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Full Length Research Paper

Effects of organic compounds with the concentration of heavy metals on the atmosphere of Faisalabad

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Faisalabad is the biggest industrial city with huge air quality problems, being one of the most polluted cities in the world. Although public policies have been developed to minimize atmospheric aerosol pollution, there is lack of adequate knowledge and poor characterization of these aerosols. In this study, 18 (15+2+1) aerosol samples were sampled from different pools covering almost all the aspects of Faisalabad environment. The aerosol samples were collected using air volume sampler on Watmann filter paper for the period of 24 h per day. The results obtained from an investigation of solid aerosols in the industrial city of Faisalabad (Pakistan) are reported and analysed in this paper. X-ray diffraction studies of the various solid aerosols pools (residential, industrial, transportational, commercial and mix pools) showed that non-clay organic compounds such as GB-Naphthylbismuthdioxide, Sodiumhippurate, Sodium-GA-naphthylamine-4-sulfonate tetrahydrate, Potassium phenoxide, Bismuth salicylate, Cadmium salicylate hydrate and Bariumphenolsulfonate are contained in most of the samples in almost comparable amounts. The results of solid aerosols collected from various pools showed that the sources of identified phases in the solid aerosols are both local and remote. The maximum elemental constituents and concentration for Zn, Cu, Cr, Ni, Pb, Mg and Cd in ppm using AAS technique were found to be Cadmium Cd(1) having weight percentage of 15.215%, Chromium Cr(2) having weight percentage of 0.093%, Nickel Ni(3) having weight percentage of 4.192%, Lead Pb(4) having weight percentage of 5.301%, Zinc Zn(5) having weight percentage of 14.663%, Magnesium Mg(6) having weight percentage of 8.154% and Calcium Ca(7) having weight percentage of 52.382% 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 different pools under investigations. Furthermore, the health hazards due to identified trace metals were also investigated and were found that the metals were highly toxic and generating serious health hazards.

Key words: Solid aerosol, atmospheric pollution, Bismuth salicylate, potassium phenoxide, Sodium-GA-naphthylamine-4-sulfonate tetrahydrate and Cadmium salicylate hydrate as major pollutants, remote and local origin, co-relationship, health hazards, predicted equations, sociological survey, protective measures.

INTRODUCTION

Solid aerosols play an important role in the earth‟s climate system and in the bio chemical cycles. They may affect the earth radiation balance by scattering and geo absorbing solar and terrestrial radiation, they may modify the cloud properties by occurring as cloud condensation nuclei and may influence the atmospheric chemistry by providing media for heterogeneous reactions and by serving as carriers for the chemical species. The comprehensive analysis of solid aerosols can be assessed only on the basis of adequate data collected at properly selected sampling stations, using well defined sampling procedures along with analytical techniques. It is preferable to conduct both physiochemical and

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biological monitoring and correlate their results to evaluate an integrated approach for air pollution control. Keeping in view these facts, it was imperative to study the physiochemical composition of solid aerosols collected from Faisalabad environment so as to ascertain their contributions to the overall pollution in Faisalabad. It is the third largest industrial city in Pakistan, with an estimated population of almost 4 million citizens. It is an important center for industrial production and is located in the Punjab Province. The district lies between East longitudes 73° and 74°, and North latitudes 30° and 31.15°. Gujranwala and Sheikhupura districts bound it in its North. The district is a flat alluvial plain formed by Chenab and Ravi rivers. The Ravi River flows along the South-Eastern boundary of the district. The land close to the river is relatively much fertile than that away from it. The area is exceptionally favorable for canal irrigation. There is no interruption in the monotony of the plain and the lands fall to only 55 m from North-East to the South-West of the district. A general elevation of the land comprising Faisalabad district is about 150 m above the sea level. The climate of the district is hot and dry. Its mean maximum and minimum temperatures in summer are about 39 and 27°C and in winter, they are about 21 and 6°C respectively. Its summer season starts almost from the end of March and stretches up to October. May, June and July are the hottest months. The winter months are November, December and January, of which December and January are the coldest months. The rainy season is from July to September, though July and August receive more rains than any other months of the year. Most of the winter rain falls in the months of January, February and March. The mean minimum humidity in winter ranges from 46.9% in March to 54.5% in December, while the mean maximum humidity in summer ranges from 57% in May to 79.5% in August. The mean maximum humidity in the rainy season is 77.7% and the mean minimum humidity in the rainy season is 59.9% (Source: Meteorological Cell Department of Crop Physiology U.A.F., 2005). Faisalabad district has made rapid strides in the field of industry after independence. It is now called "the Manchester of Asia" for its extensive development of the textile industry. The development has been made possible by the continued efforts of pioneering entrepreneurs as well as workers over a period of four decades. Before independence of Pakistan, there were only five industrial units in Faisalabad (formerly called Lyallpur). Now, there are dozens of textile mills with other subsidiary units which show the complexity and heterogeneity of the Faisalabad environment due to industrial revolution on behalf of which Faisalabad city is called the Manchester of Asia.

