Water Microbiology

- Study of microorganisms and their communities in water environment is called *Aquatic microbiology*,
- while *Water Microbiology* relates to the study of microorganisms in potable water.

- The scope of Aquatic Microbiology is wide and includes the habitats like planktons, benthos, microbial mats and biofilm which may be found in lakes, rivers, streams, seas, groundwater, rain, snow and hail.

Drinking Water Microbiology

- Drinking or *potable water* is water that is free from pathogens and chemicals that are dangerous to human health.
- Any taste, odor and color must be absent from the water to be palatable.
- Raw water may contain many contaminants derived from sewage and nearby industries.
- Many enteric pathogens are water borne.
- Therefore water is treated and disinfected to remove chemicals and pathogens respectively.

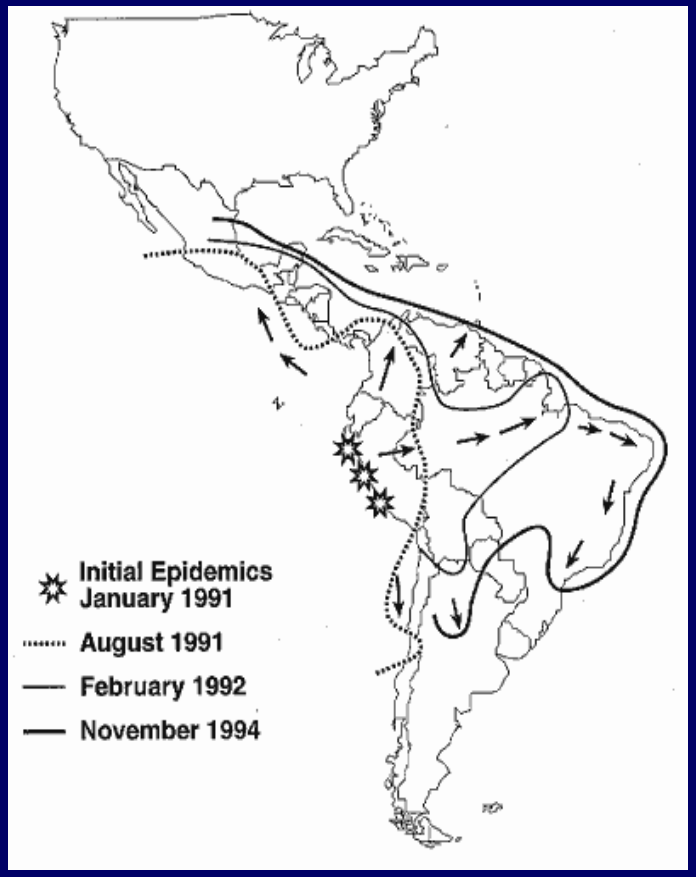
Water-borne diseases

- An important aspect of Water Microbiology is numerous disease causing microorganisms spread through water.
- Many bacteria, viruses, fungi and protozoa are responsible for waterborne diseases.
- The recurrence of waterborne illness has led to the improvement in water purification.

Water borne pathogens

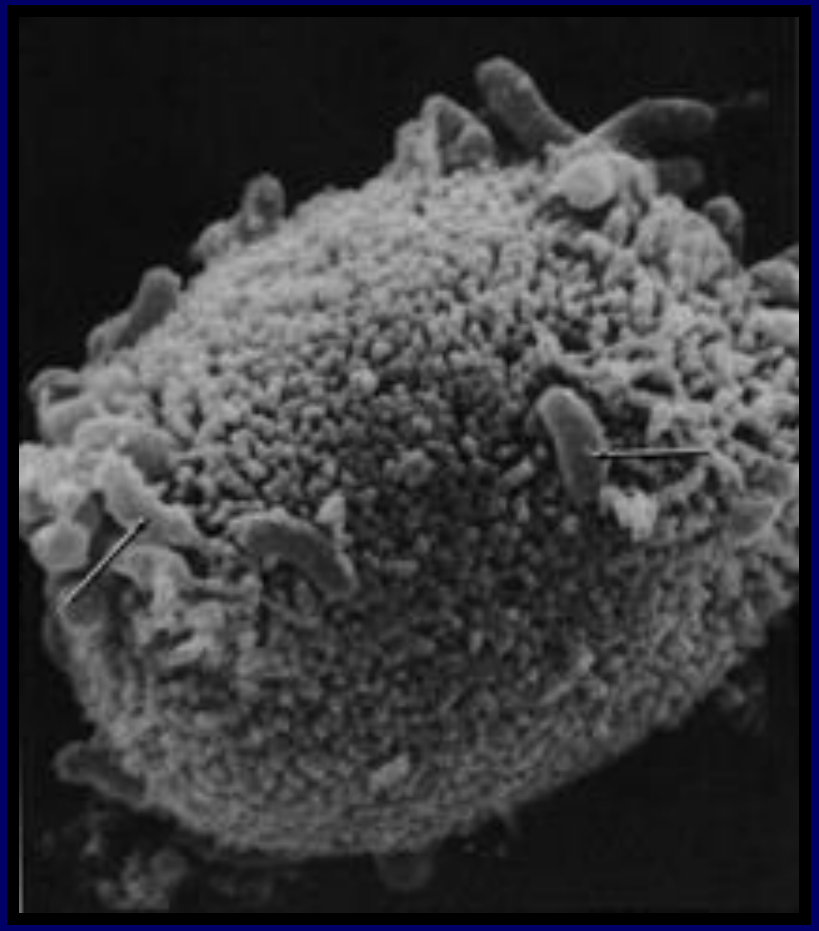
1991 Cholera Epidemic
1,000,000 cases/10,000 deaths

