Comments on Draft Indoor Air Quality Report: California Air Resources Board Report in response to Assembly Bill 1173

Submitted by
Hal Levin
Building Ecology Research Group
2548 Empire Grade, Santa Cruz, CA 95060
hal.levin@buildingecology.com

General comment:
I would like to start by acknowledging that ARB's report addresses most of the important problems and issues. It is clear that ARB has developed a rather advanced understanding of indoor air pollution. The ARB's investment in indoor air research over the past 15 years or more has certainly provided some valuable insights as well as many elements of a basic framework for addressing the problem. However, I do think the emphasis of the report could be somewhat different in certain places.

My overall main concern is that ARB has not developed an effective plan for addressing the issue. This shortcoming does not come primarily from a lack of recognition of the need nor from a lack of understanding of potentially effective actions that can be taken. The report should take a stronger position regarding the actions that should be taken to protect the citizens of California from indoor air pollution. Many actions are identified, some more specifically than others. I believe the report should define criteria for selection and implementation of the actions and develop recommendations for actions to be taken in the short, intermediate, and long term.

Some Details
There is clear evidence that certain indoor air pollutants exceed recommended levels for health (Hodgson and Levin,, 2002a and 2002b – see in list of references at end of these comments). It is well known that this occurs both in residential and non-residential, non-industrial settings. Therefore, it is timely and important that ARB act to control exposure to those pollutants most frequently found at concentrations of concern.

The time has come for ARB to consider implementing indoor air pollution reduction strategies, with possible regulation of indoor air quality. Exposures indoors dominate human exposures to air pollutants and many if not most can be reduced or eliminated by control of pollutant sources, adequate ventilation, and appropriate occupant behavior. ARB has the authority and the responsibility to protect building occupants from air pollution wherever it occurs. Susceptible populations, especially children, the elderly, and the infirm, are particularly at risk from exposure to indoor air pollutants. Sufficient scientific evidence exists to identify and take action to control important indoor air pollutants. Further research should be accelerated to define more clearly the range of risks and most effective actions that can be taken.

Regulation of certain sources may be the most cost effective and generally efficacious means to protect occupants from some well-understood common indoor air pollutants such as formaldehyde. Enormous progress has been made in the past two decades to reduce formaldehyde exposures in buildings by a factor of 10 to 100. These reductions were accomplished by more intelligent use of formaldehyde in products as well as a reduction in the unnecessary use of formaldehyde-emitting products. But these gains would not have been made without emissions testing and numerous consumer and some worker lawsuits. There are other candidate chemicals for serious attention and reduced emissions into indoor air based on the concentrations found and the relationship to established health-based exposure guidelines. A recemt paper (of which I am the co-author) compares concentrations of VOCs in indoor air to guideline values and points to some of the most obvious candidates for actions (Hodgson and Levin, 2002b).

Comments on Section 6. Prioritization of sources and pollutants

Cleaning, maintenance, finishing, and re-finishing products and materials.
While building materials themselves are important sources when new and, for some denser and/or thicker solid materials, for many months or even years, a generally more important source of significant exposure often will be emissions from the products applied to clean, polish, maintain, resurface or refinish interior surface materials. The janitor brings into the building a full five-gallon can of floor wax or carpet shampoo and he carries out an empty can. Some of the emissions are rapid as the solvent or carrier evaporates. Others of the emissions occur over the life of the finish product and evaporate as gases or particles. The final emissions occur when a product such as a floor wax or wall paint is removed from the surface so that a new one may be applied to replace it. In each of these stages, there exists the potential for exposures not only of the maintenance worker or other agent but also for occupants in the building at the time or at a later time. Therefore, the category of building materials and products should be understood to include all the products recommended or otherwise commonly used to treat exposed building material surfaces. (Levin, various publications cited).

Along these lines, consumer and commercial cleaning products should be elevated to a higher place on the list of prioritized topics. Further work is needed to establish relevant and protective criteria based on health effects data.

