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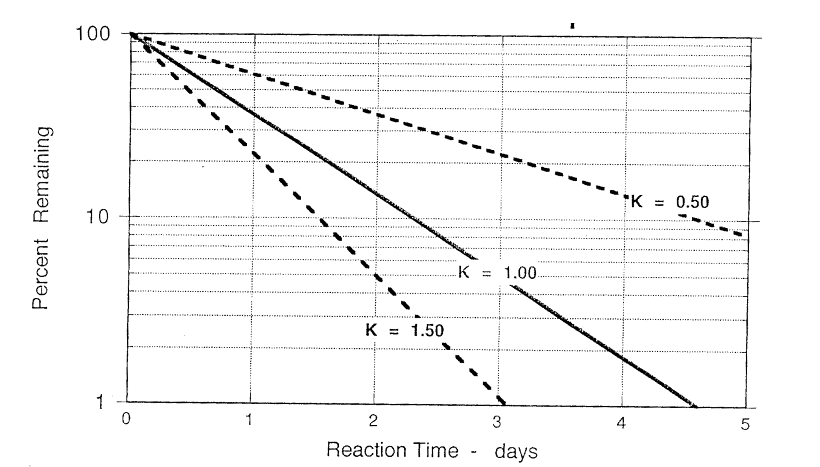
Microbes and Urban Watersheds: Ways to Kill 'Em

Managing microbes from urban watersheds can be a daunting task, as bacteria are usually present in high concentrations during storms, come from many different sources, and follow many complex pathways to reach receiving waters. In this article, we examine whether it is technically feasible to reduce microbes in urban stormwater to maintain drinking water, water contact recreation and shellfish consumption uses. The article begins with a discussion of the causes of bacteria mortality, and then reviews what is currently known about bacteria removal provided by stormwater best management practices, stream buffers, and source controls. The major focus is on fecal coliform bacteria, as this indicator has been used in nearly all performance studies conducted to date.

The review concludes that current stormwater practices, stream buffers and source controls have a modest potential to reduce fecal coliform levels, but cannot reduce them far enough to meet water quality standards in most urban settings. It is also argued that current watershed practices have even less capability to remove protozoans in stormwater runoff, such as *Giardia* and *Cryptosporidium*. The last section examines several design improvements that might enhance the bacteria removal performance of watershed management practices.

Figure 1: Effect of Different Die-off Rates (k) on Bacteria Mortality (Hydroqual, Inc., 1996)



Sources of Bacteria Mortality

Most fecal coliform bacteria thrive in the digestive systems of warmblooded animals, but do not fare well when exposed to the outside world. Over time, most fecal coliforms gradually "die-off." Key factors and practices that can be manipulated to increase bacteria die-off include the following:

- Sunlight (ultraviolet light)
- Sedimentation
- Sand filtration
- Soil filtration
- Chemical disinfection
- Growth inhibitors

The term "die-off," however, is not as final as it would appear. Often, researchers actually only measure the "disappearance" of bacteria from the water column. Bacteria and viruses settle from the water column to the bottom sediments. Given the warm, dark, moist and organic-rich conditions found in bottom sediments, many coliform bacteria can survive and even multiply in this environment. A number of researchers have documented this behavior in the sediments of storm drains, catch basins, ditches and channels. If these sediments are resuspended by turbulent stormwater flows, the bacteria can reappear in the water column.

Researchers and engineers have examined the "die-off" rates for many different microbes in fresh waters (Mancini, 1978). Bacteria die-off can be modeled as a first-order decay equation, using a k value of about 0.7 to 1.5 per day (Figure 1). In practical terms, "k" values in this range mean that about 90% of bacteria present will disappear from the water column within two to five days. The die-off rate is generally much faster in marine and estuarine waters than freshwater (Thoman and Mueller, 1987).

Exposure to Sunlight

Bacteria are a lot like vampires in that they generally can't stand the light of day. Bacteria are killed when exposed to a very specific and narrow band of the light spectrum (254 nm—ultraviolet UV light). Consequently, exposure to sunlight is one of the most important factors causing bacteria die-off. Maximum die-off requires clear water, however, and the turbidity and organic matter