MICROBIOLOGY OF WATER AND WASTE WATER

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E-mail: rg55@rediffmail.com
- Pure Water - potable water
- Waste water - any used form of water
Also, wastewater contains many pathogenic organisms which generally originate from humans who are infected with disease or who are carriers of a particular disease.
Bacterial-indicator organisms

Common groups

- COLIFORM GROUP
  - Total coliforms
  - Fecal coliforms
  - Escherichia coli
- STREPTOCOCCI
  - Fecal streptococci
  - Enterococci
- SPORE FORMERS
  - Clostridium perfringens
Coliform Characteristics

► All coliforms
  • Gram negative
  • Ferment lactose at 35 °C
  • Ubiquitous in the environment

► Fecal coliforms
  • Ferment lactose at 44.5 °C
  • possibly fecal origin

► *Escherichia coli*
  • Inhabits gastrointestinal tract
  • indicator of fecal pollution
Other fecal indicators

- **Fecal streptococci (enterococci)**
  - Gram positive cocci
  - Grows at 41 °C

- **Clostridium perfringens**
  - Present in both human and animal wastes
  - A stress-resistant spore former
  - Possible surrogate for resistant bacteria
Water
source of diseases

- Water sources
  - Well, River, etc.
- Contaminated water
- Sick person (or)
  - Infected person
- Excreta of sick or carrier person
- Consumed by person
# Water borne diseases

<table>
<thead>
<tr>
<th>Etiological agent:</th>
<th>Illness/Disease:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Viral</strong></td>
<td></td>
</tr>
<tr>
<td>Hepatitis A and B viruses</td>
<td>Infectious hepatitis</td>
</tr>
<tr>
<td>Poliovirus</td>
<td>Poliomyelitis</td>
</tr>
<tr>
<td>Norwalk virus</td>
<td>Gastroenteritis</td>
</tr>
<tr>
<td>Cosavirus A and B viruses</td>
<td>Respiratory and cardiovascular disease</td>
</tr>
<tr>
<td>Rotavirus</td>
<td>Gastroenteritis</td>
</tr>
<tr>
<td><strong>Bacterial</strong></td>
<td></td>
</tr>
<tr>
<td>Pseudomonas aeruginosa</td>
<td>Gastroenteritis</td>
</tr>
<tr>
<td>Salmonella typhi</td>
<td>Typhoid fever</td>
</tr>
<tr>
<td>Proteus vulgaris</td>
<td>Cholera</td>
</tr>
<tr>
<td>Aeromonas sp.</td>
<td>Gastroenteritis</td>
</tr>
<tr>
<td>Choleraeae sp.</td>
<td>Pneumonia</td>
</tr>
<tr>
<td>Legionella sp.</td>
<td>Leptospirosis</td>
</tr>
<tr>
<td><strong>Fungal</strong></td>
<td></td>
</tr>
<tr>
<td>Aspergillus sp.</td>
<td>Allergic and respiratory disease, toxicosis (via mycotoxins)</td>
</tr>
<tr>
<td>Cryptococcus neoformans</td>
<td>Respiratory disease</td>
</tr>
<tr>
<td>Mucor sp.</td>
<td>Respiratory disease</td>
</tr>
<tr>
<td>Candida albicans</td>
<td>Candidiasis</td>
</tr>
<tr>
<td>Yeasts, dermatophytes</td>
<td>Athler's foot, etc</td>
</tr>
<tr>
<td><strong>Protozoal</strong></td>
<td></td>
</tr>
<tr>
<td>Rhodomonas antarctica</td>
<td>Dysemtary</td>
</tr>
<tr>
<td>Chlorella ellipsoidea</td>
<td>Gastroenteritis</td>
</tr>
<tr>
<td>Cryptosporidium sp.</td>
<td>Gastroenteritis</td>
</tr>
<tr>
<td>Amoeba proteus</td>
<td>Corneal lesions</td>
</tr>
<tr>
<td><strong>Parasitic</strong></td>
<td></td>
</tr>
<tr>
<td>Tetratrichomonas sp.</td>
<td>Meningoencephalitis</td>
</tr>
</tbody>
</table>
Vibrio cholerae