The lists of “acceptable products” mentioned as being compiled by various “sustainable” and “green” building groups are often based on limited testing, insufficiently protective criteria; and an incomplete understanding of the life cycle of the material or product and of its implications for exposures.

Pesticides:
Pesticide use and exposure are conspicuously absent from the report in spite of the great health threat posed by exposure and the well-documented extensive exposure of residents to pesticides from their own homes or from agricultural use of these products. While ARB does not have regulatory authority over pesticide use per se, it does have

responsibility and authority to protect building occupants from exposure to these products as they become airborne incidental to their primary use.

Pesticide exposure from treated wood and termite applications results in substantial exposure to toxic chemicals indoors. A report of residential exposure to common pesticides in New England homes published in the journal Environmental Science and Technology (ES&T) late in 2003 documented more extensive exposure to pesticides than had previously been shown in indoor air.

Pesticides tend to be persistent in the indoor environment due to their relatively low vapor pressures and, therefore, present a great risk especially to children who can be exposed not only through inhalation but also through dermal contact and inadvertent ingestion exposure routes. ARB should increase research focused on pesticide exposure in buildings, particularly in residential environments where pesticide use is less controlled, where many cases of pesticide poisoning have been documented, and where children are at great risk due to higher exposure and greater potential susceptibility to and significance of exposure.

Combustion products:
In the California Department of Consumer Affairs 1982 report on indoor air pollution, "Clean Your Room," gas cooking devices were identified as a high priority target for control by implementation of a link between an exhaust hood and the range top burner control switches. This was a strong recommendation at hearings held by the Dept. of Consumer Affairs made by the late Craig D. Hollowell, then head of the LBL indoor air quality research program and a leading authority on indoor air quality until his untimely death in 1982. Even to this day, such a requirement has not been implemented. I recommend that such a requirement be considered along with limits on exhaust fan noise so that these devices will not be annoying and, therefore, potentially disabled or otherwise unused by consumers.

Specific comments on other sections:

1. Exposure to pollutants indoors includes a general baseline of pollutant exposure outdoors. Granted that ozone and some other exposures are lower indoors, but indoor air is basically outdoor air contaminated further by indoor sources. However, even at the lower indoor concentrations of ozone, there is sufficient ozone to create indoor air chemical reactions that in turn result in higher concentrations of many toxic and irritating chemicals as well as the formation of fine and ultrafine particles.

2. Many (most?) ARB staff reports on possible listings of TACs shows that most exposure to many toxics occurs indoors.

3. p. 27 "Health impacts, sources, concentrations" Personal activities are far more important than area sources and can dominate exposure as shown by the EPA TEAM studies reported by Wallace, Sheldon, Pellizari, and others. Rodes et al showed the importance of the "personal activity cloud" (as described in their abstract below).

"The influence of personal activity sources on exposure to indoor contaminants is defined and demonstrated using data from occupational and residential studies. The ratios of measurements from personal exposure monitors to those made by microenvironmental exposure monitoring are summarized to be typically 3 to 10 for occupational settings and 1.2 to 3.3 for residential settings. The ratios are shown to be log normally distributed, and dependent primarily on the proximity of the source to the receptors. Current models are reviewed for possible application to the prediction of indoor concentration gradients and future model development and validation studies are suggested. (Charles E. Rodes[1], Richard M. Kamens[1], and Russell W Wiener[2] "The Significance and Characteristics of the Personal Activity Cloud on Exposure Assessment Measurements for Indoor Contaminants" *Indoor Air*, 2,123-145 1991)

4. Fine particle exposure indoors includes indoor generated particles from cooking and from human metabolic activities including expiration, coughing or sneezing that produce airborne viruses and bacteria.

5. Section 2.2 Particles
There is a need for increased research on the health effects of indoor-generated particles, especially fine particles and ultra-fine particles, some of which are generated by indoor air chemical reactions between ozone and common indoor air contaminants.

6. Section 2.2 Particles
There is a need to extend regulatory authority to and apply it in the indoor environment since it is known and well-documented (as stated in the draft) that exposure to particles indoors often exceed the regulatory limits.