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 of by natural recycling process due to their excessive quantity or unique chemical composition (Adedokun et al., 1989). Any substance which is present in nature beyond permissible limits and which has detrimental effects not only on the environment but also on living organisms is called „pollutant‟, for example: Cd, Cr, Pb, Zn, Cu, Ni, Ca, 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 (Andersen et al., 2006; Ando and Tamara, 1991; Anil, 1994; Arditsoglou and Samara, 2005; Asrar, 1996; Ayrault et al., 2010; Bennett et al., 1985). The urban population is exposed to the aerosol toxic metals that often are well above natural background (Bilos et al., 2001; Bonita et al., 2006; Borbely et al., 1999; Bowen, 1979; Brunekreef and Holgate, 2002). Many studies on atmospheric trace metal concentration pollution and associated health hazard showed diverse fluctuations and disparities among the trace element constituents (Catherine and Skinner, 2007; Cholak, 1989; Davis, 1984; De-Koning et al., 1986; Drasch et al., 2005; Entwistle and Robert, 1973; Facchini, 1980; Fanning, 1988; Freitas et al., 2010; Fukasawa et al., 1983). All these trace metals produce different health hazards like oxides of Zinc along with oxides of Iron which 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 (Garcia et al., 2011; Gilfrich and Briks, 1983; Gupta et al., 2007; Hadad et al., 2003; Hammond et al., 2007; Hao et al., 2007; Harrison and Struges, 1983). Cobalt and Manganese cause chronic and acute poisoning which results in anemia and hypertension (Harrison, 1997). When these chemicals mix with the atmosphere, they enter into the human chain and cause death in some cases. Due to the lack of air quality management system, 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. Besides health hazards, trace metal pollution reduce visibility, plays an important role in acidic rain, adversely affects the radiation budget and consequently disturbs a variety of environmental processes which 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. Solid aerosols are solid or liquid particles suspended in air. Processes that control formation, transformation and the removal of atmospheric aerosols are of great interest in atmospheric science. The reason is that these particles, which are often smaller than 1 µm in diameter, play an important part in the earth‟s radiation budget through the scattering of sunlight and interaction with the clouds. Human activities, such as burning of fossil fuels and land use, change the physico-chemical properties of the solid aerosols and may therefore disturb the climate. This can be either directly through an increase in aerosols or indirectly through cloud formation disturbance of heterogeneous reactions on the aerosol particle surfaces that influence the gas phase composition and chemistry of the atmosphere, which is responsible for health hazards through inhalation. To determine the role of aerosols in our environment and the influence it has as a result of anthropogenic emissions, there is need to have an understanding of the life cycle and transport patterns of solid aerosol particles, their physico-chemical composition as well as a current knowledge of cloud formation and nucleation mechanisms which depend on the properties of the pre-existing aerosols (Hayes, 1997; Hien et al., 2001; Hoffmann et al., 2007; Holguin et al., 2007).

By definition, trace elements are chemical components that naturally occur in soil, plant and wild life in minute concentrations, also known as trace minerals. They are necessary for the optimal development and metabolic functioning of all living things. For human beings, proper cell metabolism effective immune function and healthy reproduction are dependent on a total of 72 of these elements. Since they provide nutritional value, they are sometime referred to as micronutrients. The health giving properties of trace metals vary greatly and some are not even understood yet for instance Cr is inversed in the regulation of metabolism of glucose and lipid fats and is also thought to be an aid to weight loss since it promotes the processing of fat for energy rather than its several trace elements which are essential storage for the production hormone regulation and neurotransmission in brain. But when the amount of trace metals becomes greater than permissible limit, they become toxic and generate health hazards.

Trace elements entry in the system is facilitated by transport protein or diffusion. At the topical level, there is increased production of H_2O_2 by direct action on NADPH oxidization; at the systemic level, there is disruption of phospholipids bilayer due to lipid per oxidation, leading top reduction of ROS inducing synergistic action of SOD, CAT, and APx and increasing H_2O_2 levels especially by SOD. Meanwhile excess metals enter cellular organelles like mitochondria and chloroplasts (plants), and act as a sink in the electron flow or misdirect the electron flow (depending on the redox status of the metal), which causes production of free radicals. Free radicals, in turn, initiate the antioxidant systems (Halliwel Asada Pathway) to quench H_2O_2. Unquenched H_2O_2 in addition to other free radicals gives rise to singlet oxygen. In addition, receptor metal complex in the plasma membrane causes excess calcium ion concentration which initiates the cal-modulin-Ca^{2+} system activating various kinases. These reactive molecules and kinases act as signals on the transcription factors present in the nuclear as well as the organelle DNA, leading to the production of stress protein and secondary metabolites that can act as either damage causing agents or stress causing agents.

The present study was conducted in order to assess organic compounds present in the atmosphere along with the concentration of heavy metals in the atmosphere of Faisalabad and their effect on the environment. For the confirmation of interactive relationship between solid aerosols and the environment, a co-relationship was also established. These results were also compared with other similar studies quoted in national and international journals having impact factors. It is hoped that this study will be very useful towards the future environmental study programs related to industrial cum commercial areas like Faisalabad. This effort is the continuation of the authors" Ph.D project on this issue already presented and published elsewhere. This study though not supported by sufficient data, also indicated that Faisalabad in Pakistan is emerging as a highly polluted city (Hussain, 1995; Jenq, 1992; Liu et al., 2009; Mavroidis and Chaloulakou, 2010).

MATERIALS AND METHODS

Pool classification

The city was divided into five pools: Pool-I (Residential), Pool-II (Industrial), Pool-III (Commercial), Pool-IV (Transportation) and Pool-V (Complex and Mix), among which Pool-IV and Pool-V are true representatives of the total environment of Faisalabad. Most of the pools under consideration belong to the city center, while the remaining pools were situated at (10-15) km away from the city center (Figures 1 and 2). A total of 18 solid aerosols (suspended particulate matter) samples were collected from different pools of Faisalabad city using Syntax Map Method and after sample collections, samples were mixed as total environment sample and special samples I,II and III respectively.

