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Integrated Indoor and Outdoor Exposure Assessment Framework for Fine Particulate Matter Pollution

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The 2010 Global Burden of Disease report demonstrates that fine particulate matter (PM2.5) pollution is the major environmental contributor to mortality. Exposures outdoors (ambient) and indoors (household) contribute almost equally to this burden. Unfortunately, the health impacts from exposure to PM2.5 are often excluded from life cycle impact assessment (LCIA) used for characterizing environmental performance of products and services. This is in large part because of the lack of well-vetted harmonized guidance about how to consistently assess the exposures and impacts of indoor and outdoor emissions of PM2.5 and its precursors. We present a modeling framework for calculating exposure factors for indoor and outdoor emissions of primary PM2.5 and secondary PM2.5 precursors, and a roadmap for further refining this modelling framework for operational use in LCIA. The framework was developed over the last three years by a task force convened under auspices of the Society of Environmental Toxicology and Chemistry (SETAC)/United Nations Environment Program (UNEP) Life-Cycle Initiative to provide guidance and methods for estimating the health impacts associated with PM2.5 exposure and to recommend PM2.5 characterization factors for application in life cycle assessment. The framework involves three stages--analyzing PM2.5 fate and exposure (including indoor and outdoor urban/rural environments), modeling exposure-response, and the integration of exposure-response and PM2.5 exposure reflecting population and location characteristics. We introduce the overall framework and present key components of the exposure assessment underlying the health impact characterization factors. The exposure metric at the center of this analysis is the population intake fraction (iF). Our exposure model is organized as a mass balance matrix that tracks the global fate of primary PM2.5 and secondary PM2.5 precursor emissions (both indoors and outdoors) as an embedded system of compartments including urban environments, rural environments, and indoor environments within urban and rural areas. The fate modeling system provides PM2.5 concentrations that are linked with human activity patterns and population geographical distribution patterns to determine intake fractions. After presenting the model structure, we will review initial results and will present geographic variability, discuss key uncertainties, and evaluate our model using results from other models and concentration measurements.