2.2.6.2 Indoor ozone
A major issue related to indoor ozone is its ability to form toxic and irritating chemicals through chemical reactions with common indoor contaminants. Far more attention should be given to the regulation of ozone outdoors due to its penetration indoors and its role in the formation of toxic secondary products.

Commenting on the recent ARB staff report on ozone, I wrote the following:

> I urge the Air Quality Advisory Committee to consider the implications of ozone on human health in light of the dominance of indoor air in terms of total exposure. In much of California, people use open windows rather than air conditioning as a means of cooling their homes. This occurs in coastal climates where outdoor air temperatures are not excessivley high as well as in drier inland climates where evaporative cooling can be used for control of the indoor thermal environment. In these cases, indoor to outdoor ozone rations can be from 50 to 70%, as documented by Charles Weschler in his 1989 A&WMA Journal article on ozone indoors.

Recent research including work performed for the ARB has shown that reactions of ozone with common indoor materials and with indoor source chemicals such as cleaning products and solvents results in the formation of secondary products that are often more irritating or toxic than the chemicals from which they were formed. The recent article by WW Nazaroff and CJ Weschler reporting the results of their literature review for the ARB-funded study of cleaning products and their reactions with oxidants shows that this may be a very important source of human exposure to hazardous chemicals and even to fine and ultra-fine particles. I have attached a copy of that article for your information.

5. I recommend further study of ozone concentrations indoors in a variety of environments, especially in schools, health care facilities, and public assembly spaces where air exchange rates are high enough to result in elevated indoor-outdoor ozone concentration ratios. I also recommend more thorough characterization of ozone in homes in the full range of climates found in California and through various seasons but, especially, during the so-called ozone season as defined locally.

References:

Hodgson, A.T.; Levin, H., 2002a. Volatile organic compounds in indoor air: A review of concentrations measured in North America since 1990. To be submitted for publication in *Atmospheric Environment*. LBNL-51715.

Hodgson, A.T.; Levin, H., 2002b. Classification of measured indoor volatile organic compounds based on noncancer health and comfort considerations. To be submitted for publication in *Atmospheric Environment*. LBNL-53308.

Spohn, R, Levin, H, and Jaffe, R: "Introduction," In Spohn, R (Ed.): Clean Your Room! A Compendium on Indoor Pollution. Sacramento, State of California Department of Consumer Affairs, 1982.

Additional References for further consideration:

Levin, H. and Alevantis, L., 2003. "California Indoor Air Quality Specifications for Open Office Systems Furniture and Building Materials." *Proceedings, EPA/A&WMA Indoor Air Quality: Problems and Engineering Solutions*. Raleigh, NC, July 26, 2003.

Mendell, Mark J.and Levin, Hal, 2002. Summary of On-Going Federal Research into the Effects of Environmental Quality in Schools on the Health or Performance of Students and Teachers. Prepared for the U.S. Department of Education, Washington, DC.

Alevantis, L. and H. Levin, 2002. California's sustainable building efforts in state government: Indoor air quality specifications for open office systems furniture and building materials. European Commission Joint Research Center, Ispra, Italy

Alevantis, Leon, Kathy Frevert, Rick Muller, Hal Levin, and Arnold Sowell, Sustainable Building Practices In California State Buildings. *Indoor Air 2002, Proceedings of the 9th International Conference on Indoor Air Quality and Climate*, Vol. 3, pp. 666-671.

Bernheim, A. Levin H., and Alevantis, L., 2002. Special environmental requirements for a California State office building. *Proceedings of the 9th International Conference on Indoor Air Quality and Climate, Indoor Air 2002*, Vol. 4, pp. 918-923.

Fisk, W.J., G. Brager, M. Brook, H. Burge, J. Cole, J. Cummings, H. Levin, V. Loftness, T. Logee, M.J. Mendell, A. Persily, S. Taylor, J. Zhang, A priority agenda for energy-related indoor environmental quality research. *Proceedings of the 9th International Conference on Indoor Air Quality and Climate, Indoor Air 2002*, Vol. 2, pp. 984-989.

