

Comparison of Water intake of Soil during Peak Dry and Peak Rainy Seasons using Automated Soil Infiltration Measuring Device

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ABSTRACT

The amount of water absorbed by the soil is very important to plant growth and in the transportation of nutrients during Photosynthesis This water intake of the soil at a particular time varies from season to season and differ with soil types. The seasons' variation affects plant growth either by over flooding or insufficient water intake on the soil. when the soil water intake is not control or check, it can cause over flooding which have adverse effect on the environment and plant nutrients. Researchers have used various methods such as gravitational, sprinkle, single ring and double ring to determine infiltration. The gravitational method is the mass collection of the soil into an evaporating dish and heating to dryness. This can cause erosion on the earth's surface and damage of the micro-organisms present in the soil during heating. Also, the single and double rings method have adverse effect on compacting the soil when driving the ring into the ground. In this regard, the soil properties are uttered, therefore the data obtained from infiltration measurement is inaccurate and prone to error. Hence, the percolation tube was employed to pound water into the soil in this research paper work. This percolation tube system does not require any force that will affect the soil particles and it allows gradual movement of water when inserted on the ground. The device is made up of Sensor, percolation material, a cylindrical tube, Arduino Microcontroller and SD-Card. The results showed that the month of January which is the peak dry season have a decay value of 0.58 compare to the month of July with a decay value of 0.48 for peak rainy season. The data obtained from the device was in agreement with Horton's equation.

Keywords:

Automated device,
Measurement,
Infiltration,
Percolation tube,
Peak dry season,
Peak rainy season

INTRODUCTION

Farming practice have been reduced drastically due to insecurity and over-flooding of our farm lands. This have affected production of farm produce and have crumbled the social-economic activities of the Citizen. Also, the drastic increase in population growth have caused food shortage and increase in the prizes of goods and services of any Nation. This can lead to starvation which have a negative impact on the labour force and account for increase in death rate of a Country. In addition, farming activities are practiced in rural area and most of the rural dwellers do not practice mechanized farming. This makes farm produce insufficient for consumption in urban area. Meanwhile, immigration of people from rural to urban settlement has reduce the population of farmers and this have led to shortage in farm produce and increase in the demand of

agricultural produce in urban settlement. This accounts for the drastic increase in prizes of farm produce in towns and cities. Also, most of the farm produce is seasonal and during the dry season, most of the crops water for the transportation of soil nutrients for germination and proper growth (Bouwer *et al.*, 1999). This contributes to scarcity of such farm produce and can lead to social-economic decay and decrease in the Nation gross domestic product. Therefore, the is need for farmers and researchers to determine soil infiltration during the peak dry and peak rainy seasons for irrigation practice and infrastructural development. Various approach have been used to measure infiltration as shown in equation (1). This will enable the farmers and researchers optimal water intake for crop production and reduce soil erosion which have adverse infect on the environment (Horton, 1940):

$$f_p = f_c + (f_o - f_c)e^{-kt} \quad (1)$$

where, f_p = infiltration capacity in mm/mins, f_o = initial infiltration capacity mm/mins, f_c = final infiltration constant mm/mins, k = exponential decay constant of the soil, t = time in minutes

MATERIALS AND METHODS

The block diagram in figure 1 shows the device used for the determination of soil infiltration during the peak dry and peak wet seasons using a single ring tube. Different methods such as the gravimetric and double ring methods have been employed by various researchers in determination of infiltration (Reynold,1970). The method used was the percolation tube system which allows gradual movement of water through lump and it was inserted on top of the soil type (Balmuri, 2014).

