



Consiglio Nazionale delle Ricerche

Istituto per la BioEconomia

AIR QUALITY MONITORING REPORT 1.0
JULY – DECEMBER 2021

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11/02/2022

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1. Introduction

As part of the Urban Innovative Action (UIA) project, the main goal of this report is to provide patterns of particulate matter (PM₁₀ and PM_{2.5}), carbon dioxide (CO₂) concentrations, and air temperature and relative humidity measured by the AirQino air-quality monitoring stations in various districts of Prato during the period July-December 2021. Specifically, graphs and tables are shown to illustrate some relevant figures of the analyzed variables at the station sites (Fig. 1).

Each station was classified according to ID number, name of station, geographical position and installation date. As reported in Tab. 1, most of the installations were completed during July 2021, which was chosen as starting date of the analysis.

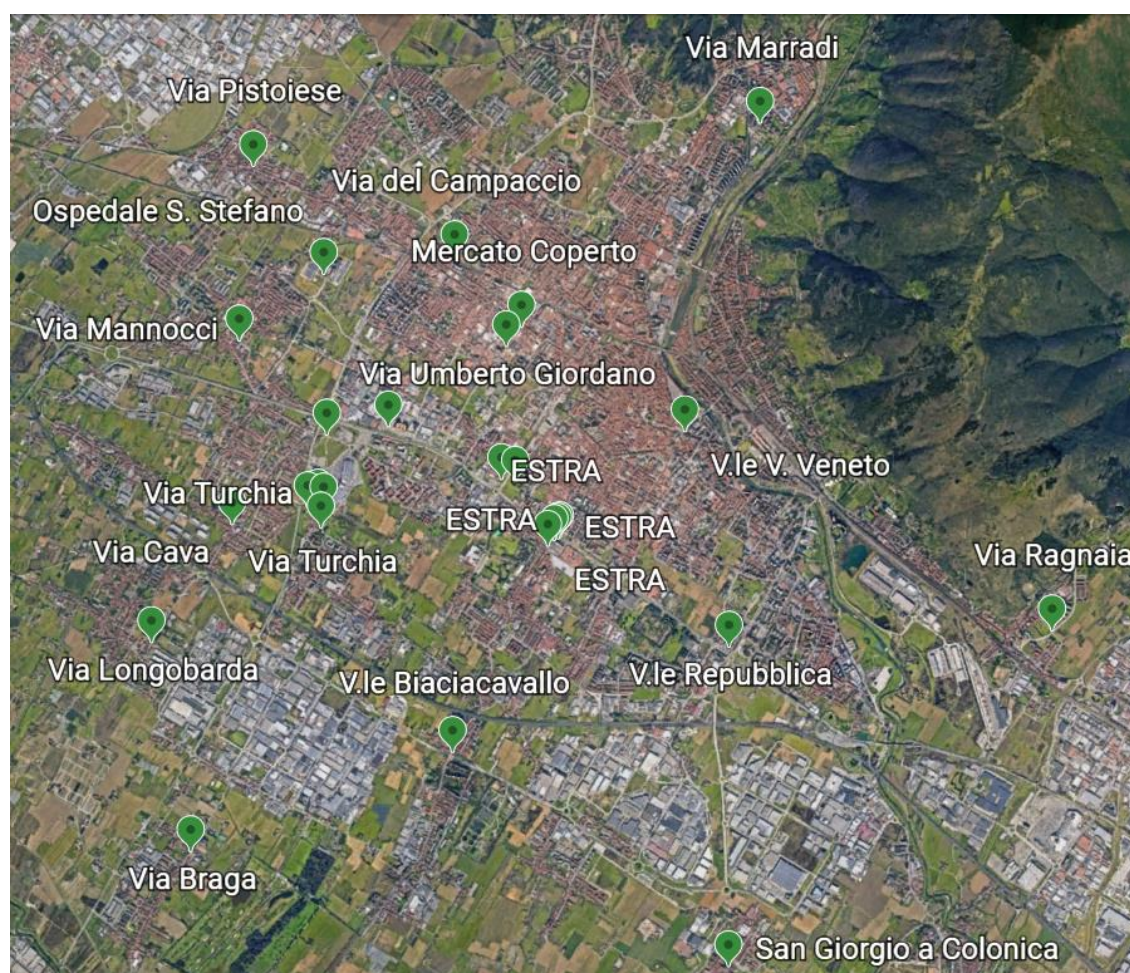


Fig. 1. Map of the installed sites.