- Bacteria
- Virus
- Protozoa
- Helmiths
- Spirochete
- Rickettsia
- Algae



Bacteria

- Enteritis, diarrhea, and dysentery
  - Campylobacter - Cholera
  - Cholera - *E. coli* 0157:H
  - Salmonella
  - Shigella
- Enteric fever
  - Typhoid
  - Paratyphoid
- Paralysis
  - Botulism
- Eye, ear, and skin infections
  - Miscellaneous bacteria
- Urinary tract infections
  - *E. coli* - Others

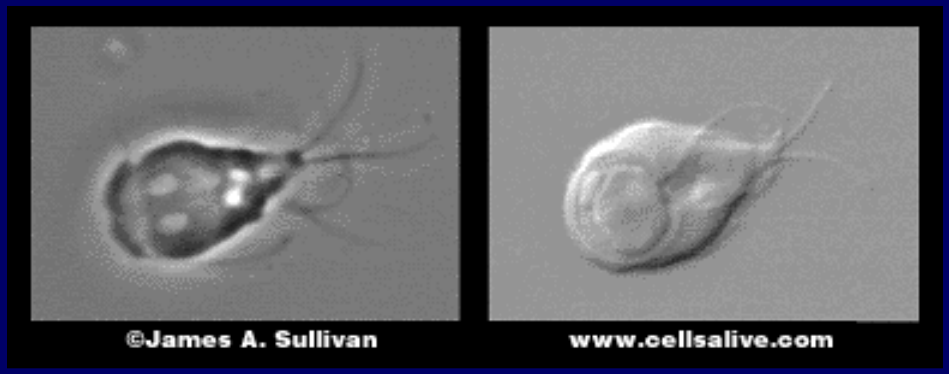


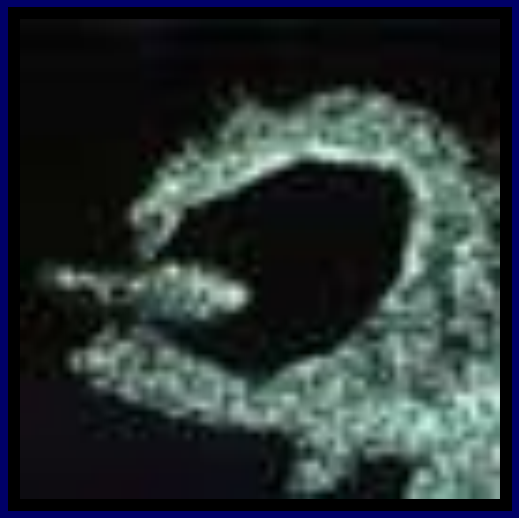
Viruses

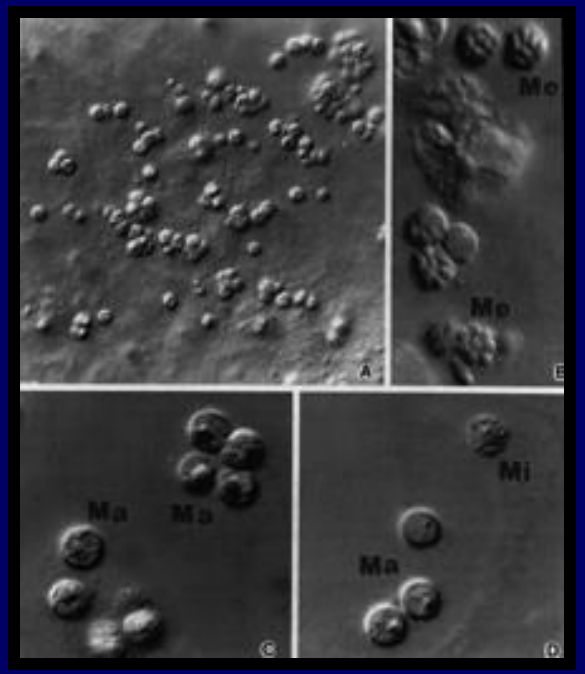
- Enteritis, diarrhea, and dysentery
  - Rotavirus
  - Norwalk
- Flu like (liver damage)
  - Hepatitis A
  - Hepatitis E
- Paralysis
  - Polio

