REPORT

Monitoring and data collection for impact assessment

ACTION B5

LIFE MONZA

Methodologies fOr Noise low emission Zones introduction And management

LIFE15 ENV/IT/000586

LIFE MONZA
Methodologies fOr Noise low emission Zones introduction And management

Technical Report

Deliverable	Report on Ante and Post Operam data collection
Action/Sub-action	B5 “Monitoring and data collection for impact assessment”
Authors	Raffaella Bellomini, Sergio Luzzi, Lucia Busa, Gianfrancesco Colucci, Giacomo Nocentini.
Status - date	Draft- 05/06/2020

Beneficiary:	Vie en.ro.se. Ingegneria srl
Contact person:	Raffaella Bellomini
E-mail:	raffaella.bellomini@vienrose.it
Project Website:	www.lifemonza.eu

TABLE OF CONTENT

1. Introduction and objectives

The main objectives of Action B5 are to collect data in ante and post operam scenarios and to perform the impact assessment of the Noise Low Emission Zone introduced in the Libertà district of Monza.
Monitoring activities were performed referring to environmental parameters and road traffic. Noise data have been carried out through a smart (sub-action B.5.1) and a traditional monitoring system (sub-action B.5.2). The smart noise monitoring system is a prototype based on a network composed by 10 low cost microphones, designed and developed in the action B3. This system was used continuously, during one year period in the ante, one in the post operam scenario (sub-action B.5.1) and it will be maintained also after the project end, at least for 3 years. By means of the traditional noise monitoring system, long/short term measurements have been performed (sub-action B.5.2). Long term noise measurements consisted of one-week campaign carried out in two seasons on two key positions receiver oriented. Short term measurements (1 hour duration) were carried out in 10 positions close to road infrastructure. A few positions were selected near to low-cost sensors, in order to check data collected. The other positions have been chosen to calibrate the noise emission model. An automatic and/or manual road traffic counting system has been used in parallel to long and short-term noise measurements. Within sub-Action B5.2, an acoustic model of the area has been developed, properly calibrated and validated with reference to the phonometric data and traffic flows collected in the weekly monitoring campaigns. The acoustic model was then used to produce acoustic maps of the pre- and post-operam scenarios through which, also considering the data of population living in the area, it was possible to evaluate the population exposed to noise in the two scenarios.

Air quality monitoring within the pilot area was carried out in sub-action B5.3 in order to assess the effects of policy measures. Pollutant monitoring was performed with a mobile station located on site. Starting from data collected in the sub-action B5.3, in the sub-action B5.6 the role of the main sources and the effectiveness of the policy measures foreseen in the traffic restricted zone, was identified through high spatial resolution model and statistical analyses of high temporal concentrations data. The analysis of temporal pattern of PM concentrations and PNC data, and their correlation with meteorological parameters as well as traffic flows, were carried out to identify relationships with the main sources of pollution present in the area of interest.

Regarding the monitoring of the quality of life (sub-action B5.4), a two-step survey was performed: before and after the institution of the noise LEZ zone. The monitoring was made by means of postal delivery of the questionnaires.

Finally, sub-action B5.5 concerned the assessment of the impacts generated by the introduction of bottom-up policies, which included the involvement of the population.

Finally, in sub-action B5.7 a preliminary analysis and systematisation of all the data collected has been carried out in order to facilitate the analysis and construction of the global and synthetic monitoring indices foreseen in action C1.

The action is divided in 7 sub-actions:
B5.1 Smart continuous monitoring by prototype system on noise and system's check (UNIFI)
B5.2 Noise and Traffic ex ante /ex post monitoring (VIENROSE)
B5.3 Air quality ex ante /ex post monitoring (ISPRA)
B5.4 Health ex ante/ex post monitoring (UNIFI)
B5.5 Bottom up actions: ex ante/ex post people participation (MONZA)
B5.6 Air quality modelling (ISPRA)
B5.7 Intermediate assessment and Top down /bottom up overall data collection and systematization (VIENROSE)

EX-ANTE MONITORING ACTIONS

ACTION B5

Methodologies fOr Noise low emission Zones introduction And management

Smart continuous monitoring by prototype system on noise and system's check – UNIFI

Life MONZA

Methodologies fOr Noise low emission Zones introduction And management

LIFE15 ENV/IT/000586

LIFE MONZA
Methodologies fOr Noise low emission Zones introduction And management

Technical Report

Deliverable	Report on Ante and Post Operam data collection
Action/Sub-action	B5.1 – "Smart continuous monitoring by prototype system on noise and system's check"
Authors	Monica Carfagni, Chiara Bartalucci, Francesco Borchi, Rocco Furferi, Lapo Governi, Yary Volpe
Status - date	Finale version- 31-03-2020

Beneficiary:	UNIFI – University of Florence - Department of Industrial Engineering of Florence
Contact person:	Monica Carfagni
E-mail:	monica.carfagni@unifi.it
Website:	www.lifemonza.eu

Table of content

1. Introduction and objectives

Action B5 of the LIFE MONZA project, titled "Monitoring and data collection for impact assessment", aims at collecting data in the ante and post-operam scenarios and to perform the impact assessment referring to environmental parameters and road traffic.

In particular, sub-action B5.1 regards the collection of noise data to be carried out through a smart noise monitoring system to be used continuously. The smart noise monitoring system is a prototype based on a network of 10 low cost microphones, designed and defined in detail in Action B3. At the end of the project, the prototype will be given free of charge to the city of Monza which will use it for monitoring activities in the three years following the LIFE period.

The present report is structured as follows: in Paragraph 2 the noise low-cost sensors' network is described, in Paragraph 3 the data download and post-processing procedures are presented, in Paragraph 4 the procedures applied to check the low-cost sensors' network are explained, in Paragraph 5 main obtained results from the carried out analysis are reported, in Paragraph 6 the list of Annexes is reported.

2. Description of the noise low-cost sensors' network

The pilot area selected by the project and to be monitored consists of a district of the city of Monza (Figure 1).

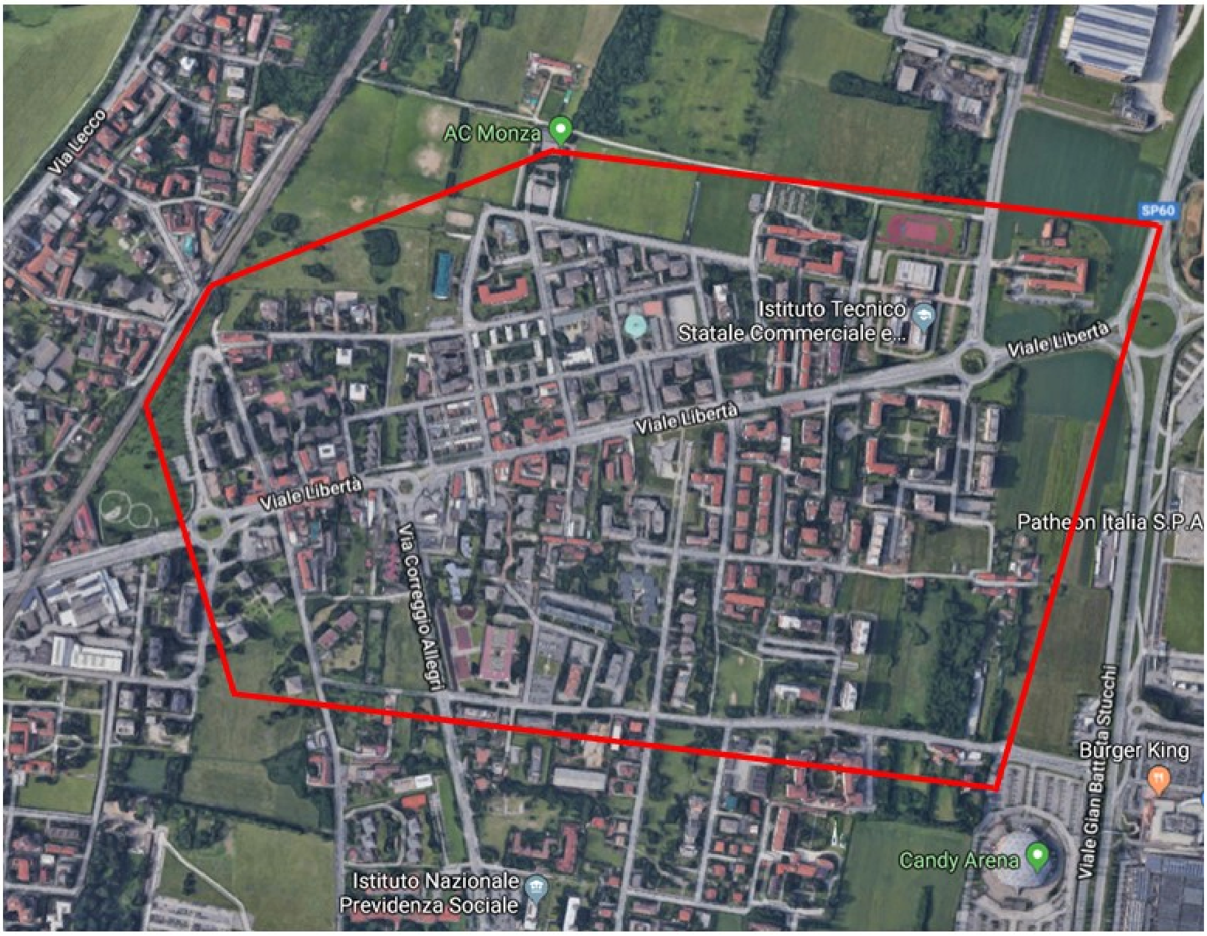


Figure 1. Perimeter of the pilot area ("Libertà" district - Monza).

A main road (Libertà street) and roads characterized by medium-low traffic are present in the selected pilot area. Significant average levels of noise pollution affect a large number of citizens so that Libertà district is identified as a hotspot in the Action Plan of the city of Monza. The noise strategic map of the city of Monza, dated 2012, highlights that in a range of 30 m from the Viale Libertà almost the 100% of the receivers are exposed to levels higher than 65 dB(A) during the day and 55 dB(A) during the night.
The Smart Noise Monitoring System (SNMS) network is meant to adequately cover the pilot area and the different types of roads. Secondarily, the possibility to have a connection to the electric energy network (avoiding the use a solar panel) is considered as an added value for the selection of measuring positions.

From a practical point of view, 10 monitoring stations have been installed in the pilot area of the Libertà district, as illustrated in Figure 2. In particular, 2 microphones have been placed along the Viale Libertà, the main street where the traffic flow mix is expected to mainly change from ante to post operam scenario. The other microphones have been uniformly distributed along other streets belonging to the pilot area.

The 10 control units were then installed on 19-20 June 2017 and from the 20th of June 2017 are continuously monitoring noise levels. It should be noted that the systems with the name "hc" have been installed on the facade of public buildings such as schools and the civic centre (an example is shown in Figure 3) while those whose name starts with the letter "T" have been installed on light poles (an example is shown in Figure 4).

Figure 2. Site plan with the identification of noise monitoring stations.

Figure 3. Example of sensor installed on the façade of a public building.

Figure 4. Example of sensor installed on a light pole.

The SNMS technical specifications were defined keeping in mind the aim of a long-term monitoring of acoustic parameters. These are expected to be useful to understand the variability of acoustic climate in the pilot area with mainly reference to the overall A-weighted continuous equivalent sound pressure level.
According to the previous general requirements and to the outcome of the state-of-the-art analysis, the following main specifications of monitoring units have been defined:
- acoustic parameters: overall A-weighted continuous equivalent sound pressure level, “LAeq” and continuous equivalent sound pressure level, “Leq”, as 1/3 octave band spectrum data;
- timing for data recording: data will be acquired with a time basis of 1 second in order to permit the recognition of unusual events in the eventual analysis phase;
- timing for data transmission: data will be sent to the remote server every hour;
- data transmission network: the data will be transmitted through the 3G cellular telephonic network;
- power supply: small solar panel (30cm x 20cm) and battery for energy storage or direct connection to electricity network;
- sensors location: on streetlight or on façade, height 4 m above the ground level;
- sensor type: ¼ or ½ inch low-cost microphone with removable rain protection;
- floor noise < 35 dB(A);
- frequency response at nominal frequencies of 1/3 octave within the class I specs ± 1dB.
Starting from the specs listed above, the monitoring system architecture has been mainly based on monitoring units designed in the Life DYNAMAP project (these units comply with all the specs), tailoring the data transmission, storage and post-analysis to the needs of the LIFE MONZA project.
Referring to the hardware components, each monitoring unit is designed to achieve a high energy efficiency and low computational burden. In particular, it has an average variable electric absorption among 200 mW and 400 mW, depending on uplink transmitting power in function of the distance to the nearest radio base station of cellular network and the kind of used transmission protocol (2G,

3G). They thus can be powered through solar panels (size 30cm x 35cm) and an integrated power battery with the possibility of being directly connected to the electricity network.
Two types of microphones have been used:

- For sensors placed on poles that use solar panel energy: In order to obtain these high performances of energy efficiency, digital MEMS microphones were used that do not require the use of an external ADC. The MEMS microphones have been adapted onto a ½ inch cylindrical plastic support to allow the insertion of a standard acoustic calibrator.
- For sensors placed on façades that use power supply connection, electret microphones have been used. For reasons related to shielding for electromagnetic compatibility they have been adapted onto a ¼ inch cylindrical plastic support to allow the insertion of a standard acoustic calibrator.

These units are also equipped with a low-power microcontroller able to perform, by mean of IIR digital filtering, the calculation of the A-weighted continuous equivalent sound pressure level, “LAeq”, and, by mean of FFT, of the 1/3 octave band continuous equivalent sound pressure level, “Leq”.
In the usage scenario foreseen for the pilot area, the units will periodically (every hour) connect to the internet and transfer the gathered acoustic data, together with statistics on battery level and quality of the transmission signal. The data will populate a dedicated database, optimized for handling large amounts of data. It has been also planned to build up a web application that allows visualization of the location of the control units on a navigable map, data representation and download.

3. Data download and post-processing procedures

Starting in March 2017, data transfer technologies from the network to the server were evaluated and a temporary web platform for the collection of data acquired by the control units was defined.

The address of the web platform is: http://influxserver.noisemote.com/grafana/?orgId=8.
Credentials to access the server have been made available to all the Project’s partners.
From the platform the user can download data collected by each sensor according to the LAeq, parameter also in terms of frequency bands in 1/3 octave, and in a selectable time span.

Recently, due to the need to migrate sensor data to a final server, at the beginning of 2019 the municipality of Monza confirmed the rental agreement, which will be finalized soon, of an Amazon server compatible with the one currently used provisionally. This being the case, it will be possible to migrate the database, presumably within one month from the availability of the new server.

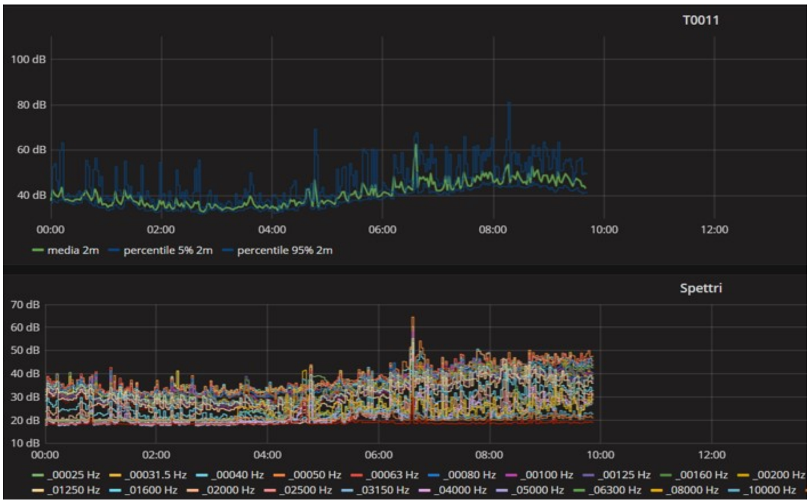


Figure 5. Web interface with possibility of selecting the time period to view and/or download.

Once the data for the ten sensors had been downloaded, they have been post-processed by using the Matlab software.

First of all, LAeq,1s values which were lower than 35 dB and higher than 80 dB were automatically excluded as they were associated with exceptional events. It is not possible to recognize in real time exceptional events, especially due to rainy periods, but it is only possible to make a post-identification by analysing data provided by a weather station located in the proximity of the Libertà district.

4. Procedures applied to check the calibration procedures and the low-cost sensors' network

Concerning the verification procedures, the low-cost sensors challenge consists in maintaining network performance during long term periods of outdoor operation.

The periodic check of the system is designed and performed to understand if the measurement accuracy is maintained in time or if sensors need to be repaired or replaced. Two system check procedures have been proposed to verify the noise monitoring system performances:

- a preliminary check procedure;

- an on-site, long-term site verification procedure.

The preliminary check has been performed for a reduced time period (two months) before the official monitoring period started in the pilot area started, by installing the system on a public building located in the city of Sesto Fiorentino (Florence). As preliminary check activities, the following time-stability verifications, two-weeks based, have been performed:

1 – a **calibration check at the frequency 1 kHz** (by using a sound pressure class I calibrator), assuming as requirements for preliminary check that the sound pressure level does not deviate more than 0.5 dB from the calibration one;

2 – a **comparison between the LAeq,60s obtained from the low-cost sensors and a class I equipment** referring to an environmental noise recorded in the range 45/105 dBA by, assuming as requirements for preliminary check a difference between the two systems within 1.5 dB(A).

The long-term, on-site verifications are planned to be performed every four months at least for two years during the noise monitoring period in the pilot area (1 year in the ante-operam scenario and 1 year in the post-operam scenario). As on-site check activities, the following time-stability verifications, four-months based, have been performed:

1 – **1 kHz calibration check**: a calibration check at the frequency 1 kHz (by using a sound pressure class I calibrator), assuming as requirements for long term check that the sound pressure level does not deviate more than 1.0 dB from the calibration one. Calibration is performed by the operator by inserting the microphone into the calibrator. Given the position of the sensors at a height of 4 m from the ground, the activity requires an elevated platform or a ladder.

2 – **Broad band check**: a comparison between the LAeq,30s* obtained from the low-cost sensors and a class I equipment both subjected to the same broad band noise signal (e.g. pink noise produced by an electroacoustic equipment **) in the range 45/105 dBA by, assuming as requirements for long term check a difference between the two systems within 2.0 dB(A).

* This analysis also permits a check of low-cost equipment in different one-third octave band.

** For this analysis also road traffic noise is usable. In this case measurement time period should be extended up to 5-10 minutes to be significant.

In the configuration with electroacoustic source, the control is carried out from the ground. Various configurations have been studied that work for the positioning of the electroacoustic speaker on the ground but presenting a problem of interference with the noise produced by road traffic (especially along high traffic roads). An ad-hoc system has been designed to raise the speaker together with the class I microphone to the height of the low-cost microphone. This setup has envisaged the study of a special support on which are placed both the playback electroacoustic system and the class I microphone.

3 – **Measurements to determine free field correction** in order to evaluate the correction necessary to move from the sensor position to a similar free field position, in the initial phase of the monitoring, matched one-hour measurements were carried out in which the low-cost sensor measurement was matched to the one with class I instrumentation by placing the microphone near the sensor but in free field conditions, i.e. at least 1m from the pole for pole installations and 1m from the façade surface for façade installations.

At the current time, six on site verifications were performed: in July and November 2017, in March and July 2018 and in January 2019.

5. Results

In the current Paragraph results obtained according to the application of the procedures described in Paragraph 4 are reported.

5.1 Current results of 1 kHz calibration check

For each SNMS a check procedure by using a class I, mono-frequency (1000 Hz) calibrator has been carried out during the on-site verifications, also in order to understand if some variations in time could be highlighted.
Regarding the sensors placed on poles it could be noted a reduction up to 3 dB of the calibration noise levels from the first to the second survey and, subsequently, a stabilization of the calibration values (Figure 6).

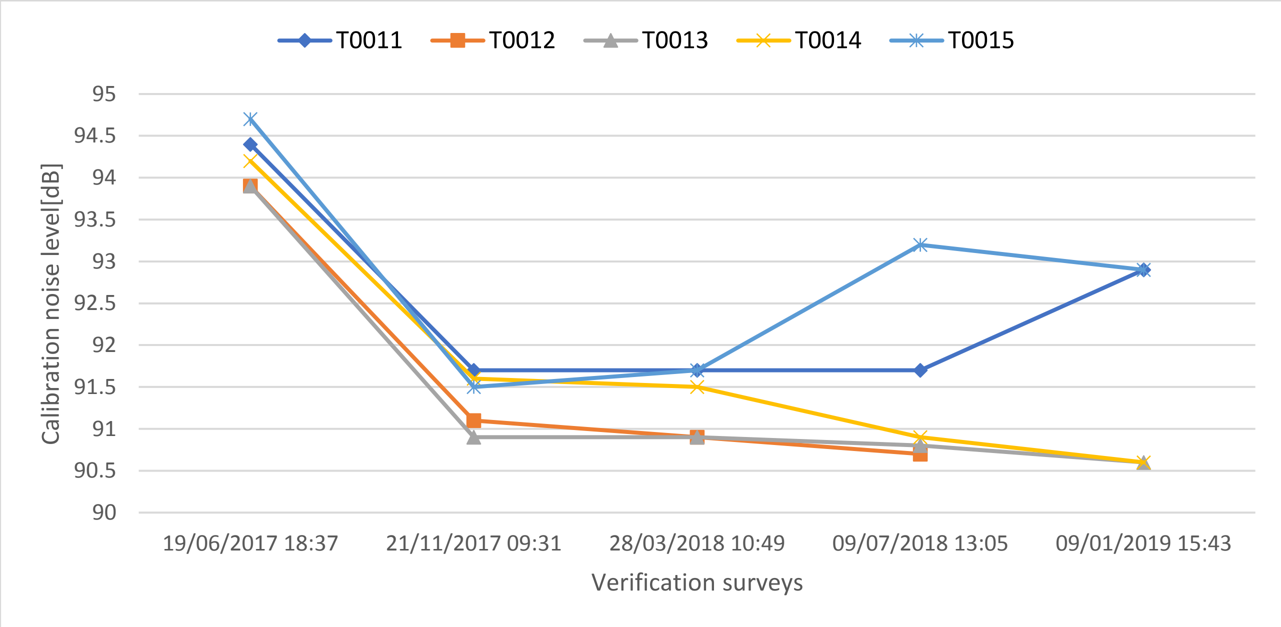


Figure 6: 1 kHz calibration check – MEMs sensors placed on poles.

Regarding the sensors placed on building's façades, such trend is not evident and calibration noise levels turn out to be more constant and generally between 93 dB and 94 dB.

It should be noted that the microphone of the smart sensor T0011 has been replaced in January 2019 before the calibration check and this could have led to an increase in the calibration noise level. Similarly, a microphone substitution has taken place in July 2018 for the smart sensor T0015.

Overall data are reported in Annex 5.

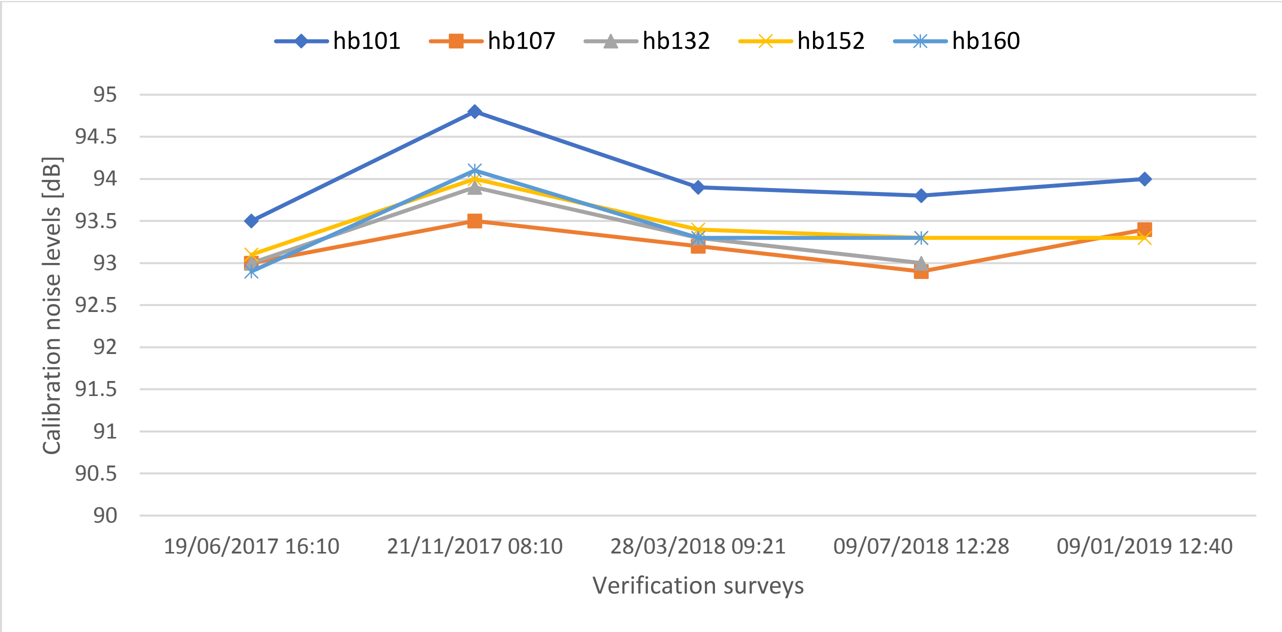


Figure 7: 1 kHz calibration check – Electret sensors placed on building's façades.

5.2 Current results of broad band check

Concerning noise measurements carried out by using road traffic noise as noise source and a measurement time period extended up to 5-10 minutes, a difference of 1.5 dB(A) between the class I noise level meter and the smart system in terms of average LAeq has been found by considering all the checked sensors. Higher differences, of about 2-2.5 dB have been encountered with smart sensors placed on poles, while smaller differences, of about 0.5-1 dB have been encountered with smart sensors placed on the façade.
An example is shown in Figure 8 the broad band calibration check.

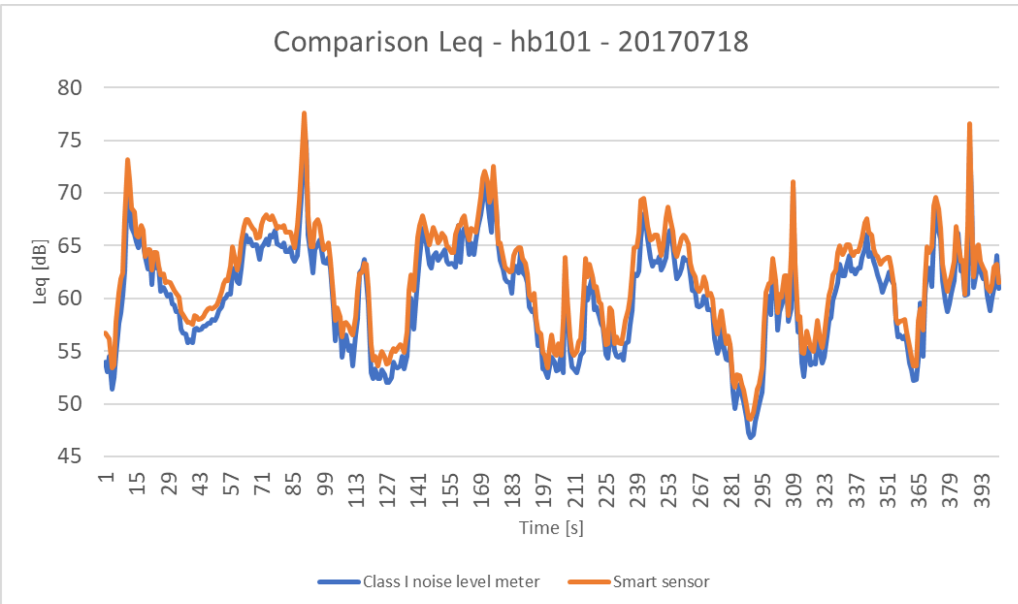


Figure 8: Broad band check (by using road traffic noise), considering 7 minutes as measurement time period – Time history of sound pressure levels, in terms of LAeq,1s [dB(A)].

Also a comparison in terms of sound spectrum has been made for all sensors, an example is reported in Figure 9.

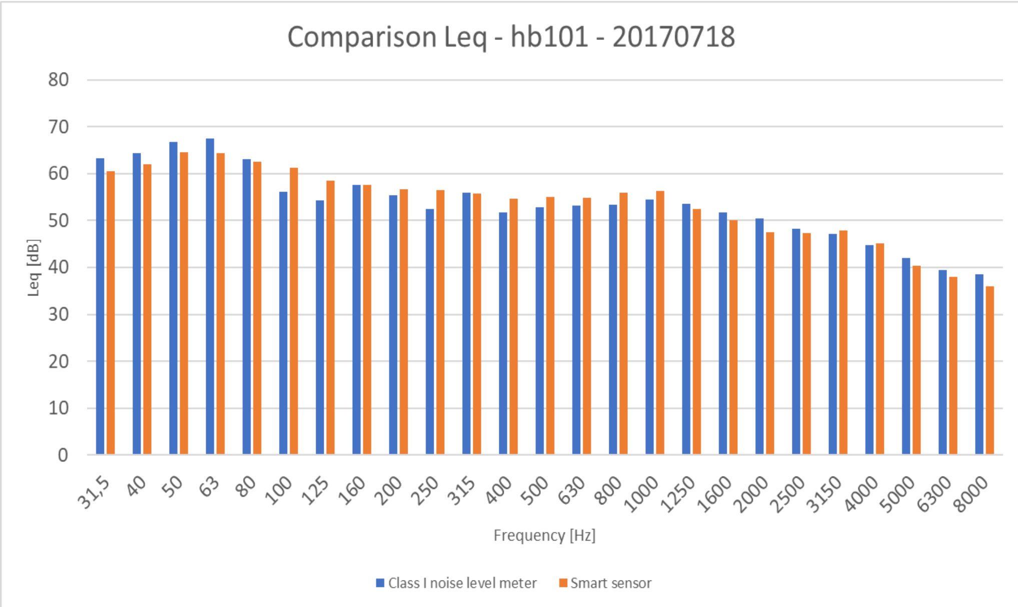


Figure 9: Broad band check (by using road traffic noise), considering 7 minutes as measurement time period – One third octave band sound pressure levels, in terms of Leq,10' [dB].

Concerning noise measurements carried out with the electroacoustic speaker by using pink noise signal and a measurement time period extended up to 30 seconds, in general a difference of 0.5-1 dB(A) between the class I noise level meter and the smart system in terms of average LAeq,30s has been found by considering all the checked sensors. No significant differences have been encountered between sensors placed on poles and on the façades.
An example is shown in Figure 10.

Figure 10: Broad band check (by using an electroacoustic source and a pink noise signal), considering 30 seconds as measurement time period – Time history of sound pressure levels, in terms of LAeq,1s [dB(A)].

Also a comparison in terms of sound spectrum has been made for all sensors, an example is reported in Figure 11.

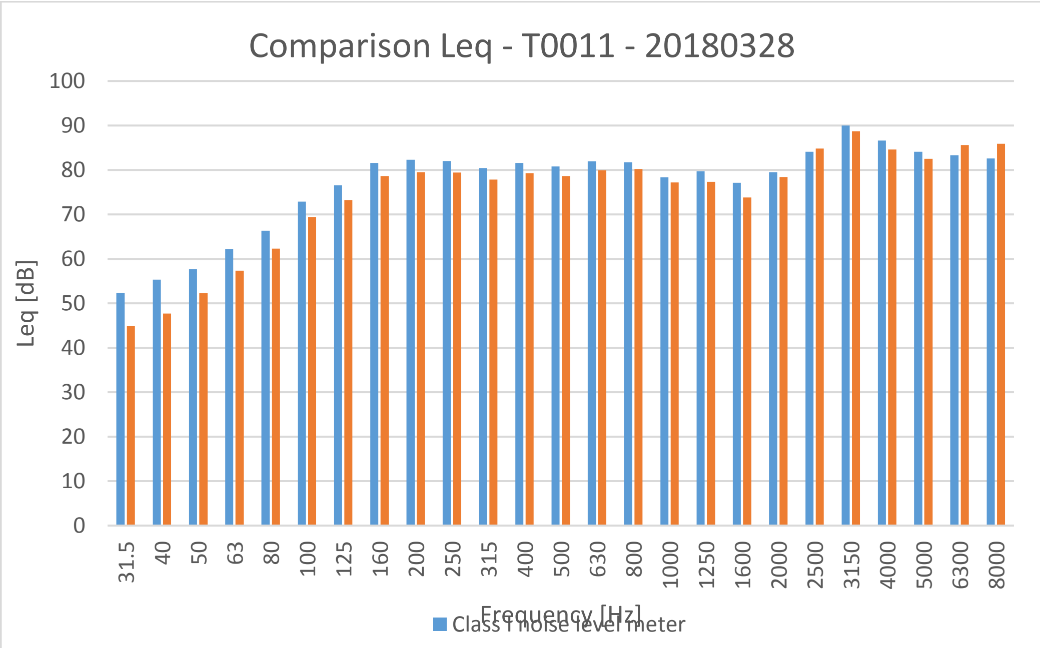


Figure 11: Broad band check (by using an electroacoustic source and a pink noise signal), considering 30 seconds as measurement time period – One third octave band sound pressure levels, in terms of Leq,30s [dB].

Full results are shown in Annex 6.

As a general remark, broad band results allow to carry out a good analysis and verification on all frequency spectrum with respect to mono frequency calibrator, with similar differences obtained at the 1 kHz frequency.
Moreover, an advantage of the broad band check is that it can be performed from the ground.
Comparing the different type of broad band checks, the technique based on electroacoustic system placed close to the sensor provides the best performance in terms of alignment with class I equipment.

5.3 Results about measurements to determine free field correction

Concerning noise measurements to determine free field correction, they have been carried out by using road traffic noise as noise source and a measurement time period extended up to 1 hour. In Table 1 results obtained in terms of average LAeq,1h to determine the free field correction are shown.

Table 1: Free field correction obtained in terms of average LAeq,1h.

	LAeq,1h Class I equipment	**LAeq,1h Smart sensor**	**Free-field correction**
Position	dB(A)	dB(A)	dB(A)
T0013	63,9	64,2	-0,3
T0014	70,3	69,2	1,1
hb101	63,5	64,4	-0,9
hb107	56,7	57,3	-0,6
hb152	58,7	58,3	0,4
hb160	61,5	62,0	-0,5

Differences between 0.4 and 1.1 dB have been encountered. Full results are shown in Annex 7.

At the moment measurements to determine free field corrections have been made for 6 sensors. In the next monitoring period, the free field correction will be evaluated for all sensors.

5.4 HARMONICA index calculation

The HARMONICA index, developed in the frame of the Harmonica Project, has been evaluated on the ante-operam period (since the 19th June 2017 to the 29th March 2018) according to the procedure made available at www.noiseineu.eu. In Table 2 is possible to read the average hourly value of the HARMONICA index obtained for each sensor in the ante operam period.

Table 2: Average hourly value of the HARMONICA index for each sensor - ante operam period.

Day hour	**T0011**	**T0012**	**T0013**	**T0014**	**T0015**	**hb101**	**hb107**	**hb132**	**hb152**	**hb160**
1	3,0	6,1	6,4	7,7	7,6	7,0	5,3	5,0	5,9	6,0
2	2,9	5,5	6,3	7,7	7,7	7,0	5,5	4,8	5,9	5,9
3	2,9	5,1	6,3	7,7	7,7	7,0	5,5	5,0	6,0	5,9
4	3,2	4,8	6,5	7,6	7,8	7,2	5,6	5,0	6,1	5,8
5	3,4	4,5	6,5	7,4	7,8	7,3	5,7	4,9	6,1	5,5
6	3,3	4,0	6,5	7,1	7,7	7,3	5,7	4,9	6,0	5,1
7	2,9	3,4	6,4	6,5	7,4	7,2	5,6	4,7	5,9	4,9
8	2,7	2,9	6,1	5,8	7,1	7,1	5,5	4,6	5,7	4,5
9	2,7	3,0	5,6	5,5	6,9	6,8	5,4	4,3	5,5	4,2
10	3,0	3,4	5,2	5,8	6,7	6,2	5,3	3,9	5,1	3,6
11	3,0	4,0	4,9	6,7	6,2	5,7	5,1	3,5	4,8	3,3
12	3,3	5,0	4,4	7,4	5,3	5,5	4,9	3,2	4,6	3,4
13	3,6	5,9	3,8	7,7	4,5	5,7	4,6	3,0	4,8	3,6
14	3,7	6,3	3,1	7,7	4,1	6,3	4,5	3,1	5,2	4,1
15	3,9	6,2	2,7	7,8	5,0	6,9	4,3	3,2	5,8	4,9
16	4,1	6,2	2,9	7,8	6,4	7,1	4,5	3,6	6,1	5,7
17	4,1	6,2	3,6	7,8	7,3	7,2	4,7	4,1	6,2	6,1
18	3,9	6,1	4,8	7,7	7,8	7,3	4,8	4,2	6,2	6,2
19	3,8	6,0	6,0	7,7	7,9	7,3	4,6	4,4	6,2	6,1
20	3,7	6,0	6,7	7,7	7,9	7,3	4,5	4,9	6,1	6,1
21	3,7	6,1	6,7	7,7	7,8	7,3	4,4	5,1	6,0	6,0

22	3,5	6,3	6,6	7,7	7,8	7,3	4,5	5,3	6,0	5,9
23	3,2	6,4	6,6	7,7	7,7	7,3	4,9	5,1	6,0	5,9
24	3,1	6,4	6,5	7,6	7,6	7,2	5,2	5,1	5,9	5,8

Overall results are reported in Annex 4.

6. Annexes

Annex 1 – Hourly data
Referring to the ante-operam period, for each smart sensor the LAeq, LA10 and LA90 parameters are hourly reported

Annex 2 – Daily data
Referring to the ante-operam period, for each smart sensor the LAeq_day (6:00-20:00), LAeq_evening (20:00-22:00), LAeq_diurno (6:00-22:00), LAeq_notturno (22:00-6:00) parameters are weekly reported, starting from hourly data.

Annex 3 – Weekly data
Referring to the ante-operam period, for each smart sensor the LAeq_day (6:00-20:00), LAeq_evening (20:00-22:00), LAeq_diurno (6:00-22:00), LAeq_notturno (22:00-6:00) parameters are weekly reported, starting from daily data.

Annex 4 – Harmonica Index
Referring to the ante-operam period, for each smart sensor, values assumed by the Harmonica Index are hourly reported.

Annex 5 – Calibration values
Calibration values (1 KHz) measured in different monitoring campaigns for each smart sensor are reported.

Annex 6 – Broad band check
In Annex 6a the time history in terms of LAeq,1s of sound pressure levels measured in the same time periods by the smart sensors and the class I system is reported. In Annex 6b the one third octave band sound pressure levels measured in the same time periods by the smart sensors and the class I system are reported.

Allegato 7 – Position correction
Measurements to determine free field correction in order to evaluate the correction necessary to move from the sensor position to a similar free field position are reported.

Noise and Traffic – VIENROSE

LIFE15 ENV/IT/000586

LIFE MONZA
Methodologies fOr Noise low emission Zones introduction And management

Technical Report

Deliverable	Report on Ante and Post Operam data collection
Action/Sub-action	B5.2 "Noise and Traffic ex ante / ex post monitoring"
Authors	Raffaella Bellomini, Sergio Luzzi, Lucia Busa, Gianfrancesco Colucci, Giacomo Nocentini.
Status - date	Final version 15/12/2017

Beneficiary:	Vie en.ro.se. Ingegneria srl
Contact person:	Raffaella Bellomini
E-mail:	raffaella.bellomini@vienrose.it
Website:	www.lifemonza.eu

Noise monitoring with traditional systems in class 1 was carried out in the ex-ante phase through two monitoring campaigns: the first in May and the second in September 2017.

2.2.1 First monitoring campaign – May 2017

In this chapter is presented the analysis of the ante-operam sound level monitoring campaign that had held in May 2017 (exactly from Monday 15th to Tuesday 23rd May).

In particular, this note reports the results of the phonometric monitoring campaign and the traffic flows collected in some road axis falling within the pilot area.

Have been taking into consideration:

- the data collected with a long-term monitoring campaign and, specifically, by counting weekly traffic flows in 2 positions with control unit with automatic radar traffic counting system showing the division into light and heavy vehicles;
- the data collected with a short-term SPOT monitoring campaign, and specifically, by time -based counting of short-term traffic flows (1 hours) in 10 positions.

Monitoring has carried out in correspondence with the receivers defined in the table 1.

Table 1 – Monitoring scenarios May 2017

ID position	Type of monitoring	Toponym
P01	Long-term (weekly)	Viale Libertà – Centro Civico
P02	Long-term (weekly)	Via A. Modigliani - Scuola
S01	Short-term (Spot)	Viale Libertà – Centro Civico
S02	Short-term (Spot)	Viale Libertà n. 93
S03	Short-term (Spot)	Via della Gallarana
S04	Short-term (Spot)	Via della Guerrina n. 31
S05	Short-term (Spot)	Via A. Modigliani - Scuola
S06	Short-term (Spot)	Via Parmenide – Asilo nido
S07	Short-term (Spot)	Via Giuseppe Impastato
S08	Short-term (Spot)	Via della Guerrina – Liceo Porta
S09	Short-term (Spot)	Viale Libertà – Istituto Mapelli
S10	Short-term (Spot)	Via Correggio Allegri

The next figure shows the planimetric location of the phonometric monitoring stations, traffic flows (contextual to the phonometric ones), of the traffic counter radar units for the monitoring of noise pollution in the pilot area.

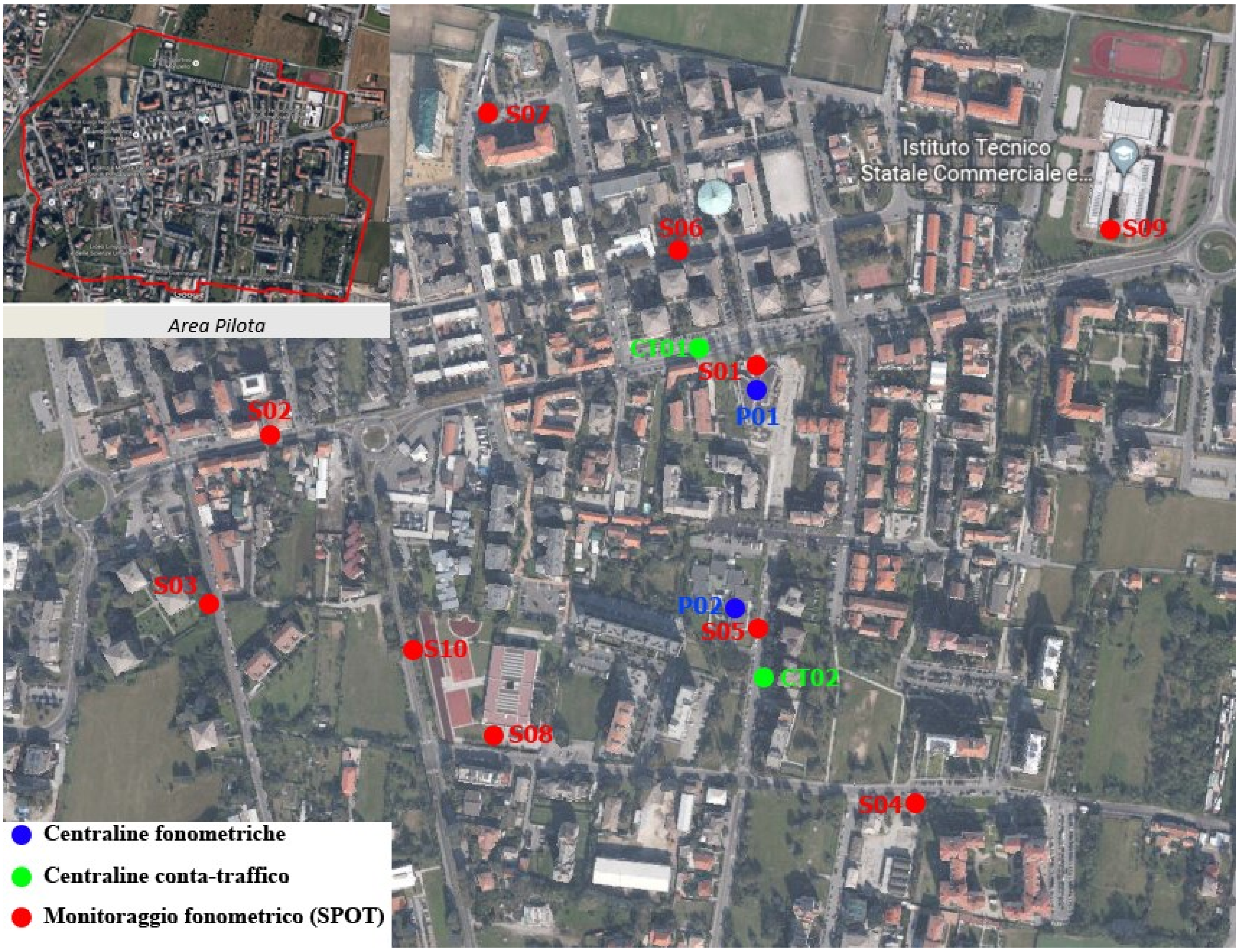


Figure 1 – Monitoring positions

➢ Measurement systems

For the measurements the following measurement systems were used:

SYSTEM NO.1

- PRECISION INTEGRATOR PHONOMETER 01dB type FUSION S.N. 11215 complying with the regulations IEC 651 – EN 60651 class 1 and IEC 804 – EN 60804;
- PRECISION MICROPHONE WITH PREPOLARIZED CONDENSER G.R.A.S. model 40 C.E. S.N. 233339 complying with the regulations EN61094-1/94 EN61094-2/93 EN61094-3/93 EN61094-4/95.

SYSTEM NO.2

- PRECISION INTEGRATOR PHONOMETER 01dB type BLUE SOLO S.N. 60982, complying with the regulations IEC 651 – EN 60651 class 1 and IEC 804 – EN 60804;
- PRECISION MICROPHONE WITH PREPOLARIZED CONDENSER 01dB type PRE21 S.N. 13936, complying with the regulations EN61094-1/94 EN61094-2/93 EN61094-3/93 EN61094-4/95 IEC 651 class 1 (imp.) e IEC 804.

SYSTEM NO.3

- PRECISION INTEGRATOR PHONOMETER BRUEL & KJÆR type 2250 S.N. 3004064, complying with the regulations IEC 651 – EN 60651 class 1 and IEC 804 – EN 60804;
- PRECISION MICROPHONE WITH PREPOLARIZED CONDENSER BRUEL & KJÆR type 4189 S.N. 2877086, complying with the regulations EN61094-1/94 EN61094-2/93 EN61094-3/93 EN61094-4/95 IEC 651 class 1 (imp.) and IEC 804.

ACOUSTIC CALIBRATOR

- BRUEL & KJÆR type 4231 S.N. 2713443, class 1 according to the standard IEC 942:1988, sound power level produced: 94 dB a 1000Hz.

For the memorization and the processing of the data was made use of the dedicated Software:

- Basic sound analysis software BRUEL & KJÆR BZ 5503;
- Noise Evaluator BRUEL & KJÆR 7820 v. 4.16.3;
- dB Trait 5.5.

The technical data of automatic traffic flow detection systems (radar systems) are reported below:

- Traffic monitoring device VIACOUNT II – VIA Traffic Controlling GmbH s.n. 13VZZ0257.
- Traffic monitoring device VIACOUNT II – VIA Traffic Controlling GmbH s.n. 11VZZ0018.

For the memorization and the processing of the data was made use of the dedicated Software: ViaGraph vers. 4.00.09.

➢ Measurement positions (phonometric monitoring)

The main information and the photographic contributes of the measurement positions used for the phonometric monitoring are shown below.

Table 2 – Positions of phonometric monitoring

Measurement station	Description	Photo
P01	**Address:** Civic center in Viale Libertà **Height from the ground level:** 6.00 m **Distance from the road axis:** 38 m **Measurement system used:** no. 1 **Acoustic class:** IV **Limit values:** 65 - 55 dB(A)	
P02	**Address:** Nursery School "A. Modigliani" **Height from the ground level:** 6.00 m **Distance from the road axis:** 15 m **Measurement system used:** no. 2 **Acoustic class:** School building in class I. External relevance area in class II. **Limit values:** 50 dB(A) class I (for schools only daytime TR is valid).	
S01	**Address:** Civic center in Viale Libertà **Height from the ground level:** 4.00 m **Distance from the road axis:** 8 m **Measurement system used:** no. 3 **Acoustic class:** IV **Limit values:** 65 - 55 dB(A)	

Measurement station	Description	Photo
S02	**Address:** Viale Libertà no. 93 **Height from the ground level:** 4.00 m **Distance from the road axis:** 6 m **Measurement system used:** no. 3 **Acoustic class:** IV **Limit values:** 65 - 55 dB(A)	
S03	**Address:** Via Gallarana **Height from the ground level:** 4.00 m **Distance from the road axis:** 5 m **Measurement system used:** no. 3 **Acoustic class:** II **Limit values:** 55 - 45 dB(A)	
S04	**Address:** Via della Guerrina no. 31 **Height from the ground level:** 4.00 m **Distance from the road axis:** 7.50 m **Measurement system used:** no. 3 **Acoustic class:** II **Limit values:** 55 - 45 dB(A)	

Measurement station	Description	Photo
S05	**Address:** Nursery School Modigliani entryway **Height from the ground level:** 4.00 m **Distance from the road axis:** 6.50 m **Measurement system used:** no. 3 **Acoustic class:** School building in class I. Area of external relevance in class II. **Limit values:** 50 dB(A) class I (for schools only daytime TR is valid).	
S06	**Address:** Via Parmenide, at Private Nursery "Cuore Immacolato di Maria" **Height from the ground level:** 4.00 m **Distance from the road axis:** 6.50 m **Measurement system used:** no. 3 **Acoustic class:** School building in class I. External relevance area in class II. **Limit values:** 50 dB(A) class I (for schools only daytime TR is valid).	
S07	**Address:** Via Giuseppe Impastato **Height from the ground level:** 4.00 m **Distance from the road axis:** 4 m **Measurement system used:** no. 3 **Acoustic class:** II **Limit values:** 55 - 45 dB(A)	
S08	**Address:** Via della Guerrina, next to Liceo "Porta" **Height from the ground level:** 4.00 m **Distance from the road axis:** 6 m **Measurement system used:** no. 3 **Acoustic class:** II **Limit values:** 55 - 45 dB(A)	n.a.
S09	**Address:** Viale Libertà, next to ITGC "Mapelli" **Height from the ground level:** 4.00 m **Distance from the road axis:** 12 m **Measurement system used:** no. 3 **Acoustic class:** School building in class I. External relevance area in class II.	n.a.

Measurement station	Description	Photo
	Limit values: 50 dB(A) class I (for schools only daytime TR is valid).	
S10	**Address:** Via Correggio Allegri **Height from the ground level:** 4.00 m **Distance from the road axis:** 12 m **Measurement system used:** no. 3 **Acoustic class:** III. **Limit values:** 60-50 dB(A)	

➤ Measurement positions (detection of traffic flows)

The main information and photo contributions of the measurement stations used to detect traffic flows automatically using a traffic device with radar system are shown below.

Table 3 – Traffic flows detection stations

Measurement station	Description	Photo
CT01	**Monitoring date:** 15-23/05/2017 **Reference road:** Viale Libertà **Measurement system used:** no. 1	
CT02	**Monitoring date:** 15-23/05/2017 **Reference road:** Via A. Modigliani **Measurement system used:** no. 2	

➤ Monitoring results

The monitoring results are fully shown in specific summary sheets attached to this technical report.

Phonometric monitoring

Regarding the **phonometric monitoring**, the sheets are divided as follows:

- General data of the measurement station (coding, description, height of the microphone from the campaign plan, distance from the microphone to the road axis, measurement system used, noise class according to the Noise Zoning Plan of the Municipality of Monza, input limit values defined according to Italian D.P.C.M. 14/11/1997).
- Territorial framework for the planimetric measurement identification and photographic documentation.
- For **long-term monitoring**: date and time of start and end of the measure, time history, equivalent L_{Aeq} levels referred, for all measurement days and as a weekly average level, to the day reference period (6.00 - 22.00) and to the night reference period (22.00 - 6.00), comparison of the levels measured with the input limit values defined under the Italian D.P.C.M. 14/11/1997.

- For **short-term monitoring (SPOT):**
    - Results of phonometric monitoring: date and time of start and end of measurement, time history and frequency composition by third-band octave, equivalent levels L_{Aeq}.
    - Results of short-term manual count (1 hour) of traffic flows: date and time of start and end of the count, traffic flows (vehic/h) divided by direction of travel and between light and heavy vehicles.

During post-processing of the measured data, it was found that in some time slots the presence of events not attributable in terms of frequency and intensity to road traffic noise produce a significant and certainly not negligible contribution to the acoustic climate of the area. Periods affected by these events were excluded from the calculation of the daily and weekly average levels.
A tabular and graphical summary of the results of the phonometric monitoring is shown below.

Table 4 - Summary of short-term monitoring results

Postazione	Descrizione	Data e ora di inizio	Data e ora di fine	L_{Aeq} [dB(A)]
S01	A bordo strada nei pressi del Centro Civico di V.le Libertà	17/05/2017 8:07:16	17/05/2017 9:07:16	67.7
S02	Viale Libertà, n. 93	17/05/2017 11:14:14	17/05/2017 12:14:14	69.6
S03	Via della Gallarana	17/05/2017 13:41:01	17/05/2017 14:41:01	61.4
S04	Via della Guerrina, n. 31	17/05/2017 15:54:58	17/05/2017 16:54:08	60.6
S05	Via Modigliani, all'ingresso della Scuola dell'infanzia	17/05/2017 17:15:29	17/05/2017 18:15:29	62.7
S06	Via Parmenide, in facciata alla Scuola dell'infanzia privata "Cuore Immacolato di Maria"	17/05/2017 18:52:07	17/05/2017 19:52:07	56.6
S07	Via Giuseppe Impastato	18/05/2017 10:05:51	18/05/2017 11:05:51	48.8
S08	Via della Guerrina, nei pressi del Liceo Statale "Carlo Porta"	19/05/2017 11:50:00	19/05/2017 12:50:00	62.5
S09	Viale Libertà, nei pressi del ITCG "Achille Mapelli"	19/05/2017 10:26:42	19/05/2017 11:26:42	65.8
S10	Via Correggio Allegri	18/05/2017 11:21:41	18/05/2017 12:21:41	65.6

Table 5 - Results (measurement station P01)

Postazione P01	**L_{Aeq} misurato (dB(A))**																								**Descrittore acustico**		
	Orario																										
DATA	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**D**	**E**	**N**
Lun 15 e Mar 23/05/2017	55.0	51.5	50.0	49.3	51.7	57.6	59.5	59.6	58.0	58.7	59.1	59.0	59.4	59.3	59.5	59.3	59.0	59.4	57.9	58.9	58.6	57.6	57.3	55.8	**59.1**	**58.1**	**54.6**
Martedi 16/05/2017	55.4	52.3	50.1	49.7	52.3	58.4	58.9	59.1	57.8	59.3	59.2	58.9	59.5	58.6	59.0	58.6	59.1	58.5	59.8	59.0	59.7	58.4	56.9	57.8	**59.0**	**59.1**	**55.2**
Mercoledi 17/05/2017	56.8	52.6	52.0	48.9	50.8	59.0	59.6	59.3	58.9	58.9	59.1	58.6	59.0	59.0	59.5	58.9	58.4	59.0	58.6	58.9	58.7	57.9	58.3	57.5	**59.0**	**58.3**	**55.8**
Giovedi 18/05/2017	56.7	53.1	51.3	47.8	52.2	57.6	59.2	59.3	59.1	58.8	59.5	59.5	59.4	59.8	59.1	59.6	59.2	58.6	59.2	59.2	59.7	58.5	57.3	57.6	**59.3**	**59.1**	**55.3**
Venerdi 19/05/2017	56.9	54.8	52.2	51.0	52.6	57.4	58.7	58.7	58.3	59.6	59.5	60.0	62.1	59.7	59.8	59.7	58.9	58.5	58.9	59.9	59.4	58.8	58.3	58.5	**59.6**	**59.1**	**56.0**
Sabato 20/05/2017	58.7	57.0	55.7	52.9	52.8	57.1	57.9	59.0	59.7	59.8	59.6	58.9	58.6	59.1	59.9	60.0	60.0	61.0	58.9	59.9	59.4	58.1	58.0	58.5	**59.5**	**58.8**	**56.8**
Domenica 21/05/2017	59.8	58.4	56.1	54.8	53.0	54.8	54.8	56.7	57.3	59.7	60.3	59.5	60.1	59.5	58.8	60.0	59.9	59.9	58.7	59.2	57.9	57.4	57.5	56.9	**59.1**	**57.7**	**56.9**
Lunedi 22/05/2017	56.4	52.6	50.0	49.3	51.9	57.8	59.5	59.9	58.1	59.3	58.9	58.5	58.6	58.7	60.4	60.9	60.0	59.2	58.8	58.4	58.0	57.1	56.9	56.7	**59.3**	**57.6**	**55.0**
																				MEDIA SETTIMANALE					**59.2**	**58.5**	**55.8**

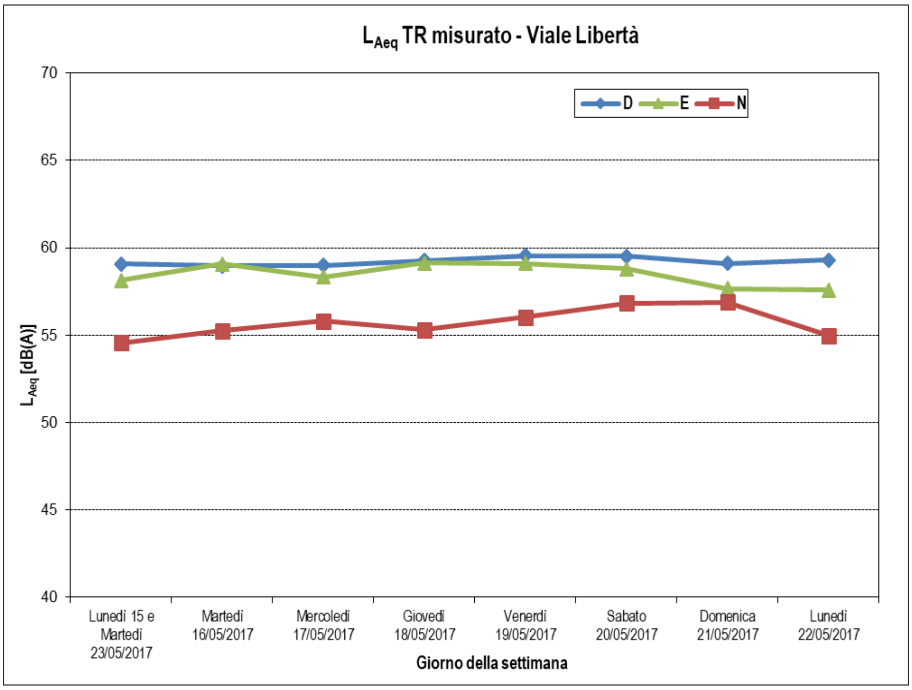
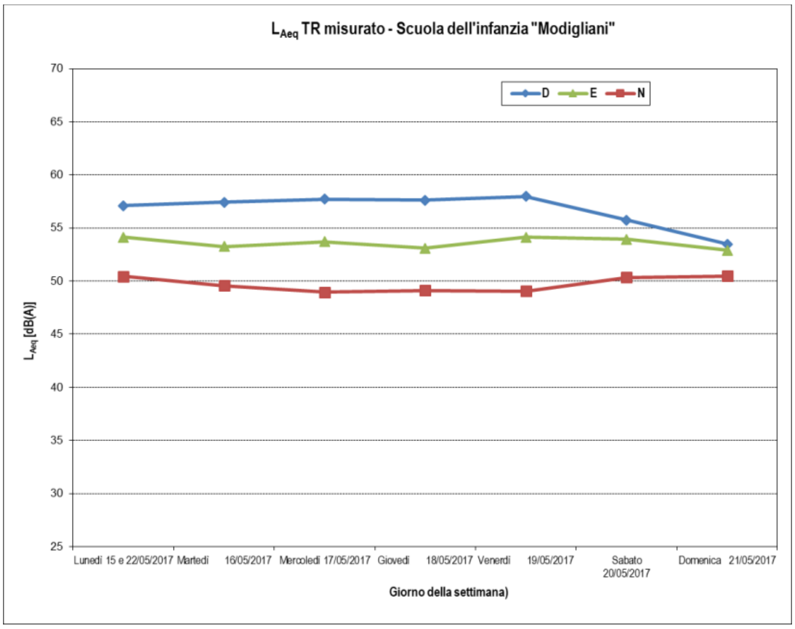


Table 6 - Results (measurement station P02)

Postazione P02	L_{Aeq} misurato (dB(A)) Orario																								Descrittore acustico		
DATA	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**D**	**E**	**N**
Lunedì 15 e 22/05/2017	50.0	49.0	47.1	47.2	50.6	53.2	54.5	58.0					56.8	59.5	56.2	57.4	58.4	58.0	57.5	56.8	55.0	53.0	52.2	50.4	**57.1**	**54.1**	**50.4**
Martedì 16/05/2017	49.4	46.7	46.0	47.0	49.8	53.0	53.2	58.6	58.3	57.6	57.1	59.1	56.6	60.8	57.0	57.2	57.3	57.8	58.1	56.4	54.4	51.7	51.1	48.7	**57.4**	**53.3**	**49.6**
Mercoledì 17/05/2017	46.0	46.5	41.8	44.5	47.2	51.6	53.3	58.4	59.0	58.4	61.1	59.8	56.8	59.0	56.7	56.9	57.5	57.3	57.5	56.2	54.7	52.4	51.9	51.7	**57.7**	**53.7**	**48.9**
Giovedì 18/05/2017	49.0	48.0	47.9	46.3	49.4	51.7	53.4	58.4	60.3	58.4	58.0	59.3	55.9	58.2	59.4	57.0	58.8	57.8	57.3	55.7	54.0	51.9	49.6	49.0	**57.6**	**53.1**	**49.1**
Venerdì 19/05/2017	48.0	43.6	43.2	39.0	45.3	51.7	52.3	57.4	59.5	58.9	58.0	58.2	59.4	59.2	57.1	58.6	57.7	58.1	60.3	57.4	55.0	53.0	52.2	52.6	**58.0**	**54.1**	**49.1**
Sabato 20/05/2017	51.7	48.1	48.5	47.2	49.4	51.9	53.9	55.3	56.7	56.9	56.5	56.6	56.5	55.6	54.6	54.8	55.4	57.3	56.4	55.2	54.7	53.0	51.5	51.6	**55.7**	**53.9**	**50.3**
Domenica 21/05/2017	51.5	50.6	50.0	48.6	49.3	51.1	50.0	50.4	52.4	53.9	54.4	55.3	54.9	52.0	52.1	52.2	53.2	54.2	55.3	55.2	53.2	52.6	51.3	50.5	**53.5**	**52.9**	**50.5**
																				MEDIA SETTIMANALE					**56.9**	**53.6**	**49.7**



▪ Traffic flows detection

Regarding **the traffic flows detection**, the sheets are structured as follows:

- General data of the measurement position (coding, description, reference road, system of measurement used).
- Territorial framework for the planimetric measurement identification and photographic documentation.
- Results of the automatic detection of traffic flows: date and time of start and end of the count, traffic flows (vehic/h) and speed values (km/h) of vehicles divided by direction of travel and between light and heavy vehicles and referred, for all measurement days and as a weekly average level, to the Day/Evening/Night period.

A tabular and graphical summary of the results of the detection of traffic flows is shown below.

Table 7 - Results referred to the acoustic descriptors Day/Evening/Night (position CT01)

Date	Acoustic Descriptor	Direction 1 - Center			Direction 2 - Periphery		
		LIGHT	HEAVY	TOTAL	LIGHT	HEAVY	TOTAL
Monday 15 & Tuesday 23/05/2017	Day	7009	187	7196	5885	80	5965
	Evening	651	11	662	439	1	440
	Night	564	13	577	694	4	698
Tuesday 16/05/2017	Day	6773	160	6933	5356	78	5434
	Evening	697	9	706	462	1	463
	Night	646	15	661	648	6	654
Wednesday 17/05/2017	Day	6884	169	7053	4964	90	5054
	Evening	651	8	659	400	4	404
	Night	798	5	803	632	5	637
Thursday 18/05/2017	Day	7014	167	7181	5010	85	5095
	Evening	728	6	734	441	2	443
	Night	757	8	765	569	4	573
Friday 19/05/2017	Day	6872	156	7028	6122	70	6192
	Evening	804	13	817	701	2	703
	Night	858	14	872	803	8	811
Saturday 20/05/2017	Day	7257	133	7390	5997	40	6037
	Evening	839	11	850	781	2	783
	Night	1083	8	1091	1090	3	1093
Sunday 21/05/2017	Day	6122	48	6170	6431	15	6446
	Evening	668	4	672	616	1	617
	Night	1114	7	1121	1057	2	1059
Monday 22/05/2017	Day	6831	189	7020	5985	65	6050
	Evening	660	8	668	551	2	553
	Night	590	5	595	843	4	847
Weekly Average	**Day**	**6845**	**151**	**6996**	**5719**	**65**	**5784**
	Evening	**712**	**9**	**721**	**549**	**2**	**551**
	Night	**801**	**9**	**811**	**792**	**5**	**797**

Table 8 - Results referred to the time data (position CT01)

Date	Acoustic Descriptor	Direction 1 - Center			Direction 2 - Periphery		
		LIGHT vehic/h	HEAVY vehic/h	TOTAL vehic/h	LIGHT vehic/h	HEAVY vehic/h	TOTAL vehic/h
Monday 15 & Tuesday 23/05/2017	Day	501	13	514	420	6	426
	Evening	326	6	331	220	1	220
	Night	71	2	72	87	1	87
Tuesday 16/05/2017	Day	484	11	495	383	6	388
	Evening	349	5	353	231	1	232
	Night	81	2	83	81	1	82
Wednesday 17/05/2017	Day	492	12	504	355	6	361
	Evening	326	4	330	200	2	202
	Night	100	1	100	79	1	80
Thursday 18/05/2017	Day	501	12	513	358	6	364
	Evening	364	3	367	221	1	222
	Night	95	1	96	71	1	72
Friday 19/05/2017	Day	491	11	502	437	5	442
	Evening	402	7	409	351	1	352
	Night	107	2	109	100	1	101
Saturday 20/05/2017	Day	518	10	528	428	3	431
	Evening	420	6	425	391	1	392
	Night	135	1	136	136	0	137
Sunday 21/05/2017	Day	437	3	441	459	1	460
	Evening	334	2	336	308	1	309
	Night	139	1	140	132	0	132
Monday 22/05/2017	Day	488	14	501	428	5	432
	Evening	330	4	334	276	1	277
	Night	74	1	74	105	1	106
Weekly Average	**Day**	**489**	**11**	**500**	**408**	**5**	**413**
	Evening	**356**	**4**	**361**	**274**	**1**	**275**
	Night	**100**	**1**	**101**	**99**	**1**	**100**

Table 9 - Results referred to the acoustic descriptors Day/Evening/Night (position CT02)

Data	Acoustic Descriptor	Direction 1 – Via Bertacchi			Direction 2 – Via Guerrina		
		LIGHT	HEAVY	TOTAL	LIGHT	HEAVY	TOTAL
Monday 15 & 22/05/2017	Day	2690	69	2759	2335	94	2429
	Evening	214	3	217	153	2	155
	Night	130	0	130	95	0	95
Tuesday 16/05/2017	Day	2671	58	2729	2421	51	2472
	Evening	184	6	190	150	2	152
	Night	141	1	142	117	0	117
Wednesday 17/05/2017	Day	2843	56	2899	2436	66	2502
	Evening	204	4	208	141	3	144
	Night	127	0	127	127	0	127
Thursday 18/05/2017	Day	2738	60	2798	2347	86	2433
	Evening	195	0	195	149	1	150
	Night	136	0	136	137	0	137
Friday 19/05/2017	Day	2699	62	2761	2440	70	2510
	Evening	182	2	184	131	3	134
	Night	158	0	158	163	1	164
Saturday 20/05/2017	Day	2120	48	2168	1681	60	1741
	Evening	192	3	195	135	4	139
	Night	177	0	177	154	1	155
Sunday 21/05/2017	Day	1340	7	1347	1110	29	1139
	Evening	149	2	151	132	3	135
	Night	205	0	205	174	1	175
Weekly Average	**Day**	**2443**	**51**	**2494**	**2110**	**65**	**2175**
	Evening	**189**	**3**	**191**	**142**	**3**	**144**
	Night	**153**	**0**	**154**	**138**	**0**	**139**

Table 10 - Results referred to the time data (position CT02)

Date	Acoustic Descriptor	Direction 1 – Via Bertacchi			Direction 2 – Via Guerrina		
		LIGHT vehic/h	HEAVY vehic/h	TOTAL vehic/h	LIGHT vehic/h	HEAVY vehic/h	TOTAL vehic/h
Monday 15 & 22/05/2017	Day	192	5	197	167	7	174
	Evening	107	2	109	77	1	78
	Night	16	0	16	12	0	12
Tuesday 16/05/2017	Day	191	4	195	173	4	177
	Evening	92	3	95	75	1	76
	Night	18	0	18	15	0	15
Wednesday 17/05/2017	Day	203	4	207	174	5	179
	Evening	102	2	104	71	2	72
	Night	16	0	16	16	0	16
Thursday 18/05/2017	Day	196	4	200	168	6	174
	Evening	98	0	98	75	1	75
	Night	17	0	17	17	0	17
Friday 19/05/2017	Day	193	4	197	174	5	179
	Evening	91	1	92	66	2	67
	Night	20	0	20	20	0	21
Saturday 20/05/2017	Day	151	3	155	120	4	124
	Evening	96	2	98	68	2	70
	Night	22	0	22	19	0	19
Sunday 21/05/2017	Day	96	1	96	79	2	81
	Evening	75	1	76	66	2	68
	Night	26	0	26	22	0	22
Weekly Average	**Day**	**175**	**4**	**178**	**151**	**5**	**155**
	Evening	**94**	**1**	**96**	**71**	**1**	**72**
	Night	**19**	**0**	**19**	**17**	**0**	**17**

Concerning the traffic flows detected by the traffic counter on Viale Libertà (CT01), it should be noted that, due to the parking of some vehicles in front of the radar detection sensor during the monitoring campaign, some periods were not correctly detected by the system in direction 1 (city centre). These periods were subject to post-processing with subsequent reconstruction of the missing data. The reconstruction was performed with reference to the data collected during the following Ante Operam campaign in November 2017.
The data contained in this report are already correct with the post-processing described.

