Air quality improvement in Chinese metropolis through Urban Smart Greening.

di Davide Triacca

The quick deterioration of the air quality in Chines metropolis, triggered by anthropic activities, causes –according to the World Health Organization statistics– hundreds of thousands deaths per year by respiratory and cardiovascular diseases and high socioeconomic costs.
An important contribution to reduce such air pollution can be obtained through a wise and strategic planning of the urban (***smart***) green infrastructure. As clearly shown by studies and researches performed in many different urban areas affected by similar air quality issues all over the world, in fact, trees has a strong potential in removing air pollutants circulating in the atmosphere. Trees can reduce air pollutants in two ways[1]:

1. by **direct** reduction from the air
2. by **indirect** reduction by avoiding the emission of air pollutants.

In **direct reduction**, trees absorb gaseous pollutants like sulfur dioxide (SO_2), nitrogen dioxide (NO_2), and ozone (O_3) through leaf stomata and also can dissolve water-soluble pollutants onto moist leaf surfaces[2]. Tree canopies can also intercept particulate matters in the air[3]. **Indirectly**, trees can reduce the air temperature through direct shading and evapotranspiration in the summer, thus reducing the emission of air pollutants from the process of generating energy for cooling purposes. Also, reduced air temperature can lower the activity of chemical reactions, which produce secondary air pollutants in urban areas[4] [5].
Tree direct reduction of atmospheric pollutants was estimated and measured in several world megacities providing the following results.
In 1994, trees in New York City removed an estimated 1,821 metric tons of air pollution at an estimated value to society of $9.5 million. Air pollution removal by urban forests in New York was greater than in Atlanta (1,196 t; $6.5 million) and Baltimore (499 t; $2.7 million), but pollution removal per m2 of canopy cover was fairly similar among these cities **(NewYork: 13.7 g/m²/year; Baltimore: 12.2 g/m²/year; Atlanta: 10.6 g/m²/year)** [6]**.** These standardized pollution removal rates differ among cities according to the amount of air pollution, length of in-leaf season, precipitation, and other meteorological variables. Large healthy trees greater than 77 cm in diameter remove approximately 70 times more air pollution annually (1.4 kg/yr) than small trees less than 8 cm in diameter (0.02 kg/yr). Air quality improvement in New York City due to pollution removal by trees during daytime of the in-leaf season averaged 0.47% for particulate matter, 0.45% for ozone, 0.43% for sulfur dioxide, 0.30% for nitrogen dioxide, and 0.002% for carbon monoxide. Best performances in

[1] Jun Yang, 2005. The urban forest in Beijing and its role in air pollution reduction
[2] David J. Nowak, 1994. Air pollution removal by Chicago's urban forest.
[3] K.P. Beckett, et al., 1998. Urban woodlands: their role in reducing the effects of particulate pollution
[4] H.Taha, 1996. Modeling impacts of increased urban vegetation on ozone air quality in the South Coast Air Basin
[5] David J. Nowak, 2000. A modeling study of the impact of urban trees on ozone.
[6] David J. Nowak, 2002. The effects of urban trees on air quality.

improving air quality are obtained through increasing both tree canopy cover and levelling tree height.

In urban areas with very high tree cover (i.e., contiguous forest stands), short-term improvements in air quality (one hour) from pollution removal by trees were **registered as high as 15% for ozone, 14% for sulphur dioxide, 13% for particulate matter, 8% for nitrogen dioxide, and 0.05% for carbon monoxide.**

Similar research approaches conducted in Beijing and Guangzhou[7] [8] highlighted that, mainly due to the higher average air pollution and the local tree species, the Chinese urban forests perform much better than those in Europe and America. The standardized pollution removal rate (g/yr per m2 of canopy cover) was 27.5 in Beijing, two times more than in New York (13.7) and Baltimore (12.2).

