Microbes may induce soil water repellency through the production of aliphatic constituents as a response to desiccation

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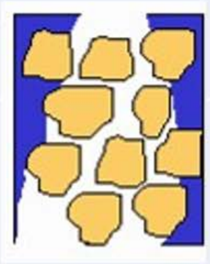
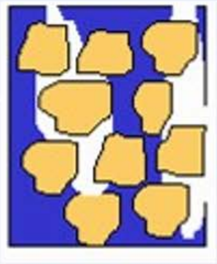
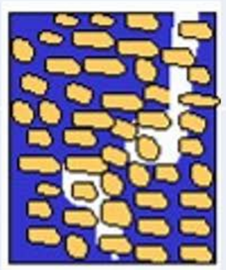
Soil degradation is a top global threat

- Soil degradation
  - Erosion
  - Reduced organic matter
  - Reduced soil fertility
- Soil water repellency
  - Rill erosion
  - Overland flow
  - Loss of topsoil

Water repellency is a function of surface tension

- Water repellency is commonly observed in
  - Dry conditions

- Water repellency is commonly observed in
  - Coarse textured soils

Texture	Sand	Silt	Clay
Particle Size (mm)	0.05 - 2	0.002 – 0.05	< 0.002
			
Pore Size	large	medium	Small
Infiltration Rate			

Water repellency may be controlled by microbes

- Water repellency is influenced by organic matter content
- Organic matter processes are controlled by soil microorganisms
- Soil microoganisms may actively control water repellency

Rationale for microbial influence

Soil wettability is seasonal

↓

Microbial activity and growth is seasonal, they produce aliphatics

↓

Aliphatic constituents are water repellent

↓

Soil becomes water repellent

Specific Research Question

Can soil water repellency be induced by the microbial community through the production of aliphatic constituents in their extracellular polymeric substances (EPS) as a response to desiccation stress?

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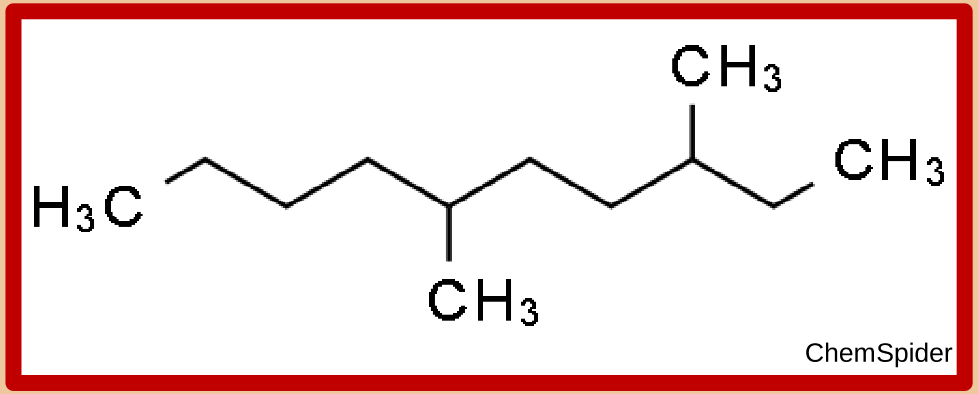

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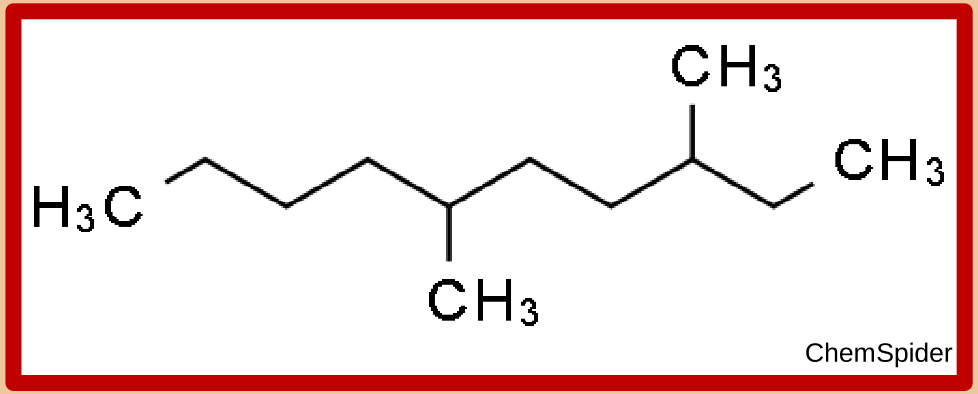
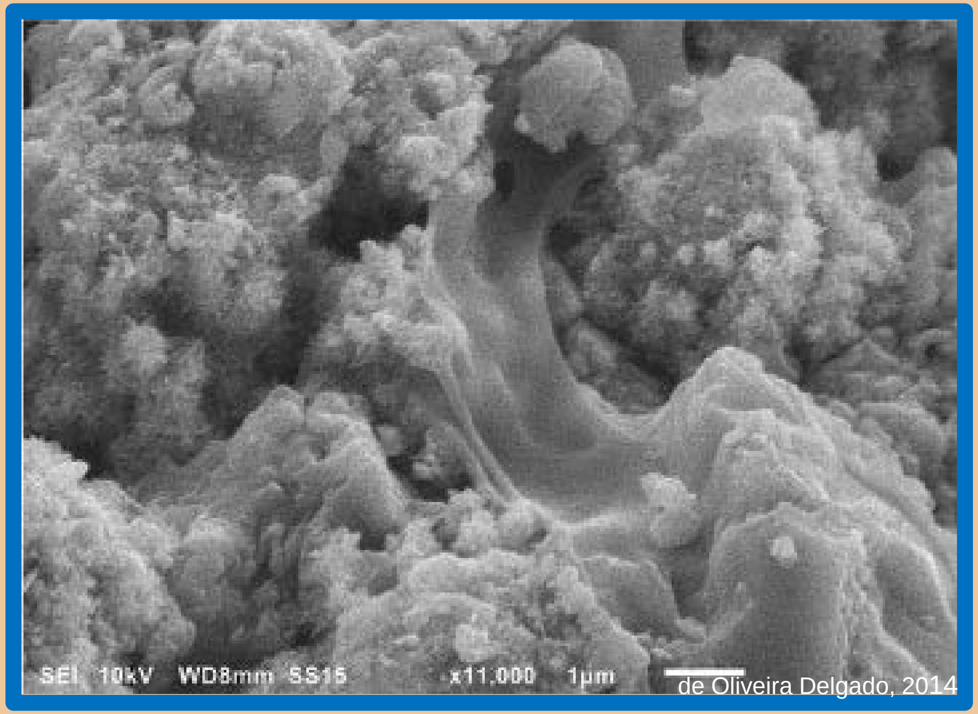




Objective 1:
Determine if water repellency was a response to desiccation stress

- Specific Hypotheses:

  - The degree of water repellency increases as the moisture content decreases

  - The degree of water repellency is greater for the subsoil (0.2-1cm) than the crust (0-0.2cm)

  - The degree of water repellency increases the longer the soil is subjected to wetting/drying cycles

Objective 2:
Determine if the microbial community actively controlled the water repellency

- Specific Hypotheses:
  - Microbial biomass decreases as the moisture content decreases
  - The microbial biomass decreases the longer the soil is subjected to wetting/drying cycles

Objective 3:
Determine if water repellency is a function of the quantity of aliphatic constituents in the soil

- Specific Hypotheses:
  - The quantity of aliphatic constituents increases as the moisture content decreases
  - The quantity of aliphatic constituents in the subsoil (0.2-1cm) is greater than in the crust (0-0.2cm)
  - The quantity of aliphatic constituents increases the longer the soil is subjected to wetting/drying cycles.

