Some examples of sustainable water management in the developing world

Saxion, Deventer
Thursday, 5 December 2013

Ruud Kampf

- Owner / Consultant Waterharmonica at Rekel/water
- Co-owner of Rekel Kenya ltd
- Guest worker Vrije Universiteit Amsterdam
- Retired researcher ecological engineering Waternet, Amsterdam

Nepal, Tanzania, Kenya

- Discharge or reuse
- Polluter pays
  - But when no money for waste water treatment do not provide drinking water to households
- Wastes bring money
  - (re)use of treated waste water
  - integrated use of wastes

This presentation

Some practical aspects of water management

in the developing world

- **Nepal: “closing the nutrient cycle”**
- **Tanzania: Waterharmonica: “reuse water from rich part of the country”**
  - **Polluter pays???**
- **Kenya: optimized agriculture instead of waste water treament**
- **Conclusions, discussion**

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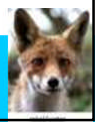

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Some practical aspects of water management in the developing world

- **Nepal: “closing the nutrient cycle”**
- Tanzania: Waterharmonica: “reuse water from rich part of the country (5 % of population)”
- Kenya: optimized agriculture instead of waste water treatment
- Conclusions, discussion

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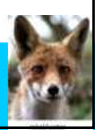


Workshop on water management in Nepal

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

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

Closing the nutrient cycle

Why and how

A way to reduce waste water problems in Nepal

- **IRC** International Water and Sanitation Center
- **ENPHO** Environment and Public Health Organization
- **NEWAH** Nepal Water for Health Organization
- supported by Theo Claassen en Ruud Kampf

The communities in the Kathmandu valley

1 Sidhipur

2 Thimi

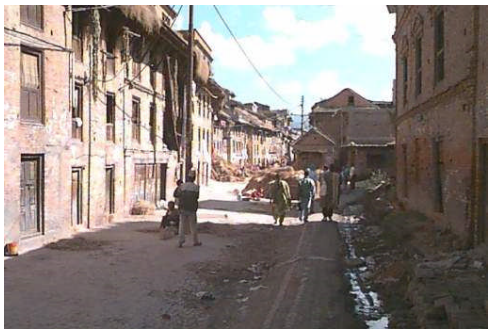
3 Panga

4 Kusunti

Example: Sidhipur

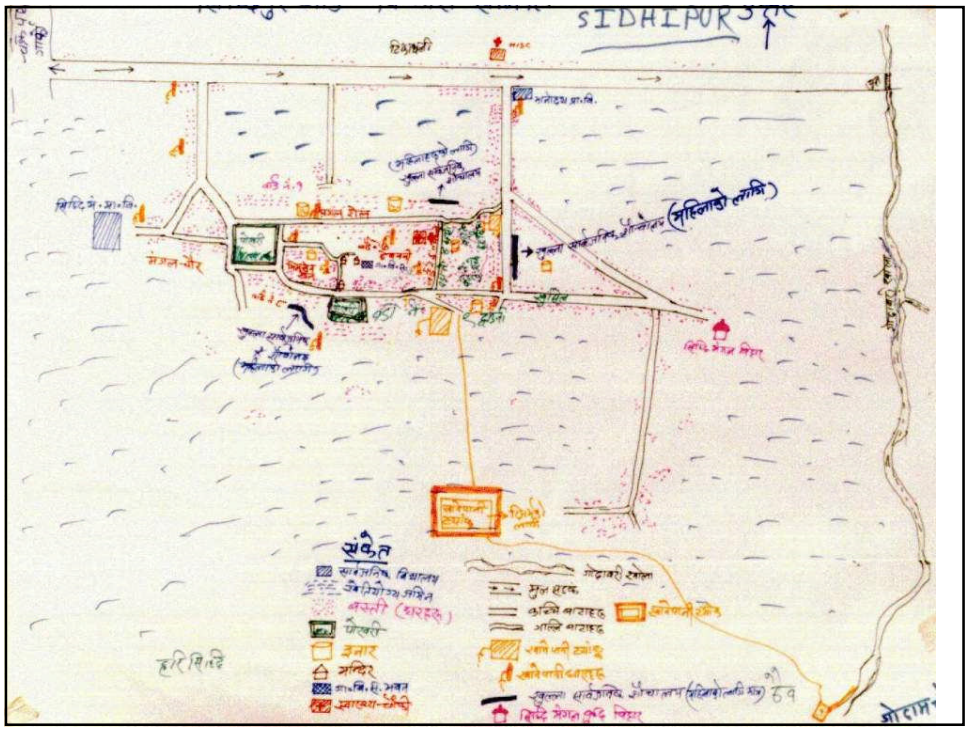
- An old Newari community
- 7000 inhabitants
- 1200 houses
- Very compact
- Farming
- Wonderful designed but neglected

Sidhipur



Limited water access

It is about people



Problems Nepal

- Many!
- Disturbed culture, community feeling
- Western influences led to poverty
- Unplanned solutions

  ⇨Unhealthy situation

Problems - continued

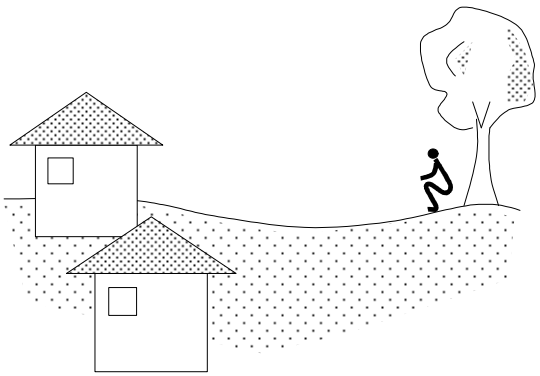
- Lack of confidence in government
- Western aid causes many new problems
- How can you cope with 3-6 % population growth without equal economical growth?

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 vs. buying fertiliser

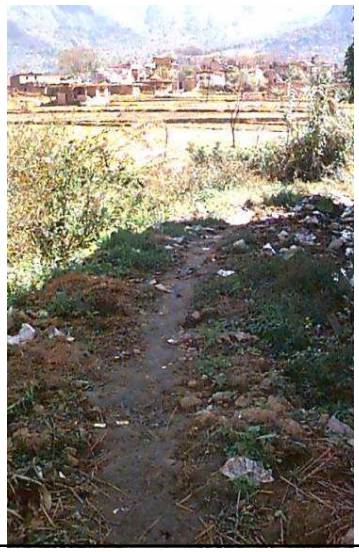
“Reuse” of wastewater

Open defecation

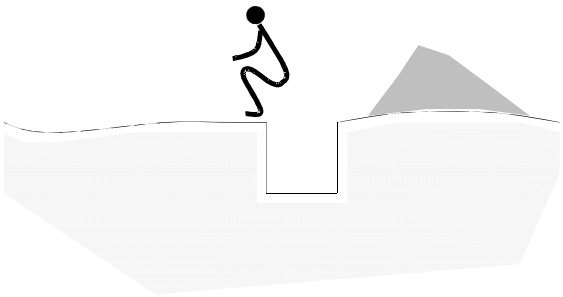


SANEX, Loetscher, 1998

Open defecation



Trench latrine



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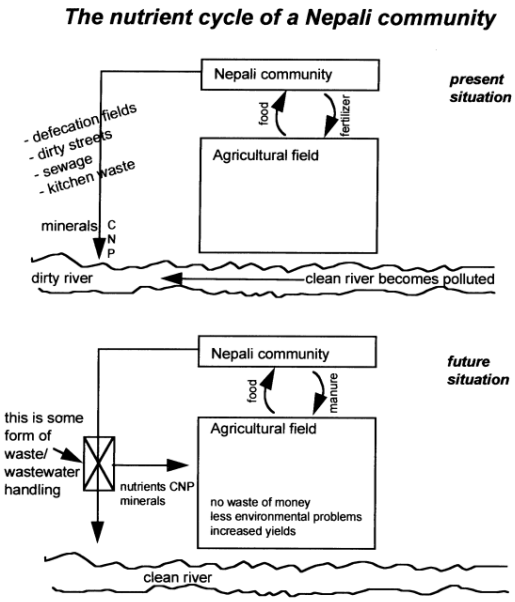


IRC, 1999

Sewage treatment western approach

Per Dutchman per year:

- 50 l faeces + 500 l urine
- + 15.000 l to flush and transport
- + > 15.000 l rain
- Large and expensive sewer and sewage

Separation of flows

- White water: rain
- Black water: faeces and urine
- Grey water: washing and rinsing, kitchen

