Pollution Monitoring in Fontana district using Geospatial Techniques

P.G. Diwakar[a] and Rudrodip Majumdar[b]

[a] ISRO Chair Professor; National Institute of Advanced Studies

[b] Assistant Professor; Energy, Environment, and Climate Change Programme, National Institute of Advanced Studies

1. Background

Particulate matter (PM) pollution in the atmosphere is an issue of grave concern as it has serious implications on the human health. However, for a long time, obtaining accurate measurements of the air-borne PM concentrations for both PM2.5 and PM10 has faced multiple obstacles. In particular, the proper choice of the locations for setting up the continuous air quality monitoring stations (CAQMS), periodical recalibration of the instruments (preferably, once in every month and possibly, once every season) and quality control of the hourly data for the PM2.5 and PM10 concentration are some of the key aspects that have impacted the efficacy of PM measurement.

A literature survey, examined recently, by examining published articles on the subject indicates that several developed and developing countries are finding it difficult to assess the severity of the problems arising due to the PM pollution. The expenses associated with the manpower deployment and the equipment costs prohibit the establishment of a large enough number of monitoring stations to ensure adequate granularity, temporally and offer enough diversity spatially. Lesser number of the air quality monitoring stations, together with improper upkeep of monitoring facilities, lead to the non-functioning of deployed infrastructure.

Geospatial techniques can serve as a very reliable and potent tool towards a broad spatial understanding of the atmospheric state-of-affairs, as the necessary data processing and interpretation can be mostly performed on a desktop computer without the need for high-end expensive processing infrastructure. However, the ground verification process to substantiate observations on a geospatial domain is very essential for the purpose of validation of the inputs from remotely sensed findings and calibration of the RS information for further deductions and interpretation (development of the matching resolution and scale of inputs).

The city of Fontana, CA has been gaining recent attention because of the PM pollution in the air, and the district administrator is keen on finding the possible reasons behind the upsurge in the PM pollution level. A study was conducted to understand the PM pollution levels over the Fontana and the surrounding city cluster as shown in **Figure 1**. As a first level priority, the study focuses on the PM2.5 concentration because of its health implications. This study was anchored using geospatial data for better understanding of the issue through geospatial representation and visualization techniques.

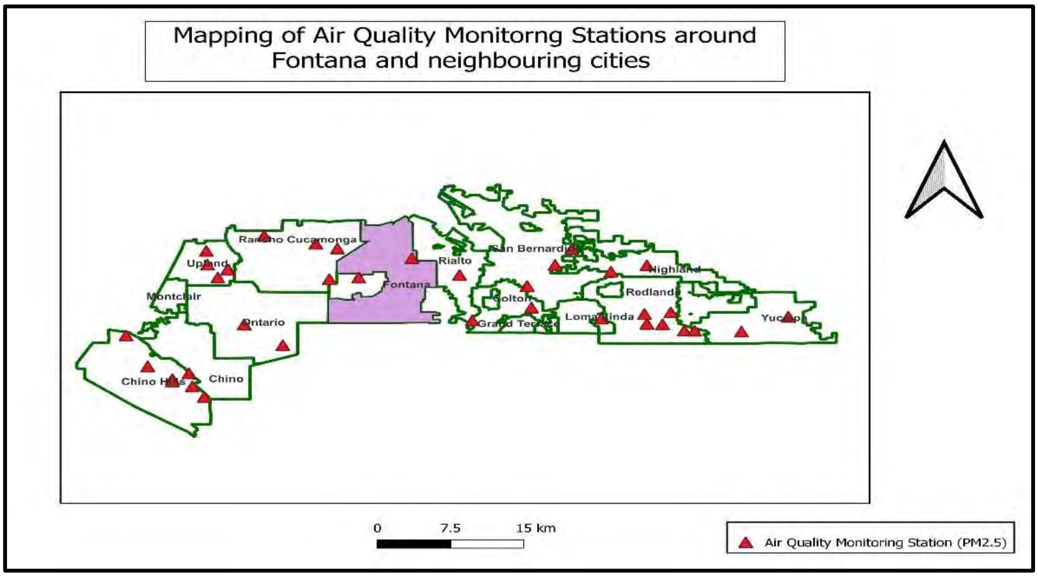

Figure 1: A map of Fontana and the surrounding city cluster. The city of Fontana proper (area of interest) is highlighted in purple

