CE 421/521 Environmental Biotechnology

Public Health Microbiology

Pathogens and parasites

I. Epidemiology

A. Definitions

- epidemiology = study of spread of d_____ in populations
- infectious disease = disease that are spread from one h_____ to another
- incidence = number of i_____ with the disease in a population
- prevalence = the p_____ of a population with the disease at a given time
- epidemic = disease outbreak with a high i_____
- endemic = disease outbreak with a l_____ incidence
- pandemic = disease outbreak across c_____

B. History of epidemiology

- one of the early theories was that disease was caused by b_____ a_____ (malaria actually means "bad air")
- microorganisms weren't s_____ until Antonie van Leewenhoek - a 17th Century native of Holland devised the first m_____ with sufficient magnification to see protozoa and bacteria
- wasn't until the middle of the 19th Century that s_____ and disease were linked - cities that cleaned up their filth and rubbish had lower i_____ of disease
- J_____ S_____ and the Broad Street pump in 1854
- he was able to show that 59 of the 77 c_____ victims used the pump on Broad Street

- There was a w_____ in the vicinity where cholera was endemic but nobody at this workhouse got cholera. This particular workhouse had its own w_____. The cause of contamination turned out to be the d_____ of an infected person that was within three feet of the well.

C. Background

- many if not most pathogens are w_____ and are therefore a concern to environmental engineers
- need to be familiar with l_____ c_____ of pathogens: some can stay infective for periods longer than one year, some less than one day, some have a l_____ period greater than one year
- almost all pathogens can be spread by a s_____ carrier - makes detection difficult
- usually the very young, very old, and those with w_____ i_____ systems are affected the most

D. Chain of infection

1. Infectious agent - m_____ i_____ dose (MID) varies widely

- b_____
- v_____
- p_____
- h_____

2. Reservoirs - required for pathogen to s_____ and m_____
   - Can be l_____: humans, animals, plants
   - Or non-living: s_____, w_____, w_____
3. Mode of transmission
   - Person to p_____ - most common (STDs, hands, coughing, sneezing fall into this category)

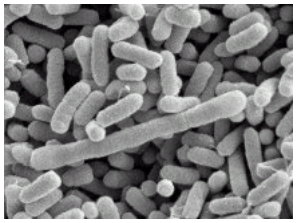
   - W_____ - intestinal illnesses (gastroenteritis), giadiasis, cryptosporidiosis (Milwaukee, Wisconsin , 1993: 400,000 affected, 47 deaths - animal runoff suspected)
   - F_____ - irrigation water, handling, preparation, shellfish
   - A_____ - legionaires disease
   - V_____ - malaria
   - F_____ - clothing, toys, etc.
4. Portal of E_____
   - Gastrointestinal t_____
   - R_____ tract
   - S_____
5. Host susceptibility
   - A_____
   - Natural or acquired i_____
   - H_____ (mental and physical)

II. Pathogens in Wastewater

A. Bacteria

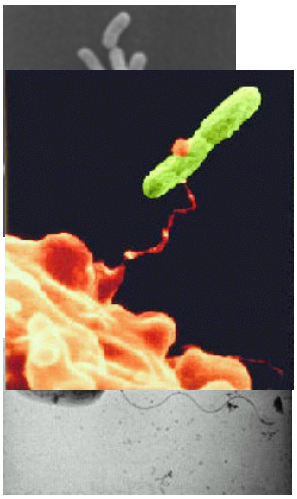
- F_____ material contains approximately 10^{12} bacteria per gram
- B_____ content is approximately 9% of the weight (wet basis)
- Most cause gastroenteritis (d_____ - inflammation of the intestines and loss of blood) or d_____ (typhoid fever is a notable exception)

- Important groups:
  - *Salmonella* - most p_____ (over 2000 types)
    - primarily a f_____ contaminant, but transmission by _____ water possible
    - causes gastroenteritis
    - *Salmonella typhi* produces t_____ causing

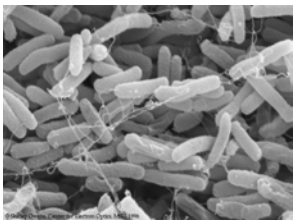


typhoid fever

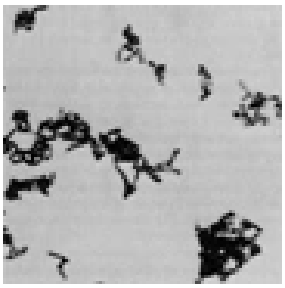
- *Shigella* - causal agent of bacillary d_____
  - small i_____ dose (as low as 10 organisms)
    - mode of t_____: primarily person to person, but f_____ and waterborne possible (outbreak in Florida of 1200 people)
      - difficult to e_____ in laboratory (viable but not culturable)



