

Innovative Scenario's for immobilization of Hydrophobic Organic Compounds (HOC) in sediment by Activated Carbon

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Environmental Technology

Biorecovery
Residual streams of cities, industries, agriculture and mines become increasingly attractive as a source of energy, metals, and minerals. Our research focuses on bio-based technologies for recovery of valuable components from these sources in the form of fuels, electricity, sulphur, copper, and phosphate.

Reusable Water
Water shortage threatens billions of people. Reuse and protection of our water sources are essential. Our research focuses on removal of salts, nutrients, pathogens and micropollutants from water.

Urban Environmental Technology & Management
The speed and scale of urbanization, especially in the developing world do not cope with basic urban services. Our research focuses on development of sustainable concepts and technologies for urban water, sanitation, waste and energy management.

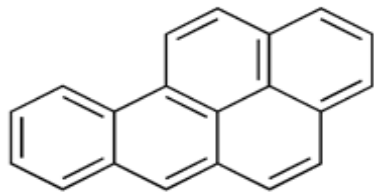
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The infographic also features three circular icons: 'Biorecovery' with a battery symbol, 'Reusable Water' with a water drop, and 'Urban Environmental Technology & Management' with a building and tree icon.

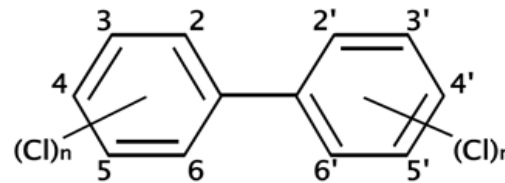
Hydrophobic Organic Compounds (HOC): bind to organic and mineral constituents of heterogeneous sediment matrix

Non-polar
Persistent
Toxic
Low H₂O
soluble

PAH



PCB



Amorphous Organic Carbon
(soil organic matter)

- relatively low affinity for HOC

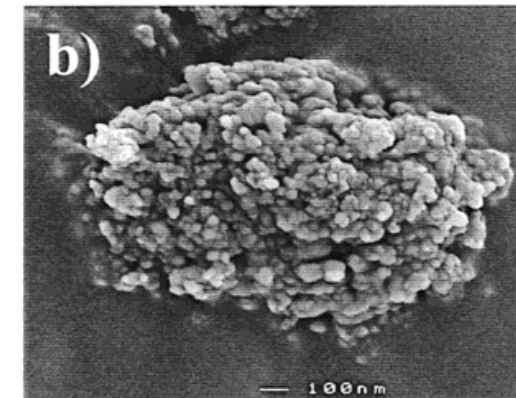
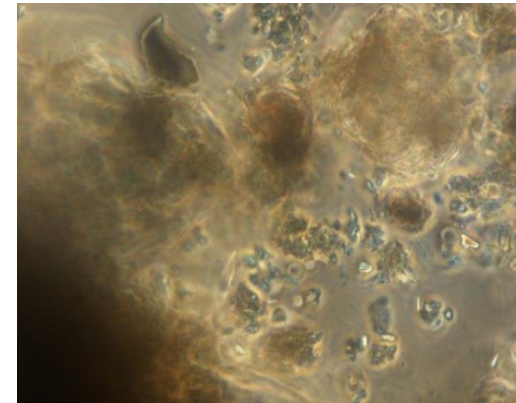
Fast release



Condensed Organic Carbon
(soot, char, black carbon)

- high affinity for HOC

Slow release



Problem definition

Wetland Passewaaij, Tiel



Grote Veenderplas, Ede
(Shift from deep to shallow pits)



Harbour Antwerp



Zuidplas polder
(Reuse of sediment)



Immobilization of HOC in sediment by Activated Carbon?