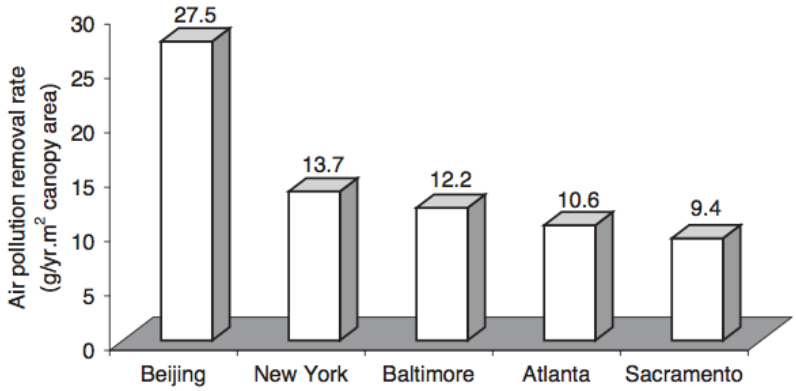

Figure 1 – Standardised air pollution removal rate in Beijing and a few American Cities. *Source: Jun Yang, 2005.*

The total annual (from November 2001 to October 2002) air pollutant uptake by trees from the atmosphere in Beijing was around 1261.4 tons (see picture below). The harmful PM10 accounted for 61% of total air pollutants removed from the atmosphere.

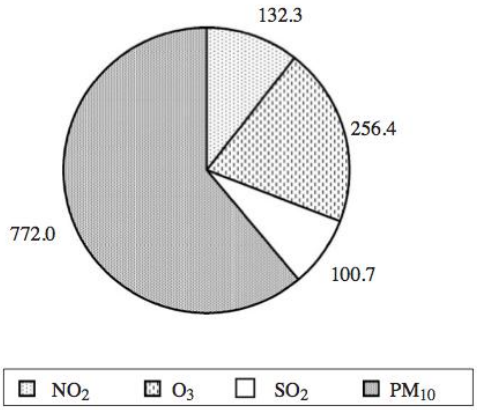

Figure 2 – Annual air pollutant removal by trees in the total study area in Beijing (unit: ton). The percentages of different pollutants to total removal NO_2 (11%), O_2 (20%), SO_2 (8%) and PM_{10} (61%). *Source: Jun Yang, 2005.*

Furthermore, with a tree/shrub cover of 16.4%, the total air temperature decrease by current trees and shrubs was 1.61°C. The air temperature decrease led to less air conditioning use. The total electricity saving by trees through lowering air temperature was calculated as 0.238GWh thus contributing both to reduce the energy expenditure and the atmospheric emissions associated to energy generation.

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[7] Jun Yang, 2005. The urban forest in Beijing and its role in air pollution reduction

[8] C.Y. Jim, Wendy Y. Chen, 2011. Ecosystem service of air pollution abatement by urban forest

Similar outstanding data were observed in Guangzhou, **emphasizing the potential for optimizing trees' health conditions, selecting the most efficient species in removing air pollution and wisely planning the distribution of the trees in the urban area.**
Such parameter can be included in a **planting priority index**[9] that, taking into account the specific local conditions, can support the local Authorities through the development of a green infrastructure master-plan.
Such **smart green master-plan** would effectively drive the improvement of the urban green infrastructure reducing the air pollution and fully valorising the ecosystem services provided by trees.

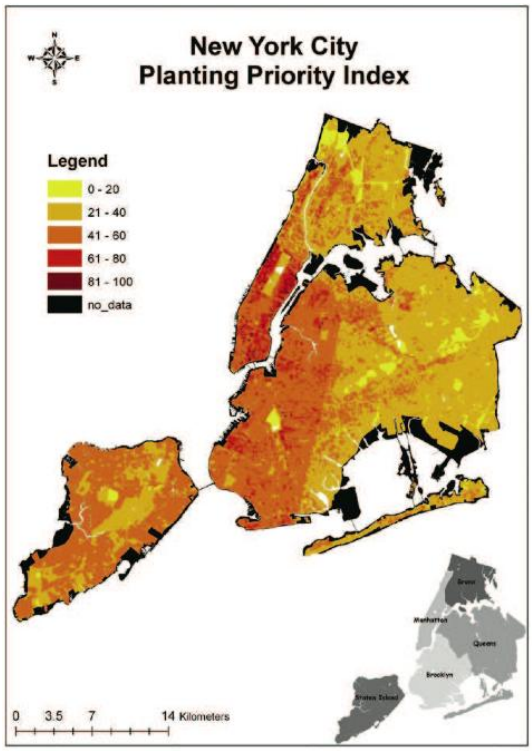

Figure 3 – Example of Planting Priority Index in NY. ***Source: Arianna Morani et al.***.

[9] Arianna Morani et al., 2011, How to select the best tree planting locations to enhance air pollution removal in the MillionTreesNYC initiative.