

Slide 1

***School Floor Coverings:
Effects on Children's Well-
Being and Learning***

Professor Alan Hedge
*Dept. Design & Environmental Analysis
Cornell University, Ithaca, NY 14853.*

Slide 2

Floor Covering Issues

- *How do floor coverings affect indoor air quality?*
- *How do floor coverings affect safety and the learning environment?*



Slide 3

Indoor Air Quality in Schools

- ***Sources of IAQ problems include:***
 - *HVAC contamination - a frequent source of indoor air quality problems*
 - *Microbiological contaminants - usually originate outdoors*
 - *Water damage*
 - *Inadequate maintenance*
 - *Localized sources*



Slide 4

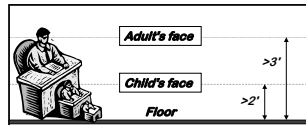
School IAQ depends on Many Factors

- *Outdoor air quality - gases, particles, bacteria, fungi*
- *HVAC design, operation and maintenance - air handling units, filters, ducts.*
- *Building materials - woods, caulking, adhesives, mineral wools*
- *People - odors, clothing, bioeffluents*
- *Activities - cooking, labs., correction fluids, cleaning and maintenance practices, pest control*
- *Technology - photocopiers, computers, laser printers*
- *Finishes - paints, varnishes, wall coverings*
- *Furnishings - furniture, draperies, floor coverings*

Slide 5

IAQ and Respiratory Effects

- *Research studies repeatedly have shown that people respond to what is in the air in their breathing zone, not what is trapped in surface materials.*



Slide 6

Floor Covering Issues


- **Source**
How are floor coverings a source of some air pollutants?
- **Sink**
How are floor coverings a reservoir for some air pollutants?
- **Safe**
How are floor coverings an effective trap for some air pollutants?



Slide 7

Indoor Air Pollutants


- **Volatile Organic Compounds (VOCs)**
 - Paints
 - Materials
 - Adhesives
 - Cleaning
 - Equipment
- **Biologicals**
 - Bacteria, Endotoxin
 - Fungi, Mycotoxins
 - Allergens (Cockroaches, Dust mites, Dogs, Cats)



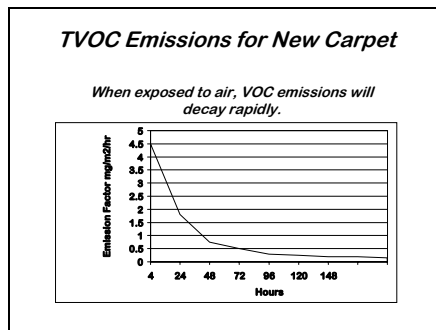
Slide 8

New Carpet Emissions

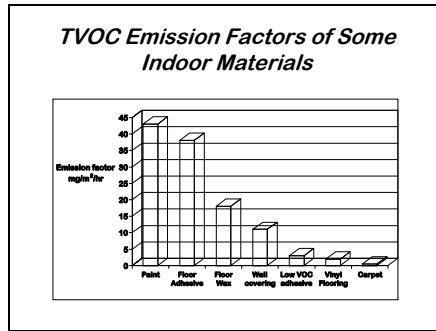
- New carpet can emit a number of volatile organic compounds (VOCs) when first exposed to the air.
- Emissions will vary with the type of carpet.



Slide 9




Slide 10



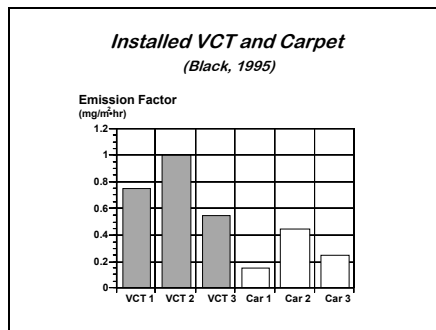
Slide 11

New VCT Emissions

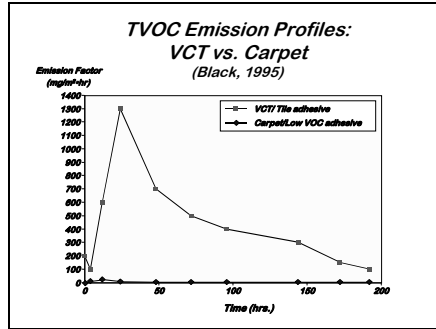
- New VCT can emit a number of volatile organic compounds (VOCs) when first exposed to the air.
- Emissions will vary with the type of VCT and adhesive.



