

Part 1. The Earth's Atmosphere

Chapter 7. Chemistry of Urban and Indoor Atmosphere

Chapter 7. Chemistry of Urban and Indoor Atmosphere

7.1 Pollutants in the urban atmosphere

- WHO guidelines for air quality

Pollutant	Maximum time-weighted average concentration	Averaging time ^a
Sulfur dioxide/ $\mu\text{g m}^{-3}$	500	10 min
	350	1 h
	100–150	24 h
	40–60	1 y
Carbon monoxide/ mg m^{-3}	30	1 h
	10	8 h
Nitrogen dioxide/ $\mu\text{g m}^{-3}$	400	1 h
	150	24 h
Ozone/ $\mu\text{g m}^{-3}$	150–200	1 h
	100–120	8 h
Suspended particulate matter (SPM)/ $\mu\text{g m}^{-3}$		
Black smoke	100–150	24 h
	40–60	1 y
Total suspended particulates	150–230	24 h
	60–90	1 y
Respirable particulates (PM ₁₀)	70	24 h
Lead/ $\mu\text{g m}^{-3}$	0.5–1	1 y

^aThe averaging time refers to the period during which the weighted-average value should not exceed the specified guideline concentration. Reproduced with permission.

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7.1 Pollutants in the urban atmosphere

- Air quality of some megacities with over 10 million populations

Table 7.2 Summary of air quality in twenty megacities from all continents around the globe						
	SO ₂	SPM	CO	NO ₂	O ₃	Pb
Bangkok	—	++	—	—	—	+
Beijing	++	++	na	—	+	—
Bombay	—	++	—	—	na	—
Buenos Aires	na	+	na	na	na	—
Cairo	na	++	+	na	na	++
Calcutta	—	++	na	—	na	—
Delhi	—	++	—	—	na	—
Jakarta	—	++	+	—	+	+
Karachi	—	++	na	na	na	++
London	—	—	+	—	—	—
Los Angeles	—	+	+	+	++	—
Manila	—	++	na	na	na	+
Mexico City	++	++	++	+	++	+
Moscow	na	+	+	+	na	—
New York	—	—	+	—	+	—
Rio de Janeiro	+	+	—	na	na	—
São Paulo	—	+	+	+	++	—
Seoul	++	++	—	—	—	—
Shanghai	+	++	na	na	na	na
Tokyo	—	—	—	—	++	na

— Low pollution; WHO guidelines normally met. Short-term guidelines may be exceeded occasionally.
 + Moderate to heavy pollution; WHO guidelines exceeded by up to a factor of two. Short-term guidelines may be exceeded regularly in some locations.
 ++ Serious pollution; WHO guidelines regularly exceeded by a factor of more than two.
 na No data or insufficient data.
 Data reproduced with permission.

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7.2 Indoor air quality: **generals**

- Four major factors determining indoor air quality:
 1. Nature of the ambient air, outdoors around the building
 2. Infiltration rate or air exchange rate for a building
 3. The material present in the building as construction material or in other forms.
 4. The activities going on inside a building
- Rate of production of the compound inside: $R_i = k_e C_i - k_e C_0$ (7.1)
In the steady state: $C_i = C_0 + R_i / k_e$
When outdoor contribution is negligible: ?
When none of the chemical is produced indoors: ?

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7.2 Indoor air quality: Radioactivity (mainly by Radon)

- Sources of Radon (Rn): from clay based construction materials
 1. Uranium-238: half-life=4.5 billion yrs
 2. Thorium-232: half-life=14 billion yrs
- Half-life of Rn: $\text{Rn}^{222}=3.8$ days, $\text{Rn}^{220}=55.6$ s by α -emission:

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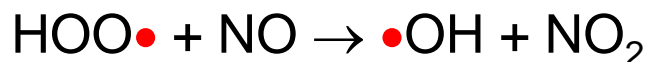
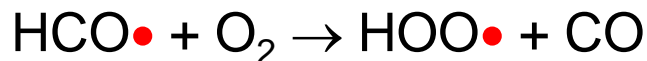
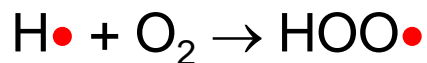
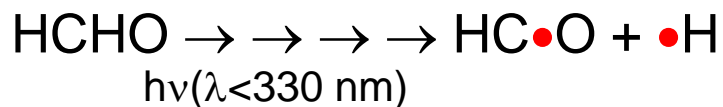
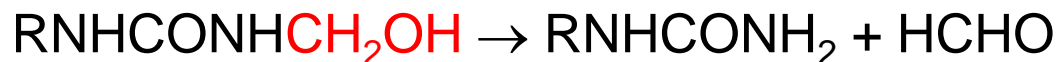
7.2 Indoor air quality: Volatile organic compounds

- Sources of VOCs in indoors: construction materials, furnishings, consumer products, combustion processes, etc.

