Health Aspects of Ecological Sanitation and the WHO Guidelines

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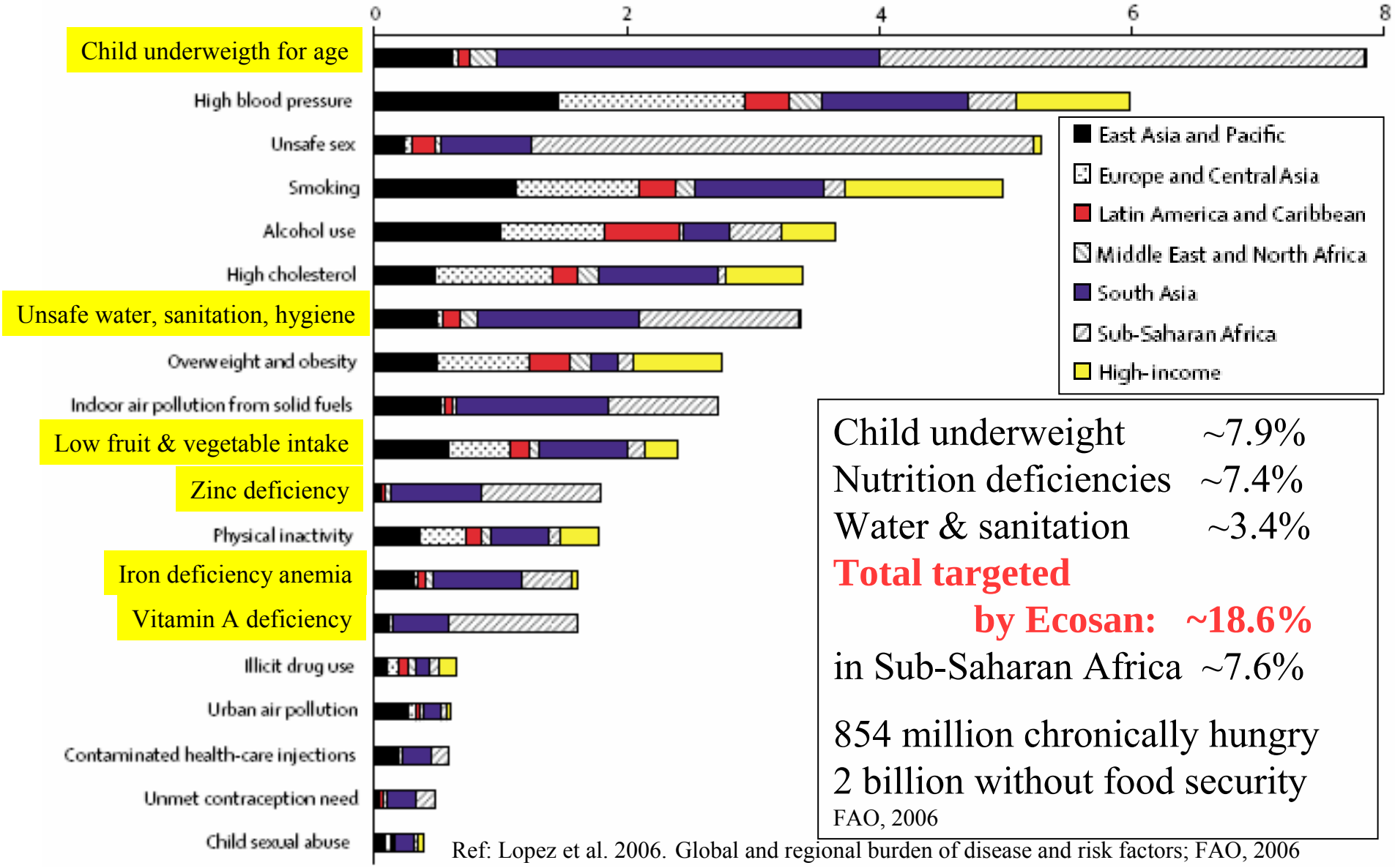
International conference on Sustainable Sanitation: "Food and Water Security for Latin America"
25-28 November 2007, Fortaleza, Ceará, Brazil

Global risk factors for disease and premature deaths (% of DALYs)

