

**REPORT ON THE TECHNICAL AND SCIENTIFIC
"KNOW HOW" OF THE FINE PARTICLES FILTRATION SYSTEM**

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Subject of the examination and documentation reports

The undersigned prof. Francesco Pedrielli received the mandate from System Solutions srl to make an assessment of the scientific and technical knowledge pertaining to the dust filtering technology called "*systemlife*".

He was a professor at the University of Ferrara, from November 1972 until Dec. 31st, 2011 and particularly as Associate professor of Physics, from February 1985, at the Faculty of Science of the University of Ferrara; currently he holds teaching position at the University of Ferrara and associate at the Laboratory IMAMOTER CNR in Ferrara.

Technology "*systemlife*" was developed to obtain a purification of the polluted air mainly for the so-called "fine particles", classified as PM10, PM2.5 and PM1,0 as well for nano powders both in open environment as indoor.

The technology adopted for open environment has greater significance in situations, typical of historical Italian cities, with conformation road-buildings as a whole.

This technology responds to increasingly stringent regulatory criteria and also to the population request, for those living in environments reducing the risks of polluted areas.

The writer based himself on personal tests as well from data provided by third party qualified institutions (as University and Research institutes).

This assessment is aiming to identify the components of an important industrial and social know-how, often intangible, that must also be addressed to the possible development, at European or world level, of research activities both inside and outside the company.

December 31, 2013 is the reference date of the "*systemlife*" technology estimate.

The documentation which was examined is based on:

1. Description of the filter station
2. Tests carried out in Italy and abroad
3. Reports of the executors of the tests

which is extensively collected in separate electronic format.

This estimation aims to summarize and highlight the experiments for their value as documentary interest for public health.

In these pages I would point out the strengths of the original *systemlife* technology as follows:

1. Project simple and strong visual impact / environmental.

2. Optimization of mechanical filtering component.
3. Optimization of the electrostatic filter component.
4. Inserting components for felling eluent.
5. Existence of multiple sites where the system was tested
6. Life cycle of over 15 years with simple maintenance.
7. proven resistance to environmental conditions
8. Interaction with ICT. Transfer data to all interested parties.
9. Inserting panels / display for video information and / or advertising
10. Creation of a monitoring network with information to the public

CHARACTERISTIC FEATURES OF THE FILTERING STATION

The "*systemlife*" Filtering Station technology is an innovative project specifically aimed at air purification in those particular urban settings similar to canyon, tunnel or "urban rooms" that contribute with high amounts of pollutants due to the topography of the area .

The Filtering Station consists of the following elements:

- A filtering advanced system through which the station continuously sucks the polluted air, holds dust particles, pollutants and odors, returning clean air to the outside environment.
- An automatic management system, called "Climate Box", which controls the filtering system and is able to calibrate the operation in relation to the real external conditions of the air due to weather conditions.
- A system for monitoring and display of input and output air quality. With and complementary system it is possible to recognize the presence of other pollutants which can be connected to monitoring networks with simple data presentation to the public data either local or remote.

