

# N-removal in constructed wetlands

Janjo de Haan



APPLIED PLANT RESEARCH  
WAGENINGEN UR

# Motive (2004)

- Nitrate leaching is inevitable
- Intercept leaching and reuse or remove nitrogen
  - Intensive drainage system
- Large amounts of drain water
  - Rainfall excess in NL is 300 mm = 3000 m<sup>3</sup>/ha
  - About 2/3 can be intercepted by drains (2000 m<sup>3</sup>/ha)
- Restrict amount of drain water to collect
  - Crops with high leaching risks (vegetables)
  - Periods with high nitrogen concentrations

# Objective

## Perspectives constructed wetlands to remove nitrogen from drain water

### ■ Removal efficiency

- 3 types of wetlands
- Decrease concentration from 20-30 mg/l to  $< 3$  mg/l N

### ■ Costs

### ■ Applicability

- Scale (field – farm – local – regional)
- Combination with other functions

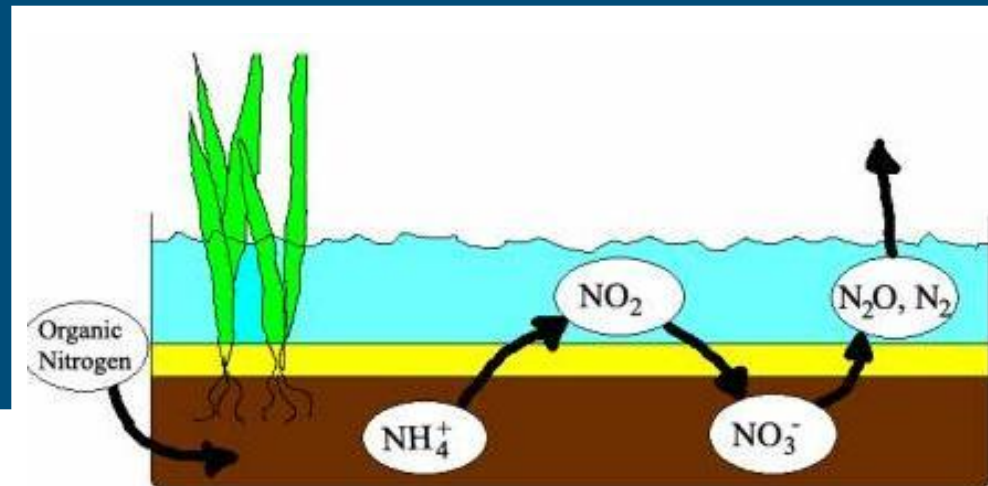
# Process nitrogen removal

## ■ Denitrification

- Carbon source: Water plants, helophytes, crop residues
- Anaerobic conditions
- Temperature

