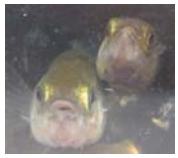
The Waterharmonica
Ecological engineering

Food-chain approach in re-use of treated waste



Ruud Kampf

IWE Seminar Series "Water and Health"
Thursday 6 April 2006 (10:30-12:15)
WUR, Nieuwlanden, P71

Resources

www.waterharmonica.nl

Pdf of this presentation:

www.waterharmonica.nl/iwe

Introduction

Ruud Kampf:
Hoogheemraadschap Hollands Noorderkwartier
The Netherlands

Close cooperation with **Theo Claassen**: Wetterskip Fryslan

PhD at Vrije Universiteit Amsterdam and Technical University Delft

With support of Universiteit van Amsterdam

"Clear effluents"

Waste water was the finest water we had:

Originally
drinking water and rain water

Waste water
or
"waste in water ?"

This presentation:

- **Introduction Waterharmonica**
- Texel: Tourists, Spoonbills, Master Plan Water
- Texel: the Everstekoog constructed wetland to make a "living water" from waste water
- food chains and the Waterharmonica: "kwekelbaarsjes" or "gricklebacks"
- Europe: a Spanish example
- The Waterharmonica in Nepal and Tanzania:
  - sustainability, biodiversity, surface water quality, health

The Waterharmonica:
the link between treated waste water and surface water

Aerial view STP Everstekoog

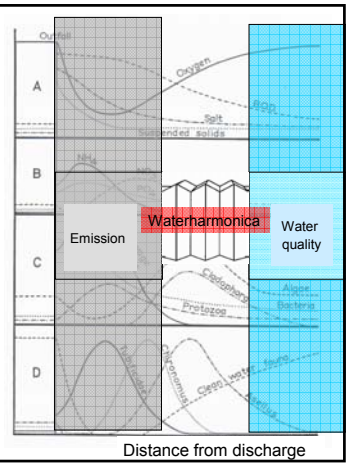
Schematic effect of discharges of wastewater

A physical – chemical

B nutrients

C micro-organisms

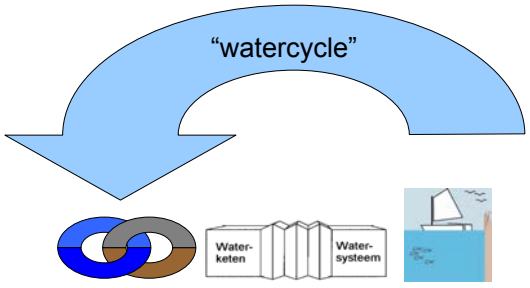
D macro-organisms



Two separate worlds

Emissions	Surface waters
reduction discharges	quality standards
black lists pollutants	aquatic ecosystems
best available techniques most feasible techniques	water systems
action programmes / regulations	general directives
legislation control	integrated water management master plan consensus involvement

Missing link in water management



The natural link from tap to source

The Waterharmonica project

- winning idea in 1996: 25 years celebration Dutch Foundation for Applied Water Research (STOWA) by Theo Claassen

STOWA project 2003-2004:
research and implementation

- for reports, papers conferences, etc:

www.waterharmonica.nl

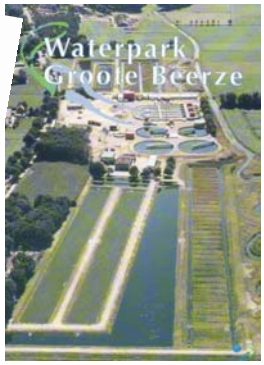
stowa WETTERSKIP FRYSLÂN Hollands Noorderkwartier ROYAL HASKONING LeAF

Stowa reports

Pdf on
www.waterharmonica.nl

STP Land van Cuijk,
Waterboard de Maaskant

Water park Groote Beerze



STP Hapert De Dommel

Main Conclusions

- Use your effluents !!
  - Do not throw away (waste) water
  - Manage the waste water quality
  - Make the effluent as 'clean' as possible
  - Nutrients, sludge particles, food chains
- Waterharmonica is a usable tool
  - Integrated water management
  - Engineers dare to meet biologists….

