Elemental Analysis of Solid Aerosols Using AAS Technique And Estimation of their Effect on Atmospheric Radiation Budget

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Abstract

Atomic absorption spectroscopy (AAS) because of its selectivity, sensitivity, reproducibility and wide dynamic concentration range was used to find out the metal constituents and concentration for 6 metals in the atmosphere of Faisalabad. The aerosol samples were collected using air volume sampler on watmann filter paper for 24 hrs per day from June 2011 to June 2012. The maximum elemental constituents and concentration for Zn, Cu, Cr, Ni, Pb and Cd in mg/kg were found to be 127.88, 1955.77, 880.99, 2075.22, 2760.44, and 802.68 respectively. The comparison of results reported in literature with the obtained results showed some differences in concentrations which could be explained on the basis of climatological and meteorological set up of the area under exploration. An attempt has been made to investigate the properties of identified trace metals in terms of their radiative absorption coefficient and the global warming effect checked by analyzing TEM micrographs. The results obtained showed complex behavior and neutral trend as a whole.

Key Words: Atmospheric pollution, trace metals, elemental composition, radiative budget, positive co-relationship, TEM micrographs, mix behavior, neutral trend.

1. Introduction

Environment, in its wider sense, includes everything, which is external to a human being. Environmental Pollution means the accumulation or concentration of wastes that cannot be disposed off by natural recycling process due to their excessive quantity or unique chemical composition [1]. Any substance which is present in nature beyond permissible limits as well as has detrimental effects not only on the environment but also on living organisms is called Pollutant e.g., CO_2, CO, SO_2, Cd, Hg, Cr, Pb, Zn, Cu, Mn, Ca, Co and Mg. These chemicals are released into the atmosphere from different natural and anthropogenic sources. High temperature industrial process release coarse fractions of Mg, Ca, Ni, Mn, Cu and Zn. Automobile exhaust and fertilizer industries also release these metals, their compounds, or other salts. Comparisons of aerosol concentration Vs optical extinction for a longer period of time showed 44% decrease in Europe from 1992 to 2009, 33% in USA from 1993 to 2010, 10% in Canada from 1994 to 2009 and 26% in China from 2000 to 2011 in mass concentration of solid aerosols. In contrast optical extinction has increased 7% in the USA, 10% in Canada and 18% in China during the above said periods. The increased mass concentration anthropogenic aerosol emissions from industry and transport partly explain this inverse trend. This partially agrees with our study. [2-8]

The urban population is exposed to the aerosol toxic metals that often are well above natural background [9-13].

Besides health hazards, heavy metal pollution impair visibility, plays an important role in acidic rain, adversely affects the radiation budget and consequently disturbs a variety of environmental processes may change the cloud properties by nucleation, condensation and chemistry of environment by providing the media for various heterogeneous reactions and carriers for chemical species. Atmospheric aerosol particles are solid or liquid particles suspended in air. Processes that control formation, transformation and the removal of atmospheric aerosols is of great interest in atmospheric science. The reason is that these particles, which are often smaller than 1 micrometer in diameter, play an important part in Earth's radiation budget through the scattering of sunlight and through the interaction with clouds. Human activities, such as burning of fossil fuels and land use, change the properties of the aerosol and may therefore influence the climate. This can be either directly through an increase in aerosols or indirectly through the way the anthropogenic aerosols change the way clouds form. Also, heterogeneous reactions on the aerosol particle surfaces influence the gas phase composition and chemistry of the atmosphere. And these particles are responsible for adverse health effects through inhalation [14-32]. To assess the role of aerosols in our environment and the influence by anthropogenic emissions requires an understanding of the life cycle and transport patterns of solid aerosol particles, their compositional evolution as well as a detailed knowledge of cloud formation and nucleation mechanisms depend on the properties of the pre-existing aerosols. [33-36].The present study was conducted in order to assess the concentration of heavy metals in the atmosphere of Faisalabad and their effect on environment. For the confirmation of interactive relationship between solid aerosols and environment co-relationship was also established. These results were also compared with other similar studies quoted in national and international journals having impact factors.

2. Materials and Methods

50 sites were randomly selected for analysis covering industrial, transport related, commercial and residential nature of the Faisalabad environment. Air samples containing solid aerosols were collected using Kimoto high volume air sampler from selected areas of Faisalabad. Samples were collected for a period of 12 hrs with an average flow rate of 0.8m^3/min. Solid aerosols were trapped on glass fiber filters with the collection efficiency of 90%.

The filters were weighed before and after sampling [37] and analyzed by atomic absorption spectrophotometer (Model No.: Varian AA-1475). The sample solution was aspirated into a flame and sample elements then converted into atomic vapours. Some atoms were thermally excited by the flame but most remained in the ground state. These ground state atoms absorb radiation given off by hollow-cathode lamp which is coated with metal to be determined. This lamp produces radiation of appropriate wavelength which while passing through