Sample collection

High volume air sampler was used for the collection of atmospheric solid aerosols from the randomly selected pools of Faisalabad city. The high volume air sampler was used to pump large volumes of air up to 2000 m^3 at a rate of 0.8 m^3/min on glass fiber filter with a collection efficiency of 99% for solid aerosols. Samples were collected for a period of 12 h (720 min) at an average flow rate of 0.8 m^3/min. Solid aerosols were trapped on each filter. Triplicate samples were collected from each site. The suspended particulate matter (solid aerosols) collected from randomly selected sites was strained in order to remove fibrous material. Samples were kept in bottles as such and were passed through two sieves for getting two parts of each sample having particle size less

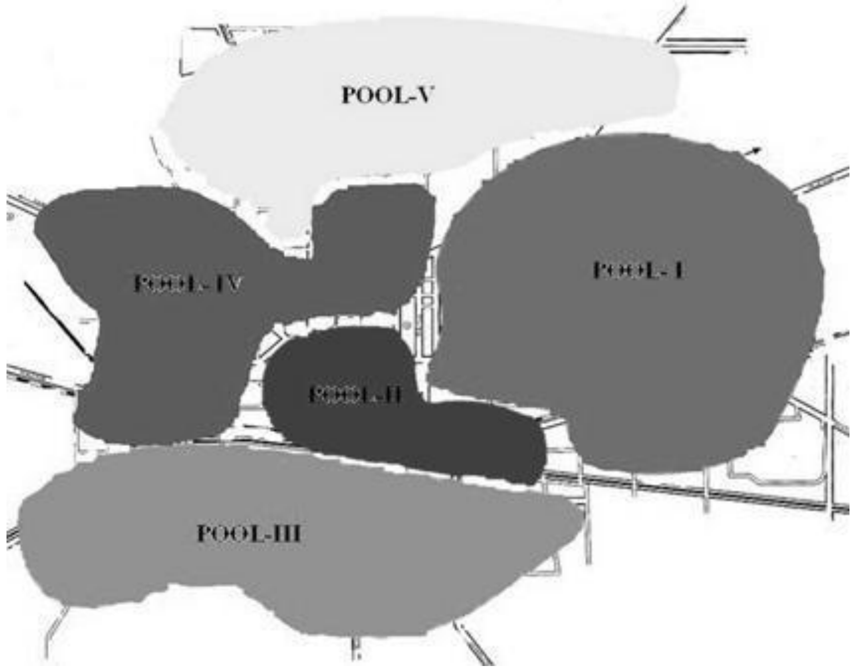

Figure 1. Pool classification for Faisalabad City.

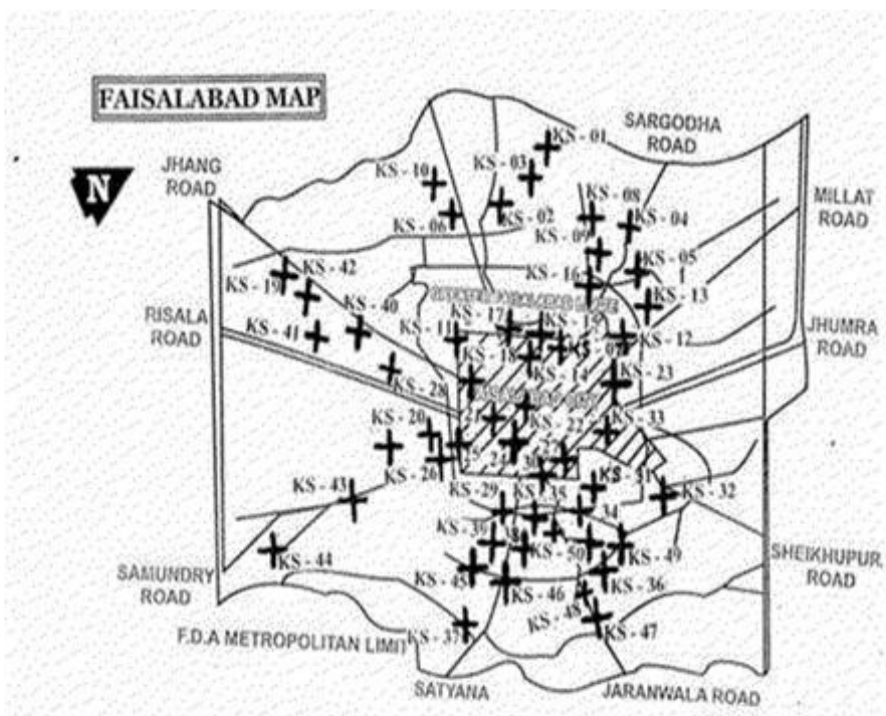

Figure 2. Site selection for Faisalabad City.

than 53 µm and less than 75 µm. All the samples were pressed gently into aluminum/glass holders before loading each of them on XRPD goniometer. Statistical analysis was carried out using t-Test and results were presented at the relevant places. Air condition filters, bucket, dish and sticky tape methods were also used as

Table 1. Diffractometer conditions used for analysis.

Parameter used	Setting value
X-radiation	Cuk_{α} (NI-Filtered)
X-ray tube voltage and current	35 KV & 20 m A
Divergent and anti-scatter slits	1°
Receiving slit	0.13 *mm*& 0.3 mm
Goniometer scanning speed/step width	1°min^{-1}/0.02°
Rate meter time constant	1 sec.
Detector	Scintillation counter
Start angle	65° (2Ɵ)
Stop angle	3° (2Ɵ)

an additional help for sample collection.

Phase/compound analysis

Phase/compound analysis of the solid aerosols were carried out by employing an automated powder X-ray diffractometer (Rigaku model D/MAX-II A) which is equip-ped with a scintillation counter and a pulse-height analyser. The electronic circuit panel of the diffractometer is capable of computing Bragg angles (2θ), d-spacing and peak height and peak width at half-maximum intensity.

In the powder X-ray diffraction method, a very fine powder having particle/crystallite size of less than 10 µm is placed in a monochromatic X-ray beam. Each crystallite of the powder is a tiny single crystal, oriented randomly with respect to the incident X-ray beam. Just by chance, some of the crystallites will be correctly oriented so that their similar lattice planes can reflect the incident beam. Other crystallites will be correctly oriented for reflections from another set of lattice planes and so on.

The result is that every set of lattice planes will be capable of reflection. The powder X-ray diffractometer gives reflections from all the possible sets of lattice planes of a crystallographic material. The set of reflections so obtained, called diffraction, pattern a plot between the Bragg angles and the integrated intensities of the corresponding reflections which is a characteristic of the material. The phases/compounds present in a sample could therefore be identified from their characteristic X-ray diffraction patterns.