2. Datasets used

It is important to mention that the PM pollution level in the air is heavily dependent on two critical meteorological parameters, the rainfall, and the wind vector (comprised of wind speed and the wind direction). The ERA5 - Land data (spatial resolution 11 km from ECMWF) has been used in this study to understand the effect of the Rainfall and the Wind Vector on the pollution level. As the current area of interest is limited, solely to the Fontana district, therefore only the ERA5- Land spatial grid covering the Fontana district was considered to investigate the wind parameters as well as for preparation of the Wind Rose Plots (**ERA5** is the fifth generation ECMWF (European Centre for Medium range Weather Forecast) atmospheric reanalysis data, which is available as an hourly estimate. The monthly average PM 2.5 plots, the monthly total rainfall plots and the monthly Wind-Rose plots were used to reach specific logical decisions.

As per the local meteorological definition, the prevalent seasons in the West Coast of the USA are described as below:

Winter: December – February

Spring: March – May

Summer: June – August

Autumn: September – November

However, the open-source information suggests that wet winter and dry summer are the two seasons predominantly observed in the Fontana area.

Based on the above information, taking into consideration the measured PM levels and satellite-derived meteorological parameters (rainfall levels and the wind parameters), five representative months (January, February, April, September, and December) have been selected from the year 2018, to further examine the impact of the critical meteorological parameters on the monthly variations observed in the PM 2.5 levels.

As the PM 2.5 levels were not available from the only Purple Air CAQMS deployed within the Fontana district boundary, the analysis used interpolation techniques based on the neighborhood district data to have an estimate of the monthly average PM2.5 levels over the Fontana district. The findings from the geospatial maps and Wind-Rose plots (based on satellite-derived data or reanalysis data) for the aforesaid five months are summarized in Figures 2-6.

3. Discussion

Published literature suggests that the main sources of the PM 2.5 are urban construction activities and the notorious California wildfires (biomass burning). In contrast, the PM 10 levels are primarily attributed to the traffic load. In the case of Fontana, the PM 10 inspection needs to be done while keeping in mind the regular traffic load as well as the traffic of heavy refrigerated trucks flocking to the Amazon warehouses present within the city cluster.

In the absence of the PM 10 ground data from the Purple Air CAQMS station in Fontana, the main source of PM 10 in the city cluster has been identified to be traffic load by inspecting NOx Data (AQMD, San Bernardino City) [The exact location of this AQMD station could not be found], and the PM10 data from the Purple Air CAQMS located nearest to a traffic monitoring station in the San Bernardino City. Upon cleaning up the raw data (involving outlier removal), a reasonably good match between the profiles PM 10 and NOx was observed (see Figure 7). The validation study indicated the importance of the Quality Control of CAQMS data.

4. Salient Findings

Our study indicates the following key points:

- The PM 2.5 levels obtained for Fontana through the interpolation of neighborhood data (Fontana Purple Air Station does not have data) *may not be solely attributed to the local activities within the Fontana District boundary*. It may be emerging from elsewhere and being carried by air, as the airborne PM pollution is not stationary. Therefore, a closer look is needed into the major ongoing activities in Rialto, Rancho Cucamonga, and Ontario, especially some of the major projects, including construction, which could be in the neighborhood of the administrative boundary of Fontana.

- Further, inspection of the local wildfire activities such as the El Dorado fire, the wildfire in the Yorba Linda region as well as that in Riverside would prove to be essential in taking necessary measures (reducing planning of internal civil construction activities within the city cluster during the fire season) so that the PM 2.5 levels do not reach unacceptably high values and persist for a large period of time (7-9 months) within a typical year. There must be a collaborative effort among the neighboring cities / districts.