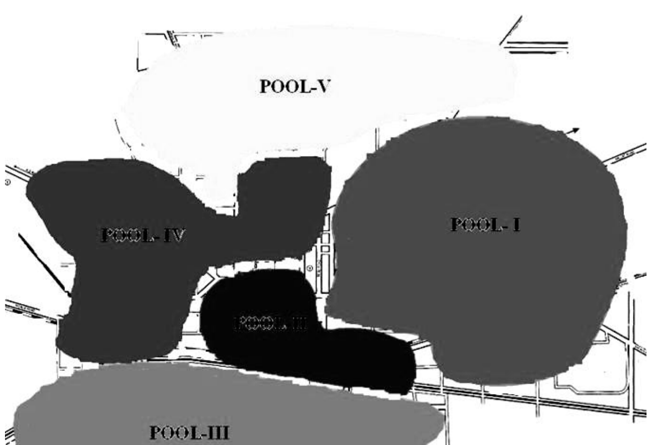

Fig.1 Pool classification for Faisalabad City

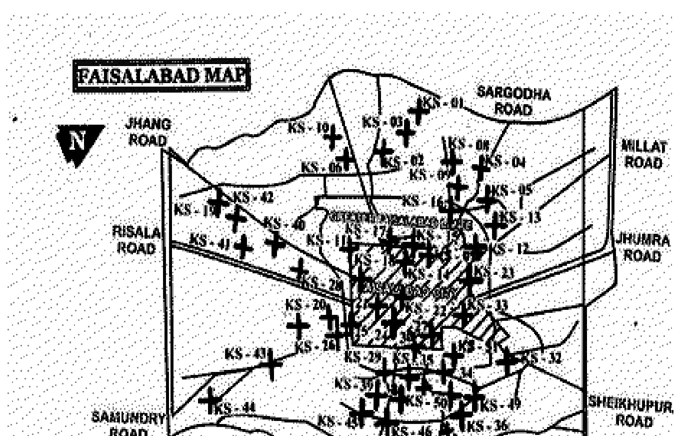

Fig.2 Site selection for Faisalabad City

the flame is absorbed by the free atoms of the sample and after passing through the monochromatic, which selects one absorption line. The reduction in beam intensity is measured by the detector.

The wave length range of atomic absorption measurement is limited due to the light absorption by the flame, most usually the Acetylene Air Flame, at shorter wavelength and by the atmosphere at longer wavelength. The absorbance is directly proportional to the concentration of atomic vapors in the flame. Standard curve of concentration in the solution versus absorbance is used for quantization.

The concentrations of six elements were found in the atmosphere of Faisalabad. These elements are capable of reducing visibility due to reduction in solar radiation, increase or decrease of Aledo and lead to atmospheric healing if they absorb radiations and may bring about cooling effect in the earth if there is back scattering of light by solid aerosols in to the space. In order to understand these optical effects, it is compulsory to know the constituents of solid aerosols and their sizes. Because these parameters not only determine the scattering and absorption properties but also provide us information to interact with gaseous pollutants in the environment and react to form new solid aerosol particles. It may be possible that they modify existing solid aerosols by homogeneous, homo molecular nucleation or homogeneous, heterogeneous molecular nucleation and they may get into human respiratory system and generate health hazards.

Since each element has its own characteristic absorption wavelength, when the sample is in solution form it is found that the measured extinction coefficient σ is proportional to the concentration of the absorbing substance and hence may be written as

$$\mu = K\,\sigma$$

Where μ is the linear extinction coefficient and K is the extinction coefficient per unit concentration. The conversion of the concentration in mg/l to mg/Kg is achieved using the following expression [37]

$$\mathrm{Mg/Kg} = \frac{\mathrm{Reading\,(mg/l)} \times 50\,\mathrm{ml}}{\mathrm{Weight\ of\ the\ sample\,(g)}}$$

Statistical analysis of the data was performed based on evaluating the mean values, range, standard deviation (S.D) and coefficient of variation (CV) to check the stability of the data [40]. The results of all the above mentioned parameters are given in the relevant tables. The characterization of solid aerosols was also performed using TEM (Model JEOL-1010, 80KV, 1500×2500) available at NIBGE Faisalabad by applying the method given below.

One ml of distilled water in enpandrof and mix the solid aerosol sample in equal amount for solid aerosol suspension. Then the sample was sonicated for three minutes and put its drop on carbon grid and the grid was loaded on the sample holder for further investigation. The micrographs for the required magnification were taken and analyzed using grid method. During sampling the relative humidity and temperature varied between 48.6% to 80.8% and 5.6^{o}C to 42.6^{o}C respectively.

The results obtained in this study slightly disagreed from similar previous and current studies conducted by other workers. This disagreement can be explained in terms of: (a) the climatological, geological, and geographical setups, (b) the latitude, longitude location with respect to solid aerosol sources, and (c) the expansion in the industrial and transport functioning set up.

3. Results and Discussion

In order to determine trace elements in the Faisalabad environment, 100 samples i.e. 20 from each pool ,residential, Industrial, Commercial, Transportational and Mix pool covering almost all the aspects of Faisalabad environment using air volume sampler following standard protocol. Atmospheric solid aerosols were randomly collected in Faisalabad city. All the samples were subjected to trace elemental analysis by the AAS technique for determination of Ca, Cd, Cr, Ni, Pb and Zn in solid aerosols the results obtained are given in the following tables.

