

Unterstützung der Klimatisierung von energetisch hocheffizienten Gebäuden durch vertikale Innenraumbegrünung

**Vertical indoor greenings as support for climate control in
low-energy buildings**

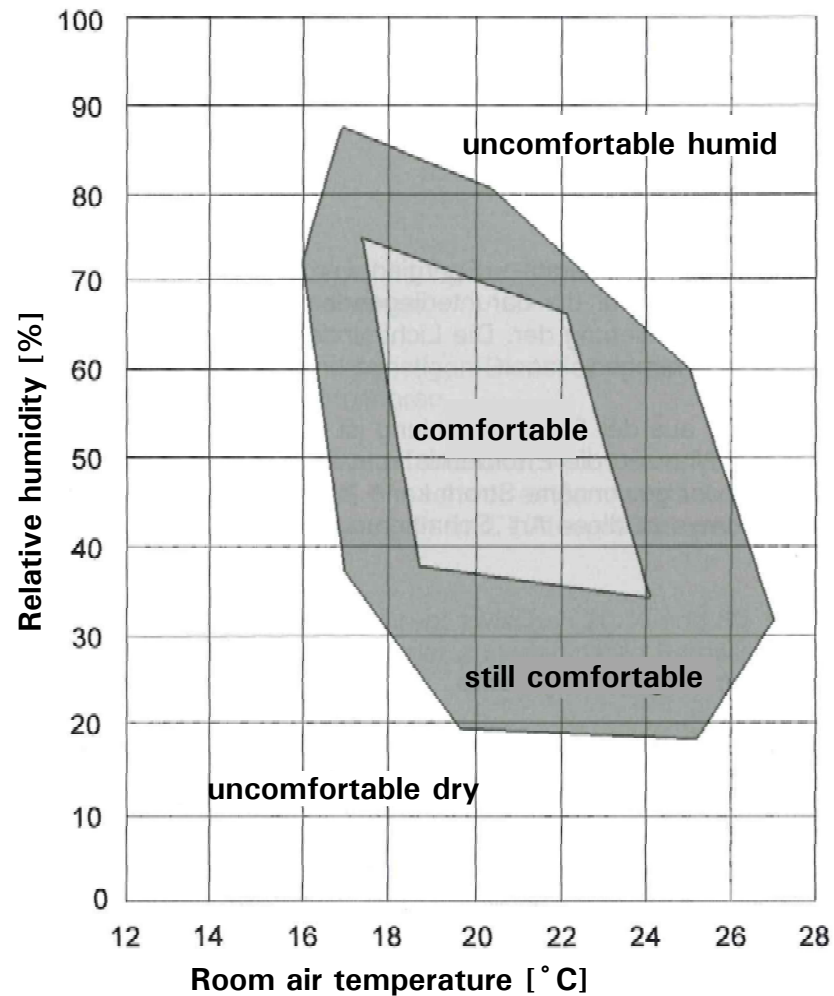
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Relative humidity in interior rooms



Comfort range for room air temperature and relative humidity in interior rooms

(according to Leusden and Freymark in FLL-Innenraumbegrünungsrichtlinien, 2011)



Increasing relative humidity by potplants

Measurement chamber for transpiration and photosynthesis

Results:

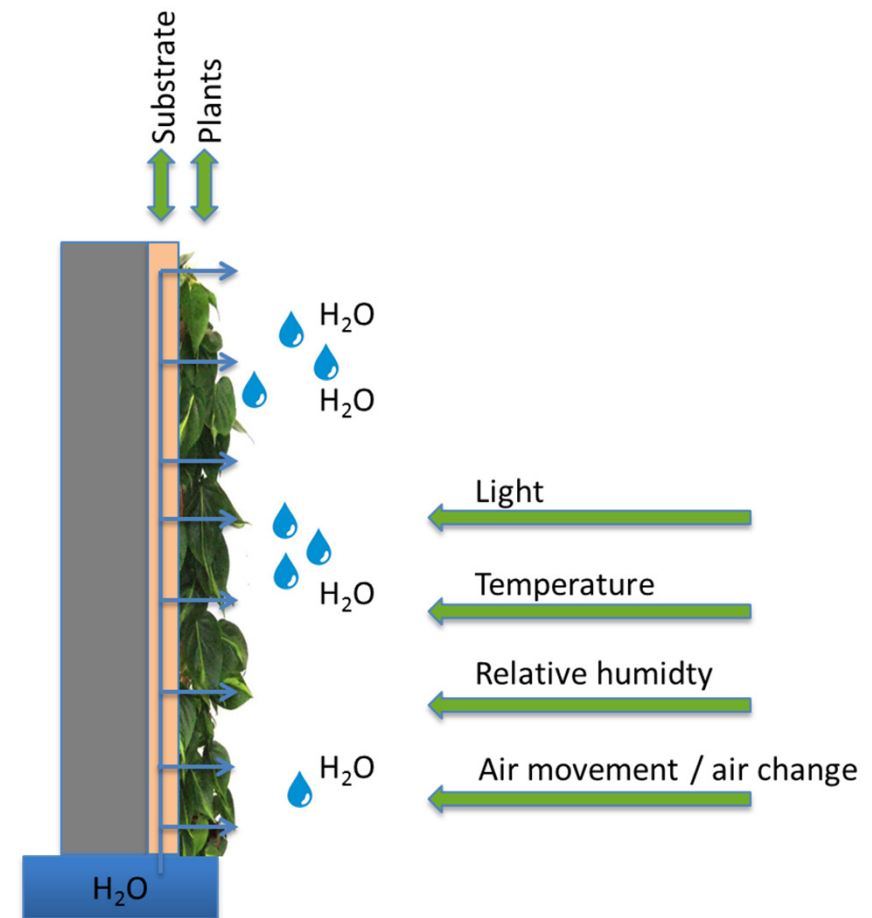
Transpiration of *Sparrmannia africana* or *Ficus benjamina* increased interior relative humidity about **4 to 5 %** under best growing conditions



