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Research Article

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The use of *Hyptis suaveolens* (L.) as a sink for dust in aerial atmosphere and a phytomonitor

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ABSTRACT

Foliar dust from Hyptis suaveolens (L.) collected from different sites in and around Tarapur industrial area was analysed using Energy dispersive X-ray spectrometry. Different sites showed different elemental compositions. Scanning electron microscopy was carried out to examine the morphology of particulate matter and to study the elemental composition of individual particles present on the leaf surface. Variations within sites in elemental composition was due to the proximity of the type of pollution sources. Hyptis suaveolens (L.) is an effective tool as phytomonitor for the quality of dust in an area. Current work is aimed at identifying the type of metals settling on foliar surfaces in an highly industrial area.

Key words: *Energy dispersive X-ray spectrometry (EDS), Hyptis suaveolens (L.), Scanning electron microscopy (SEM)*

INTRODUCTION

The ability of plants to act as sink for air contaminants has been assessed by several researchers in the past[1, 2]. Dust is captured by various plant parts like leaves, leaf epidermal outgrowths like hair and scales, hairy axils of stems and leaf base etc. Since the particles deposited on the leaves are from the air, analyses of the particles also provide information about the source of particulate air pollution in the area[3]. The higher the concentration of particulate matter in the area, the higher will be the concentration of particles settled on the leaf surface. The sizes and chemical compositions of the particles on the leaf surface are the representative of the airborne particles in the sampled area[4].

A wide variety in dust sizes has been observed by researchers. Cement kiln dust was found to be less than 30µm in diameter[5]. Particulates from motor vehicles range from 0.01- 5000 µm in diameter[6]. Thompson *et al.*[7] concluded that most of the roadside dust is in the range of 3-100 µm while that from motor vehicle exhausts is 3-30 µm. Milford *et al.*[8] noted that many metals occur as small particulates and may form an important part of smaller fractions of dust particles.

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Dust settling on plants can have both physical and chemical impacts. Physically it may smother the leaves blocking the stomata. Chemically, dust may interfere with gaseous exchange and thus in turn affecting photosynthesis, water relation, respiration and ultimate growth of plants[9]. Phytotoxicity due to heavy metals and other particles emitted from vehicular exhaust have been shown to accumulate and cause damage and death of plant species growing along the roadsides by Sturaro *et al.*[10] and Alfani *et al.*[11]. Scanning electron microscopy along with energy- dispersed analysis of X-rays (SEM/EDS) is an important tool in investigating air borne particulate matter and provides information on morphology, phase and elemental composition of individual particles [12, 13]. *Hyptis suaveolens (L.)* is an established monitor of dust in Mumbai city [14]. Current work is aimed at identifying the type of metals settling on foliar surfaces in an highly industrial area.

MATERIALS AND METHODS

1. Study area:

Tarapur industrial area was selected for this study. Site was selected based on the nearness to vehicular and industrial pollution sources. Detailed description and location of sites is given in Table 1 and Fig.1

2. Sampling and Method of analysis:

Hyptis leaves samples from the most polluted site from the study area was collected in zipper pouch and were taken to the laboratory for Scanning electron microscopic (SEM) image analysis of foliar surface. Elemental composition was determined by using **Field Emission Gun-Scanning Electron Microscopes (FEG-SEM)** Model: JSM-7600F**,** Resolution: 15 kv, 1 kv. Accelerating voltage: 0.1 to 30 kv, Magnification: x25 to 1,000,000.

RESULTS AND DISCUSSIONS

EDS analysis of majority of foliar dust samples collected from six different study sites revealed almost similar results except for Site 5- Tarapur MIDC Police Station Road with higher levels of Silicon and Molybdenum while Site 6 - Aarti Drugs Pvt. Ltd. Road showed the presence of high levels of Aluminium and Calcium (Table 2). Site 1- Tata Wires Ltd. Road, Site 2 - Valiant Glass Works Pvt Ltd. Road, Site 3- Tarapur Vidya Mandir school Road and Site 4 – G.R. Engineering Road showed higher levels of Silicon and Iron in comparison to all sites. Thus different sites showed different elemental copostion in their dusts, depending on the type of source of pollution. It would be however pertinent to mention here that it is difficult to identify an particular source where multiple source of air pollution are present.Nevertheless foliar dust on *Hyptis suaveolens* (L.) proves to be an good indicator for elemental dust pollution.

To study the interaction between dust particles and foliar surface of *Hyptis*, Scanning electron micrographs were taken which is represented in Fig. 3 and Fig. 4. Also, in order to determine the elements deposited on trichome surface and on the guard cells of stoma of *Hyptis*, EDS spot spectrum was carried out which is shown in Fig. 5.

