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THE CHEMICAL AND MORPHOLOGICAL ANALYSIS OF URBAN DUST

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ABSTRACT. Dust samples needed for the research was put at our disposal in great amount by the DKCE power station of Debrecen. In the station dust filtration of air takes place in more steps, which provides us strained of on the coarse filters in the range of 2000 μm to 10 μm, while between 10 μm to 1 μm on the fine filters. Those particles that manage to get across the filter system can be collected by the off-line washing of the turbine area. This fraction will contain fragments which are particular concern to human health as they can not only get into the lung but can attach to the alveoli. Dust sample collected in the city centre, nearby a railway station and a congested vehicular bridge contains all the contaminants that are imposed on the inhabitants of a typical big city. It is established from the size range distribution of samples collected from the coarse filters that almost 90% of the particles are under 63 μm. We determined the chemical composition of dust by using highly sensitive analytical methods after setting aside the most appropriate sampling and preparatory processes. By the side of the inorganic components, dust samples contain pollen and smut particles in higher amount, as well as spherules.

Keywords: environment, urban dust, air pollutants

INTRODUCTION

Most of the contaminants emitted by human activities access into the atmosphere and the greater part of it sticks in the lower region of 1 km. We breathe in 10-25 m3 air of that region daily, thus any contaminants of it can easily get into our respiratory system (Radojevic-Miroslav, 1999). In the last few hundred years urbanization and industrialization contributed to the emission of air pollutants significantly, of which power plants, manufacturing plants, vehicles driven by internal combustion engines, airplanes and marine transport are the principal cause. Air pollution originating from industrial production and transport affect the inhabitants of urban areas primarily which is in correlation with the increased morbidity rate The natural processes accompanied by these human emissions are not only for the inhabitants of big cities a hazardous factor. This is a global environmental issue, which according to predictions involves the possibility to change the geographical features of the Earth.

Significant part of dust content of urban atmosphere is originated from traffic and transportation. Further sources are public heating, soil surface and particles carried by wind and precipitation (Ferguson et al., 1991; Miquel et. al, 1997).

We must pay attention particularly to the dust particles under 10 μm (PM 10) which have after inhalation due to the small particle size serious effect on health (Evagelopoulos et al., 2006). Recently we do not know such a low PM 10 concentration, which does not have harmful effect on health (Rudnai, 2006). The smaller the dust particle size is, the deeper can it get to the lung and more serious diseases can it cause. Furthermore, particles under 2,5 μm (PM 2,5) are more dangerous than PM 10. Epidemiologic studies have showed that several diseases are in correlation with high level urban dust concentration (Pope, 1991; Dockery et al., 1993; Schwartz, 1994; Pope, 2002). Thus the importance of study of PM 2.5 fraction has increased significantly, meanwhile the fractionated dust sampling necessarily evolved.

We are in a lucky position since compared to a common dust sampling; high amount of dust was available. The DKCE power station of Debrecen protects their turbines from dust with a complex filter system. In a 8-9 months period the air is continuously sucked through the filters, which means nearly 5000 working hours and the total collected dust constant of 2.8 billion m3 of air which is approximately 80 kg. There is no other way to collect such a great amount of dust sample from urban atmosphere for analytical studies. Furthermore the sampling is fractionated, since the coarse filters trap particles above 10 μm diameter, the fine filters provide samples in the range of 1-10 μm finally PM 1 which enters the turbine can be sampled by the off-line washing. The last two fractions are of great influence on health. Thus the filter system of the power plant is a kind of modeling of human respiratory system. We wanted to study with several analytical methods the physical and chemical properties and composition of the dust to describe what we inhale on a longer period.

MATERIALS AND METHODS

All measurements were carried out with analytical grade reagents.

For weight measurements we used Precisa 240 A analytical balance. For sample preparation we used Milipore 0.22 μm membrane filter. For ultrasonic shaking Transsonic 460/H devise was used. Samples from the coarse filter were fractionated with Ilmvac

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THYR2 type sieve shaking devise. Microwave assisted digestions were carried out in a MLS 1200 mega high pressure device with Teflon receivers.

For the elemental analysis of dusts we used Intrepid II XDuo-ICP-OES spectrometer, and the light scattering measurements were done on a Brookhaven Research System instrument. Transmission pictures were taken with JEOL 2000 FX-II transmission electron-microscope equipped with Oxford Link-Isis energy dispersive X-ray spectrometer. The reflexive studies were carried out with HITACHI S-4300 electron microscope.

RESULTS AND DISCUSSIONS

Particle size distribution

After the samples have been separated from the filters with a vacuum cleaner, we fractionated the dust into five groups with a vibrating sieving apparatus. After 20 minutes of shaking of 100 g dust we measured the weight of the fractions of each sheaves and we found that 88% of the total sample is under 63 μm in diameter. Since the further chemical and physical measurements were carried out with the fraction under 63 μm, all of the results can be considered representative to the total dust samples.

The particle size distribution of the dust in the washing solution of the turbine area was determined by light scattering and electron microscope as well. The light scattering studies showed us that the distribution is bimodal. 96% of the particles have a diameter of 105 nm, and the remained 4% are of 415 nm. The electron microscopic measurements confirmed these results. This remarkable suspension containing homo-dispersed nanoparticles could be capitalized for the preparation of standard dust materials.

Elemental composition of the dust sample

From the dust sample under 63 μm we digested about 1 gram portion with exactly known weight in concentrated nitric acid and determined the concentrations of 19 most common elements with ICP-OES. As a blank we digested a small piece of the pure filter and subtracted the concentrations from the sample concentrations. In the case of fine filters we could not separate the dust from the filter, thus we cut out a small piece and digested it in concentrated nitric acid. As a blank we digested a small piece of the pure filter and subtracted the concentrations from the sample concentrations. We replicated each measurements 3 times, the standard deviation was under 3 % at all times. The results are shown in Table 1.

To be more illustrative, in Fig. 1 it can be observed the elemental distribution of 7 elements between the coarse fraction and the fine fraction.

In the last five years we have determined annually these concentrations and as you can see in Fig. 2 the chemical composition of the dust fraction under 63 μm practically have not changed.

Morphological study of dust fraction under 63 μm

By the electron microscopic study we wanted to know the shape of the dust particles and morphological properties of the other components. Pictures of some characteristic components are shown in Fig 5-7.

The most spectacular particles are the pollen particles (Fig. 3.) and the spherules (Fig. 4). Spherules originate most probably from the universe and they can be found in the dust of Earth in great amount. We found a well developed gypsum crystals (Fig. 5) as well.

Table 1

Concentrations of same common elements in the dust from the fraction below 63 μm

Determined elements	Coarse filter <63 μm (mg/g)	Fine filter (mg/g)
Al	14.10	14.95
As	0.03	0.20
Ca	32.33	34.8
Cd	0.00	0.02
Co	0.01	0.00
Cr	0.10	0.07
Cu	0.32	0.17
Fe	31.9	5.23
K	4.52	16.45
Mg	4.96	8.16
Mn	0.56	0.11
Mo	0.02	0.04
Na	7.48	116
Ni	0.04	0.05
Pb	0.21	0.77
S	13.0	50.6
Sn	0.01	0.04
Sr	0.11	0.17
Zn	0.80	0.25

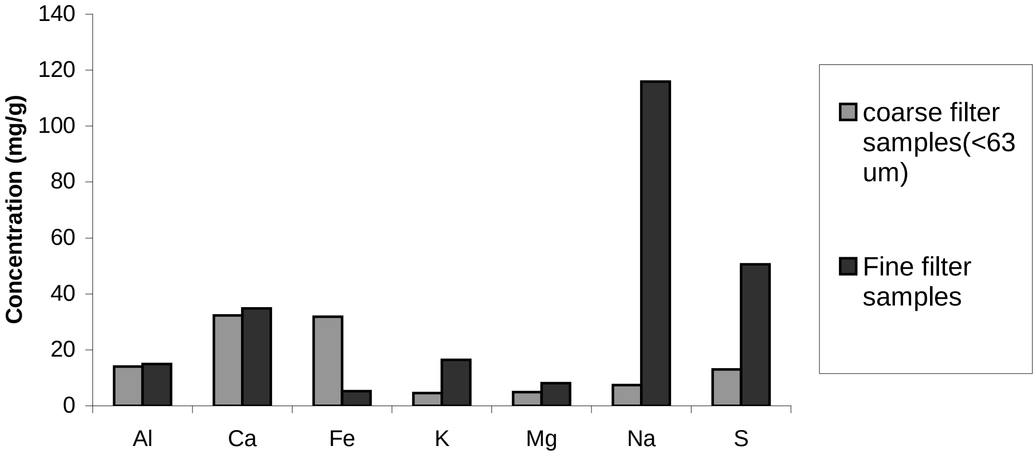

Fig. 1 Element concentration in dust sample of coarse and fine filter

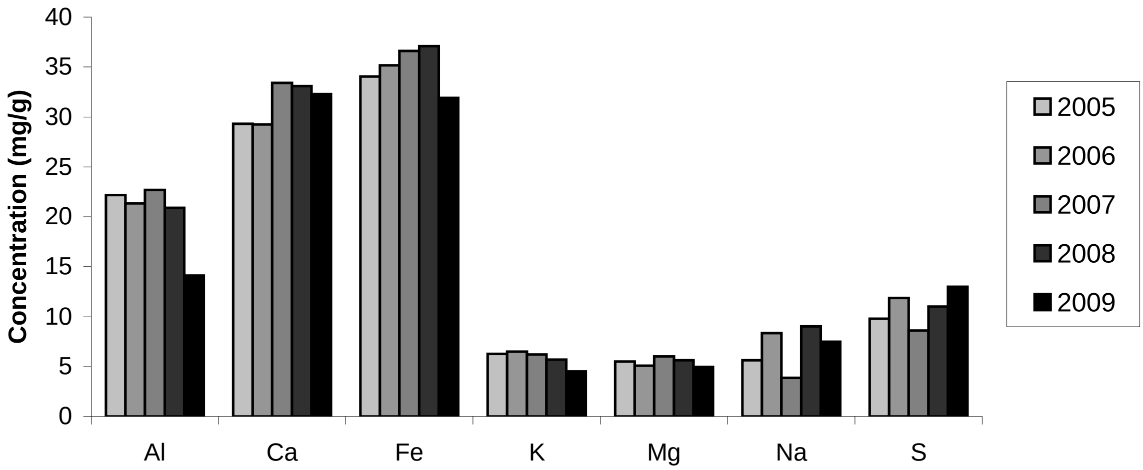

Fig. 2 Chemical composition of dust samples under 63 μm in the last five years

Analytical study of washing solution

The chemical and physical properties of this ultrafine dust fraction is significantly differ from the other two fractions. Each compound have a well defined crystal structural and according to the average size of the crystals they are enriched in different fraction. We have determined the elemental distribution of this fraction under 1 μm as well with ICP-OES after a nitric acid digestion and compared the results to the other two fraction. Some elements are shown in Fig. 6. As you can see the concentration of chromium, nickel and lead is significantly greater in the washing solution. The concentration of iron is even higher. Further investigations pointed out that the washing solution can withdraw some of the structural material of the turbine resulted from the abrasion. Nevertheless this fraction is still valuable.

Morphological study of washing solution

For the transmission electron microscopic shooting the suspension was dropped on a microscopic slide. After the suspension was dried, the particles formed aggregates, although the individual particle was detectable. One picture taken from these aggregates is shown in Fig. 7.

The results confirm the particle size measurements by light scattering.

CONCLUSIONS

As a conclusion we can state that we managed to describe the chemical and morphological properties of urban dust of Debrecen. The filter system of the power station represents the respiratory system of human body. The average concentration of the toxic elements related on a year is under the permitted level. The chemical composition of dust has been relatively constant in the last five years.

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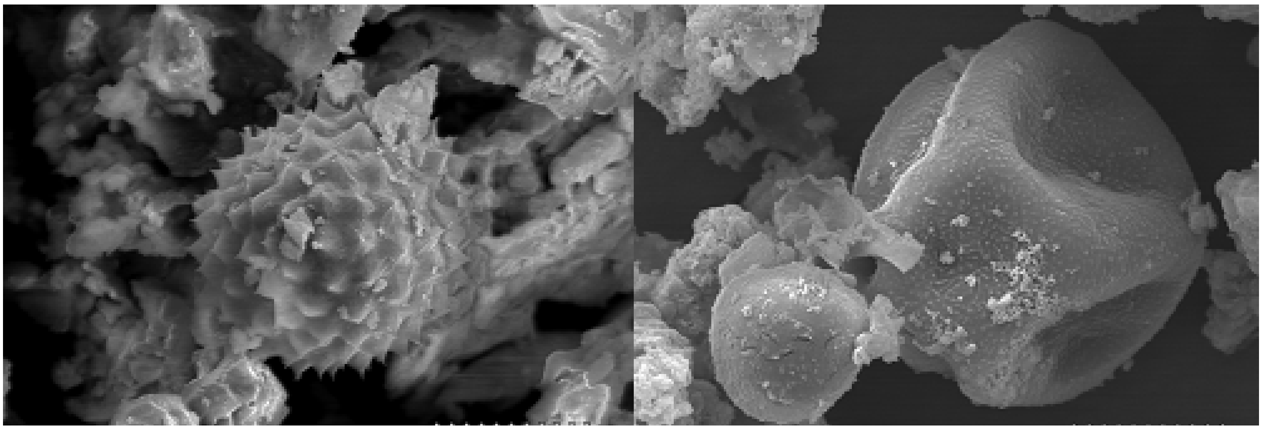

Fig. 3 Pollen particles

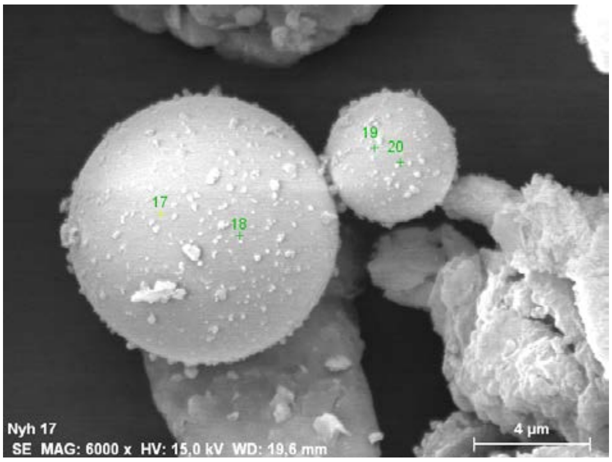

Fig. 4 Silicate containing spherules

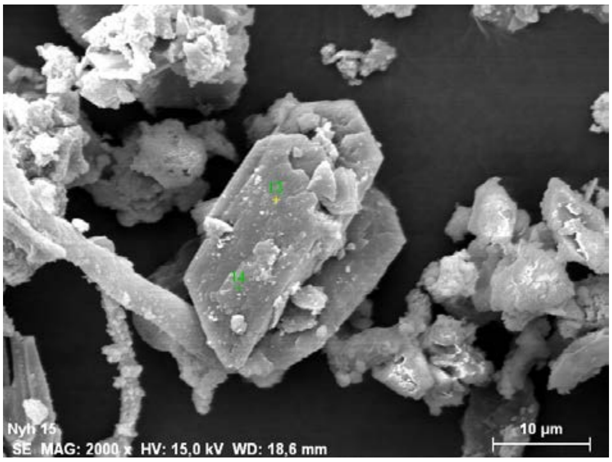

Fig. 5 $CaSO_4 \cdot 2H_2O$ (gypsum) crystals

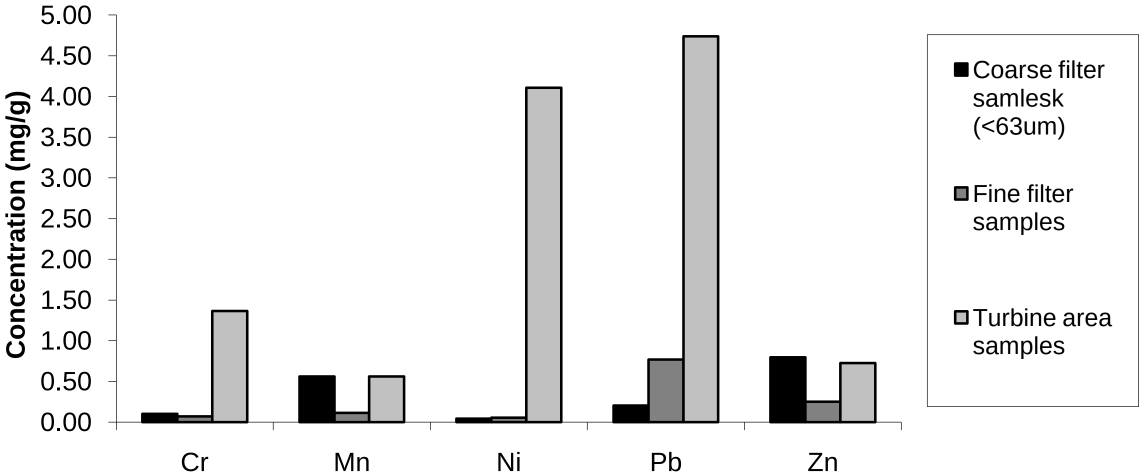

Fig. 6 Elemental distribution between the three fractions

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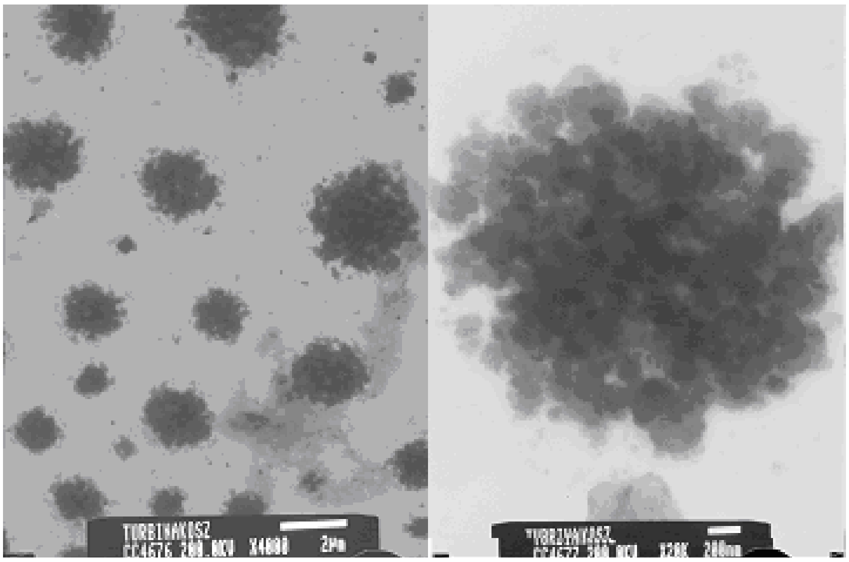

Fig. 7 Electron microscopic picture of particles after the drying of the washing solution

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