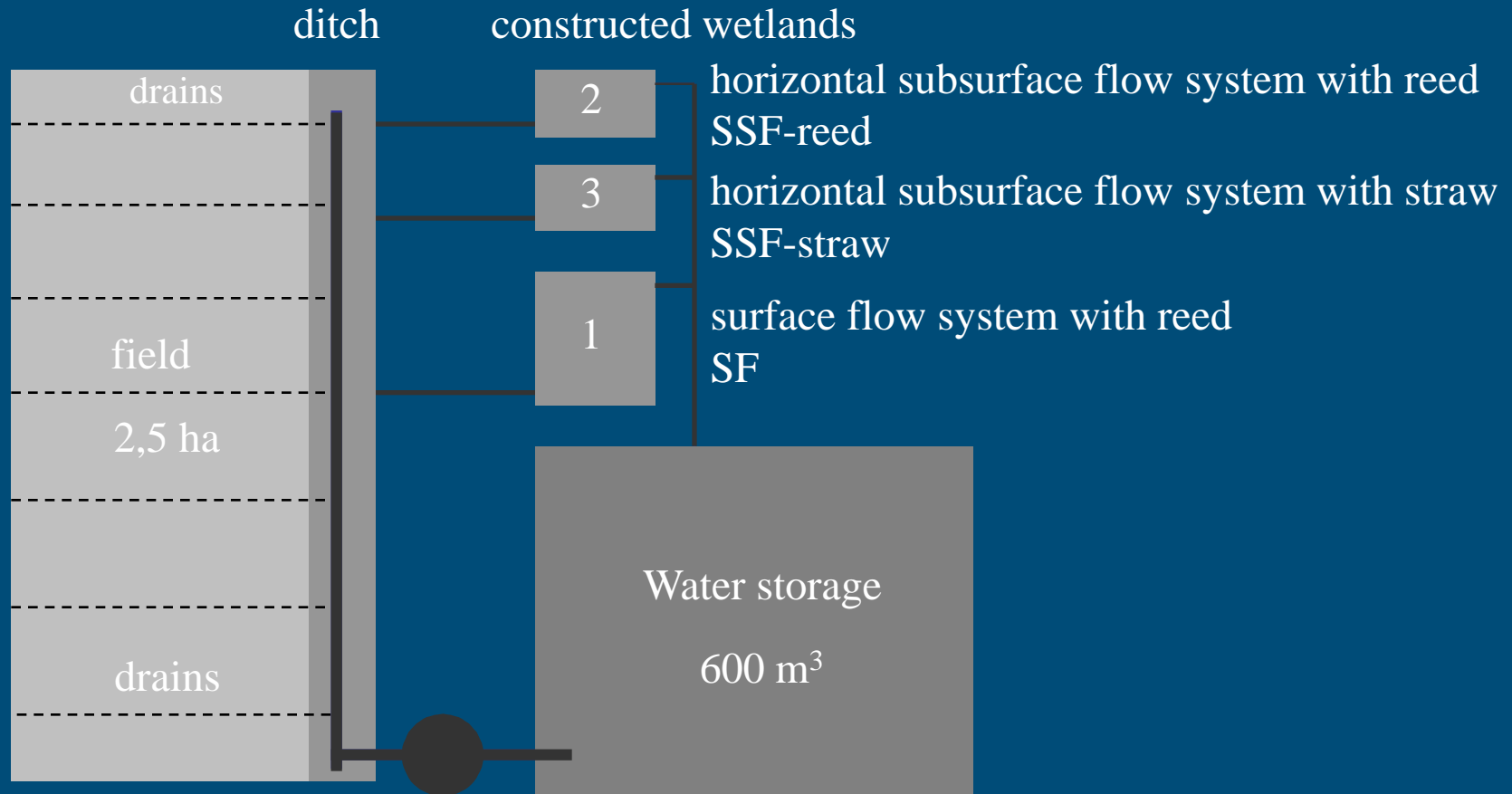
## ■ Crop uptake

- Limited compared to denitrification



**Wetland Nitrogen Cycle (Gooselink, 2001)**

# Constructed wetlands











Surface flow system  
with reed (SF)

Horizontal subsurface  
flow system with straw  
(SSF-straw)

Horizontal subsurface  
flow system with reed  
(SSF-reed)





Surface flow system  
with reed (SF)

