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Microbes and Urban Watersheds: Concentrations, Sources, & Pathways

Microbes are problematic. They are small and include hundreds of groups, species, biotypes and strains. They are ubiquitous in the environment, found on nearly every surface of the earth. They exist within us, on us, on plants, soils and in surface waters. They grow rapidly, die off, survive or multiply depending on a changing set of environmental conditions. Some microbes are beneficial to humans, while others exert no impact at all. Other microbes cause illness or disease, and a few can even kill you.

The presence of some types of microbes indicates a potential risk for water contamination, while other microbes are pathogens themselves (i.e., they are known to cause disease). Microbes are nearly always present in high concentrations in stormwater, but are notoriously variable. They are produced from a variety of watershed sources, such as sewer lines, septic systems, livestock, wildlife, waterfowl, pets, soils and plants, and even the urban stormdrain system itself.

It is little wonder that many watershed managers are thoroughly confused by the microbial world. This article seeks to provide enough background to help a watershed manager assess bacteria problems. It contains a national review and analysis of microbial concentrations, sources, and pathways in urban watersheds. The major focus is on fecal coliform bacteria, for which the most urban watershed data is available, but reference is also made to protozoa, such as *Cryptosporidium* and *Giardia*.

The article begins with a field guide to the bacteria found in urban waters. It compares the frequency of detection, origin, indicator status and measurement units of different microbes. The next section presents a national assessment of bacteria levels in urban stormwater. The last section profiles the many different human and nonhuman bacteria sources that can potentially occur in an urban watershed.

Field Guide to the Microbes

The complex microbial world is confusing to most; therefore, it is worth a moment to understand some of the terminology used to describe it. The term *microbes* refers to a wide range of living organisms that are too small to see with the naked eye. *Bacteria* are very simple single celled organisms that can rapidly reproduce by binary fission. Of particular interest are *coliform bacteria*, typically found within the digestive systems of warm-blooded animals. The coliform family of bacteria includes total coliforms, fecal coliforms and the group *Escherichia coli (E. coli)*. Each of these can indicate the presence of fecal wastes in surface waters, and thus the possibility that other harmful bacteria, viruses and protozoa may be present. Fecal streptococci (a.k.a., *Entercocci*) are another bacteria group found in feces which, under the right conditions, can be used to determine if a waste is of human or nonhuman origin. As such, all coliform bacteria are only an *indicator* of a potential public health risk, and not an actual cause of disease.

A *pathogen* is a microbial species that is actually known to cause disease under the right conditions. Examples of bacterial pathogens frequently found in stormwater runoff include *Shigella spp.* (dysentery), *Salmonella spp.* (gastrointestinal illness) and *Pseudonomas auerognosa* (swimmer's itch). Some subspecies can cause cholera, typhoid fever and "staph" infections. The actual risk of contracting a disease from a pathogen depends on a host of factors, such as the method of exposure or transmission, pathogen concentration, incubation period and the age and health status of the infected party.

Protozoa are single-celled organisms that are motile. Two protozoans that are common pathogens in surface waters are *Giardia* and *Cryptosporidium*. To infect new hosts, these protozoans create hard casings known as cysts (*Giardia*) or oocysts (*Cryptosporidium*) that are shed in feces, and travel through surface waters in search of a new host. The cysts or oocysts are very durable and can remain viable for many months. The protozoan emerges from its hard casing if and when a suitable host is found.

Table 1 provides a general comparison of the many microbes found in urban stormwater runoff, in terms of their frequency of detection, origin, indicator status, measurement units and information use.

Public health authorities have traditionally used fecal coliform bacteria to indicate potential microbial risk, and to set water quality standards for drinking water, shellfish consumption or water contact recreation. Some typical fecal coliform standards are provided in Table 2. Fecal coliforms are an imperfect indicator and regulators continually debate whether other bacterial species or groups are better indicators