ECOlogical supporting for traffic
Management in cOastal areas By using
an InteLlIgenT sYstem
01/01/2018 - 30/09/2019

Pollutants trend in Venice

Ca' Foscari University of Venice

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CONTRIBUTED TO THIS WORK

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DATA COLLECTION

Data collection started on 1st April 2018 and is still running. In this report pollution data collected until the end of the ECOMOBILITY project (30th September 2019) in Venice are discussed. Data were collected from five monitoring stations of the Environmental Protection and Prevention Agency of Veneto (ARPAV), previously selected (see deliverable "Common and harmonised data collection", act 4.1), in the area of the Municipality of Venice: two of them are located in the hystorical centre of Venice, three of them are located in the hinterland (Figure 1).
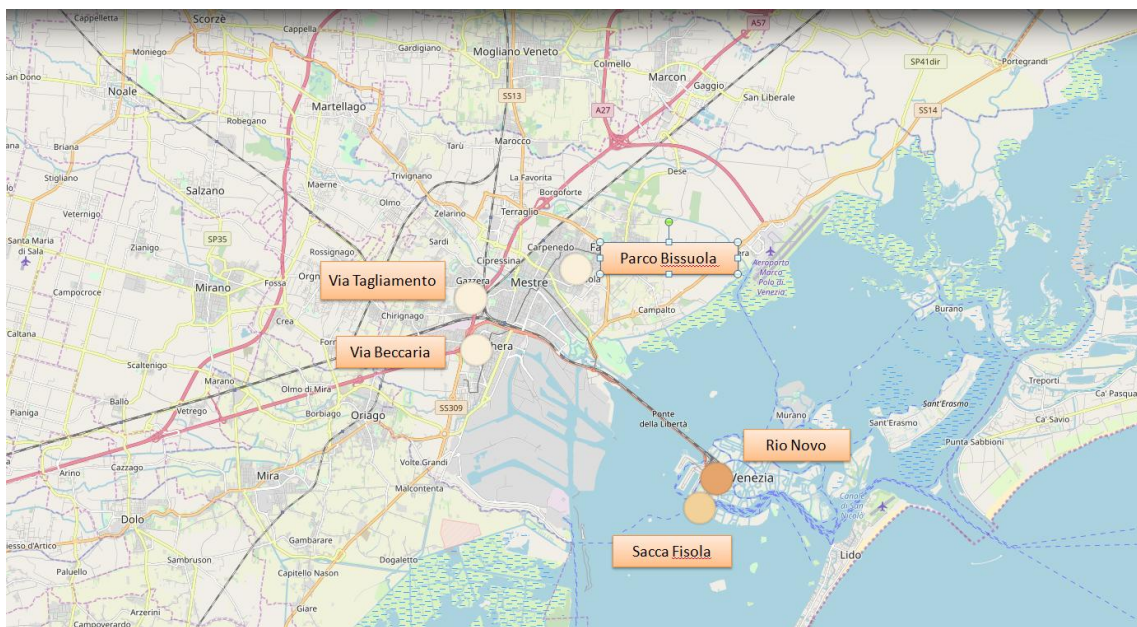

Figure 1. Map of the five monitoring stations selected for this work.

In Table 1 the list of parameters collected from the monitoring stations is reported. Nitrogen bioxide (NO_2) and particulate matter of dimension below 10 μm (PM_{10}) were chosen as parameters to be monitored with the aim of create the supporting intelligent traffic management system, in common with the city of Rijeka (see deliverable "Common and harmonised data collection", act 4.1). Thus the discussion will focus only on concentration data of NO_2 and PM_{10}.

Table 1. List of parameters collected from the monitoring stations.