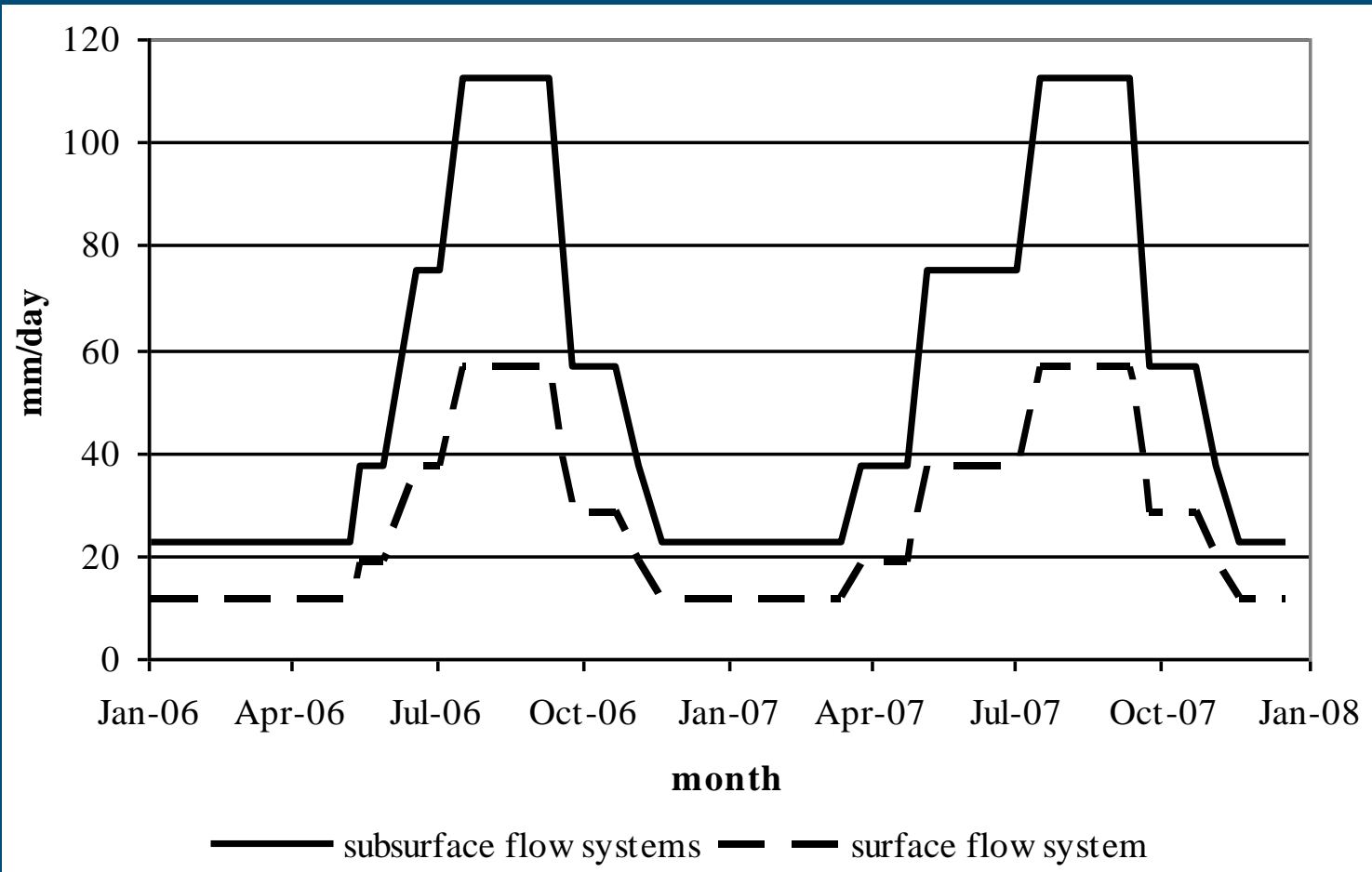
Horizontal subsurface  
flow system with straw  
(SSF-straw)

Horizontal subsurface  
flow system with reed  
(SSF-reed)



