Total Building Cleaning Effectiveness Study

The purpose of this study was to characterize the indoor environment of a 20-year-old, 40,000 square foot, multi-floor (two day care, one offices, one medical laboratories), multi-use (62 children, 214 adults), non-problem, non-complaint building through long-term sampling for biological, chemical and particulate pollutants; and to assess the effects of cleaning on indoor air quality.

The study protocol included five months of "baseline" environmental measurements, a rigorous cleaning of the entire building; and, a feasible, standard cleaning program. Air, surface and dust data from monitoring prior to the cleaning program were compared with those obtained while the improved housekeeping program was in place to assess the effectiveness of the cleaning program on the indoor environment. Correlations between pollutants and other environmental factors are also presented.

This work involved a collaborative effort by Research Triangle Institute, the U.S. Environmental Protection Agency's Environmental Criteria and Assessment Office (EPA-ECAO), the University of North Carolina a Chapel Hill (UNC), the building service contractor, and commercial cleaning and carpet industries and their suppliers.

The environmental monitoring included bioaerosol sampling, non-floor surface biologicals, floor dust samples for mass and biologicals, aerosol particle counts, aerosol dust mass, volatile organic compounds and comfort factors such as temperature, relative humidity, carbon monoxide, and carbon dioxide. Initially (July 1992), the building was inspected, and an extensive environmental screening was conducted to confirm it as a building without indoor air quality problems. Monitoring was performed monthly for the remainder of the study.

During the first four months of monitoring (Sep-Dec 1992), no changes were made in the routine housekeeping of the building. In December, outside professional companies cleaned the building to include walls, furniture, light fixtures, bathrooms, windows, tile floors and carpet. At the same time, new equipment and supplies were introduced, and the building housekeeping staff was trained to use the new equipment and to institute and follow a standardized or "improved housekeeping" program of environmental cleaning. From January to July 1993, monthly environmental monitoring continued as the improved housekeeping procedures were followed.

The study concluded that an organized cleaning program, based upon environmental management principles and fundamental environmental protection guidelines, contributed to improved indoor air quality through reduction of total suspended particles, total volatile organic compounds and culturable bacteria and fungi. The summary table with pertinent data follows:

Summary Indicating the Effects of Cleaning on Indoor Air Quality

Air Pollutant Category	Routine Housecleaning (5 Months)	Improved Housekeeping (7 Months)	% Change	Most Probable Cause of Improved Air Quality
• **Airborne Dust Burdens** - Building Means	**11.9 µg/m^3 (4.4-24.4)**	**5.7 µg/m^3 (1.4-11.9)**	**-52%**	Efficient vacuum cleaners and bags Walk-off mats at entries Damp dust cloths Frequent vacuuming and dusting Deep cleaning entire building Dust control on hard surfaces
• **Total VOC** - Building Means	**324 µg/m^3 (88-530)** (3 months)	**166 µg/m^3 (29-309)**	**-49**	Cleaning chemicals w/less VOC Extraction from carpet Balanced ventilation system
• **Biopollutants:*** (Building Means)				
Total Bacteria	**395 CFU/m^3 (71-855)**	**237 CFU/m^3 (34-868)**	**-40%**	Rapid use of disinfectants after accidents
- Gram-negative Bacteria	17 CFU/m^3 (1-171)	2 CFU/m^3 (0-9)	-88%	
- Endotoxin (surface)	352 (3-1800)	100 (4-260)	-72%	Control of foods & perishables
- Bacillus	22 CFU/m^3 (1-85)	18 CFU/m^3 (2-71)	-18%	New extraction equipment
- Actinomycetes	36 CFU/m^3 (0-312)	2 CFU/m^3 (0-4)	-94%	Hot water extraction of carpet
Total Fungi	**127 CFU/m^3 (22-406)**	**50 CFU/m^3 (2-219)**	**-61%**	Moisture control
- Penicillium	38 CFU/m^3 (4-284)	5 CFU/m^3 (1-39)	-87%	Removal of contaminated sources (moldy drywall, rotten tree stump)
- Aspergillus	4 CFU/m^3 (0-17)	1 CFU/m^3 (0-11)	-75%	
- Cladosporium	35 CFU/m^3 (8-102)	27 CFU/m^3 (0-175)	-23%	Walk-off mats
*Anderson Sampler data only				

µg/m^3 - micrograms per cubic meter
CFU/m^3 - colony forming units per cubic meter

SUMMARY OF MAJOR FINDINGS

1. Particle Results:

a. Airborne dust mass, measured as total suspended particles (TSP), provides the most meaningful particle data and showed a statistically significant reduction with improved cleaning.

b. Immediately after deep cleaning, carpet dust mass was reduced, particularly on floors with the highest dust loads.

c. Soon after deep cleaning, carpet dust mass loads quickly returned to before-cleaning levels, confirming carpet as a sink or collector of particles.

d. Airborne dust mass was decreased after deep cleaning and continued lower even though the total mass from dust in carpet soon returned to original levels.

2. Biopollutant results of data comparison:

a. This year-long study of a non-problem building showed that attention to improved housekeeping, in conjunction with proper HVAC operation and maintenance, resulted in sustained reduction of mean levels of:

(1) airborne bacteria (40%) and fungi (61%) - Anderson sampler

(2) non-floor surface bacteria (29%) and fungi (25%)

(3) carpet dust bacteria (84%), fungi (93%) and endotoxin (72%)

b. Deep cleaning resulted in reduction of mean levels of:

(1) airborne bacteria (58%) and fungi (25%) - Anderson sampler

(2) non-floor surface bacteria (58%) and fungi (15%)

(3) carpet dust bacteria (76%), fungi (99%) and endotoxin (98%)

3. Overall Results:

a. An organized cleaning program based upon environmental management principles and fundamental environmental protection guidelines contributed to indoor air quality through the reduction of total suspended particles (TSP), total volatile organic compounds (TVOCs) and culturable bacteria and fungi.

b. While airborne pollutants increased during deep cleaning, they never reached levels of concern to researchers, and were shown to decrease rapidly to levels well below the "pre-cleaning" concentrations.

c. The study data suggests that ambient, environmental pollution can be significantly controlled through an effective and managed indoor cleaning program.

d. Routine, non-floor, surface bacterial and fungal sampling can help identify areas for focused cleaning, as well as provide a useful assessment of a building's changing microbial ecology.