The X-ray diffraction results reported in this study were obtained by running the diffractometer in the step-scan mode with the diffractometer conditions (Table 1). The diffraction data (Bragg angles, d-spacing, and integrated intensities) were obtained with the step size of 0.02° (2θ). The quality of the pattern was found to decrease with the step size of larger or less than 0.02°. The peak positions (2θ angles) and d-spacing obtained with the step size of 0.02° were found to have the best accuracy.

The peak intensity, peak width at half maxima, d-values and Bragg angles were also noted using XRD x~y plotter during the step-scan mode. The relative intensities values were calculated for the above materials and presented. In this study, an attempt was also made to estimate the trace elements like Cd, Cr, Ni, Zn, Cu, Mg and Pb in the atmosphere comprising various pools of Faisalabad city. 50 sites were randomly selected from which 18 (15+2+1) samples were collected 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 h 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 (McConnell et al., 1999), after which they were analyzed by atomic absorption spectrophotometer (Model No. Varian AA-1475) and measured in ppm, using standard prescribed method as given in the literature.

RESULTS AND DISCUSSION

Phase analysis of solid aerosols by XRPD

In this study, maximum of 18 (15+2+1) samples were collected from different pools of Faisalabad. These samples were collected by air volume sampler for the study of phase analysis of solid aerosols using XRPD technique.

All the given SPM samples were strained to remove fibrous material and were loaded one by one on the Diffractometer Goniometer. For each and every sample, the running process of Diffractometer conditions was kept exactly the same. The Diffactometer was run all the time in the continuous mode. XRD patterns were obtained on scaled charts with abscissa for 2θ (degrees) and ordinate for counts per second. The given XRD data indicate peaks containing: Bragg‟s angle (2θ), FWHM (full wave half maximum), d-value, maximum intensity and relative intensity (I/I°). Qualitative phase analysis of all samples

Table 2. Total environment average weight % age of the identified phases.

S/N	Identification of compounds in solid aerosols	Chemical formula	Average intensities	Weight % age
1	GB-Naphthylbismuth dioxide	$C_{10} H_7 Bi O_2$	15.5754	11.870
2	Sodium hippurate	$C_9 H_8 N Na O_3$	15.4708	11.791
3	Sodium-GA-naphthylamine-4-sulfonate tetrahydrate	$C_{10} H_8 N Na O_3 S$ $_4 H_2 O$	22.62	17.238
4	Potassium phenoxide	$C_6 H_5 K O$	33.529	25.552
5	Bismuth salicylate	$C_{21} H_{15} Bi_2 O_9$	26.089	19.882
6	Cadmium salicylate hydrate	$C_{14} H_{10} Cd O_6 H_2 O$	13.7544	10.482
7	Barium phenolsulfonate	$C_{12} H_9 Ba O_7 S_2$	4.18	3.186

Table 3. Identified chemical analysis with integrated intensities for aerosol samples collected from the residential pool of Faisalabad (Special Sample-I).

Peak no.	2θ(degree)	d-value	Integrated intensities (I_i)	Chemical name	Chemical formula	Weight % age
1	8.8751	9.96393	40	GB-Naphthylbismuth dioxide	$C_{10} H_7 Bi O_2$	28.571
2	26.7436	3.33351	100	Sodium hippurate	$C_9 H_8 N Na O_3$	71.429
3	ND	ND	ND	Bismuth salicylate	$C_{21} H_{15} Bi_2 O_9$	ND
4	ND	ND	ND	Cadmium salicylate hydrate	$C_{14} H_{10} Cd O_6 H_2 O$	ND

Table 4. Identified chemical analysis with integrated intensities for aerosol sample collected from complex and commercial pools of Faisalabad (Special Sample-II).

Peak no.	2θ(degree)	d-value	Integrated Intensities (I_i)	Chemical name	Chemical formula	Weight % age
1	8.9922	9.8345	43.3	GB-Naphthylbismuth dioxide	$C_{10} H_7 Bi O_2$	70.315
2	12.6717	6.98588	18.28	Sodium hippurate	$C_9 H_8 N Na O_3$	29.685
3	ND	ND	ND	Potassium phenoxide	$C_6 H_5 K O$	ND
4	ND	ND	ND	Bismuth salicylate	$C_{21} H_{15} Bi_2 O_9$	ND
5	ND	ND	ND	Cadmium salicylate hydrate	$C_{14} H_{10} Cd O_6 H_2 O$	ND

was carried out by Hanawalt method, while quantitative analysis was performed by Matrix Flushing method.

Qualitative phase analysis of the samples showed the presence of organic compounds like GB-Naphthylbismuth dioxide (1), Sodium hippurate (2), Sodium-GA-naphthylamine-4-sulfonate tetrahydrate (3), Potassium phenoxide (4), Bismuth salicylate (5), Cadmium salicylate hydrate (6) and Bariumphenolsulfonate (7). The relevant codes specified in brackets are shown in Table 2 in order to know which region had lighter identified compounds in solid aerosols loadings than the others. The average pool wise phase percentages of compound in aerosols was found to be GB-Naphthylbismuth dioxide (1) having weight percentage of 11.870%, Sodium hippurate (2) having weight percentage of 11.791%, Sodium-GA-naphthylamine-4-sulfonate tetrahydrate (3) having weight percentage of 17.238%, Potassium phenoxide (4) having weight percentage of 25.552%, Bismuth salicylate (5) having weight percentage of 19.882%, Cadmium salicylate hydrate (6) having weight percentage of 10.482%, Barium phenolsulfonate (7) having weight percentage of 3.186% respectively (Table 2). The mixing of residential cum industrial pools and commercial cum complex and mix pools resulted into omission of compound Phases 3, 4 and 5, while mixing of transportational pools resulted to re-appearance of the compounds phases which means that transportation is the main contributor of these phases (Tables 3 to 5). When compared with the total pooled environment, creation of two new compounds like Sodium-$GA-naphthylamine-4-sulfonate tetrahydrate and Barium phenolsulfonate gave astonishing results. From the pool mixing technique, it was concluded that these solid aerosols contributed a lot towards environment pollution of the Faisalabad environment by addition and subtraction of phases and hence modifying the ecosystem

Table 5. Identified chemical analysis with integrated intensities for aerosol sample collected from transportational pool of Faisalabad (Special Sample-III).

