Multifunctions of wetland systems - Legnaro (Padova) 26 – 29 June 2007

Estimation of the performance of an experimental FWS wetland in the Venice Lagoon watershed

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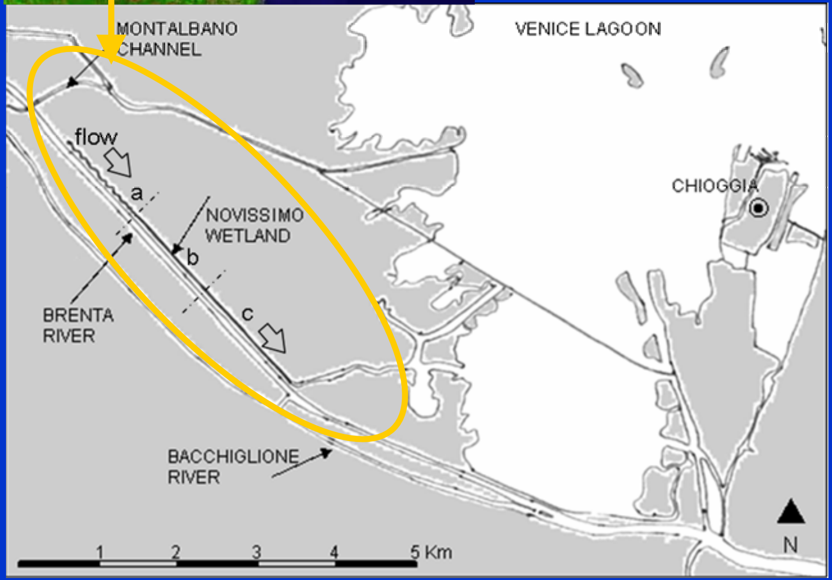
Contest: the Venice Lagoon watershed

Wetland areas counted by the “Master Plan 2000”

- Risk of eutrophication

- Wetlands as nonpoint-source pollution control tools planned in:
  - “General Plan of Interventions – 1992”, Ministry of Infrastructures – Venice Water Authority;
  - “Master Plan 2000” for nutrient load abatement, Veneto Region.

The “Canale Novissimo” wetland



- Experimental FWS wetland
- established to
  - monitor nonpoint-source pollution abatement performance
  - define the parameters of a first-order model under local environmental conditions (Kadlec and Knight, 1996)
- …achieve the knowledge needed to design a full-scale wetland.

Plant characteristics

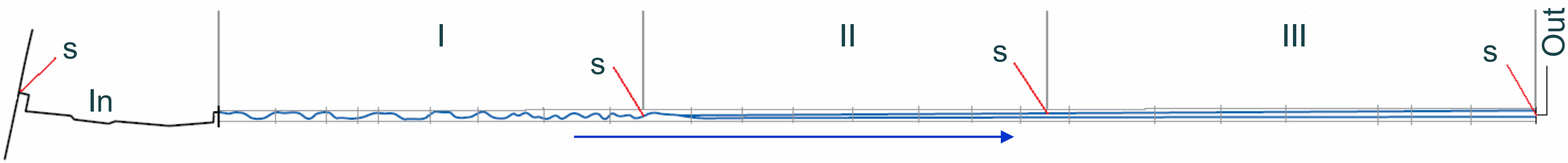
- Feeded by agricultural reclaimed water
- Main hydraulic factors controlled (flow, salinity, water stage, detention time)
- Three ecosystems: meandering riparian swamp (I), riparian and wet (II), and marsh ecosystem (III)

Design parameters:

- Flow max in/out: 0.1 $m^3 s^{-1}$
- Main volume: 30000 m^3

Monitoring design:

- free-water samples every 18 d



50 m wide, 4140 m long, mean depth 80 cm. s = sampling points.