List of Annexes of sub-action B5.2 (ante-operam monitoring - May 2017):

- Annex 8 – Calibration certificates for the measurement systems used
- Annex 9 – Monitoring sheets

2.2.2 Second monitoring campaign – November 2017

In this chapter is presented the analysis of the ante-operam sound level monitoring campaign that had held in November 2017 (exactly from Monday 20th to Monday 27th November).

In particular, this note reports the results of the phonometric monitoring campaign and the traffic flows collected in some road axis falling within the pilot area.

Have been taking into consideration:

- the data collected with a **long-term monitoring campaign** and, specifically, by counting weekly traffic flows in 2 positions with control unit with automatic radar traffic counting system showing the division into light and heavy vehicles;
- the data collected with a **short-term SPOT monitoring campaign**, and specifically, by time - based counting of short-term traffic flows (1 hours) in 10 positions.

Monitoring has carried out in correspondence with the receivers defined in the table 1.

Table 11- Monitoring scenarios November 2017

ID position	Type of monitoring	Toponym
P01	Long-term (weekly)	Viale Libertà – Centro Civico
P02	Long-term (weekly)	Via A. Modigliani - Scuola
S01	Short-term (Spot)	Viale Libertà – Centro Civico
S02	Short-term (Spot)	Viale Libertà n. 93
S03	Short-term (Spot)	Via della Gallarana
S04	Short-term (Spot)	Via della Guerrina n. 31
S05	Short-term (Spot)	Via A. Modigliani - Scuola
S06	Short-term (Spot)	Via Parmenide – Asilo nido
S07	Short-term (Spot)	Via Giuseppe Impastato
S08	Short-term (Spot)	Via della Guerrina – Liceo Porta
S09	Short-term (Spot)	Viale Libertà – Istituto Mapelli
S10	Short-term (Spot)	Via Correggio Allegri

The next figure shows the planimetric location of the phonometric monitoring stations, traffic flows (contextual to the phonometric ones), of the traffic counter radar units for the monitoring of noise pollution in the pilot area.

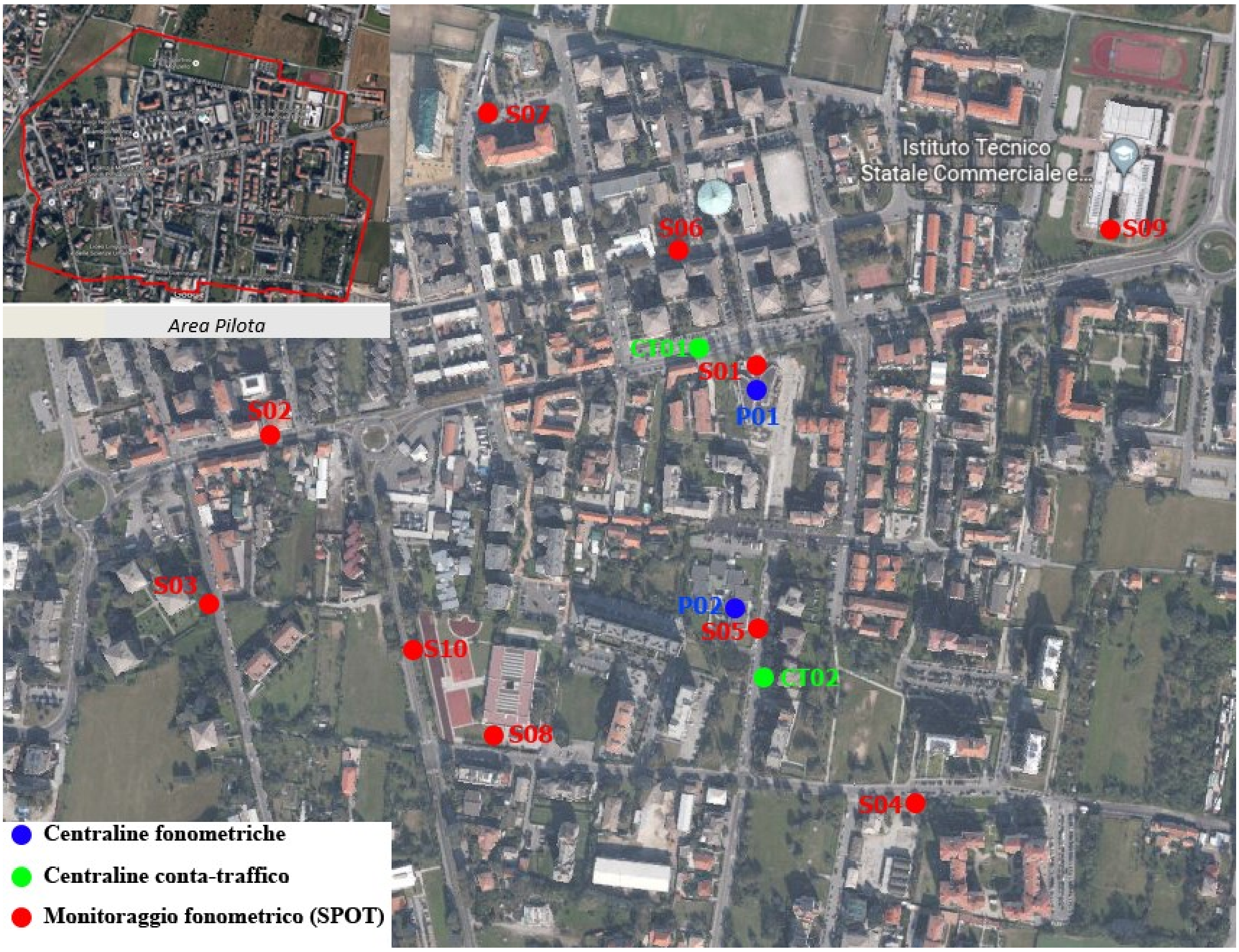


Figure 2 – Monitoring positions

➢ Measurement systems

For the measurements the following measurement systems were used:

SYSTEM NO.1

- PRECISION INTEGRATOR PHONOMETER 01dB type FUSION S.N. 11215 complying with the regulations IEC 651 – EN 60651 class 1 and IEC 804 – EN 60804;
- PRECISION MICROPHONE WITH PREPOLARIZED CONDENSER G.R.A.S. model 40 C.E. S.N. 233339 complying with the regulations EN61094-1/94 EN61094-2/93 EN61094-3/93 EN61094-4/95.

SYSTEM NO.2

- PRECISION INTEGRATOR PHONOMETER 01dB type BLUE SOLO S.N. 60982, complying with the regulations IEC 651 – EN 60651 class 1 and IEC 804 – EN 60804;
- PRECISION MICROPHONE WITH PREPOLARIZED CONDENSER 01dB type PRE21 S.N. 13936, complying with the regulations EN61094-1/94 EN61094-2/93 EN61094-3/93 EN61094-4/95 IEC 651 class 1 (imp.) e IEC 804.

SYSTEM NO.3

- PRECISION INTEGRATOR PHONOMETER BRUEL & KJÆR type 2250 S.N. 3004064, complying with the regulations IEC 651 – EN 60651 class 1 and IEC 804 – EN 60804;
- PRECISION MICROPHONE WITH PREPOLARIZED CONDENSER BRUEL & KJÆR type 4189 S.N. 2877086, complying with the regulations EN61094-1/94 EN61094-2/93 EN61094-3/93 EN61094-4/95 IEC 651 class 1 (imp.) and IEC 804.

ACOUSTIC CALIBRATOR

- BRUEL & KJÆR type 4231 S.N. 2713443, class 1 according to the standard IEC 942:1988, sound power level produced: 94 dB a 1000Hz.

For the memorization and the processing of the data was made use of the dedicated Software:

- Basic sound analysis software BRUEL & KJÆR BZ 5503;
- Noise Evaluator BRUEL & KJÆR 7820 v. 4.16.3;
- dB Trait.

The technical data of automatic traffic flow detection systems (radar systems) are reported below:

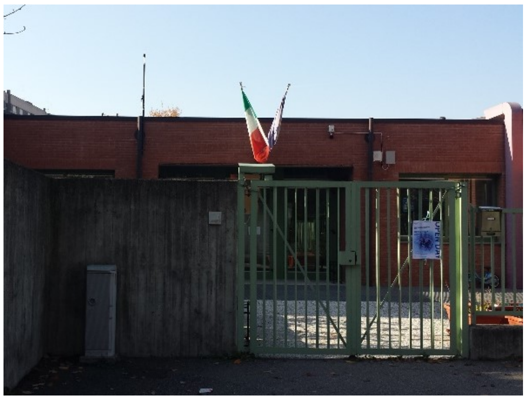
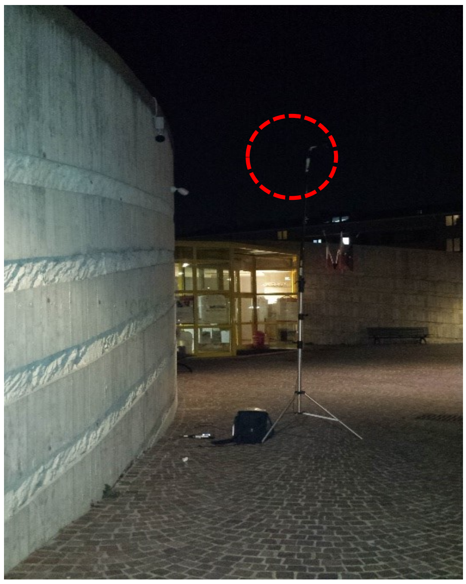
- Traffic monitoring device VIACOUNT II – VIA Traffic Controlling GmbH s.n. 13VZZ0257.
- Traffic monitoring device VIACOUNT II – VIA Traffic Controlling GmbH s.n. 14VZZ0067.

For the memorization and the processing of the data was made use of the dedicated Software: ViaGraph vers. 4.00.09.

➢ Measurement positions (phonometric monitoring)

The main information and the photographic contributes of the measurement positions used for the phonometric monitoring are shown below.

Table 12– Positions of phonometric monitoring

Measurement station	Description	Photo
P01	**Address:** Civic Center in Viale Libertà **Height from the ground level:** 6.00 m **Distance from the road axis:** 38 m **Measurement system used:** no. 1 **Acoustic class:** IV **Limit values:** 65 - 55 dB(A)	
P02	**Address:** Nursery School "A. Modigliani" **Height from the ground level:** 6.00 m **Distance from the road axis:** 15 m **Measurement system used:** no. 2 **Acoustic class:** School building in class I. External relevance area in class II. **Limit values:** 50 dB(A) class I (for schools only daytime TR is valid).	
S01	**Address:** Civic Center in Viale Libertà **Height from the ground level:** 4.00 m **Distance from the road axis:** 23 m **Measurement system used:** no. 3 **Acoustic class:** IV **Limit values:** 65 - 55 dB(A)	

Measurement station	Description	Photo
S02	**Address:** Viale Libertà no. 93 **Height from the ground level:** 4.50 m **Distance from the road axis:** 6 m **Measurement system used:** no. 3 **Acoustic class:** IV **Limit values:** 65 - 55 dB(A)	
S03	**Address:** Via della Gallarana **Height from the ground level:** 4.00 m **Distance from the road axis:** 5 m **Measurement system used:** no. 3 **Acoustic class:** II **Limit values:** 55 - 45 dB(A)	
S04	**Address:** Via della Guerrina no. 31 **Height from the ground level:** 4.00 m **Distance from the road axis:** 7.50 m **Measurement system used:** no. 3 **Acoustic class:** II **Limit values:** 55 - 45 dB(A)	

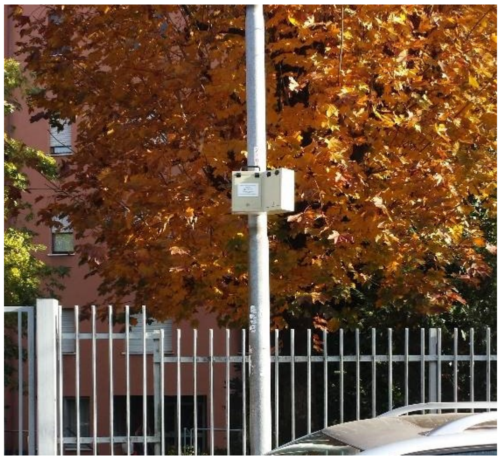
Measurement station	Description	Photo
S05	**Address:** Nursery School Modigliani entryway **Height from the ground level:** 4.00 m **Distance from the road axis:** 15 m **Measurement system used:** no. 3 **Acoustic class** School building in class I. External relevance area in class II. **Limit values:** 50 dB(A) class I (for schools only daytime TR is valid).	
S06	**Address:** Via Parmenide, at Private Nursery "Cuore Immacolato di Maria" **Height from the ground level:** 4.00 m **Distance from the road axis:** 6.50 m **Measurement system used:** no. 3 **Acoustic class:** School building in class I. External relevance area in class II. **Limit values:** 50 dB(A) class I (for schools only daytime TR is valid).	
S07	**Address:** Via Giuseppe Impastato **Height from the ground level:** 4.00 m **Distance from the road axis:** 4 m **Measurement system used:** no. 3 **Acoustic class:** II **Limit values:** 55 - 45 dB(A)	

Measurement station	Description	Photo
S08	**Address:** Via della Guerrina, next to Liceo “Porta” **Height from the ground level:** 4.00 m **Distance from the road axis:** 28 m **Measurement system used:** no. 3 **Acoustic class:** School building in class I. External relevance area in class II. **Limit values:** 50 dB(A) class I (for schools only daytime TR is valid).	
S09	**Address:** Viale Libertà, next to ITGC “Mapelli” **Height from the ground level:** 4.00 m **Distance from road axis:** 43 m **Measurement system used:** no. 3 **Acoustic class:** School building in class I. External relevance area in class II. **Limit values:** 50 dB(A) class I (for schools only daytime TR is valid).	
S10	**Address:** Via Correggio Allegri **Height from the ground level:** 4.00 m **Distance from road axis:** 12 m **Measurement system used:** no. 3 **Acoustic class:** III **Limit values:** 60 - 50 dB(A)	

Measurement positions (detection of traffic flows)

The main information and photo contributions of the measurement stations used to detect traffic flows automatically using a traffic device with radar system are shown below.

Table 13 - Traffic flows detection stations

Measurement station	Description	Photo
CT01	**Monitoring date:** 20-27/11/2017 **Reference road:** Viale Libertà **Measurement system used**: no. 1	
CT02	**Monitoring date:** 20-27/11/2017 **Reference road:** Via A. Modigliani **Measurement system used:** no. 2	

Monitoring results

The monitoring results are fully shown in specific summary sheets attached to this technical report.

Phonometric monitoring

Regarding the **phonometric monitoring**, the sheets are divided as follows:

- General data of the measurement station (coding, description, height of the microphone from the campaign plan, distance from the microphone to the road axis, measurement system used, noise class according to the Noise Zoning Plan of the Municipality of Monza, input limit values defined according to Italian D.P.C.M. 14/11/1997).
- Territorial framework for the planimetric measurement identification and photographic documentation.
- For **long-term monitoring**: date and time of start and end of the measure, time history, equivalent L_{Aeq} levels referred, for all measurement days and as a weekly average level, to the day reference period (6.00 - 22.00) and to the night reference period (22.00 - 6.00).

- For **short-term monitoring (SPOT):**
  - Results of phonometric monitoring: date and time of start and end of measurement, time history and frequency composition by third-band octave, equivalent levels L_{Aeq}.
  - Results of short-term manual count (1 hour) of traffic flows: date and time of start and end of the count, traffic flows (vehic/h) divided by direction of travel and between light and heavy vehicles.

During post-processing of the measured data, it was found that in some time slots the presence of events not attributable in terms of frequency and intensity to road traffic noise produce a significant and certainly not negligible contribution to the acoustic climate of the area. Periods affected by these events were excluded from the calculation of the daily and weekly average levels.
A tabular and graphical summary of the results of the phonometric monitoring is shown below.

Table 14 - Summary of short-term monitoring results

Postazione	Descrizione	Data e ora di inizio	Data e ora di fine	L_{Aeq} [dB(A)]
S01	In facciata al Centro Civico di Viale Libertà	20/11/2017 19:20:51	20/11/2017 20:20:51	63.5
S02	Viale Libertà, n. 93	20/11/2017 15:00:02	20/11/2017 16:00:02	70.3
S03	Via della Gallarana	21/11/2017 9:00:04	21/11/2017 10:00:04	63.9
S04	Via della Guerrina, n. 31	20/11/2017 17:50:11	20/11/2017 18:50:11	62.8
S05	Via Modigliani, in facciata della Scuola dell'infanzia	20/11/2017 16:38:12	20/11/2017 17:38:12	61.1
S06	Via Parmenide, in facciata alla Scuola dell'infanzia privata "Cuore Immacolato di Maria"	21/11/2017 14:40:41	21/11/2017 15:40:41	56.0
S07	Via Giuseppe Impastato	21/11/2017 17:25:59	21/11/2017 18:25:59	54.5
S08	In facciata al Liceo Statale "Carlo Porta"	21/11/2017 11:38:34	21/11/2017 12:38:34	56.7
S09	Viale Libertà, in facciata all'ITCG "Achille Mapelli"	21/11/2017 16:00:00	21/11/2017 17:00:00	58.6
S10	Via Correggio Allegri	21/11/2017 10:16:29	21/11/2017 11:16:29	67.3

Table 15 - Results (measurement station P01)

Postazione P01	**L_{Aeq} misurato (dB(A))**																								**Descrittore acustico**		
	Orario																										
DATA	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**D**	**E**	**N**
Lunedì 20 - 27/11/2017	57.0	53.2	50.4	48.9	52.9	57.6	59.5	60.4	60.4	59.9	59.3	59.0	59.3	59.4	59.8	59.3	59.0	59.1	58.8	59.6	59.1	58.7	58.0	58.2	**59.4**	**58.9**	**55.7**
Martedì 21/11/2017	55.8	51.6	53.4	47.4	50.5	56.6	58.8	59.5	58.2	60.3	59.5	60.4	59.8	60.4	59.8	59.0	58.4	58.5	58.6	59.3	59.3	58.0	57.2	58.0	**59.2**	**58.7**	**55.0**
Mercoledì 22/11/2017	57.2	53.3	50.2	47.9	51.4	57.7	58.9	59.5	59.7	60.7	60.0	59.8	59.6	60.1	59.5	59.6	59.1	57.9	58.3	59.1	58.7	58.3	58.2	58.1	**59.4**	**58.5**	**55.6**
Giovedì 23/11/2017	56.3	53.6	50.2	49.0	49.4	57.1	59.4	60.1	59.0	60.3	60.0	59.9	59.6	59.6	60.0	59.5	58.6	58.1	58.3	59.7	59.1	58.7	58.2	58.8	**59.4**	**58.9**	**55.5**
Venerdì 24/11/2017	57.4	54.3	52.0	49.5	51.5	57.8	60.1	60.6	59.6	60.3	60.1	59.5	59.9	61.5	60.6	59.7	57.9	57.9	57.2	58.4	58.9	58.8	58.2	61.1	**59.6**	**58.9**	**56.7**
Sabato 25/11/2017	61.6	59.9	57.3	55.5	55.3	58.2	58.9	61.1	61.8	62.0	64.0	61.3	60.9	62.6	61.7	61.6	60.0	59.6	59.6	59.6	59.4	58.7	58.5	59.9	**61.1**	**59.1**	**58.8**
Domenica 26/11/2017	60.2	58.4	58.4	54.9	51.5	52.0	53.4	54.8	56.6	57.3	57.7	57.2	57.2	57.5	58.6	59.3	58.3	58.2	58.2	59.1	59.0	58.5	58.1	57.6	**57.4**	**58.8**	**57.3**
																				MEDIA SETTIMANALE					**59.5**	**58.8**	**56.5**

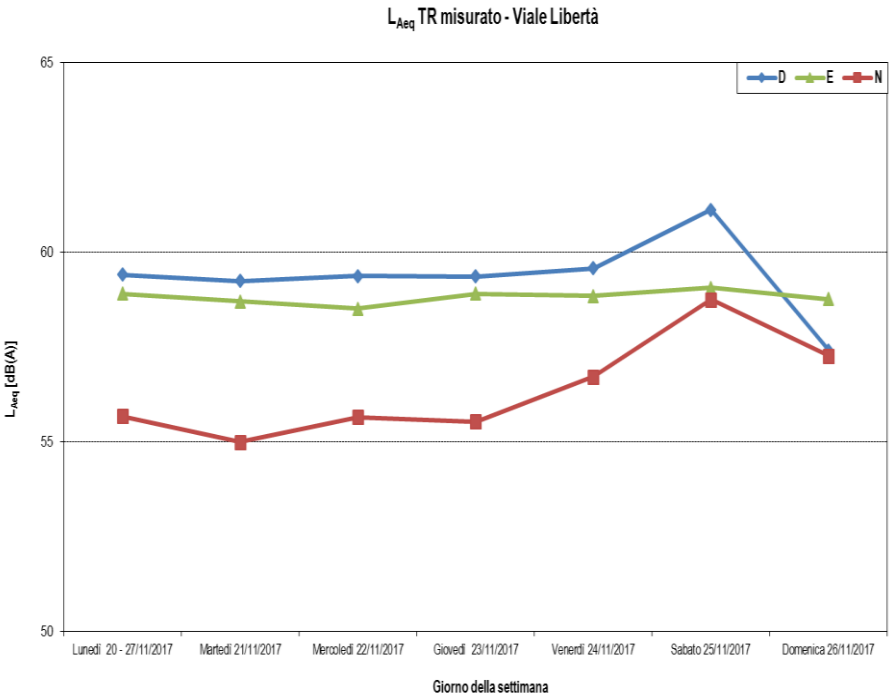
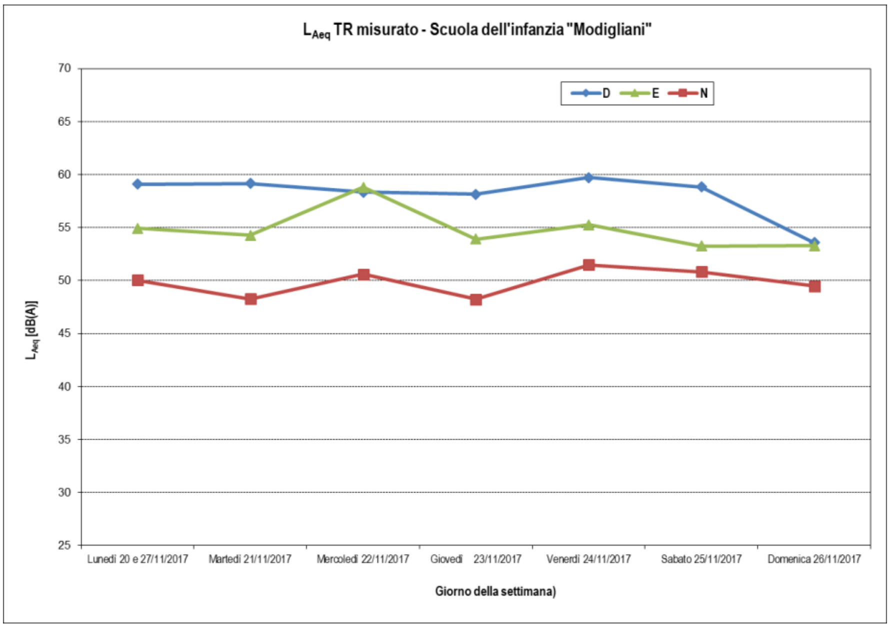


Table 16 - Results (measurement station P02)

Postazione P02	L_{Aeq} misurato (dB(A))																								Descrittore acustico		
	Orario																										
DATA	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**D**	**E**	**N**
Lunedì 20 e 27/11/2017	48.7	46.7	43.3	43.2	47.3	52.6	55.5	59.6	61.3	59.5	57.4	56.0	56.9	61.9	57.2	58.8	60.6	60.6	59.1	57.4	55.4	54.4	54.4	51.4	**59.1**	**54.9**	**50.1**
Martedì 21/11/2017	47.0	44.1	41.4	37.7	44.4	47.0	59.2	59.3	59.9	61.3	58.9	58.3	58.1	59.9	58.2	58.4	59.4	59.7	58.4	57.8	54.7	53.8	54.0	50.6	**59.2**	**54.3**	**48.3**
Mercoledì 22/11/2017	48.7	46.7	42.6	41.4	44.8	49.6	53.9	59.7	59.7	59.5	57.4	58.4	57.5	58.8	58.5	59.3	59.0	58.3	57.3	56.5	59.1	58.5	56.1	53.8	**58.4**	**58.8**	**50.6**
Giovedì 23/11/2017	47.0	46.2	45.0	40.1	44.3	48.8	53.8	59.4	59.9	59.6	56.7	56.6	57.9	59.3	57.2	58.7	58.3	58.6	57.6	57.2	55.2	52.1	52.8	50.3	**58.1**	**53.9**	**48.2**
Venerdì 24/11/2017	52.1	56.1	41.9	41.9	46.2	51.0	55.0	60.2	60.5	61.6	57.5	59.1	58.7	64.0	59.6	58.5	59.8	58.7	58.7	57.1	57.0	52.3	52.7	52.4	**59.7**	**55.3**	**51.5**
Sabato 25/11/2017	52.1	51.3	48.2	45.9	46.5	52.1	51.9	58.2	58.8	59.8	59.7	60.4	61.5	60.6	58.8	59.2	57.0	57.2	57.4	56.3	54.4	51.8	53.2	51.9	**58.8**	**53.3**	**50.8**
Domenica 26/11/2017	51.5	48.6	50.6	48.7	46.7	45.1	46.1	48.2	51.7	53.6	54.3	53.2	53.8	52.0	53.5	53.5	55.5	55.8	54.9	55.5	53.6	53.0	50.5	50.7	**53.6**	**53.3**	**49.5**
																			MEDIA SETTIMANALE						**58.5**	**55.3**	**50.0**



▪ Traffic flows detection

Regarding **the traffic flows detection**, the sheets are structured as follows:

- General data of the measurement position (coding, description, reference road, system of measurement used).
- Territorial framework for the planimetric measurement identification and photographic documentation.
- Results of the automatic detection of traffic flows: date and time of start and end of the count, traffic flows (vehic/h) and speed values (km/h) of vehicles divided by direction of travel and between light and heavy vehicles and referred, for all measurement days and as a weekly average level, to the Day/Evening/Night period.

A tabular and graphical summary of the results of the detection of traffic flows is shown below.

Table 17 - Results referred to the acoustic descriptors Day/Evening/Night (position CT01)

Date	Acoustic Descriptor	Direction 1 - Center			Direction 2 - Periphery		
		LIGHT	HEAVY	TOTAL	LIGHT	HEAVY	TOTAL
Monday 20 & 27/11/2017	Day	7301	159	7460	6850	96	6946
	Evening	767	7	774	686	3	689
	Night	705	3	708	746	3	749
Tuesday 21/11/2017	Day	7408	147	7555	6876	89	6965
	Evening	812	6	818	739	1	740
	Night	685	4	689	766	1	767
Wednesday 22/11/2017	Day	7410	147	7557	6600	80	6680
	Evening	836	7	843	711	4	715
	Night	816	10	826	762	5	767
Thursday 23/11/2017	Day	7212	145	7357	6295	86	6381
	Evening	926	8	934	732	5	737
	Night	815	6	821	848	2	850

Date	Acoustic Descriptor	Direction 1 - Center			Direction 2 - Periphery		
		LIGHT	HEAVY	TOTAL	LIGHT	HEAVY	TOTAL
Friday 24/11/2017	Day	7368	125	7493	6450	81	6531
	Evening	1044	7	1051	745	2	747
	Night	1020	7	1027	823	2	825
Saturday 25/11/2017	Day	7525	65	7590	3526	15	3541
	Evening	868	5	873	563	1	564
	Night	1357	3	1360	634	15	649
Sunday 26/11/2017	Day	6523	23	6546	6025	3	6028
	Evening	680	2	682	591	2	593
	Night	1176	2	1178	1082	1	1083
Weekly Average	**Day**	**7250**	**116**	**7365**	**6089**	**64**	**6153**
	Evening	**848**	**6**	**854**	**681**	**3**	**684**
	Night	**939**	**5**	**944**	**809**	**4**	**813**

Table 18 - Results referred to the time data (position CT01)

Date	Acoustic Descriptor	Direction 1 - Center			Direction 2 - Periphery		
		LIGHT vehic/h	HEAVY vehic/h	TOTAL vehic/h	LIGHT vehic/h	HEAVY vehic/h	TOTAL vehic/h
Monday 20 & 27/11/2017	Day	522	11	533	489	7	496
	Evening	384	4	387	343	2	345
	Night	88	0	89	93	0	94
Tuesday 21/11/2017	Day	529	11	540	491	6	498
	Evening	406	3	409	370	1	370
	Night	86	1	86	96	0	96
Wednesday 22/11/2017	Day	529	11	540	471	6	477
	Evening	418	4	422	356	2	358
	Night	102	1	103	95	1	96
Thursday 23/11/2017	Day	515	10	526	450	6	456
	Evening	463	4	467	366	3	369
	Night	102	1	103	106	0	106
Friday 24/11/2017	Day	526	9	535	461	6	467
	Evening	522	4	526	373	1	374
	Night	128	1	128	103	0	103
Saturday 25/11/2017	Day	538	5	542	252	1	253
	Evening	434	3	437	282	1	282
	Night	170	0	170	79	2	81
Sunday 26/11/2017	Day	466	2	468	430	0	431
	Evening	340	1	341	296	1	297
	Night	147	0	147	135	0	135
Weekly Average	**Day**	**518**	**8**	**526**	**435**	**5**	**440**
	Evening	**424**	**3**	**427**	**341**	**1**	**342**
	Night	**117**	**1**	**118**	**101**	**1**	**102**

Table 19 - Results referred to the acoustic descriptors Day/Evening/Night (position CT02)

Date	Acoustic Descriptor	Direction 1 – Via Bertacchi			Direction 2 – Via Guerrina		
		LIGHT	HEAVY	TOTAL	LIGHT	HEAVY	TOTAL
Monday 20 & 27/11/2017	Day	2732	73	2805	2324	70	2394
	Evening	154	1	155	108	4	112
	Night	98	1	99	98	0	98
Tuesday 21/11/2017	Day	2855	80	2935	2329	62	2391
	Evening	180	4	184	118	3	121
	Night	111	4	115	121	1	122
Wednesday 22/11/2017	Day	2816	71	2887	2317	70	2387
	Evening	198	3	201	113	3	116
	Night	105	2	107	113	1	114
Thursday 23/11/2017	Day	2848	71	2919	2346	83	2429
	Evening	179	2	181	104	2	106
	Night	125	2	127	100	1	101
Friday 24/11/2017	Day	2913	70	2983	2405	59	2464
	Evening	185	3	188	118	2	120
	Night	155	1	156	114	0	114
Saturday 25/11/2017	Day	2065	39	2104	1554	26	1580
	Evening	113	2	115	91	1	92
	Night	161	0	161	135	1	136
Sunday 26/11/2017	Day	1385	9	1394	1057	10	1067
	Evening	117	0	117	84	0	84
	Night	144	0	144	116	0	116
Weekly Average	**Day**	**2516**	**59**	**2575**	**2047**	**54**	**2102**
	Evening	**161**	**2**	**163**	**105**	**2**	**107**
	Night	**128**	**1**	**130**	**114**	**1**	**114**

Table 20 - Results referred to the time data (position CT02)

Date	Acoustic Descriptor	Direction 1 – Via Bertacchi			Direction 2 – Via Guerrina		
		LIGHT vehic/h	HEAVY vehic/h	TOTAL vehic/h	LIGHT vehic/h	HEAVY vehic/h	TOTAL vehic/h
Monday 20 & 27/11/2017	Day	195	5	200	166	5	171
	Evening	77	1	78	54	2	56
	Night	12	0	12	12	0	12
Tuesday 21/11/2017	Day	204	6	210	166	4	171
	Evening	90	2	92	59	2	61
	Night	14	1	14	15	0	15
Wednesday 22/11/2017	Day	201	5	206	166	5	171
	Evening	99	2	101	57	2	58
	Night	13	0	13	14	0	14
Thursday 23/11/2017	Day	203	5	209	168	6	174
	Evening	90	1	91	52	1	53
	Night	16	0	16	13	0	13
Friday 24/11/2017	Day	208	5	213	172	4	176
	Evening	93	2	94	59	1	60
	Night	19	0	20	14	0	14
Saturday 25/11/2017	Day	148	3	150	111	2	113
	Evening	57	1	58	46	1	46
	Night	20	0	20	17	0	17
Sunday 26/11/2017	Day	99	1	100	76	1	76
	Evening	59	0	59	42	0	42
	Night	18	0	18	15	0	15
Weekly Average	**Day**	**180**	**4**	**184**	**146**	**4**	**150**
	Evening	**80**	**1**	**82**	**53**	**1**	**54**
	Night	**16**	**0**	**16**	**14**	**0**	**14**

List of Annexes of sub-action B5.2 (ante-operam monitoring - novemb 2017):

- Annex 10 – Calibration certificates for the measurement systems used
- Annex 11 – Monitoring sheets

2.2.3 Analysis of ante-operam monitoring data and preparation of noise maps

This paragraph reports the methodology used for the analysis of the traffic data collected during the monitoring campaign on some roadways and the definition of flows to the other stretches not counted but within the pilot area.
The methodology used for the construction of the acoustic simulation model, for the creation of the noise maps and for the calculation of the exposed population (indicators) is also described.

As described in the previous chapters, during the monitoring campaigns the following data have been collected:

- long-term (weekly) traffic data on two stations by counting with automatic radar traffic counting system;
- short-term SPOT traffic data (1 hour) on ten stations by manual counting.

The following table summarizes the survey stations and the type of monitoring carried out:

Table 1 - Monitoring scenarios

Position ID	Tipology	Toponym
P01	Weekly	Viale Libertà
P02	Weekly	Via A. Modigliani
Mis001	Spot	Viale Libertà – Centro Civico
Mis002	Spot	Viale Libertà n. 93
Mis003	Spot	Via Gallarana
Mis004	Spot	Via della Guerrina n. 31
Mis005	Spot	Kindergarten “Modigliani” - Via Modigliani
Mis006	Spot	Kindergarten “Cuore Immacolato di Maria” - Via Parmenide
Mis007	Spot	Via Giuseppe Impastato
Mis008	Spot	Via Correggio Allegri
Mis009	Spot	Viale Libertà – Technical institute ITCG “Mapelli”
Mis010	Spot	Via della Guerrina – High school “Porta”

The following figure shows the roadways, which have been coloured for a better definition:

- the stretches subject to weekly traffic counts are in violet;
- the stretches subject to spot traffic counting are in red;
- the stretches within the pilot area, which are not subject to monitoring and for which flows have been estimated are in light blue;
- all stretches outside the pilot area in grey.

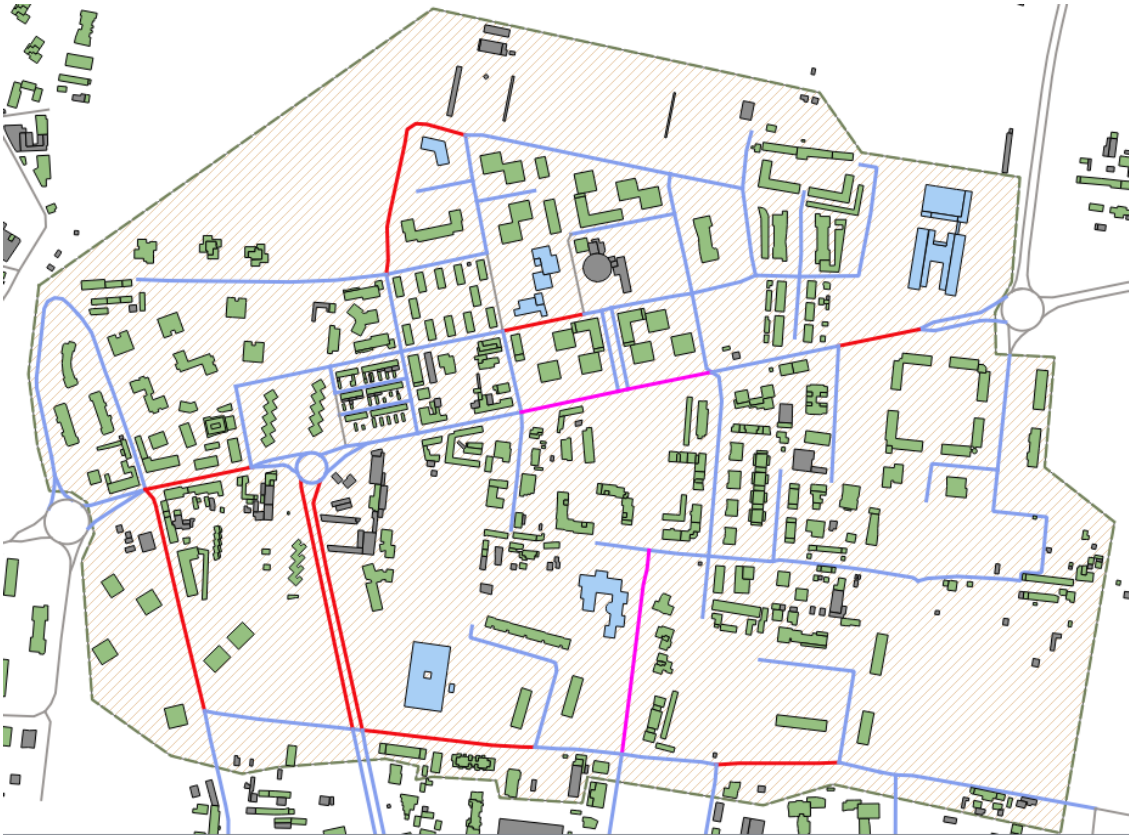


Figure 2 – Stretches under monitoring

Reconstruction of daily traffic flows and definition of stretches

For the construction and the definition of the average daily traffic flows, the following steps were considered:

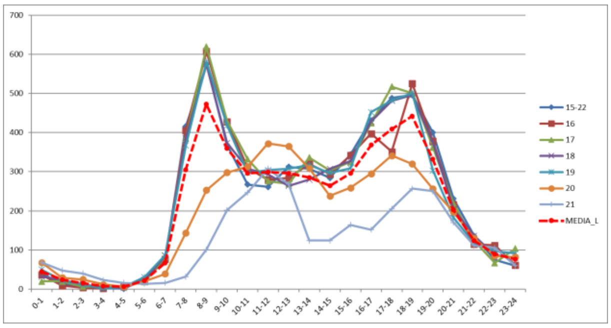
- <u>Viale Libertà:</u> from the measures carried out during the monitoring campaigns on Viale della Libertà (both in the weekly and in the spots) it has been noted that this road axis has a similar trend, both in terms of total daily traffic flow and percentage of heavy vehicles, along its entire length, but very different from the other routes within the pilot area. For this reason, it was decided to assign the traffic flows detected by the radar system in the Viale Libertà Civic Centre (weekly) to all the sections of Viale Libertà within the pilot area.

- <u>Via Modigliani:</u> to the entire stretch of the street, the flows detected on the CT02 traffic counter, installed on this road axis, have been assigned.

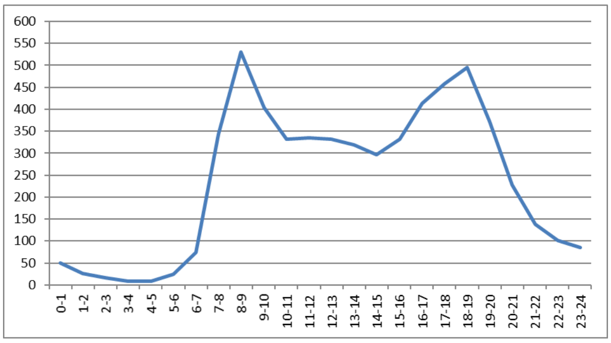
- Other monitored roads: for the other roadways, reference was made to the weekly flow measurements obtained at the Via Modigliani station. In particular, for this station, the hourly volumes of traffic were extracted per day (separate for light and heavy vehicles) and the weekly average was calculated. Subsequently, the daily average weekly traffic diagram was constructed. Considering that, as mentioned, the other monitored roadways have similar characteristics to Via Modigliani, this diagram was used to reconstruct the daily flow of all the other roadways monitored spot, starting from the hourly traffic data contextual to the phonometric measurement.

The following figure shows an example of reconstruction of the average daily flow on Via Gallarana, using the hourly distribution of Via Modigliani (referring to the ante operam campaign of May 2017).

Figure 2 – Example of Via della Gallarana – May 2017



Traffic trend on via Modigliani
Average hourly traffic flow measured during weekly monitoring



Traffic trend on via della Gallarana
Reconstructed average hourly traffic flow

Monitoraggio MAGGIO 2017			Flussi di traffico (veic/h)		
Via della Gallarana			direzione 1		
Data	Direz.		LEGGERI	PESANTI	TOTALE
17/05/2017	Dir.1		67	1	68
ora 14-15	Dir.2		228	0	228
Orario	Spot		Calcolo		
	conteggio manuale		Distribuzione flusso		
	Leg	Pes	Leg	Pes	TOTALE
0-1			50	0	50
1-2			27	0	27
2-3			16	0	16
3-4			9	0	9
4-5			8	0	8
5-6			25	0	25
6-7			74	1	75
7-8			341	2	343
8-9			529	2	530
9-10			402	1	403
10-11			331	1	332
11-12			334	1	335
12-13			331	1	332
13-14			318	1	319
14-15	296	1	295	1	296
15-16			331	1	332
16-17			412	2	413
17-18			458	1	459
18-19			494	1	496
19-20			371	1	372
20-21			227	1	227
21-22			139	0	139
22-23			100	0	101
23-24			86	0	86

When the average daily traffic flows for all the monitored stretches were reconstructed, a definition of the flows to the other roads within the pilot area, that were not monitored, was carried out. The definition was made on the basis of similar characteristics of the road network determined in close collaboration with the technical offices of the Municipality of Monza.

Acoustic model, calibration and noise maps

The construction of the noise maps and the definition of the exposed receivers (indicators) has been obtained through the construction of a sound model calibrated with reference to the phonometric surveys and traffic flows carried out in the different stations.

Construction of the acoustic model

The evaluation of the sound levels was conducted using the SoundPlan calculation software, developed by GmbH. The software uses a ray-tracing calculation algorithm with ray tracing from the receiver points.
As a calculation method, the software implements numerous standards. In this study, the French NMPB standard indicated by 2019 by Directive 2002/49/EC (implemented at Italian national level by Legislative Decree 194/2005) was used for the calculation of road traffic noise.
The following specifications have been adopted with regard to noise and calculation settings:

- order of reflection equal to 2;
- maximum study range 2000 m;
- study distance around each receiving point considered in the calculation equal to 500 m;
- maximum distance of reflections from the receiver equal to 500 m;
- maximum reflection distance from the source equal to 200 m;
- ground factor G:
- equal to 0.5 for all areas within urban and/or industrial areas;
- equal to 0.8 for all other areas (fields, rural areas, river areas, forests, etc.);
- facade reflection coefficient equal to 0,8

Simulations were performed for the following parameters:

- L_{DEN} level in dB(A) in the day-evening-night period.
- L_{NIGHT} level in dB(A) in the nighttime (10.00 pm – 6.00 am).
- $L_{Aeq,daily}$ level in dB(A), in the daytime (6.00 am – 10.00 pm).
- $L_{Aeq,night}$ level in dB(A), in the nighttime (10.00 pm – 6.00 am).

For the definition of the propagation model, the territorial data contained in the designated website of Lombardia Region and those contained in the territorial database provided by the Urban Planning Office of the Municipality of Monza were used. In particular, from these databases, all the data necessary for the definition of the morphology of the territory, for the definition of the type of the building (residential, school, health, industrial buildings) and for the construction of a map of the road infrastructure have been extracted.
Concerning the population data, the shapefile, made available on the ISTAT webpage, was used. It contains the 2011 census data relating to the entire territory of the Lombardia Region. The population data were distributed over all the residential buildings present in each census section, taking into account the volumetric dimensions of the buildings.

Calibration and validation of the calculation model

The calibration phase of the calculation model was obtained by determining appropriate K correction coefficients, defined from the difference between the measured and simulated acoustic value at the SPOT measuring stations. The K coefficient represents the actual difference with respect to the emission conditions of the road and the fleet used by the software as well as the difference in the actual driving conditions compared to those assumed in the calculation.
The correction was made with the objective of introducing minimum corrections such as to reduce the differences between the measured value and the simulated value within ±0.5 dB(A).

The procedure included the following steps:

- calculation of the generated noise level (L_{Aeq}, expressed in dB(A)), at the measurement points, by implementing the hourly flow of vehicles counted by the operator during the measurements in the reference sound source and setting a transit speed of all types of vehicles at 50 km/h;
- comparison of measured levels with similar simulated levels;
- determination of the value of the correction coefficient K, according to the abovementioned selection criteria.

The K correction, expressed in dB(A), has been implemented in the acoustic model correcting the sound emission and setting the same other input parameters.

The validation phase involved an experimental numerical comparison with reference to the weekly level determined in the two long-term stations. In this case, deviations of up to 2 dB(A) between the measured and simulated level were considered suitable.

Acoustic maps and calculation of exposed receivers

The following calculation methods were used for the construction of the noise maps and for the definition of the exposed receivers (see indicators):

- CALCULATION OF THE ACOUSTIC VALUES ON THE FACADE: sound levels were assessed as maximum levels on the most exposed façade of each residential building. The simulations were carried out at a height of 4 m, excluding the reflection of the building façade, behind the calculation point, at a distance of 1 m from the receiver's façade.

- ACOUSTIC MAP CALCULATION: a grid of points has been defined with a pitch of 10 m, positioned at a height of 4 m above the ground.

The input data for road sources are:

- Viale Libertà and Via Modigliani: the average weekly traffic flows recorded during the monitoring campaigns (divided by day, evening and night) were included in the acoustic model.
- Other monitored roads: the average traffic flows reconstructed on the basis of spot surveys (divided by day, evening and night) have been included in the acoustic model.
- Non-monitored roads: the average traffic flows assigned by the abovementioned procedure have been included in the acoustic model.

The noise maps, for the May 2017 and November 2017 monitoring (Annex 29) were produced as isophonic curves included in the defined calculation area (Pilot area) with reference to the L_{DEN} and L_{NIGHT} noise indicators respectively (in the range between 45 dB(A) and 75 dB(A)).
The values of the noise levels, measured by the receivers on the façade, were used to calculate the exposed population and to update the indicators.
The calculation was performed both in reference to the entire Lez area and to the area contained in a buffer of 30m from Viale della Libertà.

Bibliography

To draw up the report of sub-action B5.2 and the noise maps, the following Laws and regulations have been referred to:

- Legge 26 ottobre 1995, n. 447, Legge quadro sull'inquinamento acustico (G.U. n. 254 del 30 ottobre 1995);
- D.M. Ambiente del 16 marzo 1998, Tecniche di rilevamento e di misurazione dell'inquinamento acustico (G.U. n. 76 del 01 aprile 1998);
- D.P.R. 30 marzo 2004, n. 142, Disposizioni per il contenimento e la prevenzione dell'inquinamento acustico derivante dal traffico veicolare (G.U. n. 127 del 01 giugno 2004);
- D.Lgs. 19 agosto 2005, n. 194, Attuazione della direttiva 2002/49/CE relativa alla determinazione e alla gestione del rumore ambientale (G.U. n. 222 del 23 settembre 2005);
- Direttiva 2002/49/CE del Parlamento Europeo e del Consiglio del 25 giugno 2002 relativa alla determinazione e alla gestione del rumore ambientale.
- D. Lgs. 17 febbraio 2017, n. 42, Disposizioni in materia di armonizzazione della normativa nazionale in materia di inquinamento acustico, a norma dell'articolo 19, comma 2, lettere a), b), c), d), e), f) e h) della legge 30 ottobre 2014, n. 161.
- Direttiva (UE) 2015/996 della Commissione del 19 maggio 2015 che stabilisce metodi comuni per la determinazione del rumore a norma della direttiva 2002/49/CE del Parlamento europeo e del Consiglio
- Piano Comunale di Classificazione Acustica del comune di Monza.

In addition, reference was made to the following sector technical regulations:

- Nuove linee guida "Specifiche tecniche per la predisposizione e consegna della documentazione digitale relativa alle mappe acustiche e mappe acustiche strategiche (D.Lgs.. 194/05)" emanate dal Ministero dell'Ambiente e della Tutela del Territorio e del Mare 14-16 Marzo 2017.
- UNI 11143-1:2005 Acustica - Metodo per la stima dell'impatto e del clima acustico per tipologia di sorgenti - Parte 1: Generalità;
- UNI 11143-2:2005 Acustica - Metodo per la stima dell'impatto e del clima acustico per tipologia di sorgenti - Parte 2: Rumore stradale;
- UNI/TR 11326:2009 – Acustica. Valutazione dell'incertezza nelle misurazioni e nei calcoli di acustica. Parte 1: Concetti generali;
- UNI ISO 1996-1: 2016 – Acustica. Descrizione, misurazione e valutazione del rumore ambientale. Parte 1: Grandezze fondamentali e metodi di valutazione;
- UNI ISO 1996-2: 2010 – Acustica. Descrizione, misurazione e valutazione del rumore ambientale. Parte 1: Determinazione dei livelli di rumore ambientale.

Health - UNIFI

Analysis of data collected in the pre-test.
Results of the pre-test survey for the sample survey on the perception of living conditions, noise and air quality in the "Liberty District" - SECOND SECTION

Methodologies fOr Noise low emission Zones introduction And management

LIFE15 ENV/IT/000586

LIFE MONZA
Methodologies fOr Noise low emission Zones introduction And management

Technical Report

Deliverable	Report on Ante and Post Operam data collection
Action/Sub-action	B5.4 “Health ex ante/ex post monitoring”
Authors	University of Florence, Department of Experimental and Clinical Medicine, Occupational Medicine (Prof. Giulio Arcangeli, Prof. Nicola Mucci, Dr. Veronica Traversini) and Department of Health, Hygiene and Preventive Medicine (Prof. Guglielmo Bonaccorsi, Dr. Chiara Lorini)
Status - date	Final version - 22/04/2020

Summary

INTRODUCTION

The continuous economic growth, the increase in industrial production, the growing urbanization and the related transport needs will continue to increase the levels of noise pollution in European countries, with consequences for the health of all citizens. It therefore becomes essential to encourage the collection of data on exposure to noise, encourage various countries to develop their action plans and focus on reducing sources.

Recent statistics estimate that as many as 125 million European citizens are exposed to road traffic noise levels above average annual levels of 55 dB but these figures could actually be significantly higher.

This exposure leads to the perception of discomfort for 20 million inhabitants, the appearance of sleep disturbances for 8 million and it's responsible for over 40 thousand hospitalizations. In addition, some 8000 children in Europe have difficulty reading and concentrating in areas where air traffic noise is near to school buildings (3).

With these purposes, the LIFE MONZA project was born, which aims to develop the management of a "Noise Low Emission Zone" (Noise LEZ), that it is an urban area with low noise emissions subject to road traffic limitations and improvements regarding the quality of the life of the residents of a district of Monza. The project envisaged several strategies to reduce noise in the neighborhood, including the creation of a limited traffic area for trucks and interventions on the road system and public buildings. In addition, the effects on air quality and well-being conditions of residents in the neighborhood were analyzed.

The main objective of the LIFE MONZA (Methodologies for Noise low emission Zones introduction and management) project is to develop a methodology replicable in different contexts, for the identification and management of the "Noise Low Emission Zone" (the urban area under consideration traffic limitations); the impacts and benefits of which on noise pollution will be analyzed and tested in the pilot area of the Municipality of Monza.

Further objectives of the project concern the analysis of the effects of the Noise Low Emission Zone on air quality and people's well-being conditions, the definition of the type of interventions capable of inducing beneficial and synergistic effects, such as those concerning the planning of the flows of traffic and adoption of low-noise floors, and, finally, the active involvement of the population in different and more sustainable lifestyle.

In order to establish an active dialogue between institutions and citizens, questionnaires were administered regarding the various environmental issues, the development of a system for sharing good practices, through meetings with primary and secondary school students and activities for their involvement (for example, the competition of ideas dedicated to the creation of the logo of the "Noise Low Emission Zone" of the pilot area).

THE DETECTION TOOL

The sample survey, of a diachronic type, provided for the realization of two surveys: the first (pretest) defined the situation ex ante, the second (post-test) recorded the conditions found after the implementation of the infrastructure interventions and other measures envisaged by the project, in order to evaluate the changes that have occurred. The data was collected in both phases by administering semi-structured questionnaires to samples of the population residing in the "Liberty district" separated for the two time phases. The pre and post-test questionnaires share almost all the questions in common, to allow a satisfactory comparison between the ex ante and ex post situations. The area affected by the "Life MONZA" Project is the Liberty District, located in the north-east quadrant of the city, near the city park area, which represents the green lung of the city. Monza, with its resident population of 124,693 inhabitants in 2017, is the third most populous municipality in Lombardy.

The questionnaire consists of two main sections. This report refers to the contents of the second section.

The 30 questions that make up the second part of the questionnaire refer to:

- *Information on the respondent's health status (physical, psychological problems, possible therapies);*
- *Home information (proximity to public services and health care);*
- *Quality of personal life (level of satisfaction, enjoying life);*

• *Perception of sleep quality and daily concentration;*

• *Perception of the environment'safety, for personal health purposes (noise, pollution);*

• *Level of satisfaction of social networks (friends, social relationships, leisure);*

• *Presence of negative feelings (annoyance, decreased mood, anxiety, depression).*

In the first section, the ISPRA group, in collaboration with the Sapienza University of Rome, also collected information on housing, quality of life, mobility and the perception of air pollution and noise, in addition to socio-demographic data.

THE SAMPLING

The selection of the sample provided for a stratified random strategy, considering as the reference population the set of citizens residing in the study area aged between 18 and 80 and three stratification variables: (gender, 3 age'groups and spatial location). To establish the sample size, given that the reference population was equal to 6.150 units, a calculation formula was used that took into account the correction factor for finite populations. The outcome of the choices made led to the selection of a sample of 570 units. In addition to the list of sampled population, two lists of names and addresses have been prepared for replacements, to be used if it was not possible to find the sampled subject. The same procedure was replicated in 2019, on the occasion of the second survey (post-test).

THE DETECTION METHODS

ISPRA, in collaboration with the Municipality of Monza, the University of Florence, Vie en.ro.se Engineering and the "Carlo Porta High School", identified the best solution in the postal dispatch of the questionnaires. For the pretest phase, the submission began in the first days of February 2018, for both sections of the questionnaire, with an institutional letter of accompaniment from the Municipality, containing the indications for hand delivery to two locations and for the access to the alternative method of filling in electronically. After the first two weeks of collection, the first reminder was made indirectly through online notices and through local media, while the direct reminder to the sample (letter with questionnaire) was made only once in May 2018. With this strategy, the role of the detectors, tutors and students of the "Carlo Porta High School" was therefore mainly expressed in the with drawal of the completed questionnaire and the clarification of any doubts by citizens.

There were two locations identified for the manual delivery of the paper questionnaires:
• the "**Carlo Porta High School**" (Via della Guerrina, 15), which guaranteed a space also dedicated to filling in the questionnaire at the headquarters;
• the "**Liberty Civic Center**" (Viale Libertà, 144), which for a few days made the coworking room available with tables and places for up to twenty people.

The questionnaire was also administered electronically online (always in self-administration mode, with the direct access of each respondent to the Limesurvey).

RESPONDERS

In the pretest phase, a total of 177 subjects were involved, therefore approximately 31% of the cases envisaged by the sample design (Fig.1).

Gender, house'location, age

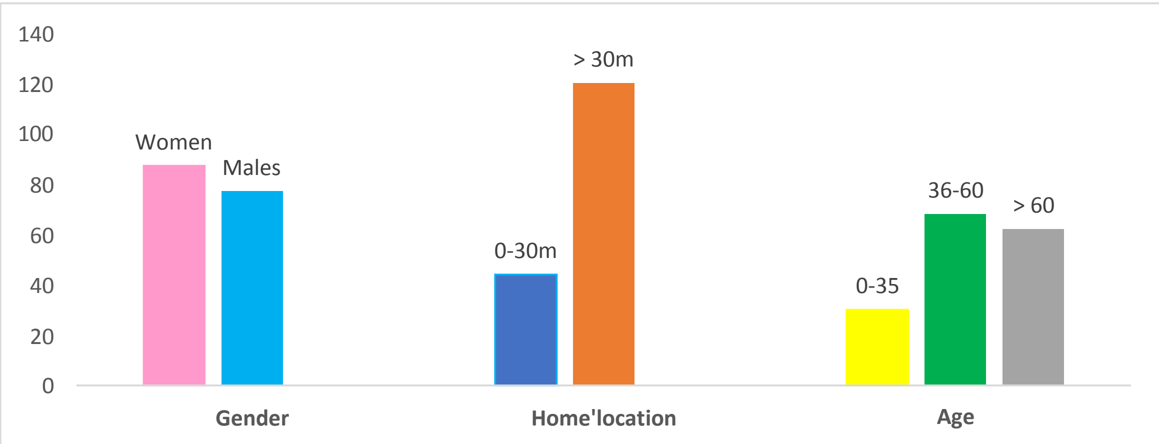


Fig.1 Socio-demographic data in the pretest phase

For gender, there is a similar distribution (87 women and 77 men in the pretest phase); about home'location, residents were more than 30 meters from Liberty Avenue in both phases (120 subjects in the first phase). Finally, as regards age, most of the responders are between 36 and 60 years (average 55 ys).

Citizenship

In the pretest phase, almost all the interviewees have Italian citizenship (176 cases; one case preferred not to answer the question). The respondents were born in Lombardy principally (74.6%) and over 44% in the province of Monza and Brianza. The sample also includes subjects born in other regions (44), especially in South Italy (in particular Campania, Sicily, Puglia and Calabria). Three respondents (1.7% of the total) were born abroad.

Education title and occupation

In the first phase, the sample has a significant incidence of diplomates (48.3%) and graduates (30.1%); about occupation, it mainly includes employed people (48.6%) and retired people (34.9%). Furthermore, over 40% of respondents work in commerce and services, while 24% are or have been employed in industry; most of them as employees (more than 87% overall).

Home

In first phase, about a fifth of respondents (25.6%) live in houses that directly overlook Liberty Avenue and 68.4% live within a distance of 100 meters from the avenue.

LIFE'QUALITY- RESULTS

Here are some of the main data that emerged in the **PRETEST PHASE**.

Stress, sleep disorders, irritability attributable to noise pollution are reported by about 17% of respondents (11% report recurrent headache episodes). In 36 cases (20.3%) declare that they never accuse any of the disorders indicated. Only 3.4% say they can concentrate little on what they do, 5.7% are very dissatisfied with sleep quality and 10.9% are not very satisfied (Fig. 2).

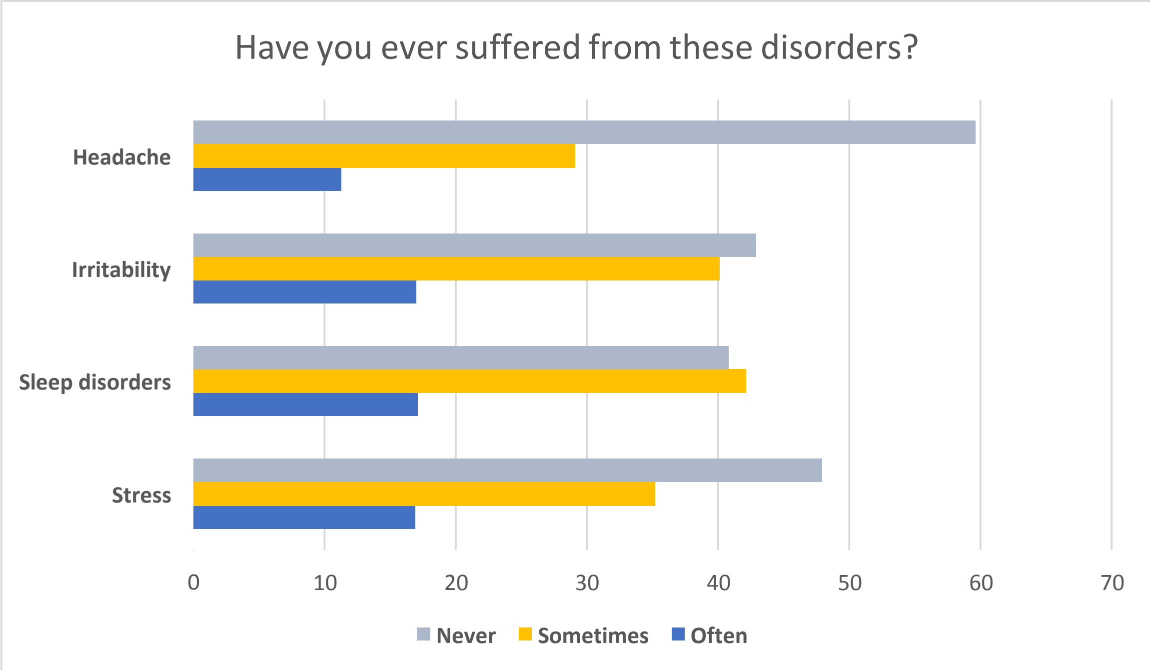


Fig.2 Frequencies (% values) of some disturbances that emerged in the pre-test phase

Their quality of life is mostly assessed in a neutral way ("neither good nor bad", 55.9%), although there is no shortage of respondents who express a negative evaluation ("bad", "very bad", 19.8%) (Fig 3). Regarding some characteristics overall, over half believe the environment is safe “enough” (57.6%) and a part of them say they find it "very" safe (26%); residents manage to carve out moments for hobbies ("much" in 55.4%) but nevertheless feel they do not enjoy life enough ("a little" - "for nothing" in 39%) (Fig. 4).

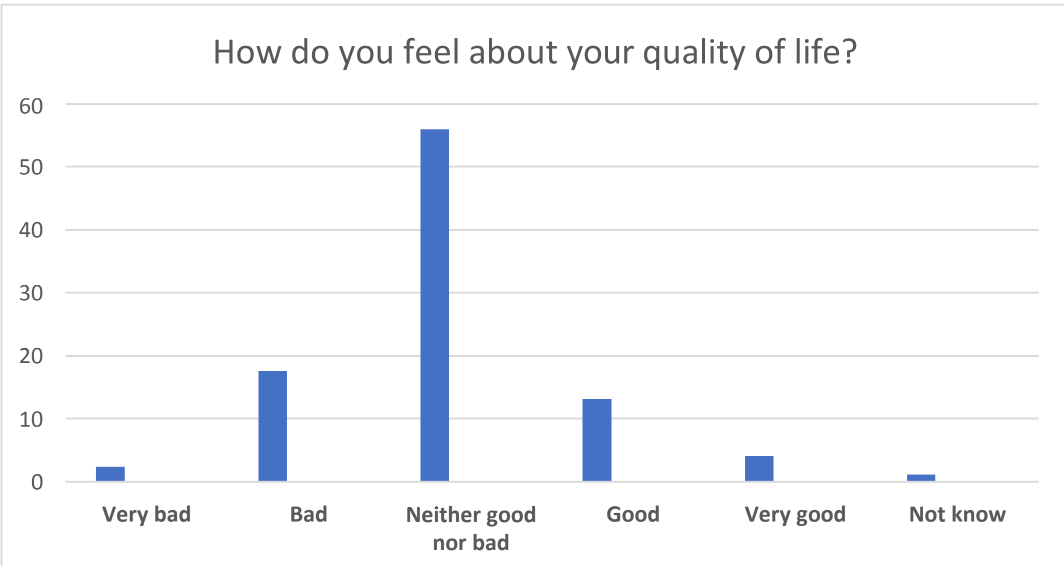


Fig.3 Level of quality of life’satisfaction (% values) in the pre-test phase

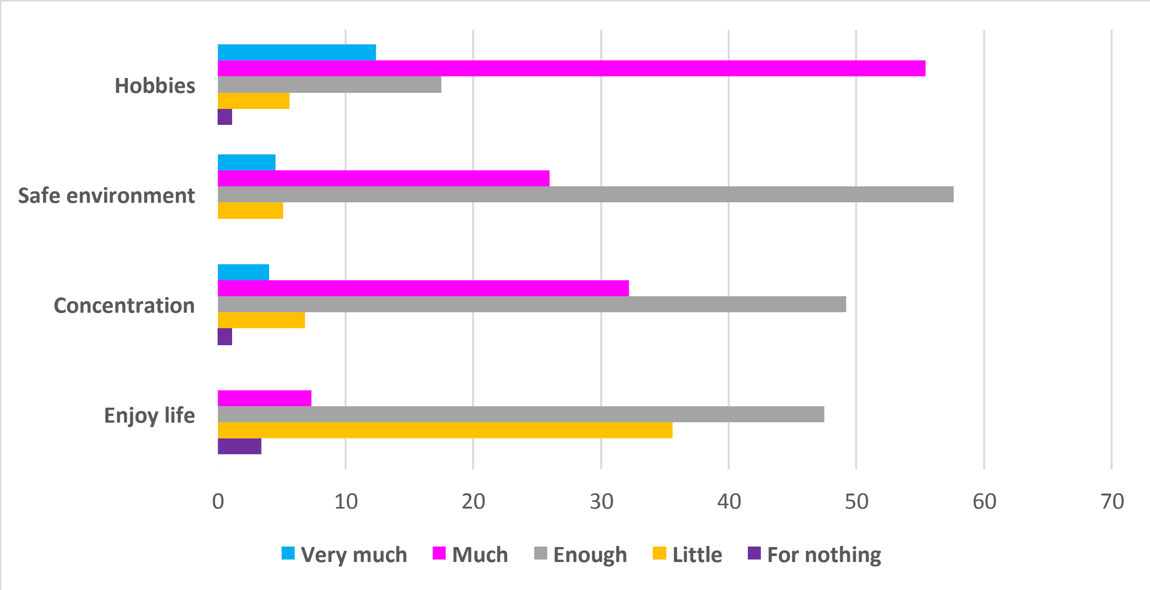


Fig.4 Frequencies (% values) of some variables in the pre-test phase

From a physical status, the residents show sufficient but not optimal levels, with low daily energy ("enough" in 42.9% and "little" in 24.9%) and they need therapies or treatments often ("enough" - "very "In 75.7%) (Fig. 5); despite some difficulties, there is appreciation for one's existence ("much" in 36.2% and "enough" in 47.5%) (Fig. 6).

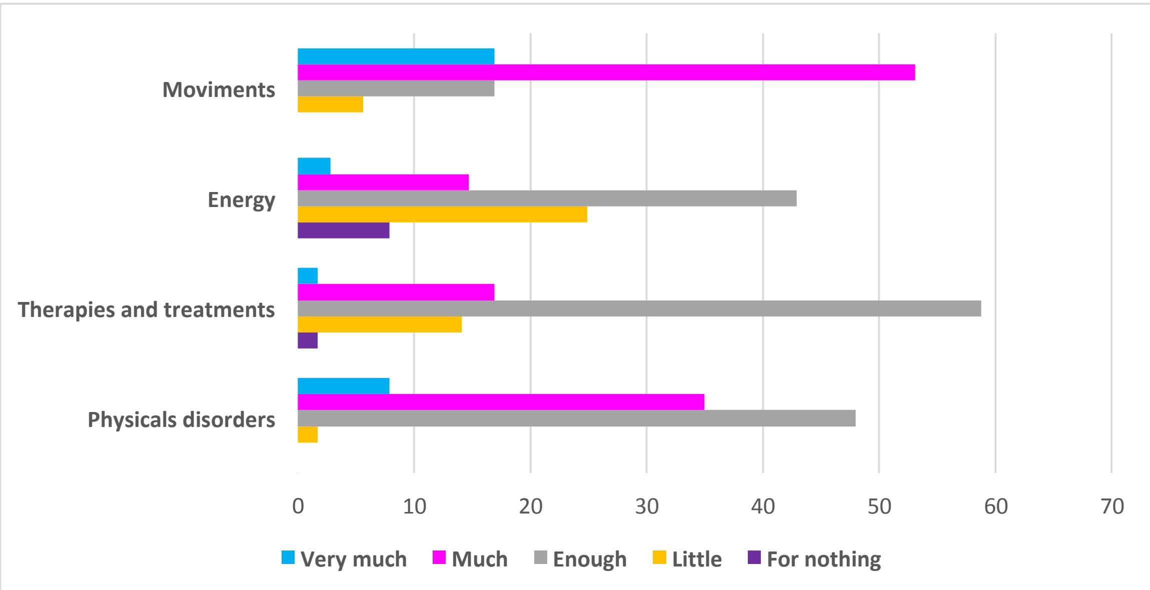


Fig.5 Frequencies (% values) of some variables in the pre-test phase

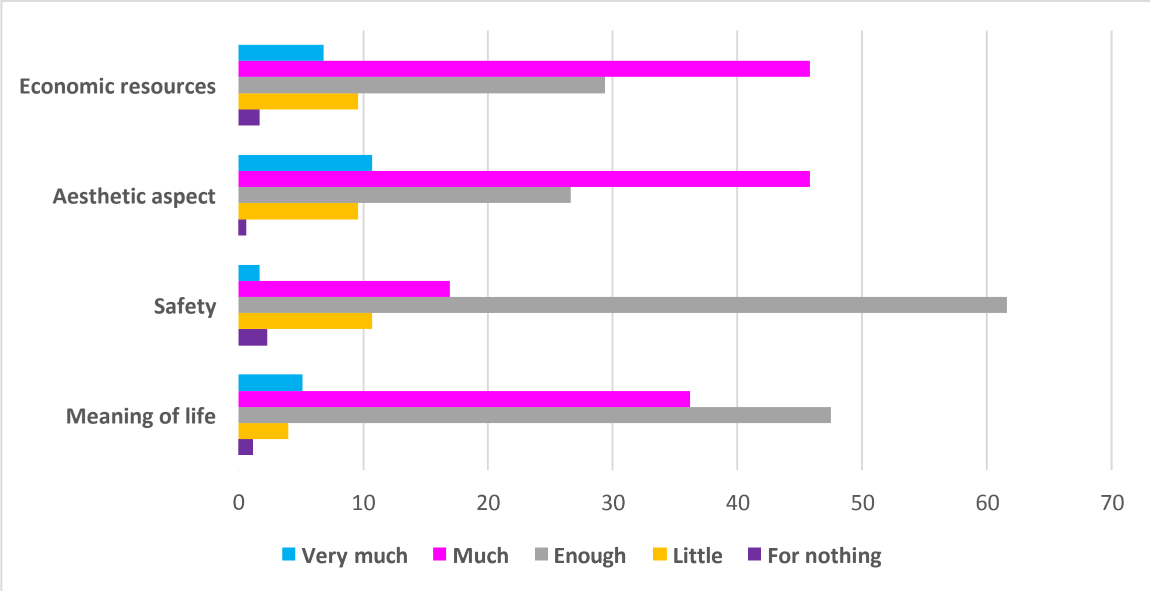


Fig.6 Frequencies (% values) of some variables in the pre-test phase

There are discrete levels of satisfaction with one's own person and daily activities, also in consideration of the commitment and perseverance made available for one's personal obligations (53.1% "satisfied", 41.8% and 49.7% respectively). On the other hand, there are poor levels of satisfaction in social relations'sphere and relationships ("not satisfied" in 73.4%) (Fig 7,8).

