**WHAT IS SOIL MOISTURE AND ITS TYPES?**

Soil Moisture is the **Water Content of the Soil**. It can be expressed in terms of **Volume or Weight**. Soil Moisture is **“the total amount of water, including the water vapor, in an unsaturated soil.”**

Soil Moisture is also called **Soil Water** represents the **water in land surfaces** that is not in rivers, lakes, or groundwater, but instead **resides in the pores of the soil**.

The level of soil moisture is determined by a host of factors beyond weather conditions, including soil type and associated vegetation. In turn, soil moisture levels affect a range of soil and plant dynamics.

**SURFACE SOIL MOISTURE** is the water that is in the **upper 10 cm of soil**, whereas **ROOT ZONE SOIL MOISTURE** is the water that is available to plants generally considered to be in the **upper 200 cm of soil**.

**THREE TYPES OF SOIL MOISTURE:**

Based on the function of water in soil the soil water is classified into three categories. These are named **gravitational water, hygroscopic water, and capillary water.**

* **GRAVITATIONAL SOIL WATER**
  + Free water moves through soil particles due to force of gravity
  + Present in the macroscopic pores of soil
  + Rarely available to plants as it seeps down rapidly to the water table
  + Available to plants only in compact soils
* **HYGROSCOPIC SOIL WATER**
  + Present in the soil as a very thin film
  + Not available to plants
  + Strong adhesive forces bind this water tightly to soil particles
  + Present in the soils with few pores like clay soil
* **CAPILLARY SOIL WATER**
  + Present in the microscopic pores of the soil
  + It composes the soil solution
  + Surface tension properties are responsible to be held in soil micropores
  + Main source of water for plants

**WHAT IS SOIL MOISTURE PREDICTION?**

**Soil Moisture Prediction is necessary for successful farming at practically every level. The prediction looks to the future and analyses**[**environmental information**](https://www.weather.gov/abrfc/exp_soil_fcst)**to make educated predictions about the moisture content of the soil.**

A new way of capturing accurate soil moisture prediction driven by local IoT-driven devices that use machine learning will drastically change the agricultural space.

In commercial agriculture, **soil moisture prediction is highly useful** because they help farmers **plan their crops, maximize their yield, control their flavours, and coordinate field operations** to avoid unnecessary losses.

**The importance of soil moisture prediction**

Soil moisture influences crop productivity in many ways, from determining if a field should be planted to its potential yield to when to harvest and how much water to use in supplemental irrigation with as little water waste as possible.

To put this into better perspective, prediction can save farms each year by helping farmers more intelligently leverage their water rights and minimize pumping costs. Furthermore, farmers can avoid over-irrigating their fields.

**The prediction system uses a wide variety of data points:**

* The modern soil moisture prediction systems **measure various data points using remote sensors,** which are then processed in the cloud
* This includes **but isn’t limited to precipitation, solar energy, wind, temperature, soil type, structure, evapotranspiration, and water** within the soil
* **Machine Learning algorithms** are to analyse this information and any traditionally available weather data over time
* It recognizes patterns that allow for a **far more accurate and localized soil moisture prediction**

**Why is Soil Moisture Important for Agriculture?**

The parameter is vital in monitoring farming activities, predicting natural disasters, managing water supply, etc. This data may signal a future flood or water deficit ahead of other indicators.

**Soil moisture affects:**

* content of air, salinity, and number of toxic substances
* ground structure and thickness
* temperature and heat capacity of the ground

**FACTORS AFFECTING SOIL MOISTURE:**

This parameter depends on various indicators such as topography, vegetation, and climate. The main soil characteristics are:

* **Texture:** the finer it is, the more pores and, therefore, better moisture retention.
* **Structure:** porous structure with a high level of aggregation improves water retention.
* **Organic matter content:** The more organic matter there is, the more significant the water-holding capacity.
* **Density:** The higher it is, the less water penetrates inside.
* **Temperature:** moisture content is higher at lower temperatures.
* **Salinity:** the higher the salt content, the less water the plants can absorb, as salt is a natural absorbent.
* **Depth:** this factor affects the amount of water available, i.e., the deeper the soil is, the more water and nutrients the plants can get.

**HOW TO MEASURE SOIL MOISTURE?**

How to calculate moisture content of soil? There are several methods. They differ in the data source that is used for this. In general, we can single out gravimetric (or direct) measurement, analysis using sensors, and remote sensing.

**Gravimetric Soil Moisture Detection**

This method extracts water from a soil sample through evaporation, flushing, and a chemical reaction. The gravimetric soil moisture is calculated based on measuring the difference between the wet and dry sample weight.

