



Behaviour of 22 emerging organic compounds from secondary treated wastewater effluent in soil aquifer treatment – Assessing the attenuation potential of biochar and compost reactive layers in a large-scale sand tank experiment

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Soil aquifer treatment (SAT) using secondary treated wastewater effluent (STWW) as infiltration feedwater is an increasingly discussed measure to mitigate groundwater level decline. It may also act as an additional treatment stage for the attenuation of emerging organic compounds (EOCs), e.g., pharmaceuticals and industrial agents, which STWW effluent still contains in varying amounts. Hence, understanding the behaviour of EOCs in SAT systems, both in the unsaturated and saturated zone, prior to implementation and operation, is of high importance. For that purpose, sand tank experiments are one possibility to study under controlled conditions the attenuation potential of natural and amended soils with e.g., permeable reactive layers.

Therefore, we designed and built novel large-scale sand tank experiments, consisting of three individual, L-shaped, tanks made from HDPE (Horovitz et al., 2024). All three tanks were packed with fine-medium quartz sand. The vertical part acts as unsaturated infiltration zone. The horizontal part consists of a saturated zone with continuously flowing groundwater in the lower part and an unsaturated zone above. The infiltration zone of two tanks were amended with one reactive layer each (biochar and compost, both mixed with the fine-medium quartz sand). The third tank acted as reference without reactive layer. Native groundwater from LNEC campus was used for continuously laterally flowing groundwater. The feedwater was a real STWW effluent from a Lisbon wastewater treatment plant. The groundwater flow rate was set to achieve a retention time of approx. one month for the STWW inside the tanks. In total, six infiltrations were performed over approx. eight months. Our setup allowed us to take samples both in the unsaturated and saturated zones. Additionally, the tanks are equipped with high-resolution oxidation-reduction potential sensors, both in vertical and horizontal direction, being an important parameter for the degradation of some EOCs.

Our results showed that for the tank setup, amended with a biochar layer, all 22 EOCs were fully

attenuated, while for the tank containing a compost layer 14 EOCs (1,2,3-Benzotriazole, 4,5-Methyl Benzotriazole, Amisulpride, Atenolol, Carbamazepine, Cetirizine, Ciprofloxacin, Diclofenac, Hydrochlorothiazide, Iopromide, Irbesartan, Metoprolol, Sitagliptin, and Venlafaxine) were attenuated with varying percentage. In contrast, for the reference tank, only a decrease of eight EOCs (Amisulpride, Atenolol, Ciprofloxacin, Iopromide, Irbesartan, Metoprolol, Sitagliptin, and Venlafaxine) could be observed.

Our results show that the implementation of tailored permeable reactive layers in SAT systems could substantially improve the quality of STWW during infiltration regarding EOCs, leading to a greater confidence in applying this technology.

References

Horovitz, M., Muñoz-Vega, E., Knöller, K., Leitão, T.E., Schüth, C., & Schulz, S., (2024). Infiltration of secondary treated wastewater into an oxic aquifer: Hydrochemical insights from a large-scale sand tank experiment. *Water Research* 267, 122542. <https://doi.org/10.1016/j.watres.2024.122542>