A microscopic examination of the dusted leaf surface revealed that deposition of particles was not uniform. The dust particles were intermingled with trichomes and were also seen clogging stomatal pores. Elements present on stoma had the following trend: Silicon> Magnesium> Calcium> Aluminium> Lead> Potassium> Molybdenum> Copper> Sodium> Iron (Table 4). Since a significant quantity of air enters into the plant body through these stomatal pores, particles larger than the pore diameter tend to pile up on the pore opening and interfere with the gaseous exchange.

The trend shown by elements present on trichome was Silicon> Molybdenum> Calcium> Iron> Aluminium> Magnesium> Zinc> Potassium> Copper> Sodium (Table 4). Although the elements present on trichome surface and on guard cells of stoma were more or less same, occurrence of Zinc and absence of Lead was recorded on Trichome surface while Stomatal guard cell showed the presence of Lead and absence of Zinc (Table 4).

Table1: Site description for EDS analysis

No.	Site Name	Site Description
1	Tata Wires Ltd. Road	Industrial area with heavy vehicular traffic.
2	Valiant Glass Works Pvt Ltd. Road	Moderate traffic of heavy vehicles.
3	Tarapur Vidya Mandir School Road	Industrial area with continuous movement of all types of vehicles.
4	G.R. Engineering Road	Connected to flyover, continuous movement of traffic.
5	Tarapur MIDC Police Station Road	Industrial area, very heavy continuous traffic of all types of vehicle.
6	Aarti Drugs Pvt. Ltd. Road	Road not well developed, moderate traffic.

