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

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Introduction

To assess the impact of local mirco-climates 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 micron diameter particulate matter (PM) at different locations as our team traveled in trains from coastal to inland areas along the Bay Area Rapid Transit (BART) system (Figure 4). PM is made of microscopic solids and liquids generated 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 human cardiovascular and respiratory systems (Beyers 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 stations, and that air at particular stations is extremely unhealthy according 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.

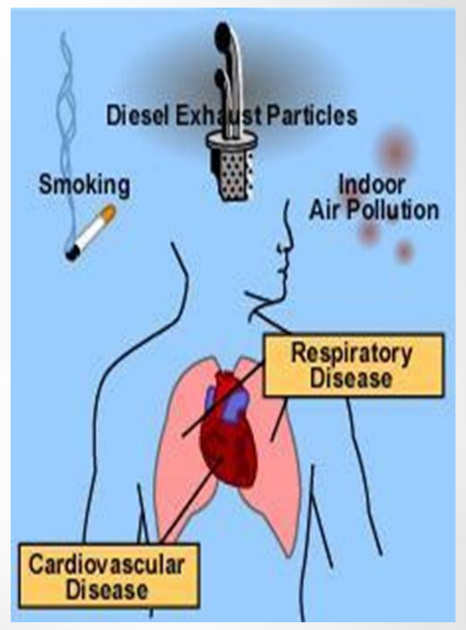

Figure 2
Health Affects of PM
http://www.home-air-purifier-expert.com/lungs.html

Figure 4
Map of Routes

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 II 8530 Aerosol Particulate Concentration Monitor synched with a mobile GPS unit. Using this set-up PM 2.5µm 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 whenever 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, Balboa Park, and Pittsburg BART stations (Figure 4). On the way to particular destinations the study team stopped at numerous stations, including Embarcadero, 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 PM 2.5µm (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 Pittsburg 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 Pittsburg 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 155.0 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 152.0 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 began striking 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.

