Are Pharmaceuticals in Your Watershed?

Understanding the Fate of Pharmaceuticals and Other Contaminants in Watersheds

Last updated: January 10, 2017

Triclosan, caffeine, and nonylphenol concentration profiles for Boulder Creek, Colorado, showing downstream (left to right) variations during spring-runoff (June 2000). The increase in concentrations in the stream from site aWWTP to site 75 is the result of the discharge from a wastewater treatment plant into Boulder Creek (see sampling location map).

USGS scientists collecting water-quality samples for the analysis of emerging contaminants, Boulder Creek, CO.

In streams and rivers across the Nation, scientists are finding detectable concentrations of pharmaceuticals and other organic wastewater chemicals. For example, a recent study of the water-quality of streams in the Boulder Creek Watershed, Colorado, found a diverse set of pharmaceuticals and organic wastewater chemicals in water samples. In fact, U.S. Geological Survey (USGS) scientists found 12 of the 22 (55 percent) pharmaceuticals, and 32 of the 47 (77 percent) organic wastewater chemicals looked for in the watershed. Many of the water samples contained a complex mixture of pharmaceuticals, wastewater chemicals, pesticides, and trace metals (see supporting information for a full listing). Understanding the fate and ecological effects of this complex chemical mixture on a watershed scale is the objective of a team of USGS scientists studying the Boulder Creek Watershed. The scientists found that:

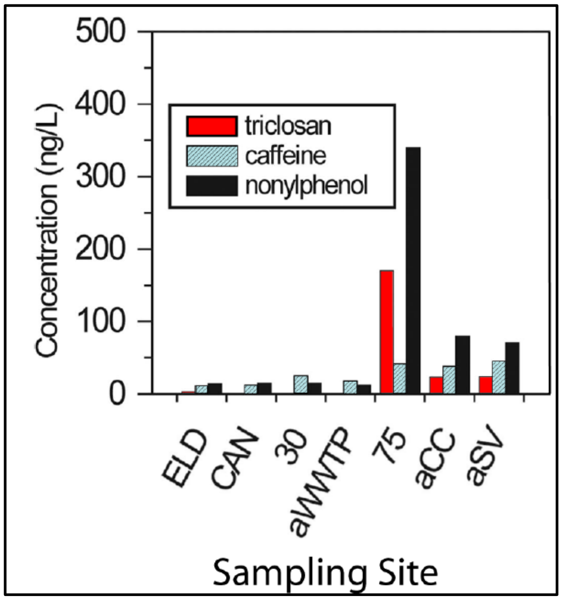
- The concentration of many of these chemicals, such as sulfamethoxazole (an antibiotic used to treat a wide range of bacterial infections), triclosan (an antimicrobial agent commonly used in soaps), and caffeine, increased dramatically downstream from the first major wastewater treatment plant (see sampling location map). However, some organic wastewater indicators (such as triclosan) were also found in much lower concentrations in the relatively pristine upper part of the watershed, and scientists attributed their occurrence to home septic systems and other sources on the landscape.

- Few of the detected compounds exceeded water-quality standards; however, many do not have water-quality standards. Although it is difficult to assess the potential for adverse ecological effects of such complex chemical mixtures in the wastewater affected part of Bounder Creek (see sampling location map), native fish populations were found to exhibit endocrine disruption, including low male-to-female sex ratio and fish having both female and male reproductive organs (gonadal intersex).

- Identifying what controls the fate and occurrence of chemicals in streams such as Boulder Creek requires an understanding of the diverse factors present in a watershed, such as the geology, ground-water quality, types of ecosystems, multiple contaminant sources, climate, land use, and amount of urbanization.

Water-resource managers can use this watershed approach to understand the complex interaction of a watershed's characteristics (land use, population density, geology, hydrology, …) and the fate and impact of contaminants, such as pharmaceuticals and organic wastewater chemicals, and to make more effective water management policies.

Triclosan, Caffeine, and Nonylphenol Concentration Profiles for Boulder Creek, Colorado



Triclosan, caffeine, and nonylphenol concentration profiles for Boulder Creek, Colorado, showing downstream variations during spring runoff (June 2000). Streamflow is from left to right. The increase in concentrations from site aWWTP to site 75 is the result of the discharge from a wastewater treatment plant (WWTP). Triclosan is an antimicrobial disinfectant used in many soaps. Caffeine is often used as an indicator of human wastewater contamination. Nonylphenol is a detergent metabolite. See the following site map and table for sampling site locations and descriptions. The graph is a modified version of figure 4C from Barber and others, 2006.