Approach: use of functional, vertical greenings to increase relative humidity

Characteristics:

- » Air moistening is passive and thus hygienically uncritical
- » Mineral substrate is chemically and physically stable
- » Mode of action corresponds to a vegetated surface evaporator



Mode of action of a functional, vertical greening

Experimental setup

Part 1

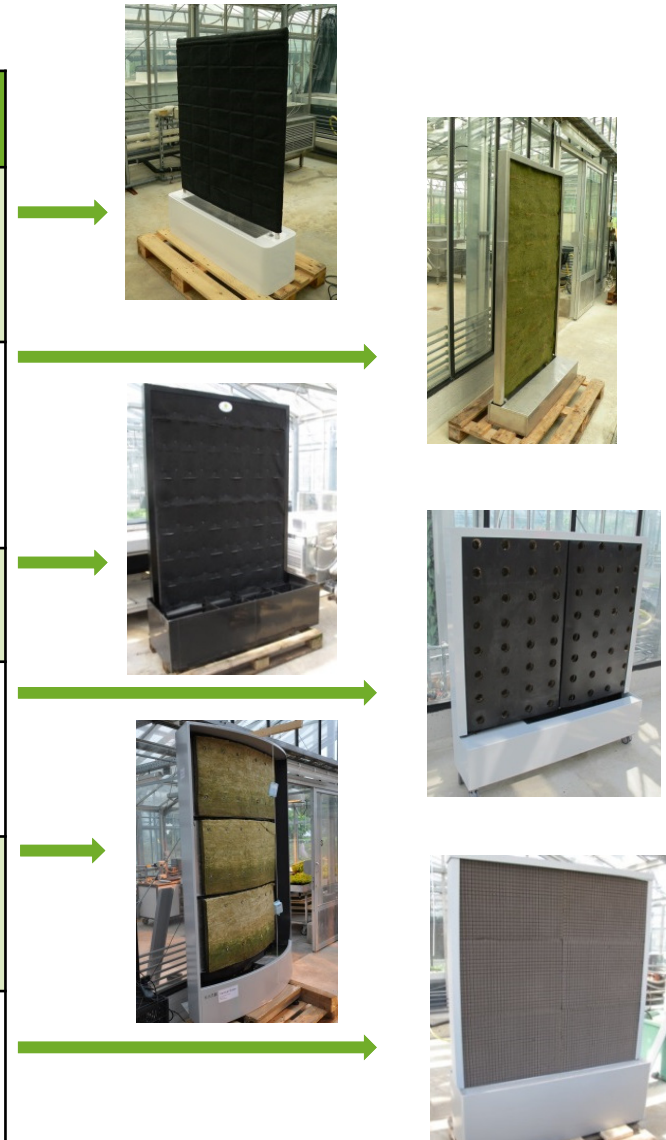
1. Selection of potentially suitable vertical greening systems
2. Recording of evaporation under controlled conditions
 - without plants
 - with plants (*Philodendron hederaceum*)
 - variation of the room climate (temperature, air movement)
 - approach to optimal irrigation-cycles
3. Identification of a suitable low-energy building