Station	Type of station	Parameters
Parco Bissuola	background	NO_2, PM_{10}, O_3, T, RH, WPV, WPD
Rio Novo	traffic	NO_2, PM_{10}, O_3
Sacca Fisola	background	NO_2, PM_{10}, O_3
Via Beccaria	traffic	NO_2, PM_{10}, O_3
Via Tagliamento	traffic	NO_2, PM_{10}

NO_2: nitrogen dioxide; PM_{10}: particulate matter <10 μm; O_3: ozone; T: temperature;
RH: relative humidity; WPV: wind prevalent velocity; WPV: wind prevalent direction.

The timing of the data collection has been the following:

- hourly, for NO_2;
- bi-hourly for PM_{10}, with the exception of the station of Sacca Fisola, which provided daily data for technical issues.

GENERAL DISTRIBUTION OF POLLUTANTS

The average concentration of the whole period (April 2018 to September 2019) is 34 μg/m^3 for hourly-NO$_2$, 27 μg/m^3 for bihourly-PM$_{10}$ and 29 for daily-PM$_{10}$. The highest collected values at all are 420 μg/m^3 for NO$_2$ (17/04/2018, 3 PM, Sacca Fisola) and 2433 μg/m^3 for PM$_{10}$ (21/01/2019, 6 PM, Rio Novo).

In Figure 2 the distribution of NO$_2$ concentration values in the five monitoring stations are represented as box plots. In this kind of box plot, the white point inside the colored box represents the average value. The colored box represents the range including all values between the mean value minus 2 times the deviation standard and the mean value plus 2 times the deviation standard: in an ideal Gaussian distribution that range includes 95% of data and gives an useful idea of the distribution of values. The whiskers indicate the minimum and maximum value, thus representing the overall distribution of data. In the graphs included in this deliverable the whicker corresponding to the minimum value is not visible, since it is covered by the colored box.
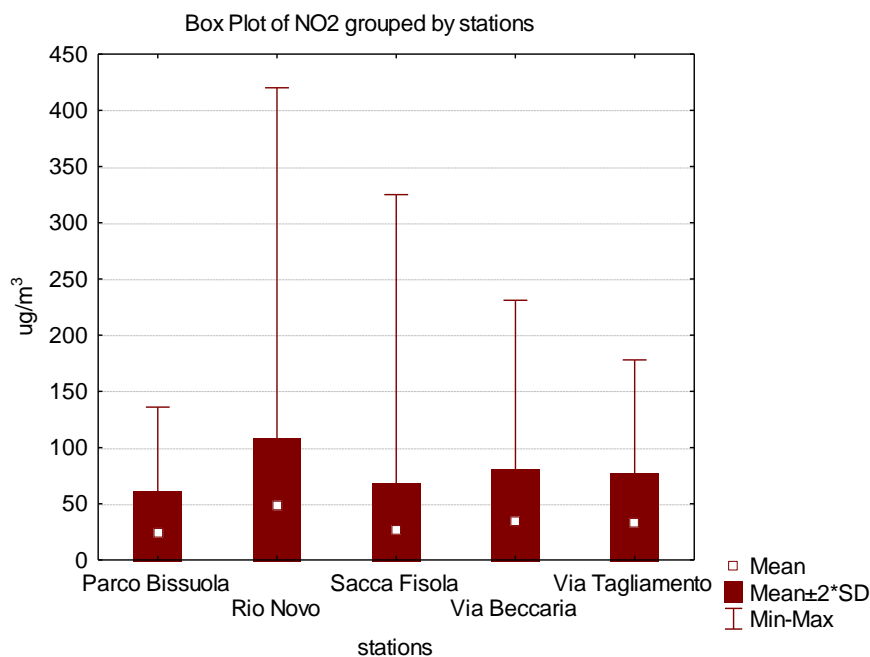

Figure 2. Box plot of the distribution of NO$_2$ in the monitoring stations of Parco Bissuola, Rio Novo, Sacca Fisola, via Beccaria and via Tagliamento, during the period April 2018-September 2019. SD: Standard deviation

The highest average NO$_2$ concentration value was found in Rio Novo station (49 μg/m^3), followed by via Beccaria (35 μg/m^3), via Tagliamento (33 μg/m^3), Sacca Fisola (27 μg/m^3) and Parco Bissuola (24 μg/m^3).

