National
Pesticide
Telecommunications
Network

Pesticides in Indoor Air of Homes

(Technical Fact Sheet)
Please refer to the **General Fact Sheet** for more general information.

The Pesticide Label: Labels provide directions for the proper use of a pesticide product. *Be sure to read the entire label before using any product.* A signal word on each product label indicates the product's potential hazard by ingestion, inhalation, dermal contact, and eye exposure.

CAUTION - low toxicity **WARNING - moderate toxicity** **DANGER - high toxicity**

Why might pesticides in the indoor air of homes be a concern?

- Many household products are pesticides, such as lawn and garden products, insect sprays and baits, disinfectants, and rat poison**.** Examples of pests that pesticides control include insects, plants, rodents, and microorganisms (1, 2).

- The acute toxicity of a pesticide in indoor air is indicated by the signal word of the specific pesticide product (Caution, Warning, or Danger). The signal word reflects the combined toxicity of active and other ingredients. Subchronic and chronic toxicity such as reproductive, developmental, and cancer effects may be of concern depending on the specific active ingredient and the exposure (route, length, and timing). See boxes on **The Pesticide Label** and **Cancer**.

Cancer: The U.S. EPA has strict guidelines that require testing of pesticides for their potential to cause cancer. These studies involve feeding laboratory animals large *daily* doses of the pesticide over most of the lifetime of the animal. Based on these tests, and any other available information, EPA gives the pesticide a rating for its potential to cause cancer in humans. For example, if a pesticide does not cause cancer in animal tests at large doses, then the EPA considers it unlikely the pesticide will cause cancer in humans. Testing for cancer is not done on human subjects.

- U.S. residents spend the majority of time indoors, possibly greater than 90% of their day. The average percent of time spent indoors at home has been estimated from 60-90% (3).

- The general population is exposed to pesticides primarily in the home (3). Studies on pesticide use estimate that 90% of all households in the United States use pesticides (4). The number and concentration of pesticides detected in indoor air have been shown to be typically greater than those detected in outdoor air (5).

- The three typical routes of exposure to pesticides are inhalation, accidental ingestion, and dermal exposure (6). Studies show that inhaling indoor air containing pesticides can be a significant contributor to the total pesticide exposure relative to other routes of exposure (5, 7-11). *Note: This fact sheet does not address indoor home exposures other than inhalation nor any routes of exposures occurring outdoors.*

- The majority of pesticide exposures in the home as a result of applications made according to the product labels are at levels below those anticipated to cause adverse health effects.

How do pesticides get into the indoor air of homes?

- Pesticides enter indoor areas via indoor use and storage, track-in by people and pets from outdoor treated areas, and by air intrusion of pesticides present outside of the home (12-15). Pesticides may be found indoors even when there is no known use of pesticides on the property (16).

- Once indoors, a pesticide may exist in air, reside on surfaces, or become incorporated in dust. A pesticide may simultaneously occur in air, on surfaces, and in dust, and move from one to another. For example, a pesticide may settle from air onto a surface, and then later leave the surface and reenter air (17).

- Pesticides in indoor air can exist in different physical forms, such as a gas or an aerosol. Aerosols are suspensions of solid or liquid pesticide particles in a gas. The suspending gas may be air or another substance. Liquid aerosols may be referred to as mists, fogs, or sprays. Solid aerosols include fumes, dust, and particulates (18). Solids may consist solely of a pesticide or may contain a pesticide sorbed on the surface of a particle.

What are the health risks from pesticides in the indoor air of homes?

- The risk associated with a pesticide in indoor air is dependent on the toxicity of the pesticide and the level of exposure. Toxicity is pesticide specific. The level of exposure is determined by the pesticide concentration in air, duration of exposure, and inhalation rate (19). See boxes on **Dose-response, Air Concentration**, and **Inhalation Rate**.

Dose-response. The effect of pesticides on human health depends on how much chemical is present, the length and frequency of exposure, and the toxicity of the pesticide. Effects also depend on the health of a person when exposure occurs. Laboratories can detect pesticides in indoor air at extremely low levels that may not necessarily be harmful to humans. Described below is the calculation of the inhaled dose from exposure to a pesticide in indoor air (7).

$$\text{*Dose} = (C \times IR \times ED)/BW$$

C = Concentration (mass/volume)
IR = Inhalation rate (volume/unit time)
ED = Exposure duration (unit time)
BW = Body weight (mass)

*Assumes that 100% of the inhaled chemical is absorbed.

