

The Waterharmonica In The Netherlands:

over 15 year
1994 ? – 2013

May 2013
Wetland Jubilee
20 years with wastewater treatment wetlands in Sweden!

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WATERHARMONICAS IN THE NETHERLANDS (1996-2012)

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The Waterharmonica in The Netherlands

over 15 years, 1994 – 2013

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The Waterharmonica session

A summary

by Karin Tonderski

The 7th INTECOL International Wetlands Conference
Utrecht, The Netherlands 25-30 July 2004

Field visit to Texel, 2004

But first 2004

Eversteekoog, Texel

first 2004

sewage treatment plant

presettling basin

9 parallel ditches with reed/cattail and aquatic plants

discharge ditch

- constructed in 1994
- research project 1995 – 1999
- extended in 2012

Wastewater polishing wetland as part of lake restoration, Hässleholm SE.

first 2004

Summary, synthesis, discussion
Karin Tonderski-Sundblad (University of Linköping, Sweden)
25 - 30 JULY 2004

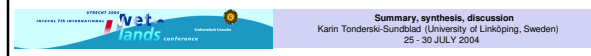
first 2004

Waterharmonica in Europe and North America

- Wise management of wastewater to promote hygienically safe surface water (for use and reuse), promote biodiversity and create recreational values

⇒ wastewater has to be managed using a catchment and ecosystem approach

The Waterharmonica:
the link between wastewater and surface water



first 2004

Some basic principles of Waterharmonica:

- Polishing and reuse of wastewater
- Integrating waterchain and watersystem
- Using ecological engineering concepts



first 2004

Waterharmonica is about communication

- communicating the need for integrated water management
 - Wastewater managers should consider the effect of their activities on adjacent ecosystems – including humans
- communicating "integrated knowledge in a usable form"

The Waterharmonica:
the link between wastewater and surface water



first 2004

Waterharmonica task: Communicating knowledge in a usable form

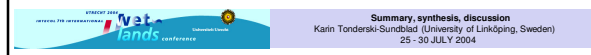
- knowledge about how to use a catchment and ecosystem approach when managing wastewater
 - examples of successful, and less successful, cases of such management
 - access to technical and practical knowledge about design and management of e.g. constructed wetlands and aquaculture systems



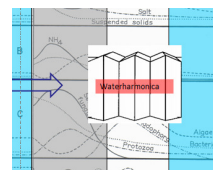
first 2004

Waterharmonica tasks:

Providing a contact network of
scientists and practioners
promoting this approach



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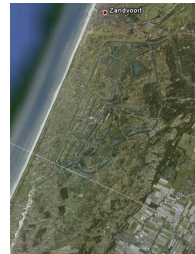
Natural processes are not new in the Watercycle



Natural processes in drinking water production Amsterdam

Artificial recharge in dunes
t = 100 days

Loenderveen basin
t = 100 days



The source for sewage

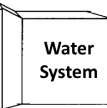
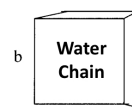
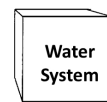
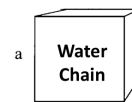
- That drinking water:
 - is used to transport wastes
 - is mixed with rain and groundwater
 - This mixture:
 - is called waste water
 - is a problem and costs a lot of money
- + rain.....

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Waterharmonica as a connection

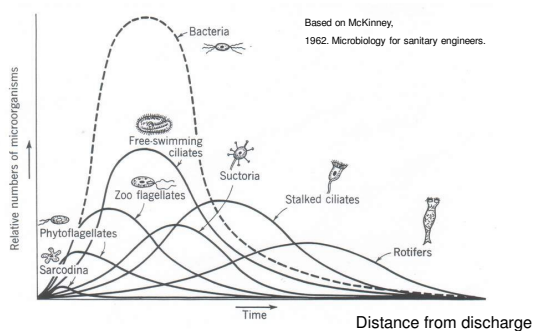


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Biological controlled self-purification



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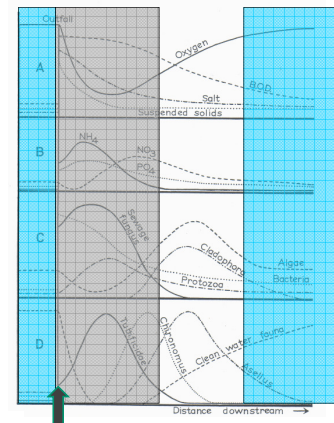
Influence of a wastewater discharge

