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Indoor vs Outdoor Air Chemistry: Cooking, Cleaning and COVID

Delphine Farmer, PhD

Colorado State University

Show #: 621 April 2, 2021

Delphine Farmer, PhD grew up in Canada, and received her BSc in Chemistry from McGill University in Montreal. She moved to warmer climates to earn her Master's in Environmental Science, Policy and Management and her PhD in Chemistry, both from the University of California at Berkeley. Her research focused on using laser spectroscopy to study forest-atmosphere interactions. Delphine then held a NOAA Climate and Global Change Postdoctoral Fellowship at the University of Colorado Boulder, working with aerosol mass spectrometers in forests in the Brazilian Amazon and California's Sierra Nevada mountains.

Nuggets mined from today's episode:

Microbes are different than molecules. Dr Farmers area of interest is molecules.

As a researcher of the outdoor air, Dr Farmer found that the high levels of some indoor air pollutants required her instruments be recalibrated.

Outdoors sunlight drives chemical reactions; there is too little sunlight indoors to cause these reactions.

Surface Area- Outdoors is much larger than indoors. The outdoors has much less surface area than the indoors. There is an absence of wind movement.

The study of outdoor air is being done by: city, state, and region. For state and regional studies monitoring is done with the aid of aircraft. Outdoor air is studied over: days, weeks, months and years.

The indoors has more surface area. Air indoors changes quickly. Indoors the relationship between surface area and air matters, outdoors not so much. Indoors chemical molecules accumulate on surfaces and then slowly come off over time. Simply opening a window, introduces ozone and hydroxyl radicals which react with skin oils and surfaces indoors to release volatiles. Outdoors these chemical molecules tend not to accumulate on surfaces.

The Clean Air Act is highly successful legislation, resulting in improving outdoor air quality in the US and saving many lives.

With similar exposure rates outdoors, epidemiologists can see correlations between poor air quality and increased: asthma, heart attacks, and hospitalizations. Exposures levels indoors are drastically different. Each person's individual experience is unique. So the epidemiology of indoor air hasn't been studied on a group scale and poses a grand challenge.

