Ecological Sanitation and Health Aspects

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WHO Guidelines for the Safe Use of Wastewater, Excreta and Greywater
Current Guidelines – Presentation

Four volumes to better reach different target audiences:

Volume 1 Policy and regulatory aspects (March 2007)
Volume 2 Wastewater use in agriculture (Sept 2006)
Volume 3 Wastewater and excreta use in aquaculture (Sept 2006)
Volume 4 Excreta and greywater use in agriculture (Sept 2006)

A 5th Volume: Sampling and laboratory aspects discussed but currently not in production.

Finding the Guidelines

http://www.who.int/water_sanitation_health/
CD-ROM 'electronic library' (from 5th edition)

Hard copy from WHO, bookshops
WHO Guidelines on water

- Protection of human health
- Advisory to national standard setting – flexible to account local social, cultural, economic & environmental context
- Risk-benefit - adaptation to local priorities for health gain
- Best available evidence - science and practice
- Scientific consensus
- Use global information and experience

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Wastewater, Excreta and Grey Water Use - Background

Wastewater use is extensive worldwide

- 10% of world’s population thought to consume wastewater irrigated foods
- 20 million hectares in 50 countries are irrigated with raw or partially treated wastewater
- The use of excreta (faeces, urine) is important worldwide for its fertiliser value
- The use of greywater is growing in both developed and less-developed countries – culturally more acceptable in some societies

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Wastewater, Excreta and Grey Water Use - Health Concerns

Current practises regarding discharge of excreta and wastewater unsatisfactory from a health viewpoint

Direct Health Effects
• Disease outbreaks (developing and developed countries)
• Contribution to background disease (e.g., helminths, + others?)

Indirect Health Effects
• Impacts on the safety of drinking water, food and recreational water
• Positive impacts on household food security and nutrition

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Global burden of disease (% of DALYs)

Lopez et al. 2006. Global and regional burden of disease and risk factors
Wastewater, Excreta and Grey Water Use – Lessons Learned

Overly strict standards borrowed from other countries often fail

Guidelines are not just numbers
= good practice + microbial water quality standards

Low-cost effective treatment technologies needed

Risk reduction strategies necessary (and possible) where wastes receive no or inadequate treatment

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2006 WHO Guidelines for Safe Wastewater, Excreta and Grey Water Use

**Objective:**
Maximize the protection of human health and the beneficial use of important resources

**Target Audience:**
Policy makers, people who develop standards and regulations, environmental and public health scientists, educators, researchers and sanitary engineers
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2006 WHO Guidelines on Wastewater, Excreta and Grey Water Use?

Guidelines provide an integrated preventive management framework for maximizing public health and environmental benefits of wastewater, greywater and excreta use.

Health components:
• Defines a level of health protection expressed as a health-based target;
• Identifies health protection measures which used collectively can achieve the specified health-based target.

Implementation components:
• Establishes monitoring and system assessment procedures;
• Defines institutional and oversight responsibilities;

Requires:
• System documentation; and
• Confirmation by independent surveillance.

Current Guidelines – General Information

Scope:

Covers intentional use but may be relevant to unintentional uses e.g., irrigation with sewage contaminated surface waters;

Covers municipal or domestic wastes without substantial industrial inputs;

Covers faecal sludges derived from on-site sanitation facilities (traditional as well as source-separating) but does not cover sludge produced from the treatment of wastewater;

Provide detailed information only on matters related to health protection
National policy perspectives

- poverty reduction
- food security
- protection of public health
- protection of the environment
- consumer protection
- integrated water resources management
- energy reliance

WHO Guidelines for the Safe Use of Wastewater, Excreta and Greywater.

Key issue:
Exposure assessment in the handling chain

Handling strategy:
Risk management; Health targets and Acceptable risk
Assess the situation and exposure routes and make priorities based on health situation/incidence of disease.

How am I exposed?

A central part of a preventive assessment is the exposure and
To minimize it!
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Approaches – Evidence based or Predictive –
Based on WHO Stockholm Framework

Manage SANITATION

Can we manage the risks?

