Humans May Be Accidentally Geoengineering the Oceans

Iron particles released by industrial activities are falling into the seas in greater quantities than previously thought

- By Chelsea Harvey, E&E News on July 15, 2019

Phytoplankton bloom in the Barents Sea. Credit: Jeff Schmaltz NASA and MODIS Rapid Response Team

As the saying goes, what **goes up** must come down—and, as it turns out, a lot of what goes up comes down into the world's oceans.

Iron particles, released by human industrial activities, are one example of a pollutant that goes into the atmosphere and eventually **settles** into the sea. Now, new research suggests that human-emitted iron is accumulating in the ocean in much greater quantities than scientists previously estimated. And it may also be dissolving into the water more easily than suspected.

The consequences are still unclear, but they're worth investigating, scientists say. Iron is one of the key nutrients that **tiny** phytoplankton organisms in the ocean need to

thrive. In regions where its levels are limited, adding more iron to the water can give plankton a boost, potentially altering both marine food webs and the ocean's carbon uptake.

In fact, this phenomenon is the basis for a controversial geoengineering concept that some scientists have proposed to tackle climate change. Known as "iron fertilization," the idea involves adding iron to certain remote regions of the ocean where iron nutrients tend to be limited. Doing so could promote the growth of phytoplankton, which naturally **suck up** carbon dioxide.

When the phytoplankton die, those that don't get eaten by other animals fall through the water column and become trapped at the bottom of the sea, effectively locking away the stored-up carbon for good.

To date, various research groups have conducted more than a **dozen** small-scale iron fertilization experiments, with somewhat mixed results. Some studies suggest that the **carbon-storing** effects are more significant than others. At the same time, some experts have expressed concern that iron fertilization could have **unforeseen** consequences on marine ecosystems. Others say more research is needed.

Now, the new study would seem to suggest that humans may already be engaging in a kind of inadvertent iron fertilization campaign. But whether it's having any significant effect on marine ecosystems or carbon storage is still unknown.

The study, led by Tim Conway of the University of South Florida, set out to investigate the difference between iron inputs from natural sources and iron from human activities.

Scientists have long known that **dust** from the Sahara, **swept** by winds into the sea, tends to be rich in iron and accounts for a great deal of the iron particles that wind up in the Atlantic Ocean. Iron input from anthropogenic sources, like the burning of fossil fuels and other industrial activities, is believed to be comparatively much lower.

The new study investigated the issue by chemically analyzing iron samples from the North Atlantic. Aerosols from dust and from human sources tend to have slightly different chemical fingerprints, related to the ratio of iron isotopes they contain.

The analyses suggested that human sources of iron are probably significantly higher than previous studies have estimated. The study also found that these human iron inputs likely dissolve into the water much more easily than iron from natural sources, making them more readily accessible to hungry phytoplankton.

The researchers used their observations to tweak certain model simulations of the entire global ocean. The adjusted simulations seem to suggest that the findings don't apply only to the North Atlantic: Human iron inputs may be higher in other regions of the world, as well, including iron-limited parts of the Pacific Ocean.

That's important because some parts of the ocean are likely more sensitive to iron fertilization than others. In the North Atlantic, for instance, the growth of phytoplankton tends to be limited by nutrients other than iron, meaning that adding more iron to the water probably won't give them that much of a boost.

In places like the equatorial Pacific, the North Pacific and the remote Southern Ocean, on the other hand, iron is more likely to be the limiting factor. If iron inputs are on the rise in these places—especially if they're easily dissolvable in the water—then plankton communities could theoretically increase in growth.
These effects could become even more pronounced in the future, as increased industrialization across the Asian continent and parts of the Southern Hemisphere produces more air pollution, said Douglas Hamilton, a postdoctoral researcher at Cornell University and a co-author on the new study.
For the time being, though, it's unclear what effect human iron inputs are actually having. The first step would be to actually verify, with on-site observations, that human iron inputs are higher than expected in places besides the North Atlantic. The new study now provides a **framework** for doing that kind of work, Hamilton noted.
Afterward, extended monitoring could determine whether these regions are experiencing any ecological changes, like an increase in phytoplankton.
Still, it might be difficult to tease out whether those kinds of changes are being caused by increased iron fertilization or by other environmental **disturbances**, like ocean warming driven by climate change. In other words, even if humans are indeed engaging in an accidental iron fertilization

experiment, scientists may find it challenging to determine just what effect it's having on the Earth.

