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SCAN ME

Research Paper

ANALYSIS OF ELEMENTAL COMPOSITION OF FOLIAR DUST IN MUMBAI

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Abstract

Dust pollution is one of the very dangerous types of air pollution. In Mumbai, excess of vehicles and continuous construction create a lot of dust pollution adding to major quantity of dust pollutants such as Suspended Particulate Matter (SPM), Heavy Metals, etc. in the city atmosphere. The excess of atmospheric heavy metals can lead to various health issues. The plants have been found to be very effective in monitoring and controlling dust pollution. The leaves too can capture good amounts of dust. In this research work, the foliar dust from *Ficus benjamina* L. var. *nuda* (Miq.) M. F. Barrett. was collected from various locations in the city. The elemental compositions of foliar dust samples were analyzed for their composition. Field Emission Gun-Scanning Electron Microscopes (FEG-SEM) was used to analyze Energy Dispersive Spectroscopy (EDS) at SAIF department in IIT, Powai. Carbon (C), Oxygen (O), Magnesium (Mg), Aluminium (Al), Silicon (Si), Potassium (K), Calcium (Ca), Manganese (Mn), Ferrous (Fe) and Copper (Cu) were discovered in the dust samples obtained from all the sites. Carbon (C) and Oxygen (O) were majorly seen in the dust samples. Similarly, Sodium (Na), Phosphorus (P), Sulphur (S), Titanium (Ti), Zinc (Zn) and Molybdenum (Mo) were found to be less common and if present, were available in traces.

Key words: *Dust pollution, Mumbai, SPM, Heavy Metals, FEG-SEM and EDS*.

INTRODUCTION

One of the major problems in Mumbai is Dust Pollution. SPM, RSPM, SO_2, NOx, many inorganic and organic pollutants, trace metals are hazardous pollutants in air [Caselles et al., 2002; Maitre et al., 2006; Curtis et al., 2006; Sharma et al., 2006; Jayaraman, 2007]. SPM system ranges from <0.01cm to >100cm [Wan- Kuen et al., 2005, 2006]. As, Cd, Co, Cr, Ni, Pb and Se are dangerous respirable particulate matter i.e. <10 µm [ATSDR, 2003; Wang et al., 2006]. 40-80% of total air pollution in the city comes from vehicular

emission [Ghose et al., 2005]. The dust and urban soil show presence of heavy metals due to traffic [Mert Guney et. al., 2010]. More vehicles create more emission leading to more Particulate Matter causing air pollution [Zanini et al., 2006]. Plants can monitor and control dust pollution and leaf surfaces play vital role in catching dust [Chaphekar et al, 1980]. The plants growing closer to the highway showed higher concentrations of heavy metals in the leaf, stem and root tissues [Falusi B. A., 2010]. The vehicles emit traces of metals which are found in Petrol, Diesel, Oil, etc. [Monacci and Bargagli, 1997]. Plant species growing on the roads involving higher number of petrol-fueled vehicles showed higher concentration of heavy metals like Lead (Pb) in foliar deposits [C. Aydinalp *et al*, 2004].

MATERIALS AND METHODS

The dust samples were collected from ten sites (Table 1) in Mumbai city from the leaf surfaces of *Ficus benjamina* L. var. *nuda* (Miq.) M. F. Barrett. The elemental composition of these dust samples were determined at SAIF department in IIT, Powai. 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 was used to analyse the dust samples. The dust samples were carried using small metal stubs coated with carbon paper on one end. Dust, being a non-conducting material, required a suitable metallic coating for better image quality. Platinum coating was done in an instrument (Model: JFC 1600) for 250 seconds. The Platinum coated metal stubs were then inserted in FEG-SEM instrument and to analyze elemental composition of the dust samples through EDS - Energy Dispersive Spectroscopy (Figure 1 and Figure 2).

RESULTS AND DISCUSSIONS

The sites selected for collecting dust samples were Marine Drive, Sion Circle, Ghatkopar, Mulund, Borivali, Goregaon, Malad, Bandra, Bandra Kurla Complex and K. C. Marg which included highways, traffic islands, link roads, primary roads and secondary roads (Table 1). The dust samples collected from selected 10 sites were analyzed for their elemental compositions in Atomic% and Weight% (Figure 1 and Table 2).