A physical – chemical

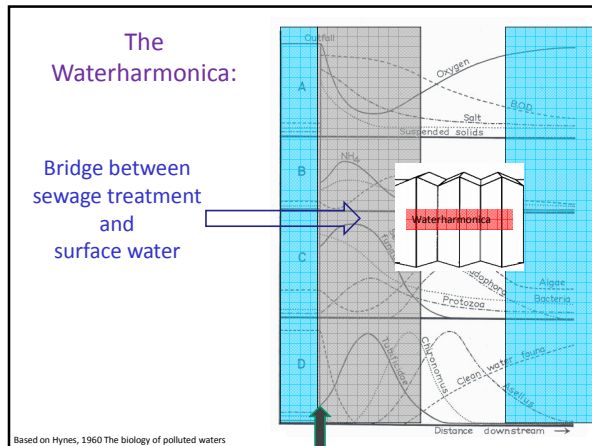
B nutrients

C micro-organisms

D macro-organisms



Based on Hynes, 1960 The biology of polluted waters



Mixing zone European Union

- Discharge of treated waste water to receiving surface water
- Mixing zone allows discharge does not meet quality of receiving water

- Waterharmonica takes the EU-mixing zone out of the EU-water body
- Effective means to meet the EU-standards

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Daphnia food chains

Empuriabrava

Grou

Eversteekoog

www.waterharmonica.nl



stowa

NATURAL CONSTRUCTED WETLANDS BETWEEN RIVERS WILL TREAT WASTE WATER AND STORE SURPLUS WATER

WATERHARMONICAS IN THE NETHERLANDS (1996-2012)

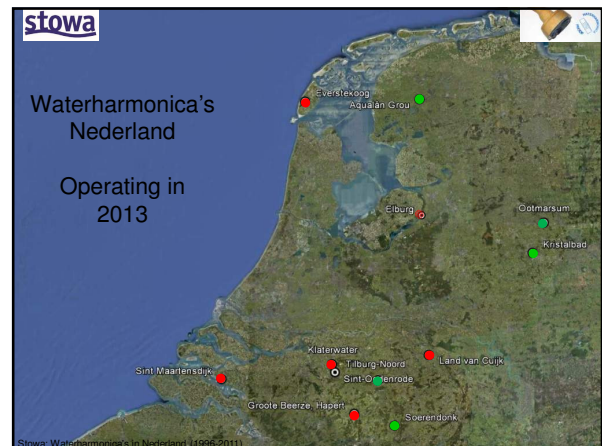
RAPPORT 08

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12 March 2013



Sint Maartensdijk Vollenhove Eiburg Grou

Efteling Eversteekog Groote Beerze Hapert

Soerendonk Tielburg Noord Ootmarsum

Sint Oedenrode Kristalbad Land van Cuijk

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Waterharmonica Aqualân Grou

- first design -

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Aqualân Grou

effluent

Three Daphnia ponds

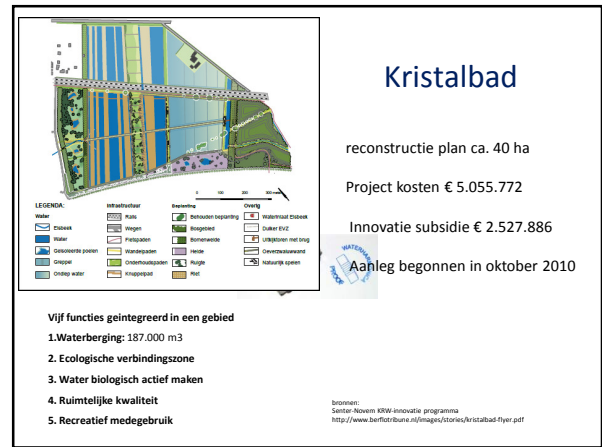
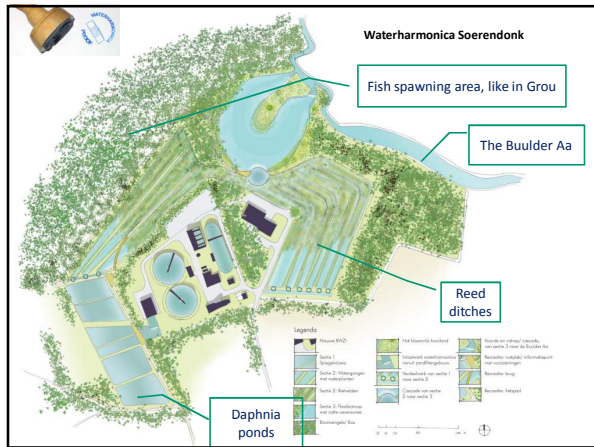
Four reed ditches

