

589 Design of Experiments

Presentation on indoor effects of
poor environmental quality (IEQ)

using

Multiple Attribute Decision Making

Introduction

- Ill-health from home environments is derived from a number of factors:
 - Dampness causing mould
 - Airborne debris levels
 - Ventilation
 - Filtration
 - Personal Hygiene and general clutter
 - And a number of less significant factors

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- IAQ issues can be obvious. Clutter, lack of hygiene, visible moulds.



- Poor IAQ can be manufactured. The Okanagan have many marijuana grow operations.

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- Other sites look perfectly clean and healthy, but in the air may lurk toxic dangers.

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- What constitutes a toxic environment?
- How can we simply and economically assess the environments we live in?
- Results from over 600 IAQ site assessments in the Okanagan may hold the answer.

Using a design of experiments process will help to determine statistically and accurately the prime effects of the indoor air quality assessment results.

From a project list of over 600 IAQ residential projects conducted in the Okanagan between 2006 and 2010, 5 were randomly chosen to screen for fungal and other IAQ issues.

Assessment Protocol

- (A) From existing data, what factors contribute the most or have the highest association with mould growth
 - An effects analysis was chosen to determine the highest and least effects in relation to fungal count.
 - The 9 factors identified were: fungal, general; fungal – stachy/chae; humidity/moisture; sickness; clutter; odours; filtration; and ventilation.
- (B) From existing data, using MADM, determine which house has the highest level of contributing factors for bad IAQ
 - A normalized weighted factor approach was chosen.

Experiment: Effects analysis of fungal count in relation to factors

Factor	Experiment number	1	2	3	4	5
A	Fungal Issue	-1	-1	1	1	1
B	Moisture/Humid Issue	1	-1	1	-1	-1
C	Airborne Debris levels	1	1	1	-1	1
D	Clutter Issue	1	-1	1	-1	-1
E	Stachy/ Chae	-1	-1	-1	1	1
F	Sickness	1	1	1	1	1
G	Ventilation issue	-1	-1	-1	1	-1
H	Organic odour issue	1	1	1	-1	-1
I	Filtration issue	-1	1	-1	1	-1

1 significant issue

.-1 is of no significance

Fungal count - data

Experiment #		1	2	3	4	5	weighting
Fungal count	A	2400	970	6700	1800	1700	0.5
Fungal count	B	2500	700	6000	930	4000	0.4
Fungal count	C	13000	1600	6400	1600	660	0.1

A = Primary - is fungal count taken at location of concern

B = Secondary - fungal count taken at area of least concern

C = Exterior - external fungal count for comparison

*Spore counts in the 1000 spores/ m³ is typical for indoor environments.
Higher counts can lead to allergenic reactions and human sickness.

Effects analysis

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Effects analysis: ave of indoor fungal counts

exper/factor	B	C	D	E	F	G	H	I	A
1	1	1	1	-1	1	-1	1	-1	2450
2	-1	1	-1	-1	1	-1	1	1	835
3	1	1	1	-1	1	-1	1	-1	6350
4	-1	-1	-1	1	1	1	-1	1	1365
5	-1	1	-1	1	1	-1	-1	-1	2850

	B	C	D	E	F	G	H	I
+	8800	12485	8800	4215	13850	1365	9635	2200
-	<u>5050</u>	<u>1365</u>	<u>5050</u>	<u>9635</u>	<u>0</u>	<u>12485</u>	<u>4215</u>	<u>11650</u>
effect	3750	11120	3750	-5420	13850	-11120	5420	-9450

CONCLUSION

- This effects analysis confirms that occupant sickness (F) and lack of adequate ventilation (G) have the largest effect from high fungal counts.
- This stands the test of reason

Weighting – cont'd

For the purpose of this experiment, conduct a weighting of fungal counts vs the other factors and determine any significant relationships

Experiment #	A	B	C	Y	X	First choice weighting $Y = .5A + .4B + .1C$ Second choice weighting $X = .75A + .1B + .15C$
1	2400	2500	13000	3500	4000	
2	970	700	1600	925	1037.5	
3	6700	6000	6400	6390	6585	
4	1800	930	1600	1432	1683	
5	1700	4000	660	2516	1774	

