ASPECTS REGARDING THE ATMOSPHERE POLLUTION MONITORING

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ABSTRACT

This paper presents information regarding the variation of aerosols concentration in a central area in Galati city. For a period of time of 2 years and 5 months, there have been done correlations between aerosols concentrations with grading classes and the dominant wind directions (E-W, N-NW~S-SE, S~N, N~NE~S-SW).

The results of the measurements are particular for only a point in time, being influenced by random variables (traffic intensity, temperature, pressure, wind speed, humidity etc.).

Keywords**:** aerosol, pollution, particulate matter, air quality.

1.Introduction

Air pollution in urban areas represents a major issue related to public health and environment protection. The development of an air quality management system is therefore an objective of utmost importance for the local public authorities.

Air pollution is one of the side effects of human activity and has a negative impact on public health. The structural changes that took place in the industrialized society, characterized by intense industrial polluting processes and services, determined an increase of the pollution level.

The strategy for improving and/or preserving the air quality involves the following steps:

- Collecting information and data concerning the origin and the concentrations of the urban pollutants, as well as their harmful effects on the environment (emissions measurements and epidemiologic data specific for urban air pollution);
- Collecting information on the causes that generate air pollution by assessing the polluting emissions (inventorying the air pollution sources)
- Adopting administrative, economic and technical control measures of air pollution in order to decrease and/or eliminate urban air pollution and its effects.

As a result of the three steps mentioned above, the main goals of Air Quality Monitoring System in urban areas are:

- o assessment of air pollution sources;
- o air quality measurements;
- o evaluation of the transport, diffusion and transformation processes of pollutants in the urban atmosphere;
- o forecasting the evolution trends of air quality, related to the emission/imission standards, as well as the effects on public health and specific environmental elements of urban areas.

1.2. Air monitoring in urban areas

The Air Quality Monitoring System in Urban Areas (AQMSUA) is a part of the Air quality management system that ensures the knowledge and the objective aggregation of information concerning air quality, useful in order to plan the environment quality, as well as to build the control loop intended to achieve the objectives of these planning.

The main goal of the Air Quality Monitoring System in urban areas is to assist the decision makers in:

- air quality planning;
- monitoring the environment quality;
- verifying (by using the monitoring data) the level of compliance with the environmental standards and regulated conditions, for each potentially polluting company;
- applying the measures for preventing, rehabilitating and controlling the air quality, in order to comply with the planned objectives.

1.3. Atmospheric pollutants

Airborne particulate matter represents a complex mixture of organic and inorganic substances. Mass and composition in urban environments tend to be divided into two principal groups: coarse particles and fine particles. The barrier between these two fractions of particles usually lies between 1 µm and 2.5 µm. However, the limit between coarse and fine particles is sometimes fixed by convention at 2.5 µm in aerodynamic diameter (aerodynamic diameter that is the size of a unit density sphere with the same aerodynamic characteristics) for measurement purposes.

The smaller particles contain the secondarily formed aerosols (gas-to-particle conversion), combustion particles and recondensed organic and metal vapours. The larger particles usually contain earth crust materials and fugitive dust from roads and industries. The fine fraction contains most of the acidity (hydrogen ion) and mutagenic activity of particulate matter, although in fog some coarse acid droplets are also present. Whereas most of the mass is usually in the fine mode (particles between 100 nm and 2.5 µm), the largest number of particles is found in the very small sizes, less than 100 nm.

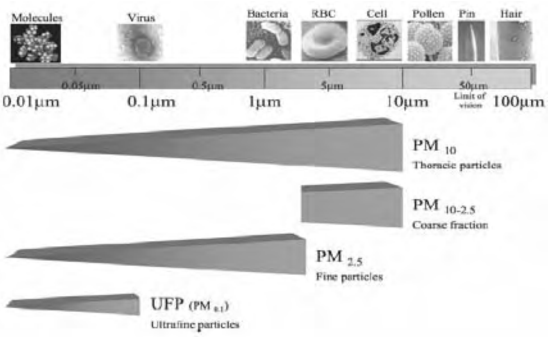


Fig. 1. *Particulate mateer classification [16].*

As anticipated from the relationship of particle volume with mass, these so-called ultrafine particles often contribute only a few percents to the mass, at the same time contributing to over 90% of the numbers. Particulate air pollution is a mixture of solid, liquid or solid and liquid particles suspended in the air. These suspended particles vary in size, composition and origin. It is convenient to classify particles by their aerodynamic properties because: (a) these properties govern the transport and removal of particles from the air; (b) they also govern their deposition within the respiratory system and (c) they are associated with the chemical composition and sources of particles.

These properties are conveniently summarized by the aerodynamic diameter. Particles are sampled and described on the basis of their aerodynamic diameter, usually called simply the particle size. The size of suspended particles in the atmosphere varies over four orders of magnitude, from a few nanometres to tens of micrometres. The largest particles, called the coarse fraction (or mode), are mechanically produced by the break-up of larger solid particles. The smallest particles, less than 0.1 µm, are formed by nucleation, that is, condensation of low-vapour-pressure substances formed by high-temperature vaporization or by chemical reactions in the atmosphere to form new particles (nuclei). Particles in this nucleation range or mode grow by coagulation (the combination of two or more particles to form a larger particle), or by condensation (the condensation of gas or vapour molecules on the surface of existing particles).

Therefore the efficiency of both coagulation and condensation decreases as particle size increases, which effectively produces an upper limit such that particles do not grow by these processes beyond approximately 1 µm. Thus particles tend to "accumulate" between 0.1 and 1 µm, the so-called accumulation range. Sub micrometre-sized particles can be produced by the condensation of metals or organic compounds that are vaporized in high-temperature combustion processes. They can also be produced by condensation of gases that have been converted in atmospheric reactions to low vapour-pressure substances.

