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# A BASELINE STUDY OF BLACK CARBON AND PM2.5 LEVELS IN VENAFRO, MOLISE

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*Air pollution, Black Carbon, Particulate Matter 2.5.*

## *Abstract*

Among air pollutants, Black Carbon (BC) and Particulate Matter (PM) 2.5 are well known health risk factors which however are not always measured. The objective of this study is to show data regarding BC and $PM_{2.5}$ collected in Venafro, a town in Molise, Italy, between May 3rd and 5th of 2013. Results show that $PM_{2.5}$ ranged from 4to 23 µg/m$^3$, below the European Union's annual limit of 25 µg/m$^3$. Particular concern relies on mean BC concentrations, which varied from about 2,000 to 16,000 ng/m$^3$ in this small city. Further investigations are needed to measure $PM_{2.5}$ and BC to better extend these preliminary data and to assess the impact and possible sources of air pollutants on small towns.

## Introduction

Air pollution is an invisible killer [1]. According to the World Health Organization, ambient air pollution kills about 3 million people annually and is affecting all regions of the world. About 90% of people breathe air that does not comply with the WHO Air Quality Guidelines [2], leading to 6000 years of life lost (YLL) due to air pollution exposure [3].Evidence suggests that air pollution is a risk factor for cardiovascular diseases, asthma, chronic obstructive pulmonary disease, lung cancer, type 2 diabetes mellitus, congenital anomalies and neurodegeneration [4-11]. Among the many air pollutant constituents, Black Carbon (BC) has become recognised as a particular health risk factor, in particular for cardiovascular diseases [12-14].Particulate Matter 2.5 ($PM_{2.5}$), on the other hand, is not only associated with cardiovascular diseases, but it is also a risk factor for respiratory diseases and for pregnancy outcomes [15-18].A consistent body of literature reports on the nature of air quality of big cities, but few of them evaluated concentrations or effects of air pollution on small towns, particularly for BC and $PM_{2.5}$.Objective of this study is to report data regarding quality of particulate air pollutants, in particular $PM_{2.5}$ and BC, measured in Venafro, Molise, a small town in rural south central Italy.

## Materials and methods

### Setting

Molise is the second smallest region in Italy, with an area of 4,438 Km$^2$ and a population of about 310,000 inhabitants [19]. There are two provinces, Campobasso and Isernia, with approximately 224,000 and 86,000 inhabitants. Venafro (N 41 29, E 14 03) is the second biggest city in Isernia province, with about 11,000 inhabitants and it is located at the eastern surface of an alluvial plain (**Figure 1**).The study took place on the weekend from Friday 3rd to Sunday 5th May 2013 (after the heating season in the area) to study characteristics of local wind and concentrations of $PM_{2.5}$ and BC during a working day and the weekend. More weekends studies have not been possible for logistic reasons.


***Figure 1. City of Venafro (N 41 29, E 14 03). Image modified by the addition of three circles to represent the monitoring stations of Black Carbon. Retrieved February 18, 2018 from https://www.bing.com/maps/***

**Equipment and analysers**

Wind directions and their velocity were measured in meters out of second (m/s) from different perspectives, based on previous pilot studies. To measure the weather conditions the model Kestrel 5500 Weather Meter was used.$PM_{2.5}$ was measured in real time (sampling time 5 min.) using the Optical Particle Counter (OPC), pre-calibrated in mass using the Beta Attenuation Monitor BAM-1020 with US EPA and German T. Ű. V., certificates model e-sampler, Metone Instruments Inc.Black Carbon (BC) was measured in real time (sampling time 1 min.) using model AE51 of Aethlab, Inc. S. Francisco.

**Procedures**

$PM_{2.5}$ and wind sensors were located on a terrace at the $5^{th}$ floor, positioned at the beginning of the "Corso", at the crossing with P.zza Vittorio Emanuele II° (N 41° 26 02 91, E 14° 02 40 06). This site can be considered as representative of the air quality within the historical centre of Venafro.Because of availability of only one BC analyser BC was measured in three different positions but in different times: "Vico 1 Anfiteatro" (N 41° 48 37 58, E 14° 04 42 86) and at the crossroads of "Via Colonia Giulia" and "Corso Campania" (N 41° 48 29 85, E 14° 04 47 88) to monitor "Strada Statale 85" (SS85), a national highway that crosses Venafro and on which heavy traffic circulates, including trucks, in the direction to and from Rome (to West) and Naples (to South). The sensor were also moved to operate in "Piazza Vittorio Veneto" (N 41° 48 59 10, E 14° 04 59 40), within the old town at some 200 meters elevation and 1 km distance from the road. Traffic is prohibited in this area and therefore it was assumed to be representative of baseline BC exposure in Venafro (**Figure 2**).


