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Department of Chemical Sciences

EXPERIMENTATION ON THE NO_2 ABATEMENT PERFORMANCE OF THE System(life) FILTERING STATION mod. Città

The attached report sets out to test NO_2 (nitrogen dioxide) abatement performance, in severe contamination conditions, associated with an improved catalytic section compared with that used for the preliminary study of the System(life) filtering system mod. Città which handles an airflow of 10,000 m^3/h.

The preliminary study of nitrogen oxide abatement - achieved by inserting a photocatalytic section into the technology train of the filtering stations – highlighted the possibility of treating these gaseous pollutants.

In order to test the performance of the filtering station under stress, an experiment was prepared in an industrial building, in conditions of elevated contamination and control that could not be achieved in the open air.

Details of the study are contained in the attached report.

The experiments performed on the System(life) filtering station Mod. Città show that the NO_2 concentrations leaving the machine, in the tested configuration, are over 40% less compared with inlet concentrations, over a wide range of NO_2 air contamination values.

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Introduction

System(life) filtering stations handle air volumes amounting to several thousands of cubic metres per hour and abate air pollutants by means of a multistage process involving filtering sections and a catalyst section.

Experimental studies performed on the System(life) filtering station [1,2,3] investigated the abatement performance of PM_{10} and submicrometric particulate, illustrating the product's capacity of abating suspended particulate.

A preliminary study [4] of nitrogen oxide abatement – achieved by inserting a photocatalytic section into the technology train implemented in the filtering stations – highlighted the possibility of treating these gaseous pollutants.

This study sets out to test NO_2 (nitrogen dioxide) abatement performance, in severe contamination conditions, associated with an improved catalytic section compared with that used for the study [4] in the System(life) filtering system mod. Città which handles an airflow of 10,000 m^3/h.

In order to test the performance of the filtering station under stress, an experiment was prepared in an industrial building, in conditions of elevated contamination and control that could not be achieved in the open air.

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Nitrogen oxides

Nitrogen oxides are collectively identified with the abbreviation NO_x

Nitrogen is able to form various oxides:

- nitrogen monoxide (NO)
- nitrogen dioxide (NO_2, also N_2O_4 as a dimer)
- nitrous oxide (N_2O)
- dinitrogen trioxide (N_2O_3)
- dinitrogen pentoxide (N_2O_5)

The abbreviation collectively identifies the nitrogen oxides that are inevitably produced as by-products during any form of combustion taking place using air (e.g.: biomasses, car engines, thermoelectric power stations and steelworks). The quantity and quality of the NO_x mixture depends on the burnt substance and the conditions in which combustion takes place.

Nitrogen oxides are considered as atmospheric pollutants and they are thought to aggravate the conditions of asthma sufferers. Some of them can react with oxygen, converting it into ozone, while nitrogen trioxide and pentaoxide can react with atmospheric humidity to form nitrous acid and nitric acid, both present in what is known as "acid rain". In urban areas, the nitrogen oxides on which attention is mainly focused are NO and NO_2, the latter being present in higher concentrations.

Ministerial Decree 60 of 2nd April 2002 establishes the limit value for the protection of vegetation at 30 $\mu g/m^3$ NO_x (over one calendar year). As regards NO_2 (nitrogen dioxide) concentrations, the above decree establishes 200 $\mu g/m^3$ as the hourly limit value for the protection of human health - not to be exceeded more than 18 times in a calendar year. This objective must be achieved within 1st January 2010. As regards NO_2, an alarm threshold is set at 400 $\mu g/m^3$, measured during three consecutive hours in a site that is representative of the air quality in an area measuring at least 100 km^2 or in an entire zone or an entire conglomeration.

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Experimentation

An experiment, aimed at determining the NO_x abatement performance of the System(life) filtering station mod. Città, was planned and performed inside an industrial building with a volume of 25,000 m^3, attention being focused on the regulatory NO_2 parameter. The experiment was performed by staff of LEnviroS s.r.l., a spin-off of the University of Bari, in collaboration with staff from the University of Trieste.

Materials and methods

The experiments were performed in an industrial building (50m x 60m x 8m), with doors and windows closed, where NO_2 was generated in a controlled way and concentrations uniformed using forced ventilation systems (Fig.1) and control of NO and NO_2 concentrations in various points of the building (Fig. 2), thanks to two Thermo Scientific mod. 42i NO NO_2 and NO_x chemiluminescence analysers. The data was acquired as mean minute values.