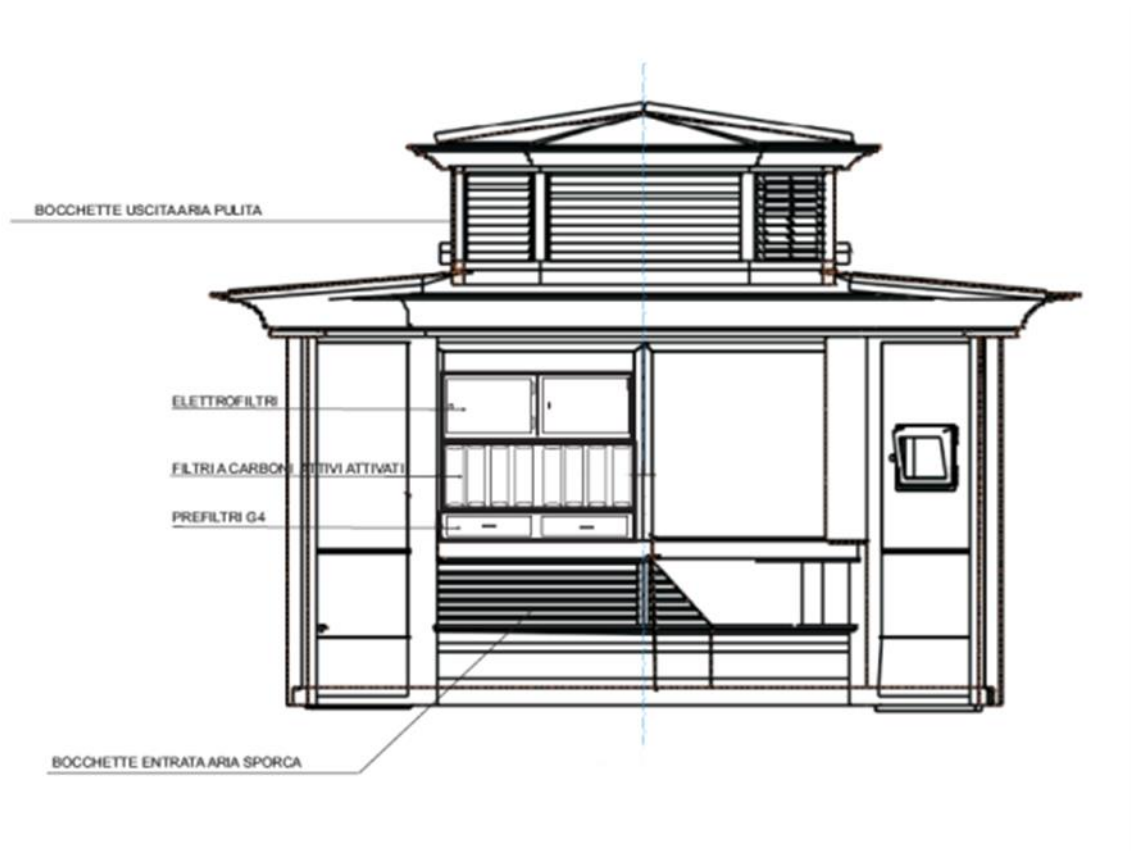
Filtering System

Inside the station there are four stage filtration complementary areas:

1. The first is made up of special and specific fabric filters (F3) with a loose weave mesh to retain the large particulate, facilitating subsequent filtering;
2. The second stage uses specific details and fabric filters (F7), with very narrow mesh, designed to retain particles with dimensions as small as 0.2 microns that is the range of fine particles;
3. The third filtering process using metal mesh filters intertwined and optimized for the passage of air on active carbon. The filter has the task of retaining gaseous pollutants and at the same time make laminar air flow passing through it. In this way, the air escaping from the machine is purified with reducing harmful gas through titanium dioxide (TiO₂) (i.e. oxides of nitrogen, oxides of sulfur, benzene, formaldehyde, ethyl benzene, acetaldehyde, toluene, ethanol, methanol, m-xylene) ;
4. The last filtering system, with higher technological content, is made of an electrostatic filter capable of retaining a total of more than 95% of the pollutants, including those with dimensions with diameters lower than 0.1 microns. In this phase, the air flow is subjected to electric field inducing charges on the pollutant particles which are then collected.



Filtering station pictures



Filtering station sketch

General data

Amount of filtered air	>10.000 m3/h
Surface served	Referred to the morphology of the territory (about 200-250m)
Performance 3-stage filter	>90% (average)
Filtered particulate diameter	below 0.1 µm
Overall dimensions	cm 450x180xH440
electric power	5 kW
Interfaces	
Sensors	Anemometer, temperature, pressure
PM measurement	Spectrometer Grimm 1.108
Ethernet	remote connection
Display	One display for air filtering information and a second for optional advertising

European Programs

The European CAFE Program (CLEAN AIR FOR EUROPE) 2001 is the basis for all policies and strategies to reduce pollution in the air.

The financial contribution of the European Union to international programs is often conditioned by the respect of the concepts contained in the "CAFE".

The Directive of the European Parliament 12/10/2007 fixed Future goals jointly with the World Health Organization:

- limits 2015→ PM10: 50/40 µg/m3
- limits 2015→ PM 2,5: 20 µg/m3
- yearly limits 2020...→ 20 µg/m3
- present yearly limits → 40 µg/m3

ATMOSPHERIC POLLUTION EFFECTS

OMS Data	100.000 units	Increase of hospitalization in Europe (OMS)
	400.000 units	Deaths due to atmospheric pollution effects in Europe (OMS)
	8.220 units	Deaths in Italy due to pollution (OMS)
Medical data for children	5.537 units	Yearly increase of bronchial asthma for children population
	10%	of 0 a 14 years old children suffer breath diseases
	5.000.000 units	Children die each year in the world for environmental causes
	6.700 µg	Amount of carbon monoxide inhaled by a baby in a stroller for a 1-hour journey
Economic data	28 billion	Social cost of the disease due to pollution in Italy

ENVIRONMENTAL DAMAGE

Particulate matter and other pollutants cause major environmental damage which are reflected on the citizen's quality of life.