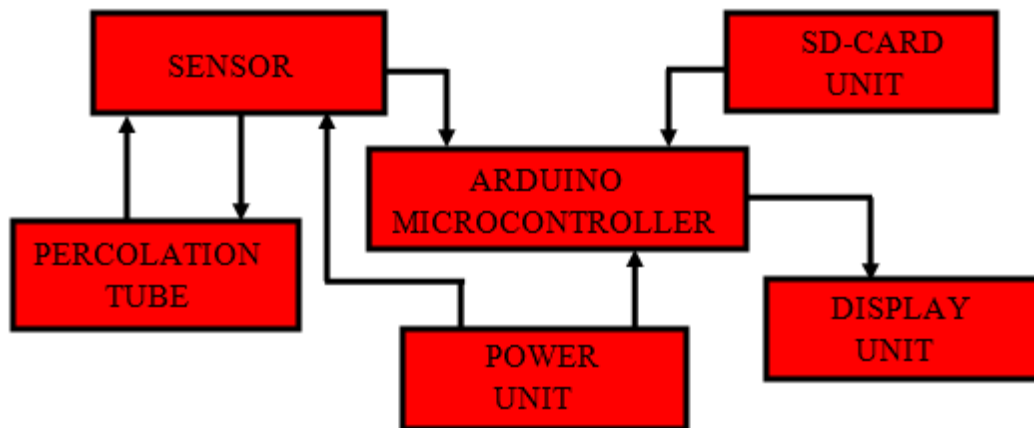


Figure 1: Block diagram of automated soil infiltration device

The sensor is a device that detects and responds to some input from the physical environment. It is a non contact device which send optical pulse to its' target. The input could be light, heat, motion, moisture, pressure or any other of environmental phenomena. The output signal can be converted to human-readable by using liquid crystal display at the sensor output or transmitted electrically for further processing. The VL6180 sensor was used to measure the water falling depth inside the

tube during the peak dry and wet seasons. This device allows the absolute distance of the target to be measured independently based on the reflectance (Gregory *et al.*, 2005). This is done when the sensor measures the time the light takes to travel to the target and reflected back to the sensor (Time-of-flight). The sensor combines an IR emitter, a range sensor and an ambient light sensor in a three-in-one ready-to-use reflow package.

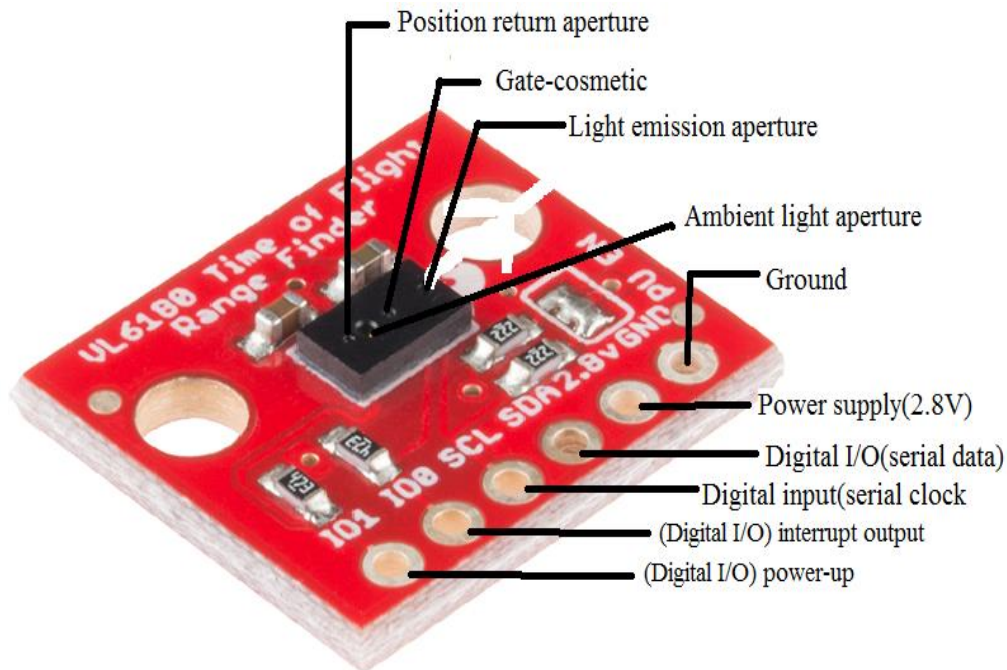


Figure 2: VL 6180 sensor

Percolation material

The percolation material allows the water to move gradually on the soil surface and prevent soil disturbance (Robinson *et al.*,1957). It was molded from coarse sand that was collected from a drainage site or peat. The coarse sand was washed to remove moisture and dry under the Sun. It was then mixed with cement and re-dry again (Umukoro *et al.*, 2023). The cement serves as a binding material for the sand particles. The mixture was molded to a lump with diameter of 50.00 mm as shown in figure 3. The lump sample was then

