Emerging Waterborne Pathogens

Debra E. Huffman and Joan B. Rose

Florida, with miles and miles of beaches, important environments such as reefs and wetlands, and an abundance of springs, supports an estimated 20 million people. Water issues where quantity and quality are intricately linked are a part of life in Florida, whether one is discussing desalination, wastewater reuse, groundwater protection, aquifer storage and recovery, beach safety, restoration of the Everglades, or septic tank issues.

Like all coastal states or countries, Florida's ground, surface, and coastal aquatic environments are under increased stress from anthropogenic activities. Nearly 90 percent of the world's population resides near coastal areas, and the risks to water quality appear to be increasing. The sources of the problems in Florida often appear to be non-point sources such as animals, cattle, dogs, wildlife, septic tanks, sewer overflows, and stormwaters.

Because the hydrologic system is interconnected, one must be concerned with the quality of water used for all purposes—sustaining life, communities, and economies. Rainwater, surface water, groundwater, coastal and beach waters are all interconnected, with the ecosystem itself connected to the food supply. Poor water quality impacts the integrity of these aquatic ecosystems, as well as public health.

In recent years, more water professionals have become aware of the risks of new and emerging contaminants: newly identified bacteria, protozoa, and viruses, as well as toxic algae that plague fresh and marine surface waters and groundwaters. While management strategies provide opportunities for better water resource management such as aquifer storage and recovery and reclamation of wastewater, serious concerns about emerging contaminants and public health must be addressed.

The Future and New Tools

In the era of the Human Genome Project and the announcement of the complete sequencing of the genetic information that makes up a human being, it is clear that the tools for characterizing microorganisms exist. This genetic assessment also leads to the knowledge of proteins and functions—in this case, the potential for causing waterborne disease. Identification of the microbial hazards, occurrence, transport, and control can all be addressed with the new methods available. Methods that can be automated through the development of instrumentation can be made field-ready. Our biggest challenges will be building consensus methods, developing databases, and interpretating the data.

- Source Tracking: Some molecular techniques are particularly promising as a means to identify the source of a contaminant. Without source identification, contamination may not be contained. Molecular fingerprints, host-specific genes, and chemical constituents provide direct evidence of source origin, while general indicators provide virtually no information about source.
- Pathogen Identification: In order to begin to identify risk, the type of pathogen present should be identified and quantified. In most cases, pathogens are non-cultivatable, and polymerase chain reaction (the system used to copy specific genes) will need to be used. Direct evaluation of microbes in the distribution system (Aeromonas, Mycobacteria), groundwaters (viruses), and surface waters (toxic algae) are now possible.
- Waterborne Genomics: More than 16 waterborne microorganisms have been or will be completely sequenced, thus allowing the identification of the complete pathogen loading of virulence genes, resistance (persistence) genes, and potency genes.
- Rapid Assessment: New instrumentation, such as biosensors that use liquid-core waveguides, will be used in the future to identify the microbial contamination within 20 minutes and will have great application to beaches and groundwaters, as well as the problems that may occur in treatment plants.

Bacterial Pathogens

Early in the 1800s when it became apparent that disinfection of drinking water could prevent waterborne disease epidemics caused by bacterial pathogens such as Salmonella typhi (typhoid fever), most people thought that the days of waterborne bacterial epidemics were gone forever. Unfortunately, this was not to be the case. During the recent decade, there have been a number of waterborne disease outbreaks caused by bacteria such as E.coli O157:H7, an enteropathogenic strain of E.coli that was first identified as a human pathogen in 1982 (Mead and Griffin 1998).

People infected with the organism can experience severe bloody diarrhea with abdominal cramping. In small children and the elderly, fluid replacement is of the utmost importance for a full recovery. A common, more serious complication of infection with E. coli O157:H7 is hemolytic uremic syndrome (HUS), which causes loss of red blood cells and kidney failure. In severe cases, HUS can cause permanent kidney damage or death.

