Global Survivability Studies Seminar
Unsafe Water, Sanitation Systems and Health

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- Need of sanitation
- Linkages between water and health
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- Impacts of sanitation
- Types of sanitation systems
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Introduction

• Good quality of drinking water important for health
• Poor drinking water quality causes diseases
  • cancer, blue baby syndrome, diarrhea, dysentery, typhoid, hepatitis, polio, skin diseases etc.
• WHO (2012)
  • 1.1 billion people with no access to water supply
  • 2.5 billion people with no access to improved sanitation
• 2 million people die each year due to diarrhea
  • mostly children less than 5 years
Need of sanitation

• Six children/minute die from disease caused by unsafe water and inadequate sanitation
• Most of them die (3000/day) from diarrhea that debilitates and makes them vulnerable to other diseases
• In Africa – 115 people die/hour from diseases, hygiene or dirty water linked to poor sanitation
• Access to latrine increases school attendance rate
Need of sanitation

- 89% (6.1 billion) of world’s population improved access to drinking water (WHO 2012) – MDG target 88%
- 11% (783 million) of the world’s population lack access to safe drinking water
- 5-6 million people/year die from water-borne diseases and air pollution in developing countries
- >5 million people/year die from diseases caused by unsafe drinking water, lack of sanitation, and insufficient water for hygiene
- 1.1 billion people – open defecation
- At any given time, patients suffering from waterborne diseases occupy 50% of the world’s hospital beds
  - In some developing countries, the figure reaches 80%
Need of sanitation

Among the main reasons responsible for this situation are:

• Lack of priority given to the sector
• Lack of financial resources
• Lack of sustainability of water supply and sanitation services
• Poor hygiene behaviours
• Inadequate sanitation in public places including hospitals, health centers and schools

WE NEED SANITATION
Linkage between water and health

• Water is important to the mechanics of the human body
  • Makes more than two thirds of the weight of the human body, and without it, humans would die in a few days. Human brain made up of 95% water, blood 82% and lungs 90%
  • A mere 2% drop in our body's water supply can trigger signs of dehydration (Are you having trouble reading this? Drink up!)

• Plays a key role in the prevention of disease
  • Many diseases are associated with insufficient and poor-quality water and inadequate provision of water for the disposal of waste water
Water...

- Moistens tissues such as those in the mouth, eyes and nose.
- Protects body organs and tissues.
- Helps prevent constipation.
- Helps dissolve minerals and other nutrients to make them accessible to the body.
- Regulates body temperature.
- Lubricates joints.
- Lessens the burden on the kidneys and liver by flushing out waste products.
- Carries nutrients and oxygen to cells.

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Perspectives on water and health

- **Ethiopia, Tigray**: micro dams caused a seven-fold intensification of malaria transmission intensity.
- **Senegal, Richard Toll**: irrigated rice and sugar cane schemes caused the intestinal schistosomiasis prevalence rate to explode from 0 to 90%.
- **Sri Lanka, Mahaweli System**: Japanese encephalitis outbreaks due to irrigation extension combined with pig rearing.
Communicable diseases associated with water

- Most of the agents that contaminate water and the food chain are biological and originate from:
  - Animal/human excreta
  - Bacteria, viruses, protozoa and parasite are introduced into the human system by ingestion
Transmission pathways of fecal-oral diseases

Pathogen source
- Human excreta
- Animal excreta

Medium
- Dry sanitation involving reuse
- Hands
- Water-borne sewage
- Non-recycling latrines

Environment
- Flies
- Soil
- Surface water
- Groundwater

Interface
- Food
- Drinking water

Humans
<table>
<thead>
<tr>
<th>Service level</th>
<th>Distance/time measure</th>
<th>Likely quantity collected</th>
<th>Level of health concern</th>
</tr>
</thead>
<tbody>
<tr>
<td>No access</td>
<td>&gt; 1000m or 30 minutes collection time</td>
<td>Very low &lt; 5 l/c/d</td>
<td>Very high</td>
</tr>
<tr>
<td>Basic access</td>
<td>Between 100 and 1000m 5-30 minutes</td>
<td>Low &lt;20 l/c/d</td>
<td>Medium</td>
</tr>
<tr>
<td>Intermediate access</td>
<td>On-plot Single tap in house or yard</td>
<td>Medium Around 50 l/c/d</td>
<td>Low</td>
</tr>
<tr>
<td>Optimal access</td>
<td>Water is piped into the home through multiple taps</td>
<td>Varies significantly &gt;100 l/c/d and &lt;300 l/c/d</td>
<td>Very low</td>
</tr>
</tbody>
</table>
WHO classification of diseases associated with water

