PM2.5 and PM1 from urban, rural and a remote site in North of Italy: different contributing sources and biological effects

M. G. Perrone[1], B. Larsen[2], M. Gualtieri[1], L. Ferrero[1], G. Sangiorgi[1], G. De Gennaro[3], R. Udisti[4], E. Bolzacchini[1] and M. Camatini[1]

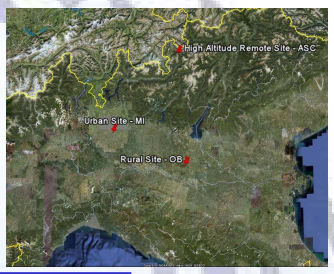
[1]POLARIS Research Center, University of Milano Bicocca, P.zza della Scienza 1, 20126 Milan, Italy
[2]European Commission Joint Research Center, IHCP, Via E. Fermi 2749, Ispra (VA) 21020, Italy
[3]Department of Chemistry, University of Bari, Via Orabona 4, 70126 Bari, Italy
[4]Department of Chemistry, University of Florence, Via della Lastruccia 3, 50019 Sesto F.no, Florence, Italy

grazia.perrone@uimib.it

SAMPLING SITES

PM1 and PM2.5 were sampled over two years (2007/2009) in three sites located in the North of Italy: an urban (Milan-MI; 45°31'19"N, 9°12'46"E), a rural (Oasi Bine-OB; 45°08'40"N, 10°26'08"E) and a high altitude remote site (Alpe San Colombano-ASC, m.2280 a.s.l; 46°27'18"N 10°18'50"E).

Daily samples were collected through a low volume gravimetric sampler (38,33 l/min): daily filters were pooled together to obtain representative samples for seasons (spring, summer, fall and winter), and analyzed for chemical composition and biological effects.



PM1 AND PM2.5 MAIN CHEMICAL COMPOSITION

Chemical analysis were performed to determine organic carbon (OC), elemental carbon (EC), inorganic ions and elements.

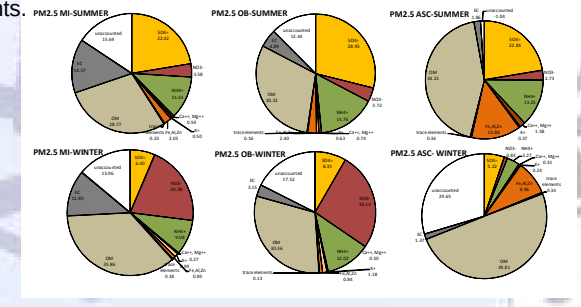


FIG.1 PM2.5 main chemical composition (%) for the three sites (MI, OB e ASC) in summer and winter.

ORGANIC MOLECULAR MARKERS

OM was chemical speciated for:

- -n-alkanes (C20-C32)
- -C2-C5 mono and dicarboxylic acids
- -levoglucosan
- -polyciclic aromatic hydrocarbons (PAHs) v

Carboxylic acids are mainly linked to secondary formation: in summer they account 8-10% of organic matter (OM) in PM2.5 (Fig.2). Primary trace organic pollutants like n-alkanes and PAHs have higher concentrations during winter. Levoglucosan is the main trace organic compound in winter (3.2% in MI).

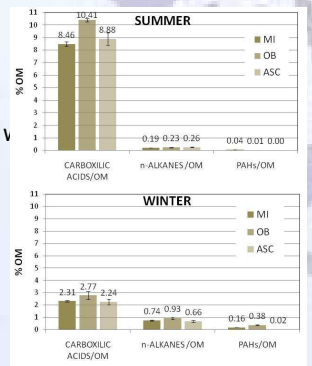


FIG.2 Trace organic compounds as a % of organic matter (OM) in PM2.5 samples

PM2.5 SOURCE ESTIMATION

Results from PM chemical composition were used for a source apportionment study by chemical mass balance (CMB 8.2, EPA). CMB computations indicate that the secondary aerosol components, ammonium nitrate and ammonium sulphate are the main source for sites in the plane, MI and OB (29 % to up 49% of PM2.5 mass in all seasons). Traffic is a primary PM source with higher values in MI, where it is estimated up to 30% of PM2.5. Wood burning contribute to 27-30% of winter fine PM in the plane.

