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AN INVESTIGATION OF THE RATE OF BIOGENIC VOLATILE ORGANIC CARBON EMISSIONS FROM COMMERCIAL CROP AND PLANTATION SPECIES IN THE MPUMALANGA PROVINCE



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A research report submitted to the Faculty of Science, University of the Witwatersrand, in partial fulfillment of the requirements for the degree of Master of Science

Johannesburg, July 2009

DECLARATION

I declare that this dissertation is entirely my own, unaided work. It is being submitted for the Degree of Master of Science in the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in any other University.

_____

Ms. Victoria Batrakova

(Signature of candidate)

----------Day of----------2009

ABSTRACT

Volatile Organic Carbons (VOCs) are extremely reactive compounds and play an important role in the ozone chemistry of the atmosphere. Biogenic Volatile Organic Compounds (BVOCs) are estimated to contribute ~10^{15} g C y^{-1} per year to the atmosphere which constitutes ~80 % of the chemically reactive VOCs added to the atmosphere each year. In the last decade considerable scientific effort has focused on quantifying biogenic emission rates in South Africa, mainly from indigenous savanna species. The Mpumalanga province occupies 6.7 % of the land area of South Africa. There is a high species diversity and variable land use which includes forestry, cropping agriculture, grazing and nature conservation. The aim of this study was to measure the emission rates of isoprene, β-pinene, α-pinene, limonene and linalool from five selected plant species. These plant species were Mangoes, Avocados and Bananas (subtropical crops) and Pines and Eucalyptus (exotic forestry species). The experimental work, which was all conducted in the field, was designed to demonstrate the effect of environmental conditions on emission rates, especially temperature and water availability. A rapid screening technique was carried out in the initial phase of the study and a more detailed leaf level study was carried out over the 2007-2008 growing season. Plantation species, emitted higher levels of BVOCs than crop species. Isoprene emission rates were similar for two functional groups of plants, however, selected monoterpene (β-pinene, α-pinene, limonene and linalool) emission rates were higher in the plantation. Isoprene emissions represented 41.6 % of the total emissions measured followed by monoterpenes: β-pinene 31.5 % and limonene, α-pinene and linalool the remaining 26.8 % of total emissions. Emissions increased immediately after the onset of the spring rains and responded to the annual cycle with increasing values in the summer months and rapid decreases in winter. The measured emission rates were higher from the selected species than those published from temperate regions of the world. The data from this study can be used in the future to develop a regional emission budget.

To my parents,

Konstantin and **Vera Batrakovy**

and **to my grandmother, Valentina Holnova**

for all their love and support during this trying time

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LIST OF ABBREVIATIONS

ABA	Abscisic acid
BHC	Biogenic hydrocarbons
BVOC	Biogenic Volatile Organic Carbon
GAP	Glyceraldehyde 3-phosphate
GC-FID	Gas Chromatography with Flame Ionization Detector
GDP	Geranyl Diphosphate
DMAPP	Dimethyl Allyl Diphosphate
DOXP	Deoxy-d-Xylulose Phosphate
IPP	Isopentenyl Diphosphate
KCl	Potassium chloride
LA	Leaf Area (cm^2)
Leaf N	Leaf Nitrogen content (%)
LNC	Leaf nitrogen concentration
MBO	Methyl-Butenol
MEP	Methyl-Erythritol
NMHC	Non Methane HydroCarbons
MVA	Mevalonic Acid Pathway
PAR	Photosynthetically Active Radiation (μmol m^{-2} s^{-1})
PEP	Phosphoenolpyruvate
PFD	Photon flux density
PID	PhotoIonization Detector
ppb	Mass solute/mass solution×10^9 = concentration ppb (parts per billion) or (μg·m^{-3})
RF	Response factor
RH	Relative humidity (%)
SLA	Specific leaf area
SWS	Soil water storage

T air	Temperature of ambient air (ºC)
Tg	10^{12} gram / yr (Teragram)
T leaf	Temperature of leaf (ºC)
VOC	Volatile Organic Carbon
CH_4	Methane
CO	Carbon monoxide
H_2O_2	Hydrogen peroxide
NO_x	Nitrogen oxide
OH	Hydroxyl
O_2	Oxygen
O_3	Ozone