Cleaning Products and Air Fresheners: Emissions and Resulting Concentrations of Glycol Ethers and Terpenoids

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Abstract:
Experiments were conducted to quantify emissions and concentrations of glycol ethers and terpenoids from cleaning product and air freshener use in a 50-m3 room ventilated at approximately 0.5/h. Five cleaning products were applied full-strength (FS); three were additionally used in dilute solution. FS application of pine-oil cleaner (POC) yielded 1-h concentrations of 10–1300g/m3 for individual terpenoids, including terpinene (90–120), d-limonene (1000–1100), terpinolene (900–1300), and terpineol (260–700). One-hour concentrations of 2-butoxyethanol and/or d-limonene were 300–6000 g/m3 after FS use of other products. During FS application including rinsing with sponge and wiping with towels, fractional emissions (mass volatilized/dispensed) of 2-butoxyethanol and d-limonene were 50–100% with towels retained, and approximately 25–50% when towels were removed after cleaning. Lower fractions (2–11%) resulted from dilute use. Fractional emissions of terpenes from FS use of POC were approximately 35–70% with towels retained, and 20–50% with towels removed. During floor cleaning with dilute solution of POC, 7–12% of dispensed terpenes were emitted. Terpene alcohols were emitted at lower fractions: 7–30% (FS, towels retained), 2–9% (FS, towels removed), and 2–5% (dilute). During air-freshener use, d-limonene, dihydromyrcenol, lina- lool, linalyl acetate, and citronellol) were emitted at 35–180 mg/day over 3 days while air concentrations averaged 30–160 g/ m3.

Practical Implications:
While effective cleaning can improve the healthfulness of indoor environments, this work shows that use of some consumer cleaning agents can yield high levels of volatile organic compounds, including glycol ethers – which are regulated toxic air contaminants – and terpenes that can react with ozone to form a variety of secondary pollutants including formaldehyde and ultrafine particles. Persons involved in cleaning, especially those who clean occupationally or often, might encounter excessive exposures to these pollutants owing to cleaning product emissions. Mitigation options include screening of product ingredients and increased ventilation during and after cleaning. Certain practices, such as the use of some products in dilute solution vs. full-strength and the prompt removal of cleaning supplies from occupied spaces, can reduce emissions and exposures to 2- butoxyethanol and other volatile constituents. Also, it may be prudent to limit use of products containing ozone-reactive constituents when indoor ozone concentrations are elevated either because of high ambient ozone levels or because of the indoor use of ozone-generating equipment.

Indoor Air Quality, Ventilation and Health Symptoms in Schools: An Analysis of Existing Information

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Abstract:
We reviewed the literature on Indoor Air Quality (IAQ), ventilation, and building-related health problems in schools and identified commonly reported building-related health symptoms involving schools until 1999. We collected existing data on ventilation rates, carbon dioxide (CO2) concentrations and symptom-relevant indoor air contaminants, and evaluated information on causal relationships between pollutant exposures and health symptoms. Reported ventilation and CO2 data strongly indicate that ventilation is inadequate in many classrooms, possibly leading to health symptoms. Adequate ventilation should be a major focus of design or remediation efforts. Total volatile organic compounds, formaldehyde (HCHO) and microbiological contaminants are reported. Low HCHO concentrations were unlikely to cause acute irritant symptoms (<0.05 ppm), but possibly increased risks for allergen sensitivities, chronic irritation, and cancer. Reported

microbiological contaminants included allergens in deposited d fungi, and bacteria. Levels of specific allergens were sufficient to cause symptoms in allergic occupants. Measurements of airborne bacteria and airborne and surface fungal spores were reported in schoolrooms. Asthma and 'sick building syndrome' symptoms are commonly reported. The few studies investigating causal relationships between health symptoms and exposures to specific pollutants suggest that such symptoms in schools are related to exposures to volatile organic compounds (VOCs), molds and microbial VOCs, and allergens.

Practical Implications:
The paper summarizes and explores the peer-reviewed literature on Indoor Air Quality (IAQ) in schools, a field that is of increasing interest to the research community, educators and school facilities managers, and the public at large. These experts generally agree that healthy indoor school environments are a necessity if a high standard of education is to be expected. Although peer-reviewed literature on this subject is sparse, there is a clear indication that classroom ventilation is typically inadequate. Researchers observed specific allergens in classrooms at levels sufficient to affect sensitive occupants. Studies of health symptom associations with IAQ conditions in the classroom are very rare, but taken with more general knowledge of IAQ, suggest that improved ventilation and targeted indoor pollutant source reductions could reduce certain occupant symptoms and improve the standard of health of the occupants.