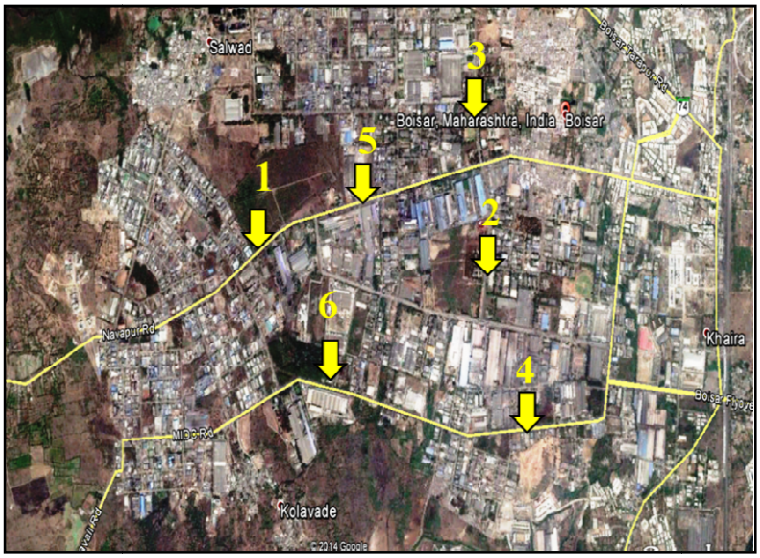

Fig.1: Location of Study sites in Tarapur industrial area

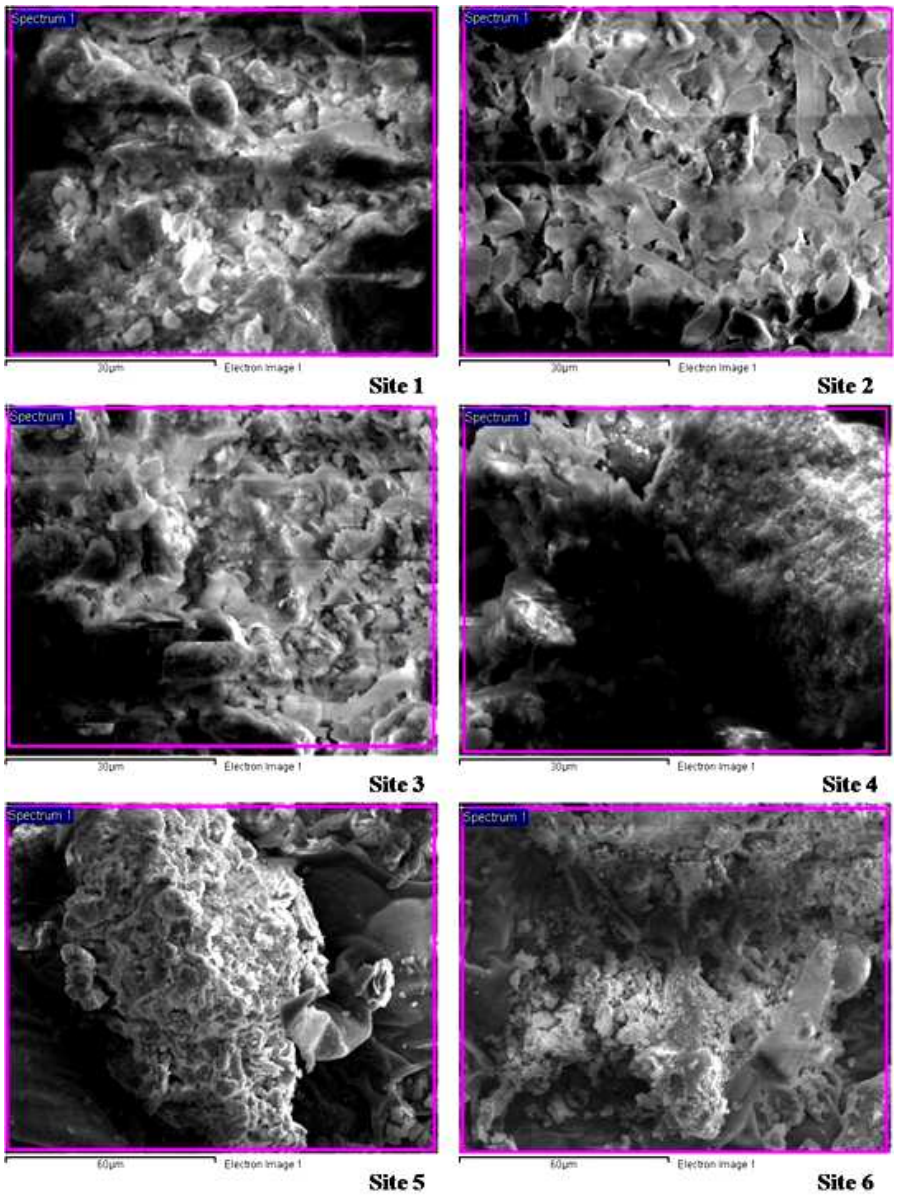

Fig. 2: Electron images of foliar dust particles collected from 6 different study sites.

Table 2. Elemental composition of different sites in Tarapur in % weights

SITE	Na	Mg	Al	Si	S	K	Ca	Fe	Cu	Zn	Mo	Pb
1	0.37	1.32	6.34	17.43	0.2	0.52	2.17	9.07	0.66	NP	NP	NP
2	0.23	1.21	2.77	6.82	1.33	0.49	3.21	4.35	NP	NP	NP	NP
3	0.32	1.21	3.73	9.07	1.07	0.43	3.95	6.81	0.51	0.76	NP	0.36
4	0.35	1.93	4.81	12.7	0.66	0.35	1.98	12.85	0.67	0.5	NP	NP
5	0.44	1.63	2.51	8.35	NP	0.62	4.53	3.54	0.59	0.64	6.03	NP
6	NP	0.75	4.62	2.03	NP	1.35	2.44	0.68	0.94	0.47	1.19	1.81

NP- Not Present

Table 3: Elemental composition of foliar dust on *Hyptis* (epidermal structures) collected from Site 5- Tarapur MIDC Police Station Road in % weights

SAMPLE	Na	Mg	Al	Si	S	K	Ca	Fe	Cu	Zn	Mo	Pb
Trichome	0.44	1.63	2.51	8.35	NP	0.62	4.53	3.54	0.59	0.64	6.03	NP
Stomata	0.75	4.62	2.03	6.8	NP	1.35	2.44	0.68	0.94	NP	1.19	1.81

NP- Not Present

Table 4: The trend of metals found on *Hyptis* leaf sample collected from Site -5 according to %weight in the Energy Dispersive Spectrum is as follows:

SAMPLE	TREND OF METALS BASED ON % WEIGHT
Trichome	Si>Mo> Ca> Fe>Al>Mg>Zn>K>Cu>Na
Stomata	Si>Mg>Ca>Al>Pb>K>Mo>Cu>Na>Fe

