Health Effects Associated with Indoor Marijuana Grow Operations

By

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Introduction:

During the 1970's, most marijuana was grown in outdoor areas that were hard to find and were not readily visible to law enforcement. However, with new law enforcement techniques, including aircraft for surveillance, these large outdoor operations have become more vulnerable to detection and in much of the country growth is seasonally limited by temperature and light. In addition, restricting the pollination of the female plants in the outdoors is more difficult thereby limiting the 8-9-tetrahydrocannabinol (THC) content of the buds. These factors have contributed to an increase in indoor marijuana grow operations.

Indoor marijuana grow operations (MGO's) enable a year-long growing season in which conditions can be tightly controlled, resulting in plants with higher THC content per plant. A number of environmental factors must be monitored and kept in balance including the amount of light, the day-night periodicity, the carbon dioxide level, the humidity level and the temperature. In addition, the plants must be provided with adequate nutrition and pests must be kept under control.

Although these production factors could be provided in a greenhouse, such a growth area is very likely to be spotted by law enforcement officials or individuals wishing to steal the crop. In order to prevent detection, MGO's are frequently established in a house or a portion of a house that can be easily confined. Since a residential structure is not designed to function as a greenhouse, contamination by pesticides and fertilizers is more difficult to control, moisture can cause damage to building materials and result in excessive mold growth, and the risk of fire is significantly increased.

In order to provide the best growth environment for marijuana, temperature and humidity must be regulated. Temperature is normally kept between 21 degrees C. and 32 degrees C. (although some references indicate that the optimum temperature may be as high as 35 degrees C). The relative humidity is normally kept between 50% and 70% according to most sources although there have been some reports of relative humidity exceeding 90%. Typically, the relative humidity is dependent upon the amount of ventilation that can be provided and not the humidity that the plant needs. The allowable ventilation is likely determined by the need for secrecy, which may result in relatively high levels of humidity. The elevated relative humidity coupled with the elevated temperatures and the need for irrigation, frequently enables fungal growth within the structure. Increased fungal growth within the structure results in elevated mold exposures, of special concern when children are involved, as well as the possibility of actual structural damage to the residence.

Airborne levels of mold spores within these structures may subject the occupants, emergency personnel and other individuals to significant health hazards. Persons residing in these homes are likely to have levels of exposure that can cause hypersensitivity pneumonitis, allergic rhinitis, asthma, and other respiratory diseases. Emergency personnel and law enforcement officers entering these facilities on a regular basis have reported upper respiratory irritation, skin rashes, and other symptoms

associated with these exposures. Officers with pre-existing conditions such as asthma have reported an exacerbation of their existing conditions while dismantling indoor MGO's.

A factor that is very important in determining the THC content of plants is an elevated carbon dioxide level. The normal carbon dioxide level in the outside air ranges from 300 ppm to 400 ppm. In MGO's it is desirable to have levels of carbon dioxide that exceed 700 ppm with 2000 ppm being the highest desirable level. Most marijuana operations attempt to keep carbon dioxide levels at between 700 ppm and 1500 ppm. While these levels of carbon dioxide are not of public health concern, they do cause to ancillary problems. First, in order to keep carbon dioxide levels high, ventilation rates normally need to be reduced often leading to excess moisture. Secondly, if the carbon dioxide is generated by the use of fossil fuel combustion, carbon monoxide and oxides of nitrogen can be produced. Both of these compounds can be very dangerous and cause significant health effects in exposed individuals.

Chemicals are also utilized as fertilizers and pesticides. Although these chemicals may not usually cause a high degree of concern when used by qualified individuals, the use by individuals unaware of the dangers may result in risk to the neighborhood, children involved with the residence, and anyone unknowingly residing in the residence after its use as an MGO.

Exposure to the fore-mentioned hazards may result in a community public health concern. Although the greatest risk is borne by the individuals residing in the residence, others may also be impacted. MGO's located in multi-family buildings may allow the distribution of the chemicals used and/or produced into the ventilation system creating an exposure situation in other residences. Exposures to children living in these operations also present a public health hazard since the exposures may result in injury or death to an innocent child. Fires and explosions may cause damage to not only the MGO but also to surrounding houses. Lastly, these operations may go undetected putting an unsuspecting family buying the residence at a later date at risk of adverse health effects.

This project was designed to quantify the chemical and biological exposures associated with MGO's in Colorado and, from this information, to determine the procedures and personal protective equipment necessary for entry into indoor marijuana grow operations.

Methodology:

As noted above, there are a number of concerns associated with MGO's. Concerns include chemical contamination, carbon monoxide and other combustion products, as well as excessive fungal contamination due to the high humidity in the home. Some MGO's have carbon dioxide generators that utilize fossil fuel combustion potentially resulting in the production of carbon monoxide and nitrogen oxides. Fungal and bacterial growth may also be of great concern due to the high humidity and presence of organic materials in the house. We were also interested in the amount of THC present in the air and on surfaces within these MGO's.

Based on these concerns, we conducted an extensive sampling effort in 30 MGO operations. These operations were identified by law enforcement and were sampled shortly after the entry of law enforcement personnel.

The first step was to survey the facility to determine the chemicals utilized, including any pesticides, fertilizers, etc. Real-time levels of carbon monoxide, carbon dioxide, temperature, and relative humidity within the MGO were collected using portable, data-recording equipment. Gas Chromatograph/Mass Spectrometer samples for organics using EPA Method TO-17 were collected for analysis at a commercial laboratory. Airborne THC levels were collected using a fiberglass filter and surface THC levels were collected using a cotton swipe.

After beginning the collection for chemical contaminants, we began sampling for bioaerosols. Bioaerosol samples were collected using an N-6 Cascade Impactor and spore traps. Using the N-6, viable fungal samples were collected using malt extract and DG-18 plates at each location. A total of 4 plates were taken for 2 minutes at each location (2 malt extract and 2 DGA-18). Two spore traps were also taken at each location for a period of 10 minutes at a calibrated flow rate of 15 liters per minute. In addition, filter samples and settled dust samples were collected for analysis using quantitative polymerase chain reaction (QPCR).