The desired NO_2 concentrations inside the building were obtained by chemical reaction between concentrated nitric acid and copper (Sigma Aldrich).

$$Cu + 4\ HNO_3 \rightarrow Cu(NO3)_2 + 2\ NO_2 + 2\ H_2O$$

Fig.1: diffusion system and position of the filtering station

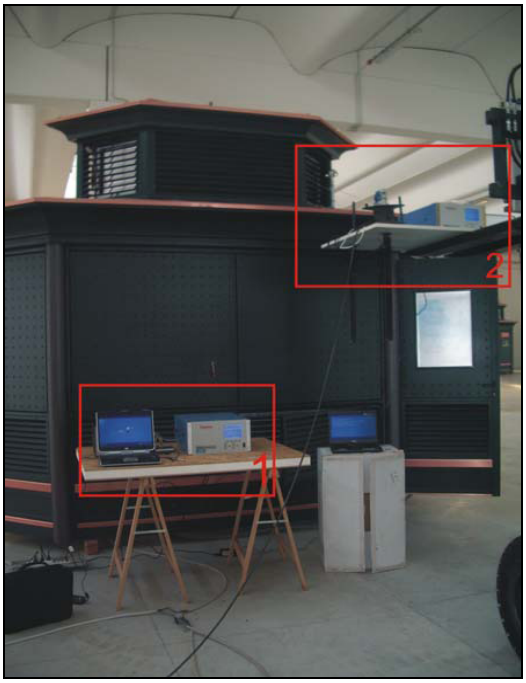

Fig.2: analysers positioned at the inlet (1) and outlet (2) mouths

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Results and discussion

Nox concentrations, particularly NO_2, were monitored in order to assess the Nox abatement performance of the System(life) filtering station.

The first experiment, performed *in the absence of the NOx abatement system*, lasted approximately 4 hours and acquired useful information:
-confirming the chemical reaction of NO_2 production, required to perform the tests.
-comparing the instrumental responses of the two NO_x analysers.
-monitoring the evolution of NO_2 concentrations inside the building.

In this case, an increase in NO_2 concentrations was observed, starting from background values of 13 $\mu g/m^3$ to a maximum of over 484 $\mu g/m^3$. The proposed NO_2 generating system satisfies the purpose. Data on NO concentrations, that does not show substantial changes in concentrations in the absence of the abatement system, is also available.

The data in question was downloaded and processed and a systematic deviation of 6% between the two analysers located in close proximity to the filtering station was observed. This was taken into consideration during subsequent processing stages in order to assess the differences in the concentrations of nitrogen oxides entering and leaving the filtering station.

With the filtering station switched off, the analysers were positioned at the inlet and outlet mouths, as shown in figure 2. A sampling probe with a minimum transfer line was inserted inside the inlet mouth.

As can be seen in figure 3:
-the series are comparable both entering and leaving the filtering station
-there is a decrease in NO_2 concentrations.

The decrease in concentrations inside the industrial building with the filtering station switched off can be interpreted considering the possible reactions between NO_2 and atmospheric humidity and dimerisation processes of this oxide, starting at relatively low temperatures, which decrease the measurable concentration.

