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Leaf enclosure measurements for determining volatile organic compound emission capacity from *Cannabis* *spp.*

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**Environmental Science & Technology**

High Time to Assess the Environmental Impacts of Cannabis Cultivation

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Volatile Organic Compounds (VOCs)

*Man Made (Anthropogenic)*
Toluene, gasoline, personal products

*Natural Made (Biogenic)*
Isoprene, Monoterpenes, Sesquiterpenes

[Images of various terpenes]

https://www.cdxlife.com/what-can-terpenes-do-for-you/
VOCs from Marijuana?
VOCs from Marijuana?

Critical Mass (8.6 μg C/hr)
- eucalyptol (32)
- β - myrcene (18)
- α - terpinene (2)
- caryophyllene (2)
- α - pinene (3)
- thujene (3)
- p - cymene (4)
- terpinolene (4)
- γ - terpinene (14)
- sabinene (11)

Elephant Purple (4.5 μg C/hr)
- myrcene (60)
- others (2)
- thujene (2)
- α - pinene (3)
- d - limonene (3)
- caryophyllene (5)
- γ - terpinene (8)
- eucalyptol (17)

Lemon Wheel (3.5 μg C/hr)
- eucalyptol (38)
- β - myrcene (26)
- β - pinene (2)
- thujene (3)
- caryophyllene (4)
- α - pinene (4)
- α - terpinene (4)
- p - cymene (5)
- d - limonene (6)
- γ - terpinene (8)

Rockstar Kush (2.2 μg C/hr)
- others (3)
- α - pinene (3)
- β - pinene (4)
- α - terpinene (6)
- eucalyptol (17)
- p - cymene (6)
- caryophyllene (7)
- d - limonene (10)
Monoterpenes Emission Rates

- Critical Mass – 8.6 µg C/g/hr
- Elephant Purple - 4.5 µg C/g/hr
- Pine Trees – ~16 µg C/g/hr
- Pistachio Trees – ~8 µg C/g/hr
- Rosemary – ~4 µg C/g/hr
Monoterpene Emissions

- EPA 2011 Santa Barbara County
- 39,042 tons/year Biogenic VOCs (78% of all VOCs)
Monoterpene Emissions

• 39,042 tons/year Biogenic VOCs
• Replacing Gerbera Daisy/Tulips are also BVOC emitters
• ~5 tons/year Monoterpenes from Cannabis Industry
  Carpinteria, CA
Biogenic VOC Exposures

• Model Predicted Concentrations Summer 2011
  • Santa Barbara County .25 ppb (.8 ppb)
  • Denver 0.1 ppb (0.2 ppb)

• Measured downwind Cannabis, Denver CO
  • 0.4 – 0.8 ppb

• Amazon Rain forest – 2-4 ppb isoprene
• Peeling an orange - ~100 ppb Limonene
• Saw Mills – ~50-100 ppm of α-pinene
Monoterpene Toxicity

• Most terpenes non-toxic
• Acute short term inhalation (limonene, α-terpineol, and α- and β-pinene) is ~106 ppm (59 mg/m³)
• 5,000 times higher in ambient terpene hotspots
VOCs and Ozone/PM

1. Sunlight

2. NOx

3. VOCs

ANTHROPOGENIC SOURCES
CCA EXH. 20

BIOGENIC SOURCES