ISSN: 2348 9510
International Journal Of Core Engineering & Management (IJCEM)
Volume 2, Issue 3, June 2015

Heavy Metal Contamination of Solid Aerosols and its Effects on Local Community in Faisalabad (Pakistan)

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Abstract

The current study is based on emission of heavy metals in the solid aerosols of randomly selected sites related to Faisalabad environment using AAS Technique. The concentration of Cd (54%), Cr (25%), Ni (29%), Pb (24%) ranging from (0.001 to 0.12), (0.001 to 0.24), (0.001 to 0.90), (0.001 to 0.082) with mean values 0.060, 0.120, 0.450, 0.042 respectively were in little excess from (TLvs) while Cu (3 %), Zn (Nil) were within permissible limits. Overall effect of all these heavy metals on the environment is only 22.5 %. While the concentration of heavy metals in human blood samples were found to be Zn (19.78%), Cu (61.45%) ranging from (0.0373 to 0.544), (0.025 to 1.69) with mean values 0.2907 and 0.8575 respectively were in little excess from (TLVs) while Cd (.182%), Cr (0.604%), Ni (0.82%), Pb (17.09%) ranging from (0.0005 to 0.005), (0.0002 to 0.0166), (0.0025 to 0.0225) and (0.0019 to 0.470) with mean values 0.0084, 0.0125, 0.2362 and 0.2907 were found to be within permissible values having 23.11% overall effect on the environment which shows the reverse behavior of the results as compared with solid aerosols. The contribution of different kinds of industries is the major source of emission of these heavy metals in the Faisalabad environment and hence affecting the health of workers and residents of the concerned areas. 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 while Pb was the only element found in blood from some other sources except 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.

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International Journal Of Core Engineering & Management (IJCEM)
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Keywords*: Heavy metal air contamination, positive co-relationship with human blood, concentration factor and pollution load index, hazardous effects on human health, additional contributing factors, protective measures suggested.*

I. 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 (Othmer, 1978). Any substance which is present in nature in greater quantity than natural abundance due to human activity ultimately has detrimental effects on environment and therefore on living organisms is called Pollutants 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 sources like coal related sources. High temperature industrial process release coarse fractions of Ng, Ca, Ni, Mn, Cu and Zn. Automobile exhaust and fertilizer industries also release these metals, their compounds, or other salts (Borbely–Kiss et al., 1999; Pakkanen et al., 2001) (Harrison et al., 1997; Hien et al.,2001; Arditsoglou and Samara, 2005; Valavanidis et al., 2006) (Jenq, 1992).The urban population is exposed to the aerosol toxic metals that often are well above natural background(Hadad et al., 2003; Salam et al., 2003; Samura et al., 2003; Zereini et al., 2005; Shridhar et al., 2010). 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(Freitas et al., 2010; Garcia et al., 2011) (Sohrabpour et al., 1999; Bilos et al., 2001; Rizzio et al., 2001; Wang et al., 2001; Ragosta et al., 2002; Quiterio et al., 2004; Gupta et al., 2007; Hao et al., 2007; Ayrault et al., 2010).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 and Copper and Carcinogenic calcium causes slowing of heart rate, leukemia,and different types of cancer (Hayes, 1997; Drasch et al., 2005; Stayner et al., 1993; Fanning, 1988; Selevan et al., 1996; Schrauzer, 2006; Singh and Garg, 1998). Cobalt and Manganese cause chronic and acute poisoning which results in Anemia and Hypertension (Hammond, 1980).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 (Andersen et al., 2006; Sarnat et al., 2006; Liu et al., 2009; Mavroidis and Chaloulakou, 2010). The present study was undertaken in order to assess the concentration of heavy metals in the atmosphere and in the blood samples of people living in the specially selected areas of Faisalabad, the third largest industrial city and Manchester of Pakistan. This effort is the continuation of our previous project on this issue already presented and published elsewhere.

