'Fingerprinting' method tracks mercury emissions from coal

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(PhysOrg.com) -- University of Michigan researchers have developed a new tool that uses natural "fingerprints" in coal to track down sources of mercury polluting the environment. The research is published in today's online issue of the journal *Environmental Science & Technology*.

Mercury is a naturally occurring element, but some 2000 tons of it enter the environment each year from human-generated sources such as incinerators, chlorine-producing plants and coal-burning power plants. Mercury is deposited onto land or into water, where microorganisms convert some of it to methylmercury, a highly toxic form that builds up in fish and the animals that eat them. In wildlife, exposure to methylmercury can interfere with reproduction, growth, development and behavior and may even cause death.

Effects on humans include damage to the central nervous system, heart and immune system. The developing brains of young and unborn children are especially vulnerable.

"There has been a lot of controversy about how much mercury is coming from different types of industrial activities, compared to natural sources, but it has been difficult to figure out the relative contributions," said co-author Joel Blum, the John D. MacArthur Professor of Geological Sciences and a professor of ecology and evolutionary biology. "And even if you can determine how much of it is coming from natural versus human sources, there's still the question of how much is from global sources, such as coal-fired power plants overseas, and how much is being

produced and deposited locally."

For the past eight years, Blum and co-workers have been trying to develop a way of reading mercury fingerprints in coal and other sources of mercury. The hope was that they could then find those same fingerprints in soil and water bodies, much as a detective matches a suspect's fingerprints to those found at a crime scene, and use them to figure out exactly what the sources of mercury pollution are in certain areas.

"For some time, we weren't sure that it was going to be technically possible, but now we've cracked that nut and have shown significant differences not only between mercury from coal and, say, metallic forms of mercury that are used in industry, but also between different coal deposits," Blum said.

The fingerprinting technique relies on a natural phenomenon called isotopic fractionation, in which different isotopes (atoms with different numbers of neutrons) of mercury react to form new compounds at slightly different rates. In one type of isotopic fractionation, mass-dependent fractionation (MDF), the differing rates depend on the masses of the isotopes. In mass-independent fractionation (MIF), the behavior of the isotopes depends not on their absolute masses but on whether their masses are odd or even. Combining mass-dependent and mass-independent isotope signals, the researchers created a powerful fingerprinting tool.

Previously, Blum and coworkers investigated the possibility of using the method to identify sources of mercury contamination in fish. The coal project was more challenging because of the difficulty of extracting and concentrating mercury from coal. The researchers developed a system that slowly burns the coal under controlled conditions in a series of furnaces and then traps the mercury that is released.

More work is needed to perfect the fingerprinting technique, but Blum envisions using it in a number of ways to track mercury and assess its environmental effects.

"Coal-burning plants are being built in China at an alarming rate—something like two per week—and the amount of mercury emitted to the atmosphere is increasing dramatically. We think we may be able to detect mercury coming from specific regions in China and watch it as it's transported and re-deposited around the globe," Blum said.

Closer to home, a number of coal-burning power plants have been proposed for construction in Michigan, and one question that arises during the permitting process is how much mercury may end up in nearby lakes and wetlands.

"Scientists have models and other ways of estimating how much mercury will be deposited locally, but we may, for the first time, be able to directly differentiate between mercury coming from local plants and mercury that has been transported longer distances."

In a project already underway, Blum's research group hopes to pinpoint which of the many mercury sources in the San Francisco Bay area are contributing most to the contamination of fish and wildlife.

"We don't know whether particular sources of mercury are more biologically available than others and thus more likely to accumulate in animals," Blum said. "If we can figure that out, then we can help local agencies decide where efforts will be most productive in terms of preventing wildlife from being exposed to mercury."

A major influence on Blum's research path into mercury isotopes was Clair Patterson, a famous geochemist on the faculty at Caltech when Blum was a graduate student there. Patterson developed and applied the

lead isotopic fingerprinting technique to show the world that unhealthy levels of lead in humans could be traced to lead additives in gasoline. His work ultimately led to the removal of lead from gasoline in the U.S.

"The approach we are taking is similar to what Patterson did with lead isotopes, except the isotopic differences in mercury are about 50 times smaller," Blum said. "If we can do a tenth of what he did, in terms of alerting people to where mercury is coming from and how people are being exposed, I'll be thrilled."

Blum's coauthors on the *Environmental Science & Technology* paper are two former postdoctoral fellows, Abir Biswas and Bridget Bergquist; Gerald Keeler, director of the U-M Air Quality Laboratory; and Zhouqing Xie of the University of Science and Technology of China. The researchers received funding from the National Science Foundation, the University of Michigan and Sigma Xi.

Source: University of Michigan