



# Mitigation of pressures on water bodies by nutrient retention from agricultural drainage effluents using purification ponds

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# Outline

- **Pressures** on waters from agricultural drainage
- **Purification Ponds** - objectives, installations
- **Methods** to determine the purification effects
- **Budgets** of purification effects
- **Processes** of purification
- **Summary & Conclusions**



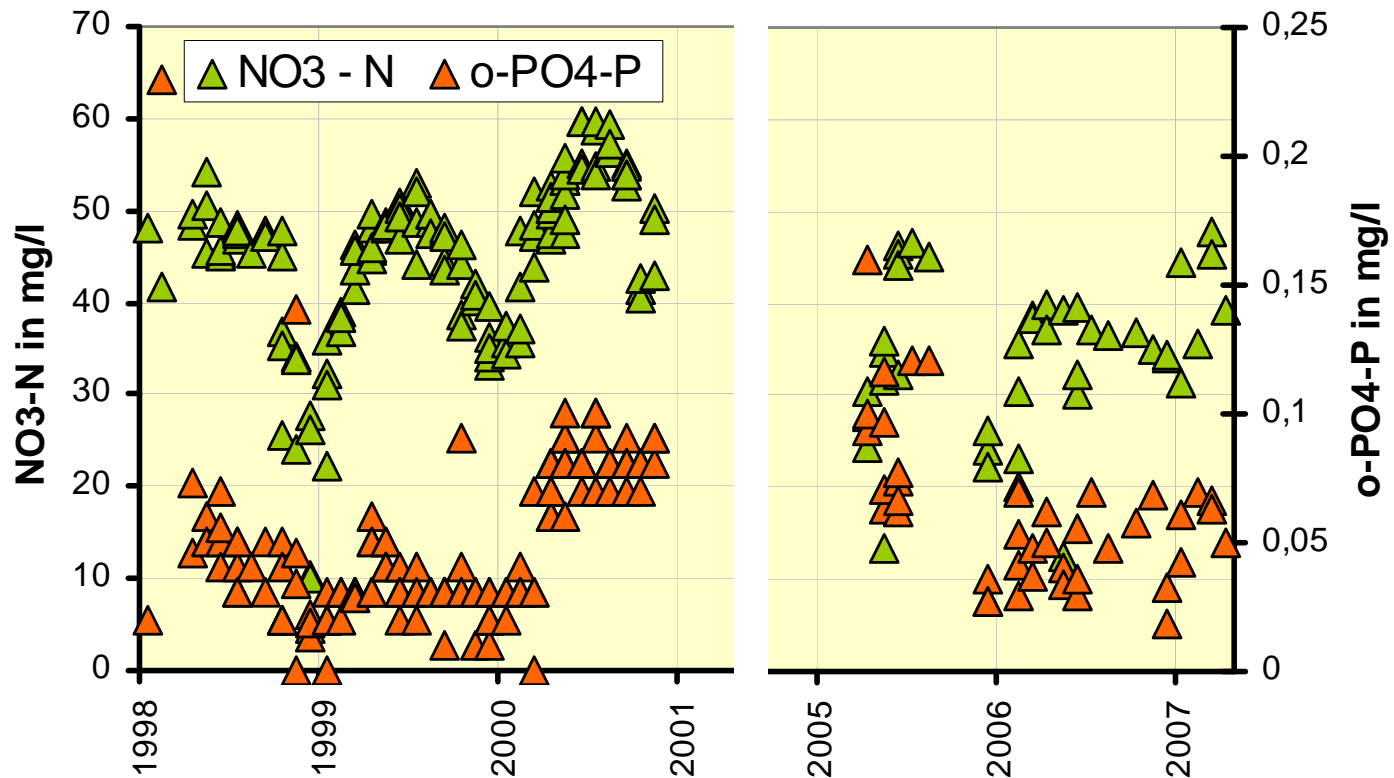
# Pressures on water bodies from agricultural drainage effluents

## Agricultural drainage systems:

- ⇒ regulate the soil water on waterlogged sites and improve their farming conditions
- ⇒ accelerate the originally strongly damped runoff processes
- ⇒ are coupled with high nutrient entries towards the receiving waters

# Pressures on water bodies from agricultural drainage effluents

Measured nutrient concentrations in an outflow of a tile drain





# Pressures on water bodies from agricultural drainage effluents

## Agricultural Drainage Systems

- ⇒ regulate the soil water on waterlogged sites and improve their farming conditions
- ⇒ accelerate the originally strongly damped runoff processes
- ⇒ are coupled with high nutrient entries towards the receiving waters
- ⇒ nearly half of the nitrogen entries (45 %) towards waters of the German Baltic Sea catchment is coming from drainage (*MEWES, 2004*)



