



Air Pollution Measurement and Mitigation for the Transport Sector

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Presentation Overview

Background

- Transport impacts on air quality and health
- Strategies to mitigate risks

EPA programs on transport sector air pollution

- Emissions measurements and compliance
- Air pollution and exposure mitigation

Resources

Current Projects

Summary

Health Effects from Air Pollution

In 2016, over 7 million deaths were attributed to air pollution worldwide (World Health Organization, WHO)

- Deaths from exposures to ambient, outdoor air pollution, and household, indoor contamination
- Leading causes of deaths were strokes, heart attacks, lung disease, and lung cancer

9 out of 10 people in the world breathe unhealthy air (above WHO standards)

Air pollution is now the fourth-highest cause of death worldwide

- Trails only smoking, high blood pressure, and diet
- The majority of deaths occurred in poorer nations

Air Pollution Emissions from the Transport Sector

Car exhaust



Particles

Gases

Truck exhaust



Particles

Gases

Brake/Tire wear



Particles

Re-suspend dust



Particles

Transportation and Air Pollution

Transport contributes significantly to local, regional, and global air pollution



Particulate (PM) emissions can contribute 70% or more to total PM depending on the urban area



More than 50% of nitrogen oxide (NO_x) and carbon monoxide (CO) emissions



Hundreds of other harmful compounds emitted from exhaust or brake/tire wear

Transportation and Air Pollution

Low- and middle-income countries are often burdened disproportionately from transport-emitted pollution

- Higher use of older, poorly maintained vehicles
- Limited access to good public transit and/or active transport options
- Limited or no air pollution standards and/or certification requirements

Transport Health Concerns

Numerous health studies have focused on people living, working, and going to school near large transportation facilities

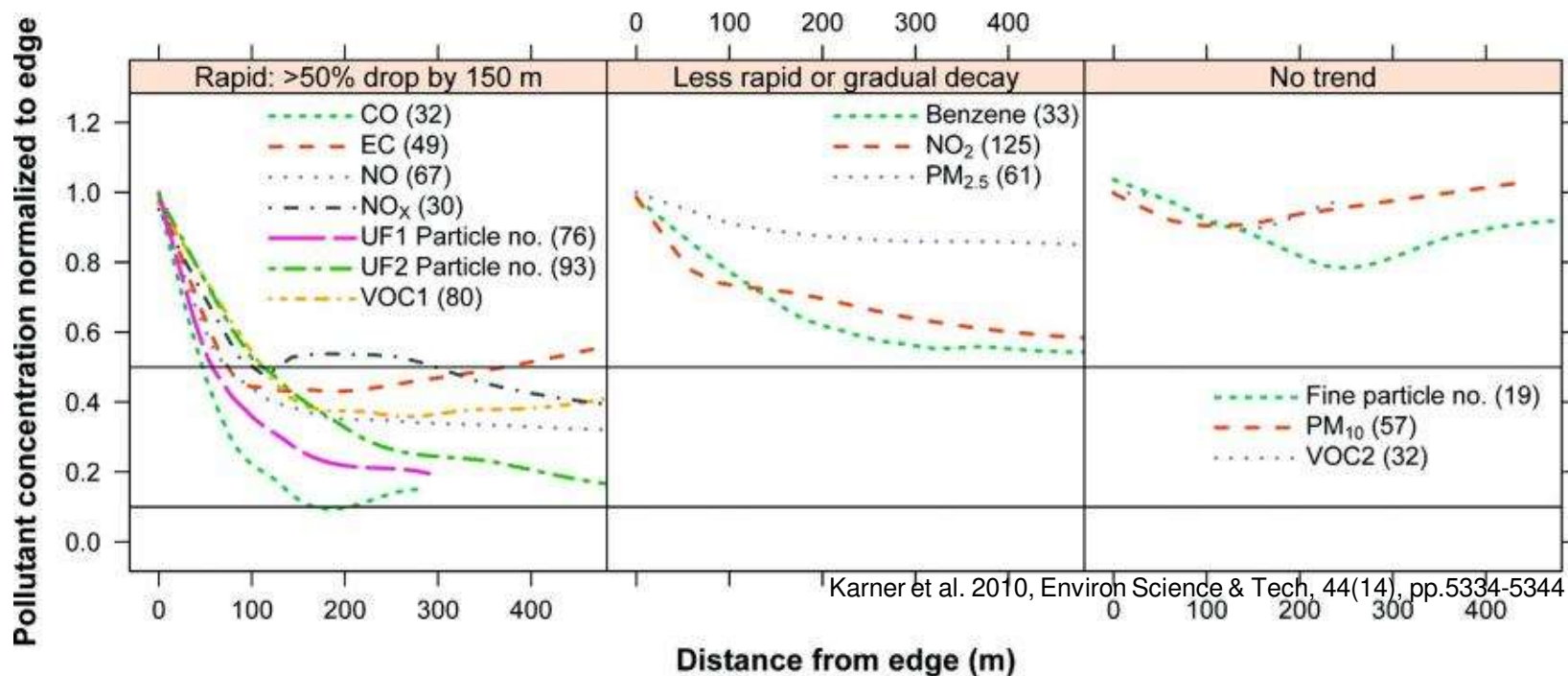
These populations face increased risks for many adverse health effects:

- Asthma and other respiratory diseases
- Cardiovascular effects
- Birth and developmental effects
- Premature mortality
- Cancer



Transport Health Concerns

Air pollution and exposures can be highly elevated near large transportation sources, notably within the first 200-300 meters



Transport Health Concerns

Large portion of the world's population exposed directly to transportation emissions

For example, in the US:

- Over 50 million people live within 100 m of a large highway, airport, marine port or rail yard
- Over 4 million children attend school within 150 m of a major highway

These figures are often higher in low and middle income countries



Mitigation Opportunities

Strategies to mitigate adverse health effects from transport-related air pollution can target:



Emissions



Concentrations



Exposures

Mitigation Opportunities

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Programs to Measure Emissions

Measurement programs are necessary to implement efficient and effective transport emission control strategies

- Understand the extent of the problem, including the impact of the transport sector to overall air quality
- Understand how different transport sources contribute to air pollution levels locally and regionally
- Understand the effectiveness of control strategies implemented and identify adjustments needed

Vehicle Emissions Measurements



Remote sensing/opacity screening of vehicle exhaust



On-board measurement systems (PEMS)



Chassis and engine dynamometers



Increasing
Cost
Complexity
Accuracy

Build capacity in countries by implementing these techniques in stages

Programs to Mitigate Emissions

Mitigation programs and policies can reduce emissions or reduce vehicle activity, such as:

- Vehicle emissions standards
- Fuel quality standards
- Fleet modernization/electrification
- Improved public transit options
- Improved walking/biking options

Lessons learned from other countries can inform choices and implementation of emission control programs appropriate for local conditions

Mitigation Opportunities

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Emissions



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Exposures

Measurement programs help us to understand the effectiveness of control strategies implemented and adjustments needed

Multiple monitoring techniques can be integrated to inform public health policy strategies

- Fixed regulatory monitors (e.g. US Embassy PM monitors)
- Portable, low-cost sensors
- Mobile platforms with regulatory and/or low-cost sensor techniques



Vehicle Emissions Modeling

Building capacity for air quality modeling supports the implementation and evaluation of transportation emissions control strategies

Motor Vehicle Emissions

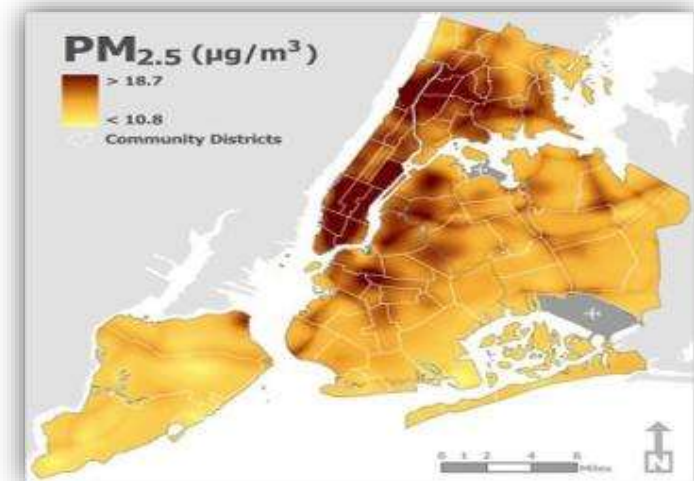
- MOVES-International provides estimates of emission rates based on US and European standards
- Country-specific emission factors can be developed using results from the emissions measurement programs

Air Quality Dispersion

- US models AERMOD or R-LINE
- European model ADMS

Policy Benefits Assessments

- AirQ+ from WHO
- BenMAP in the US





Programs to Mitigate Air Quality Impacts of Emissions

Mitigation programs and policies can improve local air quality and reduce exposures to harmful air pollution

- Low and no emission zones
- Congestion pricing
- Development exclusion zones
- **Built and green infrastructure**

Built and Green Infrastructure

Roadside structures have been shown to improve local air quality when designed properly

These structures have other positive attributes, with air quality as only one of many potential benefits