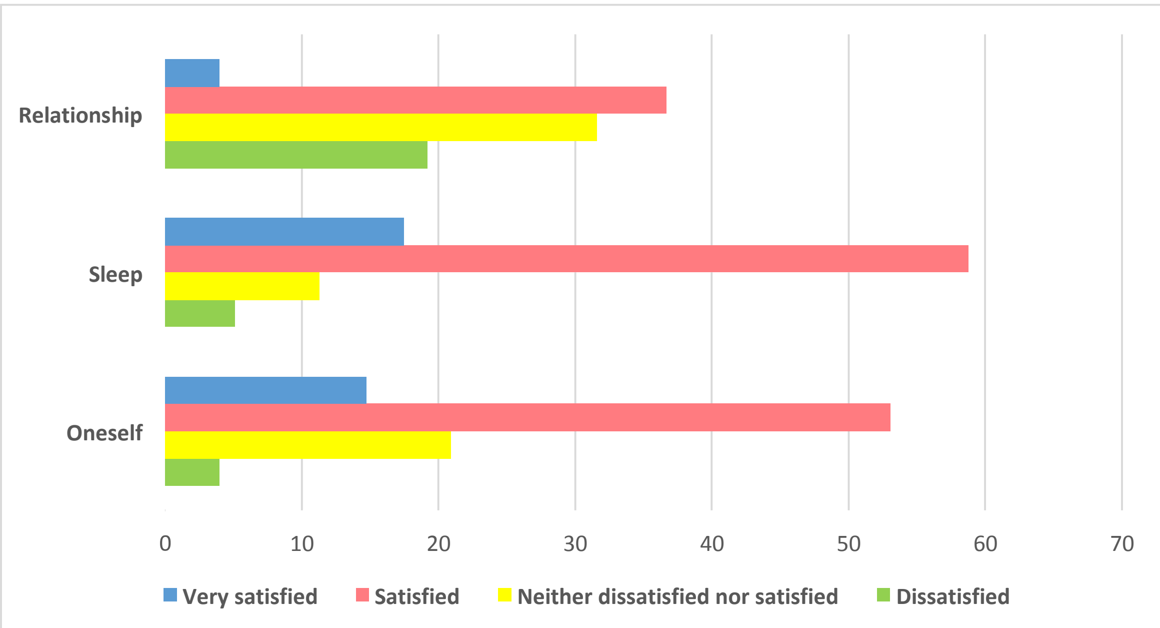


Fig.7 Satisfaction (% values) of some variables in the pre-test phase

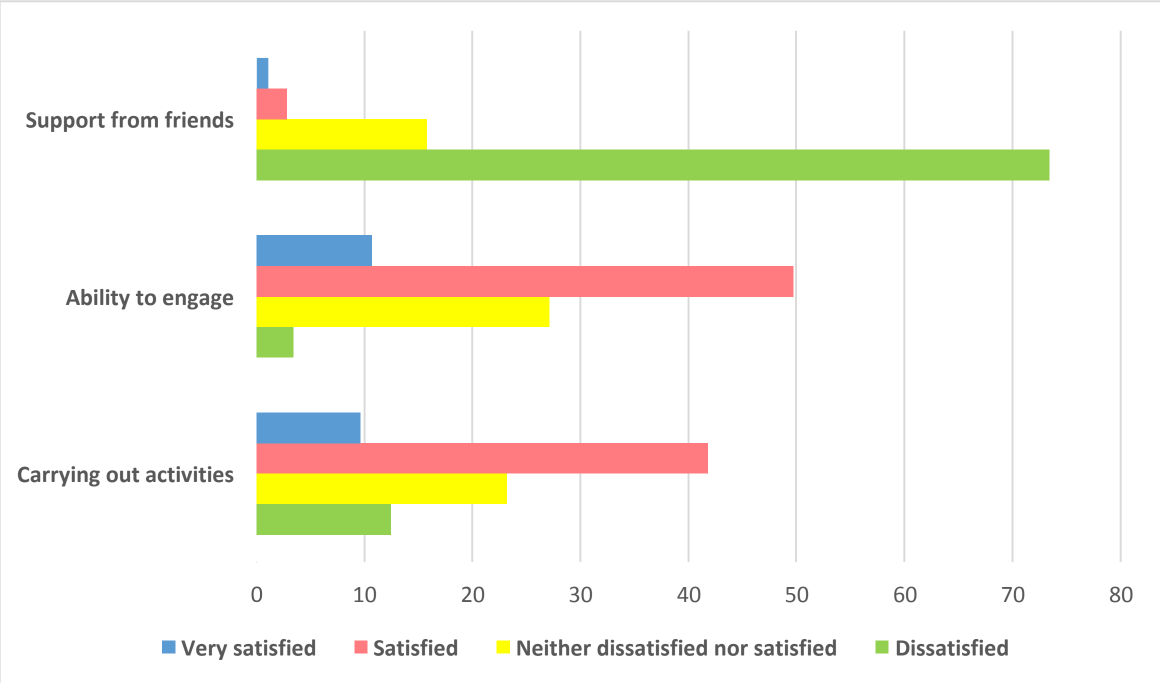


Fig. 8 Satisfaction (% values) of some variables in the pre-test phase

CONTINGENCY TABLES IN RELATION TO HOME'POSITION

Proceeding with contingency tables between 2 selected variables («Does your home overlook Liberty Avenue?» and «Distance from Liberty Avenue») and each questions, we have found an significant association (P< 0.05) only for 2 variables:

1) "Can you concentrate on things you do?"/ "Does your home overlook Liberty Avenue?" (P 0.021), highlighting on one hand a greater concentration for those who not overlook the avenue and on the other hand a greater disturbance perceived by the inhabitants overlooking the avenue (area subject to improvements) (Tab.1);
2) "Are you satisfied with how you sleep?"/ "Does your home overlook Liberty Avenue?" (P 0.002), highlighting on one hand a greater sleep'satisfaction for those who not overlook the avenue and on the other hand a greater perceived disorder by inhabitants overlooking the avenue (area subject to improvements) (Tab.2).

Does your home overlook Liberty Avenue?	Are you satisfied with how you sleep?		
	Disatisfied	Neither disatisfied nor satisfied	Satisfied- Very satisfied
No	66,7%	60%	81,4%
Yes	25%	40%	17,5%
Chi-Square	Value	gl	P value
	16.679[a]	4	**0.002**

Tab.1 Contingency table between home'position and sleep (Pre-test)

Does your home overlook Liberty Avenue?	Can you concentrate on things you do?		
	For nothing-A bit	Enough	Much-Very much
No	83,5%	73,9%	69,1%
Yes	0%	26,1%	28,4%
Not know	16,7%	0%	2,5%
Chi-Square	Value	gl	P value
	11.560[a]	4	**0.021**

Tab.2 Contingency table between home'position and concentration (Pre-test)

Bottom-up actions – MONZA

LIFE MONZA
Methodologies fOr Noise low emission Zones introduction And management

LIFE15 ENV/IT/000586

LIFE MONZA
Methodologies fOr Noise low emission Zones introduction And management

Deliverable	Report on Ante and Post operam data collection
Action/Sub-action	B5.5 “Bottom up actions: ex ante/ex post people participation”
Authors	Jonathan Monti
Status - date	Final Version- 03-05-2020

Beneficiary:	Comune di Monza
Contact person:	Jonathan Monti
E-mail:	jmonti@comune.monza.it
Project Website:	www.lifemonza.eu

1. Introduction and objectives

The LIFE MONZA project focuses on the Libertà district in the city of Monza, a densely populated area with about 10,000 inhabitants, located in the north-eastern part of the city. The neighbourhood is crossed by a main road with about 30,000 vehicles per day, which is one of the main access roads to Monza and is currently the city's main west-east transit road.
Within this area, on the basis of the Municipality's Acoustic Mapping (the so-called “Mappatura Acustica”), all buildings included in the 30 m road strip are exposed to noise levels above 65 dB(A) during the day and 55 dB(A) at night. For this reason, this is a critical area in the Monza Action Plan.
The fields of intervention of the project are:

- state of the art review
- implementation of top-down measures, consisting of infrastructures and traffic management along Viale Libertà;
- implementation of bottom-up measures, through the active involvement of residents and the spread of habits for noise reduction and improvement of air quality and health in life and the working environment.

2. Involvement of people: organization of meetings, a competition of ideas, questionnaires

Concerning the organization of meetings, the Municipality of Monza has been active in the definition of school events for the dissemination of the project. Two initiatives have been organized:
- On 26th April 2017: “Noise Awareness Day", which concerns noise awareness activities for the “Mapelli” School in the Libertà district and the organization of a day of training on acoustics (simple theoretical notions on noise, followed by practical measurements with technical instruments). The Municipality of Monza (with Nicola Sgaramella) in collaboration with UNIFI and Vie en.ro.se. Ingegneria participated in the meeting.
- On 3rd May 2017: Training day on acoustics, in which short theoretical notions on noise have been explained, followed by practical measurements with technical instrumentation. Noise education activities were carried out by “Rodari” Primary School (based on learning by playing). Nicola Sgaramella participated for the Municipality of Monza.

With regards to the competition of ideas, a contest has been set up to create a logo and a slogan for the communication and promotion of the project in the Libertà district. The aim was to represent the fundamental elements to identify the neighbourhood in terms of noise pollution and to support the various activities to improve environmental quality. Students were involved directly for raising their awareness of the project's objectives. The competition was addressed to the students of the “Mapelli” Institute. The works were evaluated based on originality, simplicity, suitability, memorability, ductility. The members of the first three winning groups were rewarded with one bicycle each, in the presence of the mayor of the city. T-shirts and pencils with the chosen logo were distributed to all participants in the competition.

Questionnaires have been written by Unifi, Ispra and Vie en.ro.se. and, then, distributed by the Municipality of Monza. They constitute a sample survey in the analysis of the effects of actions through the detection and evaluation of perceptions and behaviours of the population.
In particular, people were interested in the project concerning aspects related to the liveability of the neighbourhood and the environmental, social and welfare conditions for the community.

Questionnaires were sent by post, between 15th and 16th February 2018, together with an official letter from the Municipality, explaining the instructions for the delivery of the survey.
After the first two weeks, an indirect reminder was made via web and local media.
For the manual delivery of the questionnaires, the identified places were:
- the "Carlo Porta" High School (Via della Guerrina, 15), where a dedicated space was granted, with the possibility of filling in on site;
- the Civic Center of Libertà DIstrict (Viale Libertà, 144), where the coworking room was used for a few days.
The paper questionnaires, delivered to the Civic Center of Viale Libertà, were processed to begin with the evaluation work.
In the institutional site of the Municipality of Monza, a specific section for the Life Monza project has been realized. This section contains the objectives and actions that have been carried out during the whole life of the project. The project has also been promoted on social media.

3. Pedibus

The bottom-up action of the Pedibus, which characterizes the Life Monza project, aims at the active involvement of the community. The Pedibus, according to the "Regolamento del Pedibus Monza-Libertà" (municipal regulations), is defined as a school bus on foot and a participatory action that promotes mobility on foot in the home-school journey. Children enrolled in the Pedibus, organized in small groups, are accompanied by volunteers (parents and/or grandparents) and go from home to school following the Pedibus lines. The Pedibus is an active educational experience that can be carried out with the support of both the school and the local community.
The Municipality of Monza considers the Pedibus, an action proposed by ABCittà, as a real "common good for the city". In this perspective, the experience realized within the LIFE project in the period November 2018 - June 2020, has allowed the definition of a "Neighbourhood Pedibus", where, to take care of the accompaniment of children, are not only the parents directly concerned, but also volunteers who have recognized a concrete commitment to improve the quality of life in the neighbourhood.

Several meetings took place with ABCittà at the “Rodari” Primary School for checking the availability of the accompanying service, starting from the parents of the pupils. In the phases of promotion and subsequent start of the action, the Consulta of Viale Libertà - a group formed by citizens committed to collaborating with the Administration -, was the reference point for all citizens who found in the Pedibus an opportunity to relaunch local relations. On 29th November 2018, the first meeting took place at the district council with representatives of the Municipality of Monza and ABCittà, together with stakeholders from different local associations. The meeting brought positive effects by collecting the first applications of volunteers and interest and willingness to reach other residents.
The poster of the above-mentioned event, which was the starting point for the Pedibus, is shown below.


pedibus
IL PEDIBUS È UNO SCUOLABUS A PIEDI
PROMUOVE LA MOBILITÀ SOSTENIBILE NEL TRAGITTO CASA-SCUOLA
I bambini iscritti a Pedibus, organizzati in piccoli gruppi, sono accompagnati da volontari per recarsi da casa a scuola seguendo le linee Pedibus, itinerari definiti e certificati dalla Polizia Locale.
Il Pedibus è per bambini e ragazzi un modo divertente, salutare e sicuro per compiere i primi passi verso l'autonomia, conoscere il proprio quartiere e socializzare con gli altri.
VUOI SAPERNE DI PIÙ?
SEI INTERESSATO A DIVENTARE ACCOMPAGNATORE PEDIBUS?
Partecipa all'incontro del
29 NOVEMBRE 2018
DALLE ORE 15:00 ALLE ORE 16:30
presso il Centro Civico Libertà - Sala Co-working
PROGETTO PROMOSSO DA
A CURA DI
NELL'AMBITO DI
LIFE MONZA
(LIFE 15 ENV/IT/000586)

Intermediate assessment and Top down /bottom up overall data collection and systematization – VIENROSE

Life MONZA
Methodologies fOr Noise low emission Zones introduction And management

LIFE15 ENV/IT/000586

LIFE MONZA
Methodologies fOr Noise low emission Zones introduction And management

Technical Report

Deliverable	Report on Ante and Post Operam data collection
Action/Sub-action	B5.7 – "Intermediate assessment and Top down/ bottom up overall data collection and systematization"
Authors	Raffaella Bellomini, Sergio Luzzi, Lucia Busa, Gianfrancesco Colucci, Giacomo Nocentini.
Status - date	Final version- 05/06/2020

Beneficiary:	Vie en.ro.se. Ingegneria srl
Contact person:	Raffaella Bellomini
E-mail:	raffaella.bellomini@vienrose.it
Website:	www.lifemonza.eu

This chapter provides an overview of the data collected in the ante-operam phase of the project (see the attached documents), partly referred to in the previous chapters of this report, containing data from the monitoring of environmental components, linked to top-down actions, and data related to bottom-up activities. The attached documents are an integral part of the study carried out within the Life Monza project for the specific action B5 "Monitoring and data collection for impact assessment".

1. Systematisation of Top-down action data

The following table shows a scheme of the data collected in the top-down actions, in the ante operam phase of the project. For each activity carried out (column 1), the survey periods (column 2), any problems encountered or relevant notes (column 3), the reference to the corresponding annex (column 4) and the verification according to the planned activities (column 5) have been reported.

Table 1 – Systematisation of data collected in the ante operam phase with regard to top-down actions

ACTIVITY	PERIOD	CHECK NOTES	ATTACHED DOCUMENTS	CHECK
Smart Noise Monitoring System- Data per hour	20/06/2017-30/06/2018	On August 6, 2017 the microphone of the control unit installed on Viale della Libertà broke down after heavy rain. On September 13, 2017 the broken microphone was substituted, and 5 windproof headphones were replaced. By the year 2017 the moving of the data of the prototype system to servers owned by the municipal administration has been scheduled, with the possibility of management by UNIFI.	Attached document n.1	✓
Smart Noise Monitoring System- Data per day	20/06/2017-30/06/2018		Attached document n.2	✓
Smart Noise Monitoring System- Data per week	20/06/2017-30/06/2018		Attached document n.3	✓
Smart Noise Monitoring System-Harmonica Index	20/06/2017-30/06/2018		Attached document n.4	✓
Smart Noise Monitoring System- Sensor calibration	20/06/2017-30/06/2018		Attached document n.5	✓
Smart Noise Monitoring System-Broadband control	20/06/2017-30/06/2018		Attached document n.6	✓
Smart Noise Monitoring System- Position correction	20/06/2017-30/06/2018	Free field correction in the ante-operam phase was only made on the 6 sensors.	Attached document n.7	✓
1st noise/traffic monitoring campaign -	15/05/2017-23/05/2017		Attached document n.8	✓

Instrument calibration certificates				
1st noise/traffic monitoring campaign - Monitoring boards	15/05/2017-23/05/2017		Attached document n.9	✓
2nd noise/traffic monitoring campaign - Instrument calibration certificates	20/11/2017-27/11/2017		Attached document n.10	✓
2nd noise/traffic monitoring campaign - Monitoring boards	20/11/2017-27/11/2017		Attached document n.11	✓
Ex ante air quality monitoring campaign	2017/2018		Attached document n.12	✓

2. Systematisation of Bottom-up actions data

This section shows the data related to Bottom-up actions, summarized in the following table.

Table 2 – Systematisation of data collected in the ante operam phase with regard to bottom-up actions

ACTIVITY	PERIOD	CHECK NOTES	ATTACHED DOCUMENTS	CHECK
Sample survey questionnaire	February-May 2018		Attached document n.13	✓
Sample survey questionnaires - Sampling	February-May 2018	Unsatisfactory trend in the collection of questionnaires due to problems related to the use of the postal service. Initiatives were implemented to extend the collection, aimed at receiving the response from the	Attached document n.14	✓

		subjects belonging to the considered sample.		
International Noise Awareness Day 2017-2018	2017/2018		Attached document n.15	✓
Meetings held for the involvement of the population	19/07/2016-30/11/2018		Attached document n.16	✓

EX-POST MONITORING ACTIONS

ACTION B5

Smart continuous monitoring by prototype system on noise and system's check – UNIFI

Life MONZA

Methodologies fOr Noise low emission Zones introduction And management

LIFE15 ENV/IT/000586

LIFE MONZA
Methodologies fOr Noise low emission Zones introduction And management

Technical Report

Deliverable	Report on Ante and Post Operam data collection
Action/Sub-action	B5.1 – "Smart continuous monitoring by prototype system on noise and system's check"
Authors	Monica Carfagni, Chiara Bartalucci, Francesco Borchi, Rocco Furferi, Lapo Governi, Yary Volpe
Status - date	Finale version- 31/03/2020

Beneficiary:	UNIFI – University of Florence - Department of Industrial Engineering of Florence
Contact person:	Monica Carfagni
E-mail:	monica.carfagni@unifi.it
Website:	www.lifemonza.eu

Table of content

1. Introduction and objectives

Action B5 of the LIFE MONZA project, titled "Monitoring and data collection for impact assessment", aims at collecting data in the ante and post-operam scenarios and to perform the impact assessment referring to environmental parameters and road traffic.

In particular, sub-action B5.1 regards the collection of noise data to be carried out through a smart noise monitoring system to be used continuously. The smart noise monitoring system is a prototype based on a network of 10 low cost microphones, designed and defined in detail in Action B3. At the end of the project, the prototype will be given free of charge to the city of Monza which will use it for monitoring activities in the three years following the LIFE period.

The present report is structured as follows: in Paragraph 2 the migration procedure of the data collected by the smart sensor system to the new platform is described, in Paragraph 3 the data download and post-processing procedures are presented, in Paragraph 4 the procedures applied to check the low-cost sensors' network are explained, in Paragraph 5 main obtained results from the carried out analysis are reported, in Paragraph 6 analysis of data collected in the period January-March 2020 is reported, in Paragraph 7 general considerations are made about smart sensors and in Paragraph 8 the list of Annexes is reported.

2. Data migration to the new server

In October 2017 the data download and pre-analysis of the data began from the web platform http://influxserver.noisemote.com/grafana/?orgId=8. The methods of download and the problems that occurred in the first months were shared at the project meeting held on 13 October 2017 in the municipality of Monza.
In addition, during the project meeting, attention was drawn to the need, within the current year, to migrate the data of the prototype system to servers owned by the municipal administration with the possibility of management by UNIFI for the duration of the project.
Finally, on 28th March 2018 a meeting was held with the Municipality of Monza to evaluate the migration of the data downloaded from the Amazon servers to the servers of the Municipality of Monza. In the month of April/December 2018 data download and post-processing of the validation measures and the evaluation of the possibility of data migration to the server of the Municipality of Monza continued. Meetings were held both on July 9 at the municipality of Monza and via skype with the technicians of the Municipality. A meeting was held on 9th January 2019 at the municipality of Monza in which the migration of sensor data was discussed: the municipality confirmed the rental contract (to be finalized by January 2019) of an Amazon server compatible with the one currently used provisionally. With regard to data migration, at the meeting of 22nd March in Rome, the Municipality of Monza announced that everything was ready for the purchase of the Amazon server, but that it had not yet proceeded. In the meeting of 14th May, data migration to a new server rented by the Municipality of Monza was also discussed with the Municipality of Monza. UNIFI continued to use the original server. Although the delay in the migration has led to additional server and backup work for UNIFI, it was considered appropriate to leave things unchanged until the end of 2019, the end of the post-operam monitoring period. The migration was therefore planned between December 2019 and January 2020, followed by training and education of the Municipality's staff to back up the data in the period immediately following. Finally, due to the health emergency, it was considered appropriate to continue monitoring until March 2020. Data migration to the new server was finally completed between April and May 2020.

3. Procedures applied to check the calibration procedures

Concerning the verification procedures, the low-cost sensors challenge consists in maintaining network performance during long term periods of outdoor operation.

The periodic check of the system is designed and performed to understand if the measurement accuracy is maintained in time or if sensors need to be repaired or replaced. After the preliminary check procedures was applied (see Report on B5.1 – ante operam phase), an on-site, long-term site verification procedure have been applied both in the ante and in the post-operam periods to verify the noise monitoring system performances.

The long-term, on-site verifications are planned to be performed every four months at least for two years during the noise monitoring period in the pilot area (1 year in the ante-operam scenario and 1 year in the post-operam scenario). As on-site check activities, the following time-stability verifications, four-months based, have been performed:

1 – **1 kHz calibration check**: a calibration check at the frequency 1 kHz (by using a sound pressure class I calibrator), assuming as requirements for long term check that the sound pressure level does not deviate more than 1.0 dB from the calibration one. Calibration is performed by the operator by inserting the microphone into the calibrator. Given the position of the sensors at a height of 4 m from the ground, the activity requires an elevated platform or a ladder.

2 – **Broad band check**: a comparison between the LAeq,30s* obtained from the low-cost sensors and a class I equipment both subjected to the same broad band noise signal (e.g. pink noise produced by an electroacoustic equipment **) in the range 45/105 dBA by, assuming as requirements for long term check a difference between the two systems within 2.0 dB(A).

** This analysis also permits a check of low-cost equipment in different one-third octave band.*

*** For this analysis also road traffic noise is usable. In this case measurement time period should be extended up to 5-10 minutes to be significant.*

In the configuration with electroacoustic source, the control is carried out from the ground. Various configurations have been studied that work for the positioning of the electroacoustic speaker on the ground but presenting a problem of interference with the noise produced by road traffic (especially along high traffic roads). An ad-hoc system has been designed to raise the speaker together with the class I microphone to the height of the low-cost microphone. This setup has envisaged the study of a special support on which are placed both the playback electroacoustic system and the class I microphone.

3 – **Measurements to determine free field correction** in order to evaluate the correction necessary to move from the sensor position to a similar free field position, in the initial phase of the monitoring, one-hour measurements were carried out in which the low-cost sensor measurement was matched to the one with class I instrumentation by placing the microphone near the sensor but in free field conditions, i.e. at least 1m from the pole for pole installations and 1m from the façade surface for façade installations.

At the current time, six on site verifications were performed: in July and November 2017, in March and July 2018 and in January and May 2019.

4. Results

In the current Paragraph results obtained according to the application of the procedures described in Paragraph 4 are reported and updated until December 2019.

4.1 Current results of 1 kHz calibration check

For each SNMS a check procedure by using a class I, mono-frequency (1000 Hz) calibrator has been carried out during the on-site verifications, also in order to understand if some variations in time could be highlighted.
Regarding the sensors placed on poles it could be noted a reduction up to 3 dB of the calibration noise levels from the first to the second survey and, subsequently, a stabilization of the calibration values (Figure 1).

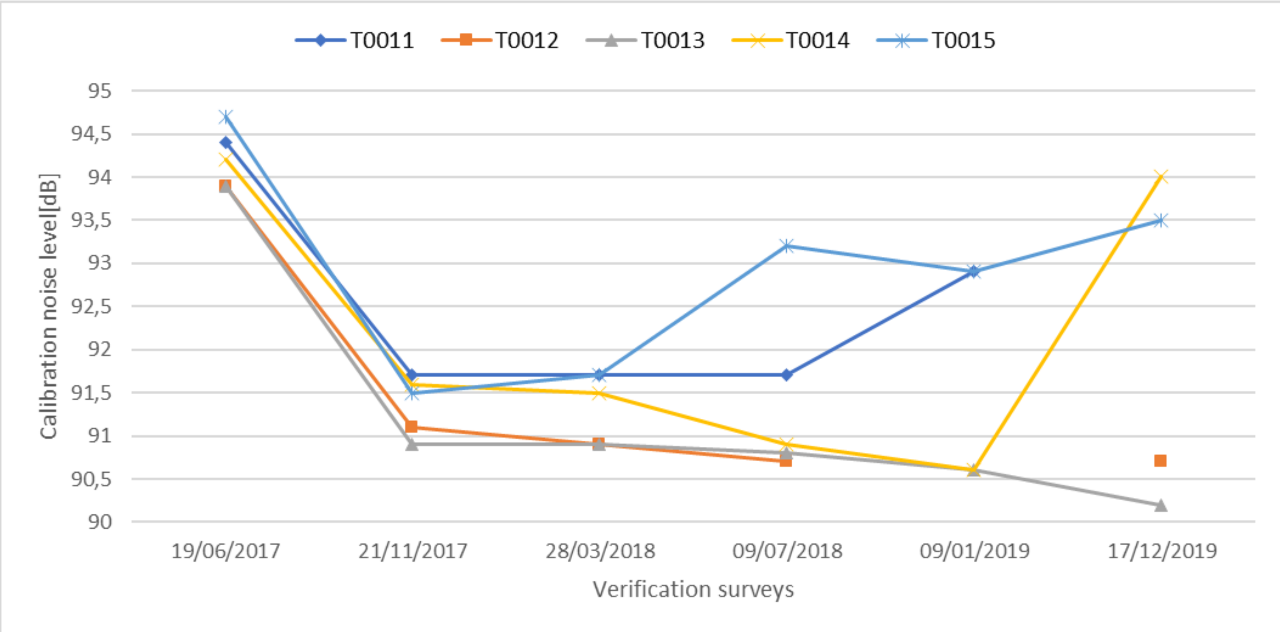


Figure 1: 1 kHz calibration check – MEMs sensors placed on poles.

Regarding the sensors placed on building's façades, such trend is not evident and calibration noise levels turn out to be more constant and generally between 93 dB and 94 dB.

It should be noted that the microphone of the smart sensor T0011 has been replaced in January 2019 before the calibration check and this could have led to an increase in the calibration noise level. Similarly, a microphone substitution has taken place in July 2018 for the smart sensor T0015.

Overall data are reported in Annex 21.

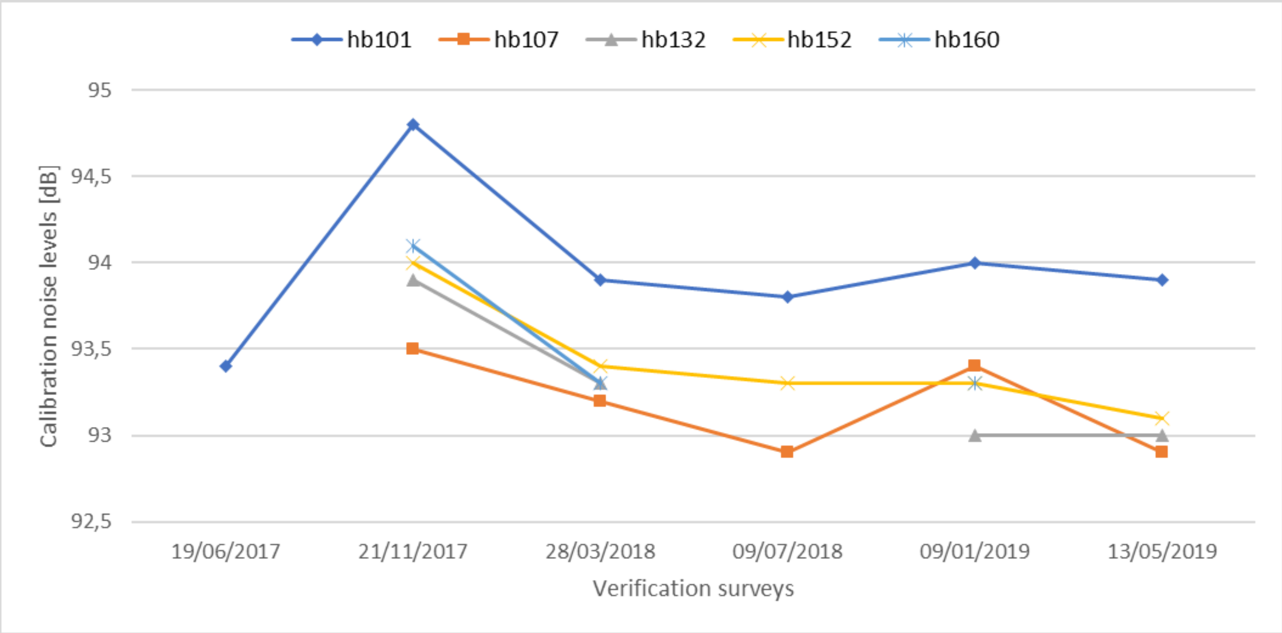


Figure 2: 1 kHz calibration check – Electret sensors placed on building's façades.

4.2 Current results of broad band check

Concerning noise measurements carried out by using road traffic noise as noise source and a measurement time period extended up to 5-10 minutes, a difference of 1.5 dB(A) between the class I noise level meter and the smart system in terms of average LAeq has been found by considering all the checked sensors. Higher differences, of about 2-2.5 dB have been encountered with smart sensors placed on poles, while smaller differences, of about 0.5-1 dB have been encountered with smart sensors placed on the façade. An example is shown in Figure 3.

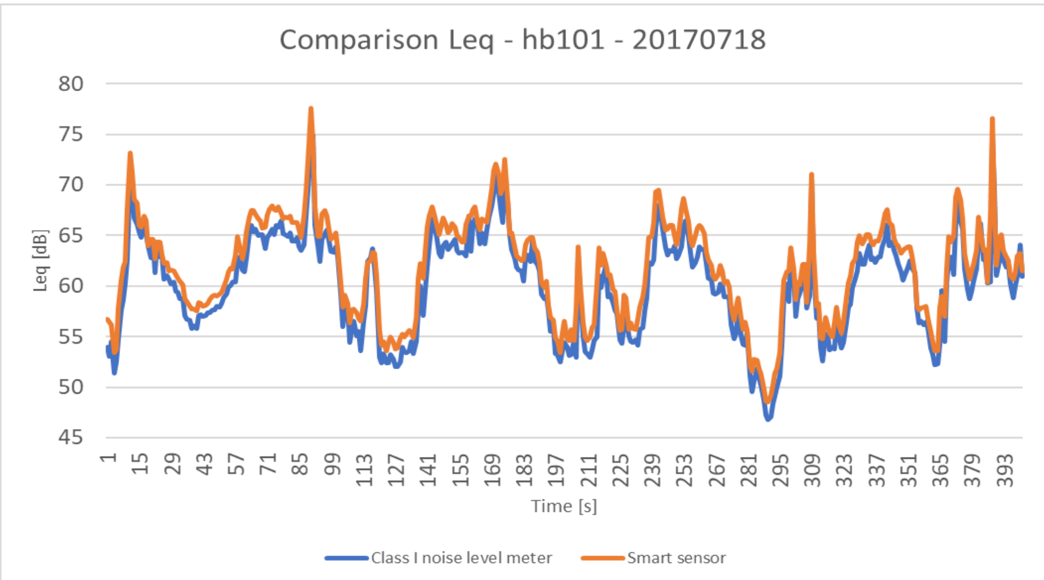


Figure 3: Broad band check (by using road traffic noise), considering 7 minutes as measurement time period – Time history of sound pressure levels, in terms of LAeq,1s [dB(A)].

Also a comparison in terms of sound spectrum has been made for all sensors, an example is reported in Figure 4.

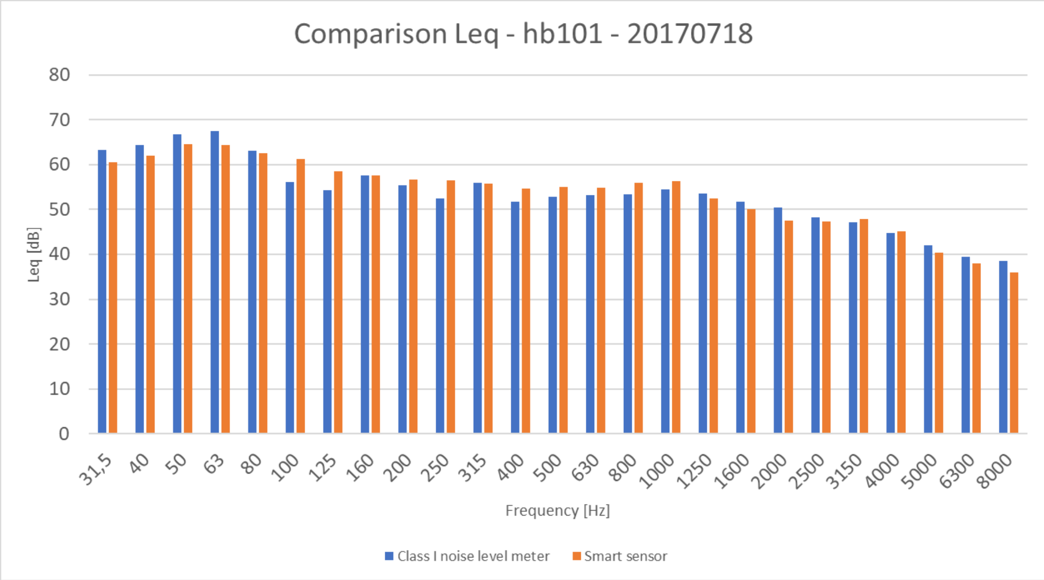


Figure 4: Broad band check (by using road traffic noise), considering 7 minutes as measurement time period – One third octave band sound pressure levels, in terms of Leq,10' [dB].

Concerning noise measurements carried out with the electroacoustic speaker by using pink noise signal and a measurement time period extended up to 30 seconds, in general a difference of 0.5-1 dB(A) between the class I noise level meter and the smart system in terms of average LAeq,30s has been found by considering all the checked sensors. No significant differences have been encountered between sensors placed on poles and on the façades.
An example is shown in Figure 5.

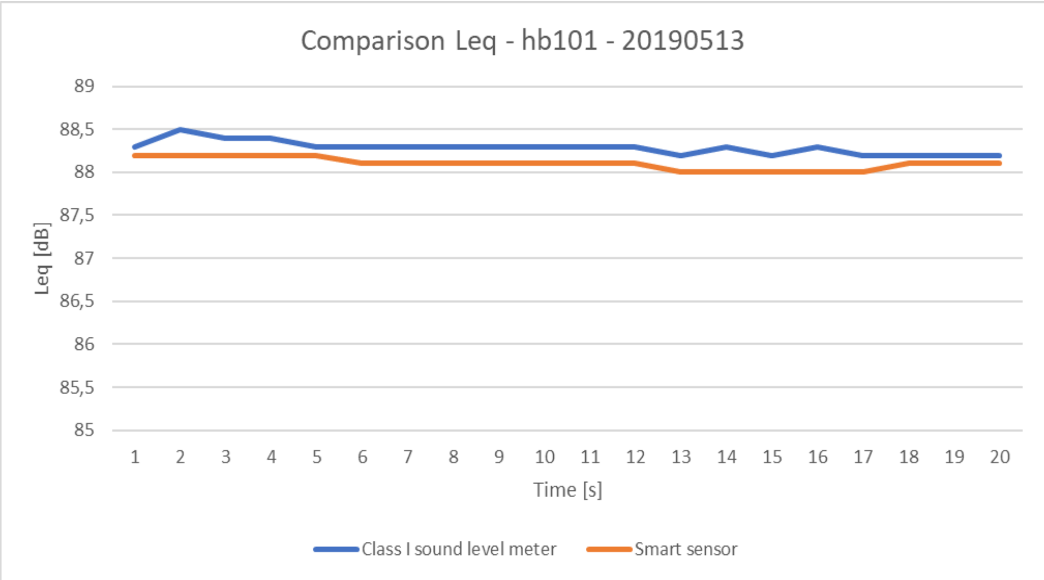


Figure 5: Broad band check (by using an electroacoustic source and a pink noise signal), considering 30 seconds as measurement time period – Time history of sound pressure levels, in terms of LAeq,1s [dB(A)].

Also a comparison in terms of sound spectrum has been made for all sensors, an example is reported in Figure 6.

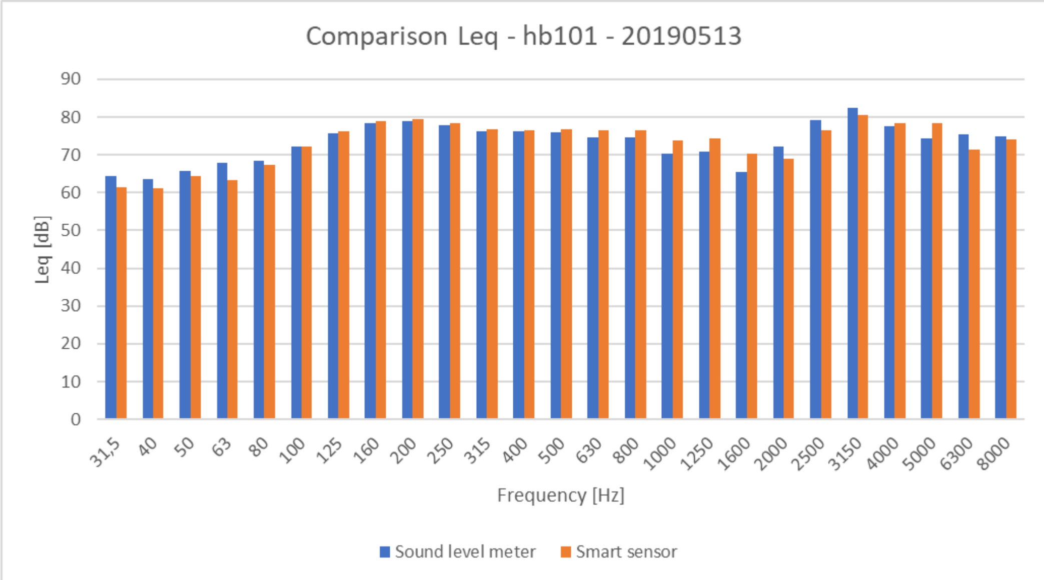


Figure 6: Broad band check (by using an electroacoustic source and a pink noise signal), considering 30 seconds as measurement time period – One third octave band sound pressure levels, in terms of Leq,30s [dB].

Full results are shown in Annex 22.

4.3 Results about measurements to determine free field correction

Concerning noise measurements to determine free field correction, they have been carried out by using road traffic noise as noise source and a measurement time period extended up to 1 hour. In Table 1 results obtained in terms of average LAeq,1h to determine the free field correction are shown.

Table 1: Free field correction obtained in terms of average LAeq,1h.

ID sensore	Data	Orario	LAeq,1h strumento classe I	LAeq,1h sensore smart*	Correzione campo libero
hb101	06-mag-19	17:24:34-18:24:34	60,9	61,5+0.1	-0,7
hb107	07-mag-19	10:47:16-11:47:16	55,7	58,6+1.1	-4,0
hb132	06-mag-19	16:07:34-17:07:34	57,2	59,5+1.0	-3,3
hb152	06-mag-19	14:50:56-15:50:56	57,8	57,8+0.9	-0,9
hb160	07-mag-19	09:33:01-10:33:01	60,7	62,1+0.7	-2,1
T0011	06-mag-19	14:51:25-15:51:25	51,1	49,1+1,1	0.9
T0012	07-mag-19	10:33:55-11:33:55	66,8	58,8+3,3	4,7
T0013	07-mag-19	09:26:14-10:26:14	63,3	59,7+3,4	0,2
T0014	07-mag-19	12:02:36-13:02:36	68,3	66,1+3,4	-1,2
T0015	06-mag-19	17:37:32-18:37:32	69,9	69,3+1,1	-0,5

**correction with respect of calibration signal is applied to noise levels determined for smart sensors.*

With the exception of sensor T0012, where difference of 4,5 dB occurred (due to the position of the smart sensor placed in a position where the traffic lines are partially masked by the pole) differences between 0 and 4 dB have been encountered. In particular, negative correction are expected and obtained at façade sensors due to the reflections of the wall. Full results are shown in Annex 23.

4.4 HARMONICA index calculation

The HARMONICA index, developed in the frame of the Harmonica Project, has been evaluated also on the post-operam period (II semester 2018, I semester 2019, II semester 2019) according to the procedure made available at www.noiseineu.eu. In Tables 2-4 is possible to read the average hourly value of the HARMONICA index obtained for each sensor in each semester of the post-operam period.

Table 2: Average hourly value of the HARMONICA index for each sensor – II semester 2018.

Day hour	T0011	T0012	T0013	T0014	T0015	hb101	hb107	hb132	hb152	hb160
1	2,2	3,1	3,0	5,4	7,9	4,6	5,6	2,5	4,9	2,8
2	2,1	2,9	2,6	5,4	7,9	4,9	5,6	3,0	4,5	2,9
3	2,1	3,0	2,5	6,2	7,9	5,6	5,6	3,9	4,3	3,3
4	3,2	3,8	3,3	7,2	7,8	6,5	5,5	4,8	4,3	4,3
5	3,7	4,8	4,7	7,8	7,6	6,8	5,5	5,3	4,5	5,4
6	3,9	5,8	6,0	7,9	7,2	6,9	5,4	5,3	5,2	6,0
7	4,0	6,1	6,6	7,8	6,9	6,9	5,2	5,3	5,7	6,1
8	4,0	6,1	6,6	7,9	6,7	6,9	4,9	5,1	5,9	6,0
9	3,9	6,1	6,5	7,8	6,3	6,9	4,4	5,3	5,9	6,1
10	3,9	6,1	6,5	7,8	5,5	6,9	4,1	5,0	5,8	5,9
11	3,7	6,0	6,4	7,8	4,7	6,9	4,1	5,1	5,8	5,9
12	3,8	5,9	6,2	7,8	4,2	6,9	4,2	5,1	5,7	5,8
13	3,8	5,9	6,2	7,8	4,4	6,9	4,2	5,1	5,7	5,9
14	3,8	6,0	6,3	7,8	5,7	6,9	4,1	5,0	5,7	6,1
15	3,7	6,2	6,4	7,8	6,9	6,8	3,9	5,0	5,7	6,2
16	3,7	6,3	6,4	7,7	7,6	6,7	3,9	4,8	5,7	6,2
17	3,8	6,3	6,5	7,7	7,9	6,7	4,4	4,6	5,7	6,1
18	3,7	6,0	6,4	7,7	7,9	6,7	5,0	4,2	5,8	5,6
19	3,6	5,4	5,9	7,7	7,9	6,6	5,4	3,9	5,8	5,0
20	3,4	4,9	5,5	7,5	7,9	6,6	5,7	3,6	5,8	4,8
21	3,4	4,7	5,0	7,2	8,0	6,5	5,7	3,1	5,7	4,6
22	3,1	4,4	4,8	6,9	7,9	6,1	5,7	2,7	5,6	4,2
23	2,8	3,9	4,3	6,5	7,7	5,6	5,6	2,4	5,5	3,7
24	2,4	3,4	3,6	5,9	7,8	4,9	5,6	2,3	5,2	3,1

Table 3: Average hourly value of the HARMONICA index for each sensor – I semester 2019.

Day hour	T0011	T0012	T0013	T0014	T0015	hb101	hb107	hb132	hb152	hb160
1	3,8	2,8	2,8	5,0	5,3	4,3	5,2	3,9	4,3	3,3
2	3,8	2,7	2,7	4,5	6,2	4,3	5,1	4,3	4,3	3,2
3	3,7	3,1	3,2	4,6	7,1	4,8	4,9	4,8	4,6	3,7
4	3,6	3,6	4,0	5,4	7,7	5,4	4,8	4,9	4,9	4,3
5	3,6	4,7	5,0	6,5	8,0	6,0	5,0	5,3	5,4	5,2
6	3,6	5,6	6,0	7,0	8,2	6,3	5,1	5,2	5,8	5,7
7	3,5	6,2	6,6	7,1	8,1	6,5	5,3	5,2	5,8	6,1
8	3,4	6,2	6,6	7,1	8,2	6,5	5,4	5,4	5,7	6,2
9	3,3	6,0	6,5	7,1	8,1	6,6	5,5	5,2	5,6	6,2
10	3,2	6,0	6,5	7,1	8,1	6,6	5,4	5,2	5,6	6,2
11	3,2	6,0	6,4	7,1	8,1	6,6	5,1	5,1	5,6	6,1
12	3,3	6,0	6,3	7,1	8,2	6,5	4,9	5,0	5,6	6,1

13	3,2	5,9	6,3	7,2	8,2	6,6	4,7	5,1	5,6	6,1
14	3,1	6,0	6,3	7,1	8,2	6,6	4,7	4,8	5,5	6,2
15	3,1	6,1	6,4	7,1	8,2	6,6	5,0	4,5	5,5	6,3
16	3,3	6,2	6,4	7,0	8,0	6,5	5,2	4,3	5,5	6,3
17	3,4	6,2	6,3	7,0	7,8	6,6	5,3	3,9	5,6	6,2
18	3,5	6,0	6,1	7,0	7,5	6,4	5,3	3,4	5,6	5,8
19	3,7	5,6	5,7	7,0	7,2	6,4	5,0	3,0	5,5	5,4
20	3,8	5,0	5,3	7,0	6,8	6,2	4,8	2,7	5,4	4,9
21	3,8	4,7	4,8	6,8	6,2	6,1	4,8	2,8	5,2	4,6
22	3,9	4,4	4,3	6,7	5,4	5,8	5,0	2,8	5,0	4,3
23	3,8	3,9	3,8	6,4	4,6	5,4	5,1	3,2	4,7	3,8
24	3,8	3,3	3,2	5,8	4,5	4,8	5,2	3,4	4,4	3,3

Table 4: Average hourly value of the HARMONICA index for each sensor – II semester 2019.

Day hour	T0011	T0012	T0013	T0014	T0015	hb101	hb107	hb132	hb152	hb160
1	3,2	5,2	2,4	1,7	4,5	5,0	3,7	3,9	4,8	4,8
2	3,2	5,3	2,2	1,7	4,3	5,6	4,2	4,3	4,9	5,3
3	3,3	5,3	2,4	1,7	5,4	6,1	4,8	4,6	5,1	5,5
4	3,3	5,4	3,5	1,8	6,8	6,4	5,3	5,1	5,4	5,7
5	3,3	5,2	4,9	1,9	7,7	6,6	5,6	5,2	5,6	5,8
6	3,4	5,0	6,0	1,9	8,1	6,7	5,7	5,2	5,7	5,9
7	3,4	5,0	6,5	1,8	8,2	6,7	5,7	5,1	5,7	6,0
8	3,4	4,8	6,4	1,7	8,2	6,8	5,6	5,3	5,7	5,8
9	3,4	4,5	6,4	1,6	8,2	6,7	5,5	5,1	5,7	5,9
10	3,4	4,0	6,3	1,6	8,2	6,8	5,4	5,0	5,7	6,0
11	3,5	3,7	6,2	1,6	8,0	6,7	5,2	5,0	5,6	6,1
12	3,6	3,6	6,1	1,6	8,0	6,6	5,3	5,0	5,6	6,2
13	3,5	3,7	6,1	1,6	8,0	6,7	5,5	4,9	5,7	6,0
14	3,4	4,4	6,1	1,6	8,1	6,6	5,5	4,6	5,6	5,6
15	3,4	5,2	6,2	1,6	8,1	6,6	5,5	4,4	5,6	5,3
16	3,3	6,0	6,1	1,6	8,2	6,6	5,5	4,2	5,6	5,0
17	3,4	6,2	6,2	1,6	8,2	6,4	5,3	3,8	5,6	4,9
18	3,4	6,1	5,9	1,5	8,0	6,4	5,1	3,5	5,4	4,7
19	3,5	5,9	5,4	1,6	7,6	6,3	5,0	3,2	5,3	4,2
20	3,5	5,7	5,0	1,7	7,2	6,0	4,9	2,8	5,0	3,6
21	3,4	5,6	4,6	1,7	7,0	5,5	4,7	2,7	4,7	3,3
22	3,4	5,5	4,4	1,7	6,7	4,9	4,3	2,7	4,5	3,1
23	3,3	5,4	3,8	1,8	6,0	4,4	4,0	3,1	4,5	3,5
24	3,3	5,2	3,0	1,8	5,2	4,4	3,6	3,4	4,6	4,1

In Figure 7 values assumed by the Harmonica index in the different semester of the post-operam period are shown, with reference to the hb101 sensor.

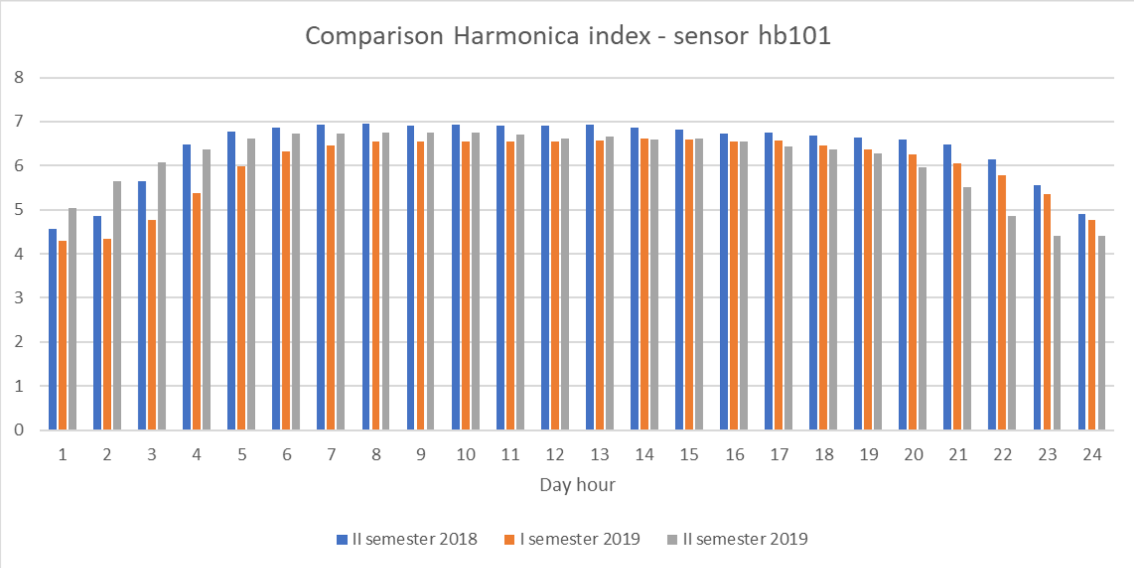


Figure 7: Comparison of values assumed by the Harmonica index in the different semesters of the post-operam period with reference to sensor hb101.

From figure 7 it is possible to see that the values assumed by the Harmonica index show a slight decrease passing from the II semester of 2018 to the I semester of 2019 and this has possibly been influenced by the laying of the new asphalt. From the I to the II semester of 2019 mean values assumed by the Harmonica index are more or less constant in the central hours of the day, while they assume higher values in the first hours of the day and lower values in the last hours.

Overall results are reported in Annex 20.

5. Data related to period January – March 2020

Due to the spread of the COVID-19 pandemic, it has been deemed of interest to analyse also LAeq data provided by the smart monitoring units in the trimester from January to March 2020.
In fact, due to the progressive adoption of restrictive measures at national level and at local level by the Municipality of Monza, a reduction in terms of noise levels is expected to be spontaneously achieved.

Coherently, a noise reduction of 6.1 – 6.7 dB in terms of Lden has been envisaged by sensors located along Viale Libertà in the period after the second week of January 2020 (the first week of January has not been considered being a week when schools were closed and many activities stopped because of the holiday period), coherently with the adoption of restrictive measures.
A higher noise reduction (up to 9.7 dB in terms of Lden) has been measured by sensors more distant from Viale Libertà.

In figure 8 an overview of the noise levels reduction, expressed in terms of Lden, is provided for all the smart sensors.

Figure 8: Noise levels reduction (Lden) measured by each smart sensor between the second week of January 2020 and the third week of March 2020.

In figures 9 and 10 the noise level trends measured respectively by a smart sensor placed in the facade of the civic centre on the main Libertà street (hb101) and by a sensor placed in a usually less busy area (hb160) in the considered trimester are shown.

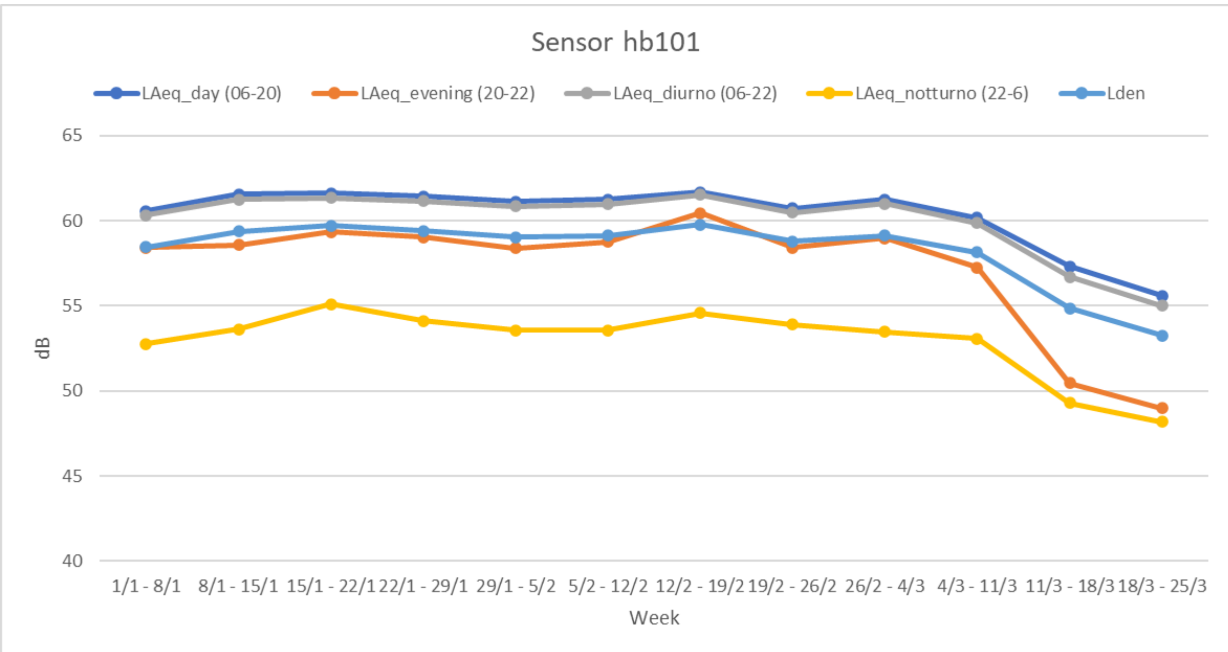


Figure 9: Weekly noise levels trends in the periods January – March 2020 for sensor hb101.

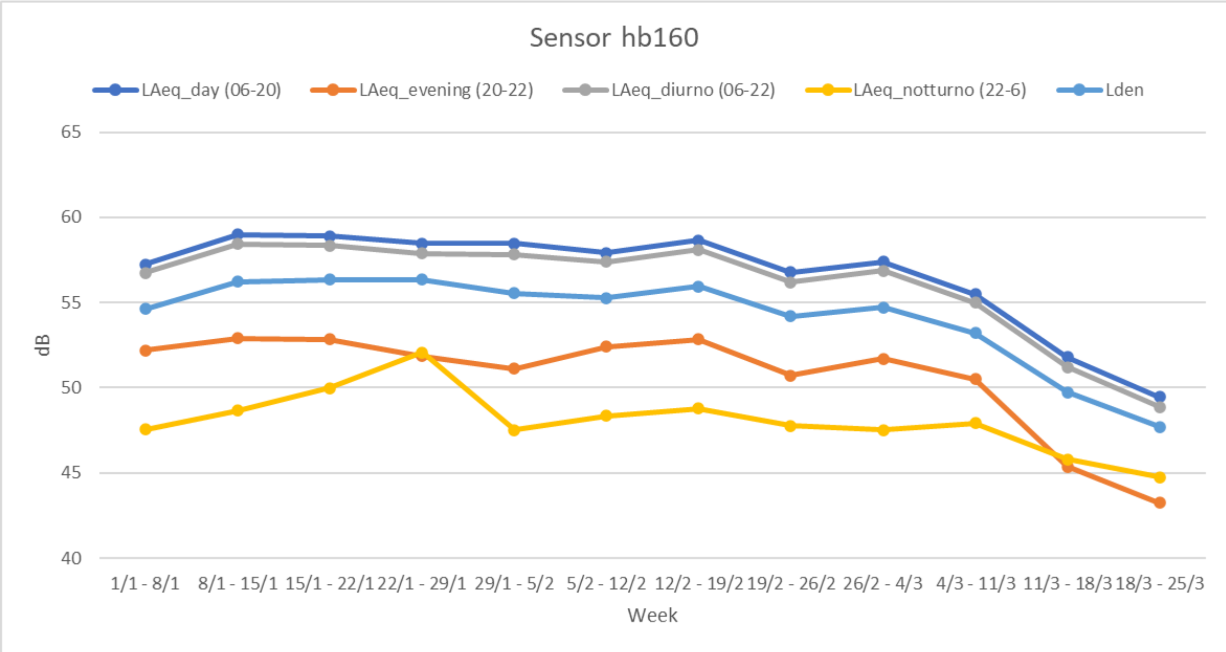


Figure 10: Weekly noise levels trends in the periods January – March 2020 for sensor hb160.

It is interesting to point put that in the city of Monza since 23rd February 2020, it has ordered the immediate activation of a series of measures, in full accordance with the indications of the Lombardy Region.
In particular, events or initiatives of any kind, events and all forms of meetings in public or private places, including those of a cultural, recreational, sporting and religious nature, have been suspended. All schools of all levels are closed, including nursery schools; master's, professional courses and courses for the health professions are also suspended, with the exception of trainees and trainees. Also museums, exhibition spaces, the Villa Reale, city libraries, cinemas, theatres and other places of culture are closed to the public.
In order to avoid dangers for the most fragile users, the Municipality has decided to close also the elderly and disabled day centres. The courses scheduled at the Civic City Centres have also been suspended.
In fact, since the 23rd of February a decreasing trend for measured noise levels has started.
Moreover, an even more marked decreasing trend is present after the entry into force of the D.P.C.M. of 11th March 2020 which approved the closure of many commercial activities.

The described trends are, as expected, more accentuated in the data achieved on Viale Libertà than in those provided by other sensors.

7. Considerations

As a general remark regarding the broadband check, results allow to carry out a good analysis and verification on all frequency spectrum with respect to mono frequency calibrator, with similar differences obtained at the 1 kHz frequency.

Moreover, an advantage of the broad band check is that it can be performed from the ground.

Comparing the different type of broad band checks, the technique based on electroacoustic system placed close to the sensor provides the best performance in terms of alignment with class I equipment.

Moreover, starting from the weekly LAeq data it is possible to use them for mapping purposes, by applying two corrections: the first one is a "time" correction according to the periodically obtained calibration values; the second one is a "position" correction for which it is possible to use the LAeq due to broad band correction.

Regarding the Harmonica index it is preferred not to apply corrections on it, since the index has a qualitative value and it will be a service provided with the App (Actions B4 and B5).

The analysis of weekly LAeq data in the ante and in the post-operam periods will be a fundamental input for the development of the GI and SGI indicators (Action C1).

Weekly LAeq data are used for testing the effectiveness of the new asphalt according to a data comparison in the ante and post-operam periods on Viale della Libertà.

Some considerations about the hardware operation (characteristics ¼" and MEMs ½" electret measuring chains, replacements made, progressive/asymptotic sensitivity loss, proposed solutions) will be made as input for Action B6.

8. Annexes

Annex 17 – Hourly data
Referring to the post-operam period, for each smart sensor the LAeq, LA10 and LA90 parameters are hourly reported

Annex 18 – Daily data
Referring to the post-operam period, for each smart sensor the LAeq_day (6:00-20:00), LAeq_evening (20:00-22:00), LAeq_diurno (6:00-22:00), LAeq_notturno (22:00-6:00) parameters are daily reported, starting from hourly data.

Annex 19 – Weekly data
Referring to the post-operam period, for each smart sensor the LAeq_day (6:00-20:00), LAeq_evening (20:00-22:00), LAeq_diurno (6:00-22:00), LAeq_notturno (22:00-6:00) parameters are weekly reported, starting from daily data.

Annex 20 – Harmonica Index
Referring to the post-operam period, for each smart sensor, values assumed by the Harmonica Index are hourly reported.

Annex 21 – Calibration values
Calibration values (1 KHz) measured in different monitoring campaigns for each smart sensor are reported.

Annex 22 – Broad band check
In Annex 6a the time history in terms of LAeq,1s of sound pressure levels measured in the same time periods by the smart sensors and the class I system is reported. In Annex 6b the one third octave band sound pressure levels measured in the same time periods by the smart sensors and the class I system are reported.

Annex 23 – Position correction
Measurements to determine free field correction in order to evaluate the correction necessary to move from the sensor position to a similar free field position are reported.

Annex 24 – Weekly data related to first trimester 2020
Referring to the period January – March 2020, for each smart sensor the LAeq_day (6:00-20:00), LAeq_evening (20:00-22:00), LAeq_diurno (6:00-22:00), LAeq_notturno (22:00-6:00) parameters are weekly reported, starting from daily data.

Noise and Traffic – VIENROSE

Methodologies fOr Noise low emission Zones introduction And management

LIFE15 ENV/IT/000586

LIFE MONZA
Methodologies fOr Noise low emission Zones introduction And management

Technical Report

Deliverable	Report on Ante and Post Operam data collection
Action/Sub-action	B5.2 – "Noise and Traffic ex ante / ex post monitoring"
Authors	Raffaella Bellomini, Sergio Luzzi, Lucia Busa, Gianfrancesco Colucci, Giacomo Nocentini.
Status - date	Final version- 15/12/2017

Beneficiary:	Vie en.ro.se. Ingegneria srl
Contact person:	Raffaella Bellomini
E-mail:	raffaella.bellomini@vienrose.it
Website:	www.lifemonza.eu

3.2.1 Third monitoring campaign – January 2019

In this chapter is presented the analysis of the post-operam sound level monitoring campaign that had held in January 2019 (exactly from Monday 21st to Tuesday 29th January).

In particular, this note reports the results of the phonometric monitoring campaign and the traffic flows collected in some road axis falling within the pilot area.

Have been taking into consideration:

- the data collected with a **long-term monitoring campaign** and, specifically, by counting weekly traffic flows in 2 positions with control unit with automatic radar traffic counting system showing the division into light and heavy vehicles;
- the data collected with a **short-term SPOT monitoring campaign**, and specifically, by time -based counting of short-term traffic flows (1 hours) in 10 positions.

Monitoring has carried out in correspondence with the receivers defined in the table 1.

Table 21 – Monitoring scenarios January 2019

ID position	Type of monitoring	Toponym
P01	Long-term (weekly)	Viale Libertà – Centro Civico
P02	Long-term (weekly)	Via A. Modigliani - Scuola
S01	Short-term (Spot)	Viale Libertà – Centro Civico
S02	Short-term (Spot)	Viale Libertà n. 93
S03	Short-term (Spot)	Via della Gallarana
S04	Short-term (Spot)	Via della Guerrina n. 31
S05	Short-term (Spot)	Via A. Modigliani - Scuola
S06	Short-term (Spot)	Via Parmenide – Asilo nido
S07	Short-term (Spot)	Via Giuseppe Impastato
S08	Short-term (Spot)	Via della Guerrina – Liceo Porta
S09	Short-term (Spot)	Viale Libertà – Istituto Mapelli
S10	Short-term (Spot)	Via Correggio Allegri

The next figure shows the planimetric location of the phonometric monitoring stations, traffic flows (contextual to the phonometric ones), of the traffic counter radar units for the monitoring of noise pollution in the pilot area.

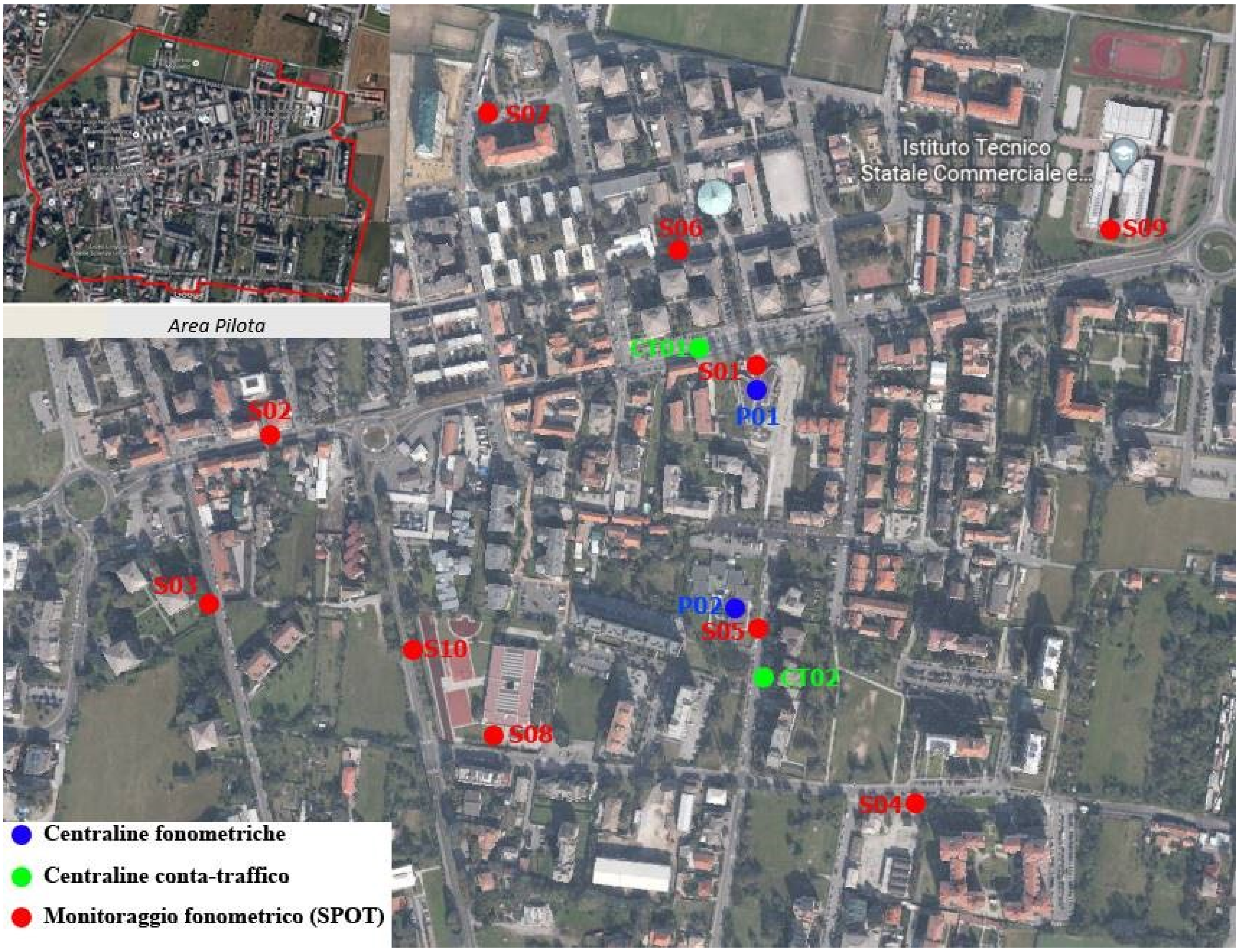


Figure 3 – Monitoring positions

The following figure shows instead the road axis object of monitoring so better defined:

- In red colour the arcs object to weekly traffic count;
- in violet colour the arcs object to the SPOT traffic count (time slot);
- in cyan colour the arcs into the pilot area non object of monitoring, for those an attribution have been proposed;
- in grey colour all the arcs out of the pilot area.

