Science of the Total Environment 651 (2019) 154–161

Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

Traffic-related air emissions in Houston: Effects of light-rail transit

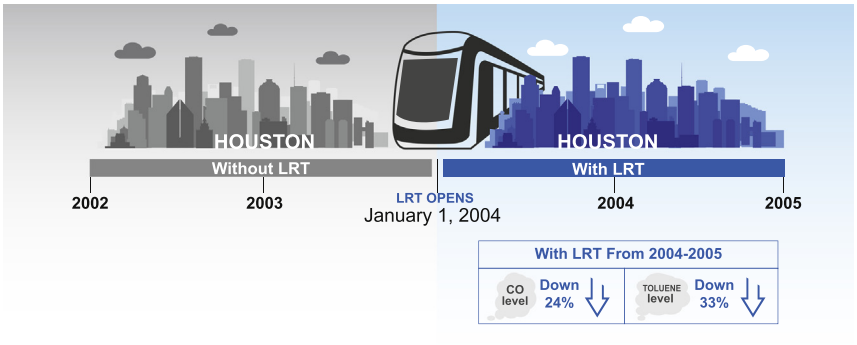
Eun Sug Park [a], Ipek Nese Sener [b,*]

[a] Texas A&M Transportation Institute, 3135 TAMU, College Station, TX 77843-3135, USA
[b] Texas A&M Transportation Institute, 505 E. Huntland Dr., Suite 455, Austin, TX 78752, USA

HIGHLIGHTS

- The effect of LRT on traffic-related air pollution was assessed.
- An interrupted time series design and analysis was used.
- Significant reductions in traffic-related pollution were observed after LRT opening.
- The data provided support for the air quality benefits of LRT.

GRAPHICAL ABSTRACT



ARTICLE INFO

Article history:
Received 22 June 2018
Received in revised form 4 September 2018
Accepted 13 September 2018
Available online 13 September 2018

Editor: Lidia Morawska

Keywords:
Light-rail transit
Intervention
Air pollution
Houston
Vehicle exhaust
Interrupted time series analysis

ABSTRACT

Recent studies have suggested that automobile pollution poses significantly more harmful health impacts than previously realized. Light-rail transit (LRT) is a major type of transportation infrastructure, but there has been little research assessing the air quality effects of LRT based on the actual air pollution data. This study aimed to assess the effects of LRT on automobile-related air emissions in Houston. Specifically, we examined the effects of LRT on key tailpipe pollutants-carbon monoxide and acetylene-as well as other traffic pollution surrogates referred to as BTEX (benzene, toluene, ethylbenzene, and xylene), measured from ambient air monitoring stations. An interrupted time series design and analysis was used to determine the impact of an intervention, where the intervention was the opening of an LRT on January 1, 2004, with two years (2002−2003) of before and two years (2004–2005) of after period data. We found that, after controlling for weather, the opening of the LRT was associated with statistically significant reductions in traffic-related air emissions. Specifically, at the exposure sites, the daily maximum carbon monoxide level was reduced roughly by 24%, and the daily level of toluene was reduced roughly by 60% (33% after accounting for the reduction at the comparison site). Our findings lend support to the air quality benefits of LRT by providing suggestive evidence of positive effects of LRT based on actual air pollution monitoring data. This study's findings also emphasize the importance of developing effective measures to assess traffic-related pollution and call for advanced data collection strategies of additional data, including traffic volume and speed data.

1. Introduction

Several recent studies have suggested that automobile pollution poses significantly more harmful health impacts than other types of sources, and more than previously realized (e.g., Krzyzanowski et al.,

* Corresponding author.
E-mail addresses: e-park@tamu.edu (E.S. Park), i-sener@tti.tamu.edu (I.N. Sener).

https://doi.org/10.1016/j.scitotenv.2018.09.169
0048-9697/

2005; Grabow et al., 2012; Atkinson et al., 2016; Ritz et al., 2016). A special report from the Health Effects Institute (HEI) Panel on the Health Effects of Traffic-Related Air Pollution (2010) provides a critical review of the literature on exposure and health effects of mobile-source air toxics. Similarly, Battelle and the Texas A&M Transportation Institute (2014) conducted a comprehensive review of the projects in the Congestion Mitigation and Air Quality Improvement (CMAQ) program to obtain a better understanding of the potential links between transportation and human health. These reviews have led several agencies to become more aware of the role of transportation infrastructure on air quality and to look for more effective ways to reduce automobile-related pollution through green transportation infrastructures, which will also eventually help address congestion and other transportation problems (Holtzclaw, 2000; Anderson, 2013; Litman, 2011).

Light-rail transit (LRT) is a major type of transportation infrastructures that has a reputation for being 'green'. While it is generally expected that LRT will bring air quality benefits, few studies have examined the air quality effects of LRT. Notable exceptions are studies by Chen and Alexander (2012), Topalovic et al. (2012), and Chester and Cano (2016). Chen and Alexander (2012) analyzed carbon monoxide (CO) and ground-level ozone data to assess the effects of the opening of the Taipei Metro System. Their study found that the opening of the Taipei Metro reduced air pollution from one tailpipe pollutant, carbon monoxide, by 5 to 15%, while it showed little detectable effects on ground-level ozone formation. Topalovic et al. (2012) presented several expected benefits of LRT, including reduction in air pollution that might be resulting from reduction in total vehicle use and greenhouse gases, for the City of Hamilton. However, no air pollution data from the City of Hamilton or any actual data analyses were included in Topalovic et al. Chester and Cano (2016) assessed the environmental effects (energy use and air emissions) from changes to transit infrastructure and travel behavior for the Exposition LRT line and a competing automobile trip in Los Angeles. The methodology of their study was based on a time-based life-cycle framework that includes vehicle, infrastructure, and energy production life-cycle processes and their supply chains, in addition to vehicle propulsion. Based on the modeled values, the study concluded that the implementation of the Expo line can be expected to produce reductions in energy use, greenhouse gas emissions, and conventional air pollutants.