- Noise barriers/fences reduce noise and improve aesthetics
- Roadside vegetation can:
 - Reduce stormwater runoff/flooding
 - Increase carbon sequestration
 - Reduce urban heat island effects
 - Improve aesthetics/property values
 - Enhance community livability

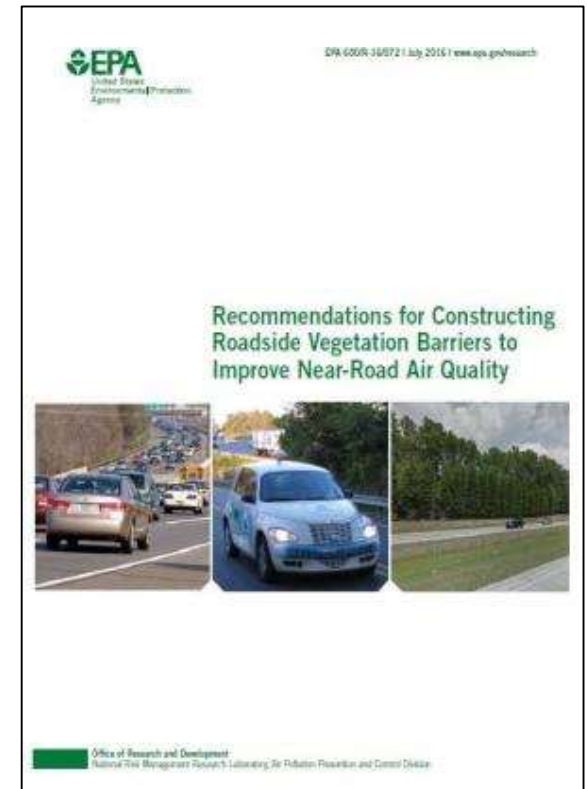
“Exposure to green space has been associated with better physical and mental health”



Dadvand et al. 2015

EPA developed recommendations for planting and maintaining roadside vegetation for air quality benefits

- Includes vegetation alone and combined with solid fences and noise barriers
- Provides designs intended to:
 - maximize the potential for local, near-road air pollution reductions
 - avoid unintended consequences and designs that may increase downwind concentrations and exposures
- Used to design planting projects in the US (Detroit, Michigan and Oakland, California)



Green Infrastructure



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 often good choices

- No seasonal effects
- Complex, rough, waxy surfaces

Mix of species (bushes/trees) may increase coverage and robustness

Examples of full coverage, pine and bush barriers

Green Infrastructure

Pollutants can meander around edges or through gaps

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



Built Infrastructure

Research shows noise barrier and fence design characteristics that can reduce downwind air pollutant levels

- The higher the barrier, the higher the downwind pollution reduction
 - Most studies conducted with barriers $\geq 4\text{m}$
- Pollutants can meander around edges
 - Sensitive areas should be $\geq 50\text{m}$ from edges
 - Sensitive areas should be below barrier top
- Pollutants can be trapped on the upwind side of the barrier
 - “Upwind” sources need to be considered
 - May lead to increased levels on the road
- Barrier should be close to the road
 - Most studies had barriers $\leq 5\text{m}$ of travel lane



Built and Green Infrastructure

Combination of vegetative and solid barriers may have the most benefit

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



Examples of solid/vegetation barriers

Green Infrastructure Review Papers



Janhäll, 2015. *Atmospheric Environment*, 105, pp.130-137

Gallagher et al, 2015. *Atmospheric Environment*, 120, pp.61-70

Baldauf, 2017. *Transport Res Part D: Transport & Environ*, 52, pp.354-361

Abhijith et al, 2017. *Atmospheric Environment*, 162, pp.71-86

EPA Roadside Vegetation Projects

- Roadside vegetation planting in Detroit and Oakland
- Collecting air quality, meteorology, and noise (Detroit only) measurements before and after vegetation planting
- Assessing benefits for air quality and water runoff control



Detroit, MI



EPA Roadside Vegetation Projects

Oakland, CA



Mitigation Opportunities

Strategies to mitigate adverse health effects from transport-related air pollution can target:



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Programs to Mitigate Exposures to Transport Emissions

Mitigating exposures to harmful air pollution emitted by transportation sources can also improve public health

