Air Pollution and Travelers

Subjects: Others

Contributor: Zhaolin Cheng

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

Keywords: 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; CO_2 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 CO_2 in 2013, which is about 2% of the total CO_2 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 PM2.5 (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.

References

1. Lin, B.; Xu, M. Regional differences on CO2 emission efficiency in metallurgical industry of China. Energy Policy 2018, 120, 302–311.
2. Dulebenets, M.A.; Moses, R.; Ozguven, E.E.; Vanli, A. Minimizing carbon dioxide emissions due to container handling a t marine container terminals via hybrid evolutionary algorithms. IEEE Access 2017, 5, 8131–8147.
3. Abioye, O.F.; Dulebenets, M.A.; Pasha, J.; Kavoosi, M. A vessel schedule recovery problem at the liner shipping route with Emission Control Areas. Energies 2019, 12, 2380.
4. Lo, P.L.; Martini, G.; Porta, F.; Scotti, D. The determinants of CO2 emissions of air transport passenger traffic: An analy sis of Lombardy (Italy). Transp. Policy 2018, 6, 108–119.
5. Hanna, R.; Oliva, P. The effect of pollution on labor supply: Evidence from anatural experiment in Mexico City. J. Public Econ. 2015, 122, 68–79.
6. Lelieveld, J.; Evans, J.S.; Fnais, M.; Giannadaki, D.; Pozzer, A. The contribution of outdoor air pollution sources to pre mature mortality on a global scale. Nature 2015, 525, 367–371.
7. Tovalin-Ahumada, H.; Whitehead, L.; Blanco, S. Personal exposure to PM2.5 and element composition—A comparison between outdoor and indoor workers from two Mexican cities. Atmos. Environ. 2007, 41, 7401–7413.
8. Braess, D. Über ein Paradoxon aus der Verkehrsplanung. Unternehmensforschung 1968, 12, 258–268.
9. Aziz, H.M.A.; Ukkusuri, S.V. Exploring the trade-off between greenhouse gas emissions and travel time in daily travel d ecisions: Route and departure time choices. Transp. Res. Part D Transp. Environ. 2014, 32, 334–353.
10. Raux, C.; Croissant, Y.; Pons, D. Would personal carbon trading reduce travel emissions more effectively than a carbon tax? Transp. Res. Part D Transp. Environ. 2015, 35, 72–83.
11. Xue, X.; Ren, Y.; Cui, S.; Lin, J.; Huang, W.; Zhou, J. Integrated analysis of GHGs and public health damage mitigation for developing urban road transportation strategies. Transp. Res. Part D Transp. Environ. 2015, 35, 84–103.
12. Romero, Y.; Chicchon, N.; Duarte, F.; Noel, J.; Ratti, C.; Nyhan, M. Quantifying and spatial disaggregation of air pollutio n emissions from ground transportation in a developing country context: Case study for the Lima Metropolitan Area in P

eru. Sci. Total Environ. 2020, 1, 134313.

13. Apparicio, P.; Gelb, J.; Carrier, M.; Mathieu, M.; Kingham, S. Exposure to noise and air pollution by mode of transportati on during rush hours in Montreal. J. Transp. Geogr. 2018, 6, 182–192.
14. Nagurney, A. Alternative pollution permit systems for transportation networks based on origin/destination pairs and path s. Transp. Res. Part D Transp. Environ. 2000, 5, 37–58.
15. Zhao, C. Dynamic traffic network model and time-dependent Braess' paradox. Discret. Dyn. Nat. Soc. 2014, 2014, 802 129.
16. Ahna, K.; Rakha, H. The effects of route choice decisions on vehicle energy consumption and emissions. Transp. Res. Part D Transp. Environ. 2008, 13, 151–167.
17. Szeto, W.Y.; Jaber, X.; Wong, S.C. Road network equilibrium approaches to environmental sustainability. Transp. Rev. 2012, 32, 491–518.
18. Alam, M.S.; Perugu, H.; McNabola, A. A comparison of route-choice navigation across air pollution exposure, CO2 emis sion and traditional travel cost factors. Transp. Res. Part D Transp. Environ. 2018, 11, 82–100.
19. Luo, J.; Boriboonsomsin, K.; Barth, M. Reducing pedestrians' inhalation of traffic-related air pollution through route choi ces: Case study in California suburb. J. Transp. Health 2018, 9, 111–123.
20. Hertel, O.; Hvidberg, M.; Ketzel, M.; Storm, L.; Stausgaard, L. A proper choice of route significantly reduces air pollution exposure—A study on bicycle and bus trips in urban streets. Sci. Total Environ. 2008, 1, 58–70.
21. Zou, B.; Li, S.X.; Zheng, Z.; Zhan, B.F.; Yang, Z.L.; Wan, N. Healthier routes planning: A new method and online imple mentation for minimizing air pollution exposure risk. Computers. Environ. Urban Syst. 2020, 3, 101456.