- Looking within the district, the heavy traffic on the highways and service-ways that run through the Fontana district (Highways 10 and 15, Rialto Airport Road etc.) is the primary source of PM 10. Therefore, heavy traffic management strategy may be an area to be considered by the administrators.
- Rainfall may occasionally bring down the PM pollution level. However, the extent of rainfall around Fontana district is small. Therefore, the correlation between the daily rainfall level and daily average PM concentrations needs more in-depth investigation.

5. Key Recommendations

1. We recommend that multiple CAQMS facilities should be made functional within the District Boundary. Each CAQMS should be equipped for measuring both PM 2.5 and PM 10.
2. From the monitoring point of view, the first-level priority locations should be the most vulnerable places, academic institutes (e.g., schools), community halls/ major public facilities and the hospitals.
3. The other high-priority locations are the places with probability of high pollution, e.g., highway junctions, highway/service-way adjacent neighborhoods etc. In the high pollution areas, the upper limit of the pollution may give useful insights about the highway traffic load. Such information would help in heavy traffic load management.
4. Further attention should be given to the major industrial hubs / commercial activity areas.

Based on the above priority criteria, the **suggestive CAQMS Locations** are indicated in Figure 8.

The five locations marked in Figure 8 are numbered 1 to 5, starting at the southern part of the Fontana district.

Location #1 (Near southwest industrial park**):** to measure pollution from industrial hubs. This also covers pollution from 10 & 15 Freeway as well as pollution from industrial areas of Ontario

Location #2 (Near Bloomington Drive before the I-15 intersection): Our wind data indicates that there is a possibility that the pollution from the traffic load in the Bloomington Drive/Freeway 10 travels towards Veterans Park.

Location #3: Near Rialto Airport Road to monitor the pollution level that possibly affects Veterans Park and Almeria Park.

Location # 4 (Close to I-15 and 210 junction) → This location will capture the pollution from outside Fontana boundary as well as the traffic from the freeway.

Location #5 (Near Coyote Canyon Park**):** This location is vulnerable to wildfire as well as air-borne dust particles from the dry riverbeds located towards the north.

These locations provide a diverse spatial perspective, and helps in segregating the local and regional/peripheral sources of PM pollution.