The objective of this study was to evaluate the effects of LRT on air quality in Houston, Texas, based on the actual Houston air quality data. Specifically, we aimed to determine if the opening of the Houston LRT reduced traffic-related air emissions. We conducted an in-depth investigation of the trends of key tailpipe pollutants—CO and selected volatile organic compound (VOC) species (acetylene and benzene–toluene–ethylbenzene–xylene [BTEX])—during the study period and assessed whether there was a noticeable change before and after the opening of the LRT.

2. Materials and methods

2.1. Study area

Houston is the fourth largest city in the United States. Automobiles are one of the major pollution sources for the city (see, e.g., Sexton et al., 2007). Fig. 1 shows the location of the original Houston METRO LRT line in Harris County. The original 7.5-mile Red Line (or North Line) opened on January 1, 2004, and ran from the Texas Medical Center to Downtown, with 16 stations along its route. As pointed out by Chen and Alexander (2012), the air quality effects of rail transit infrastructure

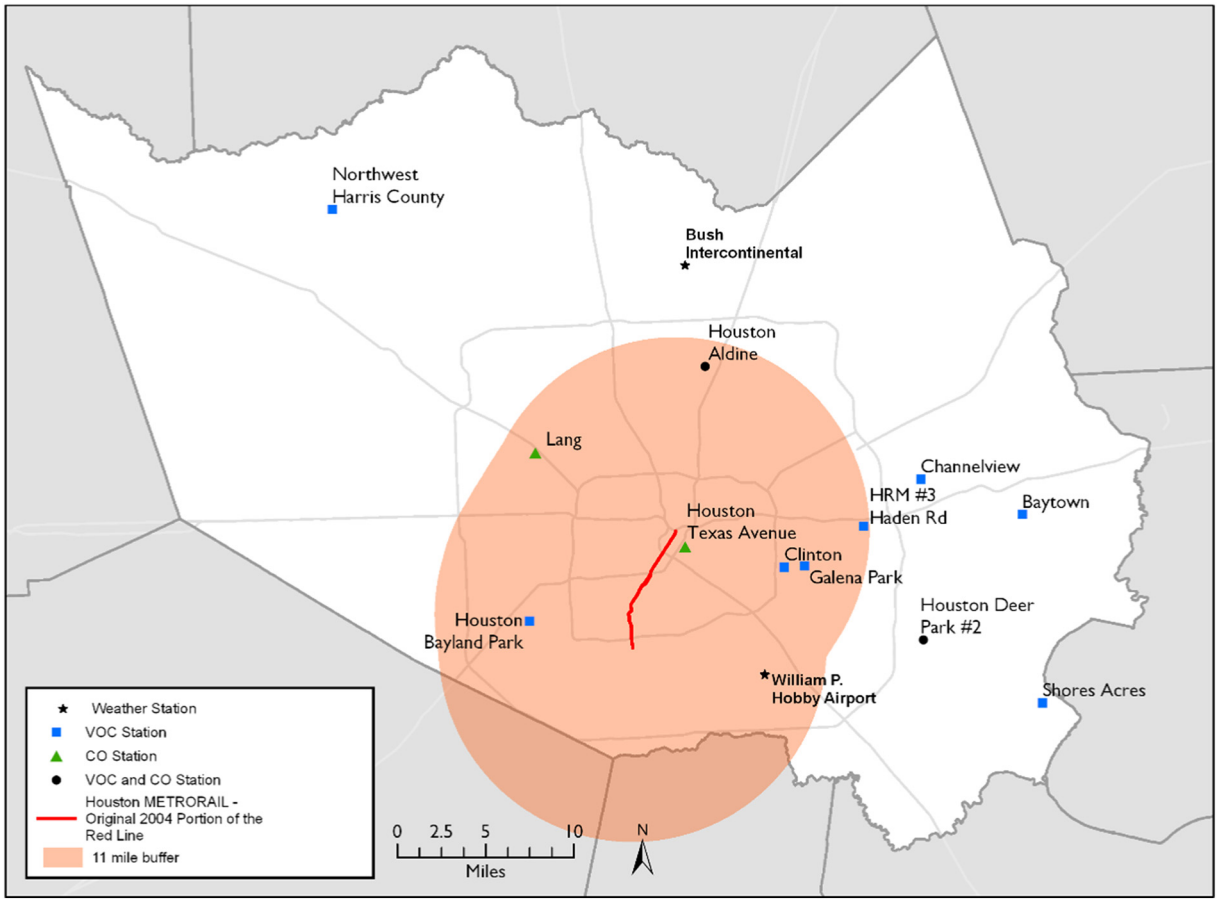


Fig. 1. Map of the Houston METRO original Red LRT line and air pollution monitoring stations in Harris County, Texas. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)