Peak no.	2θ (degree)	d-value	Integrated Intensities (I_i)	Chemical Name	Chemical formula	Weight % age
1	9.043	9.77933	10.41	GB-Naphthylbismuth dioxide	$C_{10} H_7 Bi O_2$	6.9105
2	12.6599	6.99236	5.14	Sodium hippurate	$C_9 H_8 N Na O_3$	3.412
3	26.8544	3.32	100	Potassium phenoxide	$C_6 H_5 K O$	66.383
4	27.8558	3.20289	17.61	Bismuth salicylate	$C_{21} H_{15} Bi_2 O_9$	11.690
5	29.6634	3.0117	17.48	Cadmium salicylate hydrate	$C_{14} H_{10} Cd O_6 H_2 O$	11.604

Table 6. Average concentration of identified elements in total environment of Faisalabad.

S/N	Identification of elements in solid aerosols	Concentration (ppm)	Weight % age
1	Cadmium (Cd)	2.23044	15.215
2	Chromium (Cr)	0.01351	0.093
3	Nickel (Ni)	0.61444	4.192
4	Lead (Pb)	0.77712	5.301
5	Zinc (Zn)	2.14951	14.663
6	Magnesium (Mg)	1.19532	8.154
7	Calcium (Ca)	7.67875	52.382

(Muthusubramanian and Deborrah, 1989; Nawaz, 2000; Othmer, 1978; Pakkanen et al., 2001; Quiterio et al., 2004).

Elemental analysis of solid aerosols by atomic absorption spectrophotometery (AAS)

In order to determine trace elements through solid aerosols in the Faisalabad, 18 (15+2+1) samples were collected from various sites in Faisalabad by dividing it into five pools. After this, all the given samples were subjected to trace elemental analysis by the Atomic Absorption Spectrophotometery (AAS) techniques for determination of Ca, Cd, Cr, Ni, Mg, Zn and Pb. The weight percentage concentrations of all the elements according to their pools are plotted against sample codes (Cd), (Cr), (Ni), (Cu), (Mg), (Zn) and (Pb). The weight percentage concentration of trace elements observed in the solid aerosol samples was expressed in the form of bar graph in order to know which region had lighter trace element concentration in solid aerosols loadings than the other. The weight percentage concentration of the identified elements were given in Cadmium Cd(1) having weight percentage of 15.215%, Chromium Cr(2) having weight percentage of 0.093%, Nickel Ni(3) having weight percentage of 4.192%, Lead Pb(4) having weight percentage of 5.301%, Zinc Zn(5) having weight percentage of 14.663%, Magnesium Mg(6) having weight percentage of 8.154% and Calcium Ca(7) having weight percentage of 52.382% respectively as shown in Table 6 (Ragosta et al., 2002; Rizzio et al., 2001; Sahle et al., 1990; Salam et al., 2003; Samura et al., 2003; Sarnat et al., 2006; Schrauzer, 2006; Selevan, 1996; Shahid, 1997).

The phase analysis of all solid aerosol samples showed the presence of organic compounds indicating the occurrence of some compounds grown in the atmosphere through photosynthesis which means that the industry and transport are contributing a lot in the atmosphere. Furthermore, the present study does not indicate any co-relation between the trace elements and the identified phases except opacity which shows semi transparent, semi opaque stack emission of one of the most basic effects of air stack pollution confirmed through Ringleman chart technique. Sociological survey of basic health units, hospitals and private clinics along with predicted equations indicate that the diseases associated to air pollution like ENT, fatigue, heart attack, headache, skin, respiratory tract were aggravated in the local population (Tables 7 and 8).

In some other studies, it was claimed that some other causative factors like traffic density, fuel consumption, noise pollution and heredity were also involved in generating health hazards. Truly speaking, these factors interact with each other in the atmosphere and may not be treated as individual entities rather as part of the ecosystem. Furthermore, the backup strategy followed for health hazards was purely based on WHO standards and was well justified, that is, priority fixation on the basis of magnitude, severity, feasibility, cost effectiveness and political will, assigning the score grades and decision about the cut-off points and then calculating the

Table 7. Predicted regression equation used.

Variable	Equation
ENT	14.6 + 0.0417 Fe -26.3 Ni + 75.53 Cd + 0.07 Zn -2.53Pb
Giddiness	61.4 + 0.0629 Ni +66.0 P +11.4 Ni – 42.7 Cd – 0.210 Zn + 4.66 Pb
Fatigue	-497- 0.0079 Fe + 0.5 P- 5.4 Ni + 1.0 Cd + 0.034 Zn + 0.63 Pb
Gastrointestinal	-19.0 + 0.0001 Fe +1.6 P + 13.3 Ni + 26.6 Cd – 0.067 Zn + 2.88 Pb
Urinary	-6.7 -.0096 Fe – 6.6 P +10.6 Ni – 21.7 C – 0.00 Zn- 6.38 Pb
Cancer	06.64 + 0.0031 Fe+ 1.23 P + 0.337 Ni+ 0.61 Cd – 0.0083 Zn – 0.023 Pb
Heart attack	8.1 – 6.5 N – 0.529 Mn + 10.5 K – 0.0232 Fe – 39.8 P – 8.19 Ni -6.9 Cd + 0.154 Zn + 4.02 Pb
Headache	75.9 + 11.4 Ni – 42.7 Cd – 0.210 Zn + 4.66 Pb
Skin diseases	-17.9 N – 6.5 N + 0.122 Mn + 3.4 K + 0.0848 Fe + 28.1 P + 6.24 Ni + 2.3 Cd – 0.13 Zn + 0.51 PB
Respiratory diseases	-5.5 + 53.8 N + 1.28 Mn – 26.2 K – 0.043 Fe + 52.5 P + 32.1 Ni – 52.6 Cd – 0.163 Zn + 9.5 Pb

Table 8. Average % age of overall health hazards related to Faisalabad environment.

