UNIVERSITÀ DEGLI STUDI DI MILANO

DIPARTIMENTO DI CHIMICA
via Golgi, 19 - 20133 Milano

Analytical report on the scientific investigations conducted to validate the HYLA-EST system

1. Set-up used to perform measurements

In order to validate the efficiency of the HYLA-EST device (air and room cleaning system, called HYLA in this report), the measurements were performed inside a room with a size of 4mx4mx2.5m (corresponding to about 40 m^3) simulating a typical indoor domestic environment.

In order to evaluate the effectiveness of the HYLA device in reducing the concentration of airborne particles (PM, particulate matter) present in the environment and of volatile organic compounds (VOCs), a series of measurements were carried out evaluating the concentration of both PM and VOCs before switching on the device and during its operation. For this purpose, pollutants were artificially introduced into the room by some experiments that were carried out during which dust was dispersed and VOCs were introduced.

PM concentrations were measured using a portable fine dust monitoring unit (PM10 - PM2.5 - PM1) called P-DustMonit (Contec). TVOC (Total Volatile Organic Compounds) concentrations were determined using the Netpid (Lab Service Analytics) tool.

2. Analytical instrumentation

The P-DustMonit monitoring unit was used to measure atmospheric particulate matter. This instrument continuously measures and records airborne particles and in particular PM10, PM2.5 and PM1 fractions. This instrumentation has been recently used for the evaluation of the efficiency of air purification systems (Fermo, P., Comite, V., Falciola, L., Guglielmi, V., Miani, A. Efficiency of an air cleaner device in reducing aerosol particulate matter (PM) in indoor environments (2020) International Journal of Environmental Research and Public Health, 17 (1), art. no. 18).

The methodology used by P-DustMonit to measure particles and classify them according to their size is that of laser scattering. This methodology allows to:

- Measure in µg/m3 (in real time and simultaneously) particulate concentrations expressed as PM10 - PM2.5 - PM1
- Measure in real time and at the same time the number of particles present classifying them up to 15 different size classes
- - It also provides counts by grain size in classes:
  >0,30µm>0,40µm>0,50µm>0,60µm>0,70µm
  >0,85µm>1,00µm>1,50µm>2,00µm>2,50µm
  >3,00µm>4,00µm>5,00µm>7,50µm>10,0µm.

The mass concentration is determined starting from the number of particles and applying an appropriate conversion factor.

Fig. 1 - P-Dust Monit monitoring unit

The tests carried out to validate the HYLA system included the monitoring of 7 dimensional classes.

In order to measure the concentration of Total Volatile Organic Compounds (TVOC) the Netpid instrument of Lab Service Analytics was used.

It is a VOC sensor based on the photoionization system and capable of detecting a wide range of VOCs with a higher molecular weight than methane (which is therefore not detected). In order to validate the effectiveness of the instrument and its reproducibility, a serie of preliminary tests has been carried out dispersing in the room increasing known amounts of VOCs. A commercial nail solvent was chosen as VOC standard

The instrument was found to be reproducible. In addition, the detection limit is much lower than the minimum concentrations typically detectable in an indoor environment (between 0.1 and 0.2 ppm on average) while the maximum detectable concentration is 3 ppm.

3. Measurement of HYLA's ability to reduce TVOC concentrations in air

In order to evaluate the ability of HYLA to reduce the concentration of TVOC in the air, a series of experiments have been carried out involving the introduction, repeated over time inside the room, of known concentrations of a volatile organic compound, i.e. the common nail solvent in order to simulate a possible real situation.

For this purpose, the solvent container was opened and exposed for short or longer periods of time as described below in the experiment. The container was placed at a distance of about 30 cm from the detector.

Fig. 2 shows the entire trend of TVOC acquired during the entire measurement period (performed in the time frame 5:34 -19:10 on October 15, 2020).

The Netpid instrument was initially switched on and stabilized. The average value of TVOC concentration in the room, when the HYLA device was not working, was about 0.2 ppm.

In table 1 the peaks represented in fig.2 and fig.3 are shown (figure 3 represents an expanded zone in figure 2). For each peak is indicated the exposure time, the intensity and the operation or not of the HYLA device.

The first peak is relative to an exposure time of 15 s with the device off (the test was then repeated obtaining a peak of equal intensity, peak 2); then the test was repeated with the same exposure time but with the HYLA system on (peak 3): this has led to an evident reduction of the intensity of the peak, that is about a half of its concentration.