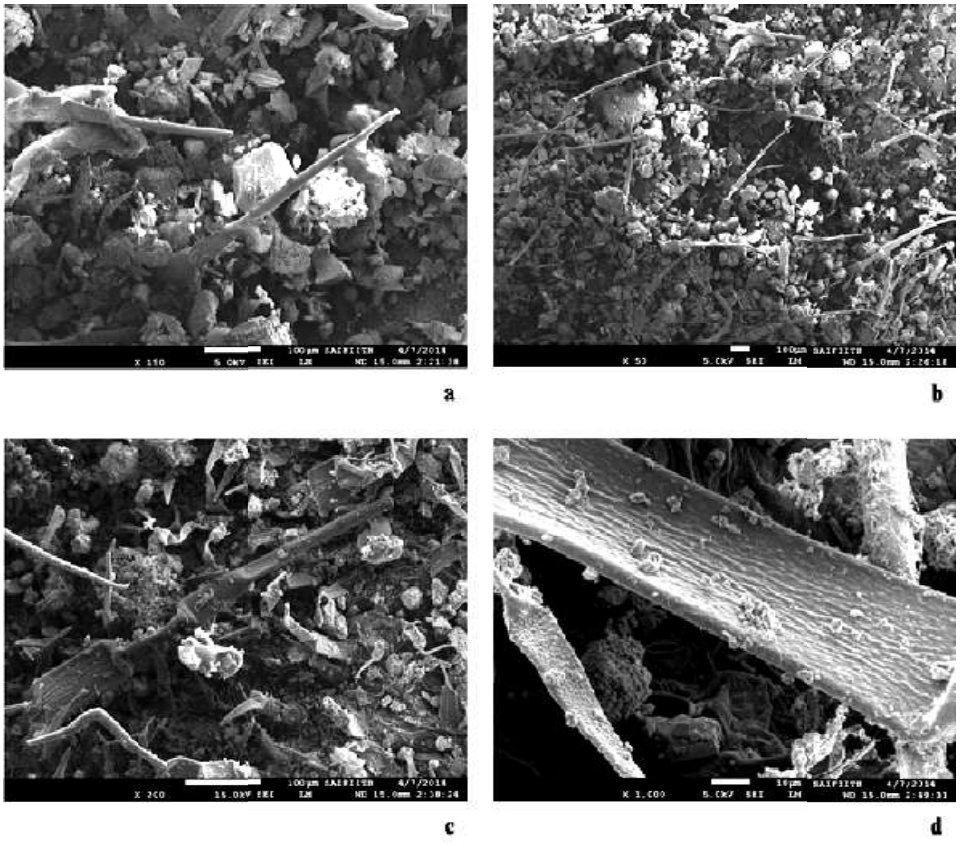

Fig.3: Scanning electron micrographs of *Hyptis* leaf surface showing trichomes and intermingled dust particles (a, b, c, d)

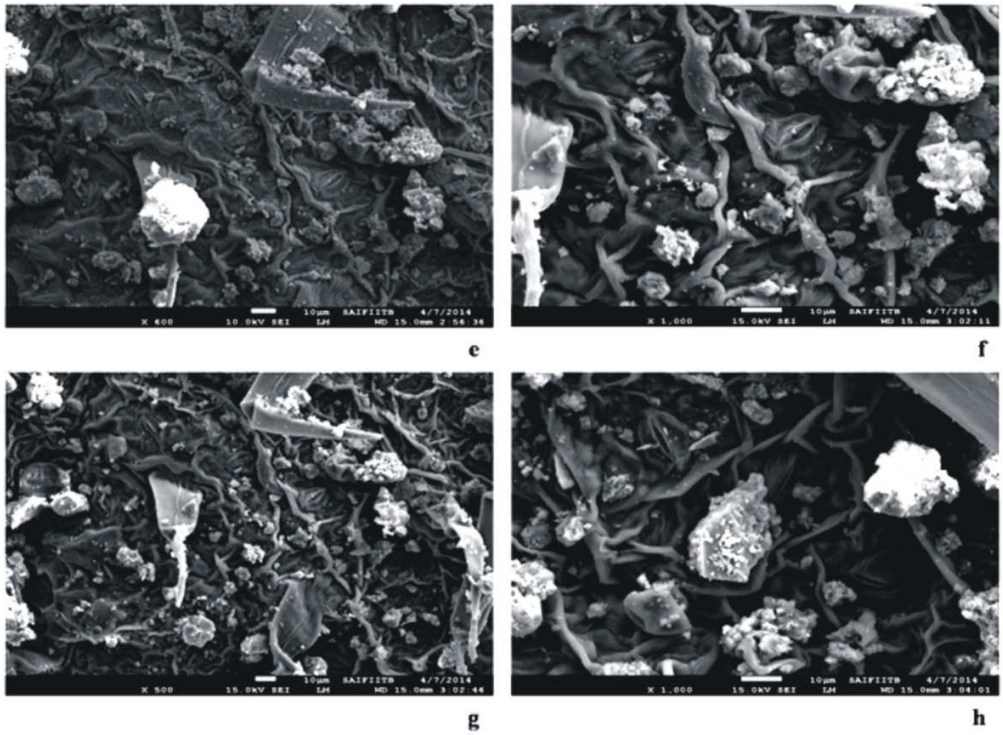

Fig. 4: Scanning electron images of *Hyptis suaveolens* leaf surface showing wrinkled epidermal layer and stomatal pore clogged with dust particles (e, f, g, h)

