Exploring the effect of temperature and volumetric moisture content on the thermal conductivity of green roof soil

By. Helen Na Yeon Kim

At GBRL…

- Green Roof at Hayden Meadows Walmart (N Portland)
- Optimize GR performance
  - Storm Water Management (retention)
  - Heat Transfer into the Building
  - Air Conditioning (RTU) Performance
  - Urban Climate (Heat Island Effect)

Research Aims

- **Thermal conductivity of green roof soil as a function of:**
  - **Volumetric Moisture Content (mL/mL)**
  - **Temperature (°C)**

Green Roof

Background

- Thermal Conductivity (W/mK): the amount of heat passing in unit time through a unit cross-sectional area of soil under a unit temperature gradient applied in the direction of this heat flow (Farouki 1981)
- How readily/easily a material can conduct heat
- Lower the thermal conductivity, better the insulation
- moisture content, temperature, phase change of soil water, compaction level, soil structure, soil components, density and porosity of soil (Farouki 1981)

Energy Balance

- Incident global radiation
- Long-wave Radiations
- Sensible heat exchange by convection
- **Latent heat flux due to evapotranspiration**
- **Sensible heat flux by conduction through roof soil**

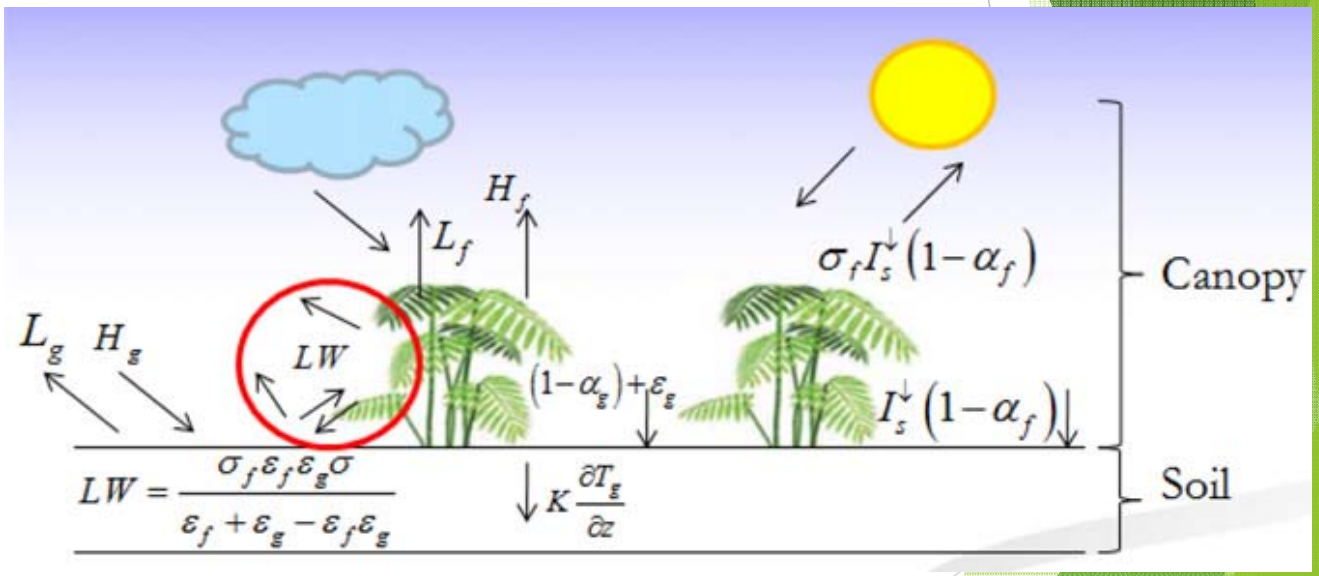


Fig 1 (Ouldboukhitine et al. 2011)

Hypothesis:

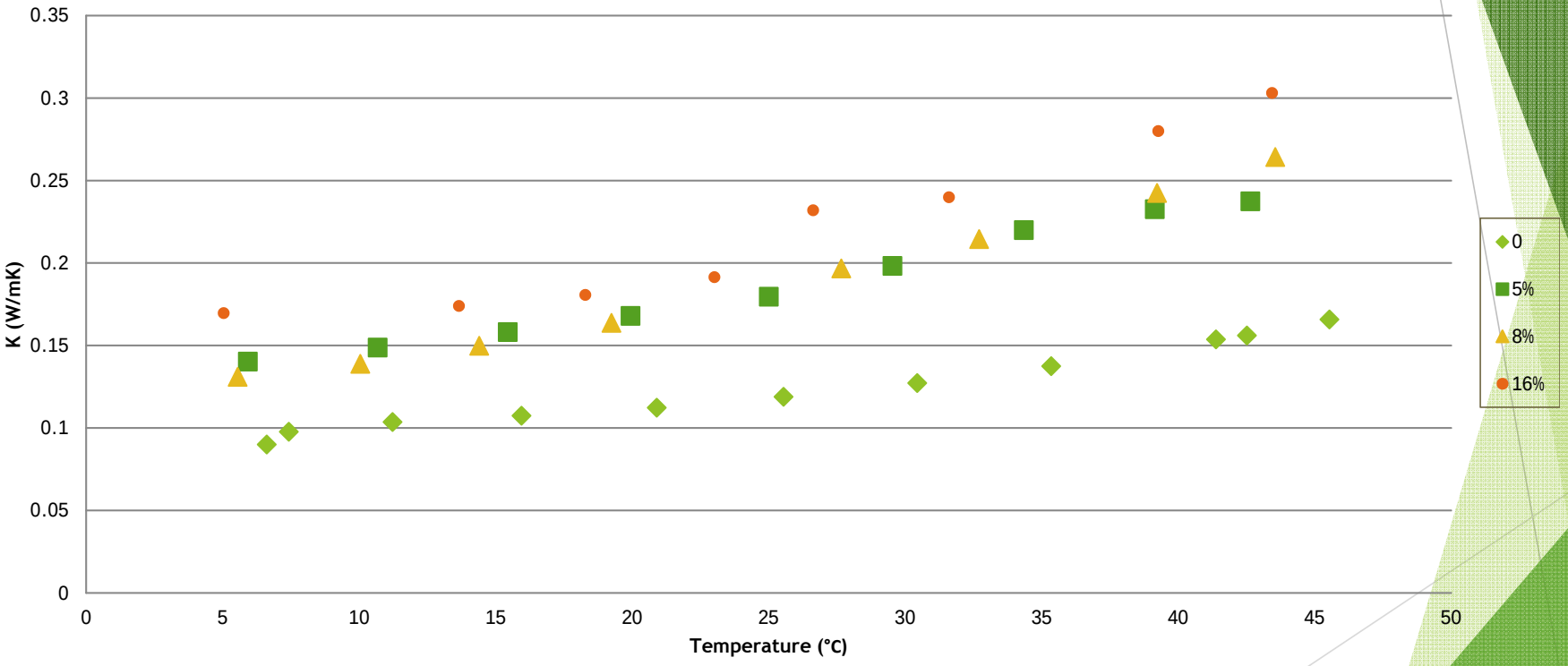
- Green roof soil will have higher thermal conductivity in average with increasing volumetric moisture content and temperature of soil.

Experimental Design

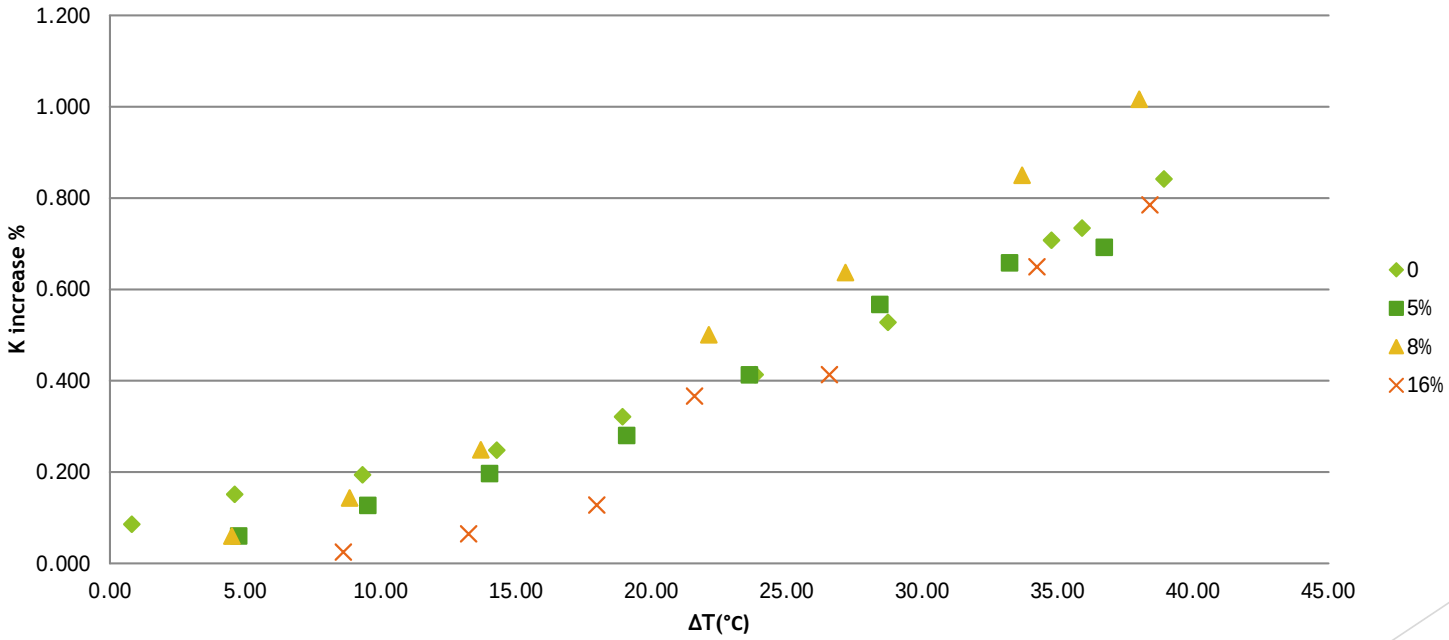
- KD2 Pro w/ dual needle probe (k and T measurements)
- Two buckets of sample soil (1250mL each)
- @ different water content levels (0%, 5%, 8%, 16%)
- Thermotron (5°C -45°C, by 5°C)
- 8 hr @ each T, 15 minute interval
- H_2O evaporated → soil weighed

