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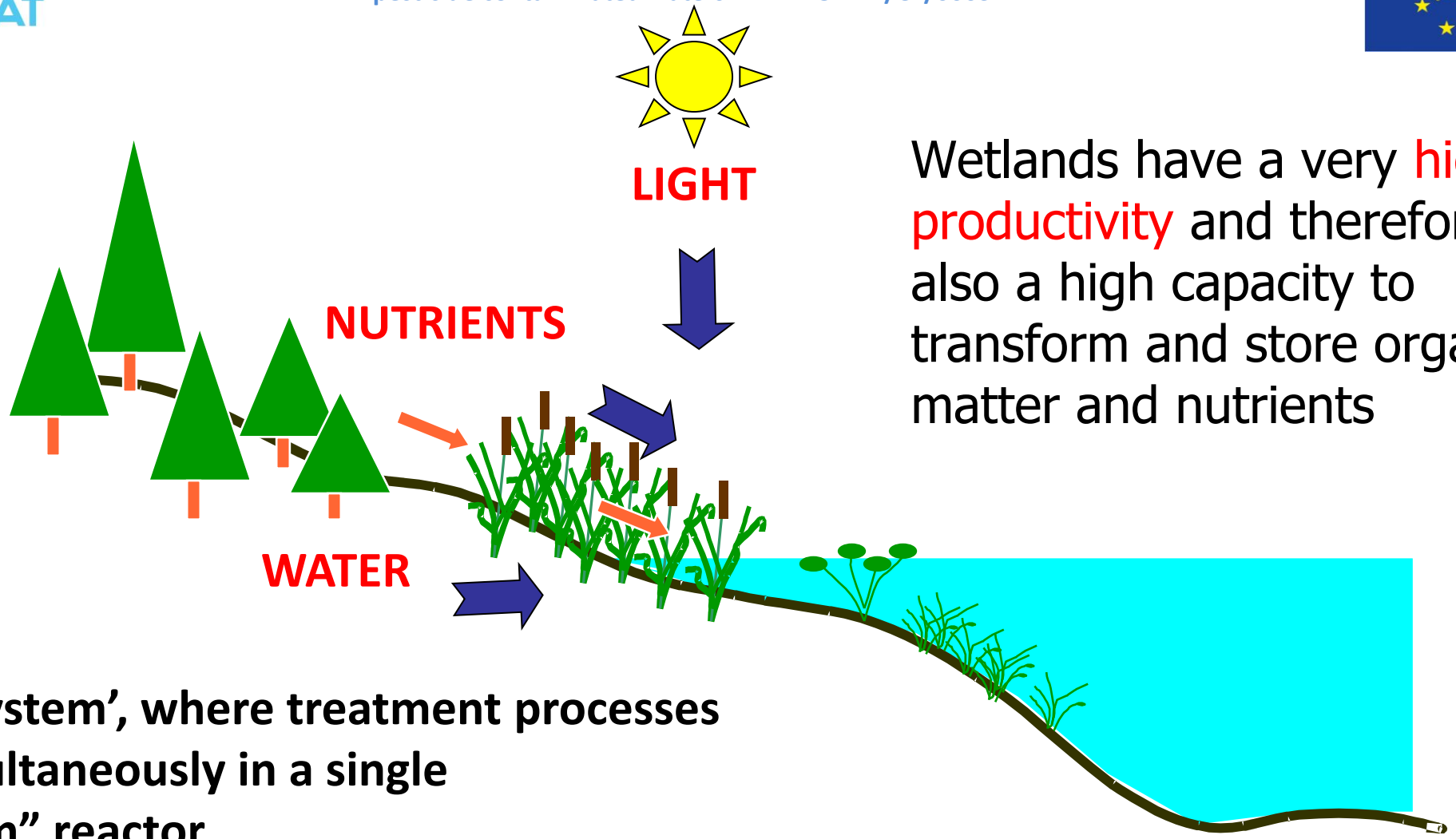
Benefits of the presence of plants in WETLAND^{+} system, treating HCH polluted sites.

- C. A. Arias, S. Vrchovecká, A. Amirbekov, Sázavská, Novotný, C. Ramirez, E. Jespersen , M. Černík, P, Hrabák



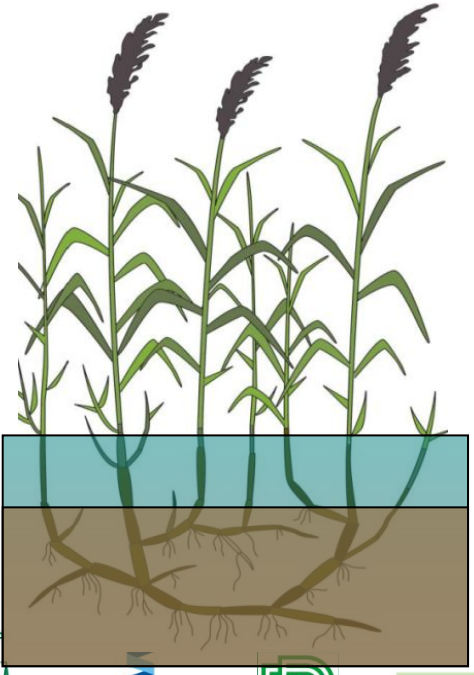
Wetlands have a very high productivity and therefore also a high capacity to transform and store organic matter and nutrients

‘Natural system’, where treatment processes occur simultaneously in a single “ecosystem” reactor

What is a Treatment Wetland?