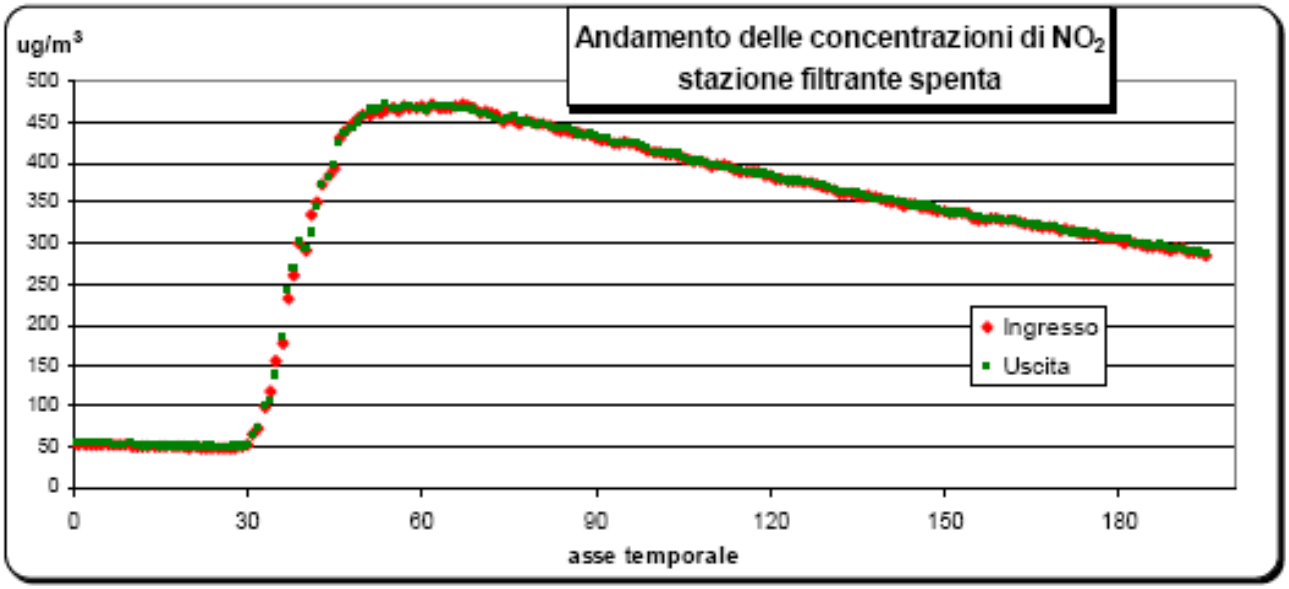

Fig. 3: evolution of the concentrations measured by 2 instruments with the filtering station switched off

During a later experiment (Fig. 4), after acquiring "natural background" values for a few minutes, the NO_x abatement system was activated. The system, already with low concentrations, shows is able to abate the NO_2 values leaving the filtering station, passing from a mean inlet value of 13.8 µg/m^3 NO2 to outlet values of 8.1 µg/m^3, equivalent to an abatement of 44%.

Particularly elevated NO_2 concentrations (max. 841 µg/m^3) were generated. This made it possible to assess the capacities of the system to abate the pollutant over an extensive range of concentrations.

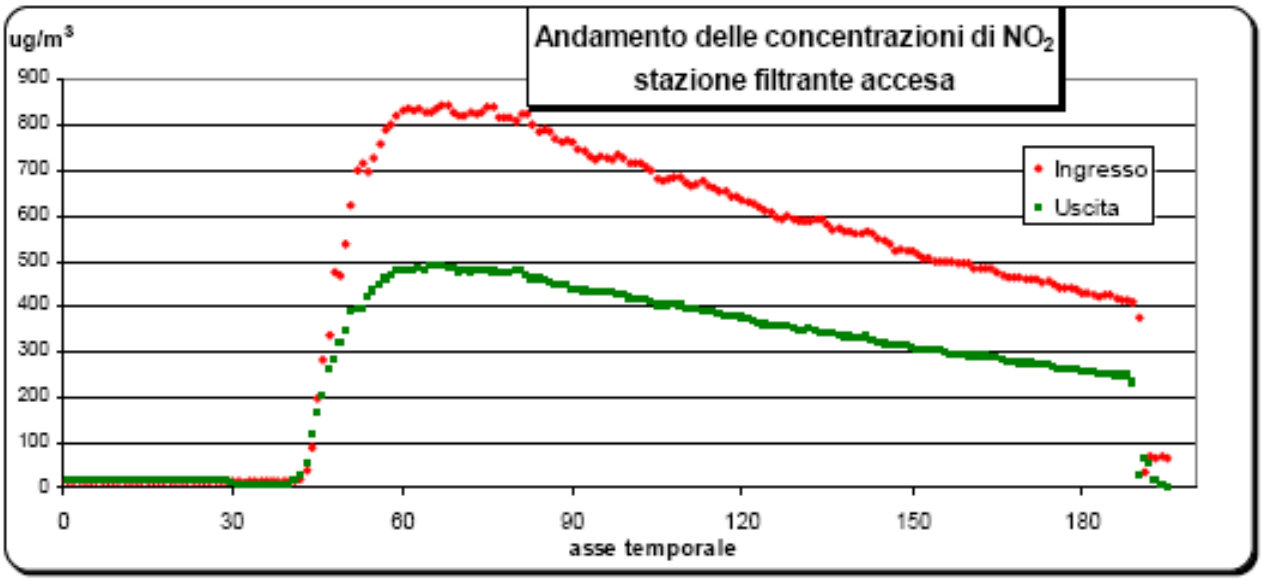

Figure 4: evolution of the concentrations measured by 2 instruments with the filtering station switched on

NO_2 abatement associated with the activation of the filtering station (changes in measured inlet and outlet concentrations), with environmental inlet concentrations varying from 13 to over 800 µg/m^3, for values recorded before the gas was generated in the building stands at an 8-measurement mean of 44% with a standard deviation of 2% and for values recorded after the maximum peak of concentrations at a 135-measurement mean of 41% with a standard deviation of 1%.

Conclusions

The experiments performed on the System(life) filtering station Mod. Città show that the NO_2 concentrations leaving the machine, in the tested configuration, are over 40% less compared with inlet concentrations, over a wide range of values.

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