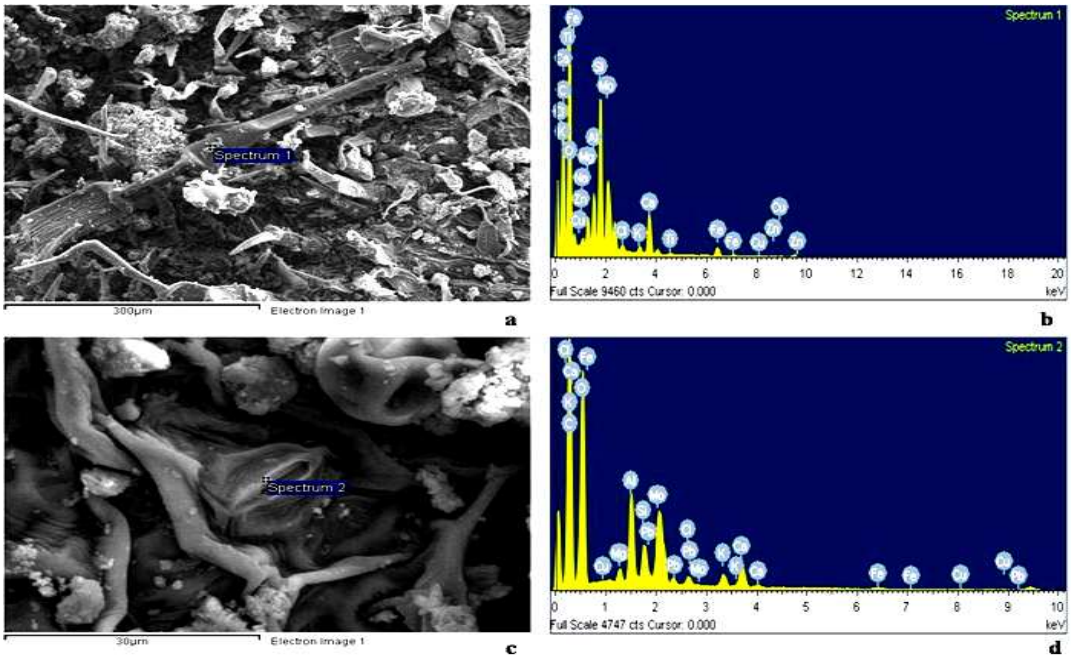

Fig.5: Scanning electron micrographs and electron spectrum of *Hyptis suaveolens* leaf surface: a) dust particles found on the surface of trichome, b) spot spectrum of the dust particle, c) dust particle found on the guard cell of stoma and d) spot spectrum of the dust particle

CONCLUSION

The EDS analysis of foliar dust collected from Hyptis reveals that metals/elements present on the leaf surface originated from roadside dust, heavy transportation vehicles, construction activities of road and particulate matters released from chimneys of various industries. The high content of Fe, Zn and other heavy metals

detected by SEM-EDS analysis showed that the vegetation is impacted with such metals and therefore human beings also.

The metals such as Ni, Zn, Fe, Mn, Mo, Pb and Cu are all the known metallic elements which are widely used in the metal/steel industrie. Tarapur industrial estate includes massive drug manufacturing units, chemical manufacturing units, steel plants and some textile plants. Also, there is continuous movement of all types of vehicles including heavy transportation trucks carrying loads like raw materials to processed goods which enter and leave this industrial area on a regular basis. So it is difficult to identify the proper source of heavy metal contamination in ambient environment.

The study helps us to understand the potential of roadside plants in retaining dust and heavy metals from the surrounding, thus preventing heavy metals from flying in the air and reducing the ambient pollution in environment to some extent. That plants even though ruderal in nature helps in abatement of heavy metals in the air.

Hyptis plant shows the presence of trichomes on its laminar surface. This could have been the reason for its ability to capture and retain atmospheric pollutants. Thus it can be concluded that the weed species, *Hyptis suaveolens* used here for foliar dust study can be used as an indicator species of metal contamination in the ambient air.

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