Evaluation of novel sorption media filter materials for the advanced treatment of stormwater runoff from highways

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(HA Hessen Agentur GmbH – Jan Michael Hosan)

1 Introduction

- **Highway runoff waters** are often contaminated with several **pollutants** (heavy metals, hydrocarbons, PAH, phosphorous) (Eriksson et al. 2007; Kayhanian et al. 2012)

  → prior discharge to receiving waters treatment is often necessary

- **Basic treatment:** elimination of particles and associated pollutants (e.g., PAH)

  → sedimentation tanks

- **Advanced treatment:** necessary predominately for specific immission issues (e.g., lakes): removal of soluble substances (heavy metals/ phosphorous)

  → sorption/ion exchange/precipitation

  specific technical filters

Hürlimann et al., 2011

1 Introduction

LOEWE research project:

- **Advanced full-scale treatment** system for **highway runoff** (A 485, Gießen, Hesse): lamella separator (particle removal) and vertically-charged filter (removal of soluble fractions)
- **Monitoring program** (1.5 years): removal efficiencies for SS, COD, Cu, Zn, PO_4

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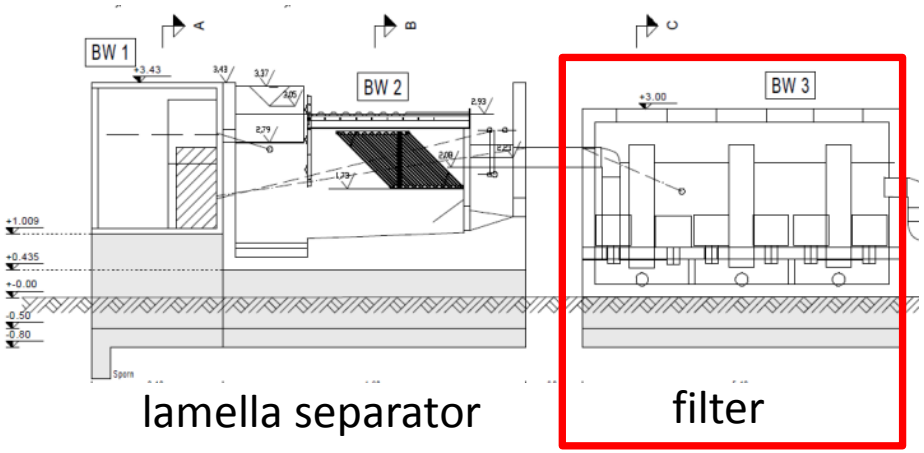


1 Introduction

- **Requirements filter material:**
  - **Simultaneous removal of heavy metals and phosphate (PO_4)**
  - **Boundary conditions**: influent composition, flow-rates, stability to de-icing salts
  - **Low asset and maintenance costs**

- **Previous batch shaking experiments** with several materials resulted in combination of **zeolite** (Z) and **calcium silicate** (CaSi)

2 Material and Methods

Lab-scale column experiments:

- **Acrylic glass columns:** diameter: 10 cm, length: 50 cm, bed height of 45 cm (15 cm zeolite and 30 cm CaSi), up-flow mode (from bottom to top)

- **Influent concentrations** (deionized water, pH 4.9±0.3)
  - 2.4 mg/L Cu
  - 20.9 mg/L Zn
  - 15.7 mg/L PO_4

