Principles of Environmental Hygiene and Sanitation
by
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Lecture 1
Sanitation

• “All precautions and measures which are necessary in production, processing, storage and distribution, in order to assure an unobjectionable, sound and palatable product which is suited for human consumption” – (WHO)

• Sanitation from Greek (Sanitas – Health)

N. G. Marriott- “The creation and maintenance of hygienic and healthful conditions”
"Sanitation" in this Guide refers to the infrastructure and service provision required for the safe management of human excreta, e.g. latrines, sewers, and wastewater treatment.

"Hygiene" in this Guide refers to the set of human behaviors related to safe management of excreta, e.g. washing hands with soap at appropriate times, the safe disposal of child feces etc.
<table>
<thead>
<tr>
<th>Setting</th>
<th>Handwashing with Soap</th>
<th>Prevalence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kerala State, India</td>
<td>After defecation</td>
<td>34 percent</td>
</tr>
<tr>
<td></td>
<td>After cleaning up a child</td>
<td>35 percent</td>
</tr>
<tr>
<td>Ghana</td>
<td>After defecation</td>
<td>3 percent</td>
</tr>
<tr>
<td></td>
<td>After cleaning up a child</td>
<td>3 percent</td>
</tr>
<tr>
<td>Peru</td>
<td>After defecation</td>
<td>6 percent</td>
</tr>
<tr>
<td></td>
<td>After cleaning up a child</td>
<td>30 percent</td>
</tr>
<tr>
<td>Senegal</td>
<td>After defecation</td>
<td>31 percent</td>
</tr>
<tr>
<td></td>
<td>After cleaning up a child</td>
<td>26 percent</td>
</tr>
<tr>
<td>Kolkata, India (slums)</td>
<td>After defecation</td>
<td>16 percent</td>
</tr>
<tr>
<td>Kyrgyzstan (rural)</td>
<td>After cleaning up a child</td>
<td>0 percent</td>
</tr>
<tr>
<td></td>
<td>After using a toilet</td>
<td>18 percent</td>
</tr>
<tr>
<td>Location</td>
<td>Action</td>
<td>Percentage</td>
</tr>
<tr>
<td>----------------------------------</td>
<td>---------------------------------------------</td>
<td>------------</td>
</tr>
<tr>
<td>Nigeria (rural)</td>
<td>After cleaning up a child</td>
<td>10 percent</td>
</tr>
<tr>
<td>Burkina Faso (urban)</td>
<td>After cleaning up a child</td>
<td>13 percent</td>
</tr>
<tr>
<td></td>
<td>After using a toilet</td>
<td>1 percent</td>
</tr>
<tr>
<td>Brazil (childcare centers)</td>
<td>After cleaning up a child</td>
<td>16 percent</td>
</tr>
<tr>
<td>Lima, Peru (shanty town)</td>
<td>After defecation (soap use ‘rare’)</td>
<td>12 percent</td>
</tr>
<tr>
<td>Northern England (peri-urban)</td>
<td>After cleaning up a child</td>
<td>47 percent</td>
</tr>
</tbody>
</table>

Pakistan

??

??
Water, Sanitation and Hygiene are the building blocks for achieving prosperity
Results of public poll of the top 15 medical advances since 1840, from over 11,000 votes.

<table>
<thead>
<tr>
<th>Most important advance</th>
<th>Number</th>
<th>Proportion (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anaesthesia</td>
<td>1574</td>
<td>13.9</td>
</tr>
<tr>
<td>Antibiotics</td>
<td>1642</td>
<td>14.5</td>
</tr>
<tr>
<td>Chlorpromazine</td>
<td>73</td>
<td>0.6</td>
</tr>
<tr>
<td>Computers</td>
<td>405</td>
<td>3.6</td>
</tr>
<tr>
<td>Discovery of DNA structure</td>
<td>1000</td>
<td>8.8</td>
</tr>
<tr>
<td>Evidence-based medicine</td>
<td>636</td>
<td>5.6</td>
</tr>
<tr>
<td>Germ theory</td>
<td>843</td>
<td>7.4</td>
</tr>
<tr>
<td>Immunology</td>
<td>182</td>
<td>1.6</td>
</tr>
<tr>
<td>Medical imaging (x-rays, etc.)</td>
<td>471</td>
<td>4.2</td>
</tr>
<tr>
<td>Oral contraceptive pill</td>
<td>842</td>
<td>7.4</td>
</tr>
<tr>
<td>Oral rehydration therapy</td>
<td>308</td>
<td>2.7</td>
</tr>
<tr>
<td>Risks of smoking</td>
<td>183</td>
<td>1.6</td>
</tr>
<tr>
<td><strong>Sanitation</strong></td>
<td><strong>1795</strong></td>
<td><strong>15.8</strong></td>
</tr>
<tr>
<td>Tissue culture</td>
<td>50</td>
<td>0.4</td>
</tr>
<tr>
<td>Vaccines</td>
<td>1337</td>
<td>11.8</td>
</tr>
<tr>
<td><strong>Total Respondents</strong></td>
<td><strong>11341</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>
Sanitation Basics

