UNIVERSITY
OF TRIESTE
Department of Chemical Science

REPORT ON THE SURVEY PERFORMED TO ASSESS THE PARTICULATE ABATEMENT EFFICIENCY OF THE SYSTEMLIFE FILTERING STATION

ASSESSMENT OF THE RANGE OF THE SYSTEMLIFE "CITTÁ" MODEL OF FILTERING STATION

INTRODUCTION

The results of the studies performed to assess the atmospheric particulate abatement efficiency of the systemlife "Città" model filtering station (f.s.) are briefly indicated. Following these studies, the direction and distance of tracing particulate was evaluated in the experiment described below in order to assess the range of the filtering station as regards the potential effects of pollution mitigation in an urban canyon context.

It was decided to perform the experiments in winter when, generally speaking, the meteorological conditions cause the atmospheric particulate to stagnate.

Preliminary experiments on the efficiency of the filtering station, conducted in Ferrara and Camposampiero (PD), highlighted the influence of meteorological conditions on PM abatement and the presence/absence of active sources (e.g.: cars) near "Città" model filtering stations (e.g.: Pedrielli, 2007; Barcieri et al., 2008a). A study on the abatement performance of the station (Favaro et al., 2008), conducted by forcing the air entering and leaving the filtering station through ducts, showed that the inlet airflow was abated by over 95%.

In autumn 2008, experiments were carried out under controlled conditions (inside a 25,000 m^3 industrial shed, on 24th and 25th September (Barbieri et al., 2008b)) concerning the abatement efficiency of the station, highlighting the elevated performance levels under the experimental conditions, with considerable abatement (from more that 600 $\mu m/m^3$ to less than 15 $\mu m/m^3$) also for the PM1 particulate, measured with GRIMM 1.108 spectrometers for the dimensional analysis of airborne dust.

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The action of removing particulate from the atmosphere is confirmed by an analysis performed by the independent laboratory, SGS Italia (SGS, 2009), which shows that – during 2,300 hours of operation (more than 90 days) of a fixed filtering station operating in Italy - 965 g of particulate were removed from 23 million cubic metres of breathable air, amounting to an average reduction of 42 µg of particulate for every square metre of treated air.

Concerning the assessment of the benefits of the filtering station in the urban environment, one question that is often asked concerns the distance reached by the purified air emitted by the station. An experiment was therefore performed using a visible and measurable tracer (smoke generated by smoke candles) to experimentally estimate how far the filtering station can push the air.

A description of the experiment performed in collaboration with the staff of systemlife srl and the Environmental Chemistry Research Unit of the Department of Chemical Sciences at the University of Trieste is given below, together with the results obtained. Considering the information collected and the experience acquired, it was agreed with the technical managers of systemlife srl to use, for the test at Feltre, GRIMM Dust Monitor series 1.108 spectrometers for the size analysis of the particulate, instead of the gravimetric samplers that were initially envisaged, in order to measure variations in particulate concentrations with an elevated temporal resolution during experimentation. It was decided to measure the environmental concentrations of particulate at intervals of six seconds. The test was performed with the support of the Feltre Fire Brigade; systemlife srl agreed and identified, with officers of the municipality of Feltre, the most suitable day for conducting the experiment.

On 30th January 2009, a "*range assessment*" experiment was performed using smoke tracers – in order to estimating the distance of influence of the filtering station as regards the potential effects of mitigation in an urban canyon – using the systemlife "Città" model filtering system (code SFC 017), located in Largo Castaldi, a street in the town of Feltre (BL).

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MATERIALS AND METHODS

To determine the spatial extension of the mitigating effect of the systemlife mod. "Città" filtering station, the following instruments were used:

- 5 smoke candles (produced by F.D.F. s.r.l.), positioned and used in sequence close to the intake system of the station;
- 4 series 1.108 GRIMM Dust Monitor laser scattering spectrometers for assessing changes in concentration and size distribution of airborne particulate;
- the filtering station, located on the traffic island in Largo Castaldi, Feltre, with its air output directed towards via Tezze, had no filtering stages in order to allow the smoke tracers to leave the station without capturing the particulate. According to information provided by systemlife srl, the pressure drop associated with the presence of the filtering stages was not significant.