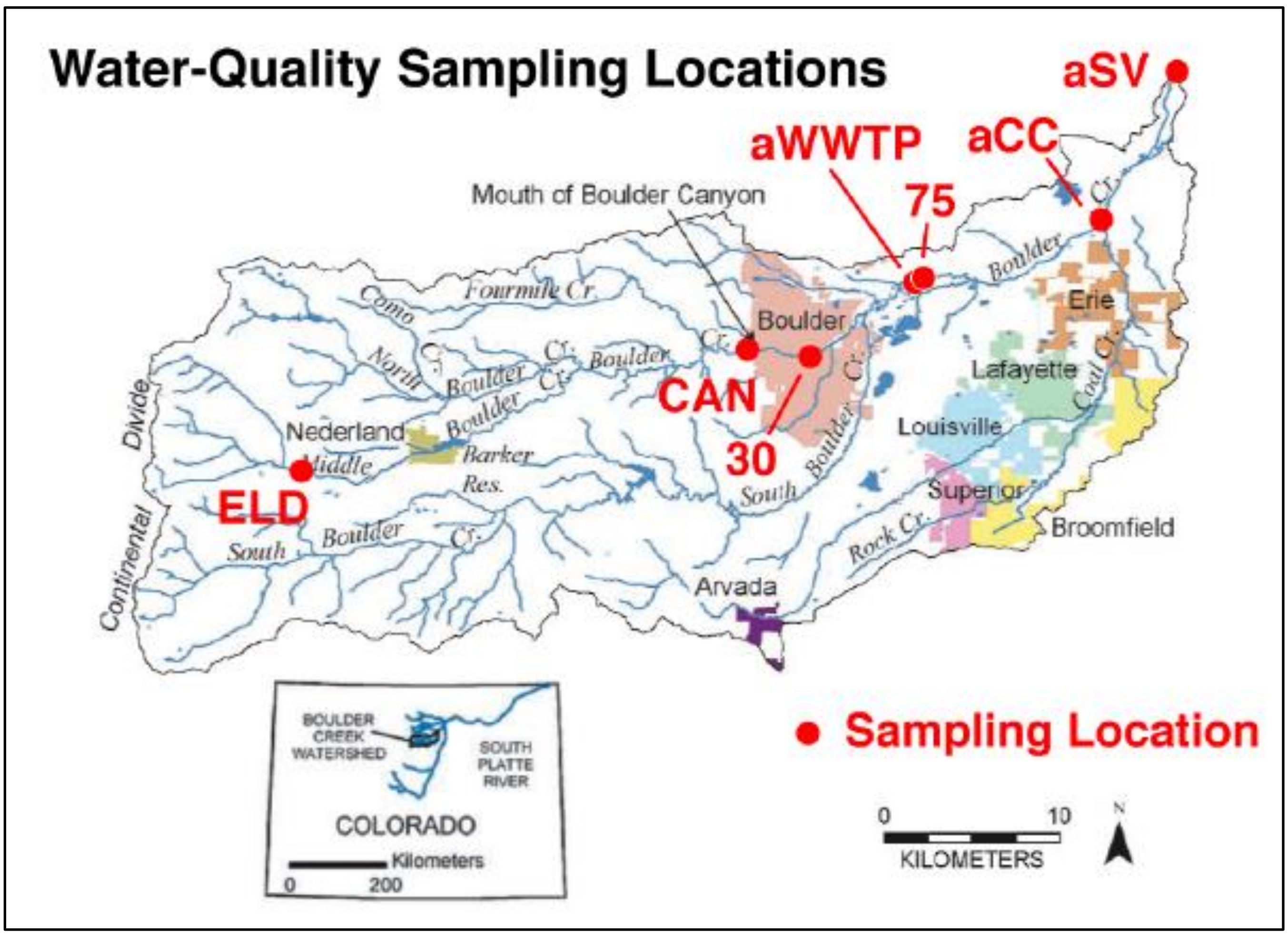


Table of Site Identifiers Used in the Above Graph and Map

The value in the distance column is the distance upstream from the confluence of Boulder Creek and St. Vrain Creek in kilometers (km). See site map for site locations. This table is an excerpt from Table SI-1 from Barber and others, 2006.

Site Identifier	Site description	Latitude	Longitude	Distance (km)
ELD	Middle Boulder Creek upstream from Eldora	39.949722	-105.590833	69.59
CAN	Boulder Creek at mouth from Boulder Canyon	40.013333	-105.294722	36.71
30	Boulder Creek downstream from 30th Street bridge	40.011111	-105.252778	32.99
aWWTP	Boulder Creek upstream from Boulder 75th Street WWTP	40.050000	-105.183889	24.44
75	Boulder Creek downstream from 75th Street bridge	40.051667	-105.177778	23.85
aCC	Boulder Creek upstream from Coal Creek	40.081944	-105.059722	10.97
aSV	Boulder Creek upstream from Saint Vrain Creek	40.158056	-105.009444	0.110

Reference: Barber, L.B., Murphy, S.F., Verplanck, P.L., Sandstrom, M.W., Taylor, H.E., and Furlong, E.T., 2006, Chemical loading into surface water along a hydrological, biogeochemical, and land use gradient—A holistic watershed approach: Environmental Science and Technology, v. 40, no. 2, p. 475-486, doi: 10.1021/es051270q. (Supporting Information)

United States Geological Survey, Environmental Health: Toxic Substances Hydrology Program
https://toxics.usgs.gov/highlights/pharm_watershed/index.html