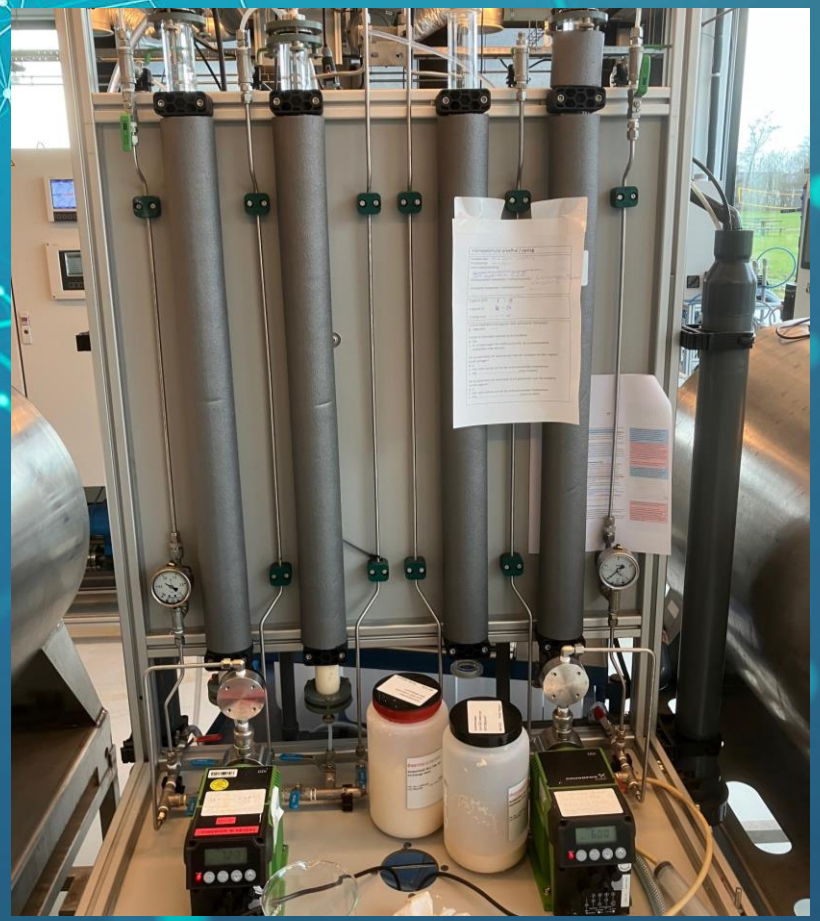


5-02-2025

SFVI overleg

Naar een praktisch inzetbaar zuiveringsmedium

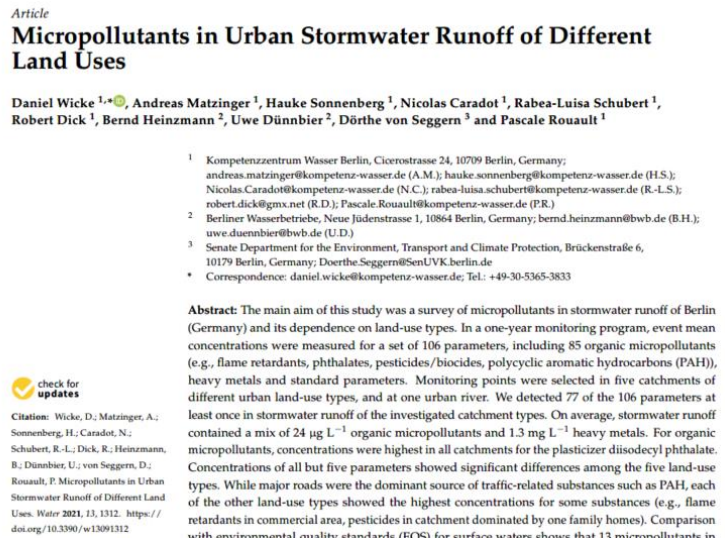
Stoffenlijst

KWR

Bridging Science to Practice

Stoffenlijst op basis van twee uitgebreide studies naar antropogene stoffen in afstromend hemelwater

- In Stowa database beperkt aantal stoffen (zwaartepunt PAK en zware metalen)
- Aanwijzingen dat er een veel groter aantal (deels ZZS) stoffen in afstromend hemelwater zit.
- Uitgebreide studies Parijs e.o. en Berlijn e.o. (2021 en 2022) verschillende gebieden, verkeersintensiteiten etc:



Article

Micropollutants in Urban Stormwater Runoff of Different Land Uses

Daniel Wicke [1,*], Andreas Matzinger [1], Hauke Sonnenberg [1], Nicolas Caradot [1], Rabea-Luisa Schubert [1], Robert Dick [1], Bernd Heinzmann [2], Uwe Dünnbier [2], Dörthe von Seggern [3] and Pascale Rouault [1]