- Dose
- Particle size
- Mixing regime
- Contact time

AC should result in:

- Reduction dissolved HOC concentrations in pore water (C_{pw})
 - laboratory
 - field test
- Reduced bioaccumulation and toxicity of HOCs in benthic invertebrates

Pilot test at Field scale with AC application

Sediment:

Biesbosch

Σ PAH: 11 mg/kg dm

Σ PCB: 0,7 mg/kg dm

44 ton

Ditches:

Length: 15 m

Width: 1.5 to 2.5 m

Depths: 1.5 m



Start: December 2011, End: September 2012



Treatment scenarios

D1

Control

No treatment

3 h mixing

D2

PAC (Powder Activated Carbon)

4% nominal

PAC mixed/raked into sediment top

D3

GAC (Granular Activated Carbon)

3~4%

GAC mixed for 3h

D4

Stripped (GAC addition and removal)

3~4%

GAC mixed for 48h → sieved at 1 mm



Delivery sediment to 4 Ditches



Control

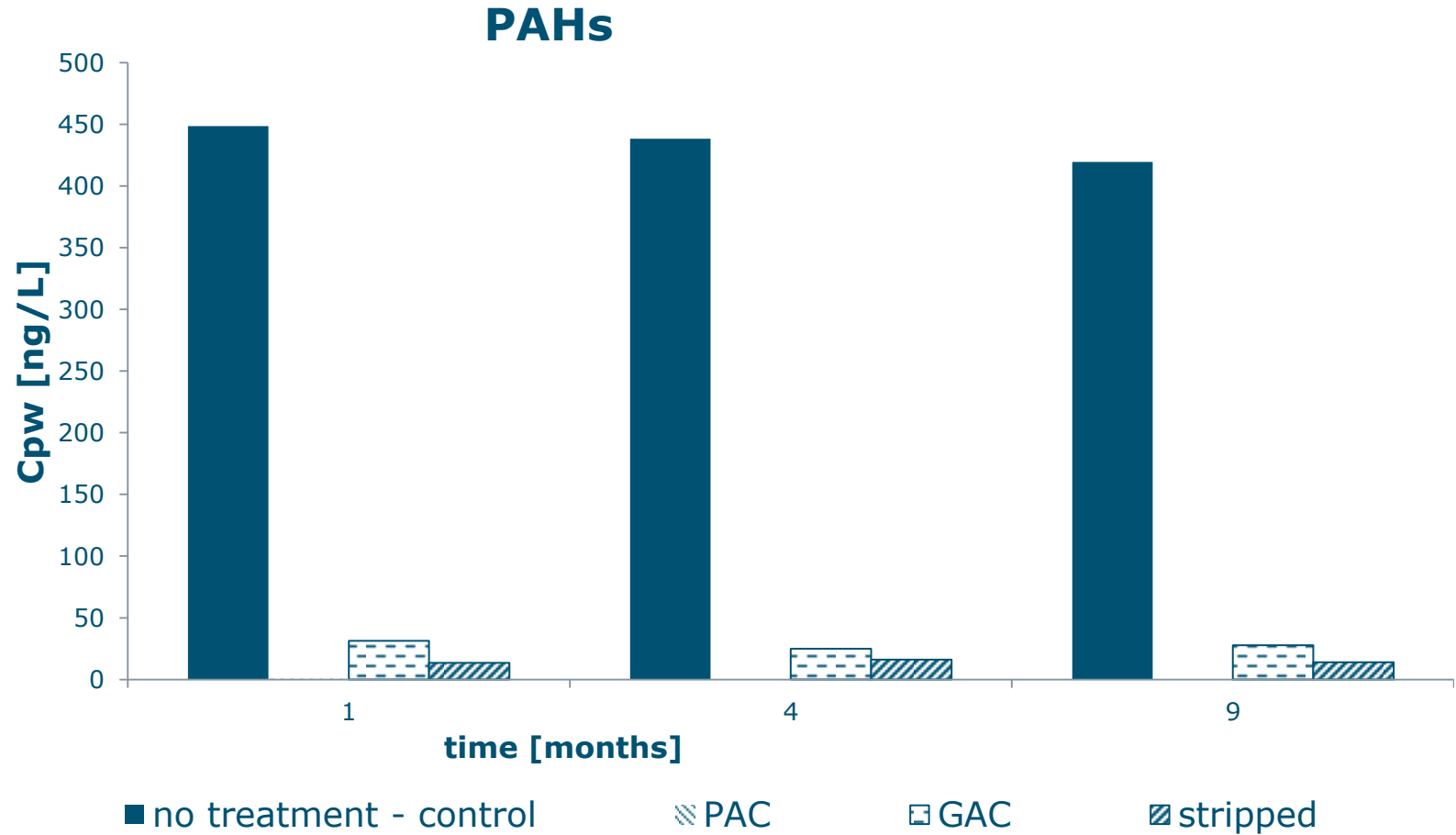
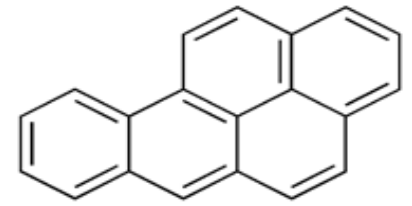
PAC added

