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Deepwater Horizon: the fate of petroleum in the deep ocean

In a new study, scientists have analysed the outcome of millions of barrels of oil and gas discharged into the Gulf of Mexico during the Deepwater Horizon disaster. By measuring changes in the composition of the fluid, scientists now have a better understanding of how pollution behaves in the deep ocean, to improve estimates of environmental impact.

Soon after the explosion at the Macondo well in April 2010, scientists found that much of the escaped petroleum (oil and gas) was contained in an underwater 'plume', extending southwestwards from the well around 1,100 metres deep. This was different to how they had seen petroleum behave near the surface of the ocean. Until now, however, scientists have not had enough data to determine which substances – or 'fractions' – of the petroleum were present in the plume and how their transport was affected by physical, chemical and biological processes.

In mid to late June 2010, with the help of an underwater robotic instrument, known as a remotely operated vehicle (ROV), scientists collected two petroleum samples as they escaped from the base of the Macondo well and over 100 water samples from within the plume, up to 35km away from the well. They analysed each well sample (but not the water samples) for more than 100 organic compounds, including volatile hydrocarbons (methane, ethane, propane, butane and pentane), light aromatic hydrocarbons (i.e. benzene, toluene) and more complex substances, such as polycyclic aromatic hydrocompounds (PAHs). The data on the water samples was derived from other published studies. [1]

Using the current official US estimate of the amount of oil released (4.1 million barrels)[2], the scientists calculated that 1.7×10^{11}g of volatile hydrocarbons (methane to pentane) entered the water during the spill. Chemical analysis revealed that a high proportion of the soluble petroleum fractions dissolved rapidly in the cold, deep water. The remainder either escaped to the surface (and the atmosphere) in buoyant liquid oil droplets, or were deposited on the seafloor.

The most abundant substance released from the well was methane. Methane is highly soluble in water and just 0.01% escaped into the atmosphere, compared to around 10% of ethane and 30% of propane. The deep plume formed as marine currents transported the dissolved hydrocarbons, together with some larger soluble compounds (mostly benzene, toluene, ethylbenzene and xylenes), southwestwards away from the well. Had the spill been closer to the surface, it is less likely that the plume would have formed. This is because the compounds would have dispersed and evaporated, rather than dissolved.

During the four days of the study, the scientists found little evidence of biodegradation – breaking down of the hydrocarbons by organisms in the water. They identified a significant fraction (10%) of 'polar hydrocarbons' in the oil. These are often overlooked in pollution studies, but can be resistant to degradation, persisting in the environment for long periods of time.

Using their own measurements and biodegradation rates from other studies, the scientists estimated that the total amount of hydrocarbon dissolved in the water from the spill was likely to reduce by half each month (i.e. it has a half life of one month). Such comprehensive data on the fate of the different crude oil fractions is key to assessing both the ecological cost of the disaster and to managing the remaining risk.

1. Camilli *et al.* (2010). Tracking Hydrocarbon Plume Transport and Biodegradation at Deepwater Horizon, *Science*. Available from http://www.sciencemag.org/content/330/6001/201.short

2. Assessment of flow rate estimates for the Deepwater/Macondo well oil spill. Report to the National Incident Command. Available from: http://www.doi.gov/deepwaterhorizon/loader.cfm?csModule=security/getfile&PageID=237763

Source: Reddy, C. M., Arey, J. S., Seewald, J. S. *et al.* (2011). Composition and fate of gas and oil released to the water column during the Deepwater Horizon oil spill. *Proceedings of the National Academy of Sciences*. DOI 10.1073.
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