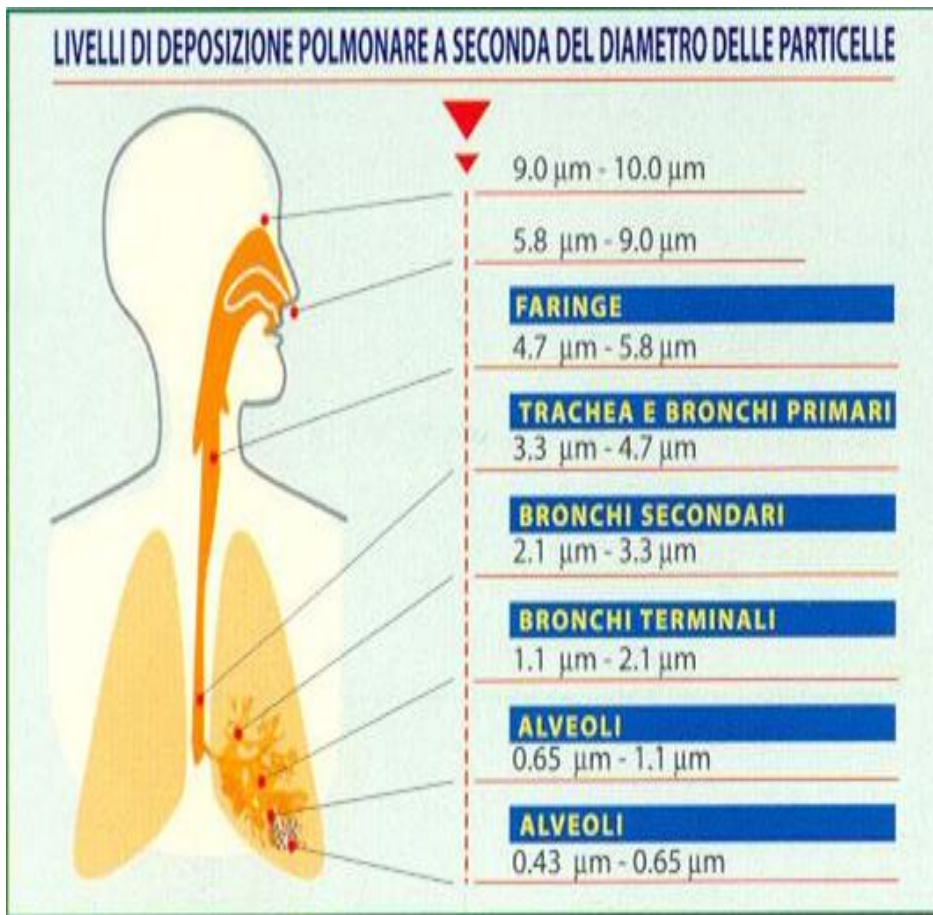
The fine particles are the major cause of smog in big cities.

Phenomena such as acid rain, due to sulfur dioxide and nitrogen oxides, cause extensive damage to forests and plantations.

The marble and other construction materials used in the main monuments of our cities are daily affected by the presence of pollutants in the air.

The dust settles on the stone facades, blackening the buildings and other monuments, and require continuous cleaning and restoration.

Furthermore the chemicals which are aggregated to PM10 can corrode the stones producing an irreversible damage.



Evaluation of the experiences which have been performed

The many different experiments were conducted on “systemlife” filtering stations to set the efficiency and effectiveness of the filtering station.

The most important tests are:

1. certificates of filtration efficiency of the filtering station and of its components (filters) and analysis of the acoustic system compliance with the standards,
2. Installation of test sites representative for the purpose of particulate reduction in Rome, Ferrara, Lugano, New Delhi, Feltre, Montegrotto.
3. Measurements, simulations and modeling (analysis of various gases in a multi-point network with 18 sensors in Rome, transport fluid dynamic analysis at Ferrara University)

Point 1. - certifications

1.a - certification carried out at the **Experimental Glass Station in Murano** with the report conclusion: ***"In the specific conditions of the test it was found a reduction of 97%"*** (from 699 mg / m³ in input down to 21 mg / m³ as output)

1.b – SGS carried out the test on a filtering station: the dust collected for a time lag of about 2300 hours (95gg) totaled 965 g (748 g in the first filter and 217 g in the second). The substances are analyzed in the report with particular emphasis on organic and metal (the chart report included the analysis of risk related to the filtered materials such as Fe, Al, Zn, Cu, Ba, Cr, Mn, Pb, Sn, Ti).

1.c - the Energy Department of Politecnico di Torino performed a test only on the electrostatic filter: 88% average filtration efficiency was demonstrated for dust of 0.4 μm mean size (ISO 12103-A2) with a filtration of the same order down to 0.25 μm particles (limit test).