Slide 12




Slide 13



Slide 14

Carpet Emissions

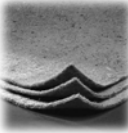
- **Volatile ingredients:**
 - Across all types of carpet
~160 different VOCs, but
most at trace levels
- **No evidence of health effects from numerous studies, including EPA.**



Slide 15

Carpet Cushion
(Shaeffer et al., 1996)


- Carpet cushion emits VOCs.
- Emissions vary by product.
- Average of 76% lower emissions from retail than factory samples of 5 cushion types.
- Average of 63% fall in emissions from 6 to 96 hours.
- Up to 90% fall in emissions when covered by carpet.



Slide 16

VOC Pollutants
(Washington + Florida AQS Studies)

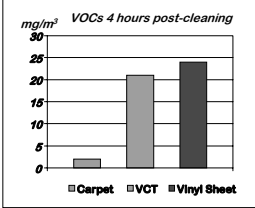
- VCT and sheet vinyl floor coverings emit more VOCs into the air than carpet
- Adhesives are the strongest emitters of VOCs in flooring systems
- Low VOC emitting adhesives can substantially reduce overall emissions



Slide 17

Floor Cleaning and VOCs
(Black 1995)

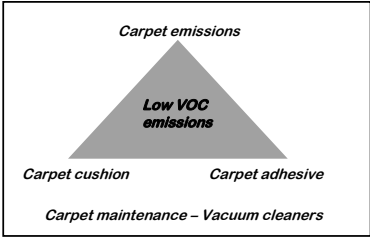
- Cleaning systems for hard surface flooring can contribute substantial amounts of VOCs into the air
- Carpet cleaning (hot water extraction) emits very low to no VOCs



Flooring Type	VOCs (mg/m³)
Carpet	~2
VCT	~20
Vinyl Sheet	~25

Slide 18

Carpet System Emissions



Carpet emissions

Low VOC emissions







Carpet cushion Carpet adhesive

Carpet maintenance - Vacuum cleaners

Slide 19

CRI Testing Initiatives


- **Carpet emissions testing.**
- **Carpet cushion emissions testing.**
- **Carpet adhesive emissions testing.**
- **Vacuum cleaner testing.**

Slide 20

CRI IAQ Carpet Testing Program


- **The CRI Indoor Air Quality Testing and Labeling Program pioneered voluntary product emissions testing.**
- **CRI program tests mill samples for:**
 - TVOCs $0.6 \text{ mg/m}^2\cdot\text{hr}$
 - Styrene $0.4 \text{ mg/m}^2\cdot\text{hr}$
 - 4-PC $0.1 \text{ mg/m}^2\cdot\text{hr}$
 - Formaldehyde $0.05 \text{ mg/m}^2\cdot\text{hr}$
- **Emissions criteria developed in conjunction with the Environmental Protection Agency.**



Slide 21


CRI Carpet Cushion Testing

- **Carpet cushion testing program:**
 - TVOCs $1.0 \text{ mg/m}^2\cdot\text{hr}$
 - Formaldehyde $0.05 \text{ mg/m}^2\cdot\text{hr}$
 - 4-PC $0.05 \text{ mg/m}^2\cdot\text{hr}$
 - BHT $0.3 \text{ mg/m}^2\cdot\text{hr}$
- **Carpet Cushion Council also undertakes emissions testing.**



Slide 22

CRI Carpet Adhesive Testing




- **Carpet adhesive testing program:**
 - TVOCs 10.0 mg/m²•hr
 - Formaldehyde 0.05 mg/m²•hr
 - 2-ethyl-1-hexanol 3.0 mg/m²•hr

Slide 23

CRI Vacuum Cleaner Testing Program


- **Soil removal**
- **Dust containment**
- **Carpet appearance retention**



Slide 24

Carpet as a Source?

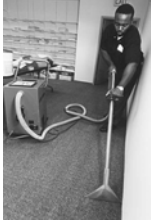
- *Carpet is not a source of formaldehyde.*
- *Carpet does not emit VOCs at levels even remotely close to a threshold of concern.*
- *4-PC emissions, if present, are low and not toxic.*
- *Most VOCs are offgassed within the first 96 hours after airing.*
- *Most carpets emit only trace amounts of a limited number of VOCs (look for the IAQ label).*



Slide 25

Floor Coverings as a Sink ?