The particles produced by the intermediate reactions of gases in the atmosphere are called secondary particles. Secondary sulphate and nitrate particles are usually the dominant component of fine particles. Combustion of fossil fuels such as coal, oil and petrol can produce coarse particles from the release of non-combustible materials, i.e. fly ash, fine particles from the condensation of materials vaporized during combustion, and secondary particles through the atmospheric reactions of sulphurxides and nitrogen oxides initially released as gases. Because of its complexity and the importance of particle size in determining exposure and human dose, numerous terms are used to describe particulate matter.

Some are derived from and defined by sampling and/or analytic methods, e.g. "suspended particulate matter", "total suspended particulates", "black smoke". Others refer more to the site of deposition in the respiratory tract, e.g. "inhalable particles", which pass into the upper airways (nose and mouth), and "thoracic particles", which deposit within the lower respiratory tract, and "respirable particles", which penetrate to the gas-exchange region of the lungs. Other terms, such as "PM10", have both physiological and sampling connotations [16].

According to the international and national legislation, particulate matter (PM) is defined in the following manner (EPA: 1997; Council Directive 1999/30/EC of 22 April 1999 relating to limit values for sulphur dioxide, nitrogen dioxide and oxides of nitrogen, particulate matter and lead in ambient air, Romanian OMAPM No. 592/25.06.2002 (OJ No 765/21.10.2004)).

- PM_{10} - particles which pass a 50% inlet cut-off at the aerodynamic diameter of 10 μm;
- $PM_{2.5}$ - particles which pass a 50% inlet cut-off at the aerodynamic diameter of 2.5 μm.

1.4. Limits of atmosphere pollutants emission

In the industrialized countries, the emission standardization has been used in the policy of environment protection together with air quality standards that limit pollutant concentrations that may be allowed to the atmosphere in a certain period.

Table 1. *Particulate Matter in the Atmosphere*

Total Suspended Particulate mass TSP < 35 μm	35 to 10 μm, mostly natural Dust, sea salt, pollen, …
Inhalable Aerosols PM10 < 10 μm	10 to 2.5 μm, largely natural Dust, sea spray, some nitrates
Fine Aerosols PM2.5 < 2.5 μm	2.5 to 0.25 μm, mostly man made Fine dust, nitrates, sulfates,organics, smoke
Very fine aerosols, < 0.25 μm,	0.25 to circa 0.01 μm, Almost entirely man made;
Ultra fine aerosols, < 0.10 μm	high temperature combustion, heavy organics, soot, metals

1.5. Aerosols' action on the human body

The particulate matter parameters of potential interest for public health are: size, surface area, number, acidity, metals, elemental and organic carbon, mass, size , distribution, ions, bioaerosols.

The respiratory system is most frequently affected by the atmospheric aerosols. Size of particles is directly linked to their potential for causing health problems. Small particles less than 10μm pose the greater problems, because they can get deep into the lungs, and some may even get into the bloodstream. Larger particles are of less concern, although they can irritate eyes, nose, and throat.

People with heart or lung diseases, older adults, and children are considered at greater risk from particles than other people, especialy when they are physically active.

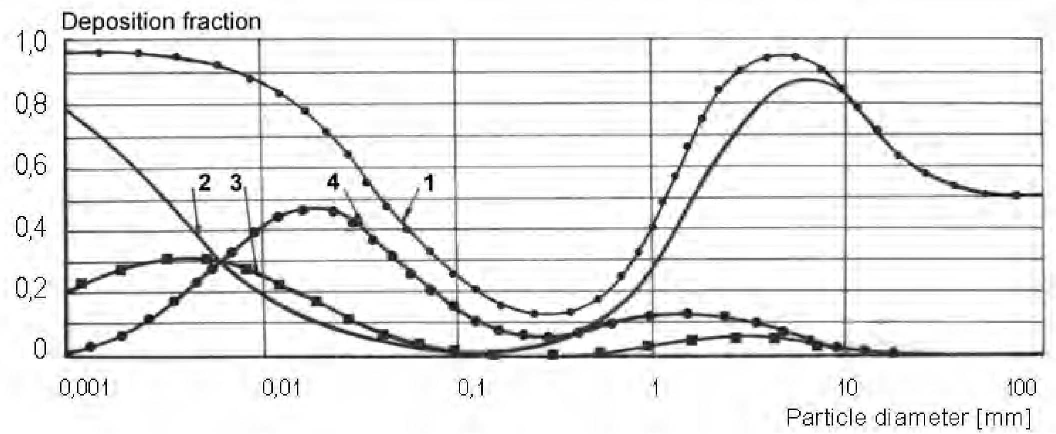


Fig. 2. *Probability of deposition in various parts of the lung, relative to particle size: 1. Total deposition; 2. head airways; 3. tracheobronchial region; 4. alveolar deposition (pulmonary region) ([15], ICRP[1]-1975).*

[1] International Commission on Radiological Protection

According to P. E. Marrow's diagram (fig. 2) one could observes that aerosols with particle diameter in the size range 0,1 – 10,0 μm get into the pulmonary alveoli, considered the most sensitive part of the respiratory system.

The harmful action of this particulate matter depends on the retained quantity.

2. Experimental results

The air quality has been monitored from November 2002 to April 2005 by "Environmental Engineering" Laboratory of the Faculty of Metallurgy and Materials' Sciences, University "Dunărea de Jos" of Galati.

The monitoring activity led to finding and accumulating information and data on the atmospheric aerosols charge in the neighbourhood of Domneasca and Basarabiei crossing street (fig. 3) [3, 4, 5].

In this area, due to the extremely intense traffic and the depletion of the natural arboreous curtain, from both sides of the street, supplementary pollutants were added to the pollutants occurring from industrial plant emissions.

***Fig. 3**. The localization of the area of experimental researches, on the Galați city map and the most frecvently wind directions:*
1- E~W, 2 - N-NW~S-SE,
3 - S-N, 4 - N-NE~S-SW.