- An engineered wetland system designed to harness natural process for the purpose of improving water quality

- Technically and operationally simple, but involving complex interactions between:
  - Water
  - Soil
  - Plants
  - Micro-organisms, and
  - the atmosphere



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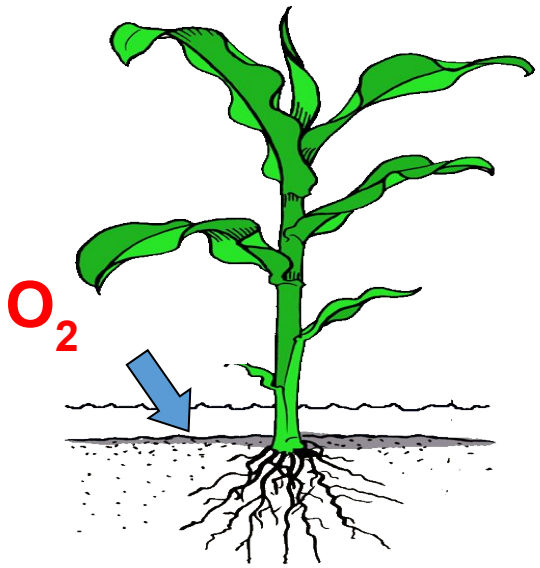
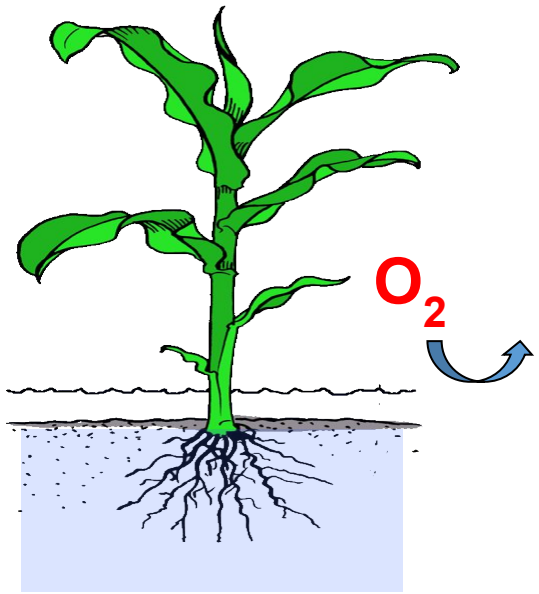
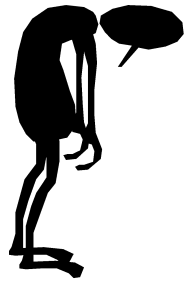


DRAINED



FLOODED

- **No mitosis**
- **Low evergy production (ATP)**
- **Ethanol accumulation**
- **Use of carbohydrate reserves**
- **Post-anoxia metabolites**
- **Superoxide radikals (O_2.-)**



Diffusion of oxygen in water 10.000 times slower than in air

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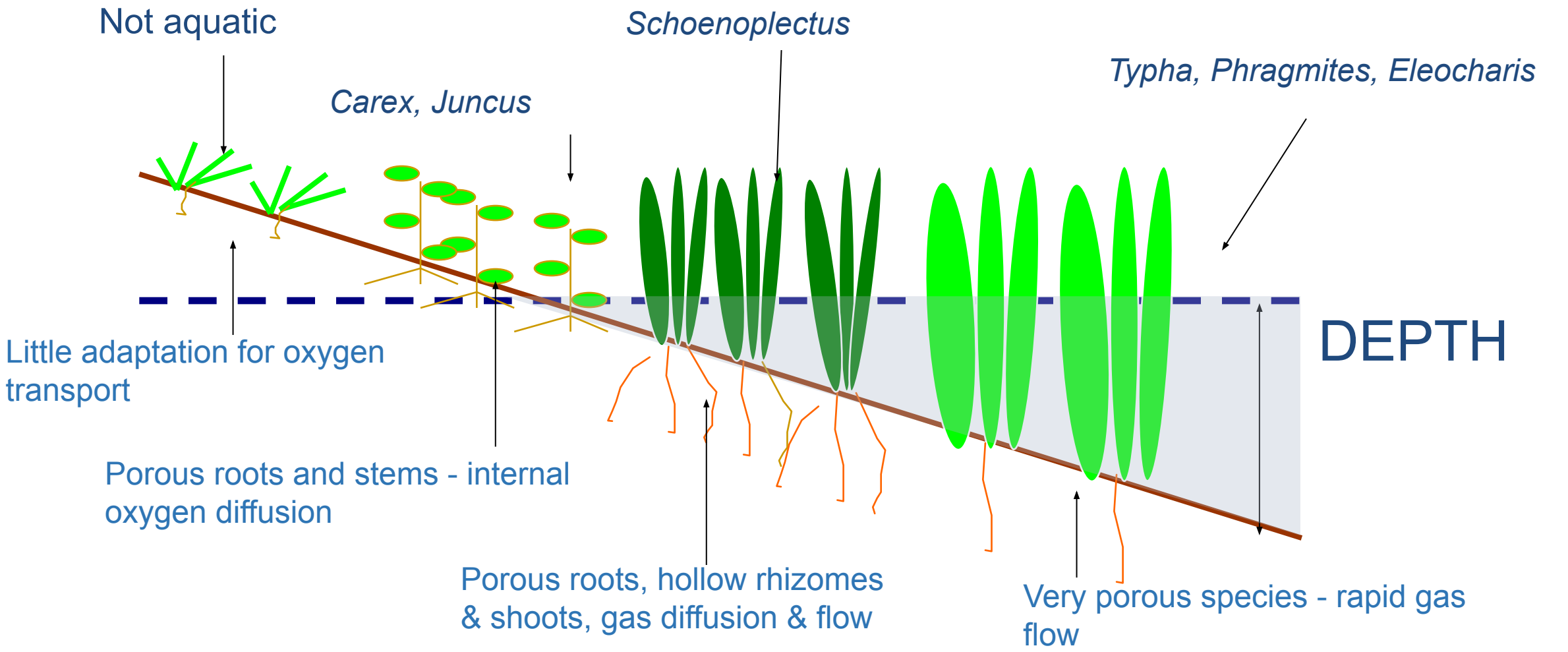

