Marine plastic pollution hides a neurological toxicant in our food

September 6 2019, by Vivian Li, Igeneration Youth

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In the mid-1950s, domesticated cats in Minamata, Japan mysteriously began to convulse and fall into the bay. The people of Minamata took on similar symptoms shortly after, losing their ability to speak, move, and think.

Chisso Corp., a Japanese chemical company, had dumped more than 600 tons of mercury into the bay between 1932 and 1968 via the company's wastewater. 1,784 people were slowly killed over the years while doctors scrambled to find the cause of the deaths that shared uncanny symptoms.

The Minamata Bay disease is a neurological illness where methylmercury poisoning causes long-term impairment of the central nervous system. The Minamata Convention on Mercury emerged in early 2013 as an international environmental treaty aiming to limit global mercury pollution, with 112 countries as current parties. Although the Environmental Protection Agency and other government organizations worldwide have since limited mercury that enters surface waters from power utilities and other corporations, this toxicant has a new and powerful avenue to the human brain: marine plastic pollution.

"The concentration of mercury in the surface level of the ocean is probably three or four times higher today than it was 500 years ago," said Dr. Carl Lamborg, an associate professor from the ocean sciences department at the University of California Santa Cruz.

Methylmercury makes its journey to our dinner plate up the food chain from the marine ecosystem's smallest organisms—phytoplankton and zooplankton—to fish and humans.

Dr. Katlin Bowman, a postdoctoral research scholar at UCSC, is researching how mercury enters the food chain. Through methylation, mercury in the ocean becomes methylmercury, an organic form of the element. It is far more dangerous because it easily concentrates while traveling up the food chain. Heavy metal toxicants naturally adhere to plastics in the water, contributing to the mercury pollution issue by creating extremely concentrated "fish food" bombs of dangerous chemicals, she said.

"Plastic has a negative charge, mercury has a positive charge. Opposites attract so the mercury sticks," Bowman said.

Microplastics are more concentrated in methylmercury as a result of their greater surface area, trapping toxic particles in the many folds and tight spaces.

"Microplastics are defined as a piece of plastic that's less than five millimeters in size," said Abigail Barrows, a marine research scientist from College of the Atlantic. "They cover a whole suite of things." These include microbeads in personal care products and microfibers that break off of clothing. As plastic bags, bottles, and utensils degrade over time, they become microplastics.

"If microplastics increase the rate of methylmercury production, then microplastics in the environment could indirectly be increasing the amount of mercury that accumulates in fish," Bowman said.

Two key concepts worsen methylmercury's impact: bioaccumulation and biomagnification.

With bioaccumulation, methylmercury never leaves the body, instead building up over time.

"The longer the fish lives, it just keeps eating mercury in its diet, and it doesn't lose it, so it ends up concentrating very high levels of mercury in its tissues," said Dr. Nicholas Fisher, distinguished professor at State University of New York Stony Brook. "The methylmercury also biomagnifies, which means that the concentration is higher in the predator than it is in the prey."

According to the European Commission's Mercury Issue Briefing of 2012, top-level predators have more than 100,000 times more

methylmercury stored in their system compared to their surrounding waters.

However, our focus should be on the plastic pollution issue rather than mercury discharge.

"The mercury bounces back and forth between the air and the ocean very easily," Lamborg said. While this toxin cycles through the environment in regular cycles, plastics serve as a magnet for mercury, prolonging its lifetime in the ocean and funneling it into the mouths of plankton and fish. When people eat affected seafood, they eat the concentrated methylmercury as well.

The Minamata Bay Disaster has already spelled out the horrific effects of mercury poisoning in all of its nitty-gritty glory. The EPA and other international agencies have passed regulations since the 1970s, such as the Clean Water Act and the Safe Water Drinking Act, that have significantly driven surface water mercury emissions downward. However, according to a report published by Science in 2015, the eight million metric tons of plastic that enter the ocean each year ensure that the problem will only swell.

"The plastic produced is on trend to double in the next 20 years," Barrows said. "So, I think that's where we need to focus on in terms of worrying about our environment."