www.waterharmonica.nl

This presentation:

- Introduction Waterharmonica: examples and plans in The Netherlands
- **Texel: Tourists, Spoonbills, Master Plan Water**
- Texel: the Everstekoog constructed wetland to make a "living water" from waste water
- food chains and the Waterharmonica: "kwekelbaarsjes" or "gricklebacks"
- Europe: a Spanish example
- Discussion:
  - sustainability, biodiversity, European Water Frame Work Directive, membrane filtration, nature

The Waterharmonica:
the link between treated waste water and surface water

Texel

- Is a beautiful island
- A tourist resort
- A bird island
- Still a strong agricultural stronghold

Spoonbills

Spoonbills in Europe

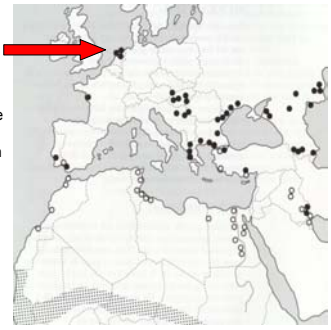
The Netherlands

One of the rarest birds in Europe

95 % West-European population in the Netherlands

Annex I European Bird directive

Symbol of good water management



Water on Texel

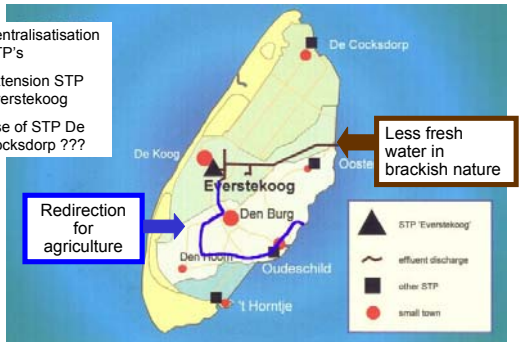
- Scarce
- Drinking water from mainland
- Masterplan Water Texel
- Projects like effluent diversion, etc

Effluent reuse on the island

Centralisatisation STP's

Extension STP Everstekoog

Use of STP De Cocksdorp ???



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The Waterharmonica:
the link between treated waste water and surface water

Aerial view STP Everstekoog

sewage treatment plant

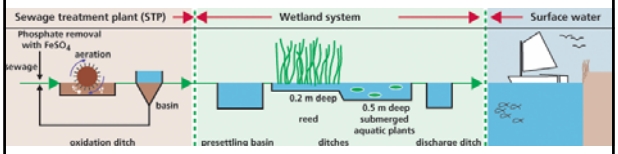
presettling basin

9 ditches with reed/cattail and aquatic plants

discharge ditch

Research project
1995 - 1999

From wastewater to surface water



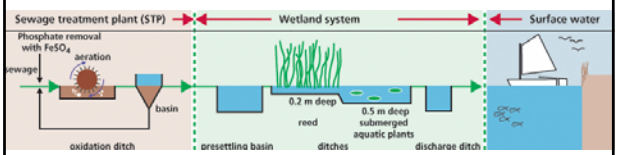
STP Oxidation Ditch

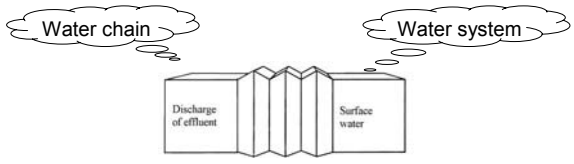
3.400 m^3/d

Constructed wetland

Surface water

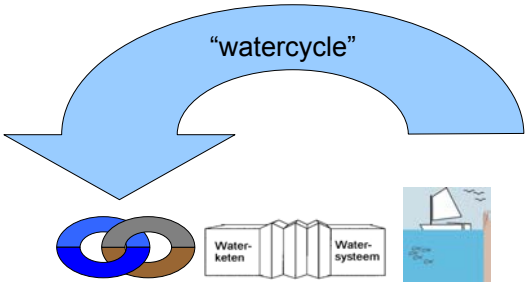
A constructed wetland to make a "living water" from treated waste water