The value of each of these mold sampling techniques was as follows:

- **Viable Samples** – These samples were collected using an Anderson Cascade Impactor to sample a known amount of air onto an agar plate. Two types of plates were utilized, malt extract plates for general molds and DG-18 plates for Stachybotris sp. This sampling technique allowed us to determine the types and amounts of molds present down to the species level.
- **Non-Viable Samples** – These samples were collected using a spore trap that collects the spores present in a known amount of air and allows them to be identified, generally to genus. The advantage to this type of sampling was that the organisms did not have to be grown and therefore some species were more easily identified. In addition, the actual number of mold spores present was more accurate since the spores are counted without the necessity of a growth phase.
- **PCR Samples** – These samples were collected on a filter that was then tested using polymerase chain reaction which is able to identify a number of species that may be present by looking for the rNA associated with that mold. This test is very specific for certain molds.
- **Dust Samples** – Samples of dust in the home were taken and analyzed using PCR technology again. The PCR is used to confirm the presence of specific molds that are associated with indoor mold growth and compare them with outside mold

species. This information was compared to an EPA database to determine the relative moldiness of the house.

As dismantling of the grow operation was expected increase exposures to law enforcement personnel, we also monitored any removal operation using the same methodologies outlined above.

Results:

Indoor MGO's Sampled

We responded and sampled a total of 24 indoor MGO's. The first MGO was a 4-plex that was essentially 4 MGO's in one and the 14th MGO was a large office building with 4 large grow rooms. The data provided will therefore contain information on a total of 30 MGO's.

Viable Mold Levels

In order to determine if mold spore levels are increased within a structure, we analyze several parameters. The first parameter that we examine is to determine if the total number of spores in the outside air is equal to the total number of spores observed within the structure. Since mold samples are grab samples and have a large distribution, we expect mold levels in problem houses to be 10 times higher than outside mold spore levels. An increase of 5 times may **suggest** that the structure has an elevated mold problem and that further data needs to be collected. In addition, we expect the species inside the house to be similar in abundance and species to the species and abundance outside. The rule of 10 times higher and 5 times higher again prevails.

Table #1 shows the relationship between the outside mold spore levels and the mold spore levels found in the different MGO's. The table provides the average mold spore levels observed in the outside air and the average mold spore levels found in the inside air. It also provides the range of mold spore levels found in each of those situations. In 5 of the MGO's sampled, the average mold spore level within the grow room was at least 10 times the average spore level in the outside air. This indicates that in those MGO's, the grow rooms were likely growing mold and may present a significant danger to individuals present within those rooms. An additional 3 MGO's had ranges where the highest range was elevated more than 10 times the levels found in the outside air again indicating that mold was growing in the structure. Table #1 also illustrates that in an additional 9 MGO's, the average level of spores was at least 5 times the outside levels suggesting that indoor mold growth was likely. Many of these samples contain results where the levels were as high as the method utilized could detect, indicating that the actual levels of mold were likely much higher.

The ranges have also been highlighted to show MGO's where the highest range within the grow room is at least 5 times the outside (yellow) or 10 times the outside levels (red).

Table #1

	Plant Number	Total Outside			Grow Rooms	
		average	range		average	range
1A	117	324	144-414		1048	522-1620
1B	77	324	144-414		1745	1190-2300
1C	58	324	144-414		662	486-1080
1D	28	324	144-414		1968	1640-2270
2	160	945	540-1256		2247	594-5330
3	65	464	360-738		>1366	396->5868
4	670	189	144-270		1085	612-1742
5	232	468	342-594		>6610	1746->11286
6	52	738	486-1044		3880	1638-9794
7	37	671	324-1134		950	900-1080
8	24	671	324-1134		752	576-918
9	86	671	324-1134		423	234-594
10	28	851	648-1116		911	504-1688
11	30	575	238-1026		386	323-468
12	11	1142	360-1886		360	306-450
13	290	554	342-756		441	216-918
14A	446	140	90-180		95	72-144
14B	323	140	90-180		>2862	252->5472
14C	107	140	90-180		>1544	144->5490
14D	84	140	90-180		>2840	198->5490
15	56	518	342-648		146	108-234
16		126	90-162		871	144-1724
17	188	401	252-594		>3150	144->5922
18	75	414	198-684		628	72-1134
19	64	824	504-1188		>3189	288->6430
20	100+	3086.5*	2182-4028*		>3613	1422->10836
21	240	438	252-756		>6422	>5976->6894
22	236	869	576-1242		>3582	846->6264
23	84	293	72-468		914	630-1188
24	168	1993	180-3740		>6728	>5436->8404

* - This outside level appears to be contaminated with inside mold

> - Greater than

These data indicate that the number of MGO's with elevated spore levels appear greatest when the number of plants exceeds 50. There are, however, some MGO's with larger numbers of plants that did not indicate elevated mold spore levels. Sample #20 includes an outside air sample that was taken on the steps of the MGO and was likely contaminated with indoor mold since the primary species (P. brevicompactum) was the main fungal contaminate inside and is not routinely found in high numbers on outside samples.

In some structures, the total mold spore counts were relatively similar between indoors and outdoors but the species of mold spores present was radically changed. We therefore looked not only at total mold spore levels but also mold species that were occurring within the MGO at levels exceeding outside levels. We found that Penicillium species typically occurred within the MGO's at much higher concentrations than are present in the outside air. Table #2 illustrates this difference.