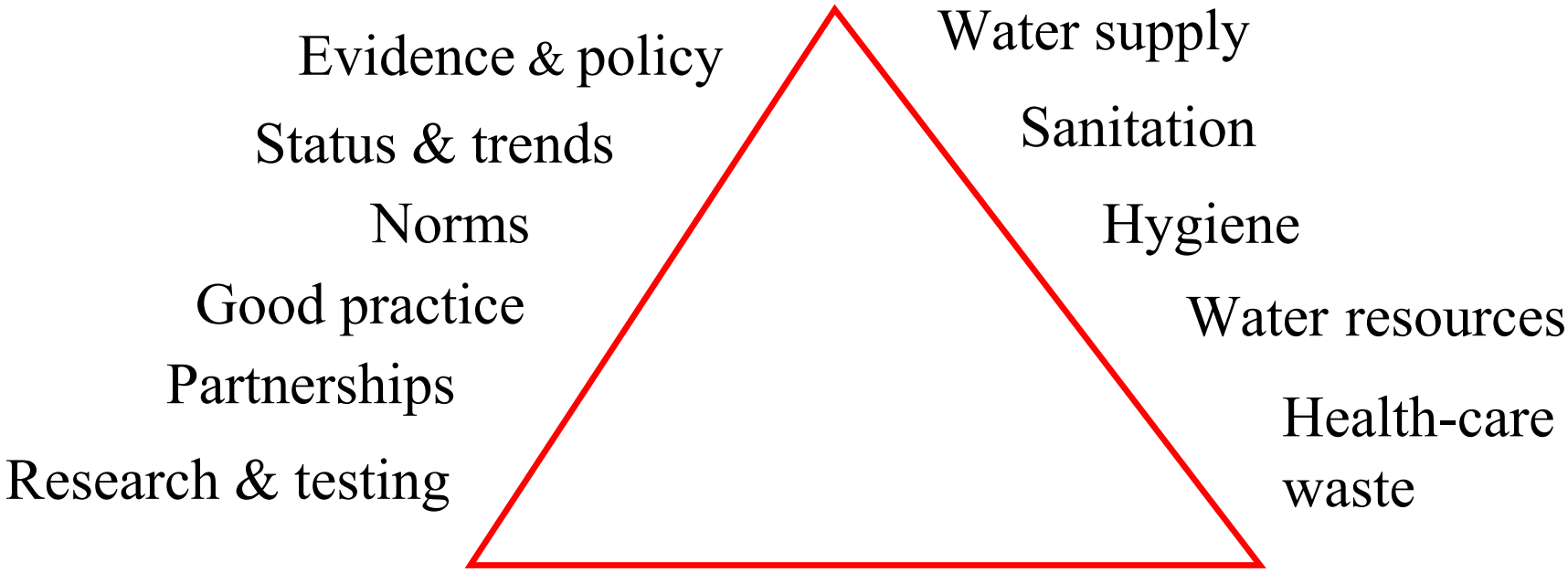


Child underweight ~7.9%
Nutrition deficiencies ~7.4%
Water & sanitation ~3.4%
Total targeted by Ecosan: ~18.6%
in Sub-Saharan Africa ~7.6%

854 million chronically hungry
2 billion without food security
FAO, 2006

Ref: Lopez et al. 2006. Global and regional burden of disease and risk factors; FAO, 2006

WHO Response on WSH issues



HQ - ROs - RECs – COs

UN system, partnerships (eg IWA)

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Wastewater, excreta and greywater 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 but the extent hasn't been quantified
- The use of greywater is growing in both developed and less-developed countries – may be culturally more acceptable in some societies

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Wastewater, excreta and greywater use – Health concerns

Direct Health Effects

- Disease outbreaks (developing and developed countries)
- Contribution to background disease (eg. 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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WHO Guidelines – Safe use of wastewater, excreta and greywater in agriculture (2006)

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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Wastewater, excreta and greywater use – Lessons learned