***Figure 2. Monitoring stations of Black Carbon. Green circle: "Piazza Vittorio Veneto" (N 41° 48 59 10, E 14° 04 59 40); Orange circle: crossroad of "Via Colonia Giulia" and "Corso Campania" (N 41° 48 29 85, E 14° 04 47 88); Red circle: "Vico 1 Anfiteatro" (N 41° 48 37 58, E 14° 04 42 86). Road in rose color indicate high traffic volume roads. Retrieved February 18, 2018 from https://www.bing.com/maps/***

## Results

During the measurements the weather was clear with temperature ranging from about 20 to 25 °C and Relative Humidity from about 55 to 67 %. Wind velocity from 0.5 to 3.6 m/sec. and wind direction from 50 to 271 degrees.Two regional Environmental Protection Agency (ARPA) stations were located inVenafro: the first one, located at Via Colonia Giulia (41,484146, 14,047358), which measured $PM_{10}$ traffic pollution, while the second station, positioned at Via Campania (41,479281, 14,047160) measured $PM_{10}$ background pollution. According to the 2013 report, on May the daily limit of 50 µg/m$^3$ was never crossed, with mean monthly values of 17 µg/m$^3$ and 11 µg/m$^3$, respectively [20].Data of $PM_{2.5}$ concentration from 3$^{rd}$ to 5$^{th}$ May were reported on **Figure 3** ranged from 4 to 23 with a mean of 10.8 (Standard Deviation SD: 3.7) µg/m$^3$.Regarding PM $_{2.5}$, it is possible to notice increases of about 10 µg/m$^3$ from 9.00 pm of the 3$^{rd}$ of May up to 2.00 am of the 4$^{th}$ of May, from 5.45 am until 12.20 pm of the 4$^{th}$ of May and from 6.00 pm of the 4$^{th}$ of May until 4.00 am of the 5$^{th}$ of May. Higher $PM_{2.5}$ concentrations were measured from 5.00 pm until 2.00 am and from direction 80-120°, that means from the main road passing through the town of Venafro (i.e. SS85). Further measurements have been unexpectedly interrupted at 12:12 pm on May 5$^{th}$ because of instrument malfunction.

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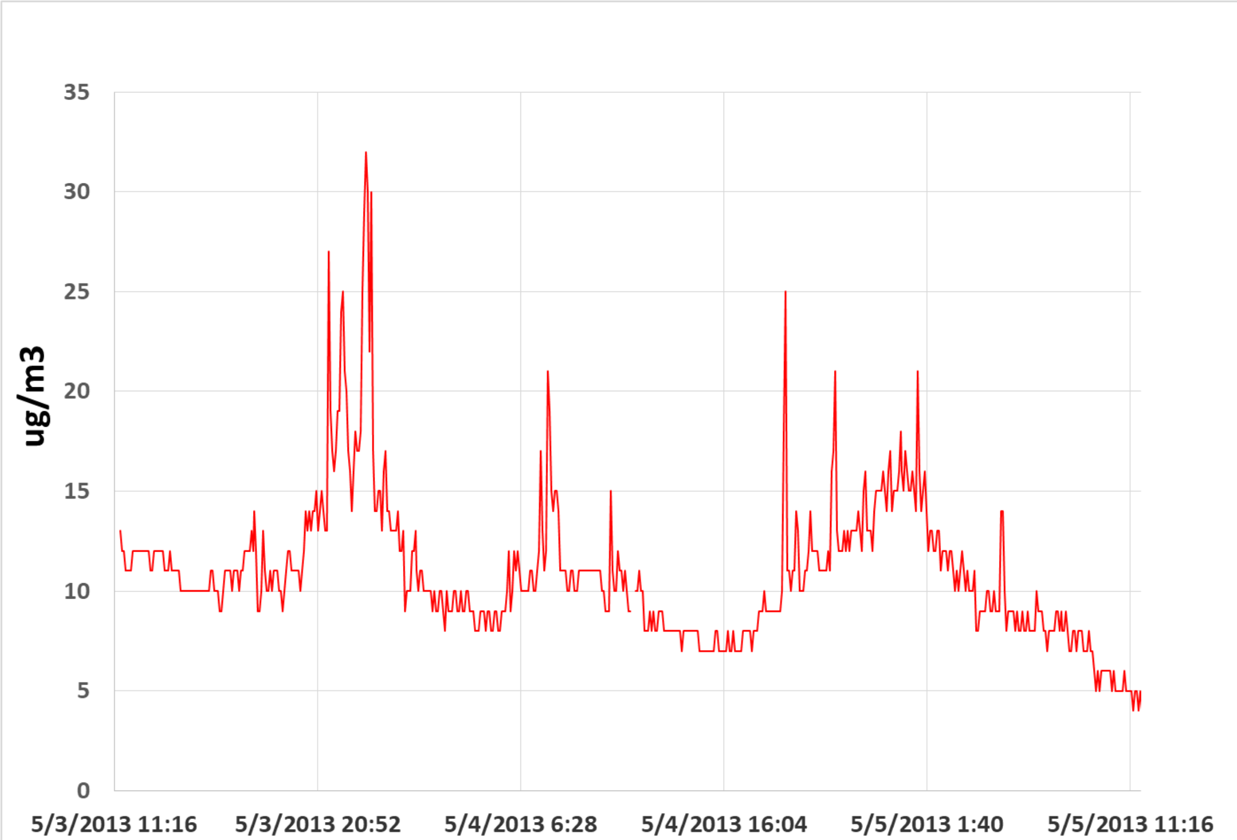