ASSESSMENT

EXPOSURE

HEALTH OUTCOME

Keypoints and audits
Institutional Arrangements

How to create institutional arrangements

- map out which sectors are of relevance
- make an inventory of successful existing institutional arrangements
- assess current and potential roles of sectors in safe use of wastewater, excreta and/or greywater
- organize a national event to start the national dialogue
- prepare an intersectoral action plan with a realistic budget

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Assessments

- Assess the exposure in the full handling chain.
- Assess the human environment in light of danger to human health.
- Account for other factors that as well that may impact – not just ”one-eyed” on water or sanitation.

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Establish an evaluation system

- Which are the critical points of exposure?
- What are the barriers that may reduce the risks?
- What other operational or behaviourws may affect the risk?

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### Pathogen reductions (log units) achieved by health-protection control measures

<table>
<thead>
<tr>
<th>Control measure</th>
<th>Pathogen reduction (log units)</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excreta &amp; urine Treatment (on-site and/or as post-treatment)</td>
<td>2–6</td>
<td>The required pathogen removal depends on the combination of the treatment and selected health-protection control measures.</td>
</tr>
<tr>
<td>Crop selection and means of application</td>
<td>2–4</td>
<td>Higher risk: Root crops and crops that grow just above (lettuce) and in partial contact with the soil. Lower risk: Crops with the harvested parts not in contact with the soil.</td>
</tr>
<tr>
<td>Pathogen die-off</td>
<td>2–4</td>
<td>Die-off on crop surfaces that occurs between application and consumption. The log unit reduction achieved depends on climate (temperature, sunlight intensity), crop type, etc.</td>
</tr>
<tr>
<td>Produce washing with water</td>
<td>1</td>
<td>Washing salad crops, vegetables and fruit with clean water.</td>
</tr>
<tr>
<td>Produce peeling</td>
<td>2</td>
<td>Fruit, root crops.</td>
</tr>
<tr>
<td>Produce cooking</td>
<td>5–6</td>
<td>Immersion in boiling or close-to-boiling water until the food is cooked ensures pathogen destruction.</td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th>Treatment option or process</th>
<th>Helminth egg log reduction</th>
<th>Duration months</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Low-cost</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Faecal sludge settling ponds</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Faecal sludge reed drying beds (constructed wetlands)</td>
<td>1.5</td>
<td>12</td>
</tr>
<tr>
<td>Drying beds for dewatering (pretreatment)</td>
<td>0.5</td>
<td>0.3–0.6</td>
</tr>
<tr>
<td>Drying beds for drying</td>
<td>2.0–3.0</td>
<td>1</td>
</tr>
<tr>
<td>Composting (window thermophilic)</td>
<td>1.5–2.0</td>
<td>3</td>
</tr>
<tr>
<td>pH elevation &gt;9</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Anaerobic (mesophilic)</td>
<td>0.5</td>
<td>0.5–1.0</td>
</tr>
<tr>
<td><strong>High-cost</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>pH elevation &gt;12</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Thermophilic, in-vessel (aerobic/anaerobic)</td>
<td>3</td>
<td>1–5 days</td>
</tr>
</tbody>
</table>

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Example of Excreta Systems

<table>
<thead>
<tr>
<th>Exposure</th>
<th>Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cleaning of blocked pipes</td>
<td>Ingestion of pathogens</td>
</tr>
<tr>
<td>Accidental ingestion when handling unstored urine</td>
<td>Ingestion of pathogens</td>
</tr>
<tr>
<td>Accidental ingestion when handling stored urine</td>
<td>Ingestion of pathogens</td>
</tr>
<tr>
<td>Inhalation of aerosols created when applying urine</td>
<td>Inhalation of pathogens</td>
</tr>
<tr>
<td>Consumption of crops fertilised with urine</td>
<td>Ingestion of pathogens</td>
</tr>
</tbody>
</table>
Greywater – same principals

Faecal input crucial to assess risk!!

Water supply

Greywater treatment options

Pretreatment

Drip irrigation

Soil Infiltration

Mound

Constructed wetland

Sand/gravelfilter

Biofilter

Reuse

Greywater – same principals

Treatment as a barrier – reduction efficiency.

