

NEWS RELEASE

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Note to Journalists: An electronic copy of last year's research paper is available from Emil Venere, (765) 494-4709, venere@purdue.edu

Purdue lab works to improve conditions at indoor swimming pools

WEST LAFAYETTE, Ind. - Researchers at Purdue University have determined how certain airborne contaminants are created when chlorine reacts with sweat and urine in indoor swimming pools, a step toward learning how to reduce the formation of "volatile disinfection byproducts" that cause respiratory irritation.

"Some indoor swimming pools seem to have a characteristic chlorine odor," said Purdue environmental engineering professor Ernest R. Blatchley III. "You may think you're smelling chlorine, but you are probably smelling a mixture of disinfection byproducts. If their concentrations get high enough, then they can become an irritant to your respiratory system, to your skin and to your eyes."

The problem received national attention last summer when the U.S. National Swimming Championships in Indianapolis were interrupted after swimmers experienced difficulty breathing.

Standard tests for swimming pool water detect inorganic byproducts, or chemical compounds that do not contain carbon-hydrogen bonds. The Purdue researchers are the first to identify the presence of organic "volatile disinfection byproducts," which become airborne and pose health concerns.

Findings from the Purdue research were published last year in the journal *Environmental Science & Technology*. Additional findings are expected to appear later this year in the same journal and will be presented during the World Aquatic Health Conference on Oct. 15-17 in Colorado Springs, Colo. Postdoctoral research associate Jing Li and Blatchley, both in Purdue's School of Civil Engineering, are leading the work.

The research is part of an effort to apply to the aquatics industry the same level of scientific rigor seen in the study of drinking-water chemistry, said Michael Beach, acting associate director for healthy water in the Centers for Disease Control and Prevention's National Center for Zoonotic, Vector-borne and Enteric Diseases.

"If you don't understand what's in the soup, you can't know how to treat the water," he said. "The Purdue research is finding all sorts of compounds that could have potential health effects."

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The CDC has documented cases where people became ill after breathing contaminants at improperly maintained indoor swimming pools.

"We see this as a very large public health issue that we are just starting to uncover, and we need to have more data," Beach said.

Swimming is the most popular recreational activity for children in the United States, and anecdotal evidence suggests that children might be more sensitive than adults to the irritating effects of disinfection byproducts, Beach said.

Chlorination is used primarily to prevent pathogenic microorganisms from growing.

"What we are trying to do is investigate the chemistry of the reactions between chlorine and the stuff that people put in swimming pools: sweat and urine," Blatchley said. "We will also investigate what happens when chlorine reacts with other contaminants, including personal care products like makeup and deodorants."

The Purdue researchers analyzed swimming pool water for the presence of organic compounds generated when chlorine reacts with creatinine, urea and amino acids, which are contained in human urine and sweat. Measurements have allowed the researchers to hypothesize specifically how the urea, creatinine and several amino acids react with chlorine to produce the disinfection byproducts.

"We focused on a couple of the amino acids that we believe are representative of those that are present in sweat and urine and likely to be present at high concentrations in swimming pool water," Blatchley said.

The Purdue researchers used an analytical technique called membrane introduction mass spectrometry to identify and measure the volatile disinfection byproducts.

The conventional technique for analyzing swimming pool water uses a test that causes a color change depending on the chemical makeup of the samples. The test, however, fails to distinguish between various types of chemical compounds.

"Basically, what we want to do is relate our measurements to the operating characteristics of the pool," Blatchley said. "To address this issue, we are collecting samples from a number of public pools and analyzing them to determine the concentrations of volatile disinfection byproducts that are present in operating pools."

That research is being conducted by three members of Blatchley's group: graduate students William Weaver and Yuli Wen and undergraduate student Jessica Johnston.

"We are also examining what can be done to the water to improve the chemistry once these chemicals have been formed," Blatchley said. "In other words, how can you break down the disinfection byproducts or prevent their formation?"

New research is focusing on what happens when disinfection byproducts are treated with ultraviolet radiation. Findings indicate that some inorganic disinfection byproducts containing

nitrogen that are subjected to ultraviolet radiation break down to "more or less innocuous compounds," Blatchley said.

The disinfection byproducts are converted to several compounds, including nitrates and nitrous oxide, also known as laughing gas.

"Currently, we know where about 75 percent of the nitrogen goes, and we think we know where most of the rest of it goes, but we need to do some experiments to confirm that," he said.

