The role of earthworm channels in water flow on a drained clay soil

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The geometry of tubular channels made by earthworms and their influence upon the drainability of a clay soil was investigated at Praha 4 - Opatov, on a meadow, with a drainage system installed 40 years ago. Soil type (according approx. to FAO classification) was Gleyic Luvisol, clayey, with approx. 50 % of particles below 10 microns in topsoil and 70 % in subsoil, wet, developed in quarternary deluvial sediments over ordovic shales. The lateral drains were laid manually into a trench that was 0,95 m deep, and 0,22 m wide at the bottom. Drain tiles of internal diameter 50 mm and of length 0,33 m were covered by humous soil material to a depth of about 0,15 - 0,20 m above the bottom, and the trench was further filled with mixed soil backfill material. The distance between lateral drains was 10 m.

Investigations were made down to a depth of about 1,1 m. Location A was above a drain, and location B was in the middle between lateral drains. On a vertical plane section, perpendicular to the drain, the old backfill soil was studied, and undisturbed cylindrical soil core samples with a volume of 100 cm^3 were taken from the most interesting points. It is clear from the results in Fig. 1 that some sort of eluviated zone had developed in the backfill, at the walls of the trench. The soil in this zone shows higher permeability, more coarse pores and less shrinkage than both the soil in the middle of the backfill and the undisturbed subsoil.

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On square plots with an infiltration area of 1 m^2 at depth 0,35 m, infiltration rates were measured at locations A and B. Infiltration rates after 8 hours were 0,13 mm/min above the drain, and 0,003 mm/min between the drains.

As no cracks were observed, we concentrated on the earthworm channels, which had, for depths greater than 0,35 m and except for the vicinity of drains, approximately vertical directions. The numbers and sizes of the earthworm channels were registered in horizontal soil sections just below infiltration plots. Only the channels with diameters above 2 mm were taken into consideration. The maximum diameter observed was 10 mm. In Fig. 2, vertical profiles are given of the frequency of the channels, of their areal fraction (macroporosity) and of their laminar hydraulic conductance:

$$\Omega_T = \frac{3}{2}\pi \cdot \sum_i n_i R_i^4$$

where R_i ... mean radius of channels of the i-th class,
n_i ... number of channels of the i-th class in unit cross-sectional area.

The maximum depth to which the earthworms borrowed their channels between drains was 1,15 m, where a hard layer occured. Most of the channels had their lower ends at depths from 0,4 to 1,1 m, in the impermeable subsoil. We found here spherical voids, where living earthworms were sometimes present, wound into a little ball. It was therefore evident that earthworm channels between drains, without mutual hydraulic connection and without any internal drainage, did not contribute substantially to water movement in the soil. The contrary was valid, however, for location A, where we removed the soil material above the drain to a depth of 0,7 m below surface. From here we followed carefully the individual earthworm channels, in order to ascertain, whether thay had a hydraulic connection with the drain. Investigations were made for a length of about 4 m, examining 11 joints between drain tiles. The methods of investigation depended mainly on the detailed structure of macropores in the vicinity of individual joints. Visual observation prevailed, with the help of photography. We measured sometimes the flow of water by pouring it into big channels by means of a funnel. We used also gypsum to obtain casts of the macropores. From these 11 joints, some marks of hydraulic connection to the interior of the drain were present in 6 cases, and in one of them (No. 10), the connection was clearly present:

Joint No.	Commentary
0	A channel, visually observed, led to the joint, apparently permeable, containing small roots.
2	Two channels, visually observed, led to the joint. The joint itself seemed to be rather clogged. Small-scale infiltration test in the backfill, 5 cm above the drain: 0,84 cm^3/s on the area of about 200 cm^2.
4	A channel ended near the joint in a spherical void with a big earthworm in it. Observed visually, hydraulic connection not sure.
7	Hydraulic connection indicated by breakthrough of gypsum into the drain. After removing the drain tile, channels filled with gypsum were visible below the drain.
8	The gap between the tiles was wider than in other joints. Not only water, but also soil and earthworms could pass through it. Not typical.
10	Both gypsum suspension and water flowed rapidly into a channel of diameter 9 mm (at the rate of 0,6 cm^3/s). A cast of the channel continued nicely into the joint and into the drain.

From the measurements of hydraulic conductivity on large soil cores (diameter 80 mm, height about 70 mm) with channels of earthworms in them, the hydraulic conductance of individual channels (with diameters about 7 mm) appeared to be approx. 8 cm^3/s. Apparently, the natural flow path of water into the drain was much more tortuous. Unsufficient permeability of the joints themselves, partially clogged with soil, was the main reason for the reduction of flow rate. Nevertheless, the positive effect of earthworms upon the hydraulic properties of the backfill is evident. In the vicinity of the drain, the channels of earthworms led also parallel to the drain. Similar observations were reported by Taylor and Goins (1967).

References:

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