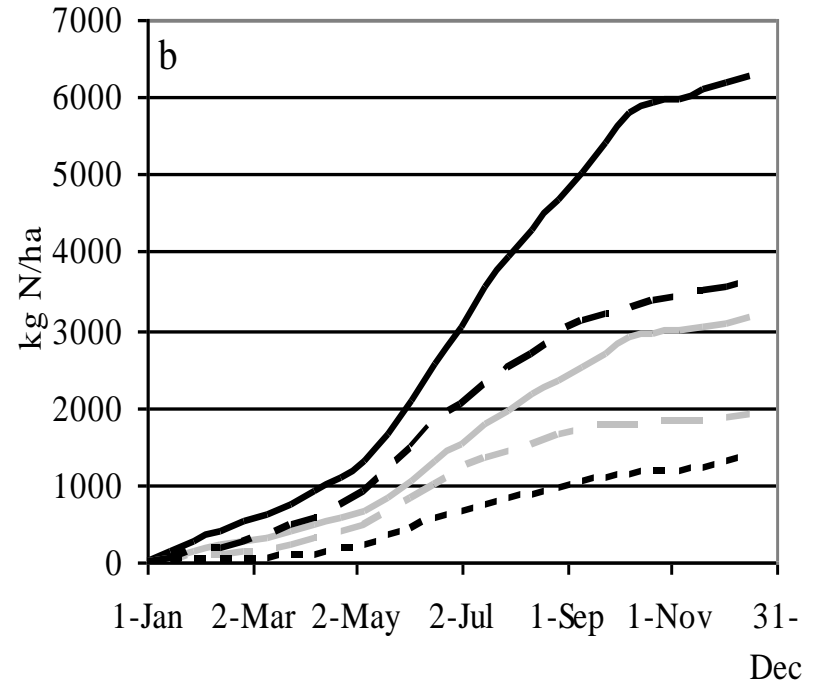
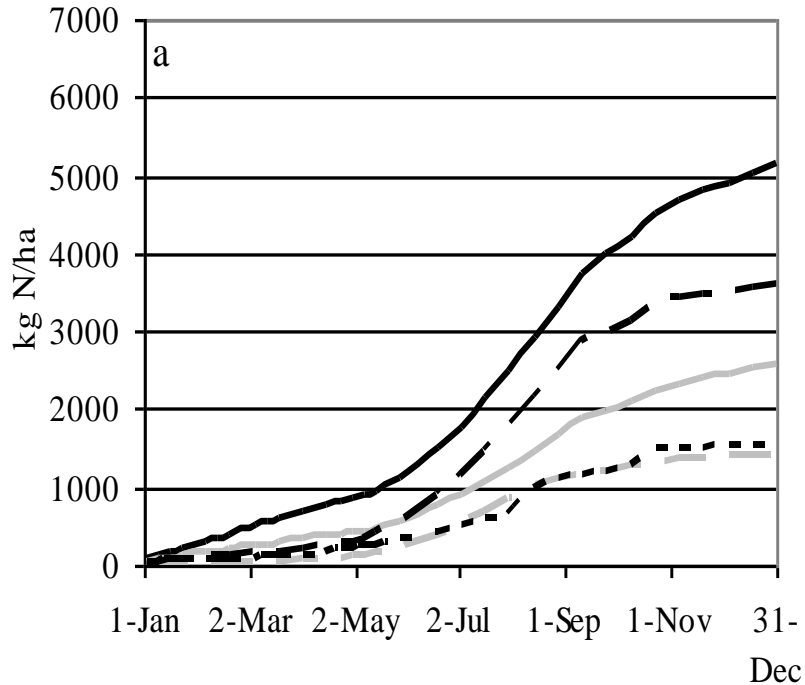
# Hydraulic load