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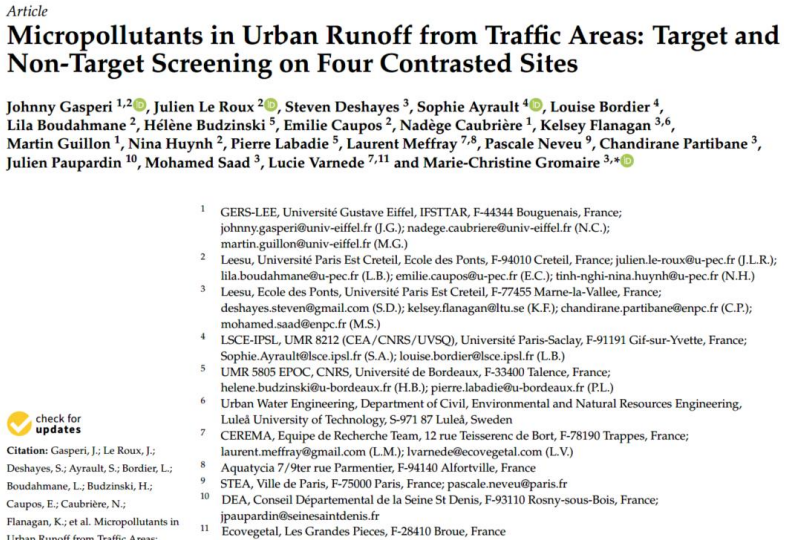
[2] Berliner Wasserbetriebe, Neue Jüdenstrasse 1, 10864 Berlin, Germany; bernd.heinzmann@bwb.de (B.H.); uwe.duennbier@bwb.de (U.D.)
[3] Senate Department for the Environment, Transport and Climate Protection, Brückenstraße 6, 10179 Berlin, Germany; Doerthe.Seggern@SenUVK.berlin.de
* Correspondence: daniel.wicke@kompetenz-wasser.de; Tel.: +49-30-5365-3833

Abstract: The main aim of this study was a survey of micropollutants in stormwater runoff of Berlin (Germany) and its dependence on land-use types. In a one-year monitoring program, event mean concentrations were measured for a set of 106 parameters, including 85 organic micropollutants (e.g., flame retardants, phthalates, pesticides/biocides, polycyclic aromatic hydrocarbons (PAH)), heavy metals and standard parameters. Monitoring points were selected in five catchments of different urban land-use types, and at one urban river. We detected 77 of the 106 parameters at least once in stormwater runoff of the investigated catchment types. On average, stormwater runoff contained a mix of 24 µg L^{-1} organic micropollutants and 1.3 mg L^{-1} heavy metals. For organic micropollutants, concentrations were highest in all catchments for the plasticizer diisodecyl phthalate. Concentrations of all but five parameters showed significant differences among the five land-use types. While major roads were the dominant source of traffic-related substances such as PAH, each of the other land-use types showed the highest concentrations for some substances (e.g., flame retardants in commercial area, pesticides in catchment dominated by one family homes). Comparison with environmental quality standards (EQS) for surface waters shows that 13 micropollutants in

check for updates

Citation: Wicke, D.; Matzinger, A.; Sonnenberg, H.; Caradot, N.; Schubert, R.-L.; Dick, R.; Heinzmann, B.; Dünnbier, U.; von Seggern, D.; Rouault, P. Micropollutants in Urban Stormwater Runoff of Different Land Uses. *Water* **2021**, *13*, 1312. https://doi.org/10.3390/w13091312



Article

Micropollutants in Urban Runoff from Traffic Areas: Target and Non-Target Screening on Four Contrasted Sites

Johnny Gasperi [1,2], Julien Le Roux [2], Steven Deshayes [3], Sophie Ayrault [4], Louise Bordier [4], Lila Boudahmane [2], Hélène Budzinski [5], Emilie Caupos [2], Nadège Caubrière [1], Kelsey Flanagan [3,6], Martin Guillon [1], Nina Huynh [2], Pierre Labadie [5], Laurent Meffray [7,8], Pascale Neveu [9], Chandirane Partibane [3], Julien Paupardin [10], Mohamed Saad [3], Lucie Varnede [7,11] and Marie-Christine Gromaire [3,*]

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[7] CEREMA, Equipe de Recherche Team, 12 rue Teisserenc de Bort, F-78190 Trappes, France; laurent.meffray@gmail.com (L.M.); lvarnede@ecovegetal.com (L.V.)
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[9] STEA, Ville de Paris, F-75000 Paris, France; pascale.neveu@paris.fr
[10] DEA, Conseil Départemental de la Seine St Denis, F-93110 Rosny-sous-Bois, France; jpaupardin@seinesaintdenis.fr
[11] Ecovegetal, Les Grandes Pieces, F-28410 Broue, France

check for updates

Citation: Gasperi, J.; Le Roux, J.; Deshayes, S.; Ayrault, S.; Bordier, L.; Boudahmane, L.; Budzinski, H.; Caupos, E.; Caubrière, N.; Flanagan, K.; et al. Micropollutants in Urban Runoff from Traffic Areas:

Screening stoffen in afstromend hemelwater

Stof	Concentratie	BKL+ZZS		overschrijding x keer
zinc	1978,53 ug/l	65	>	30,4
zinc dissolved	1231,57 ug/l	65	>	18,9
copper	645,16 ug/l	15	>	43,0
lead	142,32 ug/l	15	>	9,5
copper dissolved	98,80 ug/l	15	>	6,6
total suspended solids (TSS)	98,27 mg/l	0		
chemical oxygen demand (COD)	82,32 mg/l	0		
titanium	46,04 ug/l	0		
total suspended solids <63µm	41,81 mg/l	0		
diisodecyl phthalate + diisononyl phthalate (DIDP + DINP)	28,86 ug/l	1	>	28,9
titanium dissolved	12,40 ug/l	0		
biological oxygen deman (BOD5)	11,87 mg/l	0		
nickel	9,53 ug/l	15	-	0,6
chromium	9,36 ug/l	2	>	4,7
lead dissolved	6,43 ug/l	15	-	0,4
vanadium	4,94 ug/l	0		
tris(2-butoxyethyl)phosphate (TBEP)	3,05 ug/l	1	>	3,1
nickel dissolved	2,76 ug/l	15	-	0,2
diethylhexyl phthalate (DEHP)	2,28 ug/l	0,1	>	22,8
PAH 16 EPA	1,72 ug/l	0		
caffeine	1,55 ug/l	1	>	1,6
benzylbutyl phthalate	1,45 ug/l	0,1	>	14,5
dioctyl phthalate	1,36 ug/l	0,1	>	13,6
cadmium	1,25 ug/l	0,4	>	3,1
vanadium dissolved	1,23 ug/l	0		
nicotine	1,18 ug/l	1	>	1,2

Toetsing op Rijksregels:

- BKL 8.89 Bijlage XIX
- KRW normen voor grondwaterlichamen
- Signaleringswaarde antropogene stoffen (1 of 0.1 ug/l voor ZZS)

Let op: voor PFAS is muv PFOS en PFOA nog 0.1 ug/l aangehouden

Idem voor bisphenol A

Stoffenlijst antropogene stoffen afstromend hemelwater

	substance	PREFERED NAME	CASNR
alkaline earth metals		Barium	7440-39-3
heavy metals	zinc	Zinc	7440-66-6
	zinc dissolved	Zinc (II) cation	23713-49-7
	copper	Copper	7440-50-8
	lead	Lead	7439-92-1
	chromium	Chromium	7440-47-3
	cadmium	Cadmium	7440-43-9
Nutrients	total phosphorus	Phosphorus	7723-14-0
Phtalates	diisodecyl phthalate + diisononyl phthala	Diisodecyl phthalate	26761-40-0
	diethylhexyl phthalate (DEHP)	Di(2-ethylhexyl) phthalate	117-81-7
	dibutyl phthalate	Dibutyl 1,2-benzenedicarboxylate	84-74-2
	dioctyl phthalate	Di(2-ethylhexyl) phthalate	117-81-7
	benzylbutyl phthalate	Benzyl butyl phthalate	85-68-7
		Diisobutyl phthalate	84-69-5
		Dimethoxyethyl phthalate	NOCAS_1353783
		Bis(4-methyl-2-pentyl) phthalate	84-63-9
		Dipentyl phthalate	131-18-0
		Dihexyl phthalate	84-75-3
		Bis(2-butoxyethyl) phthalate	117-83-9
		Dicyclohexyl phthalate	84-61-7
		Di-n-octyl phthalate	117-84-0
		1,2-Benzenedicarboxylic acid, dinonyl ester	84-76-4
Thiazoles	benzisothiazolinone	1,2-Benzisothiazolin-3-one	2634-33-5
	methylthiobenzothiazole	2-(Methylthio)benzothiazole	615-22-5
	hydroxybenzothiazole	Benzothiazolone	934-34-9
	benzothiazole	Benzothiazole	95-16-9
		1,2,3-Benzotriazole	95-14-7
		4-Methyl-1,2,3-benzotriazole	29878-31-7
		5-Methyl-1H-benzotriazole	136-85-6
Organophosphates	tris(2-chloroethyl)phosphate (TCEP)	Tris(2-chloroethyl) phosphate	115-96-8
	tris(2-butoxyethyl)phosphate (TBEP)	Tris(2-butoxyethyl) phosphate	78-51-3

	substance	PREFERED NAME	CASNR
Alkylphenols	bisphenol A	Bisphenol A	80-05-7
	4-tert-octylphenol	4-(1,1-Dimethylethyl)phenol	98-54-4
	4-tert-butylphenol	4-(1,1,3,3-Tetramethylbutyl)phenol	140-66-9
		Bisphenol A	80-05-7
		4-(1,1,3,3-Tetramethylbutyl)phenol	140-66-9
		4-Nonylphenol	104-40-5
		Ethylene glycol nonylphenyl ether	27986-36-3
		Nonylphenoxypolyethoxyethanol	9016-45-9
Pyrines	formyl-amino-antipyrine (FAA)	4-Formylaminoantipyrine	1672-58-8
PAH's	fluoranthene	Fluoranthene	206-44-0
	pyrene	Pyrene	129-00-0
	phenanthrene	Phenanthrene	85-01-8
	chrysene	Chrysene	218-01-9
	benzo[b]fluoranthene	Benzo(b)fluoranthene	205-99-2
	benzo[k]fluoranthene	Benzo[k]fluoranthene	207-08-9
	benz[a]anthracene	Benz(a)anthracene	56-55-3
	benzo[a]pyrene	Benzo[a]pyrene	50-32-8
	indeno[1,2,3-c,d]pyrene	Indeno[1,2,3-cd]pyrene	193-39-5
	benzo[g,h,i]perylene	Benzo[g,h,i]perylene	191-24-2
	anthracene	Anthracene	120-12-7
		Acenaphthylene	208-96-8
		Dibenz[a,h]anthracene	53-70-3
Azines	desethylterbuthylazine	Desethylterbutylazine	30125-63-4
	terbuthylazine	Terbutylazine	5915-41-3
Pesticides	terbutryn	Terbutryn	886-50-0
	diethyltoluamide (DEET)	DEET	134-62-3
	carbendazim	Carbendazim	10605-21-7
	diuron	Diuron	330-54-1
	mecoprop	(+/-)-2-(4-Chloro-2-methylphenoxy)propionic acid	93-65-2
	glyphosate	Glyphosate	1071-83-6
	AMPA	(+/-)-alpha-Amino-3-hydroxy-5-methyl-4-isoxazolepropio	77521-29-0
other	nicotine	(-)-Nicotine	54-11-5
	caffeine	Caffeine	58-08-2
PFA's	perfluorooctanoic acid (PFOA)	Perfluorooctanoic acid	335-67-1
	perfluorooctanesulfonic acid (PFOS)	Perfluorooctanesulfonic acid	1763-23-1
	LNAPFOS		
	BrNAPFOS		