Protozoa

- Giardia
- Cryptosporidia
- Amoeba

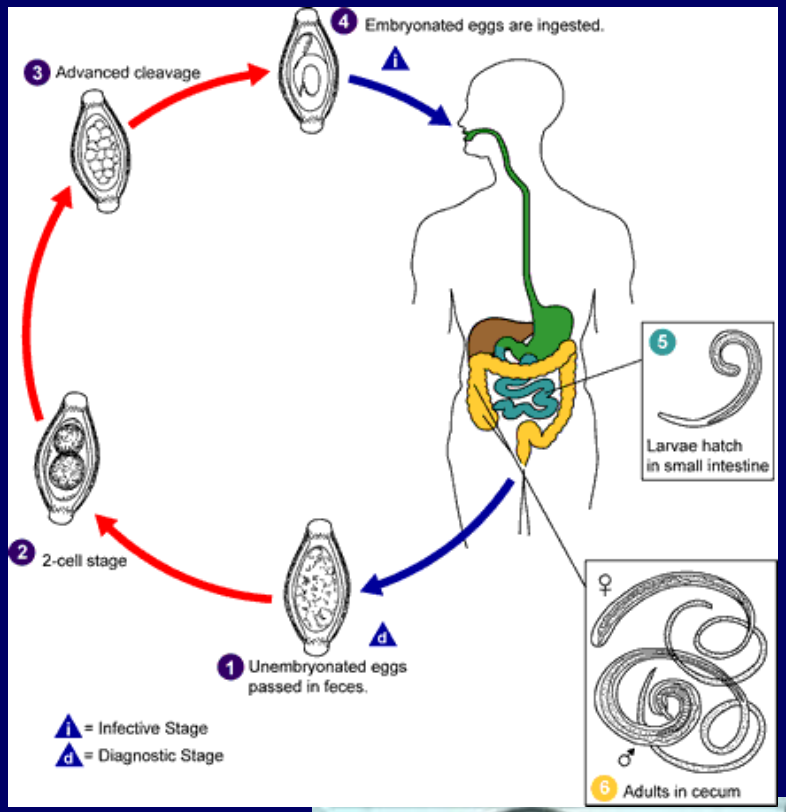


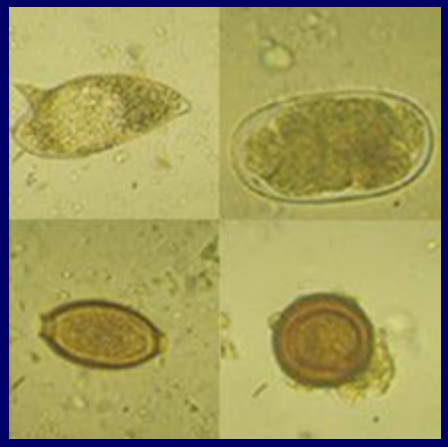


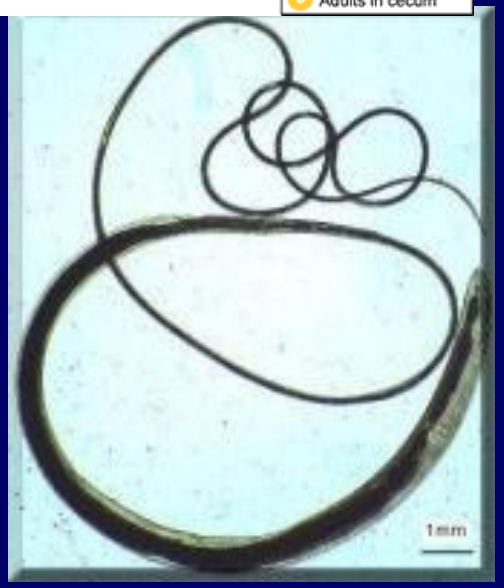


Helminthes

- Round worm
- Tape worm
- Hook worm
- Whip worm

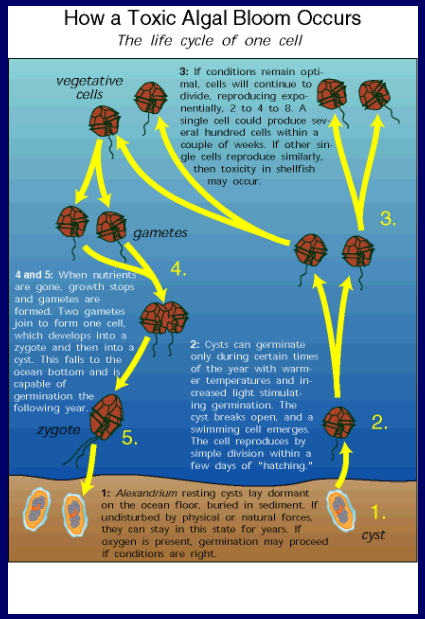


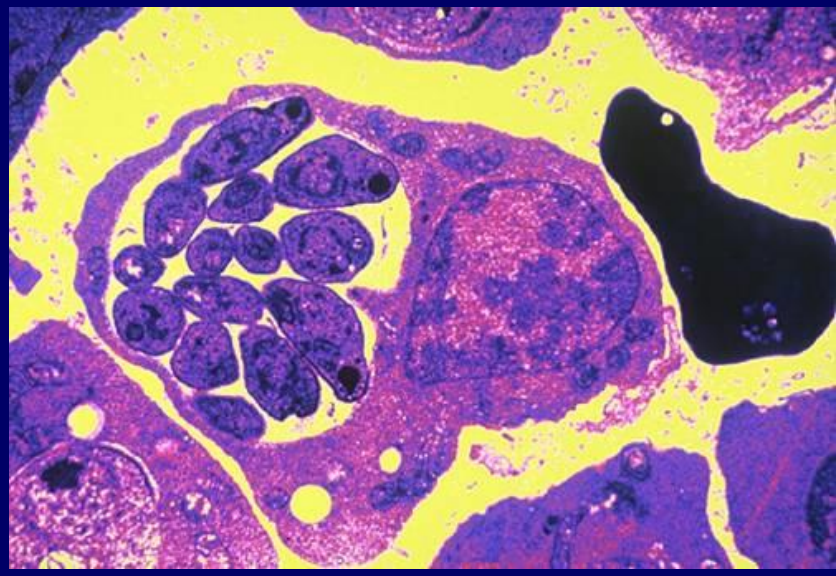




Others

- Algae
  - Mycrocystis
  - Dinoflaggelates
- Fungi
- Water-related diseases
  - Malaria
  - Schistosomiasis
  - Yellow fever
  - Dengue fever





water-borne diseases and their causative agent

Bacteria	Disease
Salmonella typhi	Typhoid
Other *Salmonella* spp	Salmonellosis (gastroenteritis)
Shigella spp.	Shigellosis (bacillary dysentery)
Vibrio cholerae	cholera
Vibrio parahaemolyticus	Gastroenteritis
Escherichia coli	Gastroenteritis
Legionella pneumophila	Legionnaire’sdisease
Yersinia enterolitica	Gastroenteritis
Campylobacter spp.	Gastroenteritis
Leptospira spp.	Jaundice

Virus	**Disease**
Hepatitis A virus	Hepatitis
Polio virus	Poliomyelitis
Protozoa	**Diseases caused**
Giardia intestinalis	Giardiasis
Balantidium coli	Balantidiasis
Entamoeba histolytica	Amoebic dysentery
Cryptosporidium parvum	Cryptosporidiosis
Cyclospora cagetanensis	Diarrhoea
Naegleria fowleri	Encephalitis

Microbiological Examination of Water

- **Numerous water borne pathogens**
- **Individual pathogen numbers may be too low to detect in a reasonable sized water sample**
- **Isolation and detection of some pathogens can take several days, weeks, or months**
- **Absence of one particular pathogen does not rule out the presence of another**