1.d - measurements of noise levels that do not exceed the limits (measurements made by M. Faggin, expert n. 111 in technical acoustics list of the Veneto Region): *"The measured noise level (at various distances), is less than limit set by the dB differential criteria both during daytime and night time"*.

2. - Scientific tests carried out on the particulate matter

Dimensional analysis and qualitative dust, which was absorbed by the filtering station, showed particles with diameters less than 0.1 μm (report of Nanodiagnostics).

The tests were conducted to determine the areas of influence of the filtering station in an open environment (Engineering Campus, Ferrara University, Connaught square - New Delhi), in semi-open environment (Lugano square parking near arch. Botta bus stop and shelter) as well in a closed environment (*systemlife* factory, Rome and Milan Metro station, Caserta tire scrapping Industry).

In the Technological Center of the University of Ferrara we made of series of continuous measurements of particulate matter at distances from the filtering station up to a distance of 210 m. We operated with reasonable continuity from September to March under various weather conditions. The data of the first period showed a shift of the masses purified, issued by the filtering station, with an influence distance of the clean air up to 200m.

It was finally conducted a full day of testing at the site of the pole University Technology Ferrara which noticed the concentration lowering of the PM₁₀, PM_{2.5}, PM_{1.0} for the two measurement stations at the Dip. Physics and Dip. Engineering.

Data analysis was performed by prof. P.L. Barbers (University of Trieste - Department of Chemistry) on the data provided by prof. F. Pedrielli (Physics Dept. - Ferrara Univ.)

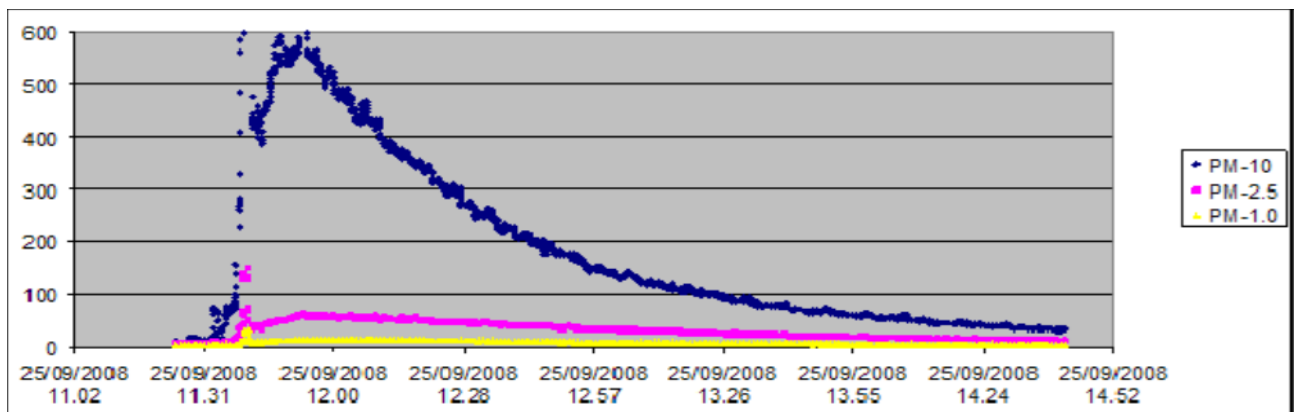
The measurement stations at distances of 90 and 210 m from the filter station show the reduction of concentrations with the same station in operation.

Prof. Michele Pinelli of the Dep. Of Engineering, has developed a simulation program that builds on the verified data on the machine with prof. Pedrielli, allowing an estimate of the purified air flow range up to more than 200 m from the filtering station.

Inside the *systemlife* building in Camposampiero (Padua, Italy) a test dust filtration was conducted on the filtering station.

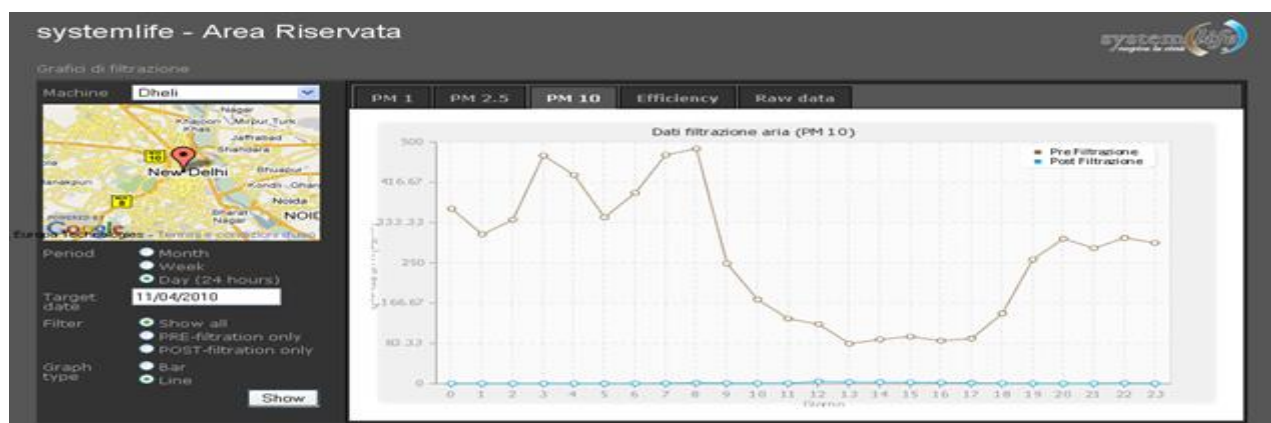
Two experiments were conducted:

1. test - two smoke candles (smoke size mode equal to $0.3\ \mu\text{m}$), with growing homogeneous concentrations up to $670\ \mu\text{g} / \text{m}^3$. –In this experiment the application of filtering station allowed to break the concentrations of $670\ \text{mg} / \text{m}^3$ down to $15\ \mu\text{g} / \text{m}^3$
2. Test - a wide prevalence of PM10 in respect to the PM2.5 and PM1, reaching concentrations in the homogeneous treated environmental of 490 (380) of $\mu\text{g}/\text{m}^3$. In this experiment, during the first hour of operation of the filtering station, there was a decrease in the concentration of PM10 to quantify the extent of 70%, from $380\ \mu\text{g} / \text{m}^3$ to $115\ \mu\text{g} / \text{m}^3$. During the whole period of operation of the filtering station (2.5 hours), the entire volume of air available was treated ($25,000\ \text{m}^3$). Following the continuous monitoring of the environmental concentrations, the percentage of the PM10 reduction in a closed environment is of 92%, showing concentration test value of $31\ \mu\text{g}/\text{m}^3$ at the test end.



Connaught Square in New Delhi

Connaught Square in New Delhi is a circular plaza, over 300 m in diameter, with heavy traffic. During the day concentrations rise to levels above $500\ \text{mg} / \text{m}^3$. The use of the filtering station showed a filtering capacity of the order of 99% (air output) under conditions of maximum input air pollution; it does not fall below values of 90% (for the three standard measures PM10, PM2.5, PM1,0) in lower concentrations condition.



At the same site we were conducted analyzes to check the NO_x concentration decrease and the values, similarly with previous experience showed a reduction of the order of 30-40%

3- Gas Filtering through the filtering station

Euromobility (spin off of the CNR -Nat. Res. Council) carried out a remarkable experience in Rome.

The filtering station was located in an area of the city strongly affected by a significant passage of buses (1,561 per day) at the exit of the Metro station at the crossing Viale Giulio Cesare/Via Lepanto. In this condition the effect of the filtering station was analyzed for the component gas abatement (with 18 passive analyzers).

The final report for a fifteen days analysis by Euromobility (Association of mobility managers) emphasizes the reduction of gaseous pollutants especially along the direction of action of the filtering station. An important filtration results for gases such as O₃, NO₂, NO_x, SO₂, NH₃, BTXE.

I should mention as a synthesis of the remarkable work of Euromobility their conclusions:

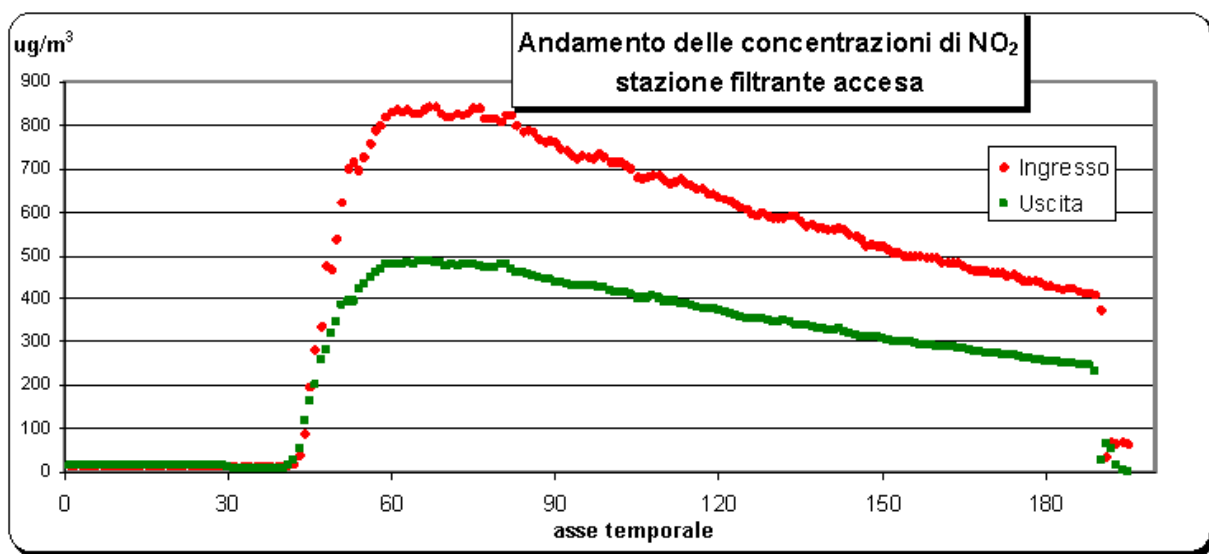
"This means that, although the area of the test is characterized by a high intake of polluted air (the traffic within 300 meters from the intersection brings between 10,000 mc/h and 20,000 mc/h of polluted air in rush hour) the filter station is able to significantly alter the composition of the air along the axis of operation of the station itself (direction C-D of the test site) "