ID	ID Station	Lat(°N)	Lon(°E)	Site	Installation date
1	SMART52	43.87156	11.06360	Via Turchia	01/07/2021
2	SMART99	43.87186	11.06298	Via Turchia	01/07/2021
3	SMART104	43.87009	11.06331	Via Turchia	02/07/2021
4	SMART91	43.87166	11.06189	Via Turchia	01/07/2021
5	SMART111	43.86119	11.04507	Via Longobarda/via Bessi	02/07/2021
6	SMART07	43.87033	11.05377	Via per Casale/Via Cava	15/07/2021
7	SMART126	43.88458	11.05452	Via Mannocci	26/07/2021
8	SMART94	43.89810	11.05602	Viaccia Narnali via Pistoiese	13/07/2021
9	SMART101	43.89111	11.07768	Via del Campaccio	09/07/2021
9 (replaced)	SMART79	43.89111	11.07768	Via del Campaccio	09/07/2021
10	SMART40	43.88413	11.08322	Via Umberto Giordano	09/07/2021
11	SMART88	43.88565	11.08486	Mercato Coperto	01/07/2021
12	SMART100	43.87792	11.07055	Via Rimini (parcheggio)	01/07/2021
13	SMART102	43.87384	11.08270	Via Nenni Parcheggio Scambiatore	01/07/2021
14	SMART112	43.87363	11.08419	Via Nenni giardini	09/07/2021
15	SMART61	43.86085	11.10715	Parcheggio V.le Repubblica	08/09/2021
16	SMART105	43.83605	11.10710	San Giorgio a Colonica	08/07/2021
17	SMART25	43.85269	11.07745	V.le Baciacavallo	26/10/2021
18	SMART51	43.84497	11.04930	Via Braga	08/07/2021
19	SMART89	43.87755	11.10241	San Marco Viale V. Veneto	01/07/2021
19 (replaced)	SMART23	43.87755	11.10241	San Marco Viale V. Veneto	01/07/2021
20	SMART113	43.90139	11.11047	Via Marradi	09/07/2021
21	SMART21	43.88968	11.06355	Ospedale Santo Stefano	26/07/2021
22	SMART130	43.86934	11.08898	ESTRA	20/10/2021
23	SMART129	43.86923	11.08877	ESTRA	20/10/2021
24	SMART127	43.86912	11.08838	ESTRA	20/10/2021
25	SMART128	43.86867	11.08770	ESTRA	20/10/2021
26	SMART41	43.87728	11.06395	Via Reggiana	02/07/2021
26 (replaced)	SMART63	43.87728	11.06395	Via Reggiana	02/07/2021
27	SMART106	43.86223	11.14178	Via Ragnaia	08/07/2021

Tab. 1. Location of the stations' sites and installation date.

2. Data processing

2.1. Variables of AirQino stations

The AirQino stations (named “SMART”) were developed to measure air pollutants and CO₂ concentrations both open and close in environment. This document focuses on: PM₁₀, PM_{2.5} (µg/m³) and CO₂ concentrations (ppm) air-temperature (°C) and relative humidity (RH %).

2.2. Data analysis

High-frequency data of pollutants and meteorological variables were extracted for the period 01/07/2021 – 31/12/2021. Because of the seasonality of the pollutants’ concentrations, the period of analysis was further divided in two sub-periods: summer (01/07/2021 – 21/09/2021) and autumn (22/09/2021 – 31/12/2021).

Raw data were cleaned in order to remove outliers and anomalies. After this primary data processing, data from all stations were firstly synchronized with each other, and then aggregated at hourly average, daily and seasonal time step.

3. Results

Fig. 2 shows the validity of the collected data. The graphs report the numbers of valid observations expressed as a percentage of the total data collected of all the analyzed variables (PM₁₀, PM_{2.5}, air temperature, relative humidity and CO₂) for each station.

More than 80% of valid data were observed for most of the stations and for all the investigated variables during summer and autumn seasons.

In the summer period, 22 stations transmitted more than 90% of RH and air temperature valid data. Only 2 stations showed a considerable low number of data to be analysed. Precisely, Via Braga and Via Marradi did not send more than 5% of valid data out of the total. During autumn, almost the entire network (27 stations) transmitted more than 60% of valid data for both RH and air temperature.

