PROTECTING CONSUMERS FROM THE INDOOR AIR QUALITY RISKS OF COMMON HOUSEHOLD AND CONSUMER PRODUCTS

A report to the Radiation and Indoor Air Programs Branch

U.S. Environmental Protection Agency, Region VIII

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I. Background

Dozens of seemingly safe and innocuous products--ranging from home detergents to cosmetics--are commonly used by consumers who are unaware of the indoor air quality impacts caused by these products. Risks to health are further magnified when products are used in combination or in the presence of other background pollutants that can originate from a variety of sources. This report will examine some of these products, their potential risks, and what consumers can do to protect their health and minimize exposure.

II. Introduction

Because people in industrialized countries spend over 90% of their time indoors[1] (see Exhibit 1), indoor air pollution and its effects on public health have received growing attention in recent years from both state and federal governments. EPA studies indicate that in both rural and heavily industrialized areas, levels of exposure for many pollutants are two to five times higher indoors than outside and indoor levels exceed outdoor levels for virtually all volatile organic compounds (VOC's).[2] In new homes indoor VOC levels can be 100 times outdoor levels and pollutants concentrations can be 1000 times outdoor levels

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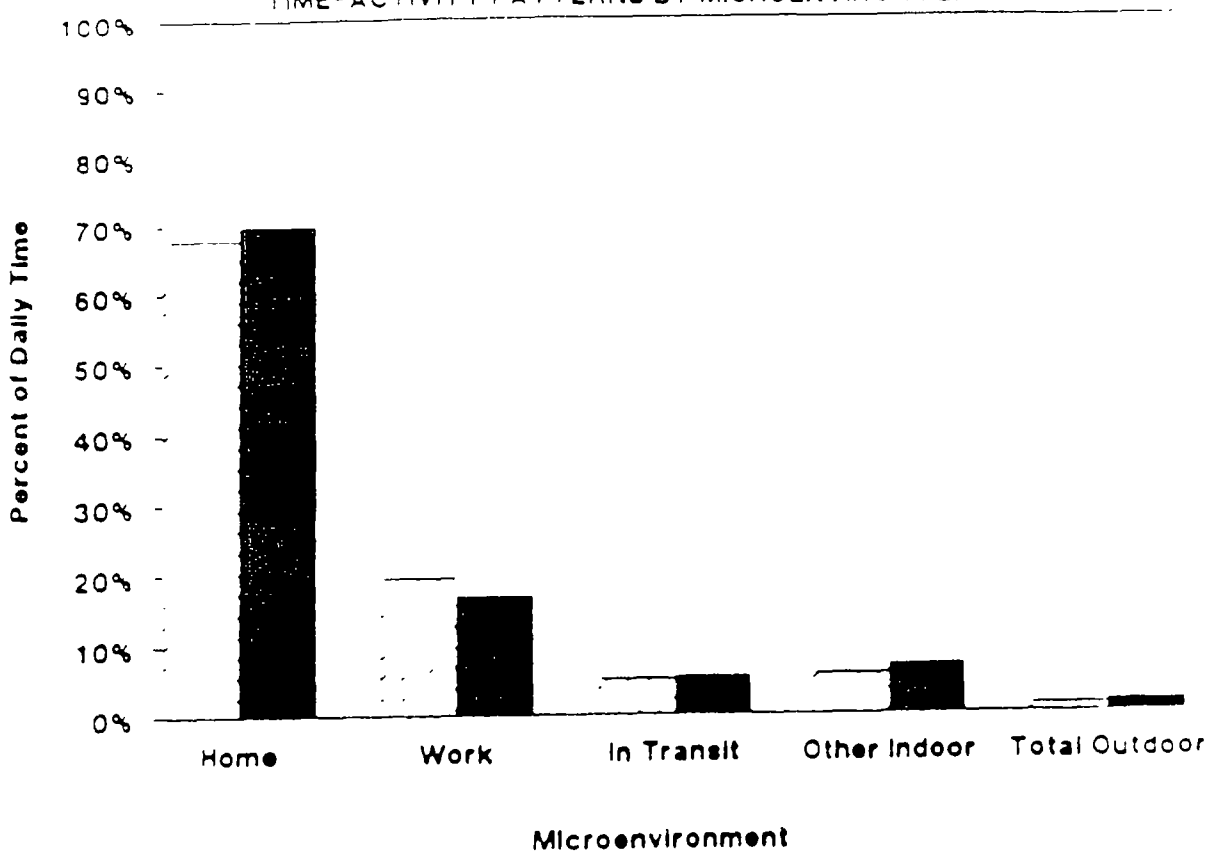
[1] Report to Congress on Indoor Air Quality, Volume II, p. i