- According to the nature of pathogen (include harmful bacteria, viruses, protozoa and other biological organisms)
  - Water-borne
  - Water-washed
  - Water-based
  - Water-related
Water-borne diseases

- Arise from the contamination of water by human/animal faeces or urine infected by viruses or bacteria (cholera and typhoid)
Water-borne diseases - control

- Improve quality of drinking water
- Improve hygiene practice
- Prevent casual uses of unprotected sources

A girl in Java, Indonesia, enjoying her new school toilet. Photo: UNICEF
Water-washed Diseases

- Stem from scarcity and inaccessibility of water
- Related to personal cleanliness
  - contagious skin and eye infections
  - infestation of lice or mite

Women carry plastic jerrycans after collecting water from a dried lake in Gunung Kidul, central Java, Indonesia. Some parts in the densely populated island have been hit by drought in 2008, forcing villagers to walk miles to find drinking water. Photo: AP
Water-washed diseases

- Example: scabies and trachoma
  - annually, some 6 million people become blind as a result of trachoma, and another 150 million people need treatment

- Control:
  - Increase water quantity used
  - Improve accessibility and reliability of domestic water supply
  - Improve hygiene practices
Water-based diseases

- Involve organisms which, during their life cycle, have intermediate hosts (snails, other aquatic animals) that live in water.
- Passed onto humans when the aquatic host is ingested or comes into contact with skin.
  - Example: guinea worm infection, schistosomiasis, lung fluke infection.
Schistosomiasis Life Cycle

260 million people infected. 76 countries – most in Africa

Fig. 298-1. Life cycle of schistosomiasis.
Water-based disease - control

- Proper excreta disposal facilities
- Reduce need for contact with infected water
- Control snail population
- Reduce contamination of surface water
Water-related diseases

- Vectors proliferating in water ecologies related to dams, irrigation schemes and other water resources projects (mosquitoes breed in water)
- Pathogen is spread by insects that feed or breed in water (flies and mosquitoes)
- Examples
  - Malaria
  - Filariasis and viral infection
  - Dengue
  - Yellow fever
  - Japanese encephalitis
Water-related diseases

- Malaria - 300 million infections and kills more than 2 million people a year (more than half of them children under the age of five)

- Dengue - unreliability of rural water supplies in parts of India stimulated people to store water in their houses to bridge periods when the supply ran dry
  - resulted in dengue outbreaks, because the stored water provided breeding places for Aedes mosquitoes
Water-related diseases - control

- Improve surface water management
- Destroy breeding sites of insects
- Reduce need to visit breeding sites
- Use mosquito netting

Indonesia - transmission of malaria drastically reduced when farmers synchronized their rice-production system to allow rice paddies to dry out completely during certain periods.

Sri Lanka - breeding of malaria mosquitoes suppressed in small rivers and irrigation canals by regularly flushing them out.
Water-related disease - Filariasis

http://www.pon.nic.in/fil-free/images/p8.jpg


http://www.cartercenter.org/images/richardsnigeria.jpg


http://www.stanford.edu/class/humbio103/ParaSites2006/Lymphatic_filariasis/Images/elephantiasis_2.GIF
RIVER BLINDNESS

Onchocerciasis, also known as river blindness, is a parasitic disease caused by tiny worms or “microfilariae” and transmitted by flies. The disease affects an estimated 18 million people worldwide.

THE DISEASE CYCLE

1. **Parasitized**
   - The insect takes a blood meal from a human. A pool of blood is pumped up into the fly, saliva passes into the pool, and infective Onchocerca larvae pass from the fly into the host’s skin.