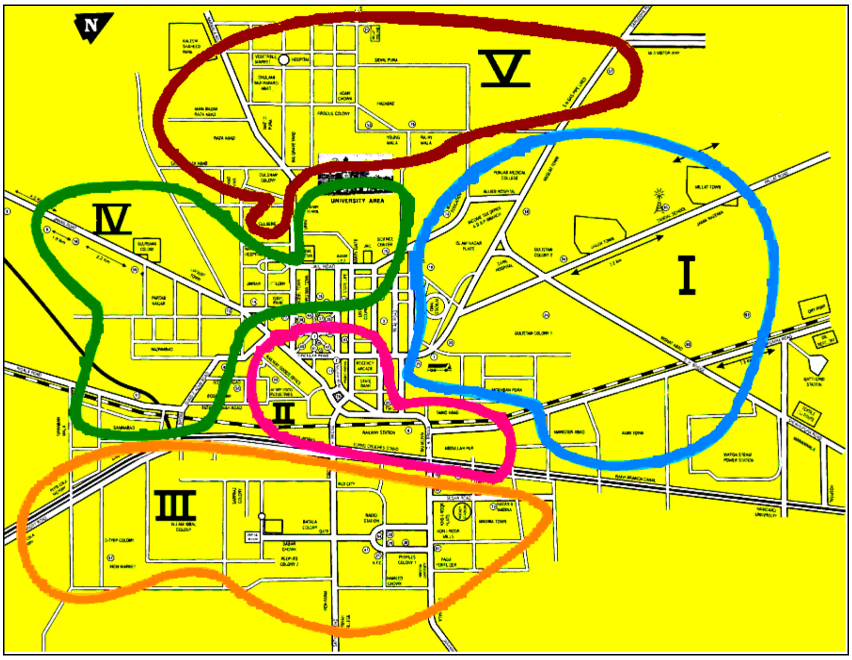

Fig 1: Site selection for Faisalabad City

II. Materials and Methods

The research project was carried out to estimate the heavy metals like Cd, Cr, Ni, Zn, Cu, and Pb in the atmosphere of various areas of Faisalabad city. 50 sites were randomly selected for analysis covering industrial, transportational, 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 (Anil, 1994). Then using oxidizing acid mixture wet digestion of solid aerosols was performed and digested samples were then analyzed by atomic absorption spectrophotometer (Hitachi 2-8200) (Perry and Young, 1997). 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 (Kolmer et al., 1959). 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 are 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.

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III. Results and Discussion

Table-1: Concentration of Heavy metals Detected in Solid Aerosols Samples

Code	Cd(PPm)	Cr (PPm)	Ni(PPm)	Cu(PPm)	Zn(PPm)	Pb(PPm)
2K01	0.11	0.10	0.60	0.09	2.82	0.04
2K02	0.10	0.10	0.60	0.07	0.72	0.25
2K03	0.10	0.15	0.50	0.09	1.01	0.050
2K04	0.11	0.15	0.60	0.11	1.91	0.080
2K05	0.11	0.17	0.57	0.08	0.86	0.09
2K06	0.10	0.15	0.60	0.09	0.91	0.08
2K07	0.09	0.15	0.50	0.12	0.85	0.04
2K08	0.12	0.15	0.65	0.09	1.04	0.05
2K09	0.11	0.15	0.02	0.09	1.42	0.06
2K10	0.12	0.17	0.08	0.09	1.24	0.04
2K11	0.12	0.10	0.72	0.11	1.38	0.07
2K12	0.10	0.20	0.75	0.13	1.39	0.05
2K13	0.12	0.15	0.75	0.09	1.20	0.026
2K14	0.12	0.10	0.60	0.11	1.44	0.024
2K15	0.12	0.17	0.90	0.07	1.32	0.025
2K16	0.12	0.20	0.90	0.09	1.35	0.068
2K17	0.12	0.17	0.80	0.05	1.13	0.051
2K18	0.11	0.19	0.57	0.05	1.23	0.051
2K19	0.09	0.19	0.60	0.09	1.17	0.049
2K20	0.08	0.20	0.80	0.10	0.77	0.068
2K21	0.11	0.16	0.65	0.12	1.17	0.05
2K22	0.09	0.20	0.62	0.11	1.25	0.07
2K23	0.10	0.10	0.80	0.10	1.51	0.06
2K24	0.12	1.18	0.72	0.10	1.42	0.058
2K25	0.09	0.16	0.45	0.11	1.40	0.049
2K26	0.10	0.10	0.50	0.09	1.23	0.049
2K27	0.10	0.24	0.77	0.10	1.20	0.024
2K28	0.13	0.19	0.77	0.09	1.36	0.023
2K29	0.11	0.20	0.75	0.09	1.21	0.025
2K30	0.12	0.19	0.77	0.12	1.21	0.038
2K31	0.11	0.22	0.90	0.21	1.42	0.034
2K32	0.006	0.06	0.01	0.57	1.42	0.024

