Isolating mercury to protect food chains

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A stream turned yellow after the ore tailings from mercury sulfide are flushed out. Credit: Flickr/Jerry Burke

Mercury gets a bad rap, and rightly so. It is incredibly toxic to many organisms, and it accumulates in the food chain. That means animals at the top of the food chain, including us humans, often get the highest doses.

To minimise the risk to humans and other living things we need to be able to accurately and efficiently measure concentrations of mercury in the environment.

The problem is mercury comes in many forms and is a slippery customer to track.

But researchers from the University of Melbourne and the University of the Balearic Islands in Spain have developed a new automated technique to isolate different forms of mercury based on the risk of each form moving into the food chain.

Most people are familiar with the liquid metal known as quicksilver, which is pure mercury, but Professor Spas Kolev says that this makes up just a very small fraction of the mercury found in the environment.

"Mercury that ends up in the environment takes other forms such as mercury sulfide, methylmercury, dimethylmercury, ethylmercury and phenylmercury," says Professor Kolev, from the School of Chemistry at the University of Melbourne.

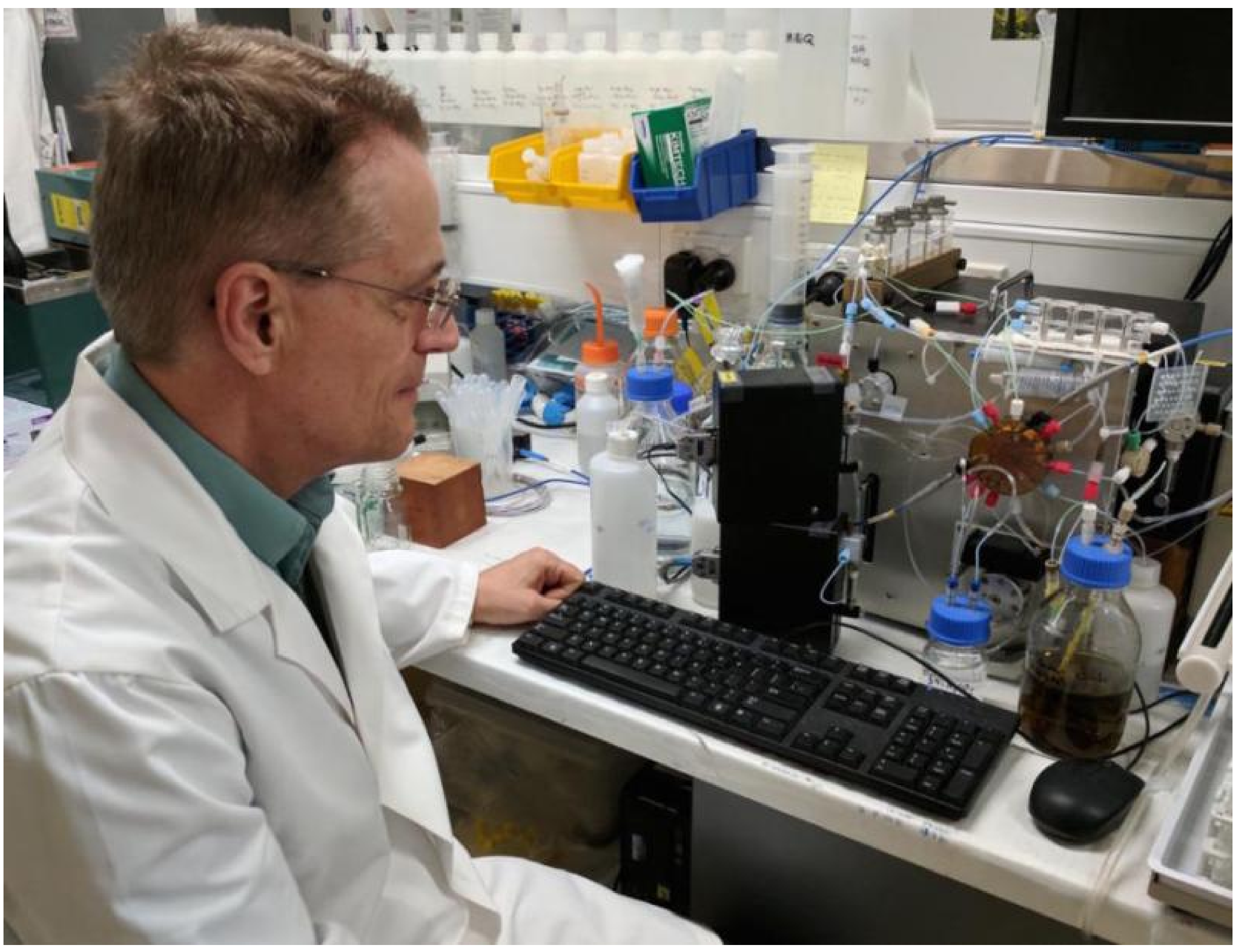
"Some of these forms are much more toxic than others, and some are more mobile than others, meaning they can move through the environment and can into humans more easily.