Table #2

		Pen. Outside		Grow Rooms	
Grow	Plant Number	Average	Range	Average	Range
1A	117	14	0-36	18	0-36
1B	77	14	0-36	707	306-1116
1C	58	14	0-36	77	0-126
1D	28	14	0-36	23	0-36
2	160	14	0-54	155	0 - 558
3	65	14	0-54	56	0-198
4	670	36	0-108	896	0-1670
5	232	171	0-378	>5712	1350->5400
6	52	95	0-342	3088	792-9506
7	37	108	18-198	81	54-126
8	24	108	18-198	612	324-882
9	86	108	18-198	95	54-198
10	28	36	18-90	612	216-1670
11	30	125	54-272	320	255-378
12	11	5	0-18	108	54-126
13	290	5	0-18	164	54-504
14A	446	5	0-18	45	18-108
14B	323	5	0-18	23	0-54
14C	107	5	0-18	140	72-252
14D	84	5	0-18	86	36-126
15	56	50	18-90	25	0-72
16		14	0-36	63	0-234
17	188	18	0-72	>2927	54->5706
18	75	108	36-180	178	0-396
19	64	9	0-36	>2768	36->5400
20	100+	2601*	2110-3146*	>4403	1188->5400
21	240	27	0-36	>5400	>5400->5400
22	236	42	0-108	171	90-270
23	84	14	0-54	477	432-540
24	168	477	162-972	>5400	>5400->5400

* - This outside level appears to be contaminated with inside mold

> -Greater than

Twenty-one of the MGO's sampled had Penicillium spore levels that exceeded 5 times the outdoor levels in either the average spore levels, the range, or both. In some cases, the difference was over 100 times the outside level. These results suggest that the mold species most commonly associated with MGO's in Colorado are Penicillum sp. This is not a surprise since other investigations that we have conducted in Colorado have also involved Penicillium sp. In several of these prior investigations, the elevated concentrations of Penicillum mold spores were associated with hypersensitivity pneumonitis among workers in the contaminated areas. Levels of Aspergillus spores were only found to be elevated in one MGO (MGO#5).

Non-Viable Mold Levels

Non-viable mold spore measurements have the advantage over viable spore levels in that the spores do not have to be grown. Since not all mold spores that are captured using the Anderson Cascade Impactor are able to grow due to viability issues, the non-viable spore levels are usually higher than the viable mold levels. Since most of the health effects due

to mold exposure are caused by the allergens in the spores, the spores need not be viable to cause health effects.

Table #3 provides the results from of the total spore counts.

Table #3

Grow	Plant #	Total Outside		Grow Rooms	
		average	range	average	range
1A	117	241	241	711	711
1B	77	241	241	1960	1960
1C	58	241	241	1410	1410
1D	28	241	241	2860	2860
2	160	NA	NA	1380	1380-7610
3	65	509	274-744	645	505-745
4	670	221	161-281	958	345-2090
5	232	556	295-816	18020	1960-45700
6	52	1470	1370-1570	3345	2670-4020
7	37	989	928-1050	900	780-1020
8	24	989	928-1050	534	471-597
9	86	989	928-1050	489	465-512
10	28	7430	6690-8170	1893	653-2880
11	30	3670	3370-3970	279	189-369
12	11	6075	5960-6190	783	716-850
13	290	2695	2240-3150	304	0-654
14A	446	503	498-507	464	464
14B	323	503	498-507	179	84-274
14C	107	503	498-507	334	323-344
14D	84	503	498-507	157	139-175
15	56	1067	864-1270	102	70-140
16		274	273-274	1045	0-2520
17	188	787	681-893	11196	893-25200
18	75	439	168-710	863	365-1490
19	64	751	231-1270	48454	245-134000
20	100+	1840	1350-2330	6868	5130-9820
21	240	186	126-246	P	P
22	236	13850	11100-16600	2500	2010-2990
23	84	95	77-112	2988	766-5210
24	168	2380	1770-2990	10800	10100-11500

P = Particle overload on spore trap.

These results are similar to Table #1 and indicate that a number of the MGO's had spore levels that were elevated above the background level. The biggest difference between the two tables are the results for MGO#14 where the viable levels of spores were much higher than the number of counted spores. The reason for this discrepancy is unknown at this time.

Table #4 shows the non-viable spore counts for the Penicillium/Aspergillus species only:

Grow	Plant #	Outside		Grow	
		average	range	average	range
1A	117	42	42	28	28
1B	77	42	42	478	478
1C	58	42	42	246	246
1D	28	42	42	97	97
2	160	NA	NA	42	42-42
3	65	0	0-0	26	0-42
4	670	32	0-42	714	190-1860
5	232	180	0-359	13724	1080-40100
6	52	84	0-105	801	482-1120
7	37	116	0-190	74	63-84
8	24	116	0-190	285	211-359
9	86	116	0-190	32	21-42
10	28	21	0-42	750	84-1460
11	30	200	0-356	0	0-0
12	11	106	0-106	42	21-63
13	290	21	0-42	63	42-84
14A	446	11	0-21	63	63
14B	323	11	0-21	53	21-84
14C	107	11	0-21	264	253-274
14D	84	11	0-21	53	42-63
15	56	264	0-401	42	21-63
16		11	0-21	162	106-211
17	188	496	0-570	10524	317-24900
18	75	201	0-380	95	63-169
19	64	380	0-739	47194	63-132000
20	100+	1192	0-1560	6445	4260-9520
21	240	127	0-211	P	P
22	236	32	0-63	559	274-844
23	84	11	0-21	1923	295-3550
24	168	2170	0-2570	10380	9960-10800

P = Particle overload on spore trap.

This table is similar to the results obtained with the viable samples. Fourteen of the MGO's were found to have elevated or possibly elevated spore levels. The results for MGO#21 were also likely elevated but the spore trap was overloaded and could not be counted. Although spore traps can't discriminate between Penicillum sp and Aspergillus sp, it is assumed that most of the spores counted were Penicillium spores since that is what was found during the viable sampling.

Combining the information obtained from both the spore traps and the viable samples collected using the Anderson Cascade Impactors, we found the following as shown in Table 5:

MGO#	Plant Number	Viable Results	Non-Viable Results	Combined
1A	117			
1B	77	Elevated	Elevated	Elevated
1C	58	Possibly Elevated	Possibly Elevated	Possibly Elevated
1D	28	Possibly Elevated	Elevated	Elevated
2	160			
3	65	Elevated		Elevated
4	670	Elevated	Elevated	Elevated
5	232	Elevated	Elevated	Elevated
6	52	Elevated	Elevated	Elevated
7	37			
8	24			
9	86			
10	28	Elevated	Elevated	Elevated
11	30			
12	11	Elevated		Elevated
13	290	Elevated		Elevated
14A	446	Possibly Elevated	Possibly Elevated	Possibly Elevated
14B	323	Elevated		
14C	107	Elevated	Elevated	Elevated
14D	84	Elevated		Elevated
15	56			
16		Elevated	Elevated	Elevated
17	188	Elevated	Elevated	Elevated
18	75			
19	64	Elevated	Elevated	Elevated
20	100+	Possibly Elevated	Possibly Elevated	Possibly Elevated
21	240	Elevated	?	Elevated
22	236	Possibly Elevated	Elevated	Elevated
23	84	Elevated	Elevated	Elevated
24	168	Elevated		Elevated

? = Particle overload on spore trap.