2. **Infection**
   - The larvae enter the host’s skin tissue, where they migrate and form nodules, and slowly mature into adult worms.

3. **Proliferation**
   - New worms form new nodules or find existing nodules and cluster together. Smaller male worms migrate between nodules to mate.

4. **Reproduction**
   - After mating, eggs form inside the female worm and develop into microfilariae. A female may produce 1,000 microfilariae per day.

5. **Transport**
   - When the infected host is bitten by another fly, microfilariae are transferred from the host to the fly.

DISEASE SYMPTOMS

- **Eye lesions**
  - If microfilariae migrate to the eye, they can cause severe lesions and in some cases blindness.

- **Skin lesions**
  - Many thousands of microfilariae migrate in the upper layers of the skin. When the microfilariae die, they cause skin rashes, lesions, intense itching and skin depigmentation.

Sources: World Health Organization, Centers for Disease Control; Map: The Carter Center

Carter Center-Assisted Onchocerciasis Control Programs

Highlighted areas in Africa represent areas where The Carter Center is actively working. The highlighted areas in Latin America represent the 13 remaining foci.
African Sleeping Sickness (Trypanosoma brucei)

http://www.sgpp.org/images/brucei_pics.gif
<table>
<thead>
<tr>
<th>Transmission Route</th>
<th>Preventive Strategies</th>
</tr>
</thead>
</table>
| Water-borne                        | ▪ Improve quality of drinking water  
▪ Prevent casual use of unprotected water                                       |
| Water-washed (or water-scarce)     | ▪ Increase water quantity used  
▪ Improve accessibility and reliability of domestic water supply  
▪ Improve hygiene                                                                 |
| Water-based                        | ▪ Reduce need for contact with infected water  
▪ Control snail populations  
▪ Reduce contamination of surface waters                                          |
| Water-related insect vector        | ▪ Improve surface water management  
▪ Destroy breeding sites of insects  
▪ Reduce need to visit breeding sites  
▪ Use mosquito netting                                                            |
## Classification of water-related infections

<table>
<thead>
<tr>
<th>Category</th>
<th>Infection</th>
<th>Pathogenic agent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fecal-oral (water borne or water washed)</td>
<td>Diarrhea and dysenteries</td>
<td>Protozoa</td>
</tr>
<tr>
<td></td>
<td>Amoebic dysentery</td>
<td>Bacteria</td>
</tr>
<tr>
<td></td>
<td><em>Campylobacter</em> enteritis</td>
<td>Bacteria</td>
</tr>
<tr>
<td></td>
<td>Cholera</td>
<td>Bacteria</td>
</tr>
<tr>
<td></td>
<td><em>E. coli</em> diarrhea</td>
<td>Bacteria</td>
</tr>
<tr>
<td></td>
<td>Enteric fevers</td>
<td>Bacteria</td>
</tr>
<tr>
<td></td>
<td>Typhoid</td>
<td>Bacteria</td>
</tr>
<tr>
<td></td>
<td>Paratyphoid</td>
<td>Bacteria</td>
</tr>
<tr>
<td></td>
<td>Poliomyelitis</td>
<td>Virus</td>
</tr>
<tr>
<td></td>
<td>Hepatitis A</td>
<td>Virus</td>
</tr>
<tr>
<td></td>
<td>Leptospirosis</td>
<td>Spirochaete</td>
</tr>
<tr>
<td></td>
<td>Ascariasis</td>
<td>Helminth</td>
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</table>
## Classification of water-related infections

<table>
<thead>
<tr>
<th>Category</th>
<th>Infection</th>
<th>Pathogenic agent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water-washed:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(a) Skin and eye infections</td>
<td>Infectious skin disease</td>
<td>Miscellaneous</td>
</tr>
<tr>
<td></td>
<td>Infectious eye disease</td>
<td>Miscellaneous</td>
</tr>
<tr>
<td>(b) Others</td>
<td>Louse-borne typhus</td>
<td>Rickettsia</td>
</tr>
<tr>
<td></td>
<td>Louse-borne relapsing fever</td>
<td>Spirochete</td>
</tr>
<tr>
<td>Water-based:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(a) Penetrating skin</td>
<td>Schistosomiasis</td>
<td>Helminth</td>
</tr>
<tr>
<td>(b) Ingested</td>
<td>Guinea worm</td>
<td>Helminth</td>
</tr>
<tr>
<td></td>
<td>Clonorchiasis</td>
<td>Helminth</td>
</tr>
<tr>
<td></td>
<td>Fasciolopsiasis</td>
<td>Helminth</td>
</tr>
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</table>
# Classification of water-related infections

