Differentiating between Clean and Moldy Indoor Environments in Residential Properties

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Common Methods for Interpreting Airborne Data

- **Reference** — **Compare Indoor with Outdoor Samples**
- **Control** — **Compare results with similar areas or buildings**
- **Database** — **Compare results with similar previous samples**

Questions Commonly Asked of Us

- Are occupants exposed to unusual concentrations of airborne mold?
- Is the structure affected by hidden mold?
- Are the contents affected by a water intrusion incident?

What We Rarely Ask

- Are the data interpretation methods we use valid?

Objective

Compare the Reference, Control, and Database methods for interpreting airborne data collected in residential properties

Limits of Discussion [Conclusions May Differ]

	RESIDENTIAL PROPERTIES	COMMERCIAL PROPERTIES
NORMAL FUNGAL ECOLOGY		
ABNORMAL FUNGAL ECOLOGY	X	

The Data

Residential Data: Rimkus Consulting Group

- Database search - 108 residential projects
  - *Asp/Pen* spores detected indoors
- Projects in 7 of the 10 EPA climate zones
- Included data from 23 cities in 9 states
  - Arizona, California, Florida, Georgia, Illinois, Louisiana, Maryland/DC, Nevada, and Texas
- Samples collected
  - Across seasons over a 2 year period
  - Using 5-minute Air-O-Cell samples

Residential Data: Rimkus Consulting Group

- 422 indoor samples
  - Typically 3-5 indoor samples per project
- 235 outdoor samples
  - 2 outdoor samples per project
    - First & last samples

Data Analyzed

- **Dominant spores only**
  - ***Cladosporium* – dominant outdoors**
  - ***Asp/Pen* – dominant indoors**
- **Statistical analysis**
  - **Average concentration per project**
  - **Maximum concentration per project**
    - **Simulated “single sample”**