Table-1: Trace element Concentration (mg/kg) of Solid Aerosols

Sr. No.	Cd	Cr	Ni	Cu	Zn	Pb
1	107.677	97.88818	587.3291	ND	195.7764	39.15527
2	97.88818	97.88818	587.3291	ND	489.4409	19.57764
3	97.88818	146.8323	489.4409	ND	146.8323	ND
4	107.677	146.8323	587.3291	ND	195.7764	244.7205
5	107.677	166.4099	557.9626	ND	195.7764	ND
6	97.88818	146.8323	587.3291	ND	195.7764	19.57764
7	88.09936	146.8323	489.4409	ND	195.7764	ND
8	117.4658	146.8323	636.2732	ND	362.1863	19.57764
9	107.677	146.8323	19.57764	ND	244.7205	6.852173
10	117.4658	166.4099	78.31055	ND	215.354	48.94409
11	117.4658	97.88818	704.7949	ND	264.2981	78.31055
12	97.88818	195.7764	734.1614	9.788818	244.7205	ND
13	117.4658	146.8323	734.1614	ND	244.7205	ND
14	117.4658	97.88818	587.3291	29.36645	146.8323	9.788818
15	117.4658	166.4099	880.9936	9.788818	342.6086	88.09936
16	117.4658	195.7764	880.9936	9.788818	489.4409	78.31055
17	117.4658	166.4099	783.1055	ND	264.2981	39.15527
18	107.677	185.9875	557.9626	ND	264.2981	48.94409
19	88.09936	185.9875	587.3291	ND	391.5527	ND
20	78.31055	195.7764	783.1055	ND	264.2981	58.73291
21	107.677	156.6211	636.2732	ND	244.7205	39.15527
22	88.09936	195.7764	606.9067	ND	244.7205	ND
23	97.88818	97.88818	783.1055	ND	2760.447	0.978882
24	117.4658	1155.081	704.7949	ND	166.4099	2.936645
25	88.09936	156.6211	440.4968	ND	215.354	ND
26	97.88818	97.88818	489.4409	ND	704.7949	4.894409
27	97.88818	234.9316	753.739	ND	195.7764	19.57764
28	127.2546	185.9875	753.739	ND	509.0185	68.52173
29	107.677	195.7764	734.1614	ND	9.788818	ND
30	117.4658	185.9875	753.739	ND	146.8323	48.94409
31	107.677	215.354	880.9936	ND	264.2981	6.852173
32	ND	9.788818	9.788818	ND	6.852173	ND
33	3.915527	19.57764	1.957764	88.09936	988.6706	6.852173
34	0.978882	19.57764	2.936645	68.52173	1869.664	5.873291
35	5.873291	19.57764	2.936645	88.09936	841.8384	0.978882
36	6.852173	2.936645	0.978882	107.677	890.7825	5.873291
37	5.873291	6.852173	3.915527	78.31055	97.88818	16.64099
38	6.852173	2.936645	0.978882	88.09936	1018.037	15.66211
39	430.708	1.957764	2.936645	117.4658	1390.012	15.66211
40	4.894409	1.957764	1.957764	88.09936	1213.813	15.66211
41	0.978882	11.74658	0.978882	88.09936	1350.857	14.68323
42	5.873291	19.57764	1.957764	88.09936	1360.646	13.70435
43	6.852173	6.852173	22.51428	107.677	1174.658	25.45093
44	1.957764	8.809936	2.936645	127.2546	1409.59	23.49316
45	3.915527	8.809936	ND	88.09936	1292.124	11.74658
46	6.852173	7.831055	ND	107.677	1321.49	66.56396
47	0.978882	2.936645	2.936645	68.52173	1106.136	49.92297
48	2.936645	4.894409	2.936645	88.09936	1204.025	49.92297
49	3.915527	0.978882	ND	48.94409	1145.292	47.96521
50	3.915527	4.894409	2.936645	48.94409	753.739	66.56396

Sr. No.	Cd	Cr	Ni	Cu	Zn	Pb
51	6.852173	0.978882	2.936645	88.09936	1145.292	48.94409
52	2.936645	58.73291	ND	97.88818	1223.602	68.52173
53	0.978882	2.936645	ND	117.4658	1478.112	58.73291
54	3.915527	19.57764	2.936645	107.677	1390.012	5.873291
55	5.873291	3.915527	ND	97.88818	1370.435	56.77515
56	6.852173	3.915527	ND	97.88818	1204.025	47.96521
57	6.852173	7.831055	2.936645	107.677	1174.658	47.96521
58	4.894409	27.40869	ND	88.09936	1331.279	23.49316
59	6.852173	19.57764	ND	97.88818	1184.447	22.51428
60	6.852173	176.1987	2.936645	88.09936	1184.447	24.47205
61	6.852173	19.57764	2.936645	88.09936	1390.012	18.59875
62	5.873291	78.31055	ND	117.4658	1390.012	7.831055
63	3.915527	7.831055	2.936645	205.5652	1370.435	ND
64	2.936645	5.873291	ND	557.9626	929.9377	ND
65	0.978882	25.45093	2.936645	1252.969	949.5154	ND
66	0.978882	13.70435	ND	1155.081	587.3291	0.978882
67	5.873291	0.978882	ND	88.09936	969.093	5.873291
68	4.894409	ND	5.873291	68.52173	969.093	19.57764
69	6.852173	2.936645	2.936645	97.88818	969.093	4.894409
70	3.915527	ND	ND	88.09936	1174.658	16.64099
71	0.978882	1.957764	ND	78.31055	734.1614	ND
72	ND	8.809936	5.873291	117.4658	1076.77	24.47205
73	6.852173	20.55652	2.936645	97.88818	1027.826	37.19751
74	6.852173	0.978882	2.936645	166.4099	1233.391	33.28198
75	3.915527	23.49316	ND	78.31055	949.5154	16.64099
76	6.852173	19.57764	3.915527	88.09936	880.9936	18.59875
77	3.915527	1.957764	ND	1585.789	244.7205	15.66211
78	2.936645	6.852173	ND	2075.229	127.2546	23.49316
79	3.915527	19.57764	2.936645	2036.074	832.0495	74.39502
80	5.873291	12.72546	ND	1066.981	734.1614	244.7205
81	6.852173	3.915527	ND	822.2607	1027.826	802.6831
82	ND	23.49316	ND	78.31055	1047.404	50.90185
83	6.852173	15.66211	2.936645	48.94409	1223.602	47.96521
84	0.978882	32.3031	18.59875	ND	33.28198	36.21863
85	ND	32.3031	5.873291	ND	6.852173	46.98633
86	0.978882	39.15527	1.957764	ND	6.852173	57.75403
87	ND	489.4409	1.957764	ND	42.09192	1.957764
88	ND	48.94409	0.978882	ND	33.28198	2.936645
89	0.978882	76.35278	ND	ND	62.64844	21.5354
90	ND	97.88818	5.873291	17.61987	62.64844	56.77515
91	1.957764	50.90185	ND	0.978882	31.32422	21.5354
92	2.936645	50.90185	ND	ND	1.957764	31.32422
93	3.915527	47.96521	1.957764	ND	77.33166	46.98633
94	ND	74.39502	6.852173	16.64099	29.36645	23.49316
95	0.978882	23.49316	ND	ND	234.9316	72.43725
96	3.915527	51.88074	ND	ND	52.85962	67.54285
97	2.936645	60.69067	ND	ND	35.23975	7.831055
98	3.915527	41.11304	3.915527	ND	11.74658	33.28198
99	1.957764	78.31055	19.57764	11.74658	80.26831	58.73291
100	ND	39.15527	ND	ND	54.81738	60.69067

