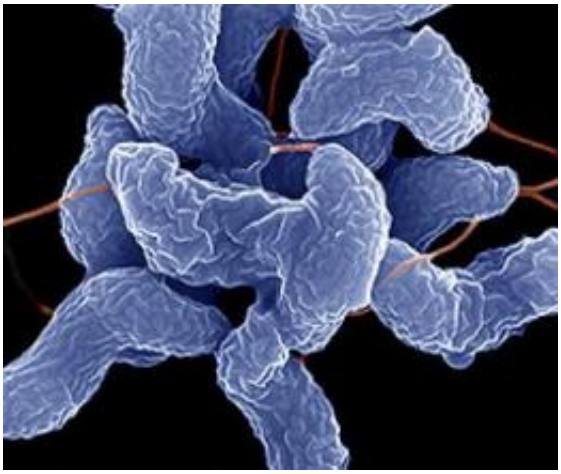
Myth of a germ-free world: A closer look at antimicrobial products

November 9 2010, by Richard Harth



Campylobacter bacteria is a leading cause of bacterial foodborne disease. Credit: USDA

Killing microorganisms has become a national obsession. A pair of antimicrobial compounds known as triclosan and triclocarban are lately the weapons of choice in our war of attrition against the microbial world. Both chemicals are found in an array of personal care products like antimicrobial soaps, and triclosan also is formulated into everyday items ranging from plastics and toys to articles of clothing.

But are these antimicrobial chemicals, as commonly used by people across the nation, really safe for human health and the environment? More pointedly, do they even work? According to associate professor

Rolf Halden, of the Biodesign Institute at Arizona State University, the answer to these questions is an emphatic "No."

A biologist and engineer, Halden is interested in chemicals produced in high volume for consumer use. "I follow the pathways of these substances and try to figure out what they do to the environment, what they do to us and how we can better manage them."

The antimicrobial triclosan was patented in 1964, and began its use in clinical settings, where it was found to be a potent bacterial killer, useful before surgical procedures. Since then, industry's drive to convince consumers of the need for antimicrobials has been aggressive and highly effective. Antimicrobials made their first appearance in commercial hand soaps in the 1980s and by 2001, 76 percent of liquid hand soaps contained the chemical.

Antimicrobials have become a billion dollar a year industry and these chemicals now pervade the environment and our bodies. Levels of triclosan in humans have increased by an average of 50 percent since 2004, according to newly updated data from the Centers for Disease Control and Prevention (CDC).Triclosan and triclocarban are present in 60 percent of all rivers and streams nationwide and analysis of lake sediments have shown a steady increase in triclosan since the 1960s. Antimicrobial chemicals appear in household dust where they may act as allergens, and alarmingly, 97 percent of all U.S. women show detectable levels of triclosan in their breast milk. Such unnecessary exposures carry risks which, at present, are ill-defined.

Halden and his team conducted a series of experiments aimed at tracking the environmental course of the active ingredients in personal care products. The disturbing results of their research indicate that triclosan and triclocarban first aggregate in wastewater sludge and are transferred to soils and natural water environments, where they were observed to

persist for months or years.

The chemistry behind these compounds, which contain benzene ring structures that have been chlorinated, make them notoriously difficult to break down. Further, they are averse to water or hydrophobic, tending to stick to particles, which decreases their availability for breakdown processes and facilitates long-range transport in water and air. A recent study demonstrated the accumulation of triclosan in dolphins from contaminated coastal waters.

Earlier, the EPA had been provided with industry-funded studies of wastewater treatment plant effluent, seemingly indicating elimination of triclosan and triclocarban during the treatment process. But Halden speculated that these chemicals might in fact persist in the solid byproduct left over after treatment—the sewage sludge. The group's suspicions were confirmed through an initial testing of a large wastewater treatment plant serving 1.3 million people, located in the Mid Atlantic region of the U.S.

In the first study of its kind, conducted by the team in 2006, it was determined that three quarters of the mass of triclocarban entering the wastewater treatment facility was simply moved from the water into the sludge. Similar tests confirmed the accumulation of triclosan in sludge with 50 percent efficiency.

"We make 13 billion pounds of dry sludge per year," Halden notes. "That is equal to a railroad train filled with sludge stretching 750 miles from Phoenix to San Francisco." One half of this sludge winds up on agricultural fields. The potential for these chemicals to migrate into food or leach into groundwater, has not received adequate consideration. It is likely that antimicrobials are capable of moving up the food chain, through a process known as biomagnification.

Both triclosan and triclocarban have been linked to endocrine disruption, with potential adverse impacts on sexual and neurological development. Further, the accumulation of these antimicrobials in the environment is exerting selective pressure on microorganisms exposed to them, thereby increasing the likelihood that a super-bug, resistant to the very antimicrobials developed to kill them, will emerge—with potentially dire consequences for human health.

On the positive side, Halden's team identified specific microorganisms adapted to not only tolerate but also break down pervasive antimicrobials. The research is part of a wider effort aimed at alerting the public and regulatory agencies, including the EPA and FDA, of the dangers of these chemicals as well as developing effective remediation strategies.

As Halden explains, "these microbes have the dual advantage of being resistant to destruction by antimicrobials and being able to break down these chemicals. You could put them to use for example by adding them to high-strength industrial wastewater before it gets combined with the domestic sewage."

In the group's recent studies, appearing in *Water Research* and The *Journal of Hazardous Materials*, levels of triclosan and triclocarban were measured, to determine the degree to which these chemicals, along with other antimicrobials, become concentrated in sludge, and what happens to them thereafter. Triclosan and triclocarban account for two-thirds of the mass of all the antimicrobials in sludge, Halden found, based on a survey of 72 chemicals entering the wastewater treatment stream. Further, massive bioaccumulation of antimicrobial chemicals has been observed in various species. Earthworms exposed to triclosan, for example, showed accumulation of the chemical by a factor of 2700 percent.

Halden notes the impact these persistent chemicals can have on other life forms in the environment that are not their intended target. The thresholds for killing microbes are much higher than those for other, more fragile life forms, like algae, crustaceans and fish. "This explains why residual concentrations of antimicrobials found in aquatic environments are still sufficiently harmful to wipe out the small and sensitive crustaceans, which are critical to the aquatic life cycle and food web," Halden says.

For certain, chemicals like triclosan and triclocarban have their place in public health, particularly in clinical settings, among people who are trained in their proper use. However, in 2005, the FDA put together an expert panel to review all the available information on these chemicals. Halden was among the voting members of this committee, which concluded that regular use of antimicrobial products by the general public was no more effective than traditional methods of proper hygiene—simply washing thoroughly with regular soap and water.

Society, Halden insists, is participating in a grand experiment in which we are all guinea pigs. While effective regulation of these chemicals is badly needed, Halden says that the inertia of regulatory agencies is a formidable obstacle. In the meantime, the best hope is for consumers to avoid triclosan and triclocarban containing products.

"The culture of fear leads people to make impulsive decisions and buy a lot of antimicrobial products that are not really needed," Halden says. "It's a profitable market to be in, but not one that is ultimately sustainable or a good idea."

Provided by Arizona State University

Citation: Myth of a germ-free world: A closer look at antimicrobial products (2010, November