- Overly strict standards borrowed from other countries often fail
- Guidelines are not just numbers
  = good practice + microbial 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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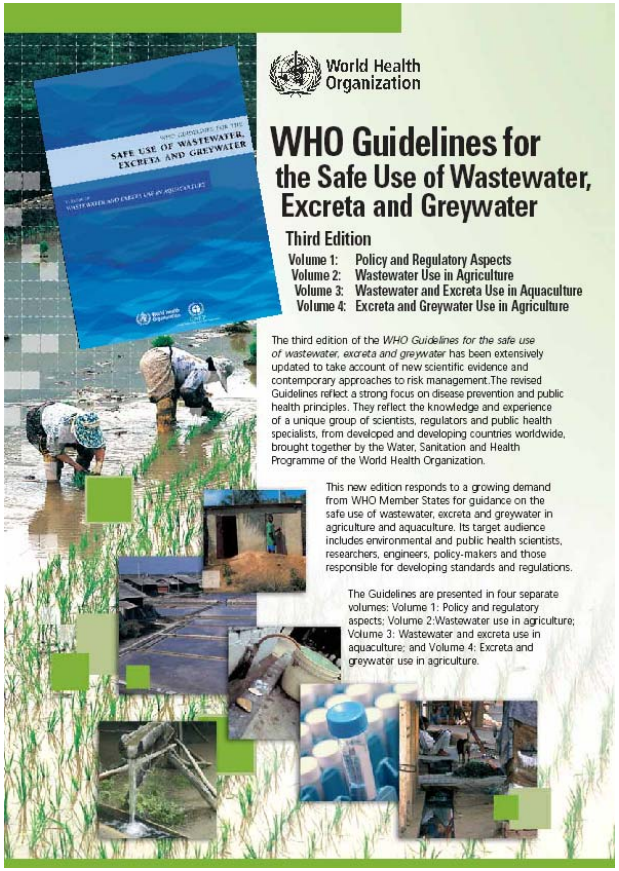
WHO Guidelines – Safe use of wastewater, excreta and greywater (2006)



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Five volumes to better reach different target audiences

- Volume 1 Policy and regulatory aspects
- Volume 2 Wastewater use in agriculture
- Volume 3 Wastewater and excreta use in aquaculture
- Volume 4 Excreta and greywater use in agriculture
- Volume 5 Sampling and laboratory aspects

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WHO Guidelines on sanitation

- Protection of human health
- Advisory to national standard setting – flexible to account local social, cultural, economic and 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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WHO Guidelines – Safe use of wastewater, excreta and greywater (2006)

Guidelines provide an *integrated preventive management framework* for maximizing public health and environmental benefits of waste use.

Health components:

- Defines a level of health protection that is expressed as a health-based target for each hazard
- 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
- Confirmation by independent surveillance

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Assessment of health risks

- Microbial analysis
  - Indicators not always reliable
- Epidemiological studies
  - Scarce, complex
- Microbial risk assessment
  - The main approach

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Health-based targets

- Standard metric of disease
  - Eg. disability adjusted life years (DALYs)
- Appropriate health outcome
  - Eg. prevention of exposure

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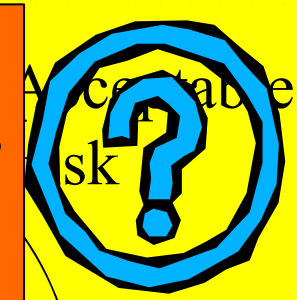
Approaches – Evidence based or Predictive – Based on WHO Stockholm Framework

Manage SANITATION

Can we manage the risks?



ASSESSMENT

EXPOSURE

Keypoints and audits

HEALTH OUTCOME

AGEMENT

1. **Mea**
(requi

stem effectiveness

alytical verifications
(process, public health)

Microbial Risk Analysis

- Risk Assessment
  - Qualitative or quantitative
  - Systematic procedure
  - Acceptable risks
- Risk Management
  - To handle the risks
  - Aims at reducing risks
- Risk Communication
  - Essential part in all systems
  - Necessary for awareness raising and health protection
  - Involve ”all” stakeholders

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Microbial Risk Assessment

- Hazard Identification
  - All enteric 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
  - Exposure scenarios evaluated (ingestion, volumes)
- Dose-response assessment
  - Published mathematical models
- Risk characterisation
  - Risk of infection per exposure and yearly.
  - Comparison with endemic level of disease (underreporting)