[2] Orientation to Indoor Air Quality: Student Manual, p. 1-5

EXHIBIT 1

TIME-ACTIVITY PATTERNS BY MICROENVIRONMENT



Report to Congress on Indoor Air Quality: Volume II; U.S. Environmental Protection Agency (August 1989)

following certain types of activities.[3] Comparative risk studies by EPA have consistently ranked indoor air pollution among the five top threats to public health.[4]

Research also indicates that the problems of indoor air pollution have grown significantly worse over the past decades due to a combination of factors including: decreased home ventilation rates caused by the increasing number of well sealed energy-efficient homes," the growing use of synthetic building materials and furnishings, and the use of chemically formulated personal care products, pesticides, and household cleaners."[5]

The most acute exposures to indoor pollutants commonly occur in the twelve month period following new home construction or renovation, due to "off-gassing" of the many synthetic products and solvents used to build and decorate the home.[6] Radon and tobacco smoke can also present continuing risk to occupants unless addressed.

However, other avenues of commonly overlooked and easily preventable exposure result from a broad array of less obvious household and consumer products. While it is known that the substances released by these products can pose risk to public health, the degree of risk

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[3] Ibid

[4] Indoor Air Facts No. 1, p. 1

[5] Ibid

[6] Indoor Air Quality in Public Buildings: Volume II, p. 2

at the concentration levels commonly encountered indoors has not in most cases yet been clearly established. Nonetheless, the presence of these potential risks, considered individually or in combination with other products or common background pollutants, should provide sufficient motivation to better educate consumers regarding what is known about these products and methods for mitigating potential exposure.

III. Indoor Air Pollution: A Worsening Problem

The presence of VOC's in the indoor environment has grown worse in recent decades due to the explosion of personal care products, household cleaners, and because more products are packaged in aerosol cans that release their contents directly into the air.[7] More energy efficient homes trap both heat and inhaleable pollutants, increasing the propensity for human exposure. Over the last two decades the number of air changes for the typical home has dropped from 1.5 per hour "to .5 or lower in energy efficient construction."[8]

The data also indicates that in most cases the concentration of specific organic compounds are higher indoors than outdoors indicating that sources are typically indoors.[9] More than 900 different VOC compounds have been identified in indoor air.[10] The health impacts

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[7] Introduction to Indoor Air Quality: A Self-Paced Learning Manual, P.2

[8] Ibid

[9] Organic Emissions From Consumer Products, P.264

[10] Report to Congress on Indoor Air Quality: Volume II, p. 3-6

of these compounds can range from sensory irritation to behavioral, neurotoxic and heptoxic effects.[11] More than 250 organics have been identified at levels exceeding 1 part per billion.[12]

In February of 1992 EPA published a report based upon a review of the literature between 1979 and 1990, on over 220 compounds found in the indoor air. The study found that while only formaldehyde had been extensively studied in the indoor air, many other sources of organic compounds "...have their origins in commonly used materials (such as)...hairsprays...rug cleaners...building materials and interior furnishings." The report also found that the most frequently reported compounds were: formaldehyde, tetrachloroethylene, 1,1,1-trichloroethane, trichloroethylene, benzene, p-dichlorobenzene, toluene, ethylbenzene, xylenes, decane, and undecane. Potential sources of these compounds will be later discussed.[13]

IV. Commonly Used Household/Consumer Products

While many consumers are aware of the indoor air risks associated with using solvents, pesticides, paints, strippers, and stains and the importance of adequate ventilation; relatively few are aware of the risks associated with dozens of seemingly innocuous products. Based

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[11] Report to Congress on Indoor Air Quality: Volume II, p. 3-6

[12] Organic Emissions From Consumer Products, P.264

[13] Indoor Air Quality Data Base for Organic Compounds, p. ii

upon review of available literature,[14] the following represents a partial listing of these products and the compounds they can emit. Where available, the potential health effects of these compounds are also noted.