- Descriptions of epidemics on the Indian
- Common in Asia, Africa, and Latin America
Giardiasis and Cryptosporidiosis

► *Giardia lamblia* and *Cryptosporidium parvum* are protozoans

► Transmission through water. 97% of all surface water

► Water treatment removes them during flocculation and filtration

► Natural streams - transmission by wild animals

► Diagnosis: microscopic observation or antigen presence

► Treated with drugs

*Cryptosporidium*
Legionellosis (Legionnaire’s disease)
(discovered in 1976)

- *Legionella pneumophila*:
  - a waterborne pathogen transmitted via aerosols
  - An intracellular parasite
  - Pontiac fever - mild headaches, sore throat, fever, that disappears after a few days
  - Pneumonia that follows flu-like symptoms in the elderly
- Treated with erythromycin
Typhoid and other diseases

Typhoid - *Salmonella typhi*
- Diarrhea
- Transmitted by contaminated food, direct contact, and drinking water

Viruses - polio and hepatitis A
- Maintaining of 0.6 µg/ml residual chlorine assures elimination
Amoebiasis

Protozoa - *Entamoeba hystolytica* - dysentery

- Anaerobic (no mitochondria)
- Cysts in water and food
- Severe cases, further penetration into blood, liver and brain
- Drug treatment available - dehydroemetine, diloxanide furoate (for asymptomatic cases)
Treatment stages:

- Primary
- Secondary
- Tertiary
- Disinfection

Aerobic

Anaerobic
- Primary treatment - physical separation
- Secondary treatment - a biological treatment process that removes dissolved organic material
  - **Aerobic**
  - **Anoxic**
- Tertiary treatment - physicochemical process
  - **Precipitation**
  - **Filtration**
  - **Disinfection**
  - **Chlorination**
Chemically, wastewater - organic and inorganic compounds, various gases.

- Organic components - carbohydrates, proteins, fats and greases, surfactants, oils, pesticides, phenols, etc..
- Inorganic components - heavy metals, nitrogen, phosphorus, pH, sulfur, chlorides, alkalinity, toxic compounds, etc.
In domestic wastewater,

- The organic and inorganic portion - approx. 50%, respectively.
- Higher portion of dissolved solids than suspended,
  - about 85 to 90% inorganic component
  - about 55 to 60% organic component
- Gases - $H_2S$, $CH_4$, $NH_3$, $O_2$, $CO_2$ & $N_2$. 
Approaches for Water Treatment

- Find out what is in the water
  - Chemistry, microbiology
- Determine if it is harmful
  - Toxicology
- Determine how to remove and/or destroy the toxic materials
  - Environmental engineering
WASTEWATER TREATMENT PROCESSES

Wastewater

Screening

Sedimentation

Sludge (insoluble)

Soluble liquid

Anoxic digestion

Oxidation

Digested sludge: drying; incineration; use as fertilizer, or burial

Disinfection

Treated effluent to stream

Activated sludge

Trickling filter

Aeration

Key:
- Raw wastewater
- Primary treatment
- Secondary treatment
Treatment

Primary

Removal by physical separation of grit and large objects (material to landfill for disposal)
Secondary process

From 1st treatment

air diffuser

Aeration and rapid mixing

To tertiary process

Settling collects sludge on bottom
Tertiary process

From secondary process

Slow mixing to keep suspended and $O_2$ out

add methanol as food source

Settling collects sludge on bottom

Effluent
WASTEWATER TREATMENT PLANT

MICROBES IN ACTION
Where microbes help

- Biologically - various microorganisms, bacteria, fungi, protozoa, and algae.
Effect of organic pollution and self-purification