There is strong agreement between both the viable and non-viable samples. Combining the results from both of the tests, we found elevated mold spore counts in 18 of the 30 MGO's for a percent elevated of 60%. We found possibly elevated levels at another 3 MGO's, which if added to the 18, result in a total of 21 MGO's with elevated spore levels (70%). The MGO's that did not show elevated mold spore levels generally had smaller numbers of plants with the exception of MGO#2 and MGO# 9. There were four MGO's that had elevated levels of mold spores but only a few plants. Two of these grows, MGO 1C and 1D were in duplexes with other larger grows were present that may have increased the spore counts for these smaller grows.

Spore Levels During Tear-out

A study conducted by DEA indicated that some of the highest mold spore concentrations occurred during the tear-out of plants from an MGO. We were able to monitor the mold spore concentrations in 10 cases where the plants were removed from the structure. The results are represented in the next tables for both viable and non-viable sampling.

Table 6.

			Viable Results			
	Total Outside		Initial Grow Room		Grow Room at Removal	
MGO #	Average	Range	Average	Range	Average	Range
2	945	540-1256	2247	594-5330	>3048	1010 - >5450
16	126	90-162	871	144-1724	>2688	1350->6840
17	401	252-594	>3150	144->5922	>2938	270->5688
18	414	198-684	628	72-1134	>7566	270->11322
19	824	504-1188	>3189	288->6430	>5837	>5796->5886
20	3087	2182-4028	>3613	1422->10836	>5560	>5400->5742
21	438	252-756	>6422	>5976->6894	>6282	>5886->6714
22	869	576-1242	>3582	846->6264	2745	1706-3948
23	293	72-468	914	630-1188	>6629	>5616->7820
24	1993	180-3740	>6728	>5436->8404	>5436	>5400->5490
	Penicillium Outside		Initial Grow Room		Grow Room at Removal	
MGO#	Average	Range	Average	Range	Average	Range
2	14	0-54	155	0-558	261	0 - 630
16	14	0-36	63	0-234	883	648-1240
17	18	0-72	>2927	54->5706	>2792	36->5400
18	108	36-180	178	0-396	>4704	162->5400
19	9	0-36	>2768	36->5400	>5400	>5400->5400
20	2601	2110-3146	>4403	1188->5400	>5405	>5400->5436
21	27	0-36	>5400	>5400->5400	>5400	>5400->5400
22	42	0-108	171	90-270	846	486-1220
23	14	0-54	477	432-540	>5198	4900->5400
24	477	162-972	>5400	>5400->5400	>5400	>5400->5400

This table indicates that the total number of mold spores in the air increased in six of the MGO's in which the plants were removed. The number of Penicillum species increased in 7 of the 10 MGO's in which the plants were removed. In some of those instances (MGO 2,14,18,22,and 23) the levels increased substantially, thereby potentially increasing the risk to the individuals conducting the operation.

The results of the non-viable samples are represented in Table 7. These results also show an increase in the total number of mold spores due to handling as well as an increase in the numbers of Penicillum/Aspergillus in the samples that were manipulated. In some instances the levels of Penicillum/Aspergillus spores reached extremely high levels (greater than 100,000 spores/cubic meter) that are not normally observed in residential samples. These high levels of spores may impart an even greater risk for exposed individuals.

Table 7

			Non-Viable Results			
	Total Outside		Initial Grow Room		Grow Room at Removal	
MGO #	Average	Range	Average	Range	Average	Range
2	NA	NA	4495	1380-7610	5555	2080 - 9030
16	274	273-274	1045	0-2520	4093	1970-7090
17	787	681-893	11196	893-25200	9838	5440-15900
18	439	168-710	863	365-1490	37260	7240-82300
19	751	231-1270	48454	245-13400	3780	3250-4310
20	1840	1350-2330	6868	5130-9820	212225	19700-534000
22	13850	11100-166	2500	2010-2990	28600	28600
23	95	77-112	2988	766-5210	190	190
24	2380	1770-2990	10800	10100-115	121500	107000-136000
	Penicillium Outside		Initial Grow Room		Grow Room at Removal	
MGO#	Average	Range	Average	Range	Average	Range
2	NA	NA	35	28 - 42	21	0 - 42
16	10.5	0-21	162	106-211	2967.5	1010-5970
17	496	0-570	10524.25	317-24900	9205	4120-15400
18	200.5	0-380	94.75	63-169	35360	6040->82300
19	380	0-739	47193.5	63-132000	1655	1560-1750
20	1191.5	0-1560	6445	4260-9520	211725	18300-534000
22	31.5	0-63	559	274-844	16200	16200
23	10.5	0-21	1922.5	295-3550	21	21
24	2170	0-2570	10380	9960-1080	121000	107000-135000

THC Levels

As part of the project, we sampled for THC in the air at the MGO's as well as on surfaces within the MGO and on the gloved hands of the investigating officers. We found airborne THC at a low level in only one MGO, suggesting that THC is not normally airborne during normal operations at MGO's. We have found THC on many of the surfaces sampled within the MGO's as well as on the hands of the investigators working in the MGO. The following results were obtained:

MGO #	**Location**	**Result (ug/wipe)**
#1	Living room table bottom north apt.	16
#1	Kitchen counter top north apt.	0.31
#1	Kitchen counter bottom south apt.	0.28
#1	Bathroom counter top north apt.	0.79
#1	Bathroom counter bottom south apt.	0.34
#1	Bathroom sink upper south apt.	0.61
#1	Kitchen counter bottom north apt.	1.2

