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Filtration studies on concrete and agglomerated CDW filter media

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Lahti



UNIVERSITY OF HELSINKI

 **LUT**
University



Smiltene novads
sanāk!



HOL
HARJUMAA OMAVALITSUSTE LIIT

Aim of the study

Evaluate the performance of different reactor fillings as potential filter material for stormwater treatment using pilot-scale columns.

Two different reactor fillings were studied

- Concrete-based construction and demolition waste (CDW)
- Agglomerated CDW composed of
 - 80% CDW
 - 20% plastic (LDPE)

Investigate the effect of particle size on treatment efficiency.

Identify the most effective filter material and particle size for real life application

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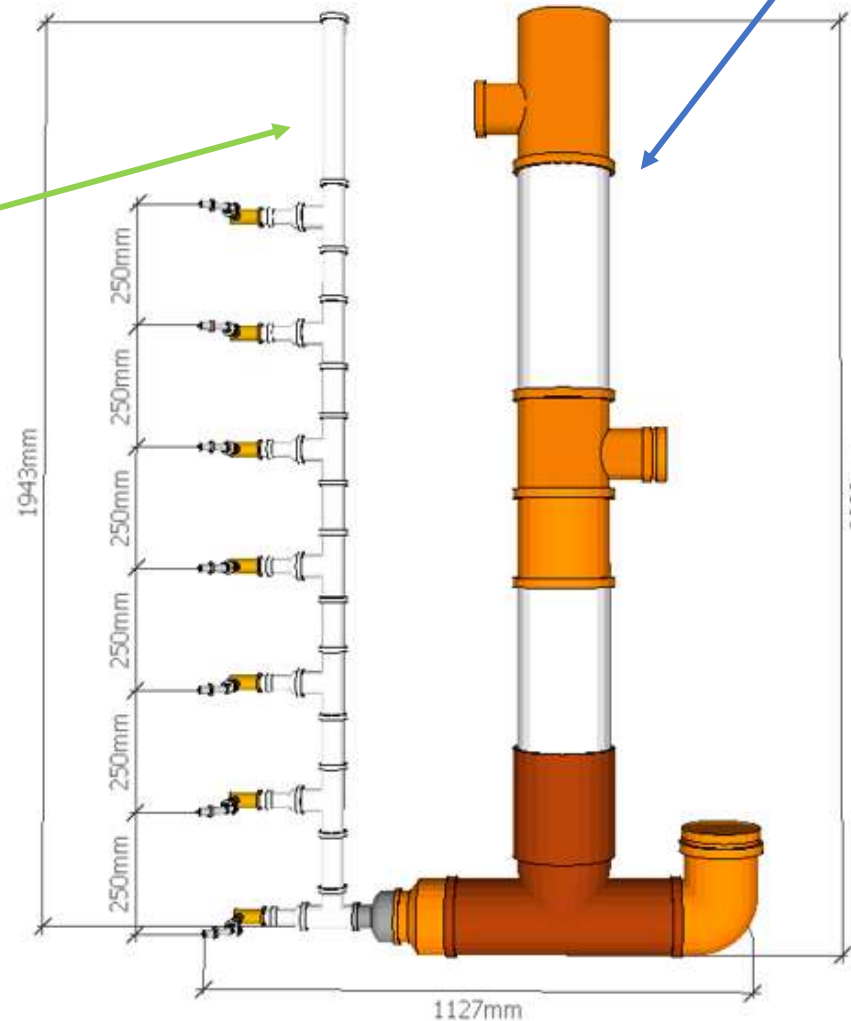
Reactors (1)

Three pilot scale reactors were constructed in TalTech

- Downflow filter
- Simulated stormwater pumped into the top of reactors with pumps

Left column:

- Not filled with filter material
- Used to regulate water level in reactor and to take outlet samples
- Column diameter: 50 mm



Right column:

- Filled with filter material
- Column diameter: 200 mm



Photo 1. Schematic and photo of reactor

Reactors (2)



Photo 2. Reactors filled with CDW

Reactor fillings: concrete based CDW

Reactor fillings supplied by ATI GRUPP OÜ

Waste code: 17 01 01

Three fractions were studied:

- 5–25 mm (Reactor 1)
- 16–32 mm (Reactor 2)
- 2.5–5 mm (Reactor 3)

Waste code: 17 01 01 (concrete)

Fraction: 16-32 mm



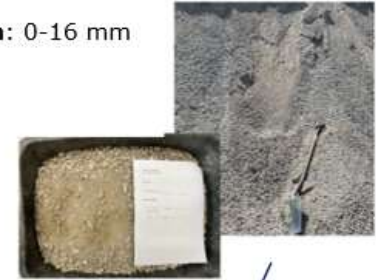
Photo 4. Composition and fraction of CDW used in the second reactor (Reactor 2)

Waste code: 17 01 01 (concrete)

Fraction: 0-25 mm



Fraction: 0-16 mm



Mixed and sieved samples (5-25 mm)



Photo 3. Composition and fraction of CDW used in the first reactor (Reactor 1)



Photo 5. CDW sample with a fraction of 0-5 mm and a fraction of 2.5-5 mm of the packed bed in the third reactor (Reactor 3)

Reactor fillings: agglomerated CDW

Agglomerates (CDW 80%, LDPE 20%) were produced by Lappeenranta–Lahti University of Technology LUT
Three fractions were studied:

- <4 mm (Reactor 1)
- equal mix of <4 mm and >4 mm (Reactor 2)
- >4 mm (Reactor 3)



Photo 6. Fraction <4 mm



Photo 7. Fraction >4 mm



Photo 8. Reactor 1 (left), reactor 2 (middle) and reactor 3 (right)

Analytical methods

Type	Parameter	Analytical instrument/method
Cations	Sodium (Na ⁺), Ammonium (NH ₄ ⁺), Potassium (K ⁺), Calcium (Ca ²⁺), Magnesium (Mg ²⁺)	Ion chromatography with conductivity detector (IC-CD)
Anions	Fluoride (F ⁻), Chloride (Cl ⁻), Nitrite (NO ₂ ⁻), Nitrate (NO ₃ ⁻), Sulphate (SO ₄ ²⁻), Phosphate (PO ₄ ³⁻)	
Heavy metals*	Zinc (Zn)	Inductively coupled plasma optical emission spectroscopy/ mass spectrometry
	Copper (Cu)	
-	TOC	Total Organic Carbon/Total Nitrogen (TOC/TN) analyzer
	TIC	
	TN	
	pH	pH - meter
	EC	Electrical conductivity meter
	Bacteria (<u>only analysed</u> in agglomerated CDW filled experiments)	Epifluorescence microscopy

Results: concrete based CDW (1)

Simulated stormwater experiment period:

- Reactor 1 *February – September 2024*
- Reactor 2 *February – October 2024*
- Reactor 3 *February – June 2024*

Graph units: L/S – volume of simulated stormwater passed through reactors divided by initially packed filter media weight

- Reactor 1 – 48.1 kg
- Reactor 2 – 45.3 kg
- Reactor 3 – 40.0 kg

Elevated pH in effluent samples

- Residual alkalinity of concrete
 - E.g. Leaching of calcium hydroxide
- Dependent on fraction size
 - Reactor 3 (2.5-5 mm) > Reactor 1 (5-25 mm) > Reactor 2 (16-32 mm)