Eerste selectie mogelijke gidsstoffen voor labexperiment

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	chromium	Chromium	7440-47-3
	cadmium	Cadmium	7440-43-9
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	benzylbutyl phthalate	Benzyl butyl phthalate	85-68-7
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		Dimethoxyethyl phthalate	NOCAS_1353783
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		Dipentyl phthalate	131-18-0
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		Bisphenol A	80-05-7
		4-(1,1,3,3-Tetramethylbutyl)phenol	140-66-9
		4-Nonylphenol	104-40-5
		Ethylene glycol nonylphenyl ether	27986-36-3
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	pyrene	Pyrene	129-00-0
	phenanthrene	Phenanthrene	85-01-8
	chrysene	Chrysene	218-01-9
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	benzo[k]fluoranthene	Benzo[k]fluoranthene	207-08-9
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Hoge concentratie in hemelwater, onderscheidend qua molecuulstructuur en tox relevant

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	benzo[a]pyrene	Benzo[a]pyrene	50-32-8
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	benzo[g,h,i]perylene	Benzo[g,h,i]perylene	191-24-2
	anthracene	Anthracene	120-12-7
		Acenaphthylene	208-96-8
		Dibenz[a,h]anthracene	53-70-3
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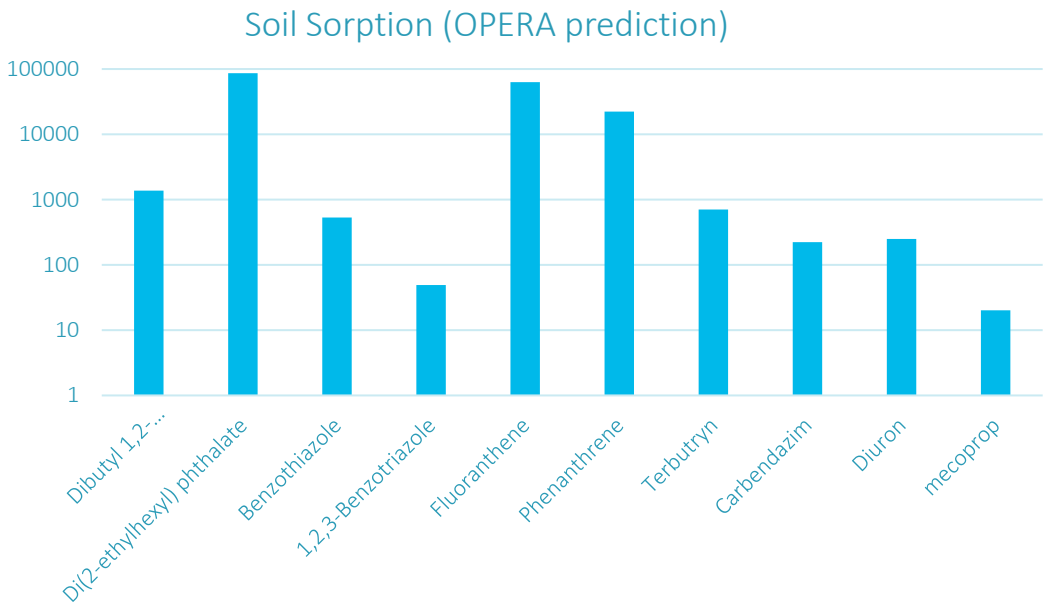
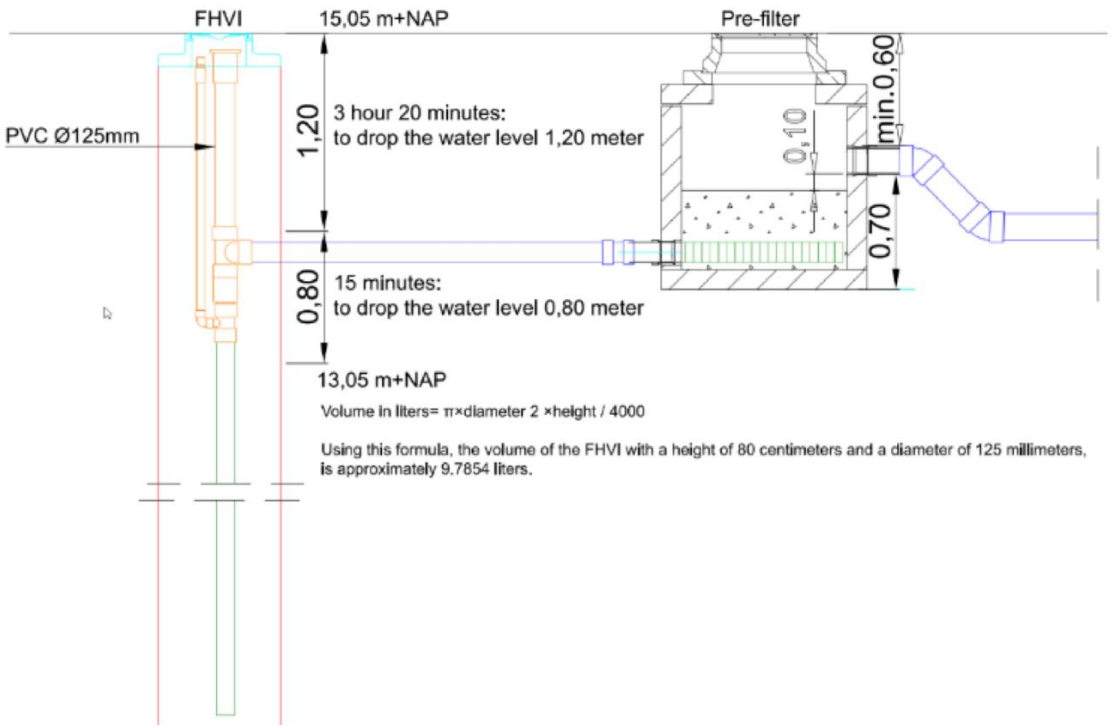


