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Analysis of the Air Pollution Sources in the city of Rome (Italy)

Gabriele Battista[a,*]

[a] University of Roma TRE, Engineering Department, Via della Vasca Navale 79, Rome 00146 Italy

Abstract

Pollution depends on many natural and human factors. The variation of pollutant and weather changes modify the concentration of pollutant in time and space. In fact, this is not only a local problem, but a regional and even global influence is highlighted. People who moved from the countryside to the cities made the air condition worse, because of the factories activities and the domestic heating. These kinds of pollutants, together with the ones related to the urban traffic, are the base of the air toxicity, which can lead to a lot of health problems. Apart from people, even monuments and works of art can be damaged by pollution, especially in the city centres. Exposure to pollutants is usually higher in cities than in the countryside. The more common pollutants produced at high density urban areas are carbon monoxide (CO), nitrogen oxides (NO_x), sulfur oxides (SO_x), ozone (O_3), particulate matter (PM) and benzene (C_6H_6). The aim of this work is to study the air pollutant level in the city of Rome in order to analyse the emissions from different sources. Furthermore, the pollutant exceeds of the limit of the Directive 2008/50/EC, the main legislation about ambient air quality, was analysed for the period taken into account.

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Keywords: air quality, pollutant emissions, statistic analysis, domestic heating, urban traffic, human exposure, weather data.

1. Introduction

In the last few years many epidemiological studies have shown associations between air pollutant concentrations and human health [1–5]. Apart from people, even monuments and artworks can be damaged by pollution, especially in city centres. Furthermore, urbanization modified microclimate conditions of the cities, and, together with urban traffic and domestic heating [6, 7], led to a discomfort of living condition. People who moved from the countryside to the cities made the air condition worse, because of the factories activities and the domestic heating. These kinds of pollutants, together with the ones related to the urban traffic, are the base of the air toxicity, which can lead to a lot of health problems [8–12]. The urban development of cities modified temperature, wind direction and humidity; these elements, together with urban traffic and a wrong kind of domestic heating, led to a discomfort of living condition in the cities [13–21]. Besides the increase of pollutions, urbanization has led to an increase of the urban heat island

* Corresponding author. Tel.: +39-06-5733-3289
E-mail address: gabriele.battista@uniroma3.it

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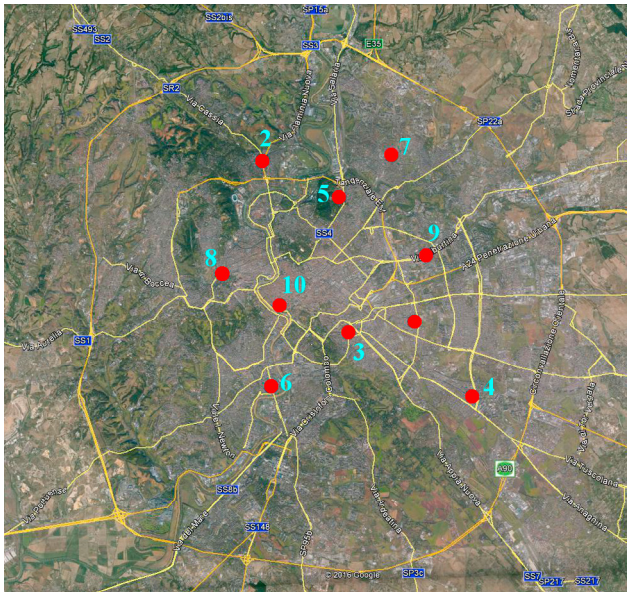

Fig. 1. Google Earth map of Rome. Red circles are the monitoring stations taken into account

intensity (spatially-averaged surface or air-temperature difference between an urban and surrounding rural area(s) [22]). Several studies are focused on the reduction of urban heat island effect with different mitigation techniques [23–26]. Moreover, tall buildings reduce wind circulation, so even the dispersion of air masses is limited [27–32]. To check these conditions is important to maintain an acceptable level of living conditions, especially in some areas, and it is a way to set a long term programme of improvement. First of all, urban traffic should be limited and domestic heating should be improved by the changing the old boilers with new ones which can guarantee the right amount of energy with more efficiency. The aim of this work is to study the air pollutant level in the city of Rome in order to analyse the emissions from different sources.

2. Materials and Methods

2.1. Characteristics of the Study Area

Rome is the capital of Italy and one of the most overcrowded cities of Europe (3 million people for 12850 km^2). Considering the extra urban areas, people are more than four million. It is an historical city that traces its origin in 753 a.C. and it was the capital of the biggest empire ever. That's why it is known as the eternal city and its cultural heritage finds no equals. Thanks to its position, Rome shows a Mediterranean climate: temperate winter and hot summer, with a temperatures that goes from 0 to 36 degrees. The greatest problem of this city is the lack of an adequate net of means of transport, so people use cars [33]. Apart from urban traffic, there are a lot of other pollutant activities such as domestic heatings.