www.waterharmonica.nl

Missing link in water management



The natural link from tap to source

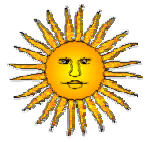
Everstekoog

Everstekoog - ditches

July 2005

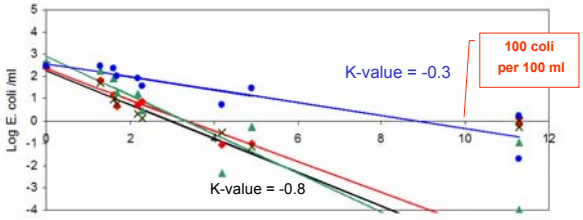
Constructed wetland

- a constructed, optimised water system
  - helophytes: reed, cattail
  - (submerged) water plants
  - plants on the banks
  - sediments
  - algae, Daphnia, etc
- works on solar energy



A constructed wetland to make a "living water" from treated waste water

Log Fecal Coli (per ml) vs retention time

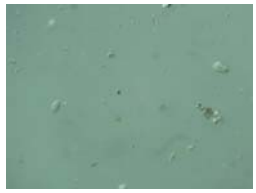


Hydraulic retention time (days)

Spring Summer Autumn Winter

After constructed wetland different water

- Natural oxygen regime
- No odour
- Less sludge particles lead to desinfection
- More, but different suspended solids
- Living water:
  - algae, daphnia
  - all kind of "waterlife"
  - fish
  - birds



Conclusions Texel

A more natural constructed wetland:

different, living water

disinfection

nutrient removal

natural values

After treatment of waste water
or
pre treatment of surface water?!

Process technology constructed wetlands

- Oxidation ditch / carrousel:
  - like polluted surface water
- Constructed wetland for effluent polishing:
  - like cleaner surface water
- Processes are comparable
  - settling, adsorption, (photo katalytic) biofilms, diffusion, growth, decay, etc.

➔ combination van (bio)procestechnology, agriculture, biology, etc.

[EcoEng-online]

➔ ecological engineering: www.IEES.CH

Water Frame Work Directive

Very strict new effluent standards !!
Leads to new very expensive filtration / membrane techniques

Engineering **vs** natural processes ?????

Or

Engineering **plus** natural processes ?????

Texel

Learning the process by doing

Resulted in a lot of knowledge and ideas!!

well treated wastewater
can be a good source of life!

More sustainable, natural water systems

Fish in the Everstekoog constructed wetland

- in first pond no fish
- fish in ditches:
  - but only after 3 days retention time
  - after 10 days a lot of fish

up to 15 Stickleback per m^2

Food chains!

http://www.intarttiles.com/robertekennedy.htm

Daphnia - trivia

- Length: 0.3 - 5 mm
- Wet weight: 0.5 - 2 mg
- Filtration capacity: 4 ml/ind.hour

(1000 Daphnia/l filtrates water 4 times per hour)

- Size of food particles between 1 - 40 µm

Protein: 60 %
Fat 10 %
Carbohydrates 6 %

C = 44 %
N = 8 %
P = 1.4 %

Sticklebacks

Harvesting Daphnia for research

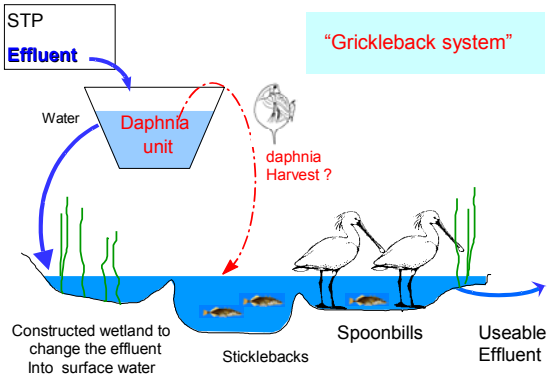
"Kwekelbaarsjes"

growing **Daphnia**
on treated wastewater

to grow **Sticklebacks**

"Gricklebacks"
=
Growing Sticklebacks

as food for **Spoonbills**



Experimental set-up Everstekoog

4 ponds

4 mesocosms

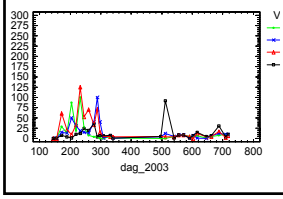
Everstekoog
Ponds and Mesocosms
from 1998 onwards

