Study finds emissions from widely used cookstoves vary with use

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In many developing countries, food is cooked over traditional biomass-burning cookstoves. Illinois researchers found that how users operate their stoves has a big effect on emissions. Credit: Cheryl Wayant

The smoke rising from a cookstove fills the air with the tantalizing aroma of dinner – and a cloud of pollutants and particles that threaten both health and the environment. How families in developing countries use their cookstoves has a big effect on emissions from those stoves, and laboratory emission tests don't accurately reflect real-world operations, according to a study by University of Illinois researchers.

Biomass-burning cookstoves are used throughout the developing world, using wood, agricultural waste and other organic matter as fuel. They are also a major cause of poor air quality in the regions where use is prevalent. Policymakers and nonprofit organizations are working to develop and distribute "improved" cookstoves, for example, adding insulation or chimneys to reduce emissions. They are especially concerned with fine particles that are emitted, which cause health problems and also affect climate.

Much like automobiles undergo emission testing before hitting the market, cookstoves are tested in the lab before distribution to gauge how effective improvements are at reducing emissions. But if the conditions aren't the same as how people use them at home, then the changes that designers make to the stove may not actually reduce emissions in the field.

"The understanding of how people really use combustion devices is important if we're going to optimize that device," said study leader Tami Bond, a professor of civil and environmental engineering at U. of I. "In the laboratory, where tests are conducted by trained people, there's a lot more attention to operating the stove carefully. At home, people are not as concerned with its operation; they're more concerned with making a meal. So they operate in ways that are non-optimal."

However, these variations in use are masked by the current methods of testing, which use only average values to determine emissions – sort of like a snapshot of the stove in operation, not accounting for variation in use. Bond's team developed a real-time analysis technique called Patterns of Real-Time Emissions Data (PaRTED) that allows researchers to compare emissions under different operating conditions and to measure how often a stove operates under certain conditions in the field.

"Wood burning is like a dance," Bond said. "A movie gives you a better

understanding than a photograph. This is a way to make movies of how users change as they make fires, and that can help people understand emission rates and make better stoves."

Using PaRTED, Bond's team tested cookstoves in use in a village in Honduras and compared the field results to lab results. The researchers found that operation under less-than-ideal conditions produces the highest emissions. They also found that in the field, stoves are rarely used under optimal conditions, a scenario not reproduced in laboratory tests.

The team compared emission profiles, or the chemical makeup of the smoke, from traditional cookstoves and two types of improved stoves: insulated stoves and stoves with chimneys. They found that although stoves with an insulated combustion chamber could increase overall efficiency, they did not significantly reduce emissions per mass of fuel burned. Chimneys did reduce certain types of particle emissions – but chimneys did not cut down on black particles, the type most harmful to climate.

"Our measurements confirm that changes in stove design cause a change in the way they operate," Bond said. "I think people weren't aware that changes in design actually change the profile of the emissions rather than just reducing emissions."

Next, the researchers will use PaRTED analysis to study variations in cookstove use in different regions of the world. Bond hopes that PaRTED and this study will inform future testing protocols for cookstoves in the lab, enabling researchers to more accurately test under realistic conditions and providing insight into a whole range of possible use scenarios.

"Insulated and chimneyed stoves are a step in the right direction, but not

as far as we need to go to get really clean stoves," Bond said. "The next step is to identify both the patterns of stove operation and the factors that lead to the characteristic profile of operation so that those can be brought into the lab and optimized. The cookstove world is moving toward having emission standards. It would be best if those standards were relevant to real operations."

More information: The paper, 'Characterizing Biofuel Combustion With Patterns of Real-Time Emission Data (PaRTED),' is available online at pubs.acs.org/doi/full/10.1021/es3003348

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