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A Study on Determination of Metals in Road Side Dust at Selected Locations of Delhi

Mrs. Namita Mishra[1], B. Sasi Devi[2], .B. K. Jakhmola[3]
[1]*Sc.'C', Central Pollution Control Board, East Arjun Nagar, Delhi-110 032.*
[2] *SSA, Central Pollution Control Board, East Arjun Nagar, Delhi-110 032.*
[3]*Sc.'E', Central Pollution Control Board, East Arjun Nagar, Delhi-110 032.*
Corresponding Author: Mrs. Namita Mishra

Abstract: *Top soil samples were collected under stable weather conditions from the heavy traffic areas of Delhi and Delhi NCR. The present paper is on estimation of concentration of heavy metals (especially trace metals) by collecting roadside dust samples. Rapid urbanization and industrialization are main reasons for deterioration of air quality in many of the metro cities like Delhi. These anthropogenic fugitive emissions are aggregated on the soil surface. The present paper is to estimate concentration of heavy metals in roadside dust samples collected from the paved roads of Delhi and Delhi NCR. Some of the heavy metals like Mn, Co, Pb, Zn, Ni, Cu and Cd were analyzed by Inductively Coupled Plasma Atomic Emission Spectroscopy (ICPAES) and Spectrophotometrically. The analysis of variants shows that Zn and Mn concentration levels were highly significant in road dust. High concentration of these heavy metals suggests that construction activities and automobiles are the major sources in the roadside soils. Metal concentration in the dust Cu concentration ranged from 43 – 653 mg/kg, Pb concentration ranged from 24 – 150 mg/kg, Ni concentration ranged from 0-25 mg/kg, Mn concentration ranged from 196-459mg/kg and Cr concentration ranged from 16-53 mg/kg.*
Keywords*- Heavy metals, road side dust, automobile pollution etc.*

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I. Introduction

Road dust comprises of particles of various sizes; some fine particulate matter (PM2.5; < 2.5-µm diameter), respirable coarse particulates (< 10-µm diameter),and non-respirable coarse particulates (> 10-µm diameter)derived from both anthropogenic (mobile and stationary)and natural sources. Previous roadside dust studies have highlighted enrichment of road dust with heavy metals like cadmium, lead, and nickel due to traffic sources [1]. The release of heavy metals is one of the most significant environmental problems caused by anthropogenic activities such as urban road construction, quarrying, agriculture, waste incinerations, sewage disposal, bush burning vehicle exhausts, industrial discharges, oil lubricants, automobile parts, [2] corrosion of building materials, atmospheric deposition [3] and particulate emission [4]. The presence of heavy metals has been considered as useful indicators for contamination in surface soil, sediment and dust environments [5]. Roadside dust is typically derived from anthropogenic activities via alteration of natural solid, liquid or gaseous material with pollutants sources such as water transported material from surrounding soil and slopes, dry and wet atmospheric deposition, biological inputs, road surface wear, road paints degradation, vehicle wear (tyres, body, brakes linings etc), vehicular fluid particulate emissions and discharge from metal processing industries [6][7].

Young children are particularly more likely to ingest significant quantities of dust than adults because of the behaviour of mouthing non food objects and repetitive hand/finger sucking [8]. Children are more vulnerable to heavy metals toxicities than adults. Studies have been carried out on street dust near places where children play since children are more sensitive to contaminant-bearing dust [9]. Particulates of smaller sizes are persistent in the environment and exert negative health impact to the exposed resident population, especially in the urban settings [10].

Common sources of air pollution (heavy metals and particulate matter (PM)) in LMICs include vehicular emissions, industrial plants, power generation plants, oil burning, waste incineration, biomass burning, electric power generators, tire friction, motor oils spills, construction and demolition activities, as well as resuspension of surrounding contaminated soils and dust [11][12]. Exposure to heavy metals in roadside dust occurs by skin contact, inhalation, and/or ingestion. The effects of heavy metals in road dust include respiratory system disorders, nervous system interruptions, endocrine system malfunction, immune system suppression, and the risk of cancer in later life [13]. The high levels of heavy metals as evident in this study and particularly Pb and Cr which are known to be carcinogenic are of concern in relation to human health, chiefly to children, the vulnerable old and pregnant women living close to and/or using busy roads [14][13].

These urbanisation rates, combined with unregulated traffic activities, poorly maintained vehicles, and limited air pollution control policies and or implementation, mean that air quality in sub-Saharan Africa (SSA) has deteriorated over time [15][16].

Metals can accumulate in fatty tissues, affecting the functions of organs and disrupting the nervous system or the endocrinal system [17] and some metals could cause mutagenic, teratogenic and carcinogenic effects in living beings [18]. The impacts of PM on the morphological, biochemical, and physiological features of urban roadside plants have been recorded by several researchers [19][20][21][22][23].

Two main sources of road dust, and consequently of the heavy metals found therein; these are deposition of previously suspended particles (atmospheric aerosols) and displaced soil [9]. Particles of different fraction sizes have different modes of transport. Strong wind is an important factor in transport of dust particles to affect regional environment and harm human health, as well as cause significant impacts on global biogeochemical cycle. Metals are non-biodegradable and accumulative in nature [24].

The samples of roadside dust collected were decided to analyse through Inductively Coupled Plasma (Atomic Emission Spectroscopy) which was installed in 2007 and doing heavy metal analysis successfully since then. Inductively coupled plasma atomic emission spectroscopy (ICP-AES), also referred to as inductively coupled plasma optical emission spectrometry (ICP-OES), and is an analytical technique used for the detection of trace metals. It is a type of emission spectroscopy that uses the inductively coupled plasma to produce excited atoms and ions that emit electromagnetic radiation at wavelengths characteristic of a particular element. It is a flame technique with a flame temperature in a range from 6000 to 10000 K. It is also a solution technique & standard silicate dissolution methods are employed. The intensity of this emission is indicative of the concentration of the element within the sample

1.1 Sources and effects of metals

Toxic trace elements and heavy metals are kept under the category of non-degradable pollutants. The problem caused by these elements is in fact due to their concentration in the environment in the bio available state and above a certain concentration becomes harmful to the living organisms. A fundamental factor which lightens the concern over the presence of toxic trace metals in the environment is their non-bio-degradability & consequent persistence. The tendency of metals is lipophilic and these get accumulated and bio-magnified. Some metals notably Mercury and Cadmium are concentrated in food chain through bio accumulation. The presence of metals in the environment depends on their natural and man-made sources. Naturally the metals are found in the Earth's crust as a major constituent of it and through the disturbance on its upper surface, they come into the environment. There are also so many man-made activities, where the metals are being used in various domestic and industrial practices, the improper disposal or by-product of that, may result into the occurrence of metals in the environment. These metals are bioaccumulative and there are possibilities that these metals can reach a critical value and threatened human health [24]. However, these trace metals play an important role is everyday activity either for agricultural or industrial and its impact on health is given in following Table.

