

Assessing Heavy Metal Contamination in Settled Dust Across Karachi's Functional Areas

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Abstract

The heavy and hazardous metals have high impact on health of living organism mostly on human beings. Settled dust has great impact on natural environment and human health as it may contain heavy and hazardous metals contributed from anthropogenic activities. Four functional areas of Karachi city, were selected for this study that are named as industrial area (Port Qasim), Traffic area (National Highway from Malir Halt to Port Qasim), Urban Area (Gulshan-e-Iqbal), Rural Area (Saadi Town). 36 samples of settled dust were drawn from all these areas and analyzed on WD-XRF spectrometer. Chromium, Copper, Iron, Manganese, Nickel, Lead, Titanium, and Zinc were studied and their average results were 384, 664, 61699, 1379,167, 427, 4656 and 5909mg Kg⁻¹. The average results of all metallic concentration of all four functional areas show that iron, Zinc, Titanium and Manganese are enriched in concentration while Nickel has the lowest concentration in settle dust. Morphological examination was carried out with SEM in which particles size, shape and particle composition was determined. SEM-EDX was used to analyze the particle's chemical composition, and Carbon was also quantify with metals and has high concentration in all samples than heavy metals. The study aided valuable data related with heavy and hazardous metals for the city of Karachi

Introduction

Peoples living in polluted areas are exposed to heavy and hazardous metals that are present in air which can be life threatening if exposed for a long period of time. Karachi is the largest and the most polluted city of Pakistan so it essential to study of heavy and hazardous metals contaminations present in settled dust. Heavy metals and hazardous metals are associated with the air pollution and it can causes number of diseases to not only the human being but all living organisms as well. In air these types of metals are present in a very low quantity but can have a great effect on living things due to which it should not present or should be in very low quantity in air dust. When dust blow due to any reason either it blow by traffic movement, air blowing or swimming, and due to industrial process etc. then dust mix with other pollutants emitted from different

sources like traffic smoke emission, industrial process emission, different process wastes or effluents etc. and then it settled down on different places ((Wan *et al.*, 2016; Godt *et al.*, 2006; Tchounwou *et al.*, 2012).

There are various studies which have been reported the deposition of harmful metals in the soils of Karachi (e.g. Karim *et al.*, 2015; Khan MN and Sarwar Anila, 2014. Mashiattullah *et al.*, 2013). All these studies assessed the inhabitant's health risk linked with Fe, Cu, Pb, Cr and Zn in urban soils of Karachi. Nevertheless, these studies did not consider the deposition of harmful metals in settled dust with no morphological study. The present work shows chemical composition of hazardous metals and morphological characteristics of settled dust of various functional areas of Karachi.

Materials and methods

Area Selection for Study

Karachi; known as city of lights, is the largest city of Pakistan having an area of 3530 square of kilometers, it covers few costal area of Arabian Sea. It has the coordinates 24°51'36"N 67°0'36"E. Karachi is most polluted city (Khan and Sarwar, 2014) as compared to all other cities of Pakistan so it is chosen for this study.

Sampling

In this study, total thirty six samples, nine samples from each of four functional areas were collected. Most of samples for urban area, rural area were collected from residential sites like not cleaned window glasses, flat roofs of outdoor, plants leaves of parks etc. whereas for industrial and heavy traffic area the samples were collected from road sides, (Verma, 2015), (Duong and Lee, 2011) poles, bridges, pipelines, places nearest to industries such as steel mills, (Omran and Fabritius, 2017) old scrapped parts like cars etc. for the collection of samples a small brush was used and samples were collected and stored in polythene bags.

Analysis

Wavelength Dispersive X-Ray fluorescence spectrometer (WD-XRF)

Sample Preparation for WD-XRF

Settled dust samples were pulverized by mixing with wax to get the homogenization by using mini ball mill, in which zirconium based balls were used. Machine was set at 240 rpm speed and the sample was rotated 2 min clockwise and 2 min anti-clockwise. Then press pellets were prepared to get the hard, flat and smooth surface with the help of Herzog press pellet machine by applying 25 KN force (Wolff, 2006). Binder (Boric Acid) was used to prevent the breaking or dispersion of sample during bombarding of high intensity X-Rays.

Sample Preparation for SEM

Samples of settled dust were bombarded with gold particles with the help ion sputter coater machine to make the sample electrical conductor and avoid the building up charges during SEM analysis, which is necessary to analyze the sample with more sensitivity on SEM so that clear images should receive. Ion sputter

coater machine is used to deposit metal coating that has thickness of few nanometers, which is very thin layer. In this study ion sputtering of Gold metal (Au) is used but we can also use platinum (Pt), Alloy of Gold and Palladium (Au-Pd) and Alloy of Platinum and Palladium (Pt-Pd) as well.

Results and discussion

(Port Qasim)

Results of heavy metallic elements in settled dust of with SEM, which with area (Port Qasim) Karachi shows the largest particle (fig. 9A), and its elemental composition with SEM-EDX spectrometer of which graph Chromium, Copper, in fig. 9B and chemical composition of particle is Titanium, and Zinc in in table 6, where the decreasing trend of metallic seen Karachi, compositions are as Al > C > Zn > Fe > Ni > Cr > Pb and the concentrations are 232220, 226410, 17637, 181, 566, 5520, and 1200, 637, 36.39mg.Kg⁻¹ (ppm) respectively. In The highest to lowest concentration particle is seen which is rectangular are as Fe > Zn > Ti > Cu > Mn > Pb is determined as D₁ shows the particles of settled dust of industrial area.

Table 1. Heavy Metallic Elemental Composition in settled dust from Industrial Area Analyzed on WD-XRF Analyzer (Axios Model).