# **Pressures on water bodies**

## **from agricultural drainage effluents**

- ⇒ **actual objectives for the water quality are declared in the**
  - **European Water Frame Directive**
  - **Convention on the Protection of the Marine Environment of the Baltic Sea Area (HELCOM)**
  
- ⇒ **more than 2 million hectares tile drainage systems exist in Germany and used for improvement the farming conditions**
  
- ⇒ **ecological and economical conflicts occur especially in catchments with a high agricultural drainage portion and with shortcomings in achieving the water quality objectives**



# Purification Ponds

## objectives

Reduction of nutrient entries from agricultural drainage systems towards receiving waters by enhancement of

- water retention,
- sedimentation processes,
- nutrient accumulation in biomass and
- biogeochemical transformation processes

with a possible long residence time.

# Purification Ponds

## objectives

⇒ using natural depressions or slopes (combined with embankments) for a environmentally adapted installation



# Purification Ponds

## pilot installations

### objectives

⇒ investigate the effects on the reduction of nutrient entries from agricultural drainage systems towards receiving waters



⇒ providing evidence for the functioning of pilot ponds

# Purification Ponds

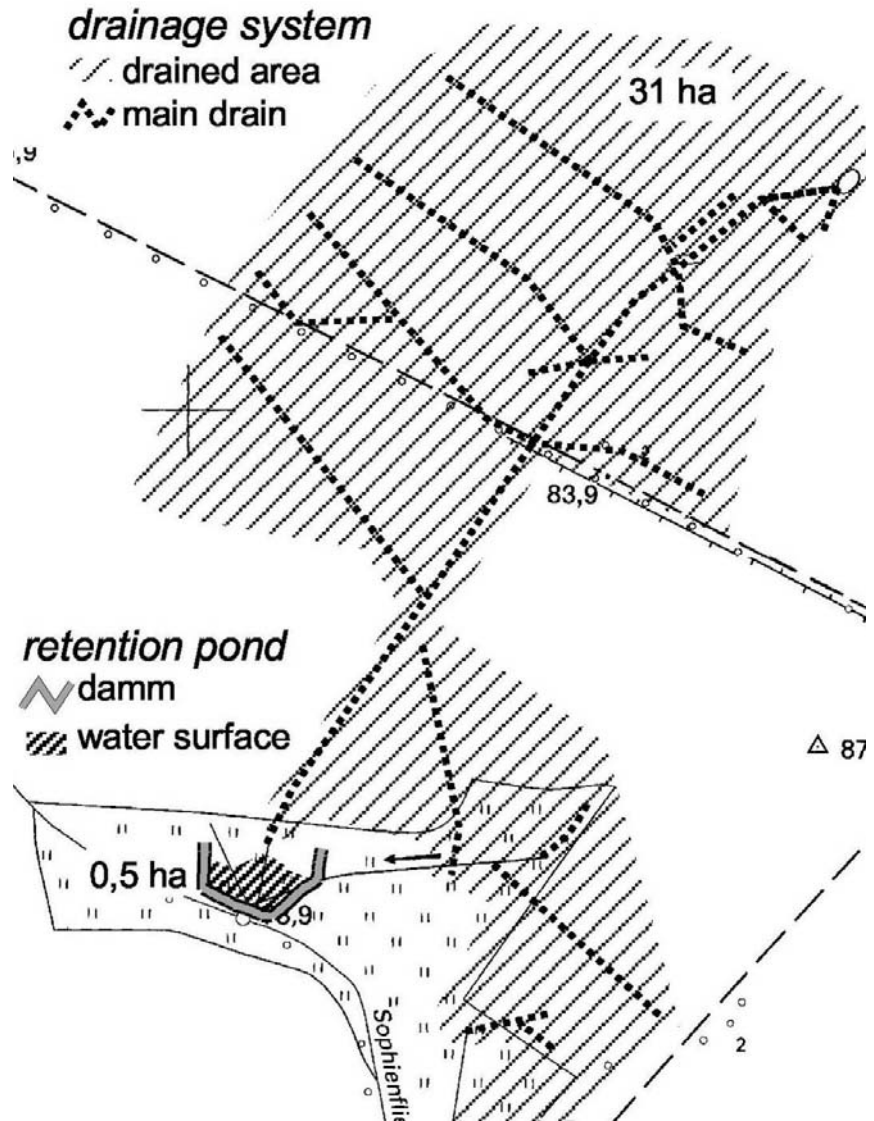
## pilot installations



Main drain and gauging weir



Pond outlet and gauging weir





# Purification Ponds

## pilot installations

### Physical Characteristics of the Pilot Ponds



I



II

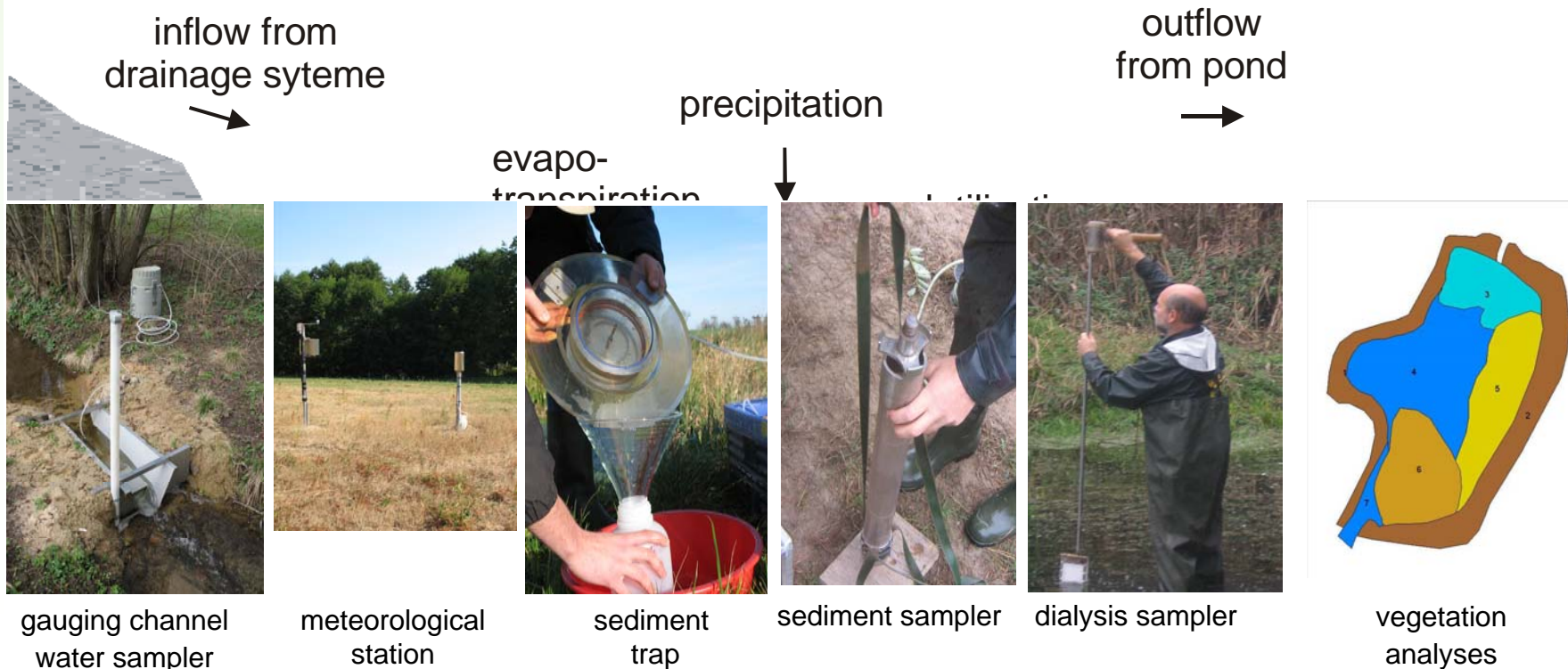


III

pond		I	II	III
drained area	ha	31	185	5
drainage system		regular	checked	regular
surface area	m <sup>2</sup>	4320	1653	614
volume	m <sup>3</sup>	705	429	293
surface area/ drained area	m <sup>2</sup> /ha	139	9	123
maximum depth	m	0,8	0,7	1,1
mean depth	m	0,2	0,2	0,5
shore length/ surface area	m <sup>-1</sup>	0,1	0,1	0,2

