**College of Agriculture Engineering Sciences**

**Soil and Water Dept. (Principle of Irrigation)**

**3rd stage Lecture (6)**

**2023-2024**

# Measurement of Water Discharge in pipes and by Volumetric

## Measurement of Water Discharge by Volumetric

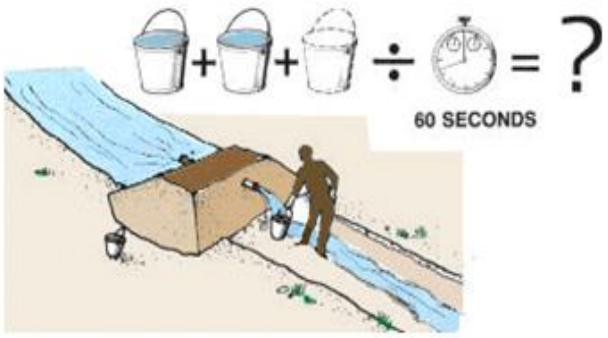
A simple method of measuring small irrigation steams is to collect the flow in a container of known volume for a measured period of time.

An ordinary bucket or barrel is used as the container or any container known as the volume.

The time required to fill the container is recorded with a stopwatch.

The rate of flow is measured by the formula:

$$Q = \frac{V}{T}$$




Where:

Q= discharge($m^3/s$)

V= volume of container ($m^3$)

T= time to required fill container (second)

**Example (1)**

Calculate the water discharge by liter/s of the water pipe when the diameter of the barrel is equal to 0.8m and the height is 95 cm, this barrel needs 2 minutes to fill by water flow this pipe.

## Calculate of the Pipe Discharge

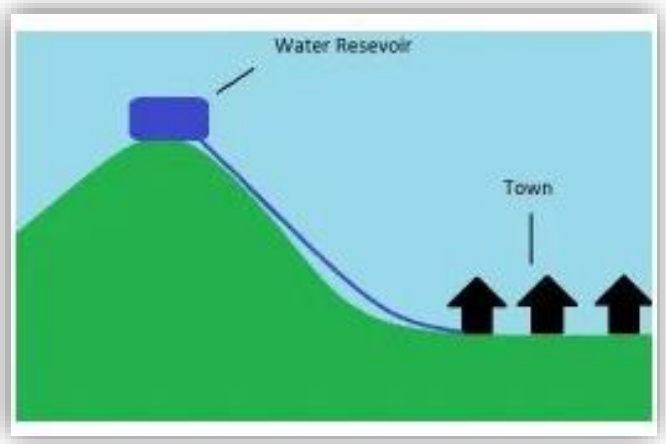
Use our pipe flow calculator to determine the velocity and flow rate of water that flows by gravity.

You only need to know the diameter of the pipe, material, length, and drop in height. We then apply the Hazen-Williams equation for you, which calculates the resulting velocity and discharge.

## The gravity flow of water

The gravity flow of water is when the flow of water in a pipe is caused by the force of gravity.

The flow will happen as long as there is a vertical difference between the source water (upstream source) and the discharge point. There must also be no external energy (for example, from a pump) used to move the water forward.




## Hazen-Williams equation

The Hazen-Williams equation is an empirically derived formula that describes the velocity of water in a gravity flow.

Remember that the Hazen-Williams equation is **valid only for water** – applying it to any other fluid will give you inaccurate results. It also doesn't take into account the temperature of the water and is only accurate for the 40-75 °F (4-25 °C) range.

**You can write down this formula as:**

$$V = K * C * R^{0.63} * S^{0.54}$$

where:

V = Velocity of water flowing in the pipe (in m/s)

K = Conversion factor = 0.849

C = Roughness coefficient

*R* = Hydraulic radius (in meters)

*S* = Slope of the energy line sometimes expressed in m/m

- **Roughness Coefficient (C*)*** depends on the material of the pipe.

In the table below you can find the values for this coefficient for different materials:

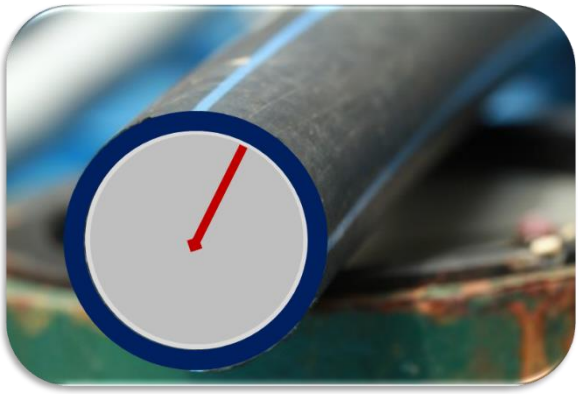
| Material | Roughness coefficient |
|---|---|
| Cast iron | 100 |
| Concrete | 110 |
| Copper | 140 |
| Plastic | 150 |
| Steel | 120 |

- **Hydraulic Radius (R),** is the **proportion between the area and the perimeter** of your pipe. If the pipe is circular, you will find it according to the following equation:

$$R = \frac{A}{P} = \frac{\pi r^2}{2\pi r} = \frac{r}{2}$$

$$R = \frac{r}{2}$$

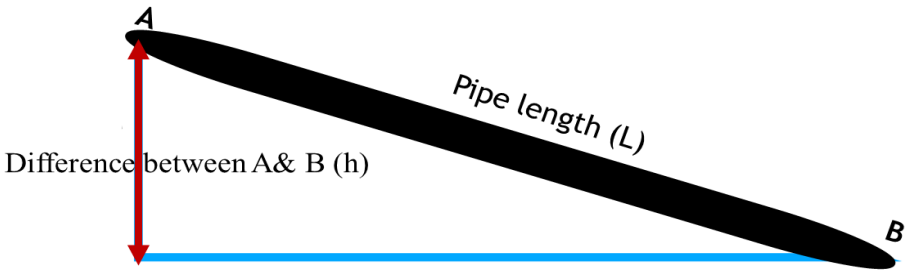
where $r$ is the pipe radius(meter).



- **To calculate the slope (*S*),** you must divide the pipe from (height difference between the beginning and endpoints (h)by the pipe length (L)

Remember that if the pipe slope is not constant but changes all the time, the actual water flow speed will differ from the obtained result.

$$S = \frac{h}{L}$$




- **The cross-sectional area** of a pipe is calculated by the below formula:

$$A = \pi r^2$$

A = cross-section area ($m^2$)

r = radius (m)

**Calculate Discharge**

Once you know the velocity of the gravity flow, you can also find the **discharge(*Q*),** by multiplying the cross-sectional area of the pipe by the flow speed:

$$Q = V * A$$

Q= pipe discharge ($m^3$/s)

V= velocity (m/s)

A= cross-section area ($m^2$)

**Example (2)** Calculator the discharge of a plastic pipe, 16 cm in diameter. The pipe length is 125 meters, and the difference in height between the beginning and endpoints of the pipe is equal to 80 cm.