Antimicrobials from personal care products found in statewide survey of Minnesota's rivers and lakes

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Postdoctoral research associate Benny Pycke holds a sediment sample from a Minnesota lake. The samples were collected from the upper 10 cm of the bed surface and stored in a freezer prior to analysis. Credit: Biodesign Institute at Arizona State University

In our zest for cleanliness, have we permanently muddied our nation's waters?

A science team from Arizona State University, in collaboration with federal partners, has completed the first statewide analysis of freshwater bodies in Minnesota, finding widespread evidence of the presence of active ingredients of personal care products in Minnesota lakes, streams and rivers.

These products are a billion dollar industry and can be found in antimicrobial soaps, disinfectants, and sanitizers to scrub our hands and clean countertops. Hundreds of antimicrobial products are sold in the U.S., many marketed with efficacy claims that remain elusive due to the short duration of the average consumer's handwashing practices. The fate of these products can be traced from home use to sewers to wastewater treatment plants to eventually, downstream bodies of water.

The research team focused on two active ingredients found prominently in antibacterial soaps;triclosan and triclocarban; which have come under scrutiny by the EPA and FDA due to their environmental and human health concerns. These compounds persist for decades in the environment, and both triclocarban and triclosan are among the top ten pharmaceuticals and personal care products most frequently found in the environment and in U.S. drinking water resources.

"This study underscores the extent to which additives of antimicrobial consumer products are polluting freshwater environments in the U.S.; it also shows natural degradation processes to be too slow to counter the continuous environmental release of these endocrine disrupting chemicals," said Halden, director of Environmental Security at the Biodesign Institute and professor in the Ira A. Fulton School of Sustainable Engineering and the Built Environment. Halden's research focuses on the interconnectedness of the water cycle and human health, with special emphasis on the role of manmade products and human lifestyle choices on environmental quality.

In a previous study, Halden's team found significant concentrations of harmful soap related chemicals dating back to the 1950's in sediments of Jamaica Bay and Chesapeake Bay, into which New York City and Baltimore discharge their treated domestic wastewater, respectively.

This is a close-up of the sediment sample. Credit: Biodesign Institute at Arizona State University

Upon their use, triclosan and triclocarban are absorbed through the skin and hence contaminate human blood, urine, and even breast milk. Ultimately, these chemicals together with the pharmaceuticals we use end up in our sewage and surface waters. In 2002, the USGS published a landmark study that showed 80 percent of 139 streams sampled from across 30 U.S. states were found to contain measurable levels of organic wastewater contaminants. The human health risks associated with these personal care product chemicals are still not fully understood despite them being used for decades.

In the ASU study, river, creek and lakebed sediment samples from 12 locations upstream and downstream of wastewater treatment plants were analyzed for the presence of antimicrobial compounds.

For Halden's team, which consisted of postdoctoral researcher Benny Pycke, environmental engineering graduate student and first author Arjun Venkatesan, the results showed that overall concentrations of triclocarban were 3- to 58-times higher than those of the more frequently monitored triclosan.

"We were able to detect these two compounds both upstream and downstream of suspected input sources, and the levels of the antimicrobial soap ingredient triclocarban were usually higher compared to triclosan," said Venkatesan. "Although triclosan is used in a larger number of formulations and personal care products, we found triclocarban to be more abundant in freshwater environments." The team also found degradation products of TCC but transformation of this antimicrobial is known to be very slow in natural environments.

"Also, we expected to find these compounds mostly downstream of wastewater treatment plants; but when we consistently found detectable levels upstream and downstream, we realized that there are probably multiple sources contributing to the contamination of these sites, potentially including additional wastewater treatment plants further upstream and runoff from sites where antimicrobial-laden sewage sludge had been applied."

"Every site is essentially downstream of something," added Pycke. A site in the immediate vicinity of a wastewater treatment plant near Duluth (St. Louis Bay at Lake Superior) had the greatest concentration of triclocarban and its lower chlorinated derivatives, and the Duluth site and Shagawa Lake site had concentrations three times higher than river and creek sediments. There was a strong correlation between the level of contamination with wastewater treatment plant discharge, stream flow and the population density of the surrounding region.

"As the name suggests, these antimicrobial compounds (triclosan and triclocarban) are incompatible with biological wastewater treatment infrastructure paid for with tax dollars," said Halden. "Municipalities in Minnesota and across the U.S. work hard using state-of-the-art equipment to keep our freshwater environments clean but they cannot control what consumers, misled by aggressive marketing, discharge into the sewage collection system."

Wherever antimicrobial personal care products are in use, water and sediment have been contaminated, a situation that certainly is not unique to the state of Minnesota. "Regulatory agencies are aware of the overuse of antimicrobials but no state or federal restrictions have been implemented yet for either triclosan or triclocarban," said Halden. "Aside from ecological concerns, widespread environmental occurrence of antimicrobials also is a potential public health concern because unwarranted use of antimicrobials can promote drug resistance of human pathogens."

Halden's research is developing engineering solutions to clean up environments impacted by antimicrobial compounds. However, he emphasizes that the best solution right now in combating this pollution is for consumers to limit their use of antimicrobial personal care products that, ironically, provide no measurable health benefits to the average consumer, as determined by an expert panel convened by the Food and Drug Administration in 2005.

More information: For the online paper, go to: A.K. Venkatesan, et al., Occurrence of triclosan, triclocarban, and its lesser chlorinated congeners in Minnesota freshwater sediments collected near wastewater treatment plants, *J. Hazard. Mater.* (2012), Vol. 229-230, Pages 29-35. dx.doi.org/10.1016/j.jhazmat.2012.05.049 (accessed August, 2012).

U.S. Environmental Protection Agency, St. Louis River Area of Concern, 546 2011, www.epa.gov/greatlakes/aoc/stlouis.html (accessed August, 2012).

In 2010, the American Chemical Society (ACS) published online and in print a new book entitled, "Contaminants of Emerging Concern in the Environment: Ecological and Human Health Considerations." pubs.acs.org/isbn/9780841224964

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