WATER BORNE MICROBIAL DISEASES

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INTRODUCTION

• Microbial infections are one of the major water borne health hazards in developing countries

• Less than 100 years ago cholera, typhoid fever and dysentery are major diseases

• In India, more than 80% emergencies are water borne.

• Microbial disease spread either directly or through flies or filth, water is the chief medium and hence termed as Water-borne disease.

• The WHO estimates that there are 2.1 million deaths from diarrhoeal diseases every year in the world, most of them among children, and that 65% of these deaths could be prevented by water hygiene and sanitation interventions WHO, 2002.
SOURCES OF DRINKING WATER

- Ground or Surface Water sources
- Urban – municipally treated systems (relatively sophisticated treatment systems, depending on size of community)
- Rural – private wells, river, channels (typically untreated)
- Remote – water stored and transported to consumers
- Microbiological monitoring = indicator organisms
SOURCES OF DRINKING WATER

- Surface Water versus Groundwater
  - surface water collected in reservoirs
  - rivers, streams, lakes or ponds
- groundwater
  - from wells
- Surface water is almost certain to carry some bacteria etc
- Most cities rely on surface water
POTENTIAL CAUSES OF WATERBORNE DISEASE

- Contaminated source
- Treatment failure (partial/total)
- Direct breach of a distribution system (construction etc.)
- Recreational Water Exposure... (pool, beach)
DRINKING WATER GUIDELINES

- Public Drinking Water Systems-
  - No sample should contain *Escherichia coli*
  - No sample should contain total coliforms

- Semi-public and Private Drinking Water Systems
  - No sample should contain *Escherichia coli*
  - No sample should contain total coliforms

- Protozoa
  - Numerical guidelines not proposed at this time
    (for *Cryptosporidium* or *Giardia*) due to low recovery rates of methods, and lack of infectivity data

- Viruses
  - Numerical guidelines for human enteric viruses not proposed at this time.
CAUSATIVE ORGANISMS

- Protozoa - Enteric Protozoa
- Bacteria - Pathogenic Bacteria (including enteric and aquatic bacteria)
- Viruses - Enteric Viruses.
PROTOZOA

- Parasitic and free-living
- Range in size from 2-15 µm
- Resistant to chemical disinfection
- Removal is best option for treatment
- Enteric protozoa: *Cryptosporidium*, *Giardia*, *Cyclospora*, *Entamoeba*
Water-borne Protozoan Diseases

- **Disease**: Giardiasis (*Giardia lamblia*)
- **Description**: traditionally been considered a tropical disease, but is becoming more common in developed countries, causes diarrhoea, flatulence, and abdominal cramps, often accompanied by weight loss. Chronic disease includes severe diarrhoea, gas in stomach, allergy, malnutrition, and stunted growth.
- **Route of exposure**: gastro-intestinal
- **Mode of transmission**: Waterborne, faecal-oral route
Entamoeba histolytica

- **Disease:** Amoebic dysentery
- **Description:** severe, often bloody diarrhea, vomiting, fever; life-threatening if untreated
- **Route of exposure:** gastro-intestinal
- **Mode of transmission:** food/water borne
Cryptosporidium

- Small oocysts
- Resistant to chemical disinfection (Cl2)
- Ubiquitous in the environment
- Anthroponotic (person) and zoonotic (animal) sources
- Low infectious dose
- Difficult for immuno-compromised patients because infections can become chronic (no effective therapeutic agents)
Cryptosporidium parvum

- **Disease:** Cryptosporidiosis
- **Description:** severe diarrhea; life-threatening if immune system is impaired
- **Route of exposure:** gastro-intestinal
- **Mode of transmission:** waterborne
Water Borne Bacterial Diseases

*Escherichia coli*

- Worldwide distribution.
- Inhabit intestinal tract of human and animals.
- Water becomes contaminated by faeces.
- Most strains are avirulent but opportunistic infections may occur.
- Pathogenic strains possess virulence factors, which allow them to colonize mucosal surfaces.
Enterotoxigenic *E. coli*

- Produces heat labile (LT) and heat stable (ST) enterotoxins.
- LT induces hypersecretion in gut
- ST reduces absorption
- Primary cause of traveler’s diarrhea and infant diarrhoea in developing countries
- Causes diarrhea in neonatal piglets, calves and lambs; also causes post weaning diarrhea in pigs.
Enteropathogenic *E. Coli*

- Nature of toxins uncertain
- Cause destruction of microvilli, atrophy and shedding of enterocytes resulting in indigestion and diarrhea in piglets, lamb and pups.