Discharge of waste organic matter

Bacteria and fungi

Dissolved oxygen

Degradation zone

Active decomposition zone

Recovery zone

Clean water zone

BOD
Water quality and pollution

Eutrophication

Normal food chain

<table>
<thead>
<tr>
<th>CO₂</th>
<th>Green algae (plants)</th>
<th>Zooplankton</th>
<th>Fish</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen and phosphorus</td>
<td></td>
<td></td>
<td></td>
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</table>

Unbalanced food chain

<table>
<thead>
<tr>
<th>Excess nitrogen and phosphorus</th>
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<td>Blooms of blue-green algae</td>
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</table>

Settling

Decomposition by bacteria, Reduced dissolved oxygen, Odors from decay

Aquatic food chain unbalanced by eutrophication compared with normal chain
Eutrophic lake

Excess nitrogen and phosphorus → Sunlight

Growth of green algae → Green colored water

Bacterial decomposition of decaying algae → Reducing DO

Decaying algae settle to the bottom

Anaerobic condition in organic mud

Eutrophic lake
• The accepted upper limits for lakes free of algal blooms:
  (Ammonia + Nitrate)-N 0.3 mg/l
  Orthophosphate-P 0.02 mg/l

Lakes will exhibit algal blooms:
  Total-N 0.8 mg/l
  Total-P 0.1 mg/l
Biological treatment
1. Activated sludge process

Wastewater → Primary settling → aeration → Biological aeration basins → Final settling → Chlorination

Sludge → Power generator → Methan gas

Anaerobic digestion tank
• Biological treatment systems
  ✅ Activated sludge process
  ✅ Advanced wastewater treatment
  - Biological nitrogen removal
  - Biological phosphorus removal
Sludge Treatment

- *Sludges* are the product of biological treatment of wastewater
- Sludges comprise solids found in wastewater plus organisms used in the treatment process
- Disposal is a major issue
- Various disposal techniques are used but each has advantages and disadvantages
Waste water treatment by activated sludge system

- **Waste water** (Organic matter)
- **Oxygen**
- **Organic matter**
- **Metabolization**
- **Bacteria**
- **Ingestion**
- **Protozoa**
- **Activated sludge**
- **CO₂**
- **Effluent**
- **New bacterial growth** (Waste sludge to disposal)

**Biological reaction in the tank**

**Treatment efficiency**
- BOD: 70–90%
- Nitrogen: 10–40%
- Phosphorus: 4–20%
Advanced wastewater treatment
Advanced

► Biological nitrogen removal

Nitrogen content in municipal wastes 4-6kg of nitrogen per person per year.
Common form of nitrogen organic, ammonia, nitrate and nitrite.
Decomposition of nitrogenous organic matter
Bacterial decomposition
Organic nitrogen compounds $\rightarrow$ NH3
**Advanced .........................**

- Nitrification and nitrogen removal

  ✓ Bacterial nitrification (autotrophic bacteria)

  \[
  \text{NH}_4^+ + \frac{3}{2} \text{O}_2 \rightarrow 2 \text{NO}_2^- + 2\text{H}^+ + \text{H}_2\text{O}
  \]

  ✓ Bacterial denitrification (heterotrophic bacteria)

  dissolved organic -C + NO\text{\textsubscript{x}} \rightarrow \text{N}_2, \text{CO}_2, \text{H}_2\text{O}, \text{biomass}
Advanced

Three activated sludge system
(N$_2$ removal)
Advanced ........................

Treatment efficiency

- Conventional activated sludge process
  BOD 70 – 80%
  Nitrogen 10 – 40%

- Advanced activated sludge process
  BOD 80 - 90%
  Nitrogen 60 – 70%
Advanced

Biological phosphorus removal

- Anaerobic:
  - phosphate release

- Aerobic:
  - phosphate uptake
  - net elimination

Flow:
- Influent
  - Anaerobic zone
  - Aerobic zone
  - Return sludge
- Settling tank:
  - Effluent
  - Waste sludge
Drinking water purification

✓ Disinfection
Schematic overview of a typical community water purification system
Sedimentation
Coagulation
Filtration
Chlorination
Storage
Conclusion

✓ Save drinking water
✓ Use beneficial microbes and microbiological methods