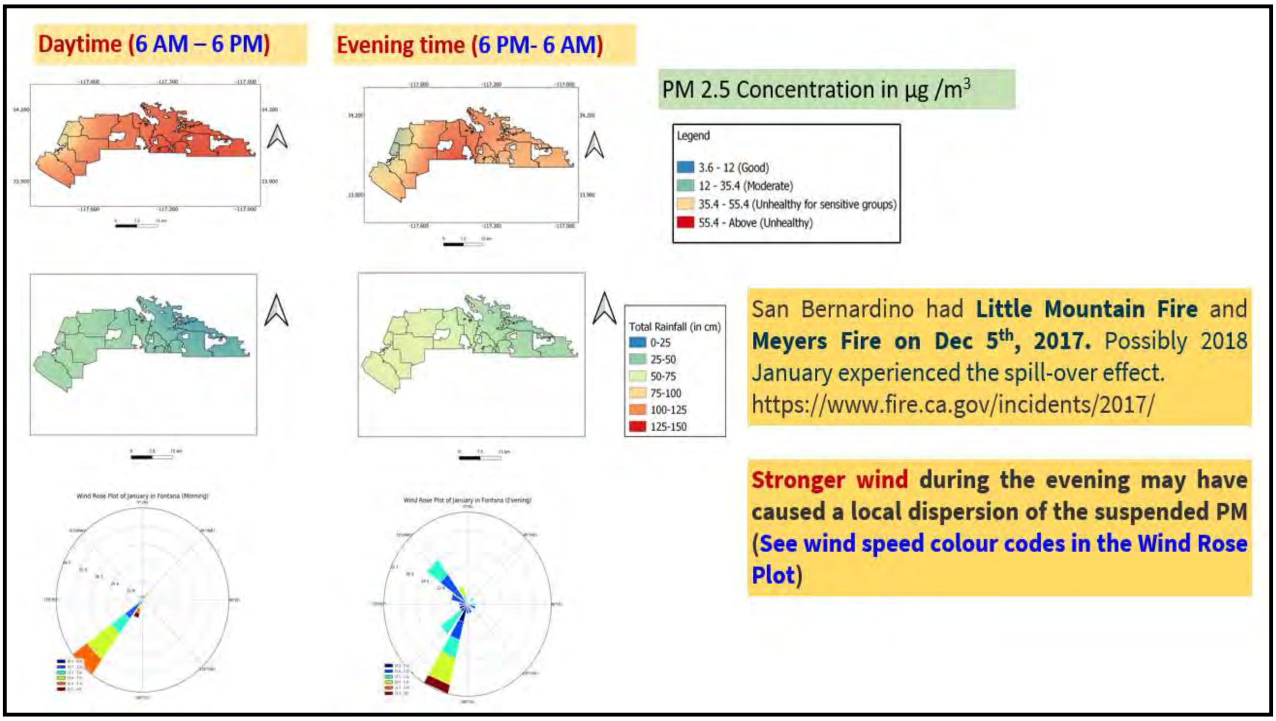

Figure 2: Monthly Average PM 2.5 Maps, Total Rainfall Maps, and the Wind Rose Plots for January 2018

