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UCL

CAN VEGETATION HELP PRESERVING BUILT HERITAGE?

A case study-based approach on how boundary conditions affect the performance of vertical greening on historic building materials

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EGU General Assembly

Abstract

CONTEXT

Context:
Cities implement nature-based solutions to mitigate the urban environment but historic buildings, crucial components of urban environments, are neglected in these mitigation strategies, despite their cultural and economic values. One of the reasons for this exclusion is the uncertainty about the impact of green initiatives on historic building materials.

Aim research:
Considering the significant concerns about the impact of green initiatives on built heritage, this research explores the co-benefits of vertical greening on historic buildings by analysing environmental alterations in the microclimate and considering common degradation processes.

Methodology:
Monitoring case studies in the historic city centre of Antwerp (Belgium) enables an understanding of how vertical greening affects the local microclimate and identifies key factors determining the effectiveness of this greenery (e.g. seasonality, orientation, time of day, and cloud cover).

Implementation of vertical greening on built heritage

How vertical greening changes the local microclimate

Effect on degradation of historic building materials due to microclimatic changes

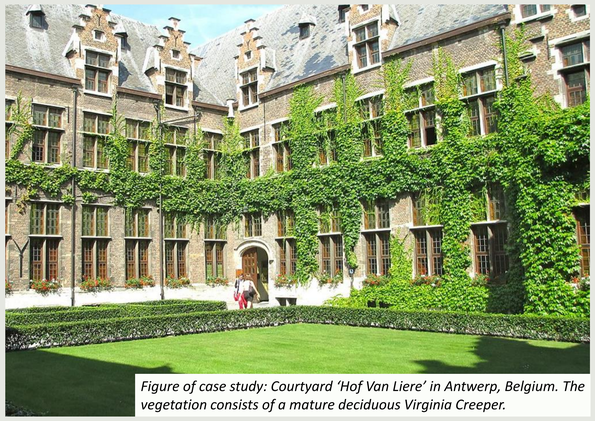
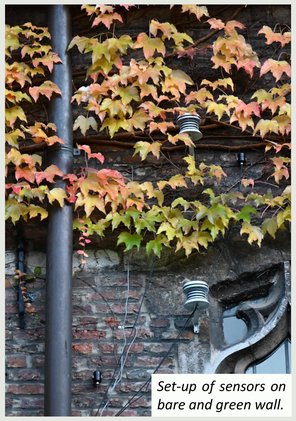


Figure of case study: Courtyard 'Hof Van Liere' in Antwerp, Belgium. The vegetation consists of a mature deciduous Virginia Creeper.

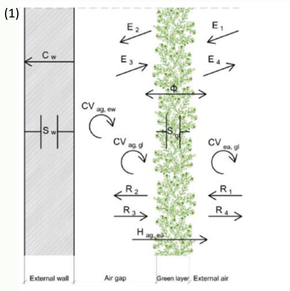


Set-up of sensors on bare and green wall.

RESULTS

General impact:
Vertical greening can **reduce the amplitude of temperature and relative humidity fluctuations** on the wall and **reduce the amount of solar irradiation** received by the wall surface. The green façade enables those **more stable conditions** on the wall surface due to different **mechanisms of the vegetation**. The following examples are three main mechanisms but are not limited to those mechanisms:

1. Vegetation produces **transpiration:** plants add moisture to the environment resulting in lower air temperatures.
2. The **vegetation layer acts as a shield** protecting the underlying wall from incoming solar irradiation, precipitation and air pollution.
3. The presence of the extra layer creates a **thermal blanketing effect** resulting in reduced heat exchange between the wall surface and the outdoor environment.



Boundary conditions affecting the performance of vertical greening:
Further analysis focuses on the **maximum and minimum values of the environmental parameters** as they have significant importance in the degradation processes of historic building materials. The **extent** of the performance of vertical greening on the wall surface depends on various **environmental boundary conditions** (including but not limited to orientation, seasonality or cloud cover) or **plant characteristics** (e.g. leaf area index, deciduous or evergreen plants). Every environmental parameter is affected by various boundary conditions but is not equally dependent on them. **Since the extent of deterioration on building façades is also dependent on different environmental boundary conditions, understanding the interaction** between the boundary conditions and the performance of vertical greening is important for a **thoughtful implementation of vertical greening**.