During summer, the major part of the installed stations (17) showed more than 80% of suitable PM10 and PM2.5 data. The sites of V.le Repubblica, Via Braga and Via Marradi provided less than 5% of valid data compared to the whole dataset (100% of data). In autumn, most of the sites (22) presented a wide range of available data (60% to 99%) for both PM10 and PM2.5.

Several stations (17) showed more than 80% of valid data of CO₂ in the summer season. Via Braga and Via Marradi provided less than 5% of CO₂ valid data out of the total. In autumn, almost all the sites (26) worked properly, providing more than 70% of useful data.

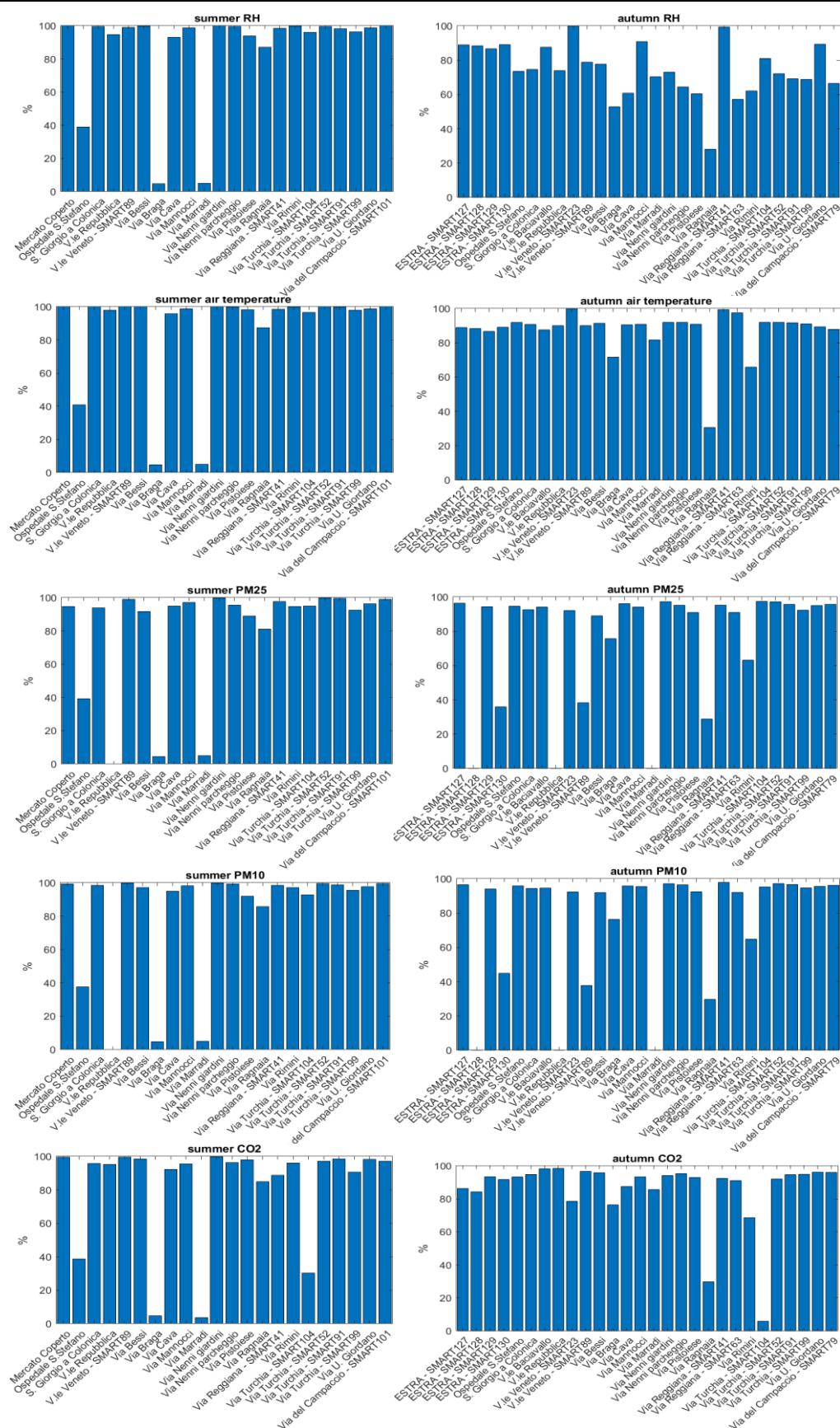


Fig. 2. Autumn and summer bar graphs of the percentage of valid data of the analysed variables for each station.

