MVOCs as Indicators of Prevalent Indoor Fungi in 23 Homes

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PURPOSE

1. **Seeking occurrence, prevalence, and association between:**
   - **Microbial Volatile Organics (MVOCs)**
   - **Dominant airborne molds**

2. **Fewer than 10 published studies on MVOCs, most in N. Europe, Canada**

Accepted MVOCs*

3-methyl furan	**3-octanone**
1-butanol	**3-octanol**
3-methyl-1-butanol	**1-octen-3-ol**
3-methyl-2-butanol	**2-octen-1-ol**
2-pentanol	**2-nonanone**
2-hexanone	**borneol**
2-heptanone	**geosmin**

* Listed by 3 or more authors in field studies, AIHA Field Guide, 2nd Edition. © 2005.

WHY MVOCs?

Potential for MVOCs includes:

- **latent mold detection**
- **rapid turnaround using extensive US laboratory infrastructure**
- **quantitative indicators of contamination, unlike aerosol data**
- **Real-time monitoring post-event**

STUDY OVERVIEW

- **23 homes convenience sample in S.E. Ohio**
- **All non-complaint, with basements seeking "worst case"**
- **June-August sampling**
  - **Summer among "wettest on record"**
- **Compared upstairs to downstairs for**
  - **MVOCs**
  - **Bioaerosols**
  - **Environmental measures**

METHODS

I. Created Likert-type “MOW” measures of:
   - Mold
   - Organic Mass
   - Water (not moisture or relative humidity)

II. Collected bioaerosols up, down, and out

III. Collected 8 hour MVOC samples

I. “Extent of Mold Present” Scores

1	No Visible Mold
2	Slight odor and no visible mold or ≤2 s.f. in diffuse colonies
3	Distinct odor and no visible mold or ≤5 s.f. in diffuse colonies
4	Distinct odor and visible patches of mold (2– 5 s.f.)
5	Distinct odor and visible colonies covering a large area (>10 s.f.)

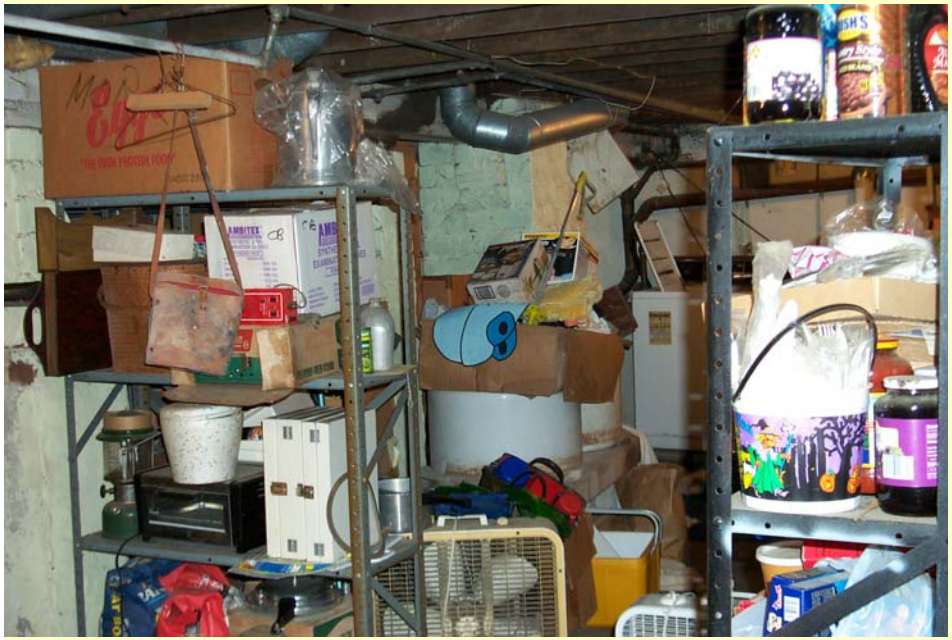
Example: Typical Mold Score

Score: 2

I. “Extent of Organic Mass” Scores

1	<10% of floor space used, essentially empty basement
2	25% of floor space used, mainly inorganic materials; limited wood shelves, cardboard boxes
3	50% of floor space used. Multiple stored cardboard boxes, hanging clothes, papers, etc.
4	75% of floor space used. Floor covered in old rugs/carpet, stacks of old books/magazines.
5	>75% of floor space used. Leather, food, clothes, wood, covers majority of available floor space