1) **xylenes** --[pharmaceutical, grease cleaners]
--narcotic; irritant; affects heart, liver, kidney and nervous system

2) **toluene** --[solvents and adhesives]
--narcotic; may cause anemia

3) **styrene** --[plastics, paints, resins, deodorants, health and beauty aids, ink and pen, miscellaneous housewares]
--narcotic; affects central nervous system; possible human carcinogen

4) **trichloroethylene** --[typewriter correction fluid, dry cleaning, oil and wax, degreasing products, cosmetics, health and beauty aids, ink and pen, paper, and miscellaneous housewares, and outgassing from chlorinated water]
--animal carcinogen; affects central nervous system

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[14] Introduction to Indoor Air Quality: A Reference Manual, pp.91, 94-95; Indoor Air Quality Data Base for Organic Compounds, pp. B-1 to B-10; Household Solvent Products: A "Shelf Survey" With Laboratory Analysis, pp. 2-1, 2-4, & 3-9

5) **ethyl benzene**
--[styrene related products]
--severe irritation to eyes and respiratory tract; affects central nervous system

6) **methylene chloride**
--[spray shoe polish, suede protectors, water repellents, fabric finishes, spot removers, wood cleaners, general purpose liquid cleaners, general purpose spray cleaners/degreasers, and acoustic office partitions]
--narcotic; affects central nervous system; probable human carcinogen

7) **para-dichlorobenzene**
--moth crystals and room deodorizers
--narcotic; eye and respiratory tract irritant; affects liver, kidney, and central nervous system

8) **petroleum distillates**
--[cleaning products]
--central nervous system depressant; affects liver and kidneys

9) **benzene**
--[health and beauty aids, ink and pen, paper, miscellaneous housewares]
--carcinogen; respiratory tract irritant

10) **carbon tetrachloride**
--[aerosol cleaners, miscellaneous housewares, pen and paper]

11) **chloroform** --[miscellaneous housewares, ink and pen, and paper]

12) **limonene** --[deodorants, health and beauty aids, miscellaneous housewares]

13) **methyl chloroform** --[cosmetics, health and beauty aids, miscellaneous housewares, ink and pen]

14) **tetrachloroethylene** --[cosmetics, ink and pen, paper, suede protectors, water repellents, fabric finishes, spot removers, wood cleaners, aerosol cleaners, adhesives, general purpose liquid cleaners, general purpose spray cleaners/degreasers]

15) **formaldehyde** --[paper products: grocery bags, waxed paper, facial tissues, paper towels, disposable sanitary products; floor coverings, adhesives, and permanent press textiles; plastics, cosmetics, deodorants, shampoos, disinfectants, starch and starch based glues, adhesives, laminates, fabric dyes, and inks]

16) **perchloroethylene** --[dry cleaned clothes]

17) **1,1,1-trichloroethane** --[oven cleaners, typewriter correction fluid, spray shoe polish, suede protectors, water repellents, fabric finishes, spot removers, wood cleaners, general purpose liquid cleaners, general purpose spray cleaners/degreasers, aerosol cleaners, adhesives, non-acid drain cleaners, and general purpose spay cleaners/degreasers]

18) **1,1,2-trichloro-trifluoroethane**

--[water repellents, fabric finishes, aerosol cleaners, adhesives, general purpose spray cleaners/degreasers]

Other miscellaneous sources of VOC's (not listed above) include:

furniture polish
non-aerosol wax
floor wax
wax stripper
disinfectants
laundry pre-soak
anti-static spray
carpet cleaner
window cleaner
all purpose liquid cleaners
drain/bathroom cleaner
perfumes and hairsprays
furniture polish
hobby and craft supplies
furnishings
carpeting
shower curtains

IV. Determining Risk

Many of the VOC's which have been measured indoors are "known human carcinogens" (such as benzene), or are animal carcinogens (such as carbon tetrachloride, chloroform, trichloroethylene, tetra-chloroethylene, and p-dichlorobenzene). VOC's such as 1,1,1-trichloroethane, styrene, and pinene "are mutagens and possible carcinogens."[15] However, even with this type of information, it is difficult to estimate the degree of risk to indoor air quality and health associated with using products containing these compounds.

"In general, the health effects data base for VOC's [detected indoors], especially, low-level or intermittent exposures[16] is incomplete at best regarding the carcinogenicity and dose-response relationships." Most of the available health effects data on VOC's have been extrapolated from animal or occupational studies where concentrations are typically more acute than occur in household environments.[17] The concentration of VOC's present in the indoor environment are generally orders of magnitude below the threshold values at which health effects are known to occur.[18] While these studies provide a valuable indication of risk, quantitative determinations are complicated by the low-level concentrations and the many and variable factors which influence human exposure.