- Mixed: water flows which can not kept separated, but keep as clean as possible

White water

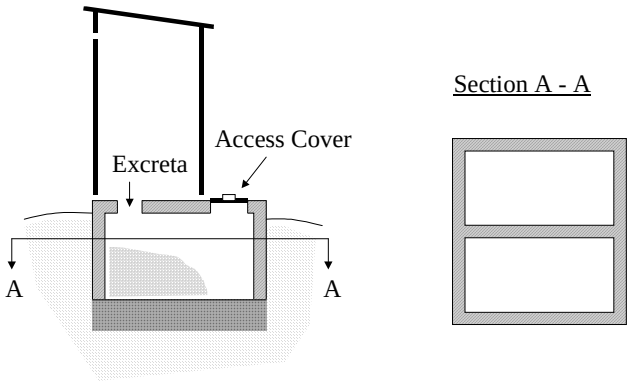
- Rain
- Do not mix with other flows
- Keep the streets clean
- Use old structures, open gutters
  - Old cultures usually knew how to prevent wet feet
- Ground water, use for drinking water
  - Note: monsoon,
  - > 100 mm/day = > 100 l/m2.day = 1000 m3/ha.day

Black wastes

- Faeces, urine, manure, kitchen wastes
- Keep as dry as possible for composting or wet digestion --->"double vault toilets"
- Urine separation possible: fungicide, N-fertiliser
- Do not mix with other streams
- Is valuable - manure, source of nutrients:

⇨Money does not stink!: small enterprises

Double vault composting latrine



SANEX, Loetscher, 1998

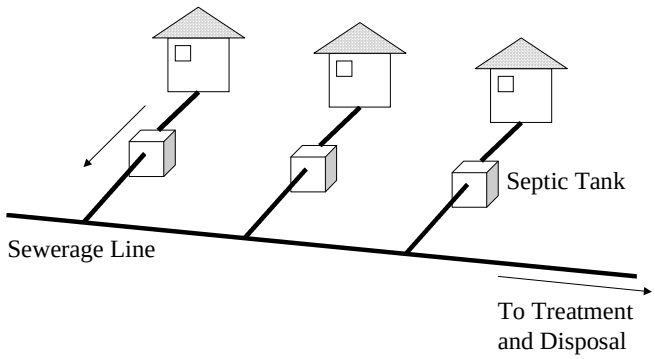
Grey water

- Washing, bathing and kitchen
- Discharge through special, small bore sewers
- Contains nutrients
- Decentralised treatments in constructed wetlands
- Yield is important: reed, bamboo, energy crops, brooms, etc. (no food)
- Reuse treated water in agriculture, groundwater recharge

Mixed flows

- When separation is impossible or after introduction of water flush toilets:
  - decentralised septic tanks
    - settled material: treat as black wastes
    - overflow: treat as grey water
  - simple water treatment
- Do not mix with white water
- White + black = grey

Septic tanks
+ simplified sewer



SANEX, Loetscher, 1998

Flush and discharge

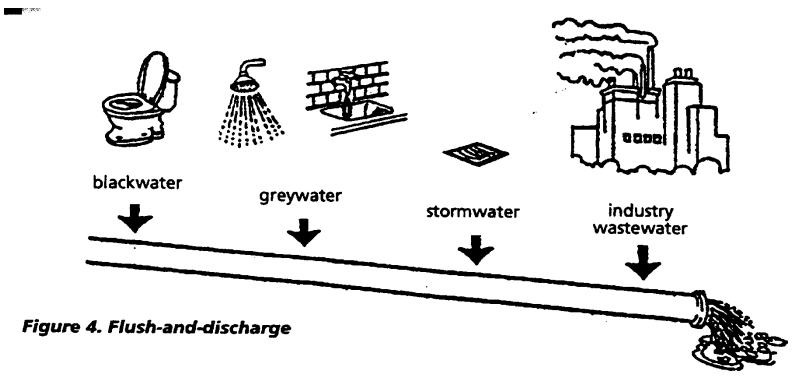


Figure 4. Flush-and-discharge

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

Distribution of resources in waste water

in % of total in sewage

	Urine	*Faeces*	*Grey water*
N - nitrogen	81	11	8
P - phosphorus	48	24	28
K - potassium	63	24	13

Swedish EPA, 1995 - Jenssen, 1999

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

Economical value of water

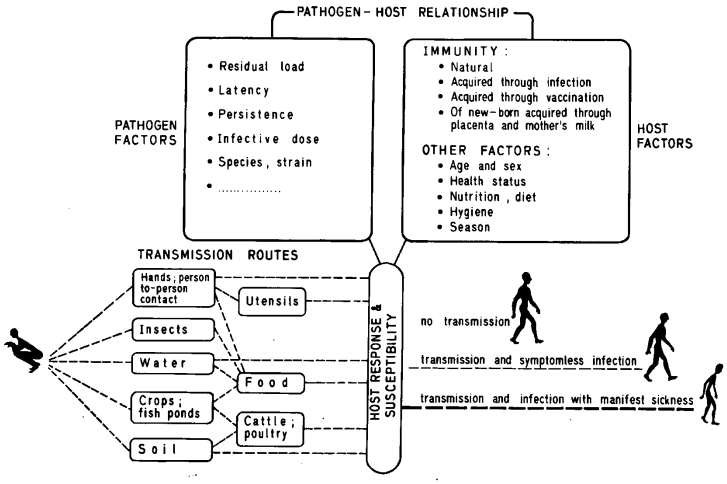
- In waste water per inhabitant:
  - 4 kg N and 1 Kg P per year
- Cost of N and P in fertiliser
  - 1 kg N = 0.50 Euro and 1 kg P = 1.00 Euro
  - value of nutrients in wastewater 3 Euro per person per year

The effect of poverty on the infant mortality rate

City	Poor	Non Poor
Manilla	210	76
São Paulo	175	42
Karachi	113	33
Dehli	118	18

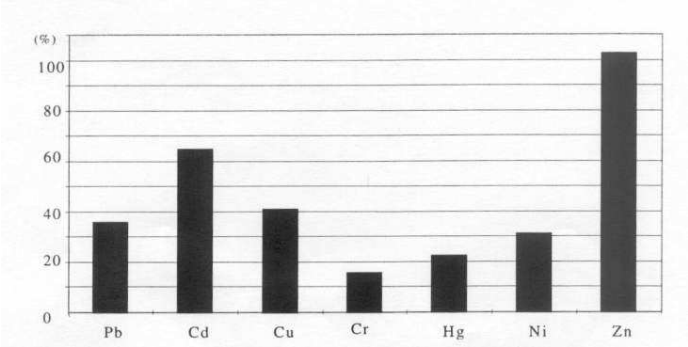
Source: EHP, 1996

Pathogens - Health risks



IRWD-News, 1995

Sludge from septic tanks



Heavy metal content in % of Swedish limit for agricultural use

Svensson, 1999

Influence of religion on black water treatment

- Science-new concepts vs. religion-old beliefs and traditions
- Locally different - western solutions?
- Christians: WC saviour for health
- Muslims and cleaning
- Spiritual compost in Asia
- Asia 2/3 of farmed fish excreta ponds
  - f.e. Calcutta: 1,100,000 m³/day in fishponds

Based on Warner, 1999

Range of Human Excreta (Utilization) Practices with Developing Country Examples

Practice	Social Unit	Examples
1. Soil fertilization with untreated or stored nightsoil	family or community	China, Korea, Taiwan, Japan, Thailand
2. Nightsoil collected and composted for use in agriculture	community or local authority	China, India
3. Nightsoil fed to animals	family	Melanesia, Africa
4. Use of composting or mouldering latrines	family	Vietnam, Tanzania
5. Biogas production	family or community	China, India, Korea
6. Fish pond fertilization with treated or untreated nightsoil	family or community	Taiwan, Korea, China, Malaysia, Indonesia
7. Fish farming in stabilization ponds	family (illegal) or local authority	India, Israel
8. Aquatic weed production in ponds	family, community or local authority	Vietnam, S E Asia
9. Agricultural Application of sewage	local authority or commercial farmer	India, South Africa
10. Irrigation with stabilization pond	local authority or commercial farmer	Israel, India
11. Algae production in stabilization ponds	local authority	Mexico, Japan