#1	Blank	Non Detect
#2	Kitchen Counter	0.27
#2	Hand of officer	50.0
#2	Floor between grow rooms	Non detect
#2	Blank	Non Detect
#2	Upstairs Bathroom sink	1.4
#3	Kitchen counter	0.15
#3	Bathroom sink	0.29
#3	Floor in MGO	0.14
#3	Clothes Dryer	0.14
#3	Floor in grow area	Non detect
#3	Blank	Non detect
#4	Surface of inside door	Non detect
#4	Door in room #1	39.0
#4	Hands of officer	11
#4	Hands of officer	1.6
#4	Prep sink	0.83
#4	Main room floor	6.5
#4	Door to room 2	Non detect
#4	Blank	Non detect
#5	Dining Table	2.1
#5	Kitchen Counter	2
#5	Basement Grow Room Floor	37
#5	Back Bathroom	Non detect
#5	Blank	Non detect
#6	Kitchen	0.015
#6	Drying Room	0.045
#6	Grow Room Floor	0.015
#6	Bath Floor	0.0054
#6	Gloves	Non detect
#6	Blank	Non detect
#7	Bathroom Adjacent to Grow	Non detect
#7	Washer	Non detect
#7	Grow Room Floor	0.0045
#7	Kitchen	Non detect
#7	Hands	0.014
#7	Hands	0.014
#8	Kitchen Counter	Non detect
#8	Upstairs Bathroom Sink	Non detect
#8	Grow Room	Non detect
#8	Upstairs Bathroom Sink #2	0.0046
#9	Kitchen Sink	Non detect
#9	Main Floor Bathroom	Non detect
#9	Bedroom Bathroom Sink	Non detect
#9	Blank	Non detect

#10	Kitchen Counter	Non detect
#10	Bathroom sink	Non detect
#10	West Grow room table	1.9
#10	East Grow room table	Non detect
#10	Gloves	Non detect
#10	Blank	Non detect
#12	Washer in Kitchen	Non detect
#12	Coffee Table	Non detect
#12	Bathroom Toilet	Non detect
#12	Blank	Non detect
#13	Bathroom Floor	0.76
#13	Large Grow Room Floor	0.30
#13	Small Grow Room Floor	0.13
#13	Kitchen Floor	0.77
#14	Bathroom Floor	0.80
#14	Processing Counter	59
#14	Kitchen Sink	0.49
#14	Refrigerator	0.13
#14	Counter	3.9
#14	Kitchen Sink	0.94
#14	Grow Room Floor	0.29
#16	Bathroom Sink	0.69
#16	Hallway	Non detect
#16	Kitchen island	Non detect
#17	Table top	Non detect
#17	Refrigerator Top	Non detect
#17	Top of Grow Light	Non detect
#17	Blank	Non detect
#18	Top of boxes	0.48
#18	Top of water tank	0.73
#18	Top of grow room table	0.38
#18	Hand wipe after tear-out	180
#18	Hand wipe after tear-out	40
#19	Top of grow light	0.41
#19	Kitchen Table	0.1
#19	Hand wipe	6.1
#19	TV table top	0.1
#19	Hand wipe	11
#19	Kitchen counter	Non detect
#19	Blank	Non detect
#20	Basement clipping table	2000
#20	Kitchen counter	0.1
#20	Bathroom counter	Non detect
#20	Floor	Non detect
#20	Blank	Non detect

#20	Hands	2.4
#20	Hands	5.8
#21	Hand wipe after tear out	1100
#21	Hand wipe after tear out	490
#21	Table in grow room	43
#21	Kitchen counter	2.4
#22	Stove top	1.4
#22	Clone room table	3.2
#22	Hand wipe after tear out	150
#22	Hand wipe after tear out	150
#23	Kitchen counter	Non detect
#23	Grow room wipe	0.19
#23	Hand wipe	9.2
#23	Hand wipe	120
#24	Kitchen counter	Non detect
#24	Grow room wipe	1.1
#24	Hand wipe after tear out	2900
#24	Hand wipe after tear out	1300

As this table indicates, the THC levels can be rather elevated on surfaces throughout the MGO. The levels observed ranged from non-detect to a level of 2900 ug/wipe on the hands of an officer participating in the tear-out of an MGO. The highest surface level observed was on a table top used for cloning where a level of 2000 ug/wipe was documented. Most surface levels within the MGO's were found to be less than 10 ug/wipe. Wipes taken on the hands of 16 officers working in the MGO's ranged from non-detect to 2900 ug/wipe. The highest levels were observed on the hands of officers tearing out the plants at the MGO's.

Although we are still researching the toxic effects of THC relating to dose, it appears that the intoxicating effects of THC can be observed in individuals without a history of use at levels as low as 2 mg (2000 ug). Levels this high on environmental surfaces were only observed on one occasion (a cloning table) while most surfaces within the MGO were found to have levels of less than 10 ug/wipe, 2 orders of magnitude below the levels found to cause euphoria. THC levels on the hands of officers did approach levels that would be considered to be intoxicating on a couple of occasions but these were observed primarily on the hands of officers tearing out the plants at MGO's. The average amount of THC on the hands of officers was approximately 400 ug/wipe. Hand protection during tear-out would still be considered to be desirable not only due to the toxic effects of THC but also as protection against herbicides, pesticides, etc.

VOC Sample Results:

Samples for volatile organics were collected at all of the sites. Samples taken inside of the MGO's were compared to samples taken outside in order to determine if any chemicals of concern were present within the structure. Since most of the MGO's that we visited had not been using any THC concentration techniques, the presence of high

concentrations of solvents were not expected. We did detect a number of solvents that are normally present in all structures such as acetone, butane, isobutene, etc. We also detected a number of compounds that cause the smell that we characterize as the marijuana smell. These compounds are present in higher quantities in the grow rooms and are alpha-pinene, beta-mycrene, beta-pinene, and limonene. These compounds do not present a known hazard to anyone inhaling them as far as we know.