Algae

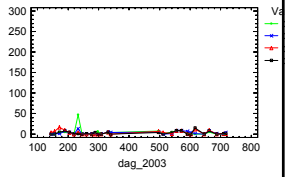
- NO_3: 1 – 4 mg/l
- PO_4: 0.5 – 1 mg/l

- Redfield ratio: 1 – 6: P in excess

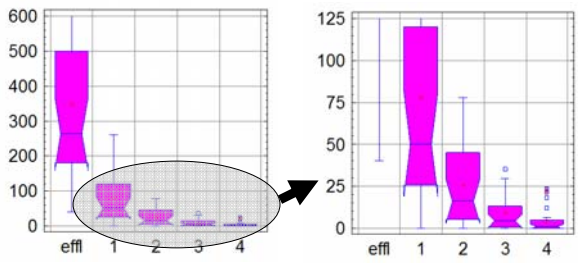
Chlorophyl_A vijvers



Chlorophyl_A bakken

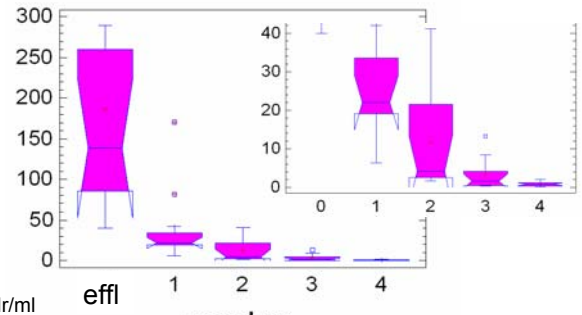


Fecal Coli removal
mesocosms 2003-2004



Nr of fecal coli/ml vs hydraulic retention time

Fecal Coli Winter 2004 - 2005



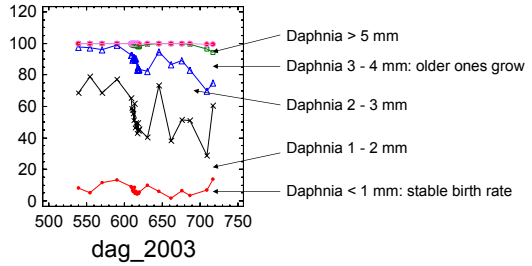
October 2004 – March 2005

Average water temperature 9 'C

Daphnia size distribution

new digital counting method

Size of Daphnia (mm)



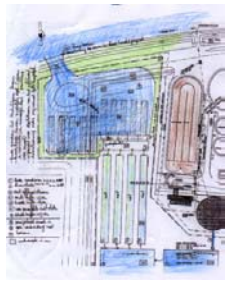
"Gricklebacks"?

"Daphnia, Fish, Spoonbills and treated waste water"

- Feasible:
  - growing Daphnia:
    - Daphnia feed on sludge particles: disinfection!
    - Daphnia keep the ponds clear: no algae
  - Sticklebacks come to the constructed wetland
  - it attracts Spoonbills

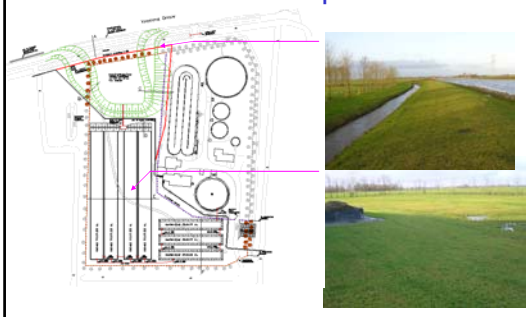
Fits in the EU Water Framework Directive