The distribution of values is different among the various stations. In Rio Novo almost all values were below 110 µg/m³; in via Beccaria and via Tagliamento below 80 µg/m³, Sacca Fisola below 70 µg/m³ and Parco Bissuola below 60 µg/m³. The Italian law (D.Lgs. 155/2010) established that the hourly limit of 200 µg/m³ can be exceed for 18 times at maximum. During the 16 months of data collecting, globally 13 values exceeded the law limit of 200 µg/m³: 7 in the period April - December 2018 and 6 in the period January - September 2019. 10 of the exceeding values have been registered in the Rio Novo station, 2 in Sacca Fisola and 1 in via Beccaria.

Although the maximum bi-hourly value of PM_{10} is very high in Rio Novo, the average value for PM_{10} is comparable among the stations represented in Figure 3a, (Parco Bissuola, Rio Novo, via Beccaria and via Tagliamento), with mean values between 22 and 26 µg/m³. Likely the 95% of values are below 120 µg/m³ in Rio Novo, below 80 µg/m³ in via Beccaria and via Tagliamento, below 70 µg/m³ in Parco Bissuola. In Rio Novo the concentration of bi-hourly PM_{10} exceeded twice 1000 µg/m³: on 21st January 2019 at 6 PM (2433 µg/m³) and on 20th August 2019 at 2 PM (1272 µg/m³). The distribution of PM_{10} concentration in the Sacca Fisola station have been graphed separately (Figure 3b), because of the different time resolution of data collecting with respect to the other stations. The average daily PM_{10} concentration, in the period April 2018 - September 2019 is 29 µg/m³, with 95% of values below 65 µg/m³.
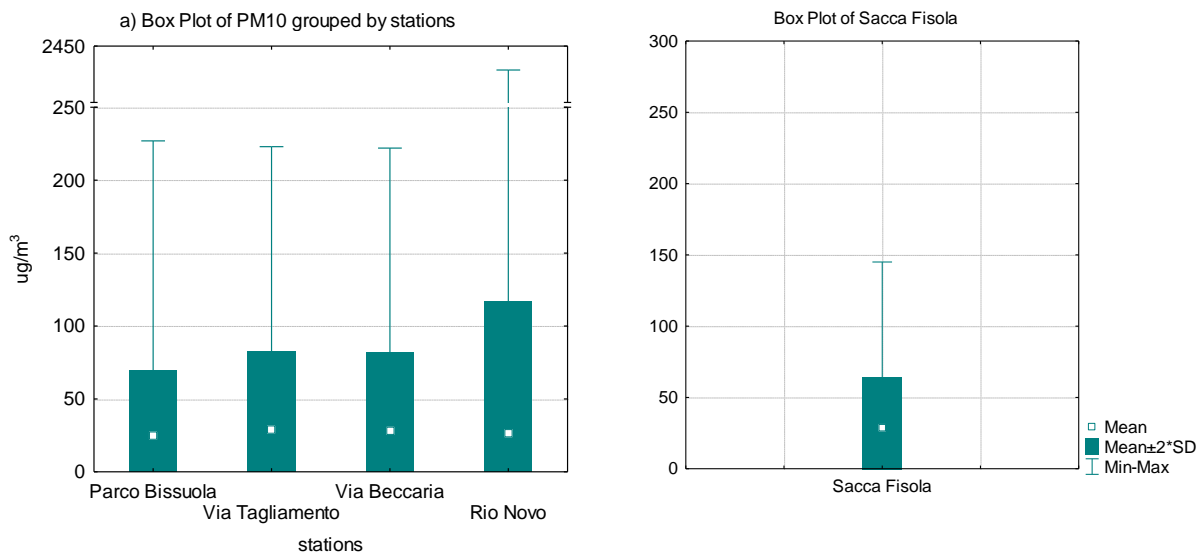