University of Trieste analysis of the on data collected in Camposampiero and Feltre

Inside *systemlife* factory building in Camposampiero, 24,000 m³ (50x60x8) volume, a test of gas filtering was carried out by controlling the NO₂ emissions and analyzing the concentration change at the inlet and outlet; environmental concentrations input varied from 13 to over 800 g/m³.

The values recorded before the generation of the gas inside the building showed a decrease of 44% with 2% standard deviation.

The values recorded after the concentrations peak showed a decrease of 41% on 135 measurements with a 1% standard deviation.

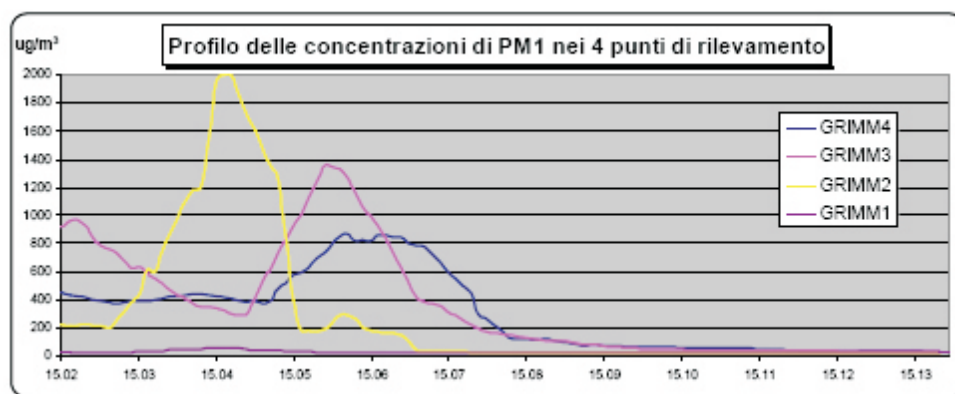


In the town of Feltre Trieste University ran an experiment of dye plume tracking to check the output lane of purified air.

The tracers allowed dye marks at distances higher than 120 m. The tracking was performed with 4 Grim spectrometers and clearly shows the area of influence of the filtering station, especially in urban areas where the particulate concentration is high in the streets where it is produced: the purified air goes to occupy areas away from the station by reducing the concentration of particulate. The distance of 120 m was tested even if the dye tracers of mass higher than air were spread (see in the graph that the peaks widen with distance). The clean air can reach distances 150-200 m.



Figura 1: Posizionamento dei Grimm e della Stazione Filtrante



Grimm 1: at the air input in the filtering station, **Grimm 2:** 40 m, **Grimm 3:** 80 m, **Grimm 4:** 120 m

Odors and smell analysis

The Water Veronesi Scarl commissioned the olfaction determination and odor concentration according to EN 13725, with olfaction detector ECOMA mod. TO7 and panel of eight rhino analysts, for air taken in via Campagnola of Tombetta in Verona (IT), near the water treatment plant.

The odor concentration OU/m³ equals 6300 upstream of the station while it falls to values of 20-25 with almost no odor perceived by the rhino analysts both for quality and intensity.

Analysis of air in subway stations

The “*systemlife*” filtering station was modified for an indoor use, i.e. for underground stations.

The new project has modified the air intake flux of to a lower value than for outdoor station.

Alongside they started in-depth analyzes and simulations of air mass behavior inside the metro stations depending on the movement of both convoys and people.

Use of the filtering station goes in the direction of reducing local pollution for both service users and suppliers as well for the issue of clean air in the surrounding streets.

