

Comparison of Analytical Methods for Evaluating Mold in Carpet Dust

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Carpet & Indoor Mold



Assessment of fungal burden in carpet is often an important part of mold evaluations

- **Covers large surface area in buildings**
- **Frequent reservoir for mold growth**
- **Restoration can be costly**



Sometimes it's obvious



Assessment Challenges



Often Not Visually Apparent – Testing Desired

Confounding Variables:

- **Tracked in fungal spores/debris**
- **Accumulation of settled airborne spores**
 - **Entrained in the carpet pile**
 - **Not entirely removed by routine cleaning**
- **Carpet type**
- **Carpet history**
 - **Spills, wet cleaning methods**

No standardized testing protocol

No standardized analytical protocol

Assessment Protocols



Suggested testing methods:

- Dust Extraction
- Tape lift
- Bulk sample

Suggested analytical methods:

- Culture (dilution plating)
- Culture (direct plating)
- Microscopy
- PCR

Getting it Right?



Do the analytical methods provide consistent or inconsistent conclusions when compared to each other?

3 Carpets Selected



- Office – no history of elevated moisture
- Residential – no history of elevated moisture
- Residential – history of significant water damage and mold on building materials

Mold not visually apparent in any of the carpets

Sample Collection



2 samples/carpet

- Heavy foot traffic & isolated areas

2 Collection methods

- Micro-vac dust extraction
 - MCE filter
 - 10 liters/minute
 - 3 passes over the carpet – 10 square feet
- Tape lift from carpet backing

Analysis



4 Analytical methods used

Dust Extract – 3 methods

- Dilution plating culture: MEA, DG18, Cellulose
- Direct plating: MEA, DG18, Cellulose
- Microscopy

Tape lift - microscopy

Dilution Plating Results Summary

Carpet Type	Conc. (cfu/g)	Genera (>20%)
Office: no water damage Foot traffic	13,690	Penicillium (46) Alternaria (27)
Office: no water damage Isolated	13,500	A. versicolor (37)
Residential – water damaged Foot traffic	4,358,000	Penicillium (62) Aureobasidium (21)
Residential – water damaged Isolated	40,250,000	S. chartarum (97)
Residential – no water damage Foot traffic	497,100	Rhizopus (76)
Residential – no water damage Isolated	88,000	Cladosporium (32)

Direct Plating Results Summary

Carpet Type	Conc. (cfu/g)	Genera (>20%)
Office: no water damage Foot traffic	4,197	Penicillium (51) Cladosporium (31)
Office: no water damage Isolated	2,858	Cladosporium (63)
Residential – water damaged Foot traffic	1,250	Penicillium (96) *Rhizopus overgrowth
Residential – water damaged Isolated	80	*S. chartarum overgrowth *Rhizopus overgrowth
Residential – no water damage Foot traffic	497,100	Rhizopus (76)
Residential – no water damage Isolated	88,000	Cladosporium (32)

Dust microscopy results summary

Carpet Type	Observations & Comments
Office: no water damage Foot traffic	Very few loose spores – no fungal structures
Office: no water damage Isolated	No fungal spores or structures
Residential – water damaged Foot traffic	Stachybotrys spores with structures (density: 2 on scale 1-4)
Residential – water damaged Isolated	Stachybotrys spores with structures (density: 2 on scale 1-4)
Residential – no water damage Foot traffic	Very few loose spores – no fungal structures
Residential – no water damage Isolated	Very few loose spores – no fungal structures

Tape lift summary results

Carpet Type	Observations & Comments
Office: no water damage Foot traffic	No fungal spores or structures
Office: no water damage Isolated	No fungal spores or structures
Residential – water damaged Foot traffic	Very few loose spores – no fungal structures
Residential – water damaged Isolated	Very few loose spores – no fungal structures
Residential – no water damage Foot traffic	No fungal spores or structures
Residential – no water damage Isolated	No fungal spores or structures