Four GRIMM spectrometers were positioned at various distances from the filtering station, as indicated in figures 1 and 2, after assessing the road layout:

Position N° 1 GRIMM1	2m (behind the filtering station)
Position N° 2 GRIMM2	40m
Position N° 3 GRIMM3	80m
Position N° 4 GRIMM4	120m

Figure 1: Positioning of the Grimms and the Filtering Station

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Figure 2: photograph showing details of the positioning of the four spectrometers

Previous studies (Barbieri, 2008b) have shown that the smoke candles used generate dust with a dimensional distribution featuring particles with a diameter of less than 0.3 µm. These perform better than large particles when acting as tracers for treated air. For the purposes of experimental valuation, the concentrations of the finer PM1 particulate area shown.

The meteorological conditions on the day in question, measured by ARPA VENETO at the Feltre station (figure 3), were the following:

Temp. aria a 2m (°C)			Pioggia (mm)	Umidità rel. a 2m (%)		Radiazione globale (MJ/m^2)	Vento a 5 m			
med	min	Max	Tot	Min	Max	Tot	Sfilato (km/g)	Raffica Ora	Raffica M/s	Direz. preval
3.2	-0.6	10.6	0.0	48	95	6.263	34.1	15:05	2.6	O

The test was performed in adequate meteorological conditions for the experiment, with the absence of fog and prevailing winds. The prevailing direction of origin of the wind was West, opposed to the direction of the jet of air produced by the filtering station whose delivery mouths were directed from Via 31 Ottobre towards Via Tezze, from East to West.

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Figure 3: Positions of the weather station and the filtering station

RESULTS AND DISCUSSION

The test began after positioning and starting the GRIMM 1.108 analysers; environmental concentrations were measured for 30 minutes on the four instruments positioned in the field, obtaining values that proved to be substantially identical for the GRIMM1 and GRIMM2 analysers (approximately 50 µg/m³ of PM10) and more elevated (with episodes in which 100 µg/m³ was exceeded) for the GRIMM3 and GRIMM4 analysers, located near the crossroads between Via 31 Ottobre and Via Liberazione. The variability of the concentrations in the various positions considered can be interpreted considering the morphology of the site and the influence of emissions associated with the "stop and go" phenomena of cars.

The smoke candles were then lit, one after the other, and inserted into the intake system of the filtering station. The first candles to be lit - white and blue - lasted a short time, after which a red smoke candle, lasting longer, was lit.

Visual inspection (Fig. 4) immediately showed that the area reached by the tracer smoke exceeded the distance taken into consideration, determined by the position of the GRIMM4 analyser, located more than 120 m from the filtering station.

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Figure 4: red tracing smoke

The red smoke candle was lit a little after 15.02. The wind speed measured using a portable anemometer during the experiment was less than 0.7 m/s and its direction varied, partly due to the movement of vehicles in the road.

Figure 5 shows a diagram illustrating the PM1 concentrations measured by the four spectrometers positioned behind the filtering station (GRIMM1, purple trace), at 40 m (GRIMM2, yellow trace), at 80 m (GRIMM3, pink trace), and at 120 metres from the filtering station (GRIMM4, blue trace), after the smoke candle was lit.