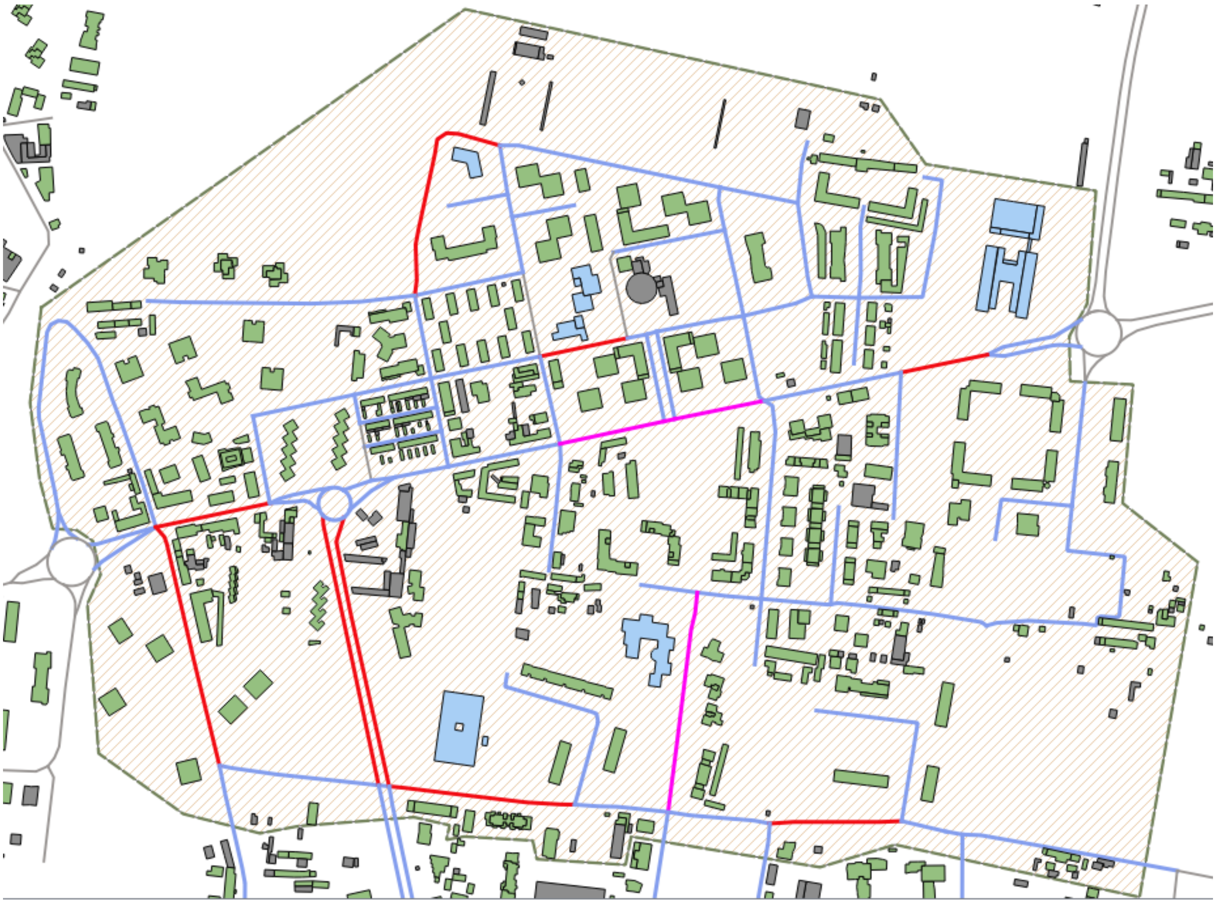


Figure 4 – Road arcs object of monitoring

➢ Measurement systems

For the measurements the following measurement systems were used:

SYSTEM NO.1

- PRECISION INTEGRATOR PHONOMETER 01dB type BLUE SOLO S.N. 60982, complying with the regulations IEC 651 – EN 60651 class 1 and IEC 804 – EN 60804;
- PRECISION MICROPHONE WITH PREPOLARIZED CONDENSER 01dB type PRE21 S.N. 13936, complying with the regulations EN61094-1/94 EN61094-2/93 EN61094-3/93 EN61094-4/95 IEC 651 class 1 (imp.) e IEC 804.

SYSTEM NO.2

- PRECISION INTEGRATOR PHONOMETER BRUEL & KJÆR type 2250 S.N. 3004064, complying with the regulations IEC 651 – EN 60651 class 1 and IEC 804 – EN 60804;
- PRECISION MICROPHONE WITH PREPOLARIZED CONDENSER BRUEL & KJÆR type 4189 S.N. 2877086, complying with the regulations EN61094-1/94 EN61094-2/93 EN61094-3/93 EN61094-4/95 IEC 651 class 1 (imp.) and IEC 804.

SYSTEM NO.3

- PRECISION INTEGRATOR PHONOMETER BRUEL & KJÆR type 2250 S.N. 3004065, complying with the regulations IEC 651 – EN 60651 class 1 and IEC 804 – EN 60804;

- PRECISION MICROPHONE WITH PREPOLARIZED CONDENSER BRUEL & KJÆR type 4189 S.N. 2876907, complying with the regulations EN61094-1/94 EN61094-2/93 EN61094-3/93 EN61094-4/95 IEC 651 class 1 (imp.) and IEC 804.

ACOUSTIC CALIBRATOR

- BRUEL & KJÆR type 4231 S.N. 2713443, class 1 according to the standard IEC 942:1988, sound power level produced: 94 dB a 1000Hz.

For the memorization and the processing of the data was made use of the dedicated Software:

- Basic sound analysis software BRUEL & KJÆR BZ 5503;
- Noise Evaluator BRUEL & KJÆR 7820 v. 4.16.8;
- dB Trait 5.5.

The technical data of automatic traffic flow detection systems (radar systems) are reported below:

- Traffic monitoring device VIACOUNT II – VIA Traffic Controlling GmbH s.n. 11VZZ0018.
- Traffic monitoring device VIACOUNT II – VIA Traffic Controlling GmbH s.n. 13VZZ0257.
- Traffic monitoring device VIACOUNT II – VIA Traffic Controlling GmbH s.n. 14VZZ0067.

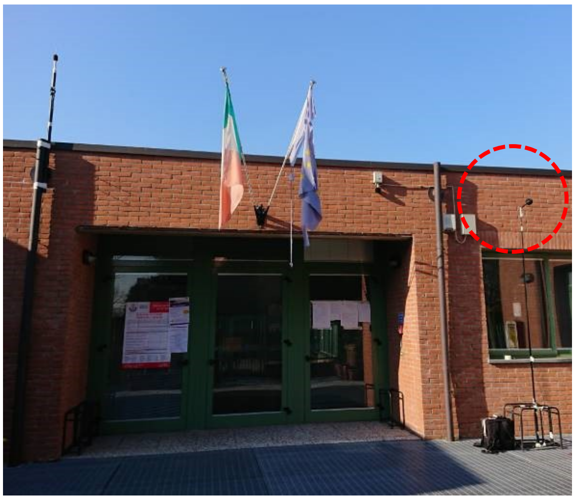
For the memorization and the processing of the data was made use of the dedicated Software: ViaGraph vers. 4.00.09.

➢ Measurement positions (phonometric monitoring)

The main information and the photographic contributes of the measurement positions used for the phonometric monitoring are shown below.

Table 22 - Positions of phonometric monitoring

Measurement station	Description	Photo
P01	**Address:** Civic Center in Viale Libertà **Height from the ground level:** 6.00 m **Distance from the road axis:** 38 m	
P02	**Address:** Nursery School "A. Modigliani" **Height from the ground level:** 6.00 m **Distance from the road axis:** 15 m	
S01	**Address:** Civic Center in Viale Libertà **Height from the ground level:** 4.00 m **Distance from the road axis:** 23 m	

Measurement station	Description	Photo
S02	**Address:** Viale Libertà no. 93 **Height from the ground level:** 4.50 m **Distance from the road axis:** 6 m	
S03	**Address:** Via della Gallarana **Height from the ground level:** 4.00 m **Distance from the road axis:** 5 m	
S04	**Address:** Via della Guerrina no. 31 **Height from the ground level:** 4.00 m **Distance from the road axis:** 7.50 m	n.d.
S05	**Address:** Nursery School Modigliani entryway **Height from the ground level:** 4.00 m **Distance from the road axis:** 15 m	

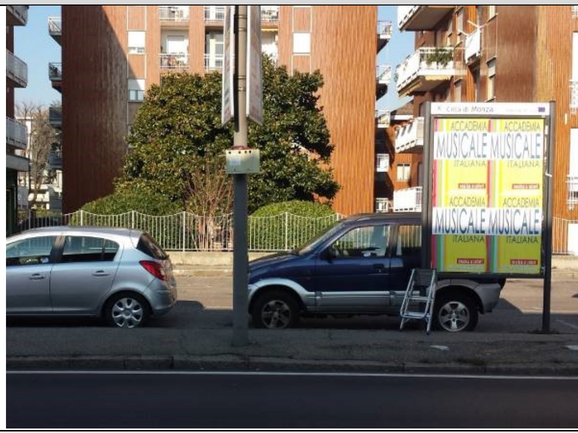
Measurement station	Description	Photo
S06	**Address:** Via Parmenide, at Private Nursery “Cuore Immacolato di Maria” **Height from the ground level:** 4.00 m **Distance from the road axis:** 6.50 m	
S07	**Address:** Via Giuseppe Impastato **Height from the ground level:** 4.00 m **Distance from the road axis:** 4 m	
S08	**Address:** Via della Guerrina, next to Liceo “Porta” **Height from the ground level:** 4.00 m **Distance from the road axis:** 28 m	

Measurement station	Description	Photo
S09	**Address:** Viale Libertà, next to ITGC “Mapelli” **Height from the ground level:** 4.00 m **Distance from road axis:** 43 m	
S10	**Address:** Via Correggio Allegri **Height from the ground level:** 4.00 m **Distance from the road axis:** 12 m	

➢ Measurement positions (detection of traffic flows)

The main information and photo contributions of the measurement stations used to detect traffic flows automatically using a traffic device with radar system are shown below.

Table 23 - Traffic flows detection stations

Measurement station	Description	Photo
CT01	**Monitoring date:** 21-29/01/2019 **Reference road:** Viale Libertà	

Measurement station	Description	Photo
CT02	**Monitoring date:** 21-29/01/2019 **Reference road:** Via A. Modigliani	
CT03	**Monitoring date:** 21-29/01/2019 **Reference road:** Viale Libertà	

➢ Monitoring results

The monitoring results are fully shown in specific summary sheets attached to this technical report.

▪ Phonometric monitoring

Regarding the **phonometric monitoring**, the sheets are divided as follows:

- General data of the measurement station (coding, description, height of the microphone from the campaign plan, distance from the microphone to the road axis, noise class according to the Noise Zoning Plan of the Municipality of Monza, input limit values defined according to Italian D.P.C.M. 14/11/1997).
- Territorial framework for the planimetric measurement identification.
- For **long-term monitoring**: date and time of start and end of the measure, time history, equivalent L_{Aeq} levels referred, for all measurement days and as a weekly average level, to the day reference period (6.00 - 22.00) and to the night reference period (22.00 - 6.00).
- For **short-term monitoring (SPOT):**
  - Results of phonometric monitoring: date and time of start and end of measurement, time history and frequency composition by third-band octave, equivalent levels L_{Aeq}.
  - Results of short-term manual count (1 hour) of traffic flows: date and time of start and end of the count, traffic flows (vehic/h) divided between typology of vehicle (light, medium, heavy vehicles, bus, motorbikes, bikes) and by direction of travel.

A tabular and graphical summary of the results of the phonometric monitoring is shown below.

Table 24 - Summary of short-term monitoring results

Postazione	Descrizione	Data e ora di inizio	Data e ora di fine	L_{Aeq} [dB(A)]
S01	In facciata al Centro Civico di Viale Libertà	22/01/2019 10:53:17	22/01/2019 11:53:17	59.6
S02	Viale Libertà, n. 93	21/01/2019 16:20:36	21/01/2019 17:20:36	68.0
S03	Via della Gallarana	22/01/2019 16:25:04	22/01/2019 17:25:04	65.2
S04	Via della Guerrina n. 31	21/01/2019 15:03:42	21/01/2019 16:03:42	61.4
S05	Via Modigliani, in facciata della Scuola dell'infanzia	22/01/2019 12:10:38	22/01/2019 13:10:38	59.9
S06	Via Parmenide, in facciata alla Scuola dell'infanzia privata "Cuore Immacolato di Maria"	22/01/2019 9:21:19	22/01/2019 10:21:19	57.4
S07	Via Giuseppe Impastato	22/01/2019 10:57:41	22/01/2019 11:57:41	50.6
S08	In facciata al Liceo Statale "Carlo Porta"	22/01/2019 13:44:59	22/01/2019 14:44:59	58.1
S09	Viale Libertà, in facciata all'ITCG "Achille Mapelli"	22/01/2019 15:15:03	22/01/2019 16:15:03	56.0
S10	Via Correggio Allegri	21/01/2019 17:37:40	21/01/2019 18:37:40	67.1

Table 25 - Results (measurement station P01)

Postazione P01	L_{Aeq} misurato (dB(A)) Orario																								Descrittore acustico		
DATA	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	D	E	N
Lunedi 21 - Martedi 29/01/2019	50.6	47.4	45.4	47.3	46.8	52.7	55.8	56.6	57.4	60.3	61.9	55.1	56.1	58.4	56.6	62.0	58.3	55.3	55.1	55.2	54.2	53.1	52.2	51.8	**57.9**	**53.7**	**50.1**
Martedi 22/01/2019	48.5	46.7	44.0	41.8	47.4	51.8	55.5	57.7	57.3	56.5	55.6	55.5	54.7	56.6	56.7	55.8	62.8	54.6	56.5	61.8	53.4	52.3	51.9	52.3	**57.6**	**52.9**	**49.4**
Mercoledi 23/01/2019	49.9	47.4	44.4	45.9	46.4	51.2	54.1	56.7	56.1	57.5	59.6	55.3	62.2	58.8	55.2	55.6	56.9	62.9	55.9	61.4	53.3	51.9	51.3	51.5	**58.4**	**52.7**	**49.2**
Giovedi 24/01/2019	50.0	46.8	43.5	43.7	45.0	50.2	54.0	56.1	59.4	58.9	56.2	55.2	60.8	58.6	57.0	55.1	55.1	55.6	55.0	61.7	54.0	53.3	52.9	52.4	**57.5**	**53.7**	**49.4**
Venerdi 25/01/2019	50.8	48.0	46.2	44.0	46.3	52.2	54.8	56.8	57.6	57.6	55.3	62.5	54.9	56.1	55.8	55.1	56.1	58.8	55.0	54.9	54.3	53.7	52.8	53.4	**56.9**	**54.0**	**50.4**
Sabato 26/01/2019	52.5	50.8	49.2	47.8	48.1	49.6	52.3	55.6	55.1	57.5	54.4	53.9	61.1	63.3	60.1	54.2	54.5	53.6	54.0	54.0	54.1	52.9	53.3	53.4	**57.1**	**53.5**	**51.1**
Domenica 27/01/2019	53.5	52.2	51.5	48.2	46.1	44.6	47.4	57.6	51.7	52.2	53.3	57.5	58.5	58.0	56.3	56.5	58.4	58.9	59.4	61.8	55.4	54.5	53.5	54.3	**57.2**	**55.0**	**51.6**
Lunedi 28/01/2019	52.7	48.9	48.0	46.5	47.0	52.9	56.0	56.6	57.2	57.1	57.2	55.5	55.2	54.6	59.1	55.0	58.0	62.4	55.6	55.4	54.6	53.1	52.8	52.9	**57.2**	**53.9**	**51.0**
																				MEDIA SETTIMANALE					**57.5**	**53.7**	**50.3**

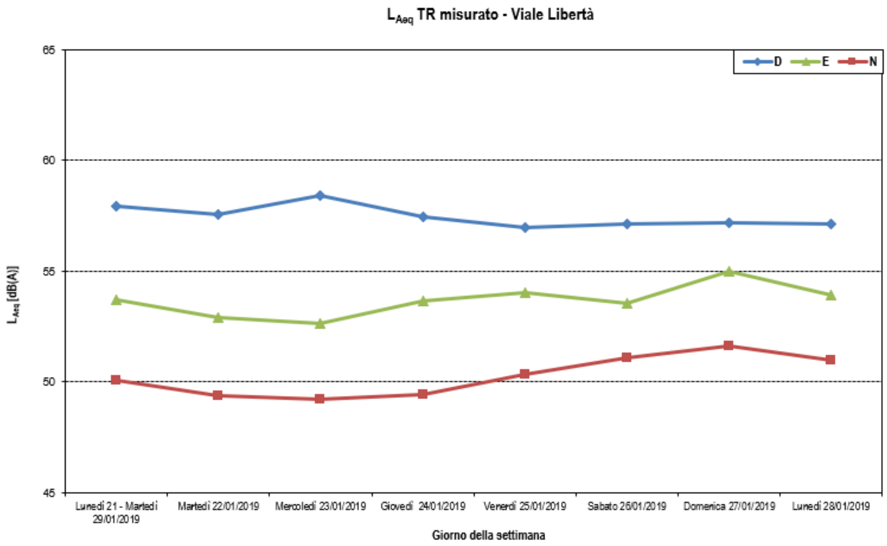
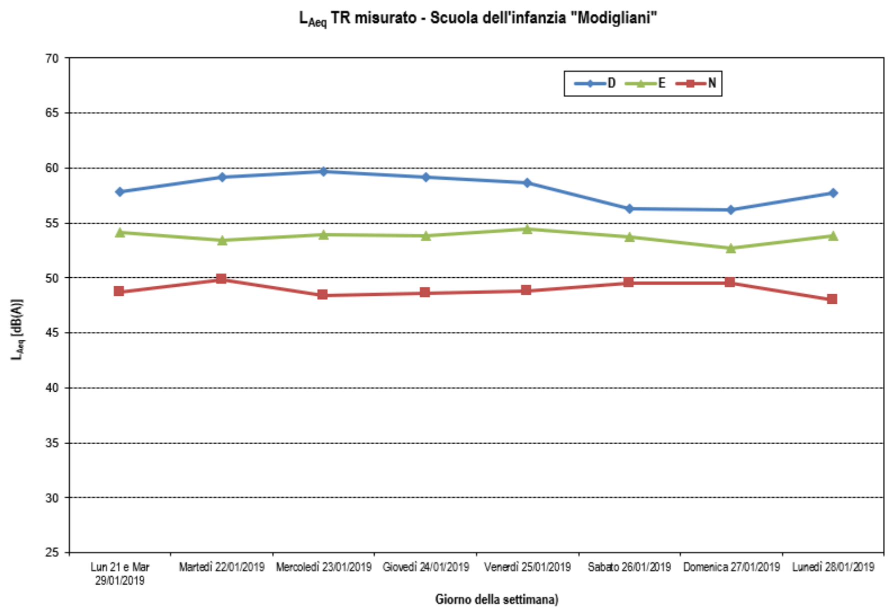


Table 26 - Results (measurement station P02)

Postazione P02	L_{Aeq} misurato (dB(A)) Orario																								Descrittore acustico		
DATA	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**D**	**E**	**N**
Lun 21 e Mar 29/01/2019	48.7	45.6	43.6	42.2	43.1	49.3	54.5	59.1	60.1	58.8					59.4	60.2	62.8	58.5	58.1	57.1	55.1	53.0	52.9	51.4	**57.9**	**54.2**	**48.7**
Martedì 22/01/2019	49.9	49.6	47.9	47.3	48.3	50.9	54.6	59.4	63.1	61.1	59.2	58.1	57.5	60.4	57.0	58.0	59.5	59.5	57.8	56.9	54.1	52.7	51.9	50.6	**59.2**	**53.5**	**49.8**
Mercoledì 23/01/2019	49.4	44.7	44.4	43.0	46.1	48.9	54.2	59.6	60.3	62.1	62.4	59.5	57.5	58.6	59.5	62.1	58.2	59.5	58.5	57.5	54.7	52.9	51.4	51.4	**59.7**	**53.9**	**48.4**
Giovedì 24/01/2019	50.0	44.4	42.2	40.6	40.2	46.7	52.1	59.4	63.3	62.1	62.1	58.5	56.6	57.8	57.3	56.5	58.1	58.3	57.5	57.0	54.5	53.1	52.6	52.6	**59.2**	**53.9**	**48.6**
Venerdì 25/01/2019	48.7	46.9	42.5	38.5	43.8	48.5	53.8	59.4	61.5	59.4	57.3	57.0	57.5	59.2	56.9	57.6	58.5	59.0	60.9	57.3	55.2	53.6	52.7	52.4	**58.6**	**54.5**	**48.8**
Sabato 26/01/2019	50.4	49.0	48.3	44.0	44.3	47.1	53.7	55.5	56.6	56.9	58.3	56.7	56.9	54.9	54.6	55.6	56.4	56.8	57.1	56.3	54.6	52.7	52.1	52.8	**56.3**	**53.8**	**49.5**
Domenica 27/01/2019	52.0	50.1	49.3	47.0	44.7	43.4	45.6	47.7	51.5	53.1	55.4	59.1	59.7	56.2	55.6	55.9	57.0	58.6	57.4	55.5	53.6	51.5	52.3	49.9	**56.2**	**52.7**	**49.5**
Lunedì 28/01/2019	49.3	44.4	39.9	35.0	43.3	47.2	53.0	59.0	61.0	58.2	57.5	57.3	56.5	57.1	56.0	56.3	57.7	57.9	58.6	57.0	54.9	52.3	52.5	51.1	**57.7**	**53.8**	**48.0**
																			MEDIA SETTIMANALE						**58.3**	**53.8**	**48.9**



▪ Traffic flows detection

Regarding **the traffic flows detection**, the sheets are structured as follows:

- General data of the measurement position (coding, description, reference road, system of measurement used).
- Territorial framework for the planimetric measurement identification.
- Results of the automatic detection of traffic flows: date and time of start and end of the count, traffic flows (vehic/h) and speed values (km/h) of vehicles divided by direction of travel and between light and heavy vehicles and referred, for all measurement days and as a weekly average level, to the Day/Evening/Night acoustic descriptors.

A tabular and graphical summary of the results of the detection of traffic flows is shown below.

Table 27 - Results referred to the acoustic descriptors Day/Evening/Night (position CT01 and CT03)

Date	Acoustic Descriptor	Direction 1 - Center			Direction 2 - Periphery		
		LIGHT vehicles	HEAVY vehicles	TOTAL vehicles	LIGHT vehicles	HEAVY vehicles	TOTAL vehicles
Mon 21/01 & Tue 29/01/2019	Day	5042	80	5122	6014	90	6104
	Evening	807	5	812	622	4	626
	Night	466	1	467	598	6	604
Tuesday 22/01/2019	Day	7151	99	7250	6125	81	6206
	Evening	837	5	842	683	5	688
	Night	925	5	930	651	4	655
Wednesday 23/01/2019	Day	6950	95	7045	6169	85	6254
	Evening	802	10	812	622	2	624
	Night	1049	5	1054	676	2	678
Thursday 24/01/2019	Day	7640	100	7740	6182	76	6258
	Evening	880	7	887	675	4	679
	Night	1095	4	1099	747	3	750
Friday 25/01/2019	Day	7793	94	7887	6594	76	6670
	Evening	969	9	978	778	5	783
	Night	1019	4	1023	884	4	888
Saturday 26/01/2019	Day	7294	68	7362	6513	47	6560
	Evening	954	9	963	766	4	770
	Night	1106	9	1115	1224	2	1226
Sunday 27/01/2019	Day	3987	20	4007	4250	8	4258
	Evening	662	6	668	570	2	572
	Night	975	3	978	939	1	940
Weekly Average	**Day**	**6551**	**79**	**6630**	**5978**	**66**	**6044**
	Evening	**844**	**7**	**852**	**674**	**4**	**677**
	Night	**948**	**4**	**952**	**817**	**3**	**820**

Table 28 - Results referred to the time data (position CT01 and CT03)

Date	Acoustic Descriptor	Direction 1 - Center			Direction 2 - Periphery		
		LIGHT vehic/h	HEAVY vehic/h	TOTAL vehic/h	LIGHT vehic/h	HEAVY vehic/h	TOTAL vehic/h
Mon 21/01 & Tue 29/01/2019	Day	360	6	366	430	6	436
	Evening	404	3	406	311	2	313
	Night	58	0	58	75	1	76
Tuesday 22/01/2019	Day	511	7	518	438	6	443
	Evening	419	3	421	342	3	344
	Night	116	1	116	81	1	82
Wednesday 23/01/2019	Day	496	7	503	441	6	447
	Evening	401	5	406	311	1	312
	Night	131	1	132	85	0	85
Thursday 24/01/2019	Day	546	7	553	442	5	447
	Evening	440	4	444	338	2	340
	Night	137	1	137	93	0	94
Friday 25/01/2019	Day	557	7	563	471	5	476
	Evening	485	5	489	389	3	392
	Night	127	1	128	111	1	111
Saturday 26/01/2019	Day	521	5	526	465	3	469
	Evening	477	5	482	383	2	385
	Night	138	1	139	153	0	153
Sunday 27/01/2019	Day	285	1	286	304	1	304
	Evening	331	3	334	285	1	286
	Night	122	0	122	117	0	118
Weekly Average	**Day**	**468**	**6**	**474**	**427**	**5**	**432**
	Evening	**422**	**4**	**426**	**337**	**2**	**339**
	Night	**118**	**1**	**119**	**102**	**0**	**103**

Table 29 - Results referred to the acoustic descriptors Day/Evening/Night (position CT02)

Date	Acoustic Descriptor	Direction 1 – Via Bertacchi			Direction 2 – Via Guerrina		
		LIGHT vehicles	HEAVY vehicles	TOTAL vehicles	LIGHT vehicles	HEAVY vehicles	TOTAL vehicles
Mon 21/01 & Tue 29/01/2019	Day	2608	57	2665	1987	48	2035
	Evening	152	1	153	80	3	83
	Night	83	0	83	93	1	94
Tuesday 22/01/2019	Day	2606	51	2657	2153	60	2213
	Evening	137	1	138	102	4	106
	Night	113	1	114	113	1	114
Wednesday 23/01/2019	Day	2558	49	2607	2106	55	2161
	Evening	163	0	163	92	3	95
	Night	97	1	98	114	1	115
Thursday 24/01/2019	Day	2582	49	2631	2122	51	2173
	Evening	174	0	174	101	3	104
	Night	115	1	116	117	0	117
Friday 25/01/2019	Day	2632	57	2689	2184	55	2239
	Evening	160	1	161	118	1	119
	Night	128	1	129	119	0	119
Saturday 26/01/2019	Day	2027	37	2064	1501	43	1544
	Evening	133	0	133	98	2	100
	Night	174	0	174	152	0	152
Sunday 27/01/2019	Day	1135	0	1135	909	21	930
	Evening	76	1	77	50	1	51
	Night	106	0	106	100	0	100
Weekly Average	**Day**	**2307**	**43**	**2350**	**1852**	**48**	**1899**
	Evening	**142**	**1**	**143**	**92**	**2**	**94**
	Night	**117**	**1**	**117**	**115**	**0**	**116**

Table 30 - Results referred to the time data (position CT02)

Date	Acoustic Descriptor	Direction 1 – Via Bertacchi			Direction 2 – Via Guerrina		
		LIGHT vehic/h	HEAVY vehic/h	TOTAL vehic/h	LIGHT vehic/h	HEAVY vehic/h	TOTAL vehic/h
Mon 21/01 & Tue 29/01/2019	Day	186	4	190	142	3	145
	Evening	76	1	77	40	2	42
	Night	10	0	10	12	0	12
Tuesday 22/01/2019	Day	186	4	190	154	4	158
	Evening	69	1	69	51	2	53
	Night	14	0	14	14	0	14
Wednesday 23/01/2019	Day	183	4	186	150	4	154
	Evening	82	0	82	46	2	48
	Night	12	0	12	14	0	14
Thursday 24/01/2019	Day	184	4	188	152	4	155
	Evening	87	0	87	51	2	52
	Night	14	0	15	15	0	15
Friday 25/01/2019	Day	188	4	192	156	4	160
	Evening	80	1	81	59	1	60
	Night	16	0	16	15	0	15
Saturday 26/01/2019	Day	145	3	147	107	3	110
	Evening	67	0	67	49	1	50
	Night	22	0	22	19	0	19
Sunday 27/01/2019	Day	81	0	81	65	2	66
	Evening	38	1	39	25	1	26
	Night	13	0	13	13	0	13
Weekly Average	**Day**	**165**	**3**	**168**	**132**	**3**	**136**
	Evening	**71**	**0**	**71**	**46**	**1**	**47**
	Night	**15**	**0**	**15**	**14**	**0**	**14**

List Annexes of sub-action B5.2 (post-operam monitoring - January 2019):

- Annex 25 – Calibration certificates for the measurement systems used
- Annex 26 – Monitoring sheets

3.2.2 Fourth monitoring campaign – May 2019

In this chapter is presented the analysis of the post-operam sound level monitoring campaign that had held in May 2019 (exactly from Monday 6th to Tuesday 14th May).

In particular, this note reports the results of the phonometric monitoring campaign and the traffic flows collected in some road axis falling within the pilot area.

Have been taking into consideration:

- the data collected with a **long-term monitoring campaign** and, specifically, by counting weekly traffic flows in 2 positions with control unit with automatic radar traffic counting system showing the division into light and heavy vehicles;
- the data collected with a **short-term SPOT monitoring campaign**, and specifically, by time -based counting of short-term traffic flows (1 hours) in 10 positions.

Monitoring has carried out in correspondence with the receivers defined in the table 1.

Table 31 – Monitoring scenarios May 2019

ID position	Type of monitoring	Toponym
P01	Long-term (weekly)	Viale Libertà – Centro Civico
P02	Long-term (weekly)	Via A. Modigliani - Scuola
S01	Short-term (Spot)	Viale Libertà – Centro Civico
S02	Short-term (Spot)	Viale Libertà n. 93
S03	Short-term (Spot)	Via della Gallarana
S04	Short-term (Spot)	Via della Guerrina n. 31
S05	Short-term (Spot)	Via A. Modigliani - Scuola
S06	Short-term (Spot)	Via Parmenide – Asilo nido
S07	Short-term (Spot)	Via Giuseppe Impastato
S08	Short-term (Spot)	Via della Guerrina – Liceo Porta
S09	Short-term (Spot)	Viale Libertà – Istituto Mapelli
S10	Short-term (Spot)	Via Correggio Allegri

The next figure shows the planimetric location of the phonometric monitoring stations, traffic flows (contextual to the phonometric ones), of the traffic counter radar units for the monitoring of noise pollution in the pilot area.

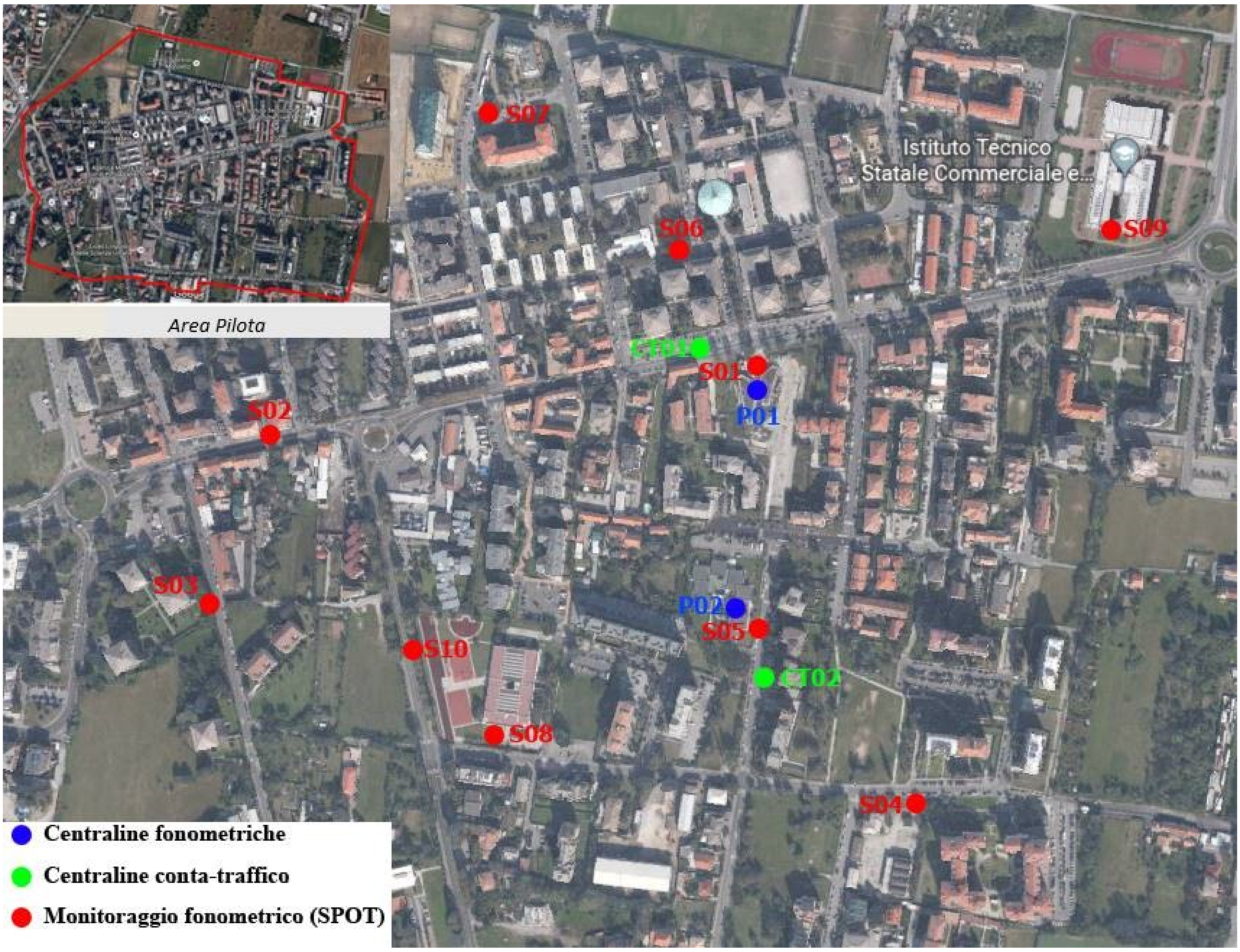


Figure 5 – Monitoring positions

The following figure shows instead the road axis object of monitoring so better defined:

- In red colour the arcs object to weekly traffic count;
- in violet colour the arcs object to the SPOT traffic count (time slot);
- in cyan colour the arcs into the pilot area non object of monitoring, for those an attribution have been proposed;
- in grey colour all the arcs out of the pilot area.

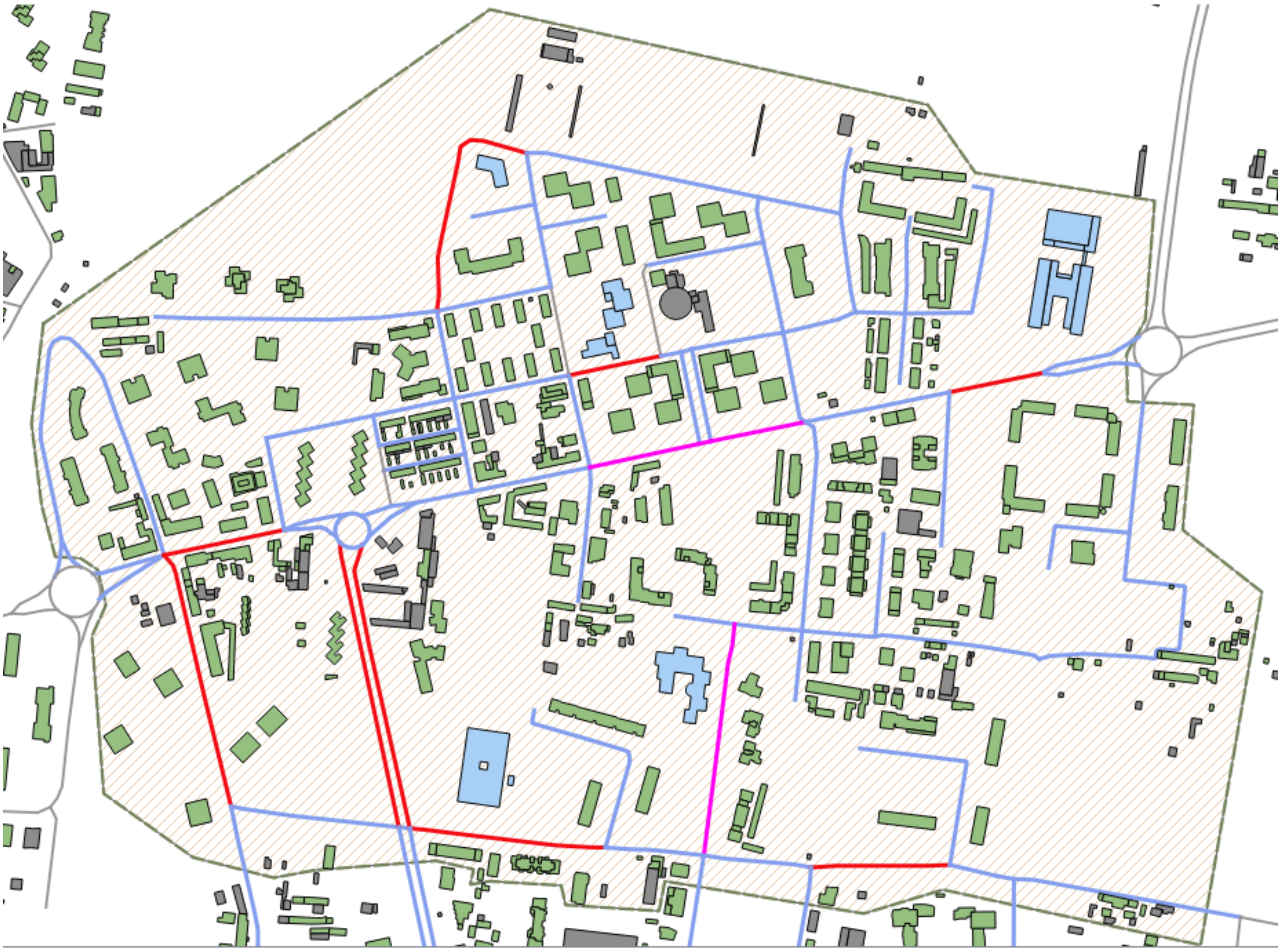


Figure 6 – Road arcs object of monitoring

➢ Measurement systems

For the measurements the following measurement systems were used:

SYSTEM NO.1

- PRECISION INTEGRATOR PHONOMETER 01dB type FUSION S.N. 11215, complying with the regulations IEC 651 – EN 60651 class 1 and IEC 804 – EN 60804;
- PRECISION MICROPHONE WITH PREPOLARIZED CONDENSER 01dB type GRASS model 40 CE S.N. 233339, complying with the regulations EN61094-1/94 EN61094-2/93 EN61094-3/93 EN61094-4/95.

SYSTEM NO.2

- PRECISION INTEGRATOR PHONOMETER 01 dB type BLUE SOLO S.N. 60982, complying with the regulations IEC 651 – EN 60651 class 1 and IEC 804 – EN 60804;
- PRECISION MICROPHONE WITH PREPOLARIZED CONDENSER 01 dB type PRE21 S.N. 13936, complying with the regulations EN61094-1/94 EN61094-2/93 EN61094-3/93 EN61094-4/95 IEC 651 class 1 (imp.) and IEC 804.

SYSTEM NO.3

- PRECISION INTEGRATOR PHONOMETER BRUEL & KJÆR type 2250 S.N. 3004064, complying with the regulations IEC 651 – EN 60651 class 1 and IEC 804 – EN 60804;

- PRECISION MICROPHONE WITH PREPOLARIZED CONDENSER BRUEL & KJÆR type 4189 S.N. 2877086, complying with the regulations EN61094-1/94 EN61094-2/93 EN61094-3/93 EN61094-4/95 IEC 651 class 1 (imp.) and IEC 804.

SYSTEM NO.4
- PRECISION INTEGRATOR PHONOMETER BRUEL & KJÆR type 2250 S.N. 3004065, complying with the regulations IEC 651 – EN 60651 class 1 and IEC 804 – EN 60804;
- PRECISION MICROPHONE WITH PREPOLARIZED CONDENSER BRUEL & KJÆR type 4189 S.N. 2876907, complying with the regulations EN61094-1/94 EN61094-2/93 EN61094-3/93 EN61094-4/95 IEC 651 class 1 (imp.) and IEC 804.

ACOUSTIC CALIBRATOR
- BRUEL & KJÆR type 4231 S.N. 2713443, class 1 according to the standard IEC 942:1988, sound power level produced: 94 dB a 1000Hz.

For the memorization and the processing of the data was made use of the dedicated Software:
- Basic sound analysis software BRUEL & KJÆR BZ 5503;
- Noise Evaluator BRUEL & KJÆR 7820 v. 4.16.8;
- dB Trait 5.5.

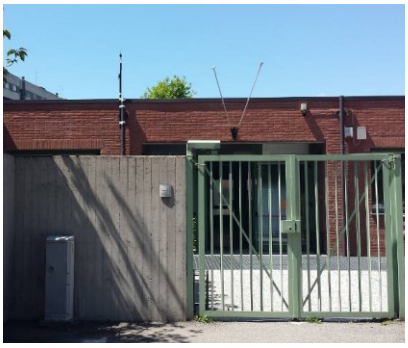
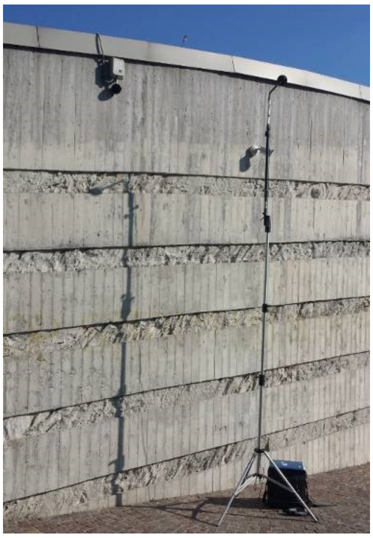
The technical data of automatic traffic flow detection systems (radar systems) are reported below:
- Traffic monitoring device VIACOUNT II – VIA Traffic Controlling GmbH s.n. 11VZZ0018.
- Traffic monitoring device VIACOUNT II – VIA Traffic Controlling GmbH s.n. 13VZZ0257.
- Traffic monitoring device VIACOUNT II – VIA Traffic Controlling GmbH s.n. 14VZZ0067.

For the memorization and the processing of the data was made use of the dedicated Software: ViaGraph vers. 4.00.09.

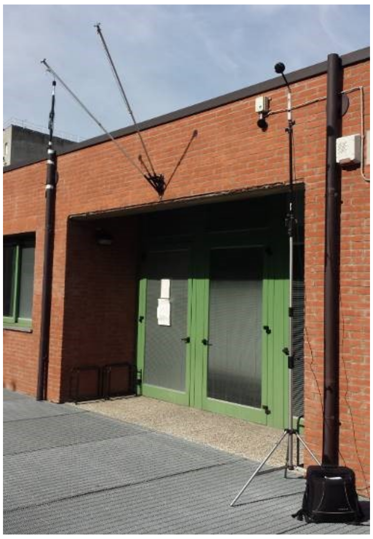
➢ Measurement positions (phonometric monitoring)

The main information and the photographic contributes of the measurement positions used for the phonometric monitoring are shown below.

Table 32 - Positions of phonometric monitoring

Measurement station	Description	Photo
P01	**Address:** Civic Center in Viale Libertà **Height from the ground level:** 6.00 m **Distance from the road axis:** 38 m	
P02	**Address:** Nursery School "A. Modigliani" **Height from the ground level:** 6.00 m **Distance from the road axis:** 15 m	
S01	**Address:** Civic Center in Viale Libertà **Height from the ground level:** 4.00 m **Distance from the road axis:** 23 m	

Measurement station	Description	Photo
S02	**Address:** Viale Libertà no. 93 **Height from the ground level:** 4.50 m **Distance from the road axis:** 6 m	
S03	**Address:** Via della Gallarana **Height from the ground level:** 4.00 m **Distance from the road axis:** 5 m	
S04	**Address:** Via della Guerrina no. 31 **Height from the ground level:** 4.00 m **Distance from the road axis:** 7.50 m	

Measurement station	Description	Photo
S05	**Address:** Nursery School Modigliani entryway **Height from the ground level:** 4.00 m **Distance from the road axis:** 15 m	
S06	**Address:** Via Parmenide, at Private Nursery “Cuore Immacolato di Maria” **Height from the ground level:** 4.00 m **Distance from the road axis:** 10 m	
S07	**Address:** Via Giuseppe Impastato **Height from the ground level:** 4.00 m **Distance from the road axis:** 4 m	

Measurement station	Description	Photo
S08	**Address:** Via della Guerrina, next to Liceo “Porta” **Height from the ground level:** 4.00 m **Distance from the road axis:** 28 m	
S09	**Address:** Viale Libertà, next to ITGC “Mapelli” **Height from the ground level:** 4.00 m **Distance from road axis:** 43 m	
S10	**Address:** Via Correggio Allegri **Height from the ground level:** 4.00 m **Distance from the road axis:** 12 m	

➢ Measurement positions (detection of traffic flows)

The main information and photo contributions of the measurement stations used to detect traffic flows automatically using a traffic device with radar system are shown below.

Table 33 - Traffic flows detection stations

Measurement station	Description	Photo
CT01	**Monitoring date:** 6-13/05/2019 **Reference road:** Viale Libertà	
CT02	**Monitoring date:** 6-13/05/2019 **Reference road:** Via A. Modigliani	
CT03	**Monitoring date:** 6-13/05/2019 **Reference road:** Viale Libertà	

➢ Monitoring results

The monitoring results are fully shown in specific summary sheets attached to this technical report.

▪ Phonometric monitoring

Regarding the **<u>phonometric monitoring</u>**, the sheets are divided as follows:

- General data of the measurement station (coding, description, height of the microphone from the campaign plan, distance from the microphone to the road axis, noise class according to the Noise Zoning Plan of the Municipality of Monza, input limit values defined according to Italian D.P.C.M. 14/11/1997).

- Territorial framework for the planimetric measurement identification.
- For **long-term monitoring**: date and time of start and end of the measure, time history, equivalent L_{Aeq} levels referred, for all measurement days and as a weekly average level, to the day reference period (6.00 - 22.00) and to the night reference period (22.00 - 6.00).
- For **short-term monitoring (SPOT):**
    - o Results of phonometric monitoring: date and time of start and end of measurement, time history and frequency composition by third-band octave, equivalent levels L_{Aeq}.
    - o Results of short-term manual count (1 hour) of traffic flows: date and time of start and end of the count, traffic flows (vehic/h) divided between typology of vehicle (light, medium, heavy vehicles, bus, motorbikes, bikes) and by direction of travel.

A tabular and graphical summary of the results of the phonometric monitoring is shown below.

Table 34 - Summary of short-term monitoring results

Postazione	**Descrizione**	**Data e ora di inizio**	**Data e ora di fine**	**L_{Aeq} [dB(A)]**
S01	In facciata al Centro Civico di Viale Libertà	06/05/2019 17:24:34	06/05/2019 18:24:34	60.9
S02	Viale Libertà, n. 93	07/05/2019 12:02:36	07/05/2019 13:02:36	68.3
S03	Via della Gallarana	07/05/2019 9:26:14	07/05/2019 10:26:14	63.3
S04	Via della Guerrina n. 31	06/05/2019 17:37:32	06/05/2019 18:37:32	62.5
S05	Via Modigliani, in facciata della Scuola dell'infanzia	07/05/2019 9:33:01	07/05/2019 10:33:01	59.0
S06	Via Parmenide, in facciata alla Scuola dell'infanzia privata "Cuore Immacolato di Maria"	06/05/2019 16:07:34	06/05/2019 17:07:34	57.2
S07	Via Giuseppe Impastato	06/05/2019 14:51:25	06/05/2019 15:51:25	51.1
S08	In facciata al Liceo Statale "Carlo Porta"	07/05/2019 10:47:16	07/05/2019 11:47:16	55.7
S09	Viale Libertà, in facciata all'ITCG "Achille Mapelli"	06/05/2019 14:50:56	06/05/2019 15:50:56	57.8
S10	Via Correggio Allegri	07/05/2019 10:33:55	07/05/2019 11:33:55	66.8

Table 35 - Results (measurement station P01)

Postazione P01	L_{Aeq} misurato (dB(A)) Orario																								Descrittore acustico		
DATA	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**D**	**E**	**N**
Lunedi 06/05/2019													56.1	57.5	56.0	55.6	56.2	57.2	55.2	55.2	55.2	52.8	51.7	52.4	**56.2**	**54.2**	**52.1**
Martedi 07/05/2019	48.1	46.0	44.4	44.1	47.5	52.8	55.3	56.9	55.9	55.8	55.1	54.8	56.2	55.3	56.9	54.5	55.7	55.5	56.5	54.7	53.4	51.8	51.0	50.8	**55.7**	**52.7**	**49.1**
Mercoledi 08/05/2019	48.6	45.5	42.8	43.5	47.9	51.0	54.0	55.2	56.0	57.0	56.0	54.6	57.0	58.6	60.0	59.8	61.6	57.5	57.3	57.0	55.7	54.3	56.4	57.4	**56.6**	**55.1**	**47.5**
Giovedi 09/05/2019	55.6	53.2	49.7	47.2	48.9	54.6	57.1	57.1	57.0	56.9	55.6	55.7	59.7	57.0	56.0	55.5	55.4	55.7	55.3	54.3	54.8	53.3	52.9	51.4	**56.5**	**54.1**	**52.4**
Venerdi 10/05/2019	50.8	48.3	45.0	45.3	47.6	51.4	54.5	56.6	55.9	58.8	56.6	55.1	55.5	58.1	57.4	54.8	56.5	55.6	54.5	55.1	53.6	53.4			**56.3**	**53.5**	**48.7**
Lun 13 e Martedi 14/05/2019	48.8	45.1	42.3	43.5	48.3	51.7	56.2	56.8	55.3	55.0	55.0	54.3	54.7	56.6	56.1	54.6	55.4	56.9	55.0	55.3	53.2	52.0	50.7	50.3	**55.6**	**52.6**	**48.7**
	in rosso: L_{Aeq} orari esclusi dal calcolo																				**MEDIA SETTIMANALE**				**56.2**	**53.8**	**50.2**

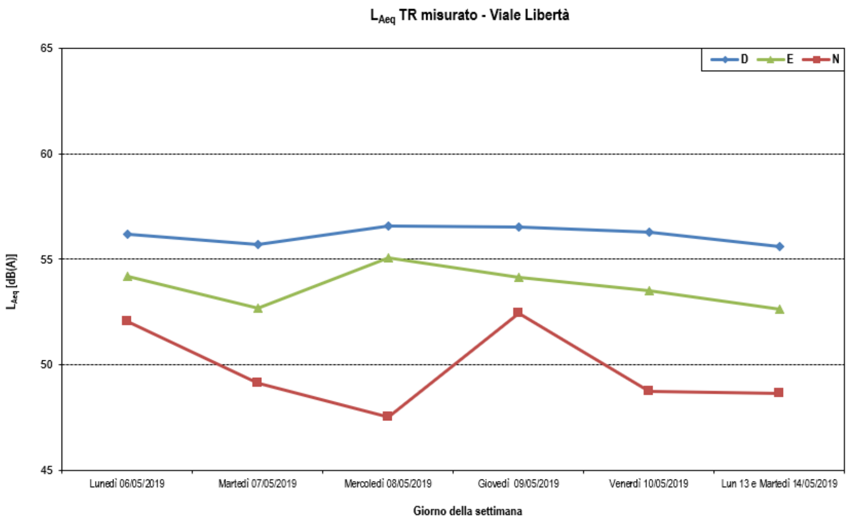
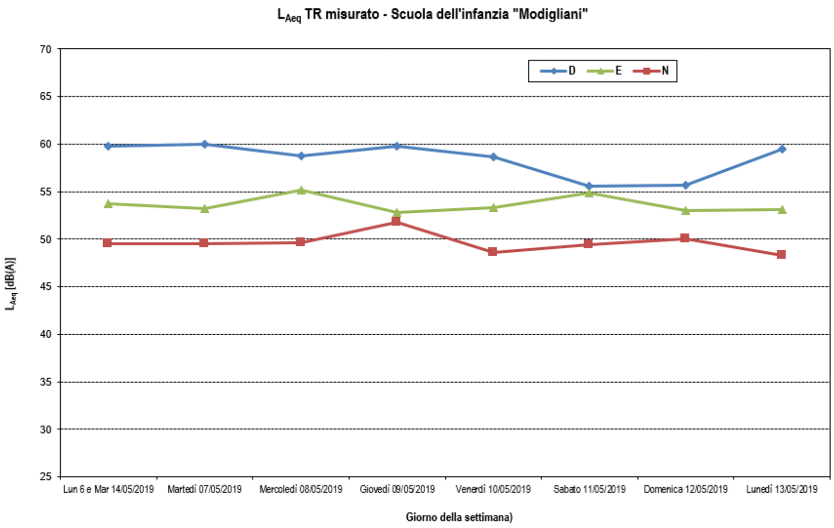


Table 36 - Results (measurement station P02)

Postazione P02	L_{Aeq} misurato (dB(A)) Orario																								Descrittore acustico		
DATA	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**D**	**E**	**N**
Lun 6 e Mar 14/05/2019	48.2	43.1	40.9	41.2	45.0	53.6	55.1	59.5	59.5	57.5	62.8	64.2	58.2	63.9	56.6	59.6	60.9	60.2	60.8	58.9	55.0	51.9	52.7	52.1	**59.8**	**53.7**	**49.5**
Martedi 07/05/2019	45.4	46.1	40.9	42.6	45.4	55.3	54.6	60.1	59.6	59.9	60.4	59.2	58.8	63.1	59.8	60.8	62.9	59.0	57.7	57.5	53.9	52.5	51.0	50.2	**60.0**	**53.3**	**49.5**
Mercoledi 08/05/2019	49.5	45.7	39.3	40.4	46.5	55.5	55.3	58.4	69.4	64.7	63.2	63.4	61.8	66.2	62.5	63.2	62.9	61.4	60.5	59.3	56.4	53.4	56.9	59.7	**58.8**	**55.2**	**49.6**
Giovedi 09/05/2019	56.6	57.0	58.4	44.0	50.6	54.5	54.3	60.4	61.3	61.2	60.7	64.8	56.7	62.2	63.0	58.5	59.1	57.5	57.6	55.9	53.9	51.4	52.6	51.7	**59.8**	**52.8**	**51.8**
Venerdi 10/05/2019	48.8	47.0	42.7	39.8	44.3	51.6	54.4	58.6	58.5	57.9	57.7	60.6	58.2	62.0	59.0	58.8	57.4	58.4	57.1	57.4	54.6	51.6	51.8	50.1	**58.6**	**53.4**	**48.6**
Sabato 11/05/2019	48.5	47.1	46.6	44.5	47.3	51.5	53.7	55.4	56.0	55.8	56.2	56.2	57.0	55.3	54.0	55.1	55.2	61.1	69.8	64.0	56.3	52.6	52.1	51.6	**55.5**	**54.8**	**49.4**
Domenica 12/05/2019	49.3	50.0	47.6	47.8	47.6	52.5	50.4	48.5	51.8	54.9	55.2	59.5	59.3	55.2	56.0	54.8	53.6	57.0	55.9	54.9	54.4	50.9	51.8	50.6	**55.7**	**53.0**	**50.0**
Lunedi 13/05/2019	46.0	44.4	42.2	39.7	46.6	53.4	53.8	59.3	58.9	56.6	55.8	60.7	61.5	65.3	57.4	58.2	58.6	59.6	57.3	56.3	54.6	50.9	49.9	49.0	**59.5**	**53.1**	**48.3**
	in rosso: L_{Aeq} orari esclusi dal calcolo																			**MEDIA SETTIMANALE**					**58.7**	**53.7**	**49.7**



▪ Traffic flows detection

Regarding **the traffic flows detection**, the sheets are structured as follows:

- General data of the measurement position (coding, description, reference road, system of measurement used).
- Territorial framework for the planimetric measurement identification.
- Results of the automatic detection of traffic flows: date and time of start and end of the count, traffic flows (vehic/h) and speed values (km/h) of vehicles divided by direction of travel and between light and heavy vehicles and referred, for all measurement days and as a weekly average level, to the Day/Evening/Night acoustic descriptors.

A tabular and graphical summary of the results of the detection of traffic flows is shown below.

Table 37 - Results referred to the acoustic descriptors Day/Evening/Night (position CT01 and CT03)

Date	Acoustic Descriptor	Direction 1 - Center			Direction 2 - Periphery		
		LIGHT vehicles	HEAVY vehicles	TOTAL vehicles	LIGHT vehicles	HEAVY vehicles	TOTAL vehicles
Mon 6 & 13/05/2019	Day	6054	83	6137	5569	83	5652
	Evening	824	4	828	601	6	607
	Night	758	2	760	900	2	902
Tuesday 07/05/2019	Day	6995	81	7076	5730	95	5825
	Evening	795	2	797	670	7	677
	Night	924	3	927	712	7	719
Wednesday 08/05/2019	Day	6072	95	6167	5875	86	5961
	Evening	750	2	752	635	8	643
	Night	900	3	903	698	5	703
Thursday 09/05/2019	Day	6584	71	6655	5700	115	5815
	Evening	730	3	733	646	4	650
	Night	946	4	950	844	7	851
Friday 10/05/2019	Day	6794	94	6888	5812	101	5913
	Evening	650	2	652	636	3	639
	Night	1007	3	1010	687	8	695
Saturday 11/05/2019	Day	6360	45	6405	5445	54	5499
	Evening	653	2	655	584	6	590
	Night	755	2	757	1024	2	1026
Sunday 12/05/2019	Day	4387	35	4422	3956	45	4001
	Evening	552	2	554	499	6	505
	Night	758	2	760	1080	2	1082
Weekly Average	**Day**	**6178**	**72**	**6250**	**5441**	**83**	**5524**
	Evening	**708**	**2**	**710**	**610**	**6**	**616**
	Night	**864**	**3**	**867**	**849**	**5**	**854**

Table 38 - Results referred to the time data (position CT01 and CT03)

Date	Acoustic Descriptor	Direction 1 - Center			Direction 2 - Periphery		
		LIGHT vehic/h	HEAVY vehic/h	TOTAL vehic/h	LIGHT vehic/h	HEAVY vehic/h	TOTAL vehic/h
Mon 6 & 13/05/2019	Day	432	6	438	398	6	404
	Evening	412	2	414	301	3	304
	Night	95	0	95	113	0	113
Tuesday 07/05/2019	Day	500	6	505	409	7	416
	Evening	398	1	399	335	4	339
	Night	116	0	116	89	1	90
Wednesday 08/05/2019	Day	434	7	441	420	6	426
	Evening	375	1	376	318	4	322
	Night	113	0	113	87	1	88
Thursday 09/05/2019	Day	470	5	475	407	8	415
	Evening	365	2	367	323	2	325
	Night	118	1	119	106	1	106
Friday 10/05/2019	Day	485	7	492	415	7	422
	Evening	325	1	326	318	2	320
	Night	126	0	126	86	1	87
Saturday 11/05/2019	Day	454	3	458	389	4	393
	Evening	327	1	328	292	3	295
	Night	94	0	95	128	0	128
Sunday 12/05/2019	Day	313	3	316	283	3	286
	Evening	276	1	277	250	3	253
	Night	95	0	95	135	0	135
Weekly Average	**Day**	**441**	**5**	**446**	**389**	**6**	**395**
	Evening	**354**	**1**	**355**	**305**	**3**	**308**
	Night	**108**	**0**	**108**	**106**	**1**	**107**

Table 39 - Results referred to the acoustic descriptors Day/Evening/Night (position CT02)

Date	Acoustic Descriptor	Direction 1 – Via Bertacchi			Direction 2 – Via Guerrina		
		LIGHT vehicles	HEAVY vehicles	TOTAL vehicles	LIGHT vehicles	HEAVY vehicles	TOTAL vehicles
Mon 6 & 13/05/2019	Day	2666	49	2715	2081	55	2136
	Evening	171	1	144	128	3	131
	Night	105	1	106	93	0	93
Tuesday 07/05/2019	Day	2660	59	2719	2208	48	2256
	Evening	165	0	145	100	3	103
	Night	122	1	123	122	1	123
Wednesday 08/05/2019	Day	2550	48	2598	2095	61	2156
	Evening	168	1	149	108	0	108
	Night	115	0	115	110	0	110
Thursday 09/05/2019	Day	2741	46	2787	2215	55	2270
	Evening	180	0	170	98	3	101
	Night	144	1	145	107	0	107
Friday 10/05/2019	Day	2425	56	2481	1817	56	1873
	Evening	186	0	169	135	3	138
	Night	156	0	156	160	0	160
Saturday 11/05/2019	Day	2054	45	2099	1789	47	1836
	Evening	158	1	159	126	2	128
	Night	106	0	106	95	1	96
Sunday 12/05/2019	Day	1254	15	1269	898	19	917
	Evening	120	1	121	116	0	116
	Night	118	0	118	93	0	93
Weekly Average	**Day**	**2336**	**45**	**2381**	**1872**	**49**	**1921**
	Evening	**164**	**1**	**151**	**116**	**2**	**118**
	Night	**124**	**0**	**124**	**111**	**0**	**112**

Table 40 - Results referred to the time data (position CT02)

Date	Acoustic Descriptor	Direction 1 – Via Bertacchi			Direction 2 – Via Guerrina		
		LIGHT vehic/h	**HEAVY vehic/h**	**TOTAL vehic/h**	**LIGHT vehic/h**	**HEAVY vehic/h**	**TOTAL vehic/h**
Mon 6 & 13/05/2019	Day	190	4	194	149	4	153
	Evening	86	1	72	64	2	66
	Night	13	0	13	12	0	12
Tuesday 07/05/2019	Day	190	4	194	158	3	161
	Evening	83	0	73	50	2	52
	Night	15	0	15	15	0	15
Wednesday 08/05/2019	Day	182	3	186	150	4	154
	Evening	84	1	75	54	0	54
	Night	14	0	14	14	0	14
Thursday 09/05/2019	Day	196	3	199	158	4	162
	Evening	90	0	85	49	2	51
	Night	18	0	18	13	0	13
Friday 10/05/2019	Day	173	4	177	130	4	134
	Evening	93	0	85	68	2	69
	Night	20	0	20	20	0	20
Saturday 11/05/2019	Day	147	3	150	128	3	131
	Evening	79	1	80	63	1	64
	Night	13	0	13	12	0	12
Sunday 12/05/2019	Day	90	1	91	64	1	66
	Evening	60	1	61	58	0	58
	Night	15	0	15	12	0	12
Weekly Average	**Day**	**167**	**3**	**170**	**134**	**3**	**137**
	Evening	**82**	**0**	**76**	**58**	**1**	**59**
	Night	**15**	**0**	**16**	**14**	**0**	**14**

List Annexes of sub-action B5.2 (post-operam monitoring - May 2019):

- Annex 27 – Calibration certificates for the measurement systems used
- Annex 28 – Monitoring sheets
- Annex 29 – Noise maps

3.2.3 Analysis of post-operam monitoring data and preparation of noise maps

Construction of the acoustic model

As far as acoustic modelling is concerned, reference was made to the model built for the ante operam scenarios.

Model calibration and validation

Also for the post operam phase, the calibration procedure of the calculation model was carried out by determining appropriate K correction coefficients, at least for Viale Libertà where, after the laying of the low-noise pavement and the modification of the driving conditions (generated by the introduction of roadway narrowing), the emission conditions are certainly different from the ante operam scenario. The K coefficient of Viale Libertà is reduced by 4 dB compared to the value used in the ante operam scenario. For the other roads, the work was a verification that confirmed the values used in the ante operam scenario.

The validation phase involved an experimental numerical comparison with reference to the weekly level determined in the two long-term stations. In this case, deviations of up to 2 dB(A) between measured and simulated level were considered suitable.

Acoustic maps and calculation of exposed receivers

For the construction of the noise maps and for the definition of the exposed receivers (see indicators) we proceeded using the same calculation methods used for the ante operam phase, as follows:

- CALCULATION OF THE ACOUSTIC VALUES ON THE FACADE: sound levels were assessed as maximum levels on the most exposed façade of each residential building. The simulations were carried out at a height of 4 m, excluding the reflection of the building façade behind the calculation point, at a distance of 1 m from the receiver façade.

- CALCULATION OF NOISE MAPS: a grid of points with a pitch of 10 m has been defined, positioned at a height of 4 m from the ground.

The input data for road sources are:

- <u>Viale Libertà:</u> The average weekly traffic flows recorded during the monitoring campaigns (divided by day, evening and night) were included in the acoustic model. With regard to the emission parameters, since the characteristics of the road have changed compared to the ante operam situation, the corrective factor K has been reduced by 4 dB(A) in relation to the laying of the new asphalt and the speed of the vehicles at the newly built protected pedestrian crossings has also been reduced.
- <u>Via Modigliani:</u> The average weekly traffic flows recorded during the monitoring campaigns (divided by day, evening and night) were included in the acoustic model.
- <u>Other monitored roads</u>: The average traffic flows have been included in the acoustic model, reduced according to the percentages measured at the fixed station in via Modigliani.

- Non-monitored roads: The allocated average traffic flows, also reduced in traffic volume by the procedure described above, have been included in the acoustic model.

The noise maps for January 2019 and May 2019 monitorings (Annex 29) were produced as isophonic curves included in the defined calculation area (Pilot area) with reference to the L_{DEN} and L_{NIGHT} noise indicators respectively (in the range between 45 dB(A) and 75 dB(A)).
The values of the noise levels measured by the receivers on the facade were used to calculate the exposed population and to update the indicators.
The calculation was performed both in reference to the entire Lez area and in reference to the area contained in a buffer of 30m from Viale della Libertà.

Bibliography

To draw up the report of sub-action B5.2 and the noise maps, the following Laws and regulations have been referred to:

- Legge 26 ottobre 1995, n. 447, Legge quadro sull'inquinamento acustico (G.U. n. 254 del 30 ottobre 1995);
- D.M. Ambiente del 16 marzo 1998, Tecniche di rilevamento e di misurazione dell'inquinamento acustico (G.U. n. 76 del 01 aprile 1998);
- D.P.R. 30 marzo 2004, n. 142, Disposizioni per il contenimento e la prevenzione dell'inquinamento acustico derivante dal traffico veicolare (G.U. n. 127 del 01 giugno 2004);
- D.Lgs. 19 agosto 2005, n. 194, Attuazione della direttiva 2002/49/CE relativa alla determinazione e alla gestione del rumore ambientale (G.U. n. 222 del 23 settembre 2005);
- Direttiva 2002/49/CE del Parlamento Europeo e del Consiglio del 25 giugno 2002 relativa alla determinazione e alla gestione del rumore ambientale.
- D. Lgs. 17 febbraio 2017, n. 42, Disposizioni in materia di armonizzazione della normativa nazionale in materia di inquinamento acustico, a norma dell'articolo 19, comma 2, lettere a), b), c), d), e), f) e h) della legge 30 ottobre 2014, n. 161.
- Direttiva (UE) 2015/996 della Commissione del 19 maggio 2015 che stabilisce metodi comuni per la determinazione del rumore a norma della direttiva 2002/49/CE del Parlamento europeo e del Consiglio
- Piano Comunale di Classificazione Acustica del comune di Monza.

In addition, reference was made to the following sector technical regulations:

- Nuove linee guida "Specifiche tecniche per la predisposizione e consegna della documentazione digitale relativa alle mappe acustiche e mappe acustiche strategiche (D.Lgs.. 194/05)" emanate dal Ministero dell'Ambiente e della Tutela del Territorio e del Mare 14-16 Marzo 2017.
- UNI 11143-1:2005 Acustica - Metodo per la stima dell'impatto e del clima acustico per tipologia di sorgenti - Parte 1: Generalità;
- UNI 11143-2:2005 Acustica - Metodo per la stima dell'impatto e del clima acustico per tipologia di sorgenti - Parte 2: Rumore stradale;

- UNI/TR 11326:2009 – Acustica. Valutazione dell'incertezza nelle misurazioni e nei calcoli di acustica. Parte 1: Concetti generali;
- UNI ISO 1996-1: 2016 – Acustica. Descrizione, misurazione e valutazione del rumore ambientale. Parte 1: Grandezze fondamentali e metodi di valutazione;
- UNI ISO 1996-2: 2010 – Acustica. Descrizione, misurazione e valutazione del rumore ambientale. Parte 1: Determinazione dei livelli di rumore ambientale.

Health – UNIFI

Analysis of data collected in the post-test. Results of the post-test survey for the sample survey on the perception of living conditions, noise and air quality in the "Liberty District" - SECOND SECTION

LIFE15 ENV/IT/000586

LIFE MONZA
Methodologies fOr Noise low emission Zones introduction And management

Technical Report

Deliverable	Report on Ante and Post Operam data collection
Action/Sub-action	B5.4 "Health ex ante/ex post monitoring"
Authors	University of Florence, Department of Experimental and Clinical Medicine, Occupational Medicine (Prof. Giulio Arcangeli, Prof. Nicola Mucci, Dr. Veronica Traversini) and Department of Health, Hygiene and Preventive Medicine (Prof. Guglielmo Bonaccorsi, Dr. Chiara Lorini)
Status - date	Final version - 22/04/2020

Summary

THE DETECTION TOOL

The sample survey, of a diachronic type, provided for the realization of two surveys: the first (pretest) defined the situation ex ante, the second (post-test) recorded the conditions found after the implementation of the infrastructure interventions and other measures envisaged by the project, in order to evaluate the changes that have occurred. The data was collected in both phases by administering semi-structured questionnaires to samples of the population residing in the "Liberty district" separated for the two time phases. The pre and post-test questionnaires share almost all the questions in common, to allow a satisfactory comparison between the ex ante and ex post situations. The questionnaire consists of two main sections. This report refers to the contents of the second section.

The 30 questions that make up the second part of the questionnaire refer to:

- *Information on the respondent's health status (physical, psychological problems, possible therapies);*
- *Home information (proximity to public services and health care);*
- *Quality of personal life (level of satisfaction, enjoying life);*
- *Perception of sleep quality and daily concentration;*
- *Perception of the environment'safety, for personal health purposes (noise, pollution);*
- *Level of satisfaction of social networks (friends, social relationships, leisure);*
- *Presence of negative feelings (annoyance, decreased mood, anxiety, depression).*

In the first section, the ISPRA group, in collaboration with the Sapienza University of Rome, also collected information on housing, quality of life, mobility and the perception of air pollution and noise, in addition to socio-demographic data.

THE SAMPLING

Also on the occasion of the second survey (post-test), held in 2019, the selection of the sample provided for a stratified random strategy, considering as the reference population the set of citizens residing in the study area aged between 18 and 80 and three stratification variables: (gender, 3 age'groups and spatial location). To establish the sample size, given that the reference population was equal to 6.150 units, a calculation formula was used that took into account the correction factor for finite populations. The outcome of the choices made led to the selection of a sample of 570 units. In addition to the list of sampled population, two lists of names and addresses have been prepared for replacements, to be used if it was not possible to find the sampled subject.

THE DETECTION METHODS

For the post-test phase, the same methods of administration and collection were used.
For the pretest phase, the submission began in the first days of April 2019, for both sections of the questionnaire, with an institutional letter of accompaniment from the Municipality, containing the indications for hand delivery to two locations and for the access to the alternative method of filling in electronically. After the first two weeks of collection, the first reminder was made indirectly through online notices and through local media, while the direct reminder to the sample (letter with questionnaire) was made only once in June 2019. With this strategy, the role of the detectors, tutors and students of the "Carlo Porta High School" was therefore mainly expressed in the with drawal of the completed questionnaire and the clarification of any doubts by citizens.

There were two locations identified for the manual delivery of the paper questionnaires:
• the "**Carlo Porta High School"** (Via della Guerrina, 15), which guaranteed a space also dedicated to filling in the questionnaire at the headquarters;
• the "**Liberty Civic Center"** (Viale Libertà, 144), which for a few days made the coworking room available with tables and places for up to twenty people.

The questionnaire was also administered electronically online (always in self-administration mode, with the direct access of each respondent to the Limesurvey).

RESPONDERS

The post-test questionnaires were 140 in total (26% of the sample).

In the figure 1 are shown some characteristics (Fig.1).