Not aquatic
Schoenoplectus
Typha, Phragmites, Eleocharis
Carex, Juncus
DEPTH
Little adaptation for oxygen transport
Porous roots and stems - internal oxygen diffusion
Porous roots, hollow rhizomes & shoots, gas diffusion & flow
Very porous species - rapid gas flow

AARHUS UNIVERSITY

Plant processes of importance in TWs

- Growth and biomass production
- Photosynthesis
- Nutrient uptake
- Water uptake
- Oxygen transport
- Metabolism
- Food chain support

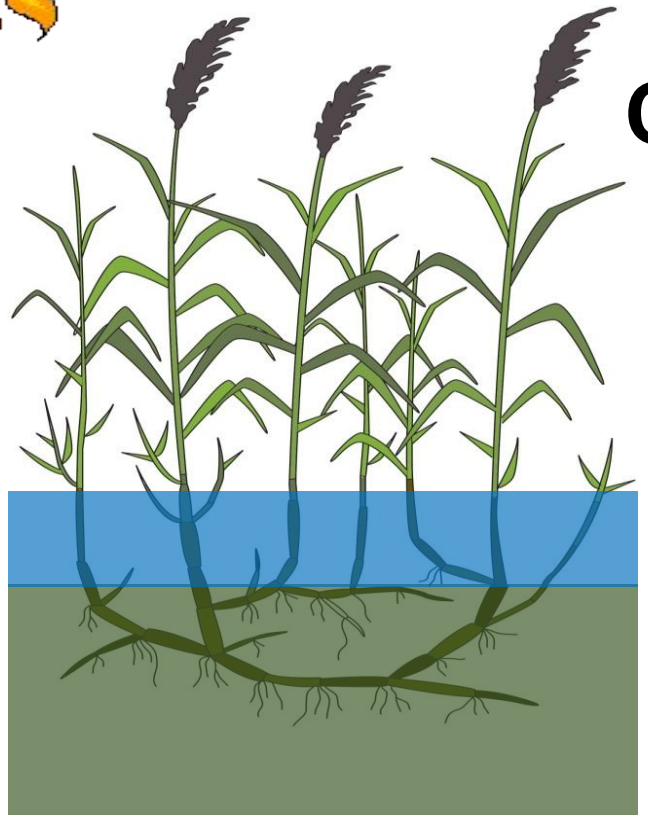
How much can biomass contribute?

Typical biomass production:

2 kg dw m^{-2} @ 40% C

***c.* 8000 kg C ha^{-1} $year^{-1}$**

Photosynthesis

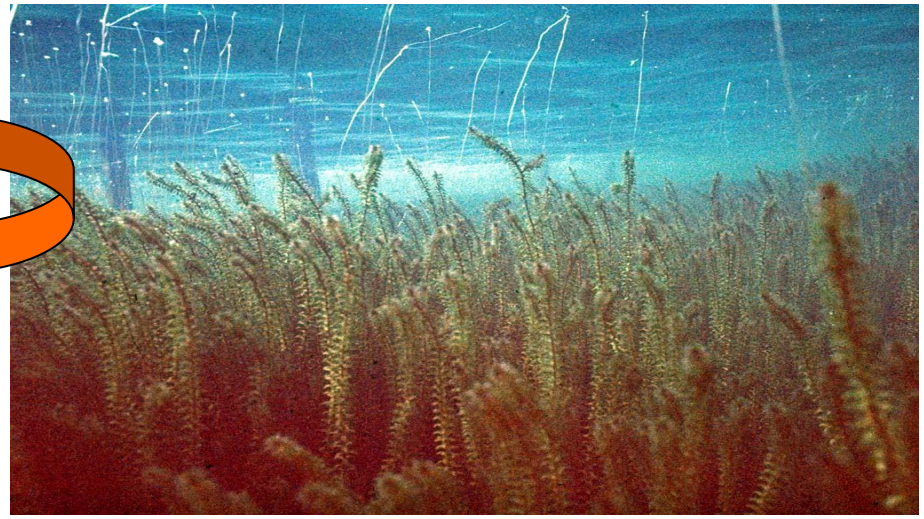


CO_2 O_2

CO_2
O_2

Oxygenation of water

O_2 and pH variations



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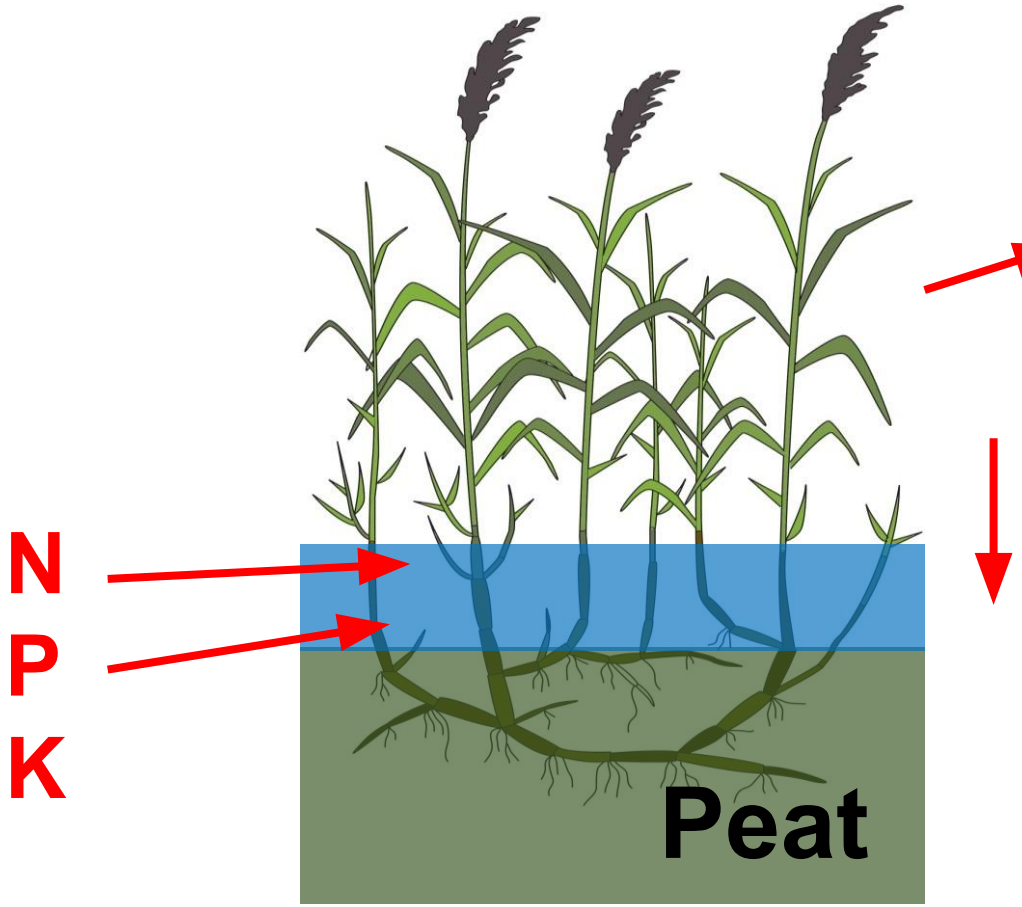
Nutrient uptake



