DISTRIBUTION OF ACCUMULATION PARTICLES IN THE URBAN ATMOSPHERE

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Abstract: *„Accumulation particles" are called the fine particles with diameters between 0.1 and 1 μm, that are suspended in atmosphere. This paper presents the generation sources, the specific legislation and also the effects on human health and environment for this type of particle. The experiments have established the distributions of particles in relation with their size (in term of particles number on size intervals) in urban atmosphere. Measurements were performed both in open space (in the vicinity of road with a medium traffic) and in enclosed space (the pilot station of the faculty). The particles sizes were determined using an aerosol particle counter type PK.GTA 0.3-002. Were established the correlations between the particle size distribution and the measurement location (indoor and outdoor), respectively, the height from ground for which the measurements were performed. It was been established which are particles that appear in the highest amount, the causes, the risks and also possible remediation measures that may apply.*

Keywords: *accumulation particles, urban atmosphere, size distribution*

1. Introduction

In atmosphere are suspended solid or liquid particles called aerosols. The fog, smoke and dust are very fine particles (aerosols) with sizes in the range of 0.001 to 100 μm. These particles have different emission sources and chemical compositions. Particulate matter (PM) is a complex mixture consisting of small solid and liquid particles suspended in the air Their sizes can vary from a few nanometers to ten of micrometers and by this parameter they can be classified into four, respectively two categories [1]:

- for pulverulent solid particles
  - course particles (> 1.0 μm);
  - fine particles or accumulation particles (0.1 - 1 μm);
  - very fine particles or Aitken particles (0.01 – 0.1 μm);
  - ultra fine particles or UHP (< 0.01 μm);
- for pulverized liquid particles
  - drops (1 – 10 μm);
  - fog (< 1 μm).

Coarse particles with a diameter over 10 μm, raises fewer problems because, under the influence of gravity, they sediment within a few hours. The particles with diameters between 0.1 and 1 μm, which are analyzed in this work, reach this size mainly by coagulation of particles smaller than 0.1 μm. They are also called „accumulation particles" because they sediment very difficult and accumulate in the atmosphere until these will be removed by rain or other precipitation (process called wet deposition). Dust emissions are released in air from industrial installations (emissions point-sources or hot points) or from cars (emissions mobile points). A special category is emissions to air from the natural sources that affect significant (although for limited periods) the air quality parameters. Most aerosols are naturally formed, having the origin from volcanoes, dust storms, forest fires or other vegetation and marine fog. Aerosols that are anthropogenic produced represents 10 % of the existing total emissions. They results from various human activities such as burning fossil fuels, emissions of internal combustion engines, wind blown dust from the construction or places whence the water and the vegetation were removed by drainage, deforestations, etc.

In most European urban areas road transport-related emissions are the primary source of ambient particulate mater (especially PM10) [2]. For this reason, the particulate emissions from

vehicles are severely restricted in recent years. So European Union has imposed standards for particulate emissions originated from vehicles engines at the level of 0.025 g/km, and for United States, especially California, a standard more restrictively, 0.006 g/km. Latest particulate filters introduced by major vehicles manufacturers tend to reduce the emission of particles (especially so-called black carbon) to 0.003 g/km, thus less than the required standards. In our country there are efforts for the renewal of the vehicle park and financial stimulated by the reduced fees, the purchase of cars fitted with performing filters and catalyst (such as Euro 4 and Euro 5). Also, to reduce pollution of engines it proposes the utilization of diesel fuel mixed with a quantity of biogas (bioDiesel).