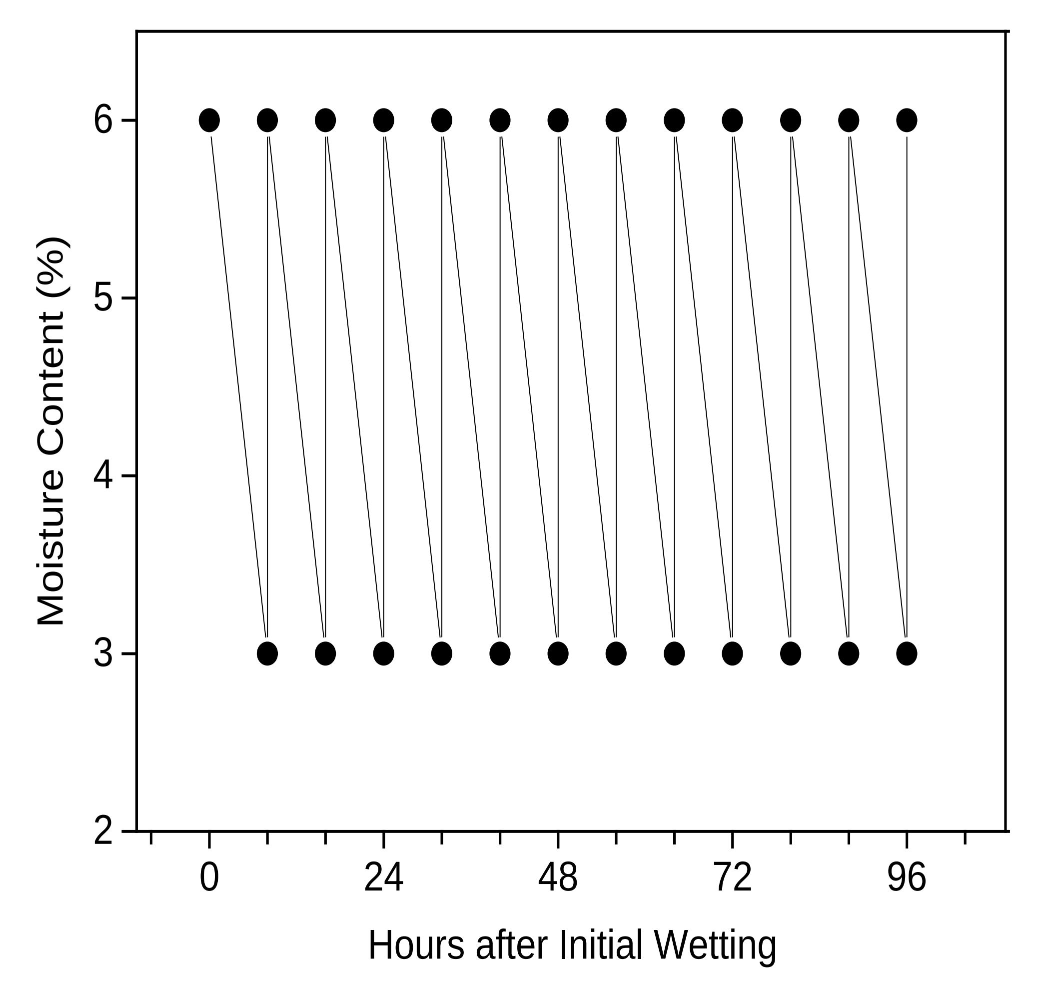
The Quincy soil series

- Coarse textured soil
  - Mixed mesic Xeric Torripsamment
- Agriculturally important
- In-situ water repellency

Treatments

Wetting Interval (hours)	Gravimetric Moisture Treatments
8	3%
24	2%
48	1.8%
No wetting interval	0.65%

Rewetting Intervals



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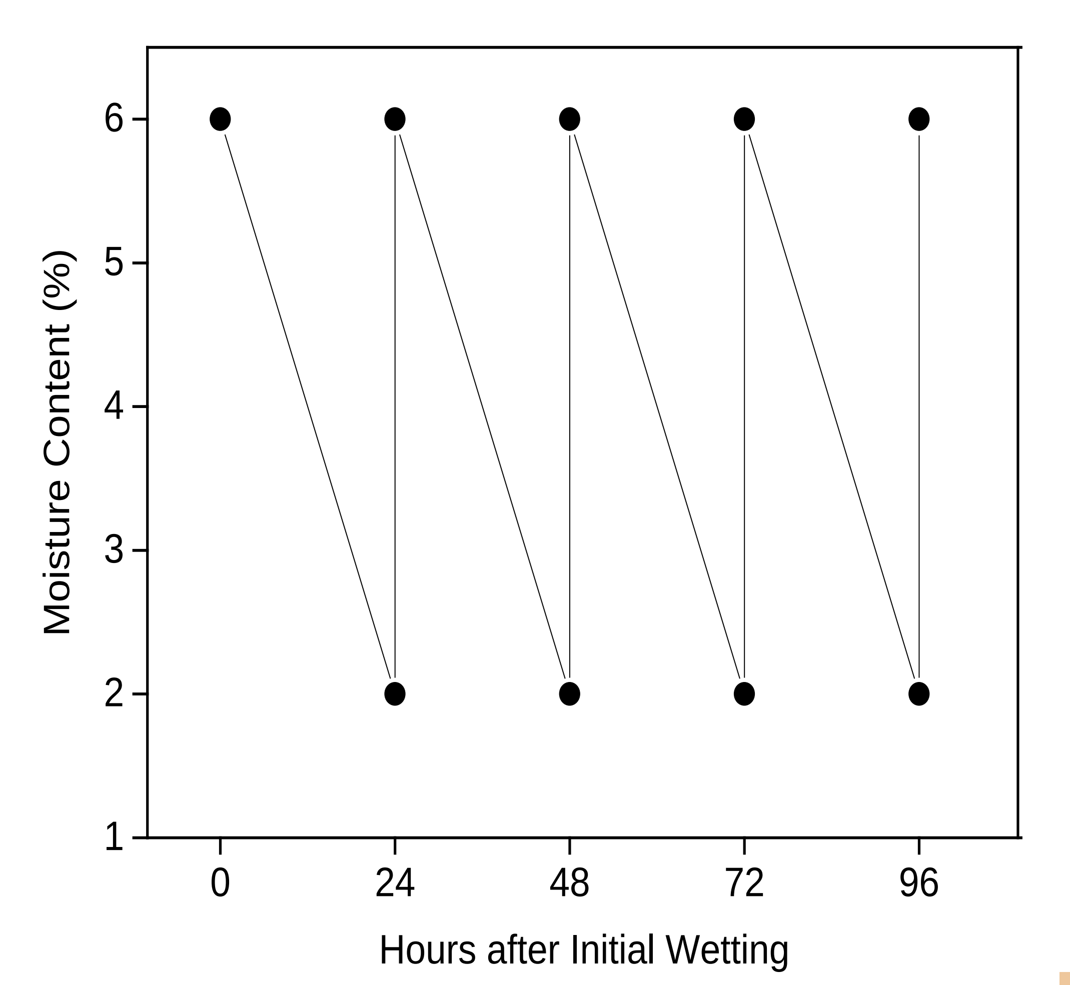

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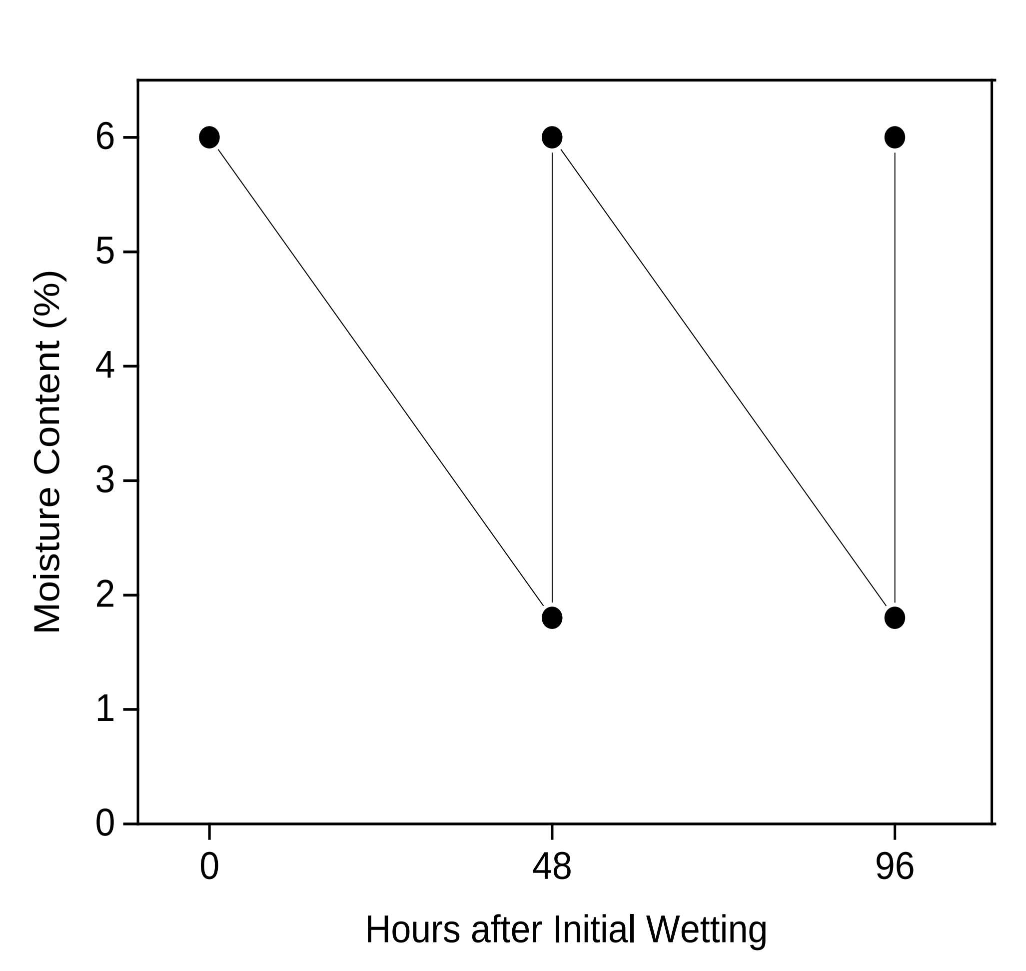