		Gemiddelde concentratie (ug/l)		
Stof	**CAS**	**Parijs**	**Berlijn**	**Stowa**
Zinc	7440-66-6	359	414	165
Copper	7440-50-8	169	63	21
Phosphorus	7723-14-0	722	641	340
Dibutyl 1,2-benzenedicarboxylate	84-74-2	1,72	1,40	
Di(2-ethylhexyl) phthalate	117-81-7	24,76	-	
Benzothiazole	95-16-9	-	1,14	
1,2,3-Benzotriazole	95-14-7	1,81	-	
Fluoranthene	206-44-0	0,49	0,44	0,11
Phenanthrene	85-01-8	0,25	0,17	0,07
Terbutryn	886-50-0	-	0,16	
Carbendazim	10605-21-7	-	0,24	
Diuron	330-54-1	-	0,15	
	93-65-2	-	0,58	

Doel: Verdere zuivering in HWZI pre-filterput



Randvoorwaarden filtermateriaal:

- Hoge doorlatendheid
- Passief belastbaar (geen terugspoeling)
- Eenvoudig verwijderbaar
- Verwijdering organische micro's, metalen en fosfaat
- Regenereerbaar?!

Is steenwol mogelijk als draagmedium voor adsorbens?

Verschillende mogelijk geschikte adsorbens:

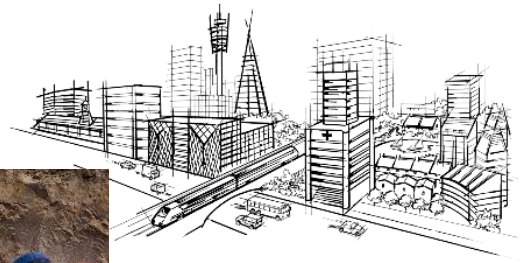
- (gemodificeerde zeolieten)
- Actief kool
- harsen
- IJzer(hydr)oxiden
- …

Mogelijk voordeel bij integratie in steenwol als draagmedium:

- Filtratie en sorptie tegelijkertijd
- Toepasbaar in filterplaten
- Geen inzakking van het bed
- Makkelijk te plaatsen en verwijderen

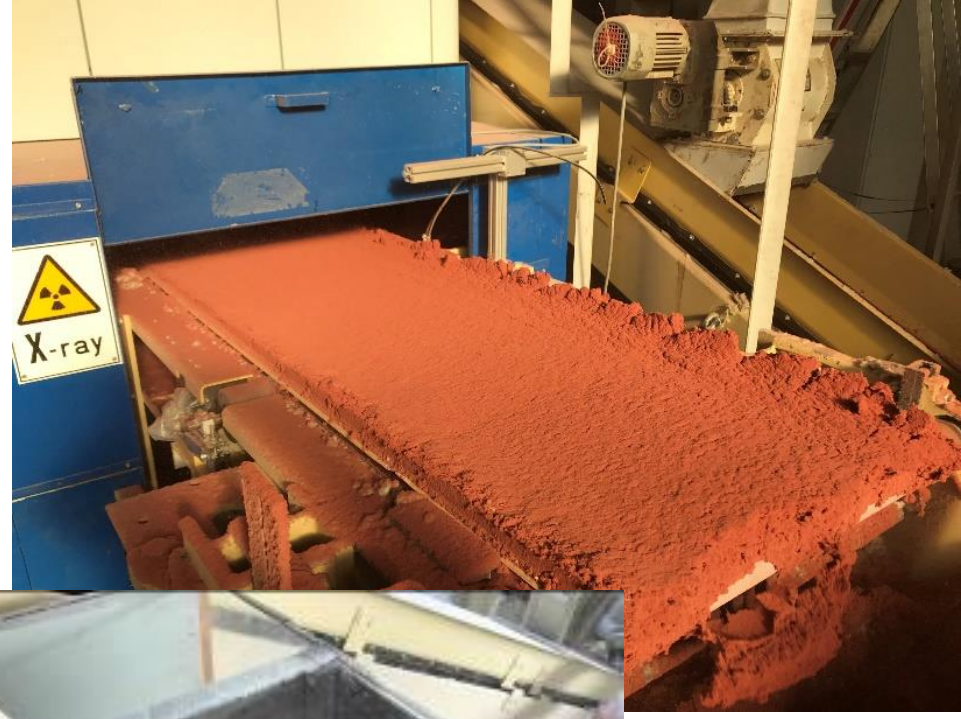
Filter slabs stone wool

February 2025



Addition of additives to stone wool

- Colour board experiments
- Addition of 4% pigment mix at dosing chute
- Use of vacuum spike forming process
- Full homogeneous colouring possible
- Small particle size (fluffy material, flour-like texture) iron oxides used