mm/day 2006 and 2007



# Cumulative load and retention of nitrogen

kg/ha a. 2006 and b. 2007



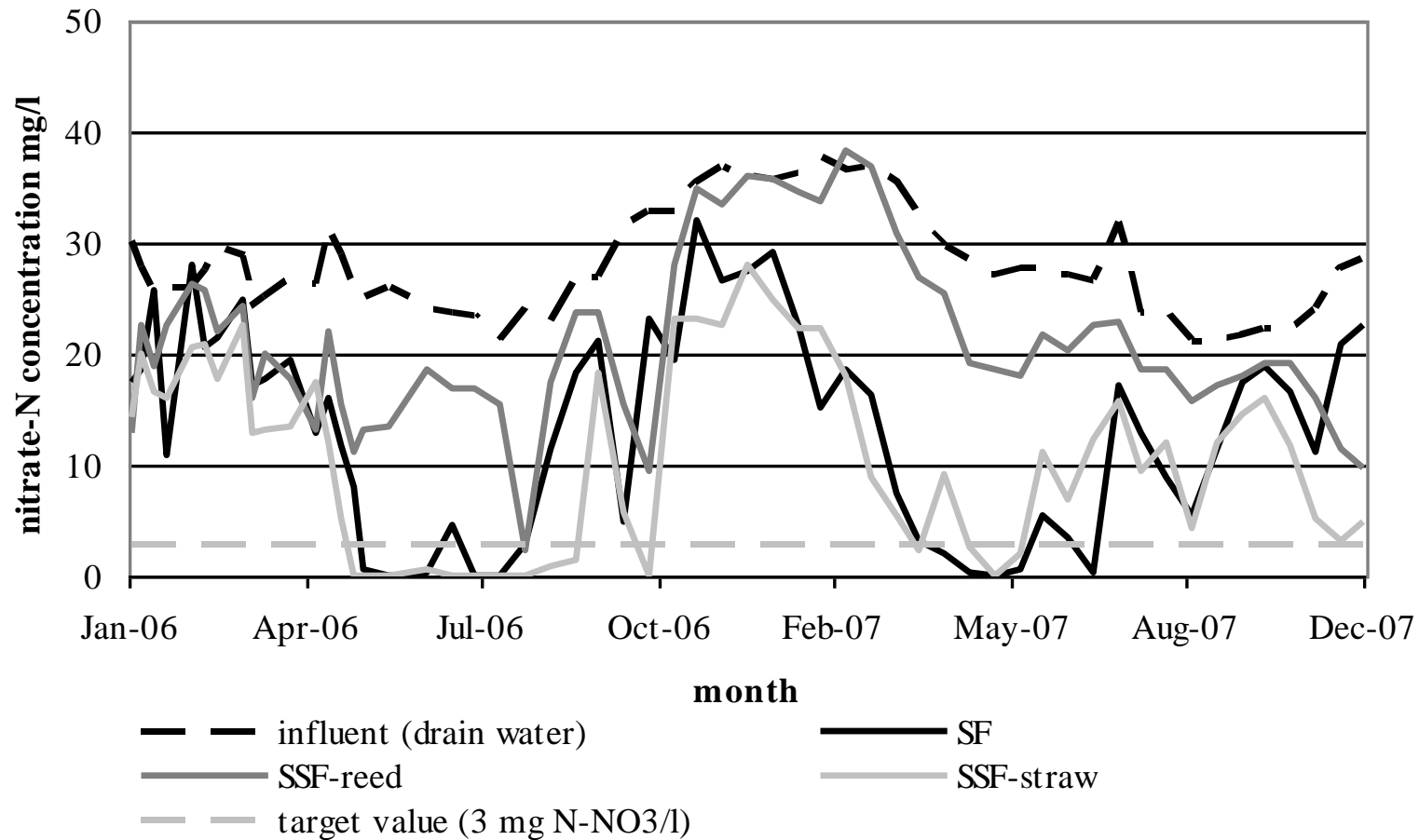
— In SSF      — In SF  
- - - Retention SF      - - - Retention SSF-reed  
- - - Retention SSF-straw





