National Institute of Environmental Health Sciences

Superfund Research Program

Research Brief 285

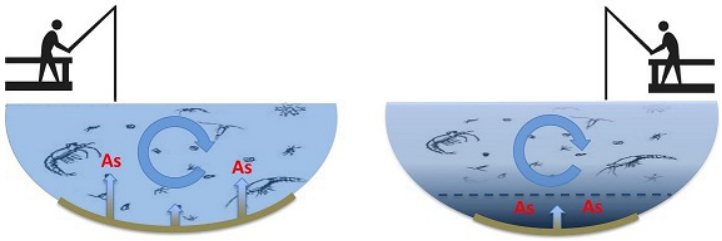
Release Date: 09/05/18

# Why Shallow Lake Food Webs May Have More Arsenic

Lake properties impact the amount of arsenic that transfers from sediments into the aquatic food web, according to a new Superfund Research Program (SRP) study. Researchers discovered high concentrations of arsenic in the water and plankton of well-mixed shallow lakes.

With warm summer temperatures, the water near the surface of a lake is heated by the sun, making it less dense than colder water beneath. In deep lakes, this leads to thermal stratification, a phenomenon where lakes develop a discrete top layer of warm water that doesn't mix with the colder water near the bottom.

In contrast, the water in shallow lakes warms more uniformly, enabling these lakes to remain well-mixed with only brief periods of stratification. According to the study by University of Washington (UW) SRP Center researchers, this mixing leaves more of an opportunity for arsenic in the sediments to move up into the overlying water and enter the aquatic food web.




Arsenic movement from sediment in a weakly-stratified lake, left, and a thermally stratified lake, right. Lake mixing status impacts the level of arsenic transfer from sediments to plankton at the base of the aquatic food web. (Reprinted from Science of the Total Environment, 625, Barrett et al., Increased exposure of plankton to arsenic in contaminated weakly-stratified lakes, 1606-1614, Copyright 2018, with permission from Elsevier)

### Lake Differences Matter

A research team led by Rebecca Neumann, Ph.D., and James Gawel, Ph.D., examined the movement of arsenic from sediments into water in four urban lakes, with varying levels of water mixing, in the Puget Sound region of Washington. Because the lakes are downwind of a former copper smelter site, a source of arsenic emissions, the lakes have high or moderate levels of arsenic-contaminated sediment. The researchers took water and plankton samples over the course of a year to account for seasonal differences. Each lake was sampled once or twice per month at four different water depths.

In lakes with strong seasonal thermal stratification, high levels of arsenic were limited to the bottom thermal layer that formed during the summer. However, in weakly-stratified lakes with higher levels of mixing, the entire water column, including surface waters, had elevated concentrations of arsenic during the summer. In both types of lakes, arsenic concentrations were lowest over the winter.

They also explored the accumulation of arsenic into plankton at each lake. Comparing two lakes with similar levels of sediment arsenic, they found that plankton in the weakly-stratified lake accumulated up to ten times more arsenic than plankton in the stratified lake.

In weakly-stratified lakes, they primarily found arsenic in the form of arsenate, which is readily taken up by plankton because it is structurally similar to phosphate, an essential nutrient for plankton growth. Once it is taken up by plankton, arsenic can be transferred through the food web to other organisms who eat them, including to fish consumed by humans.

## Implications for Health and the Environment

Arsenic-contaminated sediments have been documented in lakes across the United States, resulting from a variety of sources including historical application of arsenic herbicides to surrounding areas, disposal of hazardous waste, and aerosol smelter emissions.

UW SRP Center researchers collect water samples from Lake Killarney, a well-mixed shallow lake in the study. (Photo by Kenneth Burkart)

According to the authors, well-mixed shallow lakes, which are common in densely populated urban areas, may be uniquely vulnerable to environmental and human health risks from arsenic contamination in sediments. Smaller urban lakes play an important role in supporting human recreation and food needs, yet they are understudied compared to larger, thermally-stratified lakes, especially with regards to arsenic contamination.

The authors add that well-mixed water columns likely promote bioaccumulation of arsenic both by positioning arsenic closer to phytoplankton near the surface of the water and by favoring a form of arsenic that is readily taken up by phytoplankton. Hence, lake mixing status may be a good metric for assessing the vulnerability of aquatic life to arsenic accumulation in impacted lakes.

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### To learn more about this research, please refer to the following source:

Barrett PM, Hull EA, King CE, Burkart K, Ott KA, Ryan JN, Gawel JE, Neumann RB. 2018. Increased exposure of plankton to arsenic in contaminated weakly-stratified lakes. Sci Total Environ 625:1606-1614. doi: 10.1016/j.scitotenv.2017.12.336 PMID: 29996457