Engineered weathering process could mitigate global warming
Researchers invent technology to accelerate Earth's own solution to greenhouse gas accumulation

Cambridge, Mass. – November 7, 2007 – A team of Harvard researchers have invented a technology, inspired by nature, to reduce the accumulation of atmospheric carbon dioxide (CO_2) caused by human emissions. By electrochemically removing hydrochloric acid from the ocean and then neutralizing the acid by reaction with silicate (volcanic) rocks, the researchers say they can accelerate natural chemical weathering, permanently transferring CO_2 from the atmosphere to the ocean. Unlike other ocean sequestration processes, the new technology does not further acidify the ocean and may be beneficial to coral reefs.

Lead author Kurt Zenz House, a Ph.D. candidate in Harvard’s Earth and Planetary Sciences Department, working with faculty members Christopher H. House, of the Department of Geosciences at the Pennsylvania State University, Daniel P. Schrag, of Harvard's Earth and Planetary Sciences Department and the Harvard School of Engineering and Applied Sciences and Director of the Harvard University Center for the Environment, and senior author Michael J. Aziz of the Harvard School of Engineering and Applied Sciences reported their innovative approach to tackling climate change in the November 7 issue of *Environmental Science and Technology*.

"The technology involves selectively removing acid from the ocean in a way that might enable us to turn back the clock on global warming—removing CO_2 directly from the atmosphere while simultaneously limiting the rate at which man-made CO_2 emissions are acidifying the ocean,” says House. “Essentially, our technology dramatically accelerates a cleaning process that Nature herself uses for greenhouse gas accumulation."

In natural silicate weathering atmospheric carbon dioxide dissolves into fresh water, forming a weak carbonic acid. This acid is neutralized as rain water percolates through continental rocks, producing an alkaline solution of carbonate salts. The dissolution products eventually flow into the ocean, where the added alkalinity enables the ocean to hold the dissolved carbon instead of releasing it into the atmosphere. As weathering dissolves more continental rock, more carbon is permanently transferred from the atmosphere to the ocean and ultimately to the sediments.

“In the engineered weathering process we have found a way to swap the weak carbonic acid with a much stronger one (hydrochloric acid) and thus accelerate the pace to industrial rates,” says House. “To minimize the potential for adverse side effects on the environment we combine it with other chemical processes, the net result of which is identical to the natural weathering process. As a result, ocean’s alkalinity would increase, enabling the uptake and storage of more atmospheric CO_2 in the form of bicarbonate, the most plentiful and innocuous form of carbon already dissolved in the earth’s waters. That means we may be able to safely and permanently remove excess CO_2 in a matter of decades rather than millennia,” says House.

Unlike other climate engineering schemes that propose reflecting sunlight back into space to cool the planet, the approach counteracts the continued ocean acidification that threatens coral reefs and their rich biological communities. Moreover, the process works equally well on all sources of CO_2, including the two-thirds of human emissions that do not emanate from power plants, and could be run in remote locations and powered by stranded energy, such as geothermal and flared natural gas.

The team cautions, however, that while they believe their scheme for reducing global warming is achievable, implementation would be ambitious, costly, and would carry some environmental risks that require further study. Replicating natural weathering would involve building dozens of facilities, akin to large chlorine gas industrial plants, on coasts of volcanic rock.

“The least risky trajectory is to significantly cut our carbon dioxide emissions—but we may not be able to cut them rapidly enough to avoid unacceptable levels of climate change," says Aziz. "If it looks like we’re not going to make it, the ‘House Process’ has the potential to let us rescind a portion of those emissions while mitigating some of the chemical impacts the excess CO_2 will have on the oceans. It won't be ready in time, though, if we wait until we're sure we'll need it before pursuing R&D on the technical and environmental issues involved”. He says that more research is needed on the effects on ocean biology and on improved efficiency and scalability of some of the chemical processes.

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