# Methods

to determine the purification effects

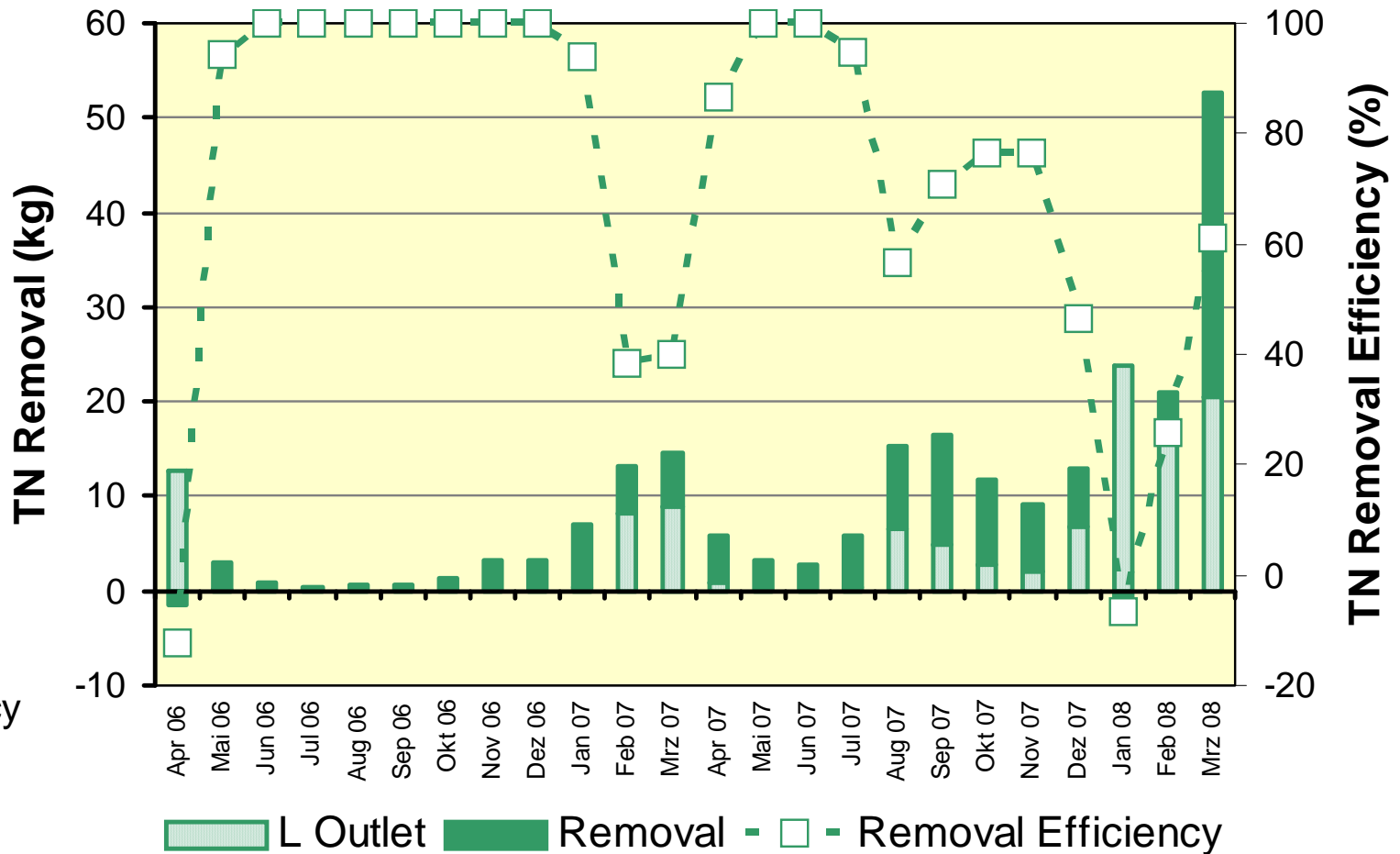


# Budgets of purification effects

## *pilot pond III*



### Monthly Removal of Total Nitrogen



Removal

$$R_M = L_{Inlet} - L_{Outlet}$$

Removal Efficiency

$$R_{eff} = \frac{R_M}{L_{Inlet}}$$