<table>
<thead>
<tr>
<th>Category</th>
<th>Infection</th>
<th>Pathogenic agent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water-related insect vector:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(a) Biting near water</td>
<td>Trypanosomiasis (Sleeping sickness)</td>
<td>Protozoa</td>
</tr>
<tr>
<td>(b) Breeding near water</td>
<td>Filariasis</td>
<td>Helminth</td>
</tr>
<tr>
<td></td>
<td>Malaria</td>
<td>Protozoa</td>
</tr>
<tr>
<td></td>
<td>Onchocerciasis (River blindness)</td>
<td>Helminth</td>
</tr>
<tr>
<td></td>
<td>Mosquito-borne viruses</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Yellow fever</td>
<td>Virus</td>
</tr>
<tr>
<td></td>
<td>Dengue</td>
<td>Virus</td>
</tr>
<tr>
<td></td>
<td>Others</td>
<td>Virus</td>
</tr>
</tbody>
</table>
According to WHO, the overall burden of disease is assessed using the disability-adjusted life year (DALY), a time-based measure that combines years of life lost due to premature mortality and years of life lost due to time lived in states of less than full health.
## Death by age, gender, region (2002)

<table>
<thead>
<tr>
<th>Cause</th>
<th>Total number of deaths (thousands)</th>
<th>0–4 years (%)</th>
<th>Gender Male (%)</th>
<th>Female (%)</th>
<th>AFR (%)</th>
<th>SEAR (%)</th>
<th>WPR (%)</th>
<th>EMR (%)</th>
<th>AMR (%)</th>
<th>EUR (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>All causes</td>
<td>57,029</td>
<td>18</td>
<td>52</td>
<td>48</td>
<td>19</td>
<td>26</td>
<td>21</td>
<td>7</td>
<td>10</td>
<td>17</td>
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<tr>
<td>Diarrhoeal disease</td>
<td>5,798</td>
<td>90</td>
<td>52</td>
<td>48</td>
<td>39</td>
<td>34</td>
<td>9</td>
<td>14</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Malaria</td>
<td>1,272</td>
<td>90</td>
<td>48</td>
<td>52</td>
<td>89</td>
<td>5</td>
<td>1</td>
<td>5</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Schistosomiasis</td>
<td>15</td>
<td>0</td>
<td>65</td>
<td>35</td>
<td>8</td>
<td>2</td>
<td>23</td>
<td>61</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>Lymphatic filariasis(^2)</td>
<td>0</td>
<td>n/a(^3)</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Onchocerciasis</td>
<td>0</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Dengue</td>
<td>19</td>
<td>22</td>
<td>45</td>
<td>55</td>
<td>1</td>
<td>63</td>
<td>20</td>
<td>5</td>
<td>11</td>
<td>0</td>
</tr>
<tr>
<td>Japanese encephalitis</td>
<td>14</td>
<td>36</td>
<td>49</td>
<td>51</td>
<td>0</td>
<td>61</td>
<td>21</td>
<td>17</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Trachoma</td>
<td>0</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Intestinal nematode infections</td>
<td>12</td>
<td>23</td>
<td>50</td>
<td>50</td>
<td>32</td>
<td>36</td>
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<tr>
<td>Protein-energy malnutrition(^4)</td>
<td>260</td>
<td>57</td>
<td>50</td>
<td>50</td>
<td>40</td>
<td>26</td>
<td>5</td>
<td>10</td>
<td>16</td>
<td>2</td>
</tr>
<tr>
<td>Drowning(^5)</td>
<td>382</td>
<td>15</td>
<td>69</td>
<td>31</td>
<td>17</td>
<td>26</td>
<td>35</td>
<td>7</td>
<td>6</td>
<td>10</td>
</tr>
</tbody>
</table>

