

*Mariola JABŁOŃSKA¹, Wiesława Ewa KRAWCZYK², Grażyna BZOWSKA¹,
Marzena BARCZYK²*

INTERACTIONS BETWEEN RAINFALL AND ATMOSPHERIC DUST IN POLLUTED REGION, PRELIMINARY RESULTS FROM SOSNOWIEC

INTRODUCTION

Since 1989, when analyses of atmospheric precipitation in Sosnowiec has been started (Leśniok, 1996) the decreasing trend in precipitation pH is observed; lately average yearly pH has fallen down below 4 (pH=3.71 in 2000 and pH=3.61 in 2001). Silica concentrations in rainfall have shown that aggressive precipitation dissolves not only calcium carbonate particles but also aluminosilicate and silicate minerals (Krawczyk and Chrupała, 1999). Studies of atmospheric dust in Sosnowiec have been performed since 1994 (Rietmeijer and Janeczek, 1997). Components in falling and suspended dust have been distinguished (Maneck et al. 1988, 1991, Jablonska 2000, Jablonska and Janeczek 2000, 2001). On July 17-27, 2001 during only twelve days 133.3 mm of rain has fallen, 87% of the monthly total. The stagnant synoptic situation during these days has given the possibility to detect local sources of gaseous and particulate pollution of air. This first attempt to combine rainfall chemistry and dust mineralogy resulted in the project on complex research of inorganic and organic components in atmospheric precipitation together with aeromineralogy (i.e. mineralogy of atmosphere) in single precipitation events that has been started in 2002.

EXPERIMENTAL

Nine rainfall events have been sampled on July 16-27, 2001 in Sosnowiec. Samples were collected using polypropylene funnel with area of 0.25 m², situated at the height of 2 meters above the ground in the meteorological plot of Department of Climatology, some 200 meters from the Faculty of Earth Sciences building (50°17,912' N 19°07,968' E). Immediately after sampling measurements of pH (with Elmetron CP-315 meter) and specific electric conductivity (with Elmetron CC-318 meter) were made. Sub samples were filtered on 0.45 μm cellulose acetate membrane filters in a glass filtering system. Concentrations of Cl⁻, SO₄²⁻ and NO₃⁻

¹ *Katedra Geochemii, Mineralogii i Petrografii, Wydział Nauk o Ziemi UŚ, 41-200 Sosnowiec, ul. Będzińska60, e-mail: mjablons@us.edu.pl*

² *Katedra Geomorfologii, Wydział Nauk o Ziemi UŚ, 41-200 Sosnowiec, ul. Będzińska60, e-mail: wkraw@us.edu.pl*

were determined by ion chromatography, using a Metrohm IC 761 instrument. The concentrations of Ca^{2+} , Mg^{2+} , Na^+ and K^+ were determined by atomic adsorption spectroscopy (AAS) with Solaar M6 instrument. Before cation analysis samples were acidified with HNO_3 . Concentrations of dissolved silica were determined by spectrometry using the method of reduction to molybdenum-blue (Krawczyk, 1996).

Dust samples collected on filters have been analysed by X-ray powder diffraction on Philips PW 3710 instrument (with CoK_α radiation) and by scanning electron microscopy method (SEM) on Philips XL30 TMP microscope equipped with Sapphire EDS, in environmental mode.

RESULTS AND DISCUSSION

Stagnant masses of polar-marine air have dominated over the region on July 18-31, 2001. It was very special synoptic situation because air masses arrived from N and NE, such circulation makes only 6%. Typical for Upper Silesia region is circulation from W and NW, it makes 29%.

Specific conductivity of rainfall samples was in the range 9.1-70 $\mu\text{S}/\text{cm}$, pH in between 3.66 and 4.55 (with mean v/v pH=4.01). Ranges of ion concentrations are wide in the case of anions (Table 1) and anions dominate over four cations analyzed, showing that NH_4^+ is most probably present in rainfall.

Table 1. Range of ion concentrations in rainfall (in mg/l).

	Ca^{2+}	Mg^{2+}	Na^+	K^+	SO_4^{2-}	NO_3^-	Cl^-	SiO_2
Min	0.17	0.06	0.11	0.07	2.70	0.50	0.99	0.00
Max	1.11	0.70	0.59	0.49	24.14	5.40	4.25	0.23

The highest concentration of sulphate (24.14 mg/l) was found in rainfall on July 21/22. Concentration of nitrate is much lower but the highest NO_3^- content is more than ten times higher than in Hornsund on Svalbard (Krawczyk et al. 2002).

Marine components have been subtracted according to procedure described in Krawczyk et al. (2002). In result it has been found that chlorides in rainfall are of anthropogenic origin, probably from dissolution of gaseous HCl. Anthropogenic chloride made from 70% (Jul 24/25) to 95% (Jul 17/18) of total chloride concentration. Only in the rainfall on July 21/22 silica was not detected. The lowest concentration of SiO_2 (0.05 mg/l) was detected in the highest rainfall (29.9 mm) on July 17/18.

In all dust samples analysed the following minerals and elements have been found: quartz, aluminosilicates with K, Mg, Fe, Ca, Na; clay minerals: kaolinite and chlorite, feldspar and mica. Other components were different in following rainfall events. Results are summarised in Table 2.

The most interesting is sample no 4 containing numerous AgCl particles (chlorargyrite) shown on Fig. 1. These particles have been also found in dust

collected during rainfall on July 24/25 but in smaller quantities. Traces of AgCl have been even found in sample no 6. Air exchange system of photographic laboratory could supply AgCl particles to the air.

Table 2. Mineralogical composition of atmospheric dust samples.

No	Date	Description
1	July 17/18	Aluminosilicate particulate dominates over quartz, mica and feldspar; graphite and iron oxides also present
2	July 19/20	Aluminosilicate particulate dominates over quartz, mica and feldspar; graphite and iron oxides also present
3	July 20/21	Quartz, Na-feldspar, aluminosilicates with Ti, Ca, Mg, Fe, Fe oxides
4	July 21/22	AgCl (chlorargyrite), polyphase particles containing sulphur, Ti, Fe, K (fig. 2), iron and Zn oxides
5	July 24/25	AgCl (trace), quartz, clay minerals, Na and Ca feldspar, iron oxides, traces of calcite and syderite
6	July 25/26	Aluminosilicates with K, Fe, Na and Mg, traces of ZnS, Bi, Cu, traces of gypsum, sporadic AgCl
7	July 26/27	Aluminosilicates with K, Fe, Na and Mg, iron oxides
8	July 27	Aluminosilicates with K, Fe, Na and Mg

Phases of atmospheric dust in rainfall events no 6, 7 and 8 had more amorphous character. Aluminosilicate particles characteristic for coal combustion (probably from power station “Będzin” situated in the close vicinity) have been observed also. Graphite particles found in the dust most probably origin from electric engines in tramways.

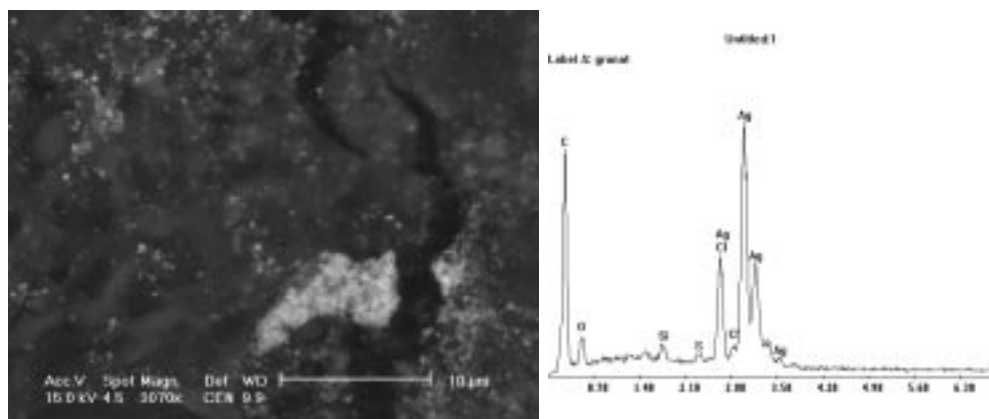


Fig. 1 AgCl particles (white points) in sample no 4 with EDS spectrum.

Sample no 4 is also the only one containing polyphase particles with sulphur, Ti, Fe and K (Fig. 2).

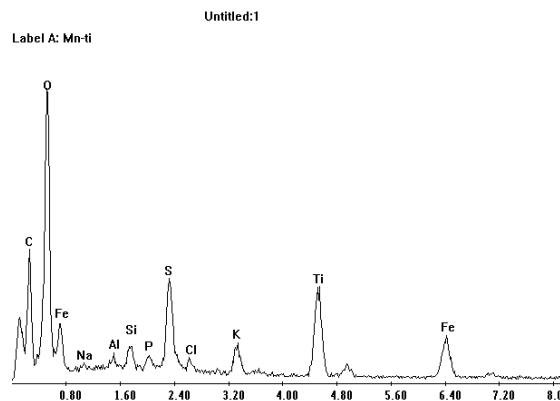


Fig. 2. EDS of dust particles containing Ti, Fe, S and K (sample no 4).

CONCLUSION

Dust particles washed out with rainfall like quartz, clay minerals, mica and feldspars are of natural origin. Particles of calcite or dolomite have been dissolved in this acid rain (pH<4), crustal Ca^{2+} and Mg^{2+} found in rainfall can show for this origin. Plot of silica concentrations in relation to total of crustal cations shows some relation for five rainfall events, rainfall from July 19/20 and July 27 is out of this plot. This confirms that dissolution of aluminosilicate minerals takes place in falling aggressive rain. Particles of anthropogenic origin are also present. Graphite and AgCl particles are most probably of local pollution.

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