ND = not detected

Table-2: Absorption Coefficient of identified Trace element of Solid Aerosols

Sr. No.	Cd	Cr	Ni	Cu	Zn	Pb
1	-3.09104	-0.28768	-1.79176	ND	3.218876	0.223144
2	-2.99573	-0.28768	-1.79176	ND	2.302585	0.916291
3	-2.99573	-0.69315	-1.60944	ND	3.506558	ND
4	-3.09104	-0.69315	-1.79176	ND	3.218876	-1.60944
5	-3.09104	-0.81831	-1.74047	ND	3.218876	ND
6	-2.99573	-0.69315	-1.79176	ND	3.218876	0.916291
7	-2.89037	-0.69315	-1.60944	ND	3.218876	ND
8	-3.17805	-0.69315	-1.8718	ND	2.60369	0.916291
9	-3.09104	-0.69315	1.609438	ND	2.995732	1.966113
10	-3.17805	-0.81831	0.223144	ND	3.123566	0
11	-3.17805	-0.28768	-1.97408	ND	2.918771	-0.47
12	-2.99573	-0.98083	-2.0149	4.867534	2.995732	ND
13	-3.17805	-0.69315	-2.0149	ND	2.995732	ND
14	-3.17805	-0.28768	-1.79176	3.768922	3.506558	1.609438
15	-3.17805	-0.81831	-2.19722	4.867534	2.65926	-0.58779
16	-3.17805	-0.98083	-2.19722	4.867534	2.302585	-0.47
17	-3.17805	-0.81831	-2.07944	ND	2.918771	0.223144
18	-3.09104	-0.92954	-1.74047	ND	2.918771	0
19	-2.89037	-0.92954	-1.79176	ND	2.525729	ND
20	-2.77259	-0.98083	-2.07944	ND	2.918771	-0.18232
21	-3.09104	-0.75769	-1.8718	ND	2.995732	0.223144
22	-2.89037	-0.98083	-1.82455	ND	2.995732	ND
23	-2.99573	-0.28768	-2.07944	ND	0.572701	3.912023
24	-3.17805	-2.75578	-1.97408	ND	3.381395	2.813411
25	-2.89037	-0.75769	-1.50408	ND	3.123566	ND
26	-2.99573	-0.28768	-1.60944	ND	1.937942	2.302585
27	-2.99573	-1.16315	-2.04122	ND	3.218876	0.916291
28	-3.2581	-0.92954	-2.04122	ND	2.263364	-0.33647
29	-3.09104	-0.98083	-2.0149	ND	6.214608	ND
30	-3.17805	-0.92954	-2.04122	ND	3.506558	0
31	-3.09104	-1.07614	-2.19722	ND	2.918771	1.966113
32	ND	2.014903	2.302585	ND	6.571283	ND
33	0.223144	1.321756	3.912023	2.67031	1.599488	1.966113
34	1.609438	1.321756	3.506558	2.921624	0.962335	2.120264
35	-0.18232	1.321756	3.506558	2.67031	1.760261	3.912023
36	-0.33647	3.218876	4.60517	2.469639	1.703749	2.120264
37	-0.18232	2.371578	3.218876	2.788093	3.912023	1.07881
38	-0.33647	3.218876	4.60517	2.67031	1.570217	1.139434
39	-4.47734	3.624341	3.506558	2.382628	1.258781	1.139434
40	0	3.624341	3.912023	2.67031	1.394327	1.139434
41	1.609438	1.832581	4.60517	2.67031	1.287354	1.203973
42	-0.18232	1.321756	3.912023	2.67031	1.280134	1.272966
43	-0.33647	2.371578	1.469676	2.469639	1.427116	0.653926
44	0.916291	2.120264	3.506558	2.302585	1.244795	0.733969
45	0.223144	2.120264	ND	2.67031	1.331806	1.427116
46	-0.33647	2.238047	ND	2.469639	1.309333	-0.30748
47	1.609438	3.218876	3.506558	2.921624	1.48722	-0.0198
48	0.510826	2.70805	3.506558	2.67031	1.402424	-0.0198
49	0.223144	4.317488	ND	3.258097	1.452434	0.020203
50	0.223144	2.70805	3.506558	3.258097	1.870803	-0.30748