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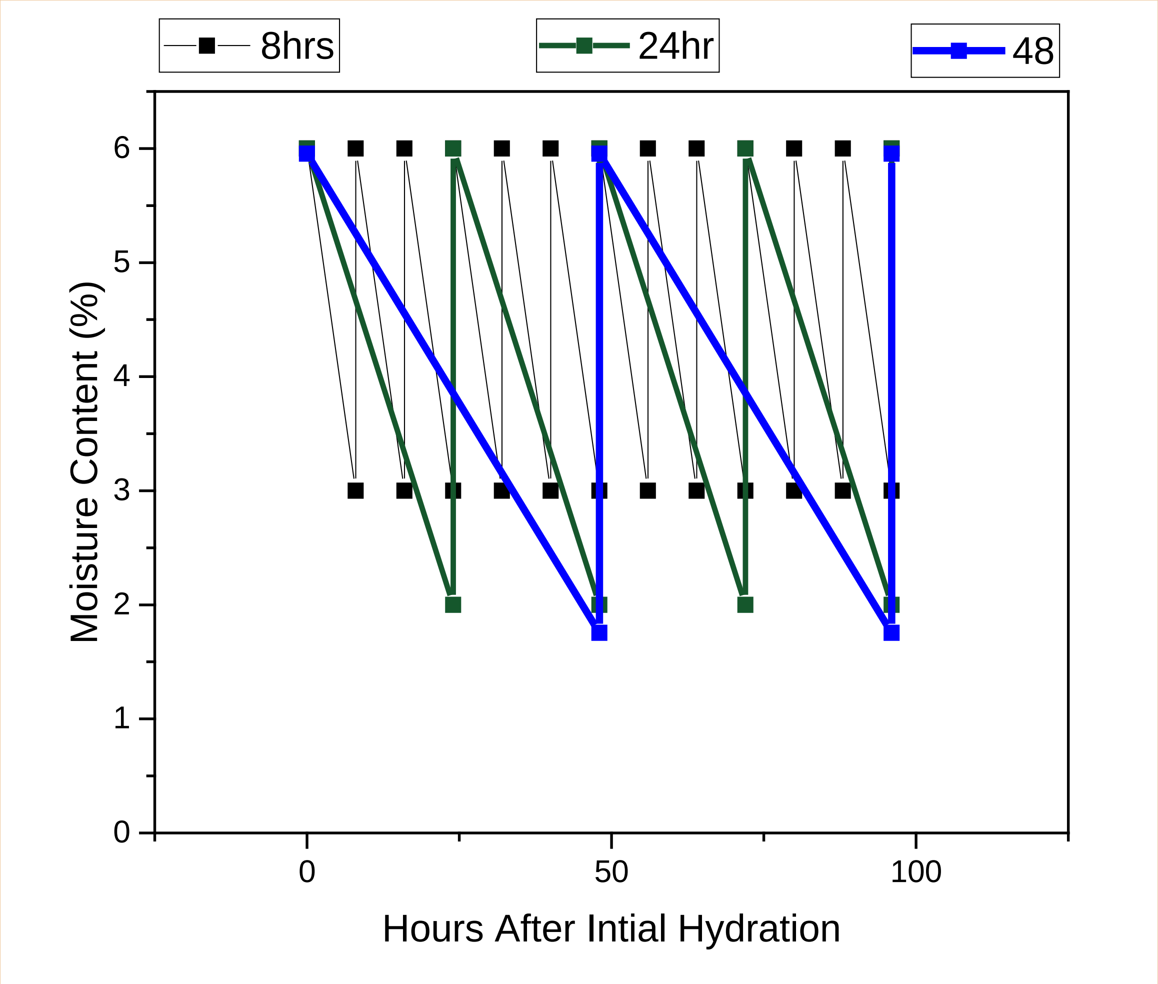
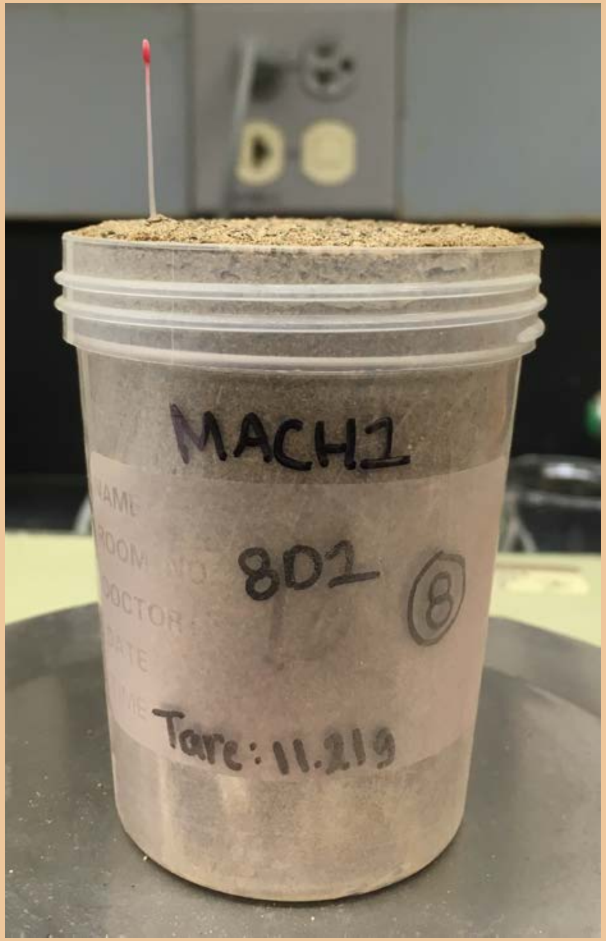


Experimental Conditions

- Diurnal temperature
- Two week duration
  - Sampling week 1 and week 2
- Rewet up to initial moisture content of 6%
- Rewetting solution
  - Carbon & nitrogen



Analyses

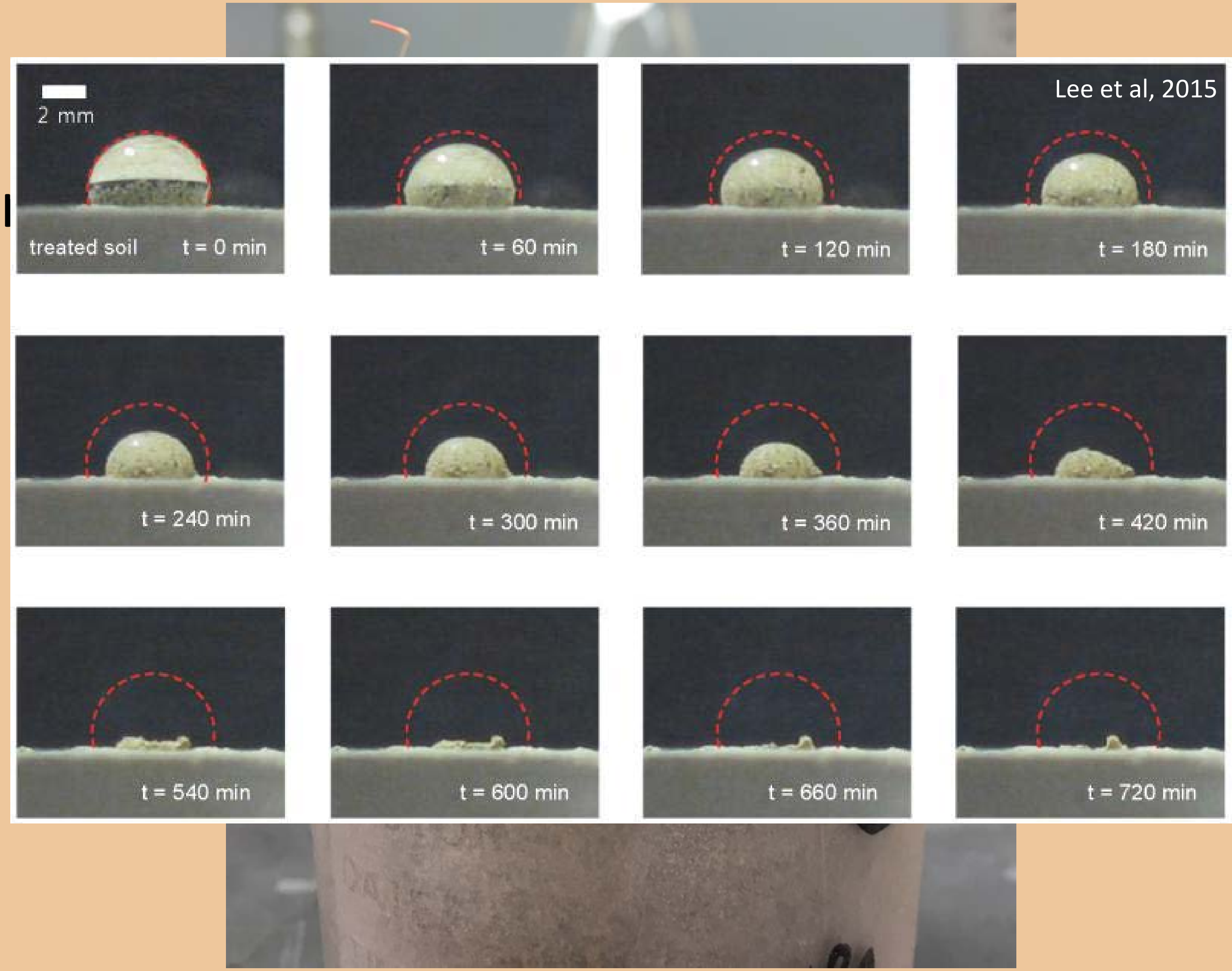
- Degree of water repellency
  - Water drop penetration time
  - Contact angle