Indicator Organism Concept

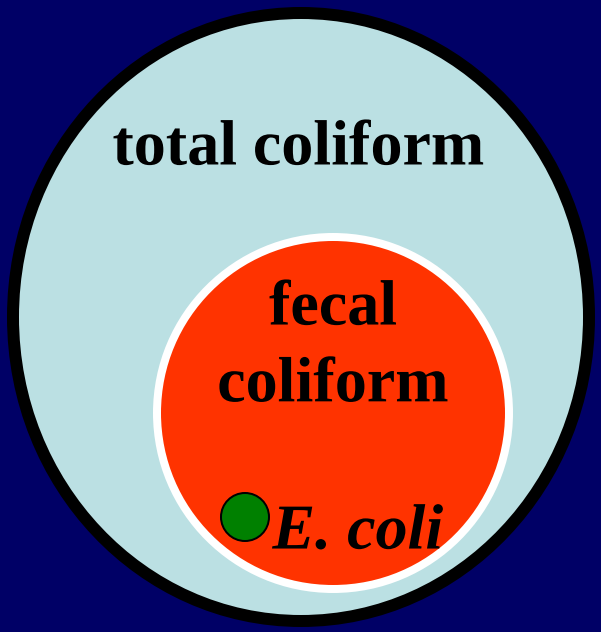
- Correlated to the presence of pathogens
- Population large enough to isolate in small water samples (100 mL)
- Rapid
- Inexpensive
- Safety, not culturing pathogens

Coliform Group (total coliform)

- Enterobacteriaceae
  - Facultative anaerobe
  - Gram negative
  - Non-spore forming
  - Rod shaped
  - Ferment lactose
  - Produce gas and acid within 48 h @ 35ºC
- Coliform genera
  - *Enterobacter*
  - *Klebsiella*
  - *Citrobacter*
  - *Escherichia*

Coliform Group

- Total coliform
- Fecal coliform
  - All total coliform criteria
  - Grows at 44.5ºC
- *Escherichia coli*
  - Individual species
  - Enzyme specific



Streptococcus and *Enterococcus*

- **Fecal Strep**
  - ***S. faecalis***
  - ***S. faecium***
  - ***S. avium***
  - ***S. bovis***
  - ***S. equinus***
  - ***S. gallinarum***

- ***Enterococcus***
- **Fecal Streps that survive in 6.5% sodium chloride**
  - ***S. faecalis***
  - ***S. faecium***
  - ***S. avium***
  - ***S. gallinarum***

Other indicator organisms

Indicator organism	Characteristics	Significance
Clostridium perfringens	anaerobic spore former, gram positive rod shaped and exclusively of fecal origin. Spores are resistant and persist for long periods.	useful indicator of past pollution, a tracer for less hardy indicators, protozoans and viruses.
Bifidobacterium and *Bacteroids*	primarily associated with humans they can distinguish human and animal contamination.	*B. bifidus*survives for a short time therefore its presence suggests relatively recent pollution

Indicator organism	Characteristics	Significance
F-specific RNA phage, f2, φx174, MS2, PRD-1	Coliphages, not always seen associated with fecal pollution however their presence in high numbers in wastewater and high resistance to chlorination can be an index of wastewater contamination and indicators of enteric viruses.	useful for evaluation of virus resistance to disinfectants, fate of enteric viruses in water treatment and surface or groundwater tracers and presence of host.
Phages of *Bacteroides fragilis*	of human origin exclusively	An advantage over coliphage is they help to detect human fecal contamination.They do not multiply in the water and have decay rate similar to other viruses.

Indicator organism	Characteristics	Significance
Pseudomonas aeruginosa	associated with the diseases of eye, ear, nose and throat infections. common opport-unistic pathogen, causes life threatening infection in burn patients and immuno-compromised individuals. Folliculitis, dermatitis, ear and urinary infections are common in ill maintained swimming pools.	this organism is of no value as indicator of fecal pollution however coliforms do not suit as indictor of contamination of swimming pool water as the contamination is not of fecal origin.

Indicator organism	Characteristics	Significance
Staphylococcus aureus and *Candida albicans*	suggests the sanitary quality of water because it presence is associated with human activities	Useful for recreational waters.
Aeromonas hydrophila	occurs in uncont-aminated, as well as contaminated waters. also an opportunistic pathogen in humans, animals and fish.	Because of its association with nutrient rich conditions it has been suggested as an indicator of nutrient rich status of the waters.