Cleaning Products and Air Fresheners:
Exposure to Primary and Secondary Air pollutants

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Abstract:
Building occupants, including cleaning personnel, are exposed to a wide variety of airborne chemicals when cleaning agents and air fresheners are used in buildings. Certain of these chemicals are listed by the state of California as toxic air contaminants (TACs) and a subset of these are regulated by the US federal government as hazardous air pollutants (HAPs). California's Proposition 65 list of species recognized as carcinogens or reproductive toxicants also includes constituents of certain cleaning products and air fresheners. In addition, many cleaning agents and air fresheners contain chemicals that can react with other air contaminants to yield potentially harmful secondary products. For example, terpenes can react rapidly with ozone in indoor air generating many secondary pollutants, including TACs such as formaldehyde. Furthermore, ozone-terpene reactions produce the hydroxyl radical, which reacts rapidly with organics, leading to the formation of other potentially toxic air pollutants. Indoor reactive chemistry involving the nitrate radical and cleaning-product constituents is also of concern, since it produces organic nitrates as well as some of the same oxidation products generated by ozone and hydroxyl radicals. Few studies have directly addressed the indoor concentrations of TACs that might result from primary emissions or secondary pollutant formation following the use of cleaning agents and air fresheners. I this paper, we combine directempirical evidence with the basic principles of indoor pollutant behavior and with information from relevant studies, to analyze and critically asses air pollutant exposures resulting from the use of cleaning products and air fresheners, toxicants and compounds that can readily react to generate secondary pollutants. The toxicity of many of these secondary pollutants has yet to be evaluated. The inhalation intake of airborne organic compounds from cleaning product use is estimated to be of the order of 10 mg d-1 per person-1 in California. More than two dozen research articles present evidence of adverse health effects from inhalation exposure associated with cleaning or cleaning products. Exposure to primary and secondary pollutants depends on the complex interplay of many sets of factors and processes, ventilation, sorptive interactions with building surfaces, and reactive chemistry. Current understanding is sufficient to describe the influence of these variables qualitatively in most cases and quantitatively in a few.

Update on Asthma and Cleaners

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Abstract:

PURPOSE OF REVIEW: The present study summarizes the recent literature on the relation between cleaning exposures and respiratory health, in particular asthma, including reviews, epidemiological surveys, surveillance programmes and exposure studies. The authors also aimed to identify gaps in the current knowledge and to recommend future research on the topic. RECENT FINDINGS: A large international general population study showed an increased risk of new-onset asthma associated with cleaning work, with professional use of cleaning products and with domestic use of cleaning sprays. Three surveillance studies confirm the recognition of occupational asthma cases among cleaners and among others who use cleaning products at work. Six workforce-based studies show that respiratory symptoms are partly work-related, and are associated with certain specific exposures including sprays, chlorine bleach and other disinfectants. SUMMARY: Recent studies have strengthened the evidence of asthma and other adverse respiratory effects in cleaning workers. Similar effects are seen in other settings in which cleaning products are used such as healthcare professionals and homemakers. Both new-onset asthma and work-exacerbated asthma due to cleaning exposures may play a role. Exposure to cleaning sprays, chlorine bleach and other disinfectants may be particularly relevant. The predominant effect mechanisms remain largely unclear and may include both specific sensitization and irritant-related features.

Halogenated Volatile Organic Compounds from the Use of Chlorine-Bleach-Containing Household Products

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Abstract:

Sodium hypochlorite (NaOCl) and many organic chemicals contained in household cleaning products may react to generate halogenated volatile organic compounds (VOCs). Halogenated VOC emissions from eight different chlorine bleach containing household products (pure and diluted) were investigated by headspace experiments. Chloroform and carbon tetrachloride were the leading compounds along with several halogenated compounds in the headspace of chlorine bleach products. One of the most surprising results was the presence of carbon tetrachloride (a probable human carcinogen and a powerful greenhouse gas that was banned for household use by the U.S. Food and Drug Administration) in very high concentrations (up to 101 mg m(-3)). By mixing surfactants or soap with NaOCl, it was shown that the formation of carbon tetrachloride and several other halogenated VOCs is possible. In addition to quantitatively determined halogenated VOCs (n = 15), several nitrogen-containing (n = 4), chlorinated (n = 10), oxygenated compounds (n = 22), and hydrocarbons (n = 14) were identified in the headspace of bleach products. Among these, 1,1-dichlorobutane and 2-chloro-2-nitropropane were the most abundant chlorinated VOCs, whereas trichloronitromethane and hexachloroethane were the most frequently detected ones. Indoor air halogenated VOC concentrations resulting from the use of four selected household products were also measured before, during, and 30 min after bathroom, kitchen, and floor cleaning applications. Chloroform (2.9-24.6 microg m(-3)) and carbon tetrachloride (0.25-459 microg m(-3)) concentrations significantly increased during the use of bleach containing products. During/ before concentration ratios ranged between 8 and 52 (25 +/- 14, average +/- SD) for chloroform and 1-1170 (146 +/- 367, average +/- SD) for carbon tetrachloride, respectively. These results indicated that the bleach use can be important in terms of inhalation exposure to carbon tetrachloride, chloroform and several other halogenated VOCs.