S. No.	Sample ID	Cr (ppm)	Cu (ppm)	Fe (ppm)	Mn (ppm)	P (ppm)
1	I.A*-1	320	230	86510	1540	2
2	I.A-2	320	270	87480	1360	1
3	I.A-3	330	200	86770	1520	1
4	I.A-4	370	1660	97230	1550	2
5	I.A-5	370	1900	98180	1470	2
6	I.A-6	400	1650	98010	1540	1
7	I.A-7	320	3780	91720	1510	2
8	I.A-8	390	3750	90940	1770	1
9	I.A-9	290	3880	90520	1440	1
	Mean	346	1924	91929	1522	1
	Min	290	200	86510	1360	1
	Max	400	3880	98180	1770	2
	Median	330	1660	90940	1520	1
	Standard Deviation	38	1554	4782	111	

* I.A stand for Industrial Area and the value represent the number of samples

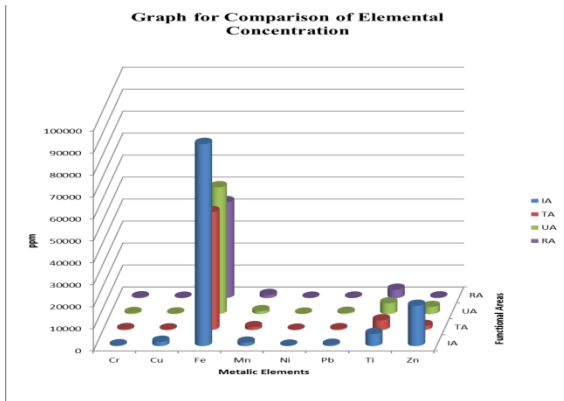


Fig. 1. Graph for comparison of metallic elemental concentration in settled dust samples analyzed by WD-XRF Spectrometer of the specified functional areas of Karachi, Pakistan. [IA stands for Industrial Area (Port Qasim), TA stands for Traffic Area (National Highway from Malir halt to Port Qasim), UA stands for Urban Area (Gulshan-e-Iqbal), and RA stands for Rural Area (Saadi Town)].

3.2 Results of Scanning Electron Microscope (SEM) analysis of settled dust.

3.2.1 Industrial Area (Port Qasim)

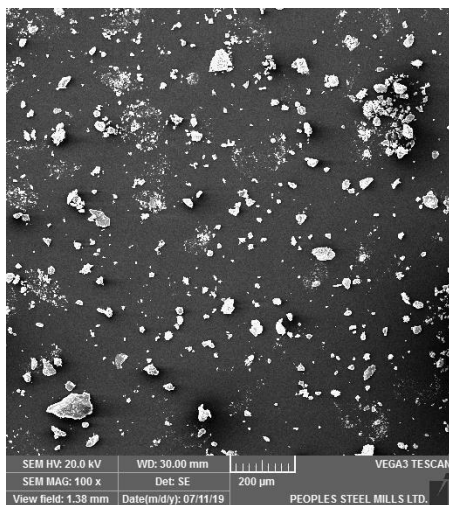


Fig. 2. Scanning Electron Microscopic fig. of settled dust particles of industrial area (Port Qasim), Karachi.

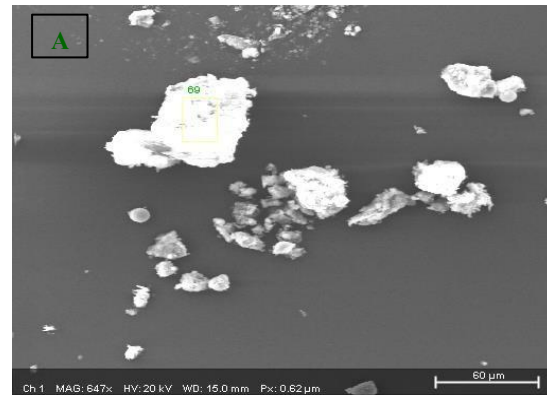


Fig. 3. A- Scanning Electron Microscopic [SEM] fig. of Particles of settled dust of Karachi. B- Graph of SEM-EDX (Energy Dispersive X-Rays) Analysis of settled dust of Karachi.

Results of heavy metallic elements in settled dust of traffic area (National Highway from Malir Halt to Port Qasim) Karachi

Table 2 shows heavy metallic elemental composition by WD-XRF spectrometer of Chromium, Copper, Iron, Manganese, Nickel, Lead, Titanium, and Zinc in settled dust of traffic area (National Highway from Malir halt to Port Qasim), Karachi, and the concentrations are 421, 271, 53606, 1308, 164, 391, 4449, 1851mg.Kg⁻¹ (ppm) respectively. The highest to lowest concentration of heavy metals are as Fe > Ti > Zn > Mn > Cr > Pb > Cu > Ni.

Fig. 5 shows the particles of settled dust of traffic area (National Highway from Malir Halt to Port Qasim), Karachi at 100 x magnification power with SEM, which when further magnified at 750 x shows the largest particles (fig. 6A), and it is analyzed with SEM-EDX spectrometer of which graph is shown in fig. 12B and chemical composition of particle is stated in table 7, where the decreasing trend of metallic compositions are as Si > C > Al > Fe > Zn > Ti > Pb and their concentrations are 151580, 149479, 75364, 45200, 2193, 1797, 529mg.Kg⁻¹ (ppm) respectively.

In fig. 7 the two large particles are seen which are rectangular shaped and their dimensions are determined as D₁ 41940.63 x D₂ 31246.16nm² for one particle and D₃ 43655.05 x D₄ 47234.55nm² with SEM.

analyzed with SEM-EDX spectrometer and its graph is

Table 2. Heavy Metallic Elemental Composition in settled dust from Traffic Area (National highway Malir Halt to Port Qasim), Karachi City, Analyzed on WD-XRF Analyzer (Axios Model).