dried in an Oven at a temperature of 200°C for four hours. This removes any dust particle present on the surface of the percolation material. Then the percolation material was rubbed with abrasive gum and inserted into a plastic cylindrical pipe of length 250.00 mm and diameter of 50.00 mm. The abrasive gum prevents water from sipping through the edge of the molded lump and cylindrical plastic surface (Umukoro *et al.*, 2023). The upper end of the tube has a vent which allows light to penetrate into the tube. The percolation and the tube made up of the percolation tube as shown in figure 4.

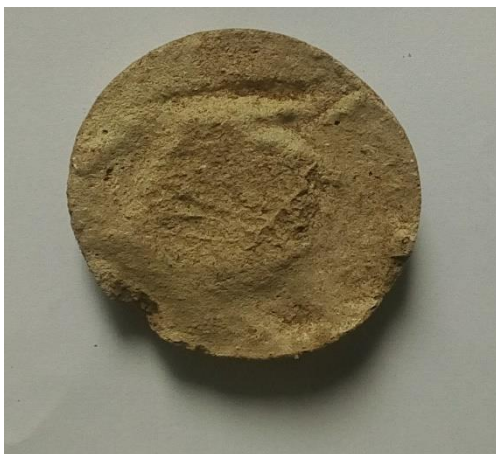


Figure 3: Percolation lump



Figure 4: Percolation tube



Figure 5: Complete soil infiltration device

RESULTS AND DISCUSSION

The readings from Tables 1 and 2 clearly showed data values obtained for infiltration during the peak dry season and peak rainy seasons with percolation tube infiltration measuring device. In this case, the values of the infiltration rate were plotted against time for the dry and rainy seasons and their results were compared. From the graph shown in figure 6, the decay value of 0.58 was obtained for the peak dry season and a decay value of 0.45 for the peak rainy season. Also from the graphs, the initial infiltration for the peak dry season was high of a value of 12.68 when compared to that of

the peak wet season with a value of 8.47. This shows that more water was absorbed by the soil during the dry season than the rainy season. This implies that during the dry season, infiltration is high compared to the rainy season. The graphs pattern show that infiltration decreases with increase in time. This was explained by Horton's infiltration model. At the constant point no water infiltrates into the soil, hence the soil has reached saturation. Hence, during dry season, more supply of water will be required for irrigation farming practice than rainy season.

Table 1: Measured data for peak dry season in the month of January 2023

Time (mins)	Water depth (mm)	Soil infiltration rate (mm/mins)
5	72	14.4
10	85	8.5
15	98	6.53
20	105	5.25
25	115	4.6
30	120	4.06
35	141	4.03
40	160	4
45	180	4

Table 2: Measured data for peak rainy season in the month of July 2023

Time (mins)	Water depth (mm)	Soil infiltration rate (mm/mins)
5	45	9
10	60	6
15	75	5
20	84	4.2
25	100	4
30	114	3.8
35	123	3.5
40	130	3.3
45	148	3.3