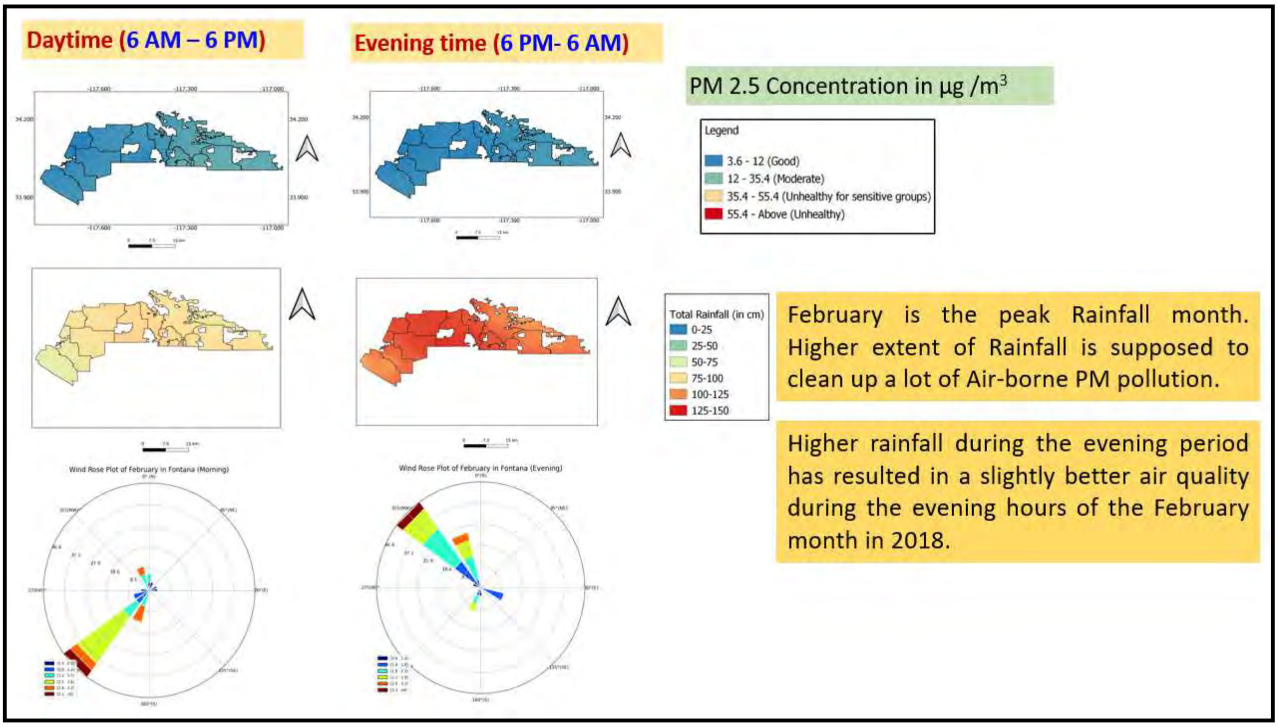

Figure 3: Monthly Average PM 2.5 Maps, Total Rainfall Maps and the Wind Rose Plots for February 2018

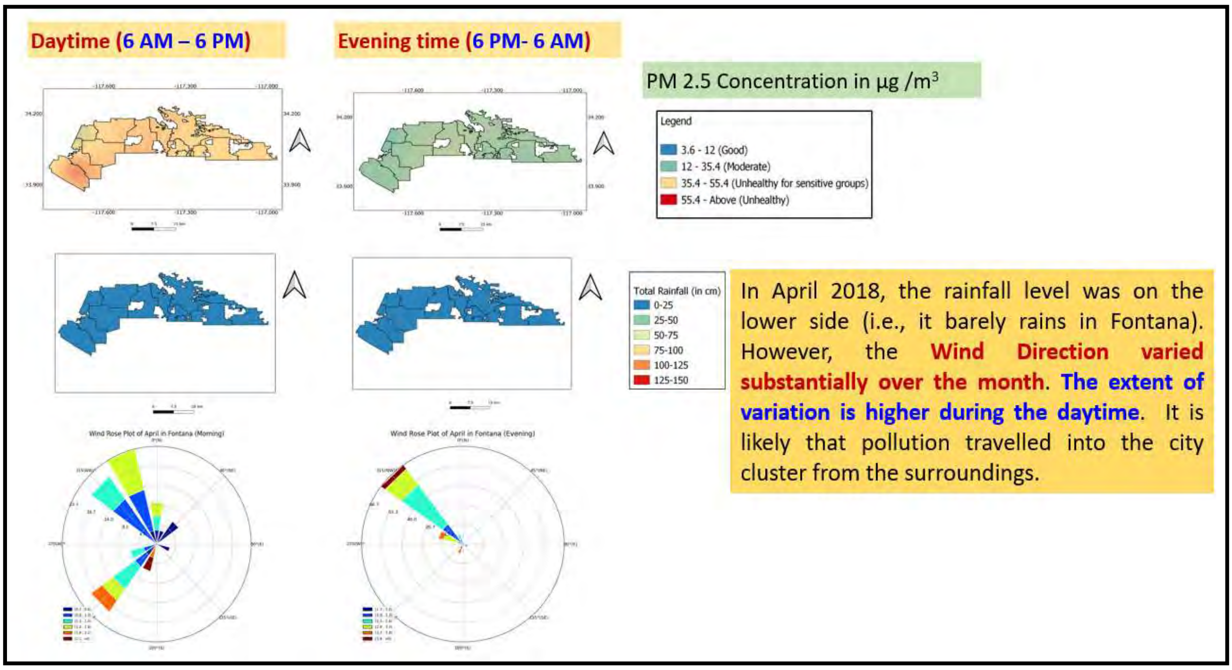

Figure 4: Monthly Average PM 2.5 Maps, Total Rainfall Maps and the Wind Rose Plots for April 2018

