Physicochemical characteristics, mutagenicity, genotoxicity and clastogenicity of atmospheric aerosols under industrial and rural influence

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Keywords: Atmospheric aerosols, physicochemical composition, genotoxicity, air pollution.
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Particulate matter (PM) toxicity occurs primarily by fine and ultrafine particles due to their physical and chemical characteristics. Although exposure to air pollution and especially to fine particulate matter ($PM_{2.5}$) is defined as carcinogenic to humans, toxicity mechanisms and particularly genotoxic pathways are not fully identified (Loomis *et al.*, 2014). Therefore, the identification of the physiological mechanisms showing the carcinogenicity of PM is crucial in order to aware the population of the harmful effects of air pollution. The industrial sampling site is affected by several sources of pollution: cement factories and quarries, phosphate fertilizer industry, transport section, and human activities.

The aim of this project was to study genotoxicity mechanisms involved in the carcinogenicity of $PM_{2.5}$. After sampling of atmospheric particles, physicochemical analyses were performed and several parameters were studied in order to identify potential biomarkers of exposure to atmospheric particulate matter and effects associated with early events in carcinogenesis (cytotoxic, genotoxic and epigenetic effects).

Particles sampling was done by cascade impaction on two sites under industrial and rural influence in Northern Lebanon. The size distribution and morphology of the fine rural (FP-R) and industrial particulate (FP-I) were characterized by laser diffraction and scanning electron microscope with energy dispersive X-ray analysis (SEM-EDX). The inorganic composition of the sampled particles was determined by both Inductively Coupled Plasma-Mass Spectrometry (ICP-MS) and Atomic Emission Spectroscopy (ICP-AES). The ionic composition was determined by ion chromatography, the organic composition by GC/MS and the elemental analysis was performed by the CHNS method. Metals, ions and carbon characterization showed the presence of markers of cement factories activities and production of phosphate fertilizers, such as Ca^{2+}, Mg^{2+}, K^{+}, PO_4^{3-}, and SO_4^{2-} higher in the industrial particulate matter. The total carbon content was high in both sites with a slight increase in the industrial site. The metals, Ag, Cd, Cu, Pb, Sb, Sc, Se, Sn and Zn, predominantly from anthropogenic sources, were found in both sites but with higher concentrations on the industrial site. Polycyclic Aromatic Hydrocarbon (PAH) mass concentrations were much higher in the industrial particles and specific calculated ratios show the possible influence of diesel combustion, gasoline engine combustion, cement factories activities, and heavy fuel used in the energy sector.

The mutagenic potential of the collected PM was assessed by performing Ames Fluctuation test, a reverse mutation assay for bacterial mutagenicity done on three strains of *Salmonella typhimurium* TA98, TA102 and YG1041. Different concentrations of each PM were tested ranging from 0.625 µg/mL to 10 µg/mL with and without metabolic activation. Industrial PM showed a higher mutagenic activity in the three different tested bacterial strains than the rural background sample (FP-R). Mutagenicity obtained with *Salmonella* YG1041 could be linked to higher concentrations of PAHs quantified in industrial PM and results obtained with *Salmonella* TA102 could suggest the induction of oxidative mechanisms by PM exposure. The genotoxic potential was also evaluated by the SOS chromotest, a quantitative bacterial colorimetric assay for DNA damage measurement in *Escherichia coli* PQ37. Different concentrations of FP-R and FP-I were tested ranging from 0.122 µg/mL till 2000 µg/mL with and without metabolic activation. The industrial PM showed a high genotoxicity with a high induction factor, while it confirmed the lower genotoxicity of the background PM. Clastogenicity of PM was evaluated on human bronchial epithelial BEAS-2B cells using γ-H2AX quantification by flow cytometry analysis and in-cell western assay.

The physicochemical characterization showed differences in the composition of the two collected PM samples, especially in the PAH concentrations. Industrial sample showed higher mutagenicity and genotoxicity compared to the rural sample. The difference in the organic composition of these samples could be the reason.

Loomis, D., Huang, W., & Chen, G. (2014). The International Agency for Research on Cancer (IARC) evaluation of the carcinogenicity of outdoor air pollution: focus on China. *Chinese Journal of Cancer*, *33*(4), 189–196.