

Air Pollution and Travelers

Subjects: **Others**

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Traveler's optimal route choice is impacted by air pollution.

paradox

health damage

the value of time

user equilibrium

system optimization

air pollution

1. Introduction

Air pollution has become an important topic in global environmental issues with economic development. A large number of greenhouse gases and pollutants are produced in the production, logistics, and other aspects of national economies. For example, large amounts of coal, coke, gasoline, diesel, and natural gas are consumed in manufacturing for the ferrous metal industry and nonferrous metal industries; CO₂ emissions are continuing to grow ^[1]. In seaborne trade, as emissions produced by oceangoing vessels and container handling equipment would lead to drastic climate changes, ship operators have to constantly adjust the speed and route to reduce air pollution^{[2][3]}. The aviation industry is in a similar condition. According to the Air Transportation Action Group (ATAG), the global aviation industry produced about 705 million tons of CO₂ in 2013, which is about 2% of the total CO₂ emissions and 13% of the total transportation-related emissions ^[4].

Air pollution has had some seriously negative impacts on the health of residents in cities, especially in big cities in developing countries. Studies found that about 3.3 million premature deaths per year were caused by outdoor air pollution on a global scale ^[5], with Asia being the most affected area ^[6]. Controlling greenhouse gas and pollutant emission is a major priority in protecting the global environment.

2. Impact of Air Pollution on Travelers

A new and typical problem is the dangerous level of air pollution caused by vehicular traffic and industrial emissions. In such an environment, travelers are exposed to higher levels of traffic-related particulate matter (PM) and higher health risks than the general population ^[7]. The exposure of travelers to traffic-related PM is particularly serious in developing countries. One problem is that motorcycles and scooters (hereafter, “motorcycles”) are an important and essential means of transportation in many developing countries, such as Vietnam, India, China, Brazil, and Thailand. For example, in Vietnam, motorcycles are the primary travel mode because of their economic practicality. Unfortunately, travelers who use a motorcycle are directly exposed to traffic-related PM.

When travelers use a car or other vehicles, they are indirectly exposed to traffic-related PM. The degree of reduction of PM by the vehicle's air conditioning system is limited, especially for finer particles, such as PM_{2.5} (i.e., particles with a mean diameter of 2.5 μm or less). This is exacerbated by the fact that most people in developing countries cannot afford to buy an expensive car equipped with a powerful and efficient air conditioning system that could mitigate the problem. Even when such a system is available, many drivers travel with the window open with the idea that driving for a long time in an airtight vehicle with the vehicle's air conditioning system operating damages their health.

For these reasons, travelers in developing countries are exposed to high concentrations of traffic-related PM. The damage caused by this pollution has become a growing concern for urban citizens and the governments responsible for protecting their health.

The increasingly serious problem of air pollution caused by vehicles and traffic congestion has created enormous challenges for transportation planners, particularly since there is strong evidence that these problems affect travel modes and behavior. For example, in Vietnam's Ho Chi Minh City, most travelers wear thick masks to prevent dust and particles from entering their mouths and noses during travel.

Although time is important to most travelers, some travelers consider both the value of time (VOT) and the health risk caused by their travel when they choose routes. This means that the perception of pollution damage has become a critical factor that affects route choices. As a result, it is no longer sufficient to just consider the goal of minimizing travel times when designing urban transportation networks, and both transportation planners and travelers must assess the importance of pollution damage. This is problematic because it complicates consideration of how to solve the classical Braess paradox ^[8], in which efforts to increase the capacity of a network by adding new routes can instead decrease its throughput. Specifically, an analysis that only considers the VOT of travelers is unpractical because it cannot minimize pollutant emission or traveler perceptions of the health risk created by pollution^[9].

Research on pollution has seen substantial growth in the transportation literature ^{[10][11]}. The consensus is that air pollution from ground transportation poses a significant threat in urban areas ^{[12][13]}. Most literature focuses on how transportation planners make decisions to reduce environmental pollution. For example, Reference ^[14] introduced two pollution permit systems for transportation networks to provide scientific support for decision-making with the goal of pollution reduction. Reference ^[15] identified three distinct paradoxes that could occur in congested urban transportation networks in terms of the total emissions generated. They demonstrated that the network topology, cost structure, and travel demand structure must be considered in any policy system that is intended to reduce vehicle emissions. Reference ^[16] investigated the impacts of route decisions on vehicle energy consumption and emission rates for different vehicle types using microscopic and macroscopic emission estimation tools. Reference ^[17] reviewed the literature on applications and approaches related to designing and managing road networks to explicitly address environmental concerns.

Some other studies have addressed the impact of air pollution derived from vehicle emissions on route choice. Reference [18] examines the contrast between traditional travel cost factors and personal exposure to PM10 in optimum route choice selections. Reference [19] developed a new method for incorporating the estimated inhaled mass of PM2.5 into walking route calculations; with their method, a low air pollution inhalation route can be found. Reference [20] found that an appropriate choice of route through an urban area might significantly reduce the air pollution exposure, and a web-based route planner for selecting the low exposure route through the city could be good for the public. Reference [21] proposed a healthier route planning (HRP) method to minimize personal travel exposure risk to air pollution by integrating techniques of fine-scale mapping of air pollutant concentration, risk weight estimation of road segment exposure to air pollutants, and the dynamic Dijkstra algorithm.

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