- Kill Organisms
- Exclude Contamination
- Prevent Multiplication
Microorganisms

- Bacteria
- Fungi (mold/yeasts)
- Viruses
Beneficial Microorganisms

• Fermentation
  – Cheese, Bread, Yogurt
• Enzymes
• Aids to human metabolism
• Decay
  – Waste treatment, composting, decomposition
“The Enemies”

• Pathogens – Food Safety
  – Illness, disease and death

• Spoilage – Food Quality
  – Poor quality, short shelf life, off flavors, customer dissatisfaction
"I HEAR THAT THEIR HOSPITALS ARE KILLING MORE PEOPLE THAN WE ARE..."
Bacteria

• Microscopic single cells
• Lots of moisture required
• Cause most food illness
• Three basic shapes
  – Rod
  – Cocci
  – Spiral
• Some spore formers
• Grow, grow, grow
  – Binary fission
Growth of bacteria

Requirements
- Food
- Acid (pH)
- Time
- Temperature
- Oxygen
- Moisture
The Spores

• Spores VERY resistant
• Two species from spores
  – Bacillus
  – Clostridium
• Difficult to destroy-reduce strategy
• Problem in cooked foods
Example: Clostridium
Example: Bacillus

Anthrax bacteria (*Bacillus anthracis*), stained
The Anthrax Cycle

1. **Ingestion**
   - Biting Fly From infected animal

2. **Inhalation**
   - Anthrax Spores

3. **Cutaneous Exposure to oxygen**
   - Cutaneous

4. **Ingestion**
   - Vegetative Forms
     - Bacteria in animal waste and decomposition

5. **Inhalation**

6. **Cutaneous**

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Fungi (Molds and Yeasts)

- Require less moisture
- Can grow in acid pH
- Very adaptable
- Grow slower than bacteria
- molds-micellular
- Form spores that are less resistant than bacterial spores
- Yeasts bud
SPOROTRICHOSIS (*Sporothrix schenckii*)
Virus

Basic virus structure
• Genetic material (DNA or RNA)
• Protein coat
• Tail fibers
• Hollow protein tail

Virus
• Tiny
• Simple structure
• Must grow in cells
• In foods-fecal contamination
• Personal sanitation to prevent
• Living?
Influenza A (H1N1) virus is a subtype of influenza A virus and was the most common cause of human influenza (flu) in 2009.
Pandemic (H1N1) 2009, Number of laboratory confirmed cases as reported to WHO

Status as of 06 July 2009 09:00 GMT

Total: 94,512 cases 429 deaths

Chinese Taipei has reported 61 confirmed cases of pandemic (H1N1) 2009 with 0 deaths. Cases from Chinese Taipei are included in the cumulative totals.

Cumulative deaths
- 1 -10
- 11 - 50
- 51 - 100
- 101 and more

Cumulative cases
- 1 -10
- 11 - 50
- 51 - 500
- 501 and more

The boundaries and names shown and the designations used on this map do not imply the expression of any opinion whatsoever on the part of the World Health Organization concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. Dotted lines on maps represent approximate border lines for which there may not yet be full agreement.

Data Source: World Health Organization
Map Production: Public Health Information and Geographic Information Systems (GIS) World Health Organization

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Map produced: 06 July 2009 09:00 GMT
Our losses

- Every year (based on CDC data):
  Over 250 billion meals are prepared
- An estimated 76 million food-borne illnesses occur
- >5000 food-borne associated deaths

Costs = $7.7 to 23 billion
Facts

• Approx. 2.6 - 3 billion people living without proper sanitation. Due to inadequate water supply, sewerage systems and lack of sanitation millions of people face death annually.
• Over 2 million people die annually only to diarrhoea, wherefrom most are under the age of five.
• Every day approximately 6000 children die to diarrhea related diseases. According to some estimates two thirds of the costs of medical treatment are used to nurse diarrhea related diseases.
• At the same time 300 million people in developed countries are using the same amount of water what many people in developing countries are entitled for a whole day by simply flushing once.
• According to WHO and UNICEF safeguarding access to clean water and sanitation to all people would cost approximately 9 billion USD annually from the year 2005 to 2015 (including only building costs).
• If you compare this cost to the cost of global armament (780 billion USD annually), to the cost of alcohol and cigarette consumption in Europe (155 billion USD annually) or even to the cost of ice-cream consumption in Europe (11 billion USD) it can be considered as a rather small cost.
This toilet is thoroughly cleaned once a week. Sadly it's tomorrow.
The principle of nutrient cycle