Spawning area for fish

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Reasons to make Waterharmonicas – until 2001		
No.	Name	Primary reason/reasons for construction
8	Eiburg	1978: to lower the nutrient level in STP effluent, taken out of operation. Has not been put back into operation because of the 'high natural values'
1	Eversteekoo, Texel	1994: as a source of fresh water for agriculture on the island, disinfection because it crosses a residential area. Has been expanded and renovated in 2012 – 2013
2	Empuriabrava, Spain	1995: to supply water for a nature reserve to create local natural value
3	Klatwater in Kaatsheuvel	1997: to produce water with a low level of nutrients and pathogens for the Effeling
4	Tilburg-Noord	1997: to buffer effluent during rainwater discharge so as not to exceed the maximum permissible effluent rate because of the limited capacity of the stream de Zandijk, ecologisation at basic discharge
5	Land van Cuijk	1999: to supply water to agriculture/nature and to reduce discharge to national waters
6	Sint Maartensdijk	2000: to reduce nutrients and obtain insight in the functioning of the helophyte filter, recreation
7	Waterpark Groote Beerze	2001: river restoration Groote Beerze, to promote wet habitats

- Nutrient removal
- Buffering water
- Supply water for agriculture, nature

Reasons to make Waterharmonicas – from 2006		
No.	Name	Primary reason/reasons for construction
9	Aqualin Grou	2006: to develop nature and a spawning pond, demonstration project and Urban Water Cycle Project
9	Ootmarsum	2010: 'ecologisation' of the effluent for discharge into a small stream and Urban Water Cycle Project
10	Sint-Oedenrode	2011: ecological corridor, 'natural water', incorporated in a trail, bird sanctuary with watchtower
11	Kristalbad	2012: regional buffering water, recreational green buffer zone, ecologisation, improvement of water quality and Dutch WFD subsidy
12	Soerendonk	2012: water buffer, recreation, to develop natural habitats, spawning pond/fish migration and Dutch WFD subsidy
13	Tilburg Moerenburg	2011-2012: to buffer 'influent', improving natural values, recreation, to prevent overflow
14	Vollenhove	2012 'purifying' riverbank

- Buffering water
- River restoration
- Surface water quality
- Fish spawning
- Making "natural habitats"
- Recreation

Load of Dutch Waterharmonicas

Load	Net load (m/day)	Net specific surface area (m ² /p.e.)	Waterharmonicas per load class as example, see also table 1
Extremely low	< 0.05	> 2.5	Klaterwater
Low	0.05- 0.1	1.25 - 2.5	Elburg
Medium	0.1 - 0.20	0.75 - 1.25	Waterpark Grootte Beerze Hapert, Aqualân Grou, the Kristalbad, Ootmarsum, Sint Oedenrode, Soerendonk, Vollenhove
High	0.2 - 0.3	0.5 - 0.75	Eversteekoo, Sint Maartensdijk, Land van Cuijk
Extremely high	> 0.3	< 0.5	Tilburg-Noord

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Some characteristics of Dutch Waterharmonicas

System	Surface area (ha) netto	Flow rate (m ³ /day)	Net hydraulic load (m/day)	Retention time (days)	Percentage of effluent (%)
Aqualân Grou	1.2	1,200	0.19	3.3	approx. 25
Eversteekoo on Teed	2.7	1,3	0.07	15	100
Klaterwater in the polder	2.7	1,380	0.02	105	approx. 10
Ootmarsum	2.7	1,380	0.13	4.6	100
Soerendonk	2.7	1,380	0.13	3.7	100
Sint Oedenrode	2.7	1,380	0.13	1.5	100
Tilburg-Noord	2.7	1,380	0.13	2	N/A
Tilburg-Moerburg	2.7	1,380	0.13	2	100
Vollenhove	2.7	1,380	0.13	2.8	100
Waterpark Grootte Beerze In	2.7	1,380	0.13	2.8	100

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Investment cost

TABLE 5 INVESTMENT COSTS OF WATERHARMONICA SYSTEMS IN THE NETHERLANDS

	price level	Not indexed		Indexed to 2012	
		investment	index	per netto hectare	per brutto hectare
Elburg	1977	200,000	1.75	15,500	2.20
Eversteekoo	1994	245,000	1.17	211,500	11.65
Grou	2006	600,000	1.17	179,500	91,000
Klaterwater	2006	575,000	1.17	176,500	129,000
Ootmarsum	1997	1,039,000	1.33	194,500	14,45
Soerendonk	2012	5,856,000	1.00	235,000	18.39
Sint Oedenrode	2000	53,000	1.17	62,000	3.20
Tilburg-Moerburg	2008	250,000	1.09	62,000	11.10
Tilburg-Noord	2011	2,400,000	1.17	62,000	41.45
Vollenhove	2012	1,000,000	1.17	62,000	1.42