***Figure 3. Concentrations of $PM_{2,5}$ (µg/m3) measured from May 3rd at 11:15 am, to 12:30 of May 5th, 2013, in "Venafro Centro" (N 41° 26 02 91, E 14° 02 40 06). Sampling time 5 min.***

Mean BC concentrations measured on May 3rd were reported on **Figure 4**. While data show minimum concentrations on the city center at P.za Vittorio Veneto, which is relatively far from the crossing and at about 200 meters elevation from it, where 2,034 (390) $ng/m^3$ were measured, the highest values were recorded along SS 85, crossed by heavy traffic: 15,952 (13,328) $ng/m^2$. The Vico 1 Anfiteatro site, although relatively far from the crossing, showed lower but still relatively high concentrations of BC, 12,425 (9,411) indicating a possible transfer of BC from the crossing.

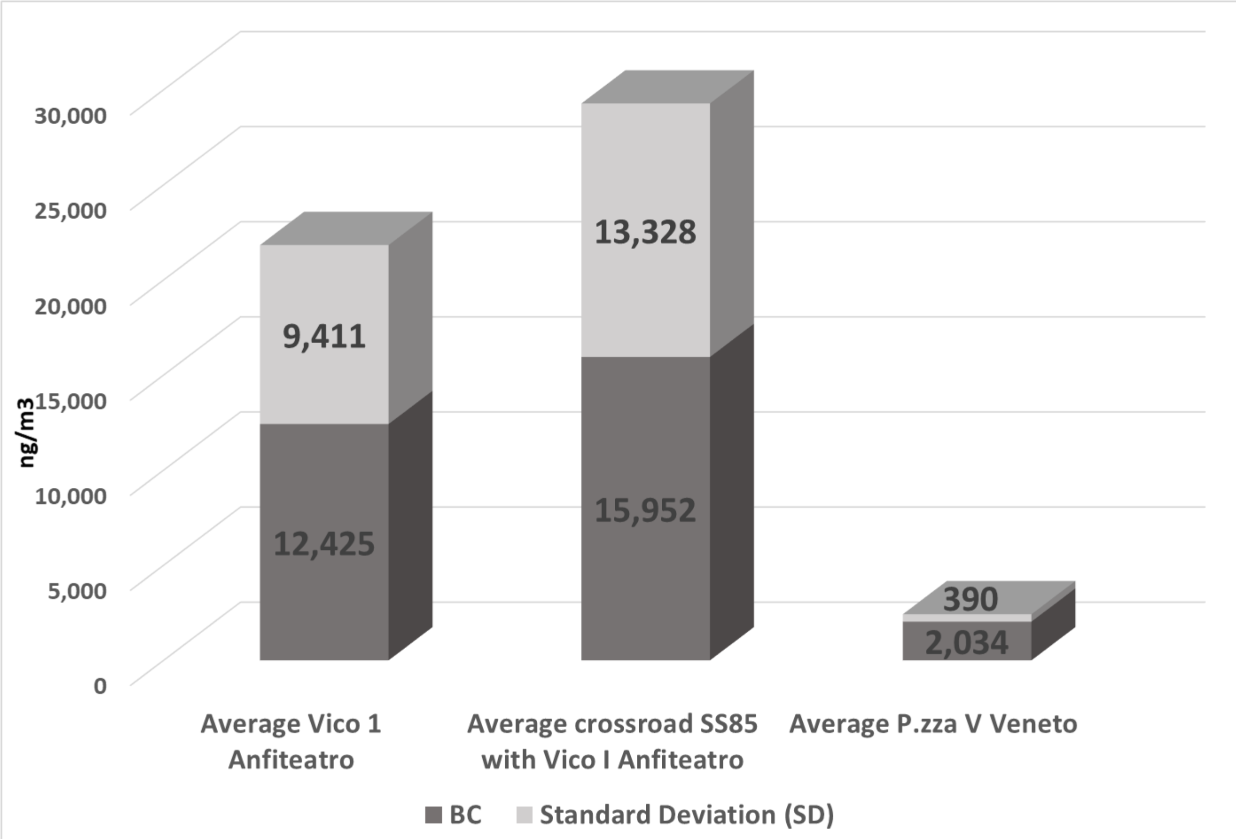


***Figure 4. Mean BC concentrations (ng/m$^3$) measured on May 3rd, 2013, at the following locations: crossroad of "Via Colonia Giulia" and "Corso Campania" (N 41° 48 29 85, E 14° 04 47 88); "Vico 1 Anfiteatro" (N 41° 48 37 58, E 14° 04 42 86); "Piazza Vittorio Veneto" (N 41° 48 59 10, E 14° 04 59 40).***