- Microbial biomass
  - Chloroform fumigation extraction
  - Shimadzu total carbon analyzer

- Quantification of aliphatic constituents
  - Hexane extraction
  - Gas chromatography mass spectroscopy

Water Drop Penetration Time

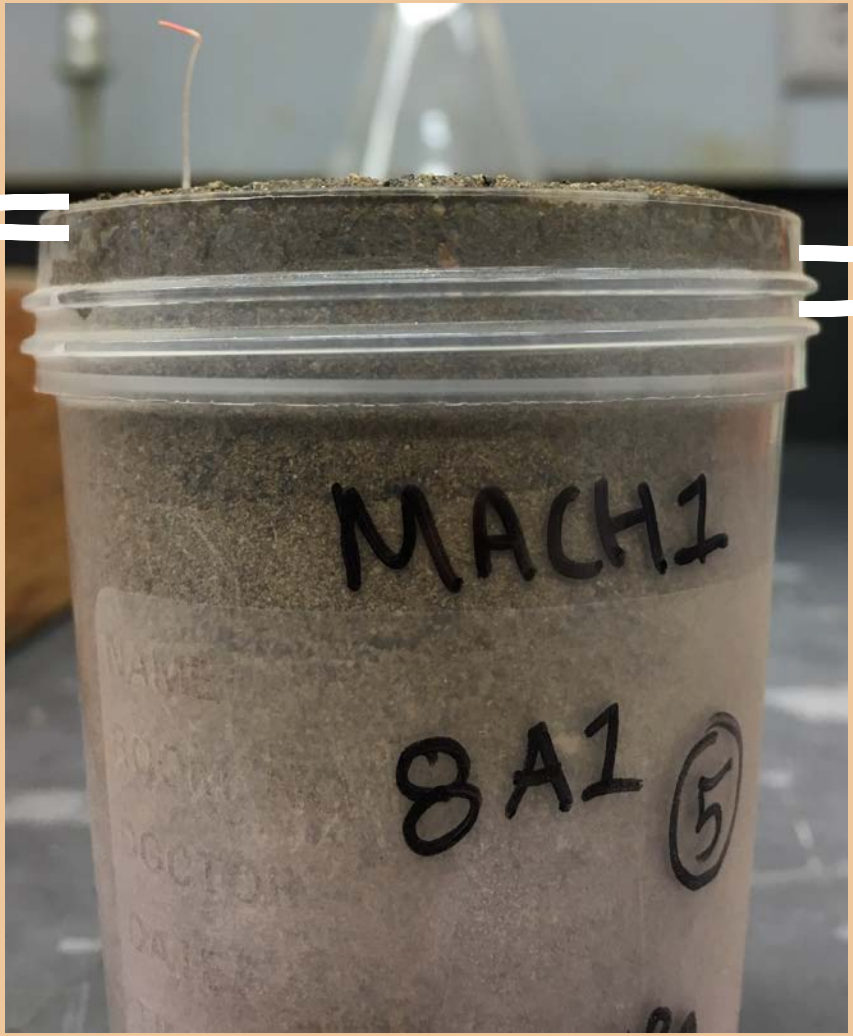
Crust (0-0.2c



ubsoil (0.2-1cm)

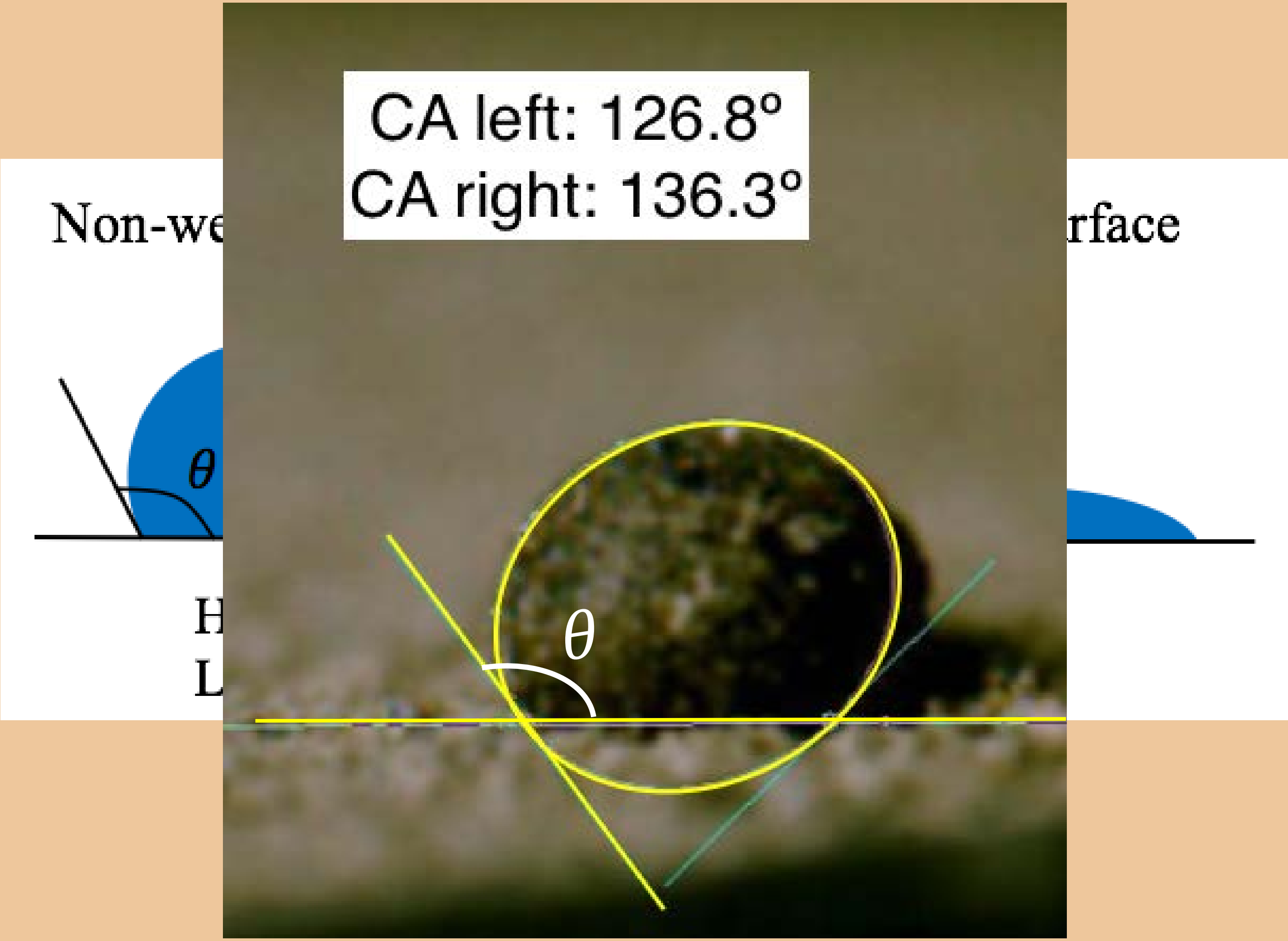
Water Drop Penetration Time

Crust (0-0.2cm)

