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Spatio-Temporal Analysis of Roadside Transportation-Related Air Quality (StarTraq 2021): A Characterization of Bike Trails and Highways in the Fresno/Clovis Area

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Introduction

Promoting alternative forms of transportation is an important aspect of transportation planning in the fight for a healthy and safe environment. Information on pedestrians' and cyclists' exposure to traffic-related air pollutants while commuting, and their utilization of parks and recreational areas is very limited in the Fresno/Clovis area. This research provides valuable insights and findings that could be used to better plan transportation facilities, and promote more active transportation. This project continues and expands on the StarTraq 2020 project funded by the Fresno State Transportation Institute (FSTI) to meet the identified needs of the Fresno/Clovis area, promoting alternative forms of transportation by examining air pollution data collected near roadways and on trails as related to active modes of transportation such as walking and cycling. This research explores the relationships of microenvironments, and the components in particulate matters in the urban atmosphere to broaden the scope of roadside, On-Road, and In-Vehicle air quality data.

Study Methods

This study acquired air pollution samplings in three scenarios: (1) bike trails; (2) local roadways; and (3) intercity roads, to see the spatio-temporal variation in transportation-related air quality.

(1) Active Transportation Mode: The particulate matters (PM_{10}, $PM_{2.5}$, and PM_1) and particle-bound black carbon concentrations were monitored using real-time aerosol monitors, namely the DustTrak DRX II 8533 (TSI, St. Paul, MN), and the microAeth AE51 (AethLab, Berkeley, CA). Active transportation mode air quality was monitored on the selected Woodward Park and Old Clovis trails and urban bike lanes. The real-time aerosol monitors, and the low-cost sensors were carried in a backpack on the bicycles during the sampling. Researchers collected GPS data via a portable GPS technology called Tracksticks.

(2) Driving Transportation Mode: Researchers monitored driving transportation mode air quality from the selected roadways within the Fresno/Clovis area (six samplings), and during the intercity trips to and from Fresno and other cities such as Berkeley, and Los Angeles (five samplings). 'On-road' (outside vehicle) monitors were installed on the roof of a vehicle, while 'In-Vehicle' monitors were installed inside of the vehicle for a comparison of the particulate pollution levels in these two contrasting microenvironments. Tracksticks logged the GPS data for the trips. Before and after driving, researchers performed collocation for any offsets or drifts of air monitors for QA/QC.

Findings

1. Relationships between PM species: PM_{10} and PM_1 concentrations were nearly identical to $PM_{2.5}$ concentrations in every microenvironment. This may imply the majority of PM generated near roadways were smaller particles, which may also indicate the particles are from combustion sources or secondary aerosol production. It is important to analyze the $PM_{2.5}$ data because it is associated with significant health effects, and, as a result, it is regulated as a criterion air pollutant by the Clean Air Act. The correlations among BC and $PM_{2.5}$ in On-Road samples were lower in most cases except when the samples were collected near the incomplete combustion vehicle emissions.
2. Variability of particle concentrations: The variability of particle concentrations was greater in the bike trails and on-road samples than the variability in the backyard or In-Vehicle samples

respectively. This was to be expected as the aerosol monitors were moving while collecting the samples on bike trails or on-road bike trails in comparison to the backyard. Bike trail PM concentrations were nearly identical (99.7%) to the ambient PM concentrations measured in the backyard. The average BC concentration level was 48% higher from the bike trail than that of the backyard sample.

3. Reduction of in-vehicle $PM_{2.5}$ and BC: In-vehicle particle concentrations were significantly reduced to a safe level compared to the on-road concentrations. In-vehicle $PM_{2.5}$ was 31% of on-road $PM_{2.5}$, while in-vehicle BC was 5.5% of on-road BC when local and intercity data were combined. In-vehicle concentrations were elevated when either a door or window was open, allowing on-road pollution to enter the vehicle. In-vehicle concentrations elevated significantly when doors were opened while the engine was running. After the closure of doors, the concentrations gradually decreased over time.
4. Intense on-road concentrations during intercity and local sampling: On-road $PM_{2.5}$ levels were 2.9 times higher than in-vehicle levels in the Fresno roadway sampling. On-road $PM_{2.5}$ levels were 4.3 times higher than in-vehicle $PM_{2.5}$ levels on intercity trips. On-road BC was 65 times higher than in-vehicle BC in Fresno roadway sampling. On-road BC was 62 times higher than in-vehicle BC in intercity trips.
5. San Joaquin Valley and Bay Area: The PM concentrations measured on-road on trips to the Bay Area demonstrated that the San Joaquin Valley has increased ambient $PM_{2.5}$ and BC compared to those in the Bay Area on every trip regardless of the daily change of air quality.
6. From our measurements, $PM_{2.5}$ levels were 21% higher than that of FRM on average for all types of samples consistently. Black carbon data was not obtained from FRM. The air sampling inlet being closer to the ground and near the emission sources, without any moisture control in the portable aerosol monitors, should have contributed to this increased level.

Ambient $PM_{2.5}$ and BC levels in San Joaquin Valley were higher than those of the Bay Area on every trip regardless of the daily changes in air quality.

Policy/Practice Recommendations

Promoting active transportation can improve urban air quality and public health. More specifically, the planning of safer bike trails can significantly reduce active transportation users' exposure to those air pollutants. The air pollution control district provides accurate real-time air quality data of PM in the area to the public. However, there is a big knowledge gap in the information on black carbon and other toxic components of PM that are emitted from internal combustion engine vehicles. This is because of the difficulties in quantification, and lack of regulation on those air pollutants.

About the Author

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To Learn More

For more details about the study, download the full report at transweb.sjsu.edu/research/2128

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