Swedish source: Flyckt, 2010

Re 1: The construction of Raalte was postponed, estimated costs from Ott, Blom et al, 2009.
Re 2: Sint Oedenrode was constructed as an expansion for landscape degradation, the costs include the

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Operational cost

- management, including basic monitoring
- € 7,500/ha/year
 - from € 3,000/ha/year for large systems like Kristalbad,
 - to € 25,000/ha/year for smaller systems, such as Soerendonk and Grou.
 - depends on the extent of the monitoring..

"Management and maintenance costs for Swedish Waterharmonica systems vary between € 1,000 and € 7,000/ha/year"

Swedish source: Flyckt, 2010

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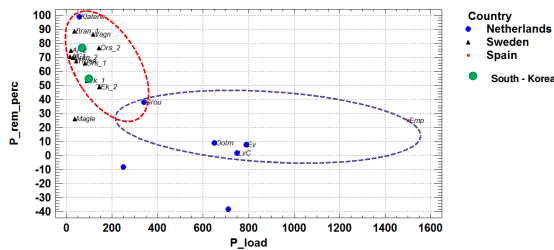
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Waterharmonica's P-removal: P-load (kg/ha.year) vs P-removal (%)



Swedish source: Flyckt, 2010

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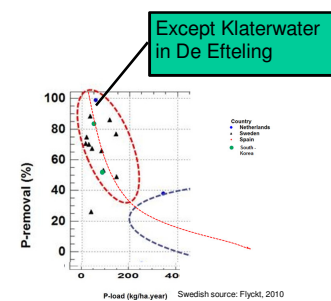
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Waterharmonica's P-removal: P-load (kg/ha.year) vs P-removal (%)

P concentrations:
Sweden much lower than Netherlands



Except Klaterwater in De Efteling

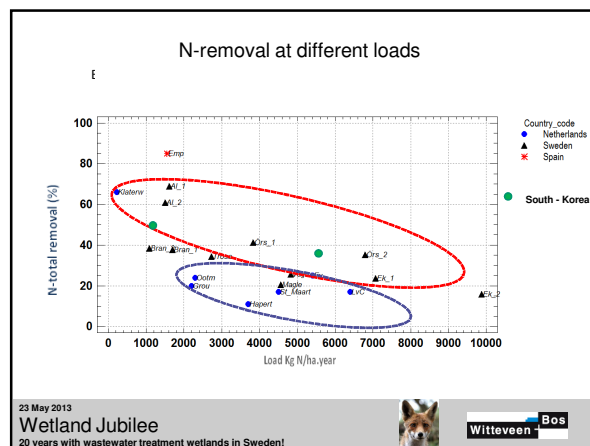
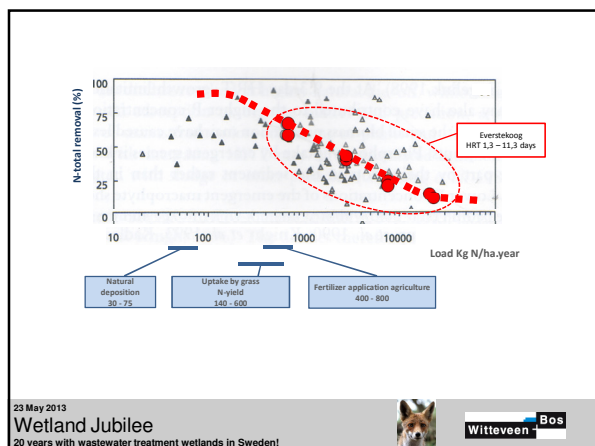
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Birds on www.waarneming.nl