Debra E. Huffman, MPH, PH.D., is a public health microbiologist at the University of South Florida. Joan B. Rose, Ph.D., is a professor of water pollution microbiology at the University of South Florida. Both authors work at the university's College of Marine Science in St. Petersburg.

E. coli O157:H7 has been shown to survive similarly to typical E.coli strains under routine drinking-water conditions. The largest outbreak of E.coli O157:H7 in the U.S. occurred in 1989 in Cabool, Missouri, resulting in 243 cases and four deaths (Geldreich et al., 1992, Swerdlow et al., 1993). The outbreak was linked to the consumption of unchlorinated drinking water. The source of the water for Cabool was deep groundwater wells with no disinfection in the distribution system. Disturbances to the distribution system included the replacement of 43 water meters and two line breaks. Disturbances to distribution systems may provide a pathway for infiltration from stormwater runoff or sewage contamination.

In August 1999, unchlorinated well water contaminated with E. coli was used to prepare beverages and ice at the Washington County Fair near Albany, New York, causing more than 900 cases of illness with 65 hospitalizations and two deaths. Also in 1999, more than 200 people in Petersburg, Illinois, became ill after consuming contaminated food and water at a festival that was being held in a cow pasture.

To date, there has been one documented waterborne outbreak of E.coli O157:H7 (two cases) in Florida. This occurred in 1994 and was associated with consumption of water from a non-community water source that had a treatment deficiency (CDC 1998).

Advanced techniques that combine standard cultural methods with enhanced PCR detection methods have revealed the presence of bacteria not previously associated with waterborne disease transmission, such as Mycobacterium avium. Mycobacterium avium complex (MAC) has been isolated from natural water and drinking-water dis-

Continued from page 21
the fecal-oral and waterborne transmission of Whipple's disease (an intestinal lipodsystrophy disorder) is likely and has yet to be fully investigated. A recent terrorist act associated with the Klingerman Virus, which causes dysentery with a high mortality, means that genetically engineered enteric organisms may now enter the waste stream and the water cycle. Only through continued monitoring studies and the application of new technologies can one address the emerging microorganisms we are likely to see in this next century in the water environment.