The filtering stations can be integrated with the station design for air conditioning and the recirculation/filtration of air masses that far exceed the limits for the outside concentration.

Preliminary tests were conducted both on the Rome Metro and in Milan with encouraging results.

Analysis of submicron particles (Nanodiagnostics)

An important section of the studies on the filtering station regards the analysis of submicron filtered particles.

It shall be emphasized that at the same concentration (in mg/m³), unit of mass nature, the number of particles of diameter 0.1 μ m is 1000 times higher than the one from 1 μ m. The particle health damage is largely dependent on the number of particles which, penetrating more deeply into the alveoli, create a greater number of risk sites.

The Nanodiagnostics co. is acknowledged as leader both nationally and internationally in research on the submicron particles and their effects. They have set up measures with a scanning electron microscope (SEM) on the particles collected by the mechanical filters as well on those which were attracted and deposited on the plates of the electrostatic filters.

In the study it is presented the analysis of the size and composition of filtered particles with sizes less than 100 nm. These nano particles filtration cannot be achieved by mechanical system filtration but can be stopped and trapped thanks to particular electrostatic filtration. It should also be noted that the nano particles are air born for a time longer than the PM10 type particle.

Their capture reduces the risks due to their higher "in flight" time spreading.

Nanodiagnostics claims to have seen no other filter systems with similar capabilities.

CONCLUSIONS

The air purification system via "*systemlife*" filtering station presents innovative features and almost exclusive market.

We have here reported experiences and certifications which allow the conclusion that the system is filtering the air with high efficiency, of the order of 80-90% rising to than 95% for high concentrations ($> 300 \text{ g / m}^3$) of PM.

Positioning in urban areas, typical of such stations, does not affect the environmental issues either in terms of noise or in terms of visual impact. Certifications and authorizations for use in major city centers ensure the compliance with the noise impact limits and their placing in the historic surroundings as for the acknowledged newsagents (same esthetic design).

PM filtering activity can be implemented with gas and odor reduction.

Topographical conditions affecting the transport capacity of the purified air in standard conditions analyzed (Feltre) exceeds 200 m with effective PM reduction. In particular for high traffic frequency positions (eg. Viale Giulio Cesare in Rome) the PM content is reduced even in neighboring areas preventing the natural diffusion of the same particulate matter. The PM pollution even if measured on daily averages nevertheless predominantly seats of origin; dramatically reducing the PM in the production sites you get a benefit for the whole surrounding area.

Deep analysis in this direction were carried out by the London Municipality with the clear identification of high concentration on the higher traffic road while surrounding areas show lower concentrations.

Further importance can be claimed for the filtration in the areas of high PM source (either by means of transport which by warming emissions) in particular for the historic cities with high population density and few large roads.

A detail not to be overlooked is ultimately expressed in the Nanodiagnostics report which writes in the conclusions:

"Thus in the writer's opinion a system like the one we examined is an essential complement to upstream action, with the advantage of being available and not requiring any form of education". It should be added that, according the writer's experience, the examined system is today the only one that can efficiently mitigate PM pollution which is growing in urban areas. "

Do not overlook the possibility of presenting a European research on filtering station and its effects in mitigating the urban pollution impact in European cities as part of the Horizon 2020.

Preliminary reports already underway with European cities (London, Prague, Stockholm, Bucharest, Barcelona) showed the interest and value of this solution and the willingness to share experiences and results.

The suction device is simple but it can play an interesting role in the field of communication and involvement of the population. This is a key factor in the environmental education and the population can be made partakers of municipal initiatives that involve their welfare and health.