Reduction in dry latrines, storage time 6 months, pH value around 9 or more. Based on added organisms, at time 0. Reduction given as log10 values.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Reduction efficiency</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bacteria (coliforms)</td>
<td>&gt; 6 log</td>
<td>Chinese exp</td>
</tr>
<tr>
<td>Bacteria (fecal enterococci)</td>
<td>4-6 log</td>
<td>Extrapolations/Mexico</td>
</tr>
<tr>
<td>Bacteriophages (index virus)</td>
<td>5-&gt;6 log</td>
<td>Chinese exp</td>
</tr>
<tr>
<td>Ascaris ova (index parasite)</td>
<td>100% reduction of viability</td>
<td>Vietnamese exp</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mexican extrapol</td>
</tr>
</tbody>
</table>

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The first thing is to assemble a suitable team for an assessment

- How do you select and which ones is the essential player?
- Which is the institutional framework that you may work within?
- Are personal suitable trained and in tune with each others?

Exposure central

- What is the volume that individual are exposed to?
- What is the likely frequency of exposure?
- How many people are exposed? (directly; indirectly)
How many of these children puts something in their mouths?

Introduction of toilets will have limited impact if the environment is contaminated. Is it?

Contaminated water and ground is part of the living environment!

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Fecal material outside a communal toilet. Does this indicate willingness but repulsion at site?
Documentation and Monitoring

- Establish a documentation system!
- Establish monitoring requirements!

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Data entry form: for a dynamic system

**WATER**

<table>
<thead>
<tr>
<th>ID</th>
<th>House no</th>
<th>Bsk Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Water Source**
- Community Tap
- Individual Tap
- Handpump
- Other

**Water Quality**
- Satisfactory
- Not Satisfactory

Supply time (hours in a day)
- 2

Time taken to collect water (minutes)
- 45

**If Individual Tap Connection**
- Male
- Female

User charges per no
- 50
- 50

Payment made to
- Hotel
- Contractor

**Definition of Monitoring Functions**

<table>
<thead>
<tr>
<th>Function</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Validation</strong></td>
<td>Testing the system or components thereof to ensure if it is meeting e.g. &quot;microbial reduction targets&quot;. Mainly relates to new systems/components.</td>
</tr>
<tr>
<td><strong>Operational monitoring</strong></td>
<td>Relates to &quot;design specifications&quot; e.g. turbidity. Indicate proper functions and variations and is the base for &quot;direct corrective actions&quot;.</td>
</tr>
<tr>
<td><strong>Verification</strong></td>
<td>Methods, procedures and tests to determine compliance with design parameters AND specific requirements (GL values, E. coli, helminth eggs, microbial and chemical analysis of crops).</td>
</tr>
</tbody>
</table>

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Microbial GL values

- Mainly applicable for verification monitoring in larger systems.
- Design criteria (system validation) - the main factor in addition to exposure control to counteract risks and variabilities.
- Storage and treatment additives as aid in the barrier efficiency.

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<table>
<thead>
<tr>
<th>Treatment</th>
<th>Criteria</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Storage; ambient temperature 2–20 °C</td>
<td>1.5–2 years</td>
<td>Will eliminate bacterial pathogens; regrowth of E. coli and Salmonella may be considered if rewetted; will reduce viruses and parasitic protozoa below risk levels. Some soil-borne ova may persist in low numbers.</td>
</tr>
<tr>
<td>Storage; ambient temperature &gt;20–35 °C</td>
<td>&gt; 1 year</td>
<td>Substantial to total inactivation of viruses, bacteria and protozoa; inactivation of schistosome eggs (&lt;1 month); inactivation of nematode (roundworm) eggs, e.g. hookworm (Ancylostoma/Necator) and whipworm (Trichuris); survival of a certain percentage (10–30%) of Ascaris eggs (&gt;4 months), while a more or less complete inactivation of Ascaris eggs will occur within 1 year (Strauss 1985).</td>
</tr>
<tr>
<td>Alkaline treatment</td>
<td>pH &gt;9 during &gt;6 months</td>
<td>If temperature &gt;35 °C and moisture &lt;25%, lower pH and/or wetter material will prolong the time for absolute elimination.</td>
</tr>
</tbody>
</table>

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Table 4.5 Recommendations for storage treatment of dry excreta and faecal sludge before use at the household and municipal levels

