Did Dispersants Help During Deepwater Horizon?

CONTROVERSIAL CHEMICAL SPRAY MAY HAVE IMPROVED AIR QUALITY

by Christopher M. Reddy & J. Samuel Arey

Dan Torres, WHOI

Natural gas piped up from a severed wellhead deep beneath the Gulf of Mexico is flared off by a ship at the surface during the Deepwater Horizon disaster in 2010. Responders trying to stop the spill and mitigate damages had to put on respirators or stop working entirely at times because of unhealthy air quality.

In the heat of the 2010 Deepwater Horizon disaster, U.S. government and industry responders had to make a crucial decision. They were facing an enormous oil spill, gushing uncontrollably from a wellhead at the seafloor—at a depth where no oil spill had ever happened before. They were pitted in a high-stakes battle against big unknowns.

On Day 25 of the spill, they made the decision: They began to inject chemical dispersants—10,000 gallons per day—at the severed wellhead 5,000 feet beneath the ocean surface in the Gulf of Mexico. The goal was to break up petroleum that surged uncontrollably from the wellhead into smaller droplets in the deep sea—with the hope of diminishing oil slicks and reducing the amount of harmful gases arriving at the ocean surface.

Chemical dispersants have been applied to marine oil spills for at least a half-century. But when responders injected Corexit EC9500A (which roughly resembles a mix of mineral oil, windshield-wiper fluid, and household dish detergent) into the depths, it was an unprecedented and untested experiment.

Seven years later, the decision continues to fuel contentious debate. Opponents say the dispersants themselves were toxic, that they may have exacerbated environmental damage, and that they were ineffective at breaking up the already dispersed oil erupting from the wellhead. Proponents say the dispersants helped diminish oil slicks on the surface, reducing the amount of oil tainting shoreline beaches and marshes.

In a new study published in August 2017 in the *Proceedings of the National Academy of Sciences*, we were part of a team of scientists who revealed a key benefit of using dispersants: It likely allowed emergency responders literally to breathe easier.

By breaking up petroleum into smaller droplets that dissolved faster in the deep ocean, the dispersant decreased the amounts of volatile toxic compounds that rose to the surface and outgassed into the air. That dramatically improved the air quality for responders—diminishing health risks, reducing the time they had to suspend cleanup efforts because of unhealthy air, and allowing them to keep working to stop the uncontrolled spill and clean up the spilled oil sooner.

Simulating real life

In the heat of the crisis, with a priority and focus on controlling the spill and mitigating damages, scientists were not allowed the time to design and implement robust experiments to measure the impacts of the dispersant injection.

So we built and tested a mathematical model that simulated the real-world disaster. It wove together the complex chemical and physical interactions among water, oil, gas, and dispersant that occurred during Deepwater Horizon. The model's results closely agreed with observations actually collected in the sea and atmosphere near the disaster site, giving us confidence that the model could replicate how the oil spill unfolded.

We then used the model to conduct a key test that was never done in real life: We ran the model to see what likely would have happened if dispersants had not been injected immediately above the wellhead during the crisis.

The results were stunning. The model showed that the deep-sea dispersant injection had a profound effect on air quality at the sea surface. In the hidden darkness of the deep sea, the dispersants caused the turbulent jet of petroleum fluids gushing from the wellhead to form oil droplets that were about 30 times smaller (by volume) than they would have been if dispersants were not present.

This subtle change caused many volatile organic chemicals in the oil to dissolve more rapidly than they would have if dispersant had not been injected. Instead of rising to the ocean surface, these rapidly dissolving chemicals, including highly toxic benzene and toluene and other petroleum compounds in oil, were transported away in deep currents. They likely affected marine organisms on and near the seafloor, but most of the benzene and toluene likely biodegraded within weeks.

A breath of fresh air

But it was a different story at the surface. There, the amounts of benzene and toluene—chemicals most harmful to humans—were significantly reduced by the disperant injection.

The model showed that, without dispersants, the atmospheric concentration of benzene would have been about 6,000 times higher. Benzene concentrations in the air two meters above the sea surface would have been 13 times higher than the levels considered acceptable to breathe during a 10-hour working day or a 40-hour work week, based on guidelines by the National Institute for Occupational Safety and Health (NIOSH). However, the model showed that with the dispersant injection, atmospheric benzene concentrations were typically about 500 times lower than acceptable NIOSH levels.

This dramatically improved the air quality for the courageous emergency responders who were working around the clock to stop the flow of petroleum from the wellhead and mitigate damage. On days when the air quality was too poor, they had to don respirators or stop working, which delayed efforts to seal the wellhead. We predict that human health risks and work delays likely would have been much more frequent if subsurface dispersant injection had not been applied. That would have made a bad situation even worse.

This one study is not the final say on whether and when to use dispersants. Before officials decide whether to use them in the future, they will conduct a "spill impact mitigation analysis," which assesses various strategies and tools to reduce environmental and economic damage, taking into account all their positive and negative impacts. This study is another row on that ledger—on the plus side.

The research team included: Jonas Gros, Scott Socolofsky, Anusha Dissanayake, and Inok Jun (Texas A&M University); Lin Zhao and Michel Boufadel (New Jersey Institute of Technology); Christopher Reddy (Woods Hole Oceanographic Institution); and J. Samuel Arey (Swiss Federal Institute of Aquatic Science and Technology). The research was funded by the Gulf of Mexico Research Initiative and the National Science Foundation.

A new study modeled the impacts of the deep-sea injection of dispersants during Deepwater Horizon—and what might have happened if dispersants were not used. The model showed that, without dispersants, more oil would have risen to the surface, putting more toxic benzene and toluene into the air. On the other hand, using dispersants greatly reduced the size of oil droplets, so that more oil was swept away in deep currents and did not rise to the surface. As a result, the amount of toxic gases released into the air was diminished and posed fewer health risks to workers.

Without Subsurface Dispersant | **With Subsurface Dispersant**