Interpretation



Allow comparison of samples analyzed with different methods

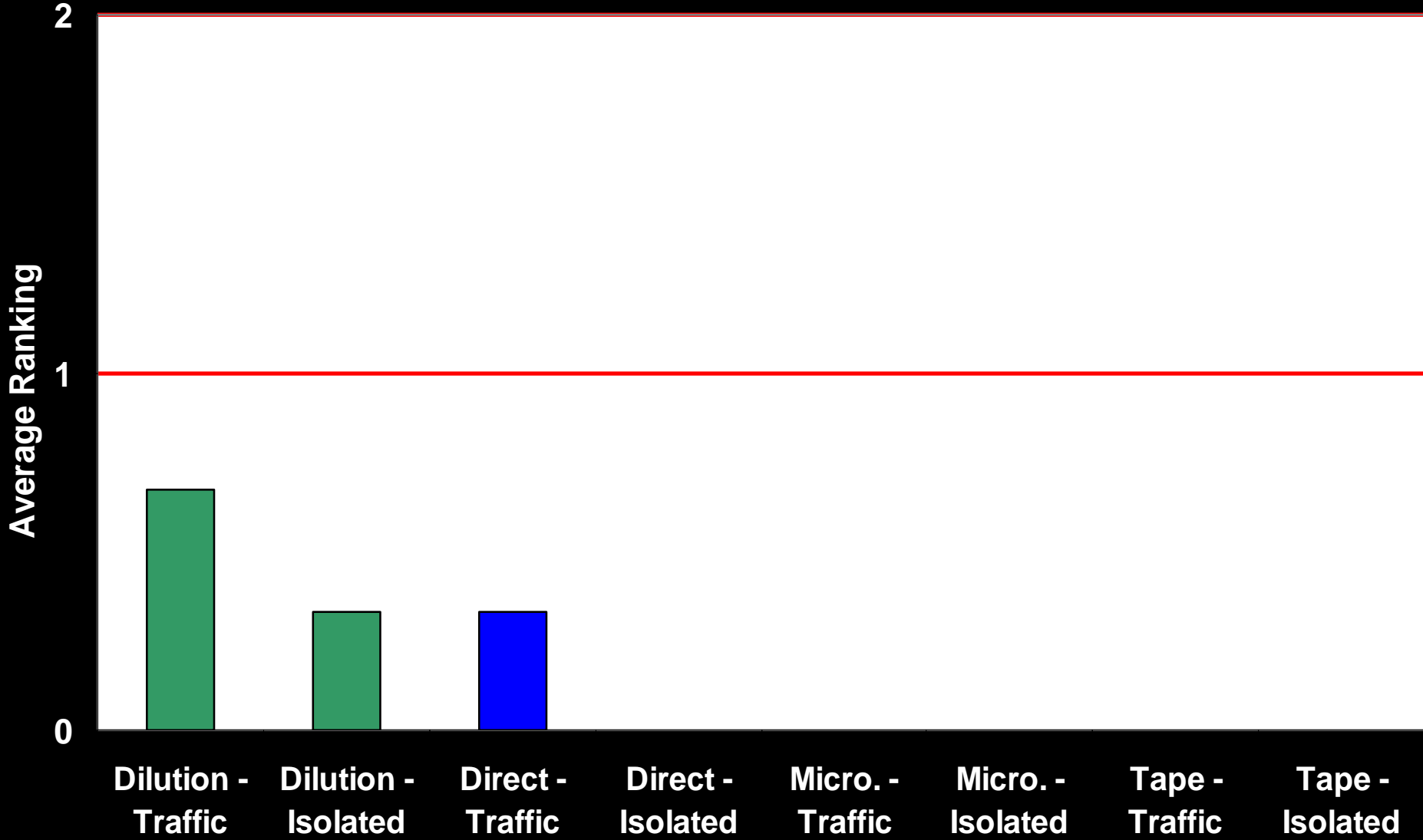
Subjective rating by 6 professionals

- 3 CIHs, 1 PhD mycologist, 1 MSPH, 1 Biologist
- Average approximately 20 years experience