Part 2

4. Test under realistic conditions in offices

Comparison of vertical indoor greening systems

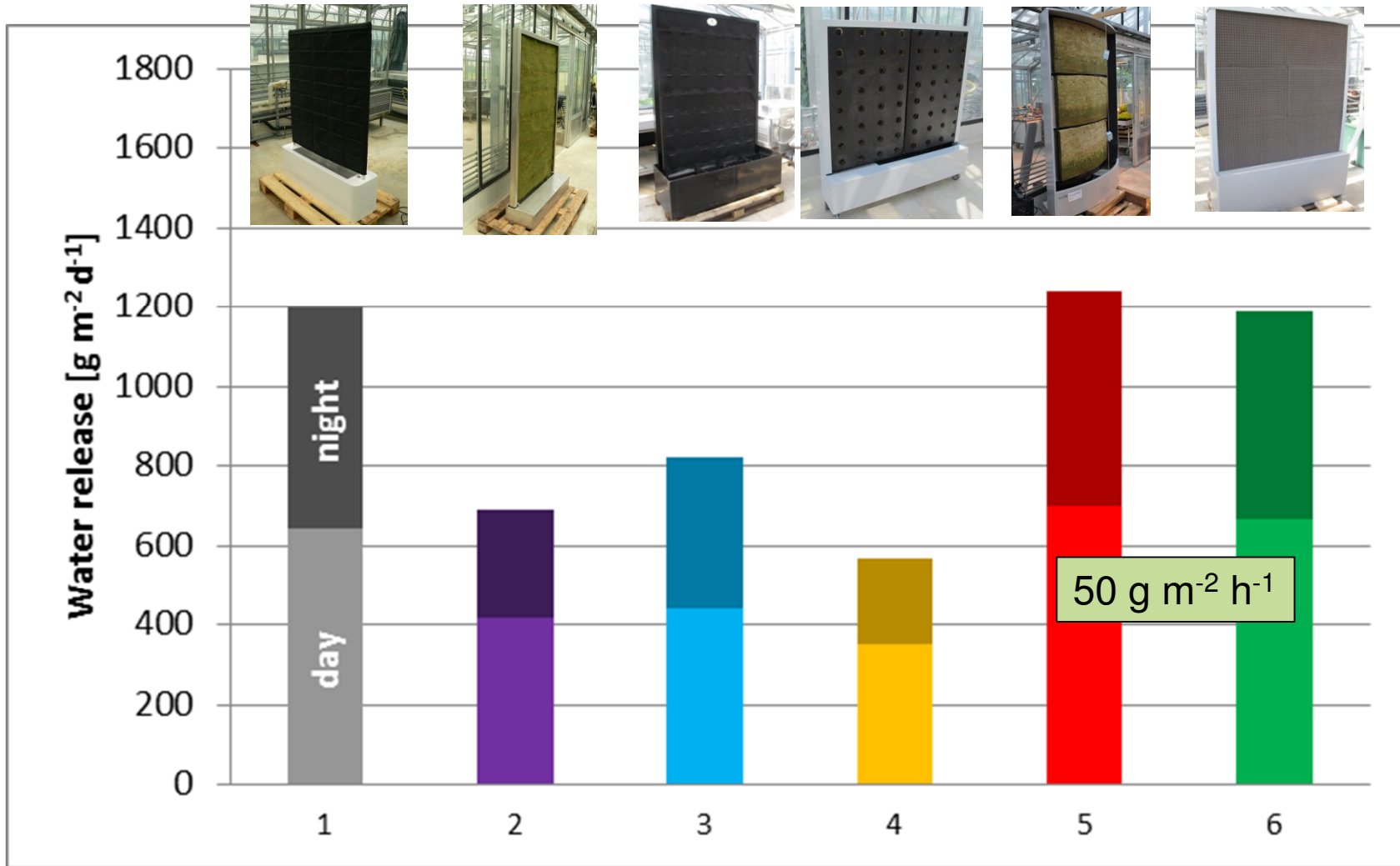
No.	Product	Provider	Substrate
1	Moving Wall	Sempergreen Vertical Systems, NL	Felt pockets
2	Vertiko	Vertiko GmbH, D	Several layers of non- woven material forming pockets filled with mineral substrate
3	Wonderwall	Copijn Utrecht, NL	Multilayered felt pockets
4	Wallflore Flex	Wallflore Systems, NL	Rockwool (Saint-Gobain / Cutilene), wrapped up in a waterproof felt layer
5	Vertical Green	Ruof Grün Raum Konzepte, D	Rockwool
6	Grüne Wand	H & W Bewässerung GmbH, D	Phenolic foam (Oasis)





Experimental setup: Vertical greening systems with plants were placed on scales in the greenhouse