- No addition of new material.
Recommendations for the use of human urine – large systems

<table>
<thead>
<tr>
<th>Storage temperature</th>
<th>Storage time</th>
<th>Pathogens in the urine</th>
<th>Recommended crops</th>
</tr>
</thead>
<tbody>
<tr>
<td>4°C</td>
<td>&gt;1 month</td>
<td>viruses, protozoa</td>
<td>food and fodder crops that are to be processed</td>
</tr>
<tr>
<td>4°C</td>
<td>&gt;6 months</td>
<td>viruses</td>
<td>food crops that are to be processed, fodder crops</td>
</tr>
<tr>
<td>20°C</td>
<td>&gt;1 month</td>
<td>viruses</td>
<td>food crops that are to be processed, fodder crops</td>
</tr>
<tr>
<td>20°C</td>
<td>&gt;6 months</td>
<td>probably none</td>
<td>all crops</td>
</tr>
</tbody>
</table>

Inactivation affected by pH (~9) and ammonia, avoid dilution of the urine

*From potential faecal cross-contamination and possibly remaining after storage

Implementation

- Establish an implementation procedure.
- Look into the questions of compliance.
- Who can monitor/check at the local scale?
- What is the likelihood of sustainability of the installation and system?
- Maintenance?

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Implementation approach

- Incidence of different disease in local context?
- Treatment efficiency and variability?
- Exposure; Who? How many? How often?

- What crops are wastewater/sludge/excreta applied to?
- When in the crop cycle is it applied? What is the waiting period between last application and harvest?
- Who are exposed? Farmers – Consumers – Others?
- How often? How many? How frequently? Likely volumes of wastewater/sludge/excreta?
- How are the products handled after harvest and before consumption?
Evidence based epidemiological information.
Durban; South Africa 2006

- A GIS-based randomized cohort study of diarrhoeal and worm disease in sanitary source separation interventions, and control areas.
- 1337 households; >7000 individuals, repeated 6 times with 14 days interval, accounting for water and hygiene habits.
- Total demographic and socio-economic information (Demographic site).
- Database of 1,200,000 entries.
- Ethically approved.

Acknowledgement:
Nelson Mandela School of Medicine,
University of KwaZulu Natal,
Ethekwini Municipality
Urine Diversion Toilet

• Separates urine and faces at source

Results

- A reduction of days with diarrhoea with 70% was achieved in areas with full coverage of dry toilets.
- The incidence of diarrhoea was especially reduced for the young and the elderly.
- Since the very infants are not using the toilets this also shows that secondary transmission to children was reduced in the society.
- An additional reduction was achieved when safe water was provided.

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### WHO Guidelines. AIMS for the future.

- **The guidelines a starting point for:**
  - Comparative assessments with uses of WW/others
  - Follow-up and implementation of WHO Guidelines site- or country based (2007-2010 and thereafter)

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#### Percentage of individuals with Disease outcome by Drinking Water Safety

<table>
<thead>
<tr>
<th>Water safety</th>
<th>N</th>
<th>% Diarrhoea</th>
<th>% Vomitting</th>
<th>% Worms</th>
<th>% Skin sores</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unsafe</td>
<td>372</td>
<td>32.5%</td>
<td>5.4%</td>
<td>10.5%</td>
<td>5.6%</td>
</tr>
<tr>
<td>Safe outside</td>
<td>4086</td>
<td>22.5%</td>
<td>2.7%</td>
<td>2.9%</td>
<td>4.3%</td>
</tr>
<tr>
<td>Safe inside</td>
<td>2755</td>
<td>18.2%</td>
<td>1.3%</td>
<td>2.1%</td>
<td>2.5%</td>
</tr>
</tbody>
</table>

#### Incidence Rate Ratio & Prevalence Ratio

<table>
<thead>
<tr>
<th>Comparison</th>
<th>IRR</th>
<th>PR</th>
<th>PR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safe outside vs. safe inside</td>
<td>1.23</td>
<td>1.38</td>
<td>1.71</td>
</tr>
<tr>
<td>Unsafe vs. safe inside</td>
<td>1.44</td>
<td>4.01</td>
<td>1.82</td>
</tr>
</tbody>
</table>

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