Experimental Set up

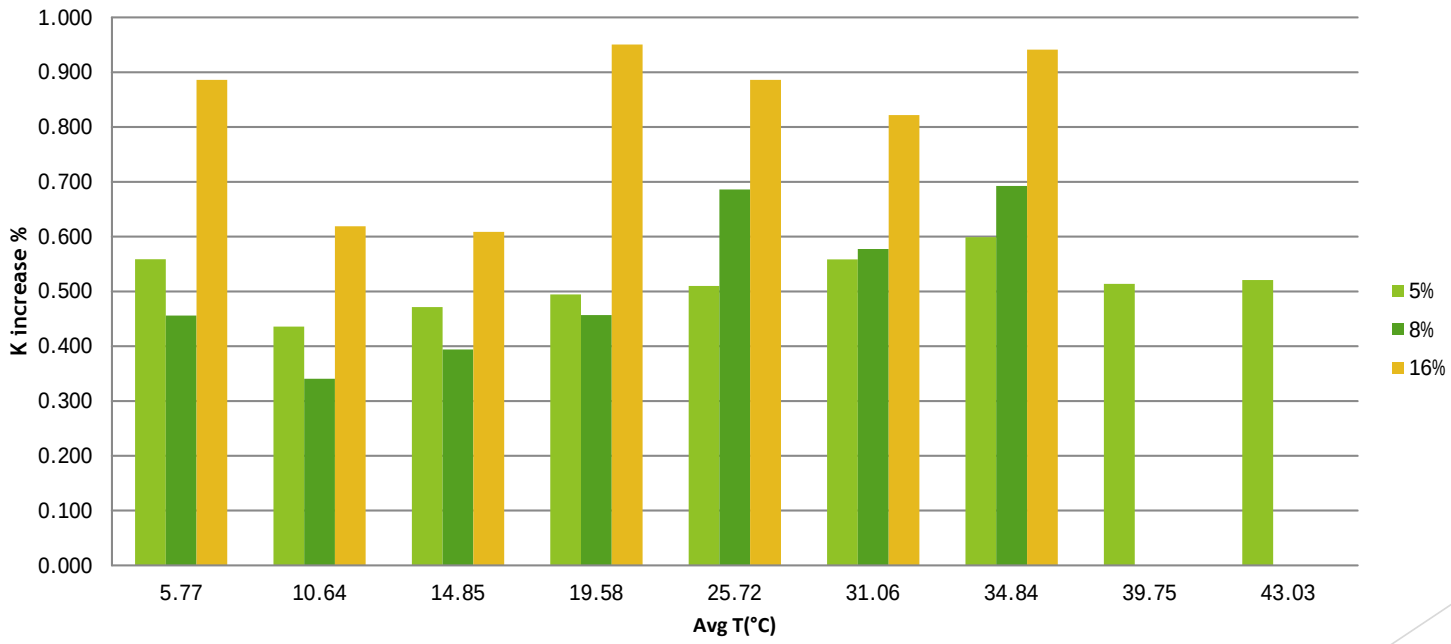
Effect of Average Temperature and Moisture Content of Soil on Average Soil Thermal Conductivity



Percentage increase in Average Thermal Conductivity Vs. Change in Average Temperature °C



Percentage increase in Thermal Conductivity Vs. Average Temperature of Soil (Comparison between Dry and Wet Soil)



Conclusion

- Average K increased by up to 83% w/ 38°C increase in average T
- Average K increased by up to 95% w/ 16% increase in moisture (5°C – 43°C)

- Temperature & Volumetric Moisture Content → SIGNIFICANT!

Citations

- Farouki, Omar T. *Thermal properties of soils*. No. CRREL-MONO-81-1. COLD REGIONS RESEARCH AND ENGINEERING LAB HANOVER NH, 1981.

- Ouldboukhitine, Salah-Eddine, Rafik Belarbi, Issa Jaffal, and Abdelkrim Trabelsi. "Assessment of green roof thermal behavior: a coupled heat and mass transfer model." *Building and Environment* 46, no. 12 (2011): 2624-2631.

Image Citations

- http://www.prarchitects.com/news/recent-news/p-r-designed-hayden-meadows-walmart-to-feature-ecoroof/ (Walmart Computer model)
- Ouldboukhitine, Salah-Eddine, Rafik Belarbi, Issa Jaffal, and Abdelkrim Trabelsi. "Assessment of green roof thermal behavior: a coupled heat and mass transfer model." *Building and Environment* 46, no. 12 (2011): 2624-2631.
- http://upload.wikimedia.org/wikipedia/en/thumb/b/b3/Portland_State_University_Logo.svg/511px-Portland_State_University_Logo.svg.png (PSU Logo)

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