## Discussion

We believe that it is very possible that the increase in both $PM_{2.5}$ and BC may be generated by the traffic, although during the night PM2.5 concentrations may increase also due to the fall of the mixing height, which may amplify the impact of the traffic itself even if these results are however below the annual European limit of 25 µg/m$^3$ [21].To date, BC limits have not been established. Compared with the low concentrations measured in the city center baseline, the BC concentrations measured on the road to Naples are about ten times greater, probably due to heavy trucks traffic and old diesel cars. Indeed, the greatest concentrations were measured at the crossing of SS 85 and "Vico I Anfiteatro", where about 16,000 ng/m$^3$ were reported.These near roadway values are quite high compared to other urban sites and even higher than what is seen in big cities, like Milan [22-23].Such high BC concentrations provide several useful facts that might to be considered. First, to reduce the exposures to residents the heavy truck traffic should not be routed through the city. It should be moved to an alternative route, i.e. "Strada Statale 85 Varinate di Venafro" (N 41° 50 68 13 E 14° 11 21 96), also known as SS85 Var, for reasons related to air quality and community safety, since SS85 is crossed by heavy trucks. Secondly, while during warmer months, such as were experienced during this study, BC concentrations are likely to be dominated by traffic, during the winter months BC concentrations could further rise, due to residential wood burning and lower atmospheric mixing heights.

## Conclusion

Among 23,6 million deaths caused by unhealthy environment, 6,6 million of them in the world are associated with indoor and outdoor air pollution. According to 2015 European Environment Agency report, in Italy approximately 85,000 premature deaths are attributable to air pollution, particularly 65,000 of them are linkable to $PM_{2.5}$ [24-26].Based to our knowledge, these are first data regarding air pollution caused by $PM_{2.5}$ and BC recorded in Molise. Indeed, Molise's Environmental Protection Agency(ARPA Molise) only measures $PM_{10}$, $NO_2$, CO, $SO_2$, $O_3$, Benzene, As, Cd, Ni, Pb and Benzo[a]pyrene [27-28].In international scientific literature, it was demonstrated that $PM_{10}$could not be considered the best indicator of air quality, because it is not representative of the linkage between air pollution and risk for the human health. To better link health effects with air pollution, rather, $PM_{2.5}$ and its harmful constituents such as BC should be measured. This because it gives us a better idea of the impacts of nearby traffic air pollution and because BC is a nanoparticle carrier of other mutagenic and teratogenic elements (e.g.: IPA, Benzene, heavy-metals, SOx) [18; 29].Recently, the International Agency for Research on Cancer (IARC) rose up the BC risk class, from 2A risk class, meaning "probably carcinogenicto humans", to 1 risk class, meaning that it is "carcinogenic to humans" [30].With this preliminary data, we would like to underline that there is no distinction between highways located in big cities and streets in small towns, because BC (**Figure 2**) would be the indicator of traffic density and topography. In this case the sites were in a small town and on small streets where traffic may pass quite close to the places where people live and work. It was indeed reported that few hundred meters from traffic line, BC concentrations drastically fall [18]. This can contribute to air pollutants that may spread across various streets, leading to a heavy BC variability across near streets. This may also lead to different risk exposure depending on different residential stays, leading to risk variability for health population.This initial research may be considered as a basis and an incentive to extend investigations of the effects of BC and $PM_{2.5}$ generated by traffic and health risks in small towns and villages in addition to the places most commonly studied: the crowded big cities. The levels of BC are elevated at the sites studied and are possibly comparable, if not even higher to the levels in many big cities. One further observation we would like to make is that more studies should be made in these semi-rural locations because people there are exposed to unexpected potentially harmful air pollution and that traffic planning has never been considered as an important issue.We need to consider limitations to our findings. Firstly, air pollutants might increase during both the winter, due to home heating, and the summer, due to anthropic activities. These factors were not measured, since the study took place only on few days on May 2013 and it has not been repeated. Secondly, the choice of the sites where the sensors were chosen and placed based largely on logic and convenience. Therefore, these data are not representative or generalizable to other cities and may reflect only what happened in Venafro. Further studies are needed.

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