S/N	Diseases	Average % age of health hazards
1	ENT	10.09002
2	Giddiness	33.28468
3	Fatigue	ND
4	Gastrointestinal	ND
5	Urinary	ND
6	Cancer	6.14492
7	Heart attack	6.8685
8	Headache	40.4711
9	Skin diseases	2.73798
10	Respiratory diseases	0.3381

percentages for each disease. Briefly speaking, the modification of the ecosystem through addition and subtraction of organic compound by pool mixing technique is a novel idea for pollution control and its hazardous effects directly coupled with mapping of the area under investigation. If mapping was fit and well justified, then its environment is friendly and healthy, otherwise it is polluted and hazardous. This idea might be used for other researchers and agencies, involving such type of studies, not only in Pakistan but also in other parts of the world.

Conclusions

It is concluded that the solid aerosols samples collected from various pools in Faisalabad contained increasingly organic compounds namely: GB-Naphthylbismuthdioxide, Sodiumhippurate, Sodium-GA-naphthylamine-4-sulfonate tetrahydrate, Potassium phenoxide, Bismuth salicylate, Cadmium salicylate hydrate, and Barium phenol sulfonate along with six toxic metals like Cd, Cr, Ni, Zn, Ca and Mg in different concentrations at different locations as pollution components. Mixing techniques showed addition and subtraction of compound phases and hence modification of the environment, thereby generating relevant health hazards. The sources of these organic compounds are both local and remote (Shahid, 2010; Shahid et al., 2012; Shahida, 2000; Shridhar et al., 2010; Singh and Garg, 1998; Snedden, 1985; Sohrabpour et al., 1999; Stayner et al., 1993; Tossavainen, 1979; Valavanidis et al., 2006; Vercruysse, 1984).

The biotic effects of heavy metals when unduly exposed to them could become potentially life threatening hence cannot be neglected, while these metals are in many ways indispensible. Good precaution and adequate occupational hygiene should be taken in handling them as per recommendations of the concerned area doctors. Although the heavy metals poisoning could be clinically diagnosed and medically treated, the best option is to prevent heavy metal‟s pollution and subsequent human poisoning.

FUTURE PERSPECTIVES

The problem of solid aerosol pollution is a complex problem of air pollution due to complexity and heterogeneity of solid aerosol compositions. They contain different types of salts (mostly ammonium and calcium sulphates, ammonium nitrate, sodium chlorides), organic and elemental carbon (mostly derived from road traffic), biological components (pollen and micro organisms), iron and other metal compounds derived from industrial processes and minerals, and rock fragments derived from the surrounding geological formations. On behalf of this, they can be classified as organic and/or inorganic, primary and/or secondary, natural (biological/geological) and/or anthropogenic. This diversity makes their classification very difficult and their theoretical modeling defective, as relevant to meteorological conditions of the environment. Because of this complexity, characterization of these solid aerosols provides insufficient information about its origins and potential hazards. No doubt the tools used in this study, even if imperfect, still yield valuable information about the Physics and Chemistry of solid aerosols related to the Faisalabad environment. However, the accurate data on physico-chemical compositions, meteorological and geographical set up and their co-relation is needed to obtain insight vision into the cause of medical diseases, global warming trends and nucleation processes in the atmosphere. A package of high resolution technique (XRD, AAS, SEM, TEM, and AFM) is necessary to understand the physics, mineralogy, geology, climatology and chemistry of these solid aerosols (Waheed et al., 2001; Wang et al., 2001; Wolff and Korsog, 1985; Zereini et al., 2005).

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REFERENCES

Adedokun JWO, Emofurieta, Adedeji A (1989). Physical mineralogical and chemical properties of barmattan dust at Illite. J. Theor. Appl. Climatol., 40: 161-169.

Andersen ZJ, Wahlin P, Raaschou-Nielsen O, Scheike TS (2006). Ambient particle source apportionment and daily hospital admissions among children and elderly in Copenhagen. Epidemiology, 17: 200-201.

Ando M, Tamara K (1991). Study of respirable suspended particulate and polycyclic aromatic hydrocarbons in indoor and outdoor air. Toxical. Ind. Health, 7(5-6): 441-448.

Anil KD (1994). Environmental Chemistry, 3rd. Ed. Versa-Bharati University, Wiley Eastern Limited Inc., pp. 150-151.

Arditsoglou A, Samara C (2005). Levels of total suspended particulate matter and major trace elements in Kosovo, A source identification and apportionment study. Chemosphere, 59: 669-678.

Asrar SA (1996). Studies on the Pollutants of the Quetta Valley and Their Metabolic Stress on the Population. Ph. D. Thesis.

Ayrault S, Senhou A, Moskura M, Gaudry A (2010). Atmospheric trace element concentrations in total suspended particles near Paris, France. Atmos. Environ., 44: 3700-3707.

Bennett BG, Kretzschmar JG, Akland GG, de-Koning HW (1985). Urban air pollution world wide", Environ. Sci. Technol., 19: 298-304.

Bilos C, Colombo JC, Skorupka CN, Presa MJR (2001). Sources, distribution and variability of airborne trace metals in La Plata city area, Argentina. Environ. Pol. 111: 49-158.

Bonita R, Beaglehole R, Kjellstrom W **(**2006).Basic Epidemiology. Ed. 2nd.World Health OrganisationISBN 92 4 154707 3 (NLMclassification: WA 105).

Borbely KI, Koltay E, Szabo GY, Bozo L, Tar K (1999). Composition and sources of urban and rural atmospheric aerosol in eastern Hungary. J. Aerosol. Sci., 30: 369-391.

Bowen HJM (1979). Environmental Chemistry of the elements. Acad. Press Inc; pp. 6-7.