But Hamilton is hopeful that there may be ways to start addressing that question in the future. He's working on improving model simulations of plankton productivity in the ocean, which may help scientists get a better handle on how changes to ocean chemistry may affect marine systems.

A GEOENGINEERING OPTION

Scientists have been exploring the possible effects of iron fertilization as a form of geoengineering for at least 15 years. In that time, various research groups have conducted at least 13 experiments in both natural and controlled environments, according to a 2016 review paper.

Scientists are still debating how useful the process could be for climate mitigation.

As the review paper notes, studies have generally demonstrated that iron fertilization does boost the growth of plankton in iron-limited waters. The remote Southern Ocean is the region that most researchers suggest would be best suited for iron fertilization.

But just how much carbon is actually getting stored away at the bottom of the ocean is less clear. Some research has suggested that the carbon-sequestering effects are minimal, while other experiments suggest a stronger impact.

Even in the best-case scenario, the overall climate impact of iron fertilization would likely be small, according to Christine Klaas, a researcher with the Alfred-Wegener Institute for Polar and Marine Research who has participated in past iron fertilization experiments.

"The rough estimates of how much carbon we could take away by fertilizing most of the Southern Ocean are around 1 gigaton per year, and our current emissions are around 11 gigatons per year," she pointed out. "So it would be around 10% of what we're emitting today."

That means that iron fertilization, like other forms of geoengineering, isn't a solution to the climate problem, she added. It's one potential tool that could help bring emissions down faster, but it's not a substitute for the urgent need to reduce greenhouse gas emissions worldwide.

The concept hasn't been without its controversies.

Some experts have cautioned that inducing phytoplankton blooms could lead to unintended consequences for marine ecosystems, either by inadvertently triggering toxic algae blooms or by altering marine food webs in unexpected ways. Other scientists, including Klaas, point out that the ideal fertilization sites in places like the Southern Ocean don't support many toxic species in the first place.

The idea of iron fertilization has become somewhat more contentious in recent years, after U.S. entrepreneur Russ George conducted a fertilization experiment that dumped about 100 tons of iron dust off the coast of British Columbia. The project was aimed at boosting salmon populations through its effects on the marine food web.

Iron fertilization experiments today are subject to certain regulations under the London Convention on the Prevention of Marine Pollution. Whether scientists should continue with them is still a matter of debate among experts.

Klaas is an advocate of continued research. Current efforts to reduce global greenhouse gas emissions are not proceeding quickly enough to meet the Paris climate agreement's targets, meaning it's increasingly likely that some form of geoengineering will be necessary to keep warming in check, she said.

Among the geoengineering options that have been proposed so far, she considers iron fertilization "one of the best" and a relatively simple process.

Hamilton, on the other hand, said that "it's better not to even go there."

"I think history has shown us that when we start tinkering with the environment, invariably things that we have not considered crop up," he said. "There's unknown unknowns in the system. This would be absolutely the case with any of the geoengineering options being talked about at the moment."

But as long as industrial activity is causing inadvertent iron fertilization anyway, he noted, the new study may be a good starting point for understanding the effects that it's already having on the global oceans.

"Before this study, we had no way to be able to measure the anthropogenic component in situ," he said. "To be able to understand the anthropogenic perturbations to the system, we need to be able to measure it.

"Moving forward now, the idea, ideally, is that we measure this in locations that we know are going to be sensitive to the changes in the iron emissions due to anthropogenic activity in the future, so that we can have a handle on how much we're perturbing that system."