Metal deposits from Chinese coal plants end up in the Pacific Ocean, research shows

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Emissions from coal-fired power plants in China are fertilizing the North Pacific Ocean with a metal nutrient important for marine life, according to new findings from a USC-led research team.

The researchers believe these metals could change the ocean ecosystem, though it's unclear whether it would be for better or worse.

The study shows that smoke from power plants carries iron and other metals to the surface waters of the North Pacific Ocean as westerly winds blow emissions from Asia to North America. Peak measurements show that up to nearly 60% of the iron in one vast swath of the northern part of the ocean emanates from smokestacks.

"It has long been understood that burning fossil fuels alters Earth's climate and ocean ecosystems by releasing carbon dioxide into the atmosphere," said Seth John, lead author of the study and an assistant professor of Earth sciences at the USC Dornsife College of Letters, Arts and Sciences. "This work shows fossil fuel burning has a side effect: the release of iron and metals into the atmosphere that carry thousands of miles and deposit in the ocean where they can impact marine ecosystems."

"Certain metal deposits could help some marine life thrive while harming other life," he added. "There are inevitable tradeoffs when the ocean water's chemistry changes."

The study was published on Thursday in the *Proceedings of the National Academy of Sciences*. Researchers from USC, Columbia University, University of Washington, MIT and the University of Hawaii, among others, collaborated.

USC-led team confirms that ocean metals stem from China

While wind-blown mineral dust from deserts has long been considered an important source of iron to open ocean waters, the new study shows

how manmade sources contribute important micronutrients that plankton and algae need. Moreover, the study shows how fossil fuel burning affects not only global warming but marine environments, too.

Previous studies have shown widely divergent estimates about how much iron is carried from various land-based sources to the ocean, especially from anthropogenic sources. Iron is a key limiting factor for marine productivity for about one-third of the world's oceans.

Instead, the USC-led research team measured metals in surface seawater. They focused on a remote part of the Pacific Ocean, hundreds of miles north of Hawaii and about midway between Japan and California. The region is downwind of industrial emissions in east Asia.

In May 2017, they boarded a research vessel and took water samples along a north-south transect at latitudes between 25 degrees and 42 degrees north. They found peak iron concentrations in about the middle, which corresponded with a big wind event over east Asia one month before. The peak iron concentrations are about three times greater than background ocean measurements, the study shows.

In addition, the scientists found elevated lead concentrations coincided with the iron hot spots. Other research has shown that most of the lead at the ocean surface comes from manmade sources, including cement plants, coal-fired power plants and metal smelters.

Moreover, the metals in the seawater samples bear telltale traces of Chinese industrial sources, the study says.

"When we collected samples in the ocean, we found that the iron isotope and lead isotope 'fingerprints' from seawater matched those of anthropogenic pollution from Asia," said Paulina Pinedo-Gonzalez, a USC post-doctoral scientist and study author who is now at the Lamont-

Doherty Earth Observatory at Columbia University.

Finally, the scientists also ruled out upwelling from the deep ocean as a source of the metals by testing water samples at depth.

What does the abundance of metals mean for marine life?

The study has important implications for marine life in the ocean. The North Pacific notably lacks iron, a key micronutrient, so an influx of metals and other substances can help build the foundation for a new ecosystem—a 'good news, bad news' outcome for Earth.

"Microscopic iron-containing particles released during coal burning impacts algae growth in the ocean, and therefore the entire ecosystem for which algae form the base of the food chain," John explained. "In the short term, we might think that iron in pollution is beneficial because it stimulates the growth of phytoplankton, which then take carbon dioxide out of the atmosphere as they grow to offset some of the carbon dioxide released during the initial burning process.

"However, it's totally unsustainable as a long-term geoengineering solution because of the deleterious effects of pollution on human health. Thus, the take-home message is perhaps a better understanding of an unintended side effect of coal burning and the ways in which that can impact ocean ecosystems thousands of miles away."

More information: Paulina Pinedo-González et al. Anthropogenic Asian aerosols provide Fe to the North Pacific Ocean, *Proceedings of the National Academy of Sciences* (2020). DOI: 10.1073/pnas.2010315117

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