Subsequently a prolonged exposure time of 30 min (peak 4) was used to obtain a very intense broad peak. At 12:55 a.m. the HYLA system was turned on and a clear reduction of the peak was observed (first green arrow on the left fig. 3). At 1:25 p.m., after the signal has stabilized, always keeping the device on, a new exposure was made for a period of 30 min (peak 5).

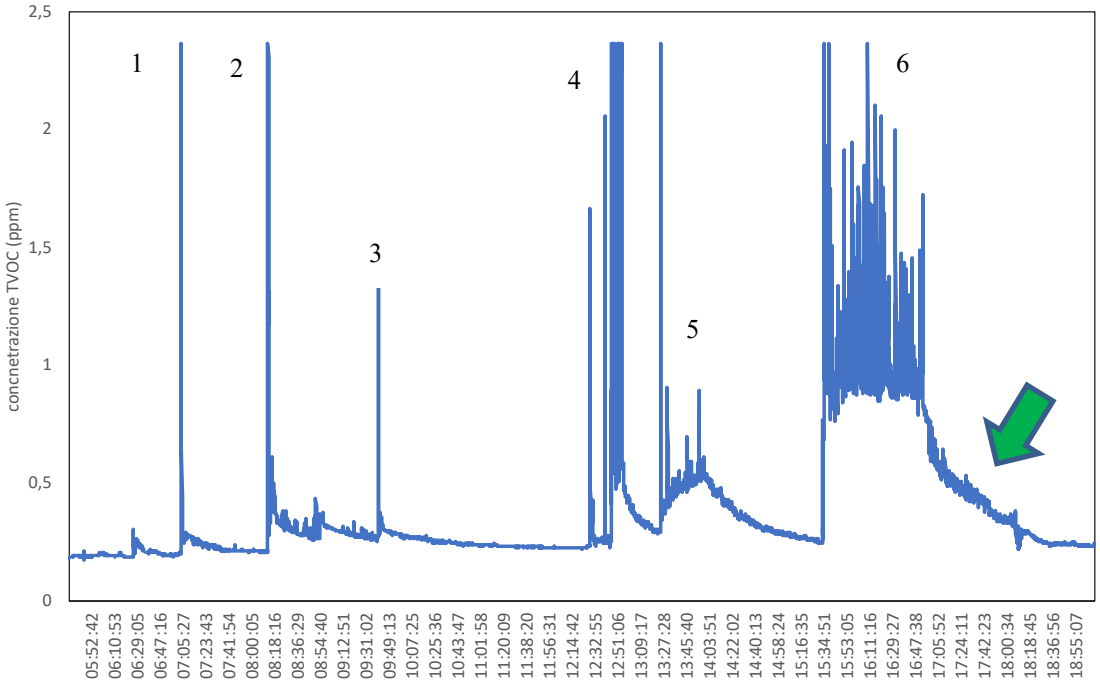

Fig. 2 – trend of TVOC concentration (ppm)

