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Soil water repellency patterns following long-term irrigation with waste water in a sandy calcareous soil, SE Spain

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One of the consequences of long-term irrigation with waste water can be the development of soil water repellency (WR). Its emergence can affect soil-water balance, irrigation efficiency and crop yield. Water repellency development has been suggested to be controlled by parameters such as organic matter quantity and type present in the waste water, soil properties (particularly the texture), and the overall time period of irrigation. Here we examine the effect of long-term (∼20 years) irrigation with low quality waste-water on soil wettability under a *Populus alba* tree stand used as a "green filter". The plot exhibited considerable micro-topography (ridges and furrows) and consisted of sandy calcareous soil (Xerofluvent). Water repellency and organic carbon content (OC) were studied in 160 samples taken from the plot and from an adjacent area used as control (no irrigated). From the control area 40 samples were taken from the first 5 cm of mineral soil (C samples). From the irrigated plot a total of 120 samples were collected. To account for the micro-topography of the terrain, 40 samples each were taken from ridges (R samples; 0-5 cm depth), furrows (F samples; 0-5 cm depth), and from furrows at depth (FD samples, 5-10 cm depth).

Soil WR was assessed in the laboratory for all air dry samples using the water drop penetration time test (WDPT Test). Samples with WDPT $\leq$ 5 seconds were classified as non-repellent. Organic carbon content (OC) was analyzed in all samples by potassium dichromate oxidation method. We also carried out a detailed chemical characterisation of the organic matter in two furrow samples that exhibited contrasting wettability, but no major difference in OC content (F10: WDPT 9960s, OC 6.7%; F31: WDPT 10s, OC 7.5%). Following accelerated solvent extraction with Dichloro-methane/MeOH (95:5), the extract was analysed by GC-MS.

All samples from the control area (C) were wettable (mean WDPT=1s). In the irrigated plot, water repellency was present for 48% of R samples (mean WDPT=135s), 95% of F samples (mean WDPT=802s), and 93% of FD samples (mean WDPT=267s). A good correlation between WR and OC was found by pooling all groups of samples (r=0.830***), and in some cases separately per group: R samples (r=0.885***), FD samples (r=0.651***). However, the correlation within group of F samples was low (r=0.269ns). This sample group had the highest frequency occurrence and the highest mean values of WR, indicating that not only quantity of OC is controlling the development of WR. This notion is supported by the results from samples F10 and F31. Despite their exposure to the same waste water, the organic material extracted from the highly repellent sample F10 exhibited more than twice the content of n-alkanols (∼C26) and alkanoic acids (C18-24) compared to sample F31.

Based on these results we speculate that for the study plot, the combination of the following factors allowed high levels of water repellency to develop: (1) sandy soil texture, (2) long-term use of waste water, (3) low quality of waste water treatments, and (4) potentially also organic matter inputs from the vegetation have. The results suggest that rather than total OC content, a specific fraction of the organic matter pool controls repellency development, with n-alkanols and alkanoic acids playing a key role. It is conceivable that water repellency-induced preferential flow has led to an increased accumulation of these compounds at the flow path margins, leading to a self-enhancement of water repellency in sample F10.