Table 1: Description of selected sites in Mumbai City

Site No.	Name of the Sites and their Description
1	**South Mumbai - Marine Drive:** Main road, facing the sea-moderate to heavy traffic, all types except three wheelers.
2	**Eastern Express Highway - Sion Circle, Dr. Babasaheb Ambedkar Road:** Main road, heavy traffic, all types of vehicles but more of heavy vehicles. This site also shows signals leading to traffic jams.
3	**Eastern Express Highway - Ghatkopar:** Main road, heavy traffic, all types of vehicles but more of heavy vehicles. No signals for longer distance, leading to faster moving traffic.
4	**Lal Bahadur Shastri Marg - Mulund:** Major arterial road passing through an industrial area showing heavy vehicular traffic.
5	**Western Express Highway - Borivali:** Main road, Heavy traffic, construction activity, all types of vehicles. Broad road with lots of vehicles moving at high speed.
6	**Swami Vivekanand Road - Goregaon:** Main road, Moderate to heavy traffic, all types of vehicles, construction activity, including three wheelers.
7	**Linking Road - Malad West:** Frequency of vehicles is very less compared to express highways. It's a broader road and this location is the common connection for various roads.
8	**Linking Road - Bandra West:** Frequency of vehicles is very less compared to express highways. It's a broader road compared to SV road.
9	**Secondary Roads – Bandra Kurla Complex:** Derived from primary roads and shows a lesser number of vehicles. It is the link between Western Express highway and Lal Bahadur Shastri marg.
10	**Secondary Roads – K. C. Marg, Bandra:** Derived from primary roads and shows a lesser number of vehicles. One end of this site opens at Worli Sea Link and the other one connects at the junction of SV road, Mahim and Western Express highway.

Table 2: Elemental composition (in Atomic%) of dust samples at selected sites

Element	Site 1		Site 2		Site 3		Site 4		Site5		Site 6		Site 7		Site 8		Site 9		Site 10	
	Weight%	Atomic%	Weight%	Atomic%	Weight%	Atomic%	Weight%	Atomic%	Weight%	Atomic%	Weight%	Atomic%	Weight%	Atomic%	Weight%	Atomic%	Weight%	Atomic%	Weight%	Atomic%
C	18.14	26.92	15.99	25.5	16.76	26.11	13.48	21.38	12.71	19.77	22.32	32.55	16.79	25.12	29.95	40.02	30.42	41.29	33.55	44
O	47.82	53.26	45.43	54.39	47.78	55.89	48.14	57.3	51.22	59.82	45.63	49.96	50.71	56.98	50.3	50.46	46.36	47.24	46.85	46.12