Metals their uses and health effects

S.No	Metal	Role of metals in everyday activity	Health Effects
1	Arsenic (As)	Alloys, pesticides, herbicides, insecticides and various bronzing and pyrotechnics.	Non-essential for plants and animals. Sever hemorrhage, brain damage, organ failure, carcinogenic effects.
2	Cadmium (Cd)	Electroplating batteries, pigments, paints, alloys.	Non-essential for plants and animals tubular proteinuria (An increased excretion of low molecular weight protein in weine)
3	Chromium (Cr)	Alloys electroplating pigments, cooling water (For corrosion control	Non-essential for plants but essential trace metals for animals, severe corrosion of tract and kidney necrosis
4	Cobalt (Co)	Alloys, paints, varnishes, in radiotherapy, industrial radiography and electroplating.	An essential growth element for plants and animals. Lung and heart effects, dermatitis, liver and kidney damage, mutagenic and carcinogenic effects
5	Copper (Cu)	Electrical wiring roofing, various alloys, pigments, cooking utensils, piping in chemical industries copper salts in water supply system to control biological growth.	An essential trace element for plants and animals. Gastric ulcers, hemolysis. jaundice, hepaticnecrosis, renal damage, pink diseases in infants, carcinogenic to animals.
6	Mercury (Hg)	Pesticides, pigments, batteries and paper industries	Tremors, gingivitis, minor psychological changes, acrodynia characterized by pink hands and feet, spontaneous abortion, damage to nervous system, protoplasm poisoning
7	Iron (Fe)	Widely used in steel and in other alloys.	An essential element in plants and animals. Excess of iron can lead to siderosios.

8	Lead (Pb)	Batteries, ammunition, solder piping, pigments, insecticides, and alloys.	Non-essential for plants and animals. Anemia, alimentary symptoms, renal damage, encephalopathy. In children-irritability, loss of appetite, occasional vomiting.
9	Manganese (Mn)	Alloys, reagent in organic chemistry, paint, batteries, for rust and corrosion prevention, steel production.	An essential trace element for plants and animals. Nervous system toxicity impaired motor skills and cognitive disorders.
10	Nickel (Ni)	Alloys, magnets, protective catalysts batteries.	An essential element for some plants and animals. Severe lung damage, headaches, vertigo, nausea, vomiting, insomnia, mutagenic effects.
11	Zinc (Zn)	Alloys (Brass and Bronze), batteries, fungicides, pigments.	An essential growth element for plants and animals. Vomiting, dehydration, electrolyte imbalance, stomach pain, nausea, muscular in coordination
12	Antimony	The largest applications for metallic antimony are as alloying material for lead and tin and for lead antimony plates in lead–acid batteries. Used in solders, bullets and plain bearings. Antimony compounds are prominent additives for chlorine and bromine-containing fire retardants found in many commercial and domestic products. An emerging application is the use of antimony in microelectronics.	The effects of antimony and its compounds on human and environmental health differ widely. The massive antimony metal does not affect human and environmental health. Inhalation of antimony trioxide (and similar poorly soluble Sb(III) dust particles such as antimony dust) is considered harmful and suspected of causing cancer.
13	Selenium	The chief commercial uses for selenium today are in glassmaking and in pigments. Selenium is a semiconductor and is used in photocells. Uses in electronics, once important, have been mostly supplanted by silicon semiconductor devices. Selenium continues to be used in a few types of DC power surge protectors and one type offluorescent quantum dot.	Selenium salts are toxic in large amounts, but trace amounts are necessary for cellular function in many organisms, including all animals. Selenium is an ingredient in many multivitamins and other dietary supplements, including infant formula. It is a component of the antioxidant enzymes glutathione peroxidase and thioredoxin reductase (which indirectly reduce certainoxidized molecules in animals and some plants). It is also found in three deiodinase enzymes, which convert one thyroid hormone to another. Selenium requirements in plants differ by species, with some plants requiring relatively large amounts, and others apparently requiring none
14	Vanadium	It is mainly used to produce specialty steel alloys such as high-speed tool steels. The most important industrial vanadium compound, vanadium pentoxide, is used as a catalyst for the production of sulfuric acid	Large amounts of vanadium ions are found in a few organisms, possibly as a toxin. The oxide and some other salts of vanadium have moderate toxicity. Particularly in the ocean, vanadium is used by some life forms as an active center of enzymes, such as the vanadium bromoperoxidase of some ocean algae. Vanadium is probably a micronutrient in mammals, including humans, but its precise role in this regard is unknown

A great number of scientific studies have linked exposure to particle pollution with a variety of problems including premature death in people with heart or lung disease, non-fatal heart attacks, irregular heartbeat, aggravated asthma, and decreased lung function [25]. In addition, increased respiratory symptoms such as irritation of the airways, coughing, or difficulty in breathing have also been linked to PM exposure [26]. For those people who spend a significant portion of their day on (or adjacent to) the road, eg. Residential areas, street vendors, traffic police, touts, and public vehicle drivers, the health consequences of PM2.5 exposures are even greater [16].

II. Methodology

The study was taken up to assess the overall scenario of the presence of metals in the roadside dust and to see the influence of location on the occurrence of the various metals. So that the eight locations were selected to ensure, covering the whole city from Delhi NCR (UP border to Haryana border). The samples collected were the settled dust on the footpaths and dividers that was generated due to the running of vehicles, and domestic/industrial activities, and carried through moving traffic and blowing wind. The detailed procedure of monitoring sample processing and analysis is discussed in the following paragraphs.

2.1 Sampling Locations and Frequency:

Samples were collected on the basis of heavy traffic levels, ecological index and pollution index. Total eight sampling points were decided to collect the dust so as to cover the whole city from East to West, North to South and Central part. Since the study was carried for the short duration i.e. for three fortnights was decided to collect the sample from footpath as well as plants/ trees. The location of the sampling point with the number of sampling along with the frequency is given in the following table.

Sampling locations and frequency

S.No.	Location of house	Duration	Frequency	Total No. of samples
01.	Singhu Border	1½ month	Fortnightly	3+3 (footpath + Leaf dust)
02.	Dhaula Kuan	1½ month	Fortnightly	3+3
03.	Ashram	1½ month	Fortnightly	3+3
04.	ITO	1½ month	Fortnightly	3+3
05.	ISBT	1½ month	Fortnightly	3+3
06.	Dilshad Garden	1½ month	Fortnightly	3+3
07.	Anand Vihar	1½ month	Fortnightly	3+3
08.	CPCB, East Arjun Nagar	1½ month	Fortnightly	3+3

2.2 Monitoring:

The dust produced due to the various anthropogenic activities is carried out by the wind and the traffic moving on the roads that finally get settled on the sideway footpaths and the leaves of the plants lying on the road side. The dust of the footpaths collected in the dust pan with the help of brush from the various points from the footpaths at the both side of roads and from the divider and finally kept in the plastic bag after mixing it properly. And in the case of leaf dust, the leaves loaded with dust picked up from the various plants/ trees and safely kept in plastic bags and the bags finally transported to the laboratory for further processing and testing.