Experience is growing

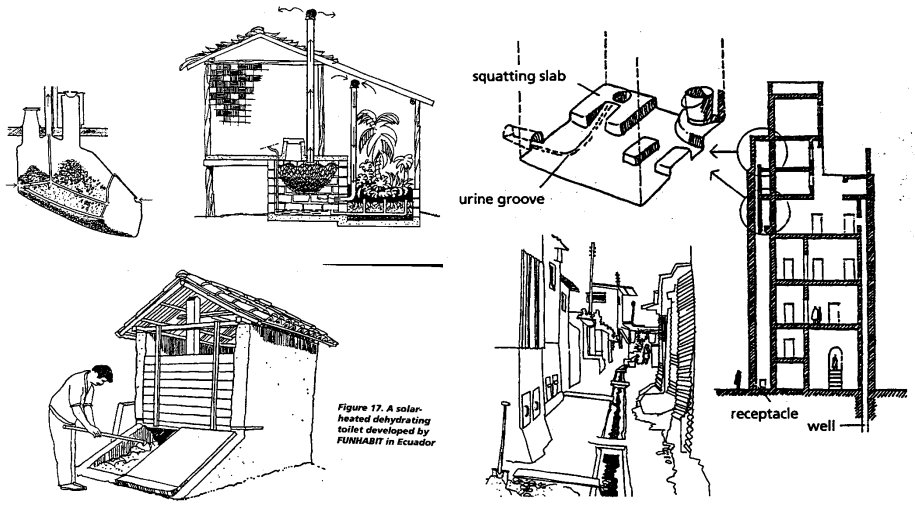
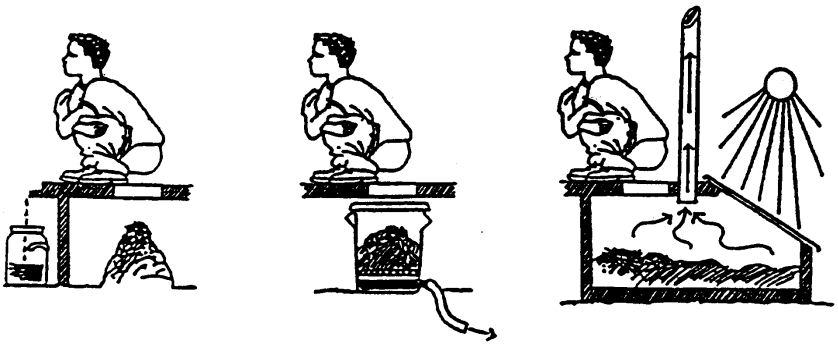


Figure 17. A solar-heated dehydrating toilet developed by FUNHABIT in Ecuador

Source separation in densely-populated squatter areas in San Salvador

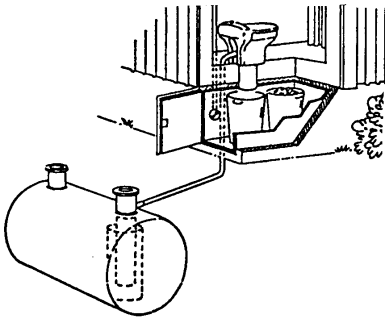
Winblad, WHO, 1996

Ways of separating urine and faeces

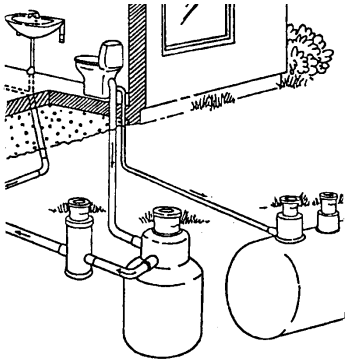


Winblad, WHO, 1996

Swedish solutions urine separation



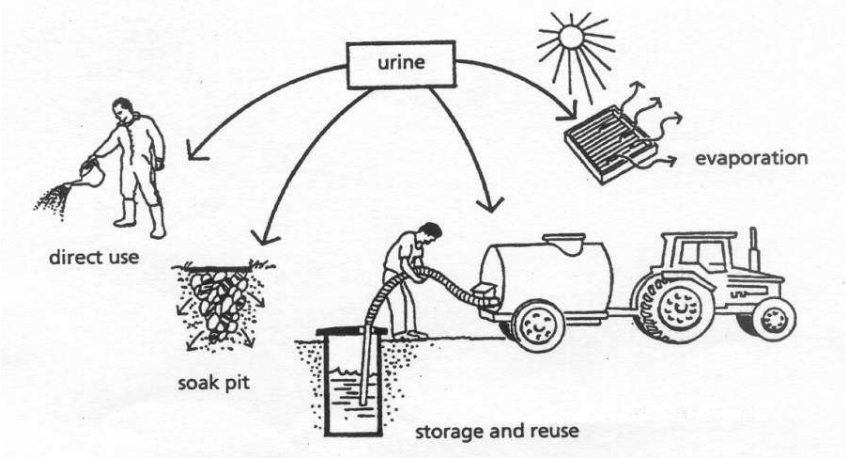
Seperate faeces and urine collection



Urine collection and septic tank

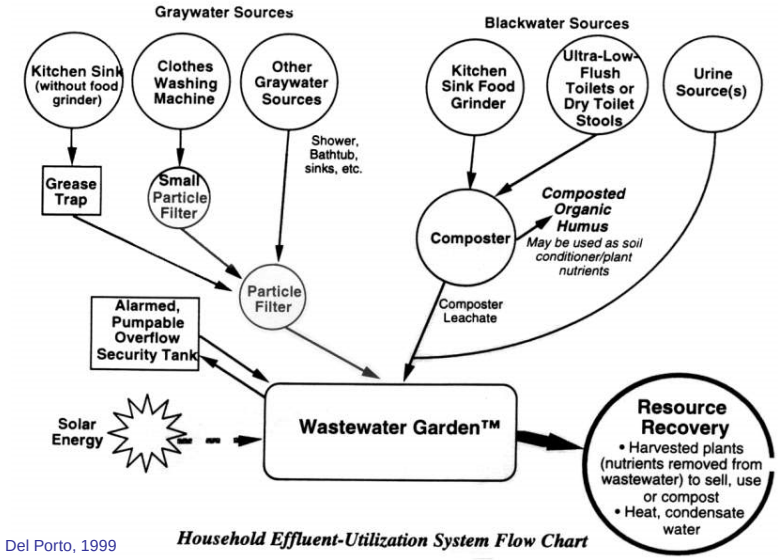
Jenssen, 1999

Alternatives managing urine



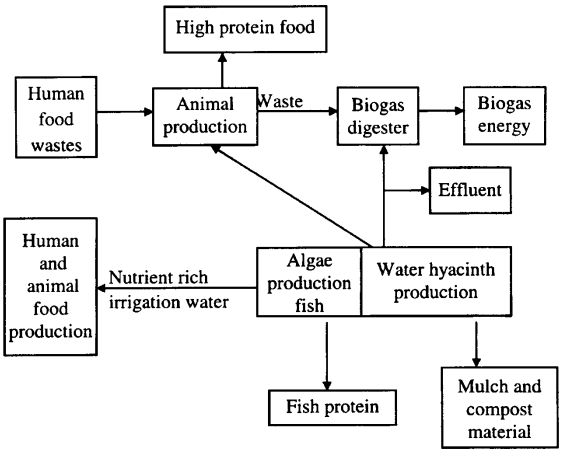
Winblad, WHO, 1996

Zero-effluent discharge



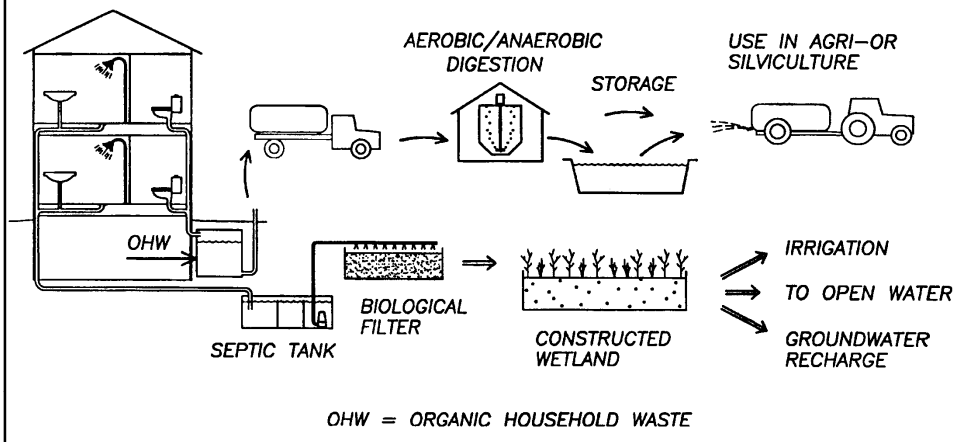
Del Porto, 1999

Integrated water hyacinth production in Brazil



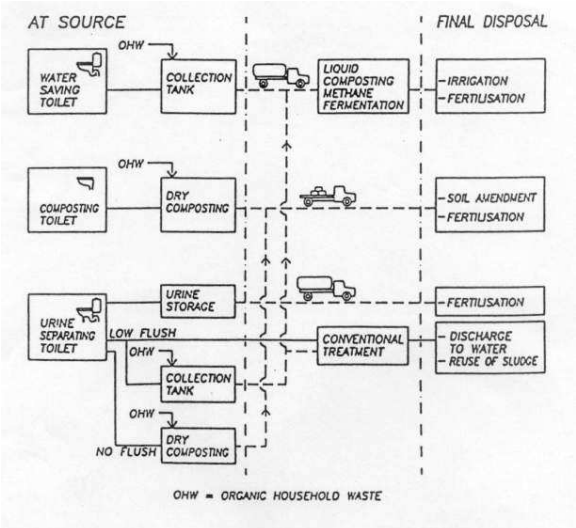
Roquette Pinto, 1999

Logistics water and resource saving toilets



Jenssen, 1999

Logistics in urban black water and organic waste flows



Vråle, 1999

Future!