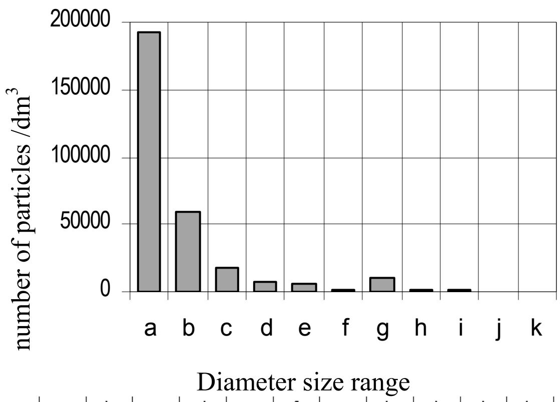
The instrument used for measurements is a particle counter that can measure up to 750 000 particles in a dm^3 of air from the environment, based on the following diameter size ranges (Table 2), that were also used on the following plots.

***Table 2.** Diameter size ranges*

a	b	c	d	e	f	g	h	i	j	k
0,4-0,5 [μm]	0,5-0,6 [μm]	0,6-0,7 [μm]	0,7-0,8 [μm]	0,8-0,9 [μm]	0,9-1 [μm]	1-1,5 [μm]	1,5-2 [μm]	2-4 [μm]	4-7 [μm]	7-10 [μm]

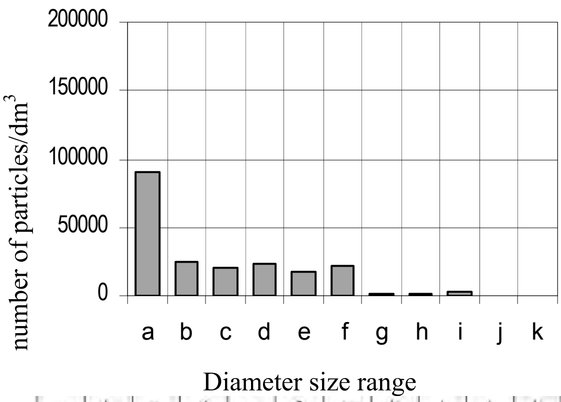
The research period was between April 2002 and May 2005. Figures 4 and 5 presents examples of the particulate matter analysis, for two days, in the research period.

Figures 7 – 20 presents the particles' concentration, analysed for a specific particle diameter size range.



a	b	c	d	e	f	g	h	i	j	k
192000	60000	78000	7200	6000	1800	11100	1800	2100	0	0

***Fig. 4.** Particulate matter analysis on 18.03.02*



a	b	c	d	e	f	g	h	i	j	k
90000	25000	20000	24000	18000	21500	1000	1500	2900	60	0

***Fig. 5.** Particulate matter analysis on 8.03.05*

Figure	Date	Temperature [^{0}C]	Humidity [%]	Visibility [km]	Wind direction
4	18.03.02	9	97	10	N-NE
5	8.03.05	-1	52	6	N-NV

