Atmospheric Metal Constituent, Concentration and Health Impacts in the Urban Environment of Faisalabad (Pakistan)

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Abstract: Currently rapidly growing heavy metal pollution is a burning issue due to deteriorating air quality and health status of the inhabitants of the world. In the present study heavy metals in the solid aerosols as well as in the human blood samples from randomly selected sites related to Faisalabad environment were estimated using Atomic absorption spectrophotometry (AAS). The order of concentration of these toxic metals were found to be Zn>Cu>Cr>Ni>Pb>Cd for solid aerosols while Cu>Zn>Pb>Ni>Cr>Cd for blood samples. Overall effect of all these elements present in solid aerosols and blood samples is 22.5 % and 23.11% respectively. The contribution of different kinds of industries is the major source of emission of these elements in the environment. From where these enter in the food web and food chain when deposited on land or inhaled by the inhabitants of the area concerned. Concentration factor and Pollution load index (PLI) were also calculated which showed the shifting of Cd, Cu, Zn, Cr and Ni from solid aerosols to human blood causing severe health hazards while Pb was the only element found in blood which has its origin other than solid aerosols. This state of affairs shows that atmosphere of Faisalabad has worsened to an extent that protective measures are urgently required to overcome the health hazards generated by these potentially toxic pollutants.

Keywords: Elemental atmospheric air pollution, positive co-relationship with human blood, confirmed through concentration factor and pollution load index, hazardous effects on human health, protective measures suggested.

1. INTRODUCTION

Environment, in its wider sense, includes every thing, 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 [2-8]. The urban population is exposed to the aerosol toxic metals that often are well above natural background [9-13]. Many studies on atmospheric metal concentration and their related health hazrds have been conducted in several parts of the world which showed diverse fluctuations and disparities among the trace element constituents [14-24]. All these metals produce different diseases like oxides of Zinc along with oxides of Iron produce gastric disorder and vomiting, irritation of skin and mucous membrane. Nickel, Chromium, Lead, Cadmium, Copper and Carcinogenic calcium causes slowing of heart rate, leukemia and different types of cancer [25-31]. Cobalt and Manganese cause chronic and acute poisoning which results in Anemia and Hypertension [32]. When these chemicals are released into the atmosphere, they enter into the human chain, as soon as they enter biological system cause deaths in some cases. Due to the lack of air quality management capabilities, the Pakistan is suffering from deterioration of air quality. Evidence from various governmental organizations and international agencies has indicated that air pollution is a significant risk to the environment, quality of life and human health [33-36]. The present study was conducted in order to assess the concentration of heavy metals in the atmosphere of Faisalabad and human blood. For the confirmation of interactive relationship between solid aerosols and blood samples co relationship was also established. These results were also compared with other similar studies quoted in national and international journals having impact factors. This effort is the continuation of our Ph. D. project on this issue already presented and published elsewhere.

2. MATERIALS AND METHODS

In this study attempt has been made to estimate the trace elements like Cd, Cr, Ni, Zn, Cu, and Pb in the atmosphere of various areas of Faisalabad city. 50

