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Volatile Organic Compounds (VOC) Emission from plant species of the Vidarbha

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***Abstract:*-- Plants emit numerous volatile organic compounds (VOC). In this study, 50 dominant plant species of Vidarbha region of Maharashtra, India were examined for VOC emissions. VOC emission rates of the plant species ranged from undetectable to75.2 μg g^{-1} h^{-1}. Maximum VOC emission rates of 75.2 μg g^{-1} h^{-1} observed from *Dalbergiasi sissoo*.**

Keywords: **Volatile organic compound; air quality, biogenic, air pollution**

I. INTRODUCTION

Plants emit numerous volatile organic compounds (VOC) in the atmosphere. It is estimated that vegetation contributes about 90 % of the total biogenic VOC emissions (Guenther et al., 1995). In the atmosphere, VOC quickly react with hydroxyl radical, ozone, and nitrate radical leading to the formation of carbon monoxide, organic acids, and secondary aerosols (Fehsenfeld et al., 1992; Atkinson, 2000). Isoprene and monoterpene are most abundant VOC emitted from the plants, which are estimated to account 44 % and 11 %, respectively to the global biogenic VOC budget of 1150 Tg C yr-1 (Guenther et al., 1995).

It has been widely reported that VOC emission rates are species specific, varying as much as four orders of magnitude depending upon plant species (Benjamin et al., 1996; Singh et al., 2011). Therefore, different plant species vary in terms of their ozone forming potential.

In India, only few selected plant species of the northern region have been examined for VOC emission (Varshney and Singh, 2003; Singh et al., 2011). Study on the VOC emission from plant species of Vidarbha region of Maharashtra is altogether lacking. In view of the above, this study was undertaken with objectives to measure VOC emission rates dominant plant species of the Vidarbha, Maharashtra.

2. EXPERIMENTAL

Dominantly occurring 50 plant species of the Vidarbha were selected for the study. Vidarbha is forest and mineral rich central region of Maharashtra state of India comprising of 11 districts. Selected plant species about five years old saplings were sampled for VOC emission. A dynamic flow through enclosure system was used for the emission measurement. Samplings were carried out for 10 minutes as described by Winer et al. (1989) at a rate of 0.10 l min^{-1} from enclosure on to Tenax TA (200 mg)/carbosieve (100 mg) II solid adsorbent (Obtained from Supelco Inc. Bellefonte, PA). Individual plant species three saplings were sampled during day light hours. Temperature and photosynthetically active radiation (PAR) were measured both inside and outside the chamber with the help of thermometer and Li Cor Quantum sensor, LI-185 (Li-Cor biosciences, Lincoln, NE, U.S.A) respectively.

A Perkin Elmer gas chromatograph (Perkin and Elmer ATD 400, Perkin Elmer, UK) with a fused silica capillary column (length: 30 m, id: 0.53 mm, bonded phase BP-50 I, Alltech Associates, Dearfield, IL, USA) connected with flame ionization detector (FID) was used for the analysis of most of the samples. For each species, representative samples were also analysed using GC-MS (Perkin and Elmer ATD 400, Perkin Elmer, UK) for optimum peak identification. Compounds were desorbed at 250 °C for 8 minutes onto a Tenax TA/ carbosieve by a thermal desorber injection system attached with the GC. The initial oven temperature was maintained at 40 °C for 5 minutes, then increased to 150 °C at a rate of 5 °C min^{-1} for 5 minutes thereafter temperature increased at a rate of 15 °C up to 250 °C and maintained for 10 minutes. N_2 was used as carrier gas. The injection temperature was 230 °C and detector temperature was 250 °C. Isoprene and monoterpene in the samples were determined with the help of standard calibration plots

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prepared from the liquid chemical standard obtained from Fluka/Sigma-Aldrich, USA.

Some monoterpene (other than two monoterpene for which standard was available) present in the samples could not be identified. Quantitative determinations of these monoterpene were carried out by using α - pinene standard calibration plot. The precision and accuracy of the GC/FID system were about 4 % as determined by repeated measurements of the standard gas. Dry foliar mass of each plant was calculated After completion of the emission flux measurements.

Measured isoprene and monoterpenes emission rates were normalised to PAR and temperature of 1000 μmol m^{-2} s^{-1} and 30 ^{0}C, respectively, using the algorithm proposed by Guenther et al. (1993) and subsequently modified by Guenther (1997).

3. RESULTS AND DISCUSSION

Plant species VOC emission rates ranged from negligible to a maximum 75.2 μg g^{-1} h^{-1}. *Dalbergia sissoo* exhibited a maximum VOC emission rate of 75.2 μg g^{-1} h^{-1}). Maximum monoterpine emission (18 μg g^{-1} h^{-1}) was observed in case of *Murraya koenigii*. Whereas, maximum isoprene emission rate (75.2 μ g g^{-1} $h^{-1)}$ was observed in case of *Dalbergia sissoo.* The observed significantly high interspecies variations could be on account of a combination of numerous factors viz. plants genetic make-up (Monson et al., 1994), growth stage (Harley et al., 1994), leaf age (Monson et al., 1994), physiological status of plants (Monson et al., 1994) and season (Singh and Varshney, 2006).