Waterharmonica Grou



News: STP Stolpen near Schagen: plans for a Marsh harrier marsh

Diagram and drawings of CW at Grou Aqualân



Realisation in 2005

Combination with Pike stocking area

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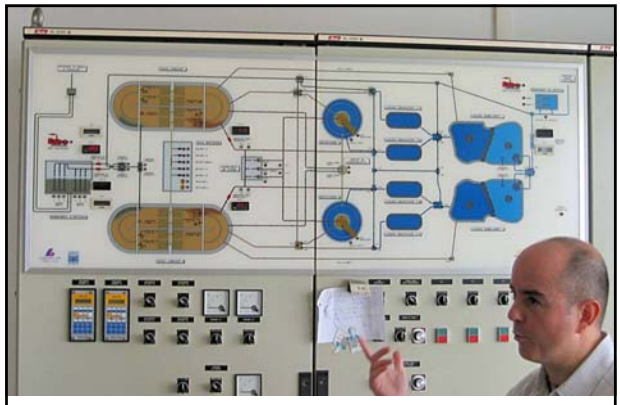
- **Europe: a Spanish example**
- The Waterharmonica in Nepal and Tanzania:
  - sustainability, biodiversity, surface water quality, health

The Waterharmonica:
the link between treated waste water and surface water

The Empuriabrava WWTP

From Lluis Sala, Concorsi de la Costa Brava

Workshop 21 October 2005



Explanation by Lluis Sala

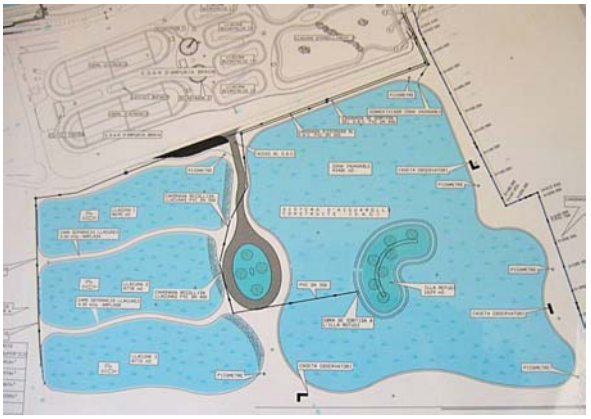
STP with the first ponds

Daphnia gallore

Part of the nature area

Hides

Hiking and biking



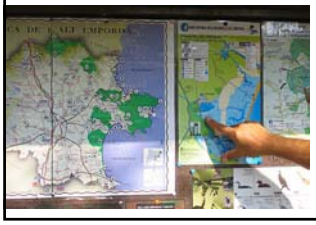
The constructed wetland

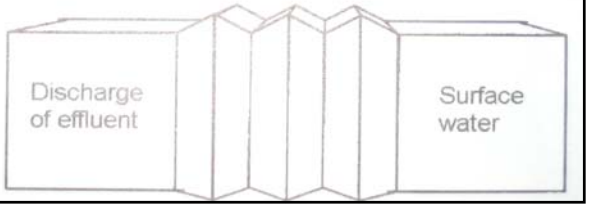
The more “natural” wetland

National park
Aiguamolls d l’Emporda

Parc Natural dels Aiguamolls de l'Empordà

Use of enhanced waste water in nature





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Workshop on water management in Nepal

A Workshop on community management of waste water(treatment and disposal) in low-income, semi-urban communities in the Kathmandu Valley, Nepal,

2-13 November 1998

Closing the nutrient cycle

Why and how

A way to reduce waste water problems in Nepal

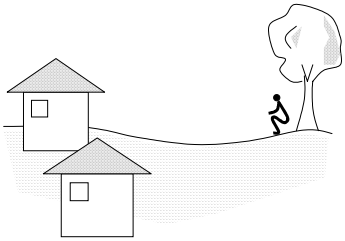
More on www.rekel.nl/water

http://www.rekel.nl/water/nepal_workshop/index.htm

Present practice: unhealthy!