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Hazards - excreta

- Urine
  - Few diseses transmitted
    - Salmonella, Schistosoma, Leptospira
  - Faecal cross contamination
- Faeces
  - Local incidence, endemic disease
  - Examples:
    - In SA 55% of households Giardia
    - Enteric parasites in El Salvador
    - Northern Europe (Sweden) viruses greatest concern
- Greywater
  - Faecal contamination (diapers, shower etc.)
  - Foodstuffs (eg. bacteria)

L. F. Corrales *et al.* **Sanitation design and enteric parasitosis**

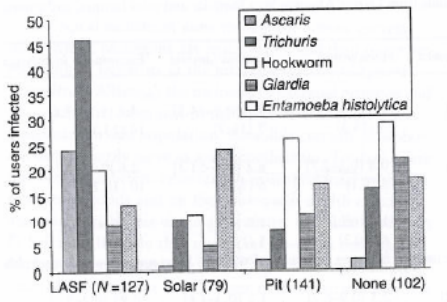

Figure 2 Prevalence of parasitic infection by latrine type.

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WHO Guidelines - Microbial Risk Assessment

- Focus on whole chain from collection to consumption of food products
- Quantitative risk based on acceptable risk of 10^{-6} DALYs pppy (per person per year)
- Calculations based on
  - Rotavirus concentration in wastewater
  - Assumptions on ingested volumes (lettuce crop)
- Gives reduction needed by treatment and other measures
- Collected faeces not diluted
  - Higher reduction needed

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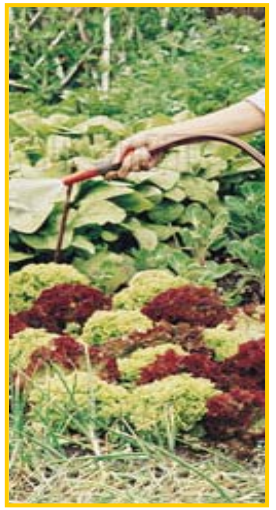
Health protection measures

- Reduce health risks for food consumers
  - Excreta and greywater treatment
  - Crop restrictions
  - Application procedures and withholding periods
  - Hygienic food handling, preparation and cooking
  - Health and hygiene promotion



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Health protection measures

- Reduce health risks for workers and their families
  - Use of personal protective equipment
  - Access to safe drinking water and sanitation facilities at farms
  - Health and hygiene promotion
  - Disease vector and intermediate host control

- Reduce health risks for local communities
  - Limited contact during handling and controlled access to fields
  - As above (consumers and families)