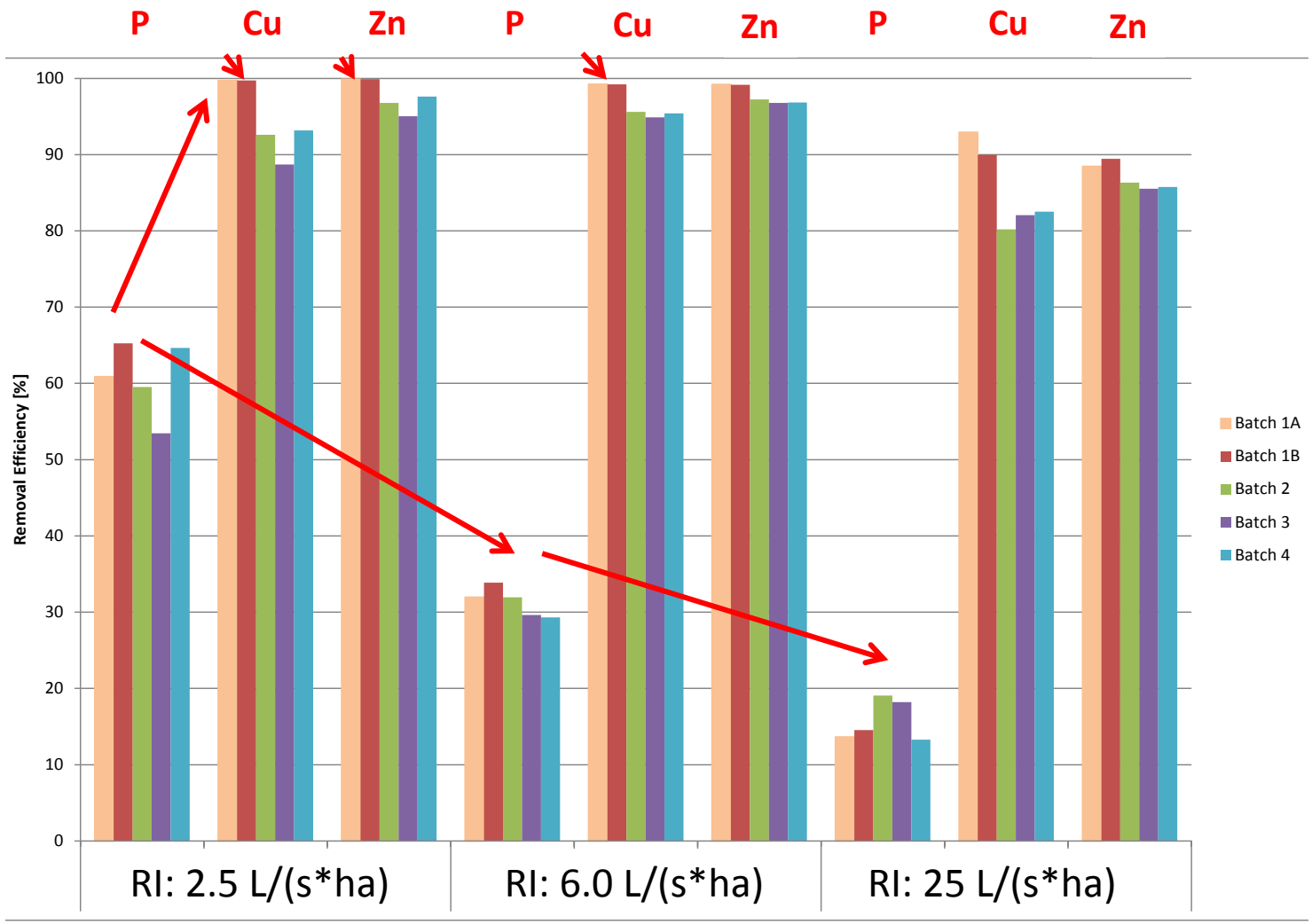
- **Flow-rate**
  - 0.35 L/min, 2.5 L/(s*ha) for 144 min
  - 0.84 L/min, 6.0 L/(s*ha) for 60 min
  - 3.50 L/min, 25 L/(s*ha) for 14 min

2 Material and Methods

Lab-scale column experiments: Variations of removal performance due to **influencing factors**