Carbon Dioxide and Carbon Monoxide Levels:

Carbon dioxide levels were not being boosted at the time of sampling in many of the MGO's. In only one instance did we find that an operator had disconnected the vent system for the furnace and hot water heater, but at the time of sampling, he was in jail and the CO_2 was at ambient levels. No other fossil fuel combustion products were observed at that unit.

In general, the carbon dioxide levels ranged from ambient (300 – 400 ppm) up to approximately 1300 ppm. Elevated levels of carbon monoxide were not identified in any of the MGO's sampled.

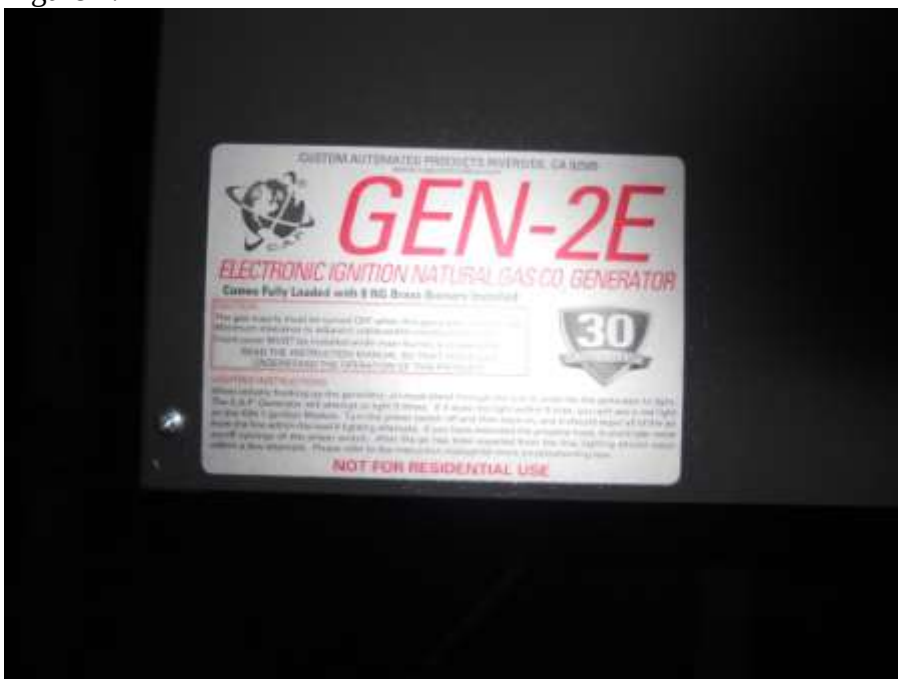
The presence of carbon dioxide tanks and regulators were observed in a number of the MGO's. In general, these setups are the best methodology for increasing the carbon dioxide levels since they do not result in the production of other combustion products that may cause pulmonary irritation or, in the case of carbon monoxide, fatalities. The typical carbon dioxide tank setup is shown in Figure 1.

Figure 1.

The second type of carbon dioxide generator that was found was a unit that produced carbon dioxide through the combustion of natural gas. These units were observed in a

number of MGO's and none of the units were ventilated to the outside. In one instance, respiratory irritation to investigators was of such a concern that the unit was turned off prior to us arriving on the scene and collecting samples. These units are labeled "NOT FOR RESIDENTIAL USE" due to the potential for the production of carbon monoxide and other combustion by-products. Although none of these units were found to be producing carbon monoxide at the time of our sampling, the potential is present and the result could be fatal if unrecognized. Figure 2 shows the warning tag on one of the units.

Figure 2.



Chemicals Utilized at MGO's

Most of the chemicals observed at MGO's fell into one of two categories, pesticides and fertilizers. Most of the compounds observed did not appear to pose a substantial threat to short duration exposures by law enforcement officers. Pesticides were primarily pyrethroids which have a relatively low toxicity. We did find, however, a number of instances of pesticides approved for outdoor use only, apparently being utilized indoors. In addition, in many instances these pesticides were being stored on the floor and within easy reach of children. In fact, a number of chemicals observed within the MGO's had label warnings to keep the chemicals out of the reach of children, yet they were still stored on the floor.

Figure #3 and #4 show the typical pesticides and fertilizers observed at the MGO's.

Figure 3.

Figure 4.

Conclusions:

A number of reports have suggested that the principal concern in indoor marijuana grow operations is the presence of excessive mold spore levels due to the elevated

temperatures, humidity, and organic material in these operations. Our study has confirmed this concern. Over 60% of the MGO's that we sampled had mold spore levels or Penicillium spore levels that exceeded outdoor levels by at least 10 times. In some cases, the levels were in excess of 100 times the outdoor level. In almost all of the MGO's, the primary species involved were Penicillium species, a species that is common in Colorado. In fact, a number of homes and commercial buildings studied by National Jewish researchers involving cases of hypersensitivity pneumonitis in patients have involved Penicillium species. It is very possible, therefore, that individuals working for long periods of time in these facilities could develop pulmonary problems such as hypersensitivity pneumonitis, asthma, and allergic rhinitis.

A study conducted by DEA personnel indicated that the manipulation of the marijuana plants results in the release of higher levels of mold spores than simply growing the plants. Our sampling confirmed that, in many cases, the tear-out of the MGO's did increase the number of airborne mold spores (especially Penicillium species spores) to relatively high levels. In one instance, the spore levels exceeded 500,000 spores per cubic meter, a level seldom observed in residential structures. These levels are high enough to indicate that respiratory protection should be worn by individuals participating in MGO investigations. Failure to utilize respiratory protection could result in respiratory irritation, headache, difficulty breathing, chest tightness, and other symptoms caused by the mold spore exposure. This is especially of concern for individuals that spend excessive time within the MGO's.

We also sampled for THC in the MGO's and found the active ingredient in marijuana to be present on many environmental surfaces. The levels found did not coincide with airborne levels suggesting that the surfaces were contaminated with large particles that had dropped onto the surfaces. The levels observed upon the surfaces do not appear to be high when related to the toxicity of THC. Although children exposed to this contamination may have some health risk, adults would not normally be expected to show symptoms. A surface in one MGO did have an excessive level of THC present but this was a cloning table with significant amounts of vegetative material on the surface.