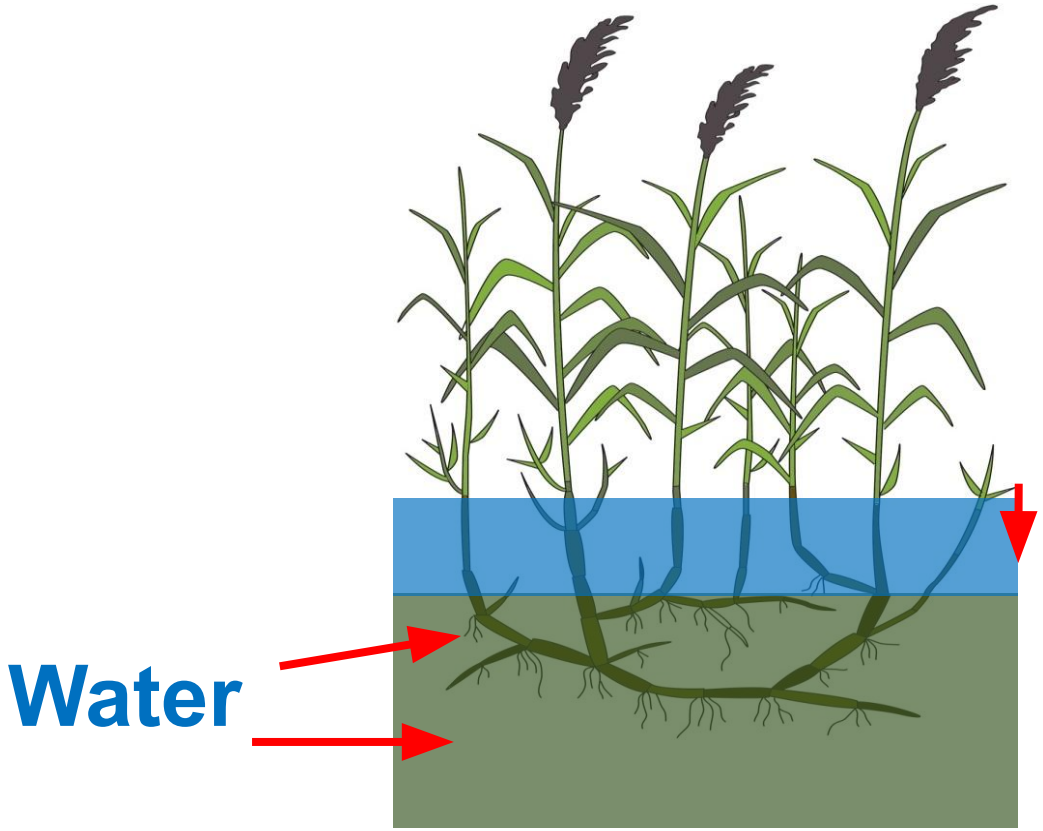
HARVEST

(in most cases not practical)

PEAT ACCRETION

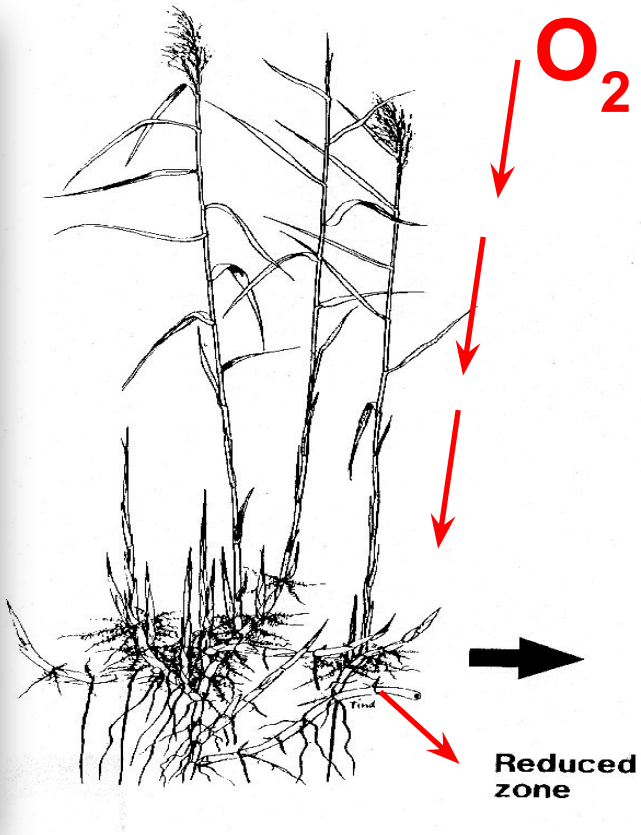
(sustainable removal process in low-loaded systems)