Construction materials: chloroform, acetone, chlorinated compounds, formaldehydes from wood composites, insulating foams, floor tiles, carpet, and adhesives

Consumer products: toluene, ethylbenzene, 2-propanol, and butanone from latex paint

- Formaldehyde:



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7.2 Indoor air quality: Volatile organic compounds

Formaldehyde:

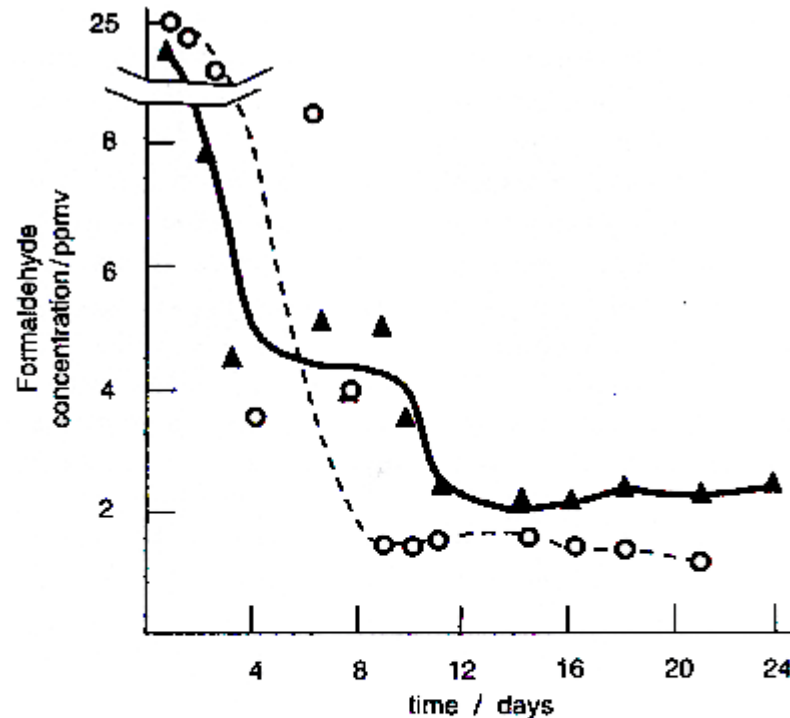


Fig. 7.8 Time sequence of formaldehyde release in a building containing formaldehyde-based polymers. Room maintained at 33 °C; measurements taken over a 30 minute sampling period. Filled triangles: high humidity conditions; open circles: low humidity conditions. (Figure redrawn from data provided in Gammage, R. B. and K. C. Gupta, Formaldehyde, in ref. 2, p. 113.)

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7.2 Indoor air quality: Particulates

▪ Solid aerosol in a building:

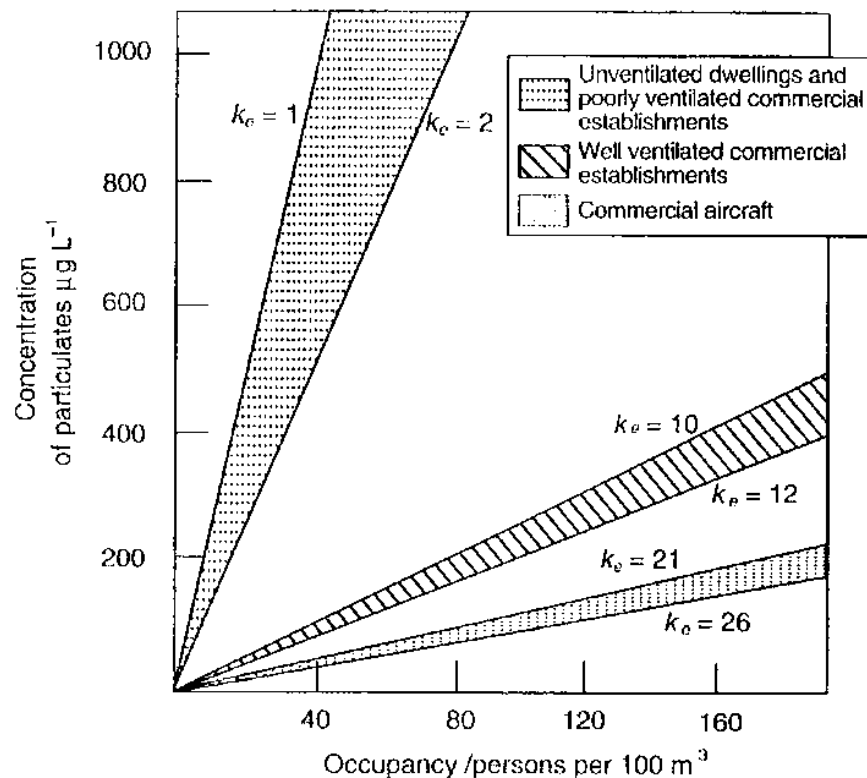


Fig. 7.9 Theoretical steady-state density of respirable suspended particulates from environmental tobacco smoke in an enclosed indoor space. Air exchange rate is $k_e \text{ h}^{-1}$. (Redrawn from Repace, J. L. and A. H. Lowrey, Indoor air pollution, tobacco smoke, and public health. *Science*, 208 (1980), 464–71.)