Benjamin et al. (1996) had suggested a method for the classification of plant species on the basis of their VOC emission rate. In accordance with the method suggested by Benjamin et al. (1996), plant species studied in this study could be classified into four categories: (a) Negligible emitter (below detection limit) 4 % plant species (b) Low emitters (<1μg g^{-1} h^{-1}) 16 % plant species (c) Moderate emitters (1 to 10 μg g^{-1} h^{-1}) 36 % plant species (d) High emitters (> 10 μg g^{-1} h^{-1}) 44% plant species. List of plant species along with their normalised VOC emission rates are given in table.

Many plant species namely *Albizzia species, Murraya koeniii, Dalberia sissoo, Syzyium cumini, Pongamia pinnata, and Techtona grandis* which are identified as high emitters of VOC screened in this study for VOC emissions have been extensively used for avenue plantation/urban forestry purpose in various cities of the India (Chaudhry et al., 2011). The considerable presence of high VOC emitting vegetation could be one of the prime reasons for significantly high levels of ozone in urban areas as because biogenic VOC quickly react with oxides of nitrogen (NOx) in the atmosphere and leads to formation of secondary air pollutants such as ozone and carbon mono oxide (Fehsenfeld et al., 1992; Atkinson, 2000).

4. CONCLUSIONS

The VOC emission rates of common Vidarbha plant species varied from negligible to 75.2 μg g^{-1} h^{-1}. *Dalbergia sissoo* plant exhibited maximum VOC emission rate of 75.2 μg g^{-1} h^{-1}. Since, different plant species vary considerably in terms of VOC emission potential. Accordingly, it is essential to select low VOC emitting plant species for urban forestry programmes.

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Table . VOC emission rate** (in $\mu g\ g^{-1}\ h^{-1}$) **of dominant plant species of Vidarbha.

SN	Scientific name	Local Name	NIER	NMER	VOC
1	Buchanania latifolia	Char	32.2	7.7	39.9
2	Buckanania lanzen	Achar	28.9	3.0	31.9
3	Odina Wodier	Mowai	49.4	3.2	52.6
4	Alstonia scholaris	Kasham	BDL	1.0	1.0
5	Holarrhena antidysenterica	Kuda	BDL	0.75	0.7
6	Millingtonia hortensis	Kaval Nimb	0.32	1.7	2.0
7	Bombax ceiba	Semar	3.8	7.5	11.3
8	Garuga pinnata	Kakad	58.2	1.9	60.1
9	Boswelia serrata	Salai	47.6	1.5	49.1
10	Cassia fistula	Amaltas	0.2	0.95	1.6
11	Cassia renigera	Pink Cassia	0.4	0.5	0.9
12	Cassia siamea	Kassod	0.3	BDL	0.3
13	Termarindus indica	Emali	0.3	3.6	3.9
14	Anogeissus latifolia	Dhawada	0.56	1.2	1.7
15	Terminalia arjuna	Arjan	BDL	1.0	1.0
16	Terminalia bellirica	Baheda	0.3	4.9	5.2
17	Terminalia tomentosa	Yen	0.5	2.3	2.8
18	Diospyros melanoxylon	Tendu	0.75	8.2	8.9
19	Butea monosperma	Dhak	13.8	BDL	13.8
20	Dalbergia latifolia	Shisak	64.8	BDL	64.8
21	Dalbergia sisoo	Sisham	75.2	BDL	75.2
22	Pongamia pinnata	Karanj	25.9	2.11	28.0
23	Dendrocalamus hamiltoni	Kagaji bans	25.2	2.0	27.2
24	Dendrocalamus strictus	Bans kabans	18.7	0.8	19.5
25	Soymida febrifuga	Rohini	0.85	0.60	1.5
26	Acacia auriculiformis	Subabul	0.25	0.25	0.5
27	Acacia farneciana	Gand babul	BDL	5.0	5.0
28	Acacia leucophloea	Heawr	0.75	3.8	4.5
29	Acacia nigrescens		10.5	0.8	11.3
30	Acacia nilotica	Kala babool	BDL	BDL	BDL
31	Acacia tortilis	Israili babool	0.74	8.0	8.7
32	Albizia julibrissin	Bhandi	35.7	0.2	35.9
33	Albizzia odoratissima	Kakur siras	3.8	1.25	5.1

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34	Albizzia procera	Safed siras	24.3	0.5	24.8
35	Syzygium cuminii	Jamun	50.6	3.3	53.9
36	Ougeinia oojeinensis	Tinsa	38.8	8.1	46.9
37	Pterocarpus marsupium	Bija	50.8	5.0	55.8
38	Zizyphus jujube	Ber	0.35	4.6	4.9
39	Zizyphus xylopyra	Ghoti	0.86	2.4	3.3
40	Adina cordifolia	Haldu	0.56	BDL	0.6
41	Chloroxylon Swietenia	Behru	BDL	BDL	BDL
42	Mitragyna parviflora	Kaim	0.66	0.34	1.0
43	Citrus lemon	Nimbu	0.25	5.8	6.1
44	Murraya koenigii	Curry patta	BDL	18.0	18.0
45	Madhuca indica	Mahua	60.7	0.36	60.9
46	Ailanthus excels	Maharukha	BDL	0.26	0.3
47	Sterculia urens	Karhu	0.2	BDL	0.2
48	Grewia titiaefolia	Dhaman	BDL	0.7	0.7
49	Gmelina arborea	Shivan	10.2	BDL	10.2
50	Tectona grandis	Teak	15.5	BDL	15.5

BDL: below detection limit ; NIER normalized isoprene emission rate ; NMER normalized monoterpenes emission rate