Sr. No.	Cd	Cr	Ni	Cu	Zn	Pb
51	-0.33647	4.317488	3.506558	2.67031	1.452434	0
52	0.510826	0.223144	ND	2.564949	1.386294	-0.33647
53	1.609438	3.218876	ND	2.382628	1.197328	-0.18232
54	0.223144	1.321756	3.506558	2.469639	1.258781	2.120264
55	-0.18232	2.931194	ND	2.564949	1.272966	-0.14842
56	-0.33647	2.931194	ND	2.564949	1.402424	0.020203
57	-0.33647	2.238047	3.506558	2.469639	1.427116	0.020203
58	0	0.985284	ND	2.67031	1.301953	0.733969
59	-0.33647	1.321756	ND	2.564949	1.418818	0.776529
60	-0.33647	-0.87547	3.506558	2.67031	1.418818	0.693147
61	-0.33647	1.321756	3.506558	2.67031	1.258781	0.967584
62	-0.18232	-0.06454	ND	2.382628	1.258781	1.832581
63	0.223144	2.238047	3.506558	1.823012	1.272966	ND
64	0.510826	2.525729	ND	0.824483	1.660731	ND
65	1.609438	1.059392	3.506558	0.015504	1.639897	ND
66	1.609438	1.678431	ND	0.09685	2.120264	3.912023
67	-0.18232	4.317488	ND	2.67031	1.619488	2.120264
68	0	ND	2.813411	2.921624	1.619488	0.916291
69	-0.33647	3.218876	3.506558	2.564949	1.619488	2.302585
70	0.223144	ND	ND	2.67031	1.427116	1.07881
71	1.609438	3.624341	ND	2.788093	1.89712	ND
72	ND	2.120264	2.813411	2.382628	1.514128	0.693147
73	-0.33647	1.272966	3.506558	2.564949	1.560648	0.274437
74	-0.33647	4.317488	3.506558	2.034321	1.378326	0.385662
75	0.223144	1.139434	ND	2.788093	1.639897	1.07881
76	-0.33647	1.321756	3.218876	2.67031	1.714798	0.967584
77	0.223144	3.624341	ND	-0.22006	2.995732	1.139434
78	0.510826	2.371578	ND	-0.48905	3.649659	0.733969
79	0.223144	1.321756	3.506558	-0.47	1.771957	-0.41871
80	-0.18232	1.752539	ND	0.176187	1.89712	-1.60944
81	-0.33647	2.931194	ND	0.436718	1.560648	-2.79728
82	ND	1.139434	ND	2.788093	1.541779	-0.03922
83	-0.33647	1.544899	3.506558	3.258097	1.386294	0.020203
84	1.609438	0.820981	1.660731	ND	4.990833	0.301105
85	ND	0.820981	2.813411	ND	6.571283	0.040822
86	1.609438	0.628609	3.912023	ND	6.571283	-0.16551
87	ND	-1.89712	3.912023	ND	4.755993	3.218876
88	ND	0.405465	4.60517	ND	4.990833	2.813411
89	1.609438	-0.03922	ND	ND	4.35831	0.820981
90	ND	-0.28768	2.813411	4.279748	4.35831	-0.14842
91	0.916291	0.366244	ND	7.17012	5.051457	0.820981
92	0.510826	0.366244	ND	ND	7.824046	0.446287
93	0.223144	0.425668	3.912023	ND	4.147745	0.040822
94	ND	-0.01325	2.65926	4.336906	5.115996	0.733969
95	1.609438	1.139434	ND	ND	3.036554	-0.39204
96	0.223144	0.347196	ND	ND	4.528209	-0.32208
97	0.510826	0.190354	ND	ND	4.933674	1.832581
98	0.223144	0.579818	3.218876	ND	6.032287	0.385662
99	0.916291	-0.06454	1.609438	4.685213	4.110474	-0.18232
100	ND	0.628609	ND	ND	4.491842	-0.21511

ND = not detected

Table-3: Percentage of Radiative effect on the environment of Faisalabad due to identified Trace element in Solid Aerosols

Sr. No.	Cd	Cr	Ni	Cu	Zn	Pb
1	37.1913	12.87682	4.652932	ND	-11.0944	19.42141
2	39.95732	12.87682	4.652932	ND	-2.60517	4.185463
3	39.95732	11.28765	5.218876	ND	-16.7104	ND
4	37.1913	11.28765	4.652932	ND	-11.0944	10.43775
5	37.1913	10.69594	4.807835	ND	-11.0944	ND
6	39.95732	11.28765	4.652932	ND	-11.0944	4.185463
7	43.22635	11.28765	5.218876	ND	-11.0944	ND
8	34.81712	11.28765	4.418157	ND	-4.3343	4.185463
9	37.1913	11.28765	-30.4719	ND	-7.98293	-138.016
10	34.81712	10.69594	9.710706	ND	-9.65257	20
11	34.81712	12.87682	4.130668	ND	-7.10656	18.37505
12	39.95732	9.904146	4.019871	-386.753	-7.98293	ND
13	34.81712	11.28765	4.019871	ND	-7.98293	ND
14	34.81712	12.87682	4.652932	-92.2974	-16.7104	-60.9438
15	34.81712	10.69594	3.552472	-386.753	-4.74074	17.64207
16	34.81712	9.904146	3.552472	-386.753	-2.60517	18.37505
17	34.81712	10.69594	3.849302	ND	-7.10656	19.42141
18	37.1913	10.15545	4.807835	ND	-7.10656	20
19	43.22635	10.15545	4.652932	ND	-3.81432	ND
20	47.15736	9.904146	3.849302	ND	-7.10656	19.70536
21	37.1913	10.98554	4.418157	ND	-7.98293	19.42141
22	43.22635	9.904146	4.555725	ND	-7.98293	ND
23	39.95732	12.87682	3.849302	ND	0.151524	-2912.02
24	34.81712	3.182866	4.130668	ND	-14.0082	-604.47
25	43.22635	10.98554	5.564616	ND	-9.65257	ND
26	39.95732	12.87682	5.218876	ND	-1.3027	-260.517
27	39.95732	9.013128	3.949637	ND	-11.0944	4.185463
28	32.75459	10.15545	3.949637	ND	-2.42955	19.09246
29	37.1913	9.904146	4.019871	ND	-521.461	ND
30	34.81712	10.15545	3.949637	ND	-16.7104	20
31	37.1913	9.436997	3.552472	ND	-7.10656	-138.016
32	ND	-101.49	-130.259	ND	-795.898	ND
33	194.2141	-16.0878	-1456.01	-18.559	-0.59355	-138.016
34	-609.438	-16.0878	-835.519	-27.4518	0.01972	-186.711
35	197.0536	-16.0878	-835.519	-18.559	-0.88402	-2912.02
36	190.9246	-739.625	-3605.17	-13.3604	-0.77335	-186.711
37	197.0536	-195.94	-554.719	-22.3512	-29.1202	-4.63586
38	190.9246	-739.625	-3605.17	-18.559	-0.54829	-8.71464
39	12.44849	-1312.17	-835.519	-11.5219	-0.18224	-8.71464
40	200	-1312.17	-1456.01	-18.559	-0.31801	-8.71464
41	-609.438	-69.3818	-3605.17	-18.559	-0.20823	-13.5982
42	197.0536	-16.0878	-1456.01	-18.559	-0.20154	-19.4975
43	190.9246	-195.94	-20.4207	-13.3604	-0.35593	13.31052
44	41.85463	-124.474	-835.519	-10.0199	-0.17	11.08462
45	194.2141	-124.474	ND	-18.559	-0.25137	-35.593
46	190.9246	-154.756	ND	-13.3604	-0.22914	19.22772
47	-609.438	-739.625	-835.519	-27.4518	-0.43117	19.99613
48	163.0581	-341.61	-835.519	-18.559	-0.32717	19.99613
49	194.2141	-3317.49	ND	-45.1619	-0.3867	19.99586