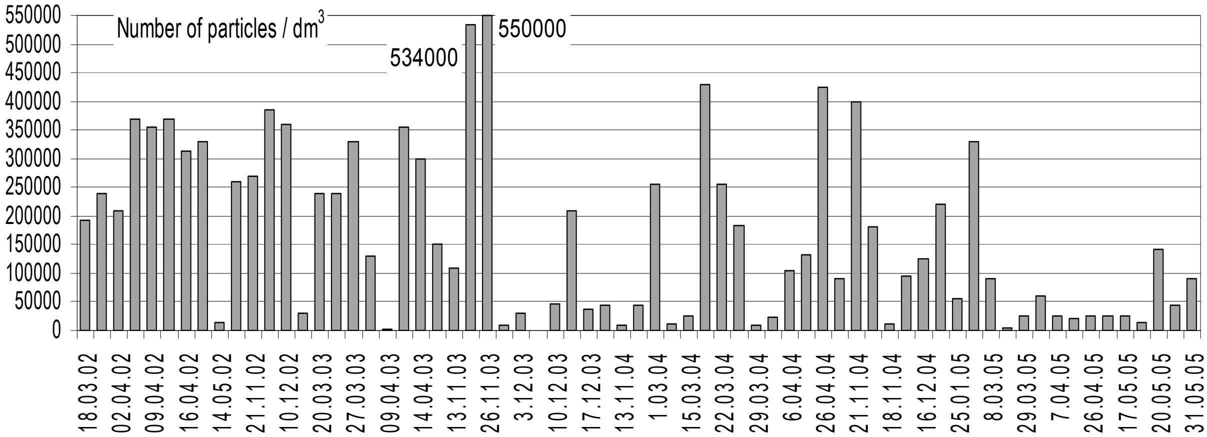


Fig.6. *Particles' concentration (diameter size range 0,4 – 0,5 µm)*

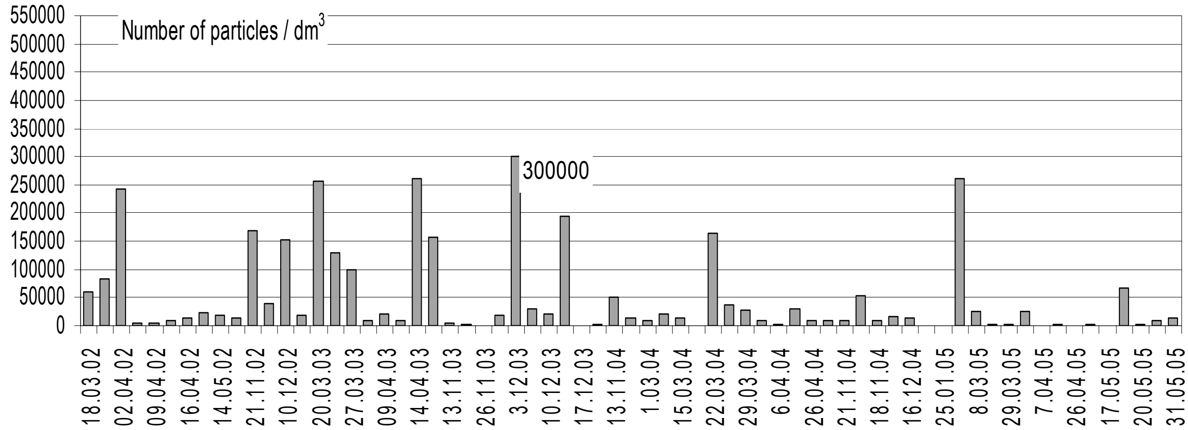


Fig.7. *Particles' concentration (diameter size range 0,5 – 0,6 µm)*

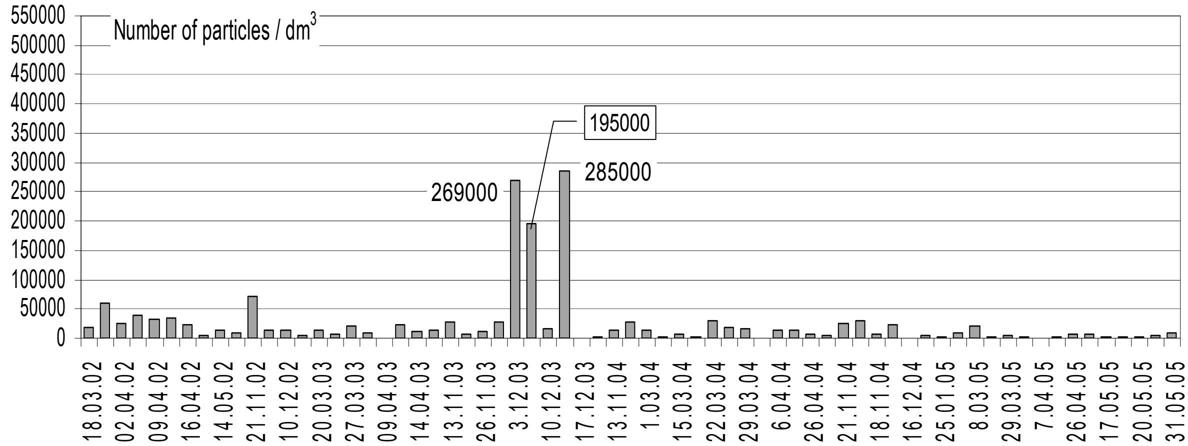


Fig.8. *Particles' concentration (diameter size range 0,6 – 0,7 µm)*

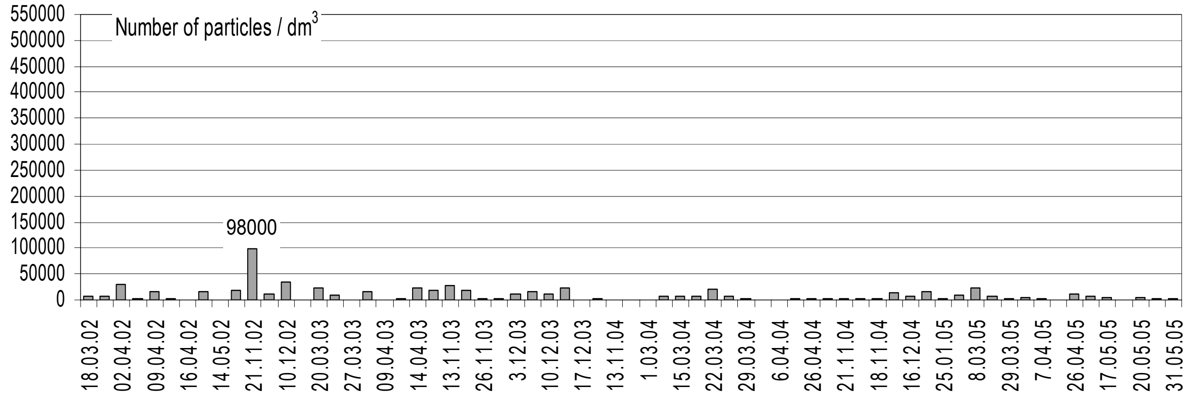


Fig.9. *Particles’ concentration (diameter size range 0,7 – 0,8 µm)*

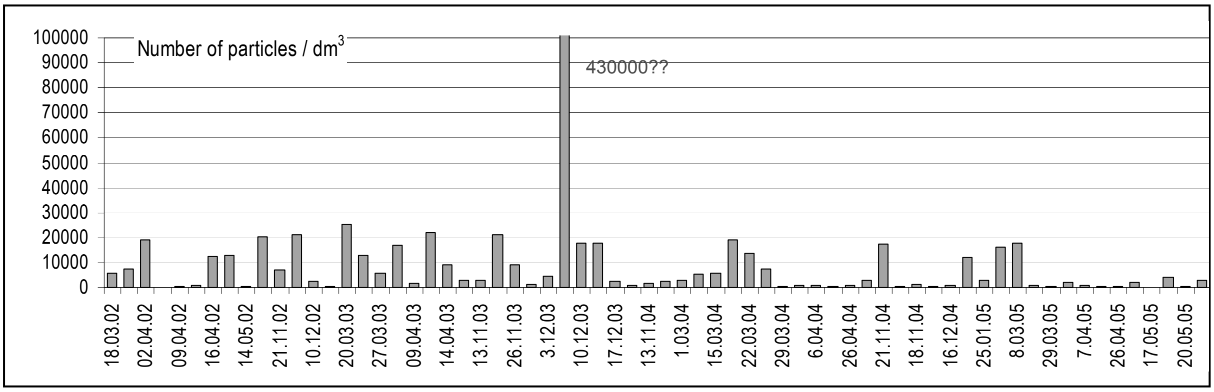


Fig.10. *Particles’ concentration (diameter size range 0,8 – 0,9 µm)*

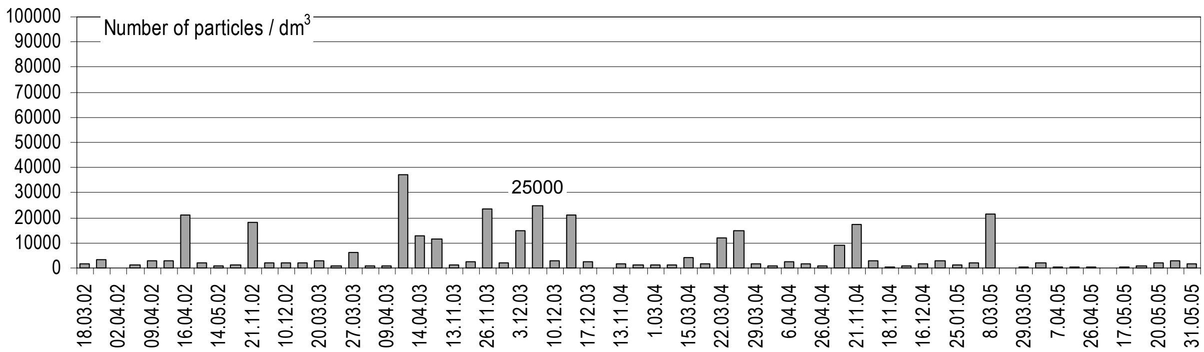


Fig.11. *Particles’ concentration (diameter size range 0,9 – 1,0 µm)*

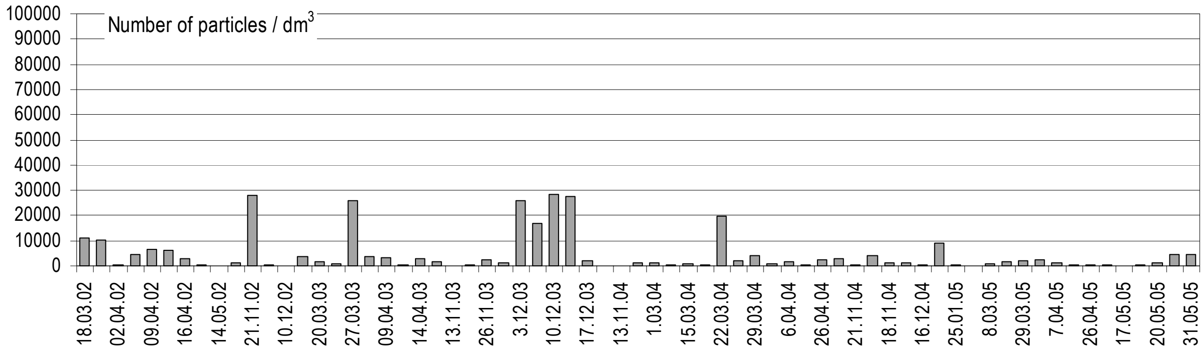


Fig.12. *Particles’ concentration (diameter size range 1,0 – 1,5 µm)*