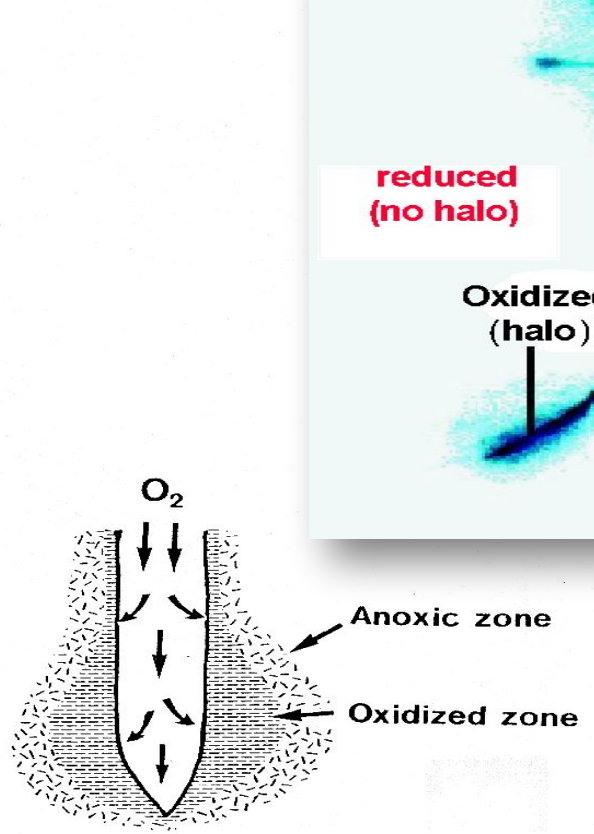
The Transpiration Pump

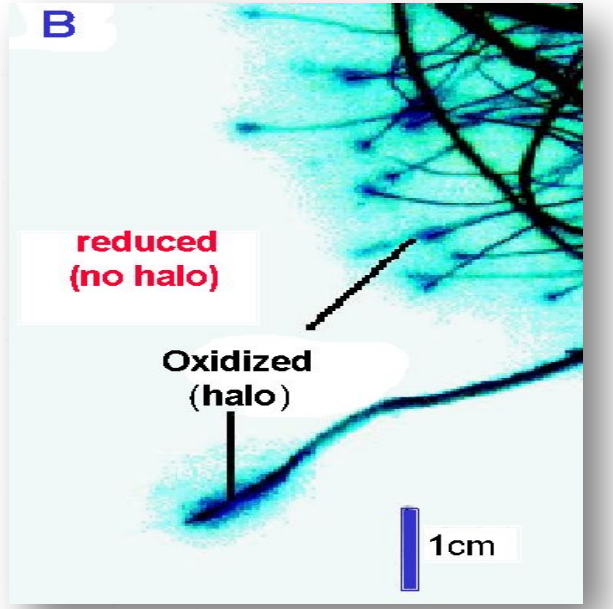


Increases flux of pollutants into the soil

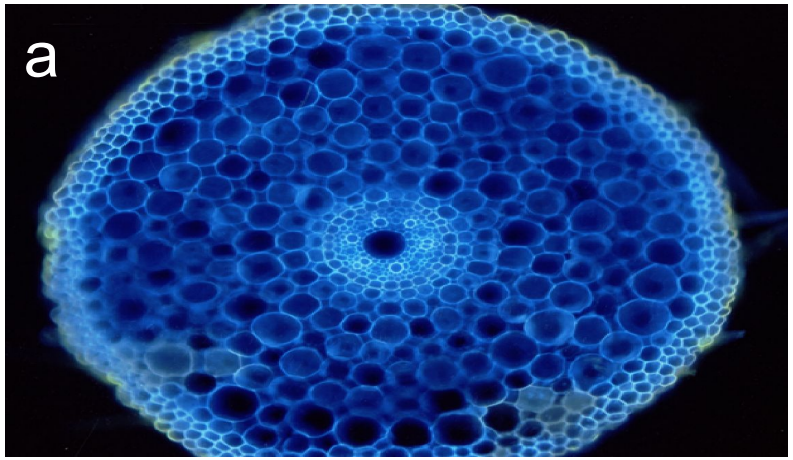
Oxygen release from roots

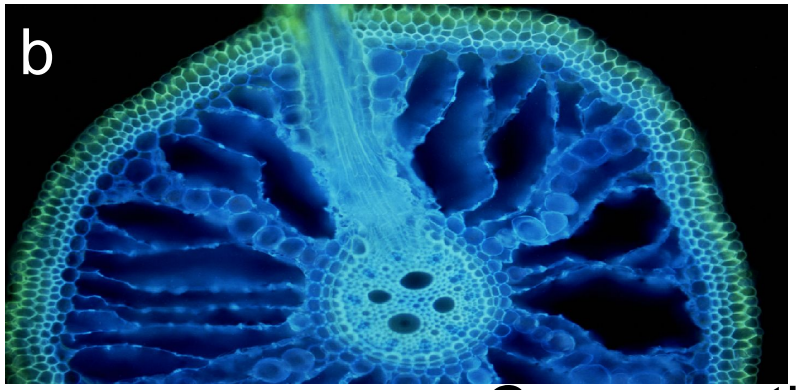


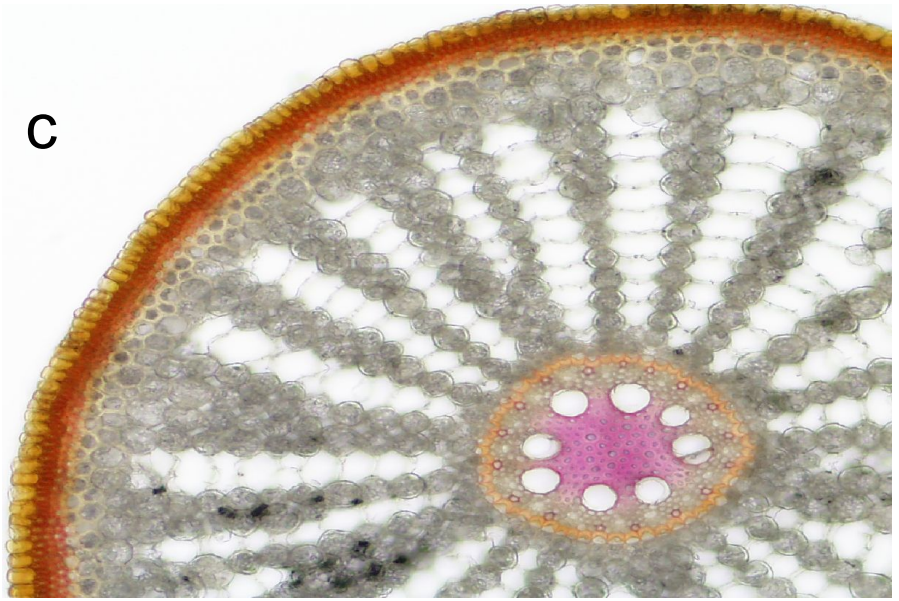




Aerenchyma: Tissue with internal air-spaces







a - *Phragmites*, schizogenous spaces near root tip
b - *Phragmites*, radially oriented lysigenous air channels
c – *Carex gracilis*, tangentially oriented lysigenous air channels