2.2. Monitoring Station Network

ARPA Lazio is the agency that monitors the air condition in Rome [34]. The Rome monitoring network consists of different monitoring stations of $[CO]$, $[SO_2]$, $[NO_x]$, $[NO]$, $[NO_2]$, $[C_6H_6]$, $[PM_{10}]$, $[PM_{2.5}]$ and $[O_3]$ that are shown in Figure 1. They collect data hour by hour in a place with a great concentration of pollution.

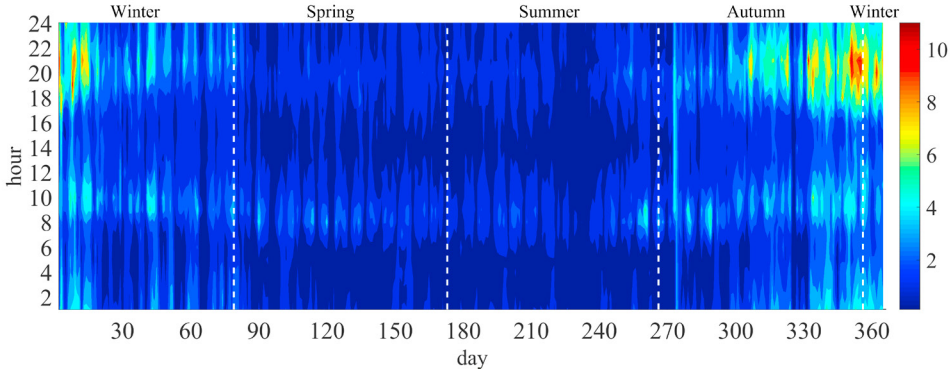

Fig. 2. Hourly annual concentration variation of C_6H_6 during 2015 in $\mu g/m^3$

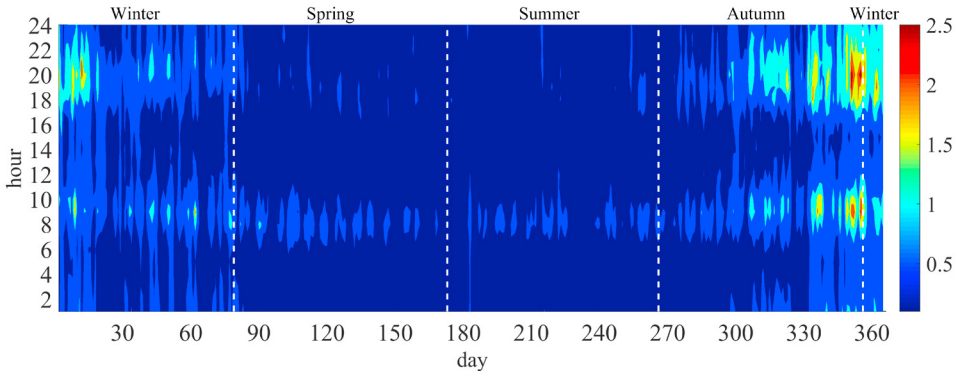

Fig. 3. Hourly annual concentration variation of CO during 2015 in mg/m^3

3. Results and discussion

In the present study, the air pollutant concentrations recorded in 2015 were analysed. The data for the city of Rome is resulting considering the mean values of ten monitoring station from number 1 to number 10 of the Figure 1 in order to represent the average pollutant concentrations inside the city. In the Figures from 2 to Figure 5 are shown the mean pollutant concentration of all the monitoring stations placed inside the city of Rome. The Directive 2008/50/EC of the European Parliament [35] is the main legislation about ambient air quality. It could be noticed that $[NO_2]$ and $[C_6H_6]$ exceeds the limit of legislation during the year. In particular, the limit of 40 $\mu g/m^3$ is exceeded for 64% of time by the $[NO_2]$ and 4% of time by the $[C_6H_6]$. In the Figures from 2 to Figure 5 are shown the different seasons in the city of Rome. The winter referred to the days when the heating systems are turned on. The heating season start on the first of November and end at the fifteenth of April. It can been seen that the major pollutant concentrations happened in the winter when there is the coupling of heating systems and urban traffic. In the spring, summer and autumn, the pollutant concentrations are due only to the urban traffic because the heating systems are turned off. This fact suggest the presence of two pollutant sources in the city of Rome: urban traffic and heating systems. The presence of the urban traffic during the entire year despite of the heating systems is confirmed analysing the $[C_6H_6]$ trend reported in the Figure 2. The $[C_6H_6]$ is strictly related to the urban traffic. The maximum values are always recorded during the hour from 7 to 14 and from 18 to 24. The pollutant concentration of $[CO]$, $[NO]$ and $[NO_2]$ reported in the Figure 3-4-5 denote a different trend compared to the $[C_6H_6]$ reported in the Figure 2. As a matter of fact, the $[CO]$, $[NO]$ and $[NO_2]$ have different trend from the winter to the other seasons. This fact suggest an high relevance of the heating systems to the pollutant concentrations inside the city of Rome during the winter compared to the urban traffic.