**GWC (%) = [(mass of moist soil (g) − mass of dry soil (g)) / mass of dry soil (g)] × 100**

**Soil Moisture Analysis with Sensors**

The type of a sensor depends on the used technology: measuring volumetric water content (VWC) or soil water tension (SWT), also known as soil Water Potential (SWP).

**Volumetric Water Content (VWC)**

This parameter (in a percentage) means the water volume to the ground volume. For example, 0.30 cubic inches of water per 1 cubic inch of ground is displayed as 30%. It can be calculated by the formula:

**VWC (%) = [volume of water (in3) / volume of ground (in3)] × 100**

**Soil Water Tension (SWT)**

SWT is used to specify the energy that crops need to get water from the ground. Tension increases as moisture level decreases. Conversely, it is very low when the ground is filled with water. Usually, SWT is measured in centibar. We should constantly refine data to get accurate results. For example, try to analyse this parameter when signs of water stress appear so that we can irrigate our plants until the indicators return to normal.

**Soil Moisture Using Remote Sensing**

The advantage of remote sensing is that it can **gauge moisture over much larger areas than conventional methods**. Additionally, satellite technology makes it possible to **generate high-resolution soil moisture maps**, which allow modeling crop yields in individual areas of the field and **improving overall production efficiency**. Given the constant development of this area, the potential of satellite data will only grow in the future.

Also, remote sensing allows growers to **measure water on the surface and in the root zone**. It is essential for irrigation management in drylands. As satellites’ spatial and temporal resolution increases, new opportunities for precise field control emerge. So, this technology is a solution for regions where monitoring fields with UAV or typical sensors is impossible.

**SOIL MOISTURE MONITORING TOOLS:**

We can determine soil moisture content for plants with several tools. The choice depends on the characteristics of a particular area, but here are the most popular devices.

**Tensiometers:**

* They are tubes filled with water to measure the water stress in the ground.
* They take readings from the root zone of the crops.
* The main disadvantage of tensiometers is the need for regular maintenance.

**Gypsum blocks (or electrical resistance blocks):**

* This tool to measure soil moisture is suitable for a broader range of work than the previous one.
* However, it has a more fragile construction, so it must be replaced regularly.

**Time Domain Reflectometry (TDR):**

* The principle of this tool is to send an electrical signal through steel rods in the ground and then calculate the returned signal to analyse the moisture level.
* Dry soil produces a signal faster than wet ground. Such sensors allow accurate results to be obtained quickly and do not require regular maintenance.
* However, interpreting data with them is more complicated and unique calibration is needed to match ground characteristics.

**Remote sensing platforms:**

* It is a complex instrument suitable for gauging various parameters.
* EOSDA Crop Monitoring is one of such platforms that allows to separate moisture content in the root and surface zones.
* So, we can analyse this parameter in an individual layer in detail.

**VARIABLES USED IN THE SOIL MOISTURE PREDICTION:**

1. **AIR HUMIDITY**

* Humidity is the content of water in air. Air has a capacity to hold water (in gaseous state).
* This capacity changes with pressure and temperature.
* At a particular temperature, there is a certain maximum quantity of water that can be held by air. This represents saturated condition or 100% humidity.

**It has three types— relative humidity, absolute humidity, and specific humidity.**

**Absolute Humidity:**

* Absolute humidity definition is the **content of water in the air** and is expressed in terms of **grams per cubic meter** or **grams per kilogram**.
* Its value in the atmosphere ranges from **almost zero to around 30 gm per cubic meter**.
* In mathematical terms, **absolute humidity (AH)** is expressed as the **mass of water vapor in the atmosphere (mH20)** divided by the **total volume of the air and the mixture of water (Vnet)**.
* The value of absolute humidity changes relative to the temperature and pressure of air if the volume is not constant.

**Relative Humidity:**

* It is defined as the ratio of the **water vapor’s partial pressure** in the air-water mixture to the **water’s equilibrium vapor pressure** over a pure water’s flat surface at a particular temperature.
* Normally, it is expressed in terms of **percentage**. The higher the percentage, the more humid the air-water mixture.

**Relative Humidity = actual vapor density / saturation vapor density \* 100%**

**Specific Humidity:**

* Specific humidity definition is the ratio of the **total mass of the water vapor** in the **atmosphere to the total mass of the air parcel**.

**UNIT OF HUMIDITY:**

Humidity **does not have an official SI unit** for measurement. Depending on certain factors, it is expressed in terms of different units.

1. **IRRIGATION FIELD**

* Irrigation is the process of applying water to the crops artificially to fulfil their water requirements.
* Nutrients may also be provided to the crops through irrigation.
* The various sources of water for irrigation are wells, ponds, lakes, canals, tube-wells and even dams.
* Irrigation offers moisture required for growth and development, germination and other related functions.

