Polyalthia longifolia (False Ashoka) is an ideal choice for better air quality at kerbside locations

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Introduction

The net impact of roadside trees on urban air quality is till date far from clear and likely depends strongly on the species planted. Overall most studies suggest that the net impact of urban trees is that of pollution removal rather than that of secondary pollution formation, however, the majority of the studies available at present consider either only the pollution formation potential or only the pollution removal capability. The capability of trees to remove pollutants is directly proportional to the dry deposition velocities of the pollutant in question(e.g. NO_2, O_3). Most highly acidic or alkaline trace gasses such as NO_2, SO_2 and NH_3 have high deposition velocities for grasses and broadleaf species (0.2-0.4 cm s^{-1})[2]. BVOCs are emitted by plants under stress conditions such as elevated temperature and CO_2 levels. In the NOx rich urban environment highly reactive BVOCs namely isoprene, terpenes and sequiterpenes can readily contribute to tropospheric ozone formation and SOA formation. In this study we quantify both the precursor emission potential and the air pollution mitigation potential of *Polyalthia longifolia* using field based measurements. Uptake of ozone and NO_2 is calculated using a simple multiplicative model for dry deposition of ozone (DO_3SE) on trees which is based on the exchange of water vapour through the stomata of leaves. BVOCs emission were measured using a dynamic branch cuvette.

Methods

Stomatal conductance was measured for 3 trees of *P. longifolia* in ambient conditions using a SC-1 leaf porometer. Met station was deployed to measure PAR, soil moisture, temperature, pressure, solar radiation and wind speeds. Ambient concentrations of trace gases and CO_2 were taken from the AAQS in IISERM.

The dynamic branch cuvette was set on *P. longifolia* during post monsoon season for 3 days and BVOCs concentrations were measured with PTR-QMS.

Figure 1: Row of trimmed *P. longifolia* on IISER Mohali campus.

Results and Discussion

DO_3SE model

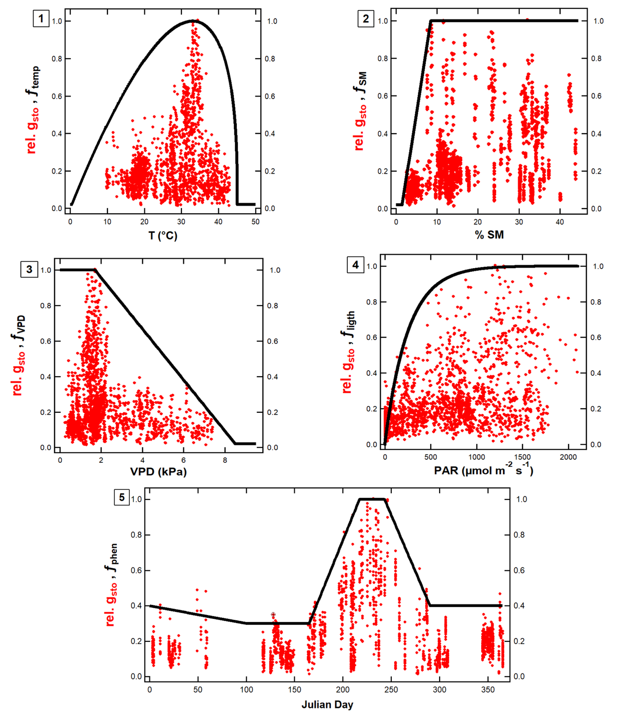

Figure 2: Relation between G_{sto} as ratio of the species specific maximum and **1** amb. T(ºC), **2** SM(%), **3** VPD(kPa), **4** PAR, (µmol m^{-2} s^{-1}) and **5** phenological stage for *P. longifolia*.

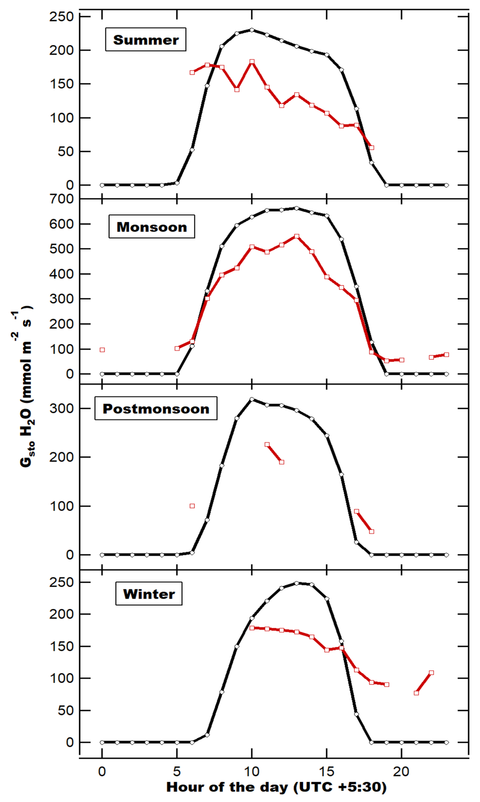

Figure 3: Seasonal diel-profiles for modelled and measured G_{sto}.