# Processes of purification

## Nitrogen Removal by Accumulation and Denitrification in the Ponds



I



II



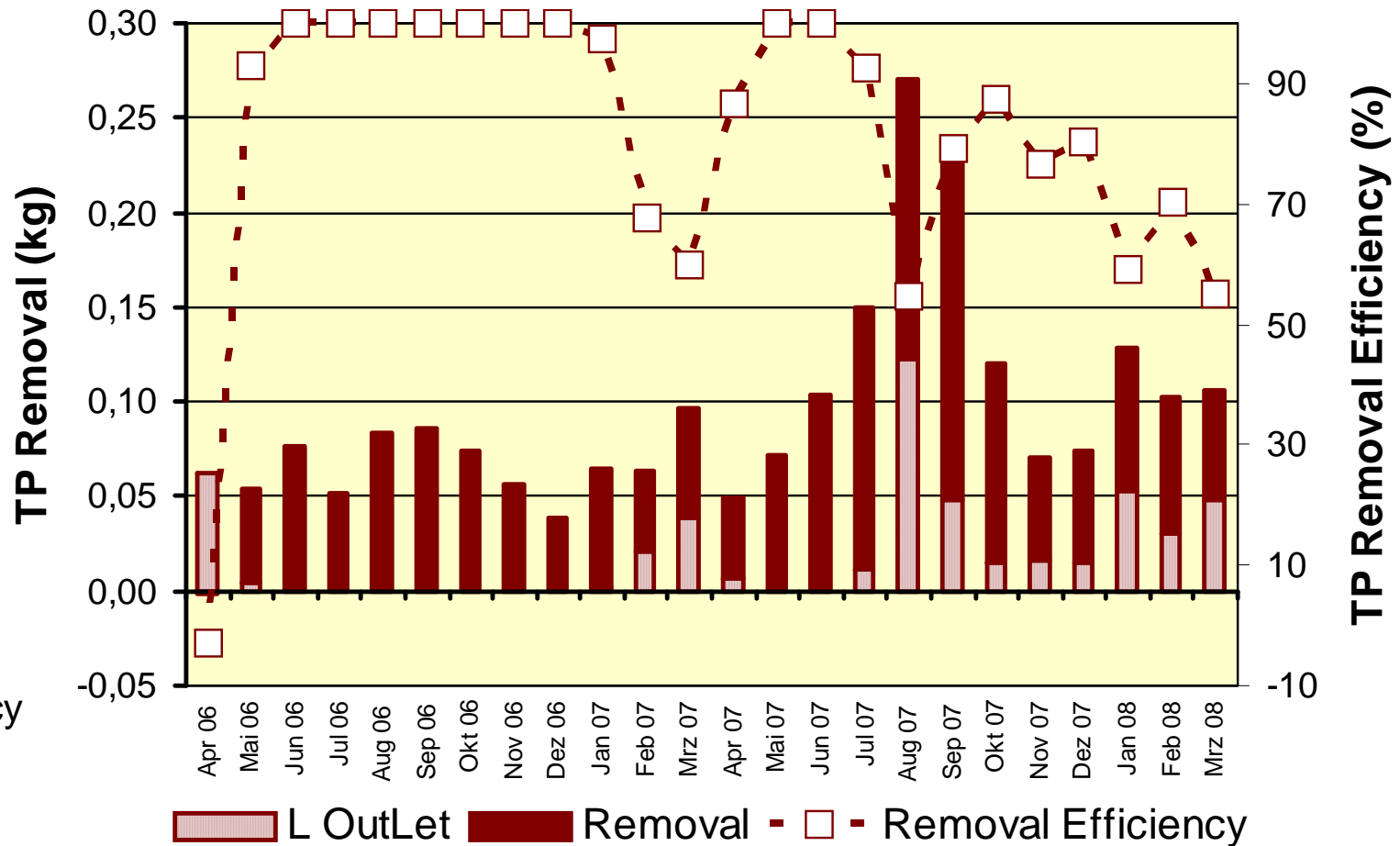
III

pond	process	
	storage in above-ground biomass of macrophytes	denitrification
	max. N in kg	kg a <sup>-1</sup>
I	112,5	17,1
II	10,4	0,9
III	1,7	10,8