- Less pollution, better ecological balance
- If possible, with economical profits
- Community based, employment
- Avoid “shiny engineers”, learn from failures of the west
- Simple technical solutions
- Include maintenance in project plan

This presentation

Some practical aspects of water management in the developing world

- Nepal: “closing the nutrient cycle”
- **Tanzania: Waterharmonica: “reuse water from rich part of the country**

  (5 % of population)”: Polluter pays???
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- Conclusions, discussion

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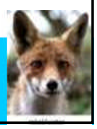
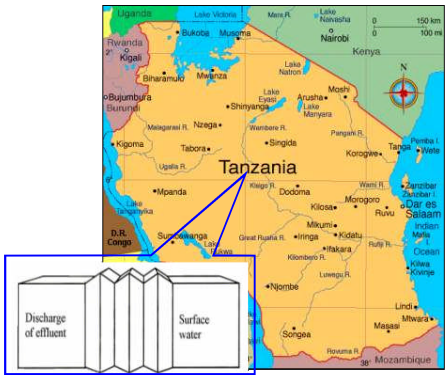


THE POTENTIAL OF WATERHARMONICA CONCEPT IN TANZANIA



"The bridge between treated wastewater and surface water"

Presented by: Hamidar Chanzi

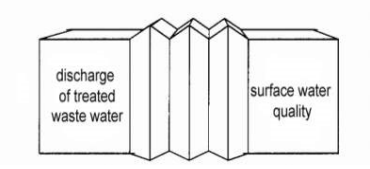
IBP 2004/5 - Environmental Science, Saxion University – Deventer

Waterboard Hollands Noorderkwartier, July 11, 2005

Main research question of Chanzi Hamidar

Waterharmonica

What is the potential of this Dutch initiative for Tanzania?



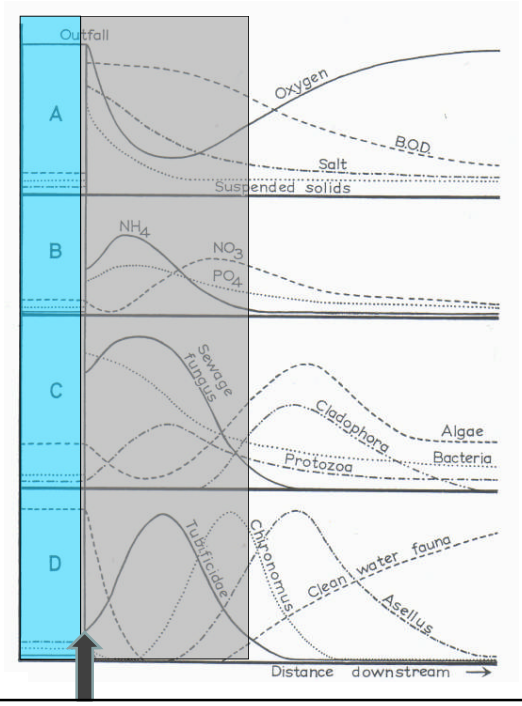
Influence of a wastewater discharge

A physical – chemical

B nutrients

C micro-organisms

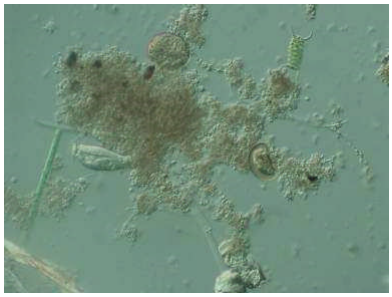
D macro-organisms



Based on Hynes, 1960 The biology of polluted waters

But: Treated wastewater

- regional STP's: water from a large area
- influence at effluent discharge:
  - sludge particles, flocs
  - loose bacteria
  - odor, foam
  - low O_2



"Dead water", not satisfied with quality

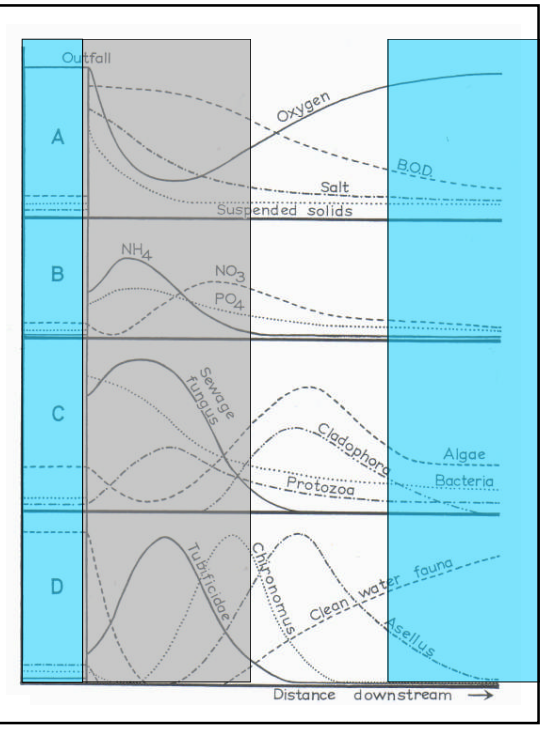
Schematic effect of discharges of wastewater

A physical – chemical

B nutrients

C micro-organisms

D macro-organisms



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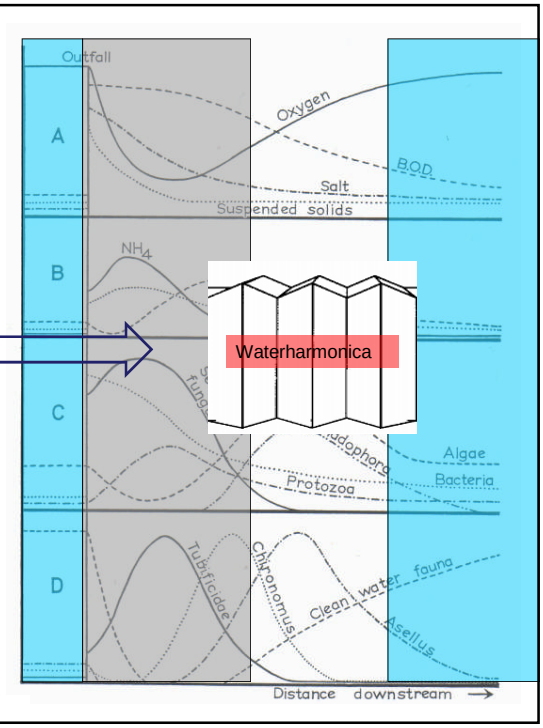
The Waterharmonica:

Bridge between sewage treatment and surface water



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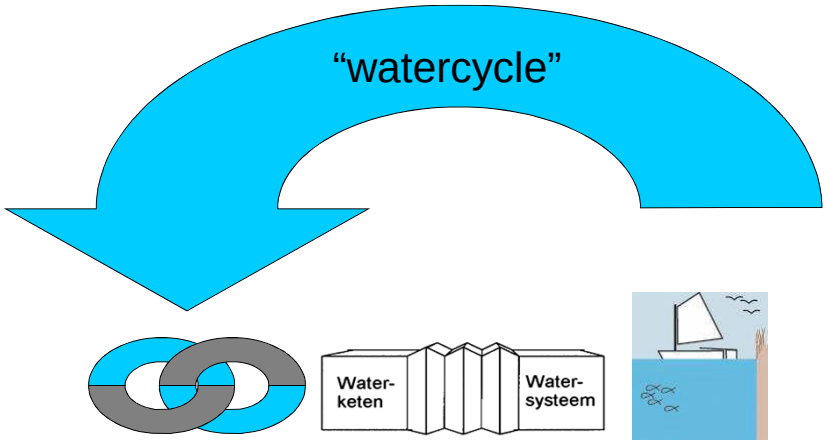
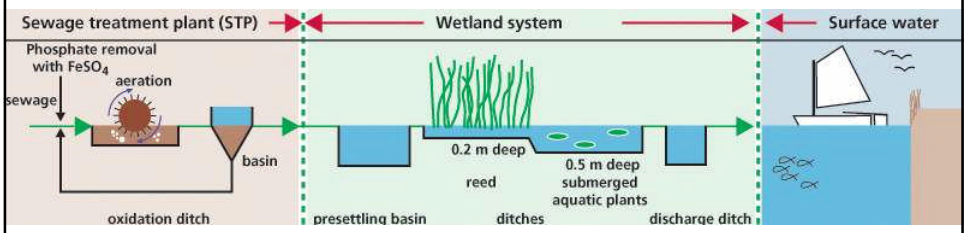
Missing link in Water Management