G_{max} and G_{min} (mmol H_2O m^{-2} s^{-1}) were defined as 865 and 17.3. False Ashoka shows maximum stomatal conductance during its fruiting period (July - Sept) at amb. T of 33ºC and relatively low moisture doesn't impact on G_{sto} unless it fall below 8.5%. P. longifolia has a moderate light sensitivity with α=0.004.

BVOCs emissions

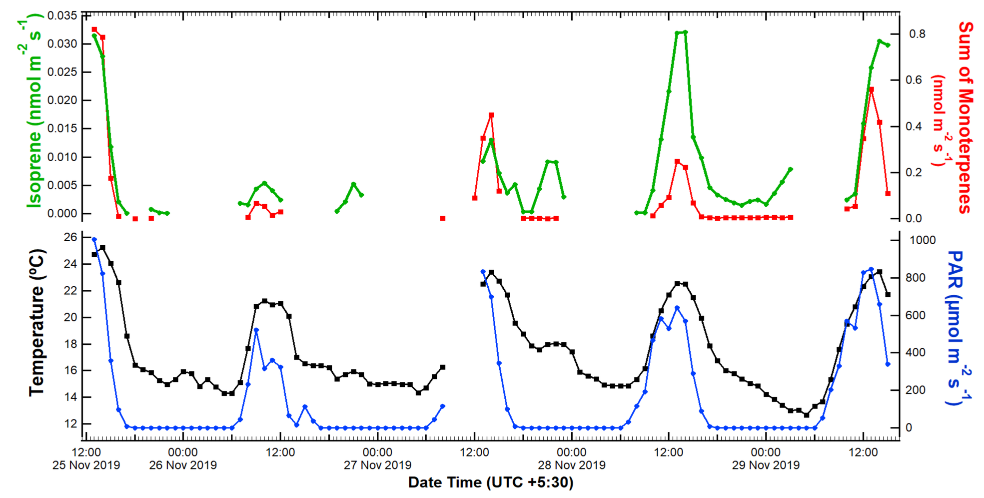

Figure 4: Isoprene and monoterpene emissions by *Polyalthia longifolia* along with PAR and ambient temperature

Low emissions of both monoterpenes (= 0.8 nmol m^{-2} s^{-1}) and isoprene (= 0.3 nmol m^{-2} s^{-1}) were observed. Highest emissions are observed when PAR and T are maximum during the day.

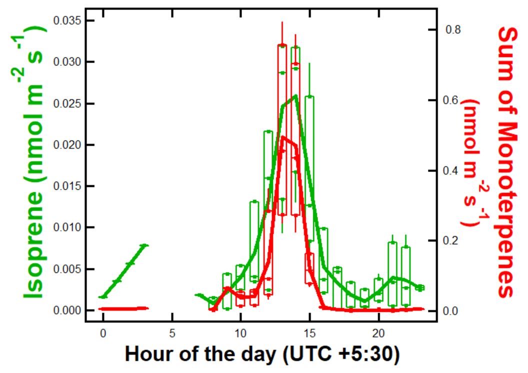

Figure 6: Diel profile of isoprene and monoterpene emissions of *Polyalthia longifolia*.

