A STUDY OF THE HYDRODYNAMICAL CHARACTERISTICS OF LOAMY SOIL

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SUMMARY: Knowledge of patterns of water movement within the soil profile is essential to the solution of problems involving irrigation, drainage and water conservation. Following are the findings of the research performed.

1. That the removal of excess water is essential to soil aeration.

2. That the flow of water through soil follows basic laws and principles.

3.That the modern techniques involving mathematical analysis and tensiometers make it possible to formulate the drainage theories that have practical applications.

4.That the design of drainage system is primarily dependant upon hydraulic conductivity, the most important parameter of this research.

Key Words: Soil profile, drainage and water conservation, soil aeration, Tensiometers, Hydraulic conductivity.

INTRODUCTION

Soil physics is a phase of soil science that has been receiving increasing interest and attention within the last twenty years. In almost every instance, the individual has been interested in only one particular aspect of the physical properties of soil. The field is so vast that it limits the scope of activity of any one person during the experiments.

It has been recognized that field spatial variability is a problem and that more efforts should be invested in the collection of data, taking into account the spatial co-ordinates at which observations are to be made.

The importance of water in crop production has been known to agronomists for a long time, however, the understanding; of crop water requirements, of the process by which water moves within the soil profile and of mechanisms by which water and nutrients are made available to plants, is far behind our practical needs to optimize crop production under various soil/climate situations around the globe.

Bruce (1972) (3) compared hydraulic conductivity (calculated by published procedures) with the hydrulic conductivity measured on similar samples by a transient out flow procedure and found that later to be sufficiently accurate for many purposes for coarse drained system or systems having a relatively narrow range of pore size.

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MATERIAL AND METHODS

These experiments were conducted simultaneously at project site of lysimetric studies at Lahore (Pakistan). Mechanical analysis was performed using Bouyoucos hydrometer method because Day (1953) (5) had compared it with pipette method for the said analysis and found a close agreement between the two techniques.

Tensiometers were installed at ten different depths each lowering by ten centimeters, (five on the upper fifty cms were mercury and the five remaining upto one hundred centimeters were gauge tensiometers respectively) in the plot of area twelve feet eight inches by seven feet three inches. After irrigation the area was covered by plastic plus mulch in order to prevent evaporation. The observation for tension was taken after twenty four hours of irrigation. The tensions were recorded by mercury manometers in centimeters of mercury and gauge tensiometer in centibars. The reading in centibars was converted into centimeters by using the formula.

-h=T (cb) x 76/101.325 x 13.6

Tensiometers have been used because they have some obvious advantages over classical lysimeters as have been recognized by Mayer (1972) (10) and by Harris and Hansan (1975) (6).

Water content has been measured by using the formula

W% = 100 (W - Wd) / Wd

Where "W" is the weight of the wet soil

"W" is the weight of the dried soil

Where as water content in volume has been found by the following relation.

Water Content in Volume = R.B.D x % of water content / 100

Bulk density = Relative Bulk Density (R.B.D) (when values are in grams and in centimeters). The Gravimetric method is used in determining the water content as had been used by Ben-Asher (1979) (1), Jurry and Eral (1977) (8) and Soklov and Clapman (1974) (11).

Pressure and Hydraulic Head Measurement: -A plenty of water was applied to the plot in order to satisfy the potentiometer's reading. By using gravimetric method soil water content was monitored at the depths from ten to hundred centimeters (Jim and Herkelrath, 1984) (7) during the free drainage of the soil mass through time (t) for the series of depths. Two positions in the field were used to drive retention relationships. The following formula has been applied to find the hydraulic head from pressure head.

H= h+Z

where h= pressure head, Z= depth at which tensiometer is installed Z has been taken negative and positive with reference point at the surface and water tube.

Water storage has been calculated with the help of water content on weight basis to its bulk density at that depth i.e.

Storage = percent of water content x bulk density. The flux density of water moving in any direction has been calculated by

q = s / t

s / t = gradient of storage with respect to time

Hydraulic Conductivity: Internal drainage in the field is usually

Table 1: Mechanical Analysis of the Soil.

S.No	Depth	Clay	Silt	Sand	Soil Type
1.	10 cm	16.4 %	32.4 %	51.2 %	CL
2.	20 cm	18.4 %	32.4 %	49.2 %	CL
3.	30 cm	14.4 %	24.4 %	61.2 %	L
4.	40 cm	14.4 %	24.4 %	61.2 %	L
5.	50 cm	15.4 %	24.4 %	60.2 %	SCL
6.	60 cm	18.4 %	32.4 %	49.2 %	CL
7.	70 cm	17.4 %	32.4 %	50.2 %	CL
8.	80 cm	16.4 %	32.4 %	51.2 %	CL
9.	90 cm	16.4 %	36.4 %	47.2 %	CL
10.	100 cm	16.4 %	36.4 %	47.2 %	CL

based on monitoring the transient flux and potential gradient values with profile as a function of depth and time. The flux density equation for the flow of water in unsaturated soil is given as

K = -q / (dh / dZ)

Where q = Flux Density, K = Hydraulic Conductivity dH / dZ = Hydraulic Gradient with respect to depth.