The natural link between drinking water and surface water: The Waterharmonica:

From STP via wetland to surface water



STP Oxidation Ditch

Constructed wetland

Surface water

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

Flush and discharge

Clean surface weater

Polluted water

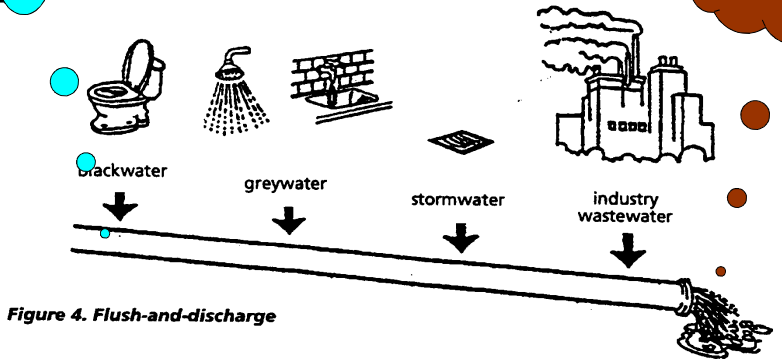


Figure 4. Flush-and-discharge

Winblad, WHO, 1996

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

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

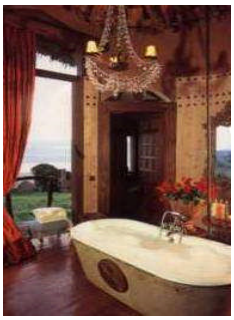
Hamidar Chanzi "from Tanzania,
in the museum "Het Kleine Huisje, Schermerhorn, 2005

This works:

- As long no drinking water delivered in the houses, because then:
  - → Water flushed toilets
  - → Waste water
  - → Surface water pollution while no money for sewage treatment

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



Hamidar Chanz, Tanzania, 2005i

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

Hamidar Chanz, Tanzania, 2005i

How?

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

When reuse: treatment becomes attractive

Hamidar Chanz, Tanzania, 2005i

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)

Hamidar Chanz, Tanzania, 2005i

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

Hamidar Chanz, Tanzania, 2005i

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”

Hamidar Chanzi, Tanzania, 2005

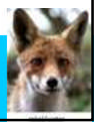
This presentation

Some practical aspects of water management in the developing world

- Nepal: “closing the nutrient cycle”
- Tanzania: Waterharmonica: “reuse water from rich part of the country (5 % of population)”
  - Polluter pays???
- **Kenya: optimized agriculture instead of waste water treatment**
- Conclusions, discussion

Saxion University – Deventer, Thursday 5 December 2013

Ruud Kampf



Improving agricultural practices as a way to meet the Millennium Developments Goals:

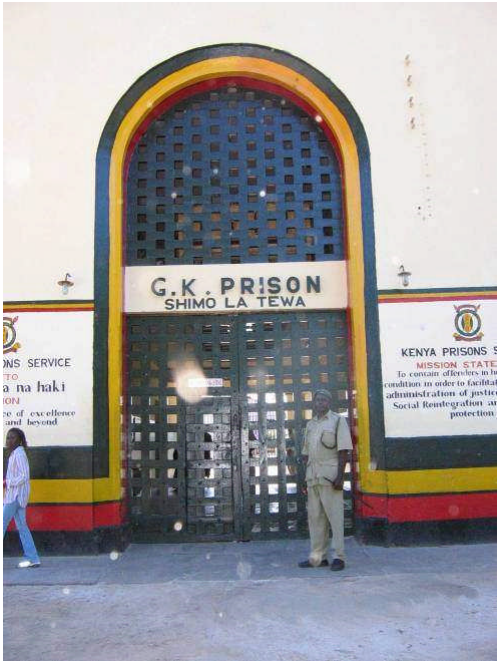
a demonstration project in the Shimo la Tewa prison in Mombasa, Kenya

Ruud Kampf
Waternet / Vrije Universiteit Amsterdam

Adriaan Mels, Nelson Opoku and Frederick Tettey-Lowor
Wageningen University and Research Centre and LeAF

The prison

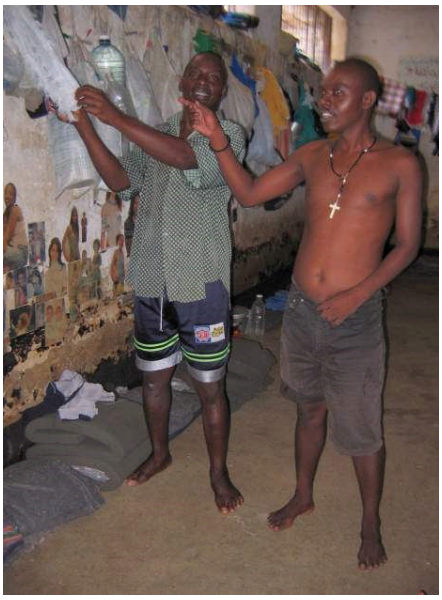
- Inmates:
  - Main prison for man: ca. 2.200 pers.
  - Woman prison: ca. 300 pers.
- Shima Annex Prison
  - Farming,gardening activities: 300 pers.
- Boys prison: 300 pers.
- Staff quarter
  - About 1500 staff and family
  - Close to the prisons, but scattered over the area
- Total surface ca. 250 ha



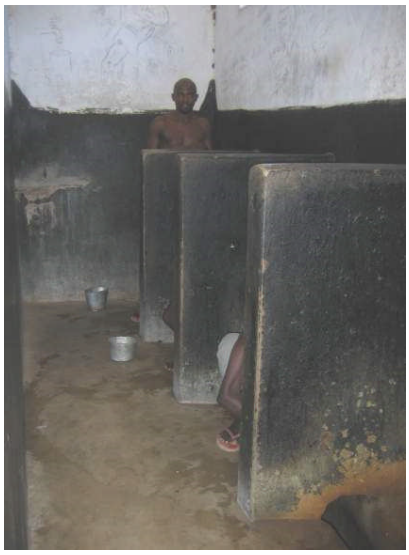
Some pictures from inside

It is quite unique I could take pictures inside so freely!

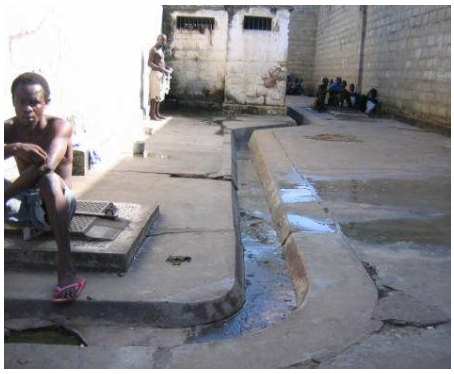
Inside a cell



Toilet facilities



Discharge through a separate sewer system: very concentrated waste water, seperate urinals



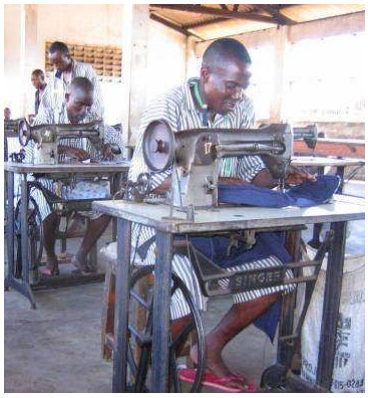
Outside room for day use

The open gutters were originally designed for rain discharge (monsoon climate!)

Now also “Grey water”

Education, training

are important part of prison life



One of the inmates, will be a good tailor when he comes out

Payment every year at Christmas

The metal workshop

Paint workshop

Shimo la Tewa Prison
Mombasa, Kenya

a constructed wetland lagoon system for improving the sanitary situation

UNEP
United Nations Environment Programme

GEF
Global Environment Facility

UNEP-GEF WIO-LaB PROJECT

ADDRESSING LAND BASED ACTIVITIES IN THE WESTERN INDIAN OCEAN

Coastal Development Authority, Mombasa
Mombasa Water & Sewerage Company
Kenya Marine and Fisheries Research Institute
Dar es Salaam University, Tanzania

a "do something project"
with very well defined goals

Shimo la Tewa

- A wetland-lagoon system for wastewater management at Shimo La Tewa Prison, Mombasa – Kenya
- One step further:
  - integration of agriculture and sanitation in the Boys prison to support a novel but old-fashioned Ecosan approach

Some headlines of the Project

1. coupled wetland-lagoon STP
2. education and awareness
3. learn to manage the system
4. reuse in agriculture and aquaculture
5. reduce pollution

NAIROBI CONVENTION

WIO-LAB in Kenya

UNEP GEF

Addressing Land-based Activities in the Western Indian Ocean

OFFICIAL LAUNCH OF THE SHIMO LA TEWA WASTE WATER MANAGEMENT PROJECT, MOMBASA ON 29TH AUGUST, 2008

- Improving sanitary situation in the main prison
- Improvement and construction of:
  - Sewage system
  - Large septic tank
  - Subsurface constructed wetland
  - Fishpond

Ready end of October 2008

Project Coordinator
Dr. Nesbert Mangale
Managing Director
Coast Development Authority (CDA)
Mombassa, Kenya
Tel: +254 41 2224490/06
E-mail: cda@cdakenya.org; md@cdakenya.org

The constructed wetland

in February 2009
Short before completion

- High walls because of invert
- Much more invert then needed
- Because of high walls extra soil behind the walls

Situation after first rains in 2009

- Discussion about the damage and possible solutions

December 2012

July 2013: Totally blocked

Could we make one step further?

