Image: mooiwatplantendoen.nl

AIR QUALITY

The major outdoor air pollutants (nitrous oxides (NO_x), particulates (PM10/PM2.5) and volatile organic compounds such as benzene) come from industry and traffic. Long-term exposure to these substances leads to lung problems and cardiovascular disease. Although air quality at most locations in the Netherlands complies with standards, this does not mean the risk is eliminated entirely. There is no safe lower limit, and concentrations can rise considerably in areas close to busy roads and intersections.

Indoor air quality is often poor; large numbers of people in a relatively small space frequently cause CO_2 levels to rise significantly. Volatile organic compounds from construction materials (such as formaldehyde and benzene) may also be present.

HOW GREENERY WORKS

- Indoor vegetation can be used to improve air quality in healthcare institutions. Given enough light and water, plants absorb CO_2 from the air, helping to reduce ambient CO_2 levels. [1]
- Indoor plants can also help humidify dry air inside buildings.
- Plants filter volatile organic compounds from the atmosphere. For example, it has been shown that the Peace Lily (Spathiphyllum, a well-known indoor plant) can absorb and convert 20 mg of formaldehyde per 500 grams of foliage per hour. Formaldehyde is a common disinfectant, but in excessive doses can be poisonous and carcinogenic to humans. [2]

RECOMMENDATIONS

- Include indoor plants to improve the air quality inside buildings through the removal of pollutants (especially CO_2 and volatile organic compounds) and by improving humidification.
- Plant shade trees in car parks to reduce the evaporation of fuel from fuel tanks, reduce visitors' heat stress and lower fuel consumption by reducing the use of air-conditioning in cars.
- Due to the importance of environmental air exchange on air quality, vegetation around healthcare institutions must be planted to allow for effective airflow.
- Planting dense vegetation can help protect sensitive locations such as hospitals and aged-care facilities from local sources of pollution (especially roads).

Image: mooiwatplantendoen.nl

Sources:
1. van Duijn, B., Klein Hesselink, J., Kester, M., Jansen, J. & Spitters, H., 2011. Report: 'Plant in de klas' [Plants in the classroom]. PT/Fytagoras/TNO.
2. BC Wolverton; WL Douglas; K Bounds (July 1989). A study of interior landscape plants for indoor air pollution abatement (Report). NASA. NASA-TM-108061.

FURTHER INFORMATION

There are many real-life applications that illustrate and demonstrate the added value of vegetation. Useful sources of information include:

www.thegreencity.com
www.wur.nl
www.royalfloraholland.com
www.groenkennisnet.nl

Specific questions on topics such as reference projects, research results, etc. can be sent directly to **joop.spijker@wur.nl**.

Greenery in and around nursing homes, hospitals and clinics is beneficial for the climate inside and outside the organisation, and has a positive effect on the patients' state of mind and ability to recover, as well as the general well-being of patients, staff and visitors.
This document provides information on the benefits of greenery in relation to recovery and well-being, including references to scientific literature. It concludes with some tips on how to ensure the successful and beneficial inclusion of greenery.

WHAT DOES GREENERY DO?

- Visible greenery, both indoors and out, reduces stress among patients and staff.
- Plants in hospitals and other institutions purify the air: they reduce concentrations of CO_2 and volatile organic compounds, keeping the air fresh and healthy.
- External vegetation reduces heat in and around buildings in the summer, lowering heat stress and reducing the need for air-conditioning.
- Green roofs and facades increase insulation capacity, reducing both heating and cooling expenditure.
- A green environment is more attractive and creates more variety, moving the focus away from pain and stress.
- Indoor plants release water vapour, humidifying the air and reducing the likelihood of headaches.
- In green environments, people spend more time outdoors and are more active. This also applies to the elderly and ambulatory patients.

APPLICATIONS

- Courtyards and other gardens as relaxation/quiet areas.
- Courtyards and other gardens as treatment areas.
- Green roofs and facades.
- Green walls and indoor gardens in central areas, company restaurants, waiting rooms and some treatment areas.
- Attractive landscaping of the hospital grounds, including green borders and trees.
- Continuing the landscape's natural flow of greenery around the hospital.

PROVEN SUCCESS

- In-bed recovery time is 20% shorter for patients whose view includes greenery. [1]
- Nursing homes that include greenery will triple their volunteer count.
- Patients staying in green environments use 30% less painkillers.
- 'I just feel unwell', said one cancer patient receiving treatment in the 'chemo garden'.

Sources:
1. Ulrich, R. S. (1984). View through a window may influence recovery from surgery. Science, 224: 420- 421.

TEMPERATURE

Many hospitals are located in urban areas, where average temperatures are higher than in surrounding areas (the 'heat-island' effect). This effect occurs in both metropolitan and provincial cities, and increases as built-up areas become denser. Measured maximum differences vary from one to several degrees, with peak values reaching around 8 °C and incidental values even exceeding 10 degrees. Heat stress caused by excessively high temperatures adversely affects health (particularly among the elderly, chronically ill and pregnant women) and can increase mortality rates. It also negatively affects the ability of staff to work and concentrate. Research has shown that even now, heat stress occurs in 35% of Dutch urban areas at least 7 days per year. Rising urban density and global warming will increase the frequency of periods of heat stress in the city. However, greenery can help to lower city temperatures.