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2K33	0.007	0.028	0.019	1.28	1.40	0.076
2K34	0.006	0.18	0.023	1.18	0.95	0.25
2K35	0.007	0.08	0.007	0.09	0.97	0.82
2K36	0.440	0.033	0.006	0.07	0.60	0.052
2K37	0.007	0.040	0.004	0.10	0.99	0.049
2K38	0.007	0.50	0.006	0.09	0.99	0.037
2K39	0.007	0.050	0.004	0.08	0.99	0.048
2K40	0.006	0.078	0.006	0.12	1.20	0.059
2K41	0.007	0.100	0.006	0.10	0.75	0.058
2K42	0.007	0.052	0.004	0.17	1.10	0.022
2K43	0.007	0.049	0.003	0.08	1.05	0.032
2K44	0.007	0.076	0.003	0.09	1.26	0.048
2K45	0.007	0.053	0.003	1.62	0.97	0.024
2K46	0.007	0.062	0.003	2.12	0.90	0.074
2K47	0.007	0.080	0.003	2.08	0.75	0.069
2K48	0.007	0.042	0.003	1.09	1.05	0.034
2K49	0.007	0.033	0.003	0.84	1.07	0.060
2K50	0.007	0.040	0.003	0.08	1.25	0.062
PERMISSIBLE LIMITS						
0.005		0.05-0.1	0.1	1.3	5	<0.05

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

Table-2: Concentration of Heavy metals Detected in Blood Samples

Code	Cd(PPm)	Cr (PPm)	Ni(PPm)	Cu(PPm)	Zn(PPm)	Pb(PPm)
2K01	0.003	0.012	0.015	0.075	0.363	0.0585
2K02	0.001	0.0076	0.0025	0.06	0.3285	0.122
2K03	0.004	0.0074	0.0125	0.075	0.3105	0.049
2K04	0.005	0.0002	0.0025	0.075	0.326	0.0805
2K05	0.004	0.0004	0.01	0.095	0.039	0.1185
2K06	0.005	0.0014	0.0025	0.07	0.0373	0.133
2K07	0.0025	0.0012	0.0075	0.075	0.5115	0.1255
2K08	0.0035	0.008	0.0225	0.1	0.445	0.063
2K09	0.001	0.012	0.0125	0.075	0.4975	0.1285
2K10	0.004	0.002	0.01	0.075	0.5005	0.0695