Observationer
skapat: 21-05-2013 17:39 nästa uppdatering: 21-05-2013 18:29

statistika: Alla
från: 2013-05-21
till: 2013-05-21

datum	antal	utseende	aktivitet	art	Observator	sub-area
20-05-2013	2	okänt	nävarande	Arta - Anas querquedula	Carl Derks	
20-05-2013	1	okänt	överflygning	Turdus - Streptopelia turtur	Carl Derks	
20-05-2013	6	okänt	nävarande	Backsvan - Riparia riparia	Carl Derks	
20-05-2013	15	okänt	nävarande	Grey-headed Wagtail - Motacilla flava thunbergi	Carl Derks	
20-05-2013	1	okänt	överflygning	Stenknäck - Coccyzus erythrophthalmus	Carl Derks	
19-05-2013	1	okänt	fodasök	Skedstork - Platalea leucorhoa	Harry Kuiphuis	
19-05-2013	3	okänt	nävarande	Mindre strandpape - Charadrius dubius	Timo Roelke	
19-05-2013	2	okänt	fodasök	Mesnappa - Calidris temminckii	Timo Roelke	
19-05-2013	1	okänt	nävarande	Gluttnappa - Tringa nebulosa	Timo Roelke	
18-05-2013	2	okänt	nävarande	Arta - Anas querquedula	Carl Derks	
18-05-2013	1	okänt	nävarande	Mindre strandpape - Charadrius dubius	Carl Derks	
18-05-2013	3	okänt	nävarande	Dillnappa - Actitis hypoleucos	Carl Derks	
18-05-2013	1	okänt	nävarande	Stensivatta - Oenanthe isabellae	Carl Derks	
15-05-2013	2	okänt	nävarande	Arta - Anas querquedula	Carl Derks	
15-05-2013	1	okänt	nävarande	Arta - Anas querquedula	Sjoerd Radstaak	
15-05-2013	2	okänt	nävarande	Mindre strandpape - Charadrius dubius	Carl Derks	
15-05-2013	1	okänt	nävarande	Dillnappa - Actitis hypoleucos	Carl Derks	
15-05-2013	4	okänt	nävarande	Dillnappa - Actitis hypoleucos	Sjoerd Radstaak	
15-05-2013	1	okänt	nävarande	Stensivatta - Oenanthe isabellae	Carl Derks	

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How does the effluent change?

1. Suspended particles/solids
2. Pathogens
3. Organic pollution and oxygen
4. Nutrients
5. Buffering peak loads
6. Ecotoxicology
7. Ecology

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Suspended particle/solids

Different definitions:

- organic / inorganic
- living / death
- big / small
- micro-organism versus virus
- does/or not have effect on environment: pathogen
- origin: in influent or shaped in STP

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Suspended particle/solids

Different determination techniques:

Often only as dry matter

	Particle size distribution	Chemical analysis	Particle composition	Biological particle composition	Spatial particle structure	Pathogen detection
Chemical analyzers						
Environmental Scanning Electron Microscopy (ESEM EDX)		X				
Inductively coupled plasma mass spectrometry (ICP-MS)		X				
Laser diffraction	X					
Laser back scattering	X					
Spatial fiber velocimetry	X					
Acoustic spectrometry	X					
Bacteroresistance counting	X					
Flow cytometry	X		X			
Particle video microscopy	X		X			
Manual microscopy			X			
Fluorescent In Situ Hybridization (FISH)			X			X
Environmental scanning electron microscopy (ESEM)			X	X		
Confocal laser scanning microscopy (CLSM)				X		
Indicator species culturing						X
Real time quantitative Polymerase Chain Reaction (QPCR)						X
Multiplex QPCR						X
Densitizing Gel Electrophoresis (DGE)						X
DNA restriction analysis						X
DNA microarrays						X
Matrix-assisted laser desorption/ionization (MALDI TOF MS)						X

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Suspended particle/solids

Several Dutch studies:

- Monitoring data of 8 Waterharmonica's
 - several years, monthly data, normal operation WWTP.

Result on suspended particles / solids:

- Elburg (1978) and Eversteekooog (1995): SS_{out} more or less equal to SS_{in} , or even an increase!
- Recent six constructed wetlands: same
- Low amount (5 a 10 mg/l), clear water

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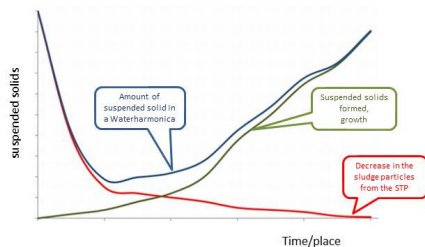
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Suspended particle/solids

Paradox! No gain? (in theory)



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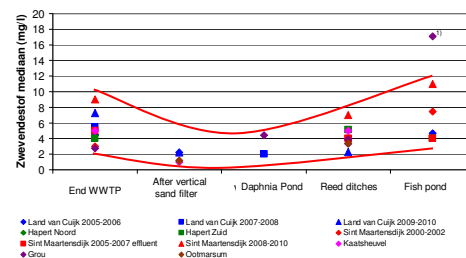
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Suspended particle/solids

Paradox based on monitoring!