Cross sections through roots

Wetland Plants

Phragmites australis	58 %
Typha latifolia	40 %
Glyceria maxima	50 %
Menyanthes	43 %
Acorus calamus	36 %
Phalaris arundinaceae	22 %

>20 %

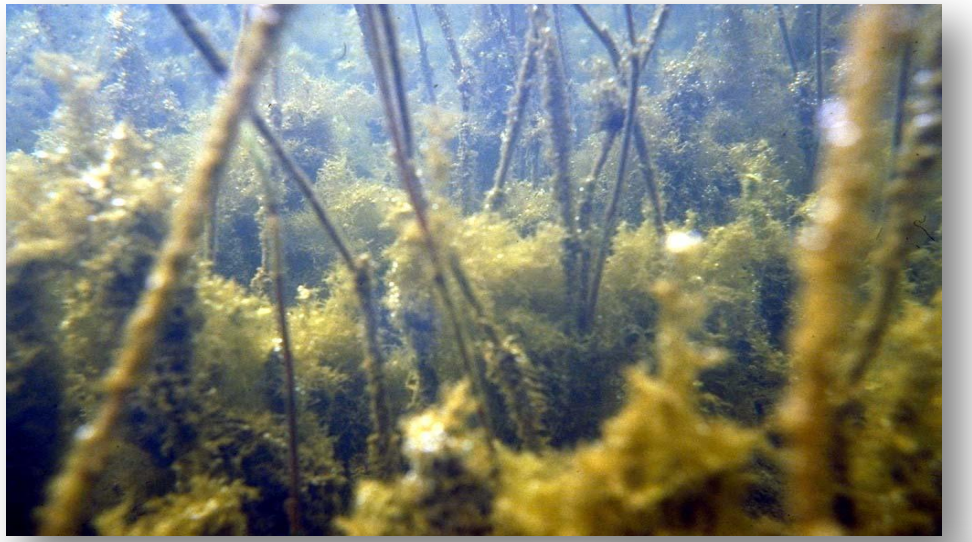
Terrestrial Plants

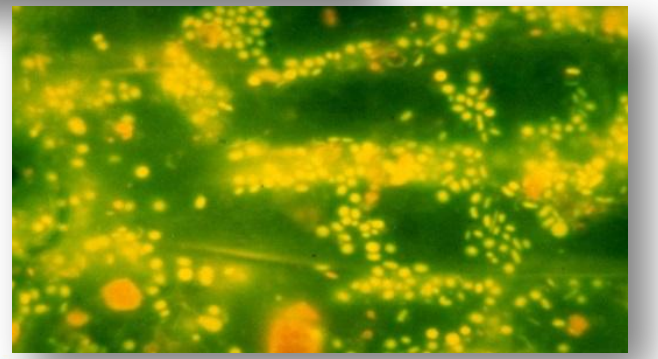
Achillea millefolium	6.6 %
Vicia faba	3.8 %
Festuca rubra	1.9 %
Silene dioica	2.9 %
Luzula campestris	3.6 %
Pisum sativum	3.8 %

< 7 %

Root porosity (% air-space)

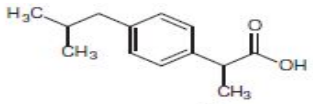
Surface area for attached microbial growth