Detention Time [d]			
Tot	**1 Eco**	**2 Eco**	**3 Eco**
14	3	5	6
7	2	2	3
5	1	2	2

DT	Main flow [$m^3 s^{-1}$]	Incoming concentrations [$mg L^{-1}$]		
		TN	**TP**	**SS**
14	29×10^{-3}	1.41	0.13	65
7	46×10^{-3}	1.81	0.06	32
5	47×10^{-3}	1.73	0.06	47

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Wetland performances

- Mass Removal Rate

$$MRR\ [kg\ d^{-1}] = M_{in} - M_{out},$$

- Percent Mass Removal

$$PMR = \frac{(m_{in} - m_{out})}{m_{in}} \times 100$$

M = mass input or output rate [kg d^{-1}]

m = mass load [kg]

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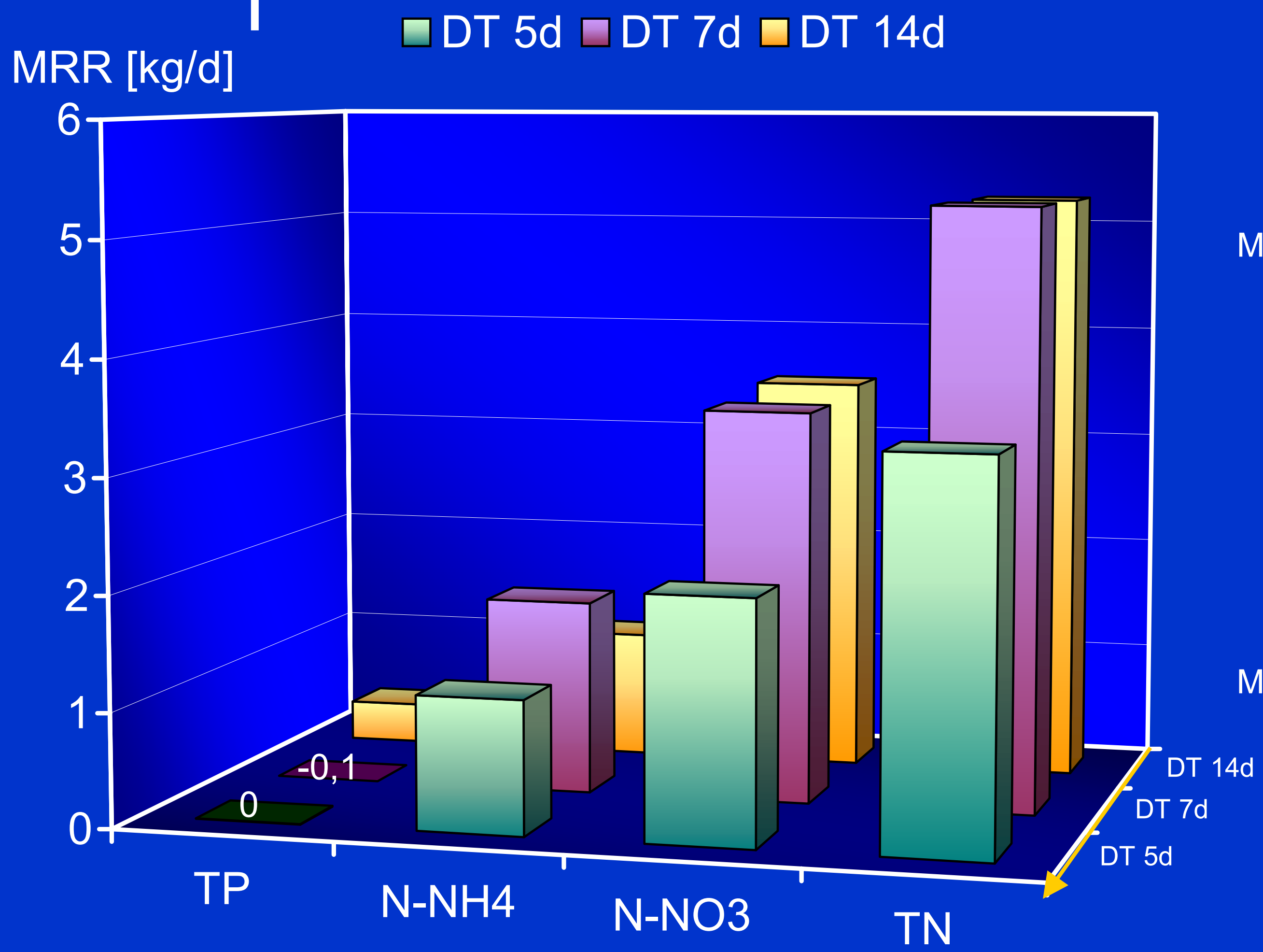
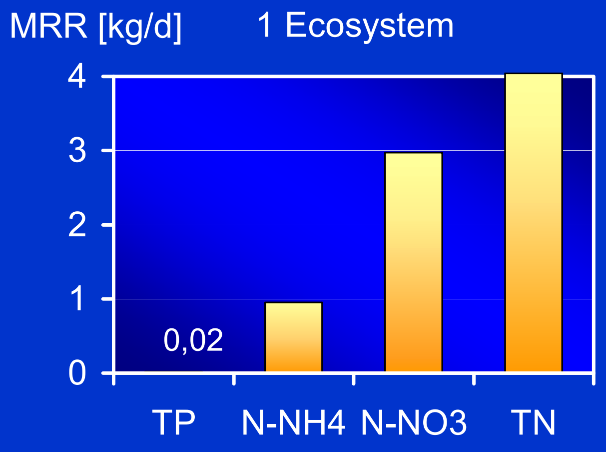
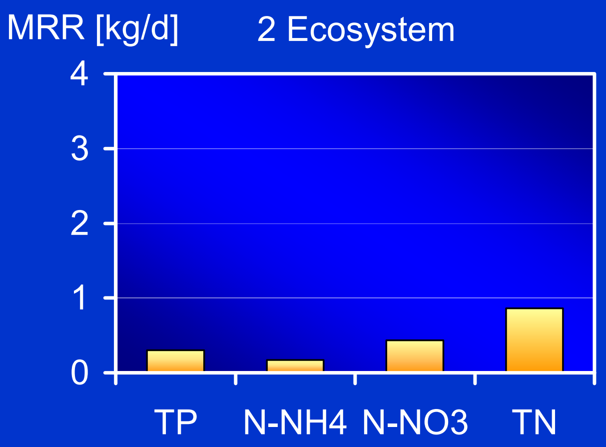
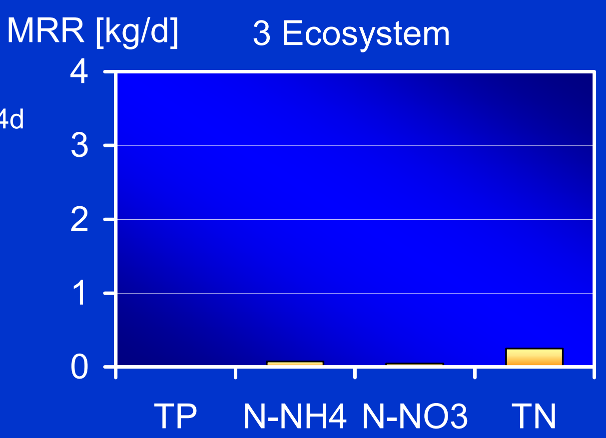
Mass Removal Rates