Gender, house'location, age

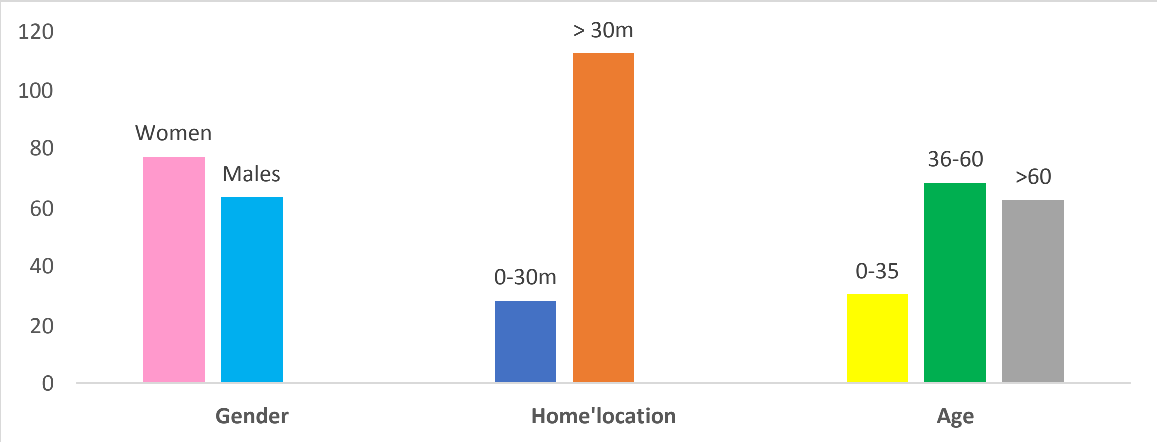


Fig. 1 Socio-demographic data in the post-test phase

For gender, there is a similar distribution (77 women and 63 men in the post phase); about home'location, residents were more than 30 meters from Liberty Avenue in both phases (respectively 120 subjects in the first phase and 112 in the second). Finally, as regards age, in both phases most of the responders are between 36 and 60 years (average 55 ys).

Citizenship

In the post-test phase, the data are similar (139 subjects have Italian citizenship).

Education title and occupation

In the second phase, the sample mainly has a high school diploma (48.6%) and a degree (29.3%); 44.3% of the sample have a job, 6.4% are unemployed or looking for their first job and, finally, 43.6% are retired, housewives or students. Over 45.7% are employees compared to 10.7% of freelancers and self-employed.

Home

In the post phase, 20% of responders live within 30 meters from Liberty Avenue, 50.7% between 31-100 meters and, finally, the remaining 29.3% live over 100 meters from the avenue.

LIFE'QUALITY- RESULTS

Interesting features of the **POST PHASE** are shown below.

Unlike the previous phase, there is an improvement in one's living conditions ("good" in 59.3%), with symptoms of psychological distress such as a decrease mood, anxiety or depression ("rarely" in over 60%) (Fig.2, 3).

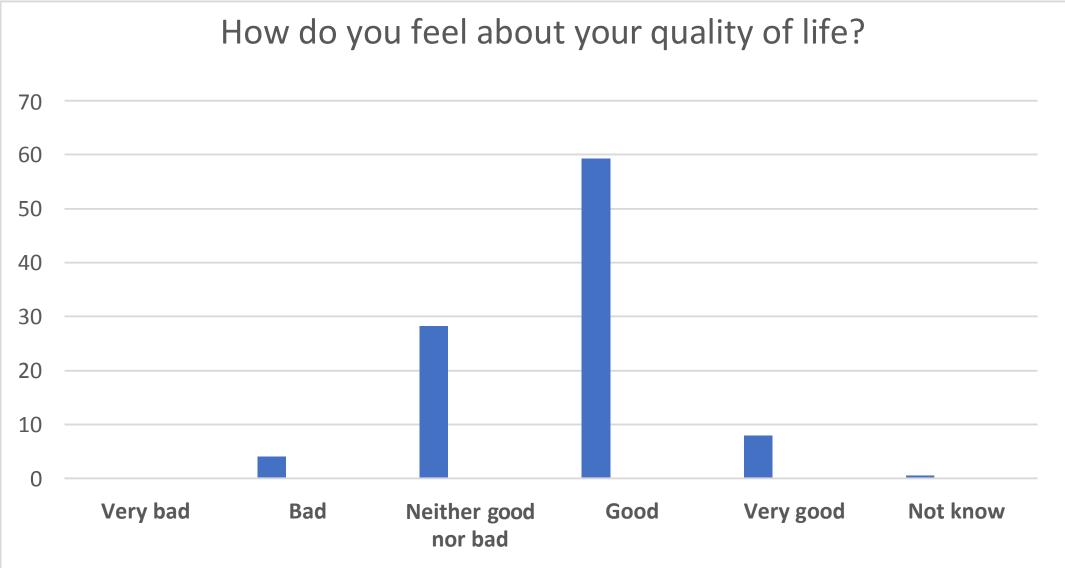


Fig.2 Level of quality of life'satisfaction (% values) in the post-test phase

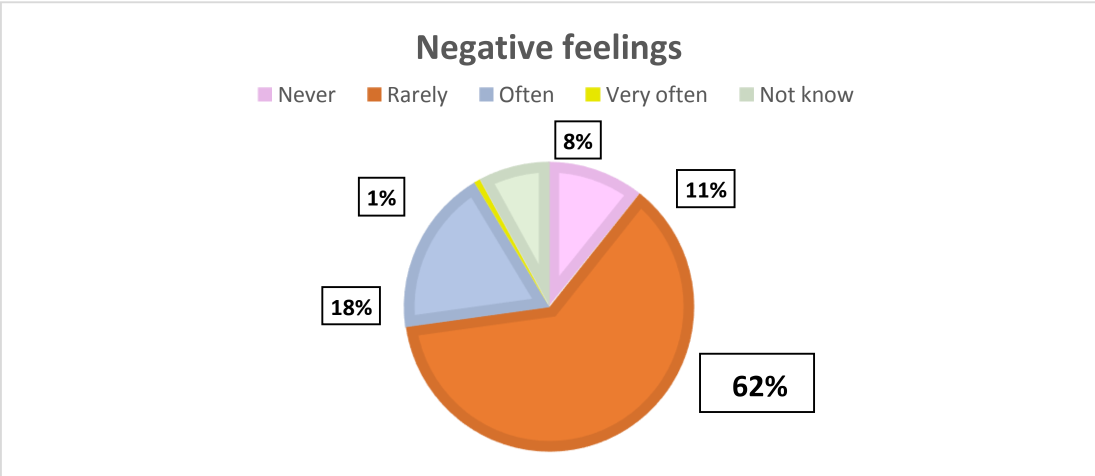


Fig.3 Frequency (% values) of negative feelings (mood decrease, anxiety, depression) in the post phase

The sample shows sufficient levels regarding moments of leisure and concentration ("enough" in 43.6%, in both cases); over half of the sample tries to carve out time to devote to their own well-being, in addition to their professional commitments (52.9% of their lives are enjoyed) (Fig. 4).

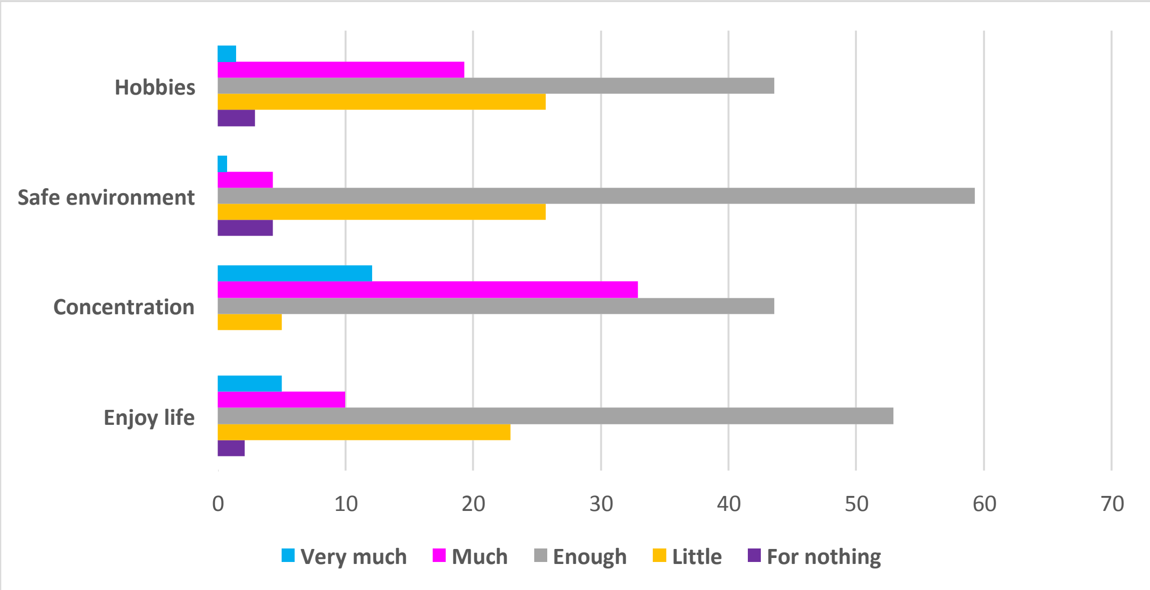


Fig.4 Frequencies (% values) of some variables in the post-test phase

Differences are observed, with respect to the pre-test phase, also as regards the health status of the residents. In fact, they report having moderate levels of energy for their activities ("much" in 33.6%), with few physical pains ("for nothing" in 35%) and need for therapy rarely ("for nothing" in 57.1%, " little "in 22.1%) (Fig. 5). This is also reflected in the satisfaction with one's existence ("much" in 39.3%) (Fig. 6).

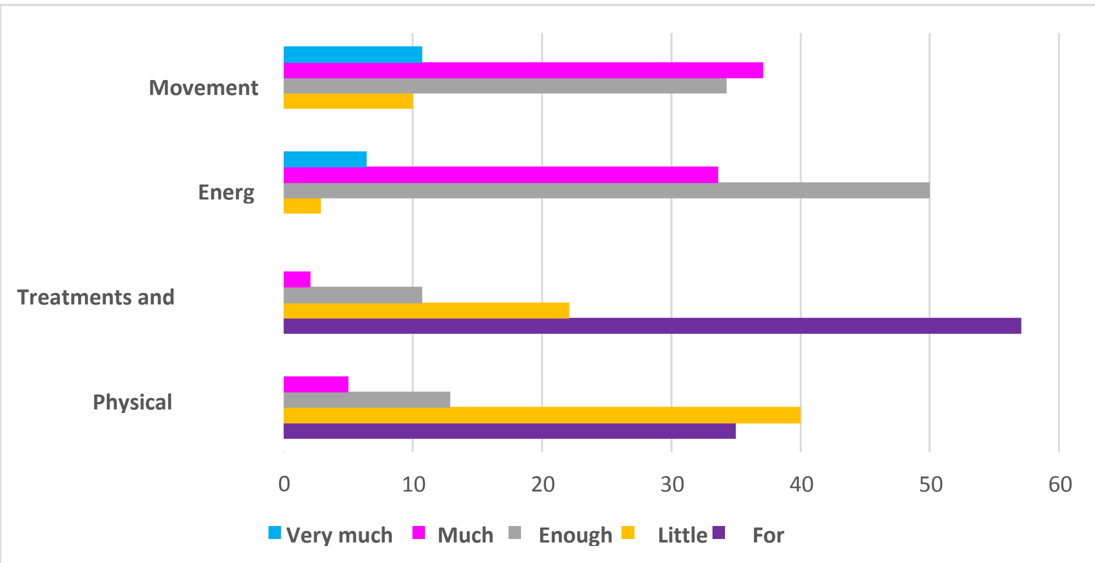


Fig. 5 Frequencies (% values) of some variables in the post-test phase

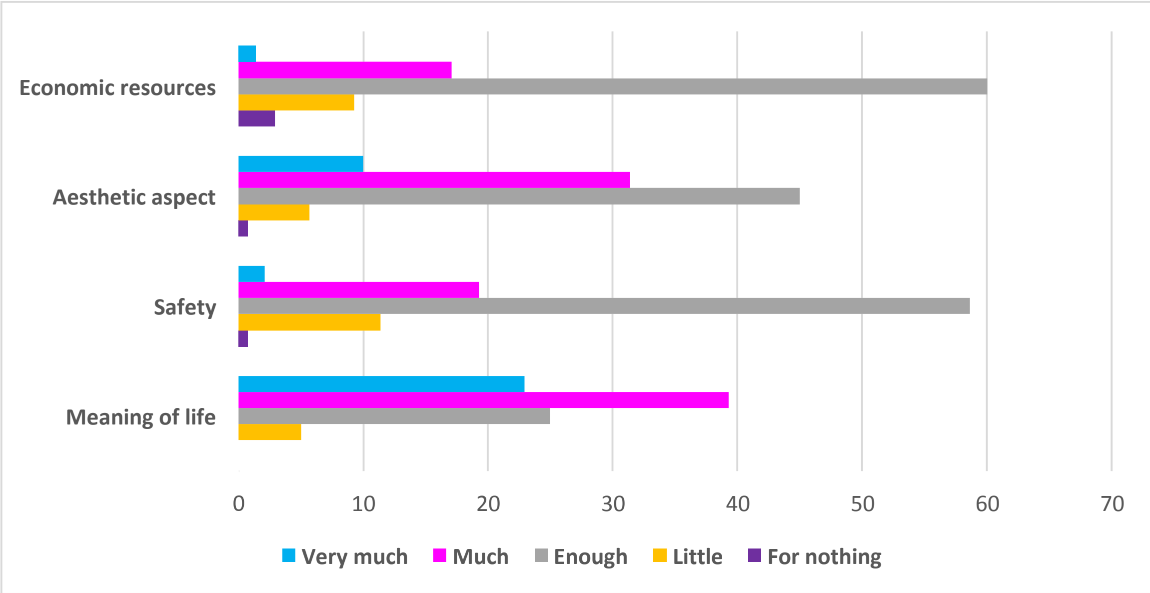


Fig. 6 Frequencies (% values) of some variables in the post-test phase

Good are the degree of satisfaction with oneself, with the sleep'quality and with the ability to commit daily ("satisfied" in 54.3%, 43.6%, 57.9%, respectively); compared to the previous phase, there is a marked improvement in social relationships and relationships with friends ("satisfied" in 47.1%) (Fig. 7, 8).

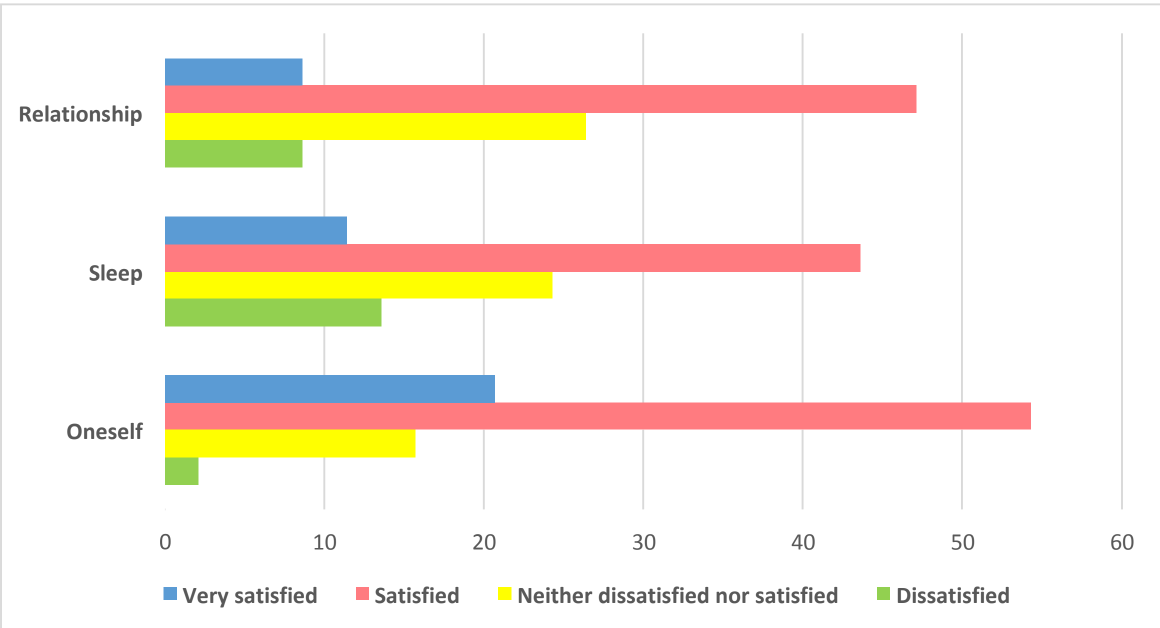


Fig.7 Satisfaction (% values) of some variables in the post-test phase

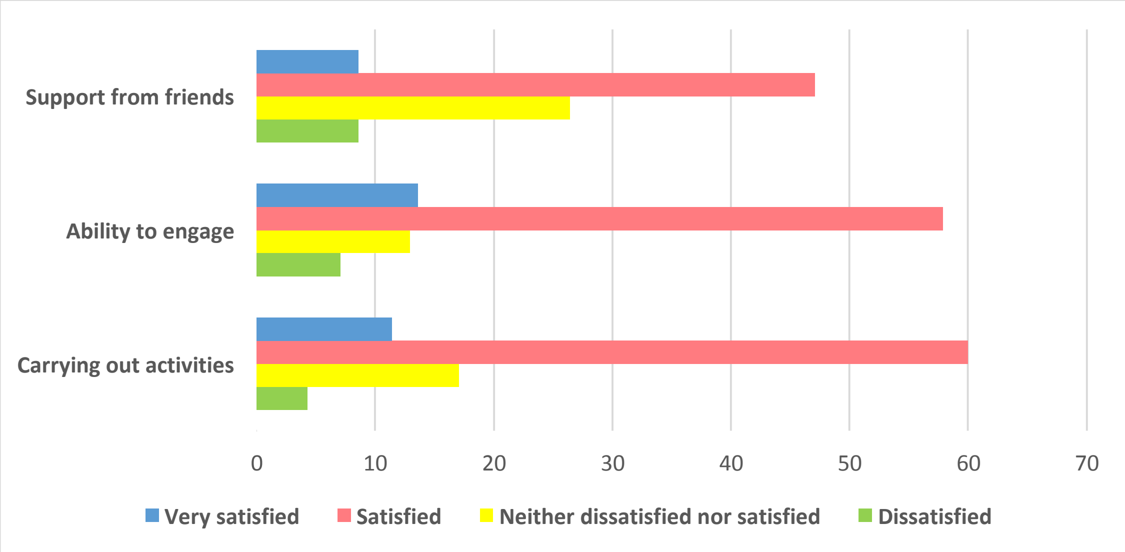


Fig. 8 Satisfaction (% values) of some variables in the post-test phase

Good levels of satisfaction also in relation to the conditions of one's home and accessibility to health services ("satisfied" in 55% and 37.9%). On the other hand, the quality and availability of public means of transport can be improved ("not very satisfied" in 31.5%) (Fig. 9, 10).

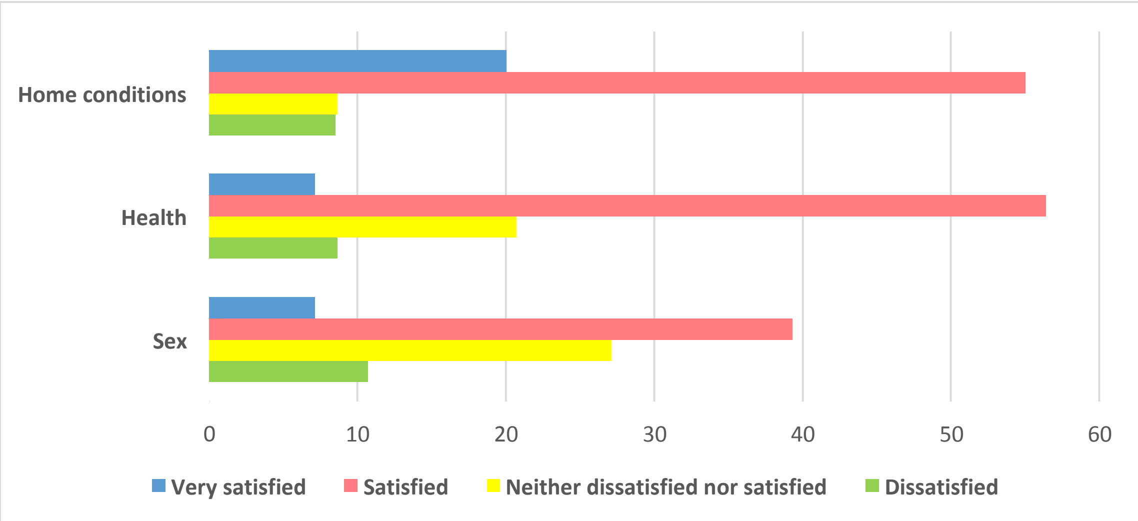


Fig.9 Satisfaction (% values) of some variables in the post-test phase

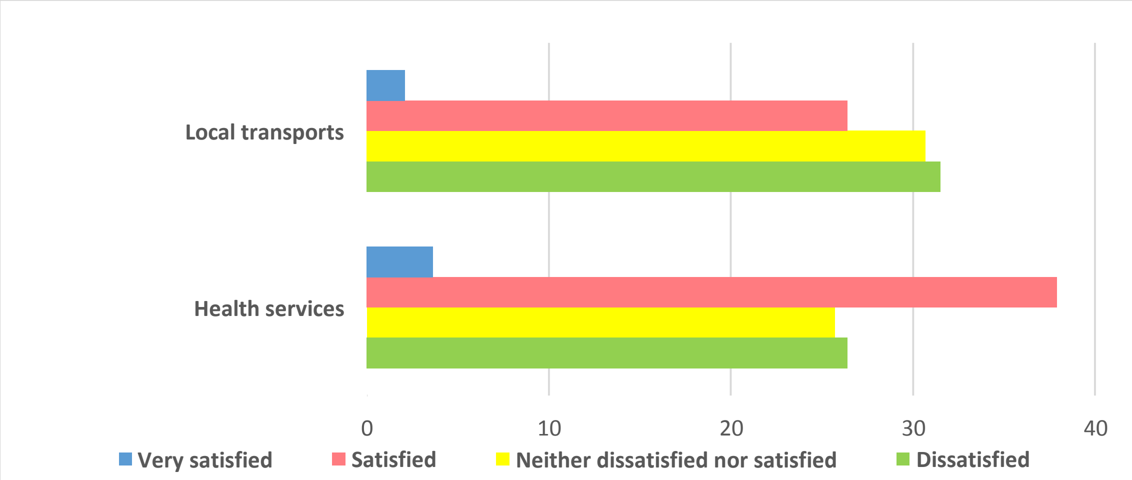


Fig.10 Satisfaction (% values) of some variables in the post-test phase

In relation to the their home'distance from Liberty Avenue, some trends are highlighted. Even though most of the sample does not report any changes in their health (59.3% answered "No"), residents within 30 m of Liberty Avenue report more frequently something that is not physically wrong (21.4% compared to 12% of the inhabitants over 100m); the latter, who lives farther from the avenue, report "very good" physical health conditions more frequently than the closest residents (12.2% vs 3.6%). On the other hand, 67.9% within 30m enjoy life "enough" but the percentage of those who enjoy "very / very" their lives increases, moving away from the avenue (14.6% over 100 m vs 3.6% within 30 m); similarly, the same trend is observed for concentration levels ("very much" in 3.6% within 30 m vs 17.1% over 100 m), as well as sleep quality ("very satisfied" in 7.1% within 30 m respect to 14.6% over 100 m). Finally, who lives within 30 m of the avenue most often experience negative feelings ("often / very often" in 32.2% compared to 19.5% in over 100 m).

CONTINGENCY TABLES (PEARSON'TESTS) BETWEEN PRE AND POST PHASE

Below we report the results of the Chi-Square Test, obtained with the contingency tables between each question and the various percentages that emerged in both phases (TAB.1-TAB.22). An association ($P<0.05$) is noted for each question because the answers are significantly different in the 2 samples. We cannot conclude that the intervention took effect because the evaluations are not repeated on the same subjects but surely that 2 samples have significantly different characteristics for each variable investigated.

How do you evaluate your life'quality?	PRE-TEST			POST-TEST		
	Bad	Neither good nor bad	Good-Very good	Bad	Neither good nor bad	Good-Very good
	19,8%	55,9%	17%	2,9%	23,6%	67,1%
Chi-Square	Value		gl		P value	
	96,614[a]		5		< 0.001	

Tab.1 Contingency table between life'quality and 2 phases

Are you satisfied with your health?	PRE-TEST			POST-TEST		
	Disatisfied	Neither disatisfied nor satisfied	Satisfied-Very satisfied	Disatisfied	Neither disatisfied nor satisfied	Satisfied-Very satisfied
	2,8%	20,3%	68,3%	8,6%	20,7%	63,5%
Chi-Square	Value		gl		P value	
	23,863[a]		4		< 0.001	

Tab.2 Contingency table between status health and 2 phases

How much do physical pains prevent its activities?	PRE-TEST			POST-TEST		
	For nothing-a bit	Enough	Much-Very much	For nothing-A bit	Enough	Much-Very much
	1,7%	48%	42,9%	75%	12,9%	5%
Chi-Square	Value		gl		P value	
	202,620[a]		5		< 0.001	

Tab.3 Contingency table between physical pain and 2 phases

Do you need treatments or therapies?	PRE-TEST			POST-TEST		
	For nothing-A bit	Enough	Much-Very much	For nothing-A bit	Enough	Much-Very much
	15,8%	58,8%	18,6%	79,2%	10,7%	2,1%
Chi-Square	Value		gl		**P value**	
	171,090[a]		5		< 0.001	

Tab.4 Contingency table between medical treatment and 2 phases

How much do you enjoy your life?	PRE-TEST			POST-TEST		
	For nothing-A bit	Enough	Much-Very much	For nothing-A bit	Enough	Much-Very much
	39%	47,5%	7,3%	25%	52,9%	15%
Chi-Square	Value		gl		**P value**	
	26,770[a]		5		< 0.001	

Tab.5 Contingency table between life'enjoy and 2 phases

Do you think your life has meaning?	PRE-TEST			POST-TEST		
	For nothing-A bit	Enough	Much-Very much	For nothing-A bit	Enough	Much-Very much
	5,1%	47,5%	41,3%	5%	25%	71,2%
Chi-Square	Value		gl		**P value**	
	44,874[a]		5		< 0.001	

Tab.6 Contingency table between life'meaning and 2 phases

Can you concentrate on things you do?	PRE-TEST			POST-TEST		
	For nothing-A bit	Enough	Much-Very much	For nothing-A bit	Enough	Much-Very much
	7,9%	49,2%	36,2%	5%	43,6%	45%
Chi-Square	Value		gl		P value	
	17,542[a]		5		0.004	

Tab.7 Contingency table between concentration and 2 phases

How confident do you feel in everyday life?	PRE-TEST			POST-TEST		
	For nothing-A bit	Enough	Much-Very much	For nothing-A bit	Enough	Much-Very much
	13%	61,6%	18,6%	12,1%	58,6%	21,4%
Chi-Square	Value		gl		P value	
	12,244[a]		5		0,032	

Tab.8 Contingency table between security and 2 phases

How safe is the environment for your health?	PRE-TEST			POST-TEST		
	For nothing-A bit	Enough	Much-Very much	For nothing-A bit	Enough	Much-Very much
	5,1%	57,6%	30,5%	30%	59,3%	5%
Chi-Square	Value		gl		P value	
	64,063[a]		5		< 0.001	

Tab.9 Contingenct table between environment security and 2 phases

Do you have energy you need to do business?	**PRE-TEST**			**POST-TEST**		
	For nothing-A bit	Enough	Much-Very much	For nothing-A bit	Enough	Much-Very much
	32,8%	42,9%	17,5%	2,9%	50%	40%
Chi-Square	Value		gl		**P value**	
	60,354[a]		5		< 0.001	

Tab.10 Contingency table between energy and 2 phases

Do you accept your physical appearance?	**PRE-TEST**			**POST-TEST**		
	For nothing-A bit	Enough	Much-Very much	For nothing-A bit	Enough	Much-Very much
	10,2%	26,6%	56,5%	6,4%	45%	41,4%
Chi-Square	Value		gl		**P value**	
	22,594[a]		5		< 0.001	

Tab.11 Contingency table between appearance and 2 phases

Are the economic resources sufficient for your needs?	**PRE-TEST**			**POST-TEST**		
	For nothing-A bit	Enough	Much-Very much	For nothing-A bit	Enough	Much-Very much
	11,3%	29,4%	52,6%	12,2%	60%	18,5%
Chi-Square	Value		gl		**P value**	
	54,763[a]		5		< 0.001	

Tab.12 Contingency table between economic resources and 2 phases

Is the information available sufficient?	**PRE-TEST**			**POST-TEST**		
	For nothing-A bit	Enough	Much-Very much	For nothing-A bit	Enough	Much-Very much
	5,1%	18,6%	68,9%	5%	58,6%	29,3%
Chi-Square	Value		gl		**P value**	
	69,465[a]		5		< 0.001	

Tab.13 Contingency table between information and 2 phases

Do you engage in leisure activities?	**PRE-TEST**			**POST-TEST**		
	For nothing-A bit	Enough	Much-Very much	For nothing-A bit	Enough	Much-Very much
	6,7%	17,5%	67,8%	28,6%	43,6%	20,7%
Chi-Square	Value		gl		**P value**	
	84,308[a]		5		< 0.001	

Tab.14 Contingency table between hobbies and 2 phases

How can you move?	**PRE-TEST**			**POST-TEST**		
	For nothing-A bit	Enough	Much-Very much	For nothing-A bit	Enough	Much-Very much
	5,6%	16,9%	70%	10%	34,3%	47,8%
Chi-Square	Value		gl		**P value**	
	26,113[a]		4		< 0.001	

Tab.15 Contingency table between movements and 2 phases

Are you satisfied with how you sleep?	PRE-TEST			POST-TEST		
	Disatisfied	Neither disatisfied nor satisfied	Satisfied-Very satisfied	Disatisfied	Neither disatisfied nor satisfied	Satisfied-Very satisfied
	5,1%	11,3%	76,3%	13,6%	24,3%	55%
Chi-Square	Value		gl		P value	
	26,942[a]		5		< 0.001	

Tab.16 Contingency table between sleep and 2 phases

Are you satisfied with how you manage your daily activities?	PRE-TEST			POST-TEST		
	Disatisfied	Neither disatisfied nor satisfied	Satisfied-Very satisfied	Disatisfied	Neither disatisfied nor satisfied	Satisfied-Very satisfied
	12,5%	23,2%	51,4%	4,3%	17,1%	71,4%
Chi-Square	Value		gl		P value	
	13,177[a]		5		0.022	

Tab.17 Contingency table between daily activities and 2 phases

Are you satisfied with your ability to engage in things?	PRE-TEST			POST-TEST		
	Disatisfied	Neither disatisfied nor satisfied	Satisfied-Very satisfied	Disatisfied	Neither disatisfied nor satisfied	Satisfied-Very satisfied
	3,4%	27,1%	60,4%	7,1%	12,9%	71,5%
Chi-Square	Value		gl		P value	
	15,713[a]		4		0.003	

Tab.18 Contingency table between activities'ability and 2 phases

Are you satisfied with yourself?	PRE-TEST			POST-TEST		
	Disatisfied	Neither disatisfied nor satisfied	Satisfied-Very satisfied	Disatisfied	Neither disatisfied nor satisfied	Satisfied-Very satisfied
	4%	20,9%	67,8%	2,1%	15,7%	75%
Chi-Square	Value	gl			P value	
	10,684ª	4			0.030	

Tab.19 Contingency table between pesonal satisfaction and 2 phases

Are you satisfied with relationships with others?	PRE-TEST			POST-TEST		
	Disatisfied	Neither disatisfied nor satisfied	Satisfied-Very satisfied	Disatisfied	Neither disatisfied nor satisfied	Satisfied-Very satisfied
	19,2%	31,6%	40,7%	9,3%	14,3%	69,3%
Chi-Square	Value	gl			P value	
	35,307ª	5			< 0.001	

Tab.20 Contingency table between relationships and 2 phases

Are you satisfied with your sexual activity?	PRE-TEST			POST-TEST		
	Disatisfied	Neither disatisfied nor satisfied	Satisfied-Very satisfied	Disatisfied	Neither disatisfied nor satisfied	Satisfied-Very satisfied
	29,9%	29,4%	31%	10,7%	27,1%	46,4%
Chi-Square	Value	gl			P value	
	37,783ª	5			< 0.001	

Tab.21 Contingency table between sexual activity and 2 phases

Are you satisfied with the support of your friends?	PRE-TEST			POST-TEST		
	Disatisfied	Neither disatisfied nor satisfied	Satisfied-Very satisfied	Disatisfied	Neither disatisfied nor satisfied	Satisfied-Very satisfied
	73,4%	15,8%	3,9%	8,6%	26,4%	55,7%
Chi-Square	Value		gl		**P value**	
	168,416[a]		5		< 0.001	

Tab.22 Contingency table between friends'support and 2 phases

CONTINGENCY TABLES IN RELATION TO HOME'POSITION

Also in Post-test, we used the contingency tables between 2 selected variables ("Does your home overlook Liberty Avenue?" and «Distance from Liberty Avenue») and each questions; in particular, we have noted an significant association (P <0.05) for 3 variables, different by first phase (Tab.23, Tab.24, Tab.25, Tab.26).

Does your home overlook Liberty Avenue?	**Are you satisfied with the support of your friends?**		
	Disatisfied-Very disatisfied	Neither disatisfied nor satisfied	Satisfied- Very satisfied
No	5,6%	23,5%	58,9%
Yes	18,8%	37,5%	43,7%
Chi-Square	Value	gl	P value
	14.000[a]	5	**0.016**

Tab.23 Contingency table between home'position and friends'support (Post-test)

Distance from Liberty Avenue	Are you satisfied with your ability to engage in things?		
	Disatisfied-Very disatisfied	Neither disatified nor satisfied	Satisfied-Very satisfied
0-30m	7,1%	10,7%	75%
31-100m	2,8%	9,9%	81,7%
Oltre 100m	14,6%	19,5%	51,2%
Chi-Square	Value	gl	P value
	16.249[a]	8	**0.039**

Tab.24 Contingency table between home'distance and ability in activities (Post-test)

Does your home overlook Liberty Avenue?	How much do you enjoy your life?		
	For nothing-A bit	Enough	Much-Very much
No	29%	44,9%	17,7%
Yes	12,5%	78,1%	6,3%
Chi-Square	Value	gl	P value
	11.740[a]	5	**0.039**

Tab.25 Contingency table between home'position and life'enjoy (Post-test)

Does your home overlook Liberty Avenue?	Are you satisfied with your home'conditions?		
	Disatisfied-Very diatisfied	Neither disatisfied nor satisfied	Satisfied-Very satisfied
No	8,4%	5,6%	75,7%
Yes	9,4%	15,6%	75,1%
Chi-Square	Value	gl	P value
	12,608[a]	5	**0.027**

Tab.26 Contingency table between home'position and home'satisfaction (Post-test)

CONCLUSIONS

Despite the limited number of responses received through the self-administered questionnaire in paper or electronic format (approximately 31% of the cases envisaged by the sample design in the first phase and approximately 26% in the second), the questionnaires provided an interesting photograph of the residents. In addition, they highlighted some changes in the post-intervention phase. Despite some limitations of the study in question, such as the small size of the sample, a sub-optimal mismatch between the two phases and the lack of incompleteness of some responses from the interviewees, we want to highlight some important aspects that emerged from this evaluation.First of all, the champion has always shown satisfactory levels of his quality of life, his social status, housing conditions; a framework already present in the initial phase, reconfirmed after the structural interventions on the neighborhood and even improved with regards to social relationships and friends'support.

However, differences emerge in relation to the home'location.

For example, among who lives near Liberty Avenue, there is a greater degree of satisfaction regarding the safety of the district, the quality of local transports and health services; instead, other aspects have always been highlighted in relation to the position of the home, such as a greater social network, a more positive attitude in enjoying life, satisfying relationships with friends, satisfaction with the home'conditions, in particular among those who live at an intermediate distance from Liberty Avenue (between 31 and 100 meters). However, we believe that these aspects are attributable to many heterogeneous factors to be investigated, including socio-demographic factors, income brackets, age and employment.

But the statistically most relevant data emerged from the comparison of the 2 phases is another. In the "pre" phase, a significant association emerged between some negative symptoms related to poor quality of life (such as sleep disturbances and difficulty concentrating) and the home'position.

In fact, the subjects most exposed to urban noise as residents near the avenue presented the typical symptoms of this phenomenon. Instead, in the "post" phase, this significance was no longer found.

We could therefore hypothesize, or at least not exclude, that the structural interventions of the LIFEMONZA Project on the neighborhood had a positive impact on some aspects of the lives of the residents.

Bottom-up actions – MONZA

Methodologies fOr Noise low emission Zones introduction And management

LIFE15 ENV/IT/000586

LIFE MONZA
Methodologies fOr Noise low emission Zones introduction And management

Deliverable	Report on Ante and Post operam data collection
Action/Sub-action	B5.5 “Bottom up actions: ex ante/ex post people participation”
Authors	Jonathan Monti
Status - date	Final Version- 03-05-2020

Beneficiary:	Comune di Monza
Contact person:	Jonathan Monti
E-mail:	jmonti@comune.monza.it
Project Website:	www.lifemonza.eu

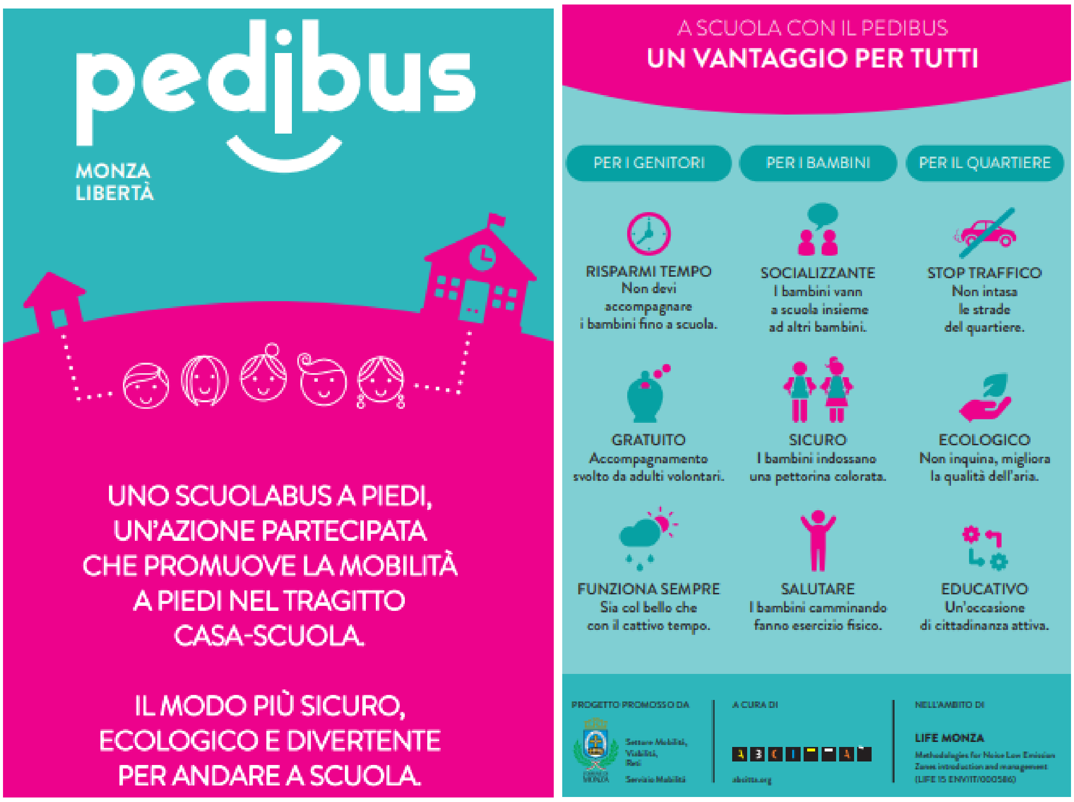
1. Involvement of people: questionnaires

The questionnaires for the post-operam phase were sent out on 24th April 2019 and achieved positive evaluations.
In mid-July, about 490 recall letters were sent to the selected people for the completion of the questionnaires on perceived well-being in the pilot area.

2. Pedibus

The "Gianni Rodari" Primary School has become a meeting point for families of children, parents and grandparents, who can, therefore, allow the school institution to collaborate with the Administration for the realization of the Pedibus. In this way, it is possible to extend the task of education also to the local and city context. For this reason, during a meeting, the headmaster of the school has spread all the information to the parents. Moreover, a visit has been carried out in the neighbourhood in order to define the Pedibus routes together with the staff of the Local Police and the representatives of the different figures involved. ABCittà has managed two dissemination/ information points outside the school and it started collecting registrations for the red line and the other two lines.
First results were successful: 11 subscribed on the red line, 6 on the green line and 2 on the blue line. The red line involved the highest number of participants and was the first line to start experimentally every day of the week.
The importance of these meetings and the spread of this action in school has led to a growing interest in participating in the Pedibus LIFE project.

The information leaflet for the spread of the Pedibus follows.



3. School mobility survey

On 12th February 2019, a meeting was held at the Libertà Civic Centre. The meeting was crucial for the activation of the service, as people who participated were volunteers and parents interested in enrolling their children in the pedibus.
On that occasion, ABCittà illustrated the results of the preparatory survey for the launch of the pedibus on school mobility promoted by the project in the “Rodari” School. The study was conducted in order to identify the habits of home-school travel and anticipate the Pedibus as an alternative option. According to the survey, the routes of the three Pedibus lines were identified and the date for the start of the service was scheduled.

In January 2019, 312 questionnaires were distributed to all pupils of the school and then 229 completed questionnaires (73% of the total) were collected and analysed achieving positive results.
The survey on school mobility described the home-school travels. The number of children who go to school by car is always higher than the number of those who go on foot (116 by car versus 114 on foot), few children use bicycles (5-2) or public transport (5). Mothers mainly accompany their children (49%), followed by fathers (32%) and grandparents (11%).
The reason why they use the car is "because it is needed to go to work" (35%), “because of the distance between home and school” (24%), “because of the hurry” (15%), “because of the weather” (8%).
The reasons they do not walk are the “distance” (23%), the "dangerousness of the journey" (18%), the "weight of the backpack" (17%), the "traffic" (11%) and, the "weather" (8%).
For the promotion/participation of the Pedibus activity:
- 27% of the interviewed said to be interested in enrolling their child in the Pedibus (a total of 63 families);
- only 3% (7 parents) are willing to become an accompanying person.
The above-mentioned survey results showed that school mobility in the Libertà district is not at a good level of sustainability and children's autonomy is very limited. A significant number of those interested in the "Pedibus-Service" do not correspond to an equal number of willing parents immediately available to accompanying groups of pupils.
The Consulta has been a strategic reference point for the Pedibus, which becomes, thanks to this, an important element for the neighbourhood. The community of volunteers has activated the action with the aim of consolidating the collaboration between parents and school. Two groups of volunteers recognized the strong impact of the action. They are the “Gruppo del Controllo del Vicinato” and the “Gruppi di Cammino” that were immediately operative in the Pedibus action and able to support sustainable school mobility.
In the months of April-June 2019, a group of about ten volunteers formed the "Pedibus del quartiere Libertà", which not only provided a service to the school community but also demonstrated the validity of a model appreciated by parents.

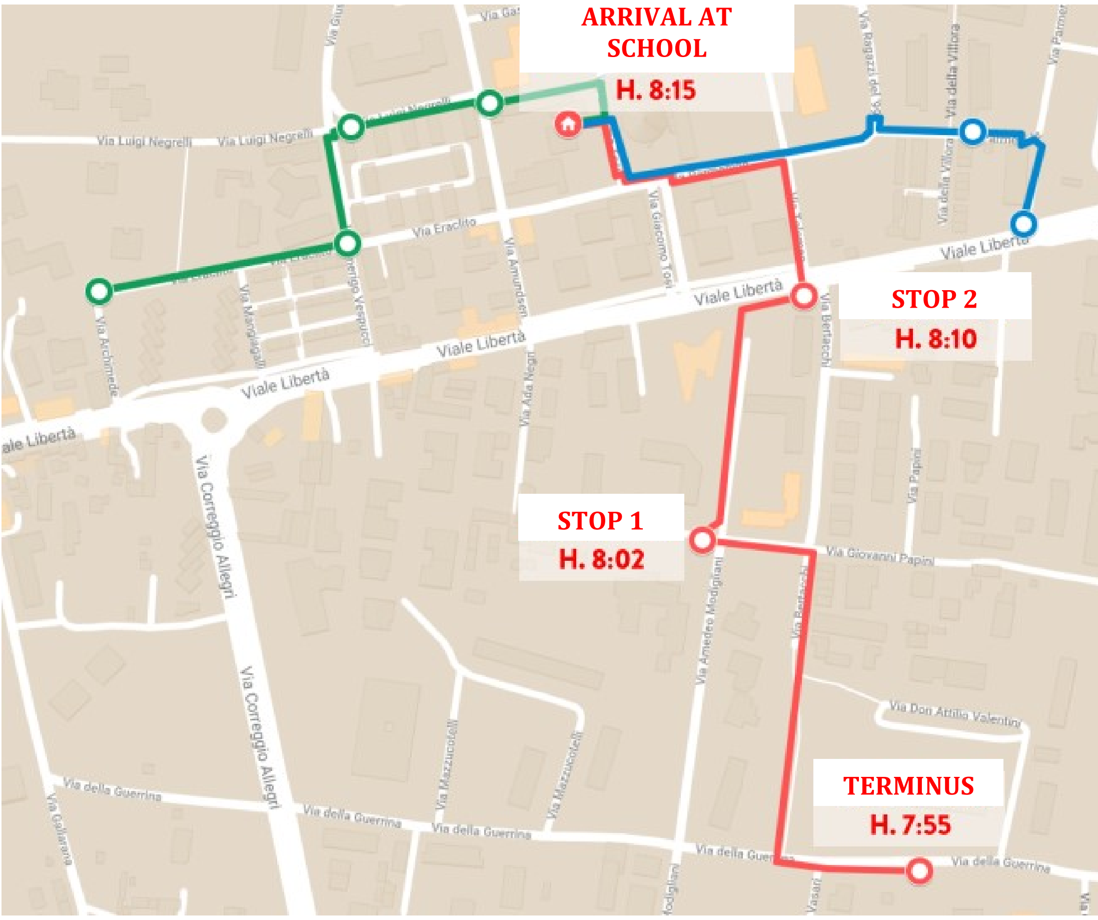
4. Rules and beginning of Pedibus action

The Pedibus is a "school bus on foot": an enjoyable, healthy and safe way for children and young people to take their first steps towards autonomy. It is also a way to get to know their neighbourhood, socialize with others and concretely promote sustainable mobility on the home-school travels. The regulation defined the lines to be followed:

- the enrolled children, organized in small groups, are accompanied by volunteers (one for every 5-10 children) to go to school following itineraries certified by the Local Police.

- Each line has an itinerary that starts from a terminus, follows an established route and collects the children-passengers at the various "Pedibus stops" along the way, respecting the set timetables.
- Each line has a group of accompanying persons, one of whom is the contact person for the line. Each contact person on the line fills in the logbook, reports any problems encountered (obstacles on the route, children who do not respect the rules, etc.) and collects proposals for the improvement to be communicated to the project representatives (institutional or not).
- The Pedibus is active in all the weather conditions, according to the school calendar and the choices of each school participating in the project.

The Pedibus started on 11th April 2019, for the children of the "Rodari" Primary School in Via Tosi. The lines start from Via Papini/Bertacchi, in the southern part of Viale Libertà, pass through the civic centre and arrive at school. The first Red Line has four stops: Via della Guerrina (7.55 a.m.), Via Modigliani, Via Bertacchi and the school. On May 14th, the Green Line started from via Archimede.
In 2019, the Blue Line was activated from Viale Libertà.
In the figures below are reported a diagram of the routes of the Pedibus lines, the timetables of the Red line and an image of a group during the Pedibus service.



5. Improvements for the Pedibus

At the end of the year, the school recognized the educational and social value of the action by including the Pedibus in the Three-Year Plan of the Educational Offer.
In the summer break between the first and the second year of the Pedibus, the collaboration between School, Local Administration, Volunteers and Parents Association has allowed improving the model. As a matter of fact, it was arranged the realization and positioning of the Pedibus signs along the routes tested in the first year and the attention to safety and insurance of children and involved adults was paid.

In addition to the certification of the lines guaranteed by the Administration and carried out with the support of the Local Police, the insurance matter has been considered in detail. Children are already covered by the insurance on the home-school travels, as the insurance is provided by the school. On the other hand, volunteers have been recognized for their commitment in the realization of a project included in the PTOF (an acronym which stands for the Three-Year Plan of the Educational Offer) and a symbol of a strong collaboration between school and community institutions. For this reason, they have been covered by insurance as well.
In the first year of start-up, a collaboration with the Parents' Association (to whom we would like to express our heartfelt thanks) has been activated and it decided to extend its insurance also to Pedibus volunteers; whereas from the second year it has been possible to insert the Pedibus in the municipal insurance that covers volunteers.

The Pedibus action has contributed to awareness-raising and education to sustainability. The contribution has not only interested the children enrolled in the Pedibus, but also the others, who had the opportunity to reflect on environmental issues that are increasingly topical, thanks to the inclusion of the Pedibus in the PTOF. On 21st October 2019, an informative and formative meeting on the theme "School mobility, Pedibus and environment" was organized and carried out for the teaching staff of the two schools. The educational value of the project was presented to the teachers and the realization of workshops in the classrooms was proposed. A kit of educational cards related to the Pedibus (the so-called "Kit di Schede didattiche Pedibus") was distributed for a development programme of the action and an autonomous implementation of exercises and activities on the issues during the period January-June 2020.

6. Conclusions and future developments of the APP

The traffic in front of the school during the hours of entry and exit was interpreted as a signal of need from parents. As a matter of fact, the number of cars can be reduced thanks to the Pedibus, as it is not strictly necessary to accompany children to school, but it is possible to reach any of the "Pedibus stops" for entrusting children to volunteers.
Three results have been obtained:

1. guaranteeing greater autonomy to children and young people,
2. reducing the number of cars in front of the school,
3. arriving at the workplace in advance avoiding the search for a parking lot in front of the school.

The Pedibus Libertà aims not only at its continuation beyond the support offered by the LIFE Project, but it can be considered as a reference model for a new Pedibus of the city, which could be proposed in the other districts.
Among the bottom-up activities for the involvement of the population, there was also the development of a free "LIFE MONZA" App, which provided updated information on the project, helped the management of the Pedibus service by parents and volunteers and stimulated sustainable lifestyles through the awarding of "green points". The app has been activated in the post-operam phase of the project and is useful for the Pedibus activity.

The app is an important tool to encourage the involvement of citizens in the activities of their municipality. It is available for both Android and iOS.
The app provides four sections:
1. Information Section on the Life MONZA project, where you can display data related to objectives, results and acoustic monitoring campaigns in the Libertà district;
2. Pedibus Section, which allows parents to book stops for their children and verify that the travel to school has not encountered any problems;
3. Green Points Section, where it is possible to start collecting points that reward sustainable mobility choices within the Libertà district (as displayed in the figure below);
4. Sensors Section, which allows to view the map of smart sensors in the neighbourhood and continuously detect their functioning over time in the area.

The App has been thought for three different users: basic user, volunteer or parent. The latter two profiles are particularly useful for the Pedibus service since the app allows the volunteer to detect the presences of children participating in the Pedibus, day by day, on the itinerary of interest. On the other hand, parents can book and monitor the accompanying service at school for their children.

A web application that acts as a control panel for the Municipality of Monza has been created, so it is possible to verify the correct functioning of the app and authorize users with relevant roles (e.g. Pedibus volunteers).

Intermediate assessment and Top down /bottom up overall data collection and systematization – VIENROSE

Life MONZA

Methodologies fOr Noise low emission Zones introduction And management

LIFE15 ENV/IT/000586

LIFE MONZA
Methodologies fOr Noise low emission Zones introduction And management

Technical Report

Deliverable	Report on Ante and Post Operam data collection
Action/Sub-action	B5.7 – "Intermediate assessment and Top down /bottom up overall data collection and systematization"
Authors	Raffaella Bellomini, Sergio Luzzi, Lucia Busa, Gianfrancesco Colucci, Giacomo Nocentini.
Status - date	Final version- 05/06/2020

Beneficiary:	Vie en.ro.se. Ingegneria srl
Contact person:	Raffaella Bellomini
E-mail:	raffaella.bellomini@vienrose.it
Website:	www.lifemonza.eu

This chapter provides an overview of the data collected in the post-operam phase of the project (see the attached documents), partly referred to in the previous chapters of this report, containing data from the monitoring of environmental components, linked to top-down actions, and data related to bottom-up activities. The attached documents are an integral part of the study carried out within the Life Monza project for the specific action B5 "Monitoring and data collection for impact assessment".

1. Systematisation of Top-down action data

The following table shows a scheme of the data collected in the top-down actions, in the ante operam phase of the project. For each activity carried out (column 1), the survey periods (column 2), any problems encountered or relevant notes (column 3), the reference to the corresponding annex (column 4) and the verification according to the planned activities (column 5) have been reported.

Table 1 – Systematisation of data collected in the post operam phase with regard to top-down actions

ACTIVITY	PERIOD	CHECK NOTES	ATTACHED DOCUMENTS	CHECK
Smart Noise Monitoring System- Data per hour	01/07/2018-31/12/2019	On June 29th, an interruption in the operation of the sensor located at the “Liceo Porta” was verified. On 9th July 2019, a replacement of the battery and internal board of the prototype installed in Via Correggio was scheduled. On 16th August 2019, there was again an interruption in the operation of the sensor located at the “Liceo Porta”, due to the temporary interruption of the power supply for external causes. On 17th December 2019, the damaged sensor on Viale della Libertà was replaced. On the same day (17/12), the battery of the sensor on Via Impastato was replaced and after the replacement it did not start again.	Attached document n.17	✓
Smart Noise Monitoring System- Data per day	01/07/2018-31/12/2019		Attached document n.18	✓
Smart Noise Monitoring System- Data per week	01/07/2018-31/12/2019		Attached document n.19	✓
Smart Noise Monitoring System- Harmonica Index	01/07/2018-31/12/2019		Attached document n.20	✓
Smart Noise Monitoring System- Sensor calibration	01/07/2018-31/12/2019		Attached document n.21	✓
Smart Noise Monitoring System- Broadband control	01/07/2018-31/12/2019		Attached document n.22	✓

		The sensor and battery will be reinstalled in June 2020. There has been a delay in the moving of data to the server of the Municipality of Monza, expected by January/February 2019. For technical reasons it has been decided to arrange the data transfer from the UNIFI Server to the one purchased by the Municipality of Monza at the end of the post-operam monitoring phase. The data shift was almost completed at the end of April 2020.		
Smart Noise Monitoring Sistem- Position correction	01/07/2018-31/12/2019		Attached document n.23	✓
Smart Noise Monitoring System- weekly data with regard to the first quarter of 2020	January-March 2020	It was considered to analyze the LAeq data provided by the smart monitoring units in the January-March 2020 quarter, to detect the impact on noise during the Covid-19 pandemic.	Attached document n.24	✓
3rd noise/traffic monitoring campaign - Instrument calibration certificates	21/01/2019-29/01/2019		Attached document n.25	✓
3rd noise/traffic monitoring campaign - Monitoring boards	21/01/2019-29/01/2019		Attached document n.26	✓

4th noise/traffic monitoring campaign - Instrument calibration certificates	06/05/2019-14/05/2019		Attached document n.27	✓
4th noise/traffic monitoring campaign - Monitoring boards	06/05/2019-14/05/2019	Some periods (highlighted in the time history) have been excluded from the calculation of the LAeq due to the adverse weather conditions (rain). Other periods, monitored from the station located at the “Modigliani” kindergarten, were excluded due to the presence of road works.	Attached document n.28	✓
Noise/traffic monitoring – Acoustic maps	May 2017- May 2019		Attached document n.29	✓
Air quality monitoring campaign	2019		Attached document n.30	✓

2. Systematisation of Bottom-up action data

This section shows the data related to Bottom-up actions, summarized in the following table.

Table 2 – Systematisation of data collected in the ante operam phase with regard to bottom-down actions

ACTIVITY	PERIOD	CHECK NOTES	ATTACHED DOCUMENTS	CHECK
Sample survey questionnaires – correlation of simple analyses between ante and post operam phase	February 2018-June 2019		Attached document n.31	✓
Sample survey questionnaires – correlations between ante and post operam phase	February 2018-June 2019		Attached document n.32	✓

Sample survey questionnaires - correlations between question and housing position	February 2018- June 2019		Attached document n.33	✓
International Noise Awareness Day 2019	08/05/2019		Attached document n.34	✓
Communication activities	20/07/2016- 11/02/2020		Attached document n.35	✓
Use of the App	January 2020	The App has been working since January 2020.	Attached document n.36	✓
Pedibus service: results of the school mobility survey	January- February 2019		Attached document n.37	✓
Pedibus service: midterm report	21/03/2019		Attached document n.38	✓
Pedibus service: midterm report	30/07/2019		Attached document n.39	✓
Pedibus service: midterm report	31/12/2019		Attached document n.40	✓

Air quality: ex ante/ex post monitoring and modelling - ISPRA

Life MONZA
Methodologies fOr Noise low emission Zones introduction And management

Air quality: ex ante/ex post monitoring ISPRA

Life MONZA

Methodologies fOr Noise low emission Zones introduction And management

LIFE15 ENV/IT/000586

LIFE MONZA
Methodologies fOr Noise low emission Zones introduction And management

Technical Report on ante and post operam data collection

Deliverable	Report on Ante and Post Operam data collection
Action/Sub-action	B5.3 "Air quality ex ante/ ex post monitoring"
Authors	Andrea Algieri, Cristina Colombi, Umberto Dal Santo, Giorgio Cattani
Status - date	Draft – 14 may 2020

Beneficiary:	ISPRA
Contact person:	Salvatore Curcuruto
E-mail:	salvatore.curcuruto@isprambiente.it
Project Website:	http://www.lifemonza.eu/

Sommario

1 Introduction

The LIFEMONZA project is aimed at introducing an easy-replicable method, and related guidelines, for the identification and the management of the Noise Low Emission Zone (NLEZ), an urban area subject to traffic restrictions, whose impacts and benefits regarding noise issues have been analyzed and tested in the pilot area of the city of Monza, located in North Italy. The infrastructural interventions, able to turn up the pilot area of Libertà district in Monza in a permanent NLEZ, named *Top-down measures*, have been carried out by the municipality, and they are the restriction of vehicles speed, the definition of traffic zone with forbidden access to trucks, the lanes-width reduction and pedestrian crossings introduction and the substitution of the current asphalt with a silent one. In order to involve the inhabitants of the area, many different actions, named *Bottom up measures*, as lessons and meetings in primary and high schools to raise awareness about noise effects, ideas contest for students, *pedibus* service for schoolchildren, have been realized. Other objectives of the project were the evaluation of complementary effects on the air quality and benefits on wellbeing conditions of the residents.

The realization of Low Emission Zones (LEZs), urban areas subject to different kinds of road traffic restrictions, primarily introduced in order to ensure compliance with the air pollutants limit values set by the European Directive on ambient air quality 2008/50/EC, is a well-established measure carried out by the cities and the effects on air quality have been analyzed in detail. Restrictions of road traffic in urban areas can be adopted through environmental zones, city tolls, congestion charging, distinguished by vehicle types, speeds and emission standards and the interventions are often used as urban redevelopment. LEZs have been introduced in many European countries, mostly in Italy, and different regulations (e.g. ECORYS, 2014) at national and local levels have been developed, causing the need of a comprehensive and integrated management process, particularly regarding the environmental effects.

This report is focused on the monitoring strategy adopted for air quality assessment before and after the Monza NLEZ establishment and the related main results and lessons learned that could allow replicability in future assessments.

2 Health effects of air pollution

Air pollution has been widely accepted and recognized by this time to have an impact in terms of cardio-vascular as well as respiratory diseases than can lead to premature mortality.

WHO produced and subsequently revised air quality guidelines (WHO, 2000, 2006) that contain recommendations and targets for selected air pollutants derived from epidemiological and toxicological evidence.

Ambient (outdoor air pollution) in both cities and rural areas was estimated to cause 3.7 million premature deaths worldwide in 2012 (WHO, 2018).

Recently the International Agency for Research on Cancer (IARC) concluded that there is sufficient evidence that exposure to outdoor air pollution causes lung cancer. Particulate matter was evaluated separately and was also classified as carcinogenic to humans (IARC, 2013).

In recent years, 16 – 21 % of Europe's urban population may have been exposed to ambient PM10 concentrations above the EU limit set to protect human health. Up to 17 % of the population living in urban areas may have been exposed to levels of ozone that exceed the EU target value.

Estimates of the health impacts attributable to exposure to air pollution indicate that PM2.5 concentrations in 2013 were responsible for about 467 000 premature deaths in Europe (41 countries), and around 436 000 in the EU-28, originating from long-term exposure. Fine particulate matter (PM2.5) in air has been estimated to reduce life expectancy in the EU by more than eight months. The estimated impacts on the population in the same 41 European countries of exposure to NO2 and O3 concentrations in 2013 were around 71 000

and 17 000 premature deaths per year, respectively, and in the EU28 around 68 000 and 16 000 premature deaths per year, respectively (EEA, 2019).
Children and young adult represent the largest subpopulation of those susceptible to the adverse effects of air pollution. Compared to adults, they express a greater vulnerability, which can be explained by differences in the circumstances of exposure related to age, their activities, their child status, differences in lung anatomy and physiology, differences in the clinical expression of disease, and their organ maturity (WHO, 2013).
Recent studies suggested four pathways that could explain combined effects of air pollution and noise exposure on several cardiovascular events. It was suggested that within these adverse pathways air pollution and noise may overlap and act synergistically [Munzel et al., 2017a; Munzel et al., 2017b]. In order to improve the knowledge on additive or synergistic effects of simultaneous noise and air pollution exposure in humans, monitoring strategies and exposure assessment methodologies development are needed. Only a few studies addressed additive or synergistic effects of air pollution and traffic noise exposure of in humans. Although most of them suggest that air pollution and traffic noise mostly act as independent risk factors of CVD incidence and mortality, the opposite effect was observed in some studies, suggesting the relevance of monitoring design as an important driving for the epidemiologic studies, particularly because the interpretation of results of studies on road traffic noise and air pollution is complicated by the appreciable collinearity of these two environmental risk factors, particularly when traffic is the main noise source [Munzel et al., 2018].

3 Air pollution: sources, status and trend legislation

Air pollution is considered as a major environmental risk for human health; it increases the incidence of a wide range of diseases and has several environmental impacts, damaging vegetation and ecosystems.
The road transport sector provides a significant contribution to the total anthropogenic emissions, together with other mobile sources, non industrial combustion plants and combustion in energy and transformation industries. Other undesired substances (known as secondary pollutants e.g. ozone) may be formed in the atmosphere due to chemical reaction between pollutant directly emitted.
Control of exposure to air pollutants requires public authorities actions at global, regional and local level. The Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on ambient air quality and cleaner air for Europe defined and established objectives for ambient air quality designed to avoid, prevent or reduce harmful effects on human health and the environment as a whole. The ambient air quality in Member States must be assessed on the basis of common methods and criteria. Results of the ambient air quality assessment should be used in order to help combat air pollution and nuisance and to monitor long-term trends and improvements. Air quality plans should be developed for zones within which concentration of pollutants in ambient air exceed the relevant air quality target value. Moreover it is mandatory for the member states to ensure that such information on ambient air quality is made available to the public.
The pollutants targeted by the 2008/50/EC directive include particulate matter ($PM_{2.5}$, PM_{10}), ozone (O_3), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), carbon monoxide (CO), and lead (Pb), while similar provisions were established for benzo(a)pirene, arsenic cadmium and nickel as high concern PM_{10} toxic components by the 2004/107/EC directive.
Over the last twenty five years, the emissions of pollutants in Europe and in Italy have generally decreased considerably. The major drivers for the trend are reductions in the industrial and road transport sectors, due to the implementation of various European Directives which introduced new technologies, plant emission limits, the limitation of sulphur content in liquid fuels and the shift to cleaner fuels (natural gas in place of coal and fuel oil). Nevertheless there are some relevant countertrend, for instance in Italy PM_{10} emissions

from non industrial combustion plants, representing about 40% of the total, show a strong increase between 1990 and 2012, equal to 149% due to the increase of wood combustion for heating (ISPRA 2014).
Atmospheric pollution is an extremely complex phenomenon. The burden of pollutant resulting from human activities and natural source evolve in time and space trough the atmosphere. The transport, dilution, transformation and deposition mechanisms are driven by specific reactivity of the substances and the meteorological conditions, that are as well largely variable in time and space, and govern the dynamics of air pollutants after emission. This lead to a non-linear relationships between emission and outdoor air pollutants concentrations.
In the EU particulate matter, ozone and nitrogen oxides are the most critical pollutants, given the still high concentrations founded in the air, compared both with the European target and the WHO guidelines, despite the emissions reduction. A statistically significant moderate decreasing trend was found in the majority of the PM_{10}, and NO_2 Europe wide concentration time series, while any downward trend was found in the large majority of ozone time series.
Cities are major sources of pollution, due to city heating, energy production and transport. The majority of the people in the world live in urban areas.

4 Low emission zones

Low emission zones (LEZs) have been established to reduce air pollutant emissions and to improve urban air quality in European countries. LEZs usually regulate the access to a zone depending on the vehicle emission standards or the vehicle type (heavy-duty vehicles, light-duty vehicles, moped etc.). LEZs may cover a variable area that can include few roads or a large part of an urban area. Those zones aim mainly at reducing exhaust emissions of traffic related pollutant, particularly PM and nitrogen oxides NOX. Policy measures (as LEZs) to reduce traffic by banning the most polluting vehicles are generally able to reduce circulating vehicles but they gave conflicting results on air pollution level [Jones et al., 2012; Holman et al., 2015].
Results of air quality monitoring activities in NLEZ of LIFE MONZA enable an in-depth characterization of the urban area.

5 Air Quality monitoring and assessment methods in LIFE MONZA NLEZ

Pilot area and implemented top-down interventions

The pilot area selected in the framework of the LIFE MONZA project consists of the Libertà district of the city of Monza shown in Figure 1.

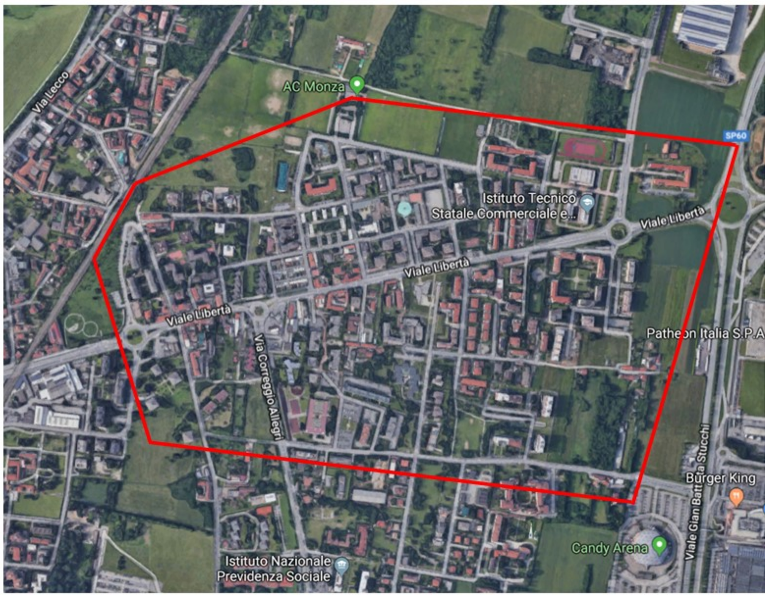


Figure 7. Perimeter of the pilot area ("Libertà" district, city of Monza).

In the selected pilot area a main road (Libertà street) and other roads affected by medium-low traffic are present. Significant average levels of noise pollution affect many citizens so that Libertà district is identified as a hotspot in the Action Plan of the city of Monza. The noise strategic map of the city of Monza, dated 2017, highlights that in a range of 30 m from the Viale Libertà almost the 100% of the receivers are exposed to levels higher than 65 dB(A) during the day and 55 dB(A) during the night.

With the aim to reduce the noise pollution in the pilot area two main interventions have been designed and implemented for the Libertà street: the laying of new low-noise paving and the closing of the road to the heavy vehicles. The low-noise asphalt represents the main instrument for the decrease, on large scale, of the traffic noise through interventions at the noise source and today several technologies are available based of composition, used materials and field of use.

For the laying of the asphalt, the typology "Dense graded at optimized weaving" has been chosen, which guarantees results of 3-4 dB(A) in term of acoustic abatement and an efficiency period about five years from the laying. This road surface has already been defined by "Progetto Leopoldo" whose results have been recognized by a deliberation of Regione Toscana in 2013 [DGR Toscana, 2013]. Progetto Leopoldo aimed to define a guideline for the design, building, control and maintenance of ordinary viability in Tuscany. This guideline allows to identify technologies, materials and kinds of interventions with the scope to improve the safety of the circulation and at the same time guarantees requests of eco-compatibility and duration. In the sample studied at Lucca, four years after the works a reduction of 5 dB(A) has been measured. In Figure 2 the section of Viale Libertà interested by the new asphalt laying is shown. In this road the work has foreseen the removal of the old road surface and the laying of 4 cm of link layer of Binder and following 4 cm of use-surface in Dense Graded.

The works to lay the new low-noise asphalt has started on Monday 17 September 2018 and finished on Saturday 22 (Fig.3).

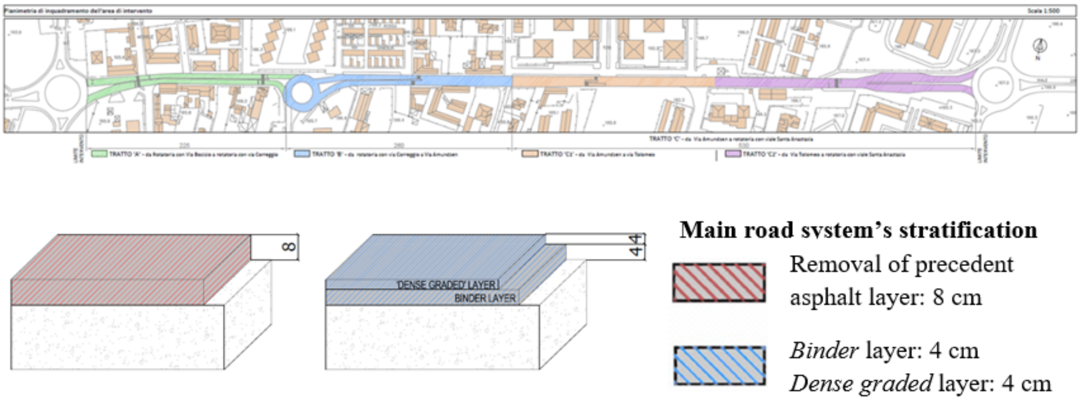


Figure 2. Detail of the design of low-noise pavement in Viale Libertà - Monza.

