Considerations concerning impact assessment of pollution with breathable PM 2.5 particulate maters

Part 1. Pollution monitoring in urban areas with intense road traffic.

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Abstract
The present paper present the preliminary results of a study concerning urban pollution with particulate maters and their effects on people health in Bucharest, Romania; there was determined the level of PM 2.5 and PM 10 into ambient air, their distribution into total dust and the dynamic of PM 2.5 over a period of 24 hours; additionally, the content of lead, cadmium, nickel, arsenic and copper were determined in all dust fraction by atomic absorption with graphite furnace after filters digestion with nitric acid.
The mean test results for 24 hours indicate levels of 179.9 ±75.7μg/m^3 TSP; 73.6 ±43.6μg/m^3 for PM 10 fraction and 52.1 ±29.4μg/m^3 for PM 2.5 fraction, comparing with national limits of 150 μg/m^3 for TSP and 50 μg/m^3 for PM 10 fraction. In was found that, as a mean value, PM 10 represents 39% of TSP and PM 2.5 represents 71% of PM 10.
The level of PM 2.5 into air is direct correlated with traffic and meteorological condition; therefore in can be observed an increase in the dust level with temperature increase, and a decrease with the increase of wind intensity.

Keywords: PM 2.5, air pollution, breathable dust**,** people health

Introduction

From the potential air pollutants from big urbane areas in the last years special attention is given to particulate maters, which are found among the "six criteria polluters" as they were named by the United States Environmental Protection Agency (EPA) next to the ozone, carbon oxide, nitrogen dioxide, sulphur dioxide and led, due to the risk they can pose to human health and the environment.
Of interest to the environment and population health are the PM 10 and PM 2.5 dust fractions, and their monitoring in the environmental air is controlled by the legislation all around the world, the PM 2.5 falling in the category of breathable dusts which can enter and accumulate in the respiratory system at the pulmonary alveolus level, causing serious health problems (Stanescu, 2002; Maite, 2006)
The research in this area have demonstrated that a source of important artificial dust pollution and especially PM 2.5 is the mobile sources represented by the means of transportation, the most important being the automobiles (Wojas, 2007; Borregoa, 2006;Tucker, 1999).
This type of pollution is especially important for human health, because of the fact that the emission takes place very near to the ground, along with other harmful chemical compounds, which can be very easily absorbed on the surface of particulate maters increasing their toxicity (Srivastava, 2007; Yatkin, 2006)
The present paper present the preliminary results of a study started on January 2008. The project is refered to determination over three years of the pollution level with particulate maters in areas with intense road traffic and assessment of this pollution on population health. This will be done by means of specific test, in a first phase for respiratory function, and in a second phase the characteristic tests for the presence of poly and mono nuclear hydrocarbons in particulate maters.
In the same time, the present study will try, trough the obtained results, to aware the authorities and public about the impact of this pollution on people health, being a starting point to introduce into environment legislation limit values for PM 2.5 dust fraction into ambient air as well as for setting up some measures to limit the level of dust pollution in urban areas with intense road traffic from big cities.

Experimental methods

The sampling site was situated 100 m far from the most crowded crossroad in Bucharest; the sampling equipment were installed according with the in force legislation in order to assure representative samples.

For a period of 15 days, from 10 to 25 March 2008, were sampled ambient TSP (total suspended particles), PM 2.5 (particles with nominal diameter less then 2.5 μm) and PM 10 (particles with nominal diameter less then 10 μm) and concentration determined by gravimetric method. For those two LECKEL INGENIEURBURO GmbH particulate maters samplers were used. The samplers are equipped with impactors for dusts fraction separation and filters holders for dust retaining on filters (in this case we used cellulose filters). In the same time a real time measurement system, MICRODUST CASELLA, was used. This equipment has the possibility to measure the dust concentration in real time (by means of infrared rays) and trap dust, as TSP or different fractions, in order to determine de dust content by gravimetric method. This instrument, do to his memorizing function of measured values in real time, it was used to determine the dynamic of dust concentration and its correlation with other parameters of influence. The samplers were run at a flow rate of 2.3 m^3/h for 24 hours following the requirements of SR EN 12341/2002 and SR EN 14907/2006; the cellulose filters, 47 mm diameter, prior to exposure were conditioned for 24 hours at 20^{o}C and 50% humidity. They were weighted prior and after exposure with a Mettler Toledo 5 decimals analytical balance.