Results - Greenhouse



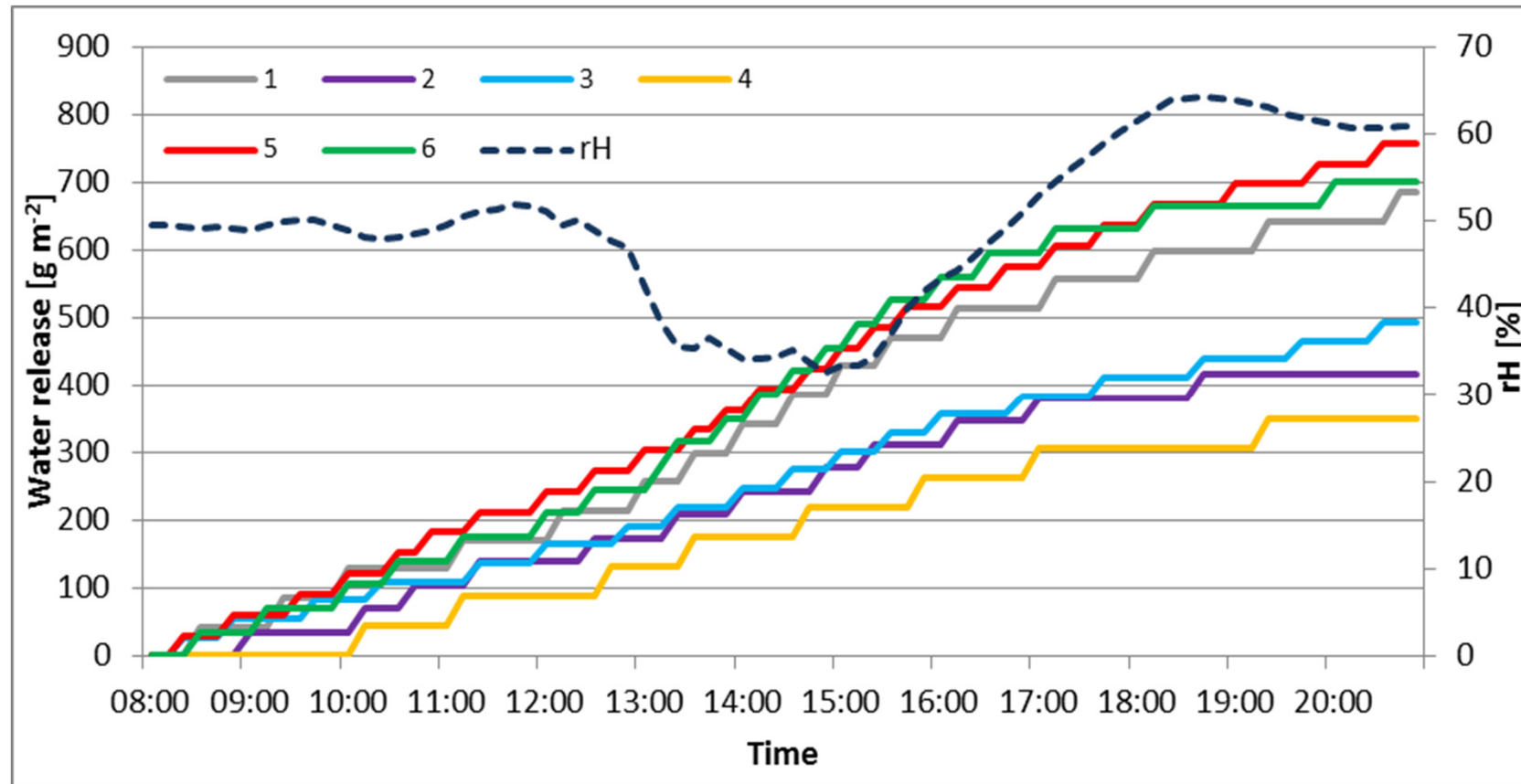
Water release of vertical greenings with plants and optimized irrigation (spread over 24 hours)

Contribution to humidity (water vapour) in homes

Source	Release of water vapour
Sleeping person	40 - 50 g h ⁻¹
Person at domestic work	90 g h ⁻¹
Person at physical loaded work	175 g h ⁻¹
Potplants	7 - 15 g h ⁻¹
Ficus (medium high)	10 - 20 g h ⁻¹
Laundry (washing machine)	200 - 350 g wash ⁻¹
Drying clothes (4,5 kg, spin-dried)	50 - 200 g h ⁻¹
Frying	600 g h ⁻¹
Cooking	450 - 900 g h ⁻¹
Dishwasher	200 g wash ⁻¹
Bath	1100 g bath ⁻¹
Shower	1700 g shower ⁻¹