The aerosol composition depends on the source of their formation. Thus, the dust carried by the wind consists of mineral oxides and other materials entrained from the Earth's crust. The marine aerosols are mostly ensemble of sodium chloride and other constituents of seawater as magnesium, sulphur, calcium, potassium. They can also contain organic components that also affect their chemical composition. These particles, which are emitted directly into the atmosphere, are also called primary particles. The secondary particles are derived by oxidation of those primary. For example, S, SO_2, SO_3, NO, NO_2, etc. can form sulphuric acid aerosols (liquid) and nitric acid (gaseous). The precursors of these aerosols (the gases from who have their origin) can be produced natural or by humans activities. In the presence of ammonia the aerosols are often the form of secondary ammonium salts (ammonium sulphate and ammonium nitrate). The secondary aerosols remain in the acidic form in the absence of ammonia. Another important type of particles in the urban atmosphere are in the form of elemental carbon, and called „black carbon".

The health effect of inhaled particles, extensively studied, occurs in both humans and animals. These determine: asthma, acute and chronic bronchitis, lung cancers, serious cardiopulmonary diseases, premature death [3]

The particle size is important for determining if they will be inhaled by entering in the respiratory tract. The large particles are generally filtered in the nose and throat and do not cause problems. Those less than 10 micrometers can be installed in the bronchus and lungs and can cause health problems. However the dimension of 10 micrometers is not a clear separation for particles that can be and what can not be inhaled (PM10 refers to particulate matter that has a diameter of 10 micrometers or less.) [4]. The small particles install in the lungs and these very small, less than 100 nanometers, can pass into the body affecting other organs. PM2.5 particles (PM2.5 refers to all PM that is smaller than 2.5 micrometers in diameter) lead to arteries diseases, causing vascular inflammation and sclerosis of the arteries (the reducing of arteries elasticity), which can cause heart attack and other vascular problems [4, 5, 6]. The ultrafine particles can also migrate to the brain where they can cause injuries such as those found at Alzheimer patients.

Diesel PM emissions are generally smaller (of the order of 100 nanometers) and are classified as especially harmful, because they contain carcinogens such as (benzo[a]pyrene) polycyclic aromatic hydrocarbons that are especially damaging to health. The great number of deaths and the large number of other health problems caused by pollution with particles was first demonstrated in 1970 [7, 8]. The pollution is considered to be the cause of 20,000 to 50,000 deaths annually in the U.S. and over 200,000 in Europe. Were implemented numerous measures to limit the pollution level but in many urban areas from U.S. and Europe, the regulations are frequently violated.

Natural aerosols and those produced by humans activities can affect climate, by changing of the way in which the solar radiation is transmitted through the atmosphere. Direct observation of the aerosols influence is limited and difficult and the trying to assess their overall effect can be achieved by means of computer models [9]. Intergovernmental Panel on Climate Change, IPCC (Intergovernmental Panel on Climate Change Council) considers the following: „While the radiant power due to gases (greenhouse effect) can be determined with an acceptable degree of accuracy, the uncertainties relating to the radiant power of the aerosols remains quite high and is largely based on the estimations realized with models of the global study that are difficult to prove at present" [2].

The direct effect (caused mainly by sulphates and „blacks") occurs through reflection and determines the planet cooling. IPPC estimated 0.4 W/m^2 for the average of radiant power of sulphates (an range of variation between 0.2 to 0.8 W/m^2), and also 0.2W/m^2 as average of the radiant power of carbon (a variation range of 0,2-0.4 W/m^2). The effect varies greatly by geographical areas, the

largest cooling is observed in the large industrial sites into direction of the wind blowing.

In the EU, those aspects of environmental legislation that directly affect human health are standardized in a system of laws that apply to all EU member states. The EC in Brussels passes directives that set standards with respect to ambient air quality. The European Union (EU) Clean Air Directives are currently among the strictest acts of legislation worldwide concerning air pollution (for PM10). One of the most aggressive responses to the new PM10 legislation in Europe has been the rapid adoption of so called "Low Emission Zones" (LEZs). An LEZ defines an area that a vehicle is allowed to enter only if it is classified as a low PM10 emitting vehicle [10].

European Directives for Air Quality Clean Air (96/62/EC, 1999/30/EC and 2008/50/EC) set the standards for the air quality for all EU member countries. These values are given in Table 1.