For dust metals content 6 filters were selected, two in a row for each particulate maters fraction (PM 2.5, PM 10 and TSP). After digestion with nitric acid the solution were analyzed by atomic absorption spectrometry with graphite furnace atomization.

Results and Discussion

The results of the tests made for dust content determination in ambiental air in 10-25 March 2008 periods are presented in Table No.1 and in the Figure 1.

We observed that in the mentioned period the particulate maters concentration in ambient air measured 179.9 ±75.7μg/m^3 TSP; 73.6 ±43.6μg/m^3 for PM 10 fraction and 52.1 ±29.4μg/m^3 for PM 2.5 fraction with frequent exceeds of maximum accepted level of 150 μg/m^3 for TSP and 50 μg/m^3 for PM 10 fraction.

In the present the Romanian legislation does not indicate an maximum accepted level for PM 2.5 content in ambiental air, but, comparing these results with the daily maximum accepted level according to The National Ambient Air Quality Standards (NAAQS) of 35 μg/m^3 we can consider that the PM 2.5 dust pollution in this area is significant.

Table 1. TSP, PM 10 and PM 2.5 in ambiental air.

Date	Meteo conditions	TSP, μg/m^3	PM 10, μg/m^3	PM 2.5, μg/m^3
10-11.03	18^{o}C, clear sky, no wind	308	142.3	92.6
11-12.03	15^{o}C, clear sky, no wind	360.4	188.9	130.8
12-13.03	16^{o}C, clear sky, no wind	254.6	116.3	82.4
13-14.03	16^{o}C, cloudy, rain	152.4	58.8	40.2
14-15.03	16^{o}C, cloudy, no wind	102.4	45.6	31.8
15-16.03	15^{o}C, cloudy, windy	128.6	48.2	32.5
16-17.03	16^{o}C, cloudy, no wind	138.5	52.4	36.6
17-18.03	14^{o}C, cloudy, no wind	206.4	87.5	62.1
18-19.03	12^{o}C, cloudy, windy	98.4	31.4	24.7
19-20.03	16^{o}C, clear sky, no wind	137.4	50.2	36.6
20-21.03	16^{o}C, clear sky, no wind	117.3	44.4	34.2
21-22.03	18^{o}C, clear sky, no wind	156.7	58.2	46.3
22-23.03	20^{o}C, clear sky, no wind	158.8	64.6	51.1
23-24.03	22^{o}C, clear sky, no wind	204.9	72.8	55.5
24-25.03	12^{o}C, clear sky, windy	175	42	24.2
Average, μg/m^3		**179.9**	**73.6**	**52.1**
St.dev, μg/m^3		**75.7**	**43.6**	**29.4**

Analyzing these results from the particulates dimension's perspective, generally, PM10 fraction represents 39% from TSP and contain 71% PM2.5. PM 2.5 dusts represents generally 28% from TSP.

From the perspective of the meteorological parameter's influence on the dusts concentration in ambiental air we can observe that the biggest particulate maters concentrations can be found in sunny periods characterized by high temperatures and the lack of the wind and the smallest particulate maters concentrations were in cloudy and windy periods. We can notice the special influence which the air masses movement can produce not only on the concentration of dust in the air but also on their dimensional composition. Thus, in the presence of the wind the PM 2.5 content in TSP decreases from 28% to 13.5%; the same PM 10 content in TSP decreases from 71% to 24% in this way increasing the concentration of dusts bigger than 10 μm on earth level.