Verotoxigenic *E. Coli*

- Produces verotoxins VT1, VT2, VT2e
- Toxins damage vasculature in intestine
Necrotoxigenic *E. coli*

- Toxins produced are necrotizing factors CNF1 and CNF2
- Causes haemorrhagic colitis in cattle. Enteritis in piglets and calves, diarrhea in rabbits and dysentery in horses.

Non enteric localized diseases

1. Uropathogenic strains of E.Coli
   - Adhesion is required for colonization.
   - Produce endotoxins and exotoxins
**Escherichia coli O157:H7**

- Produces large quantities of one or more related, potent toxins that cause severe damage to the lining of the intestine.
- These toxins [verotoxin (VT), shiga-like toxin] are closely related or identical to the toxin produced by *Shigella dysentriae*.
- Acute disease -
  - Hemorrhagic colitis.
  - Hemolytic uremic syndrome.
Salmonella

• More than 2400 serovars identified
• Organism present in water, soil, raw meat, offal and vegetables
• Worldwide occurrence.
• Common occurrence in animals and man
• Infection may range from sub-clinical carrier state to acute fatal septicemia.
• Symptoms begin in 6 to 72 hours (usually 12 to 36 hours) after exposure to Salmonella.
• Diarrhea, stomach pain, nausea and vomiting fever, headache.
## Salmonella serotypes of clinical importance

<table>
<thead>
<tr>
<th>Serotype</th>
<th>Species affected</th>
<th>Disease/ syndrome</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Salmonella Typhimurium</em></td>
<td>Humans, Animals</td>
<td>Food poisoning, Enterocolitis and septicaemia</td>
</tr>
<tr>
<td><em>Salmonella Dublin</em></td>
<td>Cattle, Sheep, horses and dogs</td>
<td>Septicaemia, abortion, joint ill, osteomyelitis and dry gangrene, Enterocolitis and septicaemia</td>
</tr>
<tr>
<td><em>Salmonella Cholerasuis</em></td>
<td>Pigs</td>
<td>Enterocolitis and septicaemia</td>
</tr>
<tr>
<td><em>Salmonella Pullorum</em></td>
<td>Chicks</td>
<td>Bacillary white diarrhea</td>
</tr>
<tr>
<td><em>Salmonella Gallinarum</em></td>
<td>Adult birds</td>
<td>Fowl typhoid</td>
</tr>
<tr>
<td><em>Salmonella Arizonae</em></td>
<td>Turkeys</td>
<td>Paracolon infection</td>
</tr>
<tr>
<td><em>Salmonella Enteritidis</em></td>
<td>Poultry, Mammals, Humans</td>
<td>Sub-clinical infection, Clinical infection, Food poisoning</td>
</tr>
<tr>
<td><em>Salmonella Brandenburg</em></td>
<td>Sheep</td>
<td>Abortion</td>
</tr>
</tbody>
</table>
Shigella

✓ Most common cause of shigellosis is *Shigella dysenteriae* which produces potent toxin – shiga toxin

✓ Pathogenesis is due to adherence, invasiveness and toxin production

✓ Found in surface waters and drinking water

✓ Organism transmitted by oral-faecal route.

✓ Causes bacillary dysentery resulting in inflammation of mucosa in humans, chimpanzee and monkeys
Vibrio species

- Disease caused: Cholera
- Endemic in certain parts of India and Bangladesh
- Humans are its major reservoir, but it persists in fresh water supplies and sea water
- Virulent strains produce cholera exotoxin which stimulate large quantities of chloride into the intestine.
- Water, sodium, and other electrolytes follow and leave the body as diarrhoea.
- Characteristic rice water stools, causes dehydration; life-threatening if untreated
Yersinia enterocolitica

- *Yersinia enterocolitica* occurs most often in young children
- The major animal reservoir is pigs, but also found in rodents, rabbits, sheep, cattle, horses, dogs, and cats
- Fever, abdominal pain, and diarrhoea, which is often bloody
- Symptoms typically develop 4 to 7 days after exposure and may last 1 to 3 weeks or longer
- Drinking contaminated unpasteurized milk or untreated water can also transmit the infection
Leptospira

• *Leptospira interrogans*, a member of Spirochete family

• The species *L. interrogans* contains over 212 serovars and grouped into 23 serogroups.

