Impact of Sustainable Urban Drainage Systems (SUDS) on Vadose Zone Water

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BG1.6/HS10.14/SSS12.11
Tue, 05 May, 08:30-10:15 | D567

Funded by

Ministerium für Umwelt, Landwirtschaft, Natur- und Verbraucherschutz des Landes Nordrhein-Westfalen

Study Area

BS2 – Commercial area

BS1 – Residential area

BS3 – Residential area

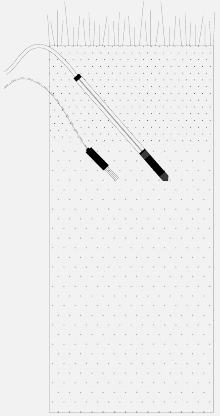
(Google Maps)

- Three long-term operated (>20 yrs) bioretention systems situated in north-eastern and central-western Germany.
- Two sites with selective inflow conditions (BS2, BS3); one site with areal inflow conditions (BS1).

Methods

- Spatial mapping of trace metal contents in the bioretention media.
- 22-month lasting monitoring of influent and effluent trace metal concentrations using a novel soil water extraction approach to qualitatively analyse soil seepage water (Reck et al., 2019, right box).
- Soil hydrological modelling of the soil water balance using HYDRUS-1D.

Principle



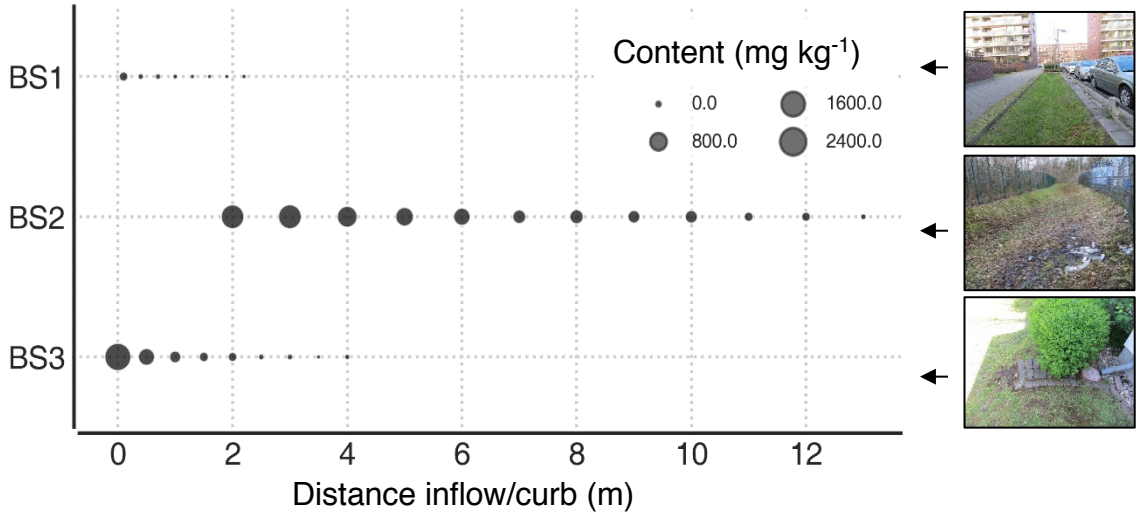
Installation

Completed monitoring station

- 2 measurement points per site à 5 suction cups each
- Additionally on inflow collector per site

→ Details in Reck, A., Paton, E., and Kluge, B. (2019): Advanced in situ soil water sampling system for monitoring solute fluxes in the vadose zone. *18(1), Vadose Zone Journal.*

Spatial Metal Contents



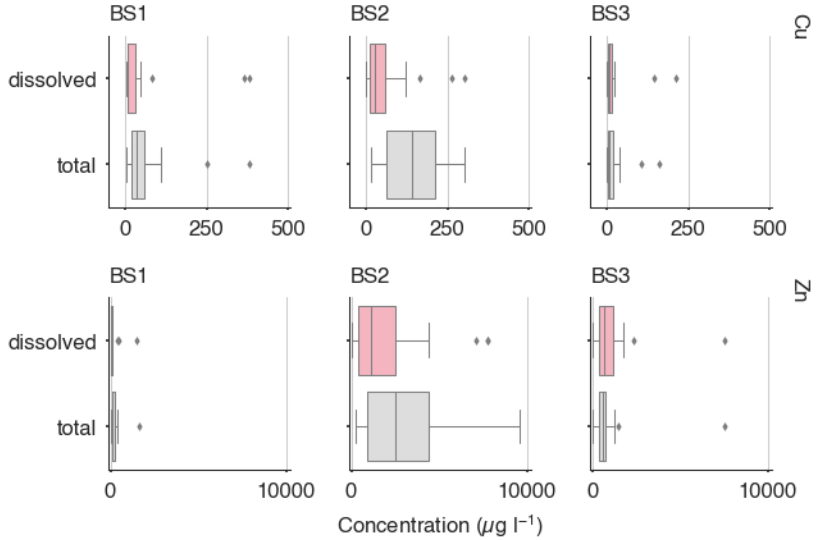
Example of spatial Zn-contents as a function of the inflow regime (BS1 vs. BS2 and BS3), drainage area type, and distance to the water inlet point.

- Lowest metal contents in the soil surface under areal inflow conditions within the residential area (BS1) and highest contents for selective inflow conditions within the commercial area (BS2).
- High Zn-contents next to the inflow at BS3 because of galvanised gutters and downpipe.

