Residential Indoor Air Pollutants: Understanding Risks and Advancing Knowledge

Our homes are our havens, yet the air within them can contain a variety of pollutants that impact our health. We spend a significant amount of our lives indoors, and this exposure can constitute 60% to 95% of our total lifetime exposure to airborne contaminants. Understanding these pollutants is the first step toward creating a healthier indoor environment. Foundational work, such as the **AIVC Technical Note 68 (TN68) "Residential Ventilation and Health"**, has been pivotal in summarizing pollutants, their health risks, sources, and control strategies, including the crucial role of ventilation.

Building on such comprehensive groundwork, recent research continues to refine our understanding. A notable advancement is presented in the study by **Morantes et al. (2024), "Harm from Residential Indoor Air Contaminants"**, which introduces a health-centred approach to quantify and compare the chronic harm caused by these contaminants using disability-adjusted life-years (DALYs). This research helps to pinpoint the most harmful contaminants commonly found in dwellings, guiding efforts to improve indoor air quality effectively.

The Most Harmful Contaminants: A Closer Look

The study by Morantes et al. (2024) identifies a critical group of contaminants that together account for over 99% of the total median chronic harm from typical indoor air pollutant exposures in dwellings. Understanding these priority pollutants, many of which are also detailed in TN68, is key:

1. **Particulate Matter ($PM_{2.5}$):** These are extremely fine inhalable particles, generally 2.5 micrometers in diameter or smaller.
    - **Plain English:** Imagine microscopic specks of dust, soot, or liquid droplets, so tiny they can travel deep into your lungs when you breathe and can even pass into your bloodstream.
    - **Common Sources:** $PM_{2.5}$ originates from both outdoor sources like traffic pollution, industrial emissions, and smoke from wood burning, as well as significant indoor sources. These indoor sources include cooking (especially frying and other high-temperature methods), smoking tobacco, burning candles or incense, and emissions from unvented or poorly functioning combustion appliances like fireplaces or gas stoves. Dust already settled in the home can also be stirred up and become airborne $PM_{2.5}$.
2. **Coarse Particulate Matter ($PM_{10-2.5}$):** These are inhalable particles larger than $PM_{2.5}$ but smaller than 10 micrometers in diameter.

- **Plain English:** These are also small particles you can breathe in, but a bit bigger than $PM_{2.5}$. They tend to get trapped in the upper parts of your airways more than the deeper lung areas but can still cause health issues.
- **Common Sources:** Similar to $PM_{2.5}$, these particles can come from outdoor dust and pollen, and indoor activities such as cooking, and the resuspension of dust from carpets, furniture, and general movement.

3. **Nitrogen Dioxide (NO_2):** A gaseous pollutant, often associated with a pungent, acrid smell and a reddish-brown colour at very high concentrations.
   - **Plain English:** NO_2 is a harmful gas with a sharp smell that's mainly produced when fuels are burned at very high temperatures.
   - **Common Sources:** Key indoor sources include gas stoves and ovens, gas-fired water heaters, and unvented gas fireplaces. Kerosene heaters can also be a source. Additionally, NO_2 from outdoor sources like vehicle exhaust and industrial plants can seep into homes.
4. **Formaldehyde (HCHO):** A colourless, flammable gas that has a distinct, strong, and pungent odour at room temperature.
   - **Plain English:** Formaldehyde is a chemical gas that you might be able to smell (a bit like pickles, or the "new" smell from some furniture or cars). It's used in making many everyday items and building materials.
   - **Common Sources:** Formaldehyde is released from a variety of materials, including pressed-wood products like particleboard, plywood, and medium-density fiberboard (MDF) commonly used in furniture, cabinets, and flooring. Other sources include glues and adhesives, some paints, varnishes, certain fabrics (especially permanent-press), cosmetics, and disinfectants. Combustion processes, including tobacco smoking, also release formaldehyde.
5. **Radon (Rn):** A naturally occurring radioactive gas that is colourless, odourless, and tasteless.
   - **Plain English:** Radon is an invisible and odourless radioactive gas. It comes from the natural decay of uranium in soil and rocks and can get into the air you breathe inside your home.
   - **Common Sources:** The primary source of radon is the soil and rock beneath and around a home's foundation. It enters buildings through cracks in solid floors, construction joints, gaps around service pipes, and sometimes from well water. It can also be transported through porous materials into indoor areas. Some building materials derived from rock or soil can also emit radon.
6. **Ozone (O_3):** A highly reactive gas made up of three oxygen atoms. Ground-level ozone is a harmful air pollutant, unlike the protective layer of ozone in the upper atmosphere.
   - **Plain English:** Ozone is a gas that can be helpful high up in the sky, but it's not good to breathe in at ground level. It sometimes has a sharp, "clean" smell, like after a thunderstorm.

- **Common Sources:** Most ozone found indoors comes from outdoor air that infiltrates the building. Some indoor devices, like certain types of air purifiers that intentionally produce ozone (which are generally not recommended for occupied spaces) or high-voltage electrical equipment like printers, can also be minor sources.

The Importance of Broader Indoor Air Quality Management

While the Morantes et al. (2024) study highlights these six contaminants as primary drivers of chronic harm, TN68 and other research also point to a wider range of pollutants that can affect residential indoor air quality and health. These include other VOCs beyond formaldehyde, carbon monoxide (primarily an acute risk), biological pollutants like mould spores (influenced by dampness), pesticides, lead, and asbestos (particularly in older homes). The presence and concentration of these can vary greatly depending on the home's age, materials, location, and occupant activities.

Strategies for a Healthier Home Environment

The principles for improving indoor air quality, as emphasized in TN68 and supported by ongoing research, revolve around a few key strategies:

1. **Source Control:** This is often the most effective approach. It involves minimizing or eliminating the sources of pollutants. Examples include:
   - Choosing building materials, furniture, and consumer products with low or no emissions of formaldehyde and other VOCs.
   - Prohibiting smoking indoors to eliminate Environmental Tobacco Smoke.
   - Ensuring fuel-burning appliances (furnaces, water heaters, stoves) are properly installed, maintained, and vented to the outside.
   - Managing moisture and promptly repairing leaks to prevent mould growth.
2. **Ventilation:** Adequate ventilation is essential for removing pollutants that cannot be entirely eliminated at the source and for bringing in fresh outdoor air to dilute indoor contaminants.
   - **Local Exhaust Ventilation:** Using targeted ventilation, such as cooker/range hoods when cooking and bathroom fans during and after showering, is critical for removing moisture and pollutants generated during specific activities.
   - **Whole-House Ventilation:** This can be achieved through natural means (e.g., opening windows when outdoor air quality is good), mechanical systems (e.g., heat recovery ventilators, exhaust fans) or hybrid systems (hybrid fans together with air inlets) designed to provide a consistent supply of fresh air. TN68 details various ventilation processes and systems.

3. **Air Cleaning:** Air cleaners and purifiers can be used to remove certain types of airborne particles and some gaseous pollutants. However, their effectiveness varies widely, and they are generally considered a supplement to, not a replacement for, source control and good ventilation.

By understanding the key pollutants of concern, drawing on foundational knowledge like that presented in TN68, and incorporating new research insights such as those from Morantes et al. (2024), we can make more informed decisions to improve the air quality in our homes and protect our health.