Table 1. Limit values of particulate matter in ambient air in accordance with 2008/50/EC [11]

	24-hour average PM10	Annual average PM10	Annual average PM2,5*
Upper assessment threshold	70 % of limit value (35 μg/m^3, not to be exceeded more than 35 times in any calendar year	70 % of limit value (28 μg/m^3)	70 % of limit value (17 μg/m^3)
Lower assessment threshold	50 % of limit value (25 μg/m^3, not to be exceeded more than 35 times in any calendar year	50 % of limit value (20 μg/m^3)	50 % of limit value (12 μg/m^3)
* The upper assessment threshold and the lower assessment threshold for PM2,5 do not apply to the measurements to assess compliance with the PM2,5 exposure reduction target for the protection of human health.			

2. Experimental

Measurements were performed using an aerosol particle counter type PK.GTA 0.3-002. The counter operates in the following conditions: ambient temperature from 10 to 35 ^{0}C; relative moisture content up to 80% at 25 ^{0}C; atmospheric pressure from 650 to 800 mm Hg. It record the aerosol particles in six classes of different dimensions respectively: 0.3 - 0.4 μm, 0.4 - 0.5 μm, 0.5 - 0.6 μm, 0.6 - 0.8 μm, 0.8 - 1.0 μm and >1.0 μm. The meter is based on the photoelectric method for recording of aerosol particles. The particles that reached in the lighting work volume dissipate the light. The dissipated light intensity depends on particles size. A photoelectron multiplier was used a light receiver. This records an electrical impulse. The amplitude of impulse is proportional to the amount of dissipated light, and so allowed the determination of particles size. Thus, it is possible analyze of the particles by size. The pneumatic system ensures the particle collection and their transmission in the workloads of the optical sensor. The workload can be: 0.1; 1.0; 10 dm^3.

Measurements were performed both in open space (in the vicinity of road with a medium traffic) and in enclosed space (the pilot station of our faculty when special activities were absent). In both determinations was chosen the maximum volume of analyzed sample (10 dm^3).

In indoor the measurements were performed at different heights from the ground, from the idea that in the absence of the air currents is possible that the distribution of very fine particle does not depend on height. In outer all experiments were conducted at same height from the ground. In Table 2 are given the results of measurements that were performed in enclosed space at different levels.

Table 2. Number of registered particles by size classes at different heights from the ground*

Measuring height, mm	Number of particle by size classes, μm					
	0.3-0.4	0.4-0.5	0.5-0.6	0.6-0.8	0.8-1.0	>1
+150	256404	90990	50737	39065	24339	7672
+950	238519	70581	34690	19516	10098	5184
+2000	168571	52148	27515	17671	8632	5003

* The average of 20 measurements in different days

Analyzing the results of interior measurements, it is found that the number of registered particles, regardless of size, decreases with the increasing of the height at which the determination is made and the greatest amount of particles is at ground level. The finest particles of size class from 0.3 to 0.4 μm

are in a quantity of approximately three times higher than the next class, so having the lowest rate of sedimentation and the greatest tendency to accumulate of the size category that is analyzed.

If the size distribution in relation with the measuring height are analysed must be emphasize the following particularities:

- the size below 0.6 μm particle, number recorded at ground level and at +950 mm is comparable;
- 0.3-0.4 μm particles are the highest number at all levels;
- over 0.6 μm, the number of particles present at +950 mm and +2000 mm is smaller and has similar values;
- lowest number of particles is records at +2000 mm, the less numerous are those > 1 μm.

Distribution of particles on size classes at various measuring heights is shown in Figure 2.