Air Concentration. The concentration of a pesticide (gas or aerosol) in air is the amount of chemical contained in a fixed volume of air and is typically expressed as the mass of pesticide per unit volume. Mass is often represented in milligrams (mg) or micrograms (µg) and volume in liters (L) or cubic meters (m^3). Pesticides in air may also be measured in terms of a mixing ratio with air, often in parts per million (ppm) or billion (ppb). This means the pesticide occupies one volume for every million or billion volumes of air (20). *Mixing ratios are appropriate to quantify gases but not aerosols* (18). Described below is the conversion of one concentration measure to another.

$$1000\ mg/m^3 = 1\ mg/L$$
$$1000\ ppb = 1\ ppm$$
$$ppm = [(mg/m^3) \times (*24.45)]/(**MW)$$

• 24.45 = conversion factor
** MW = Molecular weight of pesticide (21)

- The absorption and distribution of inhaled pesticides depends on the physical and chemical properties of the pesticide and the physiology and anatomy of the respiratory system. The physical state (gas, liquid, solid), particle size, volatility, solubility, and reactivity of pesticides are important physicochemical properties. Physiological (breathing and heart rates) and anatomical characteristics (degree of branching, airway size) dictate the absorption and distribution of inhaled pesticides (22).

> **Inhalation Rate**. The inhalation rate is the volume of air inhaled per unit time (volume/time). The rate for an individual is affected by age, gender, weight, health status, and activity level (sleeping, walking, running, etc.). Higher rates increase the exposure to pesticides in air and may translate into greater risk (19).

- The respiratory tract is the first organ system that inhaled pesticides contact. This organ system extends from the nose to the lungs and includes the mouth, pharynx, larynx, trachea, bronchi, bronchioles, and alveoli (22). The respiratory system is important in distributing inhaled pesticides because chemicals can readily enter the blood that flows through the lungs and be rapidly distributed throughout the body (23).

- Pesticides may exert systemic toxicity (toxicity to multiple organ systems) or be toxic specifically to the respiratory system. Effects specific to the respiratory system include irritation and asphyxiation. Irritants produce inflammation in exposed membranes and may be classified as primary or secondary irritants, depending on the principal toxic action (irritation or systemic toxicity). Asphyxiates deprive the body of oxygen (23).

- The health status of an individual affects the response to inhaled pesticides (24). Individuals with preexisting health conditions or impaired health status, particularly respiratory diseases, may be more susceptible to inhaled pesticides.

What factors influence the level of pesticides in the indoor air of homes?

- The pesticide level in indoor air is determined by the amount of pesticide introduced into the home by various sources and the rate of pesticide loss (25). Factors affecting the amount introduced into the home include physical and chemical properties of the active ingredient and formulation, the method and frequency of application, seasonal influences, environmental parameters, building structure, and activity patterns occurring outside and inside buildings (5, 25). The factors affecting the rate of pesticide loss are discussed below in the section titled, "**What is the fate of pesticides in indoor air of homes?**"

- The volatility of a chemical affects the likelihood and levels of a substance existing as a gas in air (26). Temperature, humidity, and formulation type influence the volatility of a pesticide (5, 17, 26, 27). See box on **Volatility**.

- Differences in air levels may be noted for different application methods such as crack and crevice, broadcast, fogging, or soil and wood termite treatments. Variability may result from applying different amounts of pesticide or traits inherent to the application method (9, 29, 30).

- Seasonal variation affects the presence and level of pesticides in indoor air. The type of season and associated weather influence pesticide use, heating, cooling, ventilation, and people's activities (5).

> **Volatility**. Volatility is the tendency of a chemical to convert from the liquid or solid phases into a gas. The level of volatility is quantified by the vapor pressure exerted by the chemical in air. The greater the volatility of a pesticide, the more likely the substance will be present as a gas. Categorization of pesticides based on volatility is described below (28).

Class	Vapor Pressure (millimeters Mercury - mm HG)
Volatile	$> 10^{-3}$
Slightly volatile	10^{-3} - 10^{-7}
Nonvolatile	$< 10^{-7}$

> Note: Pressure may be expressed in different units. Common units and their conversions are listed below (21).
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> 1 atmosphere (atm) = 760 mm Hg = 101,325 Pascals (Pa)

- Environmental factors such as temperature and humidity levels affect indoor air by influencing pesticide volatility and stability (5). Scientists determined that temperature, followed by humidity, were the most significant factors influencing pesticide volatility and subsequent air levels (17, 27).

- Building characteristics that impact indoor pesticide air levels include the volume and interior surface area of the building, the products and materials used in the construction and furnishing of the building, the presence and type of mechanical air movement systems, and the type of foundation (25). Scientists determined that the stability of a pesticide differed depending on the type of surface material that the pesticide resided on (17). Mechanical air movement systems (heating and air conditioning systems, exhaust fans) influence air movement within the home and exchange with outdoor air ("leakiness" of the home) (25).

