Long-lasting chemicals threaten the environment and human health: study

December 21 2010, by Richard Harth

Rolf Halden is a researcher at the Biodesign Institute at Arizona State University. Credit: The Biodesign Institute at Arizona State University

Every hour, an enormous quantity and variety of manmade chemicals, having reached the end of their useful lifespan, flood into wastewater treatment plants. These large-scale processing facilities, however, are designed only to remove nutrients, turbidity and oxygen-depleting human waste, and not the multitude of chemicals put to residential, institutional, commercial and industrial use. So what happens to these chemicals, some of which may be toxic to humans and the environment? Do they get destroyed during wastewater treatment or do they wind up in the environment with unknown consequences?

New research by Rolf Halden and colleagues at the Biodesign Institute at

Arizona State University seeks to address such questions. The group's results, reported recently in the Journal of Environmental Monitoring, suggest that a number of high production volume (HPV) chemicals—that is, those used in the U.S. at rates exceeding 1 million pounds per year, are likely to become sequestered in post-treatment sludge and from there, enter the environment when these so-called biosolids are deposited on land.

As Halden notes, over 4000 chemicals in common usage in the U.S. qualify as HPV chemicals, the vast majority of which have never been evaluated in terms of exotoxicity (their potential to adversely affect ecosystems), or for the risks they may pose to humans. "With each of these compounds, we are engaged in an experiment conducted on a nationwide scale," says Halden; "Odds are, some of these chemicals will turn out to be bad players and will pose problems for ecosystems, public health or both."

Unfortunately, it is neither technically nor economically feasible to perform the kind of detailed analyses necessary to declare this vast swirl of chemicals safe for humans or environmentally benign following wastewater treatment. Instead, Halden's efforts are aimed at narrowing the field of potentially troublesome chemicals, by defining traits likely to cause some chemicals to persist in the environment. To do this, the group applied a new empirical model for estimating the fraction of mass loading of chemicals in raw sewage expected to endure in digested sludge.

Chemicals which become sequestered in digested sewage sludge are a potential cause for concern in part because the treated sludge is often subsequently applied to land, including land designated for agricultural use. Halden's group screened some 207 HPV chemicals, using a model that predicted that two thirds of these compounds are likely to accumulate in digested sludge to greater than fifty percent of their initial mass loading in raw sewage. Eleven of these chemicals were flagged as compounds of special concern and deemed potential hazards to human and environmental health.

Three principal criteria dictated the selection of these problem chemicals: (a) their propensity to accumulate and persist in sludge in large amounts (b) structural characteristics suggestive of environmental persistence on land following biosolids recycling, and (c) unfavorable ecotoxicity threshold values, whether these have been experimentally determined or were forecasted with computer models.

As Halden explains, certain classes of chemicals possess physical characteristics that make them likelier to resist breakdown during wastewater treatment. Of particular concern are hydrophobic organic chemicals. As their name implies, such chemicals are 'afraid' of water and preferentially attach themselves to particulate matter, thereby becoming part of the primary and secondary sludge. This characteristic trait limits the availability of hydrophobic chemicals to aerobic and anaerobic microorganisms during sewage treatment and sludge digestion.

Rather than being broken down, such chemicals can become enriched in municipal biosolids by several orders of magnitude. Through this process, substances in heavy usage, like HPV chemicals, can accumulate as pollutants in municipal sludge to parts per million (ppm) concentrations. "It's like vacuum cleaning your home," says Halden. "When the carpet is clean, the vacuum bag holds a concentrated burden of dirt. By anology, the generation of biosolids enriched in non-biodegradable pollutants are the price you pay when purifying domestic sewage for water reuse."

In order to better gauge which chemicals may go on to present human health and environmental risks following sequestration in sludge, the group conducted a computer or in silico analysis. The method provides a streamlined and economically attractive means of isolating those chemicals deserving more in-depth field analysis. The group applied a new empirical model able to predict the fraction of total mass of a hydrophobic chemical likely to persist in biosolids after wastewater treatment.

Another advantage of the new model, applied by Halden and Assistant Professor Randhir Deo from the University of Guam, is simplicity. The model only requires two input values in order to estimate a chemical's environmental persistence. The chemicals to be screened were taken from the High Production Volume Information System database maintained by the EPA to monitor the environmental fate of chemicals produced in amounts exceeding 1 million pounds per year.

The empirical model was developed and tweaked to produce the best agreement between the mathematical framework based on a given chemical's physical properties and actual measurements derived from large sewage treatment plants. The physical characteristic found to play the largest role in a chemical's persistence in sludge was its sorption potential—the tendency of molecules of the chemical to adhere to the surface of other molecules. In the case of the HPV chemicals under consideration, high sorption values among hydrophobic chemicals caused them to stick to other particles and be sequestered from the degradative processes used to treat wastewater.

The bulk of the chemicals included in the HPV study were used for industrial purposes and included antidegradants, antioxidants, metal chelators, intermediates, by-products, catalysts, flame retardants, phenylating agents, plasticizers, heat storage and transfer agents, lubricants, solvents, anticorrosive agents, and others. The study also identified five mass-produced chemicals used as flavors and fragrances that were predicted to persist in sludge in fifty percent or greater amounts of their initial mass loading in raw sewage.

Once chemicals likely to persist in sludge were identified, estimates of their toxicity were examined. Those with high persistence levels and high environmental toxicity made the enemies list of chemicals posing the greatest potential hazard. Prominent among the toxic chemicals were the so-called organohalogen compounds, seven of which were found to accumulate in substantial quantity in treated sludge and displayed half-lives in soil estimated to range from 120 to 360 days.

Perhaps of greatest concern are halogenated chemicals known as organobromines—popular ingredients in a range of flame retardant products, which have subsequently been identified in bird tissues, in egg pools of herring gulls, and in dust samples. Halden insists that better monitoring of just such chemicals is essential for understanding their trajectory and mitigating risks to human health and the environment.

"Our work is directed at identifying problematic compounds before they cause harm to the environment and people. Environmental chemists often can foretell adverse outcomes. What's lacking are regulations to translate that knowledge into pollution prevention," says Halden. "Cleaning up after the fact, is costly and hard to do."

Provided by Arizona State University

Citation: Long-lasting chemicals threaten the environment and human health: study (2010, December 21) retrieved 26 April 2024 from https://phys.org/news/2010-12-long-lasting-chemicals-threaten-environment-human.html