Annals of Arid Zone 40(4): 425-427, 2001

Anisotropy in Some Alluvial Soils

V. Phonate, R.S. Malik and Sanjay Kumar
Department of Soil Science, CCS Haryana Agricultural University, Hisar 125 004, India

Abstract: Saturated hydraulic conductivity in vertical (KV) and horizontal (KH) directions were experimentally determined for different soil depths, i.e., 0.05 to 0.10 m, 0.15 to 0.20 m and 0.25 to 0.30 m in three alluvial soils. KH was found to be larger than KV in all soils and at all depths by a factor ranging from 1.1 to 7.2. Overall average of KH/KV ratio for all soils and depths was 2.1. There was no corresponding anisotropy in compaction in any of the soils. Higher bulk densities encountered in deeper layers indicated the formation of plough layer.

Key words: Anisotropy, hydraulic conductivity, bulk density, alluvial soils.

Many natural soils are inherently stratified to some degree, owing to the sedimentary nature of the depositional environment. It has been generally recognized that the spreading of contaminant plumes in the subsurface is controlled by the spatial distribution of hydraulic conductivity. Unequal hydraulic conductivities in three principal axes, Kx, Ky and Kz (anisotropy) is known to influence the design and management of irrigation and drainage system appreciably. Spacing between furrows and dripper would be wider in soils having higher horizontal-saturated hydraulic conductivity (KH) to the vertical conductivity (KV), respectively, in furrow and drip irrigation methods, thereby increasing their irrigation efficiencies at the farm (Marshall and Holmes, 1988). There have been only a few investigations on the anisotropy of soil in the field. This paper reports anisotropy (KH/KV) in sand, loamy sand and sandy loam soils of alluvial origin at three depths.

Materials and Methods

Vertical and horizontal core (0.05 m internal diameter and 0.05 m length) samples were excavated in triplicate from three depths (0.05-0.10, 0.15-0.20 and 0.25-0.30 m) from Ludas, Hisar loamy sand and Hisar sandy loam soils in and around the research farm of CCS Haryana Agricultural University, Hisar (221 m altitude, 29°0.5′N and 75°50′E): These soils are classified according to 7th Approximation as Ustipsamments, Typic Torripsament and Ustocrepts, respectively (Ahjua *et al.*, 1978). Sample sites in each soil were spaced on one-meter grid. Constant head permeameter was used to determine saturated hydraulic conductivity (Ks.) The particle size distribution and bulk density (Db) of the soils were also estimated following standard methods. Detailed particle size distribution, as done by hydrometer method, is described in Fig. 1. The anisotropy was also determined in a sand box-packed soil. After carrying out steady-state seepage experiments for two months, Ks and Db were determined and the average values are presented in Table 1.

Results and Discussion

Saturated hydraulic conductivity, Ks, and Db increased in both directions, i.e., vertical

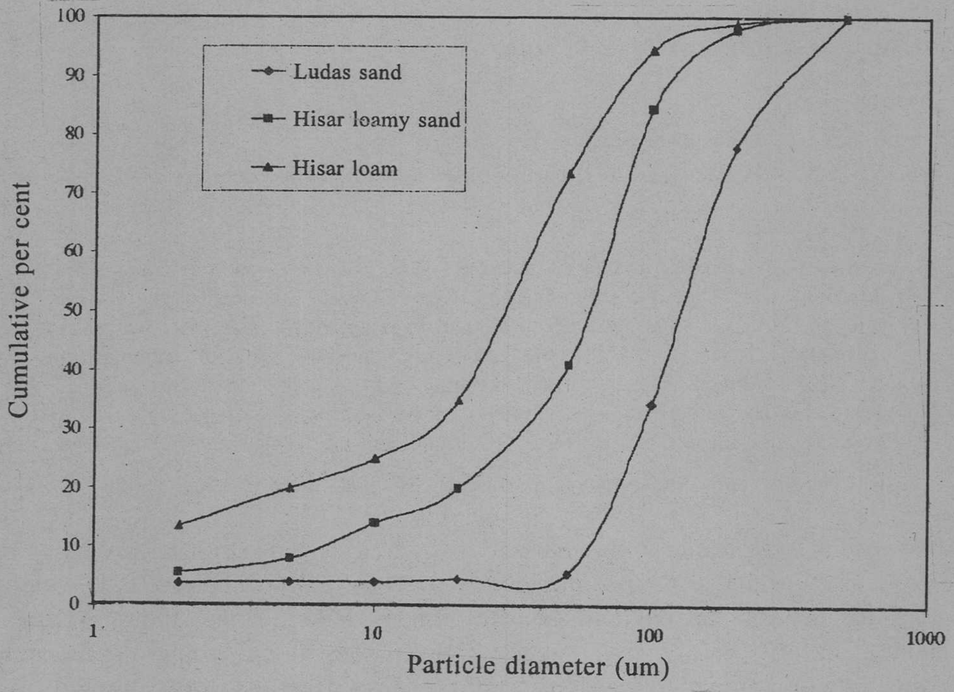

Fig. 1. Particle size distribtuon in Ludas sand, Hisar loamy sand and Hisar loam soils.