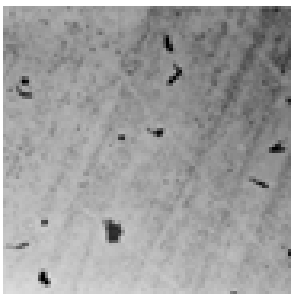
- *Vibrio cholera* - causative agent of c_____ - profuse diarrhea, r_____loss of fluid, causing death in short time period
  - e_____ in various parts of Asia (Bengal state of India, Bangladesh)
  - documented outbreaks linked to s_____ contaminated v_____
- *Escherichia coli (E. Coli)* - found in gastrointestinal tract of humans and w_____ blooded animals
  - many are harmless, some p_____
  - 2-8% have been found to be enteropathogenic (EPEC) causing t_____ diarrhea
  - infective d_____ is relatively high - 10^6 to 10^9 organisms
  - several outbreaks have been associated with water d_____ systems
    - Scotland (1990)
    - Cabool, Missouri (1990) 243 documented cases of diarrhea and four d_____



- *Yersinia* - a_____ gastroenteritis
  - s _____are a major reservoir
  - waterborne incidence was suspected as cause of some o_____
  - psychotrophic - t_____ at low temperatures (~ 4˚C)
  - poorly c_____ with bacterial indicator organisms



- *Campylobacter* - a_____ gastroenteritis
  - municipal water supplies and m_____ streams implicated for outbreaks:
    - V_____ (1978) 2,000 out of a population of 10,000 infected
    - high recovery of organisms in s_____ water in Fall (55% of samples positive) and Winter (39% of samples positive)
    - poorly correlated with bacterial i_____ organisms



- *Legionella pneumophilia* - causative bacteria in Legionaire's disease

first encountered in P_____ in 1976

- found in natural habitats such as l_____ and r_____
- acute pneumonia (respiratory distress) with high f_____ rate
- organism is s_____ by aerosolization
- microbial a_____ from evaporative condensers, humidifiers and cooling towers
- also affects gastrointestinal, u_____, and nervous system
- can be persistent in local water distribution systems (e.g. h_____)

• Other opportunistic bacterial pathogens

- *Pseudomonas*
- *Aeromonas*
- *Kleibsiella*
- *Flavobacterium*
- hospitals can harbor a_____ resistant strains

B. Viruses

• 140 known v_____ pathogens

• Smallest "living" unit, but are they alive? Require a h_____ c_____to reproduce

• Invade cells and take over their m_____ functions

• Infect h_____, animals, plants, bacteria, protozoa, etc.

• Weren't identified until 1931 with advent of e_____ microscope

• Viruses are ingested, m_____ in intestines and are excreted in large numbers

• Usually present in small numbers overall therefore need to be c_____ in order to detect

• Adsorption to m_____ filters

• D_____ using animal tissue culture, immunological testing (ELISA) or gene probes

• Most probable transmission is p_____ to person or foodborne, but w_____ transmission also possible

• Infection depends on MID and host s_____

• MID is s_____ compared to bacterial pathogens (tens of plaque forming units, PFUs)

• Viruses can cause f_____, diarrhea, respiratory infection, meningitis, or paralysis

• Difficult because can't treat with a_____ (can use antibiotics to prevent secondary infection)

• Some v_____ available

- Major Viruses of Concern
  - Hepatitis A (i_____ Hepatitis - HAV) oral/fecal route
    - short i_____ period (2-6 weeks)
    - oral/fecal route of transmission (water borne, foodborne, or person to person)
    - causes l_____ damage, nausea, fatigue, jaundice (yellowing of eyes), loss of appetite
    - p_____ worldwide
    - s_____ contamination of particular concern
    - c_____ shellfish in 1988 in Shanghai was responsible for 292,000 cases
  - Hepatitis B (s_____ Hepatitis - HBV)
    - transmitted by infected b_____ or sexual contact
    - higher m_____ than HAV (1-4%)
  - V_____ gastroenteritis
    - *rotavirus* - 70-nm particles, d_____ stranded RNA
      - acute i_____ gastroenteritis
      - responsible for significant proportion of childhood mortality in d_____ countries (millions of deaths per year)
      - major c_____ of traveler's diarrhea
      - w_____ pathogen
      - fecal/oral route most l_____, but respiratory route also suspected
      - ELISA kits are available for d_____
    - *Norwalk virus* - small 27 nm virus d_____ in Norwalk, Ohio
      - waterborne and f_____
      - difficult to detect in e_____ samples
      - gastroenteritis and traveler's diarrhea
      - 42% of n_____ gastroenteritis attributed to Norwalk virus in one study
  - Other viruses
    - AIDS/HIV - not considered a waterborne pathogen, but may s_____ in water for a limited time
    - c_____ virus - not waterborne
    - adenovirus - can cause e_____ infections (conjunctivitis) in swimming pools and respiratory disease
    - poliovirus - can cause p_____, aseptic meningitis