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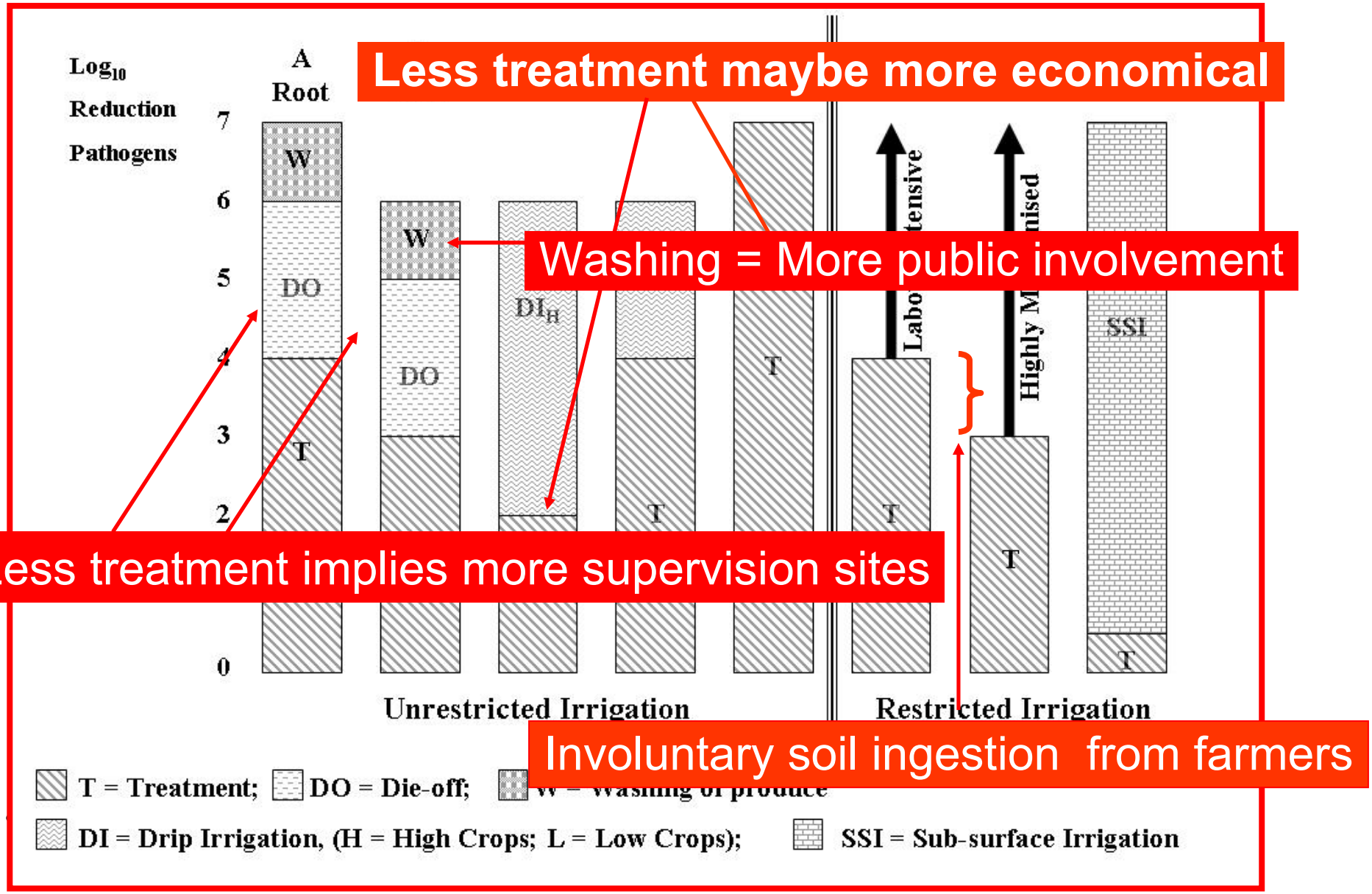
Pathogen reductions (log units) achieved by health-protection measures

Control measure	Pathogen reduction (log units)	Notes
Wastewater treatment	1–6	The required pathogen removal to be achieved by wastewater treatment depends on the combination of health-protection control measures selected
Localized irrigation (low-growing crops)	2	Root crops and crops such as lettuce that grow just above, but partially in contact with, the soil.
Localized irrigation (high-growing crops)	4	Crops, such as tomatoes, the harvested parts of which are not in contact with the soil.
Spray/sprinkler drift control	1	Use of micro-sprinklers, anemometer-controlled direction-switching sprinklers, inward-throwing sprinklers, etc.
Spray/sprinkler buffer zone	1	Protection of residents near spray or sprinkler irrigation. The buffer zone should be at 50−100 m.
Pathogen die-off	0.5–2 per day	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.
Produce washing with water	1	Washing salad crops, vegetables and fruit with clean water.
Produce disinfection	2	Washing salad crops, vegetables and fruit with a weak disinfectant solution and rinsing with clean water.
Produce peeling	2	Fruit, root crops.
Produce cooking	5–6	Immersion in boiling or close-to-boiling water until the food is cooked ensures pathogen destruction.