No.	Sample S. ID	Cr (ppm)	Cu (ppm)	Fe (ppm)	Mn (ppm)	Ni (ppm)	Pb (ppm)	Ti (ppm)	Zn (ppm)
1	T.A*-1	380	160	51940	1570	170	370	4250	630
2	T.A-2	450	120	51610	1280	120	290	4010	620
3	T.A-3	420	180	50910	1340	150	290	4330	620
4	T.A-4	400	290	56450	1400	180	520	4580	3110
5	T.A-5	400	320	56880	1200	230	450	4650	3060
6	T.A-6	350	300	57310	1160	210	530	4760	3080
7	T.A-7	390	300	52800	1260	150	370	4580	1880
8	T.A-8	390	350	52070	1270	120	370	4550	1830
9	T.A-9	610	420	52480	1290	150	330	4330	1830
Mean		421	271	53606	1308	164	391	4449	1851
Min		350	120	50910	1160	120	290	4010	620
Max		610	420	57310	1570	230	530	4760	3110
Median		400	300	52480	1280	150	370	4550	1830
Standard Deviation		76	98	2521	121	37	90	235	1065

* T.A stand for Traffic Area and the value represent the number of sample.

Results of heavy metallic elements in settled dust of urban area (Gulshan-e-Iqbal) Karachi

Table 3 shows heavy metallic elemental composition by WD-XRF spectrometer of Chromium, Copper, Iron, Manganese, Nickel, Lead, Titanium, and Zinc in settled dust of urban area (Gulshan-e-Iqbal), Karachi, and the concentrations are 442, 247, 57681, 1303, 183, 553, 4883, 3208mg.Kg⁻¹ (ppm) respectively. The highest to lowest concentration of heavy metals are as Fe > Ti > Zn > Mn > Pb > Cr > Cu > Ni.

Fig. 8 shows the particles of settled dust of urban area (Gulshan-e-Iqbal), Karachi at 100 x magnification power with SEM, which when further magnified at 750 x shows the largest particles (fig. 8A), and it is analyzed with SEMEDX spectrometer of which graph is shown in fig. 15B and chemical composition of particle is stated in table 8, where the decreasing trend of metallic compositions are as C > Al > Fe > Pb > Zn > Cr > Ti > Ni and their concentrations are 121868, 50662, 8978, 3287, 1738, 1167, 971, 146mg.Kg⁻¹ (ppm) respectively.

As Pb is very high in concentration at 1st particle due to which second particle is also selected (fig. 9A) and

shown in fig. 9B, whereas chemical composition is stated in table 9, that shows the decreasing trend of chemical composition of metal elements as C > Al > Fe > Zn > Ti > Ni and their chemical composition are 399715, 41961, 20828, 8644, 1971, 71.5, in the second particle Cr and Pb are not detected.

In fig. 8 the two large particles are seen one is rectangular shaped and the other is round shaped and their dimensions are determined as D₁ 12390.01 x D₂ 26909.02nm² for rectangular shaped particle and radius 5319.25nm or diameter 10638.50nm for round shaped particle with SEM.

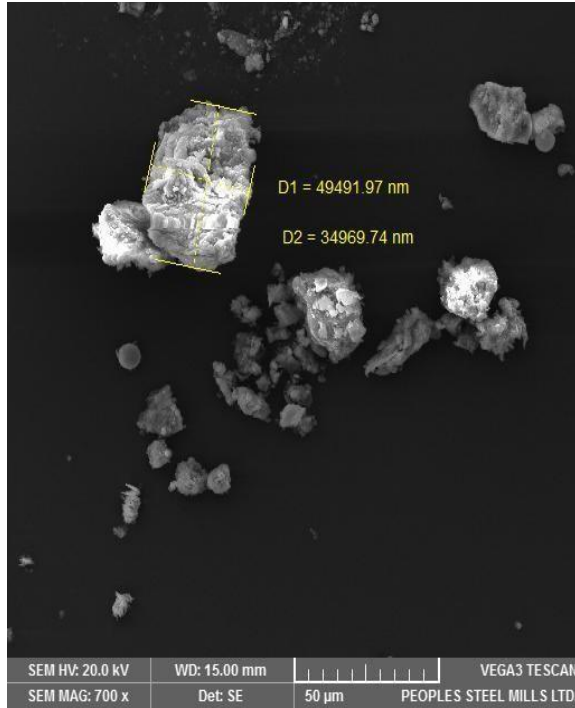


Fig. 4. Fig. of settled dust particle of industrial area (Port Qasim), Karachi using Scanning Electron Microscope.

3.2.2 Traffic Area (National Highway from Malir Halt to Port Qasim)

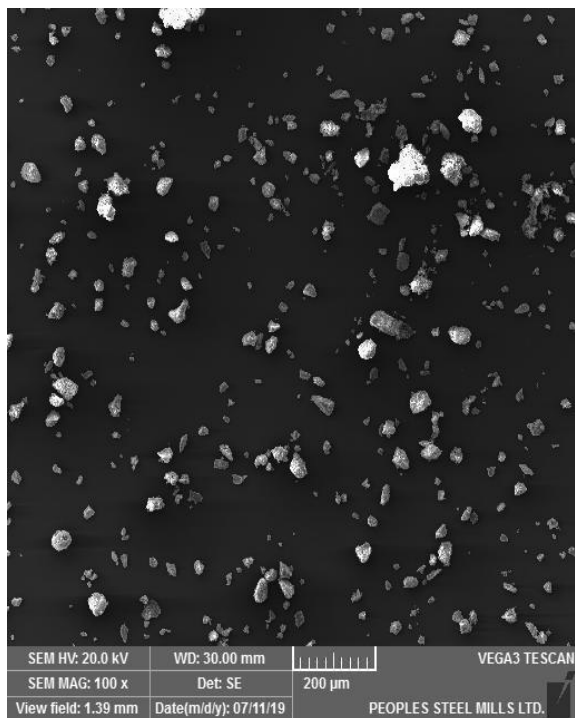


Fig. 5. Scanning Electron Microscopic fig. of settled dust particles of traffic area (National Highway from Malir Halt to Port Qasim), Karachi.