Membrane Filter Methods

- Filter water through a 0.45 µM membrane filter
- Place membrane on selective media
- Incubate
  - 35ºC total coliform
  - 44.5ºC fecal coliform
- Count colonies

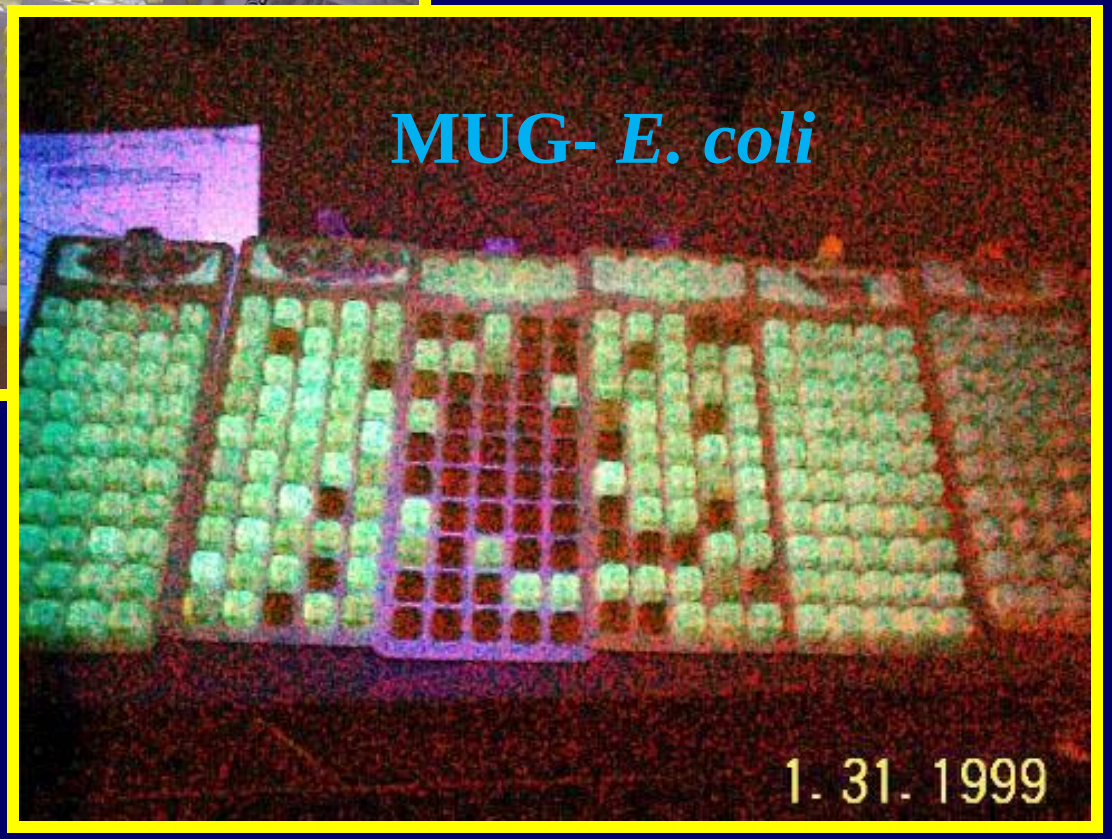
Multiple Tube Fermentation Methods

- Serial dilution to extinction
- Inoculate multiple tubes (5 or 10) of media with across the increasing series of dilutions
- Incubate
  - 35ºC or
  - 44.5ºC
- Count positive growth tubes
- Use Most-Probable-Number (MPN) table to estimate density

Enzyme Substrate or Chromogenic Substrate Method

- Used with the Presence-Absence, the Multiple Tube Methods, or Quanti-Trays™
- Total coliform have the enzyme
  - β-D-galactosidase which hydrolyses
  - ortho-nitrophenyl- β-D-galactopyranoside (ONPG)
  - Yellow when hydrolyzed
- *E. coli* has the enzyme
  - β-glucuronidase which hydrolyses
  - 4-methylumbelliferyl-β-glucuronide (MUG)
  - Fluoresces when hydrolyzed