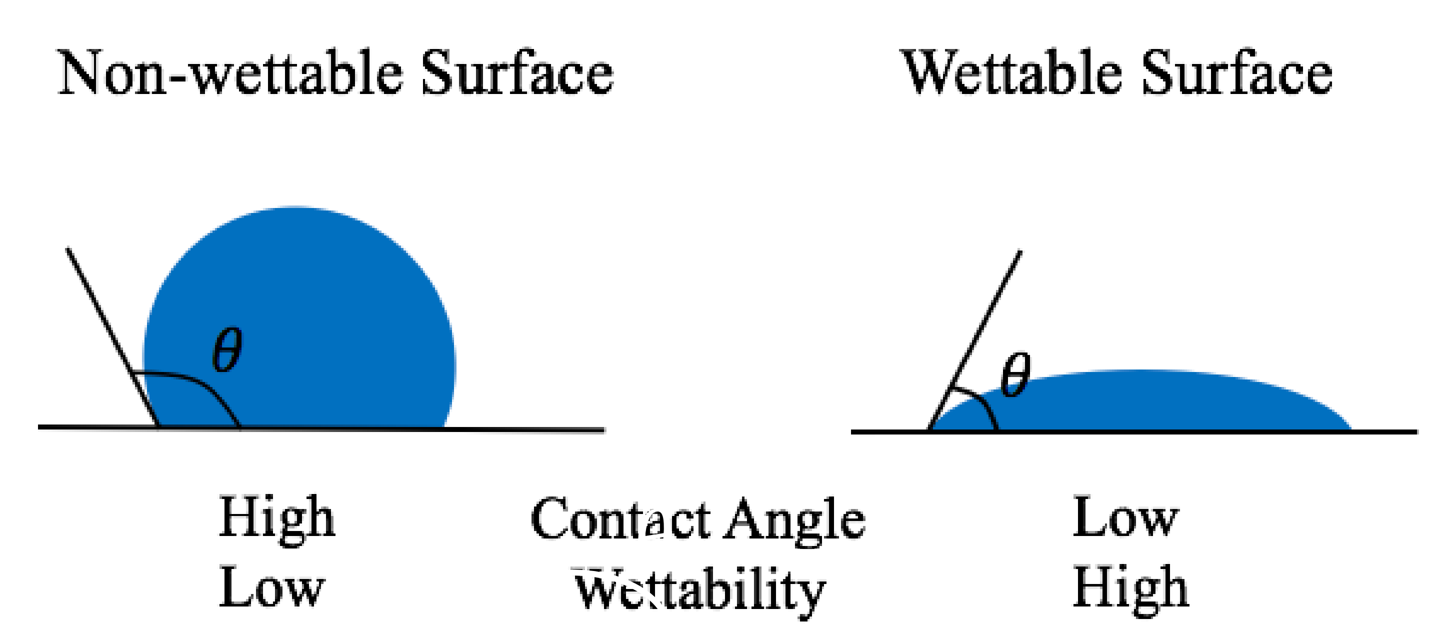


Subsoil (0.2-1cm)

Contact Angle

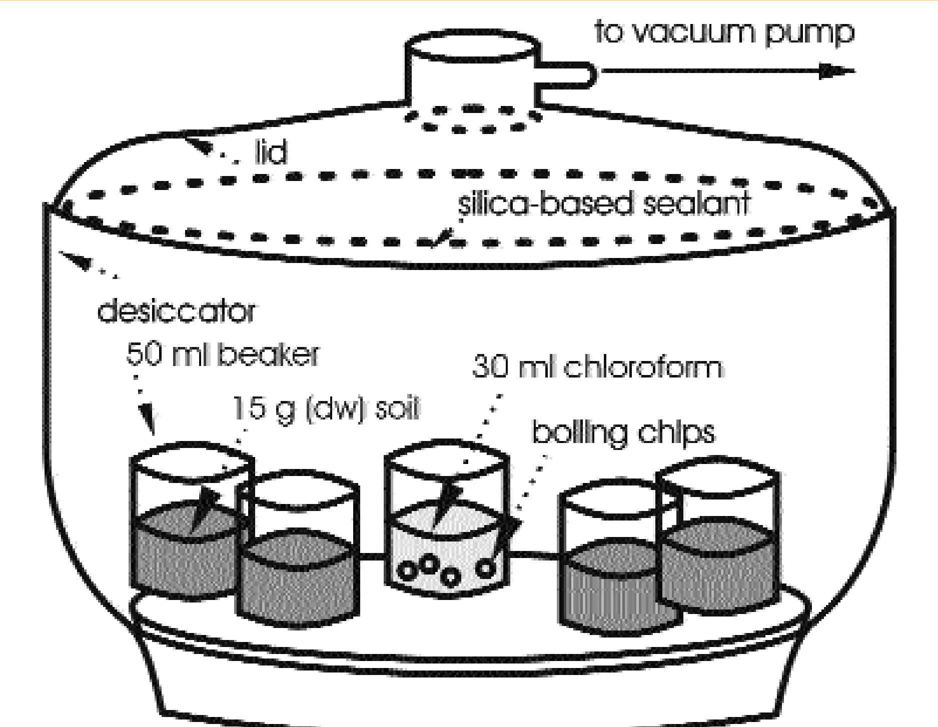


Contact Angle



Quantification of microbial biomass

- Chloroform fumigation

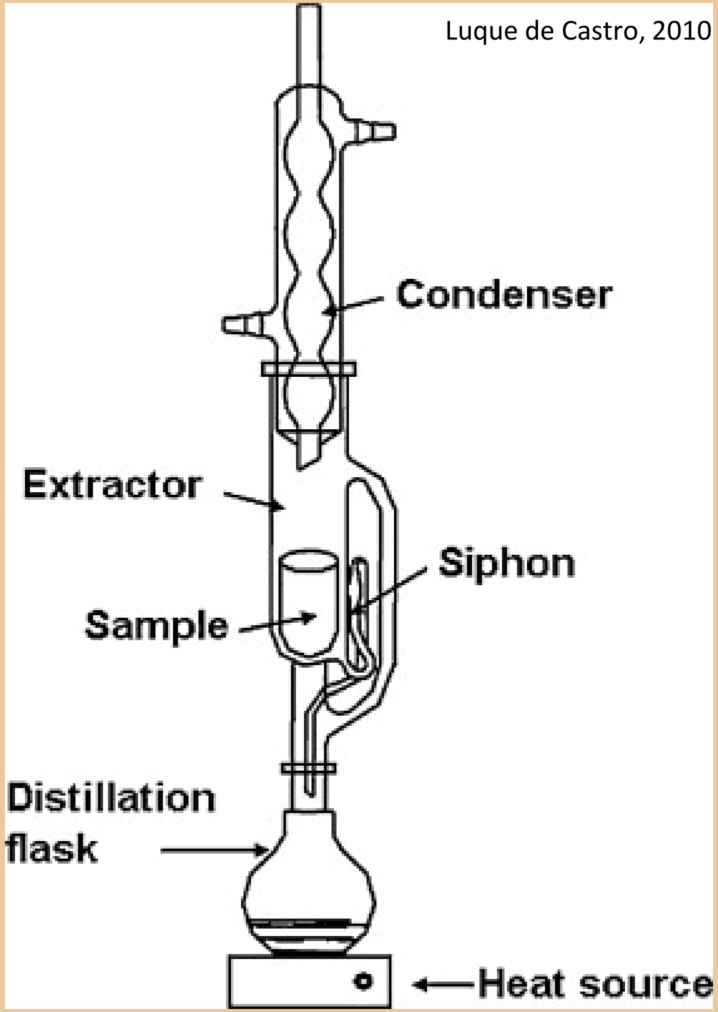


Okalebo et al., 1993

- 0.5M potassium sulfate extraction
- Shimadzu total carbon analyzer
- Calculation
  - Fumigated C – nonfumigated C

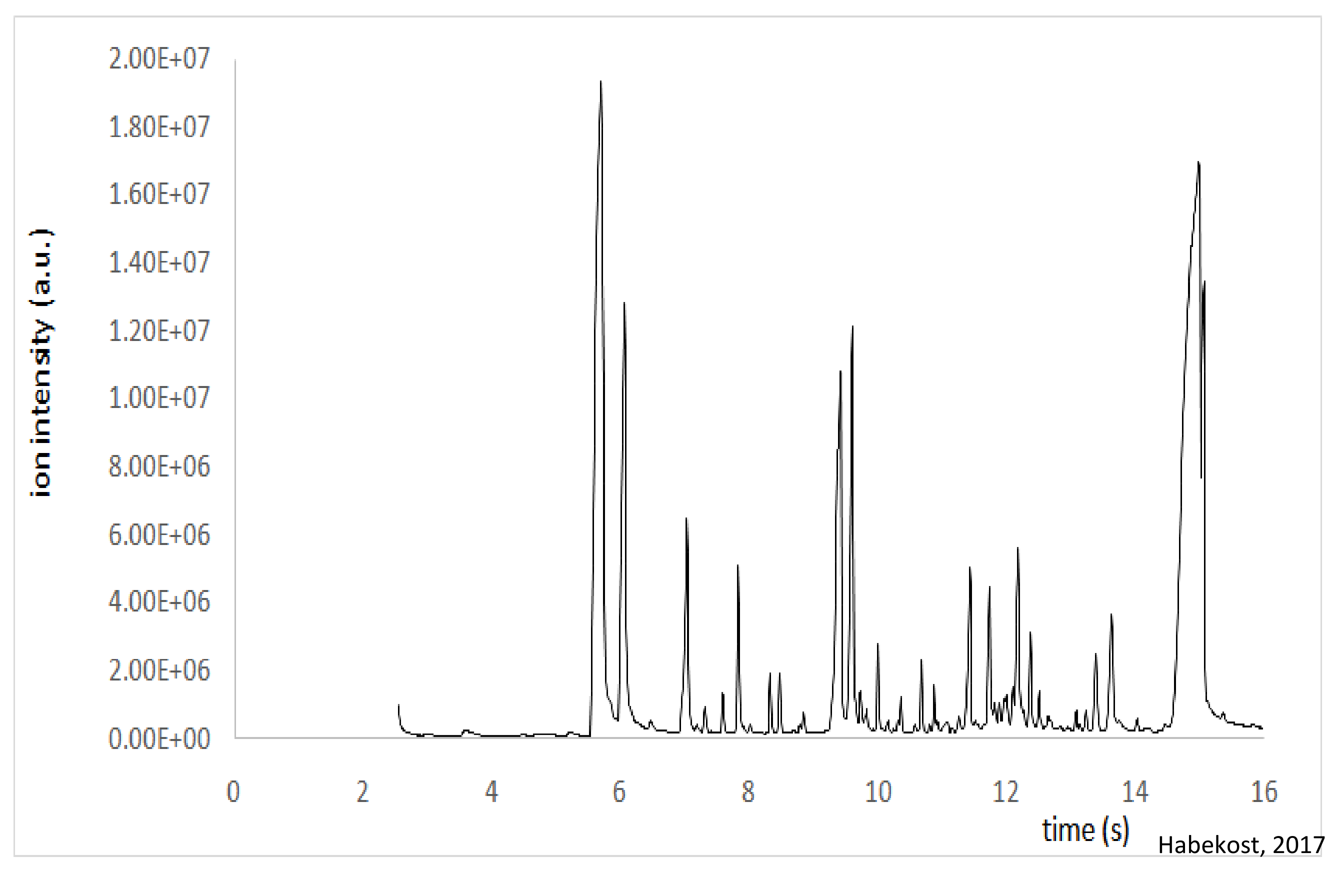
$$\frac{\left(\frac{[c](volume\ of\ extract)}{weight\ of\ dry\ soil}\right)}{0.45} = \frac{\mu g\ carbon\ in\ microbial\ biomass}{g\ dry\ soil}$$