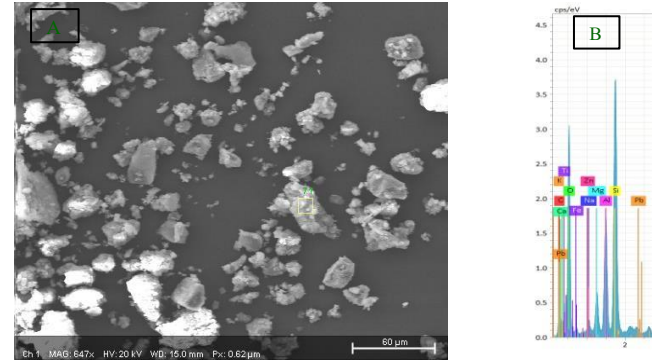


Fig. 6. A- Scanning Electron Microscopic [SEM] fig. of Particles of settled dust (from Malir Halt to Port Qasim), Karachi. B- Graph of SEM-EDX (Energy Dispersive X-ray) of selected particle in fig. A.

Table 3. Heavy Metallic Elemental Composition in settled dust from Urban Area Analyzed on WD-XRF Analyzer (Axios Model).

S. No.	Sample ID	Cr (ppm)	Cu (ppm)	Fe (ppm)	Mn (ppm)	P (ppm)
1	U.A*-1	310	250	56010	1330	210
2	U.A-2	380	260	55970	1180	190
3	U.A-3	290	250	56440	1130	180
4	U.A-4	600	280	54890	1220	200
5	U.A-5	580	240	55140	1380	220
6	U.A-6	590	190	56180	1350	210
7	U.A-7	350	280	61150	1410	230
8	U.A-8	540	230	61680	1330	210
9	U.A-9	340	240	61670	1400	220
Mean		442	247	57681	1303	210
Min		290	190	54890	1130	180
Max		600	280	61680	1410	230
Median		380	250	56180	1330	210
Standard Deviation		132	27	2909	101	15

* U.A stand for Urban Area and the value represent the number of sample

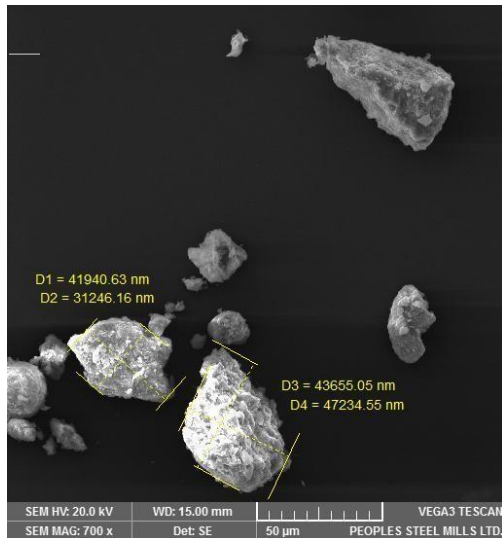


Fig. 7. Fig. of settled dust particle of traffic area (National Highway from Malir Halt to Port Qasim), Karachi using Scanning Electron Microscope.

3.2.3 Urban Area (Gulshan-e-Iqbal)

Fig. 9. A- Scanning Electron Microscopic [SEM] fig. of Particles of settled dust of urban area (Gulshan-e-Iqbal), Karachi. B- Graph of SEM-EDX (Energy Dispersive X-Rays) Analysis of elements of selected particle in fig. A.

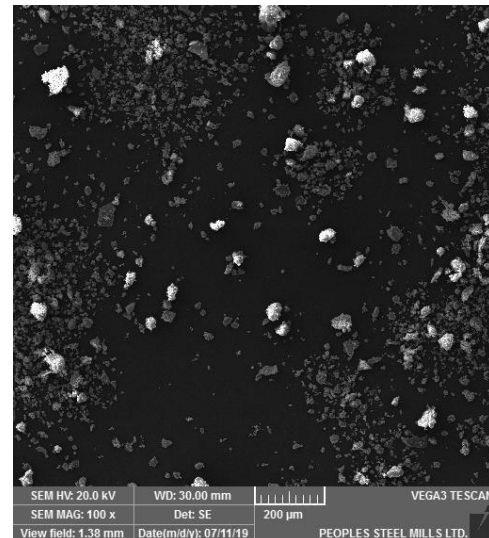


Fig. 8. Scanning Electron Microscopic fig. of settled dust particles of urban area (Gulshan-e-Iqbal), Karachi.

