

**Table 2-4. Effectiveness in disinfection by five most common disinfectants**

Pathogen	Free chlorine	Combined chlorine	Chlorine dioxide	Ozone	Ultraviolet light
Bacteria	Excellent	Good	Excellent	Excellent	Good
Viruses	Excellent	Fair	Excellent	Excellent	Fair
Protozoa	Fair to Poor	Poor	Good	Good	Excellent

## 2.8 ROLE OF INDICATOR SPECIES

Some bacterial indicator species have been used for over a century for detecting of pathogens because they are easier to detect using traditional culture methods and their presence in the environment often correlates with the presence of pathogens. Some of the most commonly used indicators are total coliforms, fecal coliforms, and fecal streptococci/enterococci. These organisms are abundant in the gastrointestinal tract of humans and other animals and are commonly used as indicators of fecal contamination. Most historical data on pathogens in surface waters and treated waters are derived from data on indicators species.

Although in recent years there is agreement that the indicator organisms do not fully capture the likely presence of pathogens, there is no agreement on alternative indicators that may be used instead. In a recent study by the National Academy of Sciences (NAS, 2004), it was found that no single indicator was suitable for all purposes. Rather a flexible indicator or indicator system was recommended for use for each circumstance. For example, the suitability of the coliform group as indicator of pathogens is complicated by the environmental behavior of viruses and protozoa. Viruses are known to be able to survive longer than members of coliform group in the environment due to their lack of metabolic activity. Protozoa such as *Giardia* and *Cryptosporidium* are known to exist in environment as cysts or oocysts, which can survive longer in the environment and are resistant to chemical disinfection. Therefore, the absence of coliforms in water does not necessary guarantee the absence of pathogenic viruses and protozoa. For warm waters, indicators such as *Clostridium perfringens* and other sulfite-reducing clostridia may also be used. *Clostridium perfringens* is an anaerobic, Gram-positive, spore-forming, rod shaped bacterium. The spores of *Clostridium perfringens* can survive for decades. The persistence of *Clostridium perfringens* spores in environment suggests that they could be good indicators for protozoa. Other indicators such as coliphages can also be useful components in a system of indicators.

A review of the literature suggests that the search for an ideal pathogen indicator, one that is accurate, as well as relatively easy to measure, will continue into the foreseeable future. For the time being, it appears that fecal indicators will remain a common source of information on the potential occurrence of microbial contamination in surface waters.

## 2.9 SUMMARY

A wide variety of pathogens may be present in surface waters. The fact that they often occur at low numbers and are living organisms with different degrees of survivability

in the ambient environment, makes it challenging to measure them either directly or indirectly through the use of indicator organisms. Despite advances in water treatment and pathogen monitoring across the U.S., outbreaks of waterborne disease nonetheless continue to occur. Municipal water suppliers need to be vigilant particularly because of the episodic, rather than continuous, nature of pathogen contamination and the potential for drinking water pathogens to impact sensitive populations such as the young, the elderly, as well as immunocompromised individuals.