Examples: Organic Mass Scores



Score: 2

Score: 4

I. “Extent of Water Present” Scores

1	**None**
2	**Intermittent or only limited presence of water (e.g. washer floor drain), or past damage visible**
3	**Currently moist areas or extensive past water damage, no currently pooled water**
4	**Current pooled water in one area**
5	**Current pooled water covering a large majority of basement.**

Examples: Higher Water Scores

Score: 3

Score: 4

OTHER METHODS

II. Bioaerosols

- N-6 type samplers
- ~3 min samples
- Malt Extract Agar
- Analysis by AIHA-EMPAT lab

III. MVOCS

- SS tube with Tenax TA and Carbopack B
- 8 hours @ 50ml/min
- TD/GC/MS analysis to known standards
- LOD 1-2 µg/m^3
- LOQ 2-5 µg/m^3

I. Results: MOW Scores

All scores significantly elevated in basement vs. upstairs ($p<0.007$ min; paired t-test)

- **Mold Extent, basements averaged 1.8 vs. 0.9 upstairs**
- **Organic Mass scores averaged 2.5 basements vs. 1.6 upstairs**
- **Water Extent scores down were 1.9 vs. 0.9 upstairs**

II. Results: Molds Detected *

Abisidia	Epicoccum nigrum *
Acrodontium crateriforme	Fusarium (2 spp) *
Alternaria alternata *	Gliocladium
Aphanociadium	Paecilomyces (2 spp) *
Arthrinium	Penicillium *
Aspergilli (5 spp) *	Phoma *
Basidiomycetes *	Pithomyces chartarum
Beauveria bassiana	Rhinocladiella
Botrytis cinerea	Rhizopus stolonifer *
Choanephora	Rhodotorula glutinis *
Cladosporium *	Trichoderma Harzarum *