• Dog, cat, cattle, rodents and wild animals are source of leptospira infection

• Urine or urine contaminated water found in ponds, surface water of rivers, moist soil and mud are sources of infection

• Most common serovars are icterohaemorrhagiae, canicola, pomona and grippotyphosa.

• In humans flu like symptoms: fever, headache, muscle pain and also causes hepatitis and jaundice

• Causes abortion, still birth, agalactia, nephritis in pups, chronic renal disease in dogs, septicemia in calves
Listeria monocytogenes

- Bacteria survive in herbage, faeces of animals, sewage effluents as well as fresh water bodies.
- Recently been recognized as an important public health problem.
- Spread very easily by direct food contact with a contaminated surface, and it can survive and grow in a refrigerated, packaged RTE product.
- In cooked foods because of post-processing contamination.
Affects primarily pregnant women, newborns, and adults with weakened immune systems.

- Fever, muscle aches, nausea or diarrhea, headache, stiff neck, or convulsions.

- Infections during pregnancy can lead to miscarriage or stillbirth, premature delivery, or infection of the newborn.

- *Listeria monocytogenes* causes meningitis, abortion, septicemia and encephlomyelitis in sheep, goat and cattle
Mycobacteria

• Bacteria found in soil, vegetation and water
• These are obligate pathogens
• Survive in environment for longer period due to lipid rich cell wall
• Cause tuberculosis in humans and various species of animals and Johne`s disease in cattle.
**Clostridium botulinum**

- **Disease:** Botulism
- **Description:** causes paralysis; life-threatening
- **Route of exposure:** gastro-intestinal
- **Mode of transmission:** food/water borne; grows in food
Water borne viral diseases

Viral gastroenteritis

Rotaviruses:

• Viruses belong to family *Reoviridae*.

• Virus survives in faeces and contaminated water for several months

• Classified into seven serogroups from A to G, three of them (groups A, B and C) infect humans

  These Viruses affect villi of proximal part of intestine resulting in malabsorption and diarrhea.
**In humans**

- Affects children during first week of life.
- Death occurs due to dehydration.

**In animals**

- Disease is known as white scours or milky scours
- Mainly affects young ones
- Death occurs due to dehydration and secondary bacterial infections.
Group A rotavirus

- Endemic worldwide and infects mammalian and avian species.
- Leading cause of severe diarrhoea among infants and children,
- Accounts for about half of the cases requiring hospitalization.
- In temperate areas, it occurs primarily in the winter, but in the tropics it occurs throughout the year.
Group B rotavirus

- Also called adult diarrhoea rotavirus or ADRV,
- Has caused major epidemics of severe diarrhoea affecting thousands of persons of all ages.
- Species specific and has been reported from cattle, sheep swine and man.

Group C rotavirus

- Has been associated with rare and sporadic cases of diarrhoea in children
- These are transmitted by the fecal-oral route.
- Person-to-person spread through contaminated hands is probably the most important means.
- Infected food handlers may contaminate food.

Group E affects swine
Group D, E and F affects chicken
Viral Hepatitis

- Viral agents are classified with entrovirus group of the family Picornaviridae (RNA Virus)
- In human beings, hepatitis A, hepatitis E and hepatitis F viruses are transmitted by contaminated water.
- These cause mild form of jaundice.
- Hepatitis E virus may sometimes cause severe jaundice in pregnant ladies.
- Viruses are excreted in the faeces
Hepatitis A virus

- The term hepatitis A (HA) or type A viral hepatitis has replaced all previous designations: infectious hepatitis, epidemic hepatitis, epidemic jaundice, catarrhal jaundice, infectious icterus, Botkins disease, and MS-1 hepatitis.
- HAV is excreted in faeces of infected people
- Contamination of water in addition to milk and milk products, vegetables, salads, shellfish, and iced drinks are commonly implicated in outbreaks.
Hepatitis E virus

- Hepatitis epidemics occurred in India in the 1950s
- That were non-A non-B and attacked mainly young adults, resulting in high mortality among pregnant women,
- The likely etiological agent, hepatitis E virus, was only recognized in 1990.
- Epidemics have been recognized in Asia, Africa, Peru and Mexico, mostly linked to faecal contamination of water.
- Based on its physicochemical properties it is presumed to be a calici-like virus.
- Disease caused by HEV is called hepatitis E, or enterically transmitted non-A non-B hepatitis (ET-NANBH).
Other names include faecal-oral non-A non-B hepatitis, and A-like non-A non-B hepatitis.