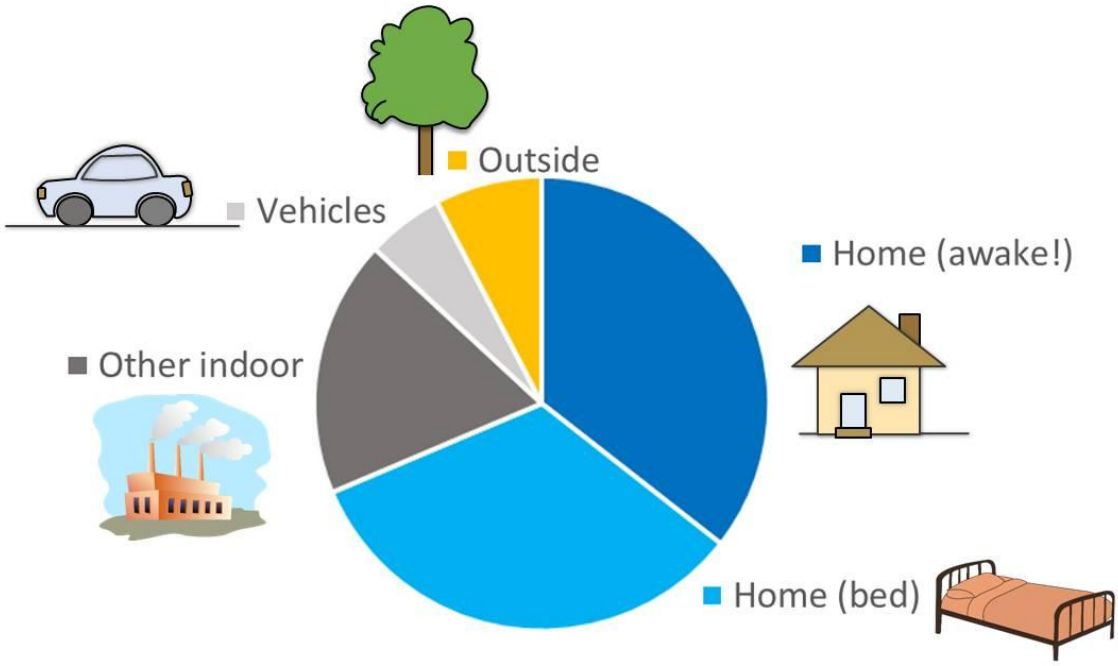
HOMEchem

Dr Delphine Farmer, and Dr Marina Vance, PhD began thinking about the chemistry that happens inside homes when cooking and cleaning which lead to a study at Dr. Richard Corsi's, test house (at U Texas, Austin). Sophisticated instrumentation was set up to monitor the air during normal indoor activities such as: daily cooking, cleaning and the preparation and making of a Thanksgiving dinner.

Some findings:

1. The air inside the home after cooking Thanksgiving dinner was like getting off an airplane in Delhi, India or cities in China with notably dirty air.
2. The gas stove gave off nitric oxide and nitrogen dioxide.
3. Cleaning with bleach kickstarted many chemical reactions. Mopping the floor with bleach solution reacted with soil, grime, proteins to produce ammonia and chloramine. When we exhale or cook meat ammonia is released. Some of the byproducts of the chemical reactions last and result in unintended consequences.

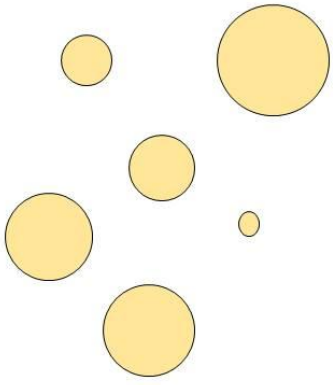
Slides from Dr. Farmer's Presentation



National Time

What is in the air we breathe?

