Ecological sanitation and associated health risks
WHO Guidelines – safe use of excreta, greywater and wastewater in agriculture

Ecosan in Bulgaria
12-14 April 2007
Thor Axel Stenström
Professor, WHO Advisor
WHO Response on WSH issues

Evidence & policy
Status & trends
Norms
Good practice
Partnerships
Research & testing

Water supply
Sanitation
Hygiene
Water resources
Health-care waste

HQ - ROs - RECs – COs
UN system, partnerships
eg IWA
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
WHO Guidelines on water

• Drinking-water Quality
• Safe Use of Wastewater, Excreta and Greywater
  – Four volumes
• Safe Recreational Waters
  – Coastal and freshwaters
  – Swimming pools and spas
• Ship Sanitation
• Hygiene and Sanitation in Aviation
WHO Framework for all Guidelines (Stockholm Framework)

- Basic control approaches
  - Water quality objectives
  - Other management objectives

- Define measures and interventions (requirements, specifications) based upon objectives

- Define key risk points and audit procedures for overall system effectiveness

- Define analytical verifications (process, public health)

- Assessment of risk
  - Acceptable risk

- Environmental exposure

- Public Health Outcome
Approaches – Evidence based or Predictive – Based on WHO Stockholm Framework

Manage SANITATION

Can we manage the risks?

ASSESSMENT

EXPOSURE

HEALTH OUTCOME

Keypoints and audits

Acceptable risk

Audit procedures for system effectiveness

Analytical verifications (process, public health)

Measures and interventions (requirements, specifications)

Assessment of Risk

Audit

Environment exposure

PUBLIC HEALTH OUTCOME

Risk management objectives

PUBLIC HEALTH

RISK MANAGEMENT

Define

Can we manage the risks?

Manage SANITATION

Can we manage the risks?
Microbial Risk Assessment

• Hazard Identification
  – All entero-pathogens potentially in excreta

• Exposure assessment
  – Exposure points, Site-specific data on removal
  – Literature data on occurrence of pathogens, removal in treatment and survival in environment

• Dose-response assessment. (Published models)

• Risk characterisation
  – Risk of infection per exposure and yearly.
  – Comparison with endemic level of disease (underreporting)
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 withing?
• Are personal suitable trained and in tune with each others?
Institutional Arrangement of Facilitator

- Developing guideline/manual
- Training/workshop
- Review/dissemination
- Monitoring and back up

- Training/workshop
- Monitoring/Facilitation
- Exchange visit

- Training/workshop
- Monitoring/Facilitation
- Exchange visit

- Training/workshop
- Monitoring
- Monitoring/Facilitation
## 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>Wastewater treatment</td>
<td>1–6</td>
<td>The required pathogen removal to be achieved by wastewater treatment depends on the combination of health-protection control measures selected</td>
</tr>
<tr>
<td>Localized irrigation (low-growing crops)</td>
<td>2</td>
<td>Root crops and crops such as lettuce that grow just above, but partially in contact with, the soil.</td>
</tr>
<tr>
<td>Localized irrigation (high-growing crops)</td>
<td>4</td>
<td>Crops, such as tomatoes, the harvested parts of which are not in contact with the soil.</td>
</tr>
<tr>
<td>Spray/sprinkler drift control</td>
<td>1</td>
<td>Use of micro-sprinklers, anemometer-controlled direction-switching sprinklers, inward-throwing sprinklers, etc.</td>
</tr>
<tr>
<td>Spray/sprinkler buffer zone</td>
<td>1</td>
<td>Protection of residents near spray or sprinkler irrigation. The buffer zone should be at 50–100 m.</td>
</tr>
<tr>
<td>Pathogen die-off</td>
<td>0.5–2 per day</td>
<td>Die-off on crop surfaces that occurs between last irrigation 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 disinfection</td>
<td>2</td>
<td>Washing salad crops, vegetables and fruit with a weak disinfectant solution and rinsing 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>
Examples options for the reduction of viral, bacterial and protozoan pathogens that achieved a health based target of ≤10⁻⁶ DALYS pppy

- Less treatment maybe more economical
- California Title 22 ≤ 2.3 FC/100 ml (virtually Zero) ONLY with treatment
- Less treatment implies more supervision sites
- Monitoring WWTP at T level
- Washing = More public involvement
- Involuntary soil ingestion from farmers

Log₁₀ Reduction Pathogens

7

A Root

6

W

2

0
Exposure Risk

Cleaning of blocked pipes  Ingestion of pathogens

Accidental ingestion when handling unstored urine  Ingestion of pathogens

Accidental ingestion when handling stored urine  Ingestion of pathogens

Inhalation of aerosols created when applying urine  Inhalation of pathogens

Consumption of crops fertilised with urine  Ingestion of pathogens
Greywater – same principals

Faecal input crucial to assess risk!!