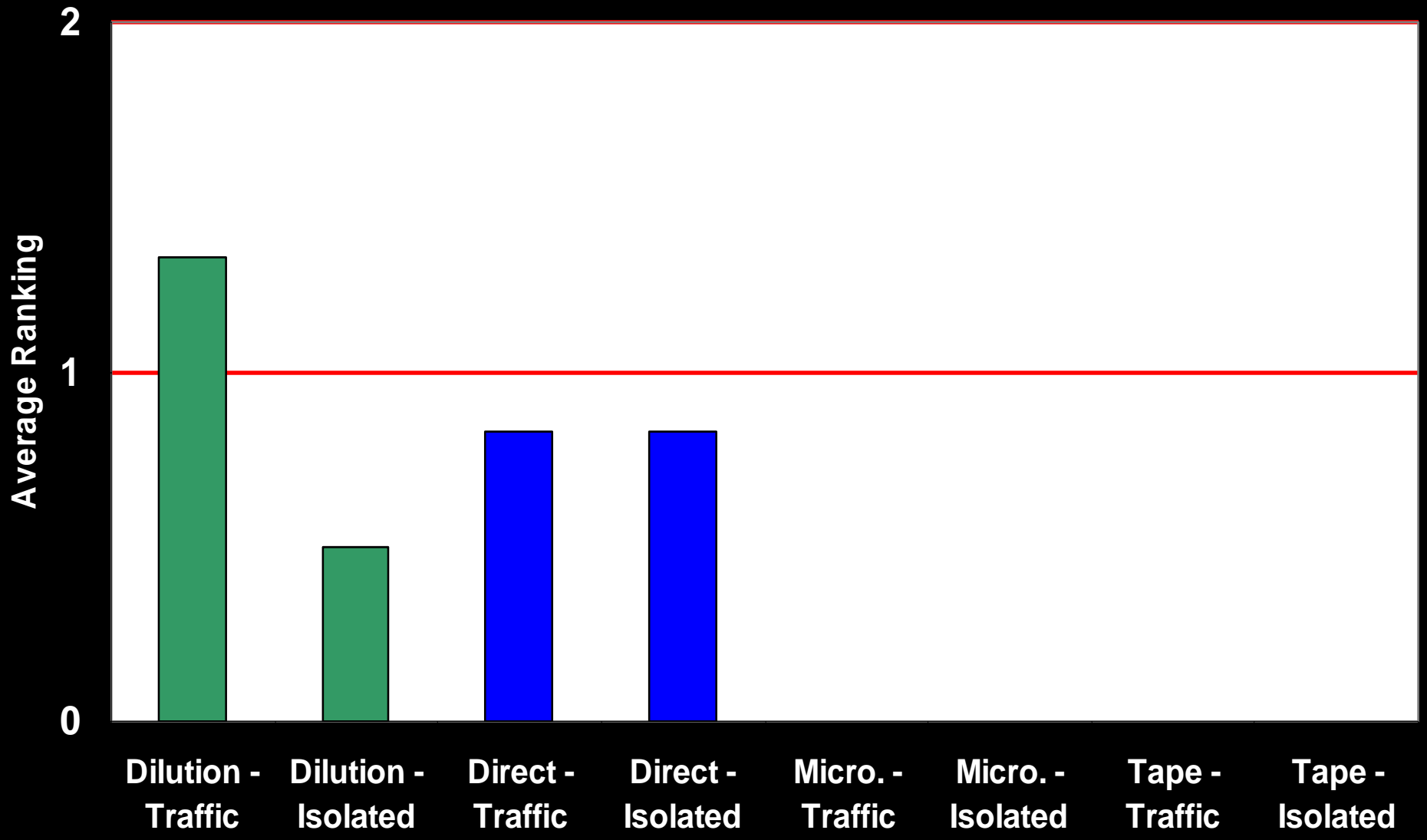
Rated results scale 0-2

- 0 = typical species array and concentration
- 1 = inconclusive
- 2 = definitely atypical array and concentration