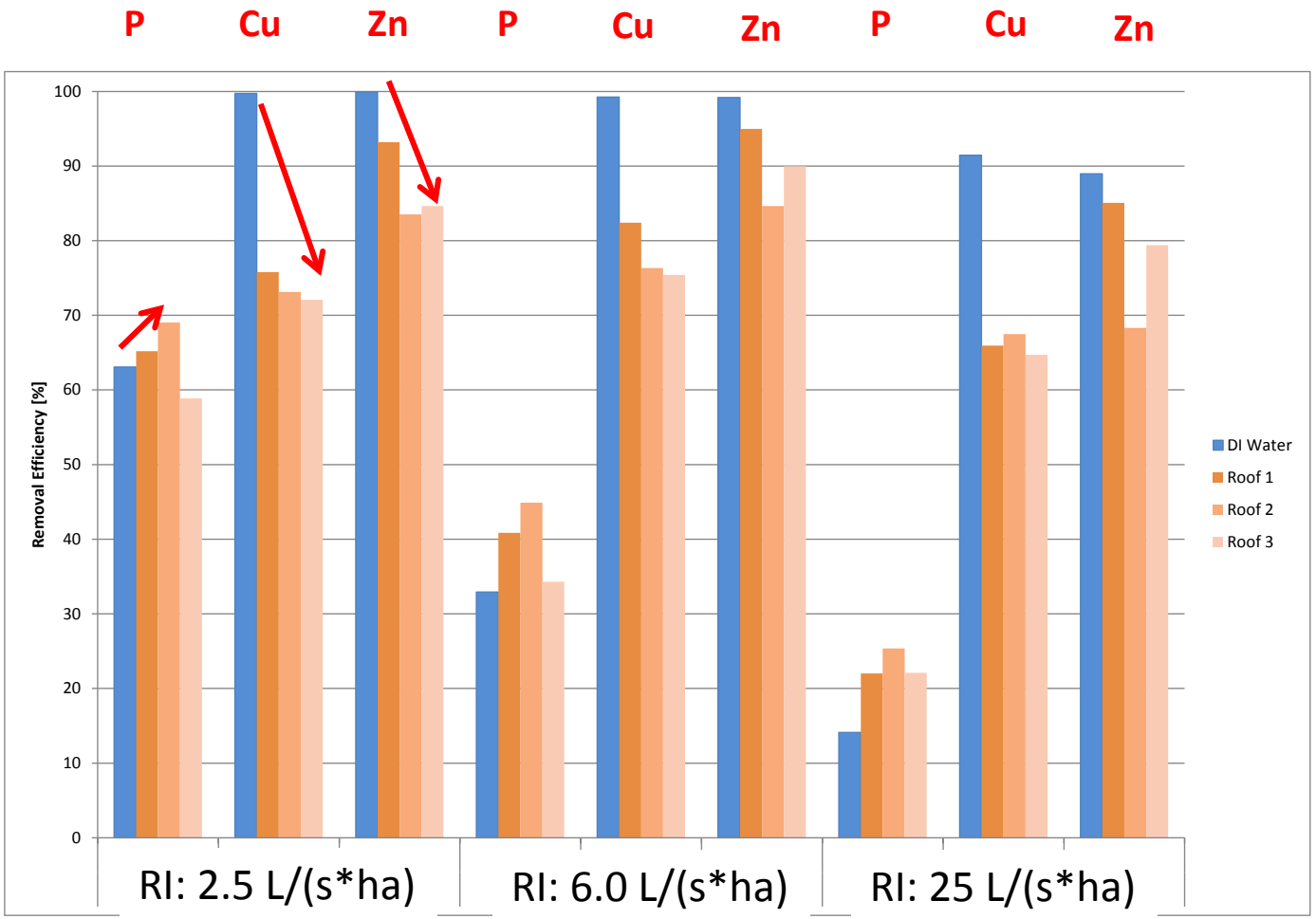
- Composition of the filter media with different **production batches** (especially CaSi)
- **Contact time** as a function of flow-rate
- Presence of **further ions** in the influent simulating real conditions: roof runoff, spiked with Cu, Zn, and PO_4
- **Influence of de-icing salts** NaCl, $CaCl_2$, and $MgCl_2$: remobilization behavior of previously retained substances

3.1 Results (batches, contact time)



- Removal Cu and Zn > PO_4
- Batches from different production sites show different removal capacities
- Strong relation to the contact time, especially for PO_4

