Identification of Organic Compounds in Solid Aerosols Related to Faisalabad Environment Using XRD Technique

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Abstract: Faisalabad is a big industrial city with huge air quality problems, being one of the most polluted cities in the world. Although public policies have developed to minimize atmospheric aerosol pollution, there is a lack of adequate knowledge and poor characterization of these aerosols. In this study we sampled 100 aerosol samples from different pools covering almost all the aspects of Faisalabad environment. 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-Naphthylbismuth dioxide, Sodium hippurate, Sodium-GA-naphthylamine-4-sulfonate tetrahydrate, Potassium phenoxide, Bismuth salicylate, Cadmium salicylate hydrate, Barium phenolsulfonate are contained in most of the samples in almost comparable amounts.The results of Solid aerosols collected from various pools show that the sources of GB-Naphthylbismuth dioxide, Sodium hippurate, Sodium-GA-naphthylamine-4-sulfonate tetrahydrate, Potassium phenoxide, Bismuth salicylate, Cadmium salicylate hydrate, Barium phenolsulfonate in the Solid aerosols are both local and remote. No doubt the main objective of this study was not to investigate the human health hazards however; an attempt has been made to correlate health hazards on behalf of their size distribution.

Keywords: Solid Aerosol, Bismuth salicylate, Potassium phenoxide, Sodium-GA-naphthylamine-4-sulfonate tetrahydrate and Cadmium salicylate hydrate as Major Pollutants, remote and local origin both, X-ray Diffraction, Particle size distribution, health co relationship (protective measures).

1. INTRODUCTION

At present our understanding of OA composition, physical and chemical properties, sources, and transformation characteristics are very limited, and estimates of their actual environmental effects are highly uncertain. In particular, potentially important feedback loops such as biosphere-aerosol-cloud-climate interactions are not yet well understood. For example, changes in organic emissions will affect cloud condensation nuclei (CCN) concentrations and could thus significantly affect cloud properties and precipitation regimes, altering the biologic productivity, which in turn leads to further changes in emissions. However, the importance of such feedbacks is still speculative, especially on a global scale. Reduction of these uncertainties will require a comprehensive characterization and investigation of OA by laboratory and environmental chamber experiments, field measurements, remote sensing, and modeling studies. Moreover, to be effective these studies require efficient planning, coordination, and exchange of research activities and results within the international scientific community.

Many epidemiological studies have indicated that solid aerosol pollution contributes to morbidity and mortality. The association between atmospheric pollution and its health hazards holds mainly for solid aerosol fraction, which is expressed as PM_{10} and $PM_{2.5}$. Both short term peaks in aerosol pollution and long term chronic exposure have been consistently associated with increased risks of respiratory and more importantly cardiovascular disease and death [2-8].

Recently a global air monitoring programmer for the study of solid aerosols (suspended particulate matter) was conducted by the World Health Organization as a part of the Global Environment Monitoring System (GEMS). Some 50 countries participated in the GEMS air monitoring project and data were obtained approximately at 175 sites in 75 cities around the world. The results of this study reported by [9, 10] showed that Teheran, Bombay and Calcutta are the most polluted cities in Asia. This study also indicated, though not supported by sufficient data, that Faisalabad in Pakistan is also emerging as a highly polluted city. Faisalabad 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 flows along the South-Eastern boundary of the district. The land close to the river is

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relatively much fertile than that away from the river. 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 meters from North-East to the South-West of the district. A general elevation of the land comprising of Faisalabad district is about 150 meters above the sea level. The climate of the district is hot and dry. Its mean maximum and minimum temperatures in summer are about 39°C and 27°C and in winter about 21°C 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, December and January are the coldest months. The rainy season is from July to September, July and August receives 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 rainy season is 77.7% and the mean minimum humidity in 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 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 others 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.

1.1. Organic Aerosols, Limited Study

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 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 over all pollution in Faisalabad. This situation motivated us to start a study on the air pollution in the area. As a first step, a Solid aerosol was collected from various pools in the city and was subjected to phase/compound analysis by x-ray diffraction.It is hoped that this study will be very useful towards the future environmental study programs related to Industrial areas cum commercial areas like Faisalabad [11-14].

2. MATERIALS AND METHODS

2.1. Pool Classification

Roughly, there are more than 512 large industrial units out of which 328 are textile units, 92 engineering units and 92 of chemicals and food processing units other industries include hosiery, carpet and rugs, nawar, and lace, printing and publishing and pharmaceutical products etc. there are also some 12000 house- hold industries, which include some 60,000 power loom factories.

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). Most of the pools under consideration belong to city center while remaining Pools were situated at (10-15) Km away from city center. Total (18) Solid Aerosols (suspended particulate matter) samples were collected from different pools of Faisalabad city using Syntax Map Method.

2.2. Sample Collection

Kimoto High Volume air sampler was used for the collection of suspended particulate matter in the atmosphere of randomly selected areas of Faisalabad city. The high volume air sampler used to pump large volumes of air up to 2000 m3 at a rate of 0.8 m3/ min. The filter used in a high volume air sampler was glass fiber filter which have a collection efficiency of 99% for particles. Samples were collected for a period of 12 hours (720 minutes) at an average flow rate of (0.8 m^3/min). Particulate matter was trapped on each filter. Triplicate samples were collected from each place- 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 than 53 μm and less than 75 μm. All the samples were pressed gently in to 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 an additional help for sample collection.

2.3. 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 equipped 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 a diffraction pattern a plot between the Bragg angles and the integrated intensities of the corresponding reflections 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 Tables **1-18**. 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^{o} 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 Table **19**. Characterization of solid aerosols (morphology, type and chemistry) was performed using SEM (Model: JEOL-1010, 80kV×1500×2500) available at NIBGE, Faisalabad.

3. RESULTS & DISCUSSION

3.1. Phase Analysis of Solid Aerosols by XRPD

In this study, maximum 18 (15+2+1) samples were collected from different pools of Faisalabad Figure **1**. These samples were collected by air volume sampler