Fig. 3 indicates the daily averages of PM10, PM2.5, air temperature relative humidity and CO₂ during July – December 2021. The seasonality clearly influenced the patterns of the previously indicated variables.

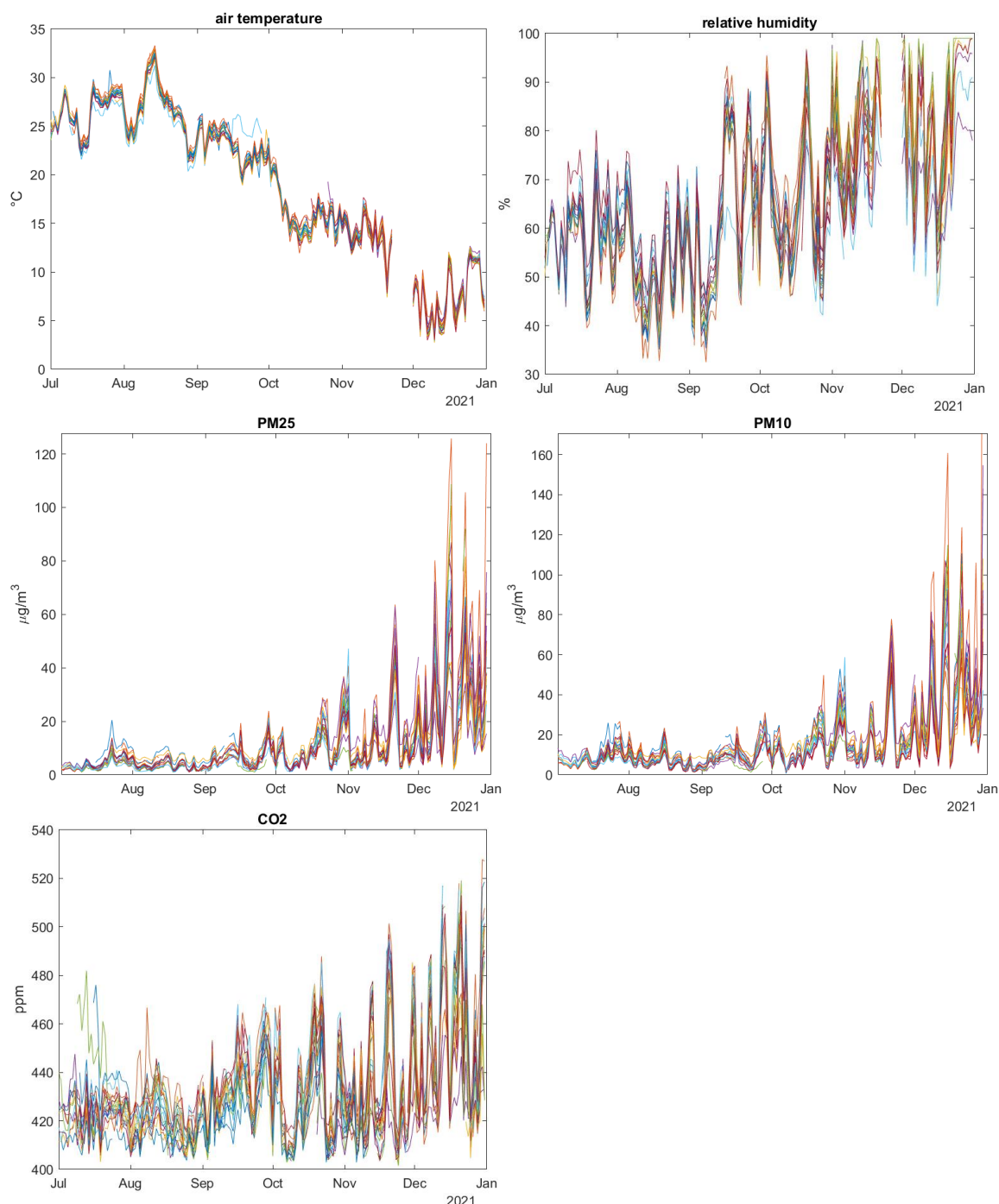


Fig. 3. Autumn and summer daily averages plots of the analysed variables.