**AFR:** Africa south of the Sahara  
**SEAR:** South-East Asia (includes India)  
**WPR:** Western Pacific (includes China)  
**EMR:** Eastern Mediterranean (includes Sudan, Afghanistan, Pakistan)  
**AMR:** the Americans  
**EUR:** Europe (includes Central Asian Republic)

(Source: WWDR 2, 2006)
# DALY by age, gender, region (2002)

<table>
<thead>
<tr>
<th>Cause</th>
<th>Total DALY (thousands)</th>
<th>0–4 years (%)</th>
<th>Gender</th>
<th>Gender</th>
<th>AFR (%)</th>
<th>SEAR (%)</th>
<th>Region¹</th>
<th>WPR (%)</th>
<th>EMR (%)</th>
<th>AMR (%)</th>
<th>EUR (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>All causes</td>
<td>1,490,126</td>
<td>29</td>
<td>52</td>
<td>48</td>
<td>24</td>
<td>29</td>
<td>18</td>
<td>9</td>
<td>10</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Diarrhoeal disease</td>
<td>61,966</td>
<td>91</td>
<td>52</td>
<td>48</td>
<td>38</td>
<td>33</td>
<td>11</td>
<td>14</td>
<td>4</td>
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<tr>
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<td>46,486</td>
<td>91</td>
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<td>52</td>
<td>88</td>
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<td>2</td>
<td>5</td>
<td>0</td>
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<tr>
<td>Schistosomiasis</td>
<td>1,702</td>
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<td>60</td>
<td>40</td>
<td>78</td>
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<td>3</td>
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<tr>
<td>Lymphatic filariasis²</td>
<td>5,777</td>
<td>4</td>
<td>76</td>
<td>24</td>
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<td>7</td>
<td>2</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Onchocerciasis</td>
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<td>4</td>
<td>58</td>
<td>42</td>
<td>97</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Dengue</td>
<td>616</td>
<td>23</td>
<td>45</td>
<td>55</td>
<td>1</td>
<td>62</td>
<td>21</td>
<td>5</td>
<td>11</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Japanese encephalitis</td>
<td>709</td>
<td>37</td>
<td>48</td>
<td>52</td>
<td>0</td>
<td>43</td>
<td>45</td>
<td>12</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Trachoma</td>
<td>2,329</td>
<td>0</td>
<td>26</td>
<td>74</td>
<td>52</td>
<td>7</td>
<td>17</td>
<td>16</td>
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<tr>
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<td>50</td>
<td>39</td>
<td>27</td>
<td>21</td>
<td>8</td>
<td>6</td>
<td>0</td>
<td></td>
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<tr>
<td>Protein-energy malnutrition⁴</td>
<td>16,910</td>
<td>88</td>
<td>51</td>
<td>49</td>
<td>34</td>
<td>36</td>
<td>13</td>
<td>12</td>
<td>6</td>
<td>1</td>
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<tr>
<td>Drowning⁵</td>
<td>10,840</td>
<td>19</td>
<td>69</td>
<td>31</td>
<td>18</td>
<td>25</td>
<td>35</td>
<td>7</td>
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(Source: WWDR 2, 2006)
Definition of sanitation

The development and establishment of environmental conditions favorable to the health of the public

(medical dictionary)

The promotion of hygiene and the prevention of germs and disease

The management of disposal, treatment and reuse of human excreta, solid waste and waste water, supported by good hygiene behaviour, in order to ensure environmental conditions in human settlements which promote the well-being and health of the population

(International Water and Sanitation Centre)
Basic Sanitation is defined in terms of the following:

- Development and implementation of household sanitation systems
- Improvement of sanitation in public institutions, especially in schools
- Promotion of safe hygiene practices
- Promotion of education and outreach focused on children, as agents of behavioral change
- Promotion of affordable and socially and culturally acceptable technologies and practices
- Development of innovative financing and partnership mechanisms
- Integration of sanitation into water resources management strategies (includes protection of water resources from biological or fecal contamination)