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[15] Introduction to Indoor Air Quality: A Reference Manual, p.90

[16] Ibid

[17] Report to Congress on Indoor Air Quality: Volume II, p. 4-14

[18] Report to Congress on Indoor Air Quality: Volume II, p. 24

V. Variables That Affect Risk

A. Characteristics of the Source: Concentration and Duration of exposure

"Every person breathes in 10,000 to 20,000 liters of air each day that contain several million particles and gas molecules. Inhalation is the most important route for airborne contaminants because the contaminants are quickly absorbed from the lungs..." and conveyed to the blood and other parts of the body.[19] Research has shown that pollutants present in breath closely correlate with personal (indoor) versus outdoor air exposures.[20]

"Dose" is the total amount of a contaminant received by the target tissues. It is determined by a variety of factors including: toxicity, pollutant concentration (which is influenced by emission rate) and duration of exposure.[21] This rate of "off-gassing" (evaporation) varies according to source and type of compound that is emitted. For example, shower curtains and home furnishings may continuously off-gas pollutants for a month to a year after installation, with concentrations often rapidly declining over time. In contrast, products requiring intermittent use such as spray room fresheners, deodorizers, or type correction fluid may involve relatively high exposures for short periods of time. Emission rates over time also vary by compound. Older furnishings will emit lower concentrations of pollutants than

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[19] Introduction to Indoor Air Quality: A Reference Manual, p.31

[20] Ibid, p.89

[21] Ibid, p.23

newer products; and wet materials emit much higher concentrations of VOC's then when they are dry (adhesives, sprays, deodorants). Emission rates are also greater for areas with high air exchange rates although sources are depleted more quickly.[22]

A National Usage Survey on 32 common household solvent products containing methylene chloride and five other chlorinated solvents found that among the most frequently used household products were type correction fluid, solvent cleaners, spot removers, contact cement and glue, stains, varnishes, and finishes. Those products used for the longest duration but less frequently included paints and strippers.[23] This research illustrated that both toxicity and period of exposure are key to projecting relative risk. "A highly toxic pollutant with low exposure may pose less risk than a pollutant with low toxicity and high exposure."[24]

B. Pollutant mixtures

Because of the many and diverse types of pollutants often found indoors (emanating from building materials, furnishings, tobacco smoke, and consumer products), indoor air may be impacted by more than one contaminant. Little is known about the additive or synergistic effects of combined pollutants where concentrations of individual compounds fall below

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[22] Organic Emissions from Consumer Products and Building Materials to the Indoor Environment, p. 264 & 267

[23] Household Solvent Products: A National Usage Survey

[24] Orientation to Indoor Air Quality Student Manual, p. 1-1

known health effect threshold levels.[25] Nonetheless, experts believe that "...exposures to mixtures of pollutants may be more important than exposures to individual pollutants."[26]

In many cases, pollutant mixtures are believed responsible for "sick building syndrome." This occurs when occupants experience health effects that don't fit the pattern of a specific illness and are difficult to trace to a specific source. Symptoms may range from dry or burning mucous membranes to headaches or dizziness.[27] "Building sicknesses, such as sick building syndrome, building related illness, and multiple chemical sensitivity are issues of potentially great significance but are poorly understood." [28]

C. Building characteristics

A variety of building related factors can affect indoor pollutant concentrations. For example, an EPA study of a test house found that several days after removing moth cakes from a closet shelf, significant concentrations of the target pollutant (paradichlorobenzene) were still being emitted. Research found that "the materials and surfaces in the house acted as sinks" which "stored" and reemitted the pollutant days after the source had been removed.[29]

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[25] Report to Congress on Indoor Air Quality, Volume II, p. 3-15

[26] Report to Congress on Indoor Air Quality: Volume II, p.3-1

[27] Indoor Air Facts No. 1, p.2

[28] Report to Congress on Indoor Air Quality: Volume II, p.3-15

[29] Evaluating Sources of Indoor Air Pollution, p.489

Factors that effect the storage and release characteristics of buildings include the composition of walls and surfaces and their absorption/deabsorption properties; the temperature and humidity of the air; and the degree of ventilation (air exchange rate).[30]