- Children and pets are significant factors in track-in and distribution of pesticides indoors from pesticide-treated lawns (12, 13). Scientists determined that activity in a room, such as walking into an area or vacuuming, may temporarily resuspend pesticides in air (25, 31).

What is the fate of pesticides in the indoor air of homes?

- Pesticides initially distribute in indoor air from an indoor or outdoor source. Researchers noted that indoor air levels of pesticides may develop concentration gradients within the building, with levels varying within a room and between rooms (7, 14, 32-34).

- One mechanism that removes pesticides from air is adsorption onto surfaces. Adsorption results from gravitational settling, diffusion, and movement driven by electrical and thermal attractions (25). Once adsorbed, the pesticide may remain on a surface (floor, wall, ceiling, furniture, dust, etc.), degrade, volatilize, or be resuspended as a particle (7, 9-11, 17, 25, 30, 34, 35).

- Another loss mechanism from air is degradation. Pesticides may be degraded by photolysis, hydrolysis, or chemical reactions such as oxidation (36). The susceptibility to degradation is typically chemical or formulation specific. Faster degradation rates typically result in lower levels and less persistence of pesticides in air (26). Degradation rates for pesticides indoors may be slower than outdoor rates and may result in prolonged presence indoors (37). The degradation rate is often represented as a half-life. See the box on **Half-life**.

> **Half-life** is the time required for half of the compound to degrade.
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> |---|---|---|
> | **1 half-life** | **=** | **50% degraded** |
> | **2 half-lives** | **=** | **75% degraded** |
> | **3 half-lives** | **=** | **88% degraded** |
> | **4 half-lives** | **=** | **94% degraded** |
> | **5 half-lives** | **=** | **97% degraded** |
>
> Remember that the amount of chemical remaining after a half-life will always depend on the amount of the chemical originally applied.

- Ventilation serves as a means for reducing indoor air pesticide levels. Ventilation often significantly reduces air levels of pesticides (9-11, 17, 26, 34, 38). Researchers suggest that indoor air levels of pesticides may depend primarily on ventilation (10, 11).

What is the risk when I smell pesticides inside my house?

- Detecting an odor is evidence of exposure to a chemical(s) in air but not necessarily evidence of toxicity nor exposure to a pesticide (30). Odor can be unpleasant, and it may generate reflex sensory responses such as upper respiratory irritation, nausea, or headaches (30, 39).

- Odor from a pesticide may be attributed to an active ingredient, an inert ingredient, or multiple formulation ingredients. Detecting an odor is a function of the concentration of the odor-causing chemical and an individual's odor threshold (lowest level that an individual can smell a chemical) (30).

How can I minimize exposure to pesticides in indoor air of my home?

- Use nonchemical methods of pest control if feasible, such as good home hygiene, sealing entry points for pests, and removing sources of food and water (40).

- For pesticides emanating from outdoor sources, minimize outside air intrusion. Close windows and shut off mechanical systems, e.g., heating and air conditioning, that ventilate with outdoor air. Open the windows when spraying indoors.

- To minimize track-in of pesticides from outdoor treated areas, remove shoes prior to entering a home or use an outdoor shoe cleaning device prior to entering the home, and limit contact of pets with treated areas (12).

- Store pesticides in the original containers in secure sites outside of areas inhabited by people and animals when possible. Keep pesticides in locations not accessible to children.

- If pesticides are used, read the label and follow the directions. Use only the amount directed at the time and under the conditions specified and for the purpose(s) listed. Adverse health effects are not expected from pesticides used in accordance with the label. Do not use a pesticide in a manner inconsistent with the labeled directions (40).

- If possible, treat indoor plants and animals outside. Mix or dilute pesticides outdoor or in well-ventilated areas (40).

- If pesticides are used to treat an indoor area, ventilate the area. If listed, follow the pesticide label for directions specific to ventilation and re-entry of treated areas (40).

- Call the National Pesticide Telecommunications Network (NPTN) at 1-800-858-PEST (7378) for more information.

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For more information contact: NPTN
Oregon State University, 333 Weniger Hall, Corvallis, Oregon 97331-6502.
Phone: 1-800-858-7378 Fax: 1-541-737-0761 Email: nptn@ace.orst.edu
NPTN at http://nptn.orst.edu/ EXTOXNET at http://ace.orst.edu/info/extoxnet/

Or:

U.S. EPA Indoor Air Quality Information Clearinghouse
IAQ INFO
P.O. Box 37133, Washington, DC 20013-7133
Copies of this fact sheet are not available at this hotline.
Phone: 1-800-438-4318 Fax: 1-703-356-5386 Email: iaqinfo@aol.com
U.S. EPA Indoor Environments Division at http://www.epa.gov/iaq/

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