C. Protozoa
- Most produce c_____ that are resistant to disinfection, can survive for

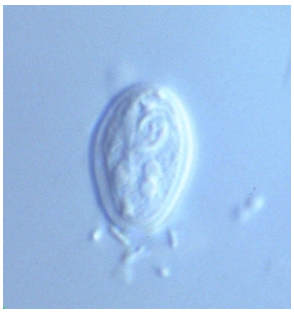
long periods of time

- In 1991-1992 there were 34 disease o_____ associated with waterborne pathogens affecting about 17,000 people
  - five of 34 were c_____ water systems
  - 29 were c_____, resorts, recreation areas, restaurants, and private systems
  - in 11 of the outbreaks the cause was i_____
  - 7 of the 11 were p_____ parasites *Giardia* or *Cryptosporidium*
  - 4 were h_____ A, shigella, or specific chemicals

- *Giardia lamblia*

- i_____ person can excrete 10^6 cysts per gram of feces
- wild and domestic animals act as r_____
- e_____ in mountain areas (beavers, muskrats, dogs, cats)
- infection may last for months to y_____
- MID is f_____ than 10 cysts
- causes diarrhea, a_____ pain, nausea, fatigue, and weight loss (rarely fatal)
  - b_____ diarrhea
  - i_____ may last from months to years

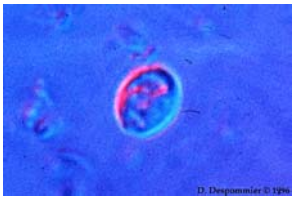
  - first major outbreak occurred in Rome, NY in 1975 - 5,000 people (10% of the population) water had been c_____ but not f_____
  - major factor in waterborne outbreaks (as high as 50%)
- i_____ organisms don't correlate well, cryptosporidium does
  - *Giardia* has been detected in 16% of p_____ water supplies at an average concentration of 3 cysts per 100 mL
  - prevalence may be as high as 80% of s_____ water supplies



- *Cryptosporidium*
  - prevalent in c_____ and sheep (billions of oocysts shed in feces every day)
  - infections in h_____ not detected until 1970's
  - incidence in w_____ outbreaks not identified until late 1980's
- cyst releases sporozoite after i_____

- l_____ MID (possibly as low as 1-10)
- p_____ diarrhea, rapid water loss, weight loss, nausea, vomiting, fever
- diarrhea lasts from 1-10 days usually, longer for immunodeficient p_____
- prevalence in population is approximately _____%
- person to person contamination most probable route, hygiene important - especially in d_____ c_____ c_____
- major waterborne outbreaks:

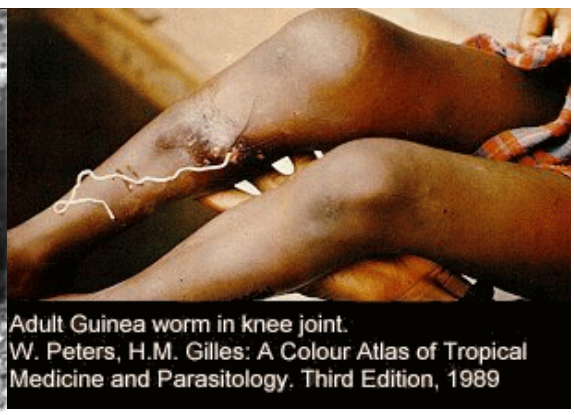
New Carrollton, Georgia
1987 - 13,000 people infected
No indicator organisms identified
39% of patients t_____ p_____ for crypto
Improper s_____ f_____ operation implicated



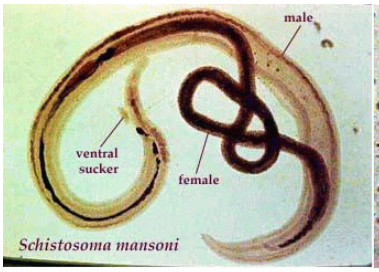
Milwaukee, Wisconsin
1993 - 403,000 people infected, several deaths (#?)
Improper c_____ and sand filter operation implicated

- *Cryptosporidium* has been detected in _____% of potable water supplies at an average concentration of 43 cysts per 100 mL
- p_____ may be higher in surface water supplies

D. Helminths
- Similar to protozoan o_____ in survivability and resistance to disinfection
- Parasitic w_____
- most are transmitted in contaminated f_____
- Some are transmitted by other routes: *Schistosoma* in u_____
- *Dracunciliasis* (guinea worm) - skin b_____