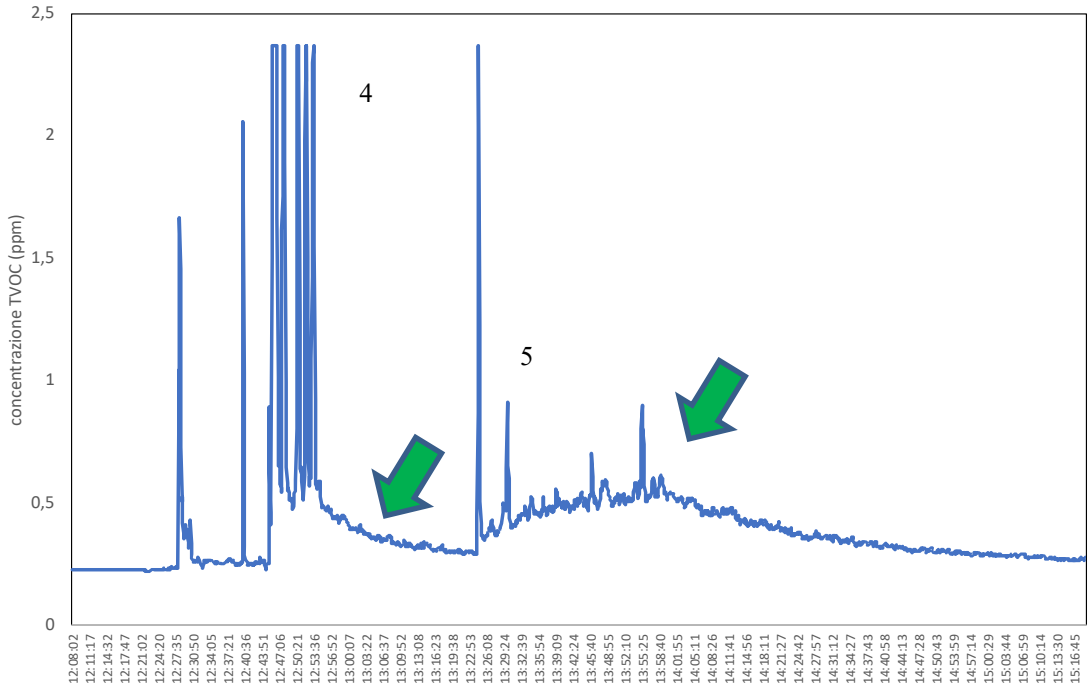

Fig. 3 – Trend of TVOC concentration (ppm): detail of fig. 2

Contrary to peak 4, in this case we observe a much less intense signal with only one initial peak comparable to the signals observed with the device off, demonstrating that HYLA is very efficient in reducing TVOCs.

Finally, an exposure time of 1h was used to greatly increase the concentration of TVOCs in the room. It is interesting to note that at 4:30 p.m., although no more VOCs are introduced into the room, the concentration remains high. At 16:48 the device is then turned on to obtain an immediate reduction of the signal that in about 2 hours reaches the initial value (see the area indicated with the green arrow in Fig. 2).

Table 1- Peak intensity (ppm) recorded by the Netpid instrument at successive time intervals and for different exposure times.

Peak	Exposure time (s)	Peak intensity (ppm)	Operation HYLA device
1	15 s	2,37	OFF
2	15 s	2,37	OFF
3	15 s	1,36	ON
4	30 min (12.25-12.55)	broad peak; high	OFF
5	30 min (13.25-13.55)	broad peak; high	ON
6	1h (15.30 – 16.30)	broad peak; high	OFF

4. Measurement of the ability to reduce concentrations of atmospheric particulate matter (PM)

In order to evaluate the ability of the device to reduce atmospheric particulate concentrations, the background concentrations present in the room were initially acquired. The following experiment was then carried out: by means of a fan, dust, which was contained in a plastic bag, was dispersed in the air in order to obtain an adequate increase in the PM concentration in the room. The concentration of the various particle size fractions then

immediately increased.

In correspondence to the first peak (15:04) an initial concentration of about 200 μg/m^3 was reached (the HYLA device was switched off in this case).
Then the test was repeated (15:34), this time suspending an amount of 963 μg/m^3. This second test was performed with the HYLA device switched on and waited until the initial conditions were restored. The third test was performed trying to suspend a quantity of powder similar to the previous one, in this case 943 μg/m^3, but this time the device was switched off. The powder descent trend confirmed what was observed with the first experiment (same slope of the curve).
The slopes of the curves observed during the phase of the recovery of the initial conditions have been evaluated comparing the one obtained with the device switched on and the one obtained with the device switched off. This evaluation was made by calculating the parameter S (slope) expressed as:

$$S = \Delta C / \Delta t$$

where:

ΔC = variation of PM concentration in μg/m^3 in the time interval

Δt= interval time

Table 2 – parameters related to the calculation of S for PM10 fraction

t (10 min)	C	S
HYLA ON		
15:37	421	31,9
15:47	102	
HYLA OFF		
15:11	75	1,9
15:21	56	