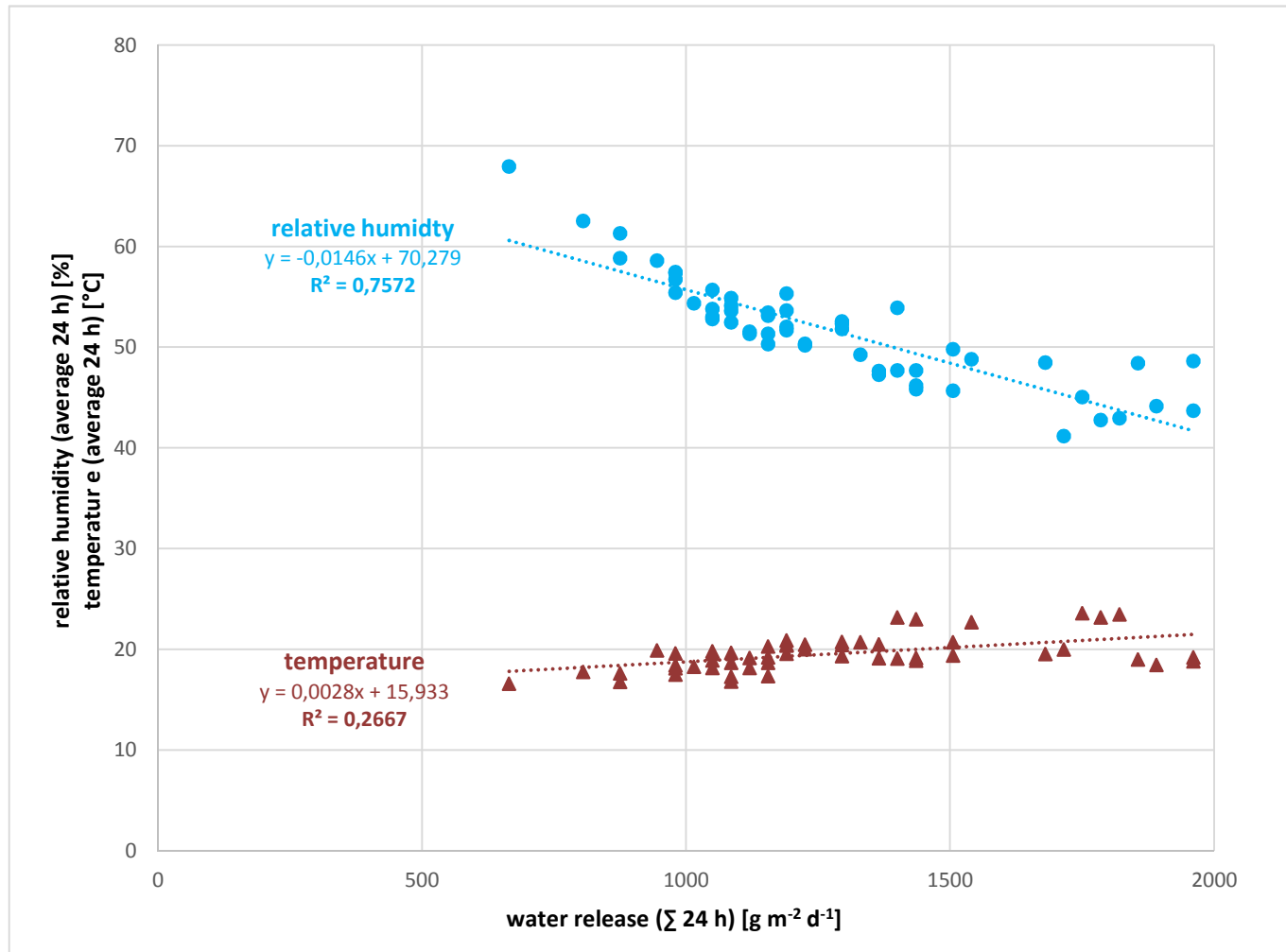
Vertical greenings:
25 - 50 g m⁻² h⁻¹

Results - Greenhouse



Effect of relative humidity on water release from vertical greenings with plants equipped with optimized irrigation (spread over 24 hours)

Values added up from 8:00 to 19:50 Uhr



System 6: Correlation between water release with plants and relative humidity or temperature



System 1



System 2



System 3



System 4



System 5



System 6

**Systems
after 4
months
with plants**

**Highly targeted
system:**

- Water release
- Practicability
- Available on the market

Conclusions – Part 1

Comparison of systems in the greenhouse

- » Significant differences between the systems (water release, user friendliness, reliability)
- » $50 \text{ g m}^{-2} \text{ h}^{-1}$ water release with the systems 5 and 6
- » Increase in relative humidity caused by the systems is higher than by potplants
- » Self-regulatory effect related to relative air humidity was visible