Clinically indistinguishable from hepatitis A disease.

Symptoms: malaise, anorexia, abdominal pain, arthralgia, and fever.

HEV has not been isolated directly from foods.

Transmitted by the faecal-oral route and through contaminated water.
Norwalk virus

- Norwalk virus is the prototype of a family of unclassified small round structured viruses “SRVs” which may be related to the caliciviruses.

- Family consists of several serologically distinct groups of viruses that have been named after the places where the outbreaks occurred.

- Also known as: viral gastroenteritis, acute nonbacterial gastroenteritis, food poisoning, and food infection.
Disease is self-limiting, mild, and characterized by nausea, vomiting, diarrhoea, and abdominal pain. Headache and low-grade fever may occur.

Transmitted by the faecal-oral route via contaminated water and foods.

Water is the most common source of outbreaks.

Outbreaks of gastrointestinal disease through ingestion of contaminated water and food (raw shellfish).
Caliciviruses

- Cause gastroenteritis in adults and older children.
- These are members of family *Caliciviridae*.
- Two genera of this family are associated with disease in young children.

1. *Norovirus*:
   - Main feature of infection is severe vomiting
   - Aerosol infection may occur.

2. *Sappovirus*:
   - Main feature is persistent watery diarrhea
   - Mortality is usually less.
Astroviruses

• Members of family Astroviridae.
• wide host range.
• present in GIT of every mammals and young ducklings.
• mild diarrhea occurs due to infection.
• in young ducklings causes severe hepatitis.
Adenoviruses

- These are members of family *Adenoviridae*.
- Second most common cause of viral diarrhea in human beings.
- Severe watery diarrhea in children of one to two years of age.
- Nosocomial infection may also occur.
- In animals and birds these are associated with respiratory and gastro intestinal disease.
Polio virus

- **Disease:** Polio
- **Description:** communicable disease, fatal if the nerve cells in the brain are attacked (bulbar poliomyelitis), causing paralysis of essential muscles
- **Route of exposure:** gastro-intestinal
- **Mode of transmission:** untreated sewage; may also be waterborne, human-to-human contact through the mouth due to faecally contaminated water or food
Avian influenza virus

- Belong to family Orthomyxoviridae
- Infect domestic birds, wild water fowls, humans, sea mammals, horses, felines and pigs.
- Wild water fowls carry these viruses across continents in their guts. Mortality has been observed in these birds.
- Virus replicates in their guts and is secreted in nasal and oral secretions and cloaca of affected birds.
- Infected water fowl excrete up to $3 \times 10^9$ EID$_{50}$ of virus per gram of faeces.
- Infection to human spreads only after gene reassortment with human influenza viruses in swine but recently direct transmission with H5N1 subtype has been recorded.
Conclusion

• Water borne epidemics and health hazards in the aquatic environment are mainly due to improper management of water resources.

• Proper management of water resources has become need of the hour as this would lead to cleaner and healthy environment.

• In order to prevent the spread of water-borne disease adequate precautions should taken.

  • the city water supply should be properly checked for leaks and cracks.

  • at home, water should be boiled or filtred.
THANKS
<table>
<thead>
<tr>
<th>S. NO.</th>
<th>MICROBIOLOGICAL PARAMETER</th>
<th>STANDARD (AS MAXIMUM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Escherichia coli</td>
<td>Not detectable</td>
</tr>
<tr>
<td>2</td>
<td>Fecal coliforms</td>
<td>Not detectable</td>
</tr>
<tr>
<td>3</td>
<td>Total coliforms</td>
<td>Not detectable</td>
</tr>
<tr>
<td>4</td>
<td>General bacteria population expressed as background colony counts on the total coliform membrane filter</td>
<td>200 colony forming units (CFU) per 100 milliliters</td>
</tr>
<tr>
<td>5</td>
<td>General bacteria population expressed as colony counts on heterotrophic plate count</td>
<td>500 colony forming units (CFU) per millilitre</td>
</tr>
</tbody>
</table>
TOTAL COLIFORMS – AN INDICATOR

- Indicator Organisms for drinking water = total coliforms, fecal coliforms, *E. coli* (generic)

- provide evidence of fecal contamination, (i.e.: pathogenic bacteria, protozoa or viruses)