Results of heavy metallic elements in settled dust of 750 x shows the largest particles (fig. 10A), and it is rural area (Saadi Town) Karachi analyzed with SEM-EDX spectrometer of which

Table 4 shows heavy metallic elemental composition graph is shown in fig. 19B and chemical composition by WD-XRF spectrometer of Chromium, Copper, of particle is stated in table 10, where the decreasing Iron, Manganese, Nickel, Lead, Titanium, and Zinc in trend of metallic compositions are as $C > Al > Fe >$ settled dust of rural area (Saadi Town), Karachi, and $Cu > Zn > Pb > Cr > Ni > Ti$ and their the concentrations are 328, 135, 43579, 1384, 139, concentrations are 156377, 13322, 7168, 1134, 1022, 198, 3772, 279mg.Kg⁻¹ (ppm) respectively. The 884, 846, 832, 470mg.Kg⁻¹ (ppm) respectively. In highest to lowest concentration of heavy metals are as fig. 14 the two large particles are seen one is $Fe > Ti > Mn > Cr > Zn > Pb > Ni > Cu$. rectangular shaped and the other is round shaped and their dimensions are determined as D_1 23246.83

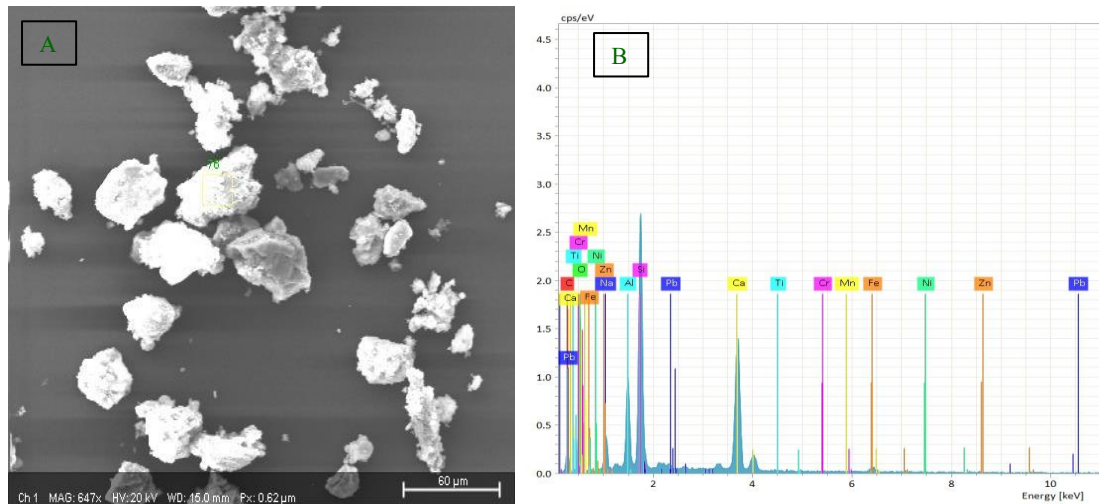


Fig. 9 shows the particles of settled dust of rural x D₂ 28034.02nm² for rectangular shaped particle area (Saadi Town), Karachi at 100 x magnification and radius 10990.75nm or diameter 21981.50nm for power with SEM, which when further magnified at round shaped particle with SEM.

Table 4. Heavy Metallic Elemental Composition in settled dust from Rural Area (Saadi Town), Karachi City, Analyzed on WD-XRF Analyzer (Axios Model).

S. No.	Sample ID	Cr (ppm)	Cu (ppm)	Fe (ppm)	Mn (ppm)	Ni (ppm)	Pb (ppm)	Ti (ppm)	Zn (ppm)
1	R.A*-1	520	110	56480	1440	220	360	5470	430
2	R.A-2	220	ND*	38100	1490	ND	ND	2830	180
3	R.A-3	480	140	58010	1320	130	300	5580	550
4	R.A-4	250	160	37650	1450	100	160	2950	160
5	R.A-5	510	160	58010	1340	190	350	5330	440
6	R.A-6	260	ND	36180	1240	ND	130	3080	250
7	R.A-7	150	150	35930	1460	90	110	2920	180
8	R.A-8	ND	90	36470	1330	120	80	2870	140
9	R.A-9	230	ND	35380	1390	120	90	2920	180
Mean		328	135	43579	1384	139	198	3772	279
Min		150	90	35380	1240	90	80	2830	140
Max		520	160	58010	1490	220	360	5580	550
Median		255	145	37650	1390	120	145	2950	180
Standard Deviation		150	29	10483	82	48	119	1269	152

* R.A stand for Rural Area and the value represent the number of sample whereas ND stands for Not Detected.