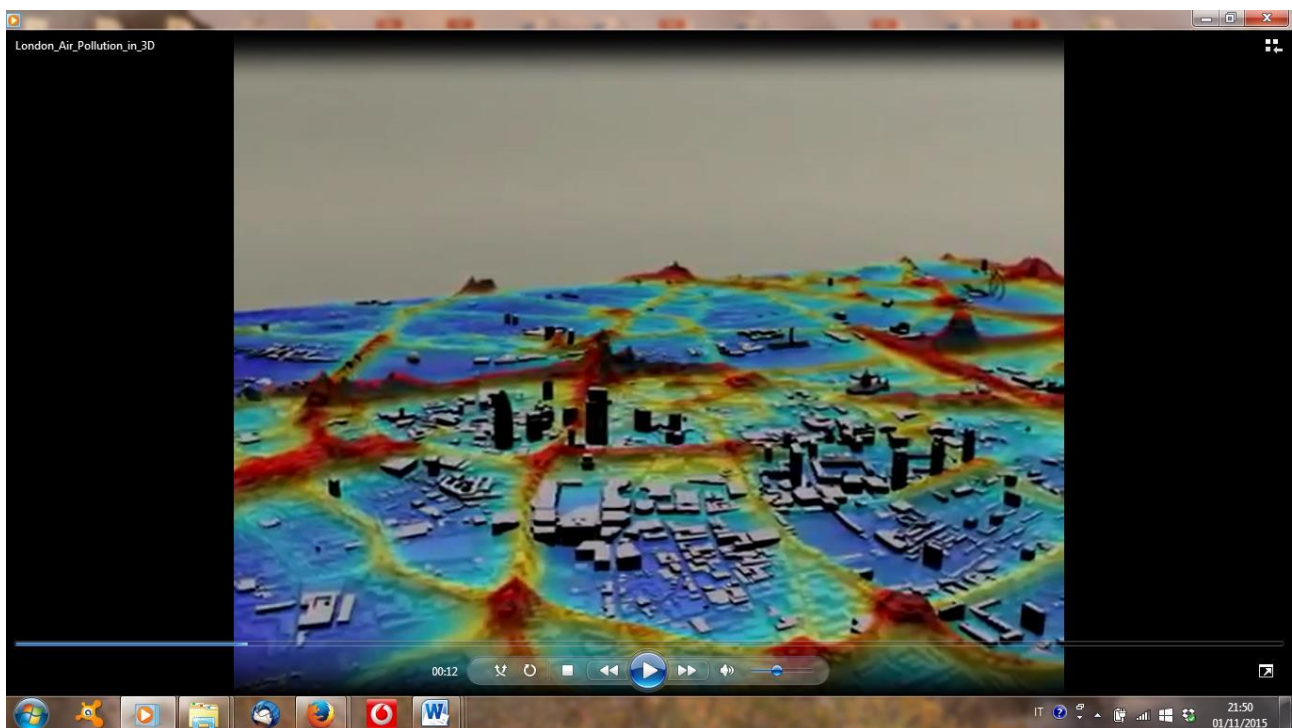
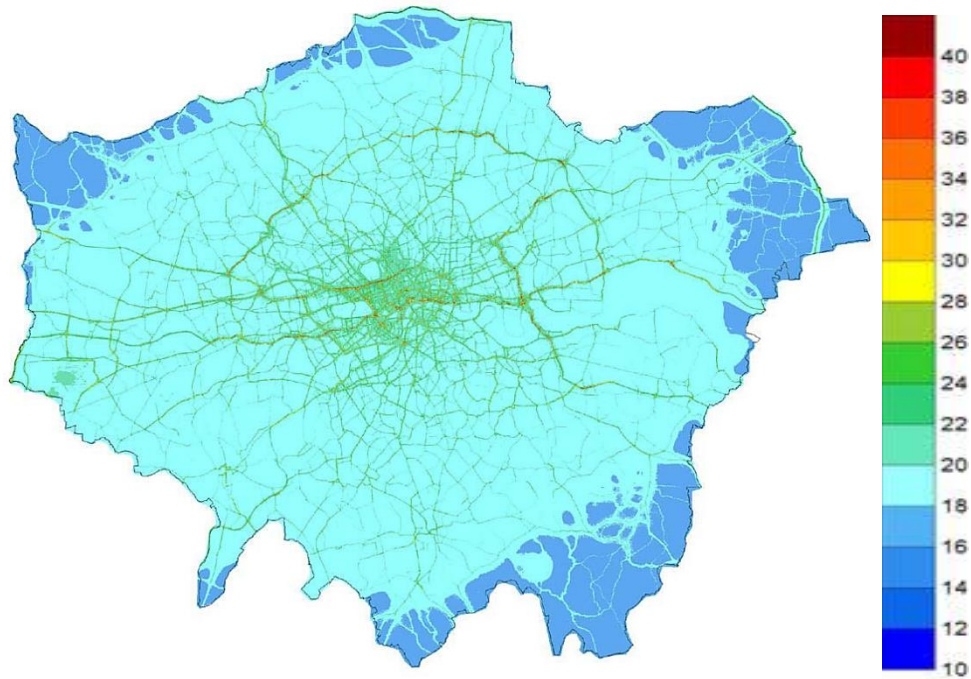
The station can be used to transmit information on the detected environmental conditions not only from internal sensors to the machine but also from remote public networks.

Prof. Francesco Pedrielli

Ferrara, 30.04.2014

Clearing the air - The Mayor's draft air quality strategy for public consultation
Greater London Authority March 2010 www.london.gov.uk
City Hall - The Queen's Walk - London SE1 2AA

Great London - PM₁₀ annual average¹⁷ concentrations ($\mu\text{g}/\text{m}^3$) for the year 2008



<https://www.youtube.com/watch?v=P-pWWj6szNs>