Ventilation characteristics are especially important. These include: the rate at which the indoor air is exchanged with the outdoor air; concentrations of pollutants in the outdoor air; and the rate at which "pollutants are removed from or chemically transformed in the indoor environment." [31] Ventilation can occur naturally, mechanically, or through infiltration/ exfiltration. "Natural ventilation occurs through windows, doors, chimneys, and other building openings. Mechanical ventilation is the mechanically induced movement of air through a building. Mechanical ventilation usually conditions and filters the air (heating and cooling) and allows for entry through outdoor openings. Infiltration/ exfiltration is the unwanted movement of air through cracks and openings in the building shell." [32]

D. Individual susceptibility

Certain people are more susceptible to indoor pollution. Susceptibility may be influenced by age, genetic predisposition, health and immune system status, and the presence of

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[30] Organic Emissions from Consumer Products and Building Materials to the Indoor Environment, p. 264

[31] Report to Congress on Indoor Air Quality: Volume II, p.1-8

[32] Ibid, p. 1-10 and 1-11

hereditary allergies.[33] Subpopulations with a potentially increased responsiveness to indoor air pollutants include: newborns, young children, elderly, heart patients; those with bronchitis, asthma, hay fever, emphysema, and smokers.[34] Together, these subpopulations which include the young, the old, the infirm, and those with prior respiratory conditions comprise a significant portion of total population (see Exhibit 2). "Certain chemicals may also be sensitizers and once sensitized individuals may be sensitive to lower doses."[35]

E. Regional and temporal factors

Regional and temporal factors such as climate, socio-economic status, building type, season of the year, time of day, and prevailing weather all add variables that influence indoor air quality and complicate the accurate assessment of how sources and pollutants will impact health.[36]

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[33] Orientation to Indoor Air Quality Student Manual, p.1-19

[34] Report to Congress on Indoor Air Quality: Volume II, p. 3-4 and 3-5

[35] Introduction to Indoor Air Quality: A Reference Manual, p.19

[36] Orientation to Indoor Air Quality Student Manual, p.1-19

Exhibit 2
Subpopulations with Potentially Increased Responsiveness to Indoor Air Pollutants

Subpopulation	Subpopulation Size	Percent of Population
Newborns[1]	3,731,000	1.5
Young children[2]	18,128,000	7.5
Elderly[3]	29,172,000	12.1
Heart patients[4]	18,458,000	7.7
Bronchitis[5]	11,379,000	4.7
Asthma[6]	9,690,000	4.0
Hay fever[7]	21,702,000	9.0
Emphysema[8]	1,998,000	0.8
Smokers[9]	69,852,000	29.9

[1]Live births in 1986; 1986 national population of 241,078,000 (USBC, 1988).

[2]Children under the age of five in 1986 (USBC, 1988).

[3]Persons over 65 or older in 1986 (USBC, 1988).

[4]Persons with heart diseases in 1986 (NCHS, 1987).

[5]Persons with bronchitis in 1986 (NCHS, 1987).

[6]Persons with asthma in 1986 (NCHS, 1987).

[7]Persons with hay fever or allergic rhinitis without asthma in 1986 (NCHS, 1987).

[8]Persons with emphysema in 1986 (NCHS, 1987).

[9]Persons 20 years of age and over who smoked in 1983; 1983 national population of 233,981,000 (PHS, 1985; USBC, 1985).

F. Types of effects

The effects of indoor air pollution can be divided into several classes:

--Acute effects usually occur within 24 hours of exposure. The result is not usually long-lasting and disappears after the exposure ends.

--"Chronic effects are long-lasting responses generally from chronic exposures to often low concentrations over long periods." These health effects are usually delayed rather than immediate.

--Subtle effects are often too slight to be noticeable and may include such things as "small changes in visual discrimination or pulmonary function."

--Discomfort effects include mild irritations such as eye strain or headache.[37]

Indoor air contaminants can also have several "modes of action" upon the body. They may be "...irritants, asphyxiants, neurotoxins, allergens, pathogens, carcinogens, mutagens, developmental toxicants, or reproductive toxicants."[38]

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[37] Introduction to Air Quality: A Reference Manual, p.16

[38] Orientation to Indoor Air Quality Student Manual, p.1-12

EPA has not established either individual risk estimates or estimates of the number of cancer cases resulting from exposure to VOC's in the indoor environments.[39] However, cancer risk estimates have been conducted by sources outside of EPA for the six most toxic and common VOC's (benzene, chloroform, carbon tetrachloride, trichloroethylene, tetrachloroethylene, and para-dichlorobenzene). Benzene is a known human carcinogen and the remaining substances are animal carcinogens. Researchers concluded that in the US these compounds were responsible for 1,000 to 5,000 "excess cases of cancer" per year.[40]