WSSD (World summit on sustainable development)
Problems associated with poor sanitation

- Causes diseases and premature death
- Pollutes water resources affecting usability
- Time loss from daily activities
- Degraded environment
- Lost opportunity for the use of excreta for energy or fertilizer
- Children, women, senior people – more vulnerable
- Affects tourism
Sewers drains emptying into rivers are common site in Asia

Health consequences of children playing in dirty water?
Water pollution affects fish production

Source: Economic impacts of sanitation in SE Asia, Feb 2008
Importance of Sanitation

- Disposal of excreta in proper manner is crucial for raising public health.
- Excreta can contain various types of disease causing microorganisms such as virus, bacteria, protozoa, and helminthes (fecal oral route or oral route).
- Improper disposal of excreta can favor the breeding of insects which may act as vectors of disease.
Pathogens in excreta

- **Bacteria:** $10^6$-$10^8$ no./gm feces
  - E.g. Enterobacteria (diarrhea); Clostridium salmonella (Typhoid); Vibrio cholerae (cholera)

- **Virus:** $10^6$ no./gm feces
  - Hepatitis A, B, and C; Poliovirus; Echovirus

- **Protozoa:** $10^4$ no./gm feces
  - E.histolytica; Giardia; Balantidium

- **Helminthes:** $10^2$-$10^4$ no./gm feces
  - Hookworm; Ascaris
Economic impact in SE Asia of sanitation

Contributions of impacts to overall economic costs for four countries

Economic losses as % GDP, 2005

Source: Economic impacts of sanitation in SE Asia, Feb 2008
Economic burden

- Total loss - US$ 9 billion/year (based on 2005 price)
- Appro. 2% of combined GDP
- Annual economic impact
  - Indonesia – US$ 6.3 billion
  - Philippines - US$ 1.4 billion
  - Vietnam - US$ 780 million
  - Cambodia – 450 million

Source: Economic impacts of sanitation in SE Asia, Feb 2008
## Improved vs unimproved sanitation

<table>
<thead>
<tr>
<th>Improved Sanitation</th>
<th>Unimproved Sanitation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use of the following facilities:</td>
<td>Use of the following facilities:</td>
</tr>
<tr>
<td>• Flush or pour-flush to:</td>
<td>• Flush or pour-flush to elsewhere (that is, not to piped sewer system, septic tank or pit latrine)</td>
</tr>
<tr>
<td>• piped sewer system</td>
<td>• Pit latrine without slab/open pit</td>
</tr>
<tr>
<td>• septic tank</td>
<td>• Bucket</td>
</tr>
<tr>
<td>• pit latrine</td>
<td>• Hanging toilet or hanging latrine</td>
</tr>
<tr>
<td>• Ventilated improved pit (VIP) latrine</td>
<td>Shared facilities of any type</td>
</tr>
<tr>
<td>• Pit latrine with slab</td>
<td>No facilities, bush or field</td>
</tr>
<tr>
<td>• Composting toilet</td>
<td></td>
</tr>
</tbody>
</table>

**Improved sanitation - hygienically separates human excreta from human contact**

Trends in urban sanitation coverage by developing regions, 1990-2010 (WHO 2012)
Trends in rural sanitation coverage by developing regions, 1990-2010 (WHO 2012)
More than half of the 2.5 billion people without improved sanitation live in India or China.
If current trends continue, the world will not meet the MDG sanitation target

Trends in global sanitation coverage 1990-2010, projected to 2015 (WHO 2012)
BENEFITS GAINED

Source: Economic impacts of sanitation in SE Asia, Feb 2008
Sanitation is an investment with high economic return

Brings 9 dollar worth of benefits for every dollar spend

• By saving time
• By reducing direct and indirect health costs
• By increasing the returns on investment on education
• By protecting investments in improved water supply
• By safeguarding water resources
• By boosting tourism revenues

Child mortality vs sanitation coverage for developing countries
Improved sanitation in SE Asia, MDG indicator %, 2004

Source: http://www.wssinfo.org/
Annual discharge from one person

- Nitrogen 4.5 kg
- Phosphorus 0.6 kg
- Potassium 1.0 kg
- BOD (organic matter) – 35 kg