Na	Mg	Al	Si	P	S	K	Ca	Ti	Mn	Fe	Cu	Zn	Mo	Total
-	7.45	4.08	13.19	-	0.7	0.1	1.25	-	0.14	6.8	0.33	-	-	100
-	5.46	2.69	8.37	-	0.39	0.05	0.56	-	0.05	2.17	0.09	-	-	100
0.6	1.4	3.35	8.88	1.24	0.1	0.37	8.16	4.81	-	8.26	0.7	0.73	-	100
0.5	1.1	2.38	6.05	0.77	0.06	0.18	3.9	1.92	-	2.83	0.21	0.21	-	100
-	0.61	1.8	6.34	-	0.44	-	23.18	0.18	-	1.66	0.7	0.56	-	100
-	0.47	1.25	4.22	-	0.25	-	10.82	0.07	-	0.55	0.21	0.16	-	100
0.74	1.92	3.68	12.26	-	0.35	0.59	10.4	0.52	0.17	6.56	0.69	0.5	-	100
0.61	1.5	2.6	8.31	-	0.21	0.29	4.94	0.21	0.06	2.24	0.21	0.15	-	100
0.67	1.45	4.15	16.24	-	-	0.47	4.23	0.56	0.15	6.73	0.39	0.46	0.58	100
0.55	1.11	2.87	10.8	-	-	0.23	1.97	0.22	0.05	2.25	0.11	0.13	0.11	99.99
-	7.34	0.77	13.28	-	-	-	1	-	0.17	8.43	0.47	0.48	0.11	100
-	5.29	0.5	8.28	-	-	-	0.44	-	0.06	2.64	0.13	0.13	0.02	100
1.21	1.64	5.21	11.7	0.34	-	0.39	5.65	0.33	0.11	4.04	0.25	0.4	1.22	99.99
0.94	1.21	3.47	7.48	0.2	-	0.18	2.54	0.12	0.03	1.3	0.07	0.11	0.23	99.98
-	0.69	2.48	6.55	-	0.23	0.2	7.84	0.17	-	1.37	0.22	-	-	100
-	0.45	1.47	3.74	-	0.12	0.08	3.14	0.06	-	0.39	0.06	-	-	99.99
0.18	0.88	3.35	9.89	-	-	0.39	3.37	0.23	-	3.77	0.48	0.39	0.3	100
0.13	0.59	2.02	5.74	-	-	0.16	1.37	0.08	-	1.1	0.12	0.1	0.05	99.99
0.69	0.81	3.66	8.32	0.19	0.21	0.43	2.08	0.33	0.04	2.14	0.38	0.32	-	100
0.47	0.53	2.13	4.66	0.1	0.1	0.17	0.82	0.11	0.01	0.6	0.09	0.08	-	99.99

Max	47.82	53.26	45.43	54.39	47.78	55.89	48.14	57.3	51.22	59.82	45.63	49.96	50.71	56.98	50.3	50.46	46.36	47.24	46.85	46.12
Min	0.1	0.05	0.1	0.06	0.18	0.07	0.17	0.06	0.15	0.05	0.11	0.02	0.11	0.03	0.17	0.06	0.18	0.05	0.04	0.01