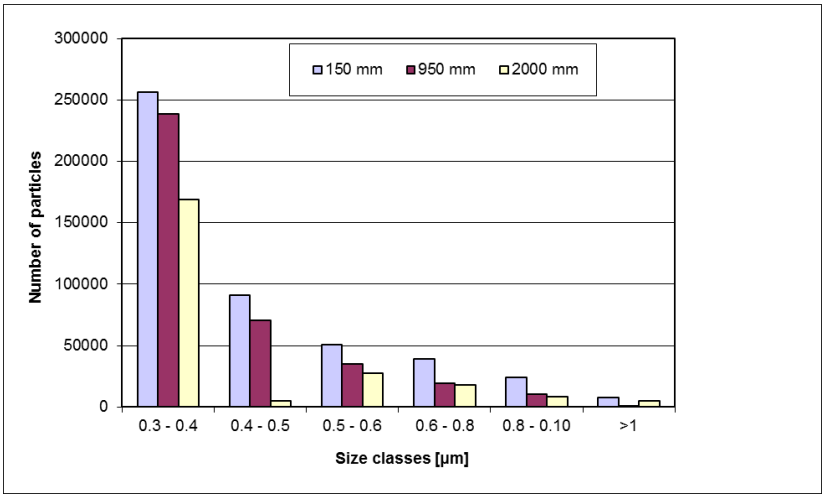

Figure 1: *Particle size distribution for aerosols measured in enclosed space at three heights*

In open space, the amount of particles presents significant variations with environmental factors and therefore the measurements were correlated with the information provided by the meteorological station from Galati. There have been three sets of measurements at the same level (+950 mm) in climate conditions shown in Table 3.

Measurement results in the outdoors are shown in Table 4 and Figure 2. A first observation is that in outdoors the quantity of particles is much higher (approximately double) for the same class dimensional considered 0.3 to 0.4 μm. In outdoors the quantity of particles is much higher (approximately double) for the same class dimensional considered 0.3 to 0.4 μm.

Table 3. Weather conditions in which the measurements were conducted in outdoors

No. samples	Temperature [^{o}C]	Humidity [%]	Wind speed [km/h]	Air pressure [hPa]	Visibility [Km]
Set 1	15-20	21-27	7,2-10 din Est	1025-1027	20
Set 2	21-26	20-25	10-14,4 din Sud	1021 -1023	20
Set 3	12-19	60-70	10,8-12 din Est	1010 -1018	20

Table 4. Particle size distribution as function of climatic factors

No. samples	Number of registered particles by size classes					
	0.3-0.4 [μm]	0.4-0.5 [μm]	0.5-0.6 [μm]	0.6-0.8 [μm]	0.8-1.0 [μm]	>1 [μm]
Set 1*	486961	90247	21104	9970	8664	4826
Set 2*	237999	67031	59663	64071	30086	10730
Set 3*	611593	203196	118492	44109	28218	14642

*The average of 20 measurements in different days

For measurements Set 1 with very low wind and low humidity, particles with sizes larger than 0.4 μm are less than into inside, so the air is more cleaner. The highest number of particles appears at the enhancement of the wind and at higher humidity. There is shown in the third set of

measurements. Set 2 of measurements was made while the wind direction was changed. There was a significant increase in the number of particles larger than 0,5 μm, compared with Set 1 when the humidity was the same.