Sr. No.	Cd	Cr	Ni	Cu	Zn	Pb
50	194.2141	-341.61	-835.519	-45.1619	-1.13091	19.22772
51	190.9246	-3317.49	-835.519	-18.559	-0.3867	20
52	163.0581	12.94761	ND	-15.6495	-0.30904	19.09246
53	-609.438	-739.625	ND	-11.5219	-0.13068	19.70536
54	194.2141	-16.0878	-835.519	-13.3604	-0.18224	-186.711
55	197.0536	-482.798	ND	-15.6495	-0.19498	19.80034
56	190.9246	-482.798	ND	-15.6495	-0.32717	19.99586
57	190.9246	-154.756	-835.519	-13.3604	-0.35593	19.99586
58	200	0.525586	ND	-18.559	-0.22202	11.08462
59	190.9246	-16.0878	ND	-15.6495	-0.34613	9.71614
60	190.9246	10.41927	-835.519	-18.559	-0.34613	12.27411
61	190.9246	-16.0878	-835.519	-18.559	-0.18224	1.706104
62	197.0536	13.30673	ND	-11.5219	-0.18224	-104.073
63	194.2141	-154.756	-835.519	-3.9191	-0.19498	ND
64	163.0581	-254.288	ND	0.307924	-0.69551	ND
65	-609.438	-2.28429	-835.519	0.769137	-0.65969	ND
66	-609.438	-48.4593	ND	0.765382	-1.86711	-2912.02
67	197.0536	-3317.49	ND	-18.559	-0.62575	-186.711
68	200	ND	-302.235	-27.4518	-0.62575	4.185463
69	190.9246	-739.625	-835.519	-15.6495	-0.62575	-260.517
70	194.2141	ND	ND	-18.559	-0.35593	-4.63586
71	-609.438	-1312.17	ND	-22.3512	-1.19616	ND
72	ND	-124.474	-302.235	-11.5219	-0.46739	12.27411
73	190.9246	-12.9984	-835.519	-15.6495	-0.53395	19.09377
74	190.9246	-3317.49	-835.519	-6.08424	-0.30026	18.06875
75	194.2141	-5.80976	ND	-22.3512	-0.65969	-4.63586
76	190.9246	-16.0878	-554.719	-18.559	-0.79422	1.706104
77	194.2141	-1312.17	ND	0.753125	-7.98293	-8.71464
78	163.0581	-195.94	ND	0.702383	-20.382	11.08462
79	194.2141	-16.0878	-835.519	0.706733	-0.90818	18.66724
80	197.0536	-57.8876	ND	0.755792	-1.19616	10.43775
81	190.9246	-482.798	ND	0.670574	-0.53395	4.630831
82	ND	-5.80976	ND	-22.3512	-0.50634	19.98501
83	190.9246	-34.0562	-835.519	-45.1619	-0.30904	19.99586
84	-609.438	5.424832	-34.7753	ND	-117.377	18.88905
85	ND	5.424832	-302.235	ND	-795.898	19.98288
86	-609.438	9.284784	-1456.01	ND	-795.898	19.75448
87	ND	5.79424	-1456.01	ND	-87.3487	-1109.44
88	ND	11.8907	-3605.17	ND	-117.377	-604.47
89	-609.438	13.32334	ND	ND	-52.4736	8.137248
90	ND	12.87682	-302.235	-182.208	-52.4736	19.80034
91	41.85463	12.18761	ND	-6170.12	-126.608	8.137248
92	163.0581	12.18761	ND	ND	-3412.02	17.30353
93	194.2141	11.72106	-1456.01	ND	-39.8449	19.98288
94	ND	13.33217	-237.037	-196.289	-137.2	11.08462
95	-609.438	-5.80976	ND	ND	-8.48564	18.81138
96	194.2141	12.31705	ND	ND	-65.3372	19.16063
97	163.0581	13.05881	ND	ND	-109.269	-104.073
98	194.2141	10.00432	-554.719	ND	-419.357	18.06875
99	41.85463	13.30673	-30.4719	-307.101	-37.9326	19.70536
100	ND	9.284784	ND	ND	-62.3543	19.59857