Optimal pH for biodegradation processes is usually in the range of 6.5 to 8.5

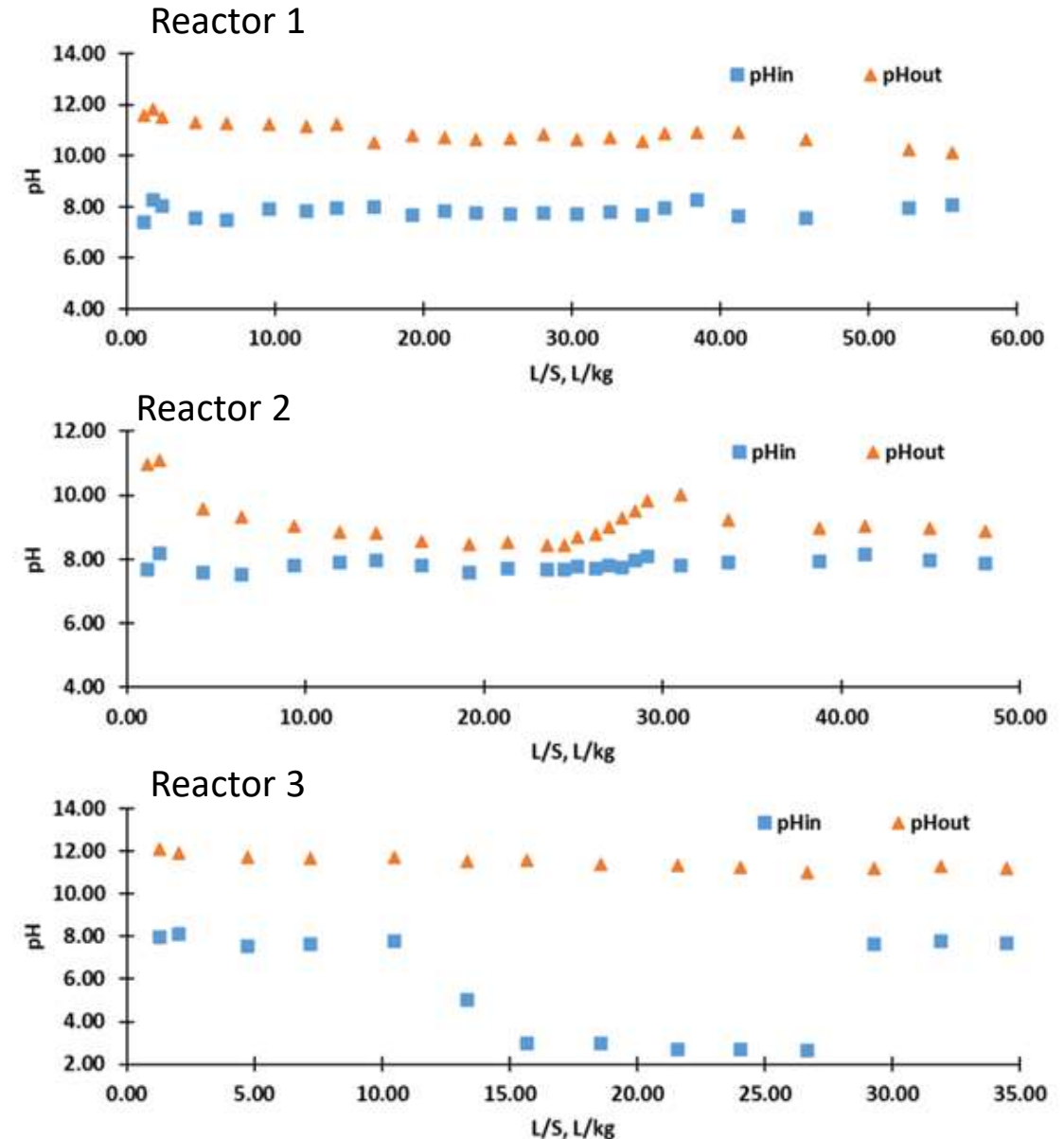


Figure 1. pH values at the inlet and outlet versus the

Results: concrete based CDW (2)

Negligible change in total nitrogen

- No visible biofilm formation in reactors

High removal (>80%) of Cu and Zn in effluent

- Initial concentrations:
 - Zn – 120 µg/L
 - Cu – 100 µg/L

Most optimal fractions for field studies (from concrete based CDW):

- 16–32 mm (Reactor 2)

Table 1 Results of measuring the concentrations of zinc and copper at the outlet of reactors

Reactor nr.	Parameter	Concentration, µg/L				
Reactor 1	L/S	1.8	6.8	14.2	38.4	
	Zn	<20	<20	<20	34	
	Cu	23	25	<20	20	
Reactor 2	L/S	1.8	6.4	13.9	25.2	29.1
	Zn	<20	<20	21	160	150
	Cu	<20	49	56	52	34
Reactor 3	L/S	2.0	7.2	15.7		
	Zn	<20	<20	<20		
	Cu	39	<20	<20		