Examples options for the reduction of viral, bacterial and protozoan pathogens that achieved a health based target of ≤10-6DALYS pppy



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 hospitilised)

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

Treatment as a health protection measure

- The most important barrier?
- Handling (contact) of excreta should be minimized, but necessary to some extent
- What is practically, socially and culturally acceptable?
  - Adapted to local conditions, education and information, sustainability
- Treatment recommendations important part of the guidelines
- Will develop, on-going research

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Treatment of excreta - Guidelines

- Urine
  - Storage (time and temperature)
  - Combined with crop restrictions
  - Direct use on houshold level
  - 1 month withholding time (fertilization – harvest)
- Faeces (in toilet and off-site/secondary treatment)
  - Storage* (years; in practice often applied)
  - Alkaline treatment* (>pH 9, >6 months)
  - Composting (>50°C, >1 week)
  - Not to use on crops that are to be consumed raw!
- Faecal sludge and Greywater
  - Examples given but not specified (options listed)

*Depending on temperature and/or moisture

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Recommendations for the use of human urine – large systems

Storage temperature	Storage time	Pathogens in the urine*	Recommended crops
4°C	>1 month	viruses, protozoa	food and fodder crops that are to be processed
4°C	>6 months	viruses	food crops that are to be processed, fodder crops
20°C	>1 month	viruses	food crops that are to be processed, fodder crops
20°C	>6 months	probably none	all crops

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

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

Faecal sludge management - Critical control points

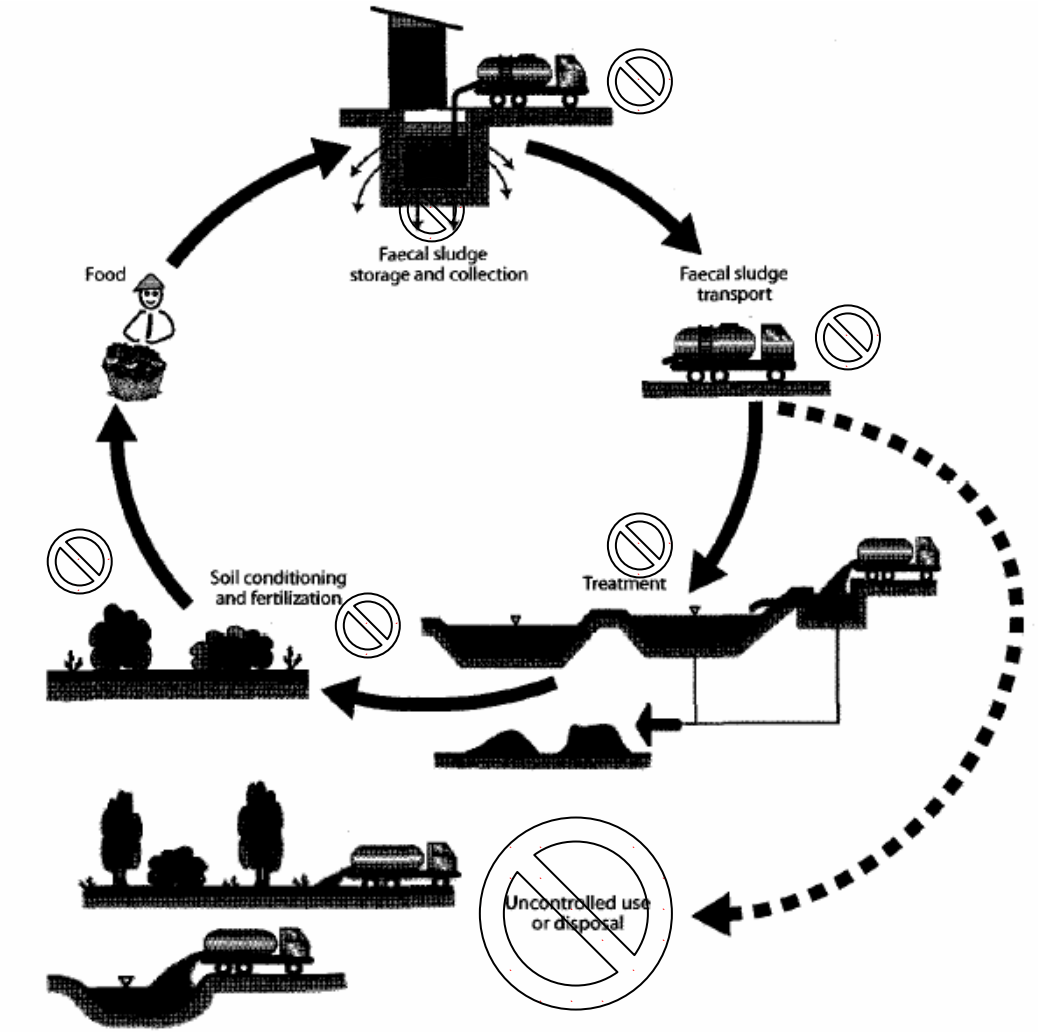
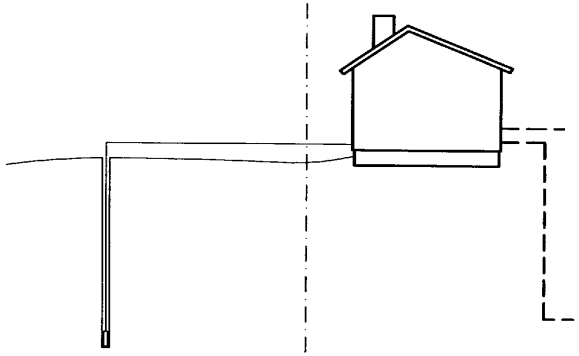


