Health Protection Measures:
WHO Guidelines Application Tools

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Regional Workshop on Health Aspects of Wastewater Reuse in Agriculture
WHO/CEHA- Amman, 30 October-2 November 2006
WHO Guidelines are Built on...

- The **Assessment And Management of health risks** associated with wastewater use **through** the application of various **health protection measures** during all steps of wastewater use and until it reach the consumer.
WHAT are the **Health Risks and Hazards**??

- **Infectious Diseases** due to contact with the Microbial hazards:
  - **Heminthes**: Eggs of *Ascaris*, hookworms and *Clonorchis* eggs
  - **Bacteria**: *E. coli*, *Salmonella*, *Shigella*, *Vibrio* and *Helicobacter*, (Hepatitis A, Rotavirus, Norwalk virus)
  - **Protozoa**: *Cryptosporidium*, *Cyclospora*, *Giardia*, *Amoeba cyst*
  - **Viral**: Hepatitis and etc.,

- **Skin diseases** due to contact with skin irritants hazards

- **Diseases due to hazards of Vector Borne Pathogens**

- **Diseases due to contact with Toxic Chemicals**: Heavy Metals (Arsenic, Cadmium, Lead, Mercury, Nickel) and organic compounds
Routes of Transmission/Exposure to Pathogens or Contaminants??

- **Human contact** with wastewater or contaminated crops
- **Inhalation**
- **Consumption of contaminated wastewater–irrigated products**
- **Consumption of drinking water contaminated due to wastewater use activities**
- **Consumption of animals or animal products contaminated due to wastewater exposure**
- **Vector borne disease transmission resulting from the development and management of wastewater irrigation schemes**
Exposure & Burden of Disease

People at risk:
- Farm workers and their families
- Nearby communities
- Consumers

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HOW WHO Guidelines Protect People at Risk?

- **Based on HEALTH Based Target** of $10^{-6}$ DALYS that provide the margin of health protection needed (Safe as drinking water and less than world diarrhea incidence of $10^{-1}$, for community to lose 1 year per million people).

- Health based target can be reached when:

  all protection measures result in pathogens reduction 6-7 log units.

Viral reduction of 6-7 Log units, is applicable by default to bacterial and protozoal pathogens

**In addition** to Helminthes eggs reduction to achieve $< 1$ egg/l (excluding the case with high growing crops using drip irrigation and when Children are involved to increase protection measures by Antiheminthic chemotherapy)
Health Protection Measures

1- Crop restriction
2- Wastewater application techniques
3- Pathogen die-off before consumption
4- Food preparation measures (washing, disinfecting, peeling and cooking)
5- Human exposure control
6- Wastewater treatment

WHIO guidelines criteria defines the total removal/inactivation efficiency needed to be achieved. How to reach it is a national decision that allows economical costs optimization!!
Crop Restriction

Produce restriction: growing plants that either are not eaten directly by humans or are always processed before consumption.

- **Crop restriction provide 4-5 log pathogen reduction**
- DALYs of $10^{-6}$ can be achieved when crop restriction is practiced by only 2-3 log pathogen reduction compared to 6-7 when is not practiced (unrestricted)

**Crop restriction is feasible** when:
- A law abiding society or good enforcement exist
- A public body control water allocation and crop restriction
- Strong farm management is practiced
- Market demand for restricted crops and crops produce reasonable profit
- Little demand for excluded crops

The first measure to be used when wastewater is used raw for irrigation of crops
Wastewater Application Techniques

- Application techniques that reduce exposure of workers and contamination of products or
- Allowing a period between wastewater application and harvest to allow pathogen die-off

**Application techniques:**
- Flood and furrow irrigation: require field workers, crop handlers and consumers protection
- Localized (drip) irrigation: provide a 2 log pathogen reduction
- Spray and Sprinkle irrigation: Drift control 1 log pathogen reduction and A Buffer zone of 100 m provide 1 log pathogen reduction
Pathogen Die-off

- The interval between final irrigation and consumption reduces pathogens by approximately 1 log unit per day.

- The precise value depend on climatic conditions with more reduction under hot and dry conditions (log 2 in hot versus 0.5 in wet and cool conditions)

- Helminthes eggs however can remain viable on crop surfaces for up to two months, although few survive beyond approximately 30 days
Food Preparation Measures

- Produce washing/disinfection/cooking to reduce contamination and potential exposure to pathogens

- Vigorous washing of vegetables eaten uncooked reduce around 1 log unit for smooth surfaces around 2 log
- Disinfecting vegetables and rinsing reduce 1-2 log, with detergent reduce helminthes egg numbers by 1-2 log
- Peeling reduce 2 log units
- Cooking reduce 6-7 log units

- Protection involves more public involvement. Hygiene education programs are required to inform local food handlers how they should wash wastewater irrigated produce effectively with water or disinfectant /Detergent solutions.
Objective: to remove pathogens and toxic chemicals to levels that do not exceed tolerable risks or that can be combined with other measures to achieve health based targets.