Our investigation did not reveal the presence of any chemical concerns at the time of sampling although several reports from Canada have suggested that toxic pesticides may be present in MGO's. Although no highly toxic chemicals were observed, the use of pesticides and fungicides by individuals not trained in that use may expose responding individuals to chemicals that may cause health concerns, especially as the plants are removed from the scene.

The use of compressed carbon dioxide tanks to raise the level of carbon dioxide significantly reduces the potential for exposures to combustion by-products that may cause pulmonary concerns. Compressed gas tanks primarily present safety concerns from tanks being knocked down and breaking the valve which will then create a missile out of the tank. There are also some thermal concerns in that if gas is rapidly released, very cold temperatures can be created. In general, however, compressed carbon dioxide gas tanks create fewer health concerns than combustion sources.

A number of MGO's did utilize combustion sources to provide the excess carbon dioxide necessary. These systems are not approved for residential use and may cause health concerns due to the production of carbon monoxide as well as oxides of nitrogen. It is important that these devices not be utilized in any residential building where adequate ventilation and monitoring does not exist. In at least one MGO, the unit did cause a noticeable respiratory irritation to the investigators.

Recommendations:

Expected Hazards:

Based on the results of our study, the primary exposure of concern is the inhalation of high numbers of mold spores that we found to be present in many of the indoor marijuana grows. The highest concentrations of fungal spores were measured when the plants were being removed from the operation and not during the initial entry. However, even the initial entry at some of the MGO's was found to expose individuals to fungal spore levels that were well above outside levels. Exposure to these elevated spore levels on a sporadic basis for short periods of time may be well tolerated by most individuals. Individuals exposed to these spore levels for excessive periods of time or with an elevated frequency may develop allergic reactions to the fungal spores resulting in upper respiratory irritation and, in some cases, hypersensitivity pneumonitis. Individuals with an immune deficiency caused by transplant surgery, corticosteroids, illness, or other causes could have severe reactions to these elevated spore levels and experience life-threatening illnesses.

In addition to elevated fungal spore levels, some studies in Canada, have suggested that exposures to carbon monoxide and chemical pesticides may also be possible. Although we did not find any significantly elevated carbon monoxide levels or very toxic pesticides associated with our MGO's, the possibility does exist that these exposures could be present in some MGO's. The RCMP has recorded at least one officer that reported symptoms compatible with pesticide poisoning after working in a large MGO for a 5 hour period of time. Elevated carbon monoxide levels have also been reported in some MGO's.

Exposure to a number of physical hazards including trip and fall hazards, electrical hazards, booby traps, firearms, and fire hazards have also been associated with MGO's and a number of fire fighters and law enforcement personnel have suffered electrical shock while entering MGO's. This is not unexpected due to the poor wiring methodology associated with these grows and the significant use of water in the operations. Physical hazards must therefore be expected in MGO's.

Current Personal Protection Guidelines:

We reviewed a number of guidelines that are currently available regarding personal protective gear requirements for entry into MGO's. The publication entitled "Clandestine

Indoor Marijuana Grow Operations – Recognition, Assessment, and Remediation Guidance" published by the American Industrial Hygiene Association in 2010 indicates that the PPE required for entry must be tailored to the specific facility in question but that the following is suggested as a minimal consideration:

Initial Response:

- Chemical resistant boots with slip and puncture protection
- Eye and face protection
- Tactical ballistic helmet
- Tear and fire resistant outer garment
- Chemical resistant gloves
- Tyvek and/or chemical resistant coveralls
- For unknown atmospheres – an SCBA
- For known atmospheres – a Powered air purifying respirator (PAPR) or air purifying respirator with P-100 cartridges.

Assessment and Product Removal:

- Chemical resistant boots with slip and puncture protection
- Eye and face protection
- Tear and fire resistant outer garment
- Chemical resistant gloves
- Tyvek and/or chemical resistant coveralls
- For unknown or IDLH atmospheres – an SCBA
- For known atmospheres – a Powered air purifying respirator (PAPR) or air purifying respirator with P-100 cartridges.

The State of Arizona suggests that for tactical operations at MGO's, entry should be initiated with a full-face air purifying respirator, a Tyvek and/or chemical resistant suit, boots and gloves that provide protection from chemicals. They also indicate that the use of SCBA as a routine entry tool be considered.

A slide show produced by Network Environmental Systems and the DEA Clandestine Laboratory Training Unit suggests that entry into MGO's should be conducted with a minimum of a full face air purifying respirator with a minimum of a P-100 cartridge, nitrile-dipped gloves, Tyvek suits, and boots.

The Calgary Fire Department in Calgary, Canada considers the minimum equipment for MGO entry to consist of the following:

- Tyvek outer garments
- A full-face air purifying respirator or, if glasses are needed, a ½ face respirator with a minimum of a P-100 cartridge
- Nitrile rubber gloves or gloves appropriate for the chemicals found
- Waterproof work boots
- Kevlar gloves for tactical officers

- A 3-gas (oxygen, Carbon monoxide, and Flammability) portable monitor

The U.S. EPA does not specifically address MGO's but does provide guidance regarding mold exposures in schools and commercial buildings. They indicate that the following PPE should be worn when entering indoor areas where mold contamination has been discovered:

Minimally contaminated areas:

- N-95 disposable respirator
- Goggles or other eye protection

Moderately contaminated areas:

- N-95 disposable respirator or ½ face air purifying respirator with P-100 cartridges
- Protective coveralls
- Goggles or eye protection

Heavily contaminated areas:

- Gloves
- Tyvek coveralls
- Head covering
- Boots
- Full-face air purifying respirator with P-100 filters

In most cases, the levels of mold found in MGO's would be considered to be heavily contaminated areas by U.S. EPA definition.

Study Recommendations:

Based on the results of our study, we believe that the primary exposures present in MGO's consist of high levels of mold spores, low toxicity pesticides and other chemicals, carbon monoxide, and electrical hazards. Other than electrical hazards, very few of these exposures are expected to cause significant health effects during short exposure periods. Most individuals will not experience significant health reactions during 20 minute exposures to excessive mold spores, especially if the individual simply enters the house and leaves without manipulation of the plants or the growing equipment.