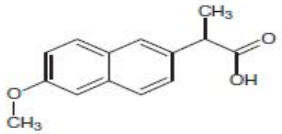


Micro-contaminants

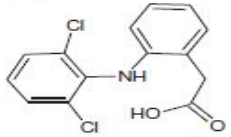
Ibuprofen



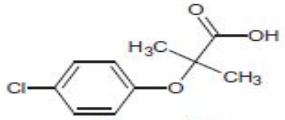
Naproxen



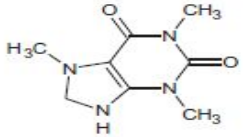
Diclofenac



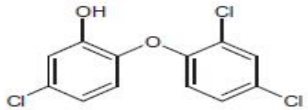
Clofibric acid



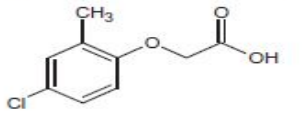
Caffeine

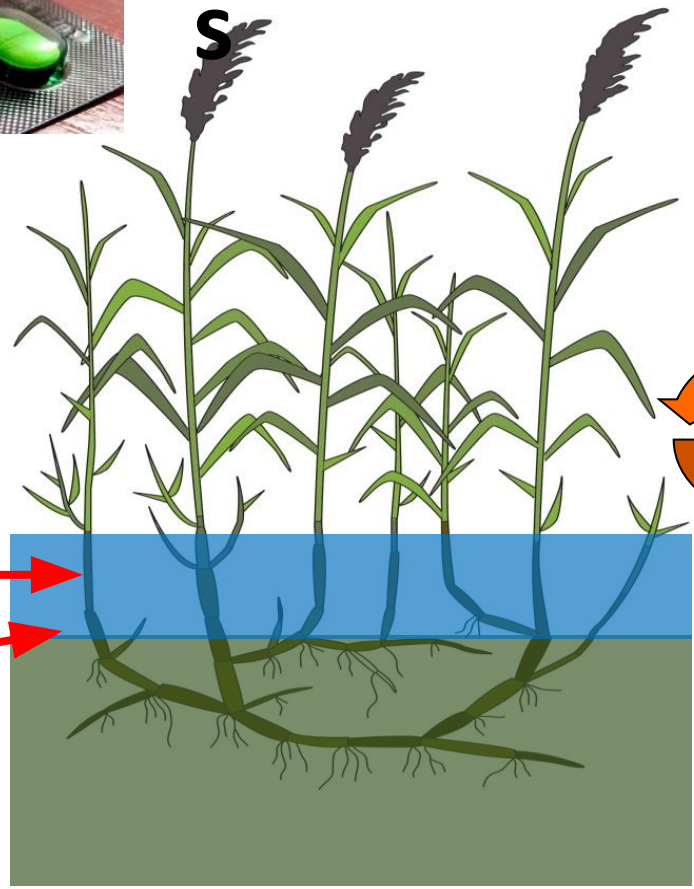


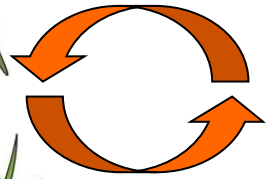
Triclosan



MCPA

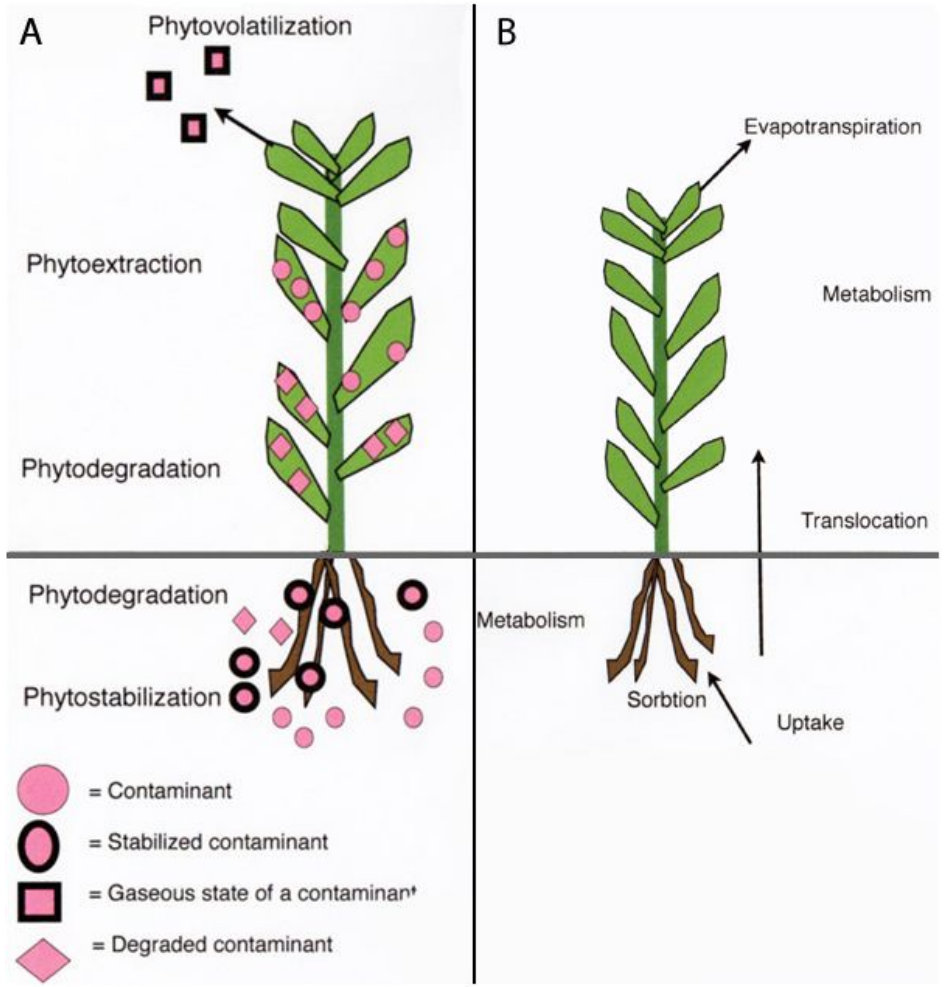






Uptake and degradation in plants

Plant functionality in wetland



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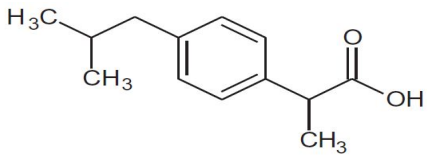
Life