System 6



System 5

Experimental setup

Part 1

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Part 2

4. Test under realistic conditions in offices

Large office



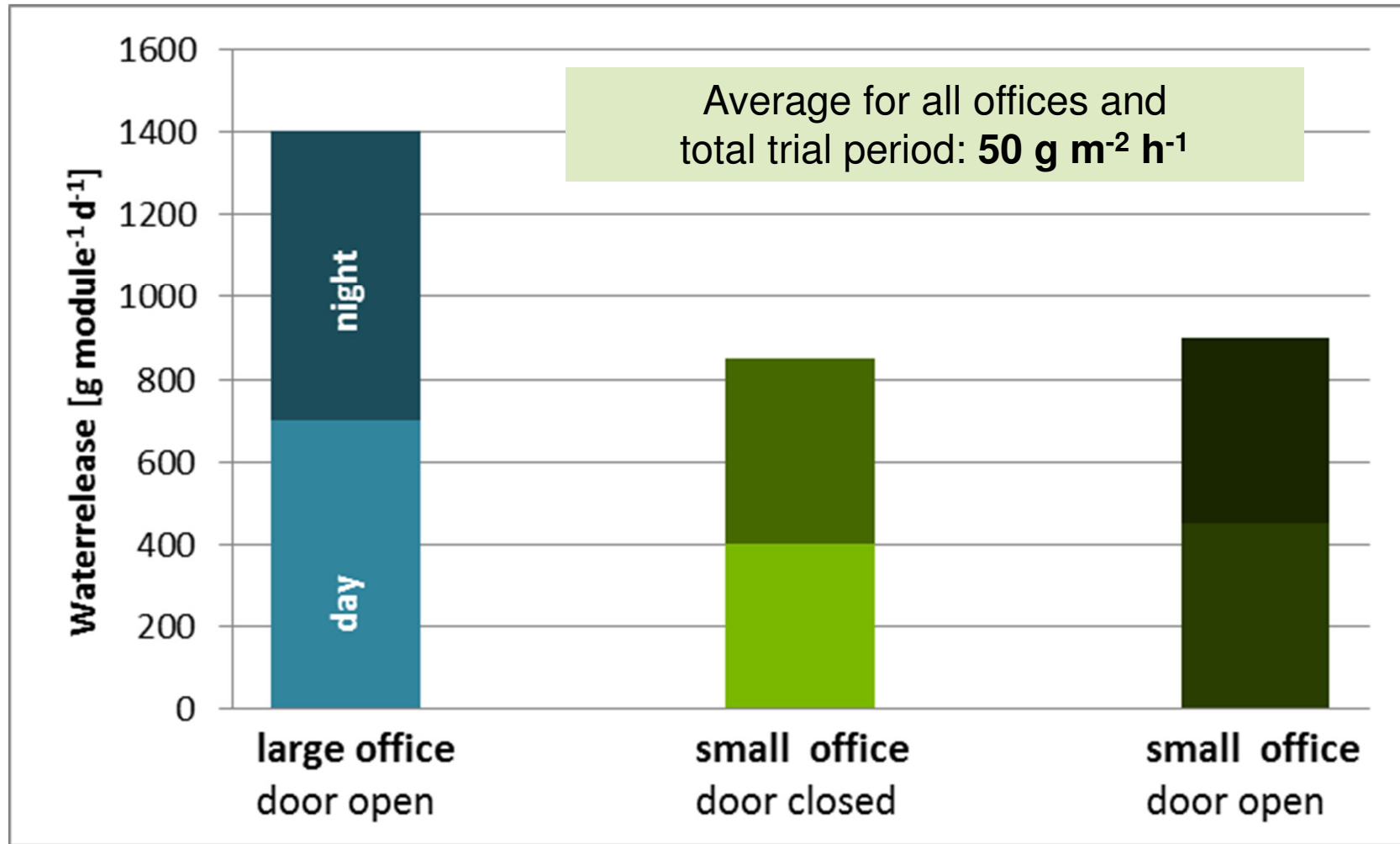
- » large office 33 m²
- » equipped with 1,4 m² of system 6