In Fig. 4 the average values for each site are reported. In the summer period, the RH average values detected by the stations were between 50% and 60%. The station located at V.le della Repubblica detected the highest value (60%), whilst the station located at Via U. Giordano the lowest (50%). Air temperature was about 25°C, with very few differences among the stations. During autumn, RH showed an increase with mean values greater than 60% for each station. Precisely, the site ESTRA – id25 reached a value greater than 80%, and via Pistoiese showed 65%. Air temperature dropped during autumn respect to summer, with values between 11 °C and 16 °C. The lowest value was found to be in Via del Campaccio, the highest in via Rimini.

During summer, PM10 presented mean values between 6 $\mu\text{g}/\text{m}^3$ and 12 $\mu\text{g}/\text{m}^3$ circa. Precisely, the site of Via Cava registered the highest level and via Bessi the lowest. PM2.5 showed values between 2 $\mu\text{g}/\text{m}^3$ and 8 $\mu\text{g}/\text{m}^3$, and via Cava was again the location with higher concentrations than the others. Contrarily, via Bessi detected the minimum level. During autumn, both pollutants mean concentration increased markedly. PM10 varied between 10 $\mu\text{g}/\text{m}^3$ and 45 $\mu\text{g}/\text{m}^3$. Specifically, the site ESTRA – id22 reached the highest average values of the city, while via Rimini the lowest. About PM2.5, concentrations ranged from 8 to about 32 $\mu\text{g}/\text{m}^3$. Once more, via Rimini was the site with the minimum value, and ESTRA – id22 showed the maximum.

CO₂ summer values ranged between 415 ppm and 430 ppm. The are of Via U. Giordano detected the highest values (about 430ppm), and the Via Reggiana the lowest (415 ppm). In the autumn period, CO₂ concentrations registered an increase, yielding mean values between 420 ppm and 450 ppm. Precisely, the site with greater levels than the others was Ospedale Santo Stefano (448 ppm), and V.le Baciavalle registered the lowest values (421 ppm).