IBUPROFEN

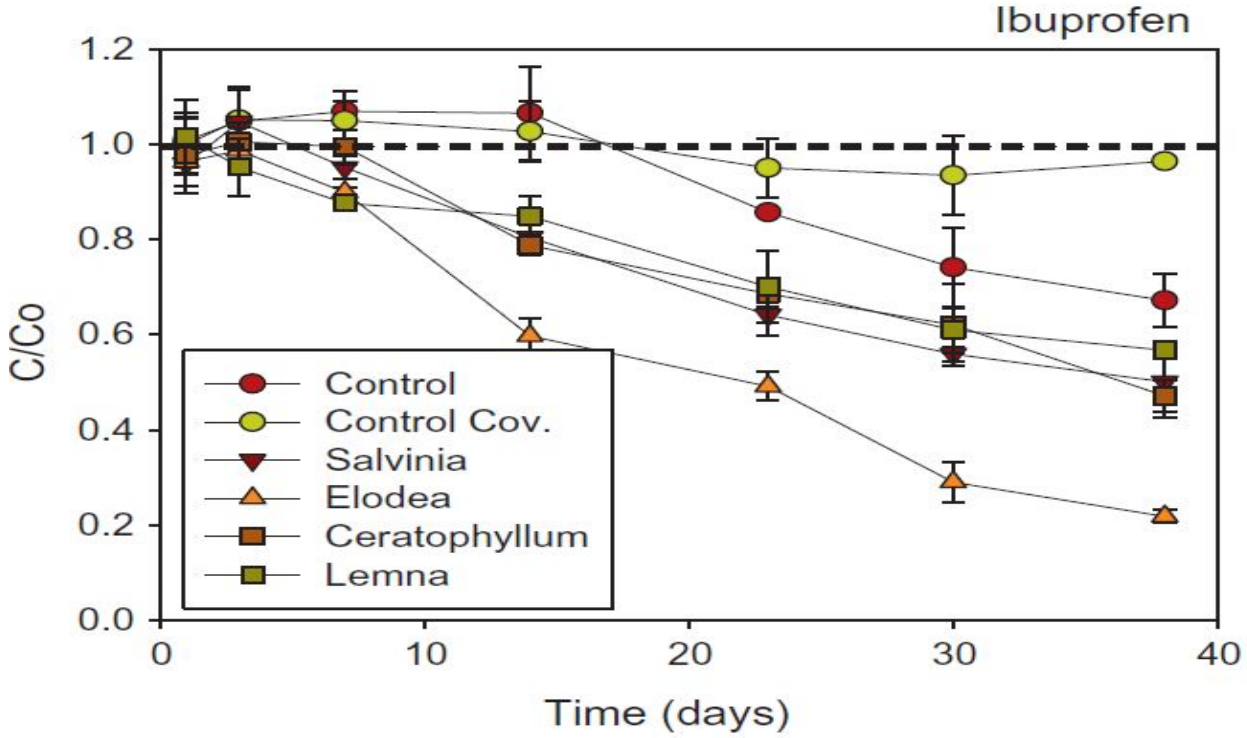


Salvinia

Elodea

Ceratophyllum

Lemna



V. Matamoros et al. / Chemosphere 88 (2012) 1257–1264

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DIAMO

Ministerstvo životního prostředí

- 60 pots with *Juncus effusus, Typha latifolia, Phragmites australis, Alnus glutinosa and blancks set up in a growth chamber*
- Spiked with HCH solution to three different pesticide concentrations (20, 200, 1000 µg.l-1)
- Two treatments – δ-HCH and t-HCH
- Reserach on removal and microbial presence

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δ-HCH	δ-HCH dose [µg. pot^{-1}]]	Total removal efficiency [% of HCH dose]	Sum of HCH in roots [% of HCH dose]	Sum of HCH in above-ground parts [% of HCH dose]	Missing δ-HCH [%]
Unplanted soil	**24**	**43.83±7.71**	-	-	-
	240	**8.90±14.77**	-	-	-
	1200	**3.01±8.3**	-	-	-
J. effuses	**24**	**62.11±12.52**	12.83±1.98	2.89±0.80	3.52±2.93
	240	**63.54±14.50*** **	10.98±0.24	1.85±0.53	41.80±16.99
	1200	**46.98±15.18** **	5.75±1.71	10.07±2.16	28.15±12.77
T. latifolia.	**24**	**52.47±9.79**	3.90±0.64	1.10±0.42	3.65±0.83
	240	**29.00±13.39**	5.51±1.25	0.47±0.17	14.11±2.89
	1200	**18.37±15.13**	5.87±2.90	3.37±0.45	6.11±8.71
A. glutinosa	**24**	**73.88±4.81***	24.86±2.02	2.40±0.54	2.80±0.25
	240	**71.62±7.74*** **	21.70±4.27	2.19±0.23	39.97±3.09
	1200	**48.72±10.85** **	21.03±2.28	4.38±0.42	20.36±0.68
P. australis	**24**	**61.23±9.53**	10.99±0.63	2.26±0.80	4.14±2.42
	240	**59.47±2.49** **	7.73±2.14	1.26±0.14	28.48±0.86
	1200	**10.09±11.17**	5.78±2.32	4.56±1.96	-1.73±1.58

Results:

- The removal efficiency of unplanted controls decreased by the increased HCH concentration
- The presence of plants increased the removal efficiency
- Removal efficiency - *Alder* > *Juncus* > *Typha* > *Phragmittes*
- All species shown better phytoexctractability toward δ-HCH isomer (max. 50-70 %) than to t-HCH of the same load (40-50 %)
- 1,3-DiCB was found as HCH transformation product in most of the plants (not found in soil)
- If the effect of environmental conditions and bacteria is excluded, it can be observed that the positive effect of the plants is most pronounced in the group exposed to 200 ug. L^{-1}

- **δ-HCH**

•possible transisomerization because α-HCH, β-HCH, and γ-HCH were also recorded – the stock solution contained only the δ-HCH, in the soil was also only δ-HCH, other isomers were recorded in plant biomass but in very low concentration (detected in all plant species at two highest exposure concentrations).

•*AG* was the high concentration of the pesticide in the trunks and, on the contrary, very low in the leaves, especially in the groups exposed to 200 and 1000 µg. L^{-1} of δ-HCH. These results correlate with the levels of 1,3-diClb where generally in *AG* trunks the concentration was the highest.

•t-HCH

•No significant preference in the removal of a specific isomer was observed

•Determined concentrations in biomass are generally lower than in the δ-HCH


Thanks for the attention