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Probe-based measurements of moisture in dung fuel for emissions measurements

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ABSTRACT

Measurement of the moisture content of biomass fuels is critical for the measurement of emission factors and accounting for differences in stove performance results from standardized tests such as the water boiling test. Moisture probe measurements have been used systematically for the assessment of moisture content of woody fuels, as it is more convenient than laboratory-based oven-drying methods because multiple measurements can be rapidly performed on-site as the fuel for the cooking task is selected for use. Current protocols, however, state that the probes used to measure moisture content in wood cannot be used with dung, crop residues, or other non-wood fuels. The averages from 5 replicate moisture probe measurements on each of 35 cow and buffalo dung patties from Haryana, India, were compared to oven drying moisture measurement at 103 ± 2 °C. Dung patties were selected ranging in moisture content from 5% to 65% on a dry basis based on probe measurements with 5 unique patties in each 10% increment. The results showed good linearity between moisture probe ≤55% and oven drying methods ($r^2 = 0.76$). Results were then used to adjust uncontrolled measurements of dung moisture taken prior to cooking for 17 homes in 4 villages in rural Haryana, India, which demonstrate that the commonly used moisture probe, when calibrated against oven-based methods, can be used to assess moisture content of dung patties over the range of dung moisture typically found and used in villages for cooking purposes.

Introduction

Use of non-woody biomass for fuel, such as dung and crop residues, is prevalent in many areas of the world. While there have been considerable efforts to develop protocols and perform laboratory-based testing of stoves using wood fuels, there has been much less (1) testing of unprocessed, non-woody biomass and dung and (2) development of stoves suited to burning these fuels. Dung from a variety of animals (cows, water buffalo, yak, camel) is used in many parts of the world to cook food and heat homes, particularly in high-altitude areas above the treeline and in arid environments where biomass is scarce, but also in agricultural areas of India and Nepal. Emissions from and properties of dung fuels, however, are not well documented (Edwards et al., 2014), with only a handful of studies on emission factors from India (Venkataraman et al., 2002; GIRA, 2014; Venkataraman and Rao, 2001; Stone et al., 2010; Smith et al., 2000). Limited data indicate that emissions of particulate matter (PM), carbon monoxide (CO), and polycyclic aromatic hydrocarbons (PAH) from dung were considerably higher than those for fuel wood or woody briquettes (Venkataraman et al., 2002), and that advanced combustion stoves may not deliver the benefits anticipated when using these fuels (GIRA, 2014; Venkataraman and Rao, 2001).

Fig. 1 shows the global distribution of dung fuel use in stoves as the primary cooking fuel compiled using the U.S. AID Demographic and Health Surveys (DHS)[1] Program "STATcompiler" Version 1.5.2 and plotted in ArcGIS, ArcMap 10.2.2. Data for Afghanistan and Kyrgyzstan were provided by the most-recent Multiple Indicator Cluster Surveys (MICS) for each country.[2] The majority of dung use is in South Asia, with Afghanistan reporting the largest percentage of total energy use arising from dung combustion and India reporting the largest population using dung fuels for cooking. Dung use is also prevalent in Africa, but with much lower frequency, and at high altitudes in Peru. Although dung represents a small fraction of the total energy use in countries where dung use is prevalent, the number of people globally using dung for fuel is large and the emissions are high relative to other fuels. Based on population data for 2014 compiled in the World Development

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[1] http://www.dhsprogram.com/
[2] Data for Afghanistan came from the 2001–2011 MICS Final Report available at http://microdata.worldbank.org/ and data for Kyrgyzstan came from the 2014 Multiple Indicator Cluster Survey Final Report available at http://mics2014.kg/images/english.pdf.