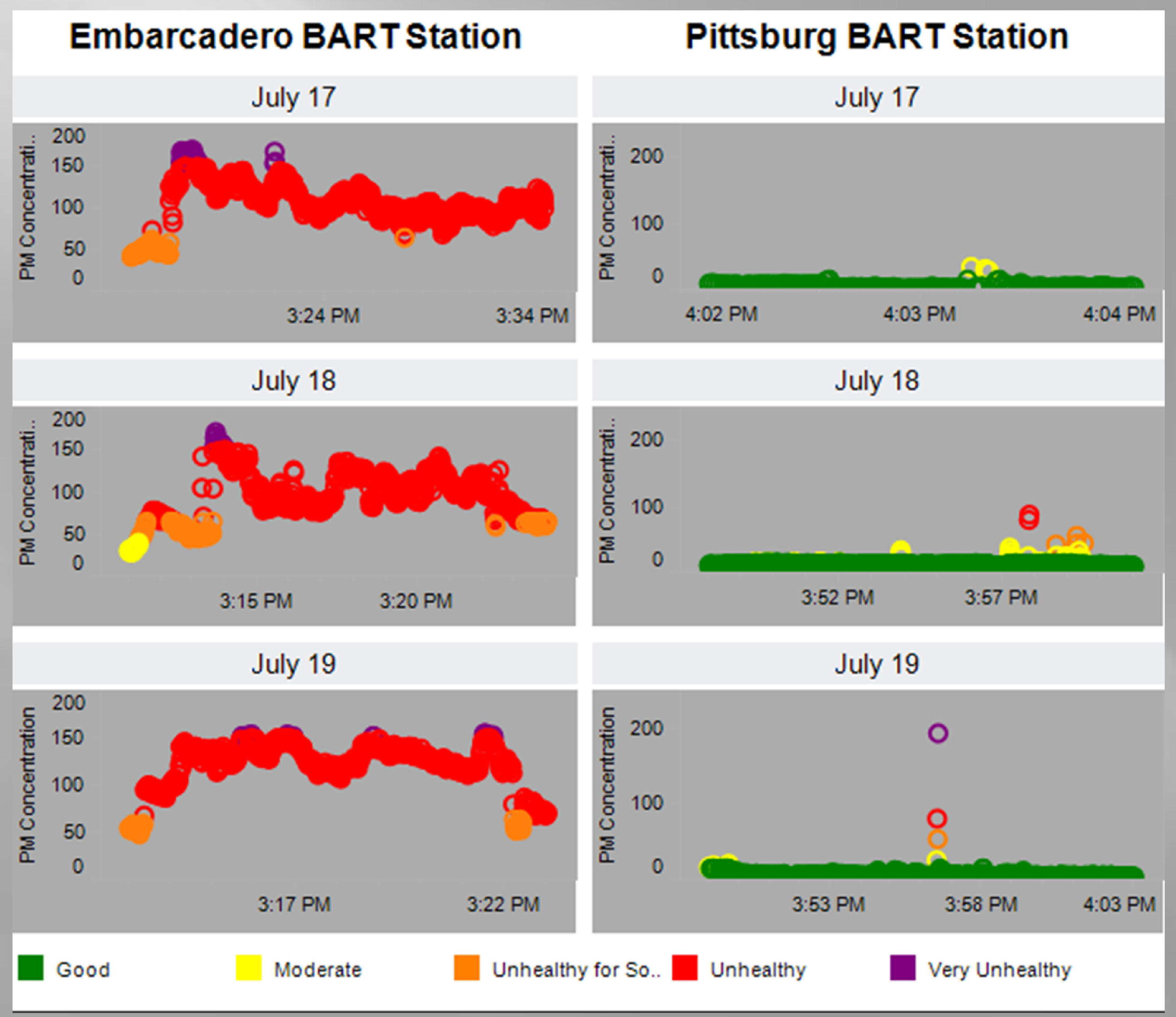

Figure 5
Comparison of PM mass concentrations at Pittsburg & Embarcadero BART Station