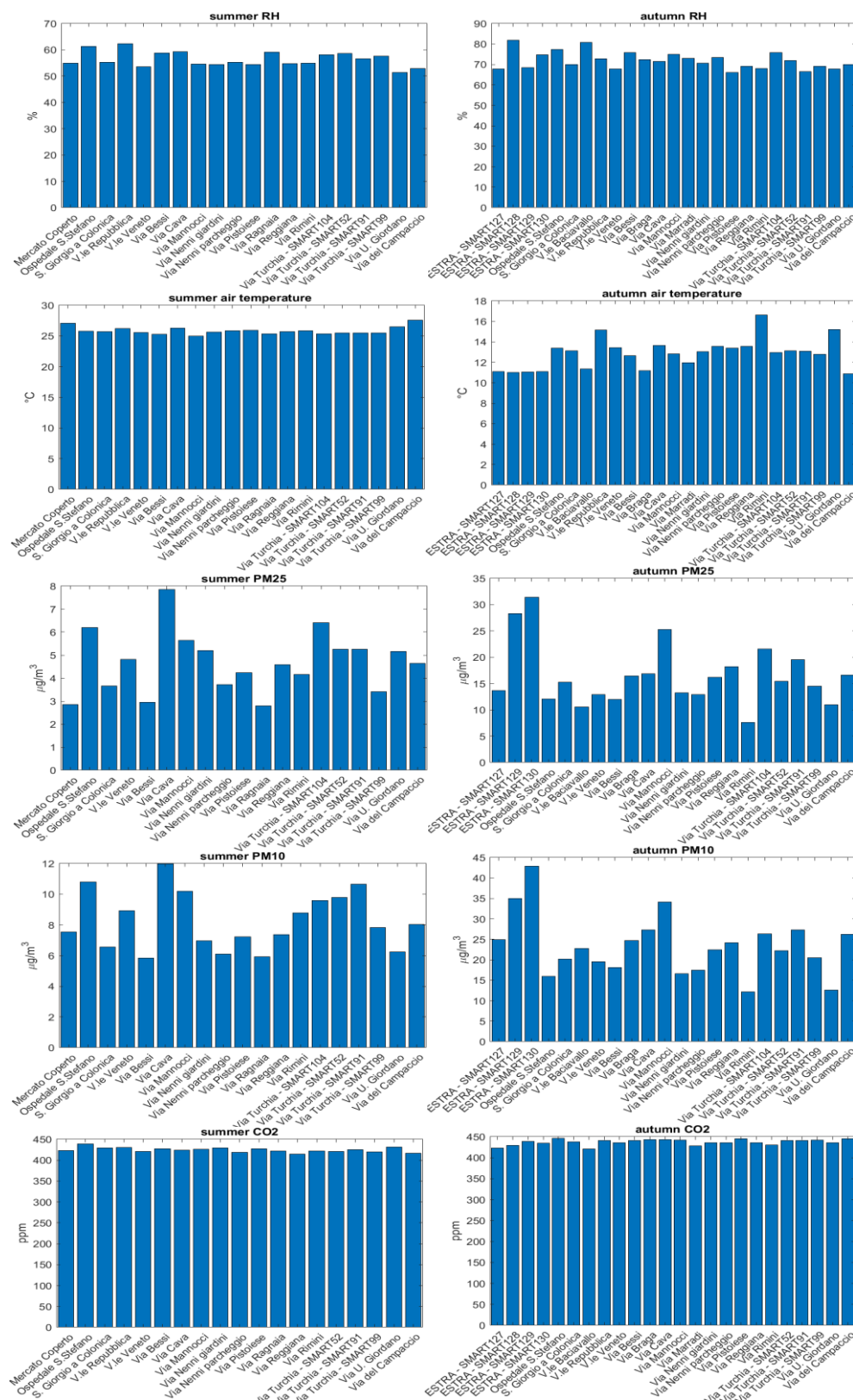


Fig. 4. Summer and autumn bar graphs for each site of the average values of the analysed variables.

In Fig. 5, autumn and summer 90th percentiles of the investigated variables are illustrated. The 90th percentile indicates a value below which 90% of the total observed and sorted data can be found.

During summer, the RH 90th percentiles were between 65% and 75%. V.le della Repubblica was the site with the highest value of about 75%, while V.le Veneto the lowest. Air temperature of 16 sites showed values ranging between 28 and 30 °C, and Ospedale Santo Stefano and via del Campaccio reached values slightly greater than 30°C. During autumn, RH increased, yielding 90th percentile values between 80% and more than 95%. Precisely, the site at ESTRA – id25 registered 99%, and via Turchia – SMART91 about 80%. Air temperature presented values between 15 °C and 22 °C. The lowest value was observed in Via del Campaccio, the highest in Via U. Giordano.

In the summer period, the 90th percentiles of PM₁₀ concentrations were between 8 µg/m³ and 19 µg/m³. The site of Via Cava registered the highest value and via Bessi the lowest. PM_{2.5} ranged between 5 µg/m³ and 13 µg/m³, and via Cava was once again the location with the highest percentile, while Via Bessi the lowest. During autumn, PM₁₀ varied between 20 µg/m³ and 90 µg/m³. Specifically, the 90th percentile of the station ESTRA – id22 was equal to 86 µg/m³, and via Rimini to about 20µg/m³. PM_{2.5} percentiles differed from 16 µg/m³ to about 80 µg/m³. Via Rimini was the site with the lowest percentile, ESTRA – id22 the highest.

The summer 90th percentiles of CO₂ concentrations presented levels in the range 420-455 ppm. San Giorgio a Colonica showed the highest values, via Reggiana the lowest. In the autumn period, the values enhanced up to almost 500ppm. The highest 90th percentile was about 493 ppm in via del Campaccio, and V.le Baciavacavallo had 432 ppm as lowest percentile.