*Resources in waste*
Average daily production and nutrient content of urine and feces

<table>
<thead>
<tr>
<th></th>
<th>urine</th>
<th>faeces</th>
</tr>
</thead>
<tbody>
<tr>
<td>Per person</td>
<td>1.2</td>
<td>150 grams (wet wt)</td>
</tr>
<tr>
<td>Nitrogen (g/ppd)*</td>
<td>11</td>
<td>2</td>
</tr>
<tr>
<td>Phosphorus (g/ppd)</td>
<td>1</td>
<td>0.6</td>
</tr>
<tr>
<td>Potassium (g/ppd)</td>
<td>2.5</td>
<td>0.6</td>
</tr>
</tbody>
</table>

* (Grams/person per day)

These nutrients should be recycled
Toilets (Latrines)

CHOICE of TECHNOLOGY

ONSITE OPTION

OFFSITE OPTION
Waste water treatment plants
Waste stabilization ponds (Aerobic, Anaerobic of Facultative)

Dry system
Pit latrine
VIP latrine
Composting toilet

Wet system
Cesspool
Aqua-privies
Septic tank

Decentralized vs Centralized
Bucket latrine

- Oldest and least hygienic systems
- Squatting slab or a sit is placed immediately above a bucket, which is filled within few days
- Bucket placed adjacent to outside wall - can be collected by the collector in a cart or burrow
- Spillage while emptying make the area heavily contaminated
- Ideally, buckets should be sealed with a lid, carried to depot and a new disinfected bucket used
- Should be used as temporary measure for e.g., camps
Pit latrines

- Consists of hand dug pit in soil over which is placed a squatting plate or slab, riser and seat
- wall or shelter constructed for privacy
- cheapest and simplest solution with or without water use. If water used, can cause pollution of ground water.
- digestion of waste solids and seepage of urine into surrounding soil
- volume of pit - 1x1x4 cubic meter
- Could accumulate excreta for a family of 5 person for 3-4 years
- Normally two pits
- When 2/3rd full - covered with soil or dirt
Problems/solutions of pit latrines

• Cleanliness – unhygienic (drop on floor)
• Odour – vented pipe and ash application after each use will minimize odour
• Insect breeding – increase in flies
• Mosquito breeding in dark
• Difficult to construct pit latrines in rocky and sandy area and those with high water tables or near water supplies.

✓ Pits should be built 15 m away from a well or from water sources.
✓ Bacteria cannot usually penetrate more than 1-2 m in most unsaturated soil.
✓ proper lining to prevent leakage and erosion by storm water.
Over hung latrine

• Sometimes necessary but undesirable method for excreta disposal
• Outhouse superstructure with toilet seat or floor hole located above river, canal, lake or sea beach
• Defecation directly in water for transport and eventual dilution or on the mudflat or beach to await the tide
  • If enough dilution – may be satisfactory, but mostly the water in the rivers are used as drinking water, personal cleaning, teeth brushing, bathing
Over hung latrine

Schematic of an overhung latrine

http://www.who.int/docstore/water_sanitation_health/onsitesan/ch08.htm
Over hung latrine

An overhung latrine on a fish pond in Vietnam

Composting/Urine Diversion (UD)

**PRINCIPLES of OPERATION:**

- Dry absorbent organic material (wood-ash, straw, vegetable matter) is added after each use to deodorise decomposing feces and/or control moisture and facilitate biological breakdown (composting).
- Urine may be separated/diverted through specially adapted pedestals (may be collected and used as fertilizer).
- Ventilation encourages evaporation of moisture.
Composting/urine diversion

Advantages

• Dry, onsite system, no mosquitoes
• Safe and affordable especially in areas with high water table and or water scarce areas
• Does not pollute the ground or surface water or the soil
• Does not produce flies or smell
• Uses less water than any other toilet. A water flush toilet for a family can use 100,000 liters of water a year for flushing, the compost toilet saves all this water
• Totally self-contained sewage treatment on site - no sewage pipes, no septic tanks, and no dangerous emptying of sludge
Cess pool