**Types of irrigation:**

* **Surface Irrigation** - In this system, no irrigation pump is involved. Here, water is distributed across the land by gravity.
* **Localized Irrigation** - In this system, water is applied to each plant through a network of pipes under low pressure.
* **Sprinkler Irrigation** - Water is distributed from a central location by overhead high-pressure sprinklers or from sprinklers from the moving platform.
* **Drip Irrigation** - In this type, drops of water are delivered near the roots of the plants. This type of irrigation is rarely used as it requires more maintenance.
* **Centre Pivot Irrigation** - In this, the water is distributed by a sprinkler system moving in a circular pattern.
* **Sub Irrigation** - Water is distributed through a system of pumping stations gates, ditches and canals by raising the water table.
* **Manual Irrigation** - This a labour intensive and time-consuming system of irrigation. Here, the water is distributed through watering cans by manual labour.

1. **AIR TEMPERATURE**

Air temperature is a measure of how hot or cold the air is. It is the most commonly measured weather parameter. More specifically, temperature describes the kinetic energy, or energy of motion, of the gases that make up air. As gas molecules move more quickly, air temperature increases.

**Why is Air Temperature Important?**

Air temperature affects the growth and reproduction of plants and animals, with warmer temperatures promoting biological growth. Air temperature also affects nearly all other weather parameters. For instance, air temperature affects:

* the rate of evaporation
* relative humidity
* wind speed and direction
* precipitation patterns and types, such as whether it will rain, snow, or sleet.

**How is Air Temperature measured?**

Temperature is usually expressed in degrees Fahrenheit or Celsius. 0 degrees Celsius is equal to 32 degrees Fahrenheit. Room temperature is typically considered to be 20-25 degrees Celsius (68-77 degrees Fahrenheit).

A more scientific way to describe temperature is in the standard international unit Kelvin. 0 degrees Kelvin is called absolute zero. It is the coldest temperature possible, and is the point at which all molecular motion stops. It is approximately equal to -273 degrees Celsius and -460 degrees Fahrenheit.

**Air Temperature Technology**

* Temperature can be measured in numerous ways, including thermistors, thermocouples, and mercury thermometers.
* The SWMP uses thermistors, which are metallic devices that undergo predictable changes in resistance in response to changes in temperature.
* This resistance is measured and converted to a temperature reading in Celcius, Fahrenheit, or Kelvin.

1. **WIND SPEED & WIND DIRECTION**

Wind speed describes **how fast the air is moving past a certain point**. This may be an averaged over a given **unit of time**, such as miles per hour, or an instantaneous speed, which is reported as a **peak wind speed, wind gust or squall**.

Wind direction describes the **direction on a compass from which the wind emanates**, for instance, from the North or from the West.

**Why is Wind Speed and Direction Important?**

Wind speed and direction are important for **monitoring and predicting weather patterns and global climate**. Wind speed and direction have numerous impacts on surface water. These parameters affect rates of **evaporation, mixing of surface waters, and the development of seiches and storm surges**. Each of these processes has **dramatic effects on water quality and water level**.

**How is Wind Speed and Direction measured?**

Wind speed is typically reported in **miles per hour, knots, or meters per second**. One mile per hour is equal to 0.45 meters per second, and 0.87 knots.

Wind direction is typically reported in **degrees**, and describes the **direction from which the wind emanates**. A direction of 0 degrees is due North on a compass, and 180 degrees is due South. A direction of 270 degrees would indicate a wind blowing in from the west.

**Wind Speed and Direction Technology**

The measurement of wind speed is usually **done using a cup or propeller anemometer**, which is an instrument with three cups or propellers on a vertical axis. The force of the wind causes the cups or propellers to spin. **The spinning rate is proportional to the wind speed**.

Wind direction is measured by a **wind vane** that aligns itself with the direction of the wind.

1. **PORE WATER PRESSURE**

* Pore water pressure is the pressure experienced by water trapped in the voids in a saturated soil mass.
* This occurs due to either the location of the soil or external forces.
* The position of the groundwater table and flow-through seepage also influences the pore water pressure.
* Piezometers are instruments installed in small diameter boreholes in construction sites to monitor the piezometric water level or pore water pressure.

**Pore water pressure can be calculated using the formula:**

**u = γw × zw**

where,

* u is the pore water pressure
* γw is the density of water
* zw is the depth of the water in the soil
* **Seasonal variations** can cause the **water table to move up or down**, resulting in a **change in the pore water pressure**.
* When the **water level below ground rises, pore water pressure increases**, **causing a decrease in effective stresses**.
* A **dip** in the water level, however, **decreases pore water pressure, increasing the effective stress** of the soil.
* The **total stress and pore water pressure**, therefore, depend on the **level of the groundwater**.