ND = not detected

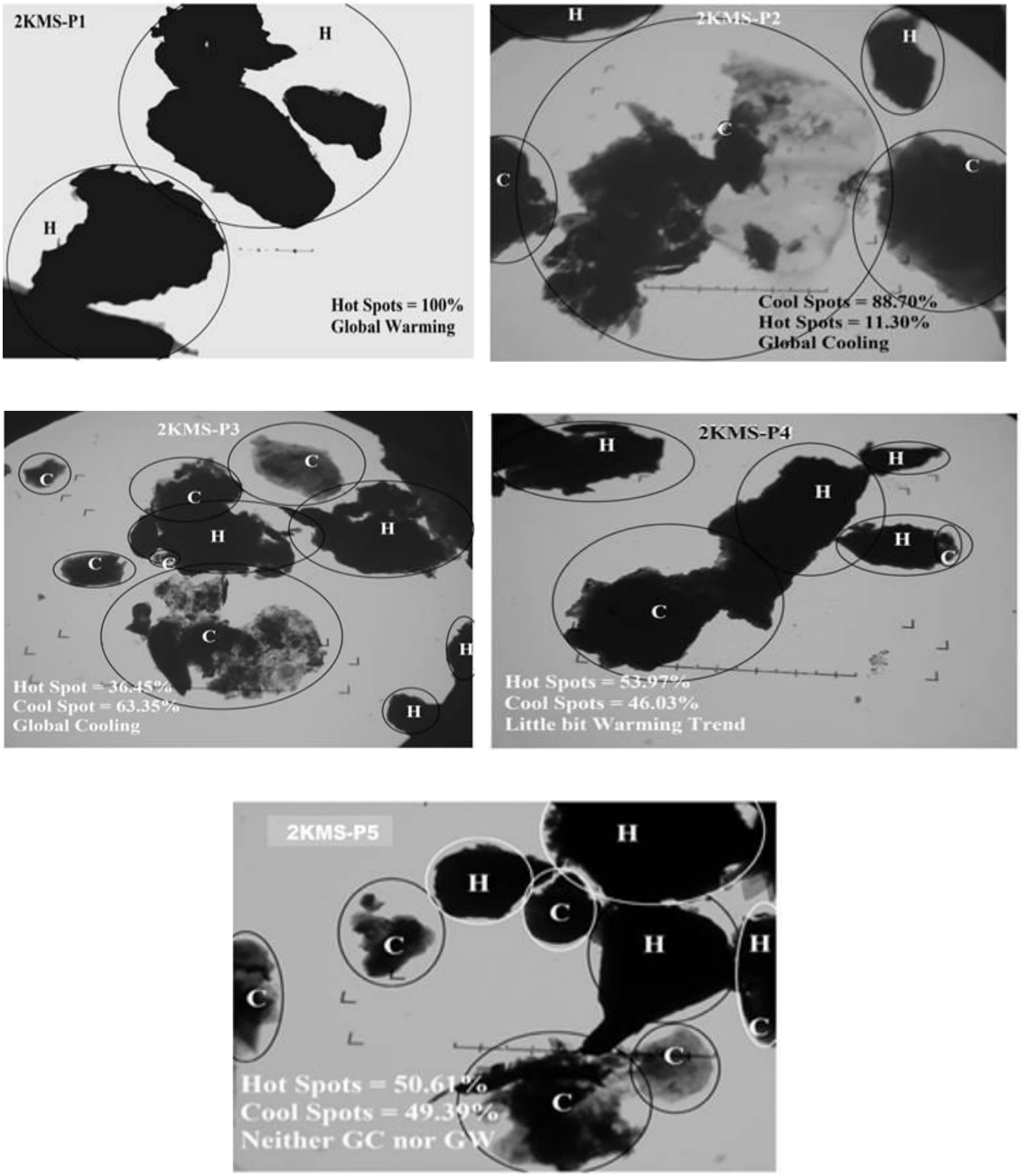

Fig: 3 TEM Micrographs representing different pooling site

Table 4: Solid Aerosol's Morphological Structure Study

Morphological Shape	Shape %age					
	2KMS-P1	2KMS-P2	2KMS-P3	2KMS-P4	2KMS-P5	Overall average
Angular (Sharp edges)	25	61.07	73.47	65.38	63.64	57.84
Round (Spherical+Circular)	25	34.04	24.49	11.11	27.27	24.38
Coarse Irregular	25	2.13	2.04	11.11	9.09	9.87
Agglomerates	25	ND	ND	11.11	ND	7.22

Table 5: Health Hazards of Solid Aerosols on the basis of their Size Classification

Solid Aerosol Size Fraction	Size %age					
	2KMS-P1	2KMS-P2	2KMS-P3	2KMS-P4	2KMS-P5	Overall average
Fine	ND	8.5	22.45	ND	ND	6.19
Respirable	60	87.23	63.26	69.23	84.85	72.91
Thoracic	40	4.26	14.29	30.77	15.15	20.89

Table 6: Global Warming and Global cooling trend of Different Pooling Sites of Faisalabad using SEM

Solid Aerosol Types	2KMS-P1 %	2KMS-P2 %	2KMS-P3 %	2KMS-P4 %	2KMS-P5 %
Ultra fine Scattering	ND	ND	ND	ND	ND
Ultra coarse Absorption	40	4.26	14.29	30.77	10.68

Table 7: Global Warming and Global Cooling Profile of Solid Aerosols using TEM

Pool Sample	Global Warming Trend	Global Cooling Trend	Overall Trend of the Pool
2KMS-P_1	63.64%	36.36%	Warming
2KMS-P_2	25%	75%	Cooling
2KMS-P_3	30.77%	69.23%	Cooling
2KMS-P_4	57.10%	42.90%	Warming
2KMS-P_5	44.44%	55.56%	Approximate neutral

Table 8: Statistical Analysis of Identified Phases

Identified Phases	Maximum	Minimum	Mean	SD	CV
	Range				
Cd	0.12	0.001	0.0605	0.0842	139.17
Cr	0.24	0.001	0.1205	0.1684	139.17
Ni	0.90	0.001	0.4505	0.6357	141.12
Cu	2.12	0.001	1.0605	1.498	141.25
Zn	1.91	0.002	0.956	1.349	141.12
Pb	0.082	0.001	0.0415	0.057	27.14

Table 9: Comparative Study of Identified Phases

< or >or =	Cd	Cr	Ni	Cu	Zn	Pb
>	54%	25%	29%	3%	ND	24%
=	3%	7%	ND	ND	ND	4%
<	43%	68%	71%	97%	100%	72%

Over All Net Effect, P1 > PS = 22. 5% (Pollutant Violators), P2 = PS = 2.4% (Pollutant Followers), P3 < PS = 75.2% (Better Living Standards)

The major purpose of the present study is to provide basic knowledge about atmospheric constituents of trace elements in different areas of Faisalabad, its possible health hazards and to obtain data for determining co-relationship between heavy metals present in aerosol samples and radiative budget of the environment related to area under investigation.. The color of aerosol samples was found to be varying from black, green and yellow, showing the interaction of industrial, transportational, municipal and hospital wastes with solid aerosols.