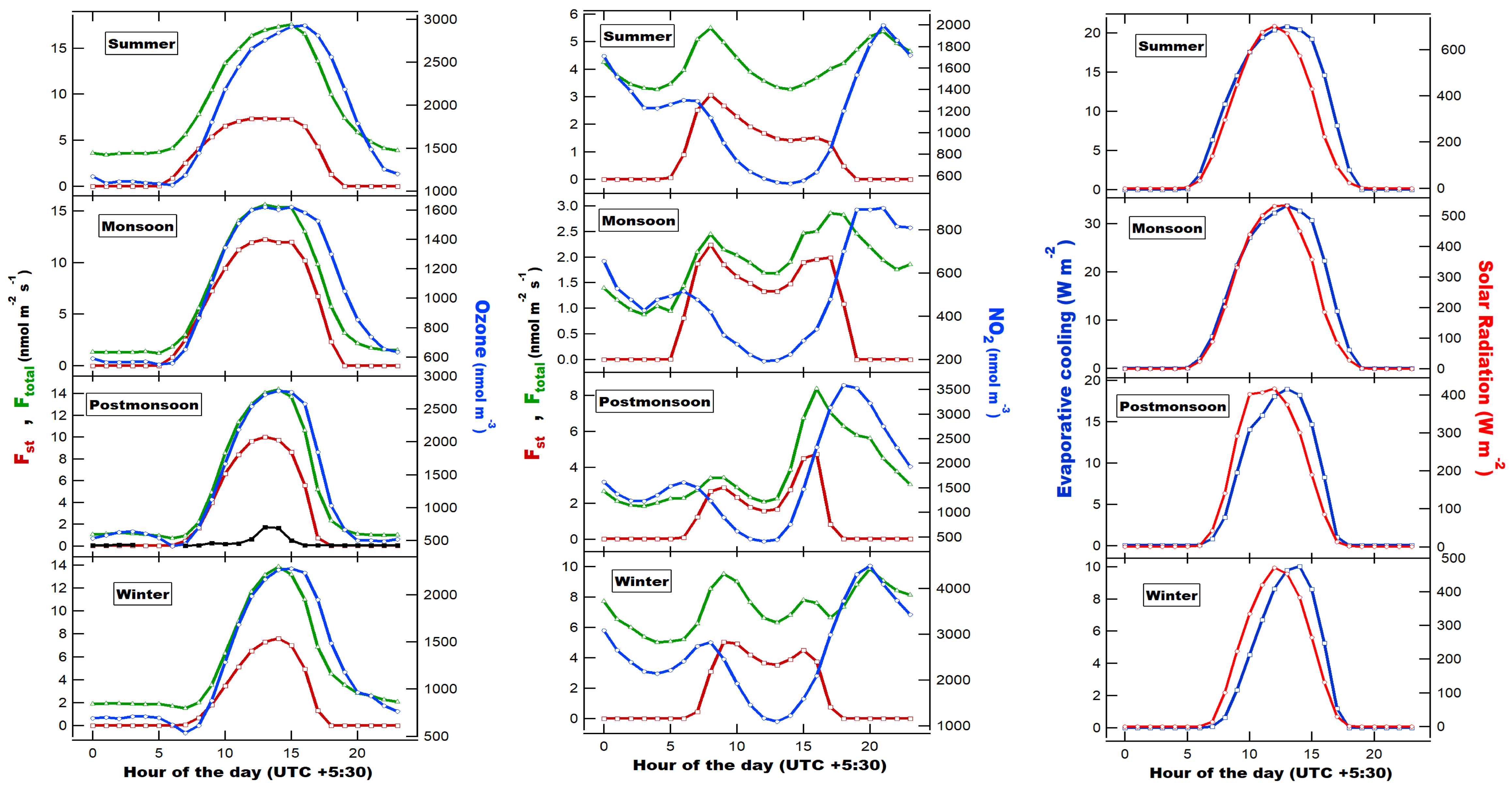

Figure 5: Seasonal diel profiles for stomatal uptake flux(F_{st}), total flux(F_{total}) of O_3(left) and NO_2(centre), and their ambient levels. Right – evapourative cooling due to *P. longifolia* and Solar radiation. Black line in represents ozone formation potential (nmol m^{-2} s^{-1}) of isoprene and monoterpene.

Conclusions

- *Polyalthia longifolia*'s potential to sustain ozone uptake under extreme conditions such as high VPD, extreme temperatures, extremely dry soil is remarkable making it potentially very efficient in ozone removal.
- It is a very low emitter of BVOC's which ensures it's low impact on ozone and SOA formation.
- Its stomatal conductance peaks during the early morning NOx peak, enabling it to efficiently sequester the ozone precursor NO_2.
- The unique combination of low VOC emission potential combined with the ability to sustain stomatal uptake of ozone and its precursors even during hot and dry conditions make this tree an interesting choice for kerbside locations, where generally the air quality standards are frequently violated.
- The largest drawback for its use is that urban planners tend to trim this tree into narrow poles or geometrical shapes. This trimming reduces the leaf area index and pollutant removal efficiency of the tree. Our model calculations were preformed for a trimmed tree with LAI 0.8 m^2/m^2 .
- If it was left to grow a large natural crown with a LAI of >5 m^2/m^2 its pollution formation potential would be immense.

References

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[2] Pugh, Thomas A. M., A. Robert MacKenzie, J. Duncan Whyatt, and C. Nicholas Hewitt. 2012. "Effectiveness of Green Infrastructure for Improvement of Air Quality in Urban Street Canyons." *Environmental Science and Technology* 46(14):7692–99.