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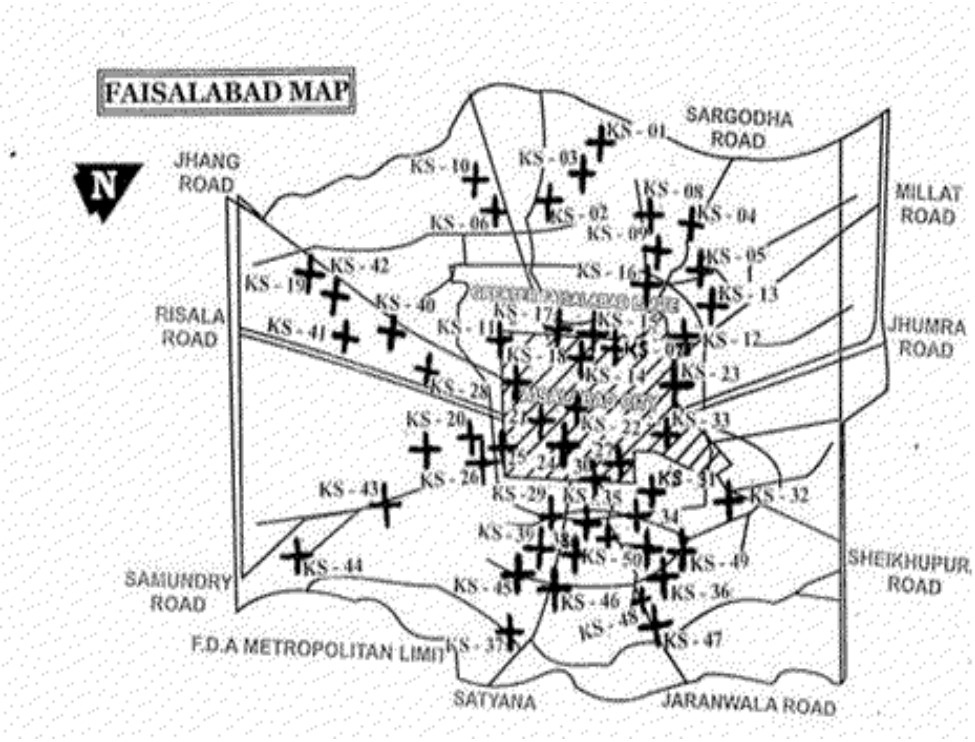

Figure 1: Site selection for Faisalabad City.

sites were randomly selected for analysis covering industrial, transportational, commercial and residential nature of the Faisalabad environment. Air samples containg 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]. Then using oxidizing acid mixture wet digestion of solid aerosols was performed and digested samples were then analyzed by atomic absorption spectrophotometer [38]. 50 samples of human blood were randomly collected keeping in view the residential (10), Industrial (20) and commercial (20) areas of Faisalabad. Blood serum from each sample was separated using prescribed procedures. Blood serum samples were subjected to wet digestion using Richard's method [39]. Cadmium (Cd), Chromium (Cr), Copper (Cu), Nickle (Ni), Lead (Pb) and Zinc (Zn) were determined in these digested samples using atomic absorption spectrophotometer (Model No.: Varian AA-1475). Statistical analysis of the data was performed comprising mean, range, standard deviation (S.D) and Coefficient of variation (CV) to check the stability of the data. The correlation of elements present in solid aerosols to that present in human blood was found by taking ratios of CVs of both samples. Pollution load index (PLI) and Concentration factor of each element was calculated to check the trafficking of these heavy metals from solid aerosols to human blood [40]. The results of all the above mentioned parameters are depicted in the relevant tables.

3. RESULTS AND DISCUSSION

In order to determine trace elements in the Faisalabad environment, 50 samples of Atmospheric solid aerosols were randomly collected in Faisalabad city. All the samples were subjected to trace elemental analysis by the AAS techniques for determination of Ca, Cd, Cr, Ni, Pb and Zn in solid aerosols and blood samples. The results obtained are given in the following Tables **1** and **2**.

The present study was carried out to determine trace elements in the Faisalabad environment sucked by or deposited on solid aerosols hanging in the environment to provide guide lines for safe agricultural practice and assessing anthropogenic emissions of trace elements in the environment. 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 aerosols and human blood samples. For this purpose 50

Table 1: Statistical Analysis of Identified Trace Elements in Solid Aerosols

PERMISSIBLE LIMITS					
Cd (ppm)	**Cr (ppm)**	**Ni (ppm)**	**Cu (ppm)**	**Zn (ppm)**	**Pb (ppm)**
0.005	**0.05-0.1**	**0.1**	**1.3**	**5**	**<0.05**
Identified trace element	**Range**		**Mean**	**SD**	**CV**
	Maximum	**Minimum**			
Cd	0.440	0.006	0.223	0.0932	41.79
Cr	1.18	0.028	0.604	0.152	25.131
Ni	0.90	0.003	0.4515	0.134	29.66
Cu	2.12	0.05	1.085	0.2035	18.75
Zn	2.82	0.60	1.71	0.211	12.32
Pb	0.82	0.022	0.421	0.126	30.01

Ref: US, EPA, D/H_2O Standard E.C.A.F.E & UNESCO D/H_2O Standard.