Figure 3. Box plots of the distribution of bi-hourly data of PM_{10} in the monitoring stations of Parco Bissuola, Rio Novo, via Beccaria and via Tagliamento (a), daily data of PM_{10} in the monitoring station of Sacca Fisola (b) during the period April 2018-September 2019.
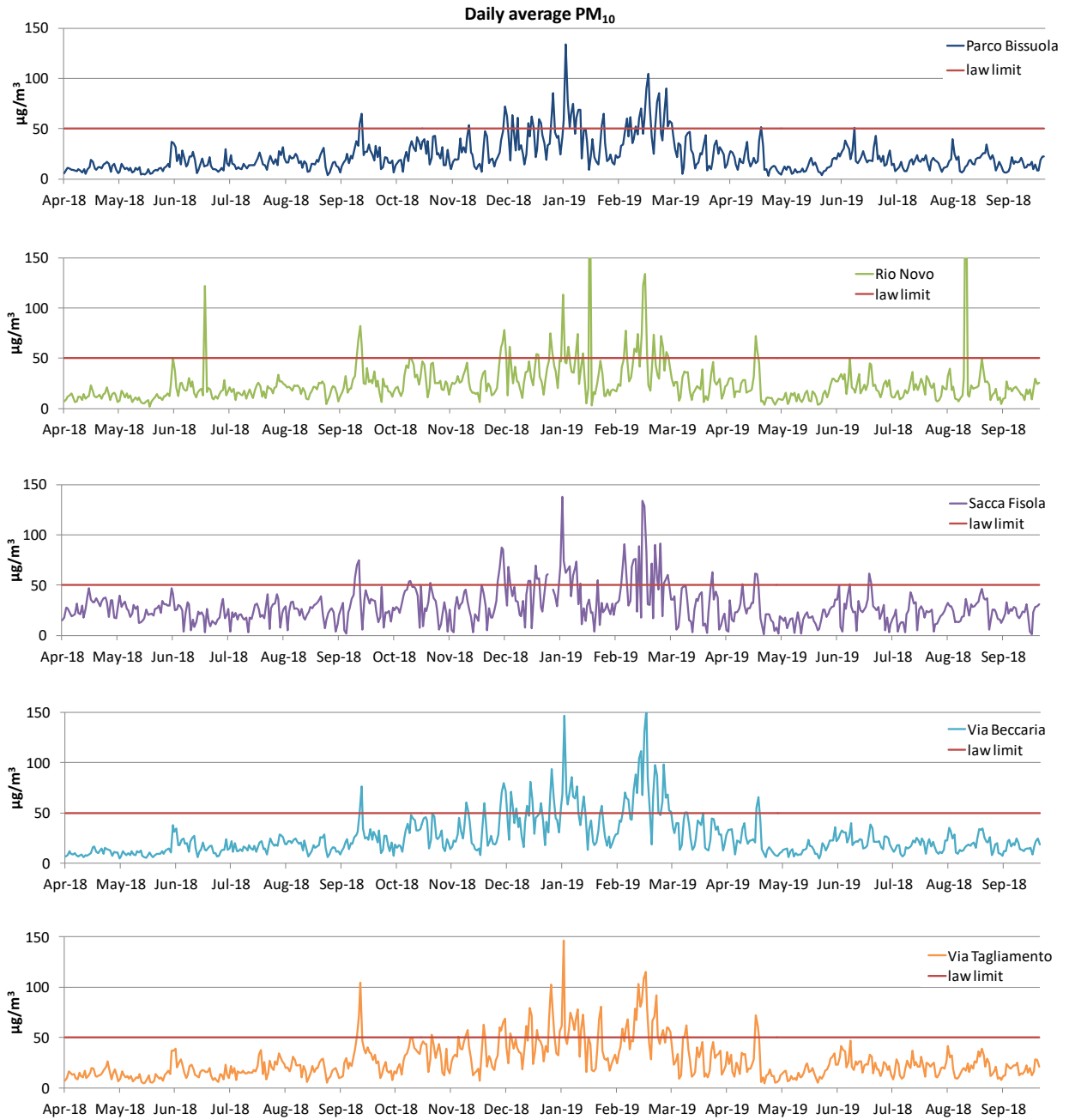
Figure 4. Daily average values of PM$_{10}$ concentration during the period June 2018 - September 2019.