Parameter	Value GEH Wasserchemie
Chemical composition	β-FeOOH and $Fe(OH)_3$
Solid content	58 wt% (± 10%)
Iron content	600 g/kg (± 10%)
Particle size	0.2 – 2 mm
Bulk density	1150 kg/m^3
Specific surface area (BET)	300 m^2/g

Small scale setup in Denmark

Spike roll

‘Double fluff principle’ to open the wool and mix with binder

Collection box

Collecting the wool after fluffing

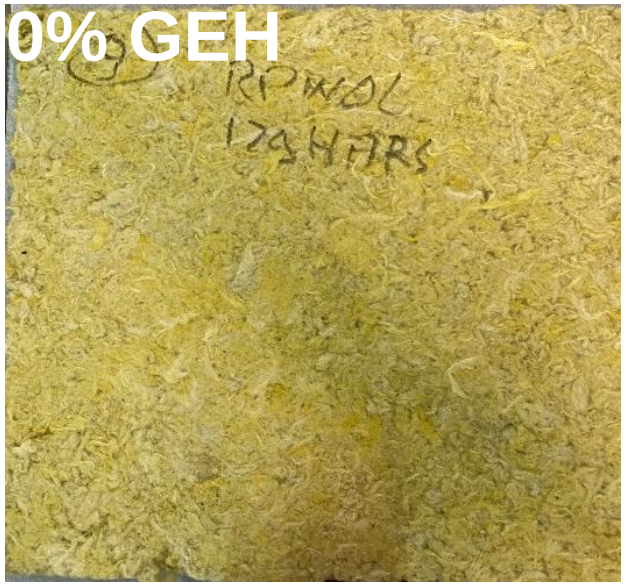
Forming box

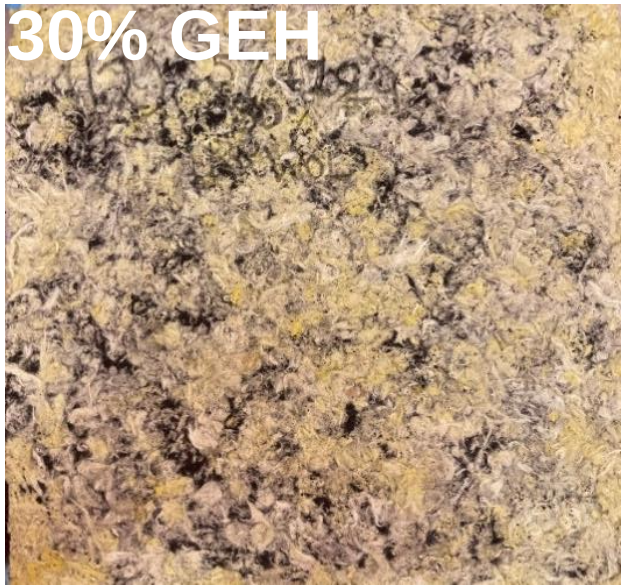
Forming an evenly distributed wool package on top of glass fleece