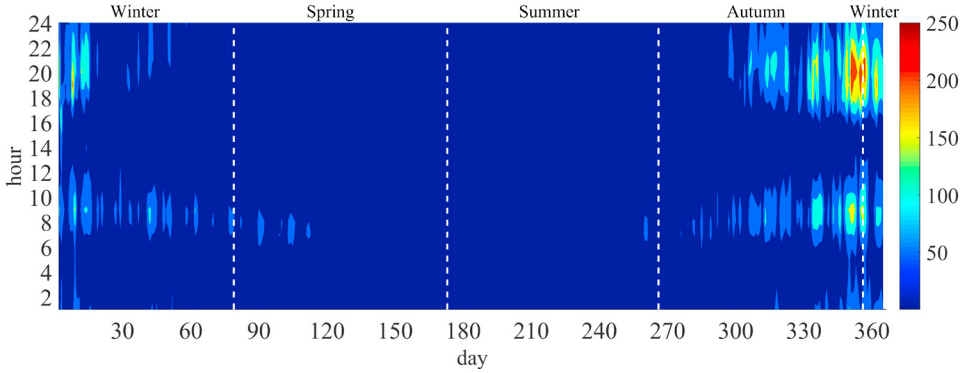

Fig. 4. Hourly annual concentration variation of NO during 2015 in $\mu g/m^3$

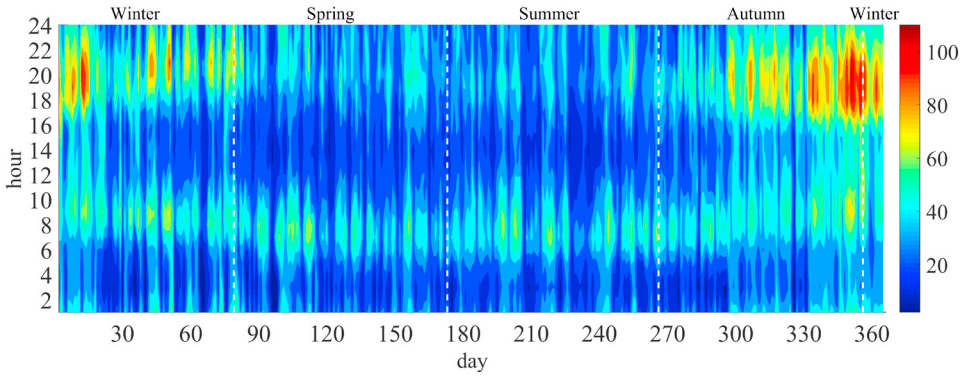

Fig. 5. Hourly annual concentration variation of NO_2 during 2015 in $\mu g/m^3$

4. Conclusions

Suitable living conditions in cities are possible focusing the attention on the reduction of the air pollution level in urban areas. Observance of air quality standards represents a great challenge in cities, especially in the ones in which urban traffic and other additional sources are combined with bad weather conditions. In the present study, the pollutant concentration of $[CO]$, $[NO]$, $[NO_2]$ and $[C_6H_6]$ in 2015 were analysed. It can been seen that the major pollutant concentrations happened in the winter when there is the coupling of heating systems and urban traffic. In the spring, summer and autumn, the pollutant concentrations are due only to the urban traffic because the heating systems are turned off. The presence of the urban traffic during the entire year despite of the heating systems is confirmed analysing the $[C_6H_6]$ trend that is strictly related to the urban traffic. The maximum values are always recorded during the hour from 7 to 14 and from 18 to 24. The pollutant concentration of $[CO]$, $[NO]$ and $[NO_2]$ denote a different trend compared to the $[C_6H_6]$. These pollutant concentration have different trend from the winter to the other seasons. This fact suggest an high relevance of the heating systems to the pollutant concentrations inside the city of Rome during the winter compared to the urban traffic. In order to reduce the pollution in Italian cities and in particular in Rome, measures are needed to decrease the level of the various substances dispersed into the air. One of the main actions that can be performed is the reduction or elimination of the use of the most polluting cars, i.e., cars Euro 0, 1 and 2. As a matter of fact, Roma Capitale has imposed the circulation reduction of these cars permanently from 15 December 2015 [36]. From the analysis of the air pollutant level in the city of Rome during the year 2015, it is clear that the heating systems have an important role on the pollutant concentrations. For this reason the government should move their attention to the improvement of the buildings heating systems. It is the necessary to replace traditional boilers with more efficient systems, such as condensing boilers. As a matter of fact, the condensing boilers allow reducing the utilization of combustion and a consequence decrease of emission. However, the boilers are only one element

of the heating systems. Its efficiency depends on other elements such as distribution, emission and regulation. Using condensing boilers coupled with other high heating systems elements, can improve the total efficiency and reduce the environmental emission.

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