TRANSPORTATION AND AIR QUALITY

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Summary

In addition to its targeted primary effects transportation also has unwanted side effects. One of the major side effects is caused by exhaust emissions produced by the motors of vehicles. Transportation's contribution to environmental pollution is particularly large in urban areas, where road transportation is by far the most significant contributor of emissions such as carbon monoxides, particular matter, nitrogen oxides, and volatile organic compounds. The last two of these combine in the atmosphere in the presence of sunlight to form ground-level ozone. There has been a radical reduction in new car exhaust emissions because of governmental regulation, first in the US and afterwards in the EU. For various reasons the reductions in real-world conditions have been somewhat more modest. As of the turn of the twenty-first century, only lead has almost totally disappeared from exhaust emissions in these countries.

Low air quality is still a major problem in cities around the world. It has been observed that current concentrations of pollutants in urban air have impacts on inhabitants' health. The situation is most serious in developing countries, where lead as well as other pollutants spoil city air and form a health risk. The improvement of city air quality is a

slow process needing, usually, decades of targeted work. Increases in urban populations, together with increasing car ownership, can counterweight improvements obtained through technological development, control actions, and demand and traffic management.

1. Introduction

In addition to its targeted primary effects transportation also has unwanted side effects. One of the major side effects is caused by exhaust emissions produced by the motors of vehicles. Transportation produces a number of emissions with varying degrees of influence. These include global pollutants (such as carbon dioxide which contributes to global warming), national or regional pollutants (nitrogen oxides which produce acidification or acid rain), and local pollutants (such as particulate matter which contributes to respiratory health problems). Transportation's contribution to environmental pollution is particularly large in urban areas, where transportation is by far the most significant contributor to air pollution.

Even though all transportation modes produce exhaust emissions, there are great differences between modes. In the local and regional contexts, it is road traffic—cars, vans, trucks, and buses—that have the biggest impact on air quality. Air quality in any area is decreased in relation to the amount of motor vehicle traffic and to the exhaust emission rates of vehicles. The amount of motor vehicle traffic depends on the size of population, car ownership rate, and the relationship between car use and other modes, for instance public transport, walking, and cycling. In addition, the volume of freight transport should be considered. The exhaust emission rates of vehicles depend mainly on the age and maintenance of vehicles.

Air quality is influenced by exhaust emissions, which mix with air. The resulting air quality in any area depends, in addition to the volume of exhaust emissions, much on local geographical and climate conditions. If the area is well ventilated with, for instance, ocean or sea winds, air quality remains much better than in an area in a closed valley. It is possible also for the wind to blow emissions from one area to another and causing air quality is improved in the first area but decreased in the second. Weather may have various influences: sunshine activates ozone and smog production from emissions, and windless weather with special temperature conditions may restrict air movements in a way that progressively concentrates pollutants in the air. Air quality is influenced also by emissions from other sources including factories, power plants, fires, and heating. Also, natural windblown dust and dust from construction and maintenance activities, including road salt and resuspended particles have to be considered.

This paper will concentrate on exhaust emissions produced by road traffic. In the next section the characteristics of exhaust emissions are discussed, thereafter a short description of air quality standards and the historical trends is given. Finally the current situation in different parts of the world are presented, methods to assess emissions and air quality are described, and possible means for improving air quality are discussed.

2. Exhaust Emissions

2.1. Road Transportation

Exhaust emissions from combustion engines include almost 200 different components. The following primary pollutants have the greatest impact on air quality: carbon monoxide (CO), nitrogen oxides (NO_x), volatile organic compounds (VOCs), particulate matter (PM), and lead (Pb).

Some emissions stay in the air as they are, but some change their appearance into secondary pollutants. The most important of the latter is ground-level ozone ($O_{3)}$. It is formed when VOCs in the atmosphere combine with nitrogen oxides in the presence of sunlight. Exposure to ozone for several hours, even at relatively low concentrations, reduces human lung function and sensitizes the lungs to other irritants.

Carbon monoxide (CO) is a poisonous gas produced by the incomplete burning of carbon in fuel. Health risks arising from CO emissions are most serious for those who suffer from cardiovascular disease. In the United States, 64% of nationwide CO emissions derive from road transportation. Carbon monoxide is not a permanent component in the air. After some hours it is transformed to carbon dioxide, which has an impact on the global climate (see also *Transportation and Energy* and *Sustainable Mobility*).

Nitrogen oxides (NO_x) contribute to the acidification of natural ecosystems and to the formation of ground level ozone, as stated above. NO_x is formed when fuel is burned at high temperatures. In the mid1990s some 42% of nitrogen oxides in the European Union (EU) originated from road transportation compared to 35% in the US. An average of 16 kg of NO_x per person per year was emitted by road transport in the EU, compared to 29 kg in the US. Nitrogen dioxide (NO_2) is a brownish gas that can irritate the lungs and reduce resistance to respiratory infections. It is mainly formed in the atmosphere through the oxidation of the primary air pollutant nitric oxide (NO), which is one component in nitrogen oxides emissions.