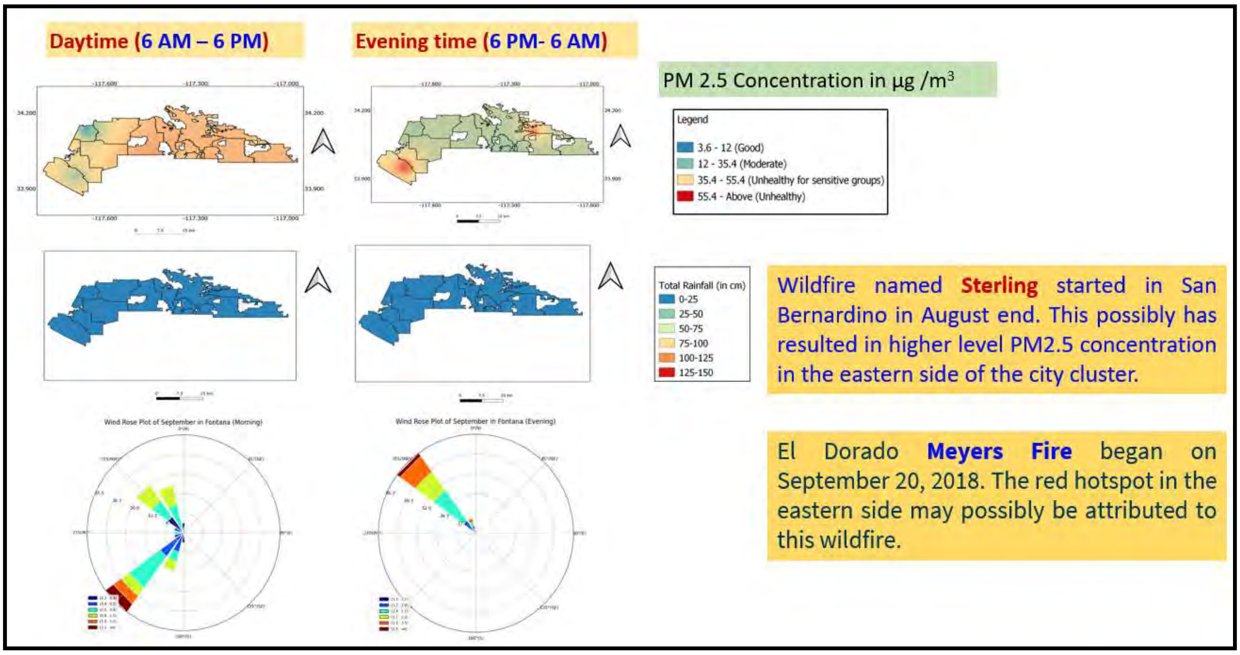

Figure 5: Monthly Average PM 2.5 Maps, Total Rainfall Maps and the Wind Rose Plots for September 2018

