

E. coli and Alternatives as Indicators of Fecal Pollution

Sheridan Kidd Haack, PhD

US Geological Survey

Michigan Water Science Center

Lansing, MI

517-887-8909

skhaack@usgs.gov



Human Sources

- WWTPs
- CSOs
- Land application of municipal biosolids or septage
- Illicit connections to storm or agricultural drains



A Michigan beach



MDEQ: image of a septage application violation



A Michigan beach



Animal Sources



Pathogens Associated with Fecal Pollution

- Bacteria (many can be transferred from animals)
 - *E. coli* O157:H7, *Campylobacter*, *Arcobacter*, *Salmonella*, *Shigella*, *Yersinia*
 - *Aeromonas*, *Pseudomonas*, *Legionella*, nontuberculosis mycobacteria, *Helicobacter*?
- Protozoa (many can be transferred from animals)
 - *Cryptosporidium*, *Giardia*, microsporidia
- Viruses (most viruses are host-specific)
 - Noroviruses, rotavirus, enteric viruses, Hepatitis A virus, adenovirus

From: Leclerc et al. 2002.

Other Concerns for Fecal Pollution

- Nutrients – e.g. nitrate, ammonia, phosphorous
- Organic Carbon – oxygen demand
- Chemicals
 - Pharmaceuticals, biogenic and synthetic hormones
 - Conventional pollutants associated with waste streams
 - Metals
 - Solvents

How Do We Evaluate Fecal Pollution of Water?

- Water must be free of “fecal pollution”
 - Not necessarily free of pathogens
- How do we define “free of fecal pollution”?
 - Quantify the numbers of “fecal indicators”
 - Microbes primarily found in intestines of animals or humans
 - do not cause disease themselves
 - presence in water is assumed to indicate fecal pollution
 - Total coliforms, fecal coliforms, *E. coli* and newer indicators such as coliphage or *Clostridium perfringens*

What Are the Characteristics of a Good Fecal Indicator?

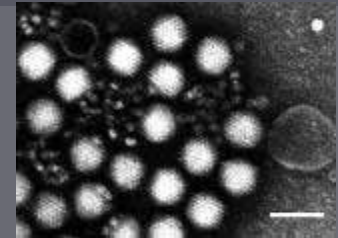
- Only source is feces
 - Does not occur naturally in environment
 - In other words: **Not a false positive**
- Behaves in environment like pathogens it represents
 - Present when they are
 - In other words: **Not a false negative**
- Is easy to measure
 - Reasonable cost
- Is *E. coli* a good fecal indicator?

Microbial Agents Differ in Physical and Survival Characteristics

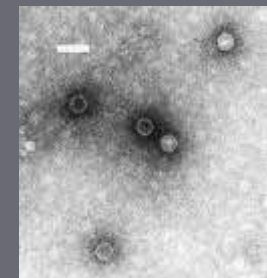
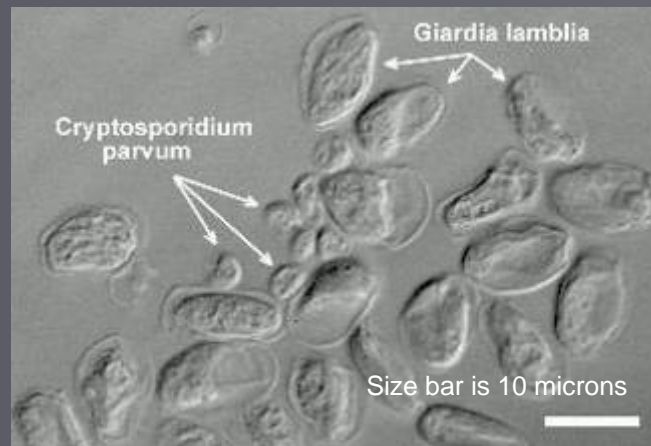


E. coli bacteria

- Fecal indicator bacteria may survive (even grow) in the environment
- Bacteria are relatively susceptible to chlorination and UV
- Viruses, *Cryptosporidium* and *Giardia* cannot grow in the environment and may be less susceptible to treatment



Adenovirus and parvovirus (upper); poliovirus, lower. Bars are 0.1 to 0.05 microns



Credits: Lewis Tomalty and Gloria J. Delisle, Department of Microbiology, Queens University, Kingston, Ontario, Canada Licensed for use, ASM MicrobeLibrary (linked to <http://www.microbelibrary.org>); H.D.A. Lindquist and F. P. Williams, U.S. EPA

E. coli Survival/Growth

- There is some evidence for some “natural” populations of *E. coli* in the Great Lakes
- Some *E. coli* may survive/grow in soils
- Such *E. coli* would be false **positive** indicators of fecal contamination
- The percentage of such *E. coli* is unknown
 - May only be an issue in waters not influenced by true sources of fecal pollution

E. coli Are Poor Indicators of Viruses or Protozoa

- *E. coli* (and most other bacteria) simply do not survive under conditions where viruses and protozoa may survive.
- Many studies have detected viruses or protozoa in water (especially ground water) that is free of *E. coli* or other indicator bacteria.
- In this case, *E. coli* would be false **negative** indicators of fecal contamination

Advantages of *E. coli*

- Proven association with human disease for recreational waters influenced by human fecal pollution
 - Also true for enterococci
- Inexpensive and easy
- Natural waters don't generally have high concentrations of *E. coli*
 - Points to "hot-spots" for further examination

Other Options

- Other microbial indicators of fecal pollution
 - Coliphage – to represent viruses
 - *Clostridium perfringens* – to represent more durable organisms like protozoa
 - Bacteroides –
 - more dominant in gut than *E. coli*
 - Survive poorly in environment
 - Can be typed with regard to human or animal

Other Options

- Other microbial indicators of fecal pollution
 - Human polyomavirus (common in humans)
 - *Esp* gene of enterococci (indicates human source)
 - Other genes of bacteria that indicate sources (cows, swine best developed)

Other Options

- Chemical indicators of fecal pollution
 - Some pharmaceuticals are dependably detected in human wastewater
 - There aren't many chemicals that dependably indicate non-human sources (yet)

Problems with Other Options

- Relation between these indicators and human health is not known
- No indicator is 100% accurate or detected 100% of the time, so multiple-lines-of-evidence are advised
- Methods are not in “kit” format and may be expensive

For Now

- All types of fecal pollution pose hazards to human health
- *E. coli* is the recognized standard
- High concentrations of *E. coli* probably indicate a problem that should be investigated more fully
- *E. coli* is not the problem—it's all the other material that accompanies waste streams that is the real issue

For More Information

- skhaack@usgs.gov
- 517-887-8909
- For USGS Publications:
<http://infotrek.er.usgs.gov/pubs/>