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2K11	0.005	0.0042	0.02	0.095	0.435	0.1385
2K12	0.0015	0.0058	0.0025	0.105	0.5165	0.1815
2K13	0.0025	0.0048	0.0025	0.075	0.474	0.1921
2K14	0.005	0.0042	0.0025	0.095	0.4855	0.216
2K15	0.001	0.005	0.0025	0.06	0.4075	0.1835
2K16	0.002	0.0048	0.0025	0.075	0.444	0.1425
2K17	0.003	0.002	0.0025	0.04	0.4225	0.1415
2K18	0.003	0.003	0.0025	0.04	0.2765	0.0895
2K19	0.005	0.0006	0.0025	0.075	0.4225	0.0695
2K20	0.002	0.0036	0.0025	0.08	0.4495	0.1095
2K21	0.001	0.002	0.0025	0.1	0.544	0.1505
2K22	0.003	0.0122	0.0025	0.095	0.5125	0.1245
2K23	0.004	0.0024	0.0025	0.08	0.5075	0.132
2K24	0.005	0.0024	0.0025	0.095	0.511	0.1625
2K25	0.005	0.0048	0.0025	0.095	0.504	0.1545
2K26	0.0035	0.0166	0.0025	0.075	0.4425	0.097
2K27	0.005	0.0118	0.0025	0.095	0.4335	0.126
2K28	0.005	0.0106	0.0025	0.08	0.4925	0.163
2K29	0.004	0.0066	0.0025	0.075	0.4365	0.15
2K30	0.0025	0.0048	0.0025	0.1	0.4355	0.106
2K31	0.004	0.0006	0.0025	0.075	0.358	0.062
2K32	0.0035	0.0002	0.005	0.06	0.358	0.0019
2K33	0.0005	0.0002	0.0025	0.08	0.432	0.1545
2K34	0.003	0.0002	0.0025	0.075	0.2695	0.162
2K35	0.001	0.0012	0.0025	0.075	0.3975	0.1125
2K36	0.0005	0.0054	0.005	0.07	0.377	0.1125
2K37	0.0005	0.0126	0.0025	0.1	0.4545	0.1265
2K38	0.0005	0.0006	0.0025	0.08	0.3495	0.006
2K39	0.0025	0.0146	0.0025	0.135	0.325	0.0815
2K40	0.0005	0.0072	0.0025	0.07	0.325	0.0885
2K41	0.003	0.0012	0.0025	1.285	0.09	0.403
2K42	0.002	0.0042	0.0025	1.69	0.047	0.4705
2K43	0.003	0.012	0.0025	1.66	0.3045	0.3275
2K44	0.004	0.0078	0.0025	0.865	0.27	0.376
2K45	0.0005	0.0024	0.0025	0.655	0.385	0.356
2K46	0.0005	0.014	0.0025	0.065	0.378	0.317

2K47	0.0005	0.0094	0.0025	0.025	0.45	0.003
2K48	0.002	0.0038	0.0025	0.45	0.342	0.005
2K49	0.001	0.0154	0.0025	1.015	0.3495	0.0605
2K50	0.001	0.0084	0.0025	0.935	0.2125	0.3095
PERMISSIBLE LIMITS						
0.01**		0.02**	0.006**	2.00*	4.8*	0.40*

*(Harper et al., 1977)
** (Vercruysse, 1984)

Table-3: Statistical Analysis of Identified Elements in Solid Aerosols

Phase	Maximum	Minimum	Mean	SD	CV
	Range				
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

Table-4: Statistical Analysis of Identified Elements in Blood Samples

Phase	Maximum	Minimum	Mean	SD	CV
	Range				
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

Table-5: Comparison B/W CV of Human Blood Samples and CV of Solid Aerosols Samples

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

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International Journal Of Core Engineering & Management (IJCEM)
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Table-6: Concentration Factor and Pollution Load Index for Human Blood with respect to Solid Aerosols

Sr. No.	Concentration Factor Cd	Concentration Factor Cr	Concentration Factor Ni	Concentration Factor Cu	Concentration Factor Zn	Concentration Factor 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

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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
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)	9.64207E+33	1.4E+40	5.82094E+37	12746.70532	8.4128E+14	2.6796E-06

The present study was carried out to determine heavy metals in the Faisalabad environment sucked by or deposited on solid aerosols hanging in the environment, providing guide lines for safe agricultural practice and assessing anthropogenic emissions of heavy metals into the natural environment. The major purpose of the present study is to provide basic knowledge about atmospheric constituents of heavy metals 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 samples of solid aerosols and 50 samples of human blood from different selected sites were collected in and around Faisalabad and were analyzed for heavy metals 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 presence of industrial, transportational, municipal and hospital wastes.

Heavy metals were detected by AAS, and it was seen that percentage of Cd (54 %), Cr (25 %), Ni (29 %), Pb (24 %) ranging from (0.001 to 0.12), (0.001 to 0.24), (0.001 to 0.90), (0.001 to 0.082) with mean values 0.060, 0.120, 0.450, 0.042 respectively were in little excess from (TLvs) while Cu (3 %), Zn (Nil) were within_permissible limits overall effect of all these heavy metals on the environment is only 22.5 % (Table 1 & Table 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 (Cholak, 1989; Facchini, 1980; Muthusubramanian and Deborrah, 1989).