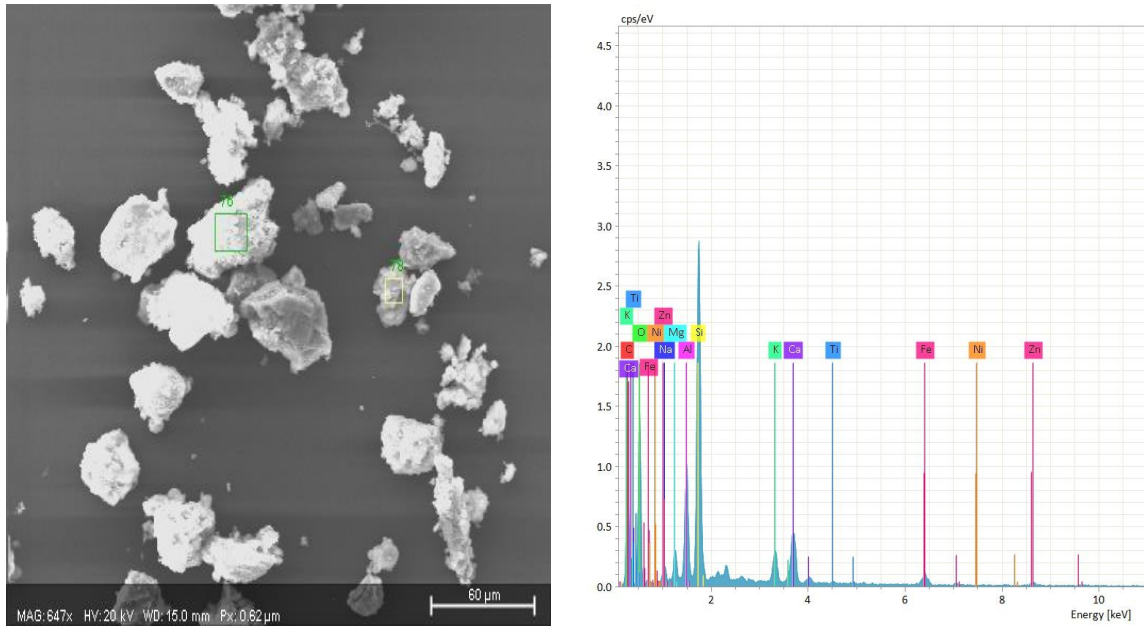


Fig. 10. Scanning Electron Microscopic [SEM] fig. of Particles of settled dust of urban area (Gulshan-e-Iqbal), Karachi. B- Graph of SEM-EDX (Energy Dispersive X-Rays) Analysis of elements of selected particle in fig. A.

Comparison of results of heavy metallic elemental composition in settled dust from different functional areas of Karachi city

Four functional areas of Karachi city, were selected for this study that are named as industrial area (Port Qasim), Traffic area (National Highway from Malir Halt to Port Qasim) where high heavy traffic is seen 24 hours a day, Urban Area (Gulshan-e-Iqbal) where high traffic, shopping malls and small units are seen, Rural

Area (Saadi Town) which is far away from industrial area and low traffic is seen. 36 samples of settled dust was drawn from all these areas and analyzed on WD-XRF spectrometer, the average results of each functional area are stated in table 5 for comparison. The average results of all metallic concentration of all four functional areas shows that iron has the highest concentration while Nickel has the lowest concentration in settle dust.

Table 5. Comparison of Heavy Metallic Elemental Concentration in settled dust samples from different functional Areas of Karachi City, analyzed on WD-XRF Analyzer (Axios Model).

S. No.	Sample ID	Cr (ppm)	Cu (ppm)	Fe (ppm)	Mn (ppm)	Ni (ppm)	Pb (ppm)	Ti (ppm)	Zn (ppm)
1	LA*	346	1924	91929	1522	181	566	5520	18297
2	T.A*	421	271	53606	1308	164	391	4449	1851
3	U.A*	442	247	57681	1303	183	553	4883	3208
4	R.A*	328	135	43579	1384	139	198	3772	279
Mean		384	644	61699	1379	167	427	4656	5909
Min		328	135	43579	1303	139	198	3772	279
Max		442	1924	91929	1522	183	566	5520	18297
Median		384	259	55644	1346	173	472	4666	2530

Standard Deviation 56 855 21007 102 20 172 735 8345

* I.A stands for Industrial Area, T.A stands for Traffic Area, and U.A stands for Urban Area, R.A stands for Rural Area.

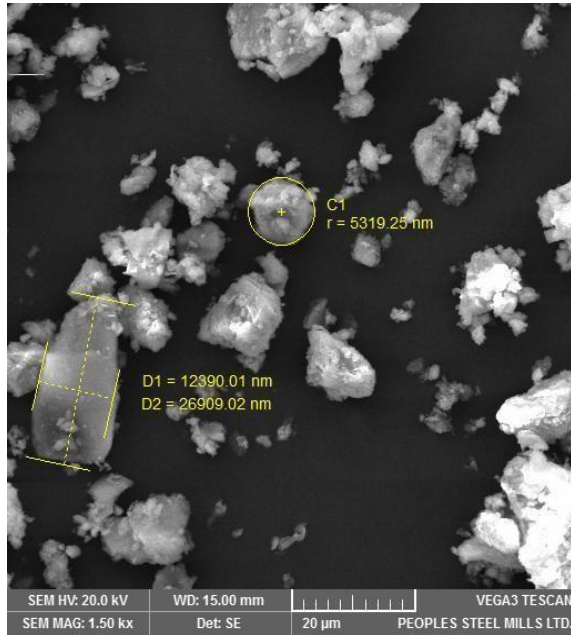


Fig. 11. Fig. of settled dust particle of urban area (Gulshan-e-Iqbal), Karachi using Scanning Electron Microscope.

3.2.4 Rural Area (Saadi Town)

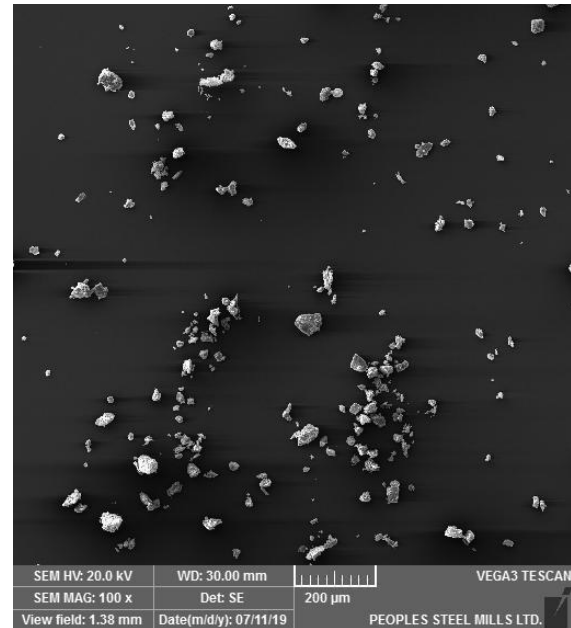


Fig. 12. Scanning Electron Microscopic fig. of settled dust particles of rural area (Saadi Town), Karachi.

