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Editorial

# Urban Trees and its Relationships with Air Pollution by Particulate Matter and Ozone in Santiago De Chile

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## Editorial

In most cities of Chile, there are air quality problems related to high levels of PM10 and PM2.5. In particular, Santiago de Chile (the capital city) is a polluted city by particulate matter, especially during autumn-winter period and by ozone during spring-summer period. The Particulate Matter (PM) is a pollutant of complex nature and particles equal to or less than 2.5 microns diameter (PM2.5), are 100% breathable and can be deposited in the alveoli. Some health effects caused by PM2.5 in Chile are premature mortality from cardiopulmonary disease, asthma, and cardiovascular diseases, and hospital admissions for pneumonia, acute bronchitis and chronic lung diseases. The annual primary standard for PM2.5, corresponding to 20 μg/Nm$^3$ and the daily primary PM2.5 standard of 50 μg/Nm$^3$ are frequently exceeded according to the official numbers given by the monitoring stations. The corresponding economic impact associated with medical expenses and lost work productivity is US $ 670 million annually, and can rise to US $ 1,900 million when considering the loss in social welfare and risk of death, due to air quality. These values are determined only with respect to pollution by PM2.5, underestimating the real impact and not considering all environmental pollutants.

On the other side, tropospheric ozone is a regulated secondary pollutant. In some areas of the Metropolitan Region of Chile (RM) exceed the regulation of 120 μg/m$^3$N for mobile average of 8-hour especially during spring-summer months. The problems of greatest concern worldwide due to ozone pollution are increased hospital admissions, exacerbation of asthma and lung inflammation. The World Bank made an estimate of savings in public health to Santiago de US $ 1,315 per ton of $O_3$ reduction, the average value varies depending on the conditions of pollution and plant cover having the different districts of the city of Santiago.

The urban forest provides many direct and indirect ecosystem services. Direct contribution occurs when trees deposit PM on the leaves or intercept PM by leaves, branches and twigs, or absorb ozone and other pollutants gaseous, through the stomata or dissolution of contaminants in the moist surfaces of the leaves; capture or interception of PM depends on many characteristics of each species, e.g. leaf structure, pubescence, wax presence on leaf surface, petioles size and canopy structure that need to be assessed in the local conditions. Among the air pollutants removed by vegetation, PM, Carbon Dioxide ($CO_2$) and Tropospheric Ozone ($O_3$) are dominant. However, vegetation also emits Biogenic Volatile Organic Compounds (BVOCs), principally isoprene and monoterpenes (scents) and so potentially contribute to ozone production in the atmosphere, especially in urban environment. Every tree emits a particular mix of chemical compounds, which reacts in a different way depending on site-specific conditions in the atmosphere generating secondary pollutants, ozone between them. Speed of BVOCs emission (emission factors, EF) is characteristic of each tree and need to be studied in relation to the real places where they are going to live (climatic, geographic, hydric and other conditions).

In this context, the atmospheric pollution of Santiago has two principal implications: economical loss and human health problems. So, our laboratory is interested in looking for solutions to improve the air quality of the city. We are studying possibilities for use the ability of special urban trees to capture PM using species which, at the same time, do not emit too much Biogenic VOCs (BVOC). Our first results show that native species are more appropriated to accomplish the two requirements; but the urban forest of Santiago is principally formed by exotic species which loss the leaves during the winter period and produce high quantities of BVOC during spring-summer period, that is, the majority of the urban trees of the city are contributors of more pollutants, not less.

Trees also participate at global level affecting the C cycle, and forming secondary organic aerosols, SOA which are part of PM2.5, some ones being very toxic to humans and possible contributing to scatter Sun radiation depending on refractive index and chemical composition therefore affecting the thermal balance and weather in the Earth. Other particles also affect solar radiation and temperature measured at superficial levels. In turns, weather changes can affect BVOCs emissions producing a positive feedback on the weather system have predicted irreversible changes due to thermal stress related to climate change, depending on species.

Also some trees produce bio-aerosols like allergenic pollen and alternaria mold spores. In Santiago there are some results of pollen production, especially coming from exotic species. Trees are also affected by pollution in both structure and performance. There is information at international level but in Chile is a new line of research open on our laboratory. Some pollutants adhere to the surface of leaves or enter through the cuticle and stoma, causing anatomical, structural and physiological response in leaves and stems modifying the resistance to pollution. So, the choice for urban trees should consider the species with better structural and functional responses to specific pollution levels for each location and other attributes locally studied minimizing maintenance and replacement costs, and maximizing the lifetime of the trees.

Research in our laboratory is using different old and new techniques of physical and chemical analysis to analyze the PM




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deposit on the leaves of trees and on streets, the physical and chemical composition of that PM, as well as PM deposit on filters by traditional methods and equipment. For instance, we are introducing magnetic techniques (Magnetic susceptibility and Saturation Isothermic Remanent Magnetization, SIRM) to identify magnetite ($Fe_3O_4$) which is a chemical compound closely related to mobile sources and vehicular flows. Other techniques are optical and electronic microscopy with EDX, XRF, Instrumental Neutron Activation Analysis, INAA, used to determine different characteristic of the PM.

In relation to ozone we are using gas chromatography coupled to an automatic temperature desorber equipment (GC-FID-ATD) to quantify the different terpenes (BVOC) emited by trees in order to better estimate EF and the proposed index, that we called Photochemical Ozone Creation Index (POCI) based on Photochemical Ozone Reaction Potentials (POCPs) proposed by Derwent et al., in 2007 which evaluate the potential of each tree to generate ozone. Also a GC-MSD chromatograph with an Injection System of Solid Phase Microextraction (SPME), is used in order to analyze other chemical compounds present or formed in the atmosphere and/or emitted by trees. Optical and electronic microscopy EDX is also used to assess the impact on trees of pollution (ozone and PM) and in time the dendrochronological analysis.

In this way it will be possible to elaborate a new inventory for VOC for better attribution of the sources of these compounds as well as of primary and secondary PM. Finally, the aim of this research is, in a future, to be able to propose to the authorities a priority list of species to replace the existing urban forest, contributing to improve the air quality of the city.

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