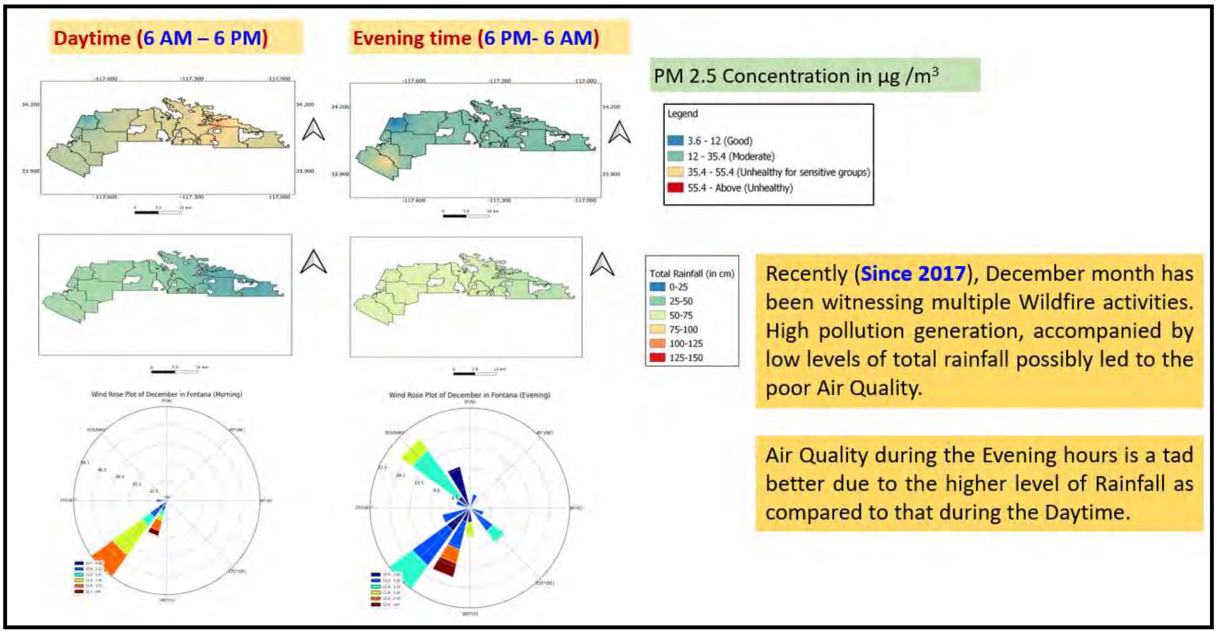

Figure 6: Monthly Average PM 2.5 Maps, Total Rainfall Maps, and the Wind Rose Plots for December 2018

