Part 2:
Some examples of sustainable water management in the developing world

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:

  Shimoo la Tawa, Mombasa

  Biological sanitation

• 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
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

SANEX, Loetscher, 1998

Trench latrine
Solutions - basics

• Aimed on the communities, done by the communities
  – short term solutions:
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    • with foreign aid, but:
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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,
  - $> 100 \text{ mm/day} = > 100 \text{ l/m}^2\text{.day} = 1000 \text{ m}^3/\text{ha.day}$

**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:

$\Rightarrow \text{Money does not stink!}: \text{ small enterprises}$
Double vault composting latrine

- 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

Grey water

SANEX, Loetscher, 1998
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

![Image: Flush-and-discharge](image.png)

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 l per cap per day</td>
<td>1.5 - 5</td>
<td>15</td>
</tr>
<tr>
<td>COD mg/l</td>
<td>35000</td>
<td>800</td>
</tr>
<tr>
<td>NH₄ mg/l</td>
<td>3500</td>
<td>50</td>
</tr>
<tr>
<td>Dry solids g/l</td>
<td>34</td>
<td>&lt; 10</td>
</tr>
<tr>
<td>Metals</td>
<td>Fairly low</td>
<td>To high</td>
</tr>
</tbody>
</table>

Only introduce piped drinking water when there is money to treat the waste water.
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

<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>Total Euro 450 per family per year</td>
<td></td>
</tr>
</tbody>
</table>

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

Cost doubled since then
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**

Heavy metal content in % of Swedish limit for agricultural use

**Sludge from septic tanks**

Heavy metal content in % of Swedish limit for agricultural use

Ruud Kampf, Rekel/Water, Rekel Kenya Ltd
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

1. Keep separate
2. Mix then drain
3. Mix then evaporate

Winblad, WHO, 1996

Swedish solutions urine separation

1. Separate faeces and urine collection
2. Urine collection and septic tank

Jenssen, 1999
Alternatives managing urine

Zero-effluent discharge

Ruud Kampf, Rekel/Water, Rekel Kenya Ltd
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

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

The main Shimo la Tewa Prison sewage gang

Supervising officer:
Salim O. Mwatimbo

Prisoners:
Tonny Aden
Peterson Mykhongo
Johne Njorogie
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-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
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)
Mombasa, Kenya
Tel: +254 41 222490/06
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
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
Agriculture in prison
Plant nursery

- Mrs Lina E. Bonto

Dr. Rene D. Haller
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 fishpond
Cultivation of worms
Fishfood
Chickenfood

Introduction of solar drying and cooking
Kisumu Mixa Foods & Beverage

• Local initiative
• Small scale Haller farm
   – In Kenya unusual products
     • Cricket farming
     • etc

Sale of local products

http://www.mixafoods.co.ke/

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.iees.ch/EcoEng/321/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

**Toilets**
- 2 m³/day

**Digester 1**
- Biogas
- Organic wastes

**Digester 2**
- Composting, verticulture, insects, etc.

**Compost**
- Worms, insects

**Agriculture horticulture**
- Products
- Food, plants, etc.

**Food supply**
- 15 m³/day

**Drink water harvesting + storage**

**Black water turned into a thin black stream**
- Co-digestion with cow manure:
  - Black water acts as "water source"
  - Add organic wastes for composting

**Water supply**
- 15 m³/day

**Urinals**
- Urine overflow

**Urine tank**

**Urine processing**
- Nitrogen fertilizer

**Agriculture horticulture**
- Products
- Food, plants, etc.
Storage of urine on ash
Sidhipur Nepal

- Simple
- Cheap
- Durable

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

- Rain water harvesting + storage: 15 m³/day
- Showers, cloth washing: 8 m³/day, max. 20 m³/day
- Constructed wetland
- Fish ponds
  - Algae
  - Fish
- Agriculture horticulture
  - Food, plants, etc
  - Compost, worms, insects
  - Products

Ruud Kampf, Rekel/Water, Rekel Kenya Ltd
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
Borstal institute project

• Project set-up has been approved
• There was 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!!

Project cancelled because of unclear money flows….
Borstal institute project started by work on extension of the gardens

Borstal in the dry season
Borstal in the wet season

- Boys prison
- Gardens, Banana field
- Site for wetlands, ponds, gardens
- Staff quarters

Clinic, school buildings, septic tank, small wetland?

- Kitchen water
- Black water
- Urine
- Gray water
- Showers, taps

- (New) septic tanks?
- Digesters
- Wetland
- Pond, water storage
- Composting
- Grey water, small bore
- Open gutter

Borstal institute Shimo la Tewa: Sketch design of the Biological Sanitation
Follow up in 2016:

Kenya Prisons Service

Kenya Prisons – Sustainable Treatment and Re-Use of Waste Water
Lessons learnt from the sanitation and re-use projects in Shomo in Tawa prison and Borstal institute, aimed on optimisation of the existing facilities, continuation of the Borstal project and applications in other Kenyan prisons.

Notes of Meeting with Rekel Kenya Ltd and the Netherlands Business Hub 12 April 2016, Prisons Headquarters

Attendees:
- Ruud Kampf
- Folkert Schoustra
- John Mathai
- Lead Technical Expert
- Project Manager
- Director Planning & Development • Kenya Prisons Service
- Rekel Kenya Limited
- NL Business Hub

Ruud Kampf, Rekel/Water, Rekel Kenya Ltd
Expression of Interest / Proposal

Biological Sanitation Demonstration Project at Shimo La Tewa Prison in Mombasa and Future Upscaling

Submitted to United Nations Environmental Programme

December 2016

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VAT number: PIB1018082

A good project setup?
Proposal to UNEP by the Dutch embassy in Nairobi in December 2016