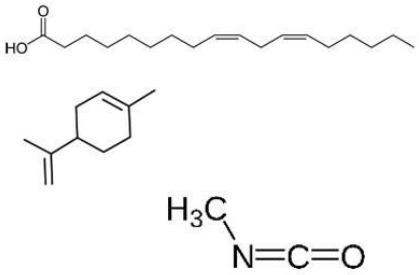
Particles



Gases

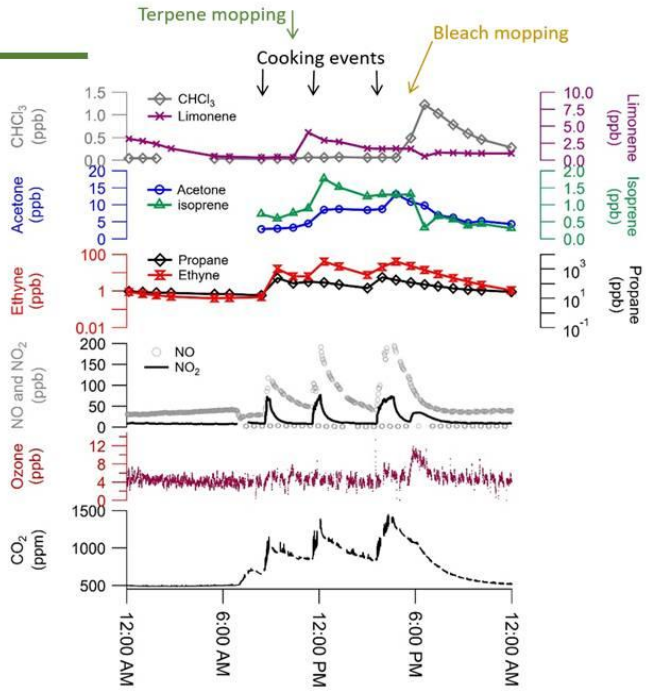
N_2, O_2

CO, CO_2, Rn

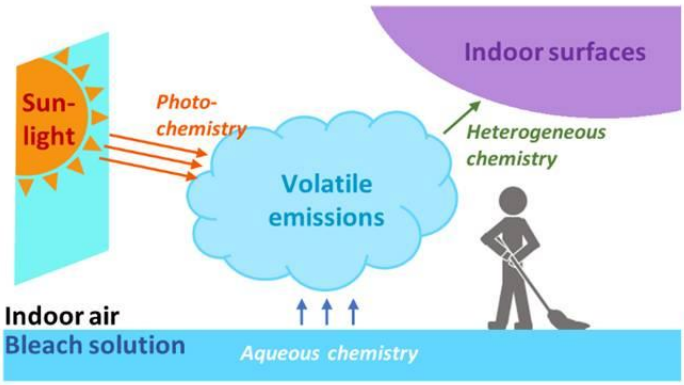


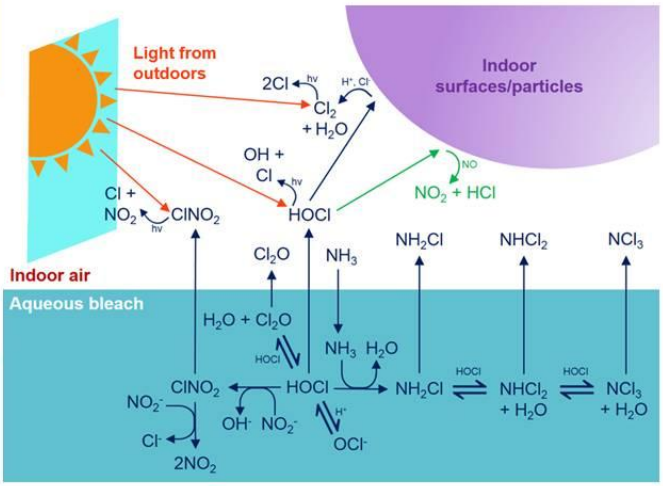
Layered Day example

- Most trace gases are very high relative to outdoors
- Exceptions: O_3, OH (& HO_2), a few VOCs
- Activities change concentrations rapidly and across a large dynamic range



[Farmer et al. ESPI. 2019]





COVID

1. Proven Strategies: Dilution/ventilation, upgrading filtration to MERV 13, circulating air rapidly and use of personal HEPA filtered air cleaners and source control (masks).
2. The EPA N list contains all the sanitizers and disinfectants the EPA is confident will kill COVID and other emerging pathogens. The list specifies product use concentration and dwell time.
3. She prefers plain soap and water which have also been shown to be effective on COVID.
4. BUYER BEWARE: Cleaning the air with chemistry is complicated. This sexy, fancy chemistry is creating unintentional consequences (e.g. formaldehyde) and triggering chemical reactions you shouldn't breathe.
5. BUYER BEWARE: There is no real-world evidence that ionizers work on COVID. Testing a machine inside a small glass box isn't the same as a real-world application. These devices don't lower PM2.5, they increase aldehydes and create unwanted byproducts.
6. Delphine recommends the *precautionary principle*, don't use things which may cause unintended consequences.

OXIDIZERS

Indiscriminate oxidizers such as ozone, ultraviolet light and hydroxyl radicals break oxidizable substances down to carbon dioxide and water vapor, and produce unintended consequences such as formaldehyde and ultrafine particles along the way.

Delphine has been studying hydroxyl radicals for 20 years. She knows what they do outdoors, bringing hydroxyl radicals indoors raises questions. They react with materials and produce formaldehyde and ultrafine particles. She finds manufacturer recommendations that hydroxyl generators be used indoors in occupied spaces to be very misleading and disturbing. Hydroxyls are orders of magnitude more reactive than ozone. Ozone doesn't react with some materials. Hydroxyls react with everything! Hydroxyls kickstart chemical reactions indoors. She is concerned about the effect of hydroxyls on lung cells. If you don't use enough hydroxyls they don't work. She is really wary of ozone use indoors and has

grave concerns over hydroxyls indoors. It's important to balance the needs of both the building and its occupants.

THE FUTURE

Excited about two upcoming studies:

1. NIST, Chemical Assessment of Surfaces and Air
2. NYC a study on consumer and personal products moving from indoors to outdoors and the effect on the outdoors.

AUDIENCE COMMENTS:

- Awesome: T Martin
- Great Show: J Charlton, UK
- Great Show: J Lapotaire

Z-Man signing off

Trivia Question:

Name the US governmental agency whose mission is to "discover how the environment affects people in order to promote healthier lives."

Answer:
National Institute of Environmental Health Sciences

Answered by:
John Lapotaire - Indoor Air Quality Solutions.