New insights about the toxicity of smoke produced by home stoves and power plants

February 2 2022, by Ingrid Fadelli

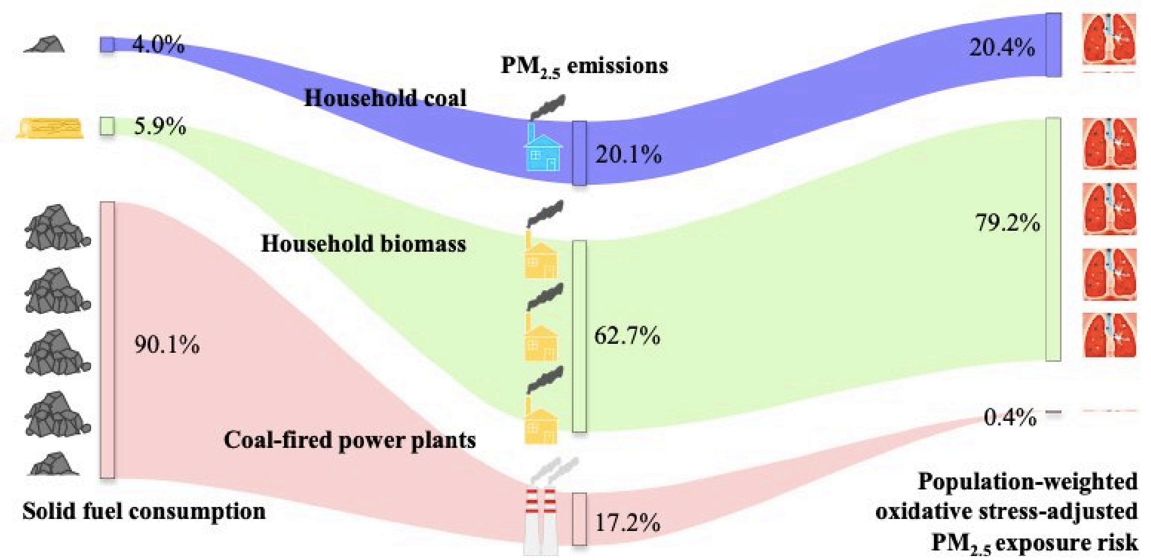

Figure. Total amounts of solid fuel consumption, $PM_{2.5}$ emissions and the population-weighted oxidative stress-adjusted $PM_{2.5}$ exposure risk contributed from household coal and biomass burning and coal-fired power plants in 2017 in mainland China, based on the estimation of measured emission factors and cellular toxicity tests from field sampling and systematic analysis as well as integration with the updated national emission inventory. The number below/above each panel indicates the ratio of consumed solid fuels, emitted aerosols, and aerosol-related toxic potency adjusted emissions for household coal and biomass burning and coal-fired power plants.

Residential combustion sources (household coal/biomass burning) may induce more significant adverse health impact than large scale coal-fired power plants. Credit: Wu et al.

The color of smoke coming out from chimneys can vary greatly based on its source and how it is produced. For instance, small coal or biomass stoves typically release dense, black smoke, while power generation plants produce lighter-colored plumes of smoke.

While these color differences are known to be linked to the different aerosols contained in smoke, so far not many studies have closely examined the major components of these aerosols and their effects on health. Researchers at Fudan University, Tsinghua University, and the Hong Kong Polytechnic University recently published a paper in *Nature Energy* outlining new interesting findings about the levels of toxicity of aerosols originating from different combustion sources, such as stoves in residential homes and coal-fired power plants (CFPPs).

"Differences in the color of smoke coming out from distinct chimneys can indicate different aerosols in plumes," Prof. Xiangdong Li, one of the authors of the paper, told TechXplore. "A crucial question is, are the major components of aerosols from these emission sources different, and can they have different health impacts? To investigate this, we collected the aerosols from large scale CFPPs and common household stoves burning wood and coal."

When Prof. Li and his colleagues analyzed the aerosols produced by CFPPs and common household stoves in the lab, they found that they had significant chemical differences. Interestingly, those emitted by household stoves primarily contained carbonaceous matter resulting from the incomplete combustion of coal or biomass material. On the other hand, large-scale powerplants that rely on efficient boilers could attain the complete combustion of fuels. This resulted in better pollution control metrics and a lower number of aerosols containing inorganic materials, such as transition and heavy metals.

In the second part of their study, the researchers used real cells from human lungs (i.e., pulmonary cells) to determine the toxicity of the inhalable particulate matter (PM) produced by household stoves and CFPPs. They specifically examined the generation of intracellular reactive oxygen species (ROS) prompted by the PM, as well as cell viability and toxicity.

"Combining the chemical data with our previous information on chemical toxicity, we conducted a further aerosol toxic experiment with respiratory cells," Prof. Li said. "In this experiment, we demonstrated that the toxicity of aerosols emitted from household coal/wood burning is more than 10 times higher than that from large scale coal-fired power plants."

The team used the data collected during this experiment to estimate the toxicity of the aerosol emissions. In addition, the same data helped them to create an advanced air quality model that simulates the ways in which aerosols disperse in the wind.

Finally, the researchers estimated the population-weighted toxic potency adjusted $PM_{2.5}$ exposure risk, based on simulated $PM_{2.5}$ concentrations and $PM_{2.5}$-associated toxic equivalent values.

"Professor Qing Li's group examined chemical characteristics from various emission sources in the last few years, Professor Xiangdong Li's group has experience on chemical toxicity for aerosols, while Professor Shuxiao Wang's group has done large scale aerosol emission inventory and air quality simulation," the researchers said. "Thus, the current study is a fully collaborative research project, in which our three teams joined forces to address this important environmental and health issue."

The overreaching goal of the study was to gather new insight that could help to enhance strategies for improving the quality of air and reducing pollution. Prof. Li and his colleagues hope that their findings will encourage policy-makers to update current pollution control strategies, taking the differences in aerosol-related toxicities that they identified into account.

In the *Nature Energy* paper, the team also proposed a series of health-oriented strategies for mitigating air pollution caused by coal-based residential stoves and CFPPs. In the future, they hope that the World Health Organization (WHO) will add these strategies to its mass concentration-oriented air quality guidelines.

"We now plan to construct a full picture of health risks of aerosols derived from all major sources and try to propose some new pollution control measures in consideration of aerosol toxicity and achieve better economic benefits," Li added.

More information: Di Wu et al, Toxic potency-adjusted control of air pollution for solid fuel combustion, *Nature Energy* (2022). DOI: 10.1038/s41560-021-00951-1