"Methylmercury for example, easily dissolves in water and can easily get into plants, fish and other animals, while mercury sulfide tends to stay locked in sediment and soil and is much less likely to get into the food chain.

"Just knowing the total concentration of mercury in the environment doesn't give us enough information to determine the risk to humans. It is equally important to know how mobile mercury is which determines its bio-accessibility."

Professor Kolev and his colleagues at the Centre for Aquatic Pollution Identification and Management (CAPIM) are interested in the risk to humans and other organisms from mercury in sewage waste that is treated and then used as fertiliser in agricultural systems.

"There are established methods for measuring the mobility of mercury in environmental solids such as treated sewage," says Professor Kolev.



Professor Spas Kolev inspects an automated flow analysis system in his lab at the University of Melbourne. Credit: University of Melbourne

"We add a series of different chemicals to a solid sample, one at a time, and each chemical extracts a different type of mercury which can then be measured using a mercury analyser."

Professor Kolev says that these established methods of measuring mercury bio-accessibility in solid samples are slow, labour intensive, and subject to human error. As a result scientists and environmental monitoring agencies aren't able to measure as many samples as they need to.

But Professor Kolev and his colleague Dr Yanlin Zhang and Professor Manuel Miro from the University of the Balearic Islands, have collaborated to develop a new method and associated instrumentation that drastically reduce the time taken to measure the bio-accessibility of different forms of mercury in solid, organic-rich samples like solid sewerage.

The trick is to use a technique called flow analysis.

"We use a flow analysis system to automatically add four different solutions with increasing leaching ability to the sewerage sample, one at a time," says Professor Kolev.

"Each solution releases a different form of mercury, which then flows through a fluorescence spectrometer which measures its concentration. The first solution contains the most bio-accessible – and hence the most toxic – mercury. The mercury forms left last in the solution have very low bio-availability.

"Using this technique we have been able to reduce the analysis time from five days to just 14 hours."

This technique is almost completely automated, so not only is it much quicker than previous methods, it is also safer and more reliable.

"It allows cost efficient and rapid environmental and health risk assessment of soil and sediment contaminated with mercury to determine if remediation is necessary," says Professor Kolev.

"The way sewerage sludge is either disposed of or reused is partly dependent on the concentration and bio-accessibility of this toxic metal and these two characteristics can now be assessed easily by the new technique."

The research was supported by the Australian Research Council and the Spanish State Research Agency and was the featured article in the July issue of the respected chemistry journal *Analytica Chimica Acta*.

More information: Yanlin Zhang et al. An automatic flow assembly for on-line dynamic fractionation of trace level concentrations of mercury in environmental solids with high organic load, *Analytica Chimica Acta* (2017). DOI: 10.1016/j.aca.2017.05.001

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