Brunekreef B, Holgate ST (2002). Air pollution and health. Lancet, 360: 1233–1242.

Catherine H, Skinner W (2007). The Earth Source of the Health Hazards. An Introduction to Medical Geology. Ann. Rev. Ear. Pla. Sci., 35: 177-213.

Cholak J (1989). The nature of atmospheric pollution in a number of communities.In 2nd National Air Pollution Symposium. Standard Research institute Los Angeles, California.

Davis B (1984). X-ray diffraction analysis and source apportion of Denver Aerosols Atmospheric Environment. J. Aerosol. Sci., 18(5): 469-477.

De-Koning HW, Kretschmar JG, Akland GG, Bennett GB (1986). Air pollution indifferent cities around the world. Ibid. 20: 101-113.

Drasch G, Schopfer J, Schrauzer GN (2005). Biological Trace Element Res., p. 103.

Entwistle, Robert (1973). The crisis we would not face squarely. Sierra Club Bull., 58(32): 9-12.

Facchini H (1980). Heavy metals in air of Milan in the month of Januaury.Inst. Fis.Univ. Milan. Italy 9: 865-5, Chem. Abst., 92(23): 18509lw.

Fanning D (1988). A mortality study of lead workers.1926-1985. Arch. Environ. Heal. 43 (3): 247-251.

Freitas MC, Pacheco AMG, Verburg TG, Wolterbeek HT (2010). Effect of particulate matter, atmospheric gases, temperature, and humidity on respiratory and circulatory diseases' trends in Lisbon, Portugal. Environ. Monit. Assoc., 162: 113-121.

Fukasawa T, Iwatsuki MJ, Tillekeratne SP (1983). X-ray diffraction analysis of airborne particulates col¬lected by an Anderson sampler: Compound distribution versus particle size. Environ. Sci. Technol. 17:569-602.

Garcia VC, Gego E, Lin S, Pantea C, Rappazzo K, Wootten A, Rao ST (2011). An evaluation of transported pollution and respiratory related hospital admissions in the state of New York. Atmos. Poll. Res., 2: 9-15.

Gilfrich J, Briks L (1983). Identification of compounds in particulate pollution by X-Ray diffraction. NTIS spring field (USA) Report (1).

Gupta AK, Karar K, Srivastava A (2007). Chemical mass balance source apportionment of PM_{10} and TSP in residential and industrial sites of an urban region of Kolkata. Ind. J. Haz. Mats., 142: 279-287.

Hadad K, Mehdizadeh S, Sohrabpour M (2003). Impact of different pollutant sources on Shiraz air pollution using SPM elemental analysis. Environ. Int., 29: 39-43.

Hammond PB, Beliles RP (2007) Metals In: Toxicology: The Basic Science of Poisons. Second Edition.

Hao YC, Guo ZG, Yang ZS, Fang M, Feng JL (2007). Seasonal variations and sources of various elements in the atmospheric aerosols in Qingdao, China. Atmos. Res., 85: 27-37.

Harrison RH, Struges WT (1983). The measurement and interpretation of Br/Pb ratios in airborne particles. Atmos. Environ., 17: 311-328.

Harrison RM, Smith DJT, Pio CA, Castro LM (1997). Comparative receptor modeling study of airborne particulate pollutants in Birmingham (United Kingdom), Coimbra (Portugal) and Lahore (Pakistan). Atmos. Env. 31: 3309-3321.

Hayes RB (1997). The carcinogenicity of metals in humans. Cancer Causes Con. 8 (3): 371- 385.

Hien PD, Binh NT, Truong Y, Ngo NT, Sieu LN (2001). Comparative receptor modeling study of TSP, PM_2 and PM_{2-10} in Ho Chi Minh City. Atmos. Environ., 35: 2669-2678.

Hoffmann B, Moebus S, Mohlenkamp S, Stang A, Lehmann N, Dragano N, Schmermund A, Memmesheimer M, Mann K, Erbel R (2007). Residential exposure to traffic is associated with coronary atherosclerosis. Circulation, 116: 489–496.

Holguin F, Flores S, Ross Z, Cortez M, Molina M, Molina L, Rincon C, Jerrett M, Berhane K, Granados A (2007). Traffic-related exposures, airway function. inflammation, and respiratory symptoms in children. Am. J. Respir. Crit. Ca. Med., 176: 1236–1242.

Hussain F (1995). Occupational Health Hazards of Heavy Metals in Industrial Areas of Faisalabad. M. Sc. Thesis. Department of Biochemistry, University of Agriculture Faisalabad, Pakistan.

Jenq FT (1992). Emission of particular matter from three major industries. J. Aero. Sci., 23: 991-994.

Liu L, Ruddy T, Dalipaj M, Poon R, Szyszkowicz M, You HY, Dales RE, Wheeler AJ (2009). Effects of indoor, outdoor, and personal exposure to particulate air pollution on cardiovascular physiology and systemic mediators in seniors. J. Occup. Environ. Med., 51: 1088-1098.

Mavroidis I, Chaloulakou A (2010). Characteristics and expected health implications of annual PM10 concentrations in Athens, Greece. Inter. J. Environ. Pol., 41: 124-139.

McConnell R, Berhane K, Gilliland F, London SJ, Vora H, Avol E, Gauderman WJ, Margolis HG, Lurmann F, Thomas DC (1999). Air pollution and bronchitic symptoms in Southern California children with asthma. Environ. Heal. Perspect., 107: 757–760.

Muthusubramanian P, Deborrah (1989). SPM. Estimation of concentration of suspended particulate matter collected in Madurrai city. Ind. J. Environ. Prot., 9(9): 650-654.

Nawaz H (2000). Test your Chemistry. Carwan Printing Press Lahore., Pakistan Inc., 289: 296-297.

Othmer K (1978). Encyclopedia of chemical technology. 1st. Ed. Weily inter Sciences Publication Inc. pp. 624-642.