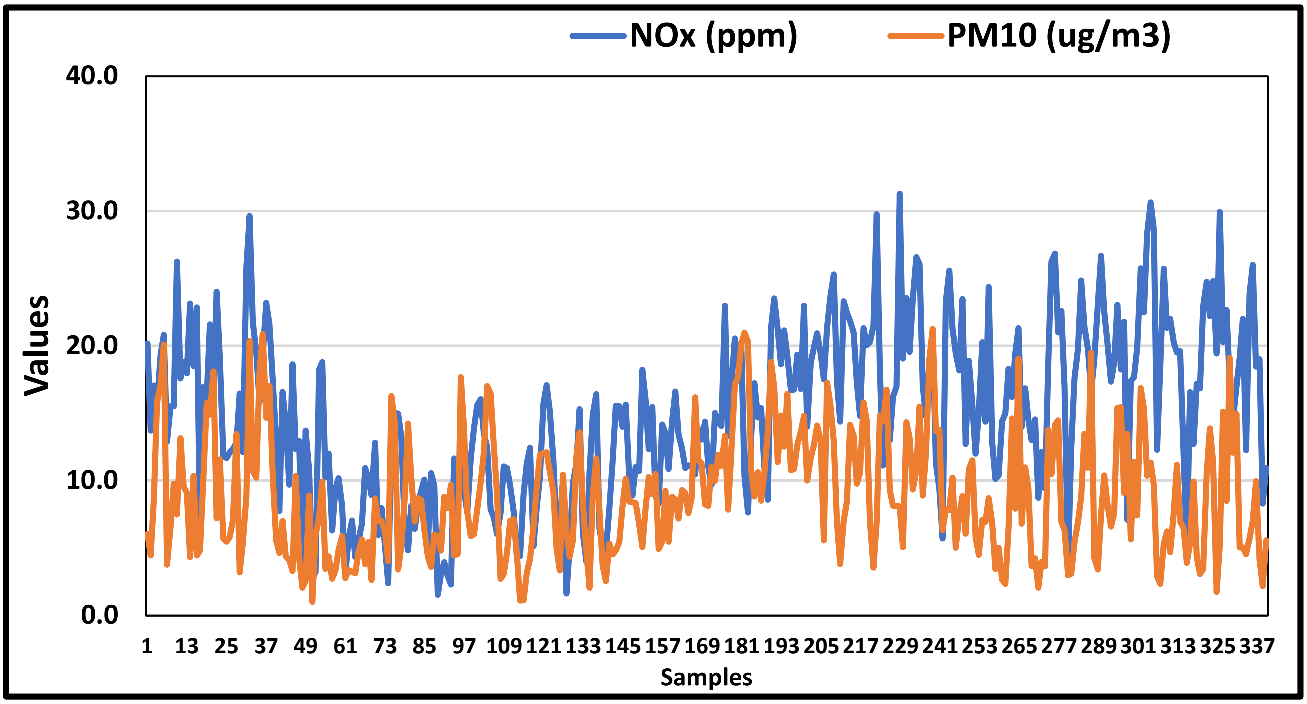

Figure 7: Representative PM 10 (Purple Air CAQMS) and NOx (AQMD) profiles of San Bernardino City (strong correlation between NO_X and PM10 indicates that the primary source of PM10 is high traffic volume)

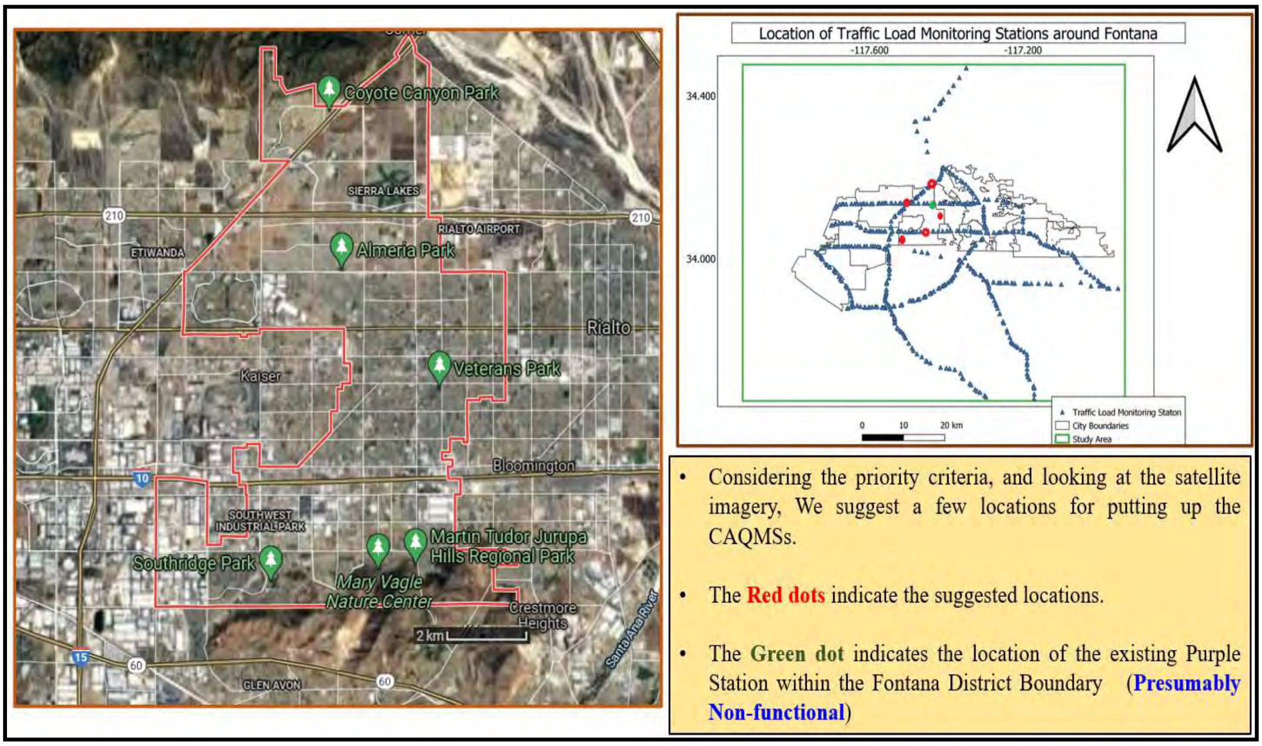

Figure 8: Suggested locations for installing PM monitoring stations within the Fontana District boundary