In Figure 4 the daily average of data from the stations of Parco Bissuola, Rio Novo, via Beccaria and via Tagliamento and the daily data from the station of Sacca Fisola are shown.

The limit value for PM_{10} in Italy is 50 µg/m^3 as daily average and can be exceeded by no more than 35 times (D.Lgs. 155/2010). The number of exceedances of the law limits are reported in Table 2. Globally, the number of exceedances has been higher in the period January - September 2019, with respect to the period June - December 2018. In Sacca Fisola, via Beccaria and via Tagliamento the number of allowed exceedances in 2019 has been already reached in the period January - September.

Table 2. Number of exceedances of PM_{10} of the daily law limit. In red the number of exceedances above the law limit are highlighted.

Station	June-Dec 2018	Jan-Sept 2019
Parco Bissuola	14	29
Rio Novo	14	24
Sacca Fisola	19	36
Via Beccaria	19	41
Via Tagliamento	21	40

CHRONOLOGICAL TRENDS

In Figure 5 the chronological trend of monitored pollutants has been shown. For both NO_2 and PM_{10} a higher concentration has been measured in winter, with respect to the other seasons.
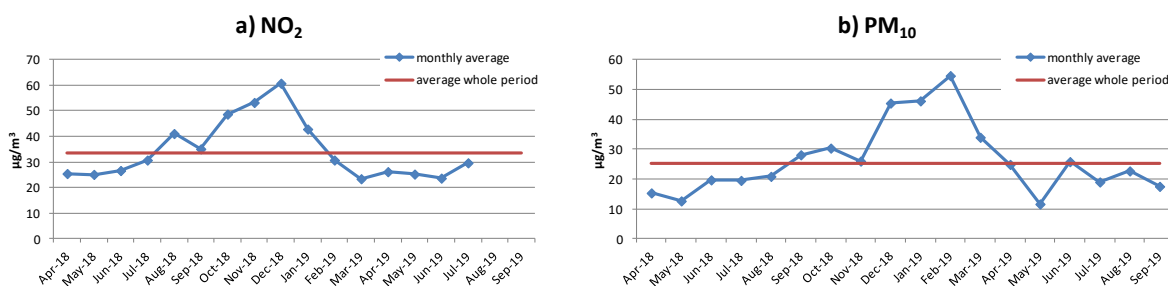

Figure 5. NO_2 (a) and PM_{10} (b) monthly average concentration in the period April 2018 - September 2019.