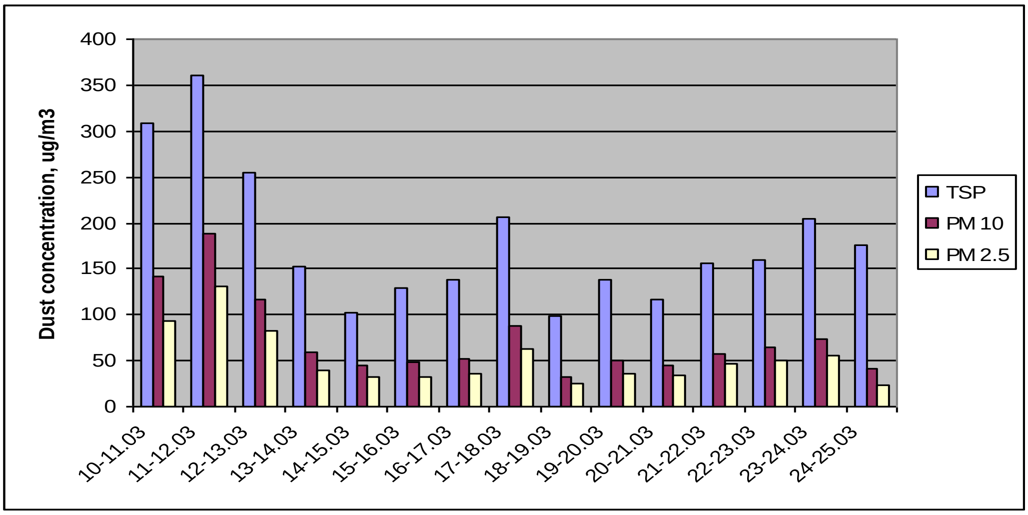

Fig. 1. Grafic representation of the evolution in time of dust concentration in ambient air between 10-25.03.2008.

The parallel measurements run in this period with the real time Dust concentration determination equipment demonstrate, as it can be observed from fig. 2, the importance of the road traffic in the urban particulate maters pollution.

Thus, we can observe a difference of approximately 100μg/m^3 between day time TSP level and night time TSP level (extreme levels were barred).

Fig. 2. Graphic representation of TSP concentration measurement in real time

The study in which those preliminary tests were made has as an objective, like it was presented, the determination of the particulate maters pollution level of the urban areas with intense road traffic from Bucharest but also the effect which this pollution type has it on the population health state. This effect is accentuated by the presence in dusts of different organic and inorganic compounds absorbed on their surface. A special accent, from this perspective, is on the metals and polycyclic aromatic hydrocarbons content.
During those preliminary tests the dust retained on the filters was analyzed also from the metal contents perspective. Thus, two in a row filters from the three types of sampled dusts, TSP, PM 10 and PM2.5, were selected and analyzed by atomic absorption spectrometry with graphite furnace; the content of lead, cadmium, nickel, arsenic and copper were determined.
The results of metals determinations are presented in Table No. 2 and graphic represented in Fig. 3, 4, 5, 6 and 7.

Table 2. Metals content in dust, µg/g

Sample No.	Dust Type	Metal content in dust, µg/g				
		Pb	Cd	Ni	As	Cu
1	PM 10	250	6	21.3	3.5	458
2	PM 10	275	5.1	43	10.7	587
3	PM 2.5	722	21.7	45	1.9	617
4	TSP	512	10.3	88.3	11.1	557
5	PM 2.5	807	29.5	15.1	5.4	424
6	TSP	588	14.1	55.6	2.7	659

