Research identifies potential cause of Minamata mercury poisoning

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One of the world's most horrific environmental disasters—the 1950 and 60s mercury poisoning in Minamata, Japan—may have been caused by a previously unstudied form of mercury discharged directly from a chemical factory, research by the University of Saskatchewan (USask) has found.

"By using state-of-the-art techniques to re-investigate a historic animal brain tissue sample, our research helps to shed new light on this tragic mass poisoning," said USask professor Ingrid Pickering, Canada Research Chair in Molecular Environmental Science. "Mercury persists for a long time in nature and travels long distances. Our research helps with understanding how mercury acts in the environment and how it affects people."

The study examining which mercury species could be responsible for the Minamata poisoning was published Feb. 12th in the journal *Environmental Science & Technology*. It is expected to prompt a wider re-assessment of the species of mercury responsible for not only the Minamata tragedy but perhaps also of other organic mercury poisoning incidents, such as in Grassy Narrows, Ontario.

Mercury-containing industrial waste from the Chisso Corporation's chemical factory continued to be dumped in Minamata Bay up to 1968. Thousands of people who ingested the mercury by eating local fish and shellfish died, and many more displayed symptoms of mercury poisoning including convulsions and paralysis.

"Something that was unknown at that time was that unborn children would also suffer the devastating effects of mercury poisoning, with many being born with severe neurological conditions," said USask Ph.D. toxicology student Ashley James, the first author of the paper. "A mother may be essentially unaffected by the poisoning because the mercury within her body was absorbed by the unborn child."

The Minamata poisoning has been considered a textbook example of how inorganic mercury turns into organic mercury, and how a toxic substance propagates up the food chain to humans. For decades, it has been assumed that micro-organisms in the muds and sediments of Minamata Bay had converted the toxic inorganic mercury from the factory wastewater into a much more lethal organic form called methyl mercury, which targets the brain and other nervous tissue. This compound was thought to spread to humans from eating contaminated seafood.

Recent studies have suggested that methyl mercury itself may have been discharged directly from the Minamata plant.

But USask research—involving 60-year-old Minamata feline tissue samples—has found these assumptions may be misplaced.

Using a new type of spectroscopy and sophisticated computational methods, the USask researchers have found that the cat brain tissue contained predominantly organic mercury, contradicting previous findings and assumptions. The team's computer modelling was also able to predict which kinds of mercury waste compounds the chemical plant would be likely to produce.

"The most probable neurotoxic chemical form of mercury discharged from the factory was neither methyl mercury nor inorganic mercury," said Graham George, Canada Research Chair in X-ray Absorption

Spectroscopy and an expert in spectroscopy of toxic heavy elements at USask's Toxicology Centre and geological sciences department.

"We think that it was caused by an entirely different type of organic mercury discharged directly from the Chisso factory at Minamata in an already deadly chemical form."

The cat brain samples from the USask study come from an experiment conducted by the Chisso company doctor in 1959 to determine the causes of the sickness, which was not at first connected to the industrial dumping. The doctor fed cats the industrial waste and they soon showed symptoms similar to the sick villagers. While the doctor was ordered to stop his experiments, he kept samples of brain tissue from one of the cats.

The USask team has found that the likely culprit of the poisoning is alpha-mercuri-acetaldehyde, a mercury waste product from aldehyde production not previously identified.

"It was this species that very likely contaminated Minamata Bay and subsequently gave rise to the tragedy of Minamata disease. We think that this was the dominant mercury species in the acetaldehyde plant waste. More work is needed to explore the molecular toxicology of these compounds, to understand the ways they could be toxic to humans, animals and the environment," said George.

The 12-member research team included researchers from USask, Stanford Synchrotron Radiation Lightsource at Stanford University, Japanese National Institute for Minamata Disease, and the environmental medicine department of the University of Rochester.

While USask is home to the Canadian Light Source synchrotron, there are only two synchrotrons in the world set up with the specialized

equipment needed for the advanced work that the team does with these precious samples—one in Grenoble, France and the other at Stanford.

The USask research was funded by the Natural Sciences and Engineering Research Council, the Canadian Institutes of Health Research, and the Canada Foundation for Innovation.

The new findings coincide with renewed public interest in the tragedy due to the much-anticipated premiere on Feb. 21st at the Berlin International Film Festival of a new movie "Minamata" which stars Johnny Depp as photojournalist W. Eugene Smith whose work publicized the devastating effects of the mercury poisoning.

More information: Ashley K. James et al, Rethinking the Minamata Tragedy: What Mercury Species Was Really Responsible?, *Environmental Science & Technology* (2020). DOI: 10.1021/acs.est.9b06253

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