Breathing House Dust is Nothing to Sneeze at

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If you were asked what the largest source of pollution is that people breathe, your answer might include power plants, diesel trucks, or automobiles. But all these answers would be wrong. Since most people spend between 65 and 90 percent of their time indoors, it is indoor sources of air pollution, not outdoor air pollution, which have a greater impact on human health. The air is filled with tiny particles called particulate matter (PM), which has been linked with allergies, asthma, and heart and lung disease. By examining PM that is "kicked up," or re-suspended by indoor human activity, I hope to find ways to reduce this pollution.

PM is defined as any substance larger than a molecule, either solid or liquid, which exists in the atmosphere, and includes things such as soot, pollen and sea spray. Next to second-hand cigarette smoke and cooking emissions, house dust re-suspended by indoor human activity is the largest source of PM that we breathe. Surprisingly, house dust contains many pollutants, including pesticides, polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), molds, allergens, and lead and other heavy metals. These pollutants are either tracked in with shoes, infiltrated through doors, windows and cracks, or are generated indoors. They then collect on surfaces and are re-suspended with human activity.

My research examines the concentration, composition, and size of re-suspended PM. The size of PM varies, and the range of sizes is referred to collectively as the size distribution. The size distribution of the PM is important because larger PM is mostly filtered out by the nose, while smaller PM can be deposited deep in the lungs. PM less than 10 micrometers (um) in diameter is able to be inhaled and hazardous to human health. PM with diameters less than 2.5 um is most easily deposited in the lungs. I have found that a variety of indoor human activities re-suspend high concentrations of PM between one and 10 um in diameter within the breathing zone.

Because we regulate pollutants in outdoor air, but breathe mainly indoor air, the United States Environmental Protection Agency (EPA) would like to determine the relationship between the concentration of PM in outdoor air and the concentration of PM a person breaths. Unfortunately, this relationship is not so straightforward. Outdoor sources of PM impact both outdoor concentrations and personal exposures, since outdoor PM easily travels indoors. However, indoor sources primarily impact personal exposures and not outdoor concentrations. Also, studies have shown that PM concentrations measured by a personal monitor (worn on the body) are consistently higher than those measured by a stationary indoor

monitor. This phenomenon is called the "personal cloud." Because of the personal cloud, stationary indoor measurements do not accurately represent what a person breathes, and therefore personal exposure must be measured directly.

Personal exposure experiments for PM are normally performed using integrated filter samples. These samples are collected by drawing air through a filter, usually for 12 to 24 hours, and analyzing the PM that collects on the filter. In 1990, the EPA performed a large integrated filter study that measured outdoor, indoor and personal exposures to PM. This study concluded that cigarette smoking, cooking and re-suspension of house dust due to human activities such as housework were the largest sources of human exposure to PM for the participants. Since then, many studies have investigated the first two sources, smoking and cooking, but very few have looked at the re-suspension of house dust.

Because standard integrated filter measurements average the effects of indoor pollution over long periods of time, they do not provide direct evidence as to which types of human activities produce the most PM pollution. In contrast, my technique, which uses real-time instruments that gather data on a minute-to minute basis in addition to filter samples, does provide direct evidence. The real-time instrument measurements allow me to develop a size distribution for each source and determine whether the re-suspended particles are small enough to be a health hazard. For my experiments, I set up the filter samplers and real-time instruments in stationary locations outdoors and indoors at a home in Redwood City, California. All instruments were located at breathing height. I carried a third identical set of instruments at breathing height while I performed a variety of activities such as dusting, vacuuming, walking, dancing, and folding clothes.

The filter samples I collected were useful for determining how much of the personal exposure to PM was from indoor and how much was from outdoor sources. Indoor and outdoor air contain different concentrations of elements, so by measuring the concentration of different elements in the PM I collected, I could figure out where the pollution came from. As predicted, most of the personal exposure to PM came from indoor activities.

Using the real-time instruments, I found that carpets increased concentrations of PM by 10 times over bare floor. Carpets that had not been vacuumed for several weeks increased concentrations by more than two times over carpets that had been vacuumed the previous week. Also, the more vigorous activities re-suspended the highest concentrations of PM. For example, dancing on a carpet increased concentrations more than walking on a carpet. Activities where dust reservoirs were disturbed, such as dry dusting, folding clothes and blankets, and making a bed, released the highest concentrations. Surprisingly, just walking around and sitting on furniture increased concentrations as much as vacuuming.

Awareness that indoor sources can affect our health allows us to reduce our exposure to PM. Based on my experiments, removing carpeting and extra cloth furnishings from the home, dusting with a damp rather than dry cloth, keeping the home as dust-free as possible, and ventilating the house well, especially after major activity such as cleaning, are some of the important measures one can take to reduce their exposure to particulate matter from indoor human activity. Reducing these sources of PM exposure could reduce the occurrence of life-threatening illnesses.

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