Effects analysis of weighted fungal counts

exper/factor	B	C	D	E	F	G	H	I	A = Y
1	1	1	1	-1	1	-1	1	-1	3500
2	-1	1	-1	-1	1	-1	1	1	925
3	1	1	1	-1	1	-1	1	-1	6390
4	-1	-1	-1	1	1	1	-1	1	1432
5	-1	1	-1	1	1	-1	-1	-1	2516

	B	C	D	E	F	G	H	I
+	9890	13331	9890	3948	14763	1432	10815	2357
-	<u>4873</u>	<u>1432</u>	<u>4873</u>	<u>10815</u>	<u>0</u>	<u>13331</u>	<u>3948</u>	<u>12406</u>
effect	5017	11899	5017	-6867	14763	-11899	6867	-10049

Conclusion #2

- Both effects assessments identified poor ventilation and sickness at the two most significant effects of high mould conditions from all the factors reviewed.
- This is in keeping with the professional determination on the projects used for this experiment data.

Weighted Environment Experiment

- Giving weighting to each factor, I wanted to determine which of the 5 home environments were the most significant (highest level of concern)
- Most criteria was given a 1-10 scale, 10 being highest level of concern.
- Fungal counts remained as counts.
- Row values were normalized.

Weighted experiment - Y

Experiment number	1	2	3	4	5	
Factor						
A	<u>Fungal Count Y</u>	0.238712	0.063088	0.43582	0.097667	0.164711
B	Moisture/Humid Issue	0.318182	0.181818	0.227273	0.090909	0.181818
C	Airborne Debris levels	0.181818	0.151515	0.212121	0.212121	0.242424
D	Clutter Issue	0.312500	0.062500	0.500000	0.062500	0.062500
E	Stachy/ Chae	0	0.181818	0	0.636364	0.181818
F	Sickness	0.218750	0.125000	0.125000	0.250000	0.281250
G	Ventilation issue	0.257143	0.114286	0.228571	0.200000	0.200000
H	Organic odour issue	0.380952	0.142857	0.380952	0.047619	0.047619
I	Filtration issue	<u>0.272727</u>	<u>0.090909</u>	<u>0.212121</u>	<u>0.212121</u>	<u>0.212121</u>
TOTAL		2.180785	1.113792	2.321859	1.809302	1.574262

Weighted experiment X

Experiment number		1	2	3	4	5
Factor						
A	Fungal Count X	0.265261	0.068802	0.436686	0.111608	0.117643
B	Moisture/Humid Issue	0.318182	0.181818	0.227273	0.090909	0.181818
C	Airborne Debris levels	0.181818	0.151515	0.212121	0.212121	0.242424
D	Clutter Issue	0.3125	0.0625	0.5	0.0625	0.0625
E	Stachy/ Chae	0	0.181818	0	0.636364	0.181818
F	Sickness	0.21875	0.125	0.125	0.25	0.28125
G	Ventilation issue	0.257143	0.114286	0.228571	0.2	0.2
H	Organic odour issue	0.380952	0.142857	0.380952	0.047619	0.047619
I	Filtration issue	<u>0.272727</u>	<u>0.090909</u>	<u>0.212121</u>	<u>0.212121</u>	<u>0.212121</u>
TOTAL		2.207333	1.119505	2.322725	1.823243	1.527194

Solution assessment

- Both weighted alternatives exposed experimental house #3 as having the “worst” IAQ.
- My report on house #3 states:

“Based on the results of the non-viable air testing, particularly the high levels fungal products denoted, and the site assessment, it is our opinion that an extensive professional remediation is required at this time. Due to the nature of the fungal debris and household odours, the remediation process should be supervised by an IICRC AMRT (applied microbial remediation technician)”.

House #3



Final conclusions

- How can we simply and economically assess the environments we live in?
- These studies indicate this may be primarily defined by the incidence of house based sickness and verification of functionality of the ventilation system.