Extraction of aliphatic constituents



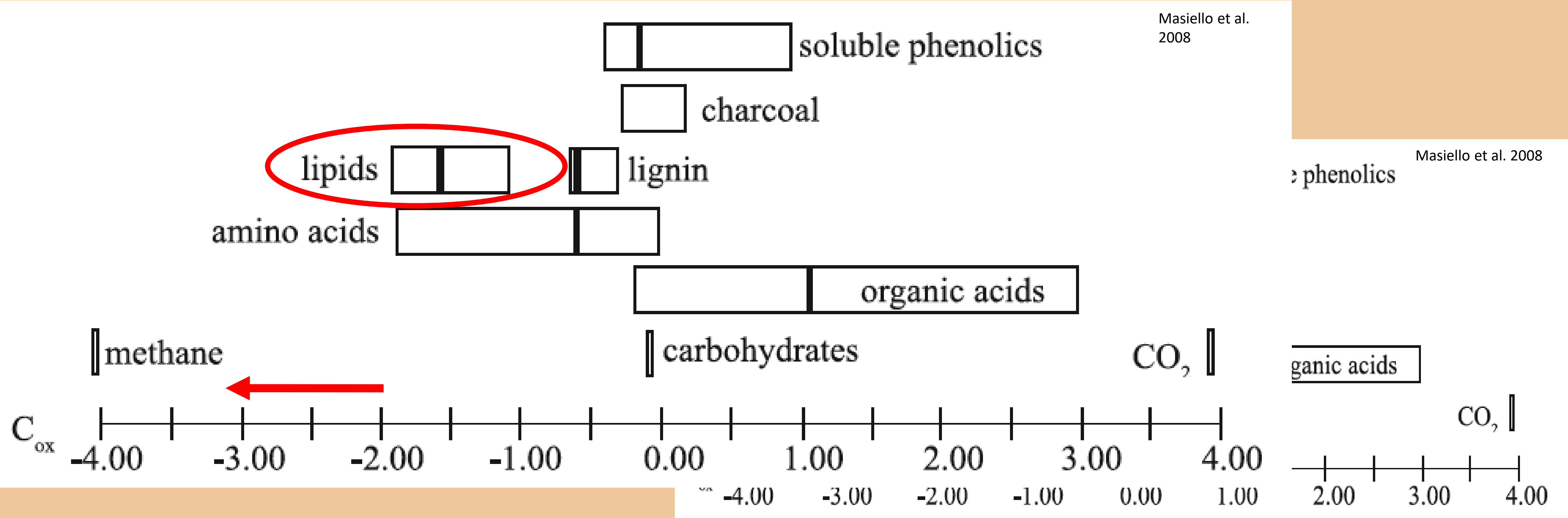
- Hexane Extraction
  - Soxhlet apparatus
  - Semi-continuous process

Quantification of aliphatic constituents



Name	Retention Time	Area %
9-Octadecene, (E)-	11.475	6.95
Cyclopropane, nonyl-	6.551	4.4
E-15-Heptadecenal	15.19	4.36
Phenol, 3,5-bis(1,1-dimethylethyl)-	10.586	3.03
1-Docosene	16.517	2.66

Identification of aliphatic constituents

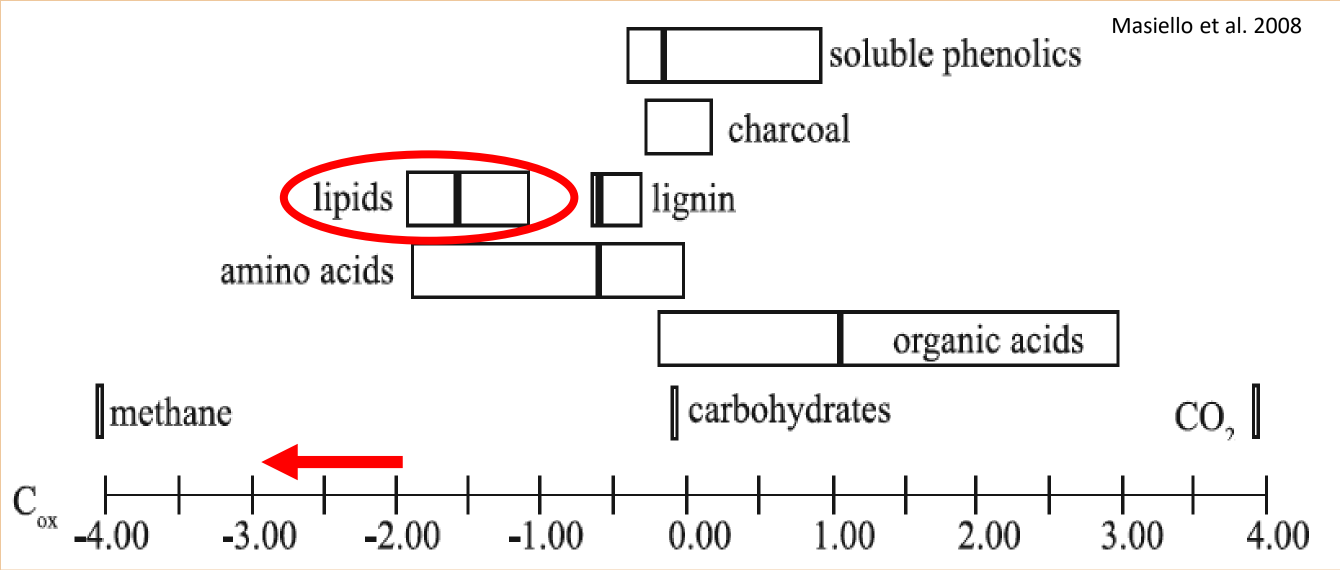


Identification of aliphatic constituents

- Nominal oxidation state of carbon

$$C_{ox} = \frac{2z - y + 3w}{x}$$

$$C_xH_yO_zN_w$$



Determine if water repellency was a response to desiccation stress

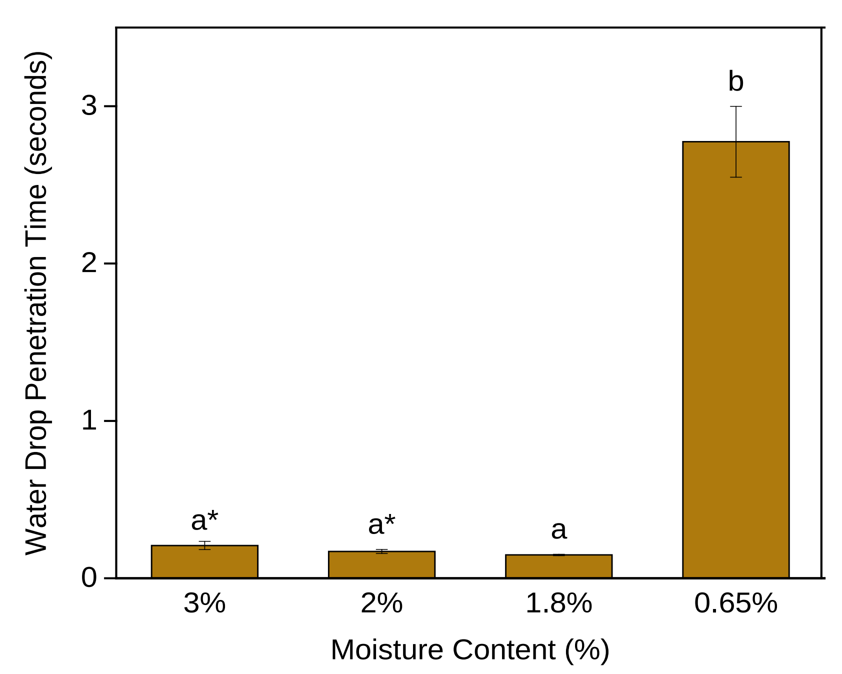


Fig. 1. Impact of moisture content on water drop penetration time. Error bars are the coefficient of variance. Letters indicate whether there was a significant difference (p < .05). Asterisks indicate difference in weeks.