Levin, H. 2000. "Critical review of environmental assessment of building materials." In *Proceedings of Sustainable Buildings 2000*. Maastricht, Netherlands, 22-25 October, 2001. pp. 271-274.

Levin, H. 2000. "Integrating indoor air quality considerations into materials life cycle assessment." In *Proceedings of Sustainable Buildings 2000*. Maastricht, Netherlands, 22-25 October, 2001. pp. 228-230.

Levin, H., 2000, Design and Construction of Healthy and Sustainable Buildings. Keynote Lecture, *Proceedings of Healthy Buildings 2000*, Helsinki, Finland, August 4-8, 2000. Vol. 4, pp. 13-22.

Levin, H., 1999, Integrating Indoor Air Quality Considerations Into Materials Life Cycle Assessment, presented as a Plenary Lecture at Indoor Air '99, The Eighth International Conference on Indoor Air Quality and Climate, Edinburgh, Scotland, August 8-13.

Levin, H. (ed.) 1998. "Indoor Air Guideline Values for Organic Acids, Phenols, and Glycol Ethers," *Indoor Air Supplement 5/1998*.Copenhagen: Munksgaard.

Bernheim, A. and Levin, H. "Material Selection for the Public Library." In J. Woods, D. Grimsrud, and N. Boschi, (Eds) *Proceedings of Healthy Buildings/IAQ '97*, (4th International Healthy Buildings conference, held in Bethesda, Maryland, September 27-October 2, 1997). Vol. 3, 599-604.

Levin, H., and Hodgson, A. T., (1996) "Screening and Selecting Building Materials and Products Based on Their Emissions of VOCs," in Tichenor, B. ed., *Methods for Characterizing Indoor Sources and Sinks* (STP 1287) Philadelphia: American Society for Testing and Materials.

Levin, H. "Emissions Testing and Indoor Air Quality," Keynote presentation in *Proceedings of Indoor Air Quality, Ventilation, and Energy Conservation in Buildings*" Montreal, Canada, May 9-12, 1995.

Levin, H. 1992, "Controlling Sources of Indoor Air Pollution" in H. Knöppel and P. Wolkoff (Eds.) 1992, *Chemical, Microbiological, Health and Comfort Aspects of Indoor Air Quality -- State of the Art in SBS*. Dordecht, The Netherlands: Kluwer Academic Publishers. pp. 321-342.

Levin, H., "General Population Exposure to Pentachlorophenol." in *Proceedings of the EPA/A&WMA Specialty Conference, Total Exposure Assessment Methodology*, November, 1989, Las Vegas, Nevada. Pittsburgh: Air & Waste Management Association, (P. O. Box 2861, Pittsburgh, PA 15230).

Levin, H. "Sick Building Syndrome: Review and Exploration of Causation Hypotheses and Control Methods." In *IAQ 89, The Human Equation: Health and Comfort*. Atlanta: American Society for Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE) and Society for Occupational and Environmental Health, 1990.

Levin, H. "Building Materials and Indoor Air Quality," in, Hodgson, M. and Cone, J., eds., *Problem Buildings, Building Associated Illness and Sick Building Syndrome,* State of the Art Reviews in Occupational Medicine, Fall 1989.

Levin, H, and Phillips, TJ "Pre-Occupancy Indoor Air Quality Procedures in Energy Efficient California State Office Buildings." In Nagda and Harper, eds, *Design and Protocol for Monitoring Indoor Air Quality*. Philadelphia: American Society for Testing and Materials, 1989.

Levin, H: "Preliminary Report: Assessment of Indoor Pollution, California Veterans Memorial State Office Building, Long Beach." Center for Environmental Design Research, Univ. of California, Berkeley 1984.

Spohn, R, Levin, H, and Jaffe, R: "Introduction," In Spohn, R (Ed.): Clean Your Room! A Compendium on Indoor Pollution. Sacramento, State of California Department of Consumer Affairs, 1982.