Table 2: Statistical Analysis of Identified Trace Elements in Blood Samples

PERMISSIBLE LIMITS					
Cd (ppm)	**Cr (ppm)**	**Ni (ppm)**	**Cu (ppm)**	**Zn (ppm)**	**Pb (ppm)**
0.01**	**0.02****	**0.006****	**2.00***	**4.8***	**0.40***
Identified trace element	**Range**		**Mean**	**SD**	**CV**
	Maximum	**Minimum**			
Cd	0.005	0.0005	0.00275	0.0095	344.98
Cr	0.0146	0.0002	0.0074	0.017	229.33
Ni	0.0225	0.0025	0.0125	0.02	160.0
Cu	1.69	0.025	.8575	0.182	21.28
Zn	0.544	0.0373	0.2907	0.101	34.63
Pb	0.4705	0.0019	0.2362	0.097	40.99

*[41], ** [42].

samples of solid aerosols and 50 samples of human blood from different selected sites were collected in and around Faisalabad and were analyzed for trace elements like Cd, Cr, Ni, Pb, Cu and Zn. 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) while Cu (3%; Max. value=2.12), Zn (Nil; Max. value=2.82) were within permissible limits over all effect of all these trace elements on the environment is only 22.5 % (Tables **1** and **3**). High concentration of above said elements is due to expanded industrialization, rapid urbanization, and mechanized transportation. They generate 50 % of Co, Pb, Cd, Cr, Ni, Zn etc causing increase in respiratory diseases [43, 44, 45].

Table 3: Comparison between CV of Human Blood Samples and CV of Solid Aerosols Samples

Identified trace element	Ratio = CV_{Blood}/CV_{SA}
Cd	8.255
Cr	9.125
Ni	5.39
Cu	1.135
Zn	2.811
Pb	1.37

The second aspect of this study was to determine the health hazards of trace elements Cadmium (Cd), Chromium (Ch), Copper (Cu), Nickle (Ni), Lead (Pb)

Table 4: Concentration Factor and Pollution Load Index for Huaman Blood with Respect to Solid Aerosols of Identified Trace Elements

Sr. No.	Cd	Cr	Ni	Cu	Zn	Pb
1	36.67	8.33	40	1.20	7.77	0.68
2	100	13.16	240	1.17	2.197	2.05
3	25	20.27	40	1.20	3.257	1.02
4	22	750	240	1.47	5.86	0.99
5	27.5	425	57	0.840	22.06	0.77
6	20	107.14	240	1.29	24.40	0.61
7	36	125	66.67	1.60	1.66	0.32
8	34.29	18.75	28.89	0.90	2.34	0.79
9	110	12.50	1.60	1.20	2.85	0.48
10	30	85	8	1.20	2.48	0.58
11	24	23.81	36	1.16	3.17	0.51
12	66.67	34.48	300	1.24	2.69	0.29
13	48	31.25	300	1.20	2.53	0.15
14	24	23.81	240	1.16	2.97	0.11
15	120	34	360	1.17	3.24	0.14
16	60	41.67	360	1.20	3.04	0.48
17	40	85	320	1.25	2.67	0.36
18	36.67	63.33	228	1.25	4.45	0.57
19	18	316.67	240	1.20	2.77	0.70
20	40	55.56	320	1.25	1.71	0.62
21	110	80	260	1.20	2.15	0.33
22	30	16.39	248	1.158	2.44	0.56
23	25	41.67	320	1.25	2.98	0.45
24	24	491.67	288	1.05	2.78	0.36
25	18	33.33	180	1.16	2.78	0.32
26	28.57	6.03	200	1.20	2.78	0.50
27	20	20.34	308	1.05	2.77	0.19
28	26	17.92	308	1.12	2.76	0.14
29	27.50	30.30	300	1.20	2.77	0.17
30	48	39.58	308	1.20	2.78	0.36
31	27.50	366.67	360	2.80	3.97	0.55
32	1.71	300	2	9.50	3.97	12.63
33	14	140	7.60	16	3.24	0.49
34	2	900	9.20	15.73	3.52	1.54
35	7	66.67	2.80	1.20	2.44	7.29
36	880	6.11	1.20	1	1.59	0.46
37	14	3.17	1.60	1	2.18	0.39
38	14	833.33	2.40	1.12	2.83	6.17
39	2.8	3.42	1.60	0.59	3.05	0.59
40	12	10.83	2.40	1.71	3.69	0.67
41	2.33	83.33	2.40	0.08	8.33	0.14