Trace elements were detected by AAS, and it was seen that percentage of Cd (54 %), Cr (25%), Ni (29%), Pb (24%) having maximum values Cd(0.440), Cr(1.18), Ni(0.90), Pb(0.82) respectively were in little excess from TLVs (Threshold level values) while Cu (3%; Max. value=2.12), Zn (Nil; Max. value=2.82) were within permissible limits overall effect of all these trace elements on the environment is only 22.5 % (Table 1 to Table 3) following the trend Cd > Cr > Ni > Pb > Cu > Zn. This trend was compared with the joint study conducted by Pakistan Environment protection Agency (Pak- EPA) with Japan international co-operation agency (JICA). In this study they claimed the following trends for four big cities of Pakistan.

Cd > Zn > Pb (Islamabad)
Cd > Pb > Zn (Gujranwala)
Cd > Pb > Zn (Faisalabad)
Zn > Pb > Cd (Bahawalpur) respectively

The high concentration of Cd may be associated with steel production units, municipal waste containing Ni-Cd batteries, Cd coated plastics and vehicles emissions while Pb may be associated with manufacturing units of automobile products, paints, pigments and plastic ceramic wares. Matching of the trend of our study not only confirms these findings but also confirms the authenticity of our experimental data.

High concentration of above said elements is due to expanded industrialization, rapid urbanization, and mechanized transportation. They generate 50 % of Co, Pb, Cd, Cr, and Ni, Zn etc causing increase in respiratory diseases [40-50].

Climatic effects of solid aerosols are usually associated with their ability of causing light extinction or visibility reduction and radiative forcing which depends upon size and hygroscopic nature of solid aerosols. Both of these factors play a major role in scattering and absorption of sunlight from solid aerosols and light extinction. If size of aerosol particle is smaller than the wavelength of incoming light beam i.e., $d_p << \lambda_{light}$, then the light beam scatters and reflects back to the space giving rise to global cooling. This happens in the case of ultra fine particles with diameters smaller than 0.1µm. For the particles in the fine and coarse mode transmission of light is prominent as wavelength of incoming light beam is equal to particle size which helps in refraction or transmission of light beam from these aerosols. Due to hygroscopic nature, aerosols takes up water and swells up in the conditions when humidity of the environment reaches from (50 to 90) %. So their size increases and becomes greater than the wavelength of incoming light beam i.e., $d_P >> \lambda_{light}$. In this case scattering cross section for light taken from different 5 pools of Faisalabad city revealed the concentration of ultra-coarse particles in the decreasing order as 2KMS-P_1>2KMS-P_4>2KMS-P_5>2KMS-P_3>2KMS-P_2 as shown in the table 6. No ultra fine particle was detected in any of these samples. This indicates that global warming trend of

Faisalabad environment decreases as we move from highly polluted areas to low polluted or clean areas i.e., from industrial to transportational, Transportational to residential cum commercial cum industrial, residential cum commercial cum industrial to residential cum commercial and residential cum commercial to residential areas. Generating related health hazards TEM micrographs of some samples also supplement our results as shown in the fig 3 and table 4 to 7. It is also evident from our findings that solid aerosols present in Faisalabad environment exhibit remote nature due to their movement from highly polluted areas to low polluted areas, decreases while absorption cross section increases giving rise to light absorption and hence global warming. This usually happens in the case of ultra-coarse particles. Furthermore, attempts has been made to investigate the radiative properties of the metals, by calculating the absorption coefficient using Lamberts Beer's law and their effect on global warming and global cooling was checked using TEM micrographs. The results showed complex behavior, but overall neutral trend. The hot and cold portions estimated from TEM images have large uncertainties because of limited particle number and over shadowing by other neighboring particles along with evaporation of semi volatile material in the chamber. On behalf of area coverage soot coating was divided in to five groups 1 unobserved 2 lightly coated 3 medium coated 4 heavily coated 5 completely coated. Medium coated and heavily coated are approximately equivalent so neutralizing each other. For the confirmation of the authenticity of the data statistical analysis was also carried out which shows the stability of the environment for the time being as indicated by slight variations in SDs and CVs and also confirmed by 75.2% better living standards for the selected environment Table 8 & 9

4. Conclusions

Solid aerosol climate forcing is a complex phenomenon because aerosols both reflects and absorb solar radiations and contribute a lot not only in global warming and global cooling trends of the environment but also for the formation and deformation of clouds. Secondly the rate at which the earth's surface temperature approaches in the equilibrium with respect to climate forcing depends upon how efficiently heat perturbations were mixed in deeper oceans which is also a complex phenomenon. So very precise and more specific studies relative to elemental composition of solid aerosol and their effect on global cooling and global warming trends along with cloud composition were recommended for future studies. [51-60]. The idea of extinction coefficient and TEM micrograph of solid aerosols suggests that coating was internally mixed, causing the adhering of sulphates and organic matter generated in to the environment due to transport industry. In this way such type of analysis may be used as a good quantitative indicator for checking global warming and global cooling trends especially when the idea of extinction co-efficient do not work well. The model predictions don't match with our observations and the same is true in case of our experimental findings [61-70].

.The global warming predictions are contradicted by the data. The vast funding which is now being directed to 'solving' global warming should be redirected to researching hypotheses which are consistent with empirical data and confirmed by observable evidence.

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