A tendency for the CMB to underestimate PM levels is observed, 30% of PM2.5 unaccounted. It indicates that a significant source has not been considered in the study (e.g. secondary organics). In ASC the unaccounted PM2.5 concentrations were up 69% in winter, when the high altitude remote site of ASC is in the free troposphere.

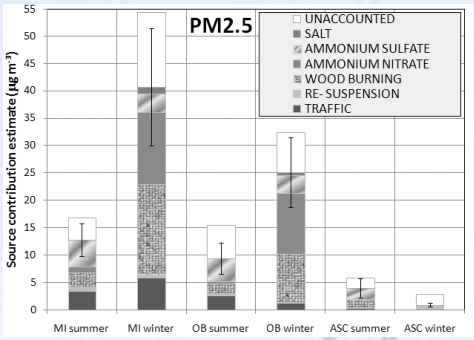
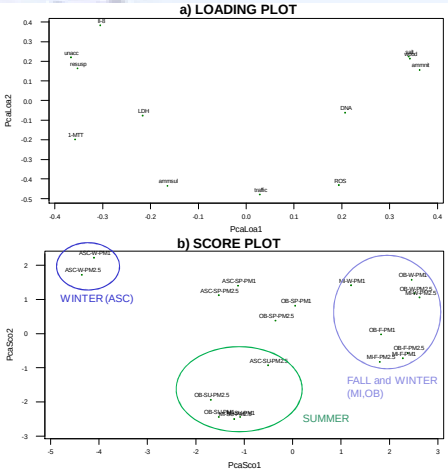


FIG.3 PM2.5 source contribution estimate (µg m^{-3}), and standard error, for the three receptor sites (MI, OB e ASC) in summer and winter.

RELATION BETWEEN SOURCE AND BIOLOGICAL EFFECTS OF FINE PMs



Biological effects of fine PM have been investigated by *in vitro* tests on the human lung carcinoma epithelial cell line A549 (Gualtieri et al., 2010). Cell viability reduction (1-MTT), IL-8, ROS, LDH and DNA damage were tested.

Multivariate analysis (PCA) has been applied to study the relationship between biological responses (cell exposure = 6 mg cm^{-2}) and PM sources (as contribution% to total PM mass).

In the score plot (Fig. 3b) all summer samples (SU) are grouped together in the down side (negative PC2 values). PM samples from summer are characterised by ROS formation and high cell viability reduction (1-MTT) (loading plot, Fig.4a) compared to other seasons.

With regards to PC1, 2 cluster are showed for fine PM samples of the cold seasons (fall F and winter W): MI and OB on the up right side of the plot (positive PC1 values) and ASC remote site on the up left side.

FIG.4 Loading (13 variables: 5 biological responses and 7 sources) and score plots (19 samples) from PCA. PC2 versus PC1 (60% of the variance explained)

CONCLUSION

Results suggest as secondary products of summer photochemical reactivity (e.g. ammonium sulphates, but also carboxylic acids or others..) would have a role in inducing cell viability reduction for fine PM from the North of Italy in summer. DNA damage was higher for fine PM samples from the plane in the cold season, when the contribution of wood burning was significant. Some biological effects were surprisingly high in ASC during winter (e.g. Inflammatory response IL-8), where fine PM samples had a high mass contribution of elements (11-13% of PM mass).

References

Gualtieri M., et al (2010). Toxicology in vitro 24, pp. 29-39

Perrone M.G. et al., (2010). Chemosphere 78, pp.1368-1377

ACKNOWLEDGMENTS. *This work was supported by Lombary Region (VESPA project), by ASI (QUITSAT project) and by Fondazione Cariplo (TOSCA project)*