Figure 1: The difference in maximum surface temperatures

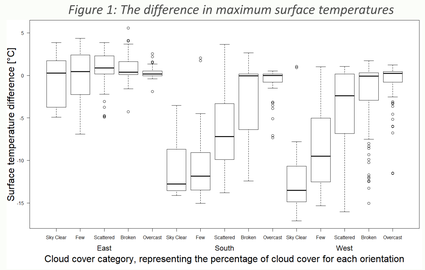


Figure 2: The reduction of the amount of solar irradiation reaching the wall surface

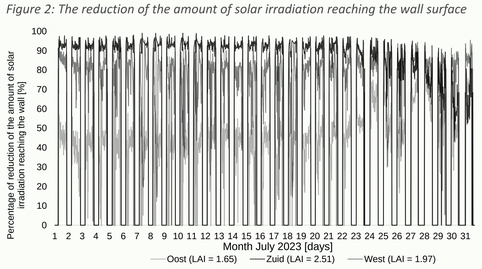
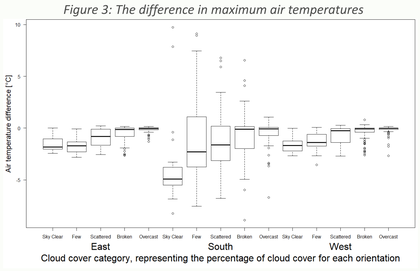


Figure 3: The difference in maximum air temperatures



Shading potential:

- Maximum surface temperatures ($T_{s,max}$) on the wall surfaces are significantly reduced:
  - An inverse correlation is observed between $T_{s,max}$ and cloudiness
  - Orientation has a significant role in cooling the wall surface. The west orientation has the most significant temperature reductions.

  The combination of those boundary conditions enhances the performance of vertical greening. In each orientation, the most significant reduction is always achieved under clear skies *(figure 1)*.
- A positive relationship between LAI and the reduction of the incoming solar irradiation on a wall surface *(figure 2)*.

Transpiration:
A decreasing air temperature *(figure 3)* and increasing relative humidity could assume the effect of transpiration. The calculations of absolute humidity in this case study can confirm the statements made by the literature:

- Transpiration increases in the morning, peaks in the afternoon and stabilizes before decreasing rapidly in the evening *(2)*.
- Cloudy weather reduces the amount of plant transpiration due to the decreased amount of solar irradiation and increased humidity *(3)*.

SET-UP

Sensors installed in May 2023

What?
Air temperature & relative humidity
Distance: 10 cm
Frequency: 15 minutes

What?
Solar irradiation
Distance: 0 cm
Frequency: 15 minutes

What?
Surface temperature
Distance: 0 cm
Frequency: 15 minutes

By monitoring environmental parameters on a bare wall and a vegetated wall for almost a year, a comparison can be made between the two types of wall. This comparison demonstrates how vertical greening can alter the local environment and provides insight into the relationship between vertical greening and its processes affecting the local environment.

Additional measurements are recently added considering the wind-driven rain and the moisture content of a bare and green wall.

CONCLUSION & FURTHER RESEARCH

Conclusion:
This research explores the preventive conservation potential of controlled vertical greening, in co-benefits with (micro)climate mitigation. Steadier conditions on wall surfaces created by vertical greening can extend the longevity of (historic) building materials while mitigating its local microclimate. The mature Virginia Creeper in this case study helps us understand the behaviour of green façades during summertime. The vegetation layer cools the environment mainly by transpiration and shadowing. Understanding the boundary conditions affecting the preventive conservation potential of vertical greening can assist urban designers in the application of vertical greening. For instance: the results of this case study demonstrate that vertical greening enables more stable surface temperature fluctuations, reducing the risk of salt crystallization. This effect is reinforced when having a high LAI or an implementation in the south or west orientation.

Further research:
Further research is needed to understand the impact of vertical in more detail and to assist the implementation on built heritage to unlock the co-benefits:

- Data on moisture content behind a vegetation layer is currently developing
- Investigating the most suitable implementation method depending on wall condition and needs, is necessary
- Looking into different plant types as vertical greening
- Impact on different (historic) building materials

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