Small office

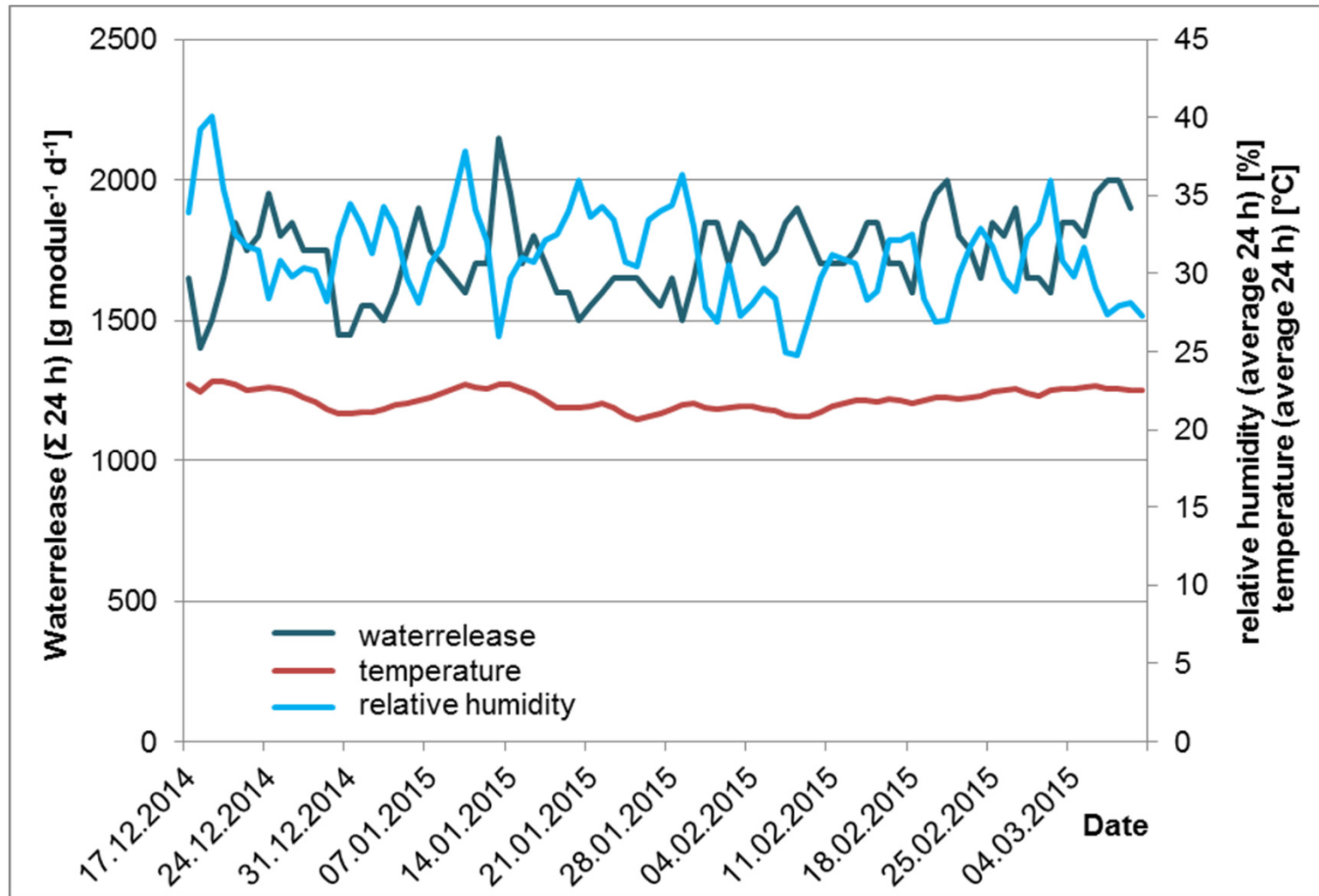


- » small office 17 m²
- » equipped with 0,7 m² of system 6

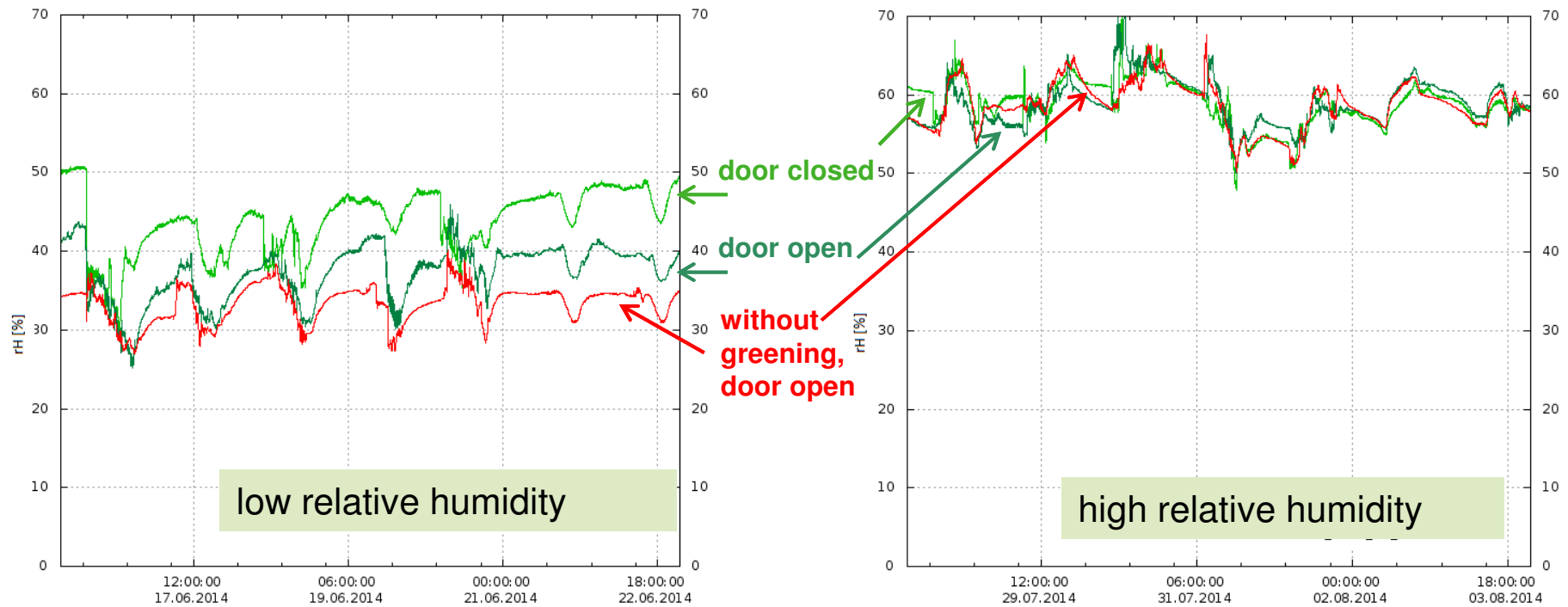
Results: Office



Water release per module and day in the offices



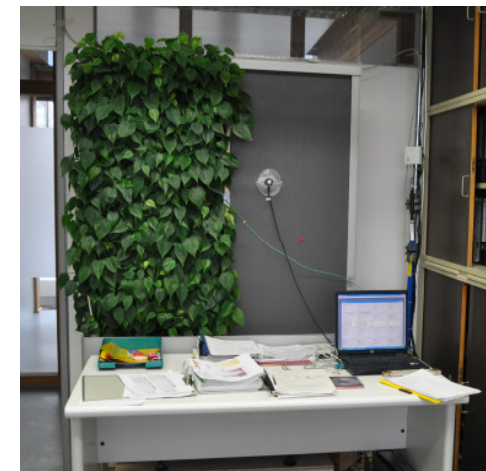
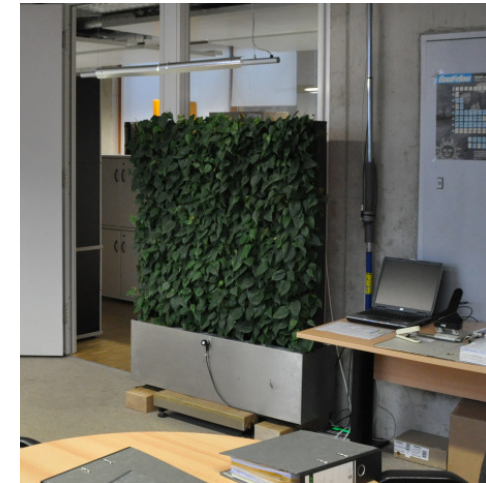
Development of water release [$\text{g module}^{-1} \text{d}^{-1}$], temperature [$^{\circ}\text{C}$] and relative humidity [%] in the large office with greening



Development of relative humidity in small offices (17 m²) with and without system 6 and different user behaviour

Maximum difference in standardized relative humidity between the office with and without greening

Office size	User behaviour	Max. difference in standardized relative humidity [%-points] between the office with and without system 6
large (33 m ²)	Door mostly open	8,3
small (17 m ²)	Door mostly closed	19,5
small (17 m ²)	Door mostly open	13,8