Adult Guinea worm in knee joint.
W. Peters, H.M. Gilles: A Colour Atlas of Tropical Medicine and Parasitology. Third Edition, 1989



- *Schistosomiasis*
    - Affects nearly _____ million
    - Africa, South A_____, parts of Asia
    - 200,000 d_____ per year
    - Causes enlargement of l_____, diarrhea, anemia
    - Free swimming l_____ in water called cercaria are emitted from s_____ which serve as intermediate hosts
    - Cercaria attach to human s_____ and penetrate to the blood stream
    - They mature in the l_____, eggs are passed in urine
    - Eggs hatch in water into free swimming c_____ larvae and infect snails
    - Milder form of schistosomiasis - s_____ i_____
    - D_____ and irrigation projects in developing countries have created ideal conditions for the spread of the disease
    - *Ascariasis* (roundworms)

- MID is a few infective e_____
- Each female can produce _____ eggs per day
- Resistant to disinfection, can survive 2-7 years in s_____
- High prevalence worldwide _____ million to __ billion (1983)
- 85% of infections are s_____
- Symptoms include pneumonia, nausea, abdominal pain, m_____
    - A child that has _____ worms may lose 10% of his daily intake of p_____
    - Vitamin ____ and ____ deficiencies possible
    - part of life cycle spent in l_____

II. Indicator Microorganisms

A. Introduction

- Use of indicator organisms dates back to 1914 when U.S. Public Health Service adopted the c_____ test as an indication of fecal contamination
- Ideal indicator should have the following characteristics:
    1. Found in i_____ of warm blooded animals
    2. Should be present when p_____ are present and absent when pathogens are absent
    3. Present in greater n_____ than pathogens

4. As r_____ as (or more resistant than) pathogens
5. It shouldn't m_____ in the environment
6. Easily detectable by r_____, inexpensive method
7. Non-p_____ itself

B. Total Coliforms

- Characteristics:
  - Aerobic and f_____ anaerobic organisms
  - gram n_____
  - non s_____ forming
  - r_____ shaped
  - ferment l_____ within 48 h at 35˚C as evidenced by gas production
  - includes *E. coli*, *Enterobacter*, *Kleibsiella*, and *Citrobacter*
  - high levels in human and animal feces _____ per capita per day

C. Fecal Coliforms

- Characteristics:
  - all coliforms that can ferment lactose at 44.5 35˚C as evidenced by g_____ production
  - includes groups such as *E. coli* and *Kleibsiella*
  - p_____ is an indication of human and animal contamination
  - human and animal contamination cannot be d_____
  - s_____ pattern is similar to bacterial pathogens
  - much l_____ resistant to disinfection than protozoan pathogens

D. Fecal Streptococci

- Characteristics:
  - includes groups such as *Streptococcus faecalis, S. bovis, S. equinus,* and *Kleibsiella*
  - inhabit i_____ of warm blooded animals and humans
  - fecal coliform/fecal strep r_____ serves as useful indicator of origin of contamination
  - ratios greater than 4 indicate h_____ origin
  - ratios less than _____ indicate animal contamination
  - inbetween rations indicate a m_____ of human and animal contamination

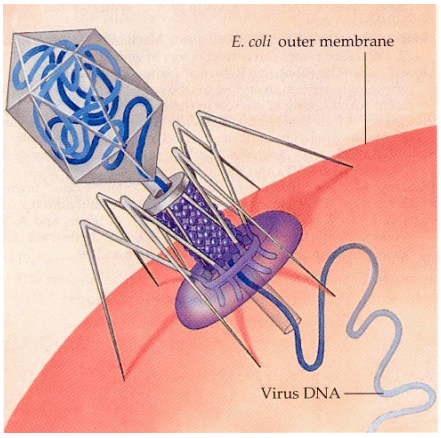
E. Anaerobes

- *Clostridium perfringens*
  - forms s_____ that are resistant to disinfection and environmental stress
  - possibly t_____ resistant to be useful as an indicator

- good for tracking contamination in m_____ environments

F. Bacteriophages

- Similar to enteric v_____ and found in higher numbers
- Suggested as water quality indicators in e_____, seawater, recreational waters, and drinking water
- C_____ exhibit best correlation to enteric viruses



G. Heterotrophic Plate Count (HPC)

- Measure of aerobic and facultative anaerobic bacteria that derive their c_____ and e_____ from organic compounds
- No known effects of high HPC on h_____ health
- HPC in drinking water ranges from less than _____ CFU/mL to more than ____ CFU/mL
- Good indicator of pathogens in r_____ wastewater