• Porous tank, like a pit, 50 cm height and 1 m diameter
• Wall made up of concrete and porous
• Liquid move out and solid stay in pool
• If cesspool sealed and has outlet pipe – similar to septic tank
• Frequent emptying is required and the system is therefore expensive

Common in Thailand
Ventilated improved pit (VIP) toilet

- Waste drops in the pit where organic material decomposes and liquids percolate into the surrounding soil
- Continuous airflow through the top-structure and above the vent pipe painted black removes smells and vents gases to the atmosphere
- A darkened interior is maintained causing insects entering the pit to be attracted towards the light at the top of the vent pipe and trapped by the fly screen (1 mm mesh, steel or glass fiber), clean once a year
PRINCIPLES of OPERATION:

- As for the VIP toilet, one pit is used until filled to within about half a meter of the top
- Defecation and vent pipe holes are then completely sealed and the other pit used
- Contents of the first pit are dug out after a period of at least two years, once the contents have become less harmful
Pour-flush toilet

PRINCIPLES of OPERATION:
• After defecation, the pan requires flushing with a few liters of water
• Water seal which is U-pipe filled with water prevents against smell, flies and mosquitoes
• Two pits used alternatively, common in Indian subcontinent
• Adv: Low water requirement and complete fly and odour control due to waterseal
Septic tanks

• **Onsite means** of disposing wastewater
• Watertight settling tanks beneath the ground level in close proximity to house, waste is carried by water flushing down a short sewer (toilet-cistern flush)
• Septic tank separates the waste and digests the solids, which need to be removed periodically
• Liquid effluent need to be disposed of, normally by soakage pit or drain field
• Single or double compartment
  • For high density – septic tank three compartments
Sewered pour-flush toilet with a two-compartment septic tank
Two-compartment septic tank
Three-compartment septic tank
Septic tanks

Advantages:
• Advantage of three compartment- effluent contains fewer faecal solids
• Drain field can be smaller
• Can be used for higher densities (200-300 persons/ha)

Disadvantages:
• Expensive, often costing more on a per household basis
• Requires large area of permeable subsoil through which it can distribute its effluent
• If cities located near rivers or delta areas, the subsoil structure is too impermeable for the leaching of septic effluent – flow across the ground and spread diseases
Septic tank and soakaway or small bore solid-free sewer
Septic tank
Full bore waterborne sewerage

PRINCIPLES of OPERATION:

• Waste from the toilet, and possibly domestic wastewater, is flushed using significant volumes of water into the sewer system for removal to a treatment facility

• Several types of such facilities and these treat effluent to high standards prior to discharge into the aquatic environment

N. B.: This is a Full Flush Toilet System
Bangladesh sanitation types

**Urban**
- Hanging, 26.30%
- Pit, 25.40%
- Water seal, 45.70%
- Open defecation, 4.20%

**Rural**
- Water seal, 7.40%
- Open defecation, 29.70%
- Pit, 29.50%
- Hanging, 39.00%
Blue baby syndrome

- Nitrates in water are ingested by an infant and converted to nitrite by the digestive system.
- Nitrite reacts with oxyhemoglobin to form methemoglobin, which cannot carry oxygen.
- Body tissues deprived of oxygen, causing the infant to develop a blue coloration of mucous membranes and possibly digestive and respiratory problems - methemoglobinemia.
- Occur when nitrate levels over 100 mg/l
What needs to be done?

- Increasing education & raising awareness
- Adopting policies that place health at the center of the development process
- Linking health & water resources management
- Emphasizing local management
- Taking initiatives from local to international level to address health issues
Eco-san and eco-water use
Conclusions

- Good quality of water is important for health
- Human excreta is source of pathogens, nutrients and organics causing diseases, environment degradation, eutrophication, water pollution etc.
- 2.5 billion people still lack access to improved sanitation
- Decentralized systems are better than centralized system
- Nutrients in the excreta should be recycled and reused

Factors with capital importance to reduce the burden of disease caused:

- Providing access to sufficient quantities of safe water
- Provision of facilities for a sanitary disposal of excreta
- Introducing sound hygiene behaviors
Are you using enough clean water to stay healthy?

Thank you for your kind attention