Separate studies have estimated these six pollutants responsible for 118 to 588 million dollars per year in direct medical costs, lost productivity, and miscellaneous uncalculated costs. While economic impacts are difficult to quantify because of the paucity of information, some studies project total costs for indoor pollutants in the tens of billions of dollars. These include: medical costs, lost productivity from absence due to illness, decreased work efficiency, and degradation of materials and equipment.[41]

VI. Methods for Minimizing Exposure and Risk

While regulation has been "the first line of defense" in protecting the public from outdoor air contaminants, it is much more difficult to set standards regulating the quality of air in

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[39] Report to Congress on Indoor Air Quality: Volume II, p.4-15

[40] Ibid, p. 4-17

[41] Ibid

the home because of the long-standing resistance to governmental regulation of activities in the home.[42]

Thus, the focus of the federal government through EPA has been to inform state and local governments and the general public about the risks associated with using products containing certain compounds and ways to minimize exposure. "Some also argue for setting 'target' concentrations, based on health or technological considerations, that would not be standards" but represent goals for guiding prevention and mitigation efforts.[43]

Reducing emissions at the source is the most direct and dependable method of controlling indoor emissions and may be the only effective approach where strong sources are present. However, in those situations where there are multiple pollutant sources or where the sources are not known, "source control may not be economically or technologically feasible." In such cases, increased ventilation or air cleaning may be the only feasible option. (Air cleaning by itself is typically insufficient to mitigate indoor air problems and should only be considered as a complement to improved ventilation.) EPA has also conducted extensive studies on increasing household temperatures or ventilation during unoccupied periods to determine efficacy as a mitigation approach.[44]

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[42] Report to Congress on Indoor Air Quality: Volume I, pp.7-8

[43] Ibid, p.9

[44] Indoor Air Facts No. 6, p.3

Individuals can also assume important roles in reducing the incidence of household air pollutants, at little or not cost. Reducing indoor air pollution from the use of household and consumer products can be accomplished by "...substituting non-polluting products, properly using and maintaining potential problems products, or modifying product composition to mitigate potential indoor air concerns."[45] Products must also be used wisely and according to instructions when available, some products should be used outdoors or separated from human activity, and in all cases homeowners must carefully balance energy conservation with the need for adequate household ventilation.[46]

Where the safety of select products is uncertain this may entail following preventive principles in product purchase and use. Other preventive control options include properly disposing of paints, aerosol sprays, solvents, and cleaners; buying them in limited quantities; and storing them in a detached garage or shed.

Manufacturers can also play a key role in reducing human exposure to toxic compounds by modifying their manufacturing process and substituting less toxic compounds. Consumers can influence these decisions by making careful choices about the products they purchase.

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[45] Report to Congress on Indoor Air Quality: Volume II, pp.6-3 to 6-4

[46] Ibid, p.6-4

VII. Conclusion

Restricting the manufacture and sale of household and consumer products that may pose unacceptable risks to indoor air quality and public health--before they enter the market--is an expensive and time-consuming process that currently falls beyond the legal and fiscal capabilities of state and federal governments. Better controls would compell manufacturers to more expeditiously inform regulators about the composition of their products before they are peritted for sale. Steps to improved governmental controls include: Obtaining information on the composition of the many household and consumer products currently manufactured; conducting the research necessary to accurately establish the risk associated with the indoor use of individual or multiple product compounds (used in isolation or in the presence of other common background pollutants); projecting and quantifying these risks given the numerous human and site variables that can affect health impacts; and developing and implementing legally defensible regulations.

Given these needs and current constraints, it is probable that governments will into the foreseeable future lack the resources necessary to keep pace with the flood of new products currently sold and continuously entering the market. It is unlikely that this balance will change significantly until stronger state and federal laws are established placing a heavier onus upon product manufacturers to prove the safety of their products before they are permitted for sale.

Similar to Superfund, changing this dynamic will necessitate establishing new funding mechanisms (perhaps involving a unit fee on certain petro-chemical feedstocks or compounds), that help develop the revenue allowing government to assume a more aggressive role in protecting the public from indoor pollutants through increased product regulation and consumer education.

Until this point in time occurs, consumers armed with available information may represent one of the most effective avenues for protecting the integrity of the indoor environment and their own health. This can be accomplished through select product purchase; using, storing, and disposing of products wisely; and by carefully balancing energy conservation priorities with the need for adequate ventilation --safeguarding individuals from risk of both the known and unknown.

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