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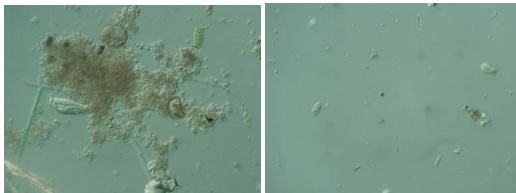


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Suspended particle/solids

But a big change in composition!

From "activated sludge (bacteria)" to "natural suspended solids"



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Pathogens

Pathogens are (micro)-organisms that can provoke diseases as a result of exposure

- Different types (viruses, bacteria, parasite, fungi)
- Different sizes (0.002-100µm)
- Many present in waste water
- Monitoring using indicator-organisms

 E. coli	 Enterococci	 Clostridium perfringens	 Bacteriodes-fagen
• Bacteria • Fecale contamination • Facultative anaerob • 2.0-0.5 µm	• Bacteria • Fecale contamination • Facultative anaerob • 0.8-1.3µm	• Bacteria • Fecale contamination • 5.0-0.5µm	• Virus • Fecale contamination • 0.026µm

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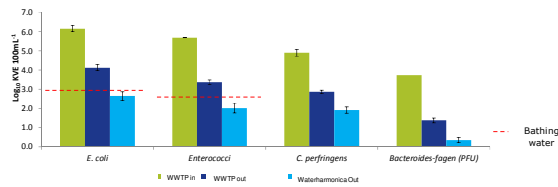


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Pathogens

Reduction of pathogens in STP and Waterharmonica

- 1 to 3 log (E.coli, Enterococci)



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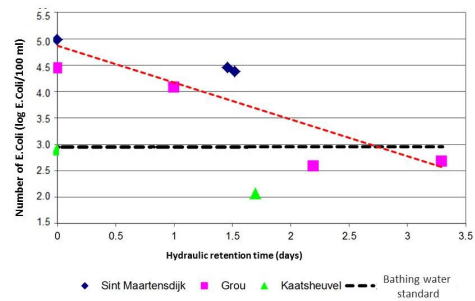
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Pathogens



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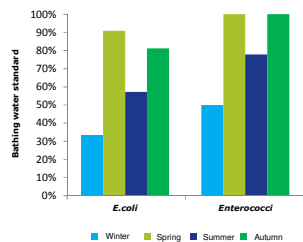
Pathogens

Differences in summer - winter?

- Mainly in summer and winter

Best hygienic quality?

- Spring and autumn



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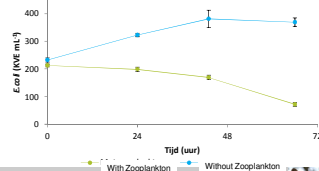


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Pathogens

What are the driving forces for removal?

- Not sedimentation
- Natural mortality and irradiation (but only 5-10 cm)
- Biofilm in reet is positive
- Mainly predation by zooplankton



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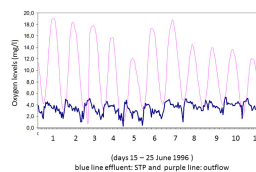


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Organic pollution and oxygen

The Waterharmonica:

- Decrease the amount of BOD (10-15%) but mainly converts it to "other" BOD (see SS)
- Increase of retention time increases the reduction of BOD and therefore ending in a better oxygen situation
- Creates a powerful day-night rhythm in the oxygen level



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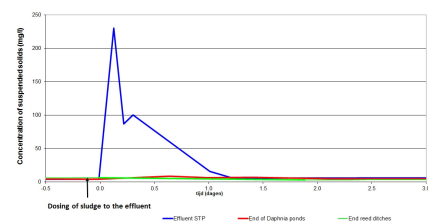


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Buffering peak loads

The Waterharmonica is very effective in reducing peak pollutions of eg. a sludge overflow:

- Both Suspended Solids (90%) as P (90%) and N (60-70%)



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Wetland Jubilee

20 years with wastewater treatment wetlands in Sweden!