3.2 Results (DI, real matrices)

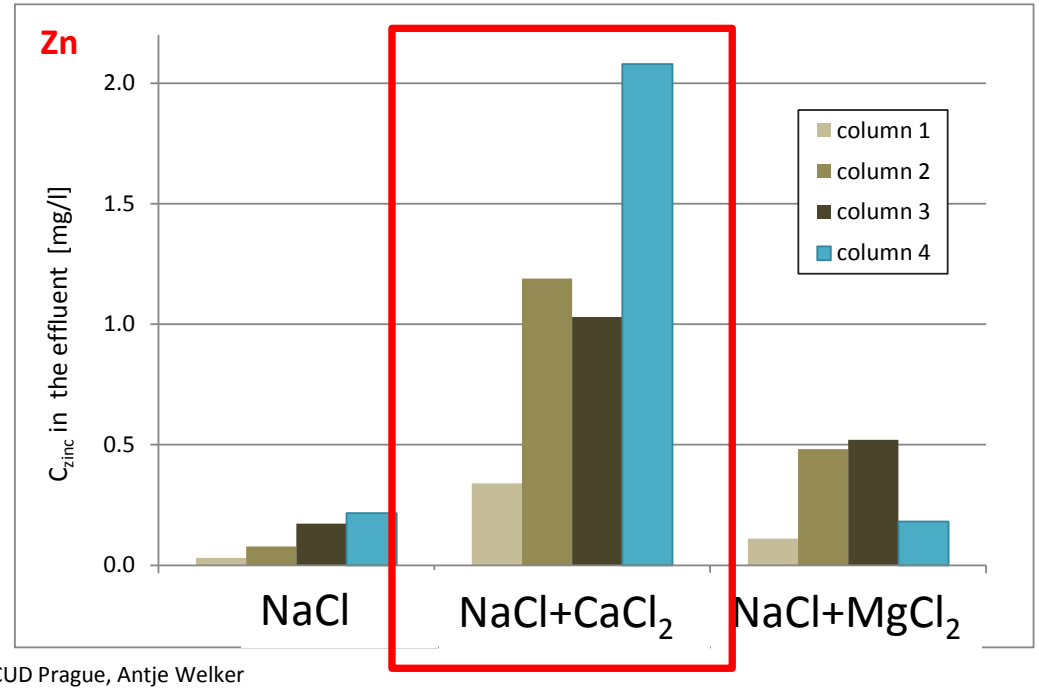


- Slight increase of the PO_4 removal
- Significant decrease of the removal efficiencies of both heavy metals.

3.3 Results (filter years, de-icing salts)

- Investigations on the **life of filter years** according to the retention of dissolved Cu and Zn → 3 years *

- Influence of **de-icing salts**
  - NaCl and $MgCl_2$ → small effects on the remobilization of the previously retained substances (PO_4>Zn>Cu)
  - $CaCl_2$ → Zn was released significantly **



* Huber, H., Welker, A., Dierschke , M., Drewes, J., Helmreich, B (2016b). A novel test method to determine the filter material service life of decentralized systems treating runoff from traffic areas Journal of Environmental Management 179, 66-75

**Huber, M., Hilbig, H., Badenberg, S.C., Fassnacht, J., Drewes, J.E., Helmreich, B., (2016c). Heavy Metal Removal Mechanisms and Remobilization under De-icing Salt Applications using Lab-scale Column Experiments. Water Research, 102 (2016) 453-463

4 Conclusions and outlook

- **Column experiments** are appropriate to determine significant **influencing factors** of the removal processes of Cu, Zn, and PO_4

- Consequences for the **field monitoring:**
  - **Removal efficiencies of Cu and Zn is higher compared with PO_4** by the developed filter combination
    → depending on the treatment goal variations in bed height are possible
  - Retention performance of CaSi is varying in different production batches
    → **guaranteeing simultaneous treatment performances** enforces measures for comparable filter material quality
  - Strong relation to the **hydraulic load**
    → dimension of the treatment plant (maximum inflow)
  - Influence of winter period by **de-icing salts**, especially Zn in case of $CaCl_2$
  - Removal is influenced by **further ions**
    → possibly varying efficiencies in the field test

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