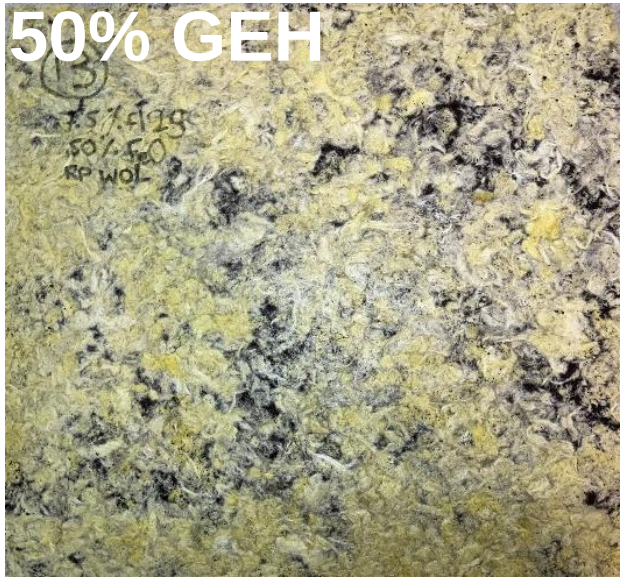
Pressing

Production of 40x40x3 cm stone wool boards

Visual inspection of stone wool boards

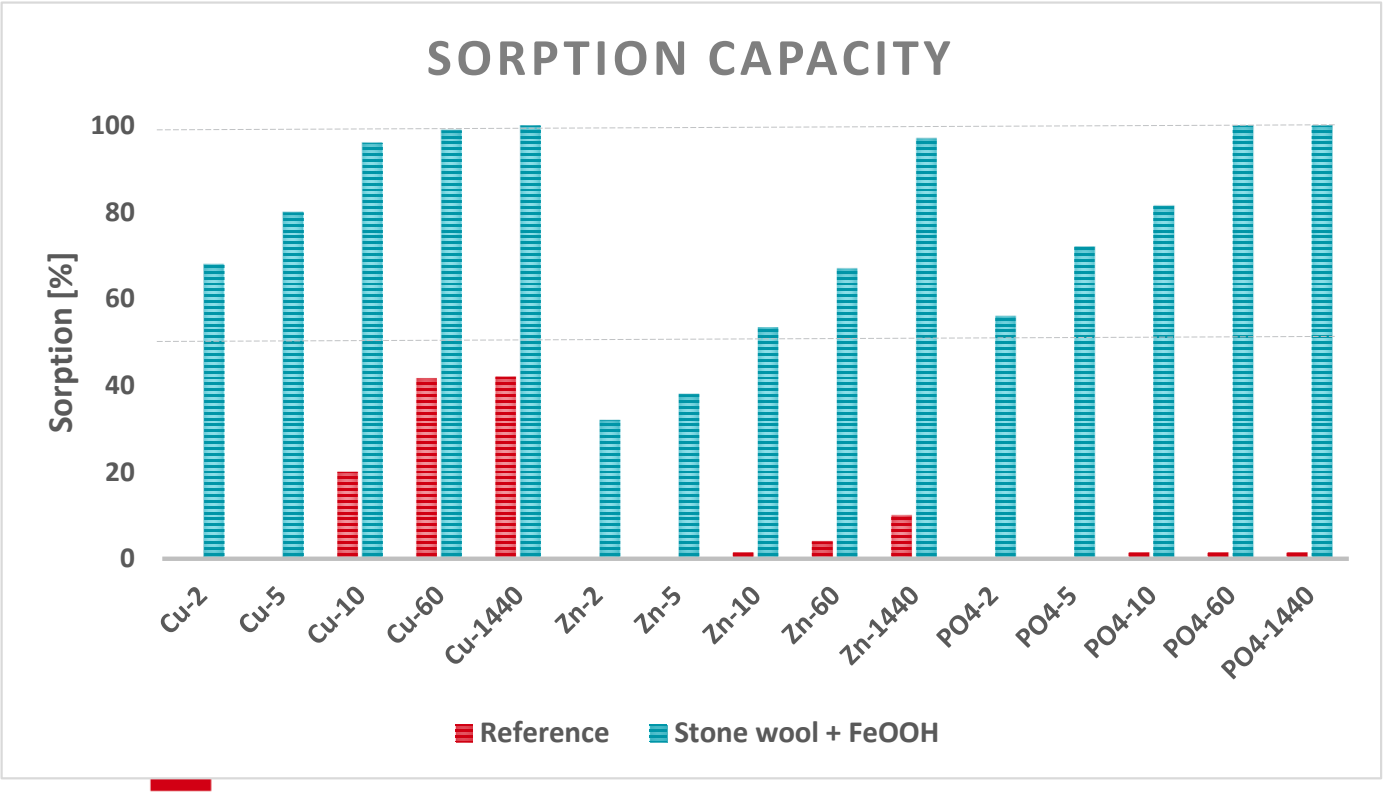






Results

Description	Specific Density [kg/m^3]	Hydraulic conductivity [L/h]	Fmax [kPa]
Reference	119	99	57 ± 10
Stone wool + 30 % GEH	148	83	45 ± 1
Stone wool + 50 % GEH	169	85	31 ± 1



Sorption capacity

- Cu: 178 mg/kg
- Zn: 171 mg/kg
- PO_4: 175 mg/kg
- GEH: 300 mg/kg

Selectie adsorbentia

FiltraSorb 400

FILTRASORB® 400 12x40 TYPICAL PROPERTIES	
Iodine Number, mg/g	1050
Surface Area, (N_2 BET method[1]), m²/g	1050
Methylene Blue Number	300
Methylene Blue Number (CEFIC), ml/0.1g	20
Backwashed and Drained Bed Density[2], kg/m³	475
Floating Content, wt%	0.1
Effective Size, mm	0.7
Mean Particle Diameter, mm	1.1
Uniformity Coefficient	1.7
Phenol loading[3] at 1 mg/l, DIN 19603, %	5.2
Detergent (TPBS) loading[3] at 1 mg/l, mg/g	200
Atrazine loading[3] at 1 µg/l, mg/g	40
Toluene loading[3] at 1 mg/l, mg/g	100
Trichloroethylene loading[3] at 50 µg/l, mg/g	20