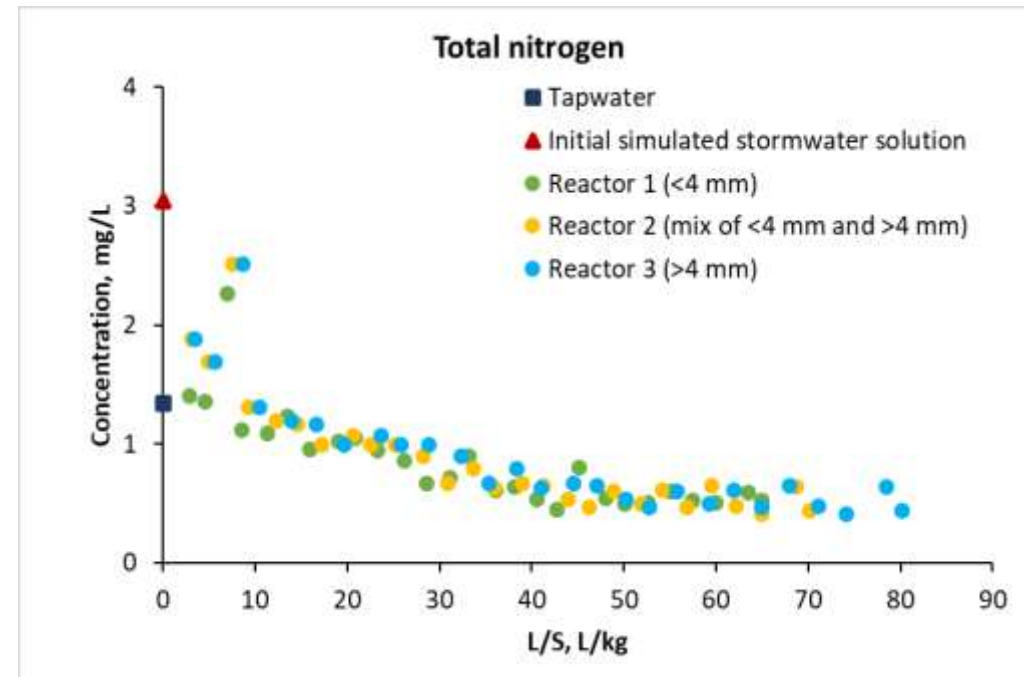
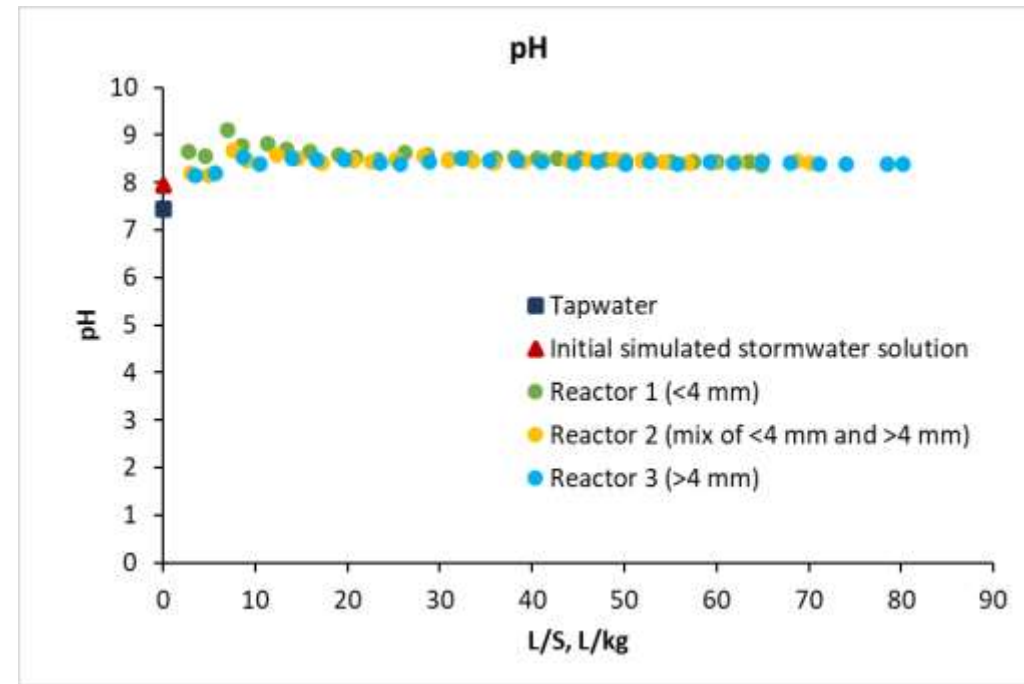
Results: agglomerate CDW (1)