It is possible however, that some individuals will experience significant health effects to these fungal spore levels. Individuals with allergies to mold, individuals with a lowered immune response, and individuals with asthma or other chronic pulmonary disease may exhibit life threatening responses to high fungal spore levels. In addition, although we did not find any chemical exposures that would present an immediate threat to responders, the possibility of very toxic compounds being present or excessive carbon monoxide levels posing a significant risk can't be discounted. In fact, a number of MGO's have been found to be associated with clandestine methamphetamine labs that produce dangerous levels of chemical exposures. For these reasons, the

recommendations that we are providing should be considered as the minimum personal protective equipment for MGO entry and disposition. An upgrade in PPE should be immediately implemented if the status of the MGO changes or if chemicals are present that may result in dangerous exposures.

Initial Responders:

The initial law enforcement responders are frequently SWAT teams or uniformed officers that are expected to participate in the entry and apprehension of individuals in the MGO. It is expected that these officers will spend very little time within the MGO and that the primary concerns will be tactical safety, booby traps, and electrical hazards. Visibility, maneuverability, ballistic protection, and access to defensive equipment may be of prime importance. For these individuals we would suggest the following minimum PPE:

- Normal ballistic gear or uniforms as outer clothing with some fire resistance desirable.
- Gloves (chemical resistance could be desirable).
- Boots that have some water resistance in case decontamination is necessary as well as slip protection.
- An N-95 or P-100 disposable respirator with NIOSH approval should be considered by any individual with significant allergies or pulmonary problems.

In addition to this PPE, law enforcement members with immune system deficiencies should not enter MGO's without a minimum of a full-face respirator with P-100 filters. Since all respirators leak to some degree and the levels of mold spores present may be extremely high, we suggest that these individuals not participate in these activities. It is also important that individuals with these problems do not handle items being removed from the MGO and that they do not have contact with individuals that have been inside the MGO until those individuals have been decontaminated.

Assuming that no contact with chemicals has occurred during the response and that significant contact with marijuana plants and grow chemicals has not occurred, an extensive decontamination is likely not necessary. Clothing and equipment utilized within the MGO can simply be laundered in the normal fashion as soon as possible after the entry. If during the entry there was exposure to unknown chemicals or other exposures of concern, decontamination should be considered.

If there is any question as to the presence of a clandestine methamphetamine lab or concern regarding the chemicals utilized in the MGO, then chemical resistant clothing, boots, gloves, and self-contained breathing apparatus (SCBA) should be utilized.

Evaluation Period:

It is expected that during this portion of the investigation, law enforcement personnel, building inspectors, fire personnel, etc. will be entering the MGO in order to determine

what hazards are present. This portion of the investigation is expected to take a longer period of time compared to the initial entry but the removal of plants and/or equipment will not occur. In addition, chemicals will not be removed or handled in such a way as to promote spillage during this phase. Individuals participating in this phase of the operation should have the following minimum PPE:

- Tyvek coveralls designed to reduce accidental spills and to enable decontamination upon leaving. Chemical resistant clothing might also be considered during this phase.
- Water resistant and puncture resistant non-slip boots
- Gloves that are chemical resistant and water proof (nitrile gloves may work well in most situations).
- An N-95 or P-100 disposable respirator or a ½ face respirator with P-100 cartridges. Some individuals that experience headaches will find that a ½ face respirator with P-100 and organic vapor cartridges will eliminate the odor of the MGO as well as protect against fungal spores.
- The use of a 3 chemical detector capable of detecting carbon monoxide, low oxygen, and explosive environments is also recommended.

As in the initial phase, individuals with immune system deficiencies should seriously consider not participating in MGO operations. Decontamination, assuming that no chemical spills occurred, can be accomplished by simply removing the outer layer of clothing. Blowing off the clothing or shaking it should not be done prior to bagging the clothing. Chemical exposures, especially pesticides, may require full decontamination of the individual and equipment utilized. If a chemical detector is utilized, it must be maintained so that the readings can be trusted. These detectors must be calibrated on a frequent basis whether or not the detectors are used.

Removal and Destruction Phase:

It is expected that this phase of the operation will consist of sampling the plants, removing the plants, and removing equipment and supplies from the MGO. It is during this phase of the operation that we consistently observed the highest exposures and it is during this phase that the exposures may be the longest and where spills and accidents are most likely. Individuals participating in this phase should have the following minimum PPE:

- Chemical resistant and fire resistant outer garments
- A full-face air purifying respirator with a minimum of a P-100 filter. Individuals may prefer a Powered Air Purifying Respirator (PAPR) and individuals with beards must use a PAPR.
- Water, slip and puncture resistant boots.
- Water and chemical resistant gloves (nitrile may be best).
- The use of a 3 chemical detector capable of detecting carbon monoxide, low oxygen, and explosive environments is also recommended.

As in the initial phase, individuals with immune system deficiencies should seriously consider not participating in MGO operations. Decontamination, assuming that no chemical spills occurred, can be accomplished by simply removing the outer layer of clothing. Blowing off the clothing or shaking it should be minimized prior to bagging the clothing. Chemical exposures, especially pesticides, may require full decontamination of the individual and equipment utilized. If a chemical detector is utilized, it must be maintained so that the readings can be trusted.

As was previously mentioned, these suggestions are minimum PPE suggestions. Any intelligence suggesting that the MGO is combined with a clandestine methamphetamine lab or other clandestine lab should suggest that PPE be upgraded. If the initial entry or any other phase of the operation suggests that exposures may be higher than expected, then PPE should be upgraded. Finally, some individuals will be much more comfortable upgrading the PPE for a specific phase. Individuals with asthma or allergies may consider using a full-face respirator or a PAPR during any phase of operation. If at any time during an operation, an individual or individuals begin to feel ill, an immediate switch to Level B (SCBA, gloves, chemical and fire resistant clothing, gloves and boots) should be conducted until it can be determined that the environment is safe for lesser PPE.

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