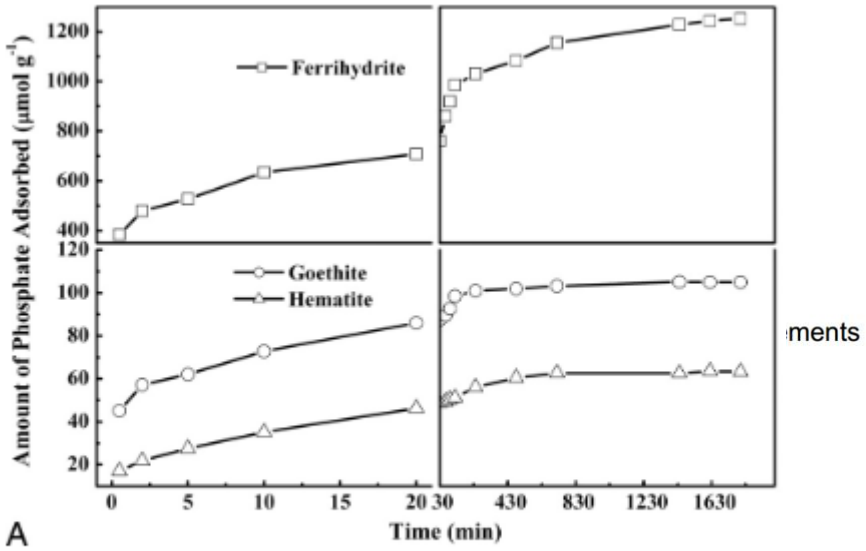


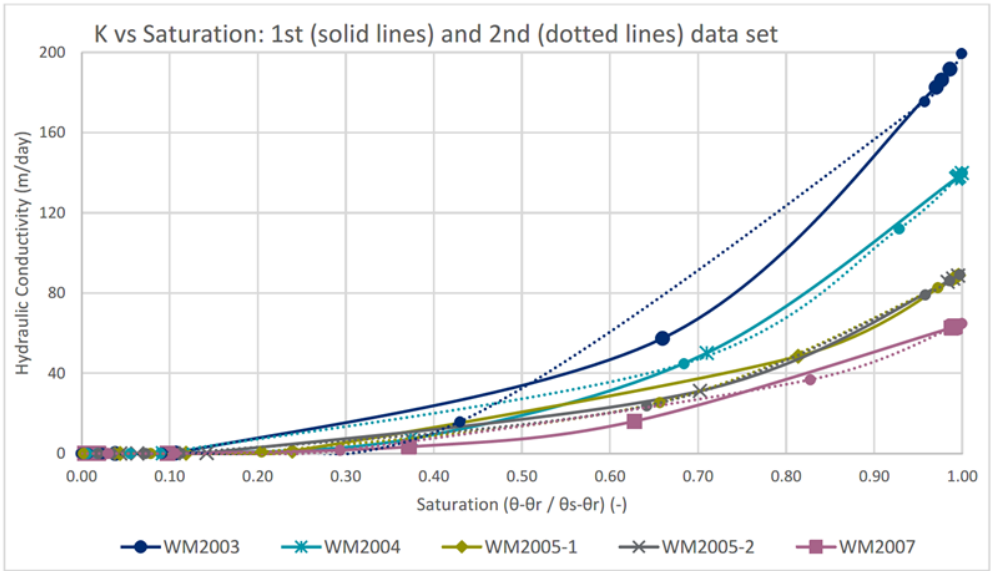
FIG. 4. The kinetic curves of the amount of phosphate adsorbed (A initial phosphate concentration of 50 mg L^{-1}.

ments

Adsorption Capacity:

- AsO_4^{3-}: 9 - 12 g/kg
- PO_4^{3-}: 12 – 16 g/kg
- heavy metals: 5 – 8 g/kg

Zijn contacttijden voldoende?



Simpel darcy sommetje:

- Horizontale stroming door een blok
- 1 meter breed medium
- Verzadigde doorlatendheid ca. 90 m/d
- Variabele dikte filtermedium
- Variabel stijghoogteverhang
- Variabel doorstroomd oppervlak

Zijn contacttijden haalbaar?

Contacttijd (min)

dH over filtermedium (m)

Dikte filtermedium (m)

	0,01	0,05	0,1	0,2	0,4	0,6
0,05	4	1	0	0	0	0
0,1	16	3	2	1	0	0
0,15	35	7	3	2	1	1
0,2	62	12	6	3	2	1
0,25	97	19	10	5	2	2
0,3	140	28	14	7	3	2
0,35	190	38	19	10	5	3
0,4	248	50	25	12	6	4
0,5	388	78	39	19	10	6
0,6	559	112	56	28	14	9
0,7	760	152	76	38	19	13
0,8	993	199	99	50	25	17
0,9	1257	251	126	63	31	21
1	1552	310	155	78	39	26

Equivalente neerslag (mm/uur) uitgaande van 400 m2

dH over filtermedium (m)

Dikte filtermedium (m)

	0,01	0,05	0,1	0,2	0,4	0,6
0,05	0,02	0,47	1,88	7,50	30,00	67,50
0,1	0,01	0,23	0,94	3,75	15,00	33,75
0,15	0,01	0,16	0,63	2,50	10,00	22,50
0,2	0,00	0,12	0,47	1,88	7,50	16,88
0,25	0,00	0,09	0,38	1,50	6,00	13,50
0,3	0,00	0,08	0,31	1,25	5,00	11,25
0,35	0,00	0,07	0,27	1,07	4,29	9,64
0,4	0,00	0,06	0,23	0,94	3,75	8,44
0,5	0,00	0,05	0,19	0,75	3,00	6,75
0,6	0,00	0,04	0,16	0,63	2,50	5,63
0,7	0,00	0,03	0,13	0,54	2,14	4,82
0,8	0,00	0,03	0,12	0,47	1,88	4,22
0,9	0,00	0,03	0,10	0,42	1,67	3,75
1	0,00	0,02	0,09	0,38	1,50	3,38

Uitgaande van minimaal ca. 10 min. contacttijd
(Ferrosorp plus: 5 min)
(Filtrasorb 400: 10 - 30 min (drinkwater 45 min))

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