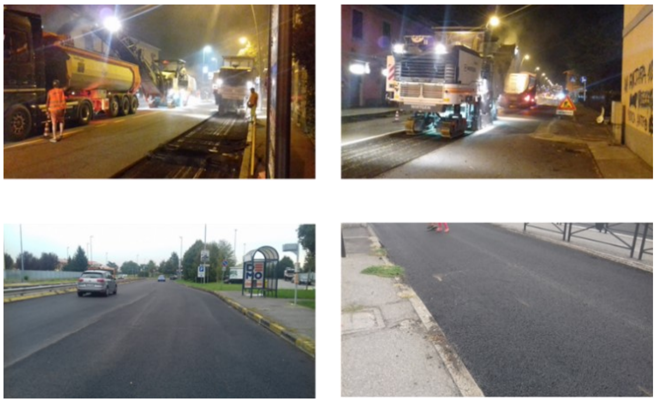


Figure 3. Works for the laying of new low-noise road surface in Viale Libertà (September 2018).

Regarding the limitations of the traffic in the pilot area of Libertà district, the first one has started since 21 January 2019 and will continue up to the end of June 2020.

Emission burden in the study area

The regional inventory of INEMAR (AIR Emissions Inventory) was used to estimate the main emission sources in the Monza municipal area, in its most recent version "Emissions in Lombardy in 2017".

The INEMAR inventory, following the settings deriving from national and international experiences, is made on the basis of bibliographic information and with participation in national and international coordination groups. Atmospheric emissions estimates are typically subject to great uncertainties, due to numerous causes distributed throughout the estimation procedure. In particular, a regional inventory, by its nature, cannot consider all local specificities and may suffer from an incomplete quality of the available statistical information. Furthermore, the subject of emissions is in continuous "movement", that is, in transformation.

The INEMAR inventory therefore provides a "picture" of the emissions i.e. a local database of the sources present in the territory with relative estimate of the quantities issued. It cannot be used as a pure and unique indicator of the air quality of a specific area, as it cannot take into account the interaction that the substances emitted can have with the atmosphere, the weather or the orography of the territory. In particular, the wind, rain, etc. they transport, disperse or deposit the pollutants emitted at the source throughout the surrounding area, so that the quality of the air depends not only on the local sources but on the set of pollutants emitted throughout the territorial basin and their interactions.

As part of this inventory, the division of the sources takes place by emissive activities. The classification used refers to the macro sectors defined according to the CORINAIR (CORe INventory of AIR emissions) methodology of the European Environment Agency.

Study area for air quality assessment - Temporal pattern

The concentration levels of the main air pollutants and some components of the particulate matter were measured inside and outside the NLEZ.

Sampling was carried out using a mobile laboratory located in Viale della Libertà (inside the NLEZ).

Results were compared with those contemporary taken at a fixed site located nearby (via Machiavelli), outside the LEZ, and in a 20 km buffer around the Viale della Libertà, all belonging to the regional air quality network.

A correct location of monitoring equipments is a crucial aspect in air quality assessment.

The European Directive 2008/50/EC states some general criteria for siting fixed sampling points addressed to the protection of human health, they are as follows:

<u>Macroscale siting criteria according to European Directive 2008/50/EC</u>

(a) Sampling points directed at the protection of human health shall be sited in such a way as to provide data on the following:

— the areas within zones and agglomerations where the highest concentrations occur to which the population is likely to be directly or indirectly exposed for a period which is significant in relation to the averaging period of the limit value(s),

— levels in other areas within the zones and agglomerations which are representative of the exposure of the general population,

(b) Sampling points shall in general be sited in such a way as to avoid measuring very small micro-environments in their immediate vicinity, which means that a sampling point must be sited in such a way that the air sampled is representative of air quality for a street segment no less than 100 m length at traffic-orientated sites and at least 250 m × 250 m at industrial sites, where feasible;

(c) Urban background locations shall be located so that their pollution level is influenced by the integrated contribution from all sources upwind of the station. The pollution level should not be dominated by a single source unless such a situation is typical for a larger urban area. Those sampling points shall, as a general rule, be representative for several square kilometres;

(d) Where the objective is to assess rural background levels, the sampling point shall not be influenced by agglomerations or industrial sites in its vicinity, i.e. sites closer than five kilometres;

(e) Where contributions from industrial sources are to be assessed, at least one sampling point shall be installed downwind of the source in the nearest residential area. Where the background concentration is not known, an additional sampling point shall be situated within the main wind direction;

(f) Sampling points shall, where possible, also be representative of similar locations not in their immediate vicinity;

(g) Account shall be taken of the need to locate sampling points on islands where that is necessary for the protection of human health.

<u>Microscale siting criteria according to European Directive 2008/50/EC</u>

— the flow around the inlet sampling probe shall be unrestricted (free in an arc of at least 270°) without any obstructions affecting the airflow in the vicinity of the sampler (normally some metres away from buildings, balconies,

trees and other obstacles and at least 0,5 m from the nearest building in the case of sampling points representing air quality at the building line),

— in general, the inlet sampling point shall be between 1,5 m (the breathing zone) and 4 m above the ground. Higher positions (up to 8 m) may be necessary in some circumstances. Higher siting may also be appropriate if the station is representative of a large area, — the inlet probe shall not be positioned in the immediate vicinity of sources in order to avoid the direct intake of emissions unmixed with ambient air,

— the sampler's exhaust outlet shall be positioned so that recirculation of exhaust air to the sampler inlet is avoided,

— for all pollutants, traffic-orientated sampling probes shall be at least 25 m from the edge of major junctions and no more than 10 m from the kerbside.,

The following factors may also be taken into account:

- *interfering sources,*

— *security,*
— *access,*
— *availability of electrical power and telephone communications,*
— *visibility of the site in relation to its surroundings,*
— *safety of the public and operators,*
— *the desirability of co-locating sampling points for different pollutants,*
— *planning requirements.,*

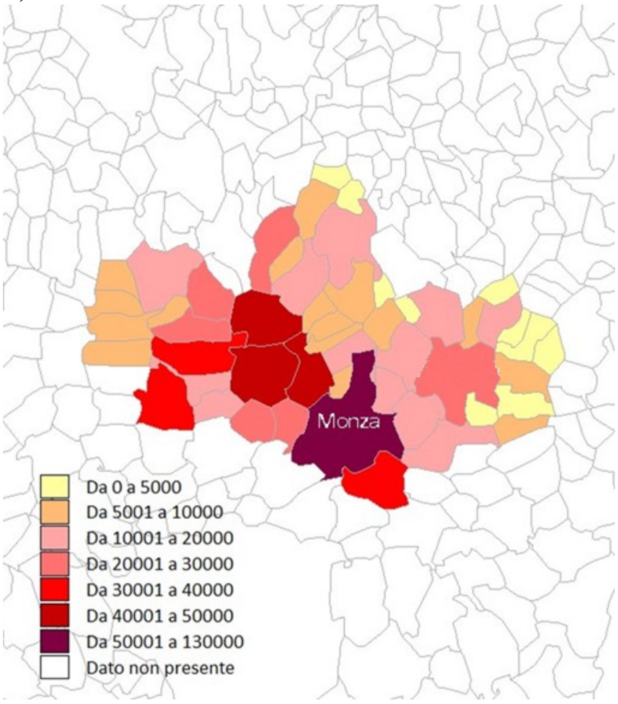


Figure 4. Monza in the province of Monza and Brianza, divided by classes according to the number of inhabitants.

Figure 5. Air Quality monitoring Network (RRQA) in the province of Monza and Brianza.

Figure 6. Mobile laboratory positioning site in Monza, Viale Libertà.

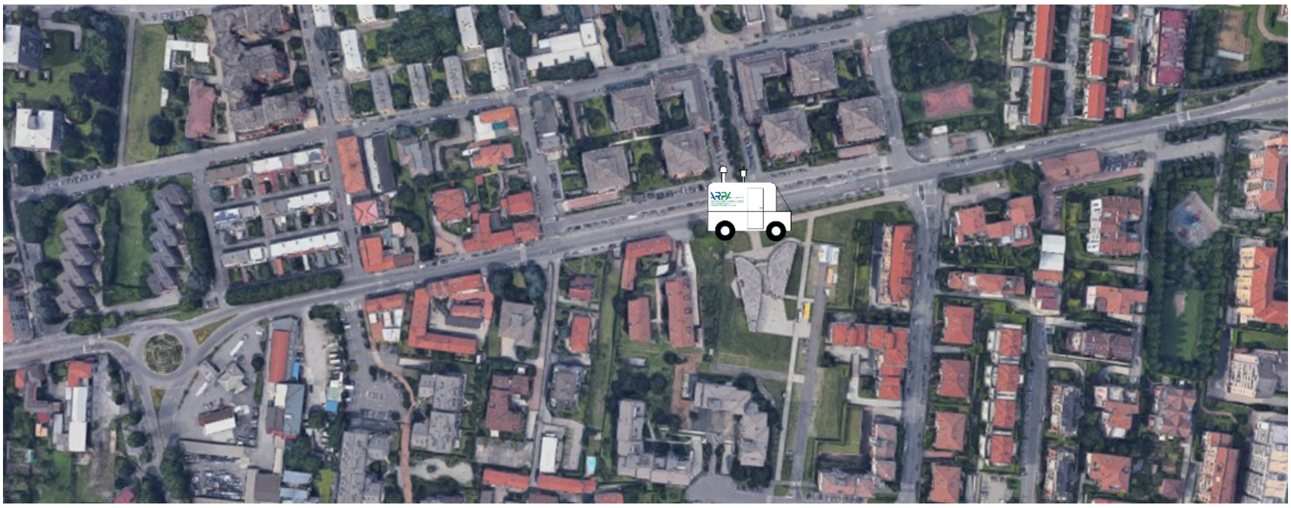


Figure 7. Detail of the positioning site of the mobile laboratory in Monza, Viale Libertà.

Pollutants monitoring and measurements method

Several regulated pollutants (Directive 2008/50/EC) - airborne particulate matter ($PM_{2.5}$, PM_{10} mass concentration), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), benzene (C_6H_6), carbon monoxide (CO) and ozone (O_3) - were determined, using the respective European reference/equivalent methods (Directive 2008/50/EC).

Hourly (SO_2, CO, NO_2, NO_X, C_6H_6,, O_3) and daily (PM_{10}, $PM_{2.5}$) averages were calculated.

PM_{10} samples were collected on quartz membrane filters: following the CEN/TR 16264:2011, these samples were analyzed to determine the carbonaceous component with TOT/TOR (Thermal-Optical Transmittance/Reflectance) instrumentation (Sunset Laboratory) which, by means of a thermo-optical process, allows to quantify the organic carbon (OC) and the elementary carbon (EC).

Continuous measurement of black carbon (BC), based on and aerosol light absorption properties were carried out using a Multi Angle Absorption Photometer (MAAP, Thermo).

Moreover, the particle number concentration (PNC) and size distribution in the 0.3 ÷ 10 µm range, were measured with aerosol particle sizers (OPC, Grimm, mod. 107) capable of counting particles with dimensions greater than 0.25 µm and classifying them into 31 dimensional classes.

Basic meteorological data (temperature, relative humidity, atmospheric pressure, rainfall, solar radiation, relative and absolute humidity, wind speed and direction) were taken from surroundings meteorological stations belonging to the regional meteorological service. Atmospheric profile data from the Milan Linate station were used to estimate the atmospheric *mixing layer height* (MLH).

Monitoring campaigns schedule
Ex ante measurements were carried out in 2017/2018, (1 campaign representing each season) and was repeated during 2019 with the same schedule (Table 1).

Table 1. ex-ante/ex-post monitoring campaigns, sites and pollutants

monitoring campaigns	
ex-ante	ex-post
I (04 -22 may 2017)	**I** (20 feb -26 mar 2019)
II (14 - 31 jul 2017)	**II** (08 - 21 may 2019)
III (9 - 30 nov 2017)	**III** (03 - 17 jul 2019)
IV (31 jan - 19 feb 2018)	**IV** (30 oct - 21 nov 2019)
Pollutants	
SO2, CO, O3, NO2, NO2 p.s.*, Benzene p.s.*, Benzene, Toluene	
PM10, PM2,5 , BC , OC , EC , TC , PNC	
Site	
Viale Libertà, 144, 20900 Monza MB	

* passive samplers

Meteorological normalization

The trends in the concentrations of atmospheric pollutants and the analysis of the data carried out on the recorded time series, allow it to be difficult to detect the effect of the measures taken to improve air quality, precisely because of the complex nature of the atmosphere chemistry. Furthermore, the effects of weather conditions can be much greater than those of the actions taken to reduce or control air pollution (Anh et al., 1997), and it can be difficult to know if some changes in concentrations are due to the effects of meteorology or to the change of emission sources.

To overcome this problem, and to understand what the real effects of the interventions undertaken in this project have been, on the reduction of atmospheric pollutants, a meteorological normalization technique has been applied (Grange et al., 2018; Grange et al., 2019).

Meteorological normalization is a technique applied to the air pollutants concentration time series, aimed at reducing the variability caused by the effect of meteorology.

Normalization is obtained by estimating a mathematical model capable of explaining some of the variations in the concentrations of pollutants through a number of independent variables connected to the weather component and to the particular instant of time in which the measurement was acquired. The variables used typically act as proxies for regular emission schedules such as time of day or season (Derwent et al., 1995). If the trained model is able to explain a significant percentage of the variability of the series studied, it can be used to remove the influence that independent variables have on the dependent variable. The normalized time series are to be considered as "average" concentrations of the sampled pollutant or with invariant weather conditions. The application of a set of tools, statistical techniques and machine learning algorithms, in particular random forests, allowed to conduct meteorological normalization on the time series of air quality data, analyzing trends, highlighting some characteristic differences unobservable on raw concentration data, and allowing to explore more effectively the effects of the interventions implemented.

The meteorological normalization technique was applied to the NO_2 and PM_{10} data measured in the monitoring campaigns (ex-ante and ex-post), and in order to apply this technique, it was necessary to reconstruct the continuous time series of the concentrations of the two pollutants , from 2017 to 2019. During the course of these three years, in fact, the monitoring campaigns were carried out not continuously but following the project phases, guaranteeing the quality objectives of the minimum data coverage period dictated by the technical regulations - legislation for indicative measures (Legislative Decree 155/2010).

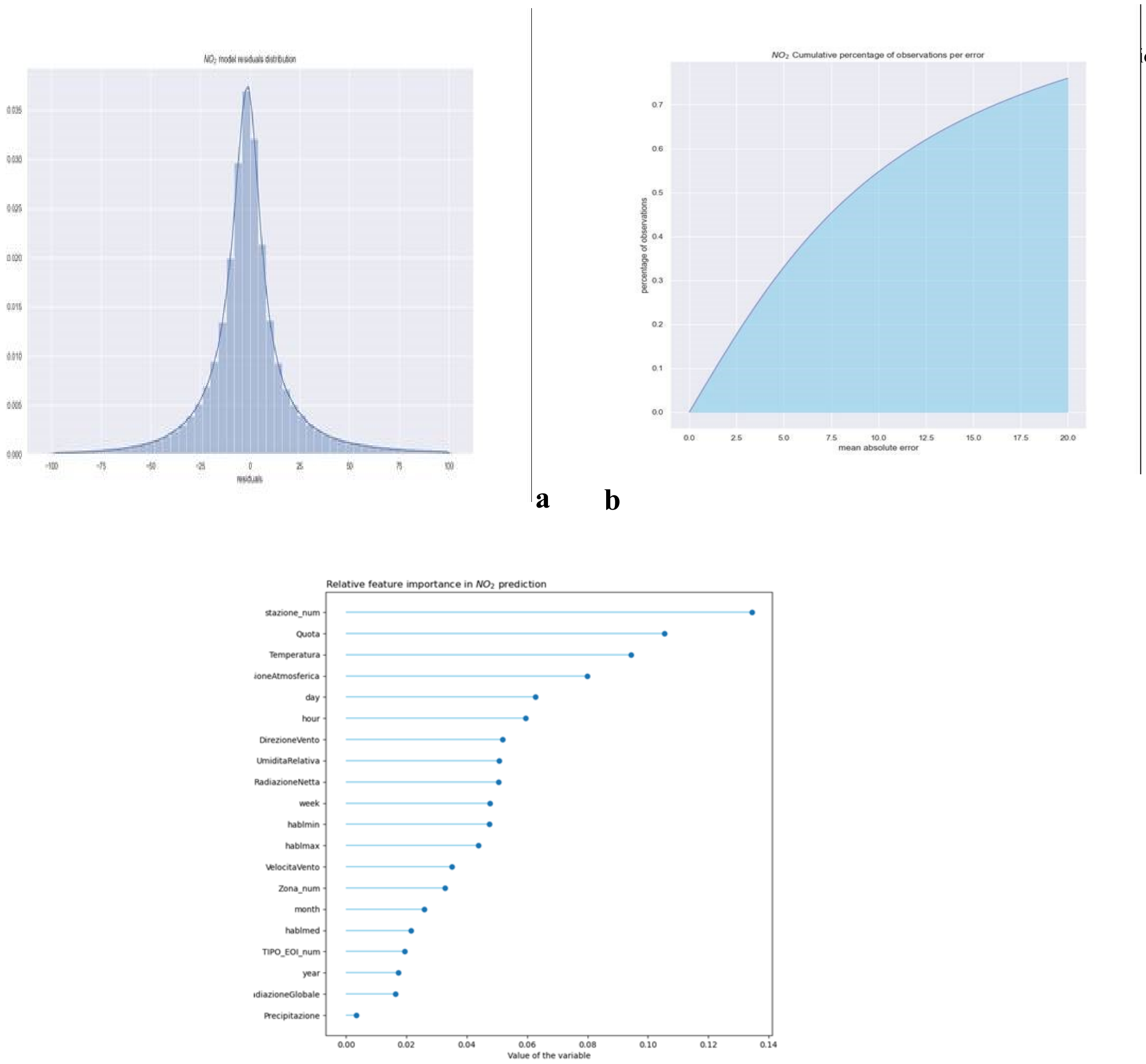
The small size of the available samples does not allow the applicability of the statistical techniques described above, which require continuous input and with an adequate number of observations. With these premises, given the need to investigate the presence of effects following the measures taken to reduce pollution, the possibility of reconstructing the time series in its missing periods was taken into consideration, using data from other stations as well as temporal and meteorological variables.

In an initial approach, the correlation between the Viale della Libertà and other stations (selected on the basis of the type and distance from the mobile laboratory) time-series was evaluated, with the aim of estimating the missing data starting from the available samples, applying a linear regression. However the model thus designed has significant intrinsic limits. The curves taken into consideration, in fact, are very correlated with each other and cannot be considered together as independent variables to avoid the presence of strongly redundant information that distorts the estimate produced.

The estimate of an average curve of the stations most correlated with the target station, even if it results in a satisfactory regression model, does not take full advantage of the available information.

The next step is to build an exhaustive dataset, obtained by relating the location and type of the reference station to each measurement carried out, the instant of time in which it took place (hour, day, week, month) and the weather parameters of the day. In this way we were able to analyze the presence of specific patterns in estimating the value of the pollutant in general, to be applied then to the Monza-Libertà data in particular.

Among the various machine learning algorithms used, the *Gradient Boosting* algorithm was chosen, in the *Python* implementation provided by the *Lightgbm* framework, both for reasons of resulting performance and for greater speed in the construction of the model compared to other frameworks.
To describe how it works in short, just think of Gradient Boosting as a series of weak learning models (in this case decision trees) trained in series, so that the i^{-th} model tries to optimize the error made in the model i^{-1} in the best possible way.
The construction of the model takes place by setting some "structural" parameters that define the way in which the model "learns" from data the relationships that unite the target variable (concentration of pollutants) to independent variables. These parameters, called *hyper-parameters*, are chosen on an empirical basis in an iterative approach. The best combination of hyper-parameters, which returns the model with the best performance, is obtained only after numerous combinations, without ever being certain that it is really excellent.
To try to optimize computational time, Bayesian search algorithms have been applied. The fundamental difference lies in keeping the results of the various attempts in memory and on the basis of these influencing the subsequent samplings towards combinations that likely bring better performance in the construction of the final model.
The framework used for the Bayesian search for hyper-parameters is *Hyperopt* (*Python*) and after three days of execution and thousands of attempts the reference set was selected for the final reconstruction of the missing data. The model in the various phases has always been evaluated with a 5-fold cross validation and shows an MAE (mean absolute error) of 15 $\mu g/m^3$ for NO_2. The final model trained on the whole set available was finally applied for the reconstruction of the missing data in the Monza-Libertà station.
Figure 8 shows respectively the distribution of the residues (fig. 8a) and the cumulative distribution of the residues in absolute value (fig. 8b), this provides a measure of the probability of finding a certain error given a model, and the relative importance of the characteristics entered (fig.8c).



a b

c

Figure 8 Distribution of residues (a), cumulative distribution of the same in absolute value (b) and relative feature importance in NO_2 prediction (c).

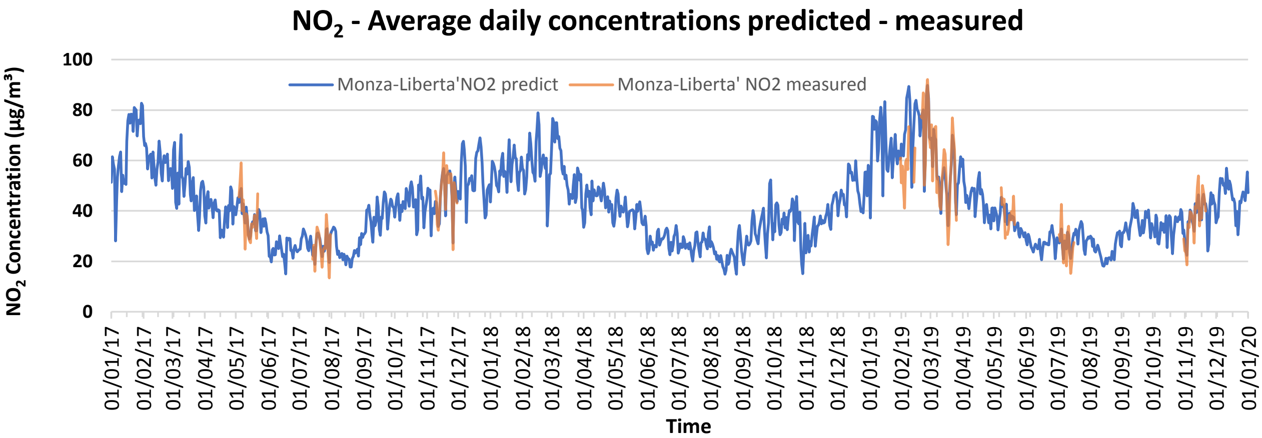


Figure 9. Comparison of the predicted and measured NO_2 daily averages.

Just as for NO_2, also for PM_{10}, considering the small size of the samples available, the possibility of reconstructing the time series in its missing periods was taken into consideration, starting from the data sampled in other stations and other time variables. and meteorological.
The model in the various phases has always been evaluated with a 5-fold cross validation and shows an MAE (mean absolute error) of 4.9 ($\mu g/m^3$) for PM_{10}. The final model trained on the whole set available was finally applied for the reconstruction of the missing data in the Monza-Libertà station.
Figure 10 shows the distribution of the residues and the cumulative distribution of the residues in absolute value, this provides a measure of the probability of finding a certain error given a model, and the relative importance of the characteristics entered.
The time series of the reconstructed PM_{10} concentrations is shown in figure 11.

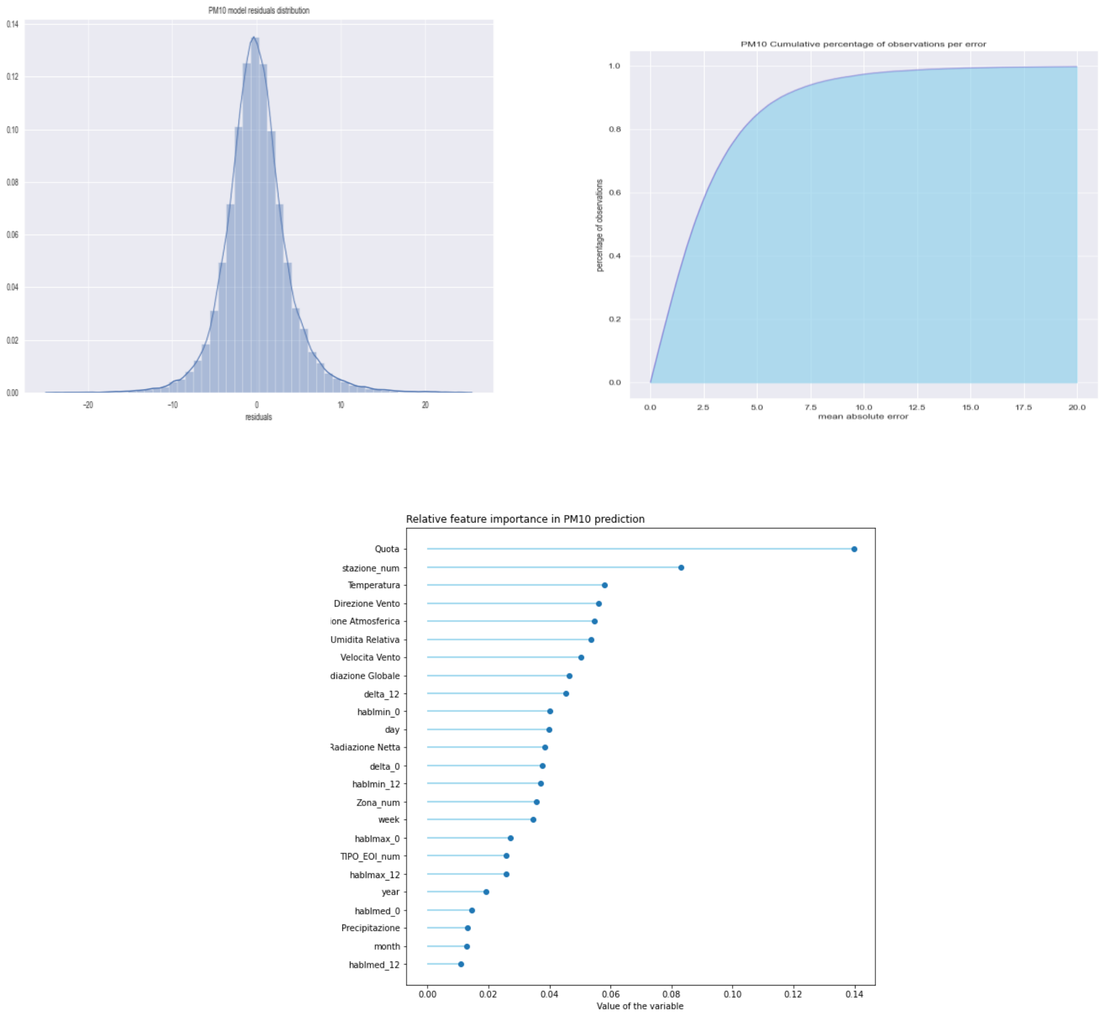


Figure 10 Distribution of residues (a), cumulative distribution of the same in absolute value (b) and relative feature importance in PM_{10} prediction (c).

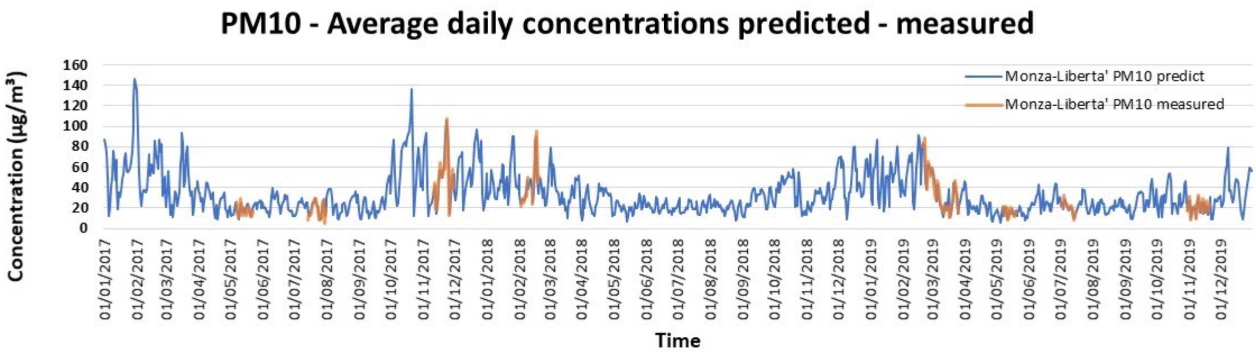


Figure 11. Comparison of the predicted and measured PM_{10} daily averages.

Spatial pattern

To assess the spatial and seasonal variability on the microscale (i.e. in the territory delimited by the NLEZ) of some pollutants tracing the emissions of internal combustion engines, empirical models were developed (See LIFEMONZA - action B5.6).
The study domain was a 4 km^2 square area around the sampling point located in Viale della Libertà assumed as the domain's and NLEZ's center.
Vehicular traffic related pollutants (benzene, toluene, NO_2) sampling was made also using passive samplers (Ring, Aquaria and Radiello, Fondazione Maugeri, respectively for VOC's and NO_2).
Duplicate samplers, provided with weather protective shelters, were deployed at 2.5 m above the ground, placed on lamp post, utility poles or street signals.
Aromatic volatile organic compounds (VOCs) were extracted with carbon disulfide then detected and quantified using internal standard capillary gas chromatography performed on a Gas Chromatograph (HewlettePackard Inc., USA) with MS detection. NO_2 measures was carried out by means a Ions Chromatograhy (Metrohm-881 Compact IC pro – Anion – MCS)
25 points were selected across the study domain to represent the microscale spatial variability of air quality variously distributed according to the distance from the main roads in the study domain (4 km^2) both inside and outside the NLEZ. The sites represent a wide range of possible scenarios that characterize the NLEZ and surrounding area context. There were sites located less than 50 m from a high traffic road in densely populated neighbourhoods (traffic sites) as well as sites over 200 m from a high traffic road in low density residential areas (urban background sites).
Microenvironmental criteria for site selection were strictly followed.

6 Results of Air Quality monitoring campaigns in LIFE MONZA NLEZ

Ante and post-operam monitoring results for air quality

Air quality status and trend in the study area

The summary of the concentration's statistics at all the monitoring sites is given at Table 2.

Monza is a medium sized city belonging to a large urban agglomeration, Milan + 106 small town surroundings, the largest in the Po valley with 3593025 inhabitants. The Po Valley is largely devoted to intensive agricultural and livestock farming, as well as important industrial and commercial activity, producing ample amounts of NOx from vehicles, NH_3 from agricultural activities, PM from residential heating, mainly from biomass burning devices and COV from solvent use in industry, vehicles and from agricultural activities due to biogenic emissions.

Moreover, the presence of the Alps and the Apennine often limits the air currents between Northern Italy and the rest of continental Europe, favouring the accumulation of air pollutants. Figure 12 shows hourly distributions of the wind speed in the different measurement periods. Feeble ventilation and frequently wind-calm conditions, with typical mean wind speed around 1 m/s, and mechanical turbulence due to the wind therefore generally low, typical conditions that occur in the PO valley. Particularly winter seasons is characterized by frequent thermal inversion at low altitude and low mixing layer heights, high pressure and calm wind conditions so that the area is frequently plunged in a stable and stagnant atmosphere. At the same time, fog often forms in the valley in fall and winter when temperature inversions trap cool, moist and polluted air near the surface.

When fog forms, sulphur oxides, nitrogen oxides, and other polluting gases are taken up or 'scavenged' by fog water droplets. Once absorbed into the droplets, the gases oxidize more rapidly than they otherwise would, becoming sulphates, nitrates, and other types of aerosol particles. What the fog and humidity do is accelerate the process of converting gaseous pollutants into haze-causing aerosols.

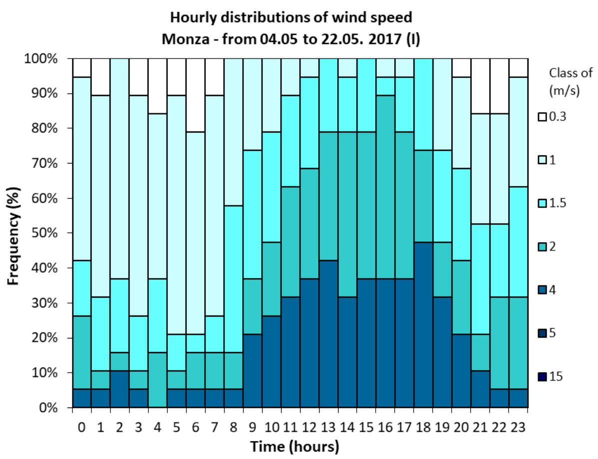
Table 2. Ex-ante and ex-post summary of the hourly pollutant concentration statistics (mean and standard deviation) at the four sites.

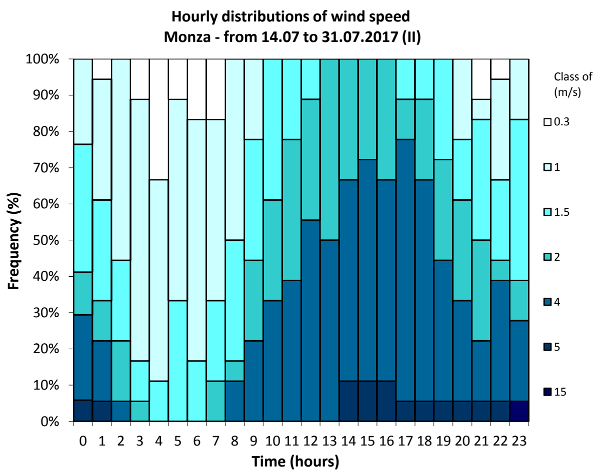
ex-ante	**I** (04 -22 may 2017)		**II** (14 - 31 jul 2017)		**III** (9 - 30 nov 2017)		**IV** (31 jan - 19 feb 2018)	
	mean (µg/m³)	st.dev.	mean	st.dev.	mean	st.dev.	mean	st.dev.
SO_2	3.7	1.4	3.9	2.1	5	1.3	5.3	2.2
CO (mg/m³)	0.4	0.2	0.7	0.1	1.2	0.4	1	0.3
O3	90.3	31.7	142.4	31.3	--	--	11.1	7.6
NO2	37.6	8.8	26	6.6	47.1	8.9	56.9	8.6
NO2 p.s.*	--	--	--	--	--	--	40.4	19.7
Benzene p.s.*	--	--	0.4	0.1	--	--	1.2	0.2
Benzene	--	--	0.3	0.1	3.3	1.8	2	1.1
Toluene	--	--	1.6	1.2	13.3	4.5	7	4.5
PM10	16.7	5.7	17.9	8	52.9	25.7	44.1	22.8
PM2,5	12.2	3.9	10.3	3.5	40.7	20.5	32.9	17.9
BC	2	1.2	1.7	1	6.7	3.4	4.3	2.5
OC	5.5	1	6.1	1.4	15.5	4.9	11.3	3.9
EC	1.6	0.4	1.4	0.4	4.7	1.7	2.7	0.9
TC	7.1	1.3	7.6	1,7	20.2	6.1	14	4.5
PNC (Cn cumulate pp/l) **	--	--	108127	18110	509673	91793	487016	69449

ex-post	**I** (20 feb -26 mar 2019)		**II** (08 - 21 may 2019)		**III** (03 - 17 jul 2019)		**IV** (30 oct - 21 nov 2019)	
	mean (µg/m³)	st.dev.	mean	st.dev.	mean	st.dev.	mean	st.dev.
SO2	--	--	--	--	5.1	2.5	2.4	0.7
CO (mg/m³)	0.8	0.2	0.6	0.3	0.7	0.3	0.9	0.2
O3	30.8	16.6	50.7	10.6	78.8	12.7	18.5	5.6
NO2	60.4	15.7	38.8	6.3	26.4	7.0	37.3	9.0
NO2 p.s.*	35.4	2.5	30.9	3.3	22.0	2.5	22.5	2.9
Benzene p.s.*	0.9	0.04	0.7	0.1	0.5	0.01	1.4	0.1
Benzene	1.0	0.5	0.3	0.1	0.6	0.3	1.0	0.3
Toluene	5.0	3.9	2.0	0.8	3.5	1.7	4.3	2.1
PM10	38.3	16.2	16.0	4.4	19.7	6.1	20.9	6.3
PM2,5	--	--	--	--	15.3	3.9	15.9	5.3
BC	3.7	1.9	1.6	0.4	1.1	0.3	3.1	0.8
OC	9.0	8.9	4.5	0.6	6.1	1.0	6.6	1.5
EC	2.2	0.9	0.9	0.2	0.8	0.2	1.6	0.6
TC	11.1	4.1	5.4	0.7	6.9	1.2	8.5	2.0
PNC (Cn cumulate pp/l)	--	--	--	--	39170	6713	47621	10114

* passive samplers ** particle number concentration

Unit of measurement of pollutants [µg/m³]





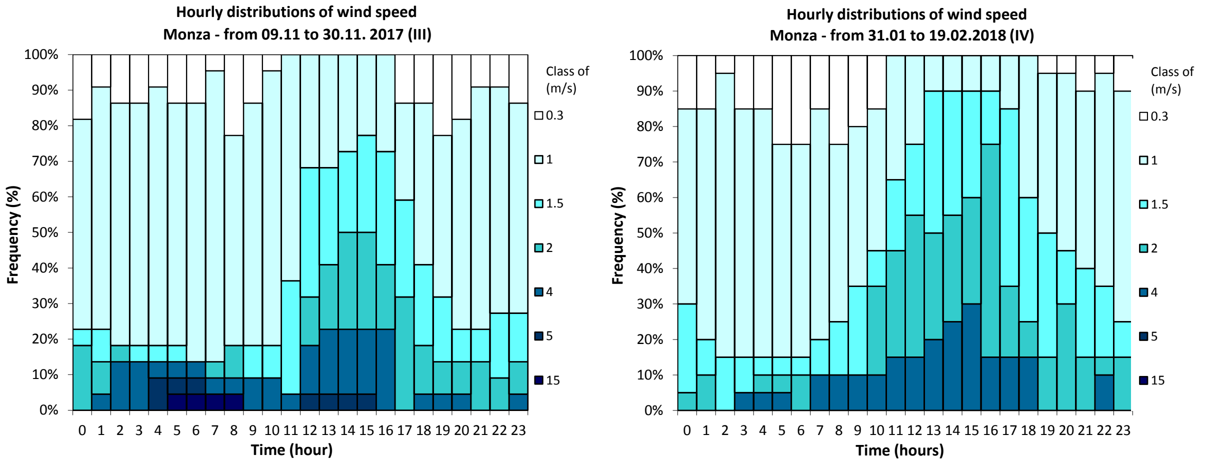
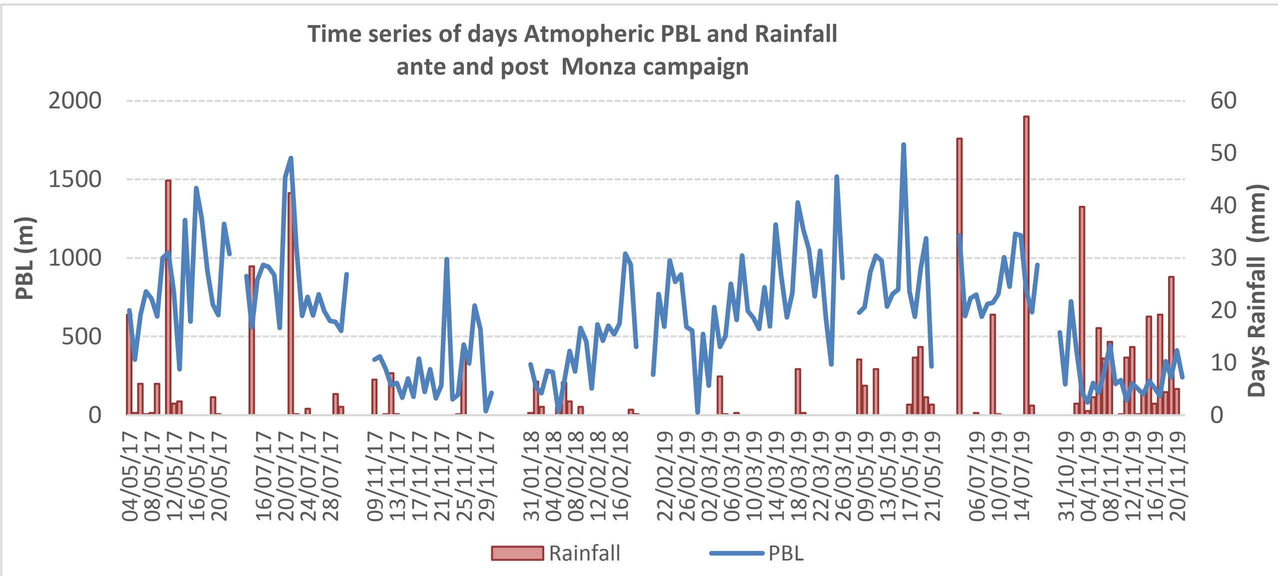
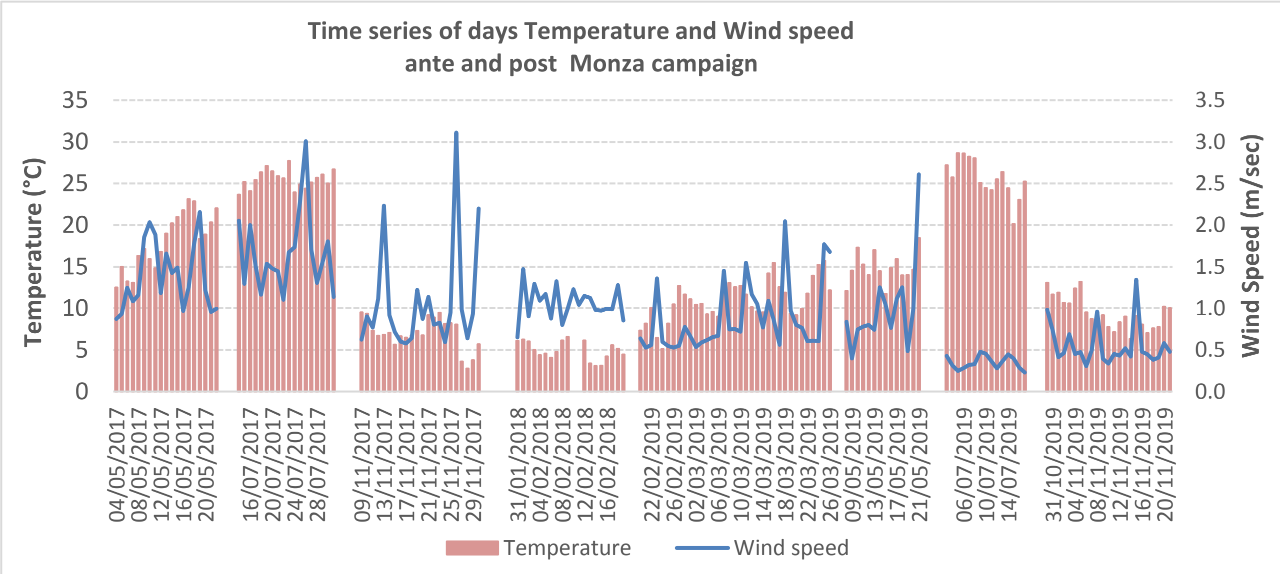


Figure 12. hourly distributions of the wind speed in the different measurement periods

Such extreme conditions favourable to pollutant accumulation, can last several days, as shown in Figure 13 that shows some meteorological parameters in different seasons. Usually the meteorological conditions that characterise the cold seasons are responsible for the rise in NO_x and other pollutants concentration in the Po Valley: as an example figure 14 shows the NOx dependencies by wind speed and direction differences among seasons. .



a



b

Figure 13: Monza. Ex-ante and post measuring campaign. Daily Temporal pattern for some atmospheric parameters.

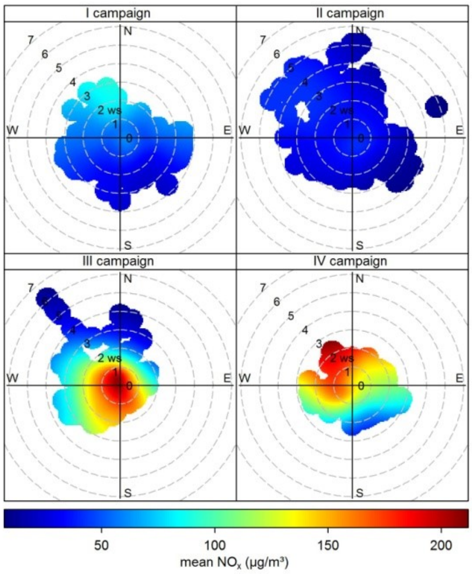


Figure 14. Monza, Viale della Libertà. Ex-ante measuring campaign. Polar plot showing the NOx mean concentrations variability by wind speed and direction. For each polar plot, the radial dimension is an indicator of wind speed (m/sec). Further away from the center of the plot, the wind speed is higher.

The atmospheric conditions that characterize the different seasons have important repercussions on the particulate matter levels and composition. PM10 winter levels in the Po Valley's cities are significantly higher than those of the other major Italian cities, while this difference is less pronounced in the summer when the atmospheric phenomena described are less (Figure 15).

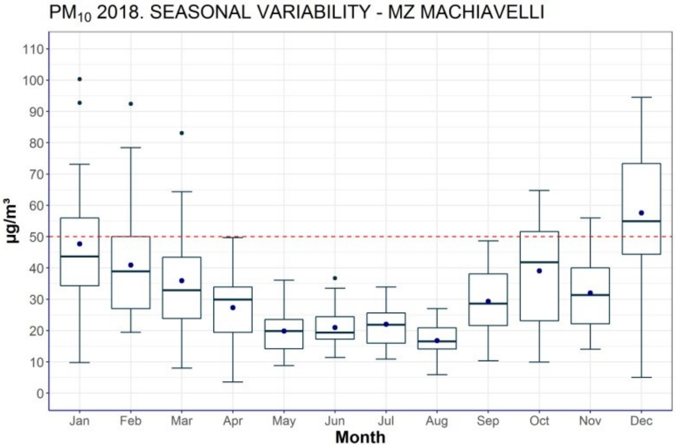


Figure 15: Monza, PM10 daily averages distribution by month, showing typical seasonal variability.

The average daily concentrations of the "temporary" site of Monza - Libertà were compared with those of the whole Lombardy region’s network and in particular with the same measured in the fixed station of Monza - Via Machiavelli. The measurements carried out at the two sites in Monza show consistent trends with each other particularly for traffic related pollutants and are generally above the 75th regional percentile, in line with the typical values detected in urban traffic stations and without presenting specific critical issues. Moreover it’s worth to note the excellent agreement between the PM10 and total carbon (OC + EC) measurements carried out in the NLEZ zone and those carried out far away within the Milan agglomerate, very consistent and contained in a narrow range of values (Figure 12).

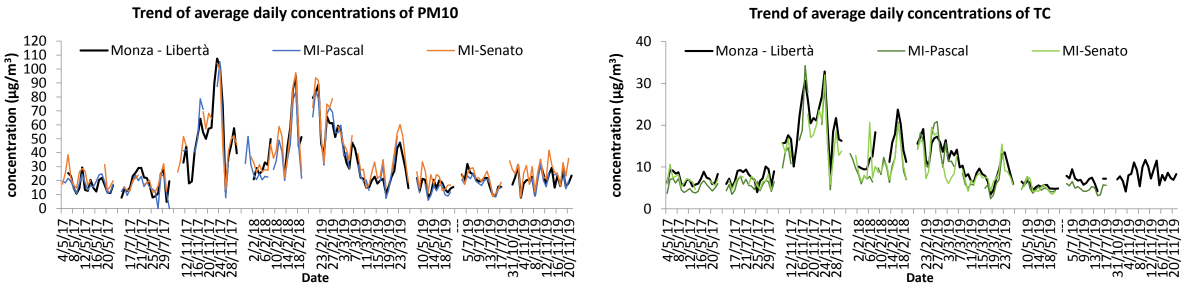


Figure 16. Average daily PM10 (a) TC (b) concentrations measured in Monza - Libertà compared with those measured in Milan - Pascal and Milan - via Senato.

The average values of the winter period were higher than those of the summer period in all the stations considered, as expected, partly due to the weather conditions more favourable to the accumulation of pollutants and partly due to the additional sources of pollution (e.g. heating buildings).
Noticeably, the OC fraction represents a large portion of PM10, with highest values (again) during winter (Figure 17).

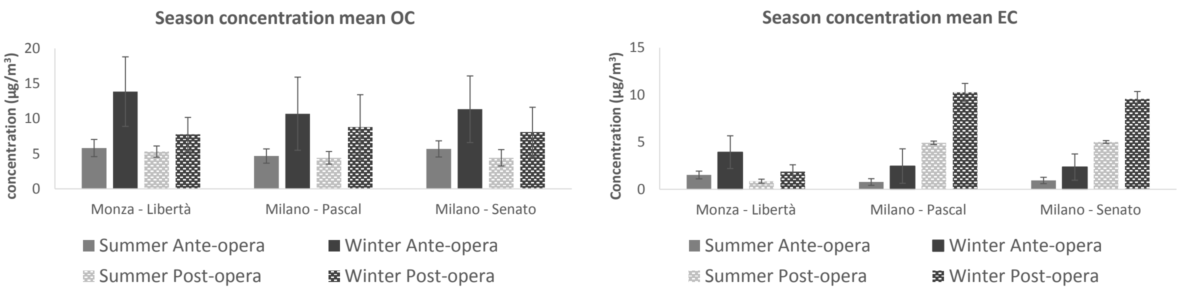


Figure 17. Average concentrations of OC and EC on the two measurement periods "summer" (from 4/5/2017 to 22/5/2017 and from 14/7/2017 to 31/7/2017 in ex-ante operam, from 8/5/ to 21/5/2019 and from 03/7/ to 17/7/2019 in ex-post operam) and "winter" (from 9/11/2017 to 30/11/2017 and from 31/1/2018 to 19/2/2018 in ex-ante operam, from 20/2/ to 26/3/2019 and from 20/7/ to 21/11/2019 in ex post-operam).

The average OC concentration over the "winter" period was even higher in Monza than in Milan, around 4 µg/m^3 during ex ante-opera campaigns, and 1.6 µg/m^3 during ex post-opera. In general, moving away from Milan downtown, towards the pre-Alpine and alpine area, the use of the wood as a heating source tends to increase, and this represents a not negligible carbon source.

Analysis of ante and post-operam monitoring results for air quality

In order to evaluate confounding factors related to the pollutants temporal pattern (drive by meteorology) and other possible difference due to contemporary city and region wide measures undertaken to tackle air pollution in 2019 (not already in force in 2017/2018), we compared the ex post vs ex ante averages calculated over all the monitoring campaigns and we cross checked the differences found at monitoring stations inside the NLEZ and outside. Table 3 show the comparison carried out for NO_2, PM_{10} and BC.

		MZ LIBERTA'	**MZ MACHIAVELLI**
PM_{10} – average (□g/m^3)	Ex ante	**32**	**34**
	Ex post	**30**	**27**
	diff %	*-18%*	*-19%*
PM_{10} - 90.4 percentile (□g/m^3)	Ex ante	**59**	**63**
	Ex post	**51**	**57**
	diff %	*-13%*	*-10%*
NO_2 – average (□g/m^3)	Ex ante	**41.0**	**41.2**
	Ex post	**37.2**	**43.5**
	diff %	*-9%*	*5%*
BC – average (□g/m^3)	Ex ante	**3.80**	**2.92**
	Ex post	**2.75**	**1.98**
	diff %	*-28%*	*-32%*

Table 3. NO_2, PM_{10} and BC mean values over the ex-ante and ex-post sampling period. Percent different comparison among measurement carried out inside (MZ-Libertà) and outside (Mz-Machiavelli) the NLEZ.

For PM_{10}, comparing annual averages, we found inside the noise LEZ (Viale della Libertà) values lower ex-post by 18% vs ex-ante.

The same happens outside Monza-Machiavelli (- 19%). Generally, considering other monitoring sites outside the LEZ, a consistent difference between ex-post and ex-ante was found, ranging between -27% and 3%. The ante-post opera ratio measured at Monza Libertà represents the 30th percentile in air quality network ratio distribution. (figure 18).

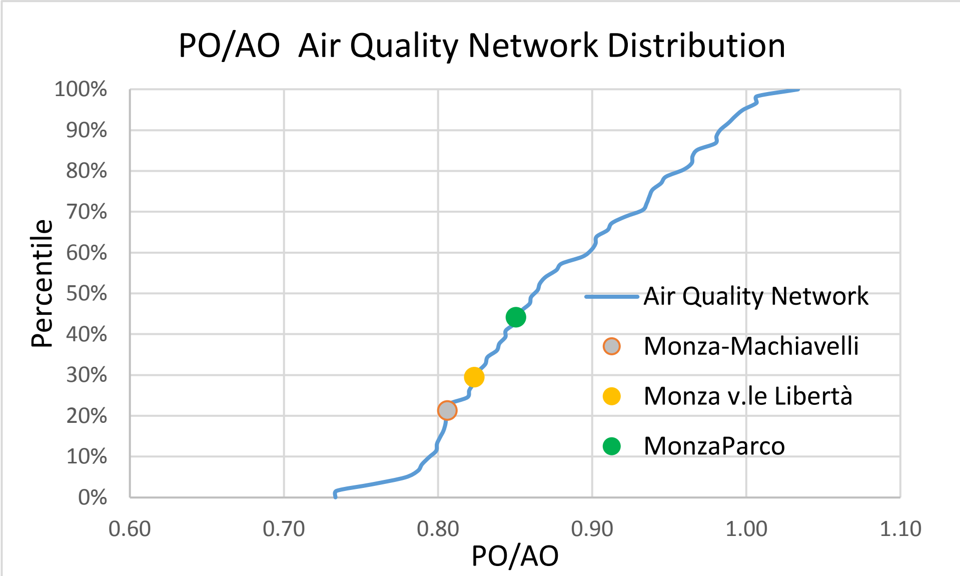


Figure 18. Ratio of the averages AO and PO measured

Thus, it would seem that there are not significant reduction effects for PM_{10} mass concentrations attributable to the introduction of the NLEZ.
Similar figures can be detected from the comparison among percentiles (90.4 percentile, representing the occurrences of more than 36 daily mean over 50 □g/m^3).
If we look at the NO_2 concentrations, it seems that the eventual effect due to the NLEZ alone was too little to be highlighted. Indeed, a small reduction (-9%) was observed inside the NLEZ while a small increase (+5%) was observed outside. However, the same happens comparing other stations outside the LEZ, that showed both small increase and little reduction, thus making ineffectual the attempt to remove the confounding factors.
The BC is of particular interest since previous studies have showed that focusing on specific "components" of PM, like black carbon, or parameter (e.g. particle number concentration) more related with exhaust vehicles emission, seems to be more suitable for assessing the impact of LEZs on local scale air quality [Jones et al., 2012], particularly when the LEZs involve traffic restriction for heavy duty diesel vehicles [Holmes et al., 2015]. However in our case, the large reduction observed between ex post and ex ante monitoring campaigns seems to be largely due to confounding factors, since it was observed with the same order of magnitude both inside (-28%) and outside the NLEZ (-26%).

The results of meteorological normalization

The performances of the meteorological normalization model, applied on the Monza Libertà NO_2 data, are reported in figure 19 (a, b, c, d), showing respectively the importance of the independent variables adopted by the model (figure 19a), coefficient of determination $R^2 = 0.63$ (figure 19b), partial dependence of the predicted value on the model with respect to independent variables (wind speed and direction, atmospheric pressure, temperature, PBL height, relative humidity, Julian day, *UNIX* dates, day of the week) (figure 19c), and finally the trend of normalized concentrations (figure 19d).

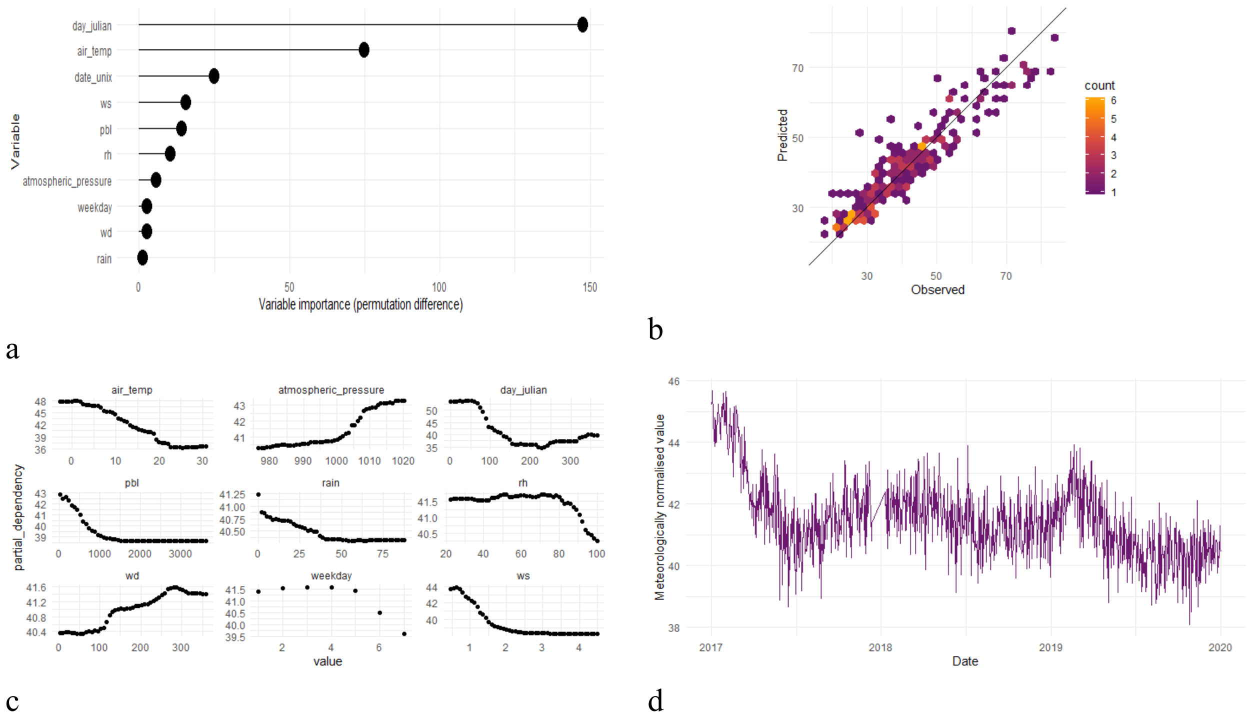


Figura 19. NO_2 - Meteorological normalization's performance.

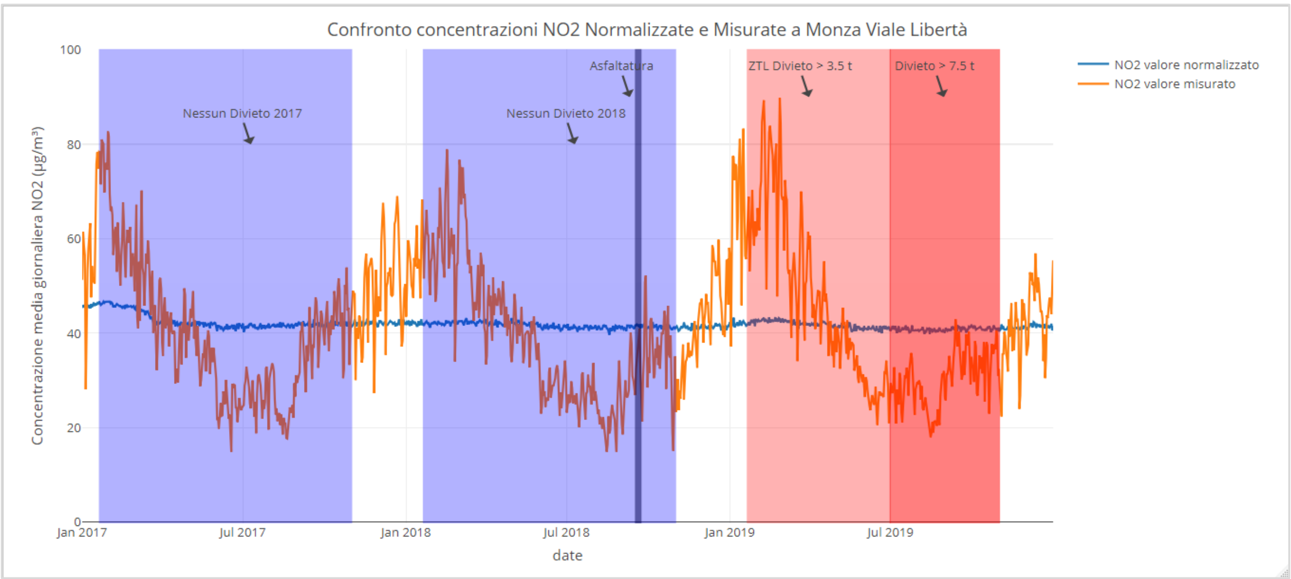


Figure 20. Meteorological normalization of average daily NO_2 concentrations

The "meteorologically normalized" concentrations are compared with the measured ones (remember that for Monza Libertà, the measured values correspond to those predicted with the Machine Learning techniques, as described in the previous paragraph) and are shown in figure 20. The blue areas delimit the ex-ante work period, in which the execution of the new road surface with sound-absorbing asphalting material falls, and all other works connected with the reduction of speed and improvement of traffic on Viale Libertà. The areas in light and dark red delimit the application of traffic bans for the different types of vehicles. This view highlights the little effect due to the air quality improvement action implemented on Viale Libertà.
For a better visualization of the normalized trend, a smoothing technique was applied to the values obtained, ie a statistical technique (in this case a moving average) which allows to capture the important trends of an historical series of data. Smoothing has also been applied to meteorologically standardized series of other stations in the Monza- Milan agglomerate area, and compared, only for the 2017-2019 period with that of Monza Libertà. The results are shown in figure 21. The slightly decreasing trend for all the stations compared is immediately evident, but above all the local character of each specific station stands out.

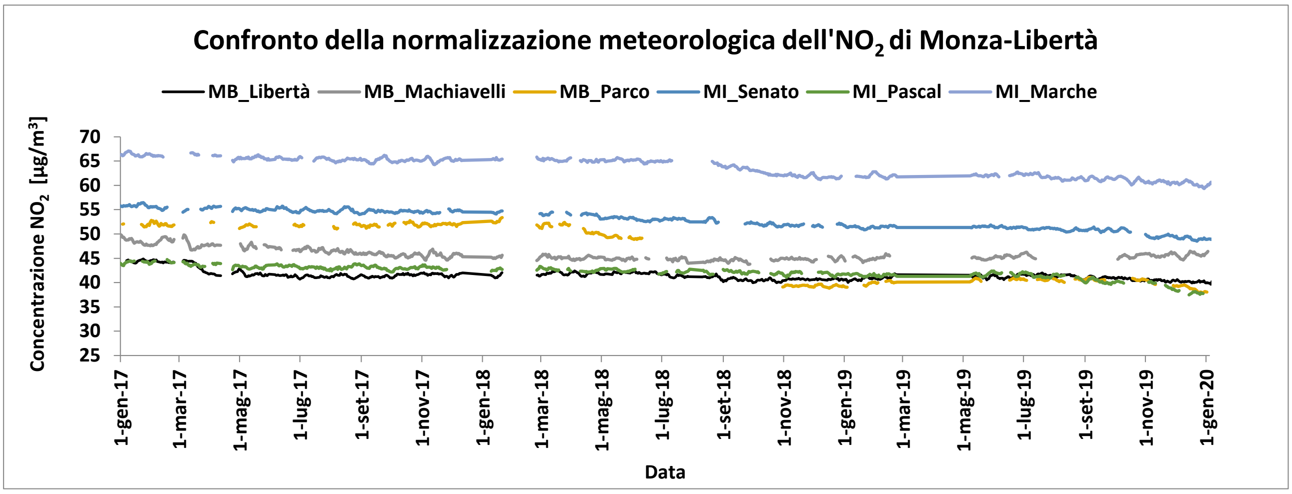


Figure 21. Comparison of the meteorological normalization of NO_2 between Monza Libertà and some stations of the RRQA.

In order to have a significant estimate of the change over the past three years, the *Change Point Detection* technique was applied, i.e. a statistical analysis that allows to detect the change or the change point of a stochastic process or time series, to identify times and probability distribution. Specific applications of this technique may concern changes in the mean, variance, correlation or spectral density of the process. In our case, we analyzed where the normalized trend had a statistically significant change. To do this, the script of R *cpt.mean* was applied, with the method *SegNeigh,* penalty *Asymptotic* and value of Q = 5.

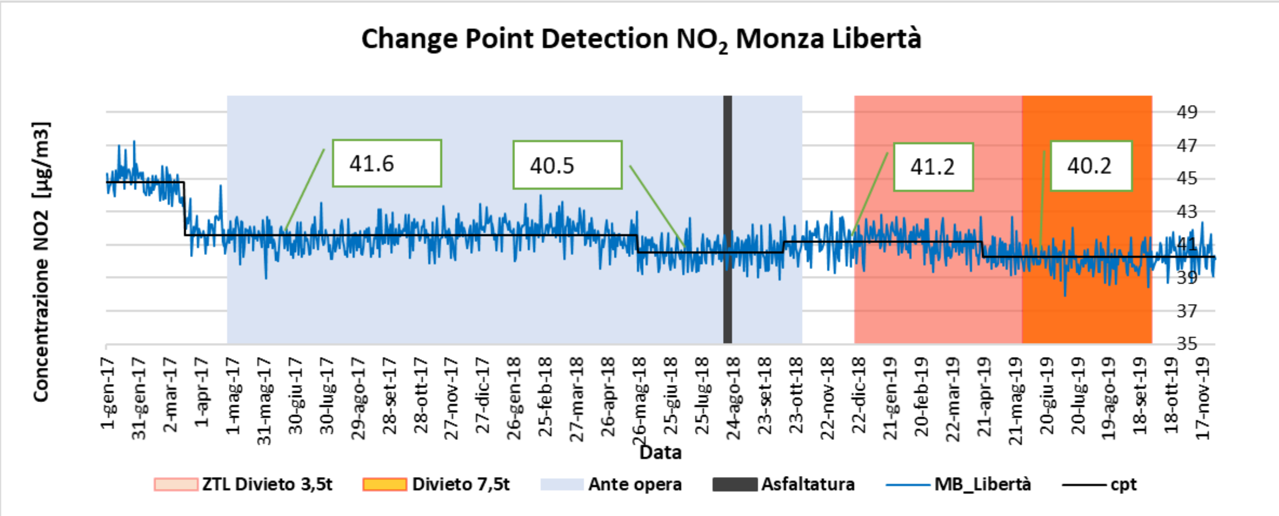
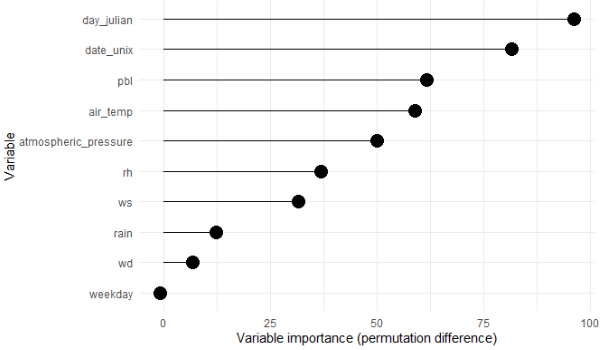
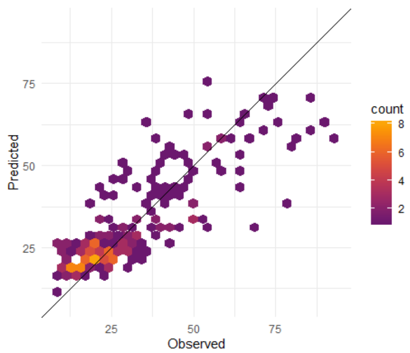


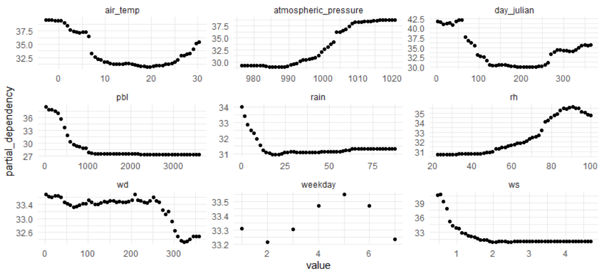
Figure 22 Change Point Detection for NO_2 normalized concentrations estimated at Monza Libertà.

The result of the change point detection on average for the NO_2 values meteorologically normalized at Monza Libertà are shown in figure 22. Evaluating the results obtained, it is highlighted that the differences between the two periods are a decrease of 1% during the winter periods, and a decrease of 0.7% during the summer period. These results, considering the method’s uncertainty, should be considered as negligible in term of capability of the measure undertaken to reduce nitrogen dioxide concentrations even at the microscale (i.e. within the NLEZ).
The performances of the meteorological normalization model, applied on the Monza Libertà PM_{10} time-series, are reported in figure 23 (a, b, c, d), showing respectively the importance of the independent variables adopted by the model (figure 23a), coefficient of determination $R^2 = 0.63$ (figure 23b), partial dependence of the predicted value on the model with respect to independent variables (wind speed and direction, atmospheric pressure, temperature, PBL height, relative humidity, Julian day, UNIX dates, day of the week) (figure 23c), and finally the trend of normalized concentrations (figure 23d).
The "meteorologically normalized" concentrations are compared with the measured ones (remember that for Monza Libertà, the measured values correspond to those predicted with the Machine Learning techniques, as already described) and are shown in figure 24. The blue areas delimit the period ex - prior work, which includes the execution of the renovation of the new road surface with sound-absorbing asphalting material, and all other works connected with the reduction of speed and improved circulation on Viale Libertà. The areas in light and dark red delimit the application of traffic bans for the different types of vehicles. Also for PM_{10}, as well as for NO_2, this visualization highlights the little effect due to the air quality improvement action implemented on Viale Libertà.