The Results

Similar results for "average" and "maximum" data

Only results for project "averages" presented

Geographical Variation in Indoor *Asp/Pen* Concentrations

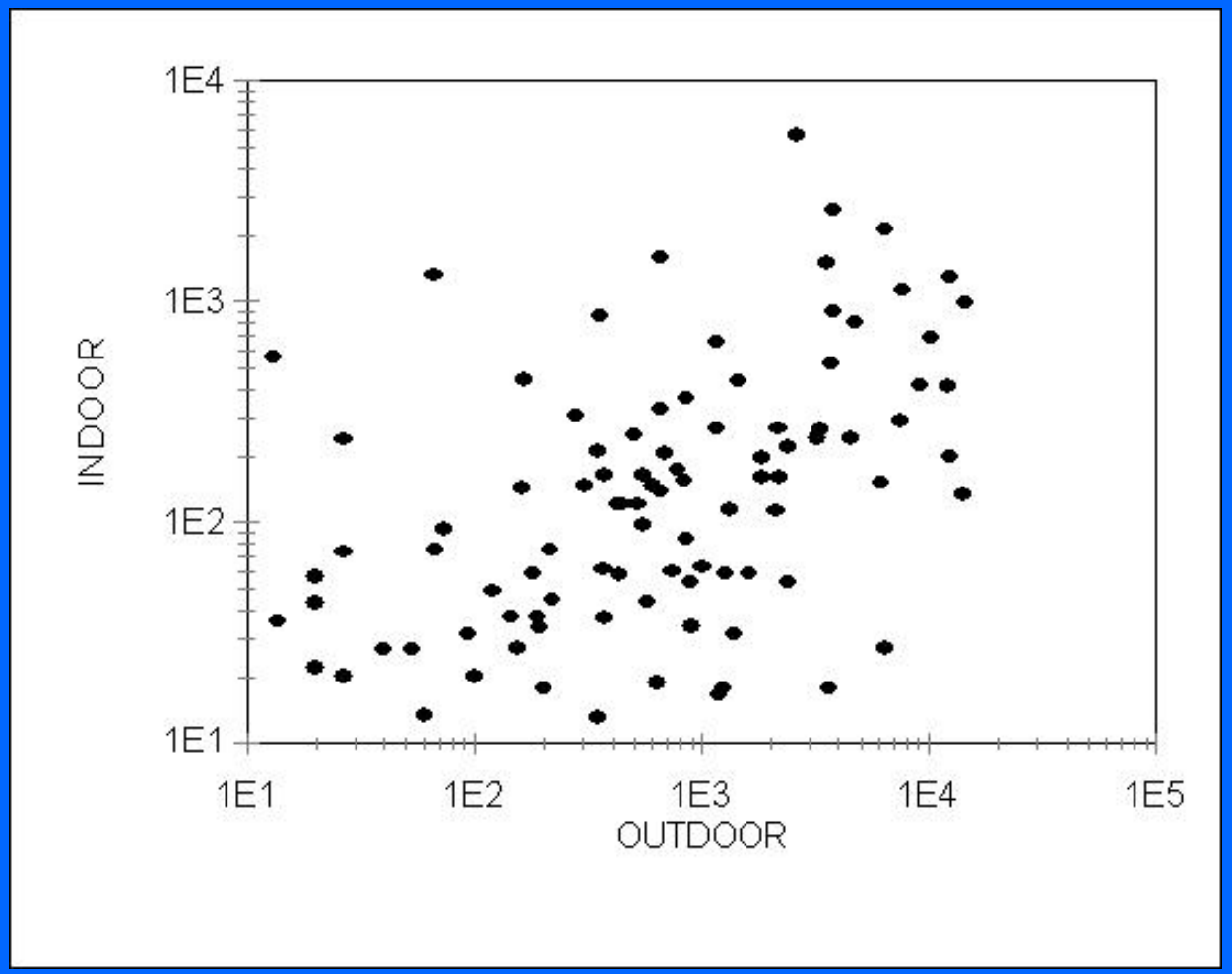
State	N	LCL	GM	UCL
LA	23	90	200	450
AZ	26	80	210	520
GA	34	180	290	480
NV	23	150	365	870
IL	66	270	465	800
TX	89	465	700	2,700
FL	56	370	770	1,600
MD	18	450	1,300	4,000

Reference Method

Indoor v. Outdoor

Did the Reference Method have any validity when applied to these 108 projects?