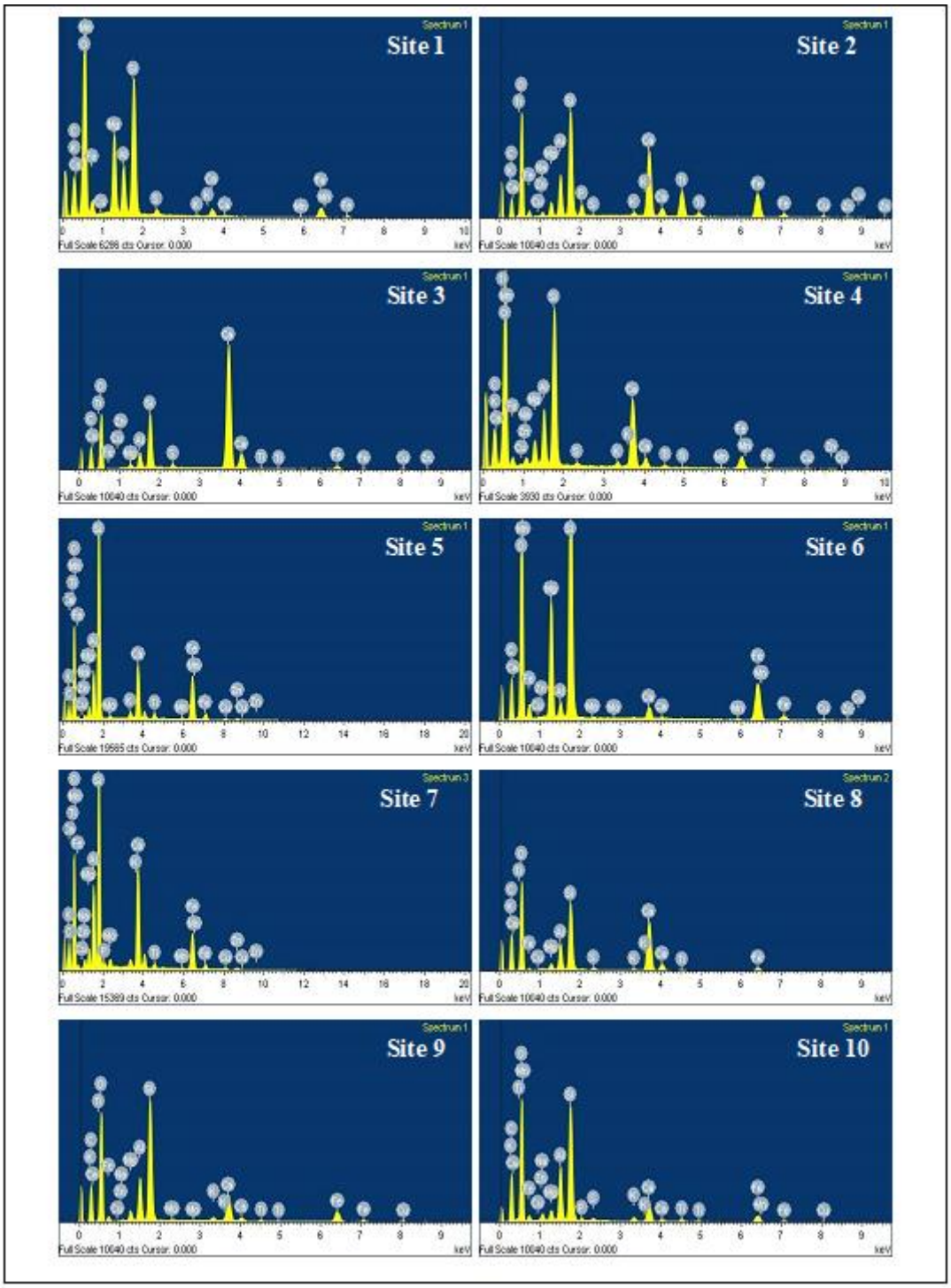

Figure 1: Elemental Composition of Dust samples from selected sites

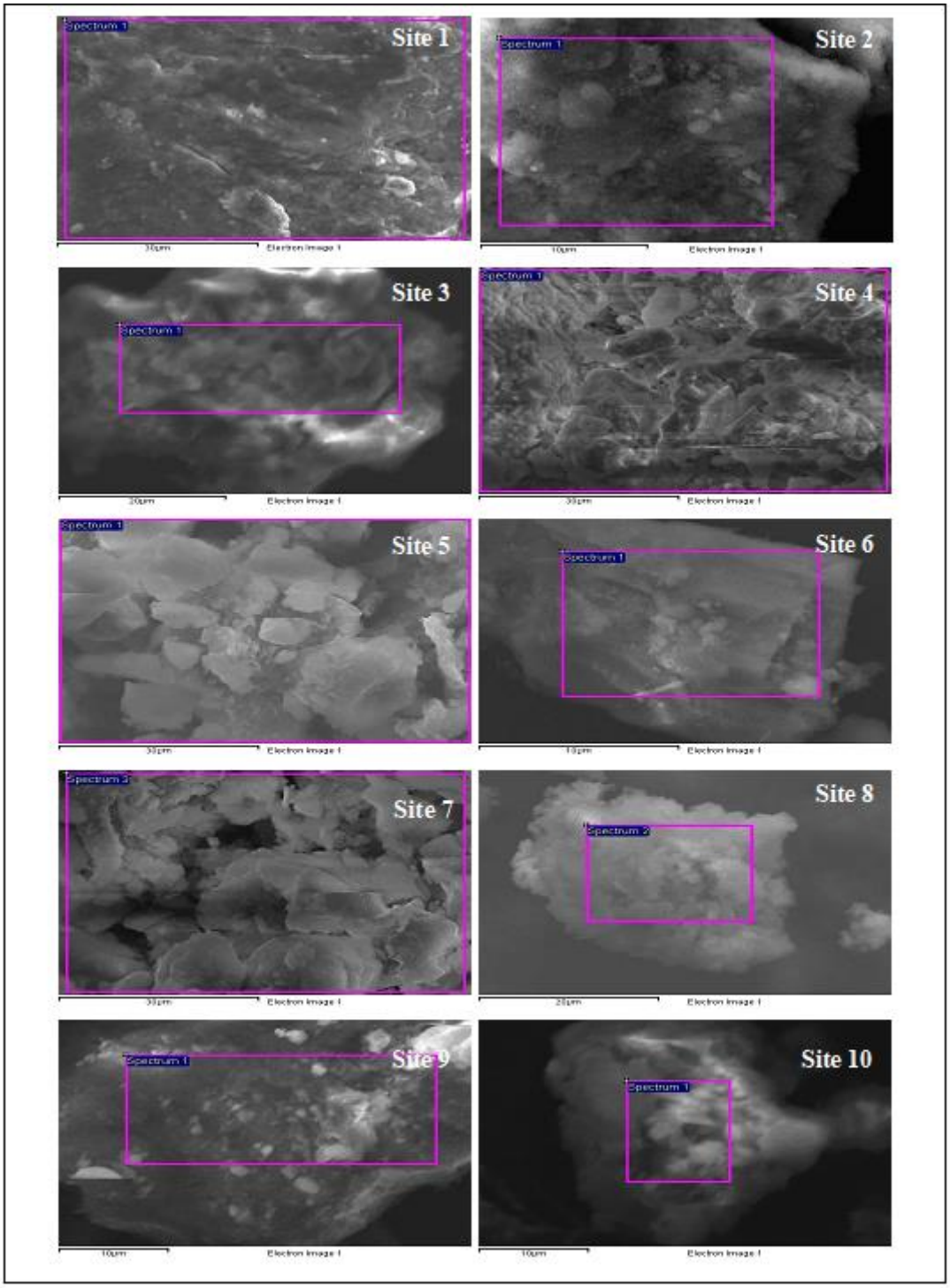

Figure 2: Scanned Electron Micrograph (SEM) of dust samples from selected sites

Site 1 : South Mumbai - Marine Drive

One of the most active sites of Mumbai was Marine Drive, a sea facing site with continuously moving private vehicles. Eleven elements; Carbon, Oxygen, Magnesium, Aluminium, Silicon, Sulphur, Potassium, Calcium, Manganese, Ferrous and Copper were discovered in the dust sample collected from this site. Oxygen and Carbon were found to

be maximum in proportion. Whereas Potassium was contributing the least, i.e. by weight % it was 0.1% and by atomic % it was only 0.05%. The heavy metal, Cu, was 0.33% by weight % and 0.09% by atomic % (Figure 1 and Table 2). Proportionally, the decreasing order of elemental composition was

O > C > Si > Mg > Fe > Al > Ca > S > Cu > Mn > K

Site 2 : Eastern Express Highway - Sion Circle, Dr. Babasaheb Ambedkar Road

Sion Circle was a very active road showing continuous slow moving traffic showing all types of vehicles. Dust collected from this site showed presence of 14 elements Carbon, Oxygen, Sodium, Magnesium, Aluminium, Silicon, Phosphorus, Sulphur, Potassium, Calcium, Titanium, Ferrous, Copper