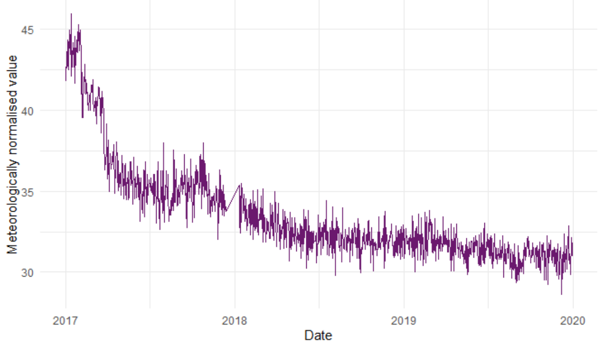




a b



c



d

Figura 23 PM10 - Meteorological normalization's performance.

For a better visualization of the normalized trend, a smoothing technique was applied to the values obtained, ie a statistical technique (in this case a moving average) which allows to capture the important trends of a historical series of data. Smoothing has also been applied to meteorologically standardized series of other stations in the Monza- Milan agglomerate area, and compared, only for the 2017-2019 period with that of Monza Libertà. The results are shown in figure 25. The decreasing trend is evident for all the stations compared, but above all the local character of each specific station stands out.

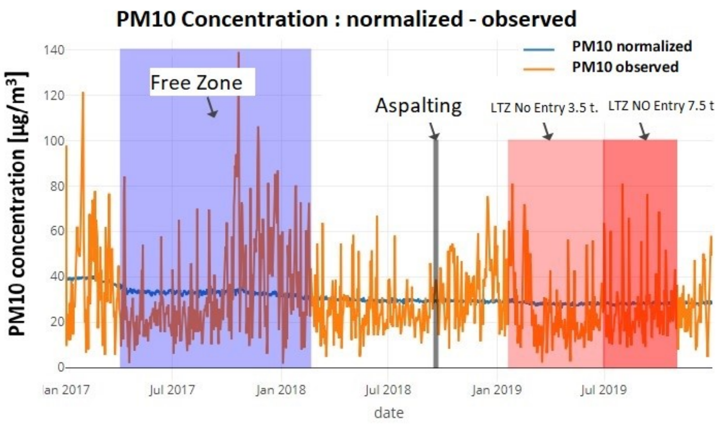


Figure 24 normalization of average daily concentrations of PM10. Comparison with the observed values

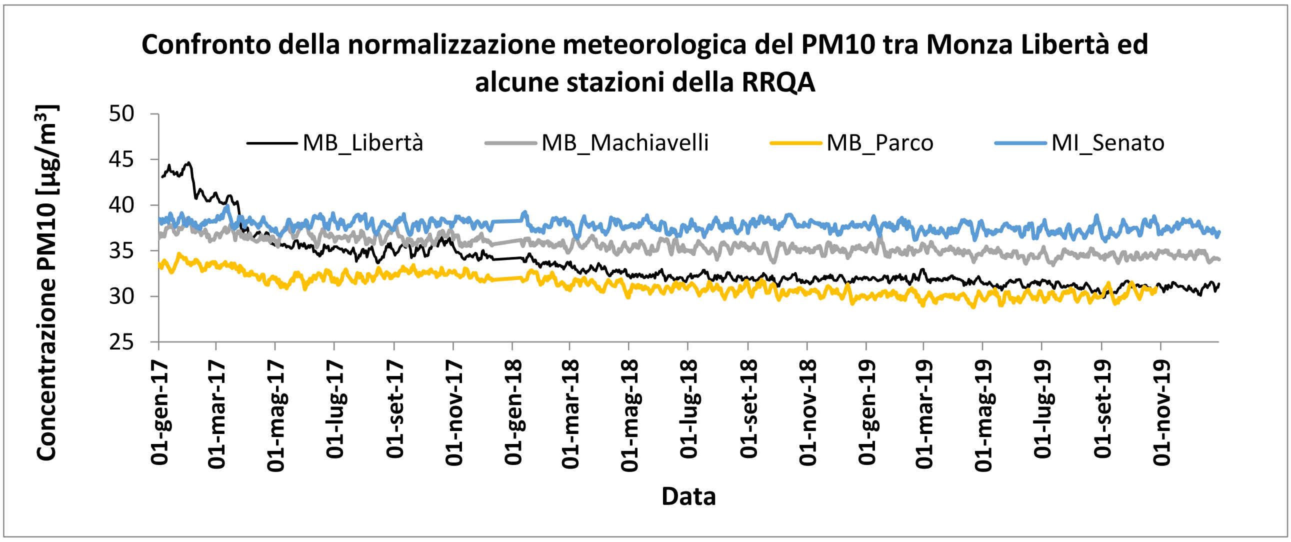


Figure 25 Comparison of the meteorological normalization of the PM10 between Monza Libertà and some stations of the RRQA.

To have a significant estimate of the change over the past three years, the Change Point Detection technique was applied. In our case, we analyzed where the normalized trend had a statistically significant change. The result of the change point detection analysis on the PM10 - meteorologically normalized - daily time-series at Monza Libertà are shown in figure 26.
The analysis highlighted two "steps". During the ex-ante operam (from May 2017 to January 2018) there was a first "step" not linked to the NLEZ implementation (roughly -3.0 µg/m3, corresponding to an average 8% decrease). This step was followed by a gentle downward trend and finally we observed a second step (-1.1 µg/m3) that could be linked to the implementation of the NLEZ since it was observed at the beginning of January 2019 when the ban on heavy duty vehicles entered into force.
The average over the whole ex ante operam phase PM10 concentration (over the normalized data) was 33.7 µg/m^3, thus the decrease between ex ante and post operam can be estimated as -7.7%.
For PM_{10} values the results seem to be better than those obtained for NO_2.

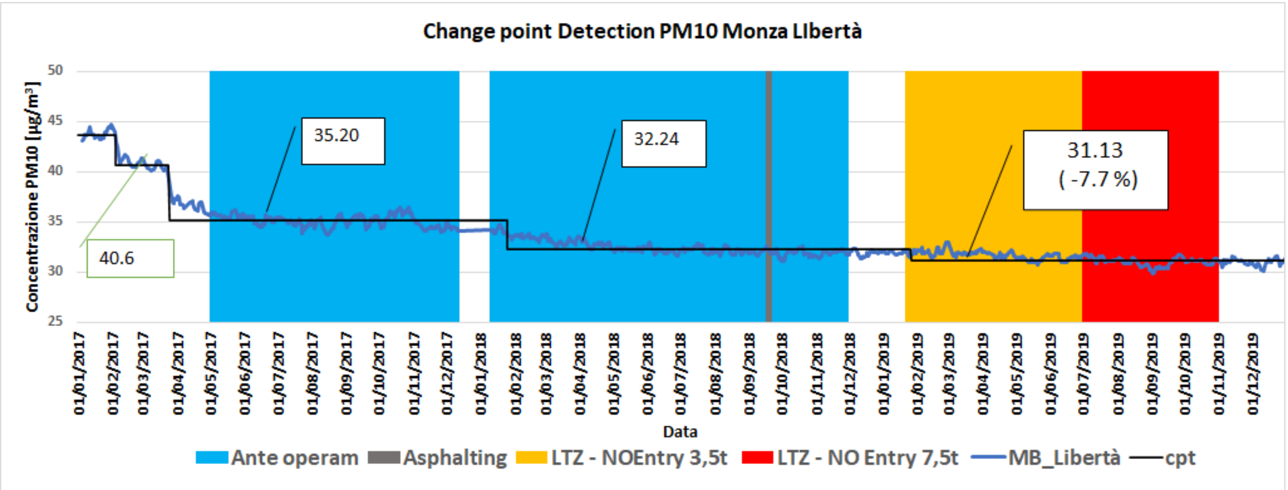


Figure 26 Change Point Detection for the PM10 values at Monza Libertà

7 Conclusion

In order to assess the environmental effects of a Noise Low Emission Zone, considering air quality conditions and environmental noise reduction, monitoring activities have been carried out in the Libertà district, the pilot area of the project, located in Monza.
The effect of the NLEZ on air pollution seems to be negligible for combustion related pollutant and carbon fractions of PM, due both to the moderate spatial effects of the measures undertaken and confounding factors due to concomitant emission sources and meteorology.
To going deeper on this topic, statistical approach allowing to meteorologically normalise the pollutant concentrations time series were used. The results of the change point analysis applied to the meteorologically adjusted time-series shown that the reduction achievable with the implementation of the NLEZ, at microscale (i.e. within the NLEZ small domain), on the targeted pollutants was around 1% for NO_2 and 7% for PM_{10}.
Our results seems to agree very well with other studies aimed to evaluate the impact of LEZs at least on a scale local or on the microscale (C. Holman et al., 2015). Indeed when studies focused on parameters related to vehicle exhaust emissions the strength and spatial coverage of the establish blockages or restrictions on circulation (particularly those regarding heavy vehicles powered by diesel) appear to be a key factor in order to achieve larger air pollution improvements (Jones at al., 2012).
The other concomitant specific policies undertaken in the study area, on air quality, sectoral transport and energy policies (e.g. change in the composition of the park in circulation, etc.), represent important confounding factors which therefore influence the evaluation process and which make it challenging to isolate the impact of single local measure to improve air quality.
Monitoring with passive samplers has made possible to highlight the existence of a statistically significant spatial gradient on the microscale and its seasonal variability (the study domain is very small, only 4 km^2) and models were developed to estimate such variability (action B5.6).
The monitoring and assessment strategy can be easily transposed to other small scale effectiveness studies aimed to evaluate the ancillary effects on air quality of NLEZ’s implementation.

8 Reference

1. Eulalia Peris. Environmental noise in Europe 2020. EEA Report No 22/2019, European Environment Agency.
2. Anh, V., Duc, H., Azzi, M., 1997. Modeling anthropogenic trends in air quality data. J.Air Waste Manag. Assoc. 47 (1), 66–71. https://doi.org/10.1080/10473289.1997.10464406.
3. Derwent, R., Middleton, D., Field, R., Goldstone, M., Lester, J., Perry, R., 1995. Analysis and interpretation of air quality data from an urban roadside location in Central London over the period from July 1991 to July 1992. Atmos. Environ. 29 (8), 923–946.http://www.sciencedirect.com/science/article/pii/135223109400219B.
4. ECORYS, 2014. Feasibility study: European city pass for low emission zones, Annex A: Standards and Guidance Document. Rotterdam, 2014
5. EEA, 2019. Report 10/2019 – *Air quality in Europe – 2019 report*. https://www.eea.europa.eu/publications/air-quality-in-europe-2019 . Consultazione del 25 febbraio 2020.
6. WHO, 2000, Air quality guidelines for Europe, World Health Organization, Regional Office for Europe, Copenhagen (http://www.euro.who.int/__data/assets/pdf_file/0005/74732/E71922.pdf) accessed 8 May 2020.
7. WHO, 2006, Air Quality Guidelines: Global update 2005. Particulate matter, ozone, nitrogen dioxide and sulphur dioxide, World Health Organization, Regional Office for Europe, Copenhagen. (https://www.who.int/phe/health_topics/outdoorair/outdoorair_aqg/en/) accessed 8 May 2020.
8. International Agency for Research on Cancer (IARC). Outdoor Air Pollution. IARC monographs on the evaluation of carcinogenic risk to humans. Volume 109. Lyon, France: IARC; 2015. (http://monographs.iarc.fr/ENG/Monographs/vol109/index.php) accessed 8 May 2020.
9. World Health Organization. Review of evidence on health aspects of air pollution – REVIHAAP Project. Copenhagen, Denmark: WHO; 2013. (http://www.euro.who.int/en/health-topics/environment-and-health/air-quality/publications/2013/review-of-evidence-on-health-aspects-of-air-pollution-revihaap-project-final-technical-report) accessed 8 May 2020
10. World Health Organization. 2018. Ambient outdoor air pollution. https://www.who.int/en/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health
11. Jones A.M. et al., "A large reduction in airborne particle number concentrations at the time of the introduction of "sulphur free" diesel and the London Low Emission Zone", Atmospheric Environment, 50, 129-138, 2012.
12. Holman C. et al., "Review of the efficacy of low emission zones to improve urban air quality in European cities", Atmospheric Environment, 111, 161-169. 2015.
13. WHO. Environmental noise guidelines for the European region (2018).
14. Münzel T, Sörensen M, Gori T, Schmidt FP, Rao X, Brook J, Chen LC, Brook RD, and Rajagopalan S. Environmental stressors and cardio-metabolic disease: part I-epidemiologic evidence supporting a role for noise and air pollution and effects of mitigation strategies. Eur Heart J 38: 550–556, 2017.
15. Münzel T, Sörensen M, Gori T, Schmidt FP, Rao X, Brook FR, Chen LC, Brook RD, and Rajagopalan S. Environmental stressors and cardio-metabolic disease: part II-mechanistic insights. Eur Heart J 38: 557–564, 2017.
16. Münzel T., Sørensen M., Schmidt F., Schmidt E., Steven S., Kröller-Schön S., Daiber A., The Adverse Effects of Environmental Noise Exposure on Oxidative Stress and Cardiovascular Risk. Antioxidants & Redox Signaling, 28(9), 873-908, 2018 (doi: 10.1089/ars.2017.7118).
17. D.G.R. Toscana n. 157 of 11 March 2013, "Risultati del progetto Leopoldo".

18. Grange SK, Carslaw DC, Lewis AC, Boleti E, Hueglin C. Random forest meteorological normalisation models for Swiss PM10 trend analysis. Atmos. Chem. Phys. 18 (9), 6223–6239, 2018.
19. Grange SK, Carslaw DC. Using meteorological normalisation to detect interventions in air quality time series. Science of the Total Environment 653, 578–588, 2019.

9 Annex: statistics of measured variables

RRQA - ARPA Lombardia, province Monza and Brianza, Varese and Milan metropolitan city: monitoring network

Name Station	Province	Network	Zone type	Station type	Altitude (m.a.s.l.)	Site
Monza - Libertà	MB	Mezzo mobile	Urban	TRAFFIC	162	Mobile lab
Meda	MB	Public	Urban	TRAFFIC	243	Fixed site
Monza Parco	MB	Public	Suburban	BACKGROUND	181	Fixed site
Monza via Machiavelli	MB	Public	Urban	BACKGROUND	162	Fixed site
Arconate	MI	Private	Suburban	BACKGROUND	178	Fixed site
Cassano d'Adda 2 – via Milano	MI	Private	Urban	TRAFFIC	133	Fixed site
Cinisello Balsamo	MI	Public	Urban	TRAFFIC	154	Fixed site
Cormano	MI	Public	Urban	BACKGROUND	149	Fixed site
Limito di Pioltello	MI	Public	Urban	BACKGROUND	122	Fixed site
Magenta	MI	Public	Urban	BACKGROUND	141	Fixed site
Milano Verziere	MI	Public	Urban	TRAFFIC	118	Fixed site
Milano - via Pascal	MI	Public	Urban	BACKGROUND	122	Fixed site
Milano Senato	MI	Public	Urban	TRAFFIC	119	Fixed site
Milano - viale Liguria	MI	Public	Urban	TRAFFIC	114	Fixed site
Milano - viale Marche	MI	Public	Urban	TRAFFIC	127	Fixed site
Motta Visconti	MI	Public	Suburban	BACKGROUND	100	Fixed site
Rho	MI	Public	Urban	BACKGROUND	158	Fixed site
San Giuliano Milanese	MI	Private	Urban	TRAFFIC	97	Fixed site
Sesto San Giovanni	MI	Public	Urban	TRAFFIC	140	Fixed site
Turbigo	MI	Private	Urban	BACKGROUND	166	Fixed site
Busto Arsizio Accam	VA	Private	Suburban	BACKGROUND	206	Fixed site
Ferno	VA	Private	Urban	BACKGROUND	215	Fixed site

Saronno via Santuario	VA	Public	Urban	BACKGROUND	212	Fixed site
Varese - via Copelli	VA	Public	Urban	TRAFFIC	383	Fixed site
Varese Vidoletti	VA	Public	Urban	BACKGROUND	425	Fixed site

DESCRIPTIVE STATISTICS – EX ANTE and EX POST OPERAM MONITORING CAMPAIGNS

Table 1. SO_2 - ex ante and post operam descriptive statistics.

ex-ante	**I** (04 -22 mag 2017)		**II** (14 - 31 lug 2017)		**III** (9 - 30 nov 2017)		**IV** (31 jan - 19 feb 2018)		**Mean**
	mean	std	mean	std	mean	std	mean	std	
SO2	3.7	1.4	3.9	2.1	5	1.3	5.3	2.2	3.8
ex-post	**I** (20 feb -26 mar 2019)		**II** (08 - 21 mag 2019)		**III** (03 - 17 lug 2019)		**IV** (30 ott - 21 nov 2019)		
	mean	std	mean	std	mean	std	mean	std	
SO2	--	--	--	--	5.1	2.5	2.4	0.7	3.5
Unit of measure [µg/m³]									**-7.8 %**

Table 2. NO_2 - ex ante and post operam descriptive statistics.

ex-ante	**I** (04 -22 mag 2017)		**II** (14 - 31 lug 2017)		**III** (9 - 30 nov 2017)		**IV** (31 jan - 19 feb 2018)		**Mean**
	mean	std	mean	std	mean	std	mean	std	
NO_2	37.6	8.8	26	6.6	47.1	8.9	56.9	8.6	40.6
ex-post	**I** (20 feb -26 mar 2019)		**II** (08 - 21 mag 2019)		**III** (03 - 17 lug 2019)		**IV** (30 ott - 21 nov 2019)		
	mean	std	mean	std	mean	std	mean	std	
NO_2	60.4	15.7	38.8	6.3	26.4	7.0	37.3	9.0	45.1
Unit of measure [µg/m³]									*+ 11 %*

ex-ante	**Monza Machiavelli**		**Monza Parco**		**MI -Senato**		**MI- Marche**	
	mean	std	mean	std	mean	std	mean	std
NO_2	40.9	17.7	57.5	16.2	48.4	17.3	59.0	22.8
ex-post	mean	std	mean	std	mean	std	mean	std
NO_2	41.6	13.2	34.5	15.0	42.7	14.4	57.9	19.8
Δ %	+ 5%		-40 %		-11.8		-1.9 %	

Table 3. CO - ex ante and post operam descriptive statistics.

ex-ante	**I** (04 -22 mag 2017)		**II** (14 - 31 lug 2017)		**III** (9 - 30 nov 2017)		**IV** (31 jan - 19 feb 2018)		**Mean**
	mean	std	mean	std	mean	std	mean	std	
NO_2	0.4	0.2	0.7	0.1	1.2	0.4	1.0	0.3	0.9
ex-post	**I** (20 feb -26 mar 2019)		**II** (08 - 21 mag 2019)		**III** (03 - 17 lug 2019)		**IV** (30 ott - 21 nov 2019)		
	mean	std	mean	std	mean	std	mean	std	
NO_2	0.8	0.2	0.6	0.3	0.7	0.3	0.9	0.2	0.8
Unit of measure [mg/m^3]									*-11 %*

Table 4. O_3 - ex ante and post operam descriptive statistics.

ex-ante	**I** (04 -22 mag 2017)		**II** (14 - 31 lug 2017)		**III** (9 - 30 nov 2017)		**IV** (31 jan - 19 feb 2018)		**Mean**
	mean	std	mean	std	mean	std	mean	std	
O_3	90.3	31.7	142	31.3	--	--	11.1	7.6	81
ex-post	**I** (20 feb -26 mar 2019)		**II** (08 - 21 mag 2019)		**III** (03 - 17 lug 2019)		**IV** (30 ott - 21 nov 2019)		
	mean	std	mean	std	mean	std	mean	std	
O_3	30.8	16.6	50.7	16.6	78.8	12.7	18.5	5.6	38.8
Unit of measure [µg/m^3]									*-51 %*

Table 5. Benzene - ex ante and post operam descriptive statistics.

ex-ante	**I** (04 -22 mag 2017)		**II** (14 - 31 lug 2017)		**III** (9 - 30 nov 2017)		**IV** (31 jan - 19 feb 2018)		**Mean**
	mean	std	mean	std	mean	std	mean	std	
Benzene	-	-	0.3	0.1	3.3	1.8	2.0	1.1	1.8
ex-post	**I** (20 feb -26 mar 2019)		**II** (08 - 21 mag 2019)		**III** (03 - 17 lug 2019)		**IV** (30 ott - 21 nov 2019)		
	mean	std	mean	std	mean	std	mean	std	
Benzene	1.0	0.5	0.3	0.1	0.6	0.3	1.0	0.3	0.8
Δ %									*-55 %*

	Sondrio-Mazzini	**MI -Senato**	**MI- Marche**
ex-ante	mean	mean	mean
Benzene	0.8	1.7	2.3
ex-post	mean	mean	mean
Benzene	0.4	1.4	1.7
Δ %	-50 %	-1.7	-26 %

Table 6 benzene – mean concentrations (passive sampling monitoring)

Punto	**Latitudine (N)**	**Longitudine (E)**	**Descrizione**	**Benzene estivo (µg/m³)**	**Benzene invernale (µg/m³)**	**Benzene mean (µg/m³)**	**Benzene mean(AO) (µg/m³)**	**Δ (µg/m³)**
p1	45.59136	9.30643	V.le Libertà (ITC Mapelli)	1.08	0.51	0.80	0.74	**0.06**
p2	45.59069	9.30266	V.le Libertà (Centro Civico)	1.31	0.53	0.92	0.81	**0.11**
p3	45.59147	9.30160	Via Parmenide	1.18	0.55	0.87	0.81	**0.06**
p4	45.59008	9.29736	V.le Libertà, 93	1.70	0.80	1.25	1.25	**0.00**
p5	45.59294	9.29966	Via Impastato	0.97	0.50	0.73	0.66	**0.07**
p6	45.58818	9.29679	Via Gallarana	1.19	0.52	0.85	0.83	**0.02**
p7	45.58860	9.29870	Via Correggio, 81	1.28	0.56	0.92	0.88	**0.04**
p8	45.58736	9.29989	Via della Guerrina (Liceo Porta)	1.43	0.69	1.06	1.02	**0.04**
p9	45.58904	9.30310	Via Modigliani	1.18	0.51	0.84	0.79	**0.05**
p10	45.58707	9.30461	Via della Guerrina, 31	1.16	0.58	0.87	0.82	**0.05**
p11	45.59282	9.30432	Via Ragazzi del '99	0.98	0.50	0.74	0.65	**0.09**
p12	45.58909	9.30531	Via Papini	1.19	0.52	0.86	0.75	**0.11**
p13	45.58961	9.31086	V.le Stucchi (autolavaggio)	1.21	0.60	0.90	0.92	**-0.02**
p14	45.57413	9.26378	Via Machiavelli	1.01	0.51	0.76	0.65	**0.11**
p15	45.58541	9.31010	V.le Stucchi (palazzetto)	1.32	0.66	0.99	0.88	**0.11**
p16	45.58177	9.30198	V.le Sicilia	1.39	0.58	0.98	0.89	**0.09**
p17	45.58612	9.30390	Via Vasari	1.09	0.64	0.87	n.d.	**n.d**
p18	45.58392	9.29992	Via Correggio, 26	1.41	0.59	1.00	0.95	**0.05**
p19	45.58243	9.29480	Via Amati (Policlinico)	1.15	0.50	0.83	0.77	**0.06**
p20	45.58632	9.29299	Via Aguggiari	1.09	0.50	0.79	0.70	**0.09**
p21	45.58836	9.28870	V.le Libertà, 33	1.78	0.86	1.32	1.17	**0.15**
p22	45.59762	9.29546	Via Lecco (ang. Gioia)	1.16	0.53	0.85	0.78	**0.07**
p23	45.58257	9.30645	Via Tognini (stadio)	0.99	0.50	0.75	0.69	**0.06**
p24	45.59215	9.29026	Via Lecco (ang. Verrazzano)	1.37	0.70	1.04	0.91	**0.13**
p25	45.59599	9.29139	Parco di Monza	0.82	0.50	0.66	0.57	**0.09**

Table 7. Toluene - ex ante and post operam descriptive statistics.

ex-ante	**I** (04 -22 mag 2017)		**II** (14 - 31 lug 2017)		**III** (9 - 30 nov 2017)		**IV** (31 jan - 19 feb 2018)		**Mean**
	mean	std	mean	std	mean	std	mean	std	
Toluene	-	-	1.6	1.2	13.3	4.5	7	4.5	7.3
ex-post	**I** (20 feb -26 mar 2019)		**II** (08 - 21 mag 2019)		**III** (03 - 17 lug 2019)		**IV** (30 ott - 21 nov 2019)		
	mean	std	mean	std	mean	std	mean	std	
Toluene	4.6	2.6	2.0	0.8	3.5	1.7	4.3	2.1	3.9
Δ %									*-46 %*

	Sondrio-Mazzini	**MI -Senato**	**MI- Marche**
ex-ante	mean	mean	mean
Toluene	2.0	7.2	13.3
ex-post	mean	mean	mean
Toluene	0.4	5.0	3.4
Δ %	-80 %	-30%	-74 %

Table 8. toluene mean concentrations (passive sampling monitoring)

Punto	Latitudine (N)	Longitudine (E)	Descrizione	Toluene invernale (µg/m³)	Toluene estivo (µg/m³)	Toluene mean (µg/m³)	Toluene mean (AO) (µg/m³)	Δ (µg/m³)
p1	45.59136	9.30643	V.le Libertà (ITC Mapelli)	4.29	2.78	3.53	3.35	**0.18**
p2	45.59069	9.30266	V.le Libertà (Centro Civico)	5.03	2.85	3.94	3.08	**0.86**
p3	45.59147	9.30160	Via Parmenide	4.67	2.81	3.74	3.64	**0.10**
p4	45.59008	9.29736	V.le Libertà, 93	6.32	3.57	4.95	3.22	**1.73**
p5	45.59294	9.29966	Via Impastato	4.13	2.74	3.43	3.51	**-0.08**
p6	45.58818	9.29679	Via Gallarana	4.72	2.77	3.75	3.72	**0.03**
p7	45.58860	9.29870	Via Correggio, 81	4.89	3.04	3.97	5.77	**-1.80**
p8	45.58736	9.29989	Via della Guerrina (Liceo Porta)	5.46	3.20	4.33	5.63	**-1.30**
p9	45.58904	9.30310	Via Modigliani	4.60	2.76	3.68	2.84	**0.84**
p10	45.58707	9.30461	Via della Guerrina, 31	4.55	2.79	3.67	3.19	**0.48**
p11	45.59282	9.30432	Via Ragazzi del ‘99	4.00	2.74	3.37	4.04	**-0.67**
p12	45.58909	9.30531	Via Papini	4.83	2.76	3.80	4.09	**-0.29**
p13	45.58961	9.31086	V.le Stucchi (autolavaggio)	4.58	3.31	3.94	3.75	**0.19**
p14	45.57413	9.26378	Via Machiavelli	4.74	2.78	3.76	3.74	**0.02**
p15	45.58541	9.31010	V.le Stucchi (palazzetto)	5.18	2.92	4.05	4.48	**-0.43**
p16	45.58177	9.30198	V.le Sicilia	5.56	2.91	4.23	4.59	**-0.36**
p17	45.58612	9.30390	Via Vasari	4.32	2.74	3.53	3.31	**0.22**
p18	45.58392	9.29992	Via Correggio, 26	5.50	2.83	4.17	3.26	**0.91**
p19	45.58243	9.29480	Via Amati (Policlinico)	4.79	2.74	3.76	3.61	**0.15**
p20	45.58632	9.29299	Via Aguggiari	4.29	2.74	3.51	3.88	**-0.37**
p21	45.58836	9.28870	V.le Libertà, 33	6.79	3.98	5.39	2.41	**2.98**
p22	45.59762	9.29546	Via Lecco (ang. Gioia)	4.56	2.81	3.68	2.81	**0.87**
p23	45.58257	9.30645	Via Tognini (stadio)	4.09	2.74	3.42	3.48	**-0.06**
p24	45.59215	9.29026	Via Lecco (ang. Verrazzano)	5.42	3.38	4.40	3.61	**0.79**
p25	45.59599	9.29139	Parco di Monza	3.43	2.74	3.09	3.64	**-0.55**

Table 9. PM10 - ex ante and post operam descriptive statistics.

ex-ante	**I** (04 -22 mag 2017)		**II** (14 - 31 lug 2017)		**III** (9 - 30 nov 2017)		**IV** (31 jan - 19 feb 2018)		**Mean**
	mean	std	mean	std	mean	std	mean	std	
PM10	16.7	5.7	17.9	8.0	52.9	25.7	44.1	22.8	32.8
ex-post	**I** (20 feb -26 mar 2019)		**II** (08 - 21 mag 2019)		**III** (03 - 17 lug 2019)		**IV** (30 ott - 21 nov 2019)		
	mean	std	mean	std	mean	std	mean	std	
PM10	39.0	16.7	16.0	4.4	19.7	6.1	20.9	6.3	27.0
Unit of measure [μg/m^3]									*- 17.7 %*

	Monza Machiavelli		**Monza Parco**		**MI -Senato**		**MI- Pascal**	
ex-ante	mean	std	mean	std	mean	std	mean	std
PM10	33.6	23.2	27.4	23.2	33.9	22.5	31.6	22.5
ex-post	mean	std	mean	std	mean	std	mean	std
PM10	27.6	18.2	23.3	15.1	31.8	18.5	27.5	18.3
Δ %	-19.4%		-15 %		-6.3%		-13.0%	

Table 10. PM2.5 - ex ante and post operam descriptive statistics.

ex-ante	**I** (04 -22 mag 2017)		**II** (14 - 31 lug 2017)		**III** (9 - 30 nov 2017)		**IV** (31 jan - 19 feb 2018)		**Mean**
	mean	std	mean	std	mean	std	mean	std	
PM10	12.2	3.9	10.3	3.5	40.7	20.5	32.9	17.9	24
ex-post	**I** (20 feb -26 mar 2019)		**II** (08 - 21 mag 2019)		**III** (03 - 17 lug 2019)		**IV** (30 ott - 21 nov 2019)		
	mean	std	mean	std	mean	std	mean	std	
PM10	--	--	--	--	15.3	3.9	15.9	5.3	15.6
Unit of measure [μg/m^3]									*- 35 %*

Table 11. BC, OC, EC and TC - ex ante and post operam descriptive statistics.

ex-ante	I (04 -22 mar 2017)		II (14 - 31 lug 2017)		**III** (9 - 30 nov 2017)		**IV** (31 jan - 19 feb 2018)	
	mean (µg/m3)	std	mean	std	mean	std	mean	std
BC	2	1.2	1.7	1	6.7	3.4	4.3	2.5
OC	5.5	1	6.1	1.4	15.5	4.9	11.3	3.9
EC	1.6	0.4	1.4	0.4	4.7	1.7	2.7	0.9
TC	7.1	1.3	7.6	1,7	20.2	6.1	14	4.5
ex-post	**I** (20 feb -26 mar 2019)		II (08 - 21 mar 2019)		III (03 - 17 lug 2019)		IV (30 ott - 21 nov 2019)	
	mean (µg/m^3)	std	mean	std	mean	std	mean	std
BC	3.7	1.9	1.6	0.4	1.1	0.3	3.1	0.8
OC	9.0	8.9	4.5	0.6	6.1	1.0	6.6	1.5
EC	2.2	0.9	0.9	0.2	0.8	0.2	1.6	0.6
TC	11.1	4.1	5.4	0.7	6.9	1.2	8.5	2.0

Unit of measure [µg/m^3]

Air quality modelling – ISPRA

Methodologies fOr Noise low emission Zones introduction And management

LIFE15 ENV/IT/000586

LIFE MONZA
Methodologies fOr Noise low emission Zones introduction And management

Technical Report on ante and post operam data collection

Deliverable	Report on Ante and Post Operam data collection
Action/Sub-action	B5.6 "Air quality modelling"
Authors	Alessandra Gaeta, Mariacarmela Cusano, Gianluca Leone, Alessandro Di Menno di Bucchianico, Giorgio Cattani, Andrea Algieri, Cristina Colombi, Eleonora Cuccia, Umberto Dal Santo
Status - date	Final version– 14 may 2020

Beneficiary:	ISPRA
Contact person:	Salvatore Curcuruto
E-mail:	salvatore.curcuruto@isprambiente.it
Project Website:	http://www.lifemonza.eu/

Annex 12- variables ex ante
Annex 30- variables ex post

1 Introduction

Air pollution is considered as a major environmental risk for human health; it increases the incidence of a wide range of diseases and has several environmental impacts, damaging vegetation and ecosystems.
The road transport sector provides a significant contribution to the total anthropogenic emissions, together with other mobile sources, non industrial combustion plants and combustion in energy and transformation industries. Other undesired substances (known as secondary pollutants e.g. ozone) may be formed in the atmosphere due to chemical reaction between pollutant directly emitted.
Control of exposure to air pollutants requires public authorities actions at global, regional and local level. WHO produced and subsequently revised air quality guidelines (WHO, 2000, 2005) that contain recommendations of targets for air quality and limits for the concentration of selected air pollutants derived from epidemiological and toxicological evidence.
The Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on ambient air quality and cleaner air for Europe defined and established objectives for ambient air quality designed to avoid, prevent or reduce harmful effects on human health and the environment as a whole. The ambient air quality in Member States must be assessed on the basis of common methods and criteria. Results of the ambient air quality assessment should be used in order to help combat air pollution and nuisance and to monitor long-term trends and improvements.
The pollutants targeted by the 2008/50/EC directive include particulate matter ($PM_{2.5}$, PM_{10}), ozone (O_3), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), carbon monoxide (CO), and lead (Pb), while similar provisions were established for benzo(a)pirene, arsenic cadmium and nickel as high concern PM_{10} toxic components by the 2004/107/EC directive.
Low emission zones (LEZs) have been established to reduce air pollutant emissions and to improve urban air quality in European countries. LEZs usually regulate the access to a zone depending on the vehicle emission standards or the vehicle type (heavy-duty vehicles, light-duty vehicles, moped etc.). LEZs may cover a variable area that can include few roads or a large part of an urban area. Those zones aims mainly at reducing exhaust emissions of traffic related pollutant, particularly PM and nitrogen oxides NO_X. Policy measures (as LEZs) to reduce traffic by banning the most polluting vehicles are generally able to reduce circulating vehicles but they gave conflicting results on air pollution level.
Evaluate the effect of a LEZ on pollution level (PM_{10}, $PM_{2.5}$, NO_X) is not an easy task because of several confounding factors: meteorological conditions, regional background levels of pollutants, other concomitant air quality policy measures (Holman C. et al., 2015). To assess the impact of the LEZs, taking into account the confounding factors, it needs to remove the influence of non local traffic pollution sources. Advanced statistical techniques are necessary to achieve this aim.
Meteorology has a great impact on yearly and daily variation of PM concentration and therefore it is necessary make adjustment over long periods to remove seasonal biases. The other concomitant air quality/transport/energy policy measures (e.g. implementation of Euro standards, vehicle fleet composition change, etc.) represent relevant confounding factors, and affect the evaluation process making hard to isolate the impact of LEZs on air quality.

2 Objectives

LIFE MONZA project (Methodologies fOr Noise low emission Zones introduction And management – LIFE15 ENV/IT/000586) addresses these issues, aiming at introducing an easy-replicable method, and related guidelines, for the identification and the management of the Noise Low Emission Zone (NLEZ), an urban area subject to traffic restrictions, whose impacts and benefits regarding noise issues have been analyzed and tested in the pilot area that was the Libertà district (about 2 km^2) of the city of Monza, located in North Italy. Other objectives of the project were the evaluation of complementary effects on the air quality and benefits on wellbeing conditions of the residents. The implementation of LEZ primarily introduced in

order to ensure compliance with the air pollutants limit values set by the European Directive on ambient air quality 2008/50/EC, is a well-established measure carried out by the cities and the effects on air quality have been analyzed in detail.
In this report the objectives were:

- to describe the spatial and seasonal variability of pollutants by estimating in particular, through the use of empirical models, the distribution on the microscale (i.e. on the territory delimited by the NLEZ) of some pollutants tracing the emissions of internal combustion engines.
- to evaluate, on the basis of the comparison of the results of the campaigns carried out before (ex-ante) and after (ex-post) the implementation of the NLEZ, any tangible effects, at local level, on air quality.

3 Background

Current methods for assessing intra-urban air pollution spatial variability have recently been reviewed (Jerrett et al., 2005). Conventional dispersion models and empirical techniques (Land Use Regression model - LURs) were the most common approaches described in most of the studies. To evaluate the efficacy of Low Emission Zones (LEZ) in urban areas, the models that were commonly used to give a reliable estimations of air pollution, were dispersion models (photochemical or lagrangian model in according to the scale of impact and the complexity of scenario's simulation). However, in recent years, LURs have been achieved best performances and results in order to capture small scale variations in air pollution concentrations, particularly from traffic sources, with sensible low costs.
In fact, higher spatial resolution of pollutant concentration estimation with a cost-effective approach was the main improvement of LURs in comparison to other techniques.
LURs combine experimental measures of air pollutants at various locations representative of the study area, and the development of a regression model using predictor variables (Mercer et al., 2011), obtained through geographic information system (GIS). Development in GIS have contributed to the popularity of LUR methods.
LURs have been performed particularly in North America and Europe within a number of studies in the last two decades (Briggs et al, 1997; Hoek et al. 2008).
Pollutant measurements were the dependent variable. A spatially network of pollutant monitoring sites must be planned: the performance of the model depends on the number and distribution of the samplers. In urban areas, routine networks (fixed monitoring stations) were not able to capture small scale variability: consequently, it was necessary to design monitoring *ad hoc* campaigns.
NO_2, NO_X, NO and Volatile Organic Compounds (VOCs) were generally measured with passive sampling method that was easy, inexpensive and reliable, whereas PM (PM_{10}, $PM_{2.5}$, ultrafine particles) was typically measured with active samplers. There is no rigorous methodology to determine the required number of monitoring locations given a certain study objective and setting; the right choose should be take into account the size of population and city to determine the right number.
Predictors were the independent variables. Significant predictors should include traffic-related variables (distance to the nearest road, road length, traffic density), population density in the census area, land use information offered by Corine Land Cover (e.g. high and low density residential area, urban green) physical geography (latitude and longitude), meteorological parameters (temperature, wind velocity, pressure, precipitation, mixing height) and emission data (available on National Emission Inventories, produced by ISPRA).
In recent works (Tang et al., 2013), other variables were investigated. By combining data on building heights and high resolution topographical data, typical of LEZ characterisation, enhanced variables can be offered to account for the effects of building volume, road and width length (street canyon).
Predictor variables were usually computed in circular buffers around each monitoring size: the selection of buffer size (Jerrett et al., 2009, Von Klot, 2011) is crucial to determining the model performance and the spatial resolution of the estimates. Ideally, buffer sizes should be selected to take account of known

dispersion pollutant patterns and the urban configuration around the study domain (heights buildings and street width).
Generalized Additive statistical Models, GAM, were developed which allow to estimate with high spatial resolution (20x20 m) in the study domain the concentration of pollutants monitored with passive samplers. GAM is a multivariate non-parametric method of analysis that was used with great results in Ecology (Zuur, 2009 e Zuur, 2012). GAM is able to model the non-linear effects of a number of covariates, to assess any simultaneous and combined contribution to the response variables (benzene and toluene mean concentrations assessed during each monitoring campaign using passive samplers). Any non-linear relationship was modelled without having to specify the non-linear functional form. The use of spline as "smoothing" functions allows to better approximate any local trends in particular intervals of the domain of existence of the explanatory variable (Clifford et al ., 2012).
In general the models have the form (Wood, 2017):

$$g(\mu_i) = A_i\gamma + \sum_j f_j(x_{ji}),\ y_i \sim EF(\mu_i, \varphi)$$

con:
y_i = response variable
$\mu_i \equiv E(y_i)$= expected value of the response y_i
$y_i \sim EF(\mu i, \varphi)$= exponential distribution of y_i
$A_i\gamma$ = i^{th} row of the matrix of the model's parameters
$f_j(x_{ji})$ = smooth function for the covariate *j*
In the example equation above, there are J smoothers and each is a function of only one covariate, though it is possible to construct smoothers of multiple variables.
Each smoother f_j is represented by a sum of K simpler, fixed basis functions ($b_{j,k}$) multiplied by corresponding coefficients ($\beta_{j,k}$), which need to be estimated:

$$f_j(x_{ji}) = \sum_{k=1}^{K} \beta_{j,k}\, b_{j,k}(x_j)$$

K, referred to as “basis size”, “basis complexity” or “basis richness”, determines the maximum complexity of each smoother.
It would seem that large basis size could lead to overfitting, but this counteracted by a *smoothing penalty* that influences basis function coefficients so as to prevent excess “wiggliness” and ensure that appropriate complexity of each smoother. A penalty term is then added to the model likelihood *L*, controlling the trade-off via a *smoothing parameter* (λ). To measure the complexity of a penalized smooth terms we use the *effective degrees of freedom* (EDF), which at a maximum is the number of coefficients to be estimated in the model, minus any constraints. The EDF can take non-integer values and larger values indicate more wiggly terms. The number of basis functions, k sets a maximum for the EDF, as a smoother cannot have more than *k* EDF. When the EDF is well below *k*, increasing *k* generally has very little effect on the shape of the function. In general, *k* should be set large enough to allow for potential variation in the smoother while still staying low enough to keep computation time low. In “mgcv R-package” , the function “check.gam” can be used to determine if *k* has been set too low.

4 Methods

To assess the exposure gradients within a city as well as to assess the effectiveness of measures addressed to reduce the air pollution, reliable estimate of both temporal and spatial variability in the study domain are needed. Two general approach can be identified as for assess small scale spatial variability: deterministic modelling (i.e. dispersion model) and empirical modelling (e.g. land use regression). Whatever the modelling approach, fixed point measurement are used to develop and or to validate the models. Thus, ad hoc monitoring are needed, since routine networks in most urban areas are not dense enough. In fact, existing monitoring networks have insufficient density to capture small-scale spatial variation of air pollution.
Diffusive sampling technique are of particular interest, because of their relatively low cost, no need of any pump or electrical power and simple operation, allowing for deploying a large number of samplers over the study area.
25 points were selected across the study domain to represent the microscale spatial variability of air quality variously distributed according to the distance from the main roads in the study domain (4 km^2) both inside and outside the NLEZ. The sites represent a wide range of possible scenarios that characterize the NLEZ and surrounding area context. There were sites located less than 50 m from a high traffic road in densely populated neighbourhoods (traffic sites) as well as sites over 200 m from a high traffic road in low density residential areas (urban background sites).
Average concentrations were measured with diffusive sampling technique, during 2017 winter and summer (14 days each), before the NLEZ implementation and were repeated during 2019/2020 after NLEZ. In the ex ante phase the samplings were made, in summer, from 14 to 28 July 2017 and, in winter, from 31 January to 14 February 2018. In the ex post phase, in winter from 6 to 21 March 2019 and, in summer, from 7 to 21 May 2019. The passive samplers, placed in the study domain, were variously distributed based on the distance from the main roads (Fig.1).

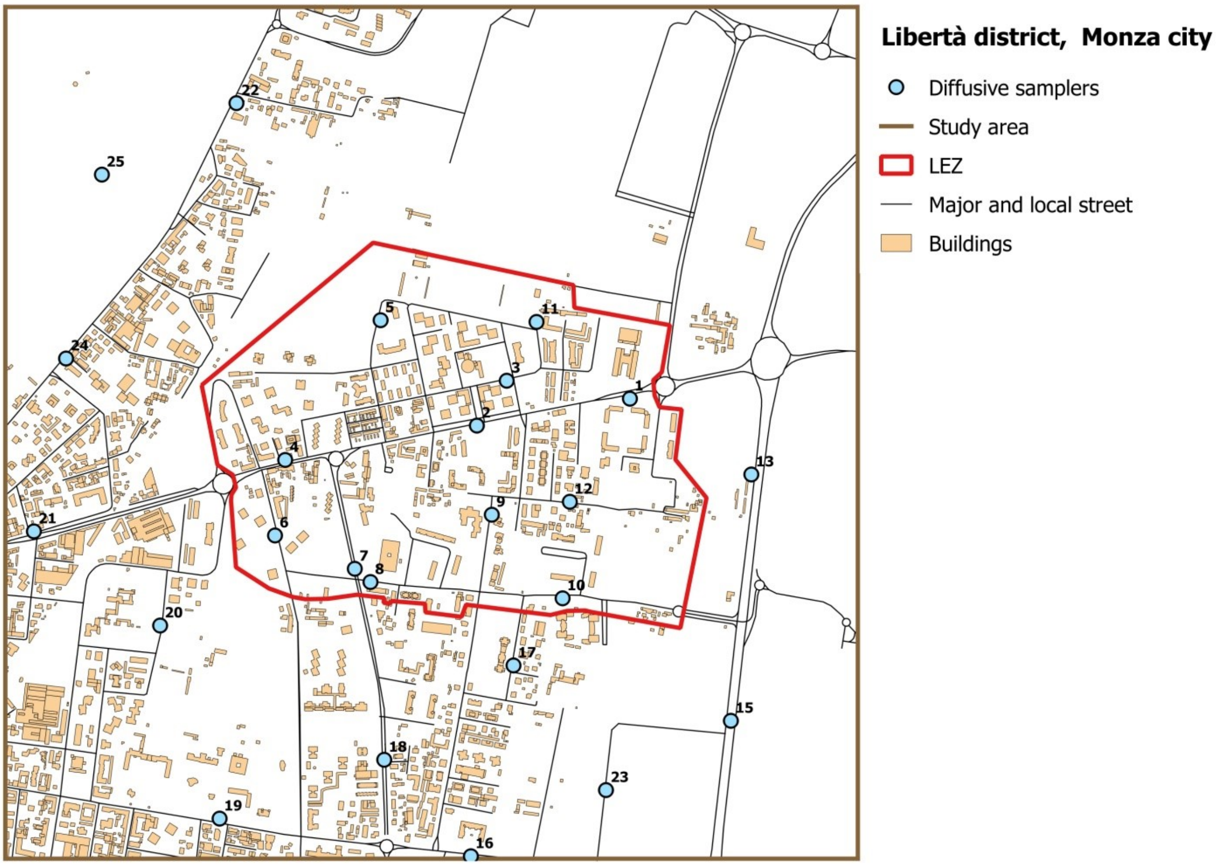


Fig.1 – Benzene and toluene diffusive samplers

Predictor variables were calculated and added as potential regressors in the generalized additive model; a detailed analysis of the traffic flows was carried out. Generalized Additive Model (GAM) with a spline-based approach was followed and results were validated using leave one out cross validation (LOOCV) method. All input data were presented in *Annex A* (*ex ante* situation) and *Annex B* (*ex post* situation).

4.1 Diffusive sampling

A diffusive sampler is a device which is capable of taking samples of gases or vapours from the atmosphere at a rate controlled by a physical process such as gaseous diffusion through a static air layer or a porous material and/or permeation through a membrane, but which does not involve the active movement of pumped air through the device.

The diffusive samplers are suitable for long-term monitoring of several gases in ambient air (e.g. nitrogen oxides, ozone, several volatile organic compounds).

The sites were visited and geo-coded using a high sensitivity GPS receiver (eTrex Vista HCx, Garmin), before and after each measurement campaign. Coordinates were checked on GIS map, and if necessary, corrected manually.

Each selected site was chosen following the provision on macro and micro siting criteria according to European Directive 2008/50/EC which provides that:

- Sampler inlet should be placed at least 20 cm from any vertical surface (such as a wall), and if possible the sampler inlet should be located at least twice the distance from an obstacle as the height of that obstacle.

- Inlet should be at least 2 m from a High volume sampler inlet and 1 meter from a medium volume sampler, and at least 50 cm from a NO_X measurement. Sampling inlet should be at least 3 m from the outlet of a pump.
- Sampler inlet should not be near exhaust flues or vents from homes or other buildings (at least 5 m away).
- Preferably the sampler inlet should also be at least 5 m away from air conditioning.
- Sampling height (inlet) at least 1.5 m (preferably 2 m) above the surface on which the sampler is placed and preferably between 1.5 and 3 m above the ground.
- The sampler should not be placed near the drip line of trees.
- Electricity available (active sampling only).
- Safe from vandalism or accidental damage.
- Accessible for field workers.

Vehicular traffic related pollutants (benzene, toluene, NO_2) sampling was made also using passive samplers (Ring, Aquaria and Radiello, Fondazione Maugeri, respectively for VOC's and NO_2).
Duplicate samplers, provided with weather protective shelters, were deployed at 2.5 m above the ground, placed on lamp post, utility poles or street signals. All NO_2 and aromatics VOCs samplers were removed 14 days after their installation.
Aromatic volatile organic compounds (VOCs) were extracted with carbon disulfide then detected and quantified using internal standard capillary gas chromatography performed on a Gas Chromatograph (HewlettePackard Inc., USA) with MS detection. NO_2 measures were carried out by means a Ions Chromatograhy (Metrohm-881 Compact IC pro – Anion – MCS)
Three field blanks were also collected during each monitoring campaign for the different passive samplers. Co-location of passive samplers at a few sites with continuous monitors has generally shown good agreement, but it remains important to include co-location in each new study.
In order to compare NO_2 and benzene measurements with the corresponding European reference method (EN 14211, 2005; EN 14622-3, 2005) two diffusive samplers were co-located at two monitoring stations managed by the Environmental Protection Agency of Lombardia (ARPA LOMBARDIA) in the urban area of Monza.
The airborne 14 day NO_2 and benzene, mean concentrations were then calculated using standard procedure (EN 13528-2, 2003).

4.2 GIS-derived predictor variables

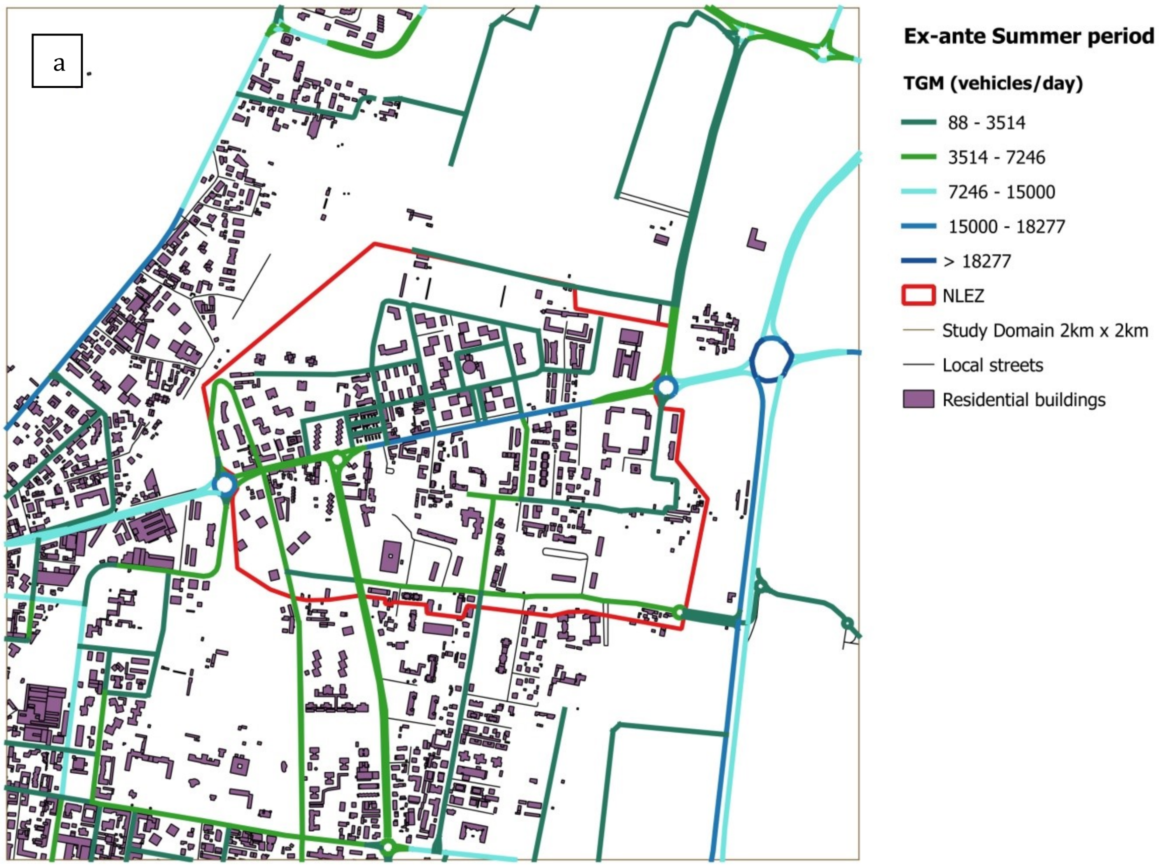
GIS-derived predictor variables related to road traffic flows, distances from nearest road, building volume representative of urban canyon, road length, land use variables by Urban Atlas of Copernicus Land Monitoring Service were evaluated in each monitoring site and in varying buffer size (25, 50, 75 e 100 m). More complex approaches, which try to take into account the height of the buildings, the length of the canyon and the continuity of the buildings, were followed (Eeftens et al., 2013).
Spatial variables were:

- Average daily road traffic that was related with the distances of the measuring points from the road; information about these variables were provided by Vie en.ro.se Engineering society;
- Building volume and road length representative of urban canyon; these variables were provided by Open Street Map and by Urban Atlas 2012 (Copernicus Land Monitoring Service).
- Land use variables as *Continuous Urban Fabric*, *Discontinuity Density, Industrial Commercial Public* were provided by Urban Atlas 2012 (Copernicus Land Monitoring Service).

All variables were calculated by using ArcGis software (Geographic Information System) ESRI ver 10.1.

4.2.1 Road traffic flows

Long-term monitoring campaign consists of a week road-traffic counting in 2 positions located in P01- Civic Centre (Libertà street) and in P02- School Modigliani. The counter-traffic control units (CT01 and CT02) have been positioned on the roadside, whose results evidence the subdivision in light and heavy vehicles. In addition, hot spot traffic counter were positioned in 10 points widespread in the study domain. To complete the traffic analyses the Strategic Noise Mapping of the Monza city was used.
In the Autumn/Winter period, the ante-operam monitoring was carried out in the period between Monday 20 and Monday 27 November 2017, while the post-operam monitoring was carried out between Monday 21 and Tuesday 29 January 2019.
Likewise, in the Spring/Summer period, the ante-operam monitoring was carried out in the period between Monday 15 and Monday 22 May 2017, while the post-operam monitoring was carried out between Monday 6 and Monday 13 May 2019. Road traffic flows in the ex ante and ex post situation were showed in Fig.2.



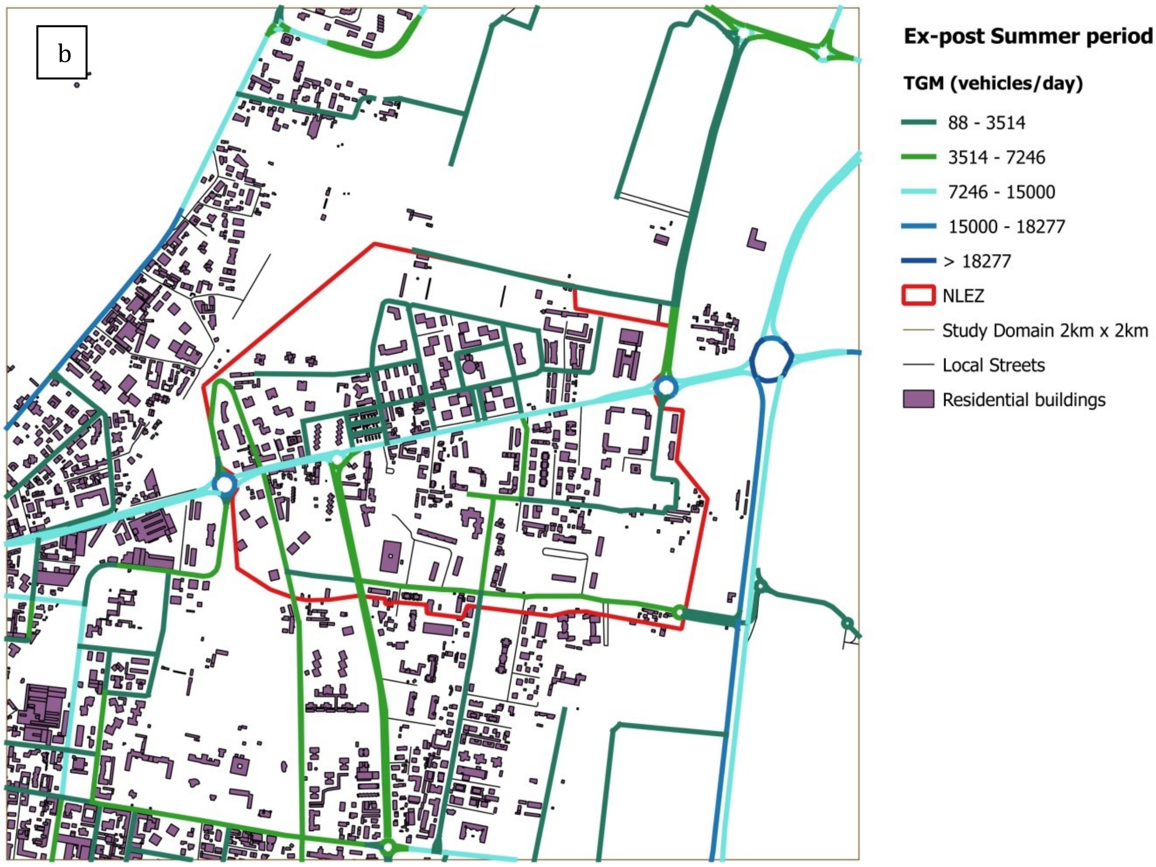


Fig. 2 – Average daily traffic in summer season, *ex ante* (a) and *ex post* (b)

4.3 Model development

GAM models were used to estimate the concentrations starting from the measurements carried out in the 25 points widespread in the in the study domain.

4 GAM models were developed for benzene concentrations estimation: one for the winter period and one for the summer period respectively in the *ex ante* situation and in the *ex post* situation; 3 GAM models were built for toluene concentrations estimation: one for the winter period and one for the summer period in the *ex ante* situation while in the *ex post* situation only the winter model with the measured data of only one week, from 6 to 14 March 2019, was developed; the low number of input data, in many cases lower of the instrumental detection limit, did not allow to build the model for the toluene summer.

Gam function of the mgcv library of the R software (R Development Core Team) was used for the model development.

4.3.1 Selection of the input variables

The explanatory variables described have been selected as potential regressors in the GAM models starting from the correlation matrix with the response variable and performing a stepwise forward selection procedure with groups of variables on the basis of the best correlation with the response variable ($p<0.01$). An example of correlation matrix for benzene in summer period of the ex ante situation was showed in Fig. 3.

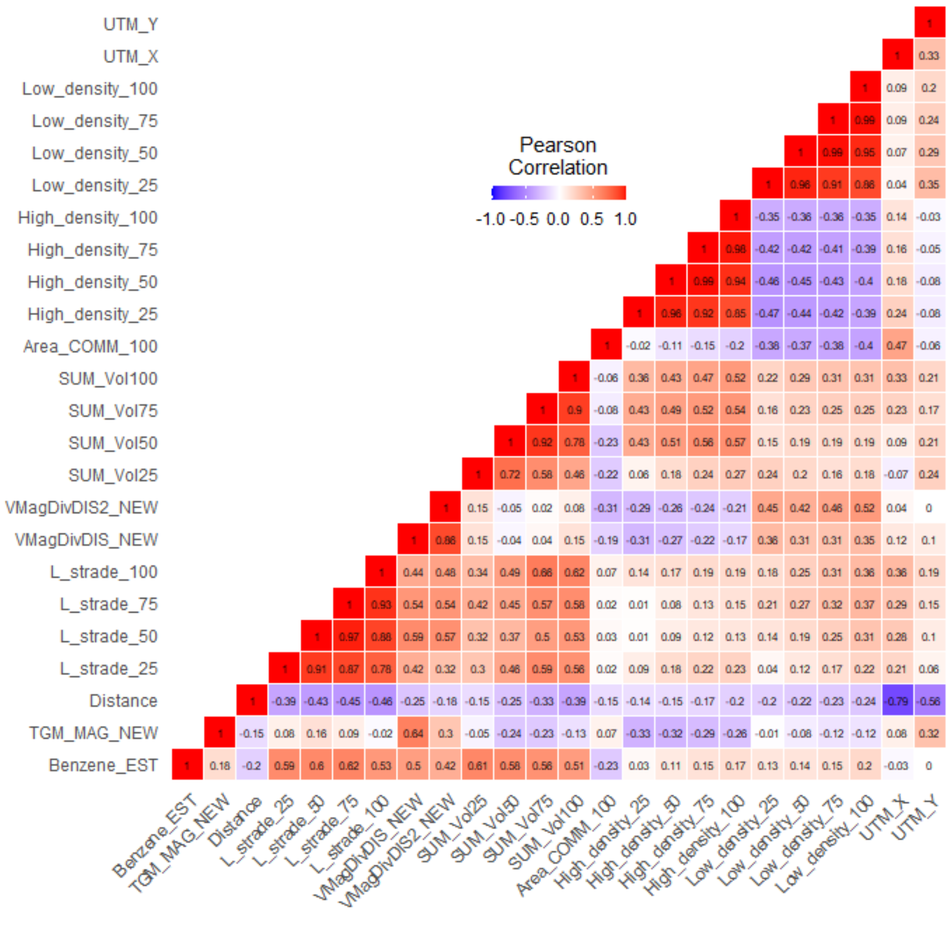


Fig.3 - Benzene concentrations ($\mu g/m^3$) *ex ante*, in summer season: correlation matrix between the response variable and the predictor variables

Test checks with various basis-dimension functions (k parameter) were performed to select the best splines for each variable. The smoothing parameter was chosen controlling:

- the balance between likelihood function and overfitting,
- convergence of the iteration algorithm,
- the significance of the EDF (Effective Degree of Freedom) parameter which represents the complexity of smoothing in terms of curve sinuosity (the higher the EDF value the greater the spline non-linearity).

All these results were provided by "gam check" function of the R software.
Residual analyses of the model output was graphically checked: normality, homogeneity, independence and influential observations was verified. Model selection was evaluated by the following parameters:

- AIC (Akaike Information Criterion) is a fined technique based on in-sample fit to estimate the likelihood of a model to predict the future values; a good model is the one that has minimum AIC among all the other models.
- GCV (Generalised Cross Validation) GCV is a means of approximating the results of an explicit CV. The GCV score in "mgcv" gam function is the minimum GCV score arrived at during fitting for various value of smoothness penalty.
- BIC (Bayesian information criterion) is another criteria for model selection that measures the trade-off between model fit and complexity of the model. A lower BIC value indicates a better fit.

4.3.2 Model evaluation

Each model was validated with the Leave-One-Out Cross Validation (LOOCV) method (Brauer et al., 2003). Under LOOCV, the data is split into two parts. A single observation is used for the test and the remaining used as the training set. This procedure is repeated n-times for the n subjects/observations. The leave-one-out cross validation error estimate is the simple average of Root Mean Square Error (RMSE). The other performance measures evaluated were the R^2 and the adjusted R^2.

5 Results

5.1 Monitoring campaign results

The 25 sampling points allowed to capture a relevant spatial and seasonal gradient (Figg. 4-6). In the ex-ante situation benzene summer mean concentration ranged between 0.20 (urban background, inside a park) and 0.83 µg/m³ (road side, Viale della Libertà 93), while in winter the range was 0.94÷1.67 µg/m³; results for the ex-post campaigns showed benzene summer mean values ranging between 0.51 and 1.02 µg/m³ while in winter the range was 0.61÷1.37 µg/m³. A less distinct pattern between ex-ante and ex-post campaigns was found for the winter mean concentration of toluene, ranging between 2.6÷6.0 µg/m³ and 2.87÷6.11 µg/m³ respectively.

