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First Study of Dispersant in Gulf Spill Suggests a Prolonged Deepwater Fate

To combat last year's Deepwater Horizon oil spill, nearly 800,000 gallons of chemical dispersant were injected directly into the oil and gas flow coming out of the wellhead nearly one mile deep in the Gulf of Mexico.

Now, as scientists begin to assess how well the strategy worked at breaking up oil droplets, Woods Hole Oceanographic Institution (WHOI) chemist Elizabeth B. Kujawinski, UC Santa Barbara geochemist David Valentine, and their research teams report that a major component of the dispersant itself was contained within an oil-gas-laden plume in the deep ocean and had still not degraded some three months after it was applied.

While the results suggest the dispersant did mingle with the oil and gas flowing from the mile-deep wellhead, they also raise questions about what impact the deep-water residue of oil and dispersant -- which some say has its own toxic effects -- might have had on the environment and marine life in the Gulf.

"This study provides a first critical look at what happened to all that dispersant injected directly into the gush of oil at the sea floor," said Valentine. "Key components of the dispersant were trapped in subsurface plumes of oil and gas, and were not rapidly biodegraded."

Kujawinski added: "This study gives our colleagues the first environmental data on the fate of dispersants in the spill. These data will form the basis of toxicity studies and modeling studies that can assess the efficacy and impact of the dispersants. We don't know if the dispersant broke up the oil. We found that it didn't go away, and that was somewhat surprising."

The study, which appears online in the American Chemical Society (ACS) journal *Environmental Science & Technology*, is the first peer-reviewed research to be published on the dispersant applied to the Gulf spill and the first data in general on deep application of a dispersant, according to ACS and Kujawinski. Some previous studies had indicated that dispersant applied to surface oil spills can help prevent surface slicks from endangering marshes and coastlines.

"By knowing how the dispersant was distributed in the deep ocean, we can begin to assess the subsurface biological exposure, and ultimately what effects the dispersant might have had," said Valentine, whose team collected the samples for Kujawinski's laboratory analysis. "The results indicate that an important component of the chemical dispersant injected into the oil in the deep ocean remained there, and resisted rapid biodegradation. This knowledge will ultimately help us to understand the biological effects of the dispersant."

Kujawinski and the other researchers found one of the dispersant's key components, called DOSS (dioctyl sodium sulfosuccinate), was present in May and June -- in parts-per-billion concentrations -- in the plume from the spill more than 3,000 feet deep. The plume carried its mixture of oil, natural gas and dispersant in a southwest direction, and DOSS was detected there at lower (parts-per-trillion) concentrations in September.

Using a new, highly sensitive chromatographic technique that she and WHOI colleague Melissa C. Kido Soule developed, Kujawinski reports those concentrations of DOSS indicate that little or no biodegradation of the dispersant substance had occurred. The deep-water levels suggested any decrease in the compound could be attributed to normal, predictable dilution. They found further evidence that the substance did not mix with the 1.4 million gallons of dispersant applied at the ocean surface and appeared to have become trapped in deepwater plumes of oil and natural gas reported previously by other WHOI scientists and members of this research team.

The team also found a striking relationship between DOSS levels and levels of methane, which further supports their assertion that DOSS became trapped in the subsurface.

Though the study was not aimed at assessing the possible toxicity of the lingering mixture -- Kujawinski said she would "be hard pressed to say it was toxic" -- it nevertheless warrants toxicity studies into possible effects on corals and deep-water fish such as tuna, she said. The Environmental Protection Agency and others have already begun or are planning such research, she added.

Kujawinski and Valentine were joined in the study by Soule and Krista Longnecker of WHOI; Angela K. Boysen, a summer student at WHOI; and Molly C. Redmond of UCSB. The work was funded by WHOI and the National Science Foundation. The instrumentation was funded by the National Science Foundation and the Gordon and Betty Moore Foundation.

In Kujawinski's technique, the target molecule was extracted from Gulf water samples with a cartridge that isolates the DOSS molecule. She and her colleagues then observed the molecule through a mass spectrometer, ultimately calculating its concentration levels in the oil and gas plume. This method is 1,000 times more sensitive than that used by the EPA and could be used to monitor this molecule for longer time periods over longer distances from the wellhead, she said.

"With this method, we were able to tell how much [dispersant] was there and where it went," Kujawinski said. She and her colleagues detected DOSS up to around 200 miles from the wellhead two to three months after the deep-water injection took place, indicating the mixture was not biodegrading rapidly.

"Over 290,000 kg, or 640,000 pounds, of DOSS was injected into the deep ocean from April to July," she said. "That's a staggering amount, especially when you consider that this compound comprises only 10 percent of the total dispersant that was added."

Kujawinski cautioned that "we can't be alarmist" about the possible implications of the lingering dispersant. Concentrations considered "toxic" are at least 1,000 times greater than those observed by Kujawinski and her colleagues, she said. But because relatively little is known about the potential effects of this type of dispersant/hydrocarbon combination in the deep ocean, she added, "We need toxicity studies."

"The decision to use chemical dispersants at the sea floor was a classic choice between bad and worse," Valentine said. "And while we have provided needed insight into the fate and transport of the dispersant, we still don't know just how serious the threat is. The deep ocean is a sensitive ecosystem unaccustomed to chemical irruptions like this, and there is a lot we don't understand about this cold, dark world."

Kujawinski added: "The good news is that the dispersant stayed in the deep ocean after it was first applied. The bad news is that it stayed in the deep ocean and did not degrade."

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† Top photo: Chemical tankers used for dispersant transport, stored in a Gulf of Mexico port facility.

†† Bottom photo: A fresh oil slick from the Deepwater Horizon spill, during June 2010. Note that one drop of detergent was added to the oil slick, forming the cleared circle.

Photos by David Valentine

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