and horizontal, with depth in all the soils (Table 1). However, a plough layer of very low conductivity and of very high bulk density (Db = 1.560 Mg m^{-3}) was observed to be formed in the lower layers, i.e., 0.15 to 0.20 m and 0.25 to 0.30 m in all the three soils (Table 1). Ratio of KH to KV, which forms an index of anisotropy, was larger than unity and varied from 1.1 to 7.2, with an overall mean of 2.1 in these soils. However, there was no corresponding anisotropy with bulk density in any of the soils (see DbH/DbV ratio in Table 1). Bathke and Cassel (1991) reported the ratio to vary from 0.01 to 25 in different horizons of an Ultisol. Similarly, Burger and Belitz (1997) measured greater hydraulic conductivity in the parallel oriented subcores for 90% of the core pairs and mean hydraulic conductivity ratios of parallel to perpendicular oriented subcores for the different lithologies ranged from 1.33 to 1.57. However, Singh *et al.* (1972) reported this ratio to be equal to 40 at deeper depths (3 m) in alluvial/aeolin soils of this region.

There was practically no difference in anisotropy of different soils in 0.05 to 0.10 m surface layer (Table 1). Even in deeper layers anisotropy of medium textured soils was approximately equal to that of sand in a sandbox (Table 1), where settling was done with the help of percolating water. It, thus, indicated that anisotropy in these soils did not depend upon texture and consolidation of soil; rather it depended on the manipulations and particle setting caused by tillage, wind and water. Anisotropy in these soils is considered to

Table 1. Values of saturated hydraulic conductivity in vertical direction KV and horizontal direction KH and those of bulk density DbV and DbH, respectively, in different soils.

Depth (cm)	KV (10^{-6} ms^{-1})	KH (10^{-6} ms^{-1})	KH/KV	DbV (Mg m^{-3})	DbH (Mg m^{-3})	DbH/ DbV
Ludas sand						
5-10	32.86±1.21	41.53±1.01	1.3	1.47±0.03	1.44±0.01	1.1
15-20	24.64±0.77	27.78±0.36	1.1	1.49±0.03	1.52±0.03	1.0
25-30	18.55±0.22	20.19±0.33	1.1	1.54±0.02	1.52±0.01	1.0
Hisar loamy sand						
5-10	2.92±0.23	3.11±0.17	1.1	1.47±0.04	1.40±0.04	1.0
15-20	0.89±0.04	1.05±0.11	1.2	1.69±0.02	1.67±0.04	1.0
25-30	1.05±0.11	2.86±0.44	2.7	1.62±0.03	1.60±0.04	1.0
Hisar loam						
5-10	1.17±0.11	1.64±0.08	1.8	1.49±0.02	1.38±0.06	1.0
15-20	0.05±0.01	0.36±0.06	7.2	1.73±0.05	1.66±0.02	1.0
25-30	0.28±0.05	0.55±0.10	2.0	1.67±0.02	1.66±0.06	1.0
Ludas sand in sand box						
0-120	11.44±0.32	22.11±0.63	1.9	1.50±0.01	1.47±0.01	1.10

be caused by deposition, orientation of particles, stratification and compaction processes (Ghildyal and Tripathi, 1987; Burger and Belitz, 1997). Moreover, in unsaturated and layered soils the anisotropy was observed to increase as pressure head and saturation decreased (Stephens and Hermann, 1988).

Conclusions

Saturated horizontal hydraulic conductivity (KH) was found to be larger than that in the vertical direction (KV) in all soils by a factor ranging from 1.1 to 7.2. Overall average of KH/KV ratio for all soils and depths was 2.1.

References

Ahuja, R.L., Garlapuri, V.N., Manchanda, H.L. and Khanna, S.S. 1978. Physiography and its soil associations of Haryana. *Journal of Indian Society of Soil Science* 26: 261-267.

Bathke, G.R. and Cassel, D.K. 1991. Anisotropy variation of profile characteristics and structured hydraulic conductivity in an Ultisol landscape. *Soil Science Society of America Journal* 55: 333-339.

Burger, R.L. and Belitz, K. 1997. Measurement of anisotropic hydraulic conductivity in unconsolidated sands: A case study from a shoreface deposit, Oyster, Virginia. *Water Resources Research* 33: 1515-1522.

Ghildyal, B.P. and Tripathi, R.P. 1987. *Soil Physics*. Cambridge University Press, Cambridge, UK.

Marshall, T.J. and Holmes, J.W. 1988. *Advanced Soil Physics*. Wiley-Interscience, New York.

Singh, J., Karwasra, S.P.S. and Kumar, R. 1992. Drainage through skimming wells. In *Proceedings of 5th International Drainage Workshop,* Vol. II, pp. 322-329, Lahore, Pakistan.

Stephens, D.B. and Hermann, S. 1988. Dependence of anisotropy on saturation in stratified sand. *Water Resources Research* 24: 770-778.