RESULTS AND DISCUSSION

The results of mechanical analysis of the soil are given in Table 1 along with the type of soil based on the textural triangle of international system. The percentage of the clay, silt and sand has been analysed and is shown in this table.

The soils at ten centimeters and twenty centimeters are clay loam and the value of bulk density at the depth mentioned is 1.34 gram per centimeter cube. The depth 30,40 and 50 centimeters have soil of the type loam and sandy clay loam respectively with the bulk density 1.32 g/cm^3 at these depths, where as at the depths 60 to 100 with a difference of 10 cm there is also clay loam having the bulk density 1.34 g/cm^3. An interesting feature of the soil is that at depths 60, 80 and 90 cm value of bulk density is 1.33 g/cm^3 where as it has value of 1.33 g/cm^3 at the depth 70 and 1000 cm.

Table 2: Water content in cm^3/cm^3 with time (hr) and depth (cm)

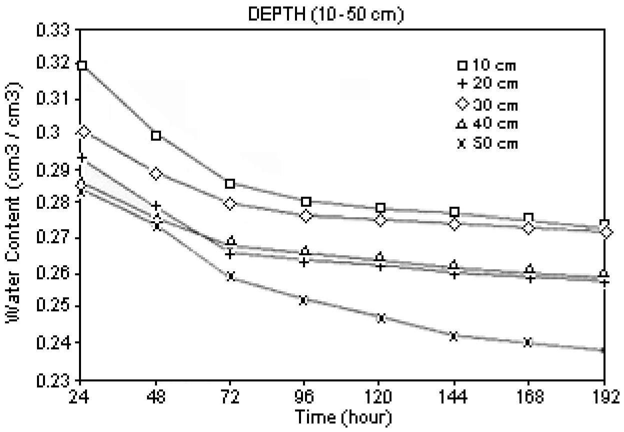
Time	O_{10}	O_{20}	O_{30}	O_{40}	O_{50}	O_{60}	O_{70}	O_{80}	O_{90}	O_{100}
24	.320	.293	.301	.286	.284	.295	.276	.280	.280	.293
48	.300	.279	.289	.276	.274	.275	.261	.267	.268	.276
72	.286	.266	.280	.268	.259	.266	.252	.259	.263	.260
96	.281	.264	.277	.266	.253	.261	.246	.255	.258	.250
120	.279	.263	.276	.264	.248	.257	.241	.252	.258	.244
144	.278	.261	.275	.262	.243	.254	.237	.250	.257	.239
168	.276	.260	.274	.261	.241	.252	.234	.250	.257	.235
192	.274	.259	.273	.260	.239	.250	.232	.249	.256	.232

The values of hydraulic conductivity at depth of each ten cm from (20-100) are given in Table 3 with time. This table gives an indication that hydraulic conductivity at particular depth decreases as the time passes on but it is also worthy to note that the hydraulic conductivity at different depths varies. It is clear from the table that the value of hydraulic conductivity at the depth of twenty cm after a duration of 24 hours of pounding is 0.032 mm/hr and at 30 cm depth after the same interval of time the value is 0.1210 mm/hr. It is clear from the above mentioned two values that the hydraulic conductivity at 30 cm is higher that at 20 cm depth. The reason for this increase in hydraulic conductivity is that the value of thydraulic gradient at 20 cm is higher than at 30 cm depths. There is similar situation at the depth of 40 and 50 cm and the same reason is applied at these depth as that on the depths of 20 and 30 cm. The hydraulic conductivity at depth 60 cm is 0.0420 mm/hr and that at the depth 50 cm it is only 0.0240 mm/hr. It is because at depths 30, 40 and 50 cm

Table 3: Hydraulic Conductivity in (mm/hr) With Time and Depth.