ONPG-Total Coliform


MUG- *E. coli*
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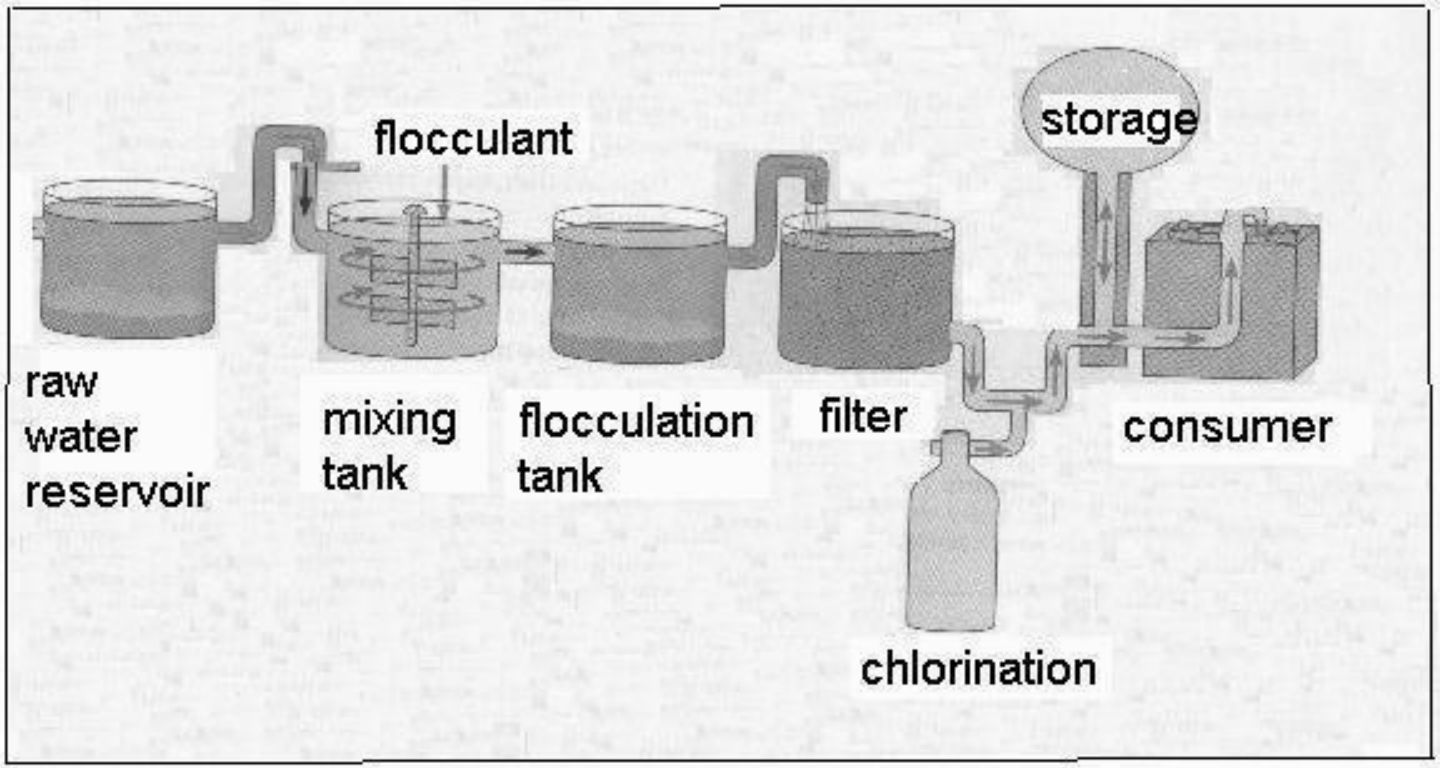
Water purification

- Water purification forms a critical link in promoting public health and safety.
- It involves variety of steps which depend upon the type of impurities in the raw water source.
- The major operations done are sedimentation, flocculation, filteration and disinfection.


flocculant
storage
raw
water
reservoir
mixing
tank
flocculation
tank
filter
consumer
chlorination

Unit processes and operations and specific impurities removed

	Unit Processes / operations	Effect
1	Aeration, chemical oxidation, ion exchange, sedimentation	Colour and precipitate removal
2	Chemical precipitation, (dosing, mixing, flocculation, settling) ion exchange	Softening (Ca, Mg removal)
3	Chemical coagulation, (dosing, mixing, flocculation, settling) filtration	Turbidity removal
4	Aeration, chemical oxidation, adsorption	Taste and odour removal
5	Irradiation, ozonation, chlorination	Disinfection