GAC added

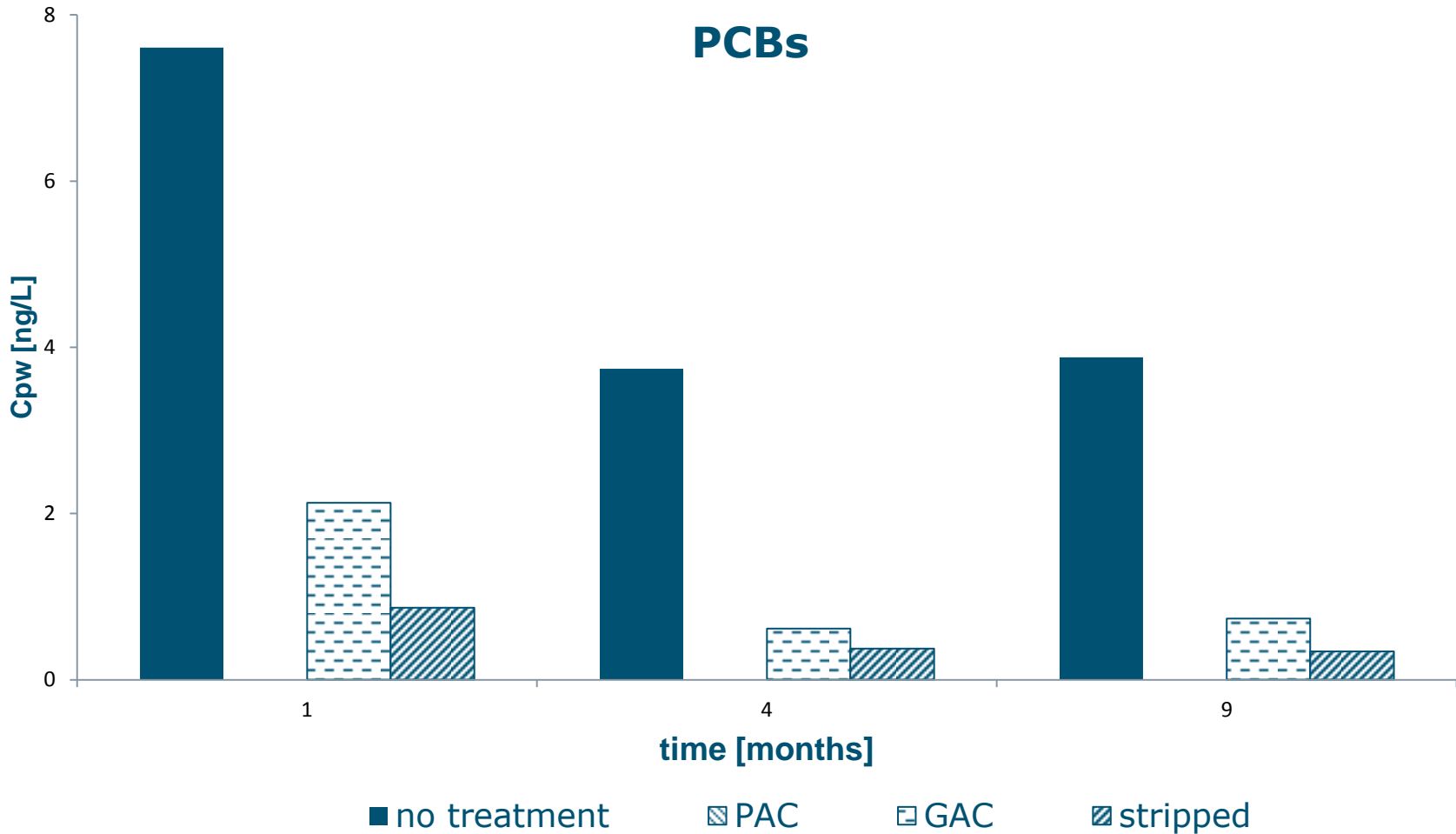
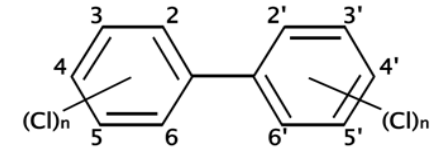
GAC stripped