- Food Production
- Food Consumption
- Composting for Manure
- Feces
# Food-borne Hazards

<table>
<thead>
<tr>
<th>Hazard</th>
<th>Est. Cases</th>
<th>Deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>Norwalk virus</td>
<td>23,000,000</td>
<td>na</td>
</tr>
<tr>
<td><em>Campylobacter</em></td>
<td>2,453,926</td>
<td>0.1%</td>
</tr>
<tr>
<td><em>Salmonella</em></td>
<td>1,412,498</td>
<td>0.8%</td>
</tr>
<tr>
<td><em>C. perfringens</em></td>
<td>248,520</td>
<td>0.05%</td>
</tr>
<tr>
<td><em>S. aureus</em></td>
<td>185,060</td>
<td>0.02%</td>
</tr>
<tr>
<td><em>E. coli O157:H7</em></td>
<td>73,480</td>
<td>0.83%</td>
</tr>
<tr>
<td><em>L. monocytogenes</em></td>
<td>2,518</td>
<td>20%</td>
</tr>
<tr>
<td><em>C. botulinum</em></td>
<td>58</td>
<td>8.6%</td>
</tr>
</tbody>
</table>
Food-borne pathogens

“Target Pathogens”
• Four major pathogens of food borne illness
  – *Salmonella*
  – *E. coli O157:H7*
  – *Campylobacter*
  – *Listeria Monocytogens*
Salmonella

• Most frequently reported
• Introduced anywhere within the food chain
• Grown on any food under the right conditions: moisture and temp
• Ideal growth temp. 10-40°C
• Cook temperature essential to kill
• Safe handling of food by consumer essential
E. Coli O157:H7 & Campylobacter

- Natural inhabitant of the GI tract of all animals
- Sanitary practices throughout the farm to table essential for control
- Consumer education of safe handling practices for food, raw and cooked, essential for control
L. monocytogenes

- Commonly found in GI tract of all animals
- Can survive for long periods in soil, sewage, dust, vegetation and water
- Resistant to cool temp. – cold storage
- Can form biofilms on surfaces to resist cleaning and sanitizing
- Biggest threat: pregnant women-miscarriages and birth defects
Example: Sanitation in live production

- Will never be sterile but don’t give up!

7 basic steps in live production sanitation
  - Obtain clean stock
  - Proper bird care
  - Vermin control
  - Moisture control
  - Feed storage
  - Biosecurity
  - Water sanitation
Obtaining clean stock

- Know the seller
- Don’t look for bargains
- Isolate birds for 2 weeks
- Monitor birds daily and separate sick ones
Proper birds care

• Healthy birds are more resistant
• Pay attention to bird behavior
• Collect dead at least daily
• Provide ventilation
Moisture control

- Litter moisture related to pathogens
- Moisture control related to:
  - Addressing obvious sources
  - Ventilation
Moisture is often the single most important factor in determining microbial growth.
Feed storage

• Protection from rodents and wild birds
• Protection from moisture
• Protection from heat and sunlight
  – Moisture migration
  – UV destruction
• Feed freshness
Effect of feed age on aflatoxin conc.
Biosecurity

“a set of preventive measures designed to reduce the risk of transmission of infectious diseases”

Procedures that work for bird pathogens also keep out human pathogens

Basic steps
• No visitor policy
• Protect personnel
• Clean equipment
• Proper dead disposal
• No visits to problems
• Lock & security
• Avoid mixing animal species

• Have farm clothes
• Clean vehicles
• No contact with other birds
• No borrowed equip.
• No wild game
Basic steps in sanitizer use

- Avoid mixing sanitizers particularly chlorine @ pH < 4 = chlorine gas
- In general, clean, scrub, rinse then sanitize
- Store sanitizers away from feed and birds
- Protect sanitizers from heat and light
- Avoid long storage times
- Use for approved purposes
  - General sanitation
  - Food contact surfaces
# Disinfectant types and qualities