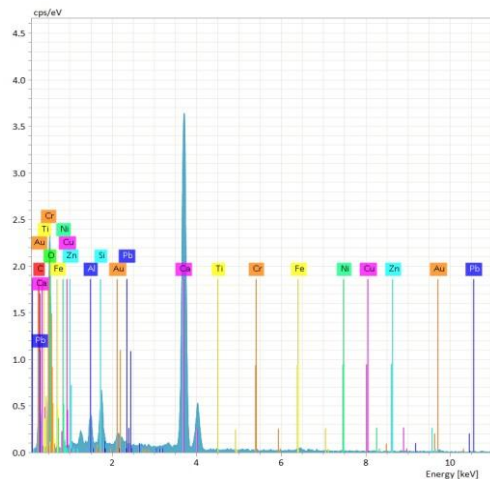
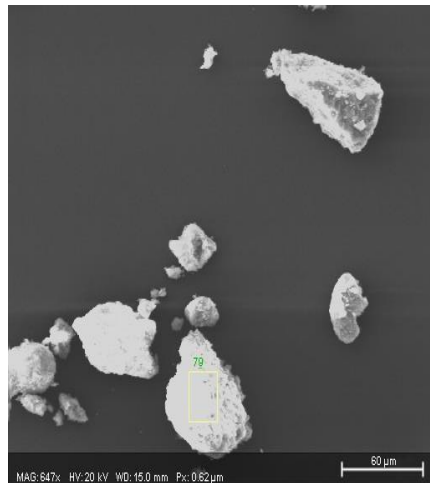


Fig. 13. Scanning Electron Microscopic [SEM] fig. of Particles of settled dust of rural area (Saadi Town), Karachi. B- Graph of SEM-EDX (Energy Dispersive X-Rays) Analysis of elements of selected particle in fig. A.

Table 6. Chemical concentration of elements present in selected particle of fig. 8.A of industrial area (Port Qasim), Karachi by SEM-EDX.

Elements	C (ppm)	Al (ppm)	Cr (ppm)	Fe (ppm)	Ni (ppm)	Zn (ppm)	Pb (ppm)
Concentration	226410	232220	637	9585	1200	17637	36.39

Table 7. Chemical concentration of elements present in selected particle of fig. 12.A of traffic area (National Highway from Malir Halt to Port Qasim), Karachi by SEM-EDX.

Elements	C (ppm)	Al (ppm)	Si (ppm)	Fe (ppm)	Ti (ppm)	Zn (ppm)	Pb (ppm)
Concentration	149479	75364	151580	45200	1797	2193	529

Table 8. Chemical concentration of elements present in selected particle of fig. 15.A of urban area (Gulshan-e-Iqbal), Karachi by SEM-EDX.

Elements	C (ppm)	Al (ppm)	Cr (ppm)	Ni (ppm)	Fe (ppm)	Ti (ppm)	Zn (ppm)	Pb (ppm)
Concentration	121868	50662	1167	146	8978	971	1738	3287

Table 9. Chemical concentration of elements present in selected particle of fig. 16.A of urban area (Gulshan-e-Iqbal), Karachi by SEM-EDX.

Elements	C (ppm)	Al (ppm)	Cr (ppm)	Ni (ppm)	Fe (ppm)	Ti (ppm)	Zn (ppm)	Pb (ppm)
Concentration	399715	41961	-	71.5	20828	1971	8644	-

Table 10. Chemical concentration of elements present in selected particle of fig. 19.A of rural area (Saadi Town), Karachi by SEM-EDX.

Elements	C (ppm)	Al (ppm)	Cr (ppm)	Cu (ppm)	Ni (ppm)	Fe (ppm)	Ti (ppm)	Zn (ppm)	Pb (ppm)
Concentration	156377	13322	846	1134	832	7168	470	1022	884

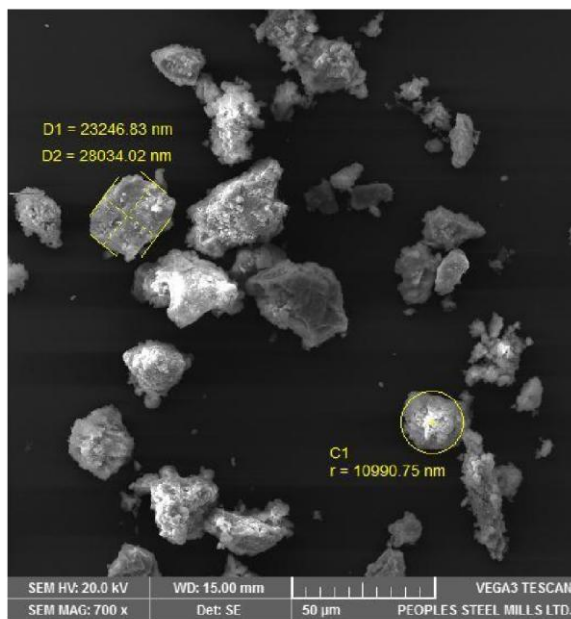


Fig. 14. Fig. of settled dust particle of rural area (Saadi Town), Karachi using Scanning Electron Microscope.

Chromium

no industrial units as well as it is far away from industries and highly traffic areas so, it has low pollution level. Chromium concentration in soil is 100-150mg.Kg⁻¹ (Arshad *et al.*, 2014), its mean more than 150mg.Kg⁻¹ of chromium concentration found in this study is not come from soil only but also from other anthropogenic activities as well.