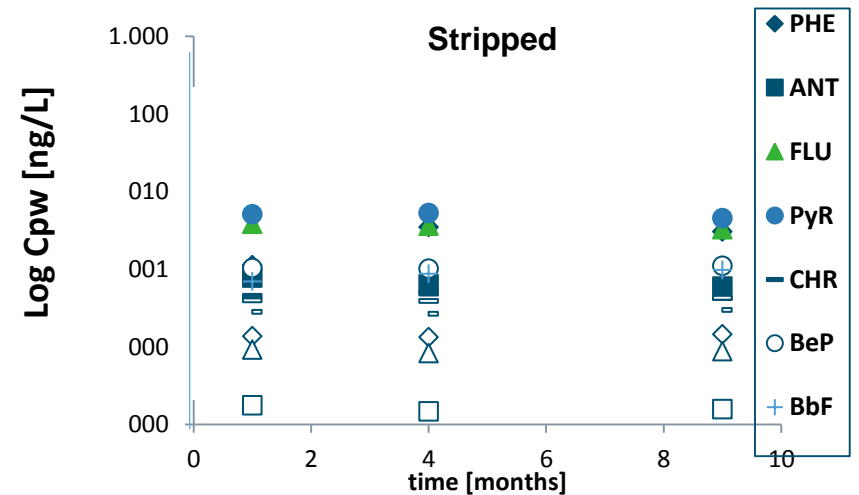
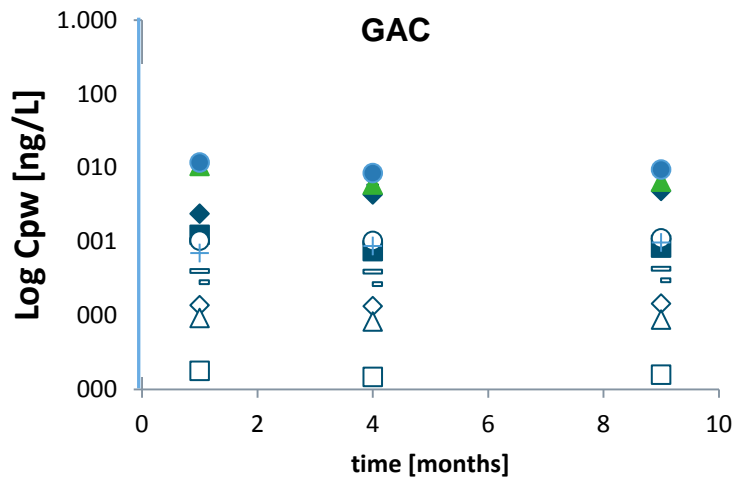
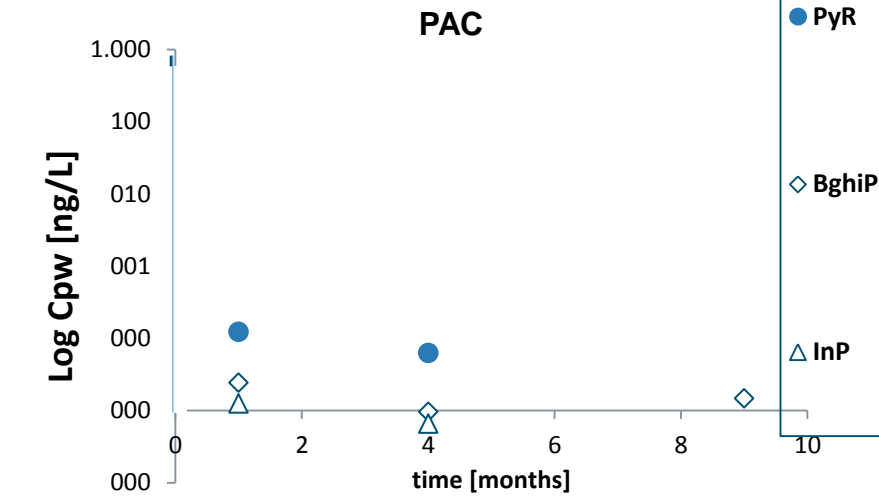
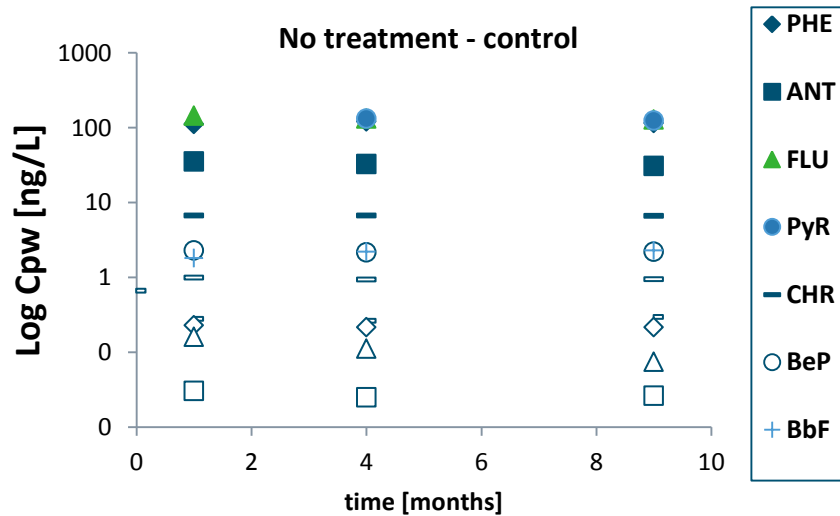
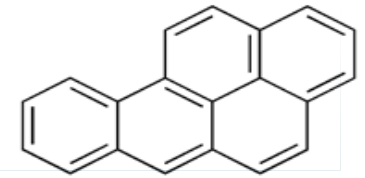
Pore water concentration (C_{pw}) (method: POM-SPE)