* "Moisture Indicator Fungi", per Mahooti-Brooks *et al*., 2004

II. Results: Mold Prevalence, Concentration by Location

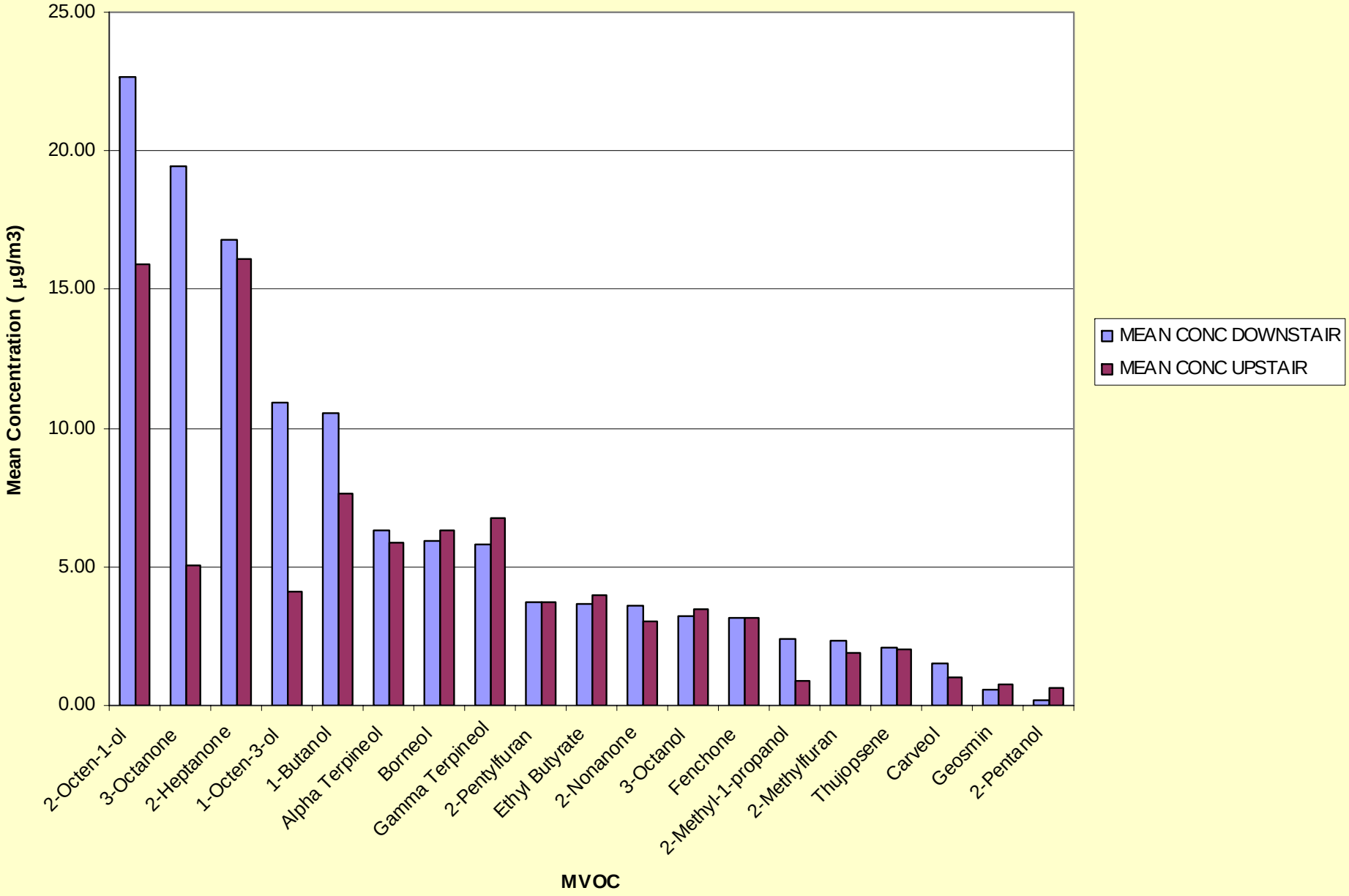
Genera	Times Detected	Average CFU/m^3	Average CFU/m^3 Downstairs	Average CFU/m^3 Upstairs
Cladosporium	44	227	213	241
Penicillium	42	165	203	128
Basidiomycetes spp.	40	150	171	129
Aspergillus spp.	30	97	142	51
All other genera, spp.	82	35	33	36