Pakkanen TA, Loukkola K, Korhonen CH, Aurela M, Makela T, Hillamo RE, Aarnio P, Koskentalo T, Kousa A, Maenhaut W (2001). Sources and chemical composition of atmospheric fine and coarse particles in the Helsinki area. Atmos. Environ., 35: 5381-5391.

Quiterio SL, da-Silva CRS, Arbilla G, Escaleira V (2004). Metals in airborne particulate matter in the industrial district of Santa Cruz, Rio de Janeiro, in an annual period. Atmos. Environ., 38: 321-331.

Ragosta M, Caggiano R, D'Emilio M, Macchiato M (2002). Source origin and parameters influencing levels of heavy metals in TSP, in an industrial background area of southern Italy. Atmos. Environ., 36: 3071-3087.

Rizzio E, Bergamaschi G, Profumo A, Gallorini M (2001). The use of neutron activation analysis for particle size fractionation and chemical characterization of trace elements in urban air particulate matter. J. Radio. Nucl. Chem., 248: 21-28.

Sahle W, Sallsten G, Thoren K (1990). Characteristics of air borne dust in a soft paper production plant. J. Ann. Occup. Hyg., 34(1): 55-75.

Salam A, Bauer H, Kassin K, Ullah SM, Puxbaum H (2003). Aerosol chemical characteristics of a mega city in Southeast Asia (Dhaka-Bangladesh). Atmos. Environ., 37: 2517-2528.

Samura A, Al-Agha O, Tuncel SG (2003). Study of trace and heavy metals in rural and urban aerosols of Uludag and Bursa (Turkey). Wat. A. S. Pol. Foc., 3: 111-129.

Sarnat JA, Marmur A, Klein M, Kim E, Russell AG, Mulholland JA, Hopke PK, Sarnat SE, Peel JL, Tolbert PE (2006). Associations between source resolved particulate matter and cardiorespiratory emergency department visits. Epidemic, 17: 267-268.

Schrauzer GN (2006). Interactive effects of Selenium and Chromium on Mammary Tumor Development and growth in MMTV- infected female mice and their relevance to human cancer. Biological Trace Element Res. 109: 281.

Selevan SG, Landrigan PJ, Stern FB, Jones JH (1996). The mortality of lead smelter workers: Am. J. Epi. 122 (4): 673-683.

Shahid MAK (2010). A comprehensive investigation of solid aerosols using XRPD and AAS Techniques. Ph. D. Thesis, University of Punjab, Lahore, Pakistan.

Shahid MAK (1997). Radioactive pollution and its Health Hazards, A study by SSNTDs and XRPD Analysis. M. Phil. Thesis, University of Punjab, Lahore, Pakistan.

Shahid MAK, Hussain K, Awan MS (2012). Atmospheric metal constituent, concentration and health impacts in the urban environment of Faisalabad (Pakistan). J. Basic Appl. Sci., 8(2): 547-553.

Shahid MAK, Hussain K, Awan MS (2012). Physico-Chemical Analysis of Solid Aerosols Generated from Different Industries of Faisalabad. J. Basic Appl. Sci., 8(2): 498-507.

Shahid MAK, Hussain K, Awan MS (2012). Seasonal Variations and Characterization of Solid Aerosols Related to Faisalabad (Pakistan) Environment. J. Basic Appl. Sci., 8(2): 572-580.

Shahida P (2000). Characterization of the compounds present in the atmospheric of Rawalpindi using x-ray diffraction technique. M.Sc.Thesis, University of Agriculture, Faisalabad.

Shridhar V, Khillare PS, Agarwal T, Ray S (2010). Metallic species in ambient particulate matter at rural and urban location of Delhi. J. Haz. Mat. 175: 600-607.

Singh V, Garg AN (1998). Biological Trace Element Res., 64: 237.

Snedden J (1985). Use of an impaction electro-thermal atomization atomic absorption spectrometric system for direct determination of Cu, Mn, and Cd in the labortary atmosphere. Anal. Lett., 18(A10): 1261-1280.

Sohrabpour M, Mirzaee H, Rostami S, Athari M (1999). Elemental concentration of the suspended particulate matter in the air of Tehran. Environ. Int., 25: 75-81.

Stayner L, Smith R, Schnorr T, Lemen R, Thun M (1993). Ann. Epi., 3: 114.

Tossavainen A (1979). X-ray powder diffraction technique for the quantitative determination of Quartz in dust samples. J. Work Environ. Health, 5(4): 379-385.

Valavanidis A, Fiotakis K, Vlahogianni T, Bakeas EB, Triantafillaki S, Paraskevopoulou V, Dassenakis M (2006). Characterization of atmospheric particulates, particle bound transition metals and polycyclic aromatic hydrocarbons of urban air in the centre of Athens (Greece). Chemicals, 65: 760-768.

Vercruysse A (1984). Hazardous metals in Human toxicology, 2nd Ed. Elsevier Amsterdam. Oxford, New York, Tokyo. Inc; pp. 56-62.

Waheed S, Ahmad S, Zaidi JH, Rahman A, Qureshi IH, Saleem M (2001). Transfer of inorganic elements in air and their enrichment in ash during coal combustion. Toxicol. Environ. Chem., 83: 13-23.

Wang CX, Zhu W, Peng A, Guichreit R (2001). Comparative studies on the concentration of rare earth elements and heavy metals in the atmospheric particulate matter in Beijing, China, and in Delft, the Netherlands. Environ. Int., 26: 309-313.

Wolff GT Korsog PE (1985). Estimates of the contributions of sources to inhale able paniculate concentrations in Detroit. Atmos. Environ., 19: 1399-1409.

Zereini F, Alt F, Messerschmidt J, Wiseman C, Feldmann I, Von BA, Muller J, Liebl K, Puttmann W (2005). Concentration and distribution of heavy metals in urban airborne particulate matter in Frankfurt am Main, Germany. Environ. Sci. Tech., 39: 2983-2989.