Elemental analysis of aerosols using PIXE method

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Abstract. In the present work we have analyzed aerosols deposits on filters from ten Romanian towns: Pitesti, Giurgiu, Resita, Ramnicu-Valcea, Baia-Mare, Craiova, Timisoara, Calarasi, Braila and Arad with different kinds and levels of industrial development by PIXE method using Yttrium like internal standard because it is a very rare element in the environmental items. We have identified 15 elements: S, K, Ca, Cr, Ti, V, Mn, Fe, Co, Ni, Cu, Zn, As, Hg and Pb. The measured elemental concentrations are given with respect to the concentration of the Ca for all analyzed samples. The obtained results can put in evidence a high ratio of Ti/Ca, Cr/Ca, Fe/Ca, Co/Ca, Zn/Ca, As/Ca, Pb/Ca in Craiova, a high ratio of Mn/Ca in Calarasi and a high ratio of Hg/Ca in Braila. Certainly the level of pollution of a region can not determine by a single filter and is need of a good statistic to draw conclusions.

1. Introduction

Environmental pollution remains an important issue, for both the population and the economic and political decision factors in all countries throughout the word are them developed or developing countries.

Huge efforts are made for the environmental pollution monitoring and control [1-2], especially in industrialized countries, and the achievements are sometimes impressive.

The small territory of Romania is affected by different pollutants: the chemical industries, iron and steel smelter, coal mining and thermal power stations, cement factories, the automobile traffic, the use of pesticides and fertilizers so, it is vital to know the atmospheric deposition of heavy and toxic elements in air and to quantify these using analytical method;

The aim of the present study was to determine levels of trace elements in aerosols from different Romanian towns using Particle Induced X-ray Emission (PIXE) method [3].

2. Experimental procedure

2.1. Sampling and samples preparation

We have analyzed aerosols deposits [4] on filters from ten Romanian towns (figure 1): Pitesti, Giurgiu, Resita, Ramnicu-Valcea, Baia-Mare, Craiova, Timisoara, Calarasi, Braila and Arad with different kinds and levels of industrial development.

Sample targets were collected by the Institute of Hydrology and Waters of Bucharest and prepared in the following manner - aerosol particles were collected on cellulose fiber filter. The flow rate was...
15 to 20 liters per minute. Air volume was measured with calibrated gas-meters with a precision of about 5%.

![Romania sampling map](image)

**Figure 1. Romania sampling map**

### 2.2. Analysis

PIXE measurements of target elements were made using a 3 MeV proton beam extracted from the Tandem Accelerator FN-8 of the National Institute of Nuclear Physics – Horia Hulubei of Magurele, Bucharest.

X-ray spectra were measured with a spectrometric chain with a CANBERRA Ge hyperpure detector with a 160 eV resolution at 6.4 KeV of Kα line of iron.

The X-ray spectrum analysis were made off-line, at Valahia University of Targoviste, using LEONE fitting programs. We use Yttrium like an internal standard because it is a very rare element in the environment items. The intense peaks of Yttrium in the X-ray spectrum could obscure the peaks of some elements possible existing in the samples: L and K lines of Yttrium overlap SKα and (Rb and Sr) K lines respectively. Therefore we have analyzed targets without Yttrium too and we have not observed any new elements. A sample of Yttrium on filter was measured too. Weak impurities of Ca, Fe and Zn were found. Concentrations of elements present in the aerosol samples were corrected for these impurities of the filter.

### 3. Experimental results

We have identified 15 elements: S, K, Ca, Cr, Mn, Fe, Co, Ni, Cu, Zn, As, Hg and Pb.

The measured elemental concentrations are given with respect to the concentration of the Ca for all analyzed samples (table 1).
# Table 1. The elemental concentrations with respect to the concentration of the Ca for all analyzed samples

| City/Element | Pitesti | Giurgiu | Resita | Rm. | Valcea | Baia | Craiova | Timisoara | Calarasi | Braila | Arad |
|--------------|---------|---------|--------|-----|--------|------|---------|-----------|----------|--------|-----|
|              |         |         |        |     |        |      |         |           |          |        |     |
| **Concentration (ppm)** |         |         |        |     |        |      |         |           |          |        |     |
| S            | 0.112   | nd'     | nd'    | nd' | nd'    | nd'  | 0.02    | nd'       | 0.012    | 0.047   |     |
| K            | 0.57    | 0.272   | 0.122  | nd' | 0.052  | 2.51 | 0.2     | 0.26       | 0.174    | 0.36    |     |
| Ca           | 1       | 1       | 1      | 1   | 1      | 1    | 1       | 1          | 1        | 1      |     |
| Ti           | 0.14    | 0.05    | 0.019  | 0.063| nd'    | 0.505| 0.15    | 0.66       | 0.017    | 0.04    |     |
| V            | 0.018   | nd'     | nd'    | 0.012| nd'    | nd'  | 0.052   | 0.35       | 0.012    | 0.006   | 0.01 |
| Cr           | 0.002   | 0.007   | 0.003  | 0.007| nd'    | 0.035| nd'     | 0.012      | 0.006    | 0.001   |     |
| Mn           | 0.027   | 0.014   | 0.021  | 0.017| 0.006  | 0.05 | 0.007   | 0.078      | 0.024    | 0.017   |     |
| Fe           | 1.09    | 0.49    | 0.532  | 0.647| 0.075  | 5.38 | 0.52    | 4.32       | 0.28     | 0.58    |     |
| Co           | nd'     | nd'     | nd'    | nd' | nd'    | .015 | nd'     | nd'        | nd'      | nd'     |     |
| Ni           | 0.009   | nd'     | nd'    | 0.006| nd'    | nd'  | nd'     | nd'        | nd'      | nd'     |     |
| Cu           | 0.004   | nd'     | nd'    | 0.001| 0.021  | 0.089| nd'     | 0.001      | 0.008    | 0.002   | 0.003|
| Zn           | 0.012   | nd'     | nd'    | 0.019| 0.023  | 0.033| 0.036   | 0.002      | 0.015    | 0.004   | 0.011|
| As           | nd'     | nd'     | nd'    | 0.004| 0.004  | 0.005| nd'     | nd'        | nd'      | nd'     | 0.001|
| Hg           | nd'     | nd'     | nd'    | nd' | nd'    | nd'  | 0.001   | nd'        | 0.003    | 0.003   |     |
| Pb           | nd'     | nd'     | nd'    | 0.006| 0.075  | 0.043| nd'     | 0.005      | 0.002    | 0.0003  |     |

*nd – not detected

## 4. Conclusions

The results obtained permitted to make preliminary comparison (figure 2, figure 3) between the analyzed filters from all the towns considered in our work, from the point of view of the pollutant elements:

- The town Craiova is put in evidence by its high ratios of concentrations Ti/Ca, Cr/Ca, Fe/Ca, Co/Ca, Zn/Ca As/Ca, Pb/Ca.
- Calarasi has the highest ratio of Mn/Ca and the filter from Braila is put in evidence by the Hg/Ca.

Certainly the level of pollution of a region can not be determined by a single filter and is need of a good statistic to draw conclusions.

All elements in atmospheric particles are potentially important. All elements contribute tot the mass of atmospheric particles. Many elements are potentially toxic and analyzing separately for each by PIXE method together with mass measurements is necessary.

The concentration of Mn, Fe, Zn, Pb element depend on the direction of wind, so it’s necessary to complete our study with measurements of wind direction and size aerosols determination.
Figure 2. The elemental concentrations in aerosols from Romania towns

Figure 3. The elemental concentrations with respect to the concentration of the Ca in aerosols from Romania towns.

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