Sampling of Road dust and Leaf dust of road side plant

2.3 Sample processing:

In the laboratory the dust was removed from the leaves collected from the roadside plants and in order to remove moisture from the dust sample collected from the footpaths as well as from the roadside leaves it was kept overnight in hot air oven in 105^0C and after desiccation the sample weighed and digested before the analysis.

Processing of Leaf dust in the laboratory

2.4 Sample Digestion:

1gm pre dried dust mixed with tri-acid mixture (5ml Nitric Acid + 3ml Per chloric Acid + 2ml Hydrochloric Acid). 100 ml distilled water added and digested on a Hot plate at 70^0C for 2 hrs or till the digested sample got transparent. Make up the total volume for 100ml after cooling down the mixture. The samples after this pre-treatment were analysed using Inductive Coupled Plasma Spectroscopy.

2.3 Quantitative Evaluation :

Instrumenation (ICP-AES)- ICP/AES is one of the most powerful and popular analytical tools for the determination of trace elements in a numerous sample types (Table 2). The technique is based upon the spontaneous emission of photons from atoms and ions that have been excited in a RF discharge. Liquid and gas samples may be injected directly into the instrument, while solid samples require extraction or acid digestion so that the analytes will be present in a solution.

Working principle of (ICP-AES): The ICP-AES is composed of two parts: the ICP and the optical spectrometer. The ICP torch consists of 3 concentric quartz glass tubes. The output or "work" coil of the radio frequency (RF) generator surrounds part of this quartz torch. Argon gas is typically used to create the plasma. When the torch is turned on, an intense electromagnetic field is created within the coil by the high power radio frequency signal flowing in the coil. This RF signal is created by the RF generator which is, effectively, a high power radio transmitter driving the "work coil" the same way a typical radio transmitter drives a transmitting antenna. Typical instruments run at either 27 or 40 MHz. The argon gas flowing through the torch is ignited with a Tesla unit that creates a brief discharge arc through the argon flow to initiate the ionization process. Once the plasma is "ignited", the Tesla unit is turned off. The argon gas is ionized in the intense electromagnetic field and flows in a particular rotationally symmetrical pattern towards the magnetic field of the RF coil. Astable, high temperature plasma of about 7000 K is then generated as the result of the inelastic collisions created between the neutral argon atoms and the charged particles.

A peristaltic pump delivers an aqueous or organic sample into an analytical nebulizer where it is changed into mist and introduced directly inside the plasma flame. The sample immediately collides with the electrons and charged ions in the plasma and is itself broken down into charged ions. The various molecules break up into their respective atoms which then lose electrons and recombine repeatedly in the plasma, giving off radiation at the characteristic wavelengths of the elements involved. Within the optical chamber(s), after the light is separated into its different wavelengths (colours), the light intensity is measured with Charged Coupled Device (CCD) Detector physically positioned to "view" the specific wavelength(s) for each element line involved. Using the Charge Coupled device (CCD) the intensities of all wavelengths (within the system's range) can be measured simultaneously, allowing the instrument to analyze for every element to which the unit is sensitive all at once. Thus, all the elements can be measured simultaneously. The intensity of each line is then compared to previously measured intensities of known concentrations of the elements, and their concentrations are then computed by interpolation along the calibration lines.

Inductive Coupled Plasma Spectrometer

III. Results and Discussion

The samples were collected from eight locations, three times fortnightly (22nd January, 11th February and 26th February), in the period of three fortnights. During the monitoring temperature and humidity were also recorded and summarized as below:

Weather conditions during the monitoring of dust

S.No.	Weather parameter	Date of sampling		
		22.01.16	11.02.16	26.02.16
01.	Average Temperature	12^{0}C	24^{0}C	27^{0}C
02.	Humidity	55%	34%	32%
03.	Sun Light	Moderate	Sunny	Sunny

The samples collected from various locations of Delhi, processed and analysed for 14 elements using ICP-AES while mercury was analysed using Mercury Analyzer with cold vapour technique and reported the concentration in mg/Kg. The results obtained after the analysis are shown in Table: 1, 2 & 3.

Table 1: Results of the Road side dust and Leaf dust samples collected from various locations at Delhi on 22.01.16

S.No	Name of element	Sampling locations							
		Singhu Border	Dhaula Kuan	Ashram	ITO	ISBT Kashmiri G	Dilshad Garden	Anand Vihar	CPCB
	Road side dust								
01.	Arsenic	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
02.	Cadmium	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
03.	Cobalt	BDL	3.0	BDL	BDL	BDL	4.0	BDL	3.0
04.	Chromium	48	23	18	18	24	31	21	26
05.	Copper	61	107	82	184	653	94	255	172
06.	Manganese	341	271	282	210	206	329	297	218
07.	Nickel	16	14	12	14	16	17	15	14
08.	Lead	63	33	38	40	41	50	30	53
09.	Antimony	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
10.	Selenium	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
11.	Vanadium	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
12.	Zinc	146	210	192	249	214	226	236	221
13.	Mercury	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
	Leaf Dust								
01.	Arsenic		BDL	BDL	BDL	BDL	BDL	BDL	BDL
02.	Cadmium		BDL	BDL	BDL	BDL	BDL	BDL	BDL
03.	Cobalt		6	5	5	5	3	5	5
04.	Chromium		51	39	50	47	34	51	67
05.	Copper		163	166	252	179	677	436	645
06.	Manganese		401	372	372	334	210	323	402
07.	Nickel		25	26	30	26	22	30	38
08.	Lead		72	81	102	85	74	103	139
09.	Antimony		BDL	BDL	BDL	BDL	BDL	BDL	BDL
10.	Selenium		BDL	BDL	BDL	BDL	BDL	BDL	BDL
11.	Vanadium		39	21	BDL	BDL	BDL	27	40
12	Zinc		501	419	745	607	425	582	679
13.	Mercury		BDL	BDL	BDL	BDL	BDL	BDL	BDL

Note : The values are in mg/kg

Table: 2 Results of the Road side dust and Leaf dust samples collected from various locations at Delhi on 11.02.2016

S.No.	**Name of element**	**Sampling locations**							
		Singhu Border	**Dhaula Kuan**	**Ashram**	**ITO**	**ISBT Kashmiri G**	**Dilshad Garden**	**Anand Vihar**	**CPCB**
	Road side dust								
01.	Arsenic	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
02.	Cadmium	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
03.	Cobalt	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
04.	Chromium	53	31	32	24	19	21	16	22
05.	Copper	43	95	74	87	136	495	142	138
06.	Manganese	360	353	265	274	229	230	210	196
07.	Nickel	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
08.	Lead	70	36	47	37	27	40	37	34
09.	Antimony	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
10.	Selenium	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
11.	Vanadium	17	27	20	19	15	18	19	20
12.	Zinc	612	224	2110	205	239	272	175	172