and Zinc. Oxygen and Carbon were mainly present. Whereas lowest contributor was Sulphur having 0.1% by weight % and 0.06 % by atomic %. Copper and Zinc were the two heavy metals discovered in the sample. The proportion of Cu by weight % was 0.7% and that of Zn was 0.73%. Similarly the proportion of both Cu and Zn by atomic % was 0.21% (Figure 1 and Table 2). The quantitative decreasing order of these elements was

O > C > Si > Fe > Ca > Ti > Al > Mg > P > Zn > Cu > Na > K > S

Site 3 : Eastern Express Highway - Ghatkopar

Ghatkopar being at Eastern Express highway, was a broad road including fast moving heavy vehicles. Eleven elements that include Carbon, Oxygen, Magnesium, Aluminium, Silicon, Sulphur, Calcium, Titanium, Ferrous, Copper and Zinc were found in the dust sample collected from here. The dust was mainly Oxygen and Carbon. The least content of the dust was by Ti i.e. 0.18% by weight % and 0.07% by atomic %. The traces of heavy metals viz; Cu and Zn were discovered in the sample. Copper was 0.7% by weight % and 0.21% by atomic %. Whereas Zinc was 0.56% by weight % and 0.16% by atomic % (Figure 1 and Table 2). The arrangement of elements in their decreasing proportion was