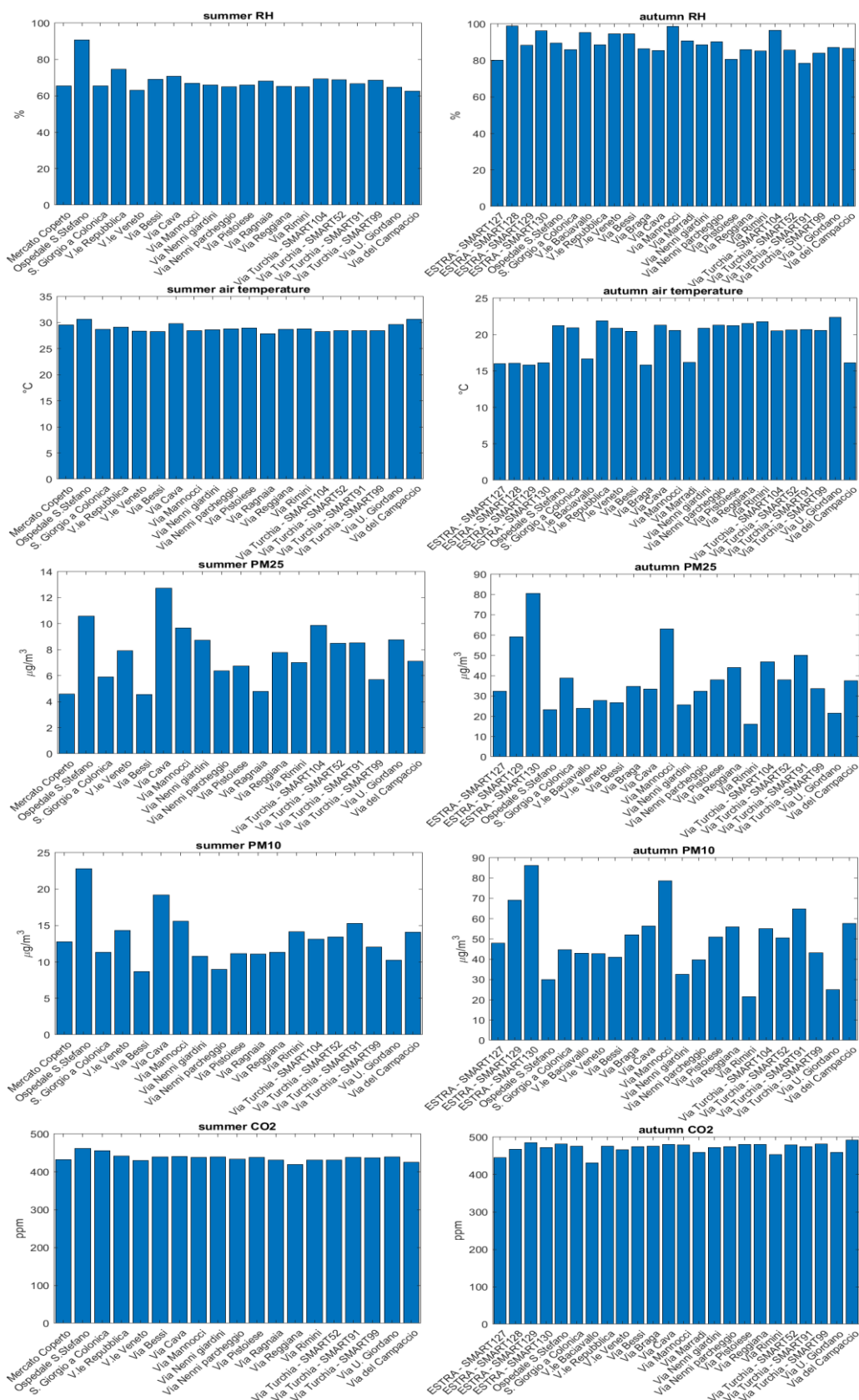


Fig. 5. Summer and autumn bar graphs for each site of the 90th percentile of the analysed variables.

Fig. 6 shows the autumn and summer daily-courses of the PM10 and PM2.5 concentrations for each site. The black line indicates the average value of the city. Autumn concentrations of both PM10 and PM2.5 showed higher variability than that observed during summer, with pollutants levels significantly lower. The higher variability of the autumn season was due to the combined effect of a higher number of emission sources (such as vehicular traffic, heating systems etc.) together with the atmospheric conditions of that period (low planetary boundary layer which makes the dispersion of air-pollutants less easy compared to summer).

