DIMENSIONAL DISTRIBUTION OF $PM_{2.5}$ AND PM_{10} IN THE ROAD PROXIMITY

Cristina Mosoarca[1], Radu Banica[1], Petrica Linul[1,2], Alexandra Ioana Bucur[1]

[1]Department of Applied Electrochemistry, National Institute for Research and Development for Electrochemistry and Condensed Matter, Dr. A. Păunescu Podeanu Street, no.144, 300569 Timişoara, Timiş, România
[2]University Politehnica Timisoara, Piata Victoriei 2, 300006 Timisoara, Romania
e-mail: mosoarca.c@gmail.com

Abstract
The particulate matter (PM) is comprised of two kinds of particles, classified after their dimensions, the $PM_{2.5}$ which encompasses particles with sizes smaller than 2.5 μm and the PM_{10} with particles ranging in size from 2.5 μm to 10 μm. As previous studies have shown, PMs have an undeniable influence, dependent on the exposure time, upon the health of the human cardiopulmonary system. In this study we focused on the dimensional distribution of PMs and the influence of altitude on their numbers. Our detailed investigation lead us to the conclusion that the particle number is increasing at higher altitudes and also that $PM_{2.5}$, which represents a greater health risk factor, is much more abundant than PM_{10}.

Introduction
World Health Organization (WHO) is estimating that air pollution is contributing at approximately eight hundred premature deaths every year, being among the first causes of premature mortality worldwide [1]. Particle sizes, that are part of the surrounding air we breathe, are in direct correlation to the health hazards they cause. The particulate matter (PM) is divided into two categories: $PM_{2.5}$ which encompasses particles with sizes smaller than 2.5 μm and PM_{10} with particles ranging in size from 2.5 μm to 10 μm [2,3].
PM is a mixture with many different constituents, as follows: sulfates, nitrates, ammonium, and other inorganic ions like sodium, potassium, calcium, magnesium and chloride; elemental and organic carbon, metals (including cadmium, copper, nickel, vanadium and zinc) and also aromatic cyclic hydrocarbons [4]. Additionally to the components previously mentioned, PM has biological elements as well, like allergens and microbial compounds. Due to their small sizes, $PM_{2.5}$ and PM_{10} are breathable particles capable of penetrating the thoracic region of the respiratory system. Short PM_{10} exposure has harmful health effects on a global scale, but mortality is caused in the greatest extend on account of long $PM_{2.5}$ exposure. Therefore $PM_{2.5}$ embodies a much higher health risk factor than PM_{10}. It is estimated that the mortality rate on account of PM_{10} will increase by 0.2-0.6 % per 10 $\mu g/m^3$ [5]. Conversely, long time exposure to $PM_{2.5}$ is associated with the increase of morbidity caused by cardiopulmonary diseases by 6-13 % per 10 $\mu g/m^3$ $PM_{2.5}$ [6]. PM can have both anthropogenic (man-made) and non-anthropogenic (natural) origins. Among the anthropogenic sources of air pollution, combustion processes and industrial activities have a major negative effect upon the air quality. Erosion of the pavement by road traffic and abrasion of brakes and tires have a less important role as a pollution source, however cannot be ignored. Agriculture is another harmful anthropogenic air pollution cause being the main source of ammonium [6,7]. Among the non-anthropogenic pollutants, Radon gas from radioactive decay within the Earth's crust; sulfur, chlorine, and ash particulates from volcanic activity, can be mentioned [8].

Experimental

The analyzes were performed using a PC200 Particle Counter (Trotec) that detects size fractions and concentrations of air particles along with the measurement of environmental factors such as air temperature, humidity, dew and wet-bulb temperature. The particle counter has 6 particle size channels: 0.3 µm, 0.5 µm, 1.0 µm, 2.5 µm, 5.0 µm, 10.0 µm with a counting efficiency of 50% at 0.3 µm and 100% for particles larger than 0.45 µm. The light source is a laser class 3B with 780 nm wave length at 90 mW. The sample inlet is represented by an isokinetic probe; the flow rate is 2.83 l/min (0.1 ft^3/min), controlled by an internal pump with a coincidence loss of 5%, 2 million particles per ft^3 (28.3 litres). The measurement temperature was in the range between 27°C and 30°C with a dew point of 9.3ºC, 27.6 % humidity and 17.9 % WB (wet-bulb). PC200 was placed at different heights with the aid of an in laboratory made lifting device that made possible the data collection at ground level (0.1 m), at 2.5 m and 5 m above ground. In order to ensure the experimental reproducibility, the data collection time was set at 120 s and made in two cycles thus obtaining 42 different acquisitions for each point calculation. PM concentration in each dimensional range was calculated as an arithmetic average of the collected data in the case of the two cycles for the purpose of minimizing errors. For more accurate results, all experiments were performed in the differential mode of the PC200 analyzer.