III. Results:
Dominant MVOCs (means, µg/m^3)

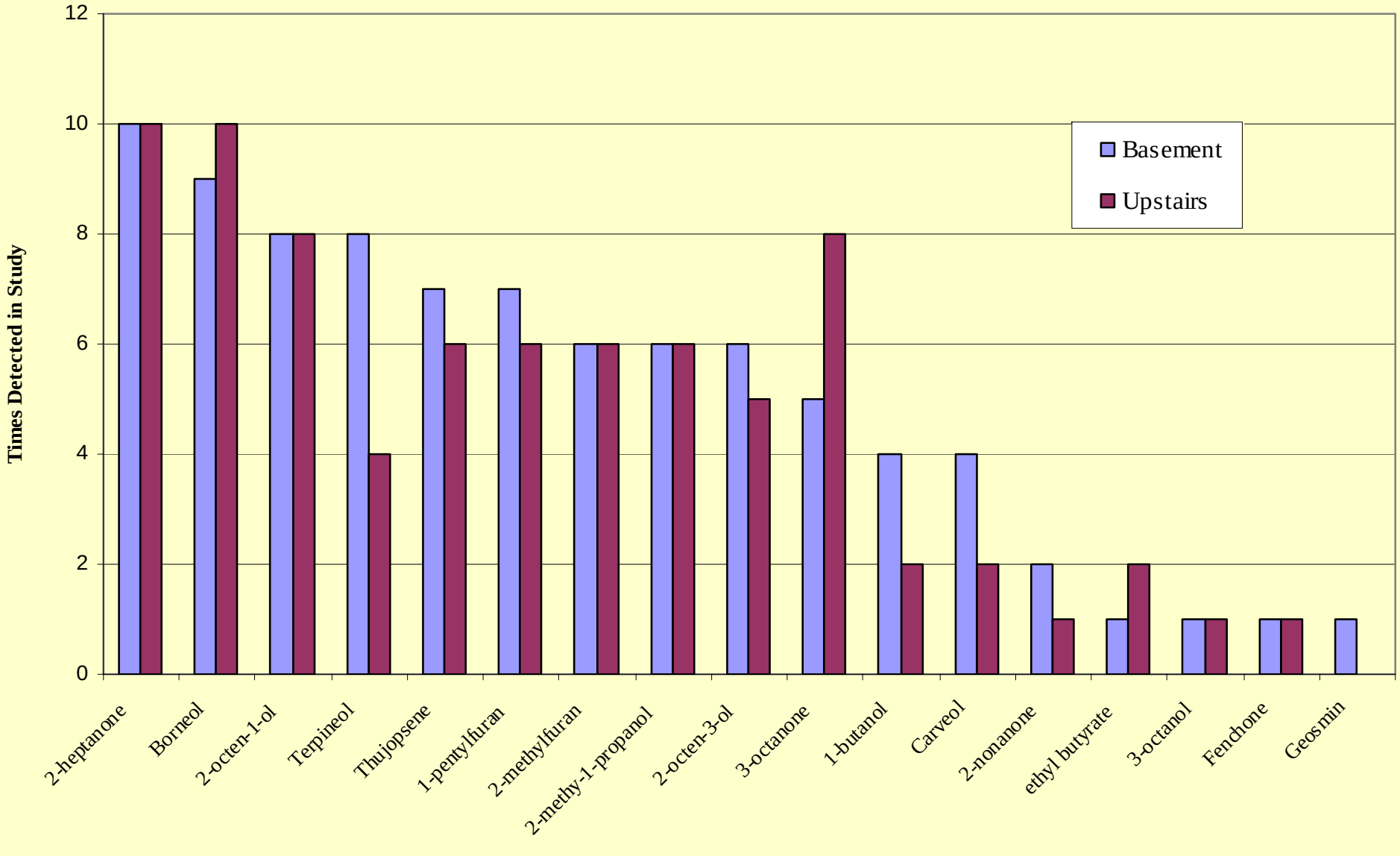
Compound	Down	Up
2-Octen-1-ol	22.64†	15.91†
3-Octanone	19.47*	5.06*
2-Heptanone	16.80	16.13
1-Octen-3-ol	10.90	4.10
1-Butanol	10.55†	7.64†
Alpha Terpineol	6.30	5.89
Borneol	5.91	6.34
Gamma Terpineol	5.81	6.78
3-Octanol	3.25	3.45

* indicates $p < 0.05$; † indicates $p < 0.10$

III. Results: MVOCs by Location



III. Results: MVOC's Prevalence



SUMMARY

- ✓ **Significant MVOCs were 3-octanone, 2-octen-1-ol, and 1-butanol**
- ✓ **Six other MVOCs elevated > LOQ**
- ✓ **High MOW scores associated with these MVOCs**
- ✓ **Many MVOCs equally distributed upstairs and downstairs**

LIMITATIONS & FUTURE RESEARCH OPPORTUNITIES

- Statistical significance issues due to small sample size
- MOW scores semi-quantitative, biased?
- Bioaerosols studied
  - collected dusts for correlations to MVOCs

Submitted for Review:

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