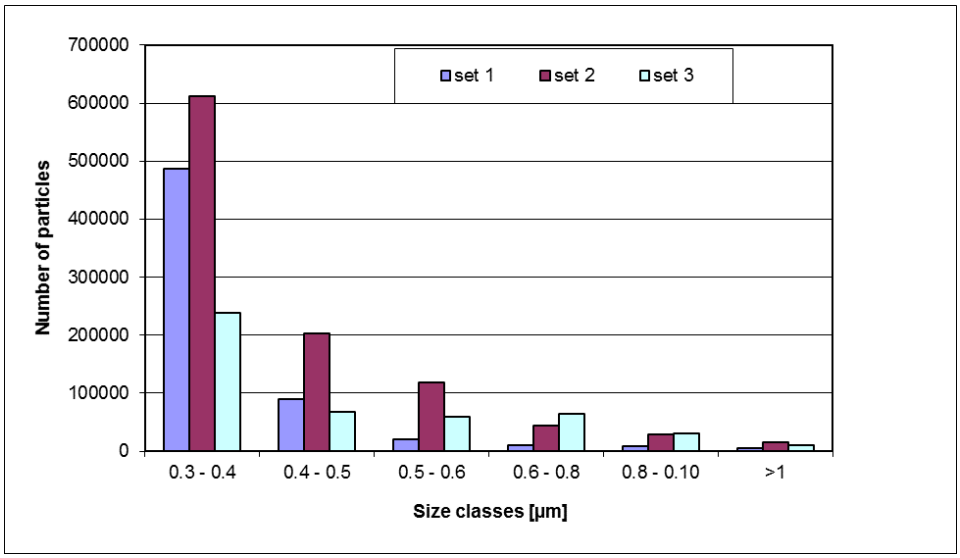

Figure 2: *Particle size distribution of aerosols in outdoors*

In Figure 3. it showed the comparative distribution of particles in indoor and outdoor for height 950mm If in outer space the accumulation particles are sedimented by means of precipitation, in interior spaces, especially in those of production, is strictly obligatory the cleaning by spraying, wiping or washing because the air is more polluted than in outside. The prolonging of drought periods require spraying with water of urban areas, not only for landscaping but and for air cleaning of fine and ultrafine particles in the air.

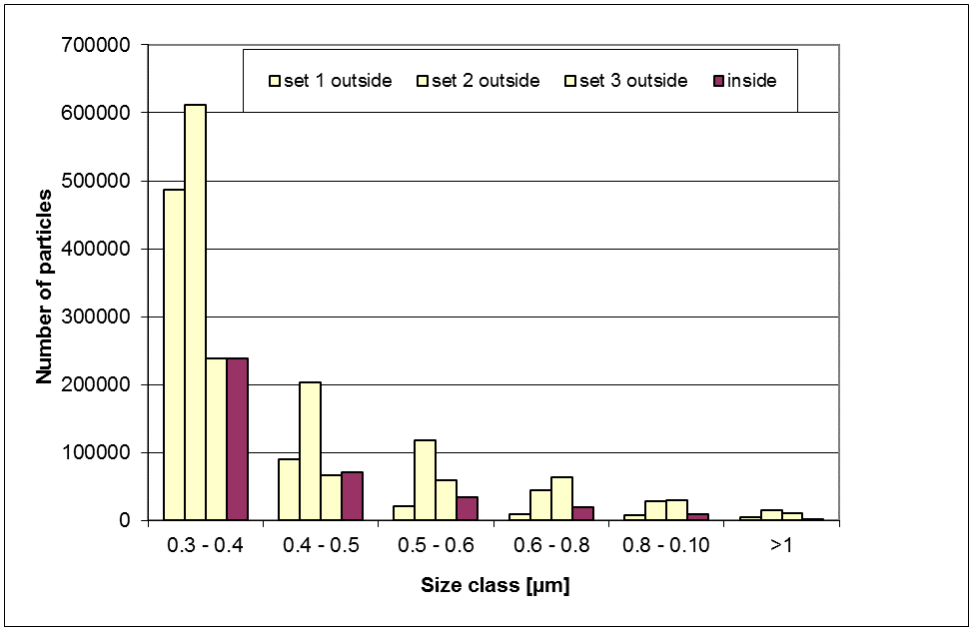

Figure 3: *Comparative distribution of particles in outside (in different weather conditions) and inside for height 950 mm*

3. Conclusions

Both in the interior and in the exterior, more accumulation particles are those situated in the size class from 0.3 to 0.4 μm;

In the interior space, in relation with the height measurement the following is observed:

- size below 0.6 μm, the number of particles recorded at ground level and +950 mm is comparable;
- particles with dimensions of 0,3-0.4 μm are the highest number at all levels;
- those that have size over 0.6 μm, the number of particles present at +950 mm and +2000 mm is lower and with similar values;
- lowest number of particles is at +2000 mm, the least numerous are those > 1 μm;
- for conditions of low humidity and very weak wind, the air is more cleaner in exterior space towards the interior space that is analysed;
- highest number of particles is increased at the intensification of wind and humidity.

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