# Nitrate-N concentrations inflow and outflow

mg nitrate-N/l 2006 and 2007

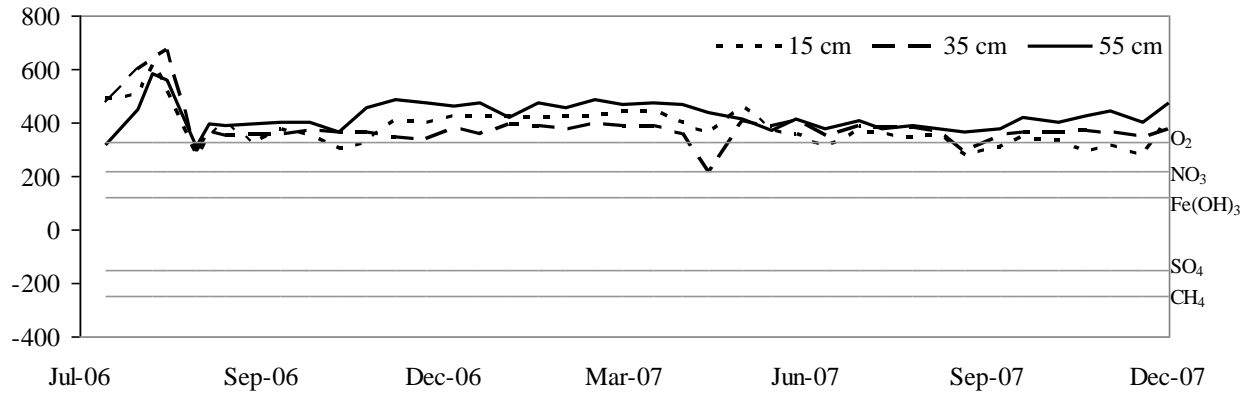


# Results total-N

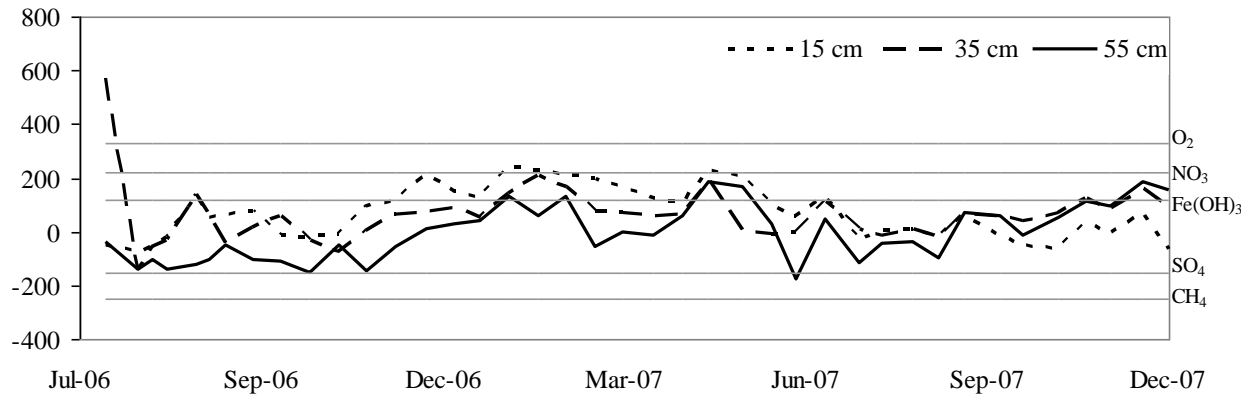
	N-ret.	effect.	daily N-removal		$k_{a20}$
			Oct-Mar	Apr- Sep	
	kg/ha/year	%	kg/ha/day		m/year
■ SF	1655	58	1.8	7.7	18
■ SSF-reed	1447	25	2.3	6.0	11
■ SSF-straw	3622	63	5.0	15.6	41