- Uncontrolled garbage management
  - even rats on the streets
- Open defecation or "shitting fields"
- Sewage on the streets, no sewers or gutters
- Polluted streams and rivers
- Risky fresh water
- Loss of nutrients with waste water
  - 4 kg N and 1 Kg P per year, value 3 Euro per person per year

Open defecation



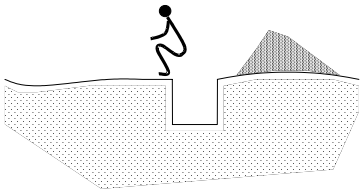
SANEX, Loetscher, 1998

Open defecation

or

"Killing fields

Trench latrine



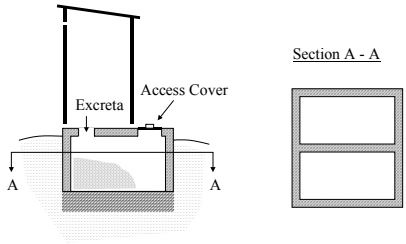
SANEX, Loetscher, 1998

Col de Bretolet, Switserland

Solutions - basics

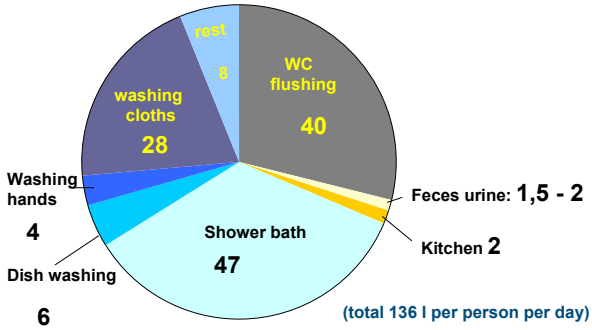
- Aimed on the communities, done by the communities
  - short term solutions:
    - self aid
  - long term solutions:
    - with foreign aid, but:
      - aimed on making jobs, income
      - minimalise loss of nutrients = chemical fertiliser:
        - » close the nutrient cycle
- Based on the local culture and knowledge

Double vault composting latrine



SANEX, Loetscher, 1998

Netherlands: how many liter water per person per day?



Clean surface weater

Flush and discharge

Polluted water

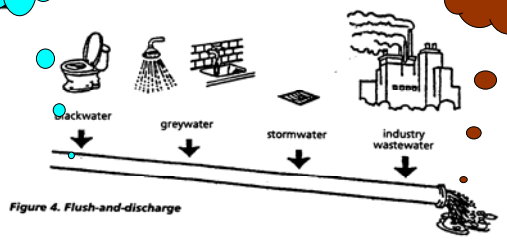


Figure 4. Flush-and-discharge

Winblad, WHO, 1996

Dilution is the problem

	High-strength	*Diluted Sewage*
Volume l per cap per day	1.5 - 5	15
COD .mg/l	35000	800
NH_4 .mg/l	3500	50
Dry solids .g/l	34	< 10
Metals	Fairly low	To high

Cost of water management in The Netherlands

per family in Euro/year

Organisation		Cos
Waterboards	"Dry feet"	50
Communities	Sewers	100
Waterboards	Sewage treatment + surface water quality	150
Water companies	Drinking water	165
	Total Euro 450 per family per year	

Based on Dutch Ministry of Transport, Public Works and Watermanagement, 1999

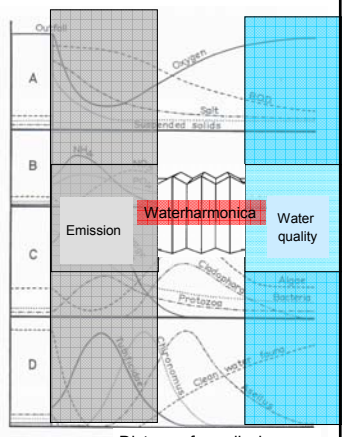
Schematic effect of discharges of wastewater

A physical – chemical

B nutrients

C micro-organisms

D macro-organisms



THE POTENTIAL OF WATERHARMONICA CONCEPT IN TANZANIA

Saxion Hogescholen

"The bridge between treated wastewater and surface water"

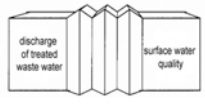
Presented by: Hamidar Chanzi

IBP 2004/5 - Environmental Science, Saxion University – Deventer

Waterboard Hollands Noorderkwartier, July 11, 2005

Waterharmonica

What is the potential of this Dutch initiative for Tanzania?



"The bridge between treated wastewater and surface water to fill the gap"

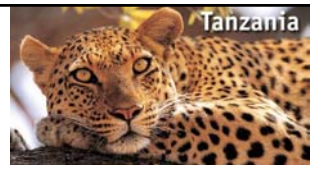
Main objective:

How can we use the basic ideas from Waterharmonica to use the “wealth of used drinking water” for poverty alleviation in Tanzania (local community)?