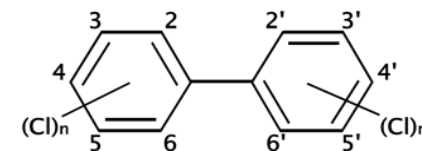
Pore water concentration (C_{pw}) (method: POM-SPE)



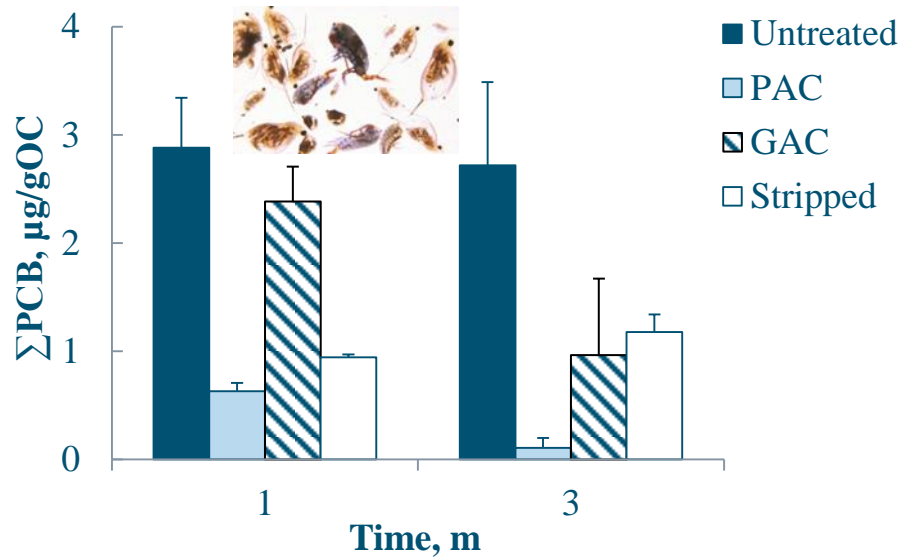
Individual PAH C_{pw}