Cladosporium: Indoor v Outdoor for Average Concentrations

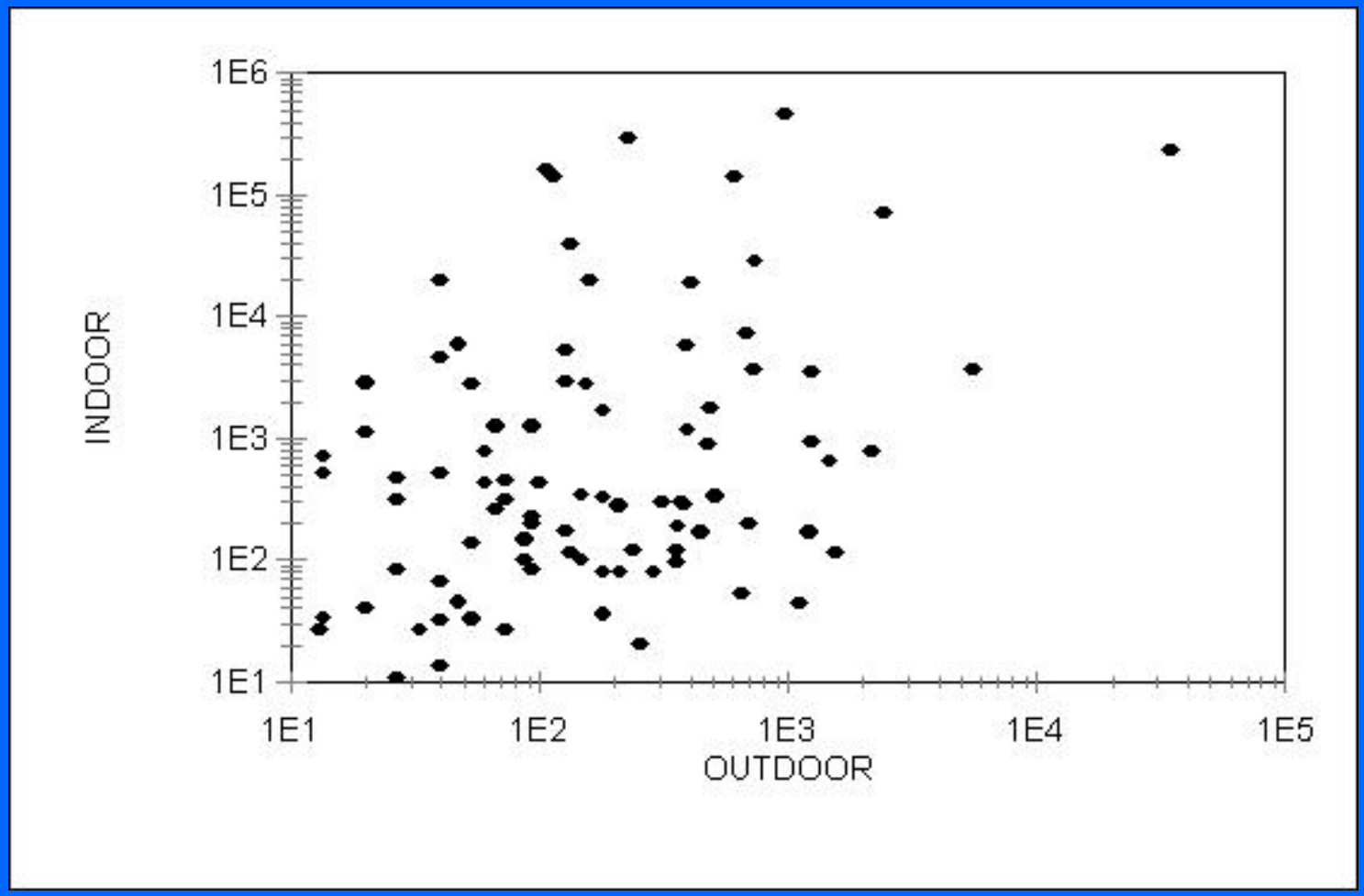


Cladosporium: Indoor v Outdoor

- "Average" project concentrations
  - $R^2 = 0.07$ [r = 0.26]
  - ANOVA: $F = 42.9$, $F_{crit} = 3.9$, $P = 4 \times 10^{-10}$
    - Log transformed data
- "Maximum" project concentrations
  - $R^2 = 0.09$ [r = 0.30]
  - ANOVA: $F = 27.2$, $F_{crit} = 3.9$, $P = 4 \times 10^{-7}$

Indoor v. Outdoor: Little correlation

Asp/Pen: Indoor v Outdoor for Average Concentrations



Asp/Pen: Indoor v Outdoor

- **"Average" concentrations**
  - **$R^2 = 0.13$ [r = 0.36]**
  - **ANOVA: $F = 25.8$, $F_{crit} = 3.9$, $P = 8 \times 10^{-7}$**
    - **Log transformed data**
- **"Maximum" concentrations**
  - **$R^2 = 0.07$ [r = 0.26]**
  - **ANOVA: $F = 36.9$, $F_{crit} = 3.9$, $P = 5 \times 10^{-9}$**

Indoor v. Outdoor: Little correlation

Conclusion

The most commonly used method of data interpretation, comparing indoor with outdoor samples, had little utility when applied to the 108 residential properties in which contaminant spores were detected

Options?