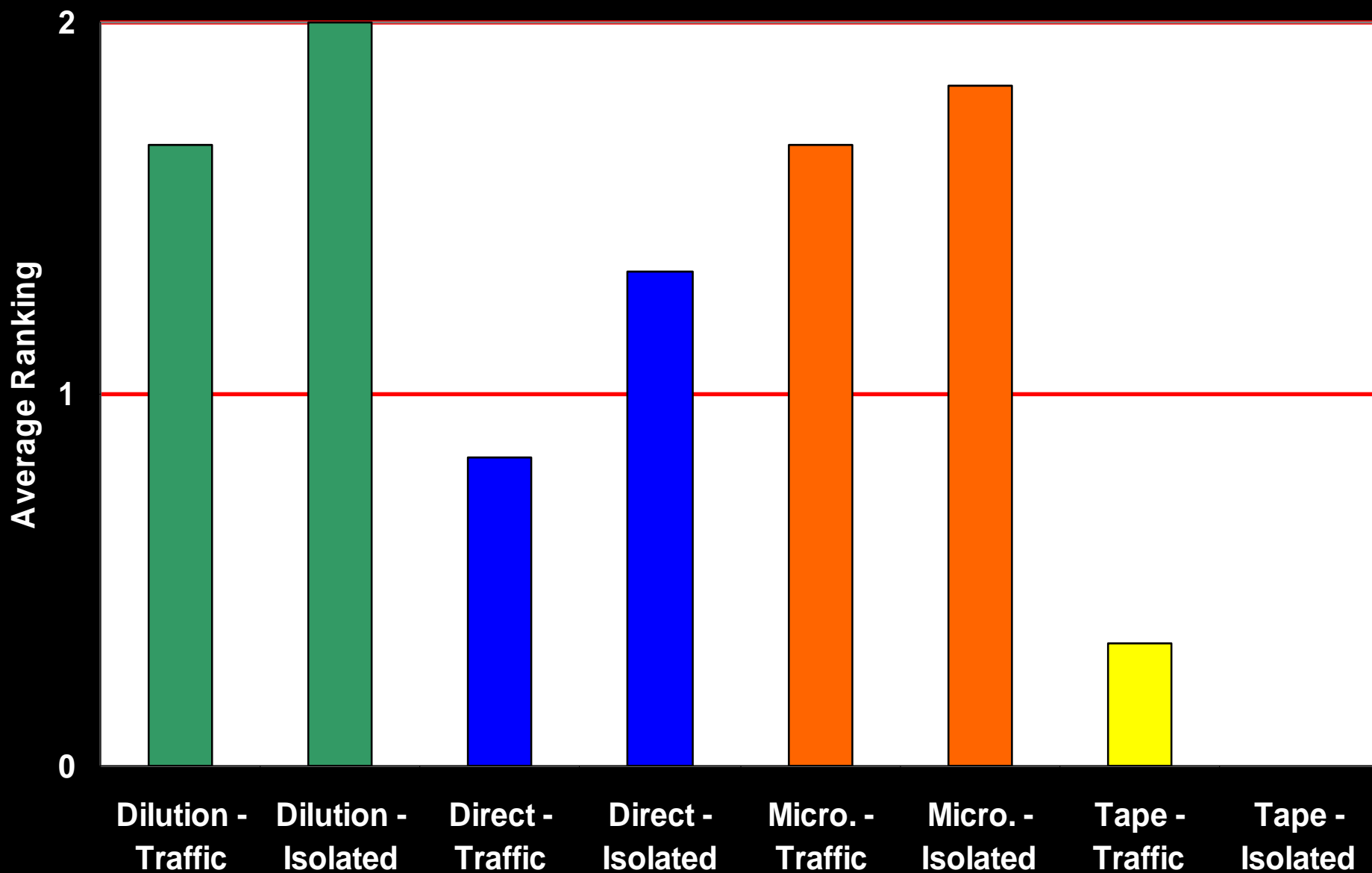
Average Ranking by Analytical Method - Office No Water Damage



Average Ranking by Analytical Method - Residential NO Water Damage



Average Ranking by Analytical Method - Residential Water Damage



Observations



Dilution Plating:

- Highest level of confidence that atypical findings occurred in water damaged carpet
- Most uncertainty with non-water damaged carpet – office or residential
 - More so in samples taken from areas with expected foot traffic

Observations



Direct Plating:

- Uncertain interpretation (value near 1) in water and non-water damaged residential
- May be from plate overgrowth or masking due to *rhizopus*

Bulk Dust Microscopy

- Interpreted as atypical in water damaged and typical in non-water damage
- Did not identify any spores or structures in non-water damage samples (some spores found in all culture methods)

Observations



Tape Lift (from underside of carpet)

- Typical fungal quantities and types in all samples – water damaged or not water damage
- Slight uncertainty in one water damage sample

Anomalies



- *Aspergillus versicolor* - 37% of genera array in office carpet (no water damage) using dilution.
 - *A. versicolor* - 2% of array using direct plating and not identified using other methods
- *Rhizopus* – 76% of genera array in non-water damaged residential carpet using dilution.
 - *Rhizopus* – 1% of genera array using direct plating and not identified in other methods

Conclusions



- Different conclusions reached with tape lift samples compared to other methods
- Strength of interpretation varied between dilution plating, direct plating and dust microscopy
- In this sample set dilution plating and dust microscopy were more likely to identify mold in water damaged carpet

Conclusions



- Standardized protocol needed
 - Sample collection & analysis
- More research to determine best approach
 - Larger sample set
 - Statistical comparisons
 - Multiple variables to consider
- Consider multiple analytical methods to increase confidence in data interpretation

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