

Investigation Finds Correlation Between Symptoms and Humidity

A separate study in six Florida schools monitored 13 carpeted classrooms for both settled and airborne contaminants. While finding low levels of dust mite and mite allergens in indoor air, as well as generally low fungal concentrations, the study indicated a correlation between humidity levels and reports of allergic-type symptoms among students and staff.

Judith Bates of Racine Industries, Inc. (Racine, Wisconsin) conducted the research. Racine is a manufacturer of dry-extraction cleaning supplies and services. The object of the study was to determine if there was any difference between complaint and noncomplaint classrooms in the schools.

Five of the six schools studied are similar, with classrooms housed in single-story buildings, eight rooms per building. Each classroom opens to the outside, and has no enclosed corridors. The sixth school, a more traditional design, has interior, enclosed corridors and all the classrooms are in one central building.

At the time of the study, three of the schools had carpeting in all rooms and three had carpet in some rooms and vinyl tile in the others. The researchers chose to study rooms that had carpeting. The ages of the schools ranged from 5 to 39 years. Two schools had no health complaints.

Study Methods

Before testing began, researchers visited the schools to meet with the custodial staff and select rooms for testing. In two schools with complaints, they chose rooms with the most symptom reports. In the other schools with symptom reports, they chose a complaint and a non-complaint room in each school. In the other two schools without complaints, they chose two typical rooms. At the time of those visits, the researchers took

dust samples from each carpet for dust mite analysis.

The testing of each room took place over two days, with carpet cleaning during the evening between days. In rooms that had tested high for mite allergens in carpet dust, the researchers sampled for airborne dust mite allergens, setting up samplers 24 inches above the carpet and allowing the samplers to run for 8 hours during normal class activities. The researchers also visited each room and took additional samples for mold spores, and tested carpet dust samples to analyze for dust mites and mite allergens. They repeated the sampling the second day.

In addition to sampling for biological contamination, the researchers monitored room temperature and RH. They also did a visual inspection of equipment and noted any disagreeable odors or visible mold. Control samples came from outdoor measurements of mold spores, temperature, and RH at each school.

Results

Indoor airborne fungal concentrations varied, but were generally lower than outdoor concentrations. While outdoor levels ranged from 340 cfu/m³ to 4,900 cfu/m³, the indoor levels ranged from 30 cfu/m³ to 2,400 cfu/m³. Mold spores in carpets ranged from 7,000 cfu/m³ to 100,000 cfu/m³, with higher levels consistently found in

Table 2 — Mold Spores in Air and Carpet Dust

School (age)	Room (* indicates complaint room)	Mold Spores (cfu/m ³)		
		Indoor Air	Outdoor Air	Carpet
#1 (10)	A *	140	1,185	60,000
	B *	200		13,000
	C *	90		9,700
#2 (7)	D	70	790	12,000
	E *	2,400		14,000
#3 (26)	F *	120	340	12,000
	G	330		30,000
#4 (28)	H *	120	2,800	100,000
	I *	30		20,000
#5 (39)	J	1,500	2,100	12,000
	K	630		20,000
#6 (5)	L	340	4,900	7,000
	M	200		35,000

Source: Judith M. Bates

complaint rooms. Table 2 shows the fungal concentrations.

Dust mite allergen levels in the carpets showed wide variability, ranging from 42 nanograms per gram (ng/g) to 14,646 ng/g. The higher levels, however, occurred in rooms with higher RH. The tests revealed no airborne dust mite allergens, even though the carpets may have had high levels. Table 3 shows the mite allergen concentration and RH levels in the classrooms.

The researchers found that carpet cleaning significantly reduced the concentrations of dust mite allergens and mold spores in carpet dust. They detected no increase in airborne mold spores during or after the carpet cleaning.

Because of the Florida climate, temperatures and relative humidity were often extreme. Outdoor temperatures ranged from 82°F to 100°F and outdoor RH ranged from 53% to 73%. In the classrooms, temperatures were in the 72°F-80°F range, but RH varied from 51%-80%. All problem rooms had RH levels 69% or above. Most of these schools also had visible mold growth on ceiling tiles.

School #1 had numerous complaints for half of its 10-year life. Three years after construction, the HVAC system failed and was off for two months during the summer. The researchers said teachers told them they returned in the fall to find books and furniture covered with mold. The HVAC system is also turned off at night, causing moisture buildup on walls and windows.

In School #4, which is a traditional building with an interior corridor, the classrooms are air conditioned, but the corridor is not. This sets up a temperature gradient, leaving the corridor walls wet to the touch.

In School #2, which had both a complaint room and a noncomplaint room, the RH in the complaint room was 13% higher than in the other room.

