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 treatment

• Conclusions, discussion
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

Ruud Kampf, Rekel/water, Schermerhorn: www.rekel.nl/water
Trench latrine

SANEX, Loetscher, 1998

Solutions - basics

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  – short term solutions:
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        » close the nutrient cycle

• Based on the local culture and knowledge
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:
  \[\Rightarrow\text{Money does not stink!: small enterprises}\]

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

blackwater  greywater  stormwater  industry wastewater

Figure 4. Flush-and-discharge

Winblad, WHO, 1996
Dilution is the problem

<table>
<thead>
<tr>
<th></th>
<th>High-strength</th>
<th>Diluted Sewage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume</td>
<td>1.5 - 5</td>
<td>15</td>
</tr>
<tr>
<td>I per cap per day</td>
<td></td>
<td></td>
</tr>
<tr>
<td>COD</td>
<td>35000</td>
<td>800</td>
</tr>
<tr>
<td>mg/l</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NH₄</td>
<td>3500</td>
<td>50</td>
</tr>
<tr>
<td>mg/l</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dry solids</td>
<td>34</td>
<td>&lt; 10</td>
</tr>
<tr>
<td>.g/l</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Metals</td>
<td>Fairly low</td>
<td>To high</td>
</tr>
</tbody>
</table>

Distribution of resources in waste water
in % of total in sewage

<table>
<thead>
<tr>
<th></th>
<th>Urine</th>
<th>Faeces</th>
<th>Grey water</th>
</tr>
</thead>
<tbody>
<tr>
<td>N - nitrogen</td>
<td>81</td>
<td>11</td>
<td>8</td>
</tr>
<tr>
<td>P - phosphorus</td>
<td>48</td>
<td>24</td>
<td>28</td>
</tr>
<tr>
<td>K - potassium</td>
<td>63</td>
<td>24</td>
<td>13</td>
</tr>
</tbody>
</table>

Swedish EPA, 1995 - Jenssen, 1999
Cost of water management in The Netherlands per family in Euro/year

<table>
<thead>
<tr>
<th>Organisation</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waterboards “Dry feet”</td>
<td>50</td>
</tr>
<tr>
<td>Communities Sewers</td>
<td>100</td>
</tr>
<tr>
<td>Waterboards Sewage treatment + surface water quality</td>
<td>150</td>
</tr>
<tr>
<td>Water companies Drinking water</td>
<td>165</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>450 per family per year</strong></td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>City</th>
<th>Poor</th>
<th>Non Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manilla</td>
<td>210</td>
<td>76</td>
</tr>
<tr>
<td>São Paulo</td>
<td>175</td>
<td>42</td>
</tr>
<tr>
<td>Karachi</td>
<td>113</td>
<td>33</td>
</tr>
<tr>
<td>Dehli</td>
<td>118</td>
<td>18</td>
</tr>
</tbody>
</table>

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
Experience is growing
Source separation in densely-populated squatter areas in San Salvador

Winblad, WHO, 1996

Ways of separating urine and faeces

keep separate  mix then drain  mix then evaporate

Winblad, WHO, 1996
Swedish solutions urine separation

Separate 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???

- Kenya: optimized agriculture instead of waste water treatment

- Conclusions, discussion
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?
Based on Hynes, 1960 The biology of polluted waters

Influence of a wastewater discharge

A physical – chemical
B nutrients
C micro-organisms
D macro-organisms

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

Based on Hynes, 1960 *The biology of polluted waters*

The Waterharmonica:

Bridge between sewage treatment and surface water

Based on Hynes, 1960 *The biology of polluted waters*
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

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”

Winblad, WHO, 1996

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, 2005

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"

[Image of Masai Mara lodge]

Why not in Tanzania?

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

Hamidar Chanz, Tanzania, 2005

How?

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

When reuse: treatment becomes attractive

Hamidar Chanz, Tanzania, 2005
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

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!

“Thank you

“My success is the result of my failures”

Hamis Dar Chanzi, Tanzania, 2005
This presentation

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  - Polluter pays???
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Improving agricultural practices as a way to meet the Millennium Development Goals: a demonstration project in the Shimo la Tewa prison in Mombasa, Kenya
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 1,500 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!
Guest lecture Saxion University, Deventer, 5 December 2013

Inside a cell
Toilet facilities

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

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

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 than 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 than in the Main prison
Guest lecture Saxion University, Deventer, 5 December 2013

Ruud Kampf, Rekel/water, Schermerhorn: www.rekel.nl/water
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
Learn how to sustain a family on 1000 m²

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
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Digesters

Gas collection
Kenyan Prisons Service
Mission Statement

To contain offenders in humane safe condition in order to facilitate responsive administration of justice Rehabilitation, Social Reintegration and community protection.

Baobab Trust

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.ieee.ch/EcoEng32/EcoEng32_intdoktor.html
- http://www.hallerfoundation.com/

Ruud Kampf, Rekel/water,
Schermerhorn: www.rekel.nl/water
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

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

- Rain water harvesting + storage
- Water supply: 15 m³/day
- 2 m³/day
- Kitchen
- Toilets
- Urinals
- Showers
- Cloth washing
- Agriculture
  - Horticulture
- Products
- Food, plants, etc
Borstal institute Sanitation pilot project: Closing the nutrient cycle – process scheme

- Water supply
  - 15 m³/day
- Rainwater harvesting + storage
- Toilets
- Urints
- Showers
- Cloth washing
- Kitchen
  - 2 m³/day
  - Sieve
- Banana field wetland
- Organic wastes
- Food supply
  - Water
  - 2 m³/day
  - 15 m³/day

- Digester 1
  - Biogas water
  - Organic wastes
  - Composting, verticulture, insects, etc
- Digester 2
  - Cow manure
  - Compost
- Agriculture horticulture
  - Products
  - Food, plants, etc

Co-digestion with cow manure:
- Black water acts as "water source"
- Add organic wastes for composting

Black water turned into a thin black stream
Storage of urine on ash
Sidhipur Nepal

- Simple
- Cheap
- Durable
Borstal institute project started by work on extension of the gardens
Guest lecture Saxion University, Deventer, 5 December 2013

Ruud Kampf, Rekel/water, Schermerhorn: www.rekel.nl/water
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
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!!

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  - Polluter pays???
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- Conclusions, discussion
Conclusion of this presentation

- Get the water out of the waste
- Use this in a clever way
Your reactions, please