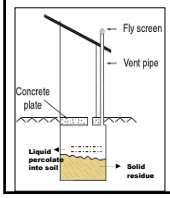
- Sewer system
- Type of sewage treatment
- Surface water quality, waterborne diseases
- How to organise?

It is a developing country: 500 Euro income per capita

Hamidar Chanz, Tanzania, 2005i



Pit latrines



Practice:

- rural areas: 93 % people
- but many are leaking: ground water pollution

But Is already Ecological sanitation when:

- Kept dry (no water with faeces and urine)
- No leakage to groundwater
- Good infra-structure aimed on re-use of nutrients

Ecological sanitation is a great option but:
Combined with Source separation

Water21, April 2005

Hamidar Chanz, Tanzania, 2005i

Double Vault separation toilet

Safe fertilizer

Short term solution for 80 – 90 % of the population

Enough fertiliser for the country

Hamidar Chanz, Tanzania, 2005i

A Dutch latrine

Hamidar Chanz, Tanzania, 2005i

Waste water in Tanzania

wastewater only produced by 5 % of population

- but this 5 % is the wealthiest part
  - offices,
  - hotels, hospitals

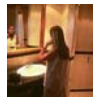
“ like in most developing countries…….
and situation likely to worse”

Hamidar Chanz, Tanzania, 2005i

Polluter pays?

The New Arusha Hotel
160 USD for double room
140 USD for single room
Dik Dik Hotel
120 USD for double room
100 USD for single room

Polluter pays



Example Masai Mara National reserve :

- **"Mara Simba** is the only lodge in Kenya which has installed a Waste Water Treatment Plant. The plant was imported from U.S.A. This plant treats all the sewage and produces crystal clear water which is then used for irrigation. We are truly the only environmentally friendly lodge in Kenya"

Why not in Tanzania?

http://www.marasimba.com/introduction.html

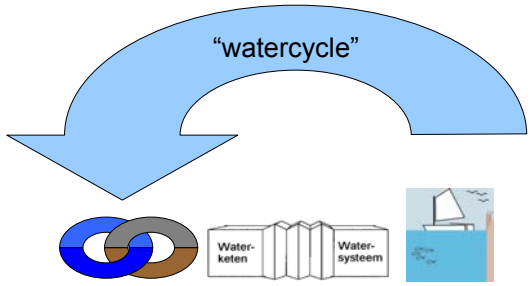
Use of treated waste water in Tanzania

Some possible treatment methods:

- *Constructed wetlands: "natural treatment"*
- *Oxidation ponds: ponds, mainly used in India*
- *Oxidation ditches: very simple aerobic treatment*
- *UASB reactors: anaerobic reactor*

(Upflow Anaerobic Sludge Blanket)

Missing link in water management



The natural link from tap to source

How?

- Ecological engineering
- Polishing and reuse of wastewater
- Link between treatment plant and surface water:

Minimise risks

- Treatment of wastewater
  - Good quality of treated waste water
    - Degree of pathogen and chemical removal
- Crops restriction
  - Crow crops with less risks to worker and consumers
- Proper use of crops and fish
  - Boil, not eat fresh crops (vegetable or fruits)

Conclusions

Waterharmonica concept is a promising approach that could promote the livelihood of local people in Tanzania

-Waterharmonica makes waste water safe

-reduce water pollution: better surface water quality

-Safe fertilizer of nutrients from safe wastewater

-agriculture, aquaculture

-Polluter pays make waste water a resource

-Water conservation

-wastewater for irrigation; fresh water for domestic uses

Finally: Some "wise words"

- "Waste water comes from drinking water"
- Do not talk about water reuse, it is "wise use"
- Polluters pay
- No drinking water when no money for sewers and treatment is available but separation
- When waste water: treat it well and use it
- Surface and (ground) water quality is important
- Think global(ly) and in water cycles

The Waterharmonica: natural link between tap and source !

"My success is the result of my failures"

The Waterharmonica:

The Waterharmonica in Nicaragua: Joost Jacobi