These findings also will shed light on what happens to drinking water when treated with ultraviolet radiation.

"Sometimes ultraviolet radiation and chlorine are used together to treat drinking water," Blatchley said. "The chemistry is very similar in both settings, so our interest in those reactions is broader than just swimming pools.

"We have a pretty good understanding of what UV radiation does to microorganisms, but what it does to these chemicals in water is not as well-understood. With that in mind, we are investigating the reaction mechanisms, as well as how fast reactions take place with exposure of these disinfection byproducts to UV radiation."

Their research is concentrating on learning how ultraviolet radiation reacts with organic disinfection byproducts that are formed as a result of chlorination of urea, creatinine, amino acids and other compounds.

In future work, the researchers are going to interview pool operators to learn more details, such as how many people use the facilities and how often the water is chlorinated.

"It's amazing how little we know about swimming pool chemistry," Blatchley said. "And that's why we have pools being shut down for reasons that are probably avoidable. We want to solve this problem so that businesses and municipalities can operate their swimming pools in a manner that doesn't cause people to get sick."

The research has been funded by the DuPont Experimental Station in Wilmington, Del., and the National Swimming Pool Foundation.

The foundation recently awarded a \$135,954 grant to the Purdue researchers to learn more about using ultraviolet radiation with chlorination to disinfect recreational water. The research focuses on chemical and photochemical reactions that form and destroy disinfection byproducts.

"Once we know the chemistry, our industry can unleash solutions to improve air quality, reduce negative health risks and enhance the aquatic experience," said Thomas M. Lachocki, CEO of the National Swimming Pool Foundation. "We want to move toward reducing exposure to chemicals that are not natural."

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Related Web sites:

Ernest R. Blatchley III: https://engineering.purdue.edu/CE/People/view_person?group_id=1920&resource_id=1986

National Swimming Pool Foundation: <http://www.nspf.org>

CDC Healthy Swimming: <http://www.cdc.gov/healthyswimming/>

PHOTO CAPTION:

Researchers Ernest R. Blatchley III and Jing Li at Purdue review data in work to better understand how certain airborne contaminants are created when chlorine reacts with sweat and urine in indoor swimming pools. The research is a step toward learning how to prevent byproducts that cause respiratory irritation. The Purdue researchers are the first to identify the presence of several organic "volatile disinfection byproducts," which become airborne and pose health concerns.

(Purdue News Service photo/David Umberger)

A publication-quality photo is available at

<http://news.uns.purdue.edu/images/+2008/blatchley-poolchemistry.jpg>

ABSTRACT**Volatile Disinfection Byproduct Formation Resulting from Chlorination
of Organic-Nitrogen Precursors in Swimming Pools**

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Clinical studies have documented the promotion of respiratory ailments (e.g., asthma) among swimmers, especially in indoor swimming pools. Most studies of this behavior have identified trichloramine (NCl₃) as the causative agent for these respiratory ailments; however, the analytical methods employed in these studies were not suited for identification or quantification of other volatile disinfection byproducts (DBPs) that could also contribute to this process. To address this issue, volatile DBP formation resulting from the chlorination of four model compounds (creatinine, urea, L-histidine, and L-arginine) was investigated over a range of chlorine/precursor (Cl/P) molar ratios. Trichloramine was observed to result from chlorination of all four model organic-nitrogen compounds. In addition to trichloramine, dichloromethylamine (CH₃NCl₂) was detected in the chlorination of creatinine, while cyanogen chloride (CNCl) and dichloroacetonitrile (CNCHCl₂) were identified in the chlorination of L-histidine. Roughly 0.1 mg/L (as Cl₂) NCl₃, 0.01 mg/L CNCHCl₂, and 0.01 mg/L CH₃NCl₂ were also observed in actual swimming pool water samples. DPD/FAS titration and MIMS (membrane introduction mass spectrometry) were both employed to measure residual chlorine and DBPs. The combined application of these methods allowed for identification of sources of interference in the conventional method (DPD/FAS), as well as structural information about the volatile DBPs that formed. The analysis by MIMS clearly indicates that volatile DBP formation in swimming pools is not limited to inorganic chloramines and haloforms. Additional experimentation allowed for the identification of possible reaction pathways to describe the formation of these DBPs from the precursor compounds used in this study.