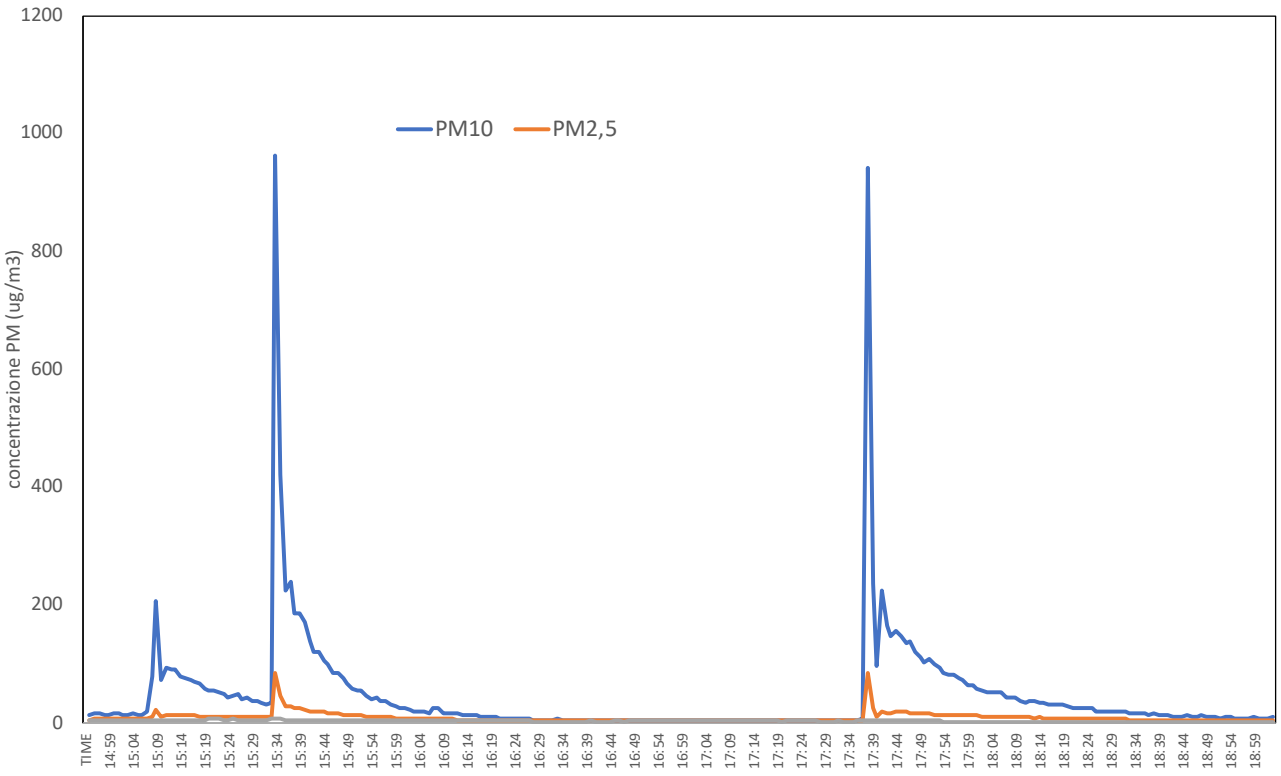

Fig. 4 –PM concentration trend

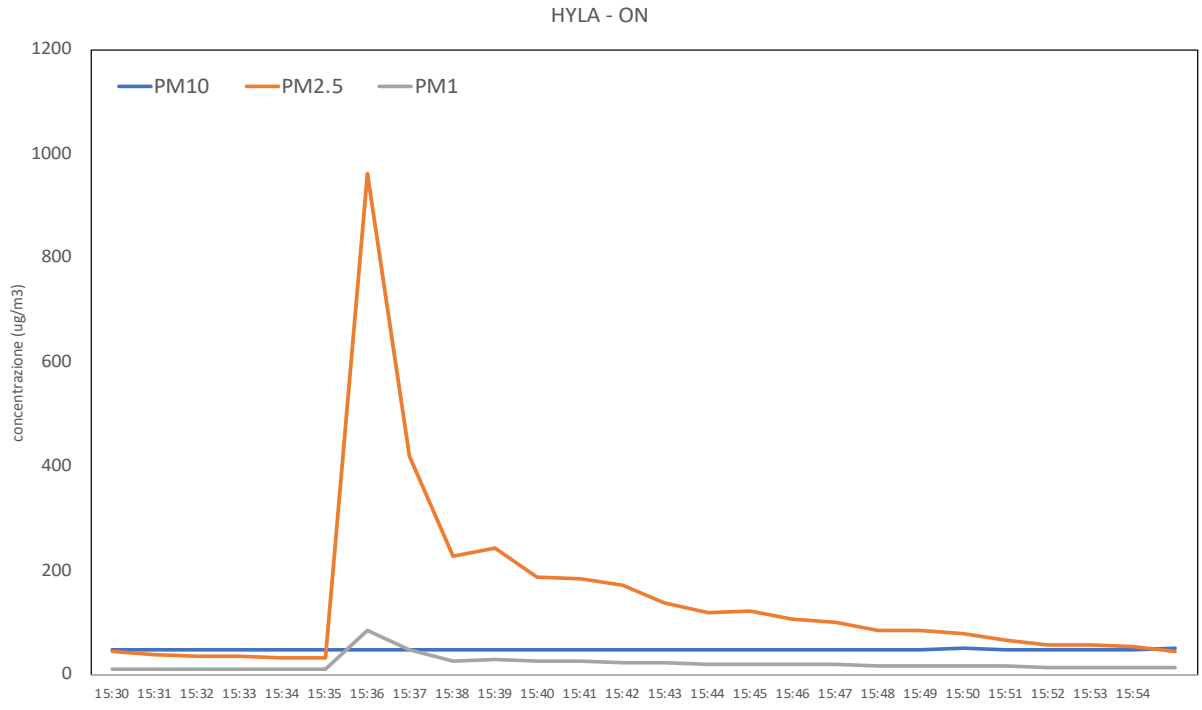

Fig. 5 – PM concentration trend with the HYLA device switched on

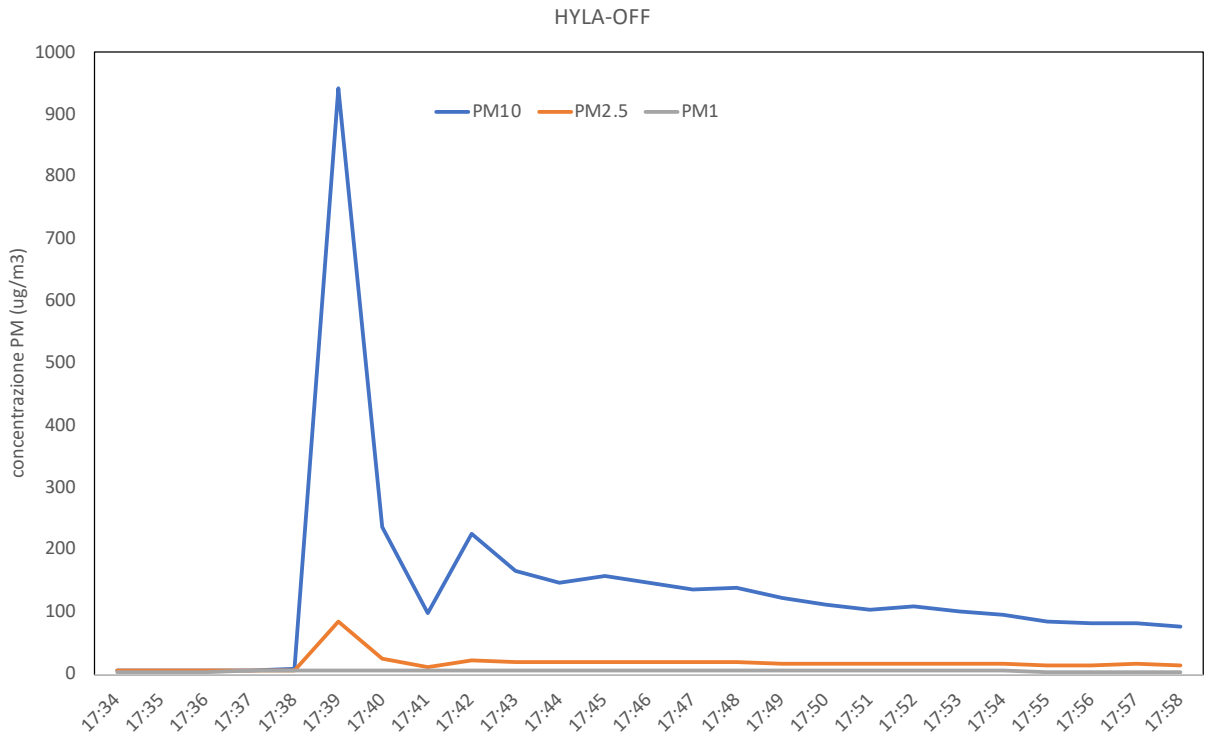

Fig. 6 – PM concentration trend with the HYLA device switched off

As can be seen from the values shown in Table 2, the S parameter when the instrument is in operation is considerably higher than when the device is turned off. In particular, the ratio between the two values is equal to 16.8 that means that HYLA system is 16.8 times more efficient in the reduction of PM10 concentrations compared to what happens naturally or by simple dust deposition. Moreover, in 20 min the HYLA device, starting from very high PM10 concentrations, allows to reach the values of dusts initially present (in the absence of the device in the same identical conditions it would be necessary a time of more than 1 hour to restore the initial situation).