Figure 5.1
Critical control points in preventing enteric disease transmission in faecal sludge management

Greywater

Water supply

Greywater treatment options



Pretreatment

Secondary treatment

Drip irrigation

Soil Infiltration

Mound

Constructed wetland

Sand-/gravelfilter

Trickling filter

Garden irrigation

Reuse

Definition of monitoring functions

Function	**Definition**
Validation	Testing the system or components thereof to ensure if it is meeting eg. ”microbial reduction targets”. Mainly relates to new systems/components.
Operational monitoring	Relates to ”design specifications” eg. temperature. Indicate proper functions and variations and is the base for ”direct corrective actions”
Verification	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).

Guideline values

- Verification monitoring
- Greywater, faecal sludge and (dry) faeces
  - Harmonised with wastewater use in agriculture (volume 2)
- Mainly applicable in larger systems
- *E. coli* – caution due to growth
- Helminth eggs – where applicable
- Sampling and laboratory procedures

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Table 4.2 Guideline values for verification monitoring in large-scale treatment systems of greywater, excreta and faecal sludge for use in agriculture

	Helminth eggs (number per gram total solids or per litre)	*E. coli* (number per 100 ml)
Treated faeces and faecal sludge	<1/g total solids	<1000/g total solids
Greywater for use in:		
• Restricted irrigation	<1/litre	$<10^{5}$ [a] Relaxed to $<10^{6}$ when exposure is limited or regrowth is likely
• Unrestricted irrigation of crops eaten raw	<1/litre	$<10^{3}$ Relaxed to $<10^{4}$ for high-growing leaf crops or drip irrigation

[a] These values are acceptable due to the high regrowth potential of *E. coli* and other faecal coliforms in greywater.

Tentative performance targets for viable helminths eggs in faecal matter and faecal sludges

- Starting point:

  wastewater performance target for unrestricted irrigation ≤ 1 egg /l

- Yearly helminths load from irrigation (using an average of e.g. 500 mm/year):

  ≤ 500 helminths eggs/m²

- Application of faecal matter in same quantities as in good agricultural practice of manure application:

  10 t manure/ha*year at 25 % TS

  = 250 g TS/m²*year

  ⇨ $[\text{helminths eggs}]_{\text{tolerable}} \leq 500/250 = 2$ helminths eggs/g TS

- (with 1000 mm/year ⇨ 4 helminths eggs/g TS)

Assessment and implementation

- Assemble a suitable team for an assessment
  - Identify and select essential players, institutional framework?
- Establish an implementation procedure
  - Compliance, monitoring at the local scale, maintenance?
  - Likelihood of sustainability of the installation and system?

- Questions
  - 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?

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Have interventions a positive impact on human health? WHO Guidelines - Aims for the future

- The guidelines a starting point for:
  - Country-based system studies including risk/epidemiological 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)
- Also expect more epidemiological studies as input

What do you choose?
What are the relative risks?

http://www.who.int/water _sanitation_health/

CD-ROM 'electronic library' (from 5th edition)

Hard copy from WHO, bookshops

Tack! Thank you! Obrigado! Gracias!

Greetings from Sweden (Senegal)

Thor Axel

…and Stockholm