Particulate Matter Concentrations in San Francisco Bay Area Rapid Transit (BART) Train Stations

Natali Romero, Richard Sanchez, Felipe Lopez, Sophia Macias, Carlos Madrigal, Lawrence Newsome, Megan Torio, Ja’lenn Polar, Victor Rios, Tony Marks-Block

Contact: ebays@berkeley.edu

Introduction
To assess the impact of local mineral dust levels on air quality in the San Francisco Bay Area, we researched particulate matter (PM) concentration levels in a variety of different settings. Air samples were collected and analyzed for 2.5 micrometer diameter particulate matter (PM2.5) at different locations as our team traveled in trains from coastal to inland areas along the Bay Area Rapid Transit (BART) system (Figure 4). PM2.5 is made of microscopic solids and liquid droplets transported through the burning of fossil fuel, as well as through abrasion of metal that results from interaction between rails and wheels on train systems. As PM has been shown to detrimentally impact both human respiratory and cardiovascular systems (Beyers et al. 2008 and Figure 2), through this study we sought to contribute to a better understanding of why rates of cardiovascular and respiratory disease are higher in certain Bay Area locations than others. Results obtained during this study indicate that air at underground stations associated with the BART system contains much higher PM concentration levels than that of above ground locations, and that air at particular stations is extremely unhealthy according to U.S. Environmental Protection Agency (EPA) standards. As such, we strongly urge the BART agency to conduct follow up research to assess and monitor PM levels at numerous stations throughout the year.

Materials and Methods
PM data was collected from various locations during transit along three different BART train routes on 7/17/12, 7/18/12, 7/19/12, and 7/23/12. This was accomplished through the use of a Dustrak 3550 Aerosol Particulate Concentration Monitor synched with a mobile GPS unit. Using this set-up PM2.5 mass concentrations were measured in samples that were collected at a rate of one per second during transit. Flow-rate and zero-count calibrations were performed on a daily basis. While traveling to and from underground stations the time and PM concentration levels were noted wherever there was a distinct shift in PM levels or the environment in which sampling occurred. Measurements were made while in transit from the West Oakland Station to Union City, BayFair Park, and Pittsburgh BART stations (Figure 4). On the way to particular destinations the study team stopped at numerous stations, including Emeryville, Orinda, MacArthur, 19th Street and Coliseum. While en route to particular destinations samples were collected in each BART train car to determine whether or not notable differences in PM concentrations occurred among cars. Collected data was correlated with the EPA’s Air Quality Index standards for PM2.5 (Figure 7). An open-source software known as Tableau was used to analyze collected data.

Data and Results
The highest average PM concentration levels were measured at the Embarcadero BART station each day data was collected. As a comparison to Embarcadero station data, we collected data at the Pittsburgh station, which is outdoors. Levels at this station were found to be much lower than those measured at Embarcadero, and similar to PM concentrations recorded at other outdoor stations (Union City, Coliseum, Orinda) where we collected data. When the team traveled to Pittsburg on July 17 the maximum PM concentration recorded was 34.00 µg/m³ and the average PM concentration level measured was 5.99 µg/m³ (Figure 5). When the team traveled to Embarcadero on July 17 the maximum PM concentration recorded was 169.0 µg/m³ and the average PM concentration recorded was 103.9 µg/m³. When the team traveled to Pittsburgh on July 18 the maximum PM concentration recorded was 88.00 µg/m³ and the average PM concentration measured was 12.98 µg/m³. When the team traveled to Embarcadero on July 18 the maximum PM concentration recorded was 171.0 µg/m³ and the average PM concentration recorded was 93.4 µg/m³ (Figure 5). When the team traveled to Pittsburg on July 19 when the maximum PM recorded was 261.0 µg/m³ and the average PM concentration recorded was 6.6 µg/m³. When the team traveled to Embarcadero on July 19 the maximum PM recorded was 154.0 µg/m³ and the average PM concentration recorded was 120.6 µg/m³ (Figure 5). When the team traveled to Embarcadero on July 23 the maximum PM recorded was 132.0 µg/m³ and the average PM concentration recorded was 101.9 µg/m³. Also, while traveling along the Pittsburg route on July 17 a member of the research team struck one of the cloth seat covers in the train car, which resulted in a corresponding increase in PM concentration readings to 3260 µg/m³ (Figure 6). Such increases were consistent on all other trains and days when the seats were struck.

Discussion
We believe that the high PM concentration levels recorded inside the Embarcadero BART station result from PM becoming trapped indoors, and the inability of fresh air to enter the station platform (Figure 1). In previous studies conducted in Paris, Los Angeles and London high levels of PM have also been found in underground stations, and have been attributed to train wheels grinding on metal tracks, as well as the constant grinding of brake pads (Kam 2011, Tokarek 2006, Seaton 2005). We believe that the high levels of PM recorded at the Embarcadero station result from the same mechanisms. In addition, according to a BART agency spokesperson, track grinding that occurs in association with the use of equipment to perform track smoothing also contributes to high PM concentrations.

PM concentration levels recorded at Pittsburg station were lower than anticipated. Prior to conducting this study the team believed that PM levels would have been much higher because this station is situated in a commercial area near a major highway and is surrounded by eight lanes of freeway traffic, and is situated near a natural gas power plant (Figure 3). This was not the case, however. On the station platform the movement of vehicles produced a significant wind draft, which potentially lowered the PM concentration levels. Similar values (between Good and Moderate) were found at other outdoor stations. Inside train cars the team observed that striking older cloth seat covers generated high levels of PM, which is likely due to their ability to accumulate dust and their inability to be thoroughly cleaned. The same phenomenon did not occur on seats composed of newer vinyl material, which is outdoors.

Conclusions
We found that the BART agency support young scientists in contributing to future air quality research. In this regard, we believe that our next steps would be to develop a better understanding of how PM levels vary at different times of day and year. In this study we attempted to reveal similar, continuous PM levels, we believe that BART should install filter systems in the underground stations like the ones that have been implemented in association with diesel-fuel burning trucks at the Port of Oakland, or those that have been utilized in the Paris Subway (Tokarek 2006), we also believe that use of ventilation fans in underground stations could help move the PM out of the station and bring in fresh air. We would also like to see monitoring take place at different levels of underground stations such as the Embarcadero. Also, we recommend that a study of the elemental composition of the PM be conducted to help determine how this particular form of PM impacts the human body compared to PM produced through the use of petroleum-based fuels. Lastly, we recommend that the BART agency support young scientists in contributing to future air quality research.

Acknowledgements
We would like to thank Margaret Gordon, Cassandra Martin, and the West Oakland Environmental Indicators Project for providing us with technical and moral support. Lastly, we would like to thank Kevin Cuff for his continuous support, and for helping us hone our research and analytical skills (including assisting us in understanding the “bigger picture”).

References

Figure 1
Figure 2
Figure 3
Figure 4
Figure 5
Figure 6
Figure 7