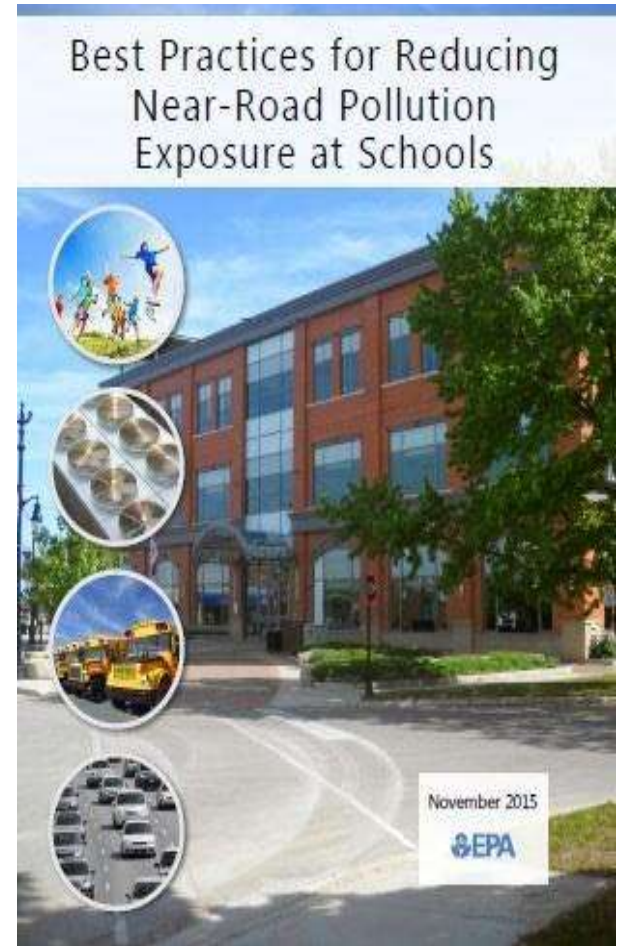
- Indoor air filtration
- Outdoor air pollution mitigation
- Site design and layout

Reducing Exposures at Schools from Transport Emissions

Developed to provide schools and parents with practical solutions to mitigate traffic-related pollution

Provides solutions for indoor air pollution exposures

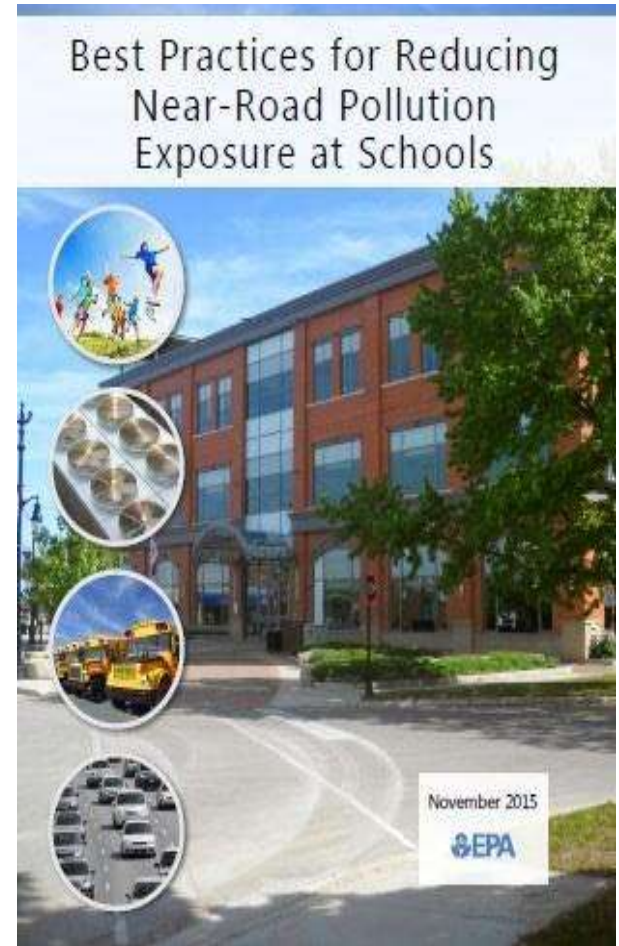
- Building Design and Operations
 - Ventilation
 - Filtration
 - Low-emitting products
 - Indoor air cleaning
- Occupant Behavior



Reducing Exposures at Schools from Transport Emissions

Provides solutions for outdoor air pollution exposures

- On-site Transportation Policies
 - Anti-Idling and idle reduction
 - Upgrade bus fleets
 - Encourage active transport
- Site Location and Design
- Roadside Structures
 - Noise barriers and fencing
 - Vegetation



Site Location and Design

EPA drafting recommendations for developers

- Encompasses Corridor Management, Building Design and Operations, Site Design and Layout, and Barrier Use
- Site Layout: Development can be implemented so that sensitive land uses are farthest from the road



Note: Drawing not to scale

Summary

Health concerns from transportation-generated air pollution have raised the importance of understanding and controlling these emissions and exposures for public health protection

EPA actively supports capacity building and training related to the measurement and control of transportation emissions impacts in other countries

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