# Budgets of purification effects

## *pilot pond III*

### Monthly Retention of Total Phosphorus



Removal

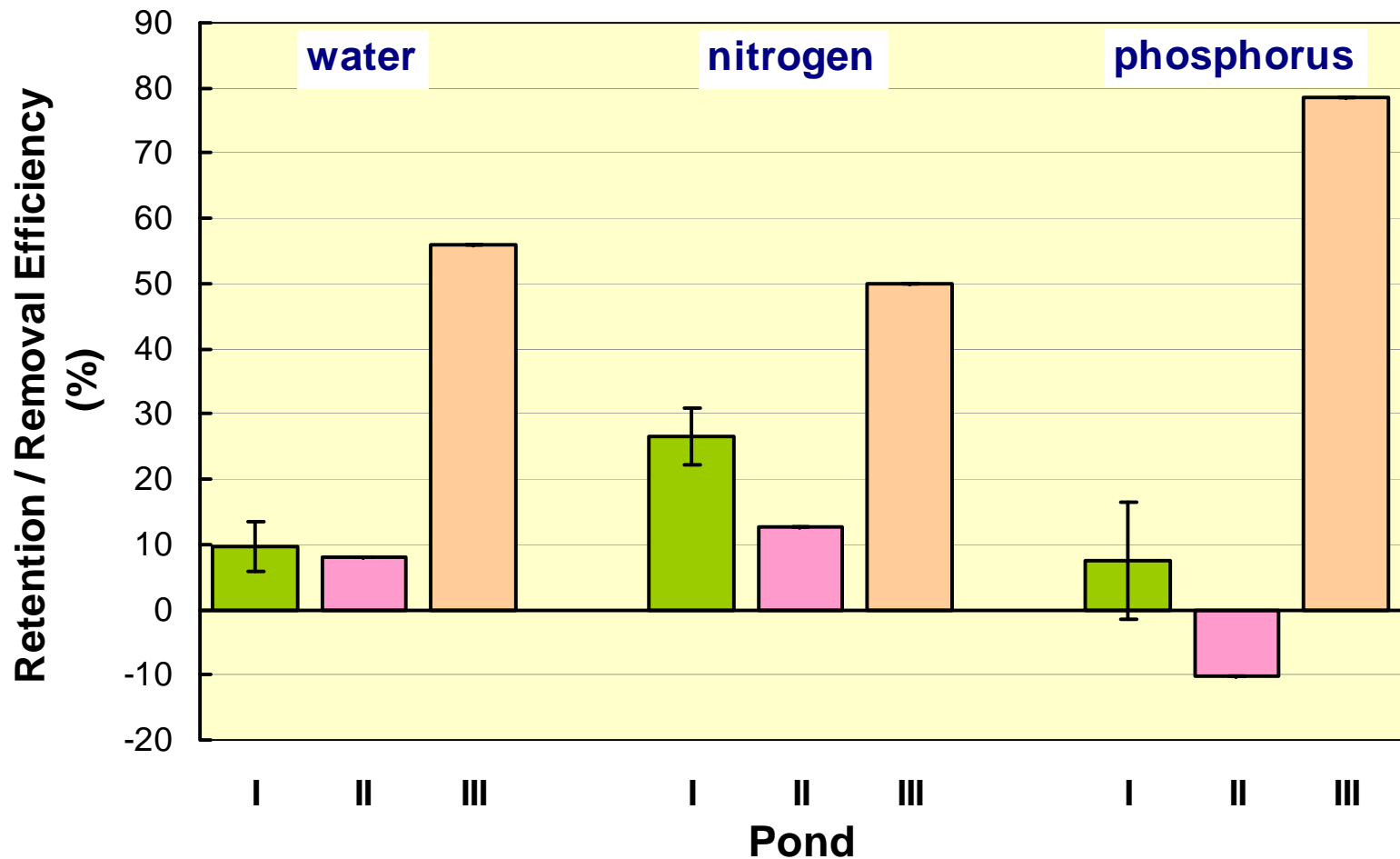
$$R_M = L_{Inlet} - L_{Outlet}$$

Removal Efficiency

$$R_{eff} = \frac{R_M}{L_{Inlet}}$$

# Budgets of purification effects

## Water Retention and Nutrient Removal monitoring period: month 1 - 24





# Summary

- Over the whole investigation period the pilot ponds impacted the pressures on the water bodies from the agricultural drainage systems by
  - runoff reduction by 8 - 56 %
  - nitrogen load reduction by 13 – 50 % and
  - phosphorus load reduction by 7 - 78 %  
(exception: increase by 13 %. in pond II)
- The pilot ponds could be placed environmentally adapted between drainage outlets and downstream receiving waters without harmful effects on the agricultural drainage systems.



# Conclusions

- The principle of purification ponds is appropriate for the reduction of nutrient entries from agricultural drain systems towards the receiving waters.
- The findings from the monitoring of the removal processes in the pilot ponds provide essential basics for guide lines on an effective installation and operation of purification ponds.

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**Thank you!**

# Pressures on water bodies from agricultural drainage effluents

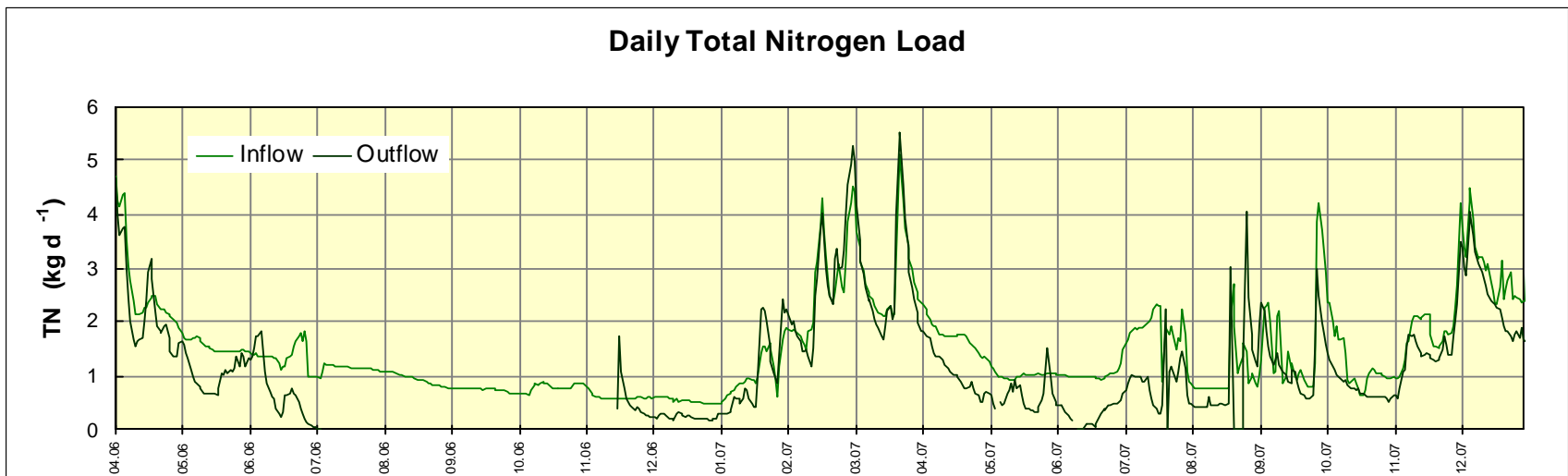
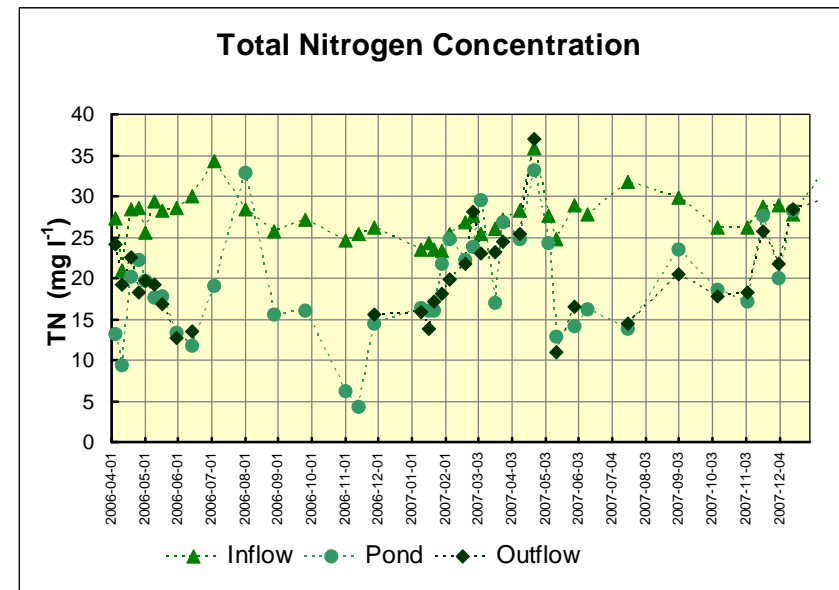
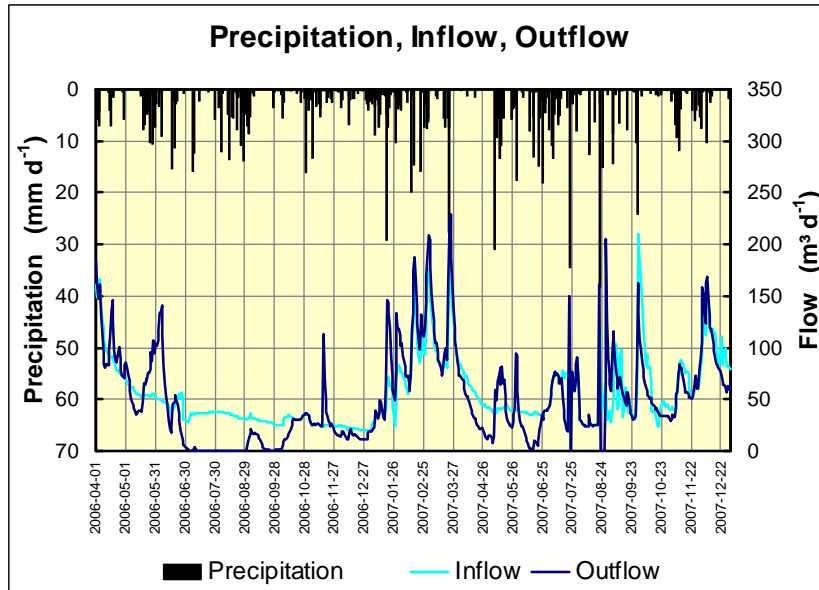
## Estimated nitrogen entries from drainage into waters of German Baltic Sea catchment (1992-1997)

catchment	Nitrogen (tN/year)		portion from drainage
	from drainage	total	
1 coast Vorpommern	1950	4609	42%
2 coast Schleswig-Holstein	1860	7500	25%
3 Warnow	1949	3708	53%
4 Peene	1780	2844	63%
5 Tollense	1257	2232	56%
6 Uecker	1011	1646	61%
7 coast Mecklenburg	1687	4111	41%
8 Recknitz	769	1235	62%
9 Trave 2	169	1283	13%
10 Zarow	385	622	62%
11 Trebel	810	1444	56%
12 Randow	238	366	65%
13 Trave	173	1291	13%
14 Stepenitz	1225	2009	61%
15 Schwentine 2	55	795	7%
16 Barthe	337	572	59%
17 Schwentine	36	497	7%
18 Ryck	200	337	59%
19 Wallensteingraben	159	358,8	44%
<b>sum</b>	<b>16049</b>	<b>37459</b>	<b>45%</b>

source:  
MEWES (2004)

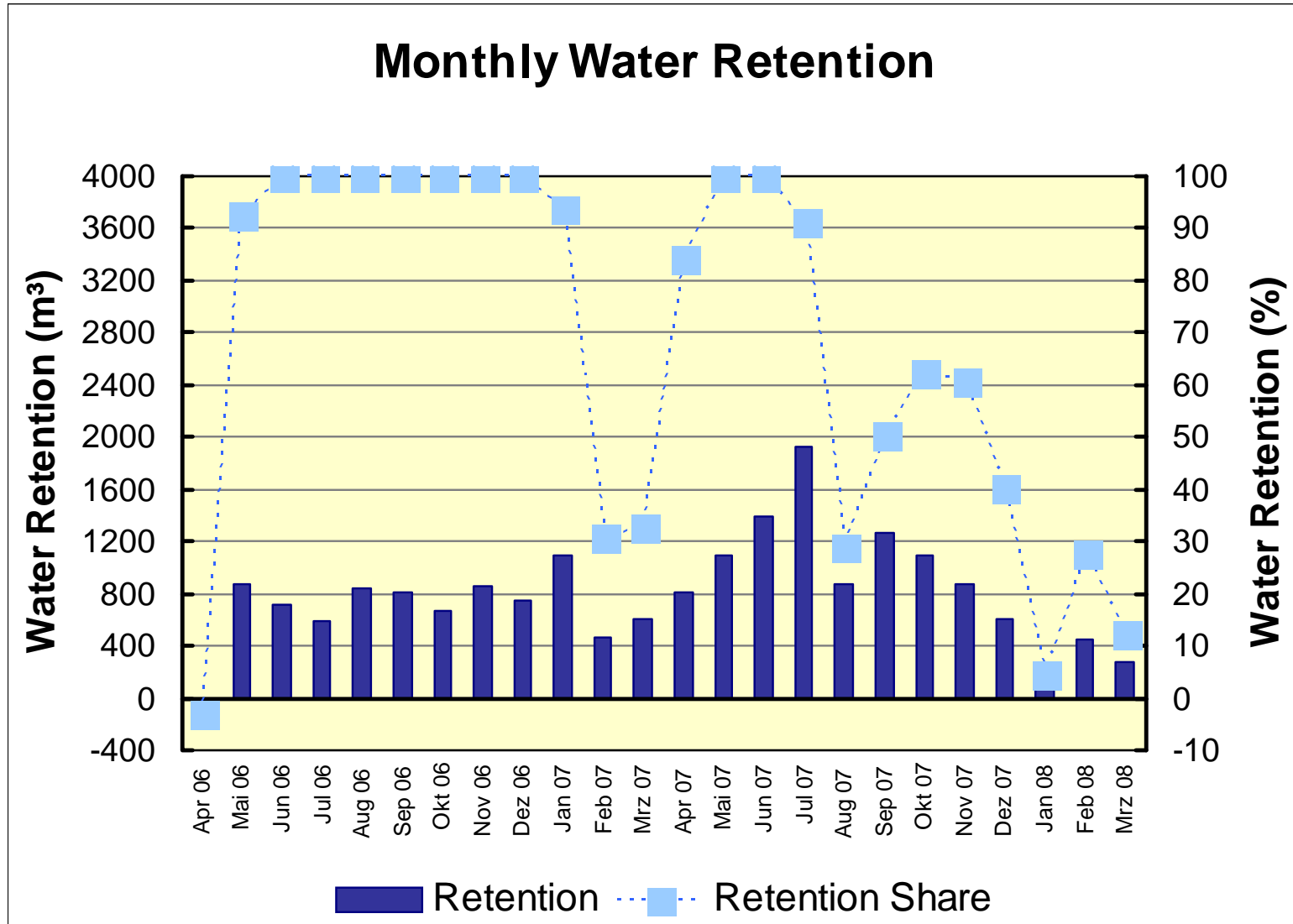
# Methods

to determine the purification effects



# Budgets of purification effects

## *pilot pond III*



Water Retention

$$R_W = Q_{Inlet} - Q_{Outlet}$$