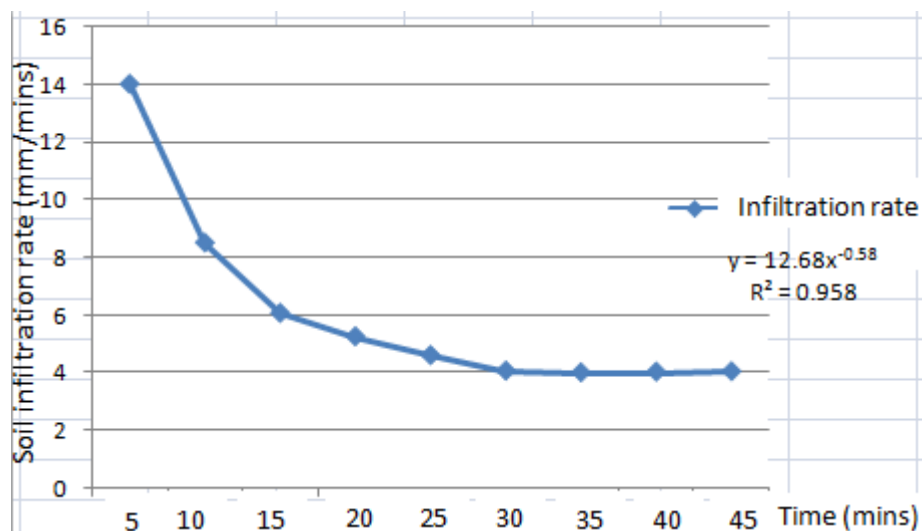


Figure 6: Infiltration variation with time

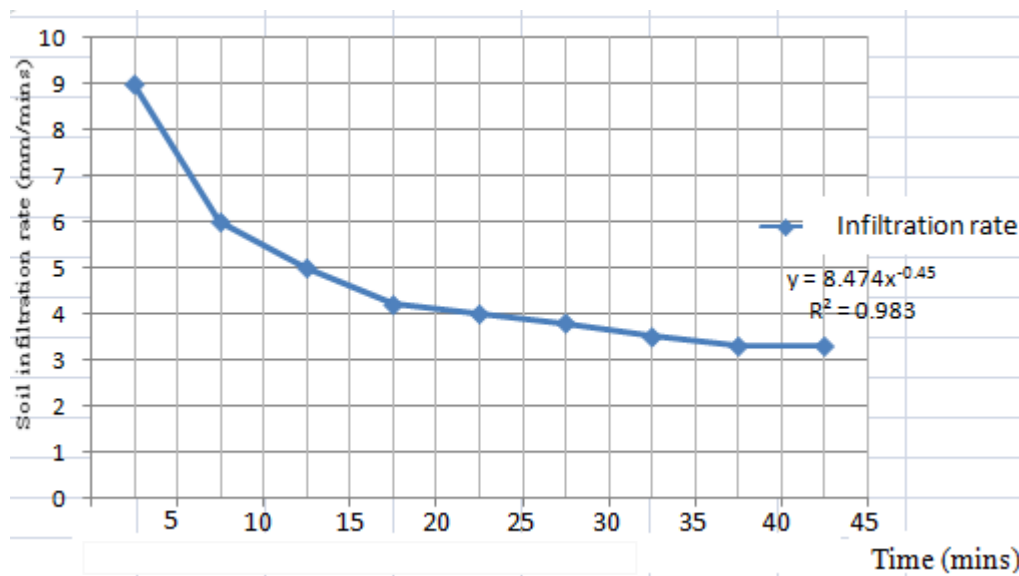


Figure 7: Infiltration rate variation with time

CONCLUSION

The percolation tube system of infiltration showed a good performance for the infiltration comparison of dry and rainy seasons. The graphs obtained are in relation with Horton's experimental model as depicted in equation (1). Also, the initial infiltration value of 12.68 was obtained for the peak dry season compared to the initial infiltration value of 8.47 for the rainy season as shown in the graphs. This is in agreement with Horton's model as shown in equation 1. and this indicates that infiltration is high during dry season than the rainy season. The results showed that the month of January which is the peak dry season have a decay value of 0.58 compare to the month of June with a decay value of 0.48 for peak rainy season. It indicates that the device can be used by researcher to measure infiltration on

different soil types. Also, the device can be used to check and control water intake during irrigation farming practice. This research paper work on soil infiltration was carried out on loamy soil. The water intake for other soil types can be further research on to ascertain their water absorption for the different seasons.

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