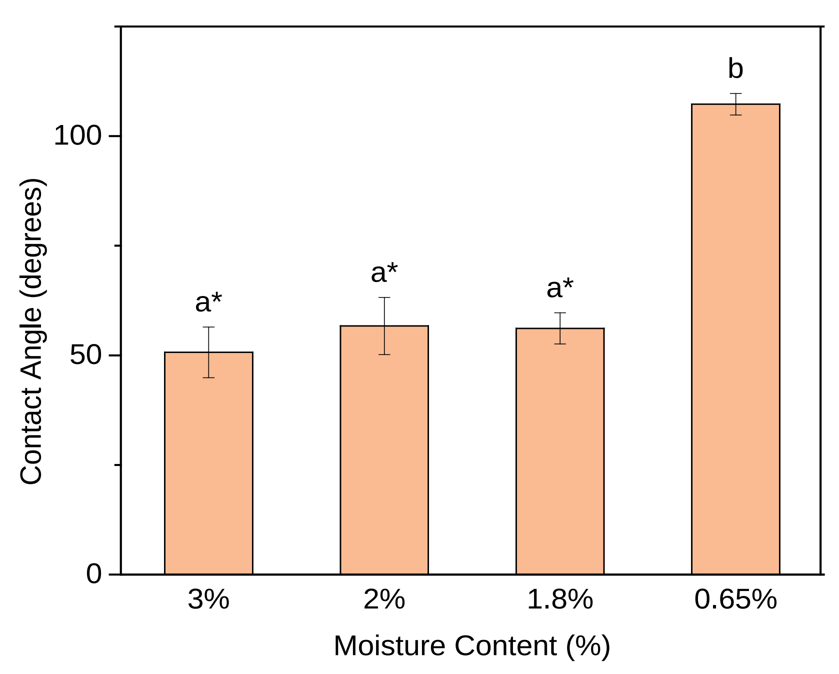


Fig. 2. Impact of moisture content on contact angle. Error bars are the coefficient of variance. Letters indicate whether there was a significant difference (p < .05). Asterisks indicate difference in weeks.

Determine if water repellency was a response to desiccation stress

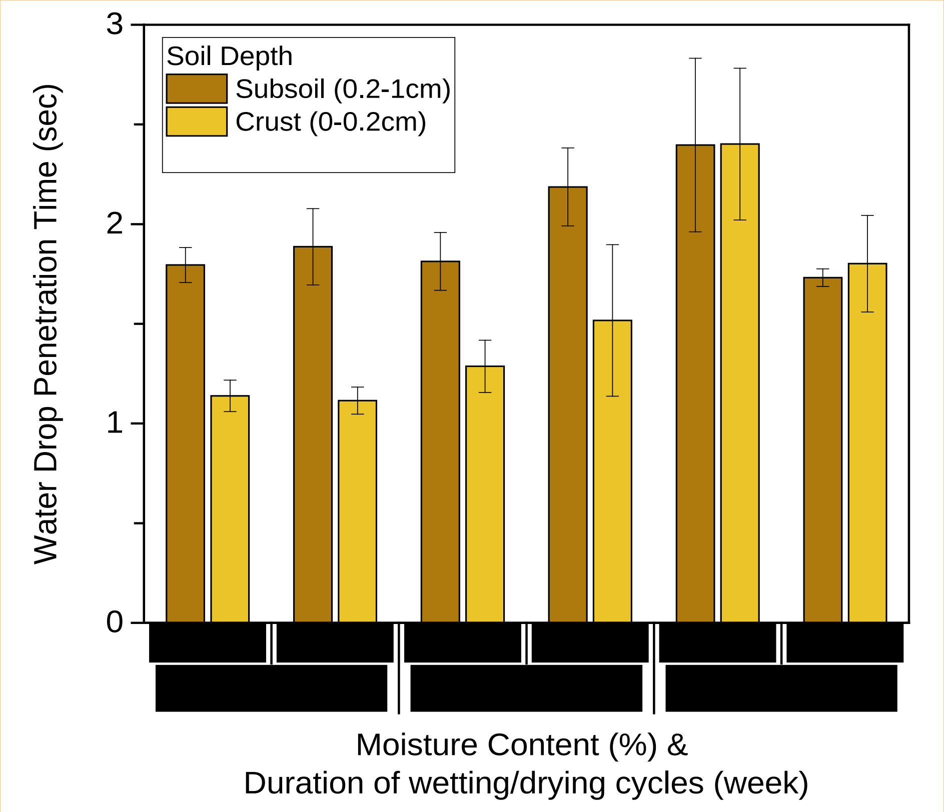


Fig. 3. Impact of duration of wetting/drying cycles, moisture content, and soil depth on water drop penetration time. Error bars calculated using the coefficient of variance.

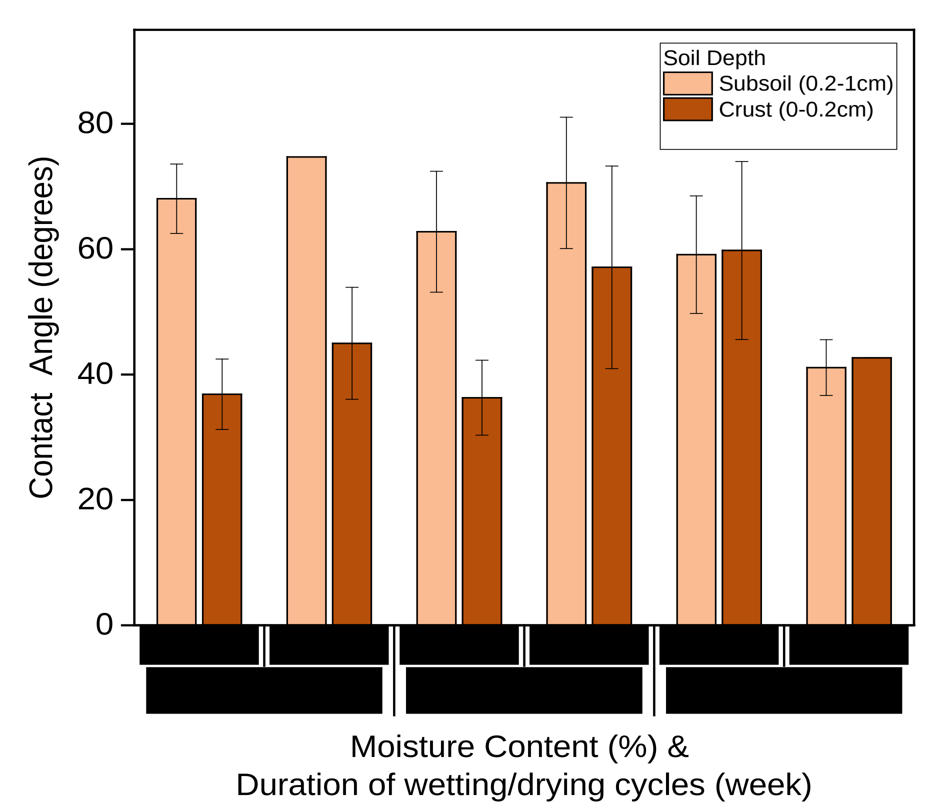


Fig. 4. Impact of duration of wetting/drying cycles, moisture content, and soil depth on contact angle. Error bars calculated using the coefficient of variance.

Determine if the microbial community actively controlled the water repellency

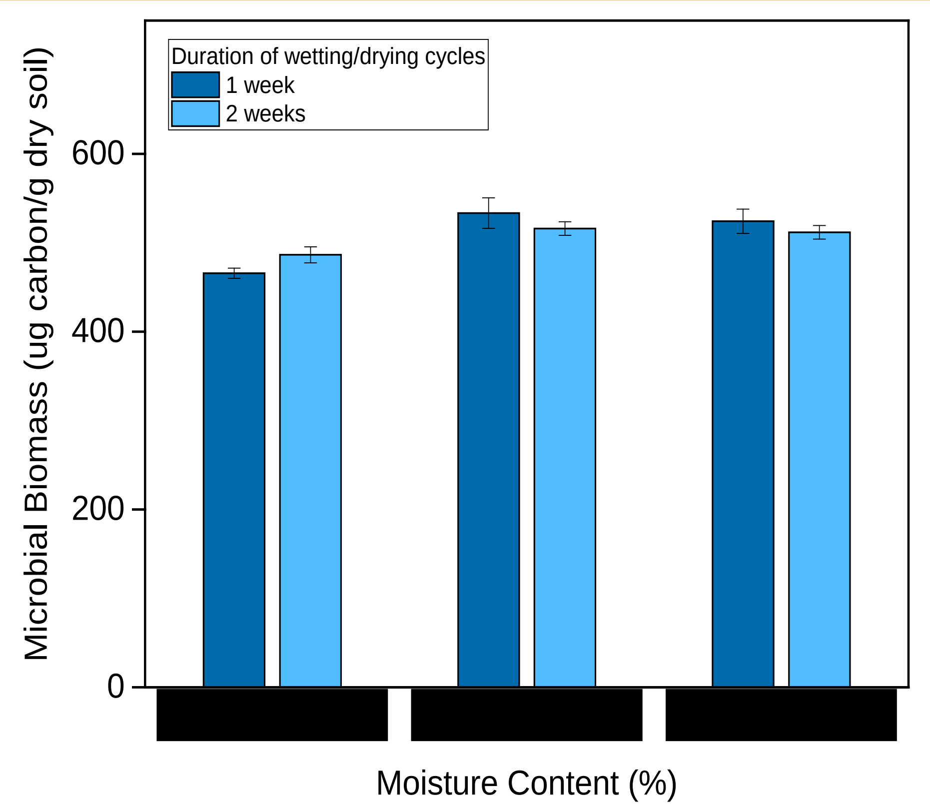


Fig. 5. Impact of moisture content on microbial biomass Error bars are coefficient of variance.