O > Ca > C > Si > Al > Fe > Cu > Mg > Zn > S > Ti

Site 4 : Lal Bahadur Shastri Marg - Mulund

Lal Bahadur Shastri Marg in Mulund was site 4 witnessing continuous movement of all types of vehicles mainly Heavy vehicles. The dust sample contained 14 elements;

Carbon, Oxygen, Sodium, Magnesium, Aluminium, Silicon, Sulphur, Potassium, Calcium, Titanium, Manganese, Ferrous, Copper and Zinc. The dust was mainly comprised of Oxygen and Carbon. Mn was contributing the minimum i.e. 0.17% by weight % and 0.06% by atomic %. The heavy metals like Cu and Zn in the dust were 0.69% and 0.5% by weight % respectively. Similarly, by atomic % Cu was 0.21% and Zn was 0.15% (Figure 1 and Table 2). Proportionally, the decreasing arrangement of elements was

O > C > Si > Ca > Fe > Al > Mg > Na > Cu > K > Ti > Zn > S > Mn

Site 5 : Western Express Highway - Borivali

Borivali was the site 5, located on Western Express highway, showing 2-wheelers, 4-wheelers, trucks, busses, etc. moving at high speed. The 14 elements detected in the dust sample of this site included Carbon, Oxygen, Sodium, Magnesium, Aluminium, Silicon, Potassium, Calcium, Titanium, Manganese, Ferrous, Copper, Zinc and Molybdenum. The major proportion of the dust was composed of Oxygen and Carbon whereas the least contribution was by Manganese. The weight % and atomic % of Mn were 0.15% and 0.05% respectively. The heavy metals found in this sample were Copper, Zinc and Molybdenum. The contribution of Cu, Zn and Mo was 0.39%, 0.46% and 0.58% by weight % and 0.11%, 0.13% and 0.11% by atomic % respectively (Figure 1 and Table 2). These 14 elements were showing the proportional sequence as

O > Si > C > Fe > Ca > Al > Mg > Na > Mo > Ti > K > Zn > Cu > Mn

Site 6 : Swami Vivekanand Road - Goregaon

The site 6 was located in Goregaon at Swami Vivekanand road which had good frequency of public and private vehicles. The 11 elements viz; Carbon, Oxygen, Magnesium, Aluminium, Silicon, Calcium, Manganese, Ferrous, Copper, Zinc and Molybdenum were detected in the dust sample collected from this site. Oxygen and Carbon were contributing the maximum of the total dust. Similarly, Molybdenum contributed the least and the values were 0.11% as weight % and 0.02% as atomic %. The dust also showed the minimal presence of heavy metals Zinc and Copper. Both of these constituted 0.13% by atomic %. But by weight % Cu and Zn were sharing 0.47% and 0.48% respectively (Figure 1 and Table 2). Quantitatively all the elements were showing the sequence

O > C > Si > Fe > Mg > Mn > Ca > Al > Zn > Cu > Mo

Site 7 : Linking Road - Malad West

On Link road, in Malad, all types of vehicles were observed with a moderate traffic. There were fifteen elements detected in the dust sample of this site which include Carbon, Oxygen, Sodium, Magnesium, Aluminium, Silicon, Phosphorus, Potassium, Calcium, Titanium, Manganese, Ferrous, Copper, Zinc and Molybdenum. The proportion of Oxygen and Carbon was too high but that of other elements was too low. The least participation was made by Manganese by sharing only 0.11% weight % and 0.03% by atomic %. Copper, Zinc and Molybdenum were the heavy metals found in the dust sample. The proportion of Cu, Zn and Mo was 0.25%, 0.4% and 1.22 % by weight % and 0.07%, 0.11% and 0.23% by atomic % respectively (Figure 1 and Table 2). The proportional sequence of all these 15 elements was