Water supply

Greywater treatment options

- Pretreatment
- Secondary treatment
- Drip irrigation
- Soil Infiltration
- Mound
- Constructed wetland
- Sand-/gravelfilter
- Biofilter

Garden irrigation

Reuse
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.
Outbreak of EHEC in Sweden

Run-off from agricultural land where grazing cattle were infected with EHEC (a zoonoses, i.e. transmission animal-human)

Transport from manure to river water

Irrigation of lettuce (no requirements for analysis of the water)

The lettuce was consumed by a large number of individuals – resulted in 100 cases (approx. 10 hospitalised)

At SMI: samples from patients (typing of isolates), water samples
Documentation and Monitoring

• Establish a documentation system!
• Establish monitoring requirements!
Which are the health Targets and guideline Procedures?

Can we Manage the Risks?

Cases and participatory Approaches on different Community levels!
## Definition of Monitoring Functions

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<th>Definition</th>
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<td><strong>Validation</strong></td>
<td>Testing the system or components thereof to ensure if it is meeting e.g. ”microbial reduction targets”. Mainly relates to new systems/components.</td>
</tr>
<tr>
<td><strong>Operational monitoring</strong></td>
<td>Relates to ”design specifications” e.g turbidity. Indicate proper functions and variations and is the base for ”direct corrective actions”</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>
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.

<table>
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<tr>
<th></th>
<th>Helm. Eggs</th>
<th>E. coli</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Treated fecals</strong></td>
<td>&lt; 1/ g TS</td>
<td>Helminths. Low incidence E coli &lt; 1000/g TS</td>
</tr>
<tr>
<td><strong>Greywater:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Restricted</td>
<td>&lt; 1/L</td>
<td>&lt; 10^5</td>
</tr>
<tr>
<td>• Unrestricted</td>
<td>&lt; 1/L</td>
<td>&lt; 10^3</td>
</tr>
</tbody>
</table>

![Graph showing microbial GL values for different times between crop fertilising and consumption.](image)

- Campylobacter
- Cryptosporidium
- Rotavirus

- Time between crop fertilising and consumption:
# Recommendations for faeces – household level

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Criteria</th>
<th>Comment</th>
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</thead>
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<tr>
<td>Storage (only treatment); Ambient temperature 2-20°C</td>
<td>1.5 - 2 years</td>
<td>Will eliminate most bacterial pathogens; regrowth of <em>E coli</em> and <em>Salmonella</em> not considered if rewetted; will substantially reduce viruses, protozoa and parasites. Some soil-borne ova may persist</td>
</tr>
<tr>
<td>Storage (only treatment) Ambient temperature 20-35°C</td>
<td>&gt; 1 year</td>
<td>As above</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>
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### Recommendations for faeces – municipal level

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<tr>
<td>Alkaline treatment</td>
<td>pH &gt;9 during &gt;6 months</td>
<td>Hypothesis: If temperature &gt;35°C or moisture &lt;25%. Lower pH and/or wetter material will prolong the time for absolute elimination.</td>
</tr>
<tr>
<td>Composting</td>
<td>Temperature &gt;50°C for &gt;1 week</td>
<td>Minimum requirement. Longer time needed if temperature requirement can not be ensured</td>
</tr>
<tr>
<td>Incineration</td>
<td>Fully incinerated (&lt;10% carbon in ash)</td>
<td>косместко</td>
</tr>
<tr>
<td>Storage</td>
<td>Ambient temperature 2-20°C</td>
<td>Time modification needed based on local conditions. Large systems needs a higher level of protection. Than at household level. Additional storage adds to safety</td>
</tr>
<tr>
<td></td>
<td>Ambient temperature 20-35°C</td>
<td></td>
</tr>
</tbody>
</table>
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)
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?
Implementation approach

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

• 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?
Control measures

- **Exposure 6**
  - Fence storage area
  - Optimisation of sludge treatment

- **Exposure 7**
  - Use of PPE
  - Optimisation of sludge treatment
  - Prolonged sludge storage
Control measures

• Exposure 8
  – Crop restrictions
  – Minimum time between fertilisation and harvest
  – Optimisation of sludge treatment
  – Prolonged sludge storage
Safe Use of Wastewater and Excreta

Management strategies to reduce health risks

• Treatment of Wastes
• Crop Restriction
• Waste Application Methods
• Control of Human Exposure
Has the intervention had a measurable positive impact on human health?
WHO Guidelines. AIMS for the future.

- The guidelines a starting point for:
  - Country-based system studies including risk/epi based approaches. (2006-2009)
  - Comparative assessments with uses of WW/others
  - Follow-up and implementation of WHO Guidelines site- or country based (2007-2009 and thereafter)

WHO do you choose?
What is the relative risks?
Tack!

Lycka till! Thor Axel