Urban Greening for Air Pollution Mitigation

Challenge

- More than 90% of people worldwide live in areas where air pollution exceeds safe levels set by the World Health Organisation. Shockingly, air pollution causes 8.8 million premature deaths each year[1], making it one of the biggest environmental threats to global health. Cleaning up our air saves lives. Just as little as a 1 µg/m^3 drop in $PM_{2.5}$ across England could prevent about 50,900 occurrences of heart disease, 16,500 strokes, 9,300 asthma and 4,200 lung cancer cases over an 18-year period[2].
- Urban greening cleans air as well as providing several other co-benefits. In 2017 alone, trees and plants in British cities scrubbed enough pollution from the air to cut healthcare costs by £163 million[3], proving that green spaces are not just aesthetically pleasing, they are life-saving.
- More green means healthier lives. Natural England's Green Infrastructure Framework is driving a bold target: 40% green cover in urban residential neighbourhoods[4], because nature can help deliver cleaner air, cooler streets, and thriving communities.

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How urban greening mitigates air pollution

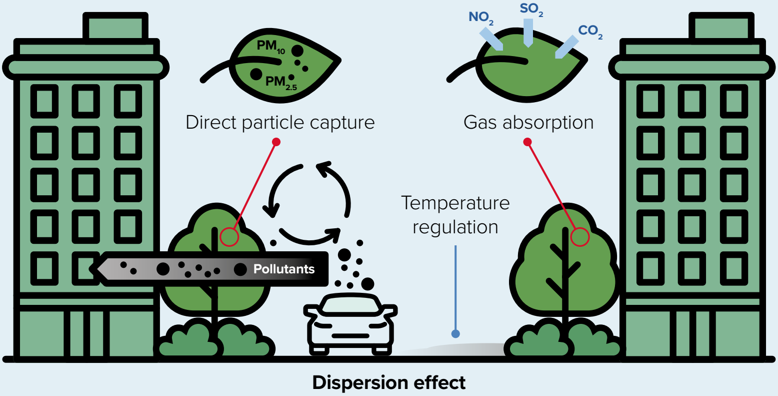

Figure 2: *Mechanisms of air pollution removal by green infrastructure.*

Urban greening reduces air pollution through different natural mechanisms (see Figure 2):

- **Direct particle capture**
  Leaves and bark trap airborne particulate matter ($PM_{2.5}$/PM_{10}), which are then washed away by rain or resuspended by wind. Urban forests, parks and gardens collectively enhance atmospheric dispersion and act as sinks for particles through dry deposition.

- **Gas absorption**
  Plants absorb harmful gases, such as nitrogen dioxide (NO_2), sulphur dioxide (SO_2) and ozone (O_3), through their stomata during photosynthesis.

- **Dispersion effect**
  Green barriers - like hedges, trees, shrubs, or their combination - act as nature's air filters to disrupt flow of polluted air from roads, trapping or diverting pollution emitted by vehicles and protecting pedestrians, cyclists, and nearby residents from harmful exposure. In some locations, the pollution trapping can cause local pollution hot-spots in street canyons, which should be avoided.

- **Temperature interactions with air quality**
  Plants are nature's air conditioners by providing shade and releasing moisture into the air, cooling our cities. This cooling can also help slow the formation of harmful ground-level ozone on hot days.

Recommended Actions

Pick the best GI type to suit your purposes. While recent publications[1] provide a comprehensive oversight of GI effectiveness against air pollution, below are some key examples.

- **Hedges** along busy roadsides could reduce local pollution by up to 63%[5]. For instance, a study in Guildford assessed the impact of hedges on pollutant concentrations and found a reduction of 31% in ultrafine particles and of 52% in BC during peak traffic.
- **Green screens** could reduce local pollution by 44%[6]. For instance, a London based study found that green screens installed along the fences of schools significantly reduced PM concentrations in playgrounds.
- **Green gates** are light green walls made of fabric-based material that hold small plants attached to the existing gate without interfering with its function. The UK's first living green gate, installed at Sandfield Primary School in Guildford, reduced PM_{10} concentrations by 32% and $PM_{2.5}$ concentrations by 19%[7].
- **Street trees** have been shown to reduce PM concentrations by as much as 50% in open road conditions when no gaps or highly porous vegetation is present; however, trees with large spacing and trees in street canyons have shown the potential to increase local air pollution levels [1, 8, 9].
- **Urban trees** across the city collectively reduce air pollution concentrations. A UK assessment showed that the health benefit or air pollution removal by urban vegetation was worth £136m in 2015[10].