Treatment systems:
1- Low rate biological processes: Pond system with long retention time:
   - Wastewater stabilization ponds
   - Wastewater storage & treatment reservoirs
   - Constructed wetlands

2- High rate biological processes: Engineered systems with short retention times
   - Primary treatment
   - Chemically enhanced primary treatment
   - Up-flow anaerobic sludge blanket reactors
   - Secondary treatment
   - Tertiary treatment

• Less Treatment implies more supervision on farm sites
## Treatment Efficiency

<table>
<thead>
<tr>
<th>Treatment process</th>
<th>Log unit pathogen removals*</th>
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<tbody>
<tr>
<td></td>
<td>Viruses</td>
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<tr>
<td><strong>Low-rate biological processes</strong></td>
<td></td>
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<tr>
<td>Waste stabilization ponds</td>
<td>1–4</td>
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<tr>
<td>Wastewater storage and treatment reservoirs</td>
<td>1–4</td>
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<tr>
<td>Constructed wetlands</td>
<td>1–2</td>
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<tr>
<td><strong>High-rate processes</strong></td>
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<tr>
<td><strong>Primary treatment</strong></td>
<td></td>
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<tr>
<td>Primary sedimentation</td>
<td>0–1</td>
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<tr>
<td>Chemically enhanced primary treatment</td>
<td>1–2</td>
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<td>Anaerobic upflow sludge blanket reactors</td>
<td>0–1</td>
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<tr>
<td><strong>Secondary treatment</strong></td>
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<tr>
<td>Activated sludge + secondary sedimentation</td>
<td>0–2</td>
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<tr>
<td>Trickling filters + secondary sedimentation</td>
<td>0–2</td>
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<tr>
<td>Aerated lagoon + settling pond</td>
<td>1–2</td>
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<tr>
<td><strong>Tertiary treatment</strong></td>
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<tr>
<td>Coagulation/flocculation</td>
<td>1–3</td>
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<tr>
<td>High-rate granular or slow-rate sand filtration</td>
<td>1–3</td>
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<tr>
<td>Dual-media filtration</td>
<td>1–3</td>
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<tr>
<td>Membranes</td>
<td>2.5–6</td>
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<tr>
<td><strong>Disinfection</strong></td>
<td></td>
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<tr>
<td>Chlorination (free chlorine)</td>
<td>1–3</td>
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<tr>
<td>Ozonation</td>
<td>3–6</td>
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<tr>
<td>Ultraviolet radiation</td>
<td>1–&lt;3</td>
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</tbody>
</table>

**Sources:** Feachem et al. (1983); Schwartzbrod et al. (1989); Sobsey (1989); El-Gohary et al. (1993); Rivera et al. (1995); Rose et al. (1996, 1997); Strauss (1996); Landa, Capella & Jiménez (1997); Clancy et al. (1998); National Research Council (1998); Yates & Gerba (1998); Karimi, Vickers & Harasick (1999); Lazarova et al. (2000); Jiménez et al. (2001); Jiménez & Chávez (2002); Jiménez (2003, 2005); von Spierling et al. (2003); Mara (2004); Rojas-Valencia et al. (2004); WHO (2004a); NRM MMC & EPHCA (2005).

*The log unit reductions are log<sub>10</sub> (initial pathogen concentration/final pathogen concentration). Thus, a 1 log unit reduction = 99% reduction; a 2 log unit reduction = 99% reduction; a 3 log unit reduction = 99.9% reduction; and so on.

<sup>b</sup>Data from full-scale plants.
<sup>c</sup>Theoretical efficiency based on removal mechanisms.
<sup>d</sup>Data from tests with up to 2 log units initial content; removal may be greater than that reported.
Ranges for Pathogen Reduction by Various Health Protection Measures

- Treatment: 1-6 Log units
- Localized drip irrigation (Low growing crops, (LGC)): 2 log units
- Localized drip irrigation (high growing crops, (HGC)): 4 log units
- Spray irrigation: 1 log units
- Spray buffer zone: 1 log units
- Pathogen die off: 0.5-2.0 log units/day
- Produce Washing: 1 log units
- Produce peeling: 2 log units
- Produce cooking: 6-7 log units
- Produce disinfecting: 2 log units
Combination of different health protection measures to achieve the health based target of $10^{-6}$ DALY’s per person per year

Source: WHO guidelines for safe use of wastewater, excreta and grey water, 2006
Options for Health Protection Measures

The option for choosing health protection measures depend on several factors:

- Availability of resources
- Existing agricultural practices
- Market demand
- Existing pattern of excreta related diseases
- Institutional capacities for monitoring, surveillance and enforcement of regulation related to protection measures
Wastewater Use in Agriculture should start by planning....

- Health impact assessment: identify hazards and health risks related to wastewater reuse practices and then assess risks and identify key points for choosing protection measures.
Go through Application ..... 

- Identification & Documentation of Health protection measures (Wastewater use Safety plans)

- Application of Health protection measures
Backed with Monitoring And Surveillance & Enforcement of Regulations

- Wastewater
- Produce
- Management practices (Health Protection measures)
- Health aspects
Wastewater use in Agriculture Should **End with**

- Assessment and Continuous improvement
- To Sustain and Ensure **Safe Use of Wastewater Use** in Agriculture

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THANK YOU!