The researchers concluded that the study indicated no contribution from the carpet to the IAQ problems at the schools. In fact, they said the study indicated that the carpet acted as a reservoir for contaminants, with no evidence that the contaminants leave the carpet prior to cleaning.

Table 3 — Dust Mite Allergen Levels and RH in Classrooms

School	Room (* indicates complaint room)	Mite Allergens in Carpet Dust		Mite Allergens in Indoor Air	Relative Humidity (%)	Reported Symptoms and Conditions
		Before Cleaning (ng/g)	After Cleaning (ng/g)			
#1	A*	948		—	74-78	Allergy-like symptoms: headaches, sore throats, stuffed sinuses, respiratory ills, coughs; musty odors in all rooms, mold growth on ceiling tiles in one room.
	B*	3,085	818	0	74-78	
	C*	4,824	27	0	74-78	
#2	D	108		—	64	No health complaints, odors, or mold.
	E*	42			77	Mold on ceiling tiles; odors.
#3	F*	9,704	3,917	0	69	Asthma, respiratory ills; no odors or mold.
	G	663		—	63	No health complaints, odors, or mold.
#4	H*	14,646	3,921	0	77-80	Respiratory illnesses and odors in all rooms. Visible mold growth on many ceiling tiles.
	I*	1,451		—	77-80	
#5	J	190		—	62-65	No health complaints, odors, or mold.
	K	102		—	62-65	
#6	L	89		—	51-52	No health complaints, odors, or mold.
	M	115		—	51-52	

Source: Judith M. Bates

Discussion

Both of these studies appear to lay to rest some concerns people have over carpets in such places as schools, offices, and even homes. However, because these studies are only pieces of a much larger puzzle, it would be inadvisable to place too much emphasis on them.

One question they don't answer that was raised in the story on page 1 is the effectiveness of various cleaning methods on removing the contaminants that accumulate in the carpets. In the study cited above, the cleaning did remove the contaminants. However, that may be method-dependent and may not always be the case. If the concerns raised by G. Wentworth Smith in the article on page 1 are correct, cleaning may not only fail to remove contaminants completely, but may drive them deeper into the carpet.

Also, while there is concern over contaminants becoming airborne from carpets, that isn't the only route of exposure. Youngsters, especially infants, are prone to significant direct contact with the carpet and engage in a lot of hand-to-mouth activity. This could provide exposure to the contaminants in the carpet, even though they remain trapped in there. In fact, some researchers have claimed that a correlation exists between the amount of lead dust in a home carpet and the level of lead in an infant's blood.

For More Information

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TOOLS AND TECHNIQUES

Ergosterol May Prove Valuable in Estimating Fungal Contamination

Measuring the extent of fungal contamination is a difficult task at best. Current methods for measuring the amount of fungal growth in a space are prone to error and often show wide variability. Now, Canadian researchers are proposing a simple, cost-effective way to measure fungal mass using cost-effective techniques to measure ergosterol, a fungal component.

J. David Miller from the Plant Research Centre, Agriculture and AgriFood Canada, told *IAQU* that ergosterol concentrations show good correlation with fungal mass and that measurement techniques bring the cost of sampling within "the tens of dollars (US)," compared to other methods that cost in the hundreds or even hundreds of thousands of dollars for similar results.

Miller and his colleague J. Christopher Young reported on their findings in the January issue of the American Industrial Hygiene Association journal (*AIHA Journal*, "The Use of Ergosterol to Measure Exposure to Fungal Propagules in Indoor Air," Vol. 58, pp. 39-43).

Miller explained to *IAQU* that health effects from mold exposure depend on two factors: the amount of mold present, and the types. "The more mold there is, the sicker you'll be," Miller said. The task facing researchers — as well as

IAQ investigators — is to determine both the total fungal mass and the species present.

Some current methods of determining fungal mass are prone to errors built into the sampling method. Collecting particles on agar media for culturing reveals only the so-called "viable" fungi and can seriously underestimate total mass. Also, this sort of approach is short-term, measuring airborne spores for only a few minutes, while some research has shown hourly variations of four orders of magnitude.

Another approach measures a fungal component — B-1,3-glucan — which Miller says is a good test, but can be expensive, running about US \$150 per sample. Using a highly reliable technique, a lipid signature profile, requires equipment that costs over US \$100,000.

Miller says that using ergosterol could allow researchers and IAQ investigators to collect samples over a long period of time — perhaps 24 hours — and then determine fungal mass from the ergosterol. The method would be considerably cheaper and more reliable than other techniques, and has the added advantage of being more "robust." Samples don't require the special care and handling that make other methods so difficult, expensive, and potentially unreliable.