Choose plant species[11] wisely to achieve best results.

- **Stress tolerance** should be considered as plant species need to be tolerant to air pollution and other urban stresses such as salt spray or drought to ensure their health and effectiveness in mitigating air pollution.
- **Leaf surface** of the chosen vegetation should be complex, waxy and/or hairy. Taller species with a high leaf surface area increase the deposition and removal of particulate pollutants.

- **Seasonal effects** should be considered where consistent plant species need to be chosen to ensure their year-round effectiveness in mitigating air pollution.
- **Low-emitting plant species** should be prioritised over strong emitters of volatile organic compounds (VOCs). VOCs from urban vegetation can contribute to increased ground level ozone and particulate pollution, thus negating some of the benefits of green interventions[12].
- **Non-invasive** and where possible native species should be used so as not to adversely impact local ecosystems.
- **Non-allergenic and non-toxic** species are preferred specially near vulnerable populations such as school children to avoid cases of poisoning or allergic reactions.

Adapt urban greening design to fit local conditions.

- **Features (design elements)** such as tree distance, canopy height, tree stand porosity, and optimal coverage need to match the site layout. For example, for hedges to operate effectively in street canyons, it is recommended to have continuous hedges with no spacing or gaps, have a height of ~2m and a minimum thickness of 1.5m.
- **Location** relative to pollution sources and receptors where, in the case that the prime objective is to reduce exposure for pedestrians or cyclists, hedges should be planted close to the road or between the road and footpaths/bike paths.
- **Growth shape** should be taken into consideration in reference to site dimensions. For example, in a shallow street canyon, a medium-sized and low density, highly porous canopy species may be suitable, whereas in a deep street canyon, a naturally compact tree or shrub may be more appropriate[11].
- **Road safety** needs to be respected where vegetation barrier design should not impede accessibility nor the visibility of drivers, cyclists or pedestrians.

Combine urban greening types for better results.

- **Mixed GI types** such as installing trees and hedges has been shown to reduce roadside pollution by up to 52%[5] in open-road conditions compared to one GI type alone.
- **Blue infrastructure (BI)** such as lakes are reported to reduce PM concentrations by up to 89%[1] compared to spaces with no waterbodies, being associated with more open spaces, which enhance natural wind dispersion.

Support local research efforts in urban greening to fill current knowledge gaps.

- Research is needed on understudied urban greening typologies such as green corridors, cycle tracks, road verges, and BI (rivers, lakes, and wetlands) to understand their influence on air quality and avoid unintended consequences from poorly informed designs. Additional evidence is also required regarding the effectiveness of various urban greening approaches in reducing gaseous pollutants, as current data remains limited.

Further Insight

Align urban greening with climate policy, in reference to national and global legislations and commitments, such as:

- The National Planning Policy Framework[13] with focus on paragraph 136.
- Natural England's Green Infrastructure Framework (2023)[14] and its Accessible Greenspace Standard (AGSt).
- Relevant UNFCCC frameworks such as UK Nationally Determined Contributions (NDCs) relating to NbS and the co-benefits of urban nature.

Utilise available practical guidance, including:

- Implementing Green Infrastructure for Air Pollution Abatement: General Recommendations for Management and Plant Species Selection (2019)[9].
- Natural England's Green Infrastructure Planning and Design Guide[15].
- Guides by Trees and Design Action Group (TDAG) such as First Steps in Urban Tree Canopy Cover.
- GI4AQ is a Green Infrastructure for Air Quality framework developed by the University of Birmingham and air quality and urban greening experts[16].

Employ online tools to help in understanding and designing urban green spaces, including but not limited to:

- HedgeDATE[17]: a decision-support tool developed to help urban planners, landscape designers, and policymakers evaluate and optimise the use of roadside trees and hedges for air pollution mitigation.
- City Explorer Toolkit[18]: GIS-based web tool developed by UKCEH to assist urban planners and policymakers in evaluating where to place GI and BI to maximise environmental and social benefits.
- Air Quality Green Infrastructure[19]: a practical guide developed in the UK to help schools reduce children's exposure to air pollution using GI.

References

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