Simulated stormwater experiment period: 11.12.2024 – 16.06.2025

- Reactor 1 – 34.0 kg
- Reactor 2 – 31.5 kg
- Reactor 3 – 27.6 kg

Compared to concrete based CDW-s:

- Significantly less elevated pH in effluent samples
 - Effluent pH stayed around 8.4 – 8.5
- Reduction of total nitrogen
 - Possible indication of biodegradation processes
 - No biofilm growth visible to the naked eye in the reactors



Results: agglomerate CDW (2) Epifluorescence microscopy

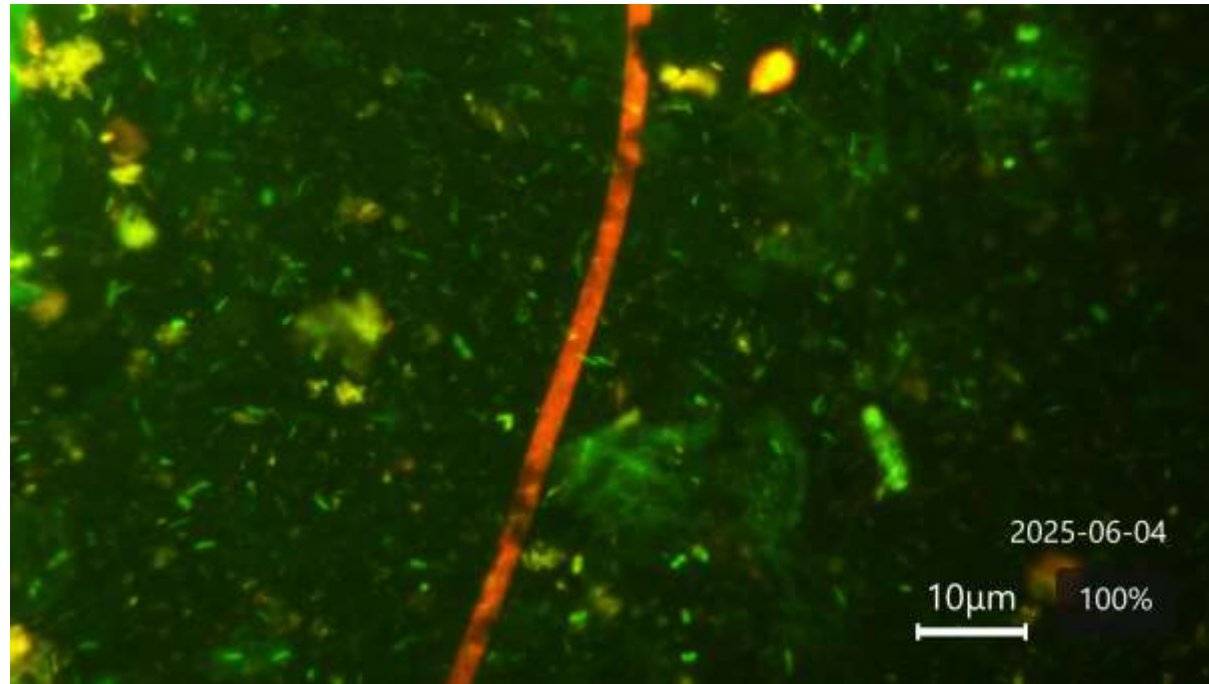


Photo 9. Reactor 2 influent

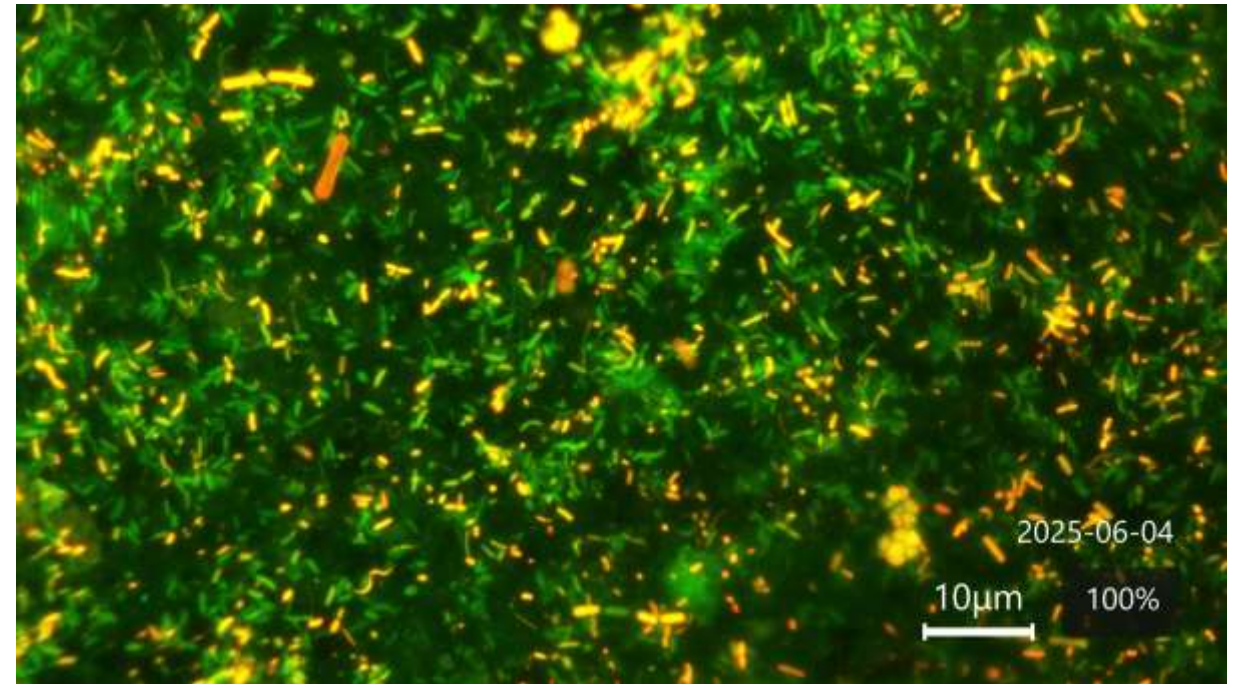


Photo 10. Reactor 2 effluent

Results: heavy metals concentration in effluent

Initial concentrations:

- Zn – 120 µg/L
- Cu - 100 µg/L

Reactor nr.	Parameter	Concentration, µg/L						
Reactor 1	L/S	2.8	8.5	19.1	31.1	45.2	55.1	64.9
	Zn	11	7.5	<20	<20	<20	<20	22
	Cu	8.8	2	<20	<20	<20	<20	28
Reactor 2	L/S	3.1	9.2	20.7	33.6	48.9	59.5	70.2
	Zn	-	14	25	33	<20	27	53
	Cu	9.7	4.5	<20	<20	<20	<20	<20
Reactor 3	L/S	3.5	10.5	23.6	38.4	55.8	68	80.2
	Zn	31	11	<20	<20	24	<20	23
	Cu	10	6.7	<20	<20	<20	<20	21

Conclusions

Concrete-based CDW caused elevated effluent pH due to residual alkalinity, with the strongest effect observed for the smallest particle fraction.

High removal efficiencies (>80%) for zinc (Zn) and copper (Cu) were achieved in both filter material types.

Among the concrete based CDW, the 16–32 mm CDW fraction showed the most favourable performance in treatment of simulated stormwater

Agglomerated CDW maintained a more stable effluent pH (approximately 8.4–8.5) and showed indications of nitrogen reduction, suggesting potential biological activity.

Due to higher production cost associated with agglomerate manufacturing, the **16–32 mm concrete based CDW fraction** was identified as the most practical and cost-effective option for further investigation under **field-scale conditions** in Estonia.

Thank you!

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