Conclusions – Part 2

Using system 6 under real conditions in offices

- » Water release of system 6 in offices was on average in the same range as in greenhouses ($50 \text{ g m}^{-2} \text{ h}^{-1}$)
- » Increase of relative humidity was about 20 %-points on maximum, when the initial relative humidity was low and the door closed
- » Self-regulatory effect: low water release with high initial humidity in the room
- » User conduct in the office had distinct influence on effectiveness

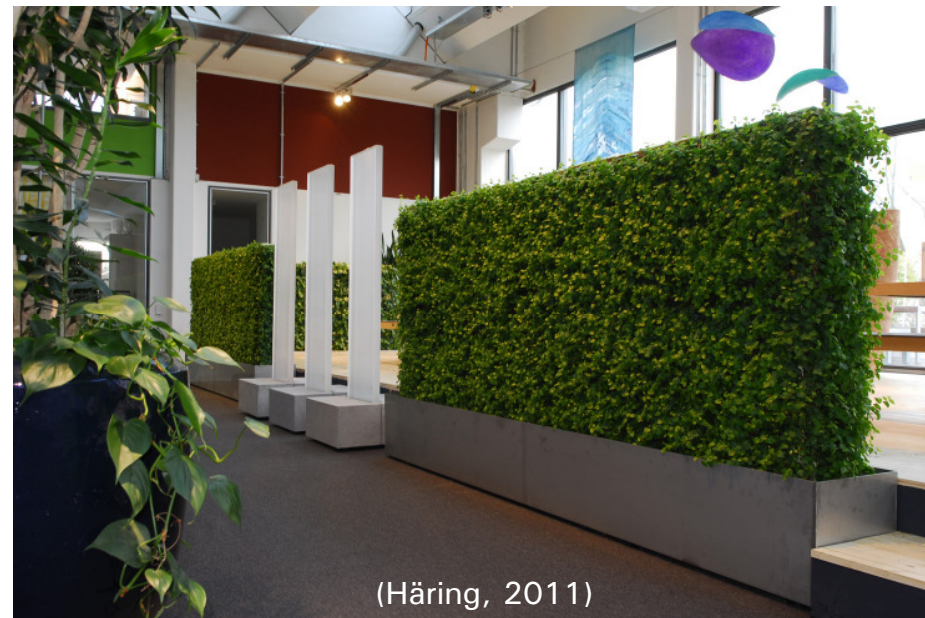


Strictly necessary:

- » Close meshed controll of greening system function
- » Artificial light necessary in most cases
- » Use system that fits horticultural requirements
- » Calculation of greening size depending on room size and room characteristics
- » Consider user behaviour



Increasing relative humidity with vertical indoor greenings in offices is possible



(Häring, 2011)