# Redox potentials

Sub surface flow system with reed

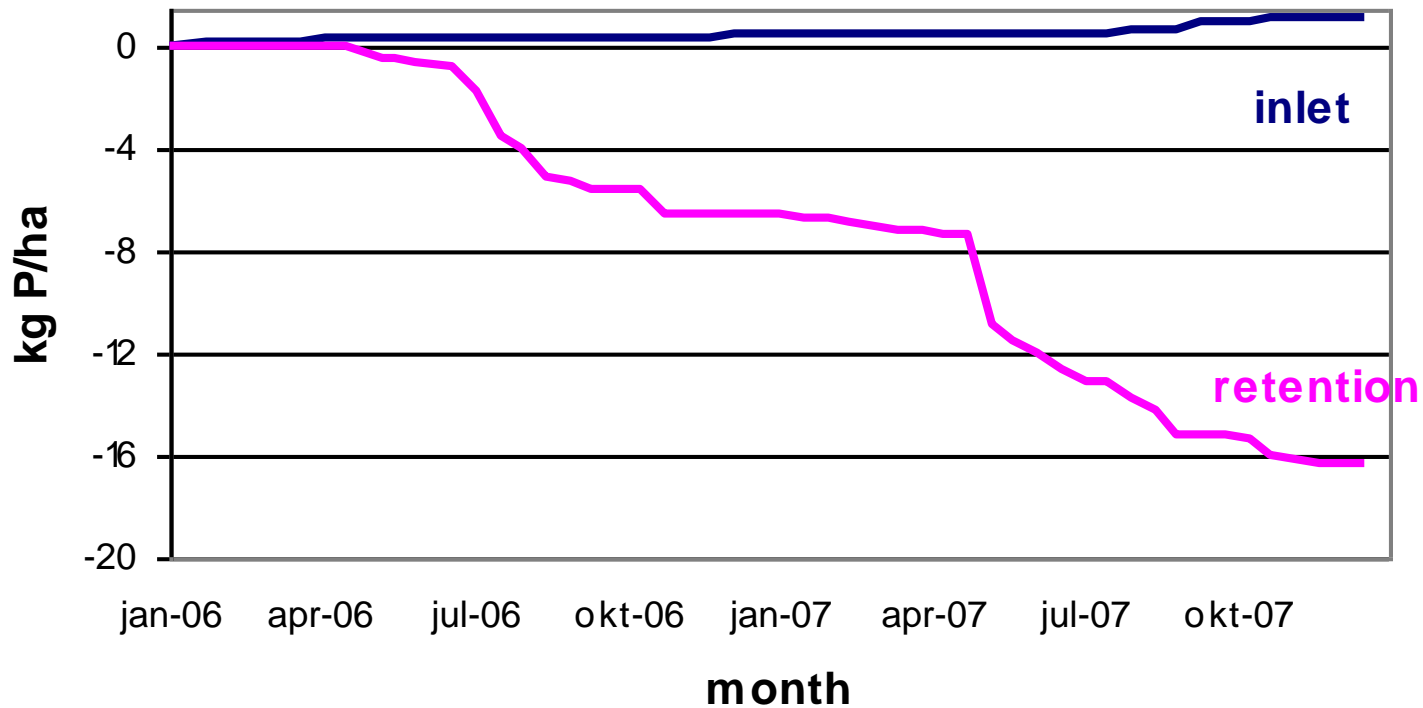


Surface flow system with reed





# Cumulative load and retention of P in SSF-straw



# Discussion & conclusions (1)

## ■ Effectiveness

- Concentration in summer 4 mg/l (0 – 15 mg/l NO<sup>3</sup>)
- Concentration in winter 15 mg/l (3 – 30 mg/l NO<sup>3</sup>)

## ■ Decreasing N surplus:

- Nitrate leaching appr. 60 kg N/ha
- About 67% was intercepted by drains
- about 50% was led through the wetlands
- Effectiveness wetlands appr. 60%
- Retention 12 kg N/ha (20%)

# Discussion and conclusions (2)

## ■ Processes

- Badly reed growth in subsurface system
- Phosphorus release of SSF-straw
- Carbon in straw is declining

## ■ Applicability

- Land use (filters 1-2%; reservoir 4-8%)
- Costs are relative high
- Scale local



# Constructed wetland without water storage



- Lower costs
- Lower efficiency
- Lower land use



# Thanks for your attention!

© Wageningen UR



APPLIED PLANT RESEARCH  
WAGENINGEN UR

# Actual situation (2008)

- Ex-ante evaluation agriculture and WFD in NL
  - Constructed wetlands are an cost-effective measure
  - Uncertainty in estimation
    - No experimental data in NL
  - Construction and maintenance costs are high
    - Construction costs for NL € 10 000 000 000
    - Maintenance costs for NL € 600 000 000
  - Land use is high: 140.000 ha in NL (6%)
- Minister of agriculture and assistant secretary on water are enthusiastic about constructed wetlands