O > C > Si > Ca > Al > Fe > Mg > Mo > Na > Zn > K > P > Ti > Cu > Mn

Site 8 : Linking Road - Bandra West

Site 8, at linking road in Bandra west, showed slow moving traffic with short distance signals. The dust sample from this site showed the presence of 11 elements; Carbon, Oxygen, Magnesium, Aluminium, Silicon, Sulphur, Potassium, Calcium, Titanium, Ferrous and Copper. The dust was mainly composed of oxygen and carbon and on the other hand remaining elements were contributing quite low. Titanium was forming 0.17% by weight % and 0.06 % by atomic % of the dust and was lowest of all elemental proportion. The sample also traced the presence of heavy metal Cu as 0.22% by weight % and 0.06% by atomic % (Figure 1 and Table 2). The decreasing order of the elements was

O > C > Ca > Si > Al > Fe > Mg > S > Cu > K > Ti

Site 9 : Secondary Roads – Bandra Kurla Complex

Western and Eastern Express highways and Lal Bahadur Shastri marg were connected with each other by Bandra Kurla Complex, the site 9. His site had active traffic including all types of vehicles. 13 elements found in the dust from this site were Carbon, Oxygen, Sodium, Magnesium, Aluminium, Silicon, Potassium, Calcium, Titanium, Ferrous, Copper, Zinc and Molybdenum. The dust was concentrated with Oxygen and Carbon whereas the least proportion was of Na. The traces of Na by weight % and by atomic % were 0.18% and 0.13% respectively. The dust also showed the presence of

heavy metals Cu and Zn. The proportion of Cu was 0.48% by weight % and 0.12% by atomic % whereas that of Zn was 0.39% and 0.1% respectively (Figure 1 and Table 2). These 13 elements were arranged in decreasing order as

$$O > C > Si > Fe > Ca > Al > Mg > Cu > K \geq Zn > Mo > Ti > Na$$

Site 10 : Secondary Roads – K. C. Marg, Bandra

The site 10, Krishna Chandra Marg, was located in Bandra west which connected primary and secondary roads with Bandra Worli Sea Link and witnessed 2-wheelers, 3-wheelers, Trucks and Buses. There were 15 elements Carbon, Oxygen, Sodium, Magnesium, Aluminium, Silicon, Phosphorus, Sulphur, Potassium, Calcium, Titanium, Manganese, Ferrous, Copper and Zinc discovered in the dust sample collected from this site. The highest proportion of the dust was by Oxygen and Carbon. Similarly, the minimum contributor was Mn having 0.04% by weight % and 0.01% by atomic %. Traces of heavy metals like Cu and Zn were detected. The weight % of both these elements were 0.38% and 0.32% and the atomic % were 0.09% and 0.08% respectively (Figure 1 and Table 2). The decreasing order of the discovered elements was

$$O > C > Si > Al > Fe > Ca > Mg > Na > K > Cu > Ti > Zn > S > P > Mn$$

CONCLUSIONS

Presence of heavy metals in foliar dust available at various sites is an indication towards the existence of excess metallic pollutants in ambient Air. There were a total 16 elements found in the dust samples collected from all the 10 sites. There were eleven elements detected in the dust sample from Marine Drive, fourteen elements from Mulund (LBS marg), similarly eleven were discovered in the dust sample from Goregaon (SV road), the dust sample from Bandra (Linking road) also had eleven elements within it, fifteen elements were found in the dust collected from Malad (Linking road), fourteen elements were seen in the dust from Borivali (Western Express highway), dust sample from Sion Circle (Eastern Express highway) contained fourteen elements, eleven elements were available in the dust from Ghatkopar (Eastern Express highway), there were fourteen elements in the dust sample collected from Mulund (Lal Bahadur Shastri marg), fifteen were detected in the dust obtained from K.C. Marg (Bandra-W) and the dust collected from Bandra Kurla Complex showed the presence of thirteen elements.

As per FEG-SEM data, Oxygen is most commonly available in dust at all the ten sites in highest proportion. Similarly, proportionally Carbon is the second highest element in dust. Whereas Silicon had been found frequently in the foliar dust. The elements found in the dust of all the ten selected sites were C, O, Mg, Al, Si, K, Ca, Mn, Fe and Cu. Whereas Na, P, S, Ti, Zn and Mo were less common and if present, available in traces.

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