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0973-0826/

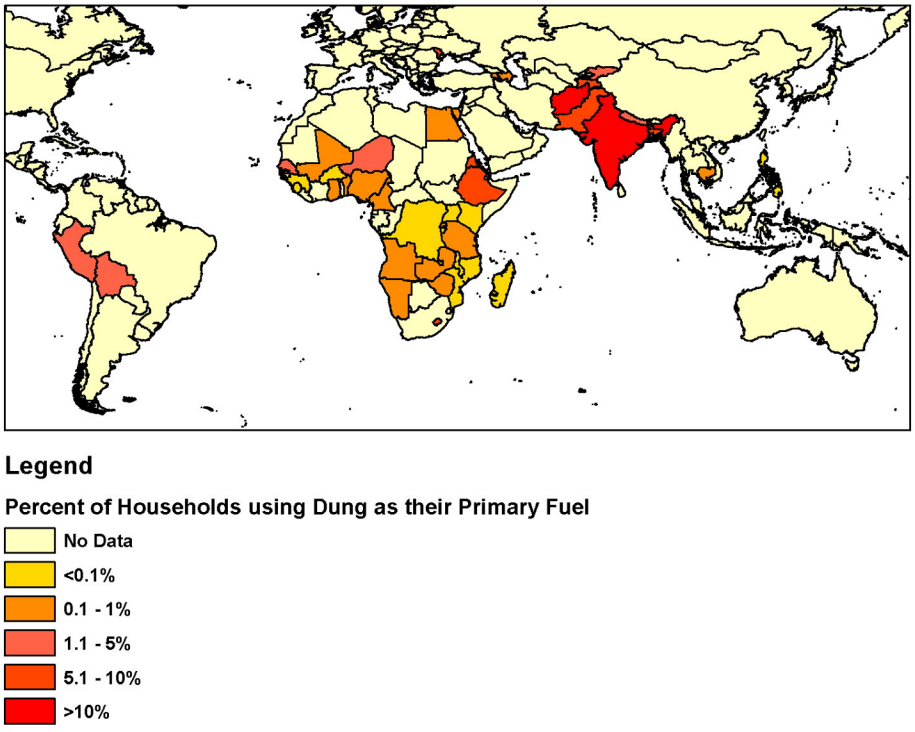
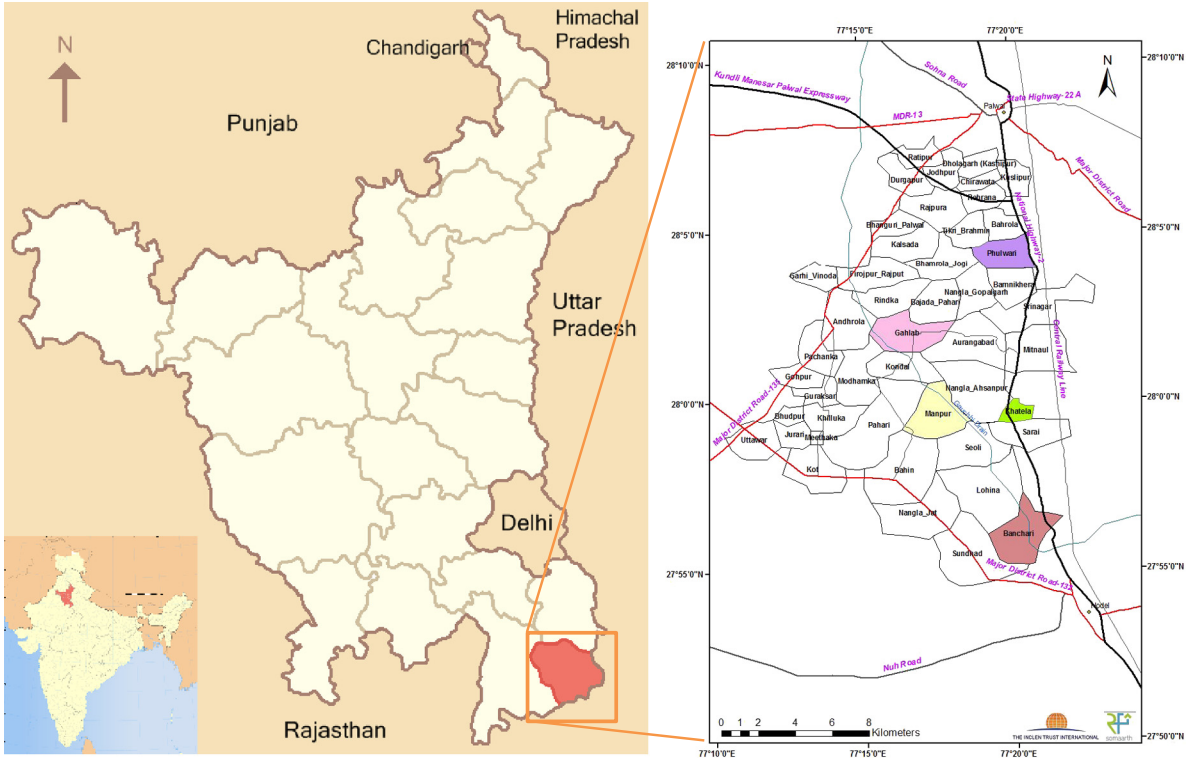


Fig. 1. Global distribution of dung fuel use in stoves for primary energy provision.



https://commons.wikimedia.org/wiki/File:HaryanaPalwal.png#file

Fig. 2. Palwal study site with villages where dung patties were collected.

Indicators database,[3] approximately 185 million individuals live in homes where cooking is primarily with dung.

Developing cleaner alternatives for dung fuels is therefore essential to reduce associated health burdens. A first step in this process is to improve the ease with which emissions from this fuel can be measured. Measurement of the moisture content of biomass fuels is critical for estimating emission factors and for accounting for differences between

[3] World Development Indicators database, World Bank, 11 April 2016 http://databank.worldbank.org/data/download/POP.pdf