Volatile organic compounds (VOCs) also contribute, as stated above, to the formation of ozone. VOCs emissions are caused not only from tailpipe exhaust, but also by evaporation of gasoline during vehicle refueling, operation, and parking. In the mid1990s 32% of all VOC emissions in the EU originated from road transport compared to 24% in the US. An annual average of 14 kg of VOCs per person was emitted from road transportation in Europe compared to 21 kg in the US.

Small particles, with aerodynamic diameters smaller than 10 μm, are likely responsible for most of the adverse effects of particulate matter because of their ability to enter the human respiratory system during inhalation. That is why air quality standards use concentrations of particles with diameters under 10 μm as indicators for particulate matter in general. Actually, a subfraction of this "PM10" particulate matter, particles which are less than 2.5 μm in diameter, are the most dangerous, since particles of this size are transported deep into the lungs.

Excessive lead exposure can cause seizures, mental retardation, and/or behavioral disorders. Even low doses of lead can damage the central nervous systems of infants

and young children. Lead can also contribute to high blood pressure. In the EU and the US, unleaded gasoline was introduced with automobiles equipped with catalytic control devices and it has currently almost totally replaced leaded gasoline.

Carbon monoxides, VOCs, and lead are mainly produced by gasoline engine cars, which also contribute to the emissions of nitrogen oxides. Diesel cars, trucks, and buses contribute mainly to emissions of nitrogen oxides and particulate matter.

2.2. Other Modes

Other transportation modes, including rail, water, and air, have less impact on air quality than road transportation. Locally they may produce significant amounts of emissions, but usually there are few people in the vicinity to suffer from them.

If railways are electrified, their emissions are related to electricity production. Diesel locomotives can be compared to trucks when considering the production of emissions, in other words the major concern is with nitrogen oxides and particulate matter.

Water transport may influence air quality not only in harbor areas, but also through acidification impacts in larger areas. Ships often use oil with a high sulfur content, resulting in emissions of sulfur dioxides (SO_2). When nitrogen oxides produced by ships are also taken into account, it has been calculated that international shipping traffic accounts for 10–15% of total deposition over Western Europe.

The influence of aviation on air quality around airports includes emissions of CO, NO_x, and hydrocarbons.

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Bibliography

COMMUTE (Common Methodology for Multi-modal Transport Environmental Impact Assessment). (1998). *Methodology Report*, Volume 1 (Introduction and Summary), Volume 2 (COMMUTE Framework for SEA), and Volume 3 (COMMUTE tool), 333 pp. Brussels: COMMUTE . [This methodology report provides a tool for estimating emissions for all transport modes and describes the procedure for strategic environmental assessment (SEA).]

European Environment Agency. (2000). *Are We Moving in the Right Direction? Indicators on Transport and Environment Integration in the EU*, 153 pp. Copenhagen: European Union. [This report describes the environmental consequences of transportation in Europe and highlights potential actions.]

Pickrell D. (1999). Cars and clean air: a reappraisal. *Transportation Research* **A33**, 527–547. [This paper presents a summary of transportation related air quality issues and an assessment of the strategies for further improvements in the US.]

US Environmental Protection Agency, Office of Transportation and Air Quality. (1999). *Final Assessment of Motor Vehicle Toxic Emissions and Exposure in Urban Areas and Nationwide*, <http://www.epa.gov/OMSWWW/toxics.htm>. Washington, DC: US Environmental Protection Agency. [This website presents current estimates on emissions and exposure in the US and links to information about related health risks and assessment methods.]

Biographical Sketch

Dr. **Veli Himanen** received his MSc in Civil Engineering 1961 and Doctor in Engineering in 1975 from Helsinki University of Technology. He worked as a Planning Engineer in the Finnish National Road Administration and Helsinki City Planning Office until, in 1970, he became the director of the Bureau for Transport Planning Coordination for the Helsinki Metropolitan Area. In 1981 he joined the Technical Research Centre of Finland (VTT). As of 2001 he works as a project manager for JP-Transplan Ltd.

Dr. Himanen has participated in thirteen research projects funded by the European Commission since 1989. His recent research activities include assessment methodologies, impacts of ICT on traveling, transportation policy, transportation economics, environmental impacts, sustainability, and public transportation. He is currently a member of Advisory Board of two international transportation journals and an editor of a book as well as a guest editor of a journal. He has published papers about transportation policy, evaluation methodologies, environmental impacts, and sustainability.