- Just take the check and leave
  - The client doesn't understand it anyway
- Explore the potential utility of the other two data interpretation methods
  - Not as simplistic to apply
  - Require more thought

Control Method

Compares Potentially Contaminated Areas with “Clean” Areas

Characterizing Interior Spaces

- **AIHA: Similar Exposure Groups**
  - Members of a SEG have similar exposure potentials
  - Should only "average" data within an SEG
- **Interior areas**
  - "Similar Exposure Areas" [SEA]
  - Areas with similar exposure potentials
  - Should only "average" data within an SEA

Indoor *Asp/Pen* Concentrations

(Sp/m^3)	RM 1	RM 2	RM 3	RM 4
Proj 1	0	0	0	15,000

An average concentration of 3,800 sp/m^3 or two SEA's?

Data: Rimkus Consulting Group

Indoor *Asp/Pen* Concentrations

Outdoor concentrations not provided
Can we still interpret these data?

(Sp/m^3)	RM 1	RM 2	RM 3	RM 4
Proj 2	230	250	870	1,240
Proj 3	30	90	270	720

Data: Rimkus Consulting Group

Including Outdoor *Asp/Pen* Concentrations for the 3 projects

(Sp/m^3)	OUT	RM 1	RM 2	RM 3	RM 4
Proj 1	0-250	0	0	0	15,000
Proj 2	650-2,300	230	250	870	1,240
Proj 3	70-350	30	90	270	720

Different interpretation?
Which method is "valid"?

Data: Rimkus Consulting Group

Conclusion

The Control Method did have utility when applied to these residential projects

Database Method

Comparing current sample results with archival data

Database Method

- **Example: Indoor sample v indoor database**
  - **The indoor *Asp/Pen* concentration for a project is at the "90th" percentile for the last "200" indoor samples collected**
    - **Therefore it is an atypical concentration and suggests a potential problem**
- **Not an example: Some laboratories report results referenced to their organizational databases**
  - **Databases composed of outdoor sample results**
  - **Indoor samples compared to outdoor samples**
    - **Variant of the Reference Method**