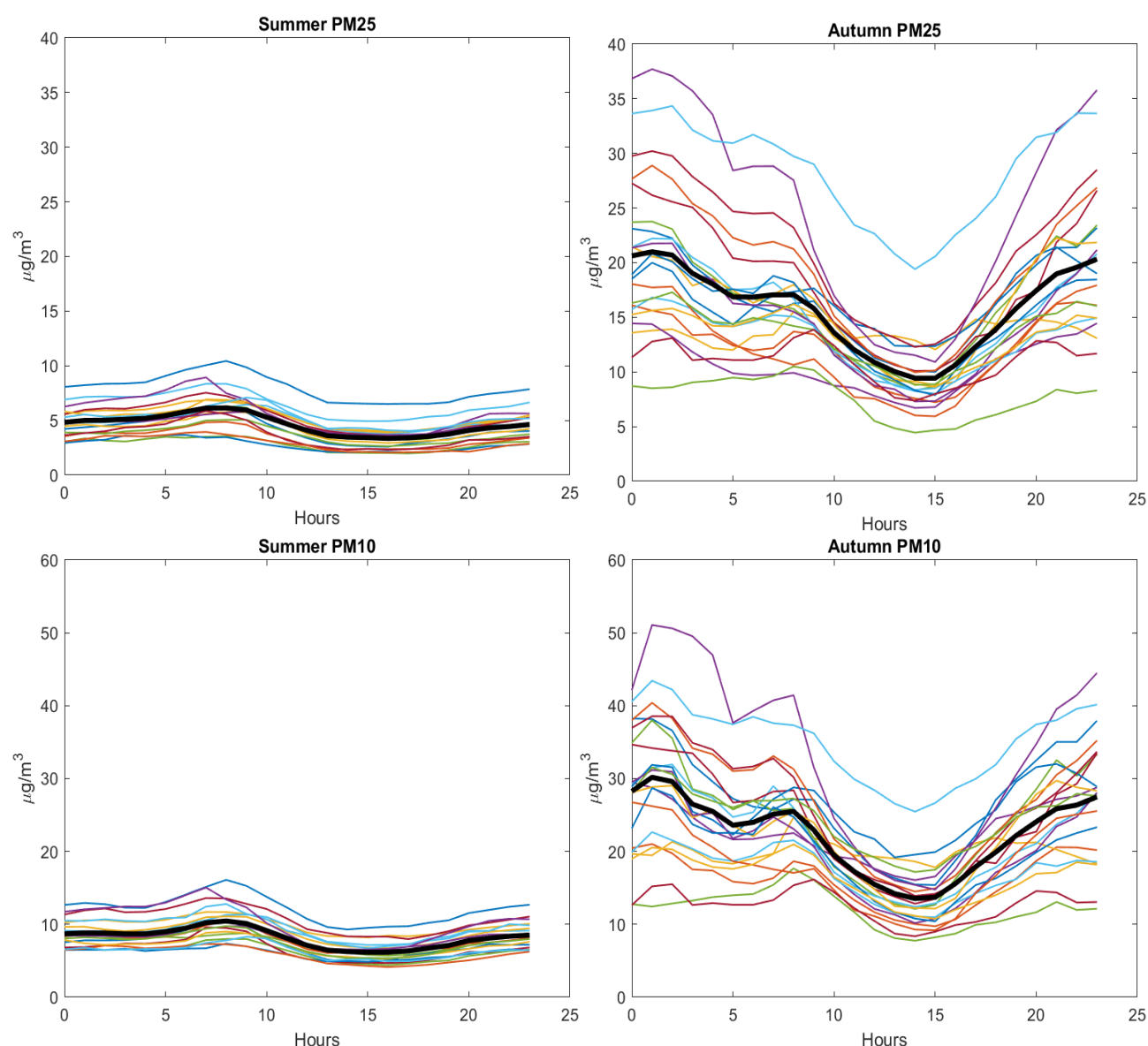


Fig. 6. Summer and autumn daily courses of the PM10 and PM2.5 concentrations for each site. The thicker black line indicates the average value of the city network.

4. Conclusions

This document showed the results of the AirQino's network in the municipality of Prato. The data of each station provided the patterns of the investigated concentrations of pollutants and climatic variables for summer and autumn 2021. Differences among each site indicated the effects of the local environment and its changes over time. This variability suggested that different areas of the same municipality are differently exposed to harmful events. Mitigation interventions are recommended to reduce risk. Further analysis will be carried out in order to increase the development of more accurate actions.