The chosen solution:

– is only for a part of prison
– does not fully use reuse potential

Exploration of the way to go:

– source separation and reuse of wastes
– use Ecosan / Ecological Engineering principles
– integration of agriculture and sanitation

Overview Shimo la Tewa prison
- 250 ha
- Agriculture: undeveloped but important

Key ideas

– What is the difference between animal manure and “human manure”?

– Solutions should be based on local agricultural practices

– How much is this influenced by cultural and health aspects?:
  • A prison is different from the “outside world”

A project in Shimo la Tewa
Boys prison or Borstal institute

- *300 boys*
- A special and attractive platform for a demonstration project on a small scale
- *Knowledge can be replicated in other Kenyan prisons and abroad*

Education even more important then in the Main prison

Agriculture in prison

Plant nursery

- Mrs Lina E. Bonto

The main Shimo la Tewa Prison sewage gang

Supervising officer:

Salim O. Mwatimbo

Prisoners:

Tonny Aden

Peterson Mykhongo

Johne Njorogie

Dr. Rene D. Haller
Baobab Trust

Baobab TRUST

Learn how to sustain a family on 1000 m^2

Nguuni Environmental Education Centre

Farmer Field School Training Programmes

Fish cultivation

Learn how to grow fish on the home farm

Duck cages above pond

Combined with cultivation of
- water hyacinth
- fish

Chicken cage above fispond

Cultivation of worms

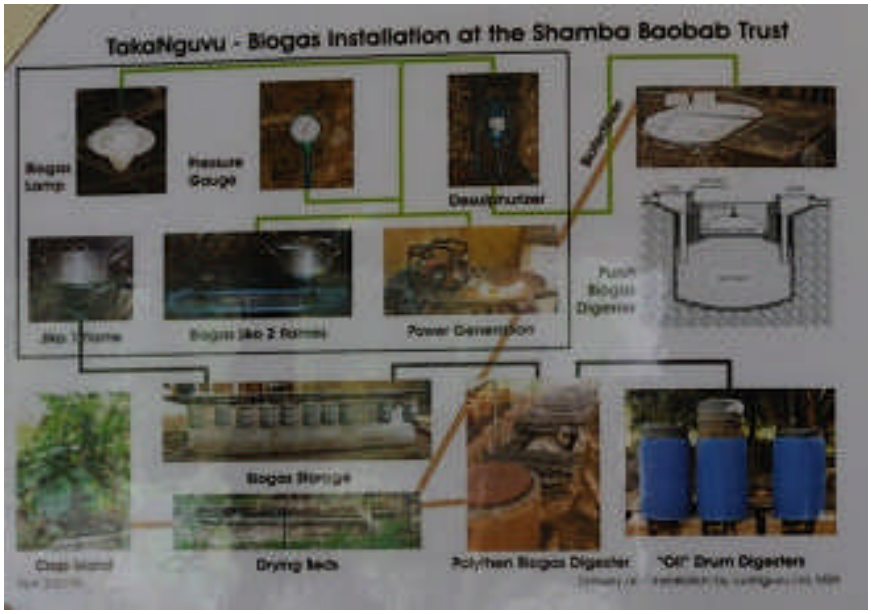
Fishfood

Chickenfood

Introduction of solar drying and cooking

Digesters

Gas collection


TakaNguvu - Biogas installation at the Shamba Baobab Trust
Biogas Lamp
Pressure Gauge
Desulphuriser
Power Generation
Biogas Storage
Drying Beds
Polythen Biogas Digester
"Oil" Drum Digesters

Gas cooker

Kenyan Prisons Service Mission Statement

Baobab Trust


dr. Haller

a good neighbouring partner in:

- logistics of black wastes
- seeking solutions in production of biogas and manure
- education of inmates in farming, aquaculture: how to set up an honest business in rural areas

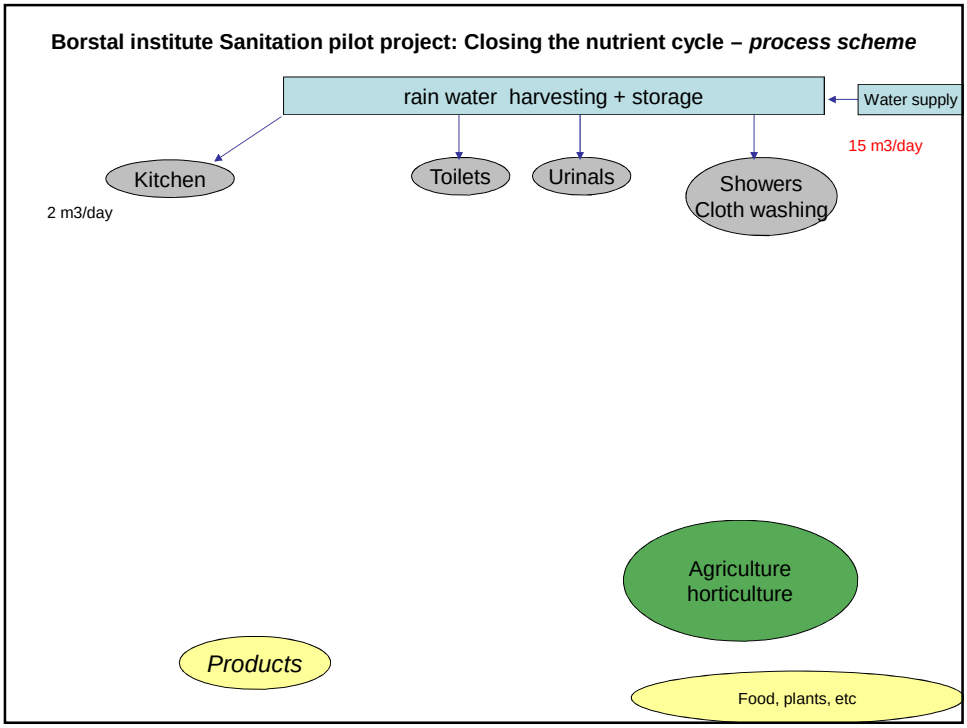
For more information on Baobab Trust and dr. Haller:

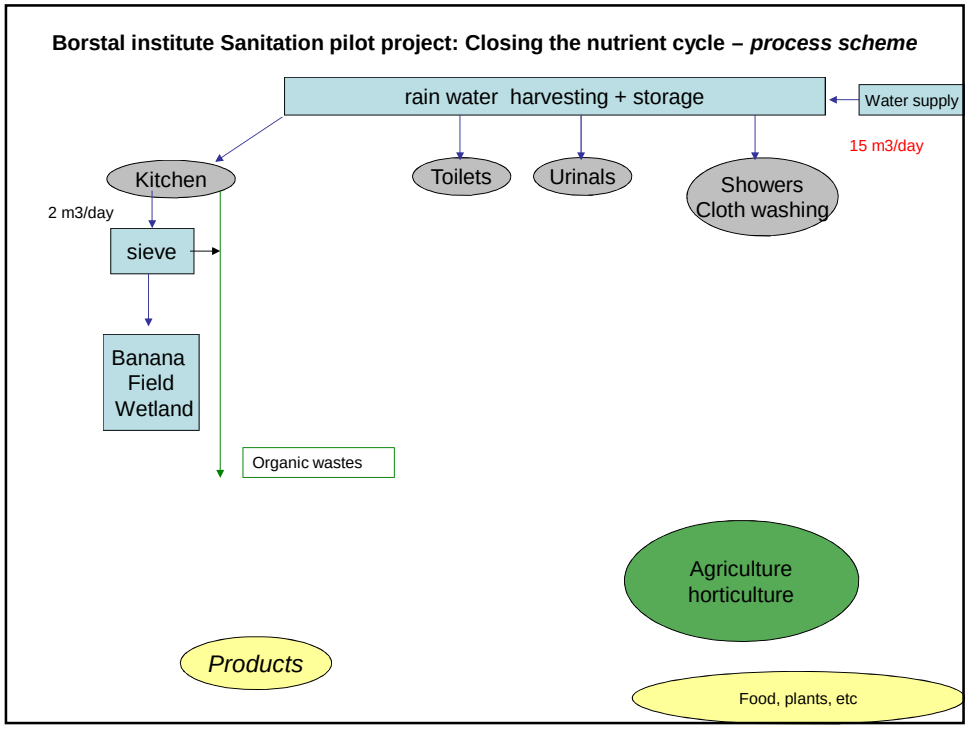
www.thebaobabtrust.com/

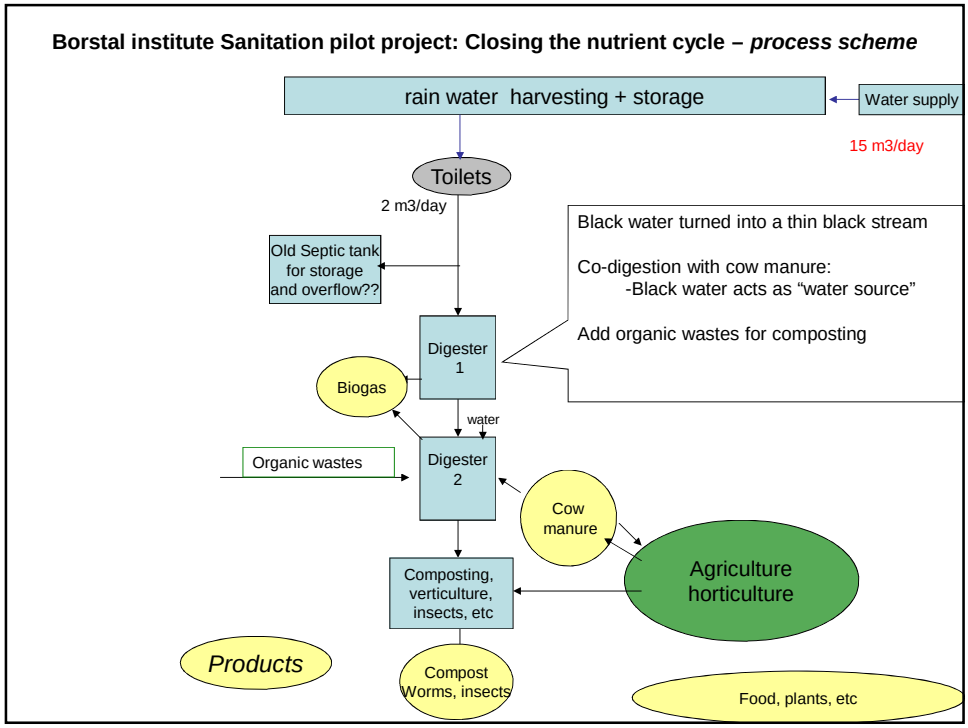
www.iees.ch/EcoEng032/EcoEng032_IntHaller.html
http://www.thehallerfoundation.com/
http://www.bamburicement.com/rehab.htm

Ghanese Students Wageningen University

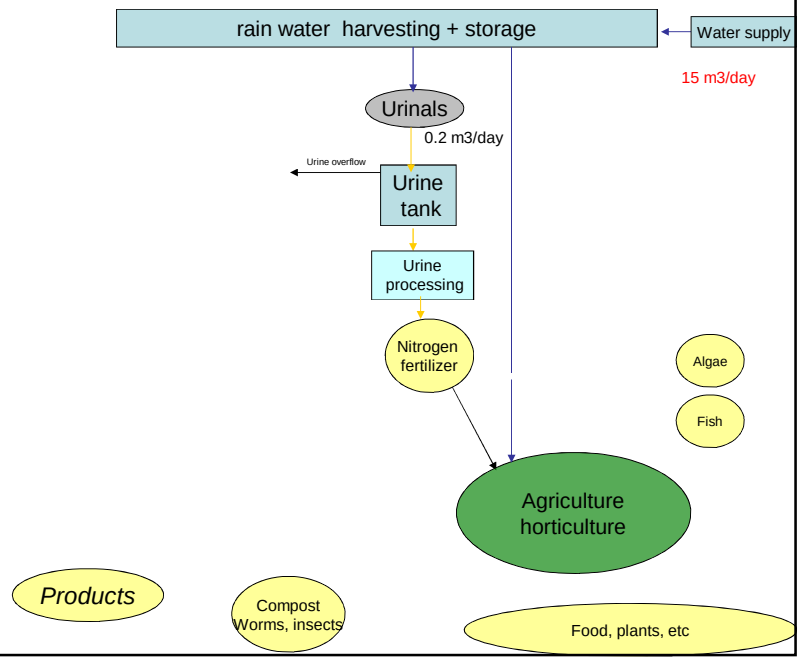
- Frederick Tettey-Lowor
  - Exploration of civil aspects, making pre-design
- Nelson Opoku
  - Overview of agriculture in prison
  - Possibilities of the integration of agriculture and sanitation




Borstal institute Sanitation pilot project: Closing the nutrient cycle – process scheme
rain water harvesting + storage
Water supply
15 m3/day
Kitchen
Toilets
Urinals
Showers
Cloth washing
2 m3/day
sieve
Banana
Field
Wetland
Organic wastes
Agriculture
horticulture
Products
Food, plants, etc

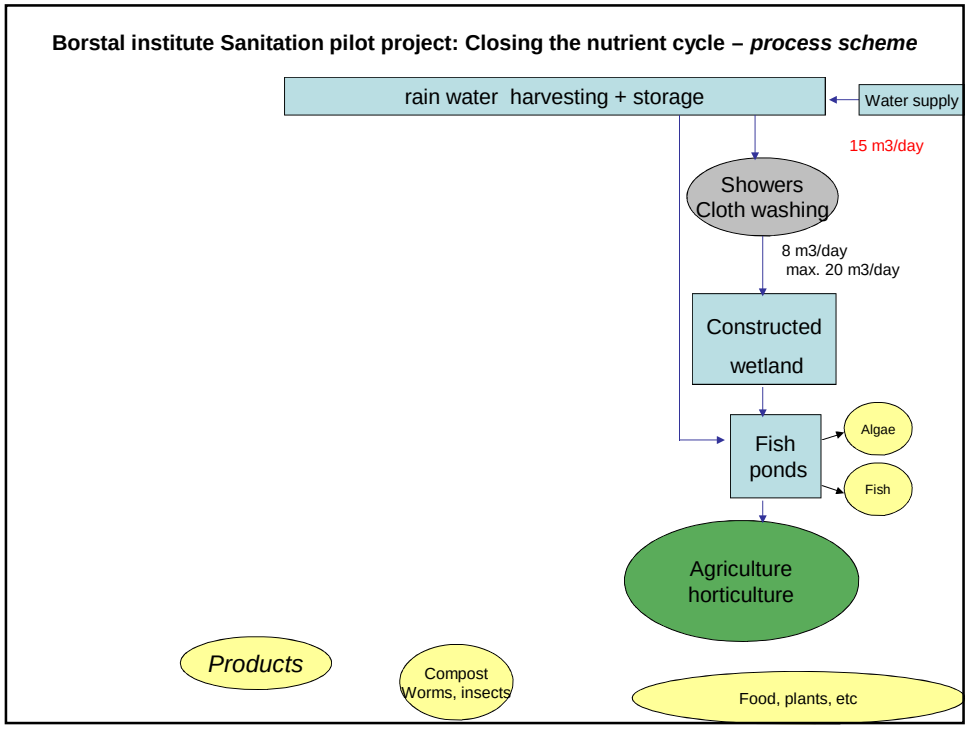

Borstal institute Sanitation pilot project: Closing the nutrient cycle – process scheme
rain water harvesting + storage
Water supply
15 m3/day
Toilets
2 m3/day
Old Septic tank
for storage
and overflow??
Black water turned into a thin black stream
Co-digestion with cow manure:
-Black water acts as "water source"
Add organic wastes for composting
Digester
1
Biogas
water
Organic wastes
Digester
2
Cow
manure
Composting,
verticulture,
insects, etc
Agriculture
horticulture
Products
Compost
Worms, insects
Food, plants, etc

Borstal institute Sanitation pilot project: Closing the nutrient cycle – *process scheme*