Determine if water repellency is a function of the quantity of aliphatic constituents in the soil

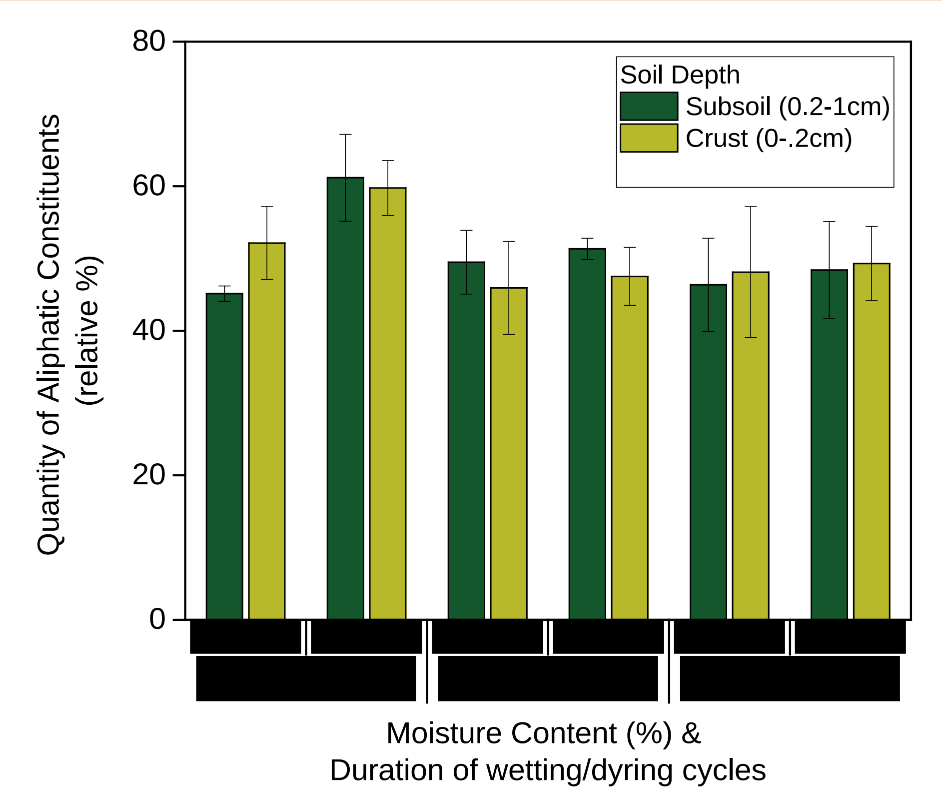
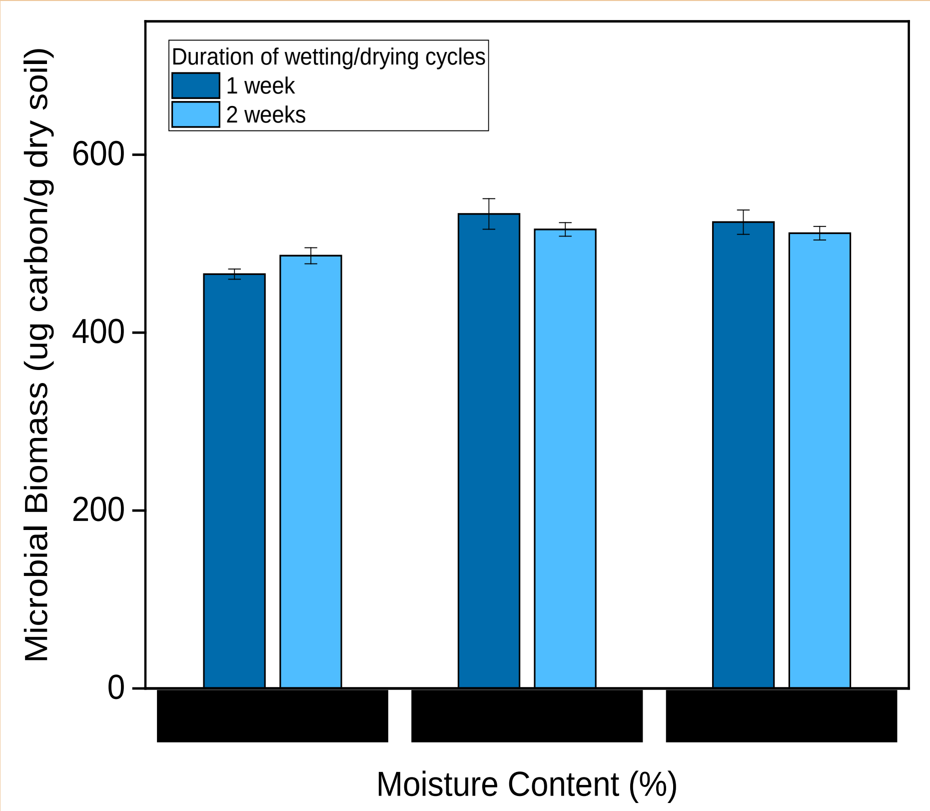


Fig. 6. Impact of moisture content on quantity of aliphatic constituents. Error bars are coefficient of variance.

Microbial Biomass



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Aliphatic Constituents

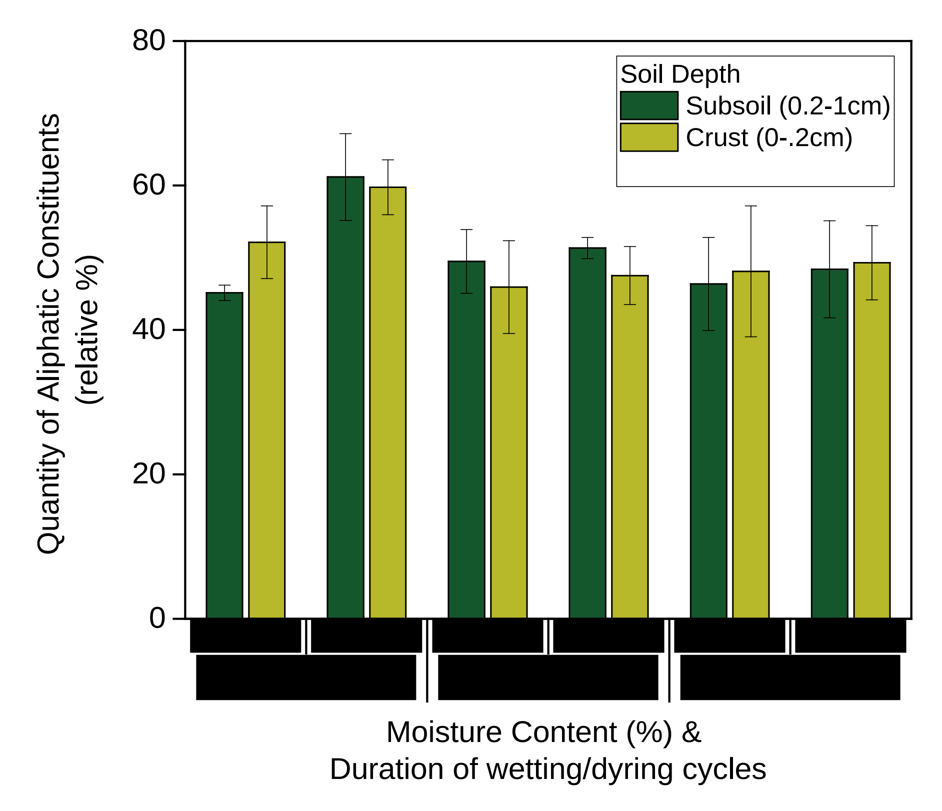

Fig. 6. Impact of moisture content on quantity of aliphatic constituents. Error bars are coefficient of variance.

Discussion Points

1. The degree of water repellency changed by moisture content over time.

2. The lower moisture content treatments were associated with a higher degree of water repellency.

3. The low moisture and high repellency treatments were found in samples that had a higher relative percentage of aliphatic constituents.

Conclusion

- Microbes may induce water repellency by producing aliphatic constituents
- Longer duration to confirm trend
- Test moisture content treatments between 1.8% and 0.65% to determine water repellency threshold

Acknowledgements

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Chris Burgess

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Thank you for your attention!