The study was conducted to determine the health hazards of heavy metals Cadmium (Cd), Chromium (Ch), Copper (Cu), Nickle (Ni), Lead (Pb) and Zinc (Zn) towards the occupational health hazards faced by the residents of Industrial, Commercial and Residential areas of Faisalabad environment. AAS of most of the blood samples showed significantly higher concentrations of Cu (1.69ppm), Zn (0.544ppm), Cr (0.0166 ppm), Ni (0.0225ppm), Cd (0.005ppm) and Pb (0.470ppm) than that of control, while a lower concentration of all the heavy metals in the blood samples of residents were detected when compared with their permissible levels in blood (Table 2 & Table 4). 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 5). 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 (Bowen, 1979; Nawaz, 2000; Snedden, 1985). Keeping in view the idea of concentration factor, the pollution load index (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 6 (Daud et al., 2007; Harrison and Struges, 1983; Waheed et al., 2001). 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 (Table 3, 4 &5). For the confirmation of our experimental findings questionnaire survey, data was collected from different hospitals along using 7 point through and the results were co-related. The questionnaire survey showed that the percentage of effectives suffering from cardiac diseases was 16 %, ENT diseases 50 %, blood pressure 60%, pulmonary diseases 58%, eye imitation 60 % and headache 70 % during the period 2013-14. The data collected from different hospitals in and around Faisalabad (public & private both) during the said period for different cases registered gave the following distribution cardiac diseases 2 %, ENT 8 %, blood pressure 22 %, eye imitation 25 %, chest diseases 3 % and headache 15 % respectively. Furthermore to know the view of the people about air quality of Faisalabad 7 point scale was used in which 05 % people did not know about the air quality because of their busy life, 40 % said the air quality is fair means not very good and not very bad, 30 % claimed that air quality was poor and 10 % said very poor. The positive view about air quality like good and very good is only 15 %. The sources of the heavy metals were found to be both mobile and stationary including rusted vehicles, construction projects, rusted bridges and fences along with the roads, metal based industry, auto workshops, printing presses, metal made utensil shops and metal polishing shops and broken and flooded sewerage system, petrol vehicles, auto workshops etc

(Ashfaque, 2000; EPA Air Quality Index, 2009; Mark, 2005; Peace and Owen, 2004; Zeka and Aznobetti, 2005).

IV. Important Conclusions and Future Recommendations

Briefly speaking the present study revealed that among the selected trace metals higher concentration was noted for Zn>Cu>Cr>Ni>Pb>Cd for solid aerosols samples while Cu >Zn>Pb>Ni>Cr>Cd in blood samples. PLI also showed positive co-relationship 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. The findings of this study will be useful for policy makers, city managers and environmentalists as monitoring of solid aerosol's and human blood's heavy metal contents are regarded as an essential component for the air quality assessment, ensure the safeguard for human health and guaranteed sustainable development of the rural/urban geophysical, geochemical and geological environment of Faisalabad. Our experimental findings can provide and essential background for the future work to be undertaken by researches of various disciplines. On behalf of this study it is strongly recommended that the future research activities of this kind would be to control on larger geographical areas and shall encompass on more solid aerosols and large number of inhabitants residing in those areas. Therefore it is recommended for the rural/urban planners to design the further transportational cum industrial expansion in out skirts of the city in order to minimize the risk factor. It is further suggested for academicians that number of metals to be analyzed for pollution assessment for solid aerosols and human blood should be large in numbers and types. The present status of air quality and human health requires an immediate action to overcome this critical issue in an industrial city of Pakistan. The implementation of air quality standards and human health guidelines, establishment of continuous monitoring systems, and the up gradation of emission control technologies and strategies are essential.

Acknowledgements

The authors are highly obliged to acknowledge the services of Director NIBGE and PINUM along with their technical teams for providing us Lab facilities, technical assistance when and where needed, their valuable suggestions, in time encouragements, healthy discussions and positive criticism in getting this work completed with utmost ease and perfection.

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ISSN: 2348 9510
International Journal Of Core Engineering & Management (IJCEM)
Volume 2, Issue 3, June 2015

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