NO_2 hourly concentration shows a specific daily trend, with higher values in the morning and in the evening, in correspondence of the traffic jam periods (Figure 6a). PM_{10} bi-hourly concentration has no peaks in correspondence of the traffic jam periods (Figure 6b). This can be due to the fact that PM_{10} has been monitored with a lower temporal resolution and that can be associated also to other sources, different from the urban traffic (domestic heating, for instance). A small decrease of PM_{10} concentration has been observed in all seasons passing from night (10 PM - 6 AM) to the middle of the day (10 AM - 4 PM). No differences in the daily trend has been observed comparing the seasons, in addition to the increased concentration of pollutants in winter, already evidenced.
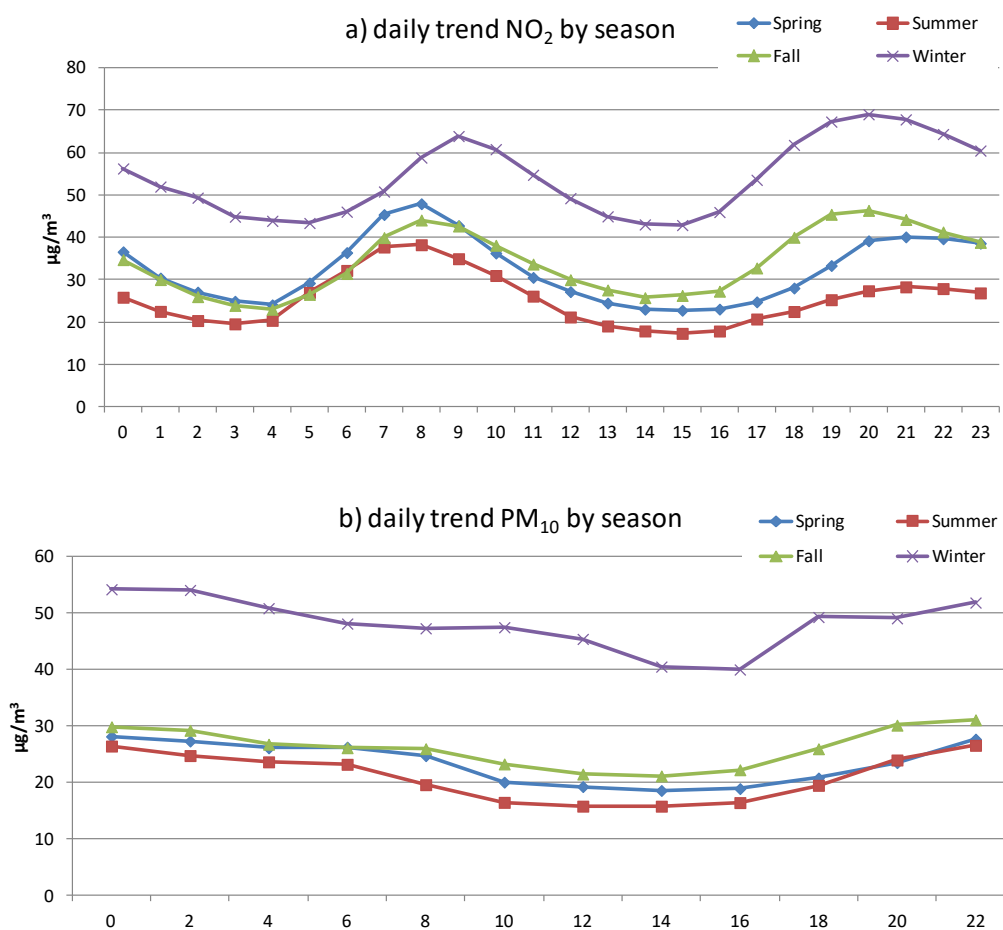

Figure 6. Daily trend of NO_2 (a) and PM_{10} (b) concentration, in the various seasons, in the period April 2018 - September 2019.