Copper

5), (Fig. 1). In the industrial area there are large Copper has highest to lowest trend according to the selected four functional areas of Karachi as Industrial Area (Port Qasim) > Traffic Area (National Highway from Malir Halt to Port Qasim) > Urban Area (Gulshan-e-Iqbal) > Rural Area (Saadi Town) with the values 1924 > 271 > 247 > 135 respectively (Table Chromium has highest to lowest trend according to the selected four functional areas of Karachi as Urban Area (Gulshan-e-Iqbal) > Traffic Area (National Highway from Malir Halt to Port Qasim) > Industrial Area (Port

Qasim) > Rural Area (Saadi Town) with the values 442 > 421 > 346 > 328 respectively (Table 5), (Fig. 1). In the urban area there are more traffic and small industrial units like power plant etc. that are responsible for the metallic pollution, whereas in rural area (Saadi Town) industrial units which are responsible for the high concentration of copper. Whereas in other areas the difference in copper concentration is not significant as compare to Industrial Area [I.A]. Copper concentration in soil at different regions in Pakistan is reported as 6 to 412mg.Kg⁻¹ and I Karachi it is reported 272mg.Kg⁻¹ (Siddique *et al.*, 2009; Arshad *et al.*, 2014) according to these results copper in concentration in this study of all functional areas except Industrial Area (Port Qasim) is come from soil only, but in Industrial Area (Port Qasim) the copper concentration i.e. 1924mg.Kg⁻¹ is very high that mean in this area copper comes from other anthropogenic activities instead of only soil.

Iron

Iron has highest to lowest trend according to the selected four functional areas of Karachi as Industrial Area (Port Qasim) > Urban Area (Gulshan-e-Iqbal) > Traffic Area (National Highway from Malir Halt to Port Qasim) > Rural Area (Saadi Town) with the values 91929 > 57681 > 53606 > 43579 respectively (Table 5), (Fig. 1). Iron [Fe] is reported in soil 35080 to 26960mg.Kg⁻¹ in Kohistan region of Pakistan (Arshad *et al.*, 2014) if it is compared with concentration of iron in this study then all the selected functional areas of Karachi has been polluted with some anthropogenic activities which is causing high iron pollution. In industrial area (Port Qasim) there are steel mills which are spreading iron content due to which it shows highest value in industrial region.

Manganese

Manganese has highest to lowest trend according to the selected four functional areas of Karachi as Industrial Area (Port Qasim) > Rural Area (Saadi Town) > Traffic Area (National Highway from Malir Halt to Port Qasim) > Urban Area (Gulshan-e-Iqbal) with the values 1522 > 1384 > 1308 > 1303 respectively (Table 5), (Fig. 1). Manganese was reported 117.6 to 309mg.Kg⁻¹ in roadside soil of national Highway N-5

Karachi (Khan *et al.*, 2011), in this study all the functional areas have high concentration of manganese its mean it's not come from soil only, but there is involvement of other human activities as well.

Nickel [Ni]

Nickel has highest to lowest trend according to the selected four functional areas of Karachi as Urban Area (Gulshan-e-Iqbal) > Industrial Area (Port Qasim) > Traffic Area (National Highway from Malir Halt to Port Qasim) > Rural Area (Saadi Town) with the values 183 > 181 > 164 > 139 respectively (Table 5), (Fig. 1). Nickel has been reported as 5.96 to 13.23mg/Kg in soil of Karachi region (Khan *et al.*, 2011). Nickel has high concentration in settled dust (Table 5) as compared to nickel concentration in soil which means there are other factors involved in contamination of settled dust with nickel.

Lead

Lead has highest to lowest trend according to the selected four functional areas of Karachi as Industrial Area (Port Qasim) > Urban Area (Gulshan-e-Iqbal) > Traffic Area (National Highway from Malir Halt to Port Qasim) > Rural Area (Saadi Town) with the values 566 > 553 > 391 > 198 respectively (Table 5), (Fig. 1). As lead contaminated fuel is used in Pakistan and reported as 24.80 µg g⁻¹ i.e. equal to 24.80mg Kg⁻¹ (Khan *et al.*, 2011). Lead is reported 121mg Kg⁻¹ in Pakistan's coastal region of Karachi (Siddique *et al.*, 2009; Arshad *et al.*, 2014) and in Lyari river Karachi sediments has 49.5mg.Kg⁻¹ Lead (Mashiatullah *et al.*, 2013). It is also reported in soil of national highway N-5 Karachi with the highest concentration of 176mg.Kg⁻¹ (Khan *et al.*, 2011). As the results of lead [Pb] in this study show higher concentration as compared to lead in soil so, its mean there are other anthropogenic activities that causes the lead contamination in settled dust.

Titanium

Titanium has highest to lowest trend according to the selected four functional areas of Karachi as Industrial Area (Port Qasim) > Urban Area (Gulshan-e-Iqbal) > Traffic Area (National Highway from Malir Halt to Port

Qasim) > Rural Area (Saadi Town) with the values 5520 > 4883 > 4449 > 3772 respectively (Table 5), (Fig. 1).

Zinc

Zinc has highest to lowest trend according to the selected four functional areas of Karachi as Industrial Area (Port Qasim) > Urban Area (Gulshan-e-Iqbal) > Traffic Area (National Highway from Malir Halt to Port Qasim) > Rural Area (Saadi Town) with the values 18297 > 3208 > 1852 > 279 respectively (Table 5), (Fig. 1). Zinc metal 37.16mg.Kg⁻¹ has been reported in soil sample along the national highway Karachi N-5 (Khan *et al.*, 2011), in Pakistan's soil highest concentration of zinc is reported 29755mg.Kg⁻¹ (Muhammad *et al.*, 2011).

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