- *Floor coverings and biologicals (fungi, cockroaches, dust mites etc.)?*
- *Floor covering maintenance?*
 - *Vacuuming*
 - *Cleaning methods*

A black and white photograph showing a person in a dark shirt and pants using a long-handled vacuum cleaner to clean a carpeted floor. The vacuum is a canister type with a long flexible hose and a motor unit on wheels.

Slide 26

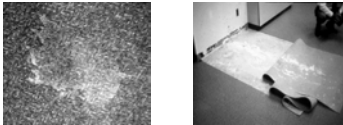
Fungi

- *Health problems can be caused by spores, parts of the fungal body, and fungal metabolites (mycotoxins).*
- *Fungi need moisture and food for growth.*

A black and white photograph showing a close-up of a wall surface. There is significant dark, fuzzy mold growth in the upper left corner, spreading slightly into the surrounding lighter-colored wall material.

Slide 27


Fungi

Two black and white photographs. The left image is a close-up of a carpet with a large, irregular patch of dark, fuzzy mold growth. The right image shows a person in a dark shirt and pants kneeling on a light-colored carpet, using a tool to lift or clean a section of the carpet. A vacuum cleaner is visible in the background.

- *Fungi can grow on and under persistently wet carpet*

Slide 28

Fungi



- *Fungi can grow on and under persistently wet VCT floors.*

Slide 29

Floor Surface Biologicals
(Black, 1995)


Fungi/Plate

	<i>March</i>	<i>April</i>
<i>Carpet</i>	<i>7</i>	<i>31</i>
<i>Ceramic Tile</i>	<i>10</i>	<i>18</i>
<i>VCT</i>	<i>-</i>	<i>48</i>

Slide 30

Microbial Growth Requirements

- *Fungi and bacteria do not feed and grow on carpet fibers or on VCT.*
- *Fungi do not grow on flooring and building materials when the RH is below 80% (Korpi et al., 1998).*
- *Regular cleaning and drying maintains flooring integrity.*



Slide 31

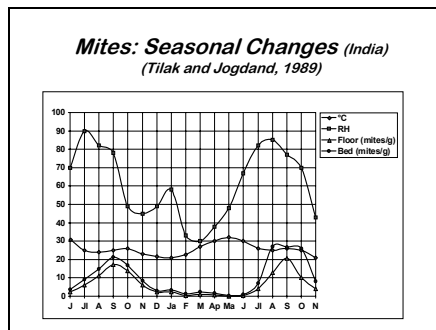


Slide 32

House Dust Mites

- People shed ~50 million skin scales/day (~1 Kg/year).
- Mites feed on fungus + dead skin scales.
- Mites cannot feed at humidity <70% and die at humidity <50%.
- Mite fecal pellets <20 μ m.
- About 15 million Americans are allergic to dust mites, mainly feces.
- 30-40% of asthmatic children are sensitized to dust mites.


Slide 33



Slide 34

Mites in Florida
(Fernandez-Caldas et al., 1990)


- *Surveyed 40 homes in Tampa, FL.*
- *Mites present in 88% dust samples.*
- *Mite allergen in carpet dust not airborne.*
- *Mattresses averaged more than twice the mites/g dust found in carpet dust.*



Slide 35

Dust Mites


- *Dust mites most common in mattresses and bedding (~1,000,000 per mattress).*
- *Dust mites present in upholstered chairs.*
- *Dust mites in carpet can easily be managed.*
- *Mites are killed by UV, liquid nitrogen, dilute tannic acid, acaracides (benzyl benzoate).*



Slide 36

Carpet and Mites

- *Most research on mites is in Europe, where different types of carpet are used.*
- *Most US research has measured mites in carpet dust not mite allergen in the air.*
- *Synthetic and wool carpet can have similar counts of mites in carpet dust, but airborne allergen levels are only high with wool carpet.*
- *Synthetic carpet better traps and holds dust, and airborne mite allergen levels are comparable to a hard floor.*



Slide 37

Dust Mites and Asthma

- *Dust mite allergen sensitization effects on asthma occur within the first 3 years and probably within the first 12 months of life.*
- *Sensitization requires exposure to high mite allergen levels for prolonged periods.*
- *Sensitization often occurs in conjunction with exposure to other allergens - cat, dog, cockroach.*
- *Mattresses, not carpets, pose the most significant risk for mite allergen exposure.*

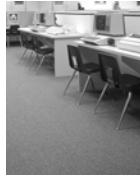


Slide 38

Floor Dust in Schools

(Dybendal et al., 1989)

