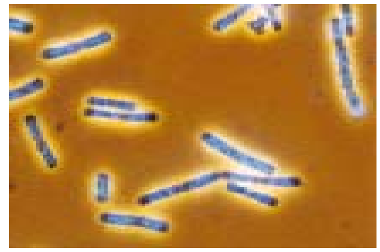
Microbes and Urban Watersheds

I. Introduction



One of the least understood consequences of urban growth is the gradual but seemingly inevitable loss of human uses of surface waters. Even a small amount of watershed development can lead to almost continuous violations of bacteria standards for drinking, swimming, shellfish harvesting or recreation during wet weather, and often during dry weather as well. Indeed, it can be argued that bacteria cause the greatest impairment of human uses in our nation's waters, and that urban stormwater ranks among the greatest sources of bacteria.

Consider some of the following sobering statistics culled from recent national water quality assessments:

- *Closing of pure drinking water supplies*

  Bacteria are considered a major water quality problem for many water supplies. For example, bacteria were cited as the third greatest pollution concern in a national survey of 272 surface water supply utilities (Robbins, 1991). Most water utilities treat and disinfect their source water to remove bacteria before it is piped to the customer. When bacteria levels are high, however, water utilities often must spend more to treat their source water. Drinking water treatment costs are expected to dramatically increase as more stringent drinking water standards are phased in under the 1996 Safe Drinking Water Act (USEPA, 1996).

  Some communities still rely on an unfiltered water supply that uses reservoirs to temporarily store drinking water before disinfecting it and sending it along to their customers. Prominent examples include much of the water supply for New York, Boston, Seattle and Portland. Bacteria loads generated by development in these watersheds have raised concerns about the purity of the drinking water supply, since water treatment may not be adequate to remove protozoans once they enter an unfiltered water supply system.

- *Closing of water contact recreation*

  Bacteria contamination was ranked as the third most common cause of non-attainment of our nation's streams and rivers, according to USEPA (1998a). Nutrients and sediment were ranked as the first and second water quality impairment. Over 80,000 miles of streams and rivers were in non-attainment because of high fecal coliform levels, which represented about 12 percent of river miles surveyed by the States. In addition, over 1.4 million lake acres were polluted by urban runoff.

- *Closing of swimming beaches*

  Over 4,000 beach closings or swimming advisories were reported in 1996 because of high bacterial levels, according to USEPA surveys (1998b). Bacterial impairment was reported at 12 percent of monitored beaches, and urban runoff was cited as the cause of the impairment 55 percent of the time (USEPA, 1998a).

- *Closing of shellfish beds*

  Harvesting of shellfish is prohibited, restricted or conditional in nearly 40 percent of all shellfish beds in the nation due to high bacteria levels (NOAA, 1992). Some six million acres are restricted, and the acreage under restriction has grown steadily over the last three decades. The prime causes of shellfish bed closures are urban runoff and failing septic systems (USEPA, 1998a; NOAA, 1992). In recent years, the reopening of shellfish beds due to improvements in municipal sewage treatment plants has been more than offset by bed closures due to rapid coastal development.

Even a small amount of development leads to almost continuous violations of bacteria standards.

Potential use impairments caused by bacteria are probably more widespread than even these disturbing statistics suggest. Most States only sample bacteria in a fraction of their surface waters. Consequently their water quality sampling networks seldom detect impairment in smaller urban streams, lakes and coastal waters (USEPA, 1998a).

Bacteria Are Highly Resistant to the Watershed Approach

Given such widespread impairment, it is amazing how few bacteria problems are managed on a watershed basis. When it comes to bacteria, the usual drill goes something like this:

- Bacteria happens
- The usual suspects are rounded up
- Examples are made of a few

- Most get off scot-free
- Bacteria still happens
- The public is asked to avoid the area
- Victory is declared.

Contrast this with our almost routine response to managing nutrients, sediments, toxicants and even habitat problems on a watershed basis. Why, then, are bacteria problems so highly resistant to the watershed approach? A wide range of reasons can be offered. To some, bacteria are simply beyond our understanding, much less our control (sort of like evil in the world). Bacteria models are considered too primitive, sources too poorly understood, and the effectiveness of watershed practices too uncertain. Others consider bacteria standards to be too stringent or largely irrelevant to real public health risks. Bacteria standards are often viewed in the same light as speed limits—something that can be routinely exceeded without any real harm.