HOW GREENERY WORKS

- Green provides cooling by blocking solar radiation (i.e. providing shade) and aiding evaporation; a 10% increase in vegetation can reduce the urban heat-island effect by an average of 0.6 °C. [1]
- Green roofs (potentially in combination with green facades) improve building insulation. They reduce warming in hospital buildings, both limiting the effects of heat stress on patients and staff and lowering heating and cooling expenses. [2]
- Planting vegetation around hospitals helps reduce environmental heat stress, and is most effective when the cooler air coming from the greenery is not impeded. [3]
- Green areas also help trap CO_2. [4]
- Shade trees above car parks reduce fuel evaporation from tanks, and reduce heat in car interiors. [5]

RECOMMENDATIONS

- Green roofs atop health institutions reduce heating and cooling costs.
- Increasing vegetated surfaces around health institutions and planting trees on nature strips reduces the heat-island effect.
- Larger green zones in and around hospital areas can help create a more pleasant climate in the broader surrounds, provided the area is structured and landscaped to allow for effective flow of air.

Sources:
1. Steeneveld, G. J., Koopmans, S., Heusinkveld, B. G., van Hove, L. W. A., & Holtslag, A. A. M. (2011). Quantifying urban heat island effects and human comfort for cities of variable size and urban morphology in the Netherlands. Journal of geophysical research. D, Atmospheres, 116(D20129).
2. Hop, M.E.C.M. & Hiemstra, J.A., 2013. Ecosysteemdiensten van groene daken en gevels: Een literatuurstudie naar diensten op het niveau van wijk en stad [The ecosystem services provided by green roofs and walls: a literature study on services at district and city level]. Wageningen UR – PPO.
3. van Hove, L. W. A., Jacobs, C. M. J., Heusinkveld, B. G., Elbers, J. A., van Driel, B. L., & Holtslag, A. A. M. (2015). Temporal and spatial variability of urban heat island and thermal comfort within the Rotterdam agglomeration. Building and Environment, 83(0), 91-103.
4. Davies, Z.G., Edmondson, J.L., Heinemeyer, A., Leake, J.R. & Gastón, K.J. 2011. Mapping an urban ecosystem service: quantifying above-ground carbon storage at a city-wide scale. Journal of Applied Ecology. Doi:10.1111/j.1365-2664.2011.0202.x.
5. Scott, K.I., Simpson, J.R. & McPherson, E.G, 1999. Effects of tree cover on parking lot microclimate and vehicle emissions. Journal of Arboriculture 25(3): 129-142.

STRESS AND STATE-OF-MIND

Visiting or staying in hospital is a stressful experience for most patients. High stress levels can stand in the way of speedy recovery. Note: Working in such environments is also stressful for nursing staff. For more information on the benefits of greenery for employees, please see the fact sheet on Greenery and Work.

HOW GREENERY WORKS

- Plants in waiting rooms reduce stress. [1]
- Plants in ward rooms reduce feelings of anxiety and pain, and lower the use of painkillers; less recovery time in bed has also been reported. [2]
- Greenery visible through the window of hospital rooms helps reduce the length of hospital stays (by nearly a day). [3]
- Patients in an American hospital recovering from gall-bladder surgery who had a view of trees from their room used weaker painkillers than those whose view was of a brick wall. [3]

Sources:
1. Ulrich, R. S., Simons, R. F., & Miles, M. A. (2003). Effects of environmental simulations and television on blood-donor stress. Journal of Architectural and Planning Research, 20(1), 38-47.
2. Lohr, V. I., & Pearson-Mims, C. H. (2000). Physical discomfort may be reduced in the presence of interior plants. HortTechnology, 10(1), 53-58.
3. Ulrich, R. S. (1984). View through a window may influence recovery from surgery. Science, 224: 420- 421.

RECOMMENDATIONS

- Make sure the view from hospital rooms includes greenery (preferably visible from the bed), as well as from other locations frequented by patients (e.g. waiting rooms, common rooms).
- Create attractive green outdoor areas (gardens) for ambulatory patients (and care providers) to relax and get away from it all; make sure these areas are accessible to people in wheelchairs or with other mobility restrictions.
- Ensure easy access to the indoor and outdoor green areas, including areas that are not necessarily part of the institution itself, such as public parks and gardens.
- Also use other means to promote the use of these green spaces (information, signs, facilitated activities, etc.).
- Larger green areas in the immediate environment provide places where staff and patients can go for walks, promoting greater productivity and recovery.

Image: mooiwatplantendoen.nl

Image: mooiwatplantendoen.nl

RECOVERY

Greenery in and around hospitals provides relaxation and diversion for convalescing patients.

HOW GREENERY WORKS

- A view that includes greenery shortens hospital stays.
- Patients complain less about hospital staff in greener environments.
- Hospitals that include greenery in their design show an increase in the amount of social support given to the admitted patients.
- Green indoor/outdoor areas can also be incorporated into various types or components of therapy (e.g. chemo gardens, or green physiotherapy exercise rooms).

FURTHER INFORMATION

There are many real-life applications that illustrate and demonstrate the added value of vegetation. Useful sources of information include:

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