Profile of PM1 concentrations at the 4 measuring points

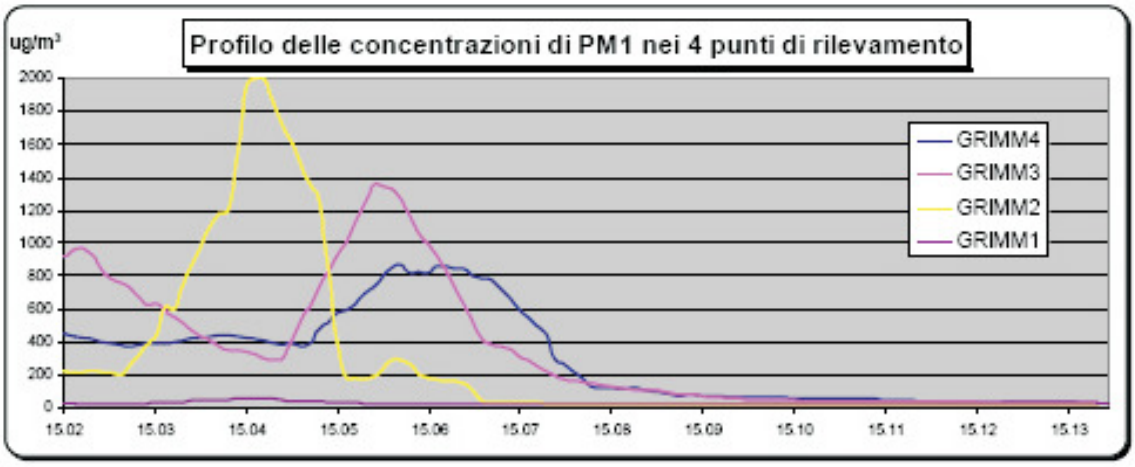

Figure 5: profile of PM1 concentrations at the 4 measuring points

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The PM1 concentrations when this smoke candle was lit were different and elevated for the analysers at 40, 80 and 120 m from the filtering station, given the smoke emitted during the previous tests and the morphology of the area which allows the particulate to stagnate in some zones of the urban canyon (there was a dip in the road at station 3, 80 m from the f.s.). Instrumental verification confirms that the whole area taken into consideration was affected by the jet of the tracers generated by filtering station as it reached and exceeded the last measurement station considered (Position 4), 120 m from the filtering station mouths.

As can be seen in figure 4, at position n°2, located 40 m from the filtering station, the effect of the tracer is indicated by the sudden increase in PM1 (yellow line) measured by the GRIMM2. The event lasted approximately 2 minutes with the maximum concentration peak being recorded at 15:04.

At position n°3, located 80m away, the duration of the event measured by the GRIMM3 (red line) remained more or less unchanged, while the maximum concentration of PM1 was measured approximately 90" after that at the previous measuring point.

Also at position n°4, despite the fact that this was located 120m away from the filtering station, the GRIMM4 (blue line) measured the effect of the tracer approximately 2 minutes after the first position (GRIMM2).

It is notable that the continued jet of clean air generated by the filtering station - after the smoke candles went out - rapidly removed the particulate, even in the dip in the road.

After the above experiment was concluded, the filtering elements were put back into the station and, in the furthest and most critical positions, caused by the presence of a crossroads, a bend and a dip in the road, the environmental concentrations of particulate were reduced even further.

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CONCLUSIONS

The constant monitoring of position 1 (GRIMM1), which was not affected by the jet of smoke, allowed the environmental concentrations of particulate to be measured, while analysis of the data collected by the spectrometers (GRIMM2, GRIMM3, GRIMM4) made it possible to verify the changes in the concentrations of the tracers emitted by the filtering station at distances of 40, 80 and 120 m respectively.

The experimental evidence obtained on the site in the configuration in which the filtering station was tested showed that it boasts a range exceeding 120 m (visually observed to be approximately 160 m).

The dispersion of the tracers produced by the machine is very quick: the time elapsing between switching on the filtering station and detecting the tracer at the furthest point considered (GRIMM4 at 120 m) is just 2 minutes; the range of the filtering station active in urban canyon conditions is significant.

It is clear that the continuance of the jet of clean air by the filtering station - after the smoke candles went out - rapidly led (in 2 minutes) to the complete removal of the particulate emitted by the smoke candles in the area subject to monitoring.

The experimental elements gathered make it even more necessary to continue to constantly improve the filtering station which, over time, has proved to provide considerable filtering performance over a large area in the meteorological and context conditions of the urban canyon considered.

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