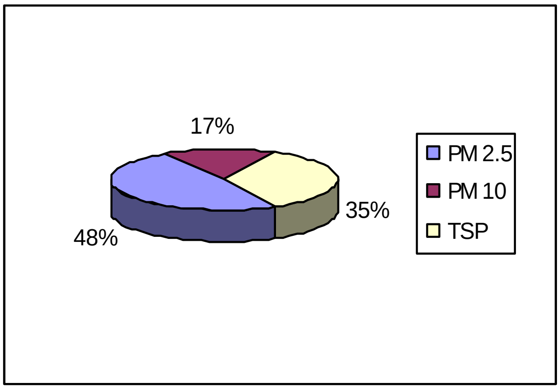

Fig. 3 Lead's part in the three dust types

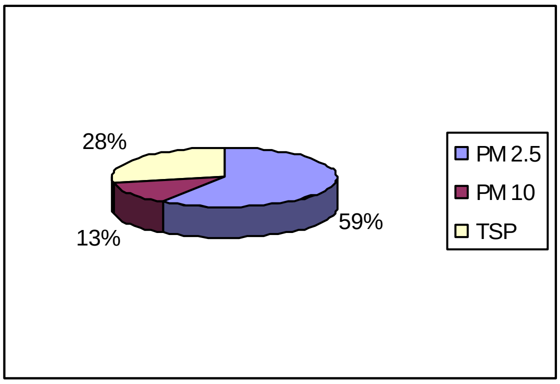

Fig. 4 Cadmium's part in the three dust types

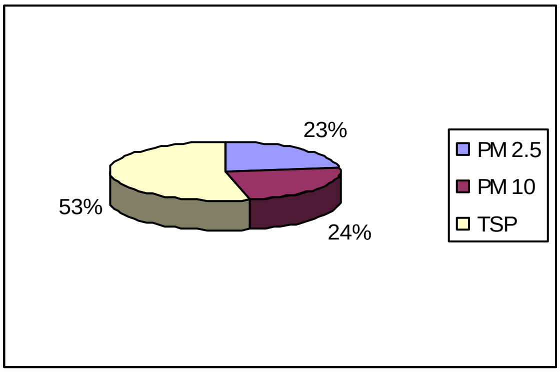

Fig. 5 Nickel's part in the three dust types

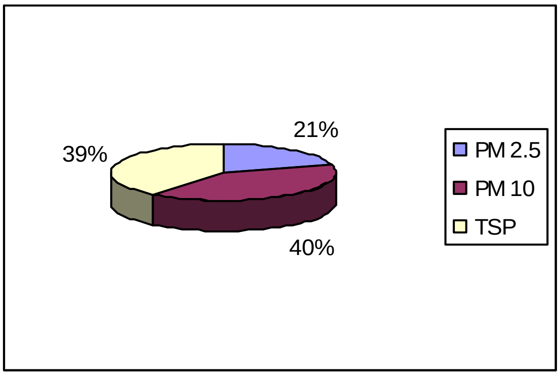

Fig. 6 Arsenic's part in the three dust types

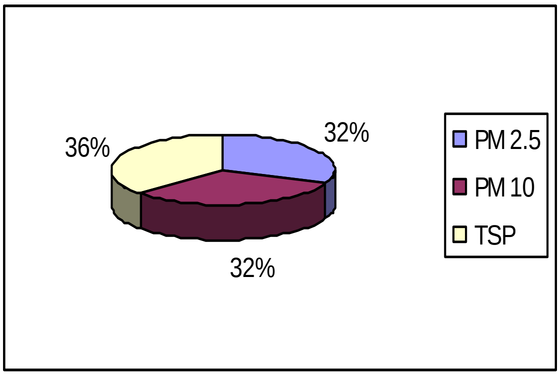

Fig. 7 Copper's part in the three dust types

From these results we can observe that lead is being found in the highest quantity in all dust types, but especially in PM 2.5 (48%). We can say the same thing about cadmium which is being found in PM 2.5 in a 59% proportion, nickel and arsenic being less distributed in PM 2.5 and more in bigger dimensions dusts; cooper is distributed in the same quantity in all the three types of particulate maters.

Conclusions

After these tests we can observe the high particulate maters pollution level of the area in which the sampling was done, pollution produced first of all by the intense road traffic. On this conclusion's behalf comes the big content of PM 2.5 from ambiental air, the presence of the lead especially absorbed on the surface of this type of particulate maters and also the variation's registered in the hourly dust concentration in air which has bigger levels in the rush hours of the road traffic.
So the particulate maters concentration in ambiental air measured 179.9 ±75.7µg/m^3 TSP; 73.6 ±43.6µg/m^3 for PM 10 fraction and 52.1 ±29.4µg/m^3 for PM 2.5 fraction with frequent exceeds of maximum accepted level of 150 µg/m^3 for TSP and 50 µg/m^3 for PM 10 fraction.
From the particles dimension's perspective, generally, PM10 dusts have in a 71% PM2.5 dusts and represents 39% from TSP. PM 2.5 represents 28% from TSP.
Dusts have absorbed on the surface the compounds with metals, lead in the highest quantity, but other metals too, such as cadmium, nickel, arsenic and copper differently distributed on the three types of studied dusts. Thus, lead and cadmium are being found in the highest measured quantity in PM 2.5 and the other analyzed metals are mostly found in dusts with bigger dimensions.
Meteorological parameters influence the particulate maters pollution level from the quantity perspective but also from their dimensional composition perspective. So in high temperature conditions, clear sky and lack of wind the dust concentrations reach the highest levels for TSP but also for PM 2.5 and PM 10.
The presence of the wind changes the rate of the three dust types; the concentration of PM 2.5 and PM 10 decreases and the concentration of dusts with bigger dimensions than 10 µm increases. The air humidity gives the decrease of the dust's level.

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