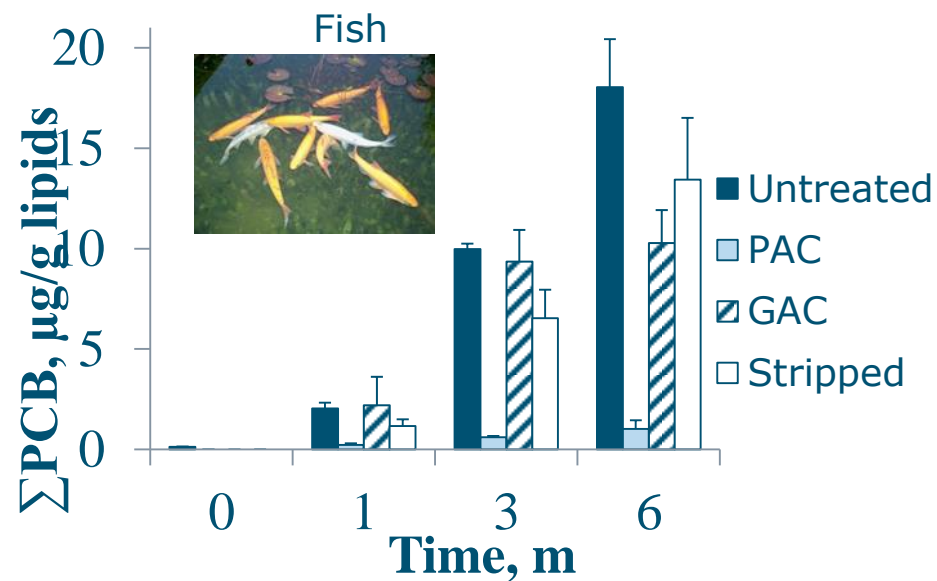
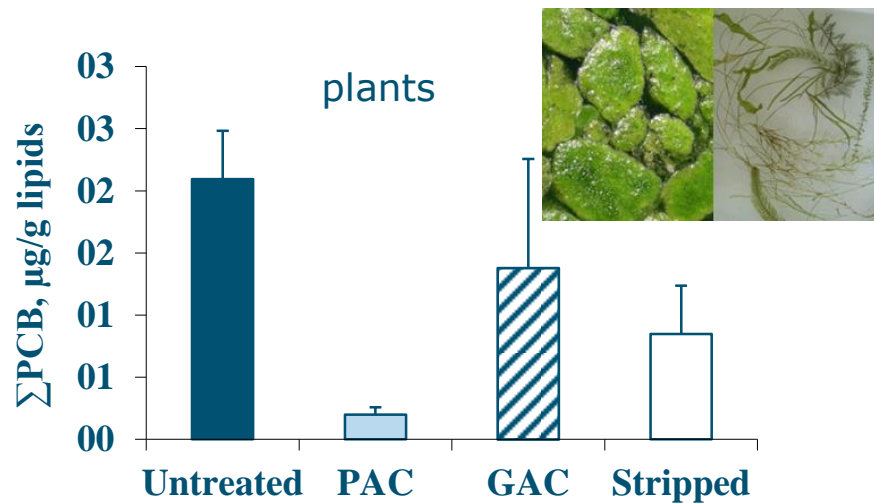
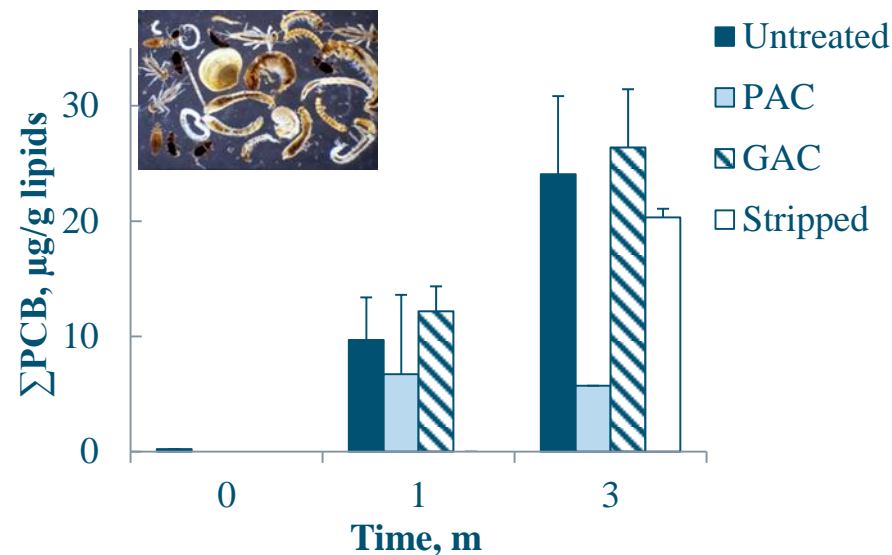
Effect on bioaccumulation PCBs



