How Urban Green Infrastructure Can Affect Air Pollution and Health

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Presentation Overview

• Background
  – Near-road air pollution health concerns
  – Roadside barrier air quality mitigation
• Green infrastructure research results
• Design recommendations
• Resources
• Conclusions
Air Pollution Health Effects

- The World Health Organization (WHO) attributes approx. 7 million deaths worldwide to air pollution exposures
  - Deaths caused by exposures to ambient, outdoor and household air pollution
  - Deaths were from strokes, heart attacks, lung disease and lung cancer
- WHO estimates 9 out of 10 people in the world breathe unhealthy air (above WHO/US standards)
- Air pollution is now the fourth-highest cause of death in the world, trailing only smoking, high blood pressure and diet deficiencies
Near-Road Health Concerns

Studies have associated people living, working or going to school near highways and large transportation facilities with adverse health effects such as:

- Asthma and other respiratory diseases
- Cardiovascular effects
- Birth and developmental effects
- Cancer (including childhood leukemia)
- Premature mortality

Air pollution and exposures often highly elevated near these large transportation sources, especially within 200-300 meters

Large portion of the U.S. population may be exposed

- More than 50 million people estimated to live within 100 m of a large highway or other transportation facility (e.g. airport, rail yard)
- Over 4 million school children attend classes within 150 m of a major highway (1 in 11 schools; 1 in 5 new schools)
Mitigating these traffic emission exposures and health effects can be achieved by:

- Reducing emissions
- Reducing vehicle activity
- Revised near-road development
- Using urban and transportation planning
  - Road location and configuration
  - Walk and bike options
  - Site design and layout
  - *Roadside vegetation and noise barriers*
Why study roadside barriers?

Public wants to know what can be done now when near-road health concerns are raised for schools, daycares, etc.

Few other “short-term” mitigation options exist

- Emission standards can take long to implement
- Planning, zoning and large investments often needed for activity reduction programs
- Limited opportunities to reconsider land use near roads
• Particulate matter generally reduced downwind of a vegetation stand
• Higher reductions occurred closer to ground-level
• Variable winds altered effects
Roadside Vegetation Effects

- Smaller size PM have higher removal rates
- Removal increases at lower wind velocities
- Branch/leaf shape and size affects removal

\[(\text{Lin and Khlystov, 2012})\]
Roadside Vegetation Effects

Plant conditions affect downwind pollution

- Thick, tall and full coverage reduced pollution
- Gaps and porous vegetation led to higher levels

(Deshmukh et al., 2018)
Combinations of solid noise barriers and vegetation may provide greater reductions than either method alone.

(Baldauf et al., 2008)
Vegetative Barrier Recommendations

EPA released recommendations for planting roadside vegetation

• Used to design planting projects in Oakland and Detroit
• Includes vegetation alone and combined with solid barriers
• Provides designs Intended to:
  − Maximize the potential for near-road air pollution reduction
  − Avoid unintended consequences and designs that may increase downwind concentrations
Vegetative Barrier Recommendations

Areas desired for reduced pollutant concentrations should avoid gaps and edge effects

- Complete coverage from the ground to the top of the canopy
- Thickness adequate to reduce porosity and avoid gaps

Pine/coniferous trees and thick bushes may be good choices

- No seasonal effects
- Complex, rough, waxy surfaces

Mix of species may increase coverage and robustness

Examples of full coverage, pine and bush barriers
Vegetative Barrier Recommendations

Pollutants can meander around edges or through gaps

- No spaces between or under trees
- No gaps from dead or dying plants; maintenance important

Examples of inadequate barriers due to gaps
Combination of solid noise and vegetative barriers may have the most benefit

- Increases air pollutant dispersion and removal
- May be solid noise barrier with vegetation behind and/or in front
- Use of climbing vegetation on solid surfaces still uncertain

Examples of solid/vegetation barriers
Other Considerations

Vegetation characteristics

• Species (e.g. native vs. non-native)
• Appropriateness for site
  – Drought/flood resistant
  – Road treatment tolerant (e.g. salt, sand)

Physical characteristics the barrier needs

• Height, thickness, length and porosity
• Non-seasonal vegetation (conifers, bushes, etc.)
• Waxy leaf and branch surfaces for pollutant removal
• Low pollution/pollen emissions

Tools to help in the design process

• USFS i-Tree model
• EPA EnviroAtlas
Other Benefits

Roadside vegetation can be designed to improve local air quality and provide other potential benefits:

- Reduced noise (with solid barrier)
- Reduced water runoff; highway and community flooding
- Improved surface water quality
- Reduced urban heat island effects
- Increased carbon sequestration
- Improved aesthetics
- Increased property values
- Enhance community livability
- Improved safety
- Overall improved public health
Ongoing Projects

• Pilot studies planting roadside vegetation for air quality and other benefits’
  – Oakland Elementary School
  – Detroit Residential Park
  – Measuring before and after planting
    • Air quality
    • Meteorology
    • Noise (Detroit)
  – Assessing benefits
    • Air quality
    • Water runoff control

• Developing algorithms to conduct dispersion modeling of roadside vegetation
California Air Resources Board Land Use Handbook on near-road mitigation including roadside vegetation

Sacramento Air Quality Management District’s roadside vegetation guidance builds on EPA recommendations

https://www.arb.ca.gov/ch/landuse.htm

The BBC reported on the air quality benefits of roadside vegetation based on research by international partners that followed many of the recommendations contained in the report by EPA.
Conclusions

• High air pollution levels near roads and other transportation facilities is a major public health concern

• Roadside vegetation can provide significant reductions in local air pollution, but only under certain plant conditions and physical design characteristics

• Recommendations were developed to help design and maintain this urban green infrastructure for air quality benefits

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