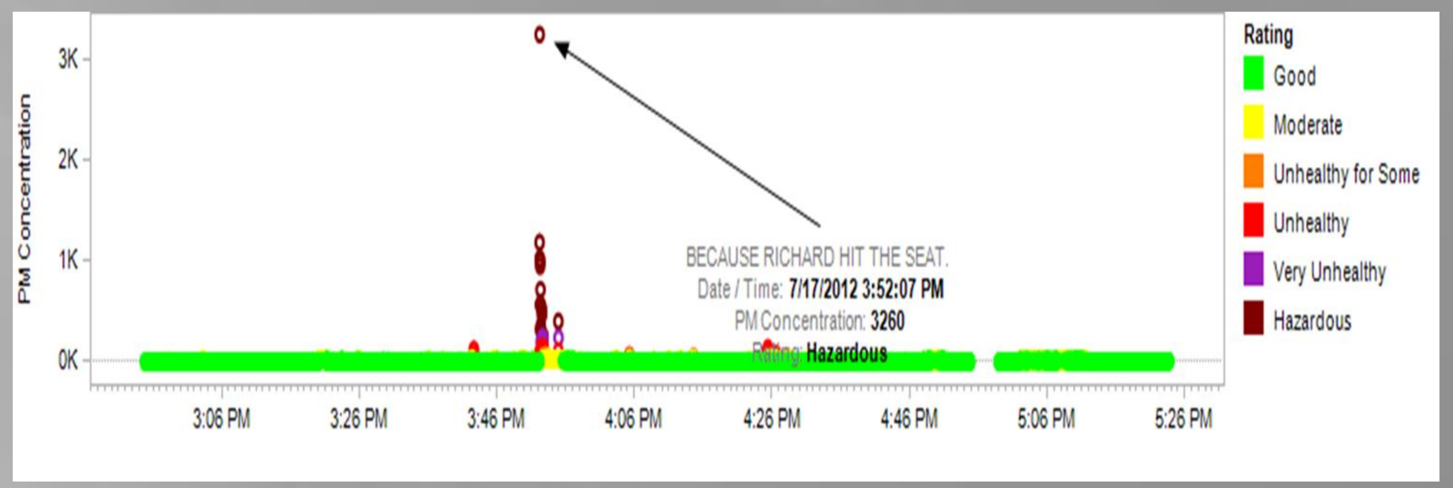

Figure 6
Particulate Matter Spike after hitting a BART seat on July 17, 2012

Rating	
Good	0.0- 15.4 µg/m³
Moderate	15.5 - 40.4 µg/m³
Unhealthy for Some	40.5 - 65.4 µg/m³
Unhealthy	65.5 - 150.4 µg/m³
Very Unhealthy	150.5 - 250.4 µg/m³

Figure 7
Environmental protection agency Standards for PM 2.5 [24-Hour]

Discussion

We believe that the high PM concentration levels detected 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 subterranean stations, and have been attributed to train wheels grinding on metal tracks, as well as the constant grinding of train 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 inland where weather conditions are hotter and more humid, 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 BART is beginning to use more consistently on train car seats.

Figure 1
Embarcadero BART Station Wall

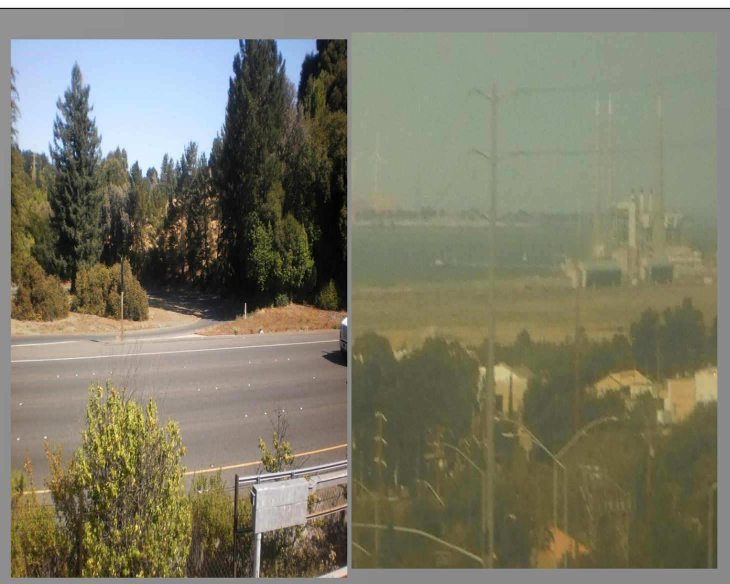

Figure 3
Surroundings of Pittsburg Train Line and view from Pittsburg BART Station

Conclusion

We believe that it is important for BART passengers and staff to be made aware of any environmental quality related issues associated with using BART trains. Thus, in light of the findings associated with this study, we recommend that air quality research related to BART underground stations continue in the future, and that related findings are made public. In this regard, we believe that year-round and 24 hour monitoring should take place to help develop an understanding of how PM levels vary at different times of day and year. If results of such an effort 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 an analysis 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

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References

- Beyers, Matt, and Janet Brown. *Life and Death from Unnatural Causes: Health and Social Inequality in Alameda County*. CAPE unit of the Alameda County Public Health Department, 2008.
- Kam, Winnie, et al. "Particulate matter (PM) concentrations in underground and ground-level rail systems of the Los Angeles Metro." *Atmospheric Environment* 45.8 (2011): 1506-1516.
- Seaton, A., et al. "The London Underground: dust and hazards to health." *Occupational and Environmental Medicine* 62.6 (2005): 355-362.
- Tokarek, S., and A. Bernis. "An example of particle concentration reduction in Parisian subway stations by electrostatic precipitation." *Environmental technology* 27.11 (2006): 1279-1287.