Storage of urine on ash
Sidhipur Nepal

- Simple
- Cheap
- Durable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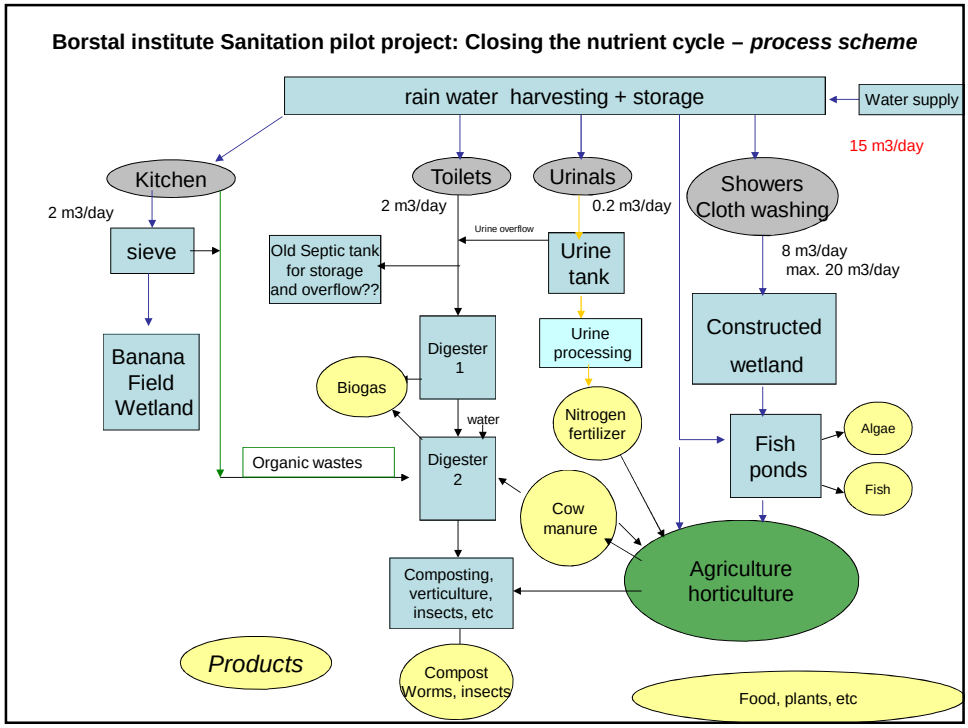
8 m3/day
max. 20 m3/day
Constructed
wetland
Fish
ponds
Algae
Fish
Agriculture
horticulture
Products
Compost
Worms, insects
Food, plants, etc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Urinals
0.2 m3/day
Urine overflow
Old Septic tank
for storage
and overflow??
Urine
tank
Urine
processing
Digester
1
Biogas
water
Digester
2
Organic wastes
Nitrogen
fertilizer
Cow
manure
Composting,
verticulture,
insects, etc
Showers
Cloth washing
8 m3/day
max. 20 m3/day
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Worms, insects
Food, plants, etc

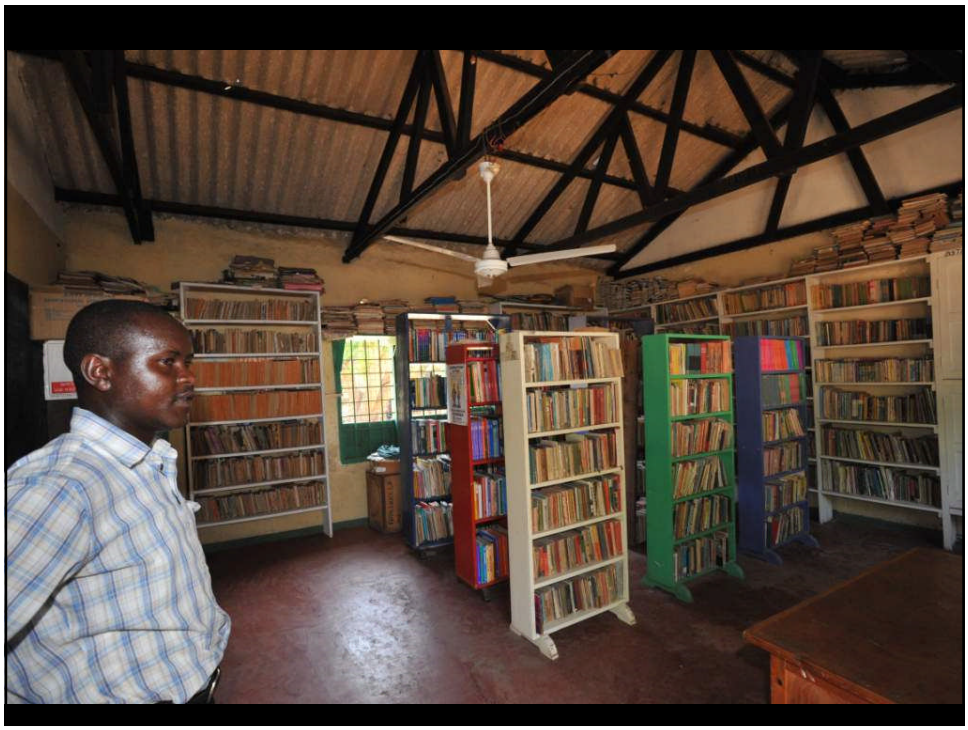
Borstal institute project started by work on extansion of the gardens


TOILETS

Quantities

- Rainwater harvesting
  2 tanks of 50 m3. Why no bigger underground storage?
  – One third of water need
- Sanitation
  – 4 Ecosan toilets, amount black wastes:
    - 1700 l/d (design 2000 l)
  – ? Urinals, 50 % of urine separated
    - 200 l/d (design max 400 l/d)
- Grey water
  – Shower plus cloth washing 42 l/person.day = 42 m3/day
- Kitchen
  – 6 l per person per day: 2 m3/day


1000
1000 EURO
1000 Euro
For books and teaching material
on sanitation and sustainable agriculture
for the Borstal Institute of Shimo la Tewa prison
Mombasa, Kenya



Status of the Borstal institute project

- Project set-up has been approved
- There is money:
  - € 59.162 funded by Aquaforall
  - plus expert cost, etc.
- A good local team
  - Coastal Development Authority
  - Kenyan prison systems
  - Mombasa Water & Sewerage Company
  - Ministry of Agriculture
  - Baobab Trust
  - Local companies Green Water, JuaNguvu Ltd
- Through several reasons:
  - Project start slow
    - Project management
    - Phasing of the project
- **But:**
  - **New project approach: do something central**
  - **Learn by doing**
  - **No large project plans, but small steps!!**

This presentation

Some practical aspects of water management in the developing world

- Nepal: “closing the nutrient cycle”
- Tanzania: Waterharmonica: “reuse water from rich part of the country (5 % of population)”
  - Polluter pays???
- Kenya: optimized agriculture instead of waste water treatment
- **Conclusions, discussion**

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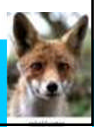
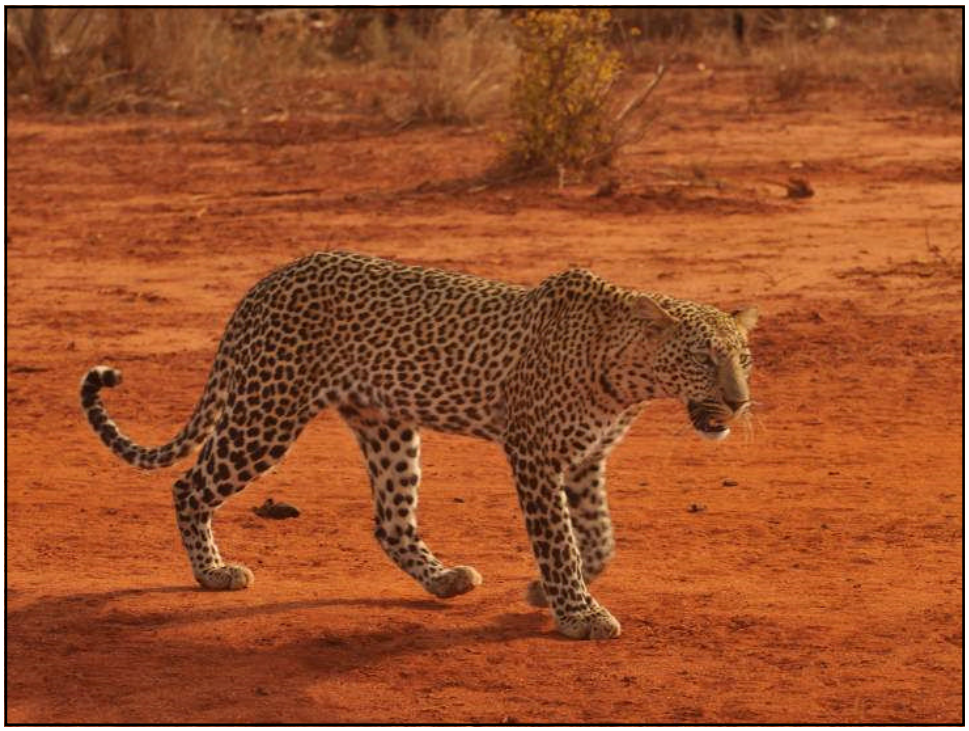


Conclusion of this presentation

- Get the water out of the waste
- Use this in a clever way



Your reactions, please