- *Floor dust samples tested from classrooms in 12 schools.*
- *No differences qualitatively or quantitatively between floor dust from carpet or linoleum.*
- *Mite allergen levels highest in air over smooth floors.*
- *School environment typically has low levels and is protective against mite allergen.*



Slide 39

Pet Allergens

(Dybendal and Elsayed, 1992)

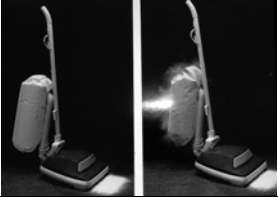
- *About 100 millions domestic animal pets in USA (56 million cats).*
- *Cat allergen (feline domesticus I - Fel d I) produced by sublingual salivary glands and hair root sebaceous glands.*
- *Fel d I can contaminate a room in 30 minutes and be detected at least 20 months after pet is removal.*
- *Cat allergen is very prevalent in school floor dust, and is introduced on clothing.*



Slide 40

Floor Dust Removal


- Effectiveness of vacuums is now tested.
- Use of high-efficiency cleaners (cleaning bags - 3-layer microfiltration) is important.



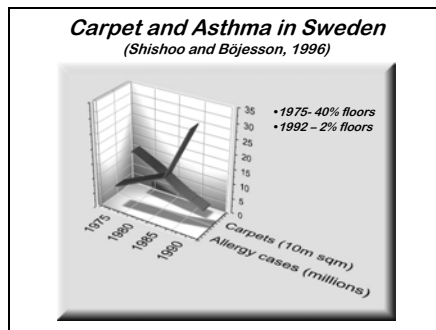
Slide 41

Managing Biocontaminants (Washington + Florida AQS Studies)

- Floor surface biologicals are similar to airborne biologicals for carpet and hard surfaces.
- Airborne biologicals track outdoor air.
- Replacing carpet does not reduce indoor airborne biologicals.
- Dust mite allergen in carpet dust is not found in the air without considerable mechanical disturbance; airborne levels are short-lived.
- Contaminants in carpet can be removed with simple maintenance.



Slide 42



Slide 43

Allergy and Asthma

(Jaakkola et al., 1999)

- 251 healthy infants and toddlers compared to 251 diagnosed with asthma.
- Children with PVC flooring in nurseries, bedrooms and other rooms had an 89% higher risk of asthma than those in PVC-free homes.



Slide 44

Emissions from Computers

(Ostman, 2000)

- When new, plastic computer monitors can emit triphenyl phosphate, an allergenic chemical that is widely used as a flame retardant, and concentrations are significant in the breathing zone, especially with new computers.



Slide 45

Childhood Asthma Risks

(Ball et al., 2000)


- Exposure of young children to other children at day care protects against the development of asthma later in childhood.



Slide 46

- **Asthma risks in infancy and childhood :**
 - Gender (males vs. females)
 - Maternal asthma
 - Maternal smoking
 - Atopy - Hay fever, eczema
 - Ethnicity (Caucasian, African American)
 - Early respiratory infection (RSV)
- **Sensitizers:**
 - Molds and fungi
 - Allergens - cockroaches, cats, dogs, dust mites
 - High fat diet
 - Inactivity
 - PVC and plasticizers
 - Acetaminophen, antibiotics
 - Air pollutants (e.g. NO_2 , O_3)


Childhood asthma risks



Slide 47

Asthma Protection

- **Infants are protected from asthma by:**
 - No maternal smoking
 - Breast feeding
 - Larger family size
 - Early exposure to other children
 - Early respiratory illnesses (not RSV)
 - Farming lifestyle



Slide 48

Effects of Floor Coverings

- **Indoor air quality**
- **Safety (slips, trips, falls)**
- **Comfort (sitting surface)**
- **Cleaning and maintenance**
- **Appearance - color, softness, texture, comfort, quality.**
- **Acoustics - ambient, impact noises (School Sound Level Study, 1986)**



Slide 49

Environmental Benefits

- *Carpet traps dust for periodic removal.*
- *Carpet is recyclable.*
- *Carpet can be cost competitive to install, and less costly to maintain than other surfaces.*



Slide 50

Educational Benefits

- *Carpet is a safe surface –*
 - *less frequent and less serious trips and falls (less force) on carpet.*
 - *no slips on carpet.*



Slide 51

Educational Benefits

- *Carpet improves thermal conditions (insulation) and acoustic conditions (impact noise, reverberation time) in classrooms and schools.*



Slide 52

Conclusion

- *Carpet can be a cost effective and beneficial floor surface for schools.*



Slide 53

If you select carpet as a floor covering...