13.	Mercury	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
	Leaf Dust								
01.	Arsenic	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
02.	Cadmium	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
03.	Cobalt	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
04.	Chromium	61	50	42	57	49	22	32	65
05.	Copper	154	182	171	230	198	588	213	679
06.	Manganese	428	415	370	382	340	162	188	374
07.	Nickel	22	19	23	21	19	BDL	BDL	29
08.	Lead	273	75	66	105	83	57	52	127
09.	Antimony	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
10.	Selenium	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
11.	Vanadium	44	44	39	45	37	22	30	52
12	Zinc	456	525	396	573	557	335	284	642
13.	Mercury	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL

Note : The values are in mg/Kg

Table: 3 Results of the Road side dust and Leaf dust samples collected from various locations at Delhi on 26.02.16

S.No	Name of element	Sampling locations							
		Singhu Border	Dhaula Kuan	Ashram	ITO	ISBT Kashmiri G	Dilshad Garden	Anand Vihar	CPCB
	Road side dust								
01.	Arsenic	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
02.	Cadmium	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
03.	Cobalt	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
04.	Chromium	42	38	29	26	31	26	19	23
05.	Copper	85	104	57	78	126	496	73	92
06.	Manganese	459	328	248	258	255	233	237	218
07.	Nickel	13	13	14	10	25	13	BDL	13
08.	Lead	150	53	31	38	49	46	24	47
