS

Example

Weight of core cylinder	=	1.72 kg
Diameter of core cylinder (d)	=	7.5 cm
Depth of core cylinder (h)	=	15 cm
Area of cross-section of core cylinder (A)	=	44.2 cm^2
Volume of core cylinder (V)	=	662.3 cc
Weight of dry soil sample with core cylinder	=	2.7 kg
Weight of dry soil sample	=	2.7 kg−1.72 kg

= 0.98 kg

= 980 gm

Bulk density (*BD*) = $\frac{980 \text{ gm}}{662.3\text{cc}}$

= 1.47 gm/cc

Exercise

Weight of core cylinder =

Diameter of core cylinder (*d*) =

Depth of core cylinder (*h*) =

Area of cross-section of core cylinder (*A*) =

Volume of core cylinder (*V*) =

Weight of dry soil sample with core cylinder =

Weight of dry soil sample =

=

=

Bulk density (*BD*) =

Weight of core cylinder =

8.4 RESULTS

Bulk density of soil = gm/cc

EXPERIMENT 9 SOIL MOISTURE

Structure

9.0 Objective

9.1 Introduction

9.2 Experiment

9.2.1 Requirements

9.2.2 Procedure

9.3 Observations and Calculations

9.4 Results

9.0 OBJECTIVE

After completing this practical exercise, you should be able to measure soil moisture at different soil depths.

9.1 INTRODUCTION

Soil moisture measurements are important to estimate the depth of irrigation to be applied at different stages of the crop as well as optimum irrigation scheduling. Measurement of soil moisture change is also necessary to estimate evapotranspiration.

Depending on the soil texture, soil moisture is held in soil pores by soil moisture suction or tension. The amount of moisture a soil holds at various tensions indicates the ease or difficulty with which moisture can be removed from a soil. In light soils, soil moisture can be taken up by plants by exerting less suction whereas in clay soils more tension have to be applied to extract the same amount of water. The clay soil can store much higher amount of soil moisture as compared to sandy soil. However, release of water from a sandy soil is much easier than that from clay soil.

9.2 EXPERIMENT

9.2.1 Requirements

- Auger for soil sampling (Fig.9.1)
- Moisture boxes
- Measuring tape
- Balance for weighing
- Oven

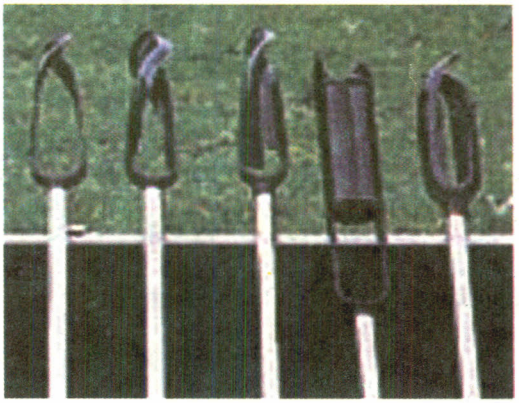


Fig. 9.1: Soil augers

9.2.2 Procedure

There are a number of methods to determine soil moisture at different depths of soil profile. Some of the methods needing sophisticated instrumentation have very limited application and are generally used for research purposes. The gravimetric method as described below is the easiest and cheapest method and gives fairly accurate estimate of soil moisture.

- Weigh the moisture box alone (W_1), gm
- Take soil samples with soil auger from pre-determined depths below ground surface and put them in moisture boxes.
- Weigh each soil sample (about 100 gm) along with moisture box (W_2), gm
- Place soil samples with box in the oven for 24 hours
- Weigh the dry soil sample with box (W_3), gm
- Estimate soil moisture content on weight basis (MC_w), per cent

$$MC_w = \frac{[(W_2 - W_1) - (W_3 - W_1)]}{W_3 - W_1} \times 100$$

- Determine the soil moisture content on volume basis (MC_v), per cent by multiplying MC_w with dry Bulk Density (BD) of soil

$$MC_v = MC_w \times BD$$

9.3 OBSERVATIONS AND CALCULATIONS

Example

Weight of box + moist soil	= 180 gm
Weight of box + dry soil	= 165 gm
Weight of empty box	= 45 gm
Weight of moisture	= 180 gm – 165 gm
	= 15 gm
Weight of dry soil	= 165 gm – 45 gm
	= 120 gm
MC_w	$= \frac{15}{135} \times 100$
	= 11.1%
Bulk density of soil	= 1.5 gm/cc
MC_v	= 11.1 × 1.5
	= 16.65 %

Exercise

Weight of box + moist soil = gm

Weight of box + dry soil = gm

Weight of empty box = gm

Weight of moisture =

= gm

Weight of dry soil =

= gm

MC_w =

= %

Bulk density of soil = gm/cc

MC_v =

= %

9.4 RESULTS

Moisture content on dry weight basis (MC_w) = %

Moisture content on volume basis (MC_v) = %

EXPERIMENT 10 FIELD VISIT

Structure

10.0 Objectives

10.1 Introduction

10.2 Procedure

10.3 Observations

10.4 Conclusions

10.0 OBJECTIVES

After completing the field visit, you should be able to:

- provide the status of various water storage and measurement structures used for rainwater harvesting;
- list the type of catchments for water harvesting and storage; and
- study the working of roof water harvesting system.

10.1 INTRODUCTION

During the programme, students have been exposed to various aspects of water harvesting in general and roof water harvesting in particular. Keeping in view, the importance of managing limited water resources which includes harvesting, conserving and utilisation, watershed/water harvesting projects need trained manpower well equipped with theory and practical aspects. Therefore, a considerable emphasis has been laid on practical hands-on exercises. Different practical exercises of vital importance for water harvesting projects include exercises on water storage and measurement structures, roofwater harvesting from a household and group housing society, discharge measurement, measurement of rainfall, water level and soil moisture.

10.2 PROCEDURE

Students will be divided into small groups for field visit. Each group will study different water harvesting and measuring structures and their components. They will also visit a group housing society and study the working of roofwater harvesting system. On the basis of visits, each group will compile a report covering all the aspects in detail.

10.3 OBSERVATIONS

Detailed description of different systems needs to be given.

10.4 CONCLUSIONS

It will include positive and negative points of water harvesting systems and structure as observed during field visit.