Lastly, the stakeholders that need to come together to solve bacteria problems on a watershed basis seldom work together. Wastewater operators, local health agencies (that regulate septic systems), stormwater managers, microbiologists, epidemiologists, state regulators, wildlife agencies, drinking water utilities, animal control officers, land use planners and water users all need to be at the table. All too often, few stakeholders consider bacteria management to be part of their primary mission.

Bacteria are highly resistant to the watershed approach.

For whatever reason, bacteria continues to be highly resistant to a watershed approach. This, however, will change rapidly over the next few years as new or recycled regulatory programs are phased in. Perhaps the most significant regulatory development will be EPA's Total Maximum Daily Load, or TMDL program. Under the Clean Water Act, a TMDL must be prepared to bring impaired waters back into attainment. States must develop TMDLs for any impaired waters on their 303(d) list, and it is not surprising that such lists contain thousands of water segments that violate bacteria standards. TMDLs must contain water quality targets, required pollutant load reductions, source inventories, pollutant load allocations, and an enforceable implementation plan to meet water quality standards. The regulatory community recognizes that TMDLs are best performed on a watershed basis (NACEPT, 1998). Consequently, it is very likely that literally thousands of watershed TMDLs will be prepared for bacteria in the next five to ten years.

At the same time, the 1996 Safe Drinking Water Amendments require that States delineate and assess the quality of source waters of drinking water and identify threats of contamination. As noted earlier, bacteria and protozoa are considered major contamination threats. EPA has strongly advocated that these source water assessments be conducted within a watershed framework, and many States plan to conduct such assessments in the coming years.

In addition, many watershed bacteria sources are technically regulated under EPA's wastewater or stormwater NPDES permit systems. Regulated discharges include combined sewer overflows, sanitary sewer overflows, stormwater discharges, illicit connections and source control. Traditionally, regulators have primarily focused their efforts on improving discharge quality from sewage treatment plants, but in recent years, they have shifted attention to the network of sanitary, combined and storm sewers that feed the plants. As more of these potential bacteria sources come under greater scrutiny, it is likely that the regulated and regulatory communities will adopt a watershed approach to maximize the benefits of future water quality investments.

While it is hard to predict exactly which regulatory force will finally drive managers towards the watershed approach for bacteria control—TMDLs, source water assessments, or municipal stormwater NPDES permits—it is a reasonably safe bet that this approach will become commonplace in the years to come.

A Framework for Managing Bacteria on a Watershed Basis

The purpose of this special issue of *Techniques* is to lay a better foundation for managing bacteria on a watershed basis by providing an in-depth analysis of what is currently known about bacteria concentrations, sources, and management measures in urban watersheds. The primary focus of the issue is on fecal coliform bacteria, as nearly all urban watershed monitoring efforts have utilized this indicator, but reference is also made to pathogens such as *Cryptosporidium* and *Giardia.*

The second article, *Concentrations, Source and Pathways*, reviews the basics about bacteria found in urban waters, and then presents a national assessment of bacteria levels in urban stormwater. The article also exhaustively reviews the many potential bacteria sources in a watershed, including sewer lines, septic systems, livestock, wildlife, waterfowl, pets, insects, soils, plants, and even the urban drainage system itself.

The third article, *Ways to Kill 'Em*, discusses the causes of bacteria mortality, and reviews what is known about the effectiveness of stormwater best management practices, stream buffers, and source controls in reducing bacteria. It is concluded that current watershed practices cannot reduce bacteria levels sufficiently to meet water quality standards. The profound implications of this finding are explored in the last article.

The fourth article, *Implications for Watershed Managers*, presents a watershed framework for managing bacteria in urban areas. It begins by presenting a general bacteria management model to make sense of the complex and confusing microbial world. The model projects bacteria impairment under wet and dry weather conditions, based on watershed factors such as density, impervious cover, sewage disposal and management practices. A step-by-step process for investigating potential bacteria sources in an urban watershed is described. Lastly, the article outlines practical strategies for managing bacteria under a range of watershed conditions, with an emphasis on practices that prevent future bacteria sources and reduce current ones.

The fifth article, *Use of Tracers to Identify Contaminant Sources in Dry Weather Flow*, provides a practical field manual on how to isolate bacteria and other contamination in dry weather flow. The sixth and last article, *Resources for Detecting Bacteria Sources*, provides a summary of other field methods to determine if septic systems, sanitary sewers and animals are sources of bacteria in your watershed.

References

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