09.	Antimony	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
10.	Selenium	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
11.	Vanadium	9	14	BDL	7	7	BDL	BDL	BDL
12.	Zinc	154	240	867	220	273	280	120	136
13	Mercury	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
	Leave Dust								
01.	Arsenic	BDL	BDL	BDL	BDL	BDL	BDL	BDL	
02.	Cadmium	BDL	BDL	BDL	BDL	BDL	BDL	BDL	
03.	Cobalt	BDL	BDL	BDL	BDL	BDL	BDL	BDL	
04.	Chromium	65	70	43	62	58	114	57	
05.	Copper	150	198	143	207	251	2974	418	
06.	Manganese	425	838	346	396	352	366	342	
07.	Nickel	26	25	25	26	22	71	27	
08.	Lead	267	94	68	106	101	244	104	
09.	Antimony	BDL	BDL	BDL	BDL	BDL	BDL	BDL	
10.	Selenium	BDL	BDL	BDL	BDL	BDL	BDL	BDL	
11.	Vanadium	34	36	22	34	23	56	47	
12	Zinc	505	620	502	599	573	1520	575	
13.	Mercury	BDL	BDL	BDL	BDL	BDL	BDL	BDL	

Note : The values are in mg/Kg

Table: 4 Average Value of Metals in the roadside dust at each location

S.No.	Locations	Chromium	Copper	Manganese	Nickel	Lead	Vanadium	Zinc
01.	Singhu Border	48	63	387	10	94	9	304
02.	Dhaula Kuan	31	102	317	9	41	14	225
03.	Ashram	26	71	265	9	39	7	1056
04.	ITO	23	116	247	8	38	9	225
05.	ISBT	25	305	230	14	39	7	242
06.	Dilshad Garden	26	362	264	10	45	6	259
07.	Anand Vihar	19	157	248	5	30	6	177
08.	CPCB, East Arjun Nagar	24	134	211	9	45	7	176

Note : The values are in mg/Kg

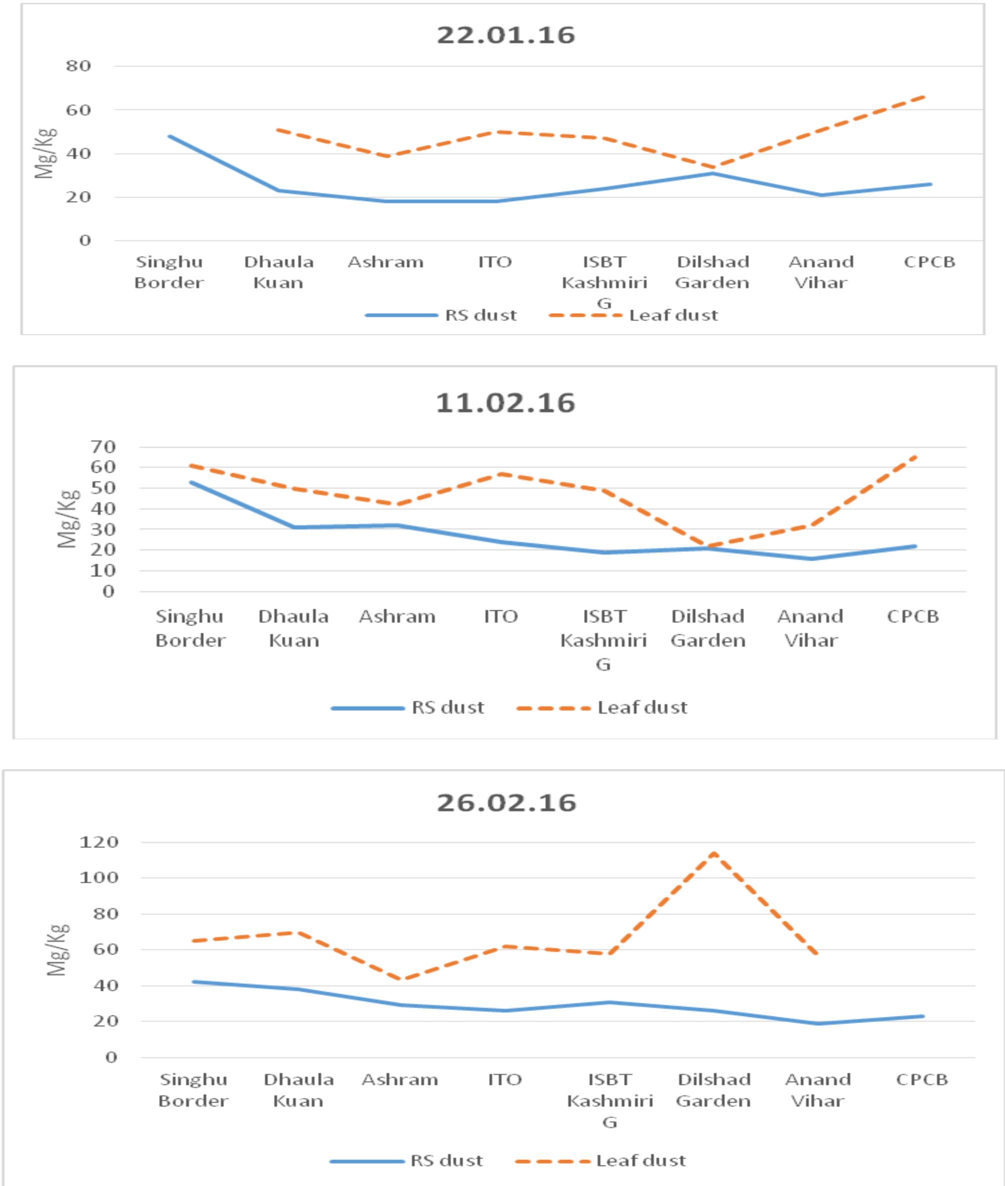
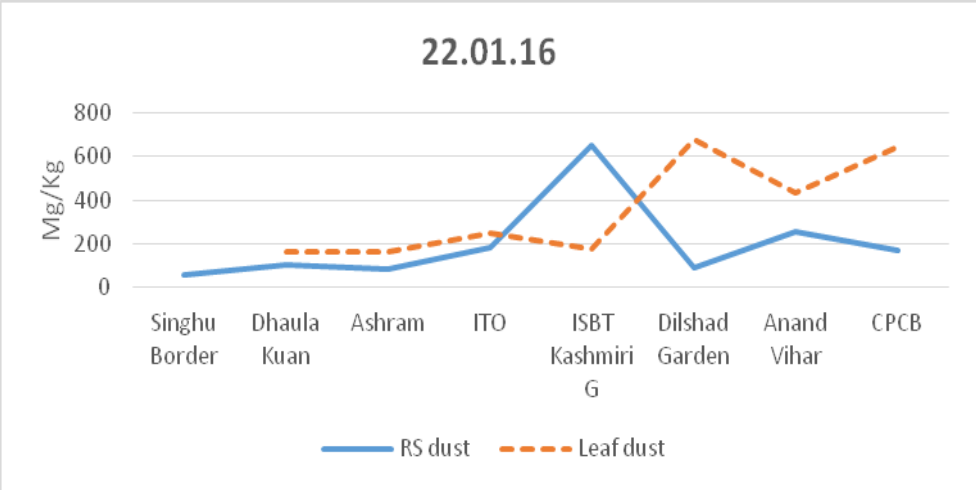
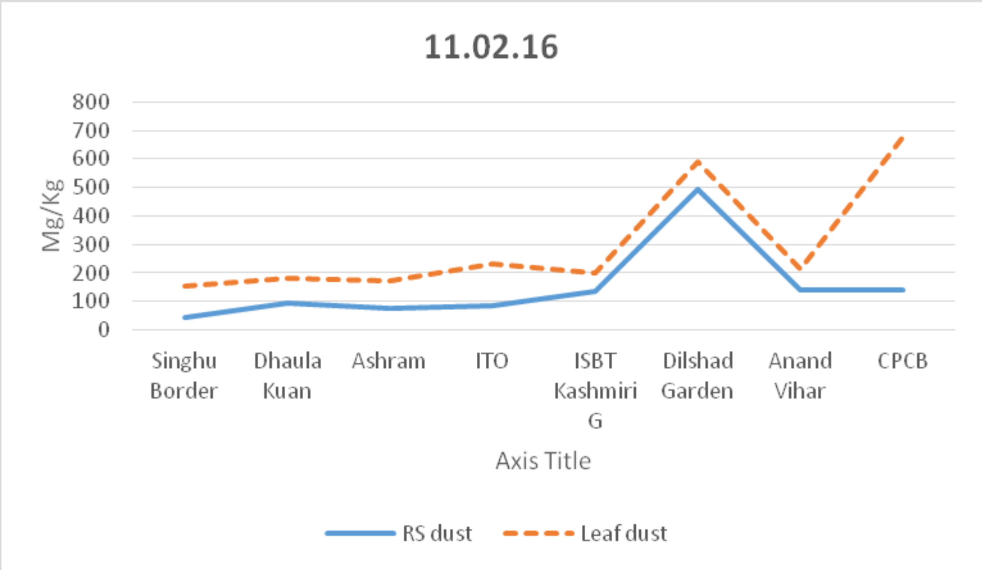