The daily trend of NO_2 is more evident from the measures of the Rio Novo stations, with an average NO_2 concentration of about 80 µg/m^3 in the morning (from 8 AM to 10 AM), higher with respect to the measures from the other stations (from 30 µg/m^3 to 40 µg/m^3 at 8 AM), which are comparable to each other. The evening peak of NO_2 has a similar pattern considering all the monitoring stations (Figure 7a). The daily trend of PM_{10} is more evident in the measures registered at the via Tagliamento station, passing from an average of 39 µg/m^3 at 10 PM - 12 AM to an average of 16 µg/m^3 at 2 PM (Figure 7b).
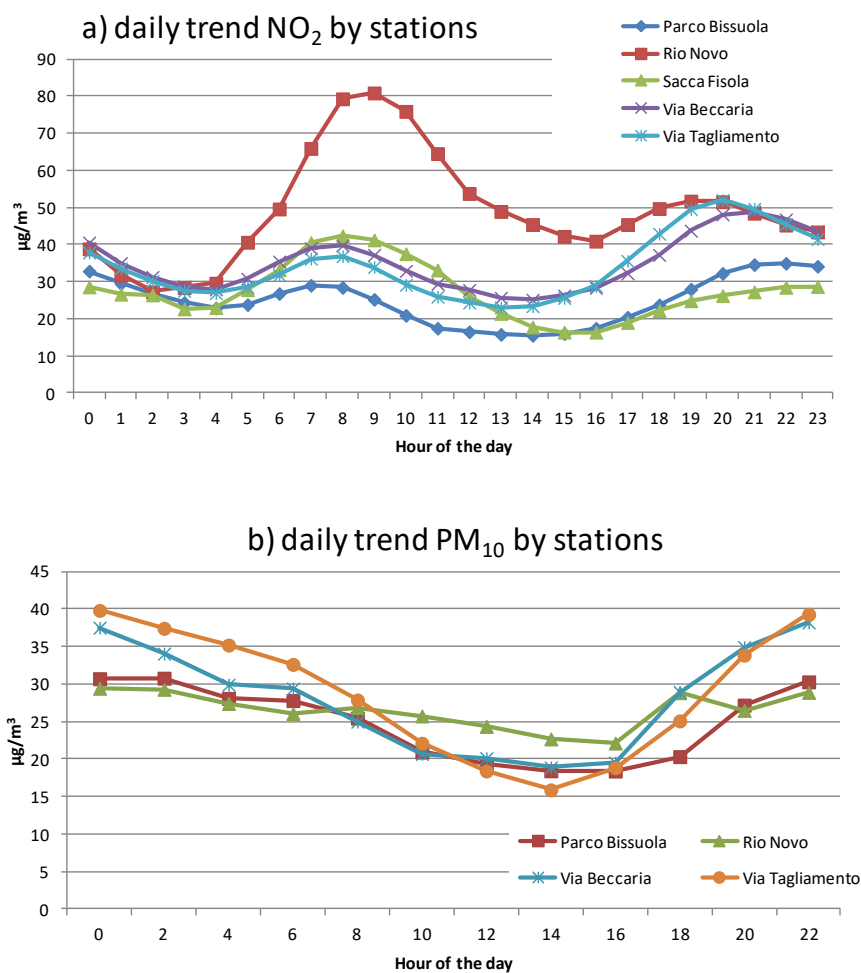

Figure 7. Daily trend of NO_2 (a) and PM_{10} (b) concentration, measured at the various monitoring stations, in the period June 2018 - September 2019.

During the week a small decrease have been observed in the NO_2 concentration values, passing from an average concentration of 34 µg/m^3 from Monday to Saturday to an average concentration of 29 µg/m^3 on Sundays (Figure 8a). A specific weekly trend has not been observed in the PM_{10} data (Figure 8b).
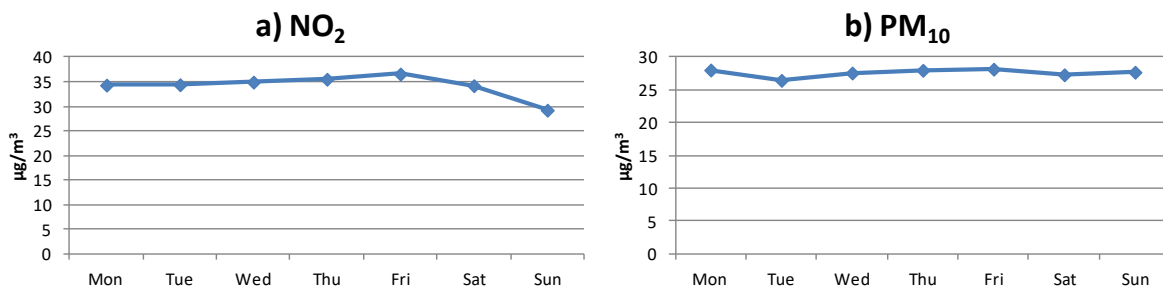

Figure 8. Weekly trend of NO2 (a) and PM10 (b) concentration, in the period April 2018 - September 2019.