Time	K_{20}	K_{30}	K_{40}	K_{50}	K_{60}	K_{70}	K_{80}	K_{90}	K_{100}
24	.0320	.1210	.0130	.0246	.0420	.0198	.0780	.0560	.0930
48	.0300	.0790	.0094	.0206	.0390	.0106	.0730	.0300	.0920
72	.0039	.0250	.0026	.0125	.0130	.0070	.0460	.0190	.0693
96	.0023	.1000	.0022	.0087	.0070	.0066	.0250	.0076	.0409
120	.0021	.0035	.0021	.0061	.0068	.0052	.0093	.0045	.0335
144	.0015	.0032	.0020	.0040	.0050	.0004	.0055	.0045	.0276
168	.0011	.0030	.0011	.0037	.0032	.0025	.0037	.0038	.0231

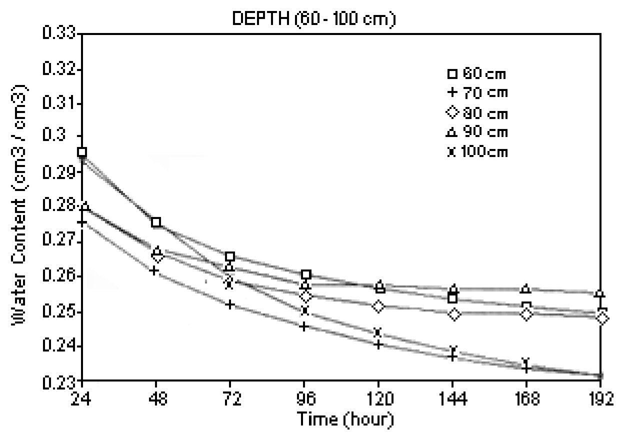
Graph No 1 Water Content vs. Time



there are layers of loam and sandy clay loam respectively and water percolates fastly through these layers. Water content at 60 cm is higher than that at 50 cm and hence hydraulic conductivity at depth 60 cm is higher than that at 50 cm depth. At the depth of 70 cm the value of hydraulic conductivity is the least and this is due to the fact that water content (Table 2) at the said depth is the least. The hydraulic conductivity at 100 cm depth is greater than those at 80 and 90 cm depths and this is due to the same reason as applied to the above situation of 70 cm depth. The graphic representation of Table 2 is given in graph No. 1 and 2.

It is further more clear from both the Tables (2 and 3) i.e. between the hydraulic conductivity and the water content that hydraulic conductivity is directly proportional to the water content of the soil. Verplancke (1983) (12). Libardi *et al.* -(1980) (9), David E. Daniel (1982) (4) and Baker *et al.* (1974) (2) used the flux method to measure the hydraulic conductivity and have shown the same results as have been drawn by us.

Graph No 2 Water Content vs. Time



CONCLUSIONS

The purpose of this research paper is to provide and overall view of the results of investigation for the hydrodynamic characteristic of the soil. It is hoped that the set of data will be useful for the development of water management to described water movement in field soil and will ultimately lead to a more efficient water use in existing agriculture through better planning of irrigation projects and better use of crucial water resources.

REFERENCES

1. Ben-Asher J: Errors determination of the water content of a trickle irrigated soil volume. Soil Sci Soc Am Proc. 43:665, 1979.

2. Baker FG, OLM Veneman, J Bouma: Limitation of the instantanous profile method for measurement unsaturated hydraulic conductivity. Soil Sci Soc Am Proc 38:885, 1974.

3. Bruce RR: Hydraulic conductivity evaluation soil profile from soil water retention relations. Soil Sci Soc Amer Proc. 36:555, 1972.

4. David E Daniel: Measurement of hydraulic conductivity of unsaturated soils with thermocouple physchrometers. Soil Sci Soc Am. 46:1125,1982.

5. Day PR: Experimental confirmation of hydro-meter theory, Soil Sci Soc Am Proc. 74:81-186, 1953.

6. Harris AR, EH Hansen: In-situ determination of soil hydraulic properties during drainage. Soil Sci Soc Am Proc 39:157,1975.

7. Jim C, WN Herkelrath: Submersible pressure out flow cell for measurement of ail water retention and diffusivity from 5 to 95 cm. Soil Sci Soc Am Proc 48:7, 1984.

8. Jury WA, HD Eral: Water movement in bare and croped soil under isolated trickle soil. Soil Science Society of America Journal 41:852,1977.

9. Libardi PL, K Reichardt, DR Nielson, JW Biggar: Simple field method for estimating soil hydraulic conductivity. Soil Sci Soc Am Proc., 44:3, 1980.

10. Mayer R: Bio-element flusees in Wurzel raum sourer waldboeden Messungen under Ergebnisse Mitt Dtsch Bodenhde Ges 16, PP-136, 1972.

11. Sokolov A, TG Chapman: Method for water balance computation. The Unesco Press, Paris, 1974.

12. Verplancke H: Determination of hydraulic conductivity using flux method. Department of Soil Physics, Faculty of Agri Sci State Univ of Gent Belgium, 1983.

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