Figure: 1 Location wise concentration of Chromium





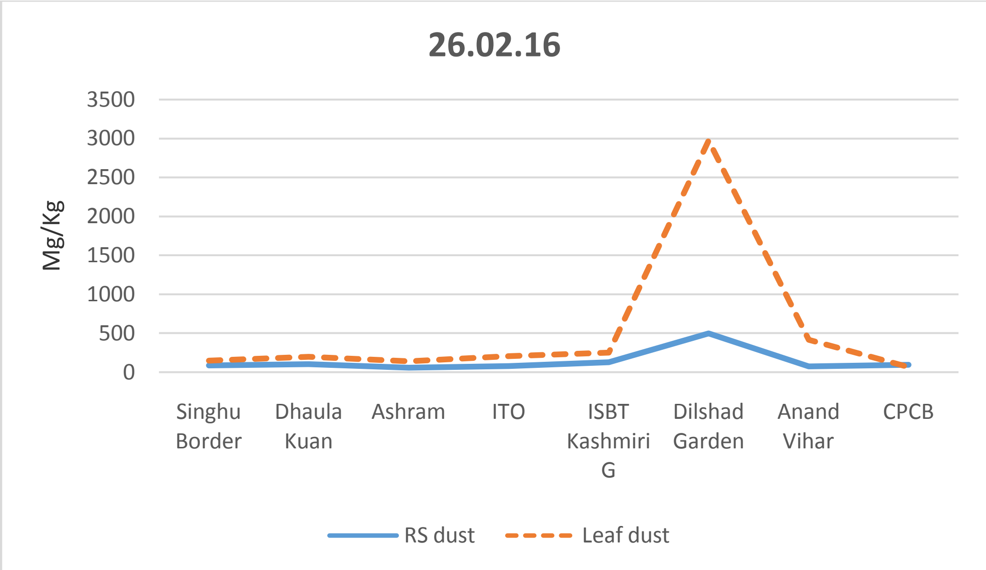


Figure: 2 Location wise variation of Copper

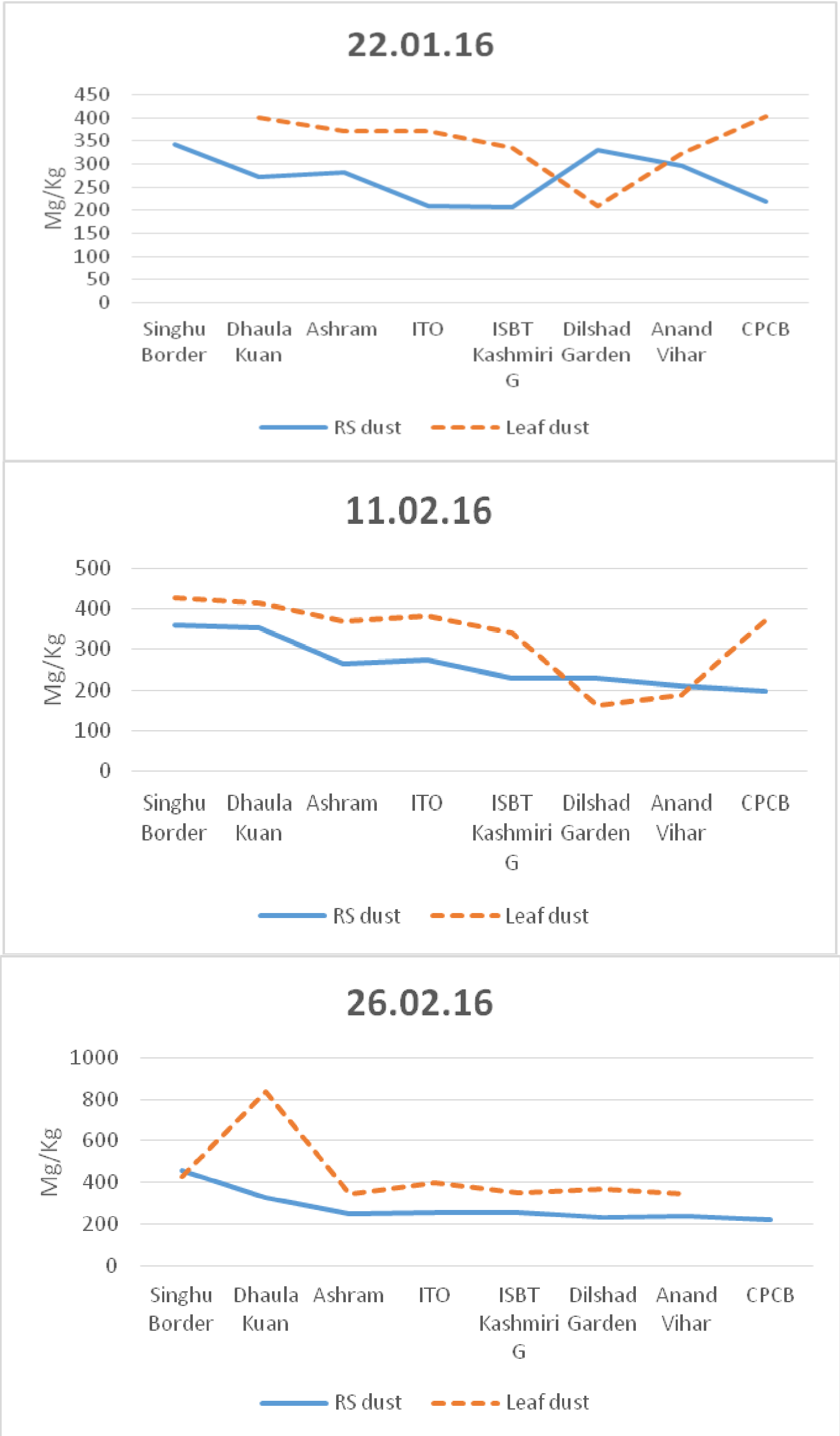


Figure: 3 Location wise variation of Manganese

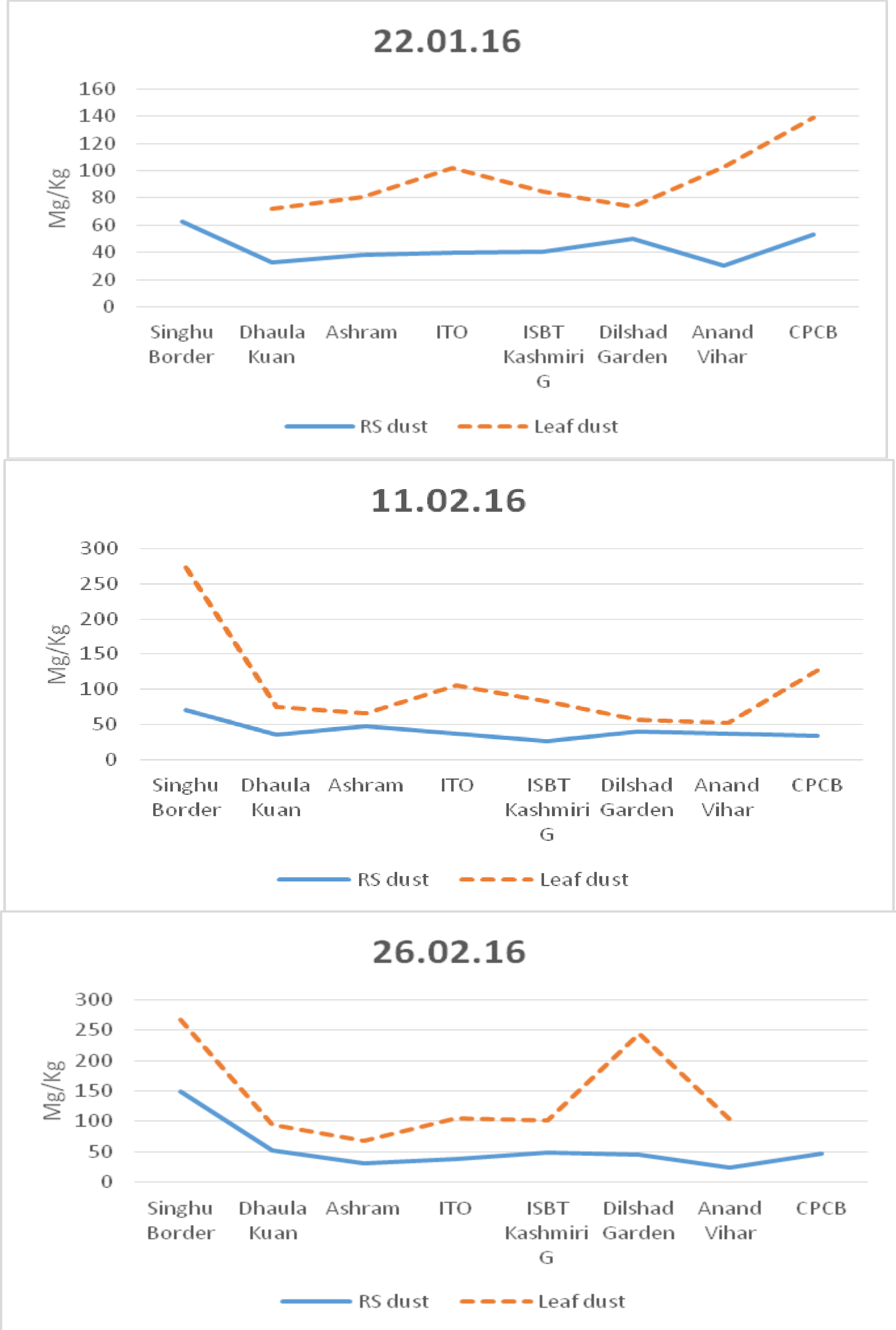


Figure: 4 Location wise variation of Lead

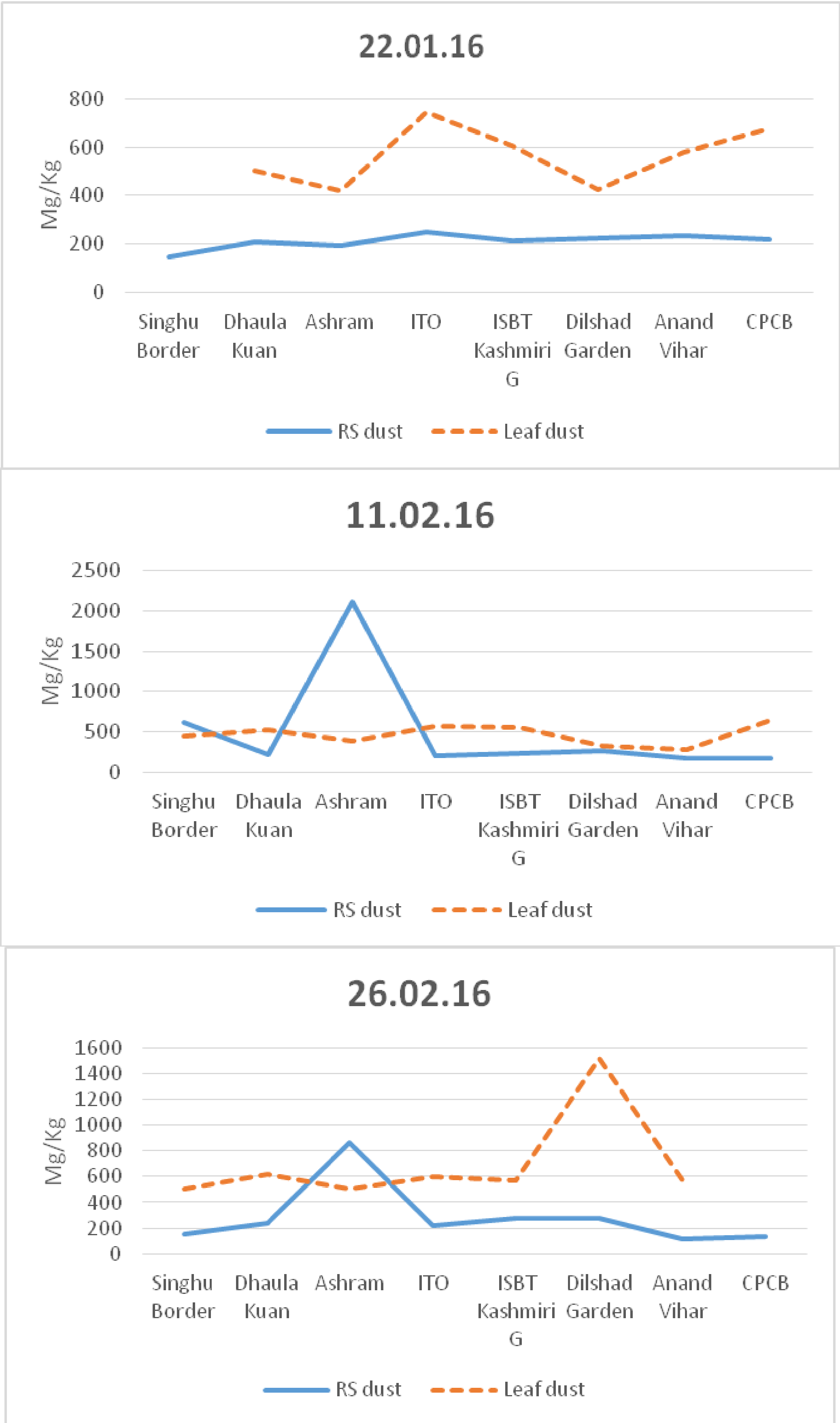


Figure: 5 Location wise variation of Zinc

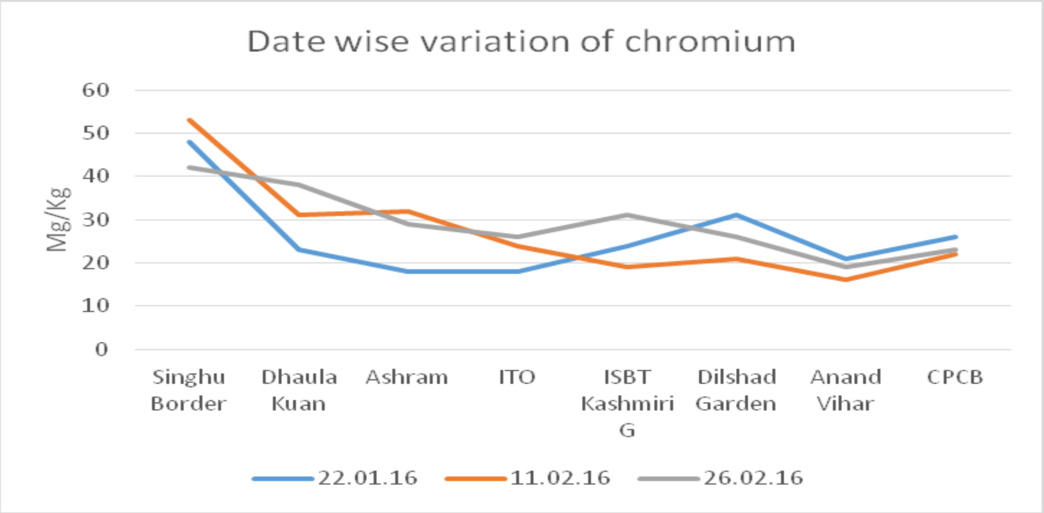


Figure: 6 Date wise Variation of Chromium in Roadside dust

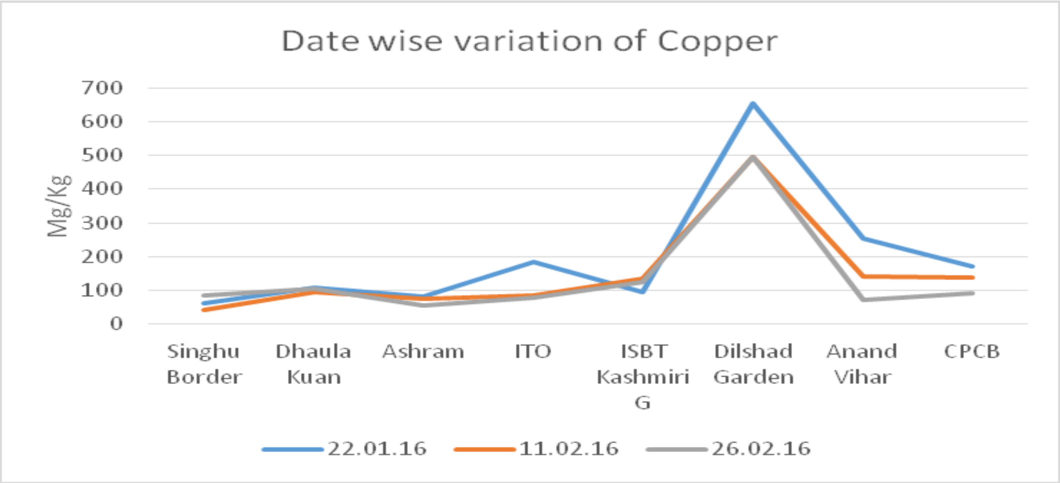


Figure: 7 Date wise Variation of Copper in Roadside dust

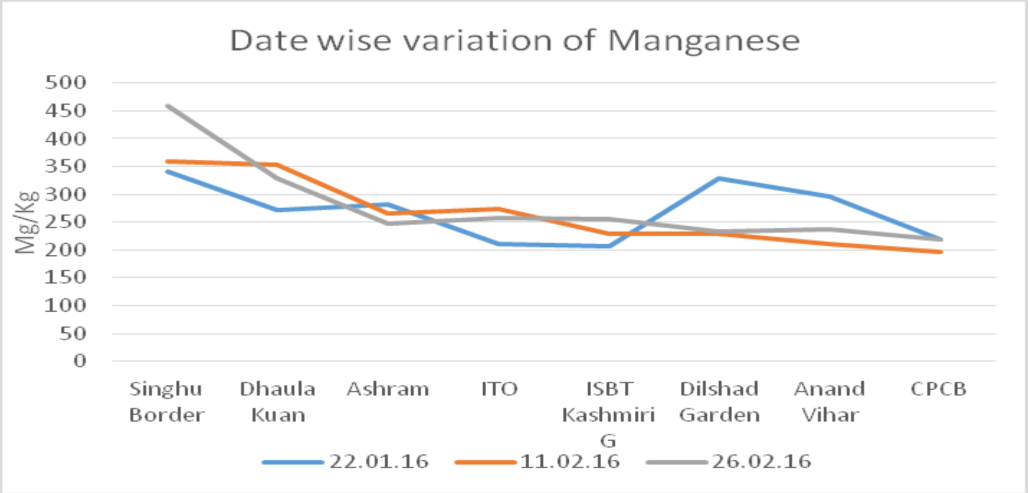


Figure: 8 Date wise Variation of Manganese in Roadside dust

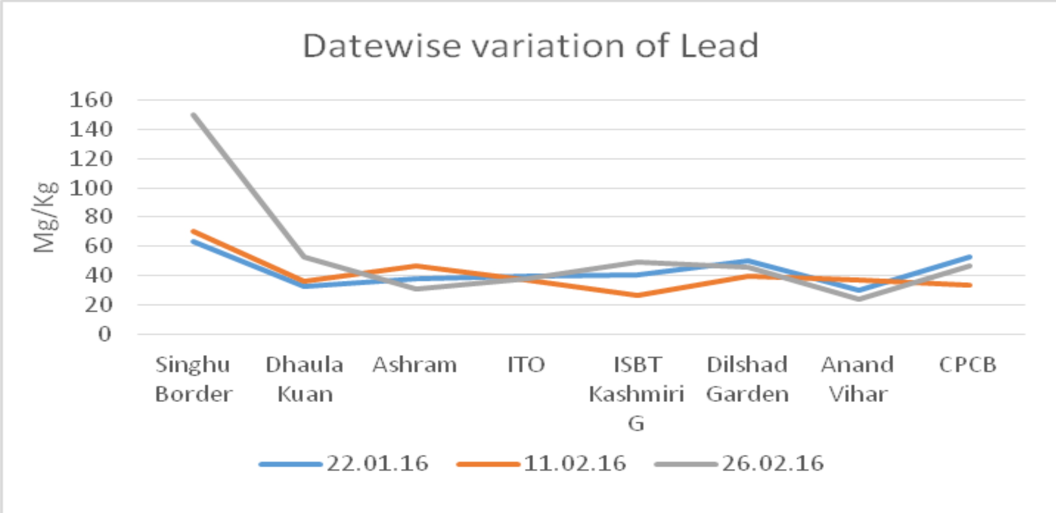


Figure: 9 Date wise Variation of Lead in Roadside dust

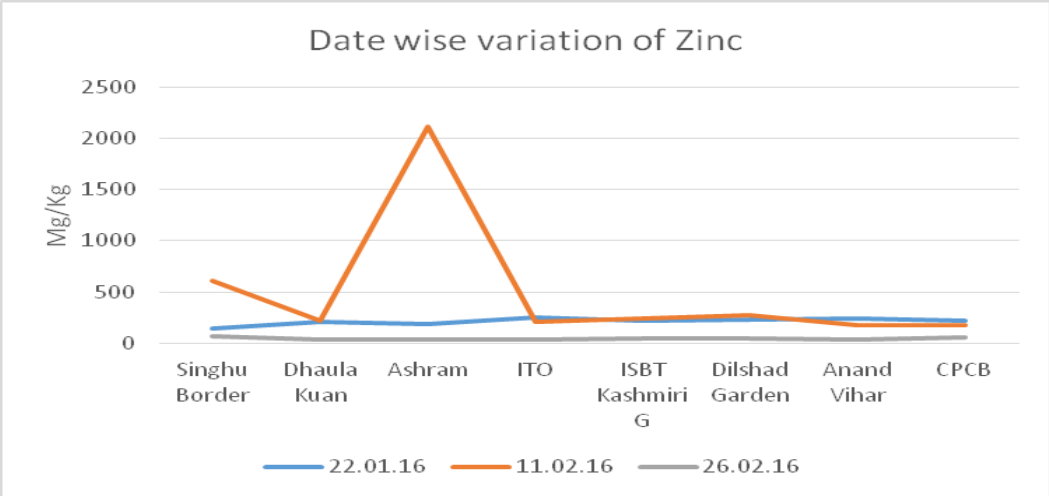


Figure: 10 Date wise Variation of Zinc in Roadside dust

IV. Conclusion