Zooplankton



Macro invertebrates



Conclusions Field test:

- AC effect on reducing HOC pore water and fluxes decrease in the order PAC > stripped > GAC
(factor 100 to 10)
- PAC reduces PCB bioaccumulation in zooplankton, macroinvertebrates, plants and fish
- Sorption to PAC is faster than GAC



Outlook for AC immobilization concepts

Wetland Passewaaij, Tiel



Grote Veenderplas, Ede
(Shift from deep to shallow pits)



Harbour Antwerp



Zuidplas polder
(Reuse of sediment)



AC immobilization concepts

■ Powder Activated Carbon (PAC):

- Wetland: PAC capping
- Deep ponds: PAC encapsulation

■ Granular Activated Carbon (GAC):

- Harbors: GAC mixed in sediment
- Reuse sediment: GAC extraction/separation





Nieuwe technologie
mogelijk maken



leading in purification



Boskalis

Deltares

Enabling Delta Life



rivm



**de Vries
& van de Wiel**

Milieu, GWW- & baggerwerken



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Michiel Kotterman

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Fabrice Ottburg

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Publications

- Kupryianchyk, D., E. T. H. M. Peeters, et al. (2012).
"Long-term recovery of benthic communities in sediments amended with activated carbon."
[Environmental Science and Technology](#) **46**(19): 10735-10742.
- Kupryianchyk, D., M. I. Rakowska, et al. (2012).
"In situ sorption of hydrophobic organic compounds to sediment amended with activated carbon."
[Environmental Pollution](#) **161**: 23-29.
- Kupryianchyk, D., M. I. Rakowska, et al. (2012).
"Modeling Trade-off between PAH Toxicity Reduction and Negative Effects of Sorbent Amendments to Contaminated Sediments."
[Environmental Science & Technology](#) **46**(9): 4975-4984.
- Kupryianchyk, D., E. P. Reichman, et al. (2011).
"Ecotoxicological Effects of Activated Carbon Amendments on Macroinvertebrates in Nonpolluted and Polluted Sediments."
[Environmental Science & Technology](#) **45**(19): 8567-8574.
- Rakowska, M. I., D. Kupryianchyk, et al. (in press).
"Extraction of sediment-associated polycyclic aromatic hydrocarbons with granular activated carbon."
[Environmental Toxicology and Chemistry](#), DOI:10.1002/etc.2066.
- Rakowska, M. I., D. Kupryianchyk, et al. (2012).
"In situ remediation of contaminated sediments using carbonaceous materials."
[Environmental Toxicology and Chemistry](#) **31**(4): 693-704.



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Environmental Technology

And visit:

<http://www.wageningenur.nl/en/Expertise-Services/Facilities/Library/Expertise/Find-discover/Wageningen-Yield.htm>

In the field 'dissertations' you can find the PhD Theses of Magdalena Rakowska and Darya Kupryianchyk.

