Mixing processes could increase the impact of biofuel spills on aquatic environments

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Ethanol, a component of biofuel made from plants such as corn, is blended with gas in many parts of the country, but has significantly different fluid properties than pure gasoline. A group of researchers from the University of Michigan wondered how ethanol-based fuels would spread in the event of a large aquatic spill. They found that ethanol-based liquids mix actively with water, very different from how pure gasoline interacts with water and potentially more dangerous to aquatic life.

The scientists will present their results, which could impact the response guidelines for ethanol fuel-based spills, at the American Physical Society's (APS) Division of Fluid Dynamics (DFD) meeting, held Nov. 18 – 20, in San Diego, Calif.

"Ethanol/gasoline blends are often presented as more environmentally benign than pure gasoline, but there is, in fact, little scientific research into the effects these blends could have on the health of surface waters," says Avery Demond, an associate professor and director of the Environmental and Water Resources Engineering program at the University of Michigan, and one of the researchers who is working on the project. Some reports written for the State of California include methods for calculating the spread of ethanol into water based on a passive diffusion/dispersion process, notes Demond, but the method was not based on strong scientific evidence of how the two fluids interact.

The Michigan researchers were motivated to fill some of the knowledge

gaps. They experimented by filling a tank with water, covering the water with a plate, and pouring ethanol mixtures on top. The plate was then pulled away and the researchers recorded videos of the two fluids as they began to mix. The videos showed flow patterns called convection cells forming at the interface of the ethanol mixture and water. The mixing of the two fluids produced heat that changed the density and viscosity of the fluid, giving rise to circulation currents. In contrast, pure gasoline is essentially insoluble in water and primarily remains on the surface where it vaporizes into the air.

"The mixing behavior [of ethanol-based fuel mixtures and water], from my perspective, is very unusual," says Demond. "I've never seen anything quite like it and it certainly is not passive the way that modeling guidelines suggest." Aline Cotel, also an associate professor at the University of Michigan and another member of the research team, will present videos of the unusual mixing patterns at the conference.

As a next step, the researchers would like to study how different ethanol mixtures vaporize, helping them to determine how much of a spill would end up mixed into the water and how much would volatilize into the air. Although ethanol is biodegradable, in high concentrations it can be toxic to fish and other aquatic life. The ethanol in ethanol/gasoline blends might also transport some of the carcinogenic components of gasoline into the water during the mixing process.

"We can't make statements about the environmental impact of ethanol before we've more fully investigated its potential effects on surface water quality in the event of a spill," note the researchers.

Ultimately, they hope their work will help answer outstanding questions about how ethanol mixes with water, giving scientists and policy makers a firmer grasp of the potential risks of ethanol-based biofuels.

More information: Presentation: "Characterization of Mixing Between Water and Biofuels," is at 9:31 a.m. on Tuesday, Nov. 20, in room 23A. Abstract: meeting.aps.org/Meeting/DFD12/Event/178765

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