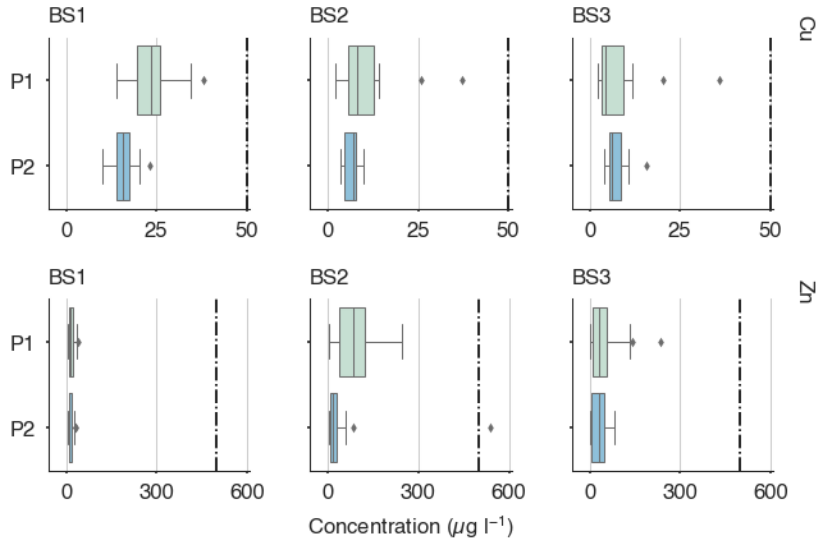
Influent and Effluent Metal Concentrations

- Highest metal concentrations in the influent of the commercial site (BS2) in combination with a high particulate fraction.
- Nearly the complete fraction of inflowing metals for the residential sites (BS1, BS3) belongs to the dissolved fraction.

- Impressive load reductions in the upper vadose zone (after the passage of the upper 30-40 soil centimetre) for all metals and sites.
- With the exception of single outliers, soil seepage water reaches legislatively harmless concentrations below SUDS even after 20 years of operation time.



Influent metal concentrations. “Dissolved” denotes filtered water samples (0.45 µm membrane), “total” denotes acid-digested water samples (HNO_3).

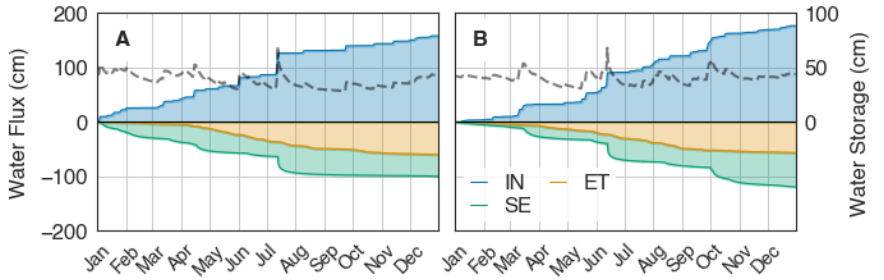


Effluent metal concentrations. For selective inflow conditions “P1” is next to and “P2” distant to the inflow point. For areal inflow conditions both points are located in the swale depression. The dashed line marks the German trigger values (BBodSchV, 1999) to label legislatively harmless seepage water qualities.

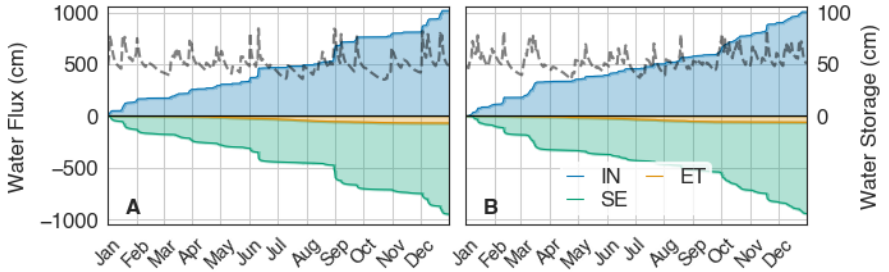
Simulated Soil Water Balance

- For site BS1 with an areal inflow regime, about one third of total infiltration is evapotranspirated (500 to 600 mm) and two thirds (1000 to 1200 mm) are deep seepage.

- Simulated water balance for site BS2 mirrors the selective inflow regime. Total infiltration inputs per year account for approximately 10000 mm near the inlet point. Annual seepage fluxes approximate 9400 mm. Total evapotranspiration is comparable to site BS1 although the fraction is marginally low compared to the cumulative infiltration.



Simulated soil water balance of site BS1 for the years (a) 2018 and (b) 2019. The model was parametrised according to the conditions in the swale depression. ”In”, “ET”, and “SE” denote the infiltration, evapotranspiration, and seepage water. The dashed line marks the soil water storage.



Simulated soil water balance of site BS2 for the years (a) 2018 and (b) 2019. The model was parametrised according to the conditions at the point next to the inflow. ”In”, “ET”, and “SE” denote the infiltration, evapotranspiration, and seepage water. The dashed line marks the soil water storage.

References

- BBodSchV (1999). Federal soil protection and contaminated sites ordinance. Bundesministerium für Umwelt, Naturschutz und nuklueare Sicherheit (BMU).
- Reck, A., Paton, E., and Kluge, B. (2019). Advanced in situ soil water sampling system for monitoring solute fluxes in the vadose zone. 18(1), Vadose Zone Journal.