References

- Abbaszadegan, M., Huber, M. S., Gerba, C.P., Pepper, I. (1993). Detection of enteroviruses in groundwater using PCR. Appl. Environ. Microbiol. 59, 1318-1324
- Carlson, L.A., Bland, L.A., Cusik, L.B. et al. (1998) Prevalence of non-tuberculosis mycobacterium in water supplies of hemodialysis centers. Appl. Env. Microbiol. 54:3122-3125.
- Carmichael, W.W. (1994) the toxins of cyanbacteria. Scientific Am J. Jan. 270:78-86
- Centers for Disease Control (1998) Surveillance for Waterborne-Disease Outbreaks – United States, 1995 – 1996. 47(SS-5); 1-34.
- Centers for Disease Control (2000) Surveillance for Waterborne-Disease Outbreaks – United States, 1997 – 1998. 49(SS04); 1-35.
- Chorus, I., Bartramm, J. eds. Toxic Cyanobacteria in Water: A Guide to their Public Health Consequences, Monitoring and Management. London: E & FN Spon, 1999.
- Craun, G. and Calderon, R.L. (1999) Waterborne disease outbreaks: Their causes, problems and challenges to treatment barriers. In Malgrande, M (Eds.), Manual of water supply practices. AWWA, Denver, CO.
- Dubey, J.P., Speer, C.A., and Fayer, R. (1990). In: "Cryptosporidiosis of man and animals" (ed J.P Dubey, C.A Speer, and R. Fayer), General biology of Cryptosporidium,. pp. 1-29, CRC Press, Boca Raton, Florida.
- duMoulin, G.C., and Stottmeier K.D. (1983) Waterborne mycobacteria: an increasing threat to health. Am. Soc. Microbiol. News 52,525-529
- Fankhauser, R.L., Noel, J.S., Monroe, S.S., Ando, T. and Glass, R.I. (1998) Molecular epidemiology of "Norwalk-like viruses" in outbreaks of gastroenteritis in the United States. J. Infec. Dis. 178(6): 1571-1578
- Geldreich, E.E., Fox, K.R., Goodrich, J.A., Rice, E.W., Clark, R.M., and Swerdlow, D.L. (1992) Searching for a water supply connection in the Cabool, Missouri disease outbreak of Escherichia coli O157:H7. Wat. Res. 26,1127-1137
- Gerba, C.P., and Rose, J.B. (1989) In "Drinking Water Microbiology" (ed G.A. McFeters), Viruses in Source and Drinking Water, pp. 380-396, Springer-Verlag, New York
- Green, K.Y., Ando, T., Balayan, M.S., Berke, T., Clarke, I.N., Estes, M.K., Matson, D.O., Nakata, S., Neill, J.D., Studdert, M.J., Thiel, H.J. (2000) Taxonomy of the caliciviruses. J. of Infec. Dis. 181(Suppl 2): 5322-5330.
- Hancock, C.M., Rose, J. B., and Callahan, M. (1998) Crypto and Giardia in US groundwater. J. Am. Wat. Works Assoc. 90, 58-61
- Jones, G.J., Burch, M., Falconer, I.R., Craig, K., (1993) In: Technical Advisory Group Report, Algal Management Strategy. Murray-Darling Basin commission, Canberra, Australia, pgs 17-32.
- Kaplan, J.E., Goodman, R.A., Schonberger, L.B., et al. (1982) Gastroenteritis due to Norwalk virus: an outbreak associated with a municipal water system. J. Infect. Dis. 146: 190-7
- Lawson, H.W., Braun, M.M., Glass, R.I., et al. (1991) Waterborne outbreak of Norwalk virus gastroenteritis at a southwest US resort: role of geological formations in contamination of well water. Lancet 337: 1200-4
- Lisle, J.T., and Rose, J.B., (1995). Cryptosporidium contamination of water in the USA and UK: a mini review. J. Wat. Supply & Res. Technol 44, 103
- MacKenzie, W.R., Hoxie, N.J., Proctor, M.E., Gradus, S., Blair, K.A., Peterson, D.E., Kazmierczak, J.J., Addiss, D.G., Fox, K.R., Rose, J.B. and J.P. David (1994) A massive outbreak in Milwaukee of Cryptosporidium infection transmitted through the public water supply. N.Engl. J. Med. 331, 161-167
- Maiwald, M., Schuhmacher, F., Hans-Jurgen, D., and von Herbay, A. (1998) Environmental occurrence of the whipple's disease bacterium. Appl. Environ. Microbiol. 64, 760-762
- Mead, P.S., and Griffin, P.M. (1998) Escherichia coli 0157:H7. Lancet 352, 1207-1212
- Phillip, R., Rowland, M.G.M., Baxter, P.J., McKenzie, C., Bell, R.H. (1991) Health risks from exposure to algae. CDR (London: England Rev) 1:R67-68.
- Schaeffer, F.W. (1999). Giardia lamblia. In: Waterborne Pathogens. Manual of water supply practices. AWWA, Denver, Co pp. 177-181.
- Singh, N., and Lu V. (1994) Potable water and Mycobacterium avium complex in HIV patients: is prevention possible? Lancet 343, 1110-1111
- Swerdlow, D.L., Woodruff, B.A., Brady, R.C., Griffin, P.M., Tippen, S., Donnel, H.D., Geldreich, E.E., Payne, B.J., Meyer, A., Wells, J.G., Greene, K.D., Bright, M., Bean, N.H., and Blake, P.A. (1993) A waterborne outbreak in Missouri of Escherichia coli O157:H7 associated with bloody diarrhea and death. Annals. Int. Med. 117, 812-819
- Yates, M.V., and Yates, S.R. (1988) Modeling microbial fate in the subsurface environment. Crit. Rev. Environ.Control. 17, 307-344