The degree of contamination, the potential ecological index and the integrated pollution index revealed that road dust from automobile exhaust in heavy traffic areas and industrial highway areas are highly contaminated by heavy metals. Due to wind blow the road dust from the residential area is also contaminated considerably.

On the basis of analytical results and their graphical representations shows:

- The values of Metals are found higher in the leaf dust than the roadside dust except for one locations Dilshad garden and Anand Vihar where it is equal, greater or lower than the roadside dust for various metals. There is also so much variation in the data of leaf dust and showing no trend
- Out of the 13 elements 5 elements were totally absent in each of the location. These elements are Arsenic, Cadmium, Antimony, Selenium and Mercury. The Cobalt where found, it was almost negligible.
- If we see the Datewise variation of each metal for the different monitoring dates, it is evident that there is no significant variation in the case of lead and chromium. Copper is always high at Dilshad Garden while manganese and zinc are high on 22^{nd} January monitoring. This is also evident from the date wise variation graphs for each metal.
- As evident with the table: 4 showing average values of the metals, the ratio of the metals in each location is more or less similar.
- Roadside dust in terms of the total metal present in each location the maximum metals were found at Dhaula Kuan and minimum metals were found at CPCB Office.
- As per analytical report chromium concentration is minimum i.e 16 mg/kg found at Anand Vihar and maximum value is 53 mg/kg at Singhu Border. Copper concentration is minimum i.e 43mg/kg at Singhu Border and maximum value is 653mg/kg at Dilshad Garden. Iron is minimum at ITO i.e 11900mg/kg and

maximum i.e. 26600mg/kg at Anand Vihar. Manganese is minimum i.e. 196mg/kg at CPCB and maximum i.e. 459mg/kg at Singhu Border. Lead is minimum i.e. 24mg/kg at Anand Vihar and maximum i.e. 150mg/kg at Singhu Border.

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