(Table 4). Continued.

Sr. No.	Cd	Cr	Ni	Cu	Zn	Pb
42	3.5	12.38	1.60	0.10	23.40	0.05
43	2.33	4.08	1.20	0.05	3.45	0.10
44	1.75	9.74	1.20	0.10	4.67	0.13
45	14	22.08	1.20	2.47	2.52	0.07
46	14	4.43	1.20	32.62	2.39	0.23
47	14	8.51	1.20	83.20	1.67	23
48	3.50	11.05	1.20	2.42	3.07	6.80
49	7	2.14	1.20	0.83	3.06	0.99
50	7	4.76	1.20	0.09	5.88	0.20
Pollution Load Index (PLI)	9.64207×10^{33}	1.4×10^{40}	5.82094×10^{37}	12746.70532	8.4128×10^{14}	2.6796×10^{-6}

and Zinc (Zn) towards the occupational health hazards faced by the residents of Industrial, Commercial and Residential areas of Faisalabad environment. The results reveals that most of the blood samples have significantly higher concentrations of Cu (1.69ppm), Zn (0.544ppm), Cr (0.0146 ppm), Ni (0.0225ppm), Cd (0.005ppm) and Pb (0.470ppm) than that of control, while a lower concentration of all the trace elements in the blood samples of residents were detected when compared with their permissible levels in blood (Tables **2** and **3**). The concentration of Cu in blood was 1.35 times more than that of its concentration in solid aerosols, consequently Zn was 2.81 times, Cr was 9.12 times, Ni was 5.34 times, Cd was 8.25 times and Pb was 1.37 times than that of their concentrations in solid aerosols (Table **3**). These results had not only confirmed our previous findings i.e., a positive co-relationship between health hazards and environmental pollution related to Faisalabad environment but also confirmed the complexity of Faisalabad environment i.e., some other factors along with solid aerosols are contributing in the said health hazards [46, 47, 48]. Keeping in view the idea of concentration factor, the PLI was calculated for blood samples and solid aerosols to check either the source of elevated levels of these heavy metals in blood is aerosols or something else. The results showed that PLI for Cd, Cr, Ni, Cu, and Zn is greater than 1 while for Pb it is lower than 1 which confirms the shifting of toxic metals from solid aerosols to human blood through food chain and food web, while in case of lead the reverse behavior is due to the switching of heavy traffic from diesel/petrol to CNG or lead free fuel as shown in Table **4** [40, 49-52]. Slight variations of means, standard deviations and CVs of both solid aerosols and blood samples also showed that heavy metals in solid aerosols are posing serious risks (Tables **1**, **2** and **3**). So, precautionary measures are urgently required to overcome health hazards generated by these heavy metals.

4. CONCLUSIONS

From this study the order of trace metal concentration was noted for Zn>Cu>Cr>Ni>Pb>Cd for solid aerosols samples while Cu>Zn>Pb>Ni>Cr>Cd for blood samples. Pollution load index (PLI) also showed positive corelatioship between solid aerosols and human blood samples for almost all the heavy metals under investigation except Lead (Pb). Statistical analysis of experimental data also supplemented the results concluded by PLI. This state of affairs may be associated with adverse effects to the inhabitants of the Faisalabad city. Thus it is the high time to curb the atmospheric pollution to protect the urban population from hazardous effects of identified potentially toxic pollutants.

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