Ocean-Injection Strategy for Combating Greenhouse Effect

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In searching for ways to counteract the greenhouse effect, some scientists have proposed capturing the culprit---carbon dioxide---as it is emitted from power plants, then liquefying the gas and injecting it into the ocean. But there are pitfalls in that plan.

The carbon dioxide can rise toward the surface, turn into gas bubbles and vent to the atmosphere, defeating the purpose of the whole grand scheme. Even worse, if the liquid-to-gas conversion happens suddenly, the gas can bubble up in a plume and erupt---a potential hazard.

Small-scale ocean experiments have been done to investigate how the carbon dioxide (CO_2) actually would behave, but such experiments are too costly and time consuming to carry out under a wide range of ocean conditions. However, a new theoretical model developed by University of Michigan researcher Youxue Zhang can be used to explore the fate of CO_2 injected into oceans under various temperature and pressure conditions. Zhang's model shows that liquid CO_2 would have to be injected to a depth of at least 800 meters (about a half mile) and possibly as much as 3,000 meters (nearly two miles) to keep it from escaping.

Eruptions from injected CO_2 are a serious concern, Zhang said, "because carbon dioxide is known to have driven deadly water eruptions." In 1986, a CO_2-driven eruption in Cameroon's Lake Nyos killed some 1,700 people, as well as animals in the area; two years earlier, a smaller release of CO_2 from Lake Monoun in the same country resulted in 37 human deaths. The deaths were not directly caused by the explosions, but resulted from carbon dioxide asphyxiation. "Carbon dioxide is denser than air, so it settled down and flowed along the river valley, choking people and animals to death."

The challenge in designing CO_2 injection strategies is figuring out how to keep droplets of the liquid from rising to 300 meters---the approximate depth at which, depending upon temperature and pressure, liquid CO_2 becomes a gas. One solution is to make the droplets smaller.

"Droplets injected to a depth of 800 meters will rise, but if they are small enough they should dissolve completely before reaching the liquid-gas transition depth---assuming everything works perfectly," said Zhang, a professor of geological sciences. However, at a high injection rate, seawater full of CO_2 droplets would have an average density smaller than that of surrounding seawater, creating conditions that could lead to a rapidly-rising plume. Problems also could occur if the injection device malfunctioned, producing larger droplets.

"An even safer injection scheme would be to inject into a depth of more than 3,000 meters, where CO_2 liquid is denser than seawater and would sink and dissolve," Zhang said.

Calculations based on Zhang's theory closely match observations from experiments in which remotely controlled submersibles tracked and photographed individual droplets of liquid CO_2.

"Of course, you cannot do such experiments under all different conditions, at different depths and different temperatures," Zhang said. "That's why you need a theory to be able to calculate the behavior under any conditions."

Injecting CO_2 into the ocean may have environmental consequences, which must be addressed before decisions are made on whether such injections are a viable way to reduce carbon dioxide emission into the atmosphere, Zhang added.

Zhang's work was described in a paper in the Oct.1 issue of the journal *Environmental Science & Technology*. The research was partially supported by the National Science Foundation and the American Chemical Society Petroleum Research Fund.

Source: University of Michigan