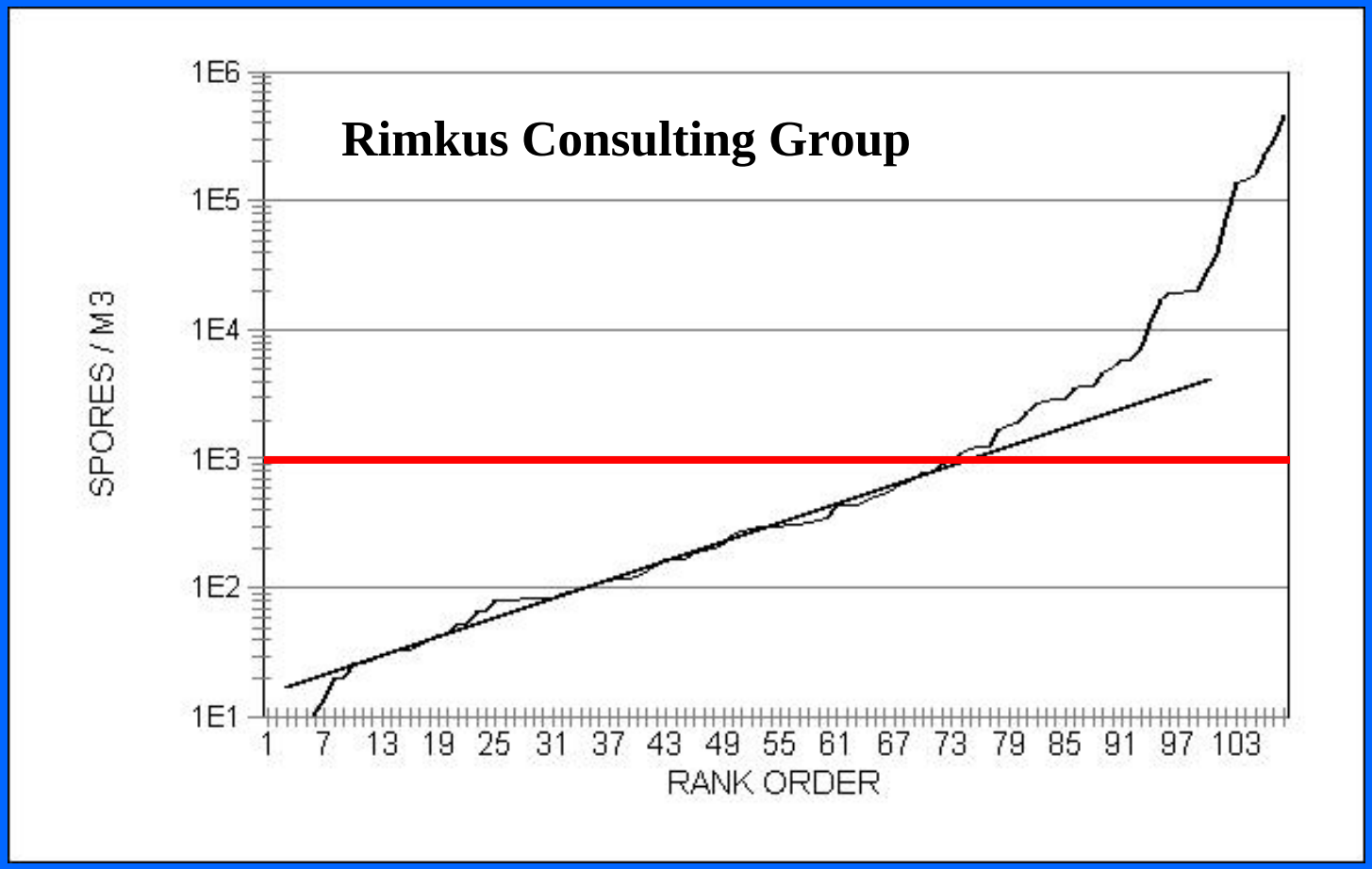
Baxter et al: Residential Data

- **Comparison of Baxter & Rimkus Data**

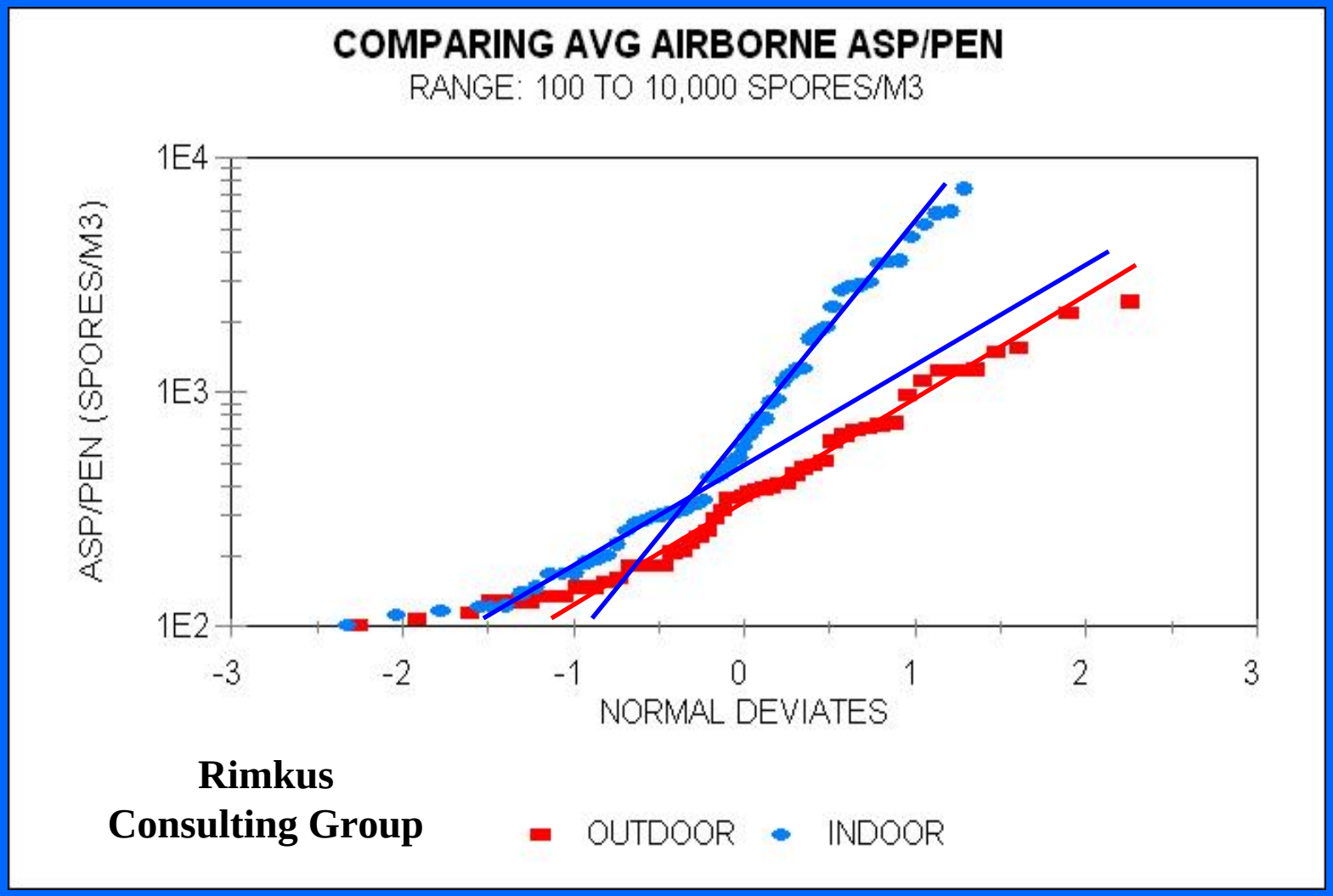
- **Concluded:**
  - **Indoor concentrations of *Asp/Pen* like spores had the most utility in determining whether a building was visibly contaminated with mold**
  - **Indoor *Asp/Pen* concentrations > 950 spores/m^3 were associated with visibly moldy houses**

Baxter, Perkins, McGhee & Seltzer; JOEH, 2:8-18 (2005)

Rank Order of Average Indoor *Asp/Pen* Concentrations



Log Plots for "Avg" *Asp/Pen*



Comparing These Databases

- **"Moldy" Buildings: *Asp/Pen* Spores**
  - **Baxter: Quartiles > 950 spores/m^3**
  - **Rimkus: Rank Order > 1,000 spores/m^3**
  - **Rimkus: Log Plot > 300 spores/m^3**

Based on either database:
***Asp/Pen* concentrations in residential properties > 1,000 sp/m^3 may be problematic**

If Control Method Doesn't Work?

(Sp/m^3)	OUT	RM 1	RM 2	RM 3	RM 4
Proj 4	0-290	280	310	350	490

Small variation in indoor concentrations

Indoor data similar to outdoor data

Outdoor *Asp/Pen* = 145;

Indoor = 360 spores/m^3

Data: Rimkus Consulting Group

Then The Database Method

(Sp/m^3)	OUT	RM 1	RM 2	RM 3	RM 4
Proj 4	0-290	280	310	350	490

All rooms "clean", or all affected by "hidden mold"?

Rank Order: Problematic if =>1,000 sp/m^3

Log Plot: Problematic if => 300 sp/m^3

Data: Rimkus Consulting Group

Conclusions

- **Reference Method**
- **Control Method**
- **Database Method**

- **Little or no utility**
- **Good utility, often used in commercial buildings**
- **Useful supplement for Control Method**

Conclusions limited to residential properties with potentially abnormal fungal ecologies

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