Look for "green" and keep it clean!




Slide 54

***Thank you...
Questions?***


Slide 55


Cornell Ergonomics Web

<http://ergo.human.cornell.edu>



CU Ergo
Cornell University Ergonomics





Navigation Links:

- [Home](#)
- [About Us](#)
- [Research Interests](#)
- [Publications](#)
- [Teaching](#)
- [Software](#)
- [Contact Us](#)

Research Interests:

- [Human Factors](#)
- [Industrial Ergonomics](#)
- [Labor Relations](#)
- [Occupational Health](#)
- [Safety](#)
- [Task Design](#)
- [Training](#)
- [Work Organization](#)

Publications:

- [Books](#)
- [Book Reviews](#)
- [Chapters](#)
- [Journals](#)
- [Theses](#)
- [Working Papers](#)

Software:

- [ErgoSoft](#)
- [ErgoSoft2](#)
- [ErgoSoft3](#)
- [ErgoSoft4](#)
- [ErgoSoft5](#)
- [ErgoSoft6](#)
- [ErgoSoft7](#)
- [ErgoSoft8](#)
- [ErgoSoft9](#)
- [ErgoSoft10](#)
- [ErgoSoft11](#)
- [ErgoSoft12](#)
- [ErgoSoft13](#)
- [ErgoSoft14](#)
- [ErgoSoft15](#)
- [ErgoSoft16](#)
- [ErgoSoft17](#)
- [ErgoSoft18](#)
- [ErgoSoft19](#)
- [ErgoSoft20](#)
- [ErgoSoft21](#)
- [ErgoSoft22](#)
- [ErgoSoft23](#)
- [ErgoSoft24](#)
- [ErgoSoft25](#)
- [ErgoSoft26](#)
- [ErgoSoft27](#)
- [ErgoSoft28](#)
- [ErgoSoft29](#)
- [ErgoSoft30](#)
- [ErgoSoft31](#)
- [ErgoSoft32](#)
- [ErgoSoft33](#)
- [ErgoSoft34](#)
- [ErgoSoft35](#)
- [ErgoSoft36](#)
- [ErgoSoft37](#)
- [ErgoSoft38](#)
- [ErgoSoft39](#)
- [ErgoSoft40](#)
- [ErgoSoft41](#)
- [ErgoSoft42](#)
- [ErgoSoft43](#)
- [ErgoSoft44](#)
- [ErgoSoft45](#)
- [ErgoSoft46](#)
- [ErgoSoft47](#)
- [ErgoSoft48](#)
- [ErgoSoft49](#)
- [ErgoSoft50](#)
- [ErgoSoft51](#)
- [ErgoSoft52](#)
- [ErgoSoft53](#)
- [ErgoSoft54](#)
- [ErgoSoft55](#)
- [ErgoSoft56](#)
- [ErgoSoft57](#)
- [ErgoSoft58](#)
- [ErgoSoft59](#)
- [ErgoSoft60](#)
- [ErgoSoft61](#)
- [ErgoSoft62](#)
- [ErgoSoft63](#)
- [ErgoSoft64](#)
- [ErgoSoft65](#)
- [ErgoSoft66](#)
- [ErgoSoft67](#)
- [ErgoSoft68](#)
- [ErgoSoft69](#)
- [ErgoSoft70](#)
- [ErgoSoft71](#)
- [ErgoSoft72](#)
- [ErgoSoft73](#)
- [ErgoSoft74](#)
- [ErgoSoft75](#)
- [ErgoSoft76](#)
- [ErgoSoft77](#)
- [ErgoSoft78](#)
- [ErgoSoft79](#)
- [ErgoSoft80](#)
- [ErgoSoft81](#)
- [ErgoSoft82](#)
- [ErgoSoft83](#)
- [ErgoSoft84](#)
- [ErgoSoft85](#)
- [ErgoSoft86](#)
- [ErgoSoft87](#)
- [ErgoSoft88](#)
- [ErgoSoft89](#)
- [ErgoSoft90](#)
- [ErgoSoft91](#)
- [ErgoSoft92](#)
- [ErgoSoft93](#)
- [ErgoSoft94](#)
- [ErgoSoft95](#)
- [ErgoSoft96](#)
- [ErgoSoft97](#)
- [ErgoSoft98](#)
- [ErgoSoft99](#)
- [ErgoSoft100](#)