Results and discussion

The data was collected from a national road in both longitudinal and perpendicular direction. 0.3 µm, 0.5 µm, 1 µm and 2.5 µm channels corresponding to $PM_{2.5}$ class (figures 1, a,b and 2 a, b) are depicted in relation to the sampling height and to the distance from point zero of the chosen area in which the measurements took place.

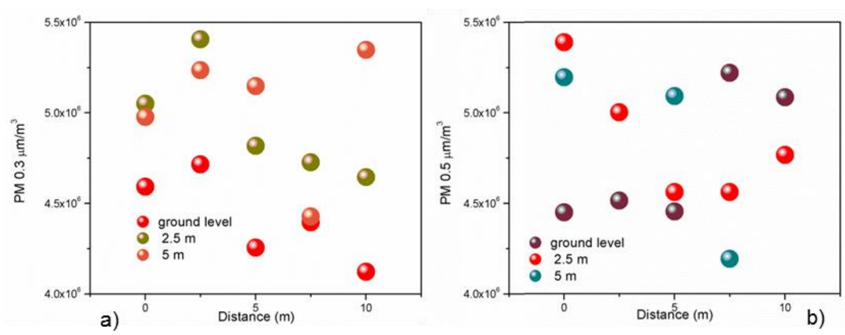

Figure 1. $PM_{2.5}$ concentration a) 0.3 µm size particles; b) 0.3 µm size particles, at ground level, 2.5 m and 5 m.

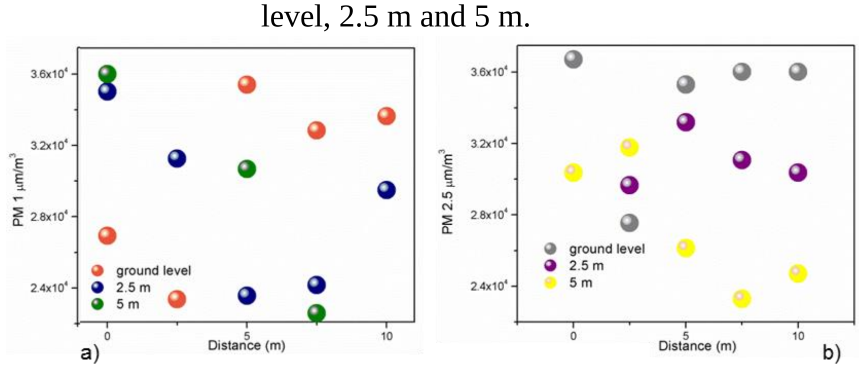

Figure 2. $PM_{2.5}$ concentration a) 1 µm size particles; b) 2.5 µm size particles, at ground level, 2.5 m and 5 m.

5 µm and 10 µm channels corresponding to PM_{10} class (figure 3, a,b) are depicted in relation to the sampling height and to the distance from point zero (situated at the edge of the road) of the intense traffic urban area in which the analyzes took place.

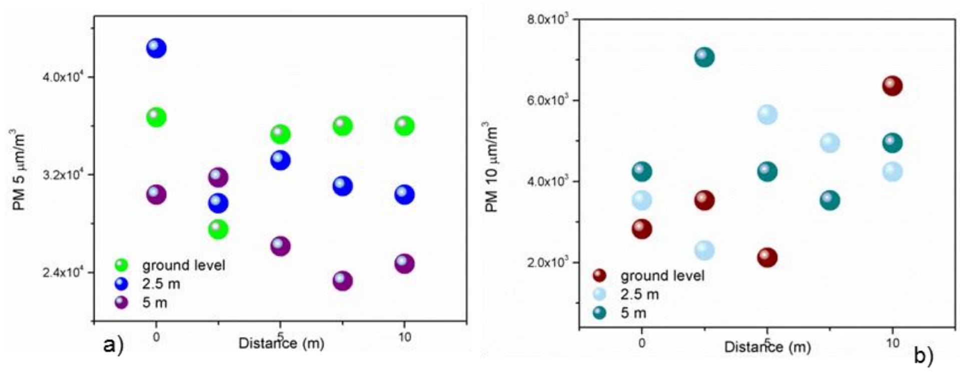

Figure 3. PM_{10} concentration a) 5 µm size particles; b) 10 µm size particles, at ground level, 2.5 m and 5 m.