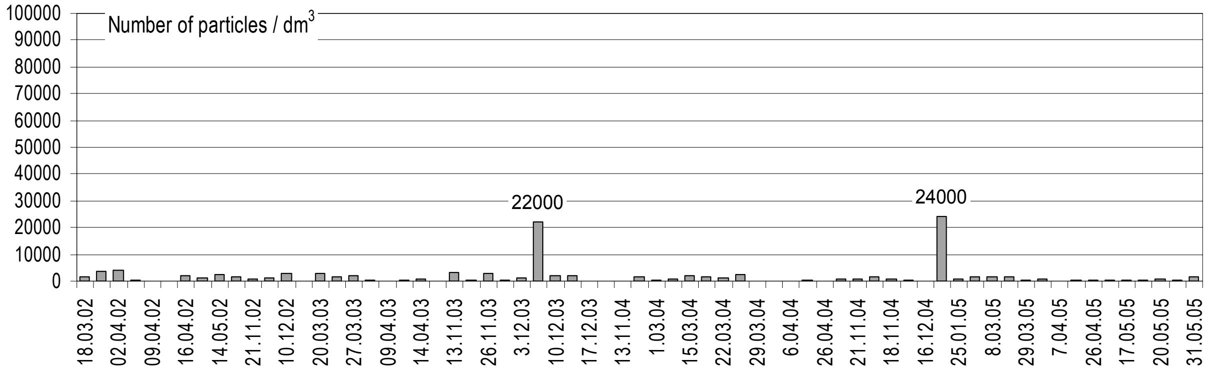


Fig.13. *Particles' concentration (diameter size range 1,5 – 2,0 µm)*

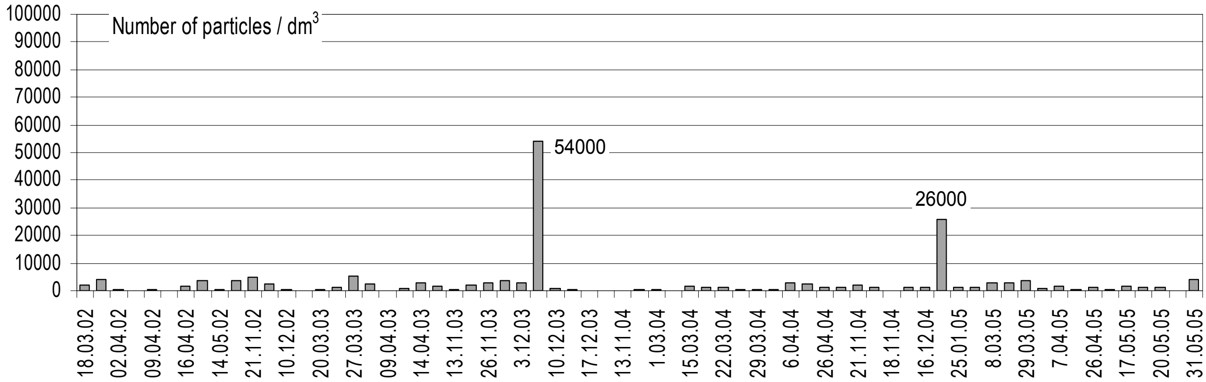


Fig.14. *Particles' concentration (diameter size range 2,0 – 4,0 µm)*

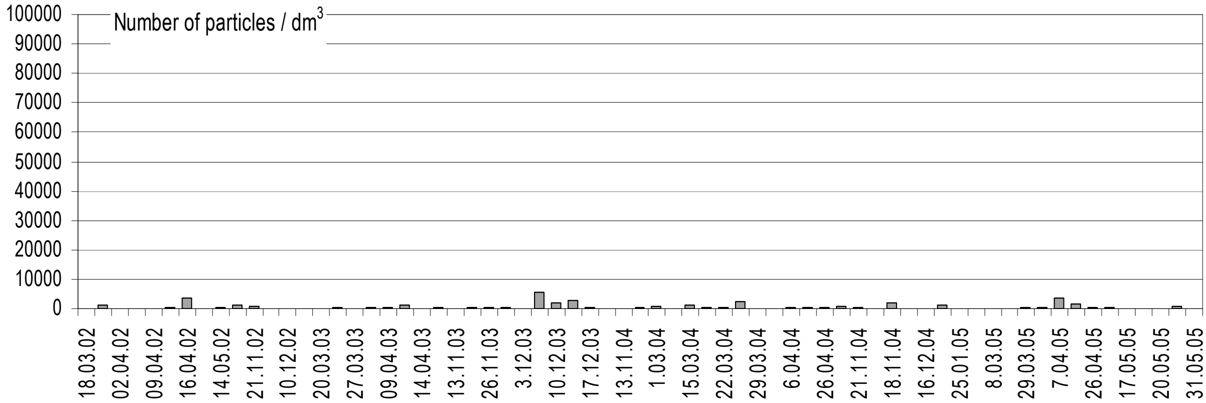


Fig.15. *Particles' concentration (diameter size range 4,0 – 7,0 µm)*

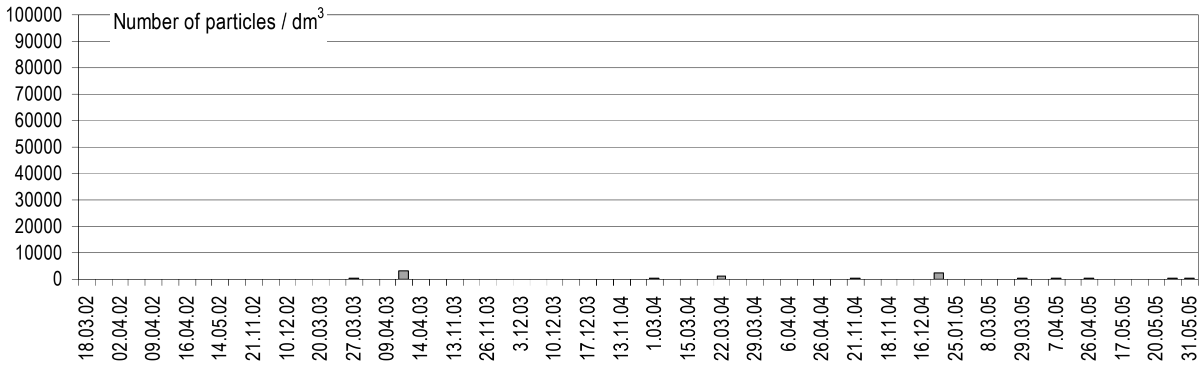


Fig.16. *Particles' concentration (diameter size range 7,0 – 10,0 µm)*

3. Study of the wind direction influence

Wind direction is a crucial parameter for the regional pollution as it indicates the origin of the air mass and the relative position of the measuring sites to the main pollution sources. Information on aerosols concentration size ranges