In fig. 7 is reported the trend of the number of particles (N/L) relative to the two fractions containing the finest particles, that is those with dimensions less than 0.5 μm and 0.7 μm. It can be observed that the effect is more marked in correspondence of the peak recorded at 15:36 or with the HYLA device switched on.

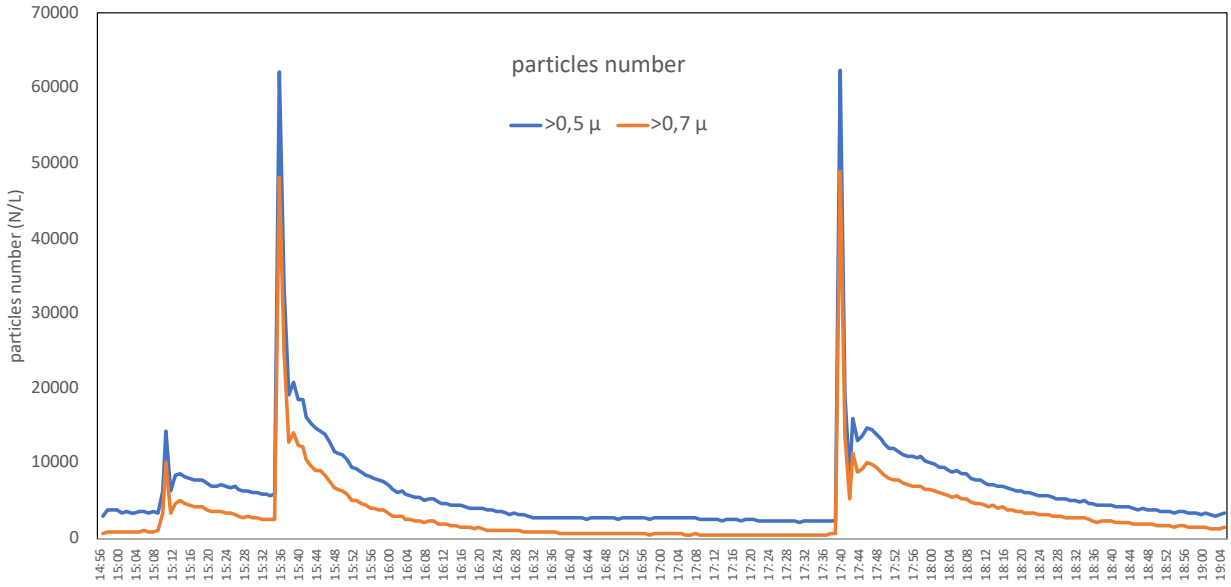

Fig. 7 – particles concentration trend (N/L)

5. Conclusions

On the basis of the tests carried out with regard to PM and VOC reduction, it can be concluded that:

- The HYLA device is effective both in the reduction of VOC level and in the reduction of airborne particles concentrations. In particular there is an improvement of a factor equal to 16.8 on a range of 10 min of what can be defined as the dust reduction efficiency; moreover in about 20 min the HYLA device, starting from very high PM10 concentrations, allows to reach the dust values initially present in the environment.
- In the presence of VOC concentrations of the order of ppm, with the HYLA device switched on, a value that is about 50% lower has been measured.

Observing the trend relative to the background concentration of TVOC, it has been observed that the device allows to restore in less than 2 hours the initial concentrations of TVOC which, otherwise, would remain high.

Finally, the HYLA-Aera device was also tested and it was possible to verify that it is able to maintain relative humidity at a constant value of 50%.

It can therefore be stated that the tests to verify the functionality of the HYLA-EST device, both with regard to airborne particles and volatile organic compounds, are deemed to have been passed. This device can therefore be used as a mitigation system of the air quality inside the domestic environment in order to reduce dust and volatile organic substances that may be present in the home as contaminants emitted by various domestic activities such as, for example, cleaning or cooking of food.

Il responsabile delle analisi
Prof. Paola Fermo, Dipartimento di Chimica
Università degli Studi di Milano