



UCL

GREEN INFRASTRUCTURE: AIR QUALITY

A factsheet on urban green and blue space



EngEx GI Factsheet

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Based on EngEx report 'Green Infrastructure for London: A Review of the Evidence'



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Urban green and blue spaces can improve air quality by diluting and dispersing pollution, directly removing pollutants from the air by capture and absorption on plant surfaces. They can help to regulate temperatures and counteract the urban heat island effect through shading and other physical processes. The air quality impacts of trees and other plants can directly influence health and wellbeing. However, trees and greening can also have negative effects on air quality by increasing urban canyons, emitting Volatile Organic Compounds (VOCs) (see Box 2) which can contribute to the formation of harmful street-level ozone and carbon monoxide.

Box 1: What is Green infrastructure?

Green infrastructure is a strategic, planned network of natural, semi-natural and artificial plant and water components, designed and managed to deliver a wide range of 'ecosystem services' (benefits to environment and people) and quality of life benefits. In an urban setting, green infrastructure may include parks, woodlands, wetlands, rivers, private gardens, street trees, allotments, playing fields, green roofs and sustainable drainage systems.



Box 2: Common urban air pollutants

- **Particulate matter (PM):** Burning fuels, disturbing dust from construction sites and some natural processes such as pollen shedding release fine particles into the air. Particles (particulate matter, PM) are defined according to their size. PM₁₀ refers to particles with a diameter of 10 micrometres (0.01mm) or less, and PM_{2.5} refers to particles with a diameter of 2.5 micrometres (0.0025mm) or less.
- **Sulphur dioxide (SO₂):** Burning of fossil fuels containing Sulphur, in power plants and other industrial facilities, generates Sulphur dioxide.
- **Nitrogen oxides (NO_x):** Reactions taking place in vehicle engines can form various oxides of Nitrogen including NO (Nitric oxide) and NO₂ (Nitrogen dioxide). These are sometimes described all together by the symbol 'NO_x'.
- **Volatile Organic Compounds (VOCs):** VOCs include compounds such as methane, benzene, xylene, propane and butane. Methane is primarily emitted from agriculture, other VOCs are emitted from transportation and industrial processes.
- **Ozone (O₃):** At ground level O₃ is created by chemical reactions between NO_x and VOC. This happens when these chemicals react in the presence of sunlight.

All of these **can be present at high levels in the urban environment**, causing health effects, especially to the lungs, and can harm sensitive vegetation and ecosystems.

Benefits and issues: Green infrastructure and air quality

Benefits

- **Reducing air pollution**
 - **Particulate matter:** Lower PM concentrations have been found in areas with a higher tree cover, as they are deposited on bark and leaves. Vegetation collects more PM if located in a place where air flows directly through from the source of the pollution. However, in very windy places PM deposited on vegetation is likely to be blown back in to the air. PM deposition can be helped by having trees with sticky surfaces and rough bark and leaves (e.g. conifers) and a variety of vegetation type and design to capture various types of PM. Low-lying vegetation may act as a barrier to reduce exposure to particulate matter (PM).
 - **NO₂, SO₂ & O₃:** Plants can absorb polluting gases through their leaves. They also emit gaseous chemicals that remove ozone from the atmosphere. Trees are the best vegetation type for NO₂, SO₂ & O₃ removal. The biggest impacts appear to be for SO₂. The overall impacts on NO₂ absorption are less because even though vegetation absorbs NO₂, other NO_x compounds are released by vegetation and soil.
- **Increasing shading:** Green infrastructure can reduce air temperatures through shading and evapotranspiration (evaporation and movement of water through plant stems and leaves). This can reduce the amount of energy used in buildings by reducing sun exposure and surface temperature. Surfaces with a tree canopy above are 5-20°C cooler than sunlit surfaces. Lower air temperatures can also reduce the chemical reactions that produce air pollutants in urban areas. Strategic tree planting is vital to optimise the effect of shading on buildings whilst also promoting effective natural ventilation. Green roofs and walls can provide insulation and shading. They are expensive to build and maintain, but in some areas, particularly where space is limited, they are more viable than cheaper options like tree planting or creation of open spaces. Insulation and shading benefits may be more easily quantified and costed in comparison to air quality benefits.

Issues

- **Reducing air flow:** Green infrastructure can reduce street-level ventilation by blocking airflow, leading to a negative impact on air quality. This can also reduce natural ventilation and cooling of buildings. To avoid creating or worsening urban canyons, vegetation should be well spaced and tree height should be below roof-top level. A number of computer models and wind tunnel studies have found that tall trees limit ventilation and dispersal of pollution. Shrubs, bushes, flowers, and grasses should be used with, or instead of, taller species of plants.
- **Causing air pollution:** Trees emit volatile organic compounds (VOCs) and in warm periods trees can emit NO_x, which can go on to form ozone (O₃), a harmful pollutant at ground level.
- **Health and wellbeing:** Trees and plants may exacerbate allergies and have been associated with a higher prevalence of asthma and childhood allergic sensitivity to tree pollens.

What don't we know yet?

- **Overall effect on air pollution:** While trees do absorb some harmful pollutants, they do not absorb others. They emit VOCs and can emit NO_x and trees may block ventilation in urban street canyons. Therefore, it is important to understand the overall balance of positive and negative effects.
- **Measuring pollution effects:** Data gathered by citizen scientists has revealed much higher concentrations of local air pollution than that recorded by the official monitoring networks and has also demonstrated lower pollution levels near green spaces. However, there are issues with comparing information collected using fixed vs. mobile monitoring devices as they work in different ways and more research is ongoing.
- **Real-world studies:** Much of the scientific evidence on air pollution and green infrastructure is based on studies in rural or forested landscapes, wind tunnels and laboratories. The results may not be directly applicable to urban green infrastructure in contexts which are much more complex and subject to variability in weather, climate and other environmental conditions. Relatively little is known directly about the influence of vegetation in higher-density, built-up environments.

Summary

While there is increasing evidence of urban green infrastructure improving air quality by removing, diluting and dispersing pollution, the overall picture is rather more complicated. In some settings urban green space may worsen the impacts of pollution by preventing air circulation or producing particles or emissions which directly contribute to reducing air quality. Further work, and real-world studies in particular, will be needed to understand more fully how green space affects air quality in a range of different urban settings.

Find out more

This factsheet accompanies a full report. For more details and key references please refer to:

- **'Green Infrastructure for London: A Review of the Evidence'**
<https://www.ucl.ac.uk/engineering-exchange/sites/engineering-exchange/files/ucl-green-infrastructure-for-london.pdf>

It is one of a series of factsheets produced by The Engineering Exchange at University College London. Others in this series are:

- **Green infrastructure:** Health and wellbeing
- **Green infrastructure:** Water

Other resources on green infrastructure and air quality:

- European Commission, 2016. The forms and functions of green infrastructure.
Available at: http://ec.europa.eu/environment/nature/ecosystems/benefits/index_en.htm
- GLA, 2015a. Natural Capital. Investing in a Green Infrastructure for a Future London. London: GLA.
Available at: <https://www.london.gov.uk/sites/default/files/gitaskforcereport.hyperlink.pdf>
- Wilebore, R., Wentworth, J., 2013. Urban Green Infrastructure, London.
Available at: <https://researchbriefings.parliament.uk/ResearchBriefing/Summary/POST-PN-448/>



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