a = (0.4-0.5) μm, b=(0.5-0.6) μm and c = (0.6-0.7) μm was processed. The level of air pollution was determined with respect to wind direction in the area.

This paper analyses the most frequent wind direction dependence of the particle size distribution, as it was noticed that aerosols charge in atmospheric air varies significantly with wind direction.
The experimental data were grouped in four predominant wind directions, as it follows: E~W, N-NW~S-SE, S-N and N-NE~S-SW. The plots below (fig. 4 -7) present the particles concentration distributions (in 1dm^3 of air) for the time period of 3 years and 2 months.

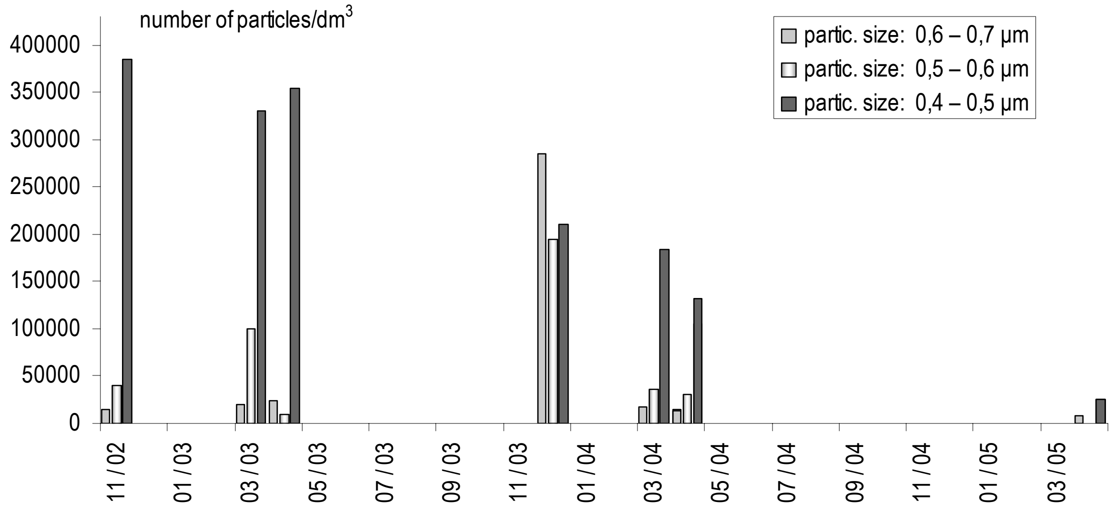


Fig. 17. *The variation of particle concentration (size range 0.4-0.7 μm), for wind direction E~W.*

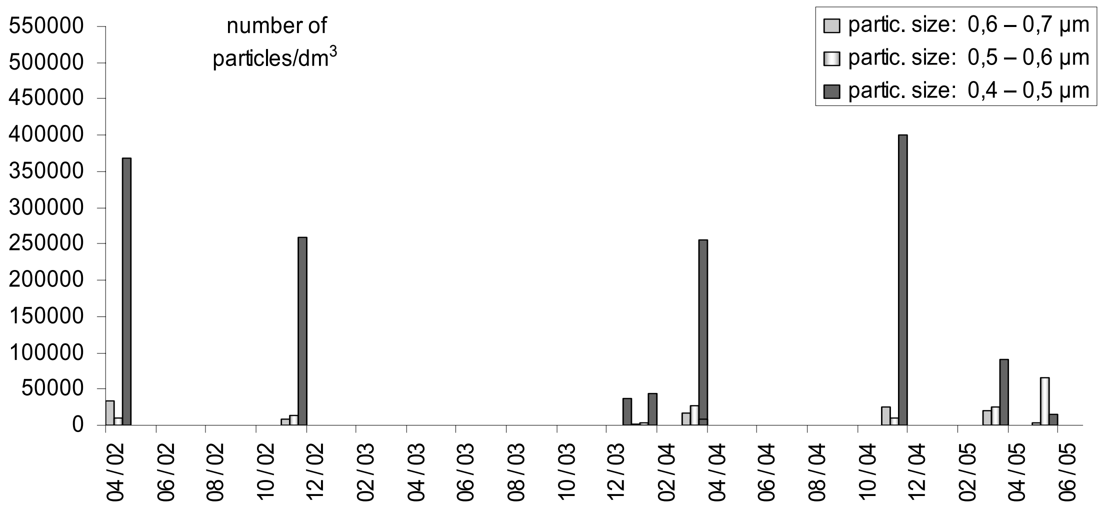


Fig. 18. *The variation of particle concentration (size range 0.4-0.7 μm), for wind direction N-NW~S-SE.*

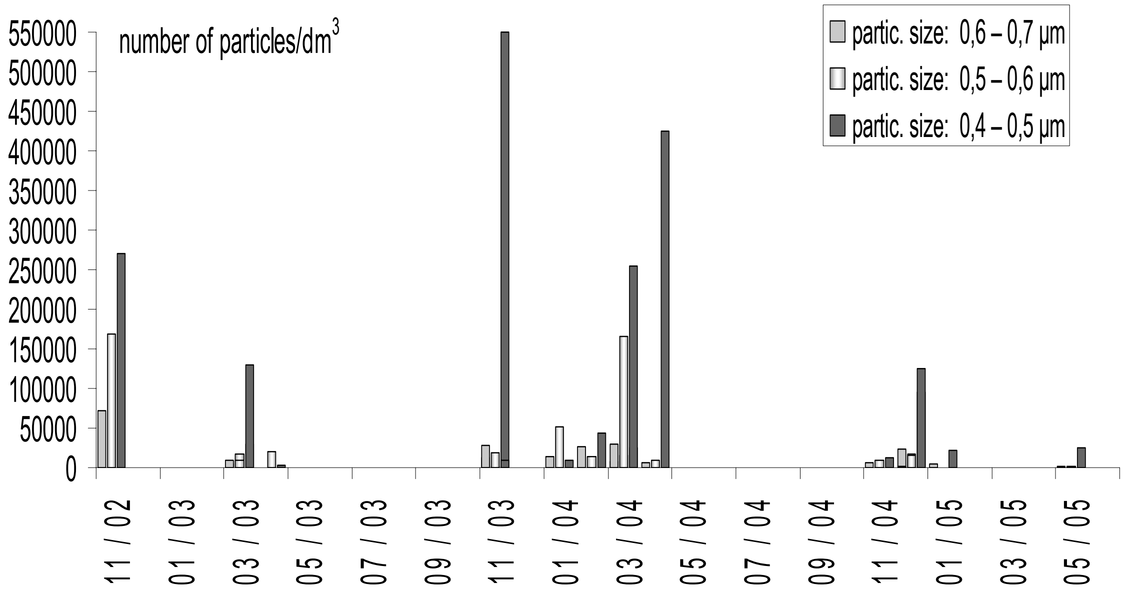


Fig. 19. *The variation of particle concentration (size range 0.4-0.7 µm), for wind direction S-N.*

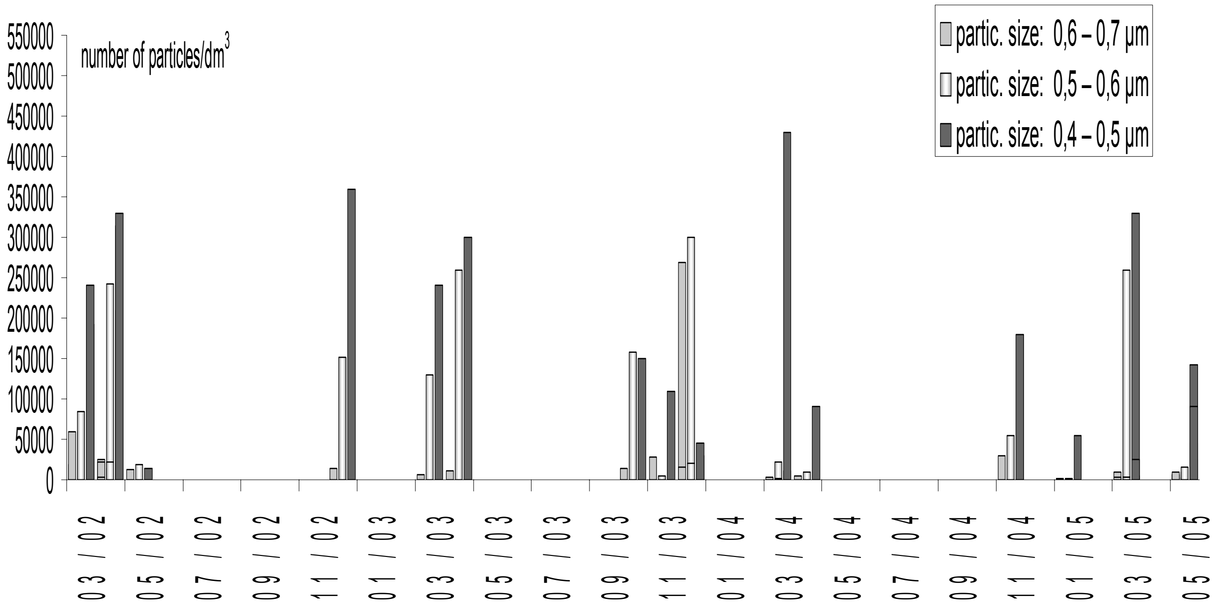


Fig. 20. *The variation of particle concentration (size range 0.4-0.7 µm), for wind direction E~W.*

4. Discutions

The results of the measurements performed show a temporary situation being influenced by factors with a random evolution in time: intensification of the traffic jam, temperature, pressure, wind speed and direction, humidity.

4.1. Influence of particles size range

The data concerning the number of aerosols, registered in the period April 2002 - May 2005 on granulometric classes, guide to following conclusions:

- The particles in 0.4-0.5 µm size range, were in most the cases around value of 400,000 particles/dm^3, but in November 2003 were registered maximum values of 500,000 particles/dm^3;
- To the particles in 0.5-0.6µm size range, were registered several cases around value of

300,000 particles dm^3, and the majority were below the value 50.000 particles/dm^3;

- The particles in 0.6-0.7µm size range, was in most the cases below the value 50 000 particles/dm^3, but in the first half of the month of December 2003 was registered values in the range 250 000 - 300 000 particles/dm^3;
- The particles in 0.7-0.8 µm size range, was bellow 50.000 particle/dm^3;
- The concentration' particles in 0.8-1.5 µm size range, was bellow 20,000 particule/dm^3;
- The particles in 1.5-2.0 µm size range, was in most the cases below 5 000 particule/dm^3, with exception of the first half of the month of December 2003 when was registered ~ 22 000 particles/dm^3 and the beginning of January 2005 when was registered ~ 24,000 particles/dm^3;
- The particles in 2.0-4.0 µm size range, was in most the cases below 5,000 particles/dm^3, with exception of the first half of the month December 2003 when was registered ~ 54,000 particles/dm^3 end the beginning of January 2005 when was registered ~ 26,000 particule/dm^3;
- The particles in 4.0-1.0 µm size range, was in most the cases in insignificant number (<1,000 particule/dm^3);
- As a general observation, after January 2005 the number of the aerosols in natural atmosphere registered important diminutions, below 150,000 particles dm^3, with a singular exception in March 2005, when were registered a growth to 300,000 particles/dm^3 for the particles in 0.4 - 0.5µm size range;

4.2. Influence of wind direction

The number of aerosols registered in the period April 2002 - May 2005 on the most frequently directions of the wind, guide to following conclusions:

1) About the variation of particles number (0.4-0.7 mm size range), for the East - West wind direction:

The particles in 0.4-0.5µm size range, registered the maxims values contained between 300,000 – 400,000 particles/dm^3 in the period November 2002 - April 2003;

- The particles in 0.5-0.6 µm size range and 0.6-0.7 µm size range had an maximum of 200.000 particles/dm^3, respectively 300,000 particles/dm^3 in December 2003;
- After these maximus, the values diminished constantly, and from April 2004 they were insignificant;

2) About the variation of particles number (0.4 - 0.7mm size range), for the Nord – Nord/West ~South/South/East wind direction:

- The particles in 0.4-0.5 µm size range, registered four maxims values in April 2002 of 350,000 particles/dm^3, November 2002 of 250,000 particles dm3, March 2004 of 250,000 particles/dm^3, November 2004 of 400,000 particles/dm^3. After this date the values diminished below 100,000 particule/dm^3;
- The particles in 0.5 - 0.7 µm size range were in insignificant number.

3) About the variation of particles number (0.4 - 0.7 mm size range), South - Nord wind direction:

- The particles in 0.4 - 0.5µm size range, registered four values maxims in November 2002 of 200,000 particles/dm^3, November 2003 of 450,000 particles/dm^3, April 2004 of 450,000 particles/dm^3;
- The particles in 0.5-0.6 µm size range, registered two values maxims in November 2002 of 200,000 particles/dm^3 and March 2004 of 150,000 particles/dm^3;
- In all other time aerosols number had registered insignificant values.

4) About the variation of particles number (0.4 - 0.7 mm size range), Nord – Nord/East~South-South/West wind direction:

- The particles in 0.4 - 0.5 µm size range, they registered the values maxims between 200,000 – 450,000 particles/dm^3 in March April 2002, December 2002, April 2003, March 2004, March 2005, in remainders the registered values were below 100,000 particles/dm^3;
- The particles in 0.5 - 0.6 µm size range, registered the values maxims of 250,000 particles/dm^3 in April 2002, December 2003, March 2005, in remainders the registered values were below 100,000 particles/dm^3;
- The particles in 0.6-0.7µm size range, registered the values maxims of 250,000 particles/dm^3 in December 2003, in remainders the registered values were below 500,00 particles/dm3.

5. Conclusions

- Emissions generated by Mittal Steel metallurgical plant, located in the neighborhood of Galati city, don't have significant influences on the pollution of the city, the circulation air flows from this direction is infrequently:

- The most large amount aerosols transported was registered on the N-NE~S-SW direction, characterized by the most active air flows;
- In the first semester of the year 2005 was ascertained a considerable diminution of the particle number, in 0.4 - 0.7μm size range, which demonstrates the efficiency of some environmental local actions.

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