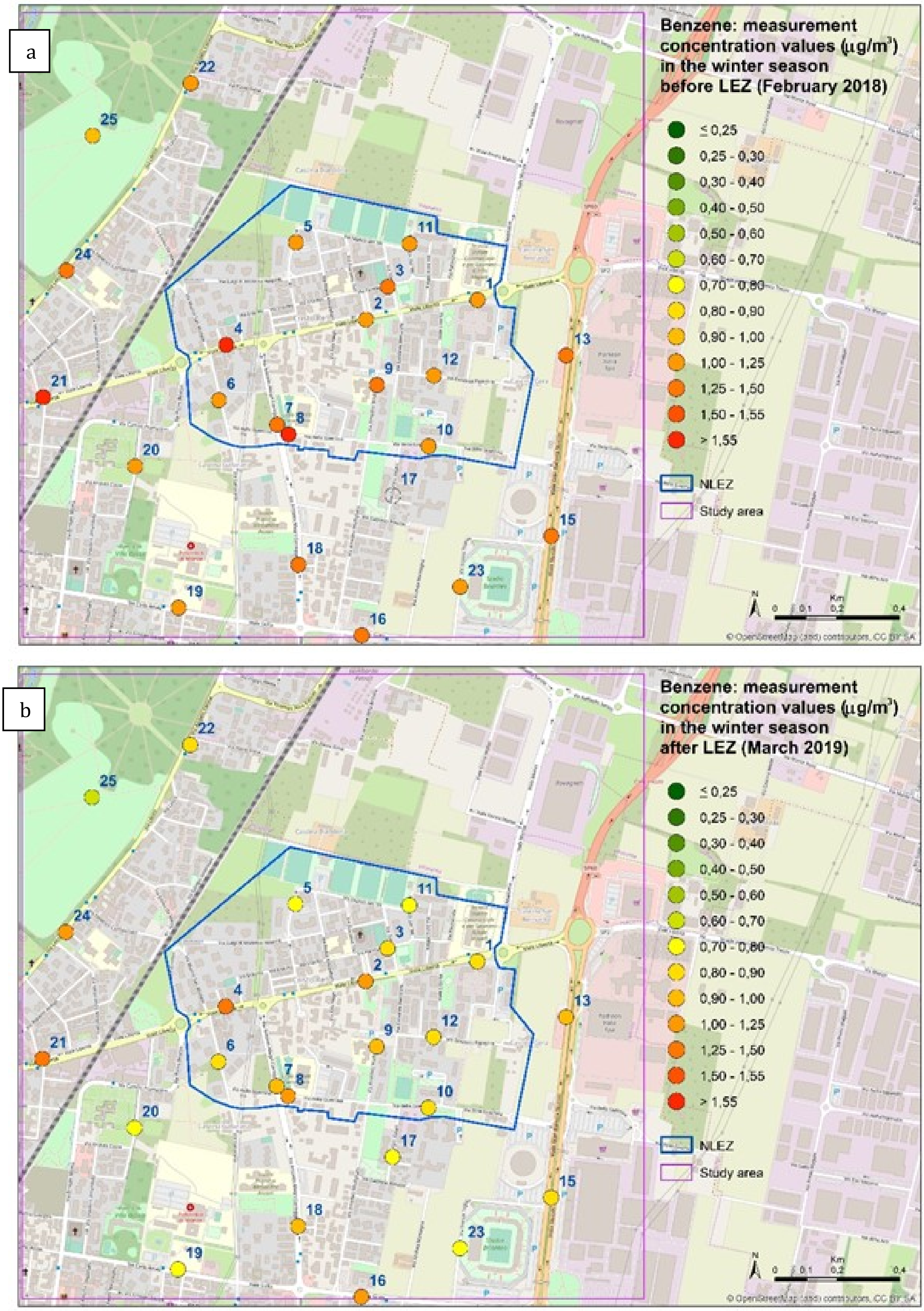
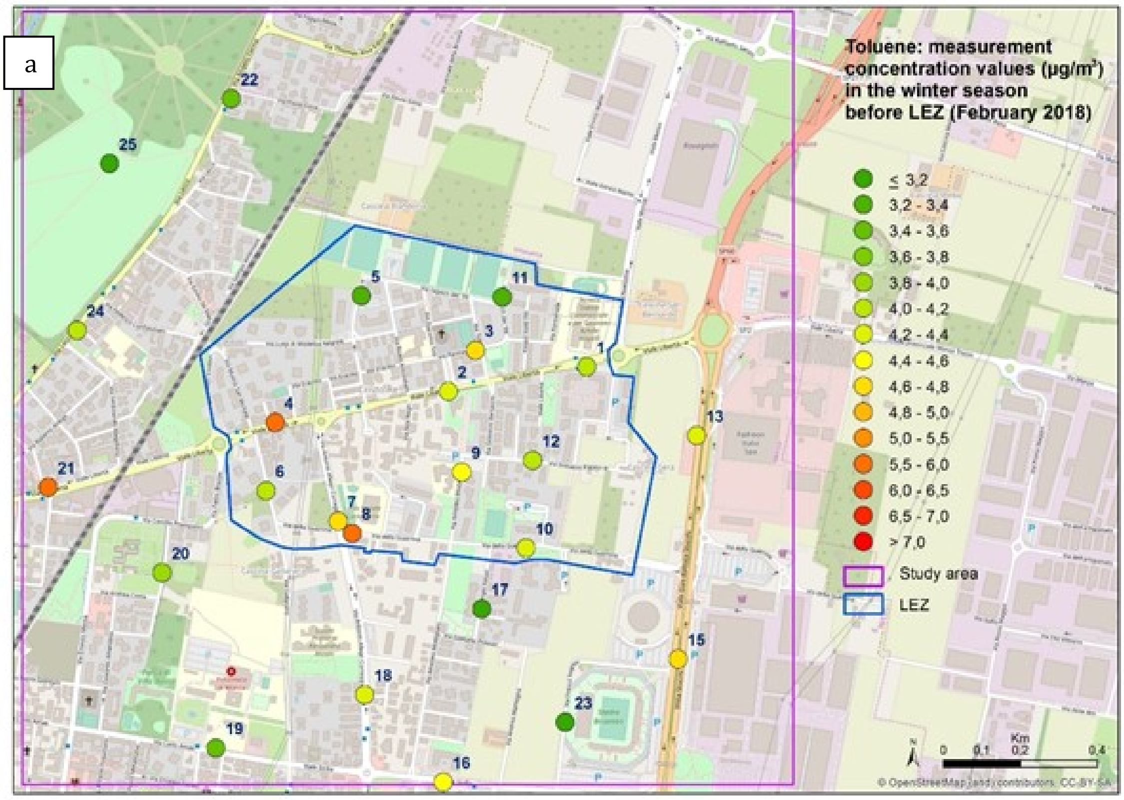


Fig. 5 - Benzene concentrations (μg/m^3) in winter season: *ex ante* (a) and *ex post* (b)



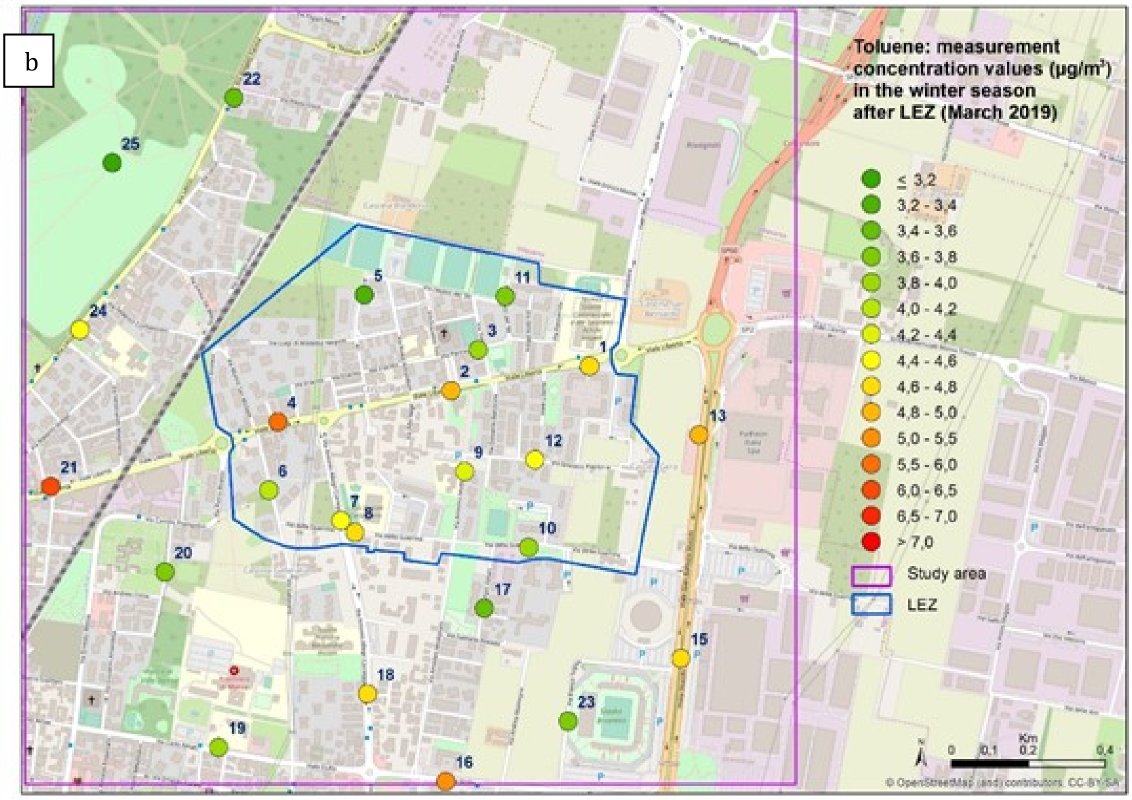


Fig. 6 - Toluene concentrations (µg/m³) in winter season: *ex ante* (a) and *ex post* (b)

5.2 Model results

5.2.1 Benzene ex ante model results

<u>*Benzene summer ex ante model*</u>

$$\text{Benzene} \sim s(\text{SUM\_Vol75}) + s(\text{VMagDivDIS\_NEW})$$

Where:
- Benzene = benzene concentration (μg/m^3)
- *SUM_Vol75*= sum of the volumes of the buildings in a buffer with a radius of 75 m (m^3)
- *VMagDivDIS_NEW* = ratio between the average daily traffic and the distance from the nearest road (vehicle/day*m)

Variable (MU)[(a)]	Coefficients (SE)	t value	Pr(>|t|)
Intercept	0.38741(0.01296)	29.9	<0.001

Table 1 – Coefficients and significance of linear terms

Smoothing terms (MU)	edf	Ref.df	F	p-value	k'	k-index	p-value
s(SUM_Vol75) [m^3]	2.832	3.451	13.27	<0.001	9.00	1.27	0.90
s(VMagDivDIS_NEW) [vehic/day*m]	1.547	1.873	11.88	<0.001	9.00	1.39	0.96

Table 2 : Coefficients and significance of smoothing terms

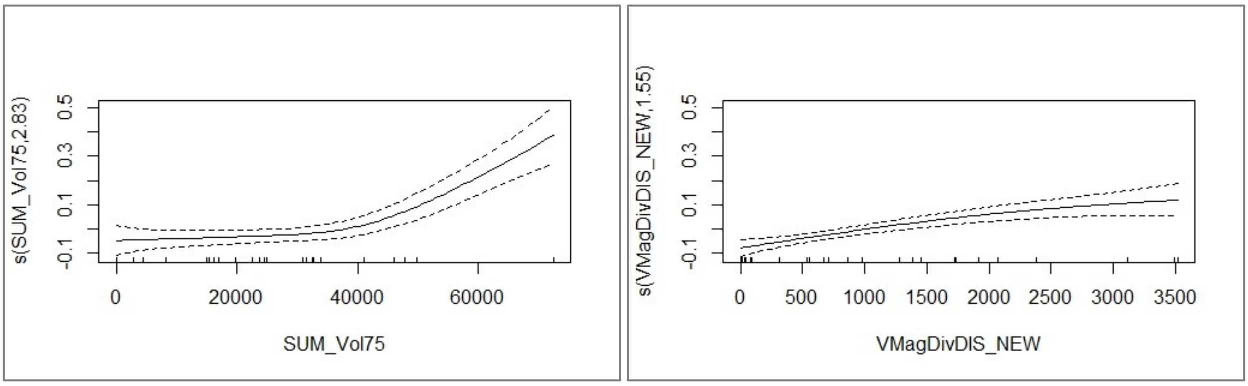


Fig. 7 – Benzene_summer_*ex ante* model: spline trend for the "sum of the volumes of the buildings in a buffer with a radius of 75 m", and the "ratio between the average daily traffic and the distance from the nearest road"

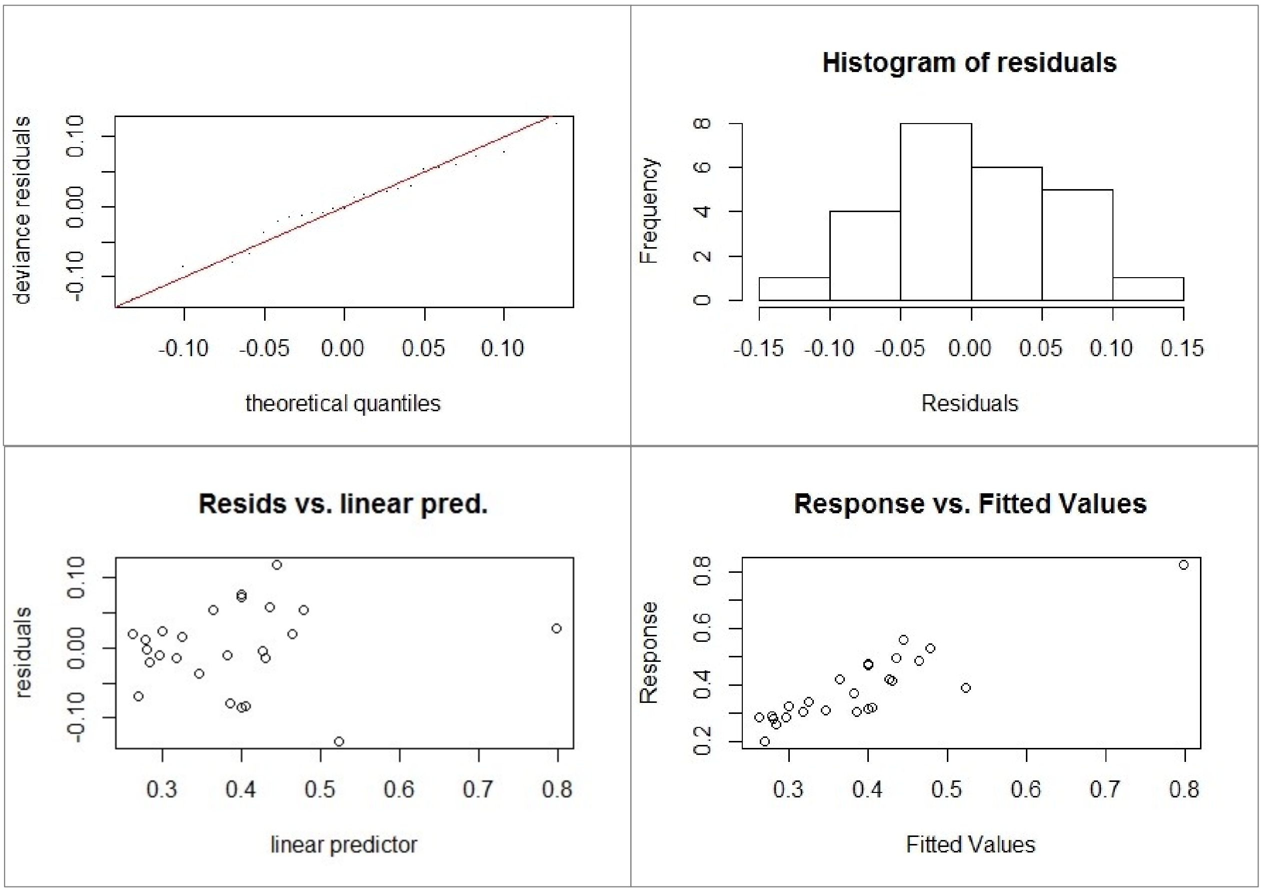


Fig. 8 – Baseline assumptions test of the benzene_summer_*ex ante* model: residuals analysis

R^2 adj	Explained variation	GCV	AIC	BIC	RMSE
0.756	80%	0.0054	-59.183	-51.409	0.14

Table 3 - Benzene_summer_*ex ante* model, statistical indices of performance

Benzene winter ex ante model

$$\text{Benzene}\sim(\text{SUM\_Vol75}) + s(\text{VMagDivDIS\_NEW})$$

Where:

- Benzene = benzene concentration (μg/m^3)
- *SUM_Vol75*= sum of the volumes of the buildings in a buffer with a radius of 75 m (m^3) *VMagDivDIS_NEW* = ratio between the average daily traffic and the distance from the nearest road (vehicle/day*m)

Variable (MU)[(a)]	Coefficients (SE)	t value	Pr(>|t|)
Intercept	1.109e+00(4.463 x 10^{-2})	24.844	<0.001
SUM_Vol75 [m^3]	6.142 x 10^{-6}	4.098	<0.001

Table 4 - Coefficients and significance of linear terms

Smoothing terms (MU)	edf	Ref.df	F	p-value	k'	k-index	p-value
s(VMagDivDIS_NEW) [vehic/day*m]	5.685	6.696	4.419	<0.001	9.00	1.46	0.99

Table 5 - Coefficients and significance of smoothing terms

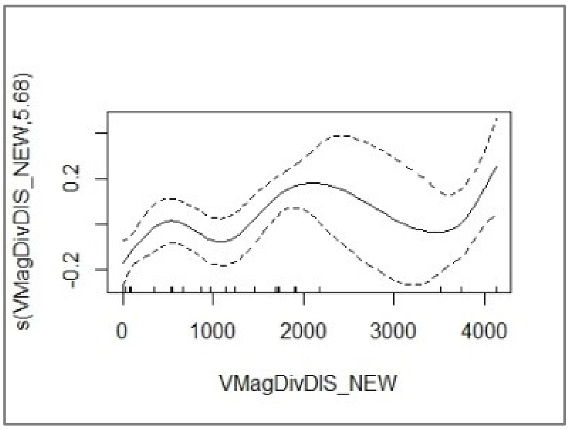


Fig. 9 - Benzene_winter_*ex ante* model: spline trend for the "ratio between the average daily traffic and the distance from the nearest road"

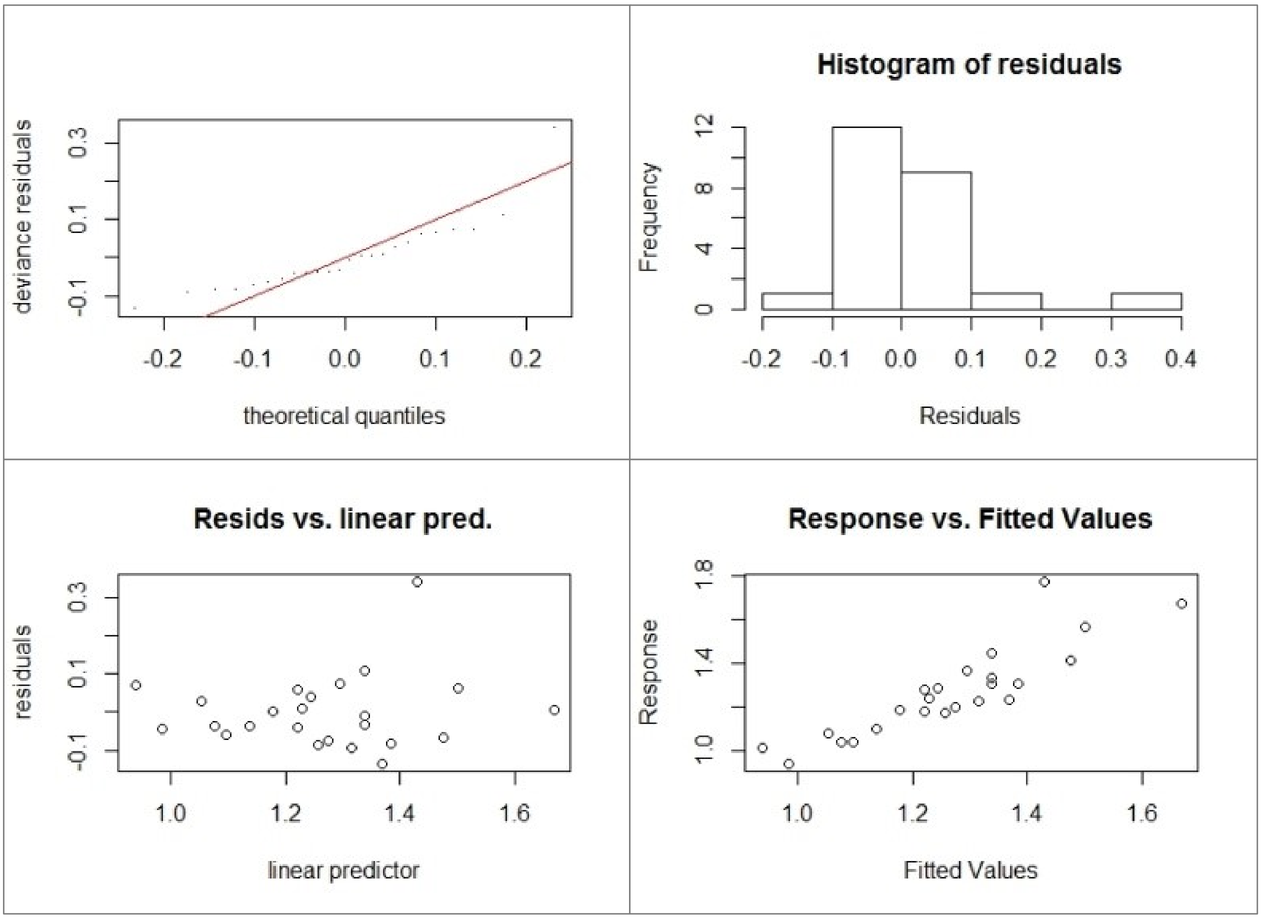


Fig. 10 - Baseline assumptions test of the benzene_winter_*ex ante* model: residuals analysis

R^2 adj	**Explained variation**	**GCV**	**AIC**	**BIC**	**RMSE**
0.687	77.8%	0.019	-28.169	-17.938	0.18

Table 6 - Benzene_winter_*ex ante* model, statistical indices of performance

5.2.2 Benzene ex post model results

Benzene summer ex post model

$$\mathrm{Benzene} \sim \mathrm{s(SUM\_Vol75, k = 5)} + \mathrm{VMagDivDIS}$$

Where:

- *SUM_Vol75*= sum of the volumes of the buildings in a buffer with a radius of 75 m (m^3)
- *VMagDivDIS* = ratio between the average daily traffic and the distance from the nearest road (vehicle/day*m)

Variable (MU)[(a)]	Coefficients (SE)	t value	Pr(>|t|)
Intercept	5.713×10^{-1} (2.474×10^{-2})	23.092	<0.001
VMagDivDIS [vehic/day*m]	5.605×10^{-5} (1.633×10^{-5})	3.433	0.0026

Table 7 - Coefficients and significance of linear terms

Smoothing terms (MU)	edf	Ref.df	F	p-value	k’	k-index	p-value
s(SUM_Vol75) [m^3]	2.567	3.091	10.59	<0.001	4.00	1.07	0.59

Table 8 - Coefficients and significance of smoothing terms

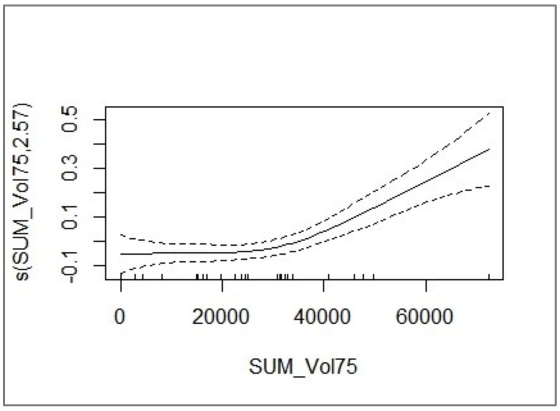


Fig. 11 - Benzene_summer_*ex post* model: spline trend for the “sum of the volumes of the buildings in a buffer with a radius of 75 m” (k=5)

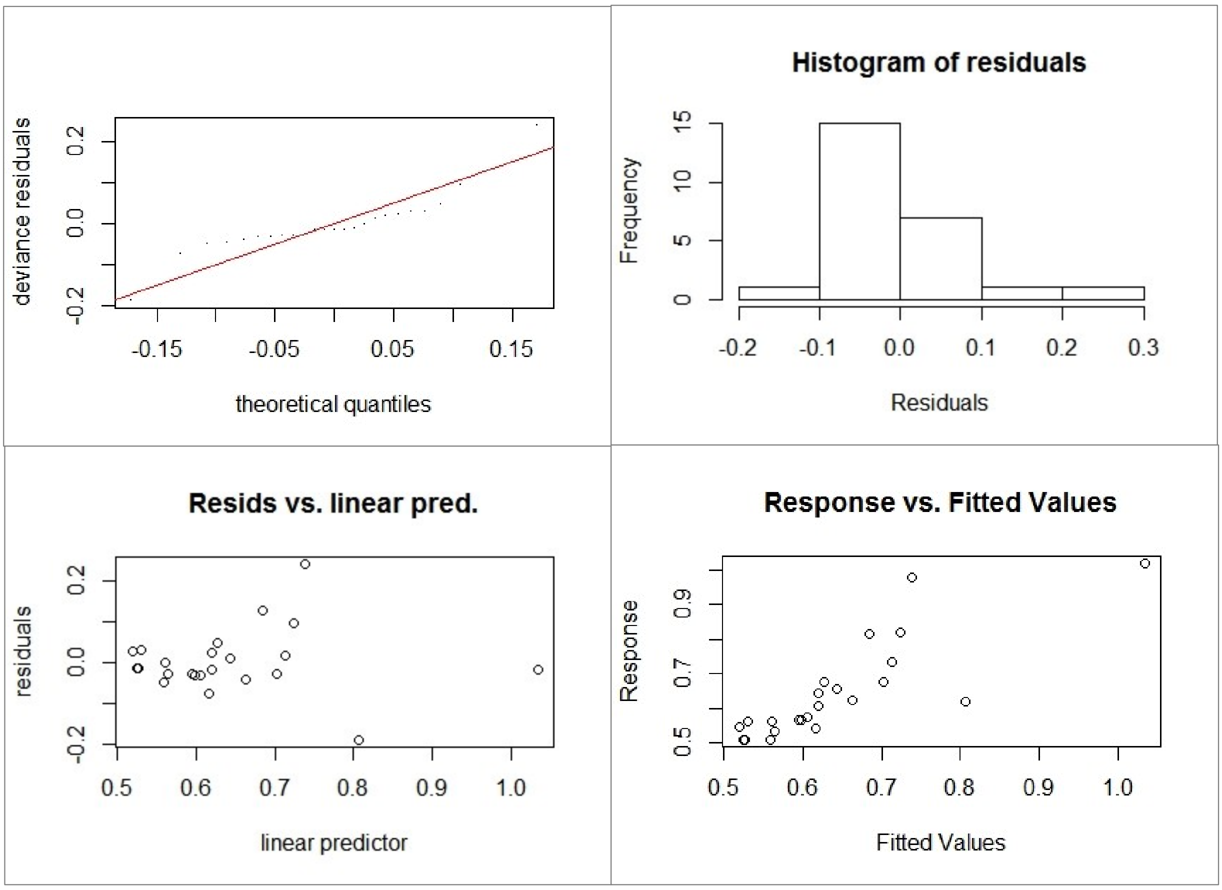


Fig. 12 - Baseline assumptions test of the benzene_summer_*ex post* model: residuals analysis

R^2 adj	Explained variation	GCV	AIC	BIC	RMSE
0.649	70.1%	0.0852	-47.137	-40.351	0.19

Table 9 - Benzene_summer_*ex post* model, statistical indices of performance

Benzene winter ex post model

$$\text{Benzene} \sim s(\text{SUM\_Vol75}, k = 5) + \text{VMagDivDIS}$$

Where:

- *SUM_Vol75*= sum of the volumes of the buildings in a buffer with a radius of 75 m (m^3)
- *VMagDivDIS* = ratio between the average daily traffic and the distance from the nearest road (vehicle/day*m)

Variable (MU)(a)	Coefficients (SE)	t value	Pr(>|t|)
Intercept	8.15×10^{-1} (2.972×10^{-2})	27.428	<0.001
VMagDivDIS [vehic/day*m]	7.566×10^{-5} (1.846×10^{-5})	4.099	<0.001

Table 10 - Coefficients and significance of linear terms

Smoothing terms (MU)	edf	Ref.df	F	p-value	k’	k-index	p-value
s(SUM_Vol75) [m^3]	2.006	2.475	11.68	<0.001	4.00	0.98	0.32

Table 11 - Coefficients and significance of smoothing terms

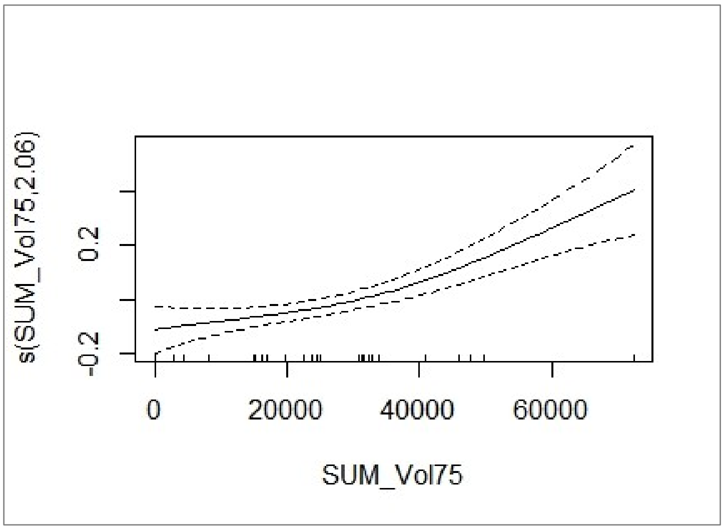


Fig. 13 - Benzene_winter_*ex post* model: spline trend for the “sum of the volumes of the buildings in a buffer with a radius of 75 m” (k=5)

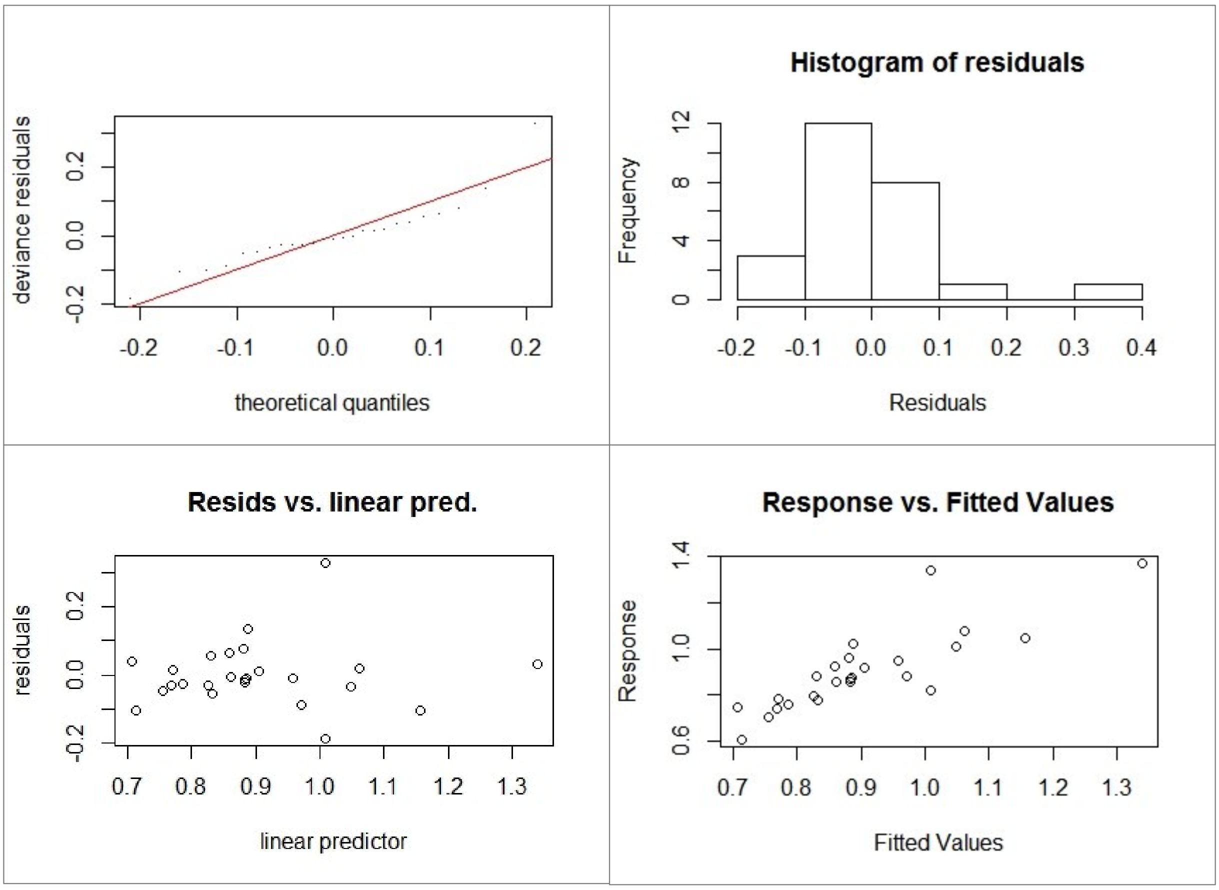


Fig. 14 - Baseline assumptions test of the benzene_winter_*ex post* model: residuals analysis

R^2 adj	Explained variation	GCV	AIC	BIC	RMSE
0.663	70.5%	0.012467	-37.390	-31.288	0.12

Table 12 - Benzene_winter_*ex post* model, statistical indices of performance

5.2.3 Toluene ex ante model results

<u>*Toluene summer ex ante model*</u>

$$\text{Toluene} \sim s(\text{SUM\_Vol75}) + s(\text{VMagDivDIS\_NEW})$$

Where:
- Toluene = toluene concentration (μg/m^3)
- *SUM_Vol75*= sum of the volumes of the buildings in a buffer with a radius of 75 m (m^3)
- *VMagDivDIS_NEW* = ratio between the average daily traffic and the distance from the nearest road (vehicle/day*m)

Variable (MU)[(a)]	Coefficients (SE)	t value	Pr(>|t|)
Intercept	2.784(0.102)	27.29	<0.001

Table 13 – Coefficients and significance of linear terms

Smoothing terms (UM)	edf	Ref.df	F	p-value	k’	k-index	p-value
s(SUM_Vol75) [m^3]	2.490	3.061	7.995	<0.001	9.00	1.26	0.84
s(VMagDivDIS_NEW) [vehic/day*m]	1.565	1.898	5.539	<0.001	9.00	1.49	0.99

Table 14 - Coefficients and significance of smoothing terms

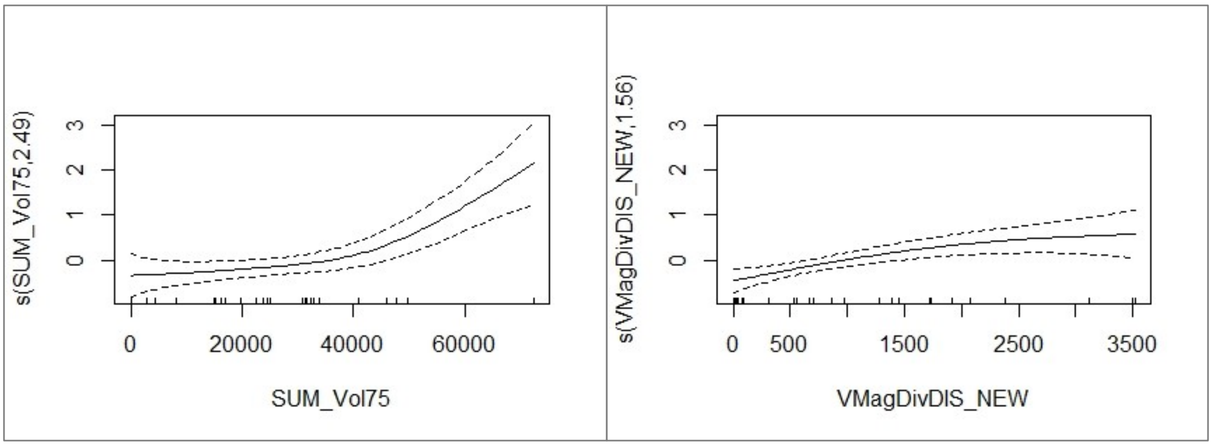


Fig. 15 - Toluene_summer_*ex ante* model: spline trend for the “sum of the volumes of the buildings in a buffer with a radius of 75 m”, and the “ratio between the average daily traffic and the distance from the nearest road”

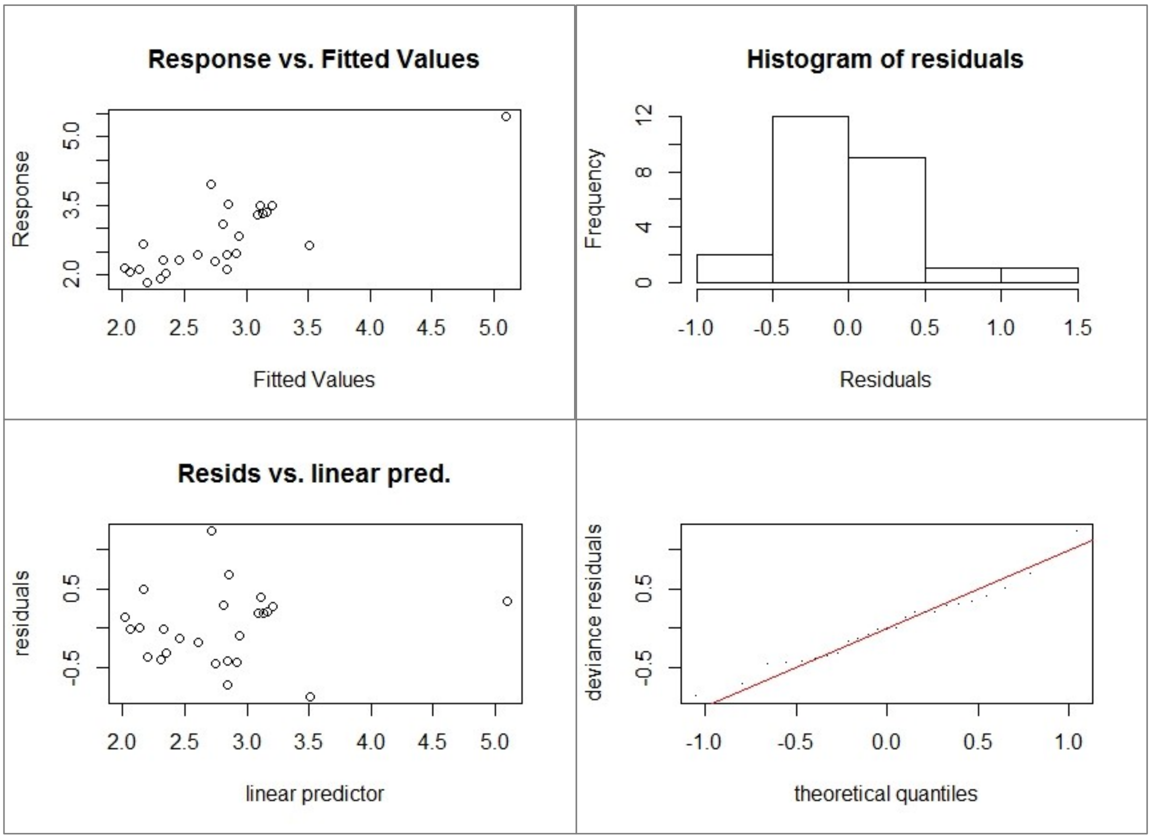


Fig. 16 - Baseline assumptions tests of the toluene_summer_*ex ante* model: residuals analysis

R^2 adj	Explained variation	GCV	AIC	BIC	RMSE
0.613	67.9%	0.32617	43.754	51.134	0.72

Table 15 - Toluene_summer_*ex ante* model, statistical indices of performance

Toluene winter ex ante model

$$\text{Toluene} \sim \text{s}(\text{SUM\_Vol75}, \text{k} = 5) + \text{VMagDivDIS\_NEW}$$

Where:

- Toluene = toluene concentration (µg/m^3)
- *SUM_Vol75*= sum of the volumes of the buildings in a buffer with a radius of 75 m (m^3)
- *VMagDivDIS_NEW* = ratio between the average daily traffic and the distance from the nearest road (vehicle/day*m)

Variable (MU)[(a)]	Coefficients (SE)	t value	Pr(>|t|)
Intercept	3.824e+00(1.659 x 10^{-1})	23.05	<0.001
VMagDivDIS_NEW [vehic/day*m]	2.948 x 10^{-4}(9.617 x 10^{-5})	3.07	0.006

Table 16 - Coefficients and significance of linear terms

Smoothing terms (MU)	edf	Ref.df	F	p-value	k'	k-index	p-value
s(SUM_Vol75) [m^3]	1.57	1.938	9.231	0.002	4.00	1.03	0.49

Table 17 - Coefficients and significance of smoothing terms

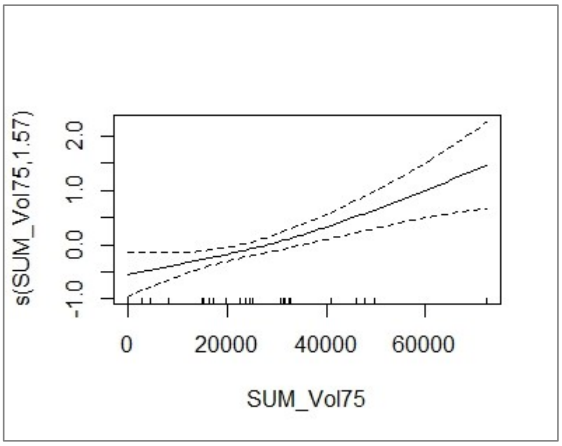


Fig. 17 - Toluene_winter_*ex ante* model: spline trend for the "sum of the volumes of the buildings in a buffer with a radius of 75 m" (k=5)

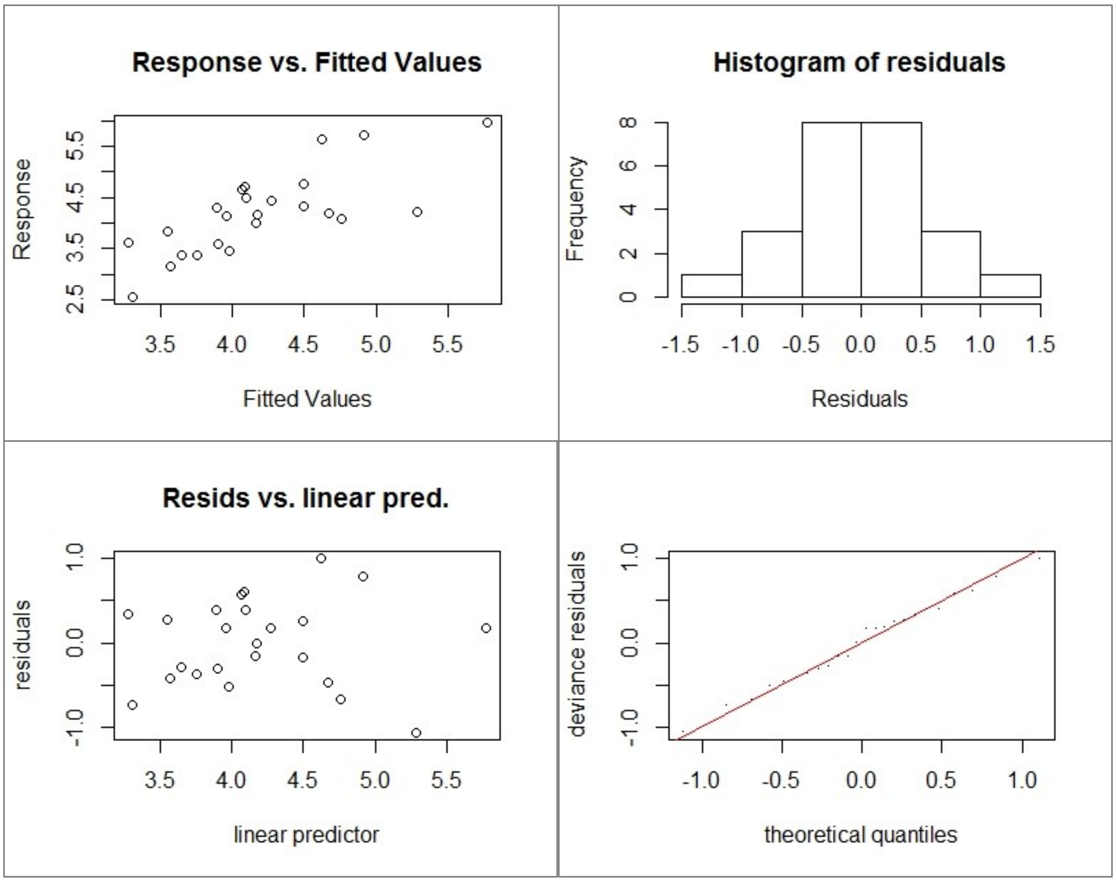


Fig. 18 - Baseline assumptions tests of the toluene_winter_*ex ante* model: residuals analysis

R^2 adj	Explained variation	GCV	AIC	BIC	RMSE
0.535	58.7%	0.35324	44.544	49.928	0.64

Table 18 - Toluene_winter_*ex ante* model, statistical indices of performance

5.2.4 Toluene ex post model results

Toluene winter ex post model

$$\text{Toluene} \sim s(\text{SUM\_Vol75}) + s(\text{VMagDivDIS})$$

Where:

- Toluene = toluene concentration (μg/m^3)
- *SUM_Vol75*= sum of the volumes of the buildings in a buffer with a radius of 75 m (m^3)
- *VMagDivDIS_NEW* = ratio between the average daily traffic and the distance from the nearest road (vehicle/day*m)

Variable (MU)[(a)]	Coefficients (SE)	t value	Pr(>|t|)
Intercept	4.311 (0.113)	38.15	<0.001

Table 19 - Coefficients and significance of linear terms

Smoothing terms (MU)	edf	Ref.df	F	p-value	k’	k-index	p-value
s(SUM_Vol75) [m^3]	1.450	1.767	6.456	0.017	9.00	1.1	0.62
VMagDivDIS [vehic/day*m]	1.588	1.907	4.379	0.019	9.00	1.1	0.61

Table 20 - Coefficients and significance of smoothing terms

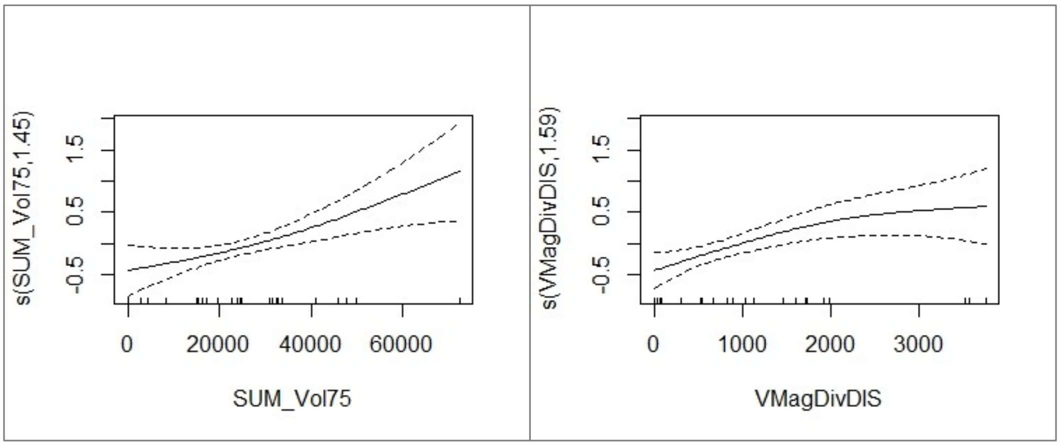


Fig. 19 - Toluene_winter_*ex post* model: splines trend for the “sum of the volumes of the buildings in a buffer with a radius of 75 m”, and the “ratio between the average daily traffic and the distance from the nearest road”

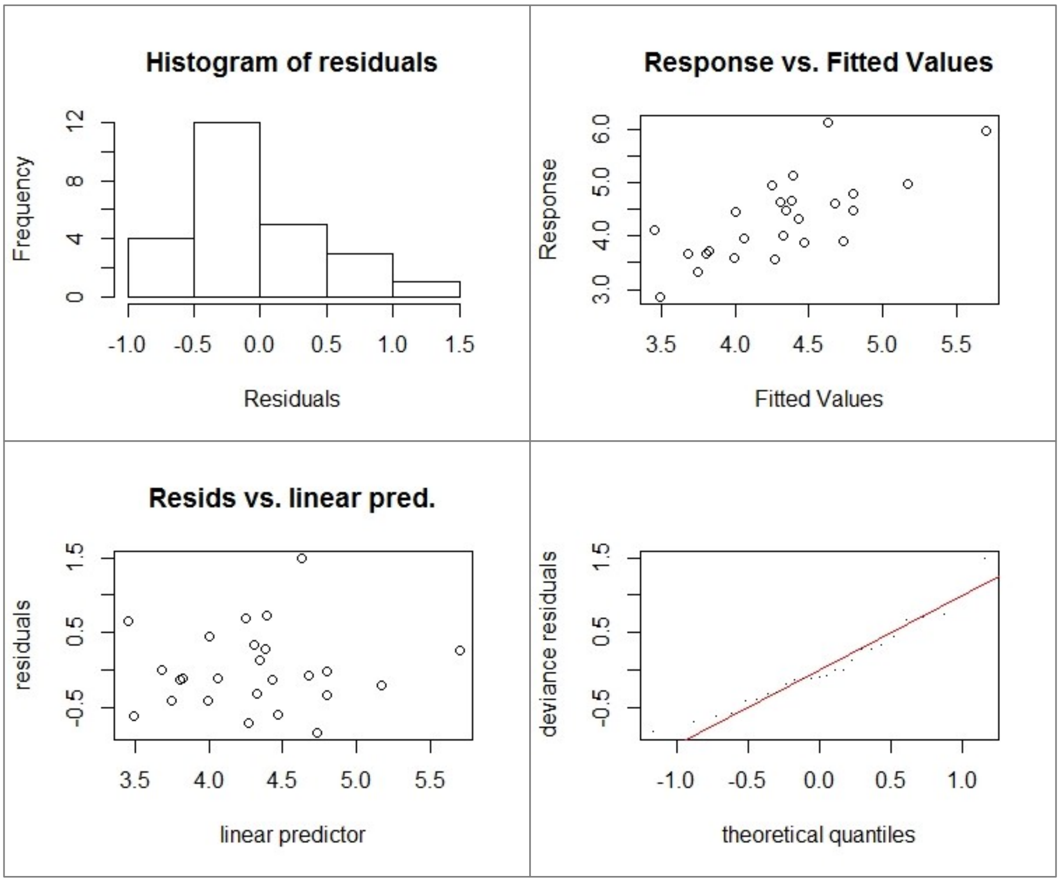


Fig. 20 - Baseline assumptions tests of the toluene_winter_*ex post* model: residuals analysis

R^2 adj	Explained variation	GCV	AIC	BIC	RMSE
0.452	52.1%	0.3808	4.8077	5.4218	0.67

Table 21 - Toluene_ winter_*ex post* model, statistical indices of performance

5.2.5 Analysis of the model results

GAM was provided a better fit to explain spatial variability of benzene in the summer season in the ex-ante situation: the explanatory power of the models was 80% (adjusted-R2=0.76, RMSE=0.14 µg/m³) while in winter was 77.8% (adjusted-R2=0.69, RMSE=0.18 µg/m³); a similar pattern was found in the *ex-post* campaigns, respectively in summer (deviance explained=70.1%, adjusted-R2=0.65, RMSE=0.19 µg/m³) and in winter (deviance explained=70.5%, adjusted-R2=0.66, RMSE=0.12 µg/m³). GAM for winter mean toluene concentration showed a less deviance explained respect to benzene: for the *ex-ante* evaluation the deviance explained was 58.7% (adjusted-R2=0.53, RMSE=0.64 µg/m³) while in the ex-post was 52.1% (adjusted-R2=0.45, RMSE=0.67 µg/m³).

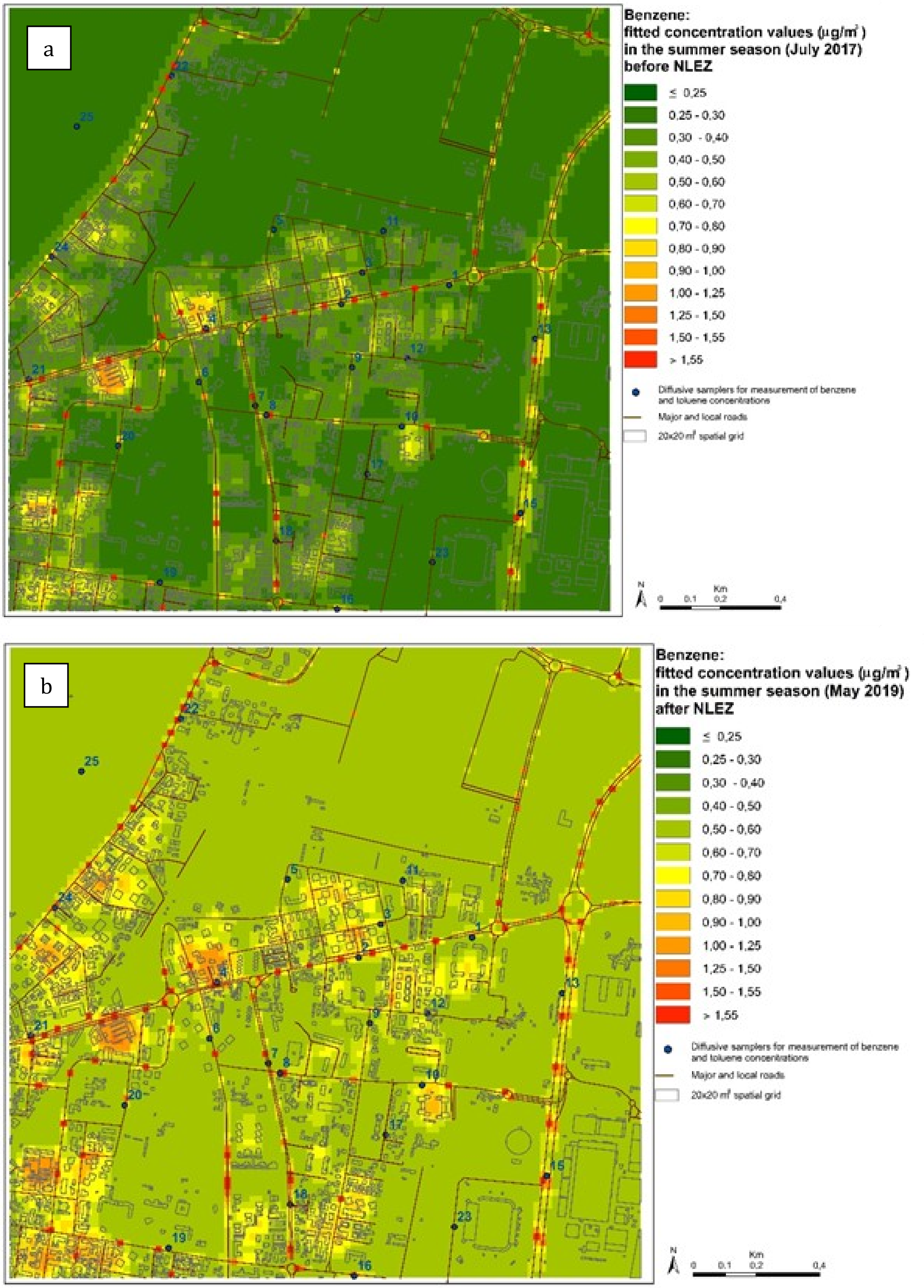


Fig. 21 - Benzene in summer season: concentration values (µg/m3) estimated from GAM models, ex ante (a) and ex post (b)

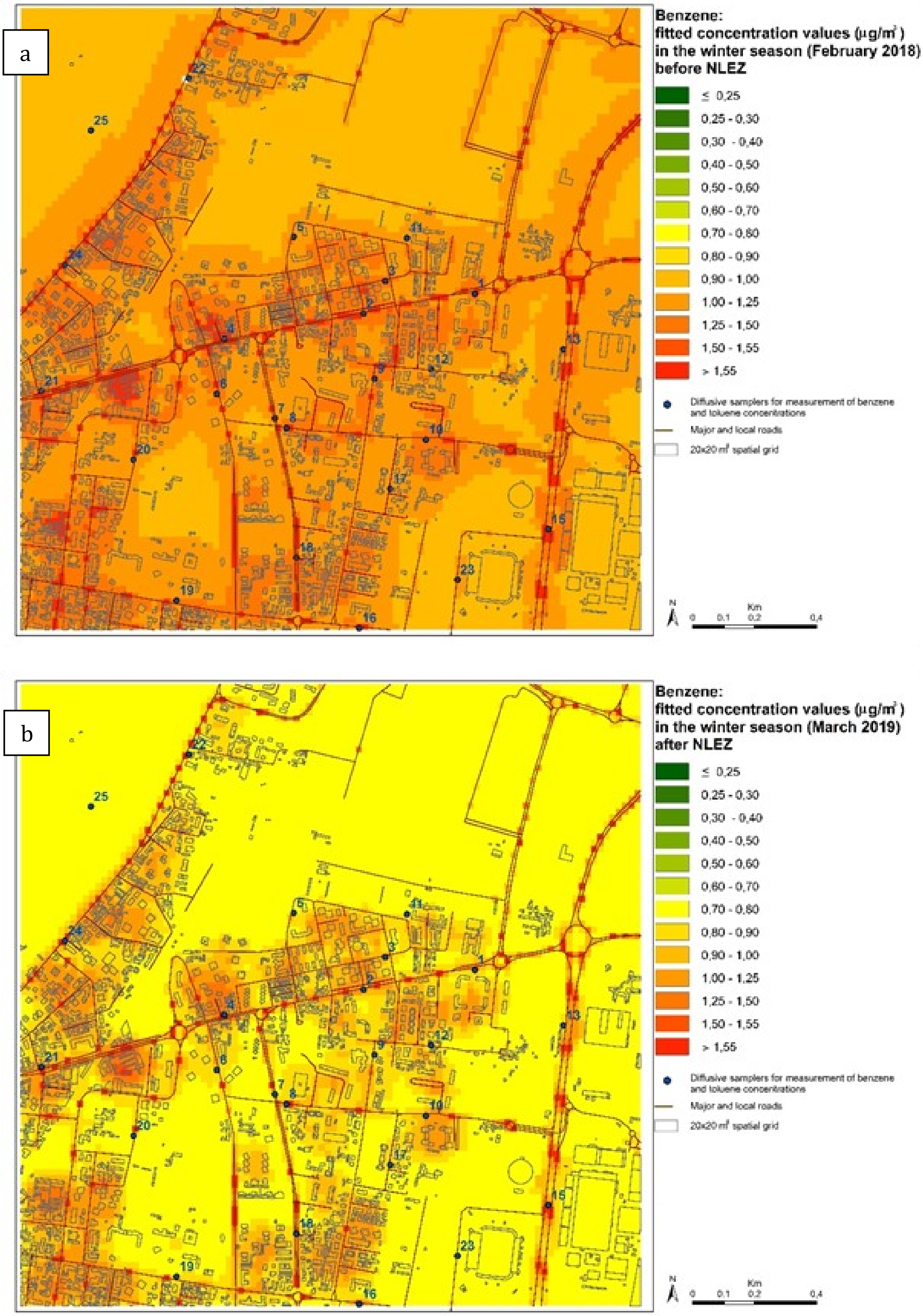


Fig. 22 - Benzene in winter season: concentration values (µg/m³) estimated from GAM models, *ex ante* (a) and *ex post* (b)

Assessing the microscale spatial variability of air pollution is still challenging. From the analysis of all the variables identified in the study, those with greater explanatory character were the volume of the buildings in buffers with a radius of 75 m and the average daily traffic and the distance from the nearest road. This is a very satisfactory result which confirms the analysis of literature and which sees in the foreground as representative variables of the spatial pattern, in addition to traffic distribution, also some parameters indirectly linked to a potential "canyon effect" created by the presence of buildings in correspondence of local roads around a few meters from the measuring point.

6 Conclusion

Monitoring with passive samplers has made possible to highlight the existence of a statistically significant spatial gradient on the microscale and its seasonal variability (the study domain is very small, only 4 km^2). The results are comforting in terms of the ability of the GAM models developed to describe reliably the spatial variability of traffic related pollutants and to identify the variables that "explain" at least in part this variability.
The monitoring and assessment strategy can be easily transposed to other small scale effectiveness studies aimed to evaluate the ancillary effects on air quality of NLEZ’s implementation.

7 Bibliography

Briggs D.J. et al., “Mapping urban air pollution using GIS: a regression-based approach”, International Journal of Geographical Information Science, volume 11, 1997 - Issue 7.

Clifford S. et al., “Using the Generalised Additive Model to model the particle number count of ultrafine particles”. Atmos. Environ., 45, 5934–5945, 2011.

Eeftens M. et al., “Quantifying urban street configuration for improvements in air pollution models”, Atmos. Environ., 72, 1-9, 2013.

EN 14211, 2005. Ambient air quality - Standard method for the measurement of the concentration of nitrogen dioxide and nitrogen monoxide by chemiluminescence.

EN 14662-3, 2005. Ambient Air Quality - Standard method for the measurement of benzene concentrations - Part 3: Automated pumped sampling with in situ gas chromatography.

EN 14662-5:2005 Ambient air quality - Standard method for measurement of benzene concentrations - Part 5: Diffusive sampling followed by solvent desorption and gas chromatography

EN 13528-2, 2003. Ambient air quality - diffusive samplers for the determination of concentrations of gases and vapours - Requirements and test methods. Part 2: Specific requirements and test methods.

EN 13528-3, 2004. Ambient air quality - diffusive samplers for the determination of concentrations of gases and vapours - Requirements and test methods. Part 3: Guide to selection, use and maintenance.

EN 16339:2013 Ambient air - Method for the determination of the concentration of nitrogen dioxide by diffusive sampling

Hoek G. et al., ”A review of land-use regression models to asses spatial variation of outdoor air pollution”, Atmos. Environ., 42, 7561-7578, 2008.

Holman C. et al., “Review of the efficacy of low emission zones to improve urban air quality in European cities”, Atmos. Environ., 111, 161-169, 2015.

Jerrett M. et al., “A review and evaluation of intraurban air pollution exposure models”, J. Expo. Anal. Environ. Epidemiol., 15, 185-204, 2005.

Jerrett M. et al., “A distance-decay variable selection strategy for land use regression modelling of ambient air pollution exposures”, Science of the Total Environment, 407, 3890–3898, 2009.

Mercer L.D. et al., “Comparing universal kriging and land-use regression for predicting concentrations of gaseous oxides of nitrogen (NOx) for the Multi-Ethnic Study of Atherosclerosis and Air Pollution (MESA Air)”, Atmos. Environ., 45, 4412-4420, 2011.

Ryan P.H. et al., “A Review of Land-use Regression Models for Characterizing Intraurban Air Pollution Exposure”, Inhal. Toxicol., 19, sup1, 127-133, 2007.

Tang R. et al., “Using Building Heights and Street configuration to Enhance interurban PM10, NOx and NO2 Land Use Regression Models”, Environ. Sci. Technol., 47, 11643-11650, 2013.

Von Klot S., “Equivalence of using nested buffers and concentric adjacent rings as predictors in land use regression models”, Atmos. Environ., 45, 4108-4110, 2011.

WHO, 2000, Air quality guidelines for Europe, World Health Organization, Regional Office for Europe, Copenhagen (http://www.euro.who.int/__data/assets/pdf_file/0005/74732/E71922.pdf) accessed 4 September 2015.

WHO, 2006, Air Quality Guidelines: Global update 2005. Particulate matter, ozone, nitrogen dioxide and sulphur dioxide, World Health Organization, Regional Office for Europe, Copenhagen.

Wood S.N., “Generalized Additive Models An Introduction with R second edition”, Chapman & Hall Book, ISBN 13: 978-1-4987-2833-1, 2017.

Zuur A.F. et al., “Mixed Effects Models and Extensions in Ecology with R”, Springer, ISBN 978-0-387-87457-9, 2009.

Zuur, A.F., “Beginner's Guide to Generalized Additive Models with R”, Highland Statistics Ltd, 2012.

Observations

Methodologies fOr Noise low emission Zones introduction And management

1. Noise and traffic

From the results of the long-term measurement campaigns conducted using traditional Class I instruments, a comparison was made, in terms of noise levels measured at the measuring station on Viale della Libertà, considering the monitoring activity carried out during the winter period in the ante-operam (November 2017) and post-operam (January 2019) scenarios, as shown in Figure 1.

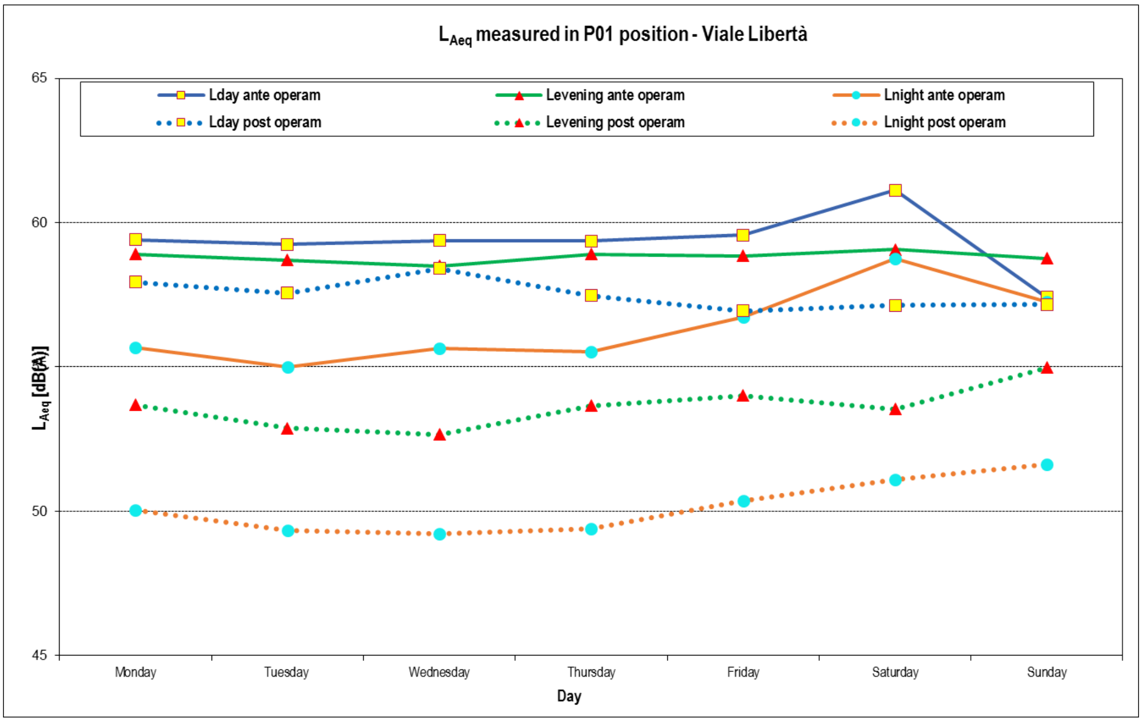


Figure 1 – Comparison of noise levels measured with class I instruments in winter in the ante- and post-operam scenarios.

Concerning the weekly average levels, with reference to the four measurement campaigns, the reduction in terms of measured sound pressure levels between ante-operam and post-operam is 2,5 dB(A) in the 'Day' period, 4,9 dB(A) in the 'Evening' period and 5,9 dB(A) in the 'Night' period.

Table 1 - Average noise reduction, in dB(A), over the 3 reference periods, during noise campaigns.

nov17 / jan19 dB[A]			may17 / may19 dB[A]			Average noise reduction Post operam - Ante operam dB[A]		
DAY	**EVE**	**NIGHT**	**DAY**	**EVE**	**NIGHT**	**DAY**	**EVE**	**NIGHT**
-2,0	-5,1	-6,2	-3,0	-4,7	-5,6	**-2,5**	**-4,9**	**-5,9**

The traffic flow data, based on the flow count carried out in the ante and post operam scenarios, shows that, in the daytime period, there is an excellent compliance between the data of the ante and post-operam scenarios.

As regards the difference between the data collected in the ante and post-operam campaigns, there is a very significant decrease in the number of heavy vehicles' transits of about 17% for the comparison between winter campaign data and 29% for the comparison of summer campaign data.

Concerning the average daily traffic (used acronym: TGM, which stands for "traffico giornaliero medio") observed in Viale della Libertà, there is a constant decrease of about 5% in both winter and summer campaigns.

Table 2 - Results obtained from traffic flow monitoring of heavy vehicles ante e post-operam.

COMPARISON ANTE-POST (HEAVY VEHICLES FLOW)										
HEAVY	ANTE			POST				ANTE/POST		
	may 2017	nov-17	mean	jan 2019	may 2019	mean			nov17/ jan19	may17 / may19
D	217	180	198	146	155	150		D	-19%	-29%
E	11	9	10	11	8	10		E	28%	-23%
N	14	9	12	8	7	8		N	-17%	-46%
TOT	**241**	**198**	**219**	**164**	**170**	**167**		**TOT**	**-17%**	**-29%**

Table 3 - Results obtained from traffic flow monitoring (TGM) ante e post-operam

COMPARISON ANTE-POST (TGM)										
TGM	ANTE			POST				ANTE/POST		
	may 2017	nov-17	mean	jan 2019	mag-19	mean			nov17/ jan19	may17 / may19
D	12781	13519	13150	12675	11774	12225		D	6.2%	7.9%
E	1272	1537	1405	1529	1326	1428		E	0.5%	-4.2%
N	1607	1757	1682	1772	1721	1747		N	-0.9%	-7.1%
TOT	**15659**	**16813**	**16236**	**15976**	**14821**	**15399**		**TOT**	**5.0%**	**5.4%**

For the definition of ante and post-operam noise maps, the traffic data collected in the weekly monitoring has been used. In particular, the weekly winter period is considered more representative than the spring period. As a matter of fact, the latter has been reconstructed from the traffic data on Viale della Libertà in the ante-operam scenario, as specified in the ante operam report.
Analysing the ante and post-operam noise maps within the pilot area, there are decreases in correspondence of buildings ranging from 0.6 dB(A) in the perimeter areas up to a maximum of 4.5 dB(A) in correspondence of some buildings closer to Viale Libertà, taking into account the Lden (day-evening-night) parameter, which represents the entire day.

Please note that the decreases detected on Viale Libertà and Via Modigliani are based on weekly data, whereas for the remaining 8 perimeter streets monitored, as well as for all those that can be classified as perimeter streets, the daily traffic flows were reconstructed by analyzing only the hourly data counted during the spot phonometric measurements (duration 1 hour), used to calibrate the model.

The analysis of the data collected by the SNMS stations on a continuous basis showed decreases between 1 and 2 dB(A) comparing the month of January 2018 (ante-operam) and January 2019 (post-operam). It can be assumed that the reduction in traffic is much higher than that estimated for the perimeter roads, roughly more than 20% of the GMT.

The percentage reduction of the receivers exposed to noise are the following:
- the percentage of receivers exposed to a value of L_{den}>65 dB(A) in the NLEZ has been reduced by about 3%;
- the percentage of receivers exposed to a value of L_{night}>55 dB(A) in the NLEZ has been reduced by about 8%;

- the percentage of receivers exposed to a value of L_{den}>65 dB(A) in the 30m band from Viale della Libertà has been reduced by approximately 19.5%;
- the percentage of receivers exposed to a value of L_{night}>55 dB(A) in the 30m band from Viale della Libertà has been reduced by about 25%.

Concerning the comparison between the results obtained by the class I monitoring system and the SMNS, table 4 shows the data obtained in the same week of ante and post operam monitoring with the low-cost sensor ("HC101" position) and with the class I measurement chain ("P01" position) at the Civic Centre.
The results of the noise monitoring, carried out in the post-operam period, show the same and constant difference of about 3 dB between the sound pressure levels measured by the low-cost sensor and the class I systems in all the analyzed periods (day, evening and night). This difference is explained by the different position of the microphones: the low-cost one is placed on the facade of the Civic Centre building and the class I one is placed on the roof of the same building.
In the measurements carried out in November 2017, only in the "Night" period the above-mentioned difference was equal to 3 dB, whereas in the "Day" and "Evening" periods there are greater deviations, probably due to the activities carried out near the low-cost sensor.

Table 4 - Results obtained by low-cost sensors and class I system.

	Period	**Lday (06-20) [dB(A)]**	**Levening (20-22) [dB(A)]**	**Lnight (22-06) [dB(A)]**
Class I instrument	Nov-17	59.5	58.8	56.5
Low cost sensor	Nov-17	64.6*	62.5*	59.2
Difference		5.1*	3.7*	2.7
Class I instrument	Jan-19	57.5	53.7	50.3
Low cost sensor	Jan-19	60.4	57.0	53.0
Difference		2.9	3.3	2.7

The analysis shows that the interventions carried out on Viale Libertà provide excellent results in terms of reducing road traffic noise. In particular, in terms of noise monitoring with class I instrument, the reduction in terms of sound pressure levels measured in the daytime period, between ante and post-operam, is equal to 2.5 dB(A). In the 'evening' and 'night' period this reduction reaches 5-6 dB(A). Moreover, by repeating the same analysis based on the low-cost sensor, it is possible to observe an excellent compliance between the noise level differences obtained between the two different measuring systems, highlighting that the low-cost system provides reliable data to evaluate the acoustic performance of the interventions.

2. Air quality

NO_2, benzene, PM_{10}, $PM_{2.5}$ and Black Carbon time series showed a marked seasonality with much higher concentrations during colder months. This is due both to the additional pollution sources during winter (e.g. heating) and to weather conditions, that favor pollutants accumulation. SO_2 and CO generally have such low concentrations, close to the method's limit of detection or to the natural background, that they do not present equally significant variations.
The NO_2 concentrations measured at the Viale della Libertà site are comparable with those measured at the Via Machiavelli station and show typical trends of urban traffic stations in the Milan agglomerate, where in many cases the average annual legal limit (40 $\mu g/m^3$) was exceeded. An interpolation of the data made it possible to estimate the annual average concentration value at the temporary site of Monza-Libertà.
From the joint analysis of the various carbonaceous fractions (BC, OC and EC), the measurement station located in Viale Libertà in Monza is comparable to a typical urban traffic station in the province of Monza and Brianza.

Monitoring with passive samplers has made it possible to highlight the existence of a statistically significant spatial gradient on the microscale (the study domain is very small, only 4 km^2). The average concentration of benzene varies between 0.20 (urban background, within a park) and 0.83 µg / m^3 (street side, Viale della Libertà 93), while in winter values ranging from 0.94 to 1.67 µg/m^3. The average concentration of toluene was between 2.4 and 5.4 in the summer and between 2.6 and 6.0 µg/m^3 in the winter.
The results are comforting in terms of the capacity of the GAM model developed to describe the spatial variability of pollutants and to identify the variables that "explain" at least in part this variability.
Variables included were the sum of buildings volumes in a 75 m radius buffer and the ratio between the average daily traffic and the distance from the nearest road (vehicle/day*m).
For benzene, the summer model, ex ante phase, explains 80% of the deviance (adjusted-R2 = 0.76, RMSE = 0.14 µg/m^3) while in winter, 77.8% (adjusted-R2 = 0.69, RMSE = 0.18 µg/m^3). A very similar pattern was found in the ex post phase, respectively in summer (R^2 = 70.1%, adjusted-R^2 = 0.65, RMSE = 0.19 µg/m^3) and in winter (R^2 = 70.5%, adjusted-R^2 = 0.66, RMSE = 0.12 µg/m^3).
The same variables as for benzene were found to explain the toluene spatial variability. However, the toluene GAM models showed a lower explained deviance compared to that found for benzene.
The results of the change point analysis applied to the meteorologically adjusted time-series shown that the reduction achievable with the implementation of the NLEZ, at microscale (i.e. within the NLEZ small domain), on the targeted pollutants (PM and NO_2) was around 1% for NO_2 and 7% for PM10.
Our results seems to agree very well with other studies aimed to evaluate the impact of LEZs at least on a scale local or on the microscale (C. Holman et al., 2015).

Table 5: reduction estimate in the average concentrations of some target pollutants observed within the NLEZ area and attributable to its implementation.

	Mean concentrations meteorologically adjusted [mg/m^3]		
	Ex-ante[a]	Ex-post[b]	Variazione stimata[c] [%]
NO_2	41.4	40.7	1%
PM_{10}	33.7	31.1	7%

[a]Ex-ante: average calculated starting from the measurements (discontinuous) carried out in four seasonal periods at V.Le Della Libertà, reconstructed and normalized for meteorology through machine learning algorithms. Reference period: 1 May 2017 - 30 November 2018.

[b]Ex-post: averages calculated as for ex-ante. Reference period:: 21 gennaio 2019 – 31 dicembre 2019.

[c] The estimated change for NO_2 is not statistically significant

Indeed when studies focused on parameters related to vehicle exhaust emissions the strength and spatial coverage of the establish blockages or restrictions on circulation (particularly those regarding heavy vehicles powered by diesel) appear to be a key factor in order to achieve larger air pollution improvements (Jones at al., 2012).
The other concomitant specific policies undertaken in the study area, on air quality, sectoral transport and energy policies (e.g. change in the composition of the park in circulation, etc.), represent important confounding factors which therefore influence the evaluation process and which make it challenging to isolate the impact of single local measure to improve air quality.