<table>
<thead>
<tr>
<th>Type</th>
<th>Activity</th>
<th>Organic matter effect</th>
<th>Cost</th>
<th>Human toxicity</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alcohols</td>
<td>Wide no spores</td>
<td>Reduces effects</td>
<td>Exp</td>
<td>Low</td>
<td>Non corrosive, fire hazard, conc 70-95%</td>
</tr>
<tr>
<td>Hypochloride</td>
<td>Wide no spores</td>
<td>Kills effects</td>
<td>Low</td>
<td>Low</td>
<td>Can be corrosive</td>
</tr>
<tr>
<td>Iodophors</td>
<td>Wide no spores</td>
<td>Reduces effects</td>
<td>Mod</td>
<td>Low</td>
<td>May stain clothing, porous surfaces</td>
</tr>
<tr>
<td>QAC (quaternary ammonia comp)</td>
<td>Limited no spores</td>
<td>Reduces effects</td>
<td>Low</td>
<td>Low</td>
<td>Soaps, detergents and hard water limit effectiveness</td>
</tr>
<tr>
<td>Phenolic</td>
<td>Wide no spores</td>
<td>Little to none</td>
<td>Mod</td>
<td>Low</td>
<td>Good residual activity</td>
</tr>
<tr>
<td>Aldehyde</td>
<td>Wide</td>
<td>Limits effects</td>
<td>Mod</td>
<td>Mod</td>
<td>Gets everything, but can be highly toxic</td>
</tr>
<tr>
<td>Oxidizer</td>
<td>Mod. no spores</td>
<td>Kills effects</td>
<td>Mod</td>
<td>Low</td>
<td>Limited residual, mod. corrosive</td>
</tr>
</tbody>
</table>
Water sanitation

- Water - a great organism transmitter
- Consider closed line system

Water line cleaners for use once a week

<table>
<thead>
<tr>
<th>Clear household ammonia</th>
<th>Household bleach</th>
<th>White household vinegar</th>
<th>Iodine (18.05%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>½ teaspoon per gallon of water</td>
<td>½ teaspoon per gallon of water</td>
<td>1 oz per gallon of water</td>
<td>¼ teaspoon per gallon of water</td>
</tr>
</tbody>
</table>
Cleaning closed watering systems with birds in the house
prepare a stock solution

<table>
<thead>
<tr>
<th>Clear household ammonia</th>
<th>Household bleach</th>
<th>Clear vinegar</th>
<th>Iodine (18.05%</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 oz per gallon</td>
<td>6 oz per gallon</td>
<td>128 oz per gallon</td>
<td>2 oz per gallon</td>
</tr>
</tbody>
</table>
Basic steps in poultry processing

- Pre-slaughter
  - Immobilize
    - Feather removal
  - Evisceration
    - Chilling
      - Further processing or packaging
Sanitation in small processing

• Work indoors if possible
• Use sanitizers labeled for food contact surfaces
• Clean and sanitize equipment before use
• Separate slaughter and picking from evisceration and cut up – job specialize
• Avoid long delays
• Keep things as clean as possible (insects)
• Don’t spare the water
• Cool processed carcasses quickly and keep them cool
Natural disinfecting agents

- Sunlight (UV rays)
- Heat (>35C)
- Cold (Freezing or below)
- Drying (aided by wind, light and heat)
- Effective, but are they reliable?
Water quality: fraction of population using improved water sources by country

- Everyone has clean water
- Most people have clean water
- At least 1 in every 4 people don’t have clean water
Global water supply coverage in the year 2000. Picture shows the percentage of population that have access to adequate drinking water supply.
Global coverage of sanitation in the year 2000. Picture shows the percentage of people with access to proper sanitation services.
HACCP

- It's often misused term
- A systematic method of documenting that food safety hazards have been addressed
- HACCP involves only food safety issues
- Out of control = unsafe food produced
- Plans unique for each unit and product
## HACCP – What is it?

<table>
<thead>
<tr>
<th>Step</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Hazard analysis</td>
<td>What are the controllable food safety hazards?</td>
</tr>
<tr>
<td>2. Establish critical control points</td>
<td>Where do things go wrong and how can we reliably control it?</td>
</tr>
<tr>
<td>3. Establish critical limits</td>
<td>What value indicates the process is in control?</td>
</tr>
<tr>
<td>4. Establish monitoring procedures</td>
<td>Who, what, when, where and how will CCP’s be monitored?</td>
</tr>
<tr>
<td>5. Establish corrective actions</td>
<td>What happens if we exceed a critical limit?</td>
</tr>
<tr>
<td>6. Establish a record keeping system</td>
<td>If you don’t write it down it doesn’t exist.</td>
</tr>
<tr>
<td>7. Establish verification procedures</td>
<td>How do you know the system works?</td>
</tr>
</tbody>
</table>
How does HACCP work?

• Processors must take the following steps:
  – Assemble a HACCP team to design their plan
  – Describe the product and its method of production, distribution and intended consumer.
  – Develop and verify process flow diagrams
How does HACCP work?

• Identify at each step the production flow chart and hazard to food safety as to:
  – Chemical
  – Physical
  – Bacterial
• Support the hazard with a decision making document and scientific data
How does HACCP work?

- If a CCP deviation is found the following must take place:
  - Identify the cause of deviation
  - Describe how the critical limit was restored
  - Describe how the deviation can be prevented from happening again
  - Describe how the adulterated product was reconditioned or what happened to the product
The End  lecture 1