Witteveen Bos

Ecotoxicology

The Waterharmonica:

- Effluent from STP can have an inhibiting effect on algae development
- WFD innovation project WIPE showed:
 - Waterharmonica has a favourable effect on the toxicological quality of the water in the outlet (possible by adsorption, degradation or smoothing peaks)
- No indications of risks of acute toxicity

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Ecotoxicology

WIPE research on:

- Xenobiotic substances (passive sampling)
- In-vivo bioassays
 - Bacteria (30 min)
 - Algae (72 h)
 - Zooplankton (48 h)
- Fish



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Ecology

The Waterharmonica:

- Increase natural diversity eg. by increase of Daphnia and decrease of monoculture bacteria of activated sludge, increase of vegetation and increase of number and variation of birds and fish



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Fish in spawning area Aqualan Grou 2008 – 2012

	2008		2009		2010		2011		2012	
	n	% brood	n	% brood	n	% brood	n	% brood	n	% brood
Perch	9	22	102	81	112	76	126	81	32	56
Roach	54	67	75	56	41	54	116	57	73	9
European bitterling	-	-	14	14	7	29	18	100	1	100
Bream	2	0	-	-	-	-	-	-	-	-
Three-spined stickleback	1	100	1	100	-	-	1	100	-	-
Goldfish	2	100	-	-	-	-	1	100	-	-
Sand loach	4	0	10	0	1	0	-	-	5	0
White bream	2	50	13	85	5	100	47	100	7	100
Eel	2	0	4	0	1	0	(+)	-	-	-
Bluff	1	100	4	25	13	77	(+)	-	-	-
Stickleback	6	33	46	43	44	87	1	100	-	-
Rudd	6	0	3	100	24	88	6	17	3	33
Pike	3	100	2	0	6	17	6	50	8	100
Ten-spined stickleback	1	100	1	100	-	-	(+)	-	1	100
Wetfish	-	-	1	100	-	-	-	-	2	100
Tench	5	40	4	100	2	50	3	67	4	50
Total	88	52	288	58	256	72	325	74	156	32
Number of species / Percentage of species with brood	14	10	14	13	13	9	10 (+3)	10	10	9

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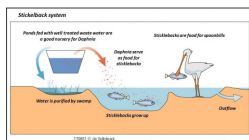
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Witteveen Bos

The Waterharmonica in The Netherlands over 15 years, 1994 – 2013



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Concept development and application
Ruud Kampf

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Waterharmonica future.....?
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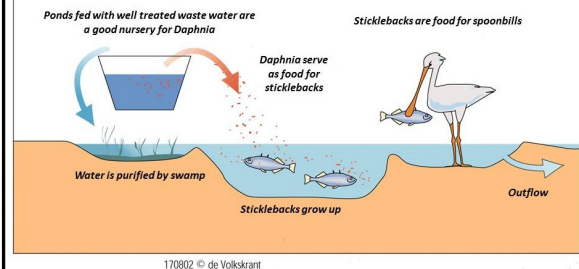
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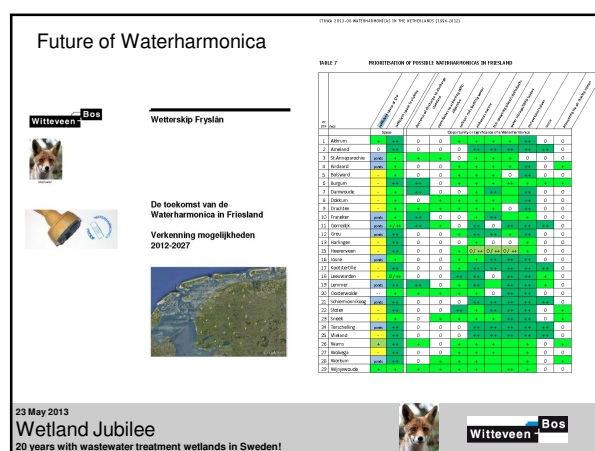
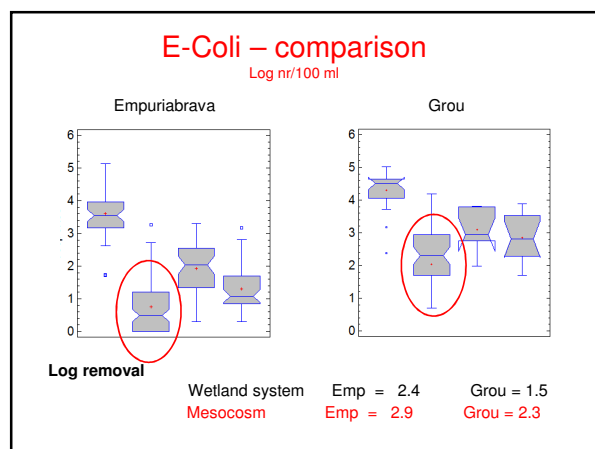