In figure 4 is depicted the 3D mapping of the PM concentration/m^3 air in relation to the dimensional distribution at three different altitudes (0.1 m, 2.5 m and 5 m), the experimental points and their corresponding projections can be noticed. The concentration of 0.3 µm particles is increasing with the increase of the collection height. The particles concentration variation of 0.5 µm channel is on the same direction as the previous mentioned one.

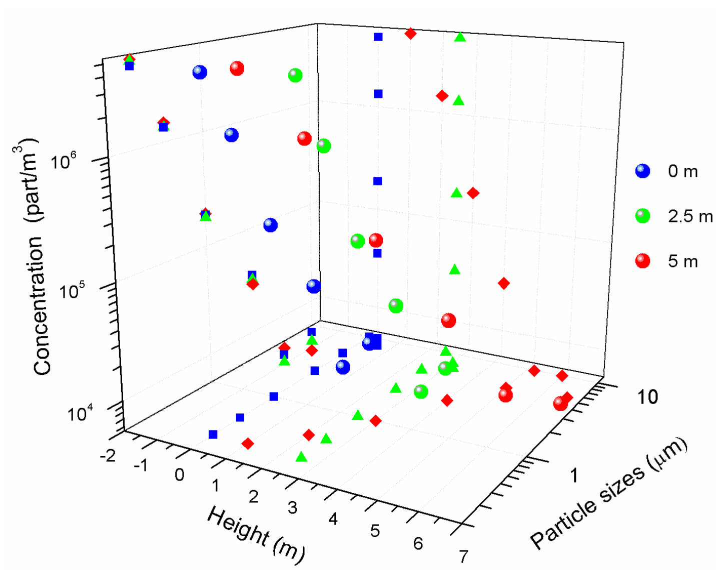

Figure 4. 3D mapping of PM concentrations depending on the data collection height and their sizes; their plan projections are also visible

With the PM dimension increase, a clear correlation between the PM sizes and their concentration dependent on the collection height it is not noticeable anymore.
As shown in figure 4, the $PM_{2.5}$ concentration is decreasing while moving farther away from the edge of the road which is lying near buildings higher than 10 m. This decrease is obvious

only for the sampling that occurred at ground level and at 2.5 m high. For the 5 m high sampling area, the decrease in $PM_{2.5}$ concentration is not relevant anymore. We are considering that this effect is due to the swirling currents of air formed in the buildings proximity. The distance between the nearest building and the first traffic band is higher than 5 m, so most likely the swirling currents are formed due to the wind and not because of the passing by motor vehicles. All measurements were performed on a real time monitoring system, on a randomly chosen urban road characterized by intense traffic, during day time, at low humidity levels.

Conclusion

PMs which are correlated with a high occurrence of pulmonary cancers, cardio-vascular diseases and a high rate of mortality were determined as follows: $\mathbf{PM_{2.5}}$ with particles of 0.3 µm, 0.5 µm, 1 µm and $\mathbf{PM_{10}}$ ranging from 2.5 µm to 10 µm. A 3D mapping of the analyzed PMs, from an urban area characterized by intense traffic, was depicted. The concentration of small particles, up to 0.3 µm, is increasing directly proportional with the sampling altitude, from approximately 4.47 million/m^3 air at the ground level to 5.04 million/m^3 air at 5 m.

At ground level (0.1m) $PM_{2.5}$ average number is slightly above 6 million, while PM_{10} average number is much lower, having the value of 8.5 thousand, as compared to 5 m height were the PM_{10} is decreasing at 7.7 thousand and $PM_{2.5}$ is exhibiting a significant increase at an average of 6.7 million.

So we can conclude that, on an urban road with intense traffic, the particle number is increasing at higher altitudes and $PM_{2.5}$, which is more likely to cause serious health problems, is much more abundant than PM_{10}.

Acknowledgements

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