→ MRRs decreased with reduced detention time

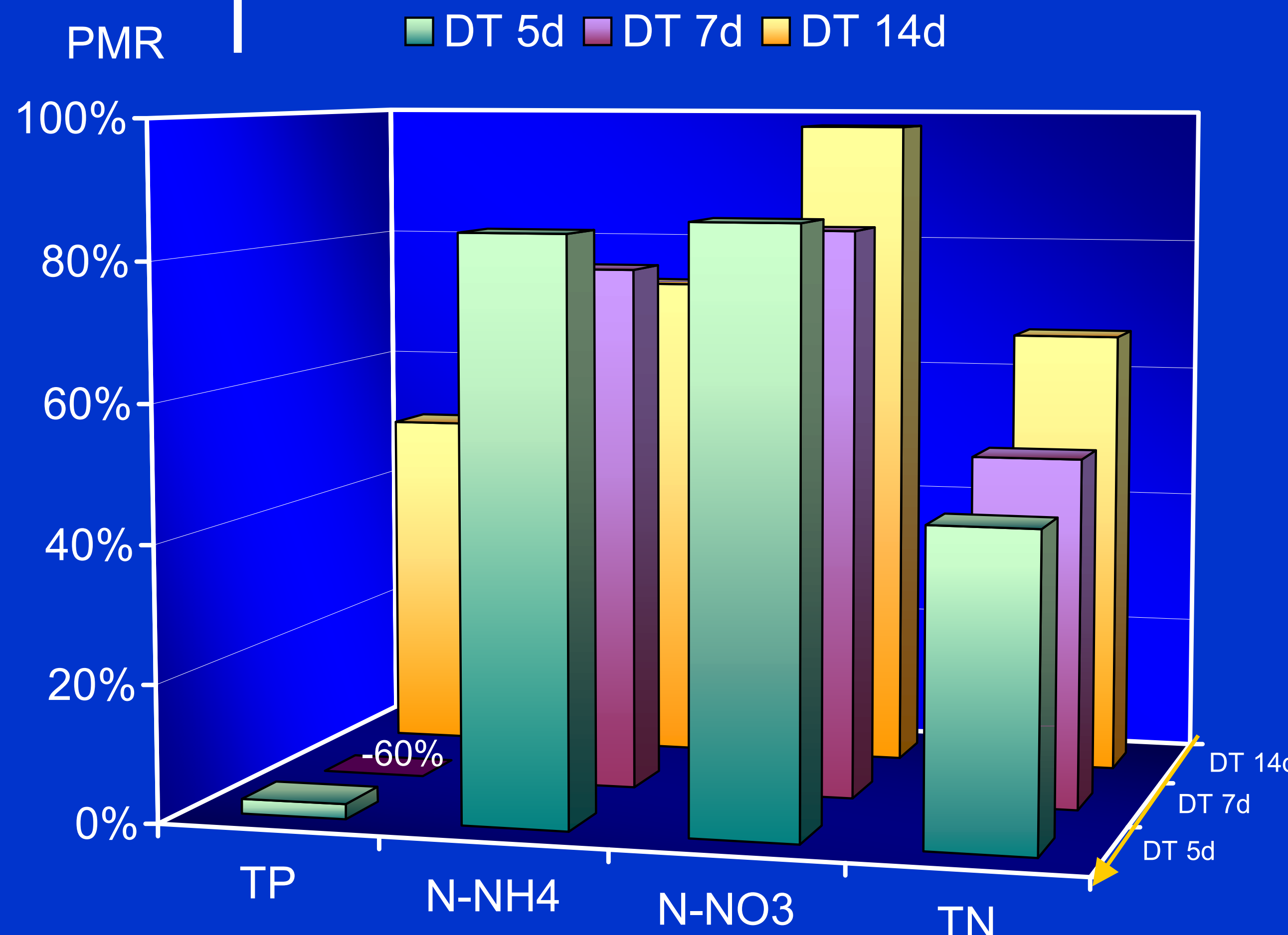


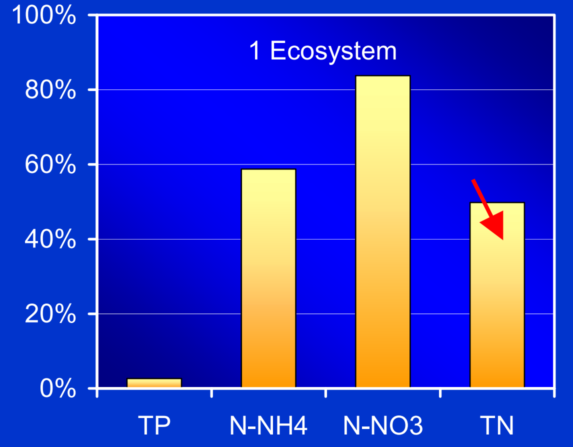


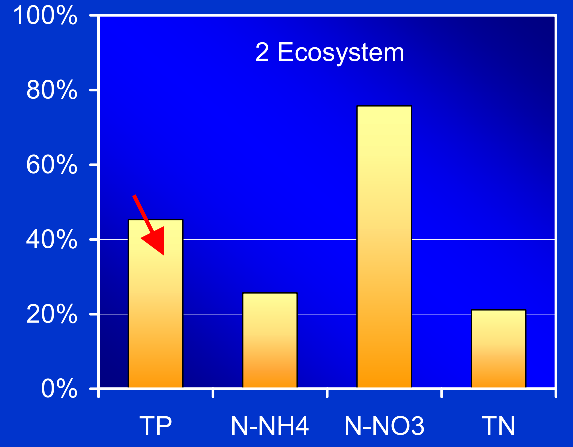


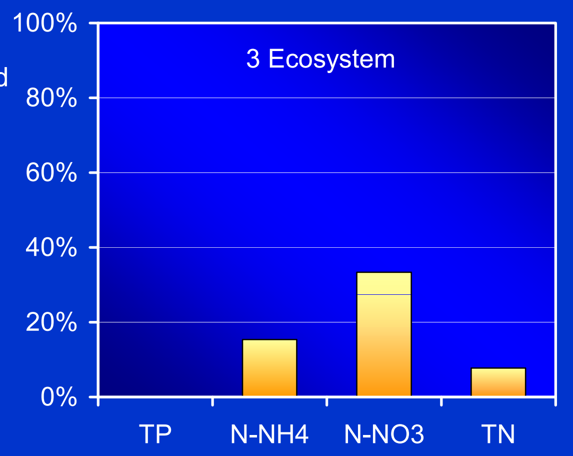
Percent Mass Removals

PMR









→ I ecosystem: best TN removal (vegetation);
II ecosystem: TP removal.

→ Whole system: best than individual subsystems.

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First order areal model

Kadlec & Knights, 1996
Rousseau et al., 2004;
Carleton, 2002; Carleton et al., 2001

- Three methods used to estimate the removal rate constant:

$$\ln\left[\frac{Co - C^*}{Ci - C^*}\right] = \frac{k}{q}$$

- input/output data, averaged k:
  k calculated over 3*DT and then averaged over the whole period;
- input/output data, calibrated k-C*:
  k and C* calibrated over the whole period by means of the Generalized Reduced Gradient (Excel Solver routine).

$$\ln\left[\frac{Cy - C^*}{Ci - C^*}\right] = \frac{k}{q}y$$

- transect data:
  k estimated by means of regression analysis.

K = removal rate constant [m d^{-1}]
Co = output concentration [g m^{-3}]
Ci = inlet concentration [g m^{-3}]
C* = background concentration [g m^{-3}]
q = hydraulic loading rate [m d^{-1}].
y = x/L = fractional distance from the inlet
x = distance from the inlet [m],
L = wetland length [m]
Cy = concentration at the y point [g m^{-3}]

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First order areal model

- The 3 methods led to similar values
- The obtained k are comparable with literature constants, despite low mass loading rates

References	TN	N-NH$_4$	N-NO$_3$	TN	N-NH$_4$	N-NO$_3$
	LR [kg ha^{-1} d^{-1}]			k [m yr^{-1}]		
This study	0.4	0.1	0.2	52	34	74
Arheimer and Wittgren, 2002	102			40		
Kallner and Wittgren, 2001		3.6			8	237
		3.4	6.7		36	29

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Conclusions

- Wetlands could be effective also with low inlet concentrations, typical of the reclaimed network: → removal rates and removal rate constants are comparable with literature data.
- Wetland efficiency increases with detention time → as observed in other wetlands.
- The whole wetland performs better than the simpler units.
- Calibration of the removal rate constants using different approaches led to comparable results → several ways to estimate reliable model parameters;

  →The values obtained could be used in the future to design full scale wetlands in the Venice lagoon watershed.

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