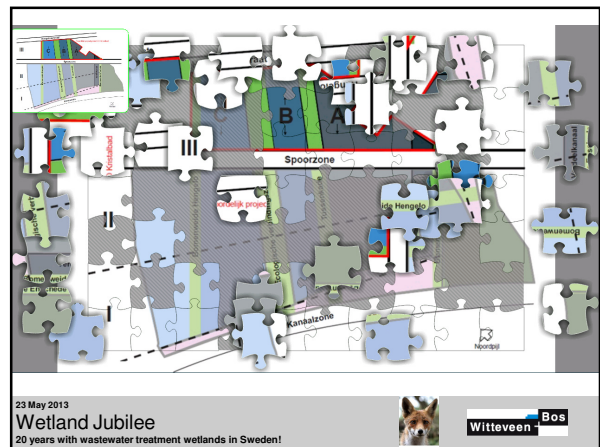
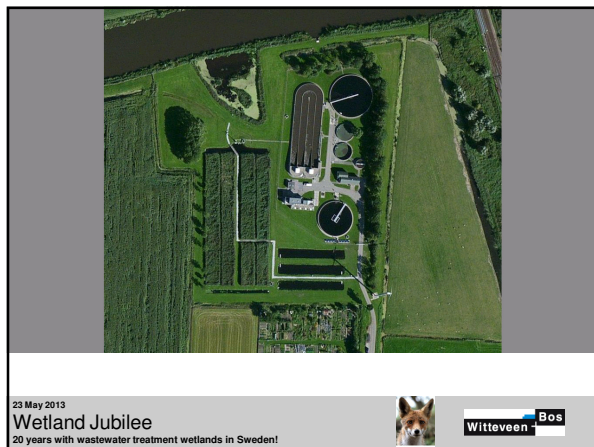
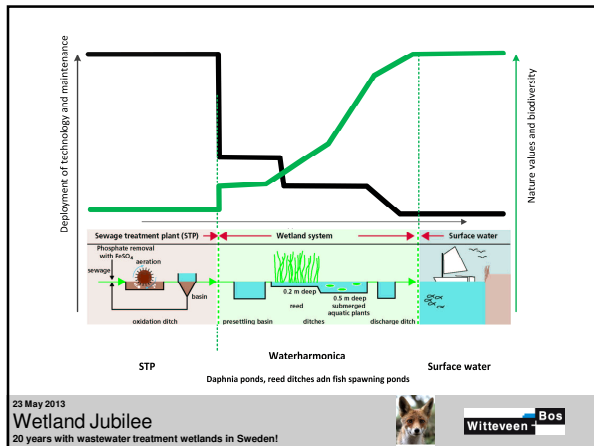
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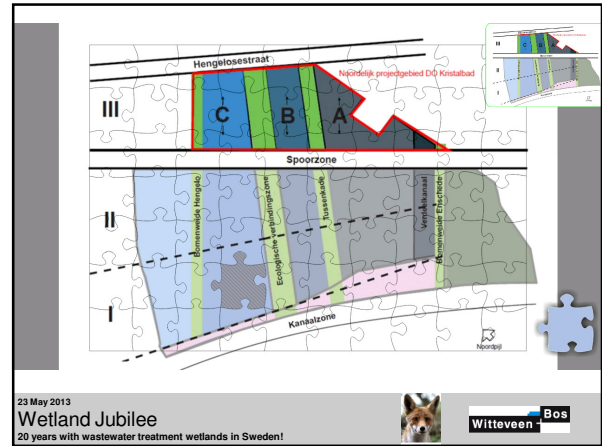
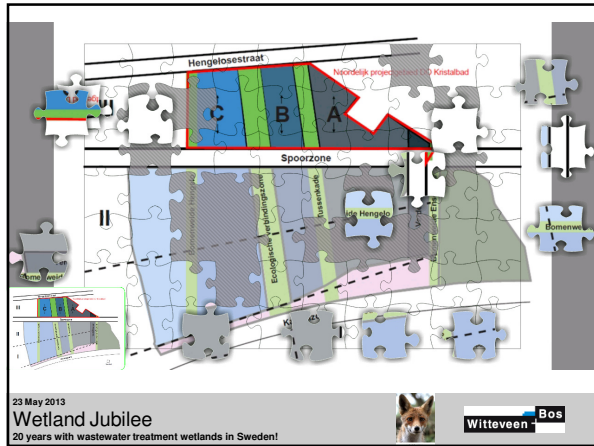
Stickleback system



170802 © de Volkskrant







WATERHANDLING
PROOF

Interesting to bring the experiences together
.....

Thank you for your attention

NYNÄSHAMN
Oxelö Energi
WRS
EVIEM

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