Characterization and transport processes of selected elements associated with atmospheric PM_{10} in the Arctic region (Ny-Ålesund, Svalbard Islands)

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The chemical composition of atmospheric aerosol is tightly connected to the impact of particulate matter on human health and, at a larger scale, on the ongoing climate changes.

The Arctic regions are showing to be the most sensitive areas to the present climatic variations. Consequently, the study of the chemical composition of atmospheric aerosol in the polar areas is important to understand the feedback processes between the climate forcing and the environmental responses (Arimoto *et al*., 2004).

In this study, the concentrations of main and trace metals in the PM_{10} collected at Ny-Ålesund (Svalbard Islands) during the spring and summer 2010, 2011 and 2012 campaigns were determined.

The results obtained show an evident seasonal pattern in the temporal profiles of the majority of the chemical components in the PM_{10}, that show higher atmospheric concentrations in March-April. In particular, we have found this seasonal trend for typically crustal elements, such as Al, Fe, Mn, REEs and Ti, and some anthropogenic elements, namely As, Cd, Pb and Zn. The most likely explanation for this trend is the influence of continental sources on the composition of the Arctic PM_{10}. Indeed, Svalbard Islands are affected by aerosols coming from desert and/or anthropized continental areas by long range transport processes, especially occurring in early spring (Gong and Barrie, 2005). Markers of sea spray aerosol, such as K, Mg and Na, and heavy metals typically correlated with ship emissions, such as Co, Ni and V, are characterized by higher concentrations in late spring and summer (Zhan *et al.*, 2014).

Principal Component Analysis shows an evident separation between spring and summer Arctic PM_{10} samples. Factor Analysis identifies four factors: F1 – geogenic source (Al, Fe, Mn, REEs with exception of Ce, Ba and Ti); F2 – sea spray source (K, Na and Mg); F3 – combustion processes source (As, Cd, Co, Ni, V, Pb and Zn); F4 – wear-related source (Cu, Zn and Ce). Dendrogram, calculated by Hierarchical Cluster Analysis (Q-mode), evidences a strong similarity among Al, Mn, Ti e Fe, as expected for metals mainly coming from crustal sources; among Na, Mg and K, markers of sea spray aerosol; among As, Cd and Pb, ascribable to long range transport of pollutants from anthropized areas in North America and Northern Europe; among Co, Ni and V, likely related to emissions from fossil fuel, coal and heavy oil combustion processes, and among Cu, and Zn, likely related to local road dust resuspension.

The enrichment factors (Table 1), calculated considering Fe as crustal reference, are higher than 100 for As, Cd, Cu, In, Mo, Na, and Zn, pointing out their different origin (anthropic and sea spray sources).

Table 1. Enrichment Factors.

Element	EF	Element	EF
Al	0.42	La	1.40
As	131	Mg	24.2
Ba	1.54	Mn	1.35
Ca	15.3	Mo	133
Cd	1390	Na	212
Co	6.77	Ni	69.0
Cu	292	Pb	44.8
Fe	1	Ti	0.56
In	185	V	23.9
K	9.86	Zn	176

Finally, we have applied a one-way ANOVA (Tukey HSD test; $p = 0.05$) on all the element concentrations determined in PM_{10} samples collected during 2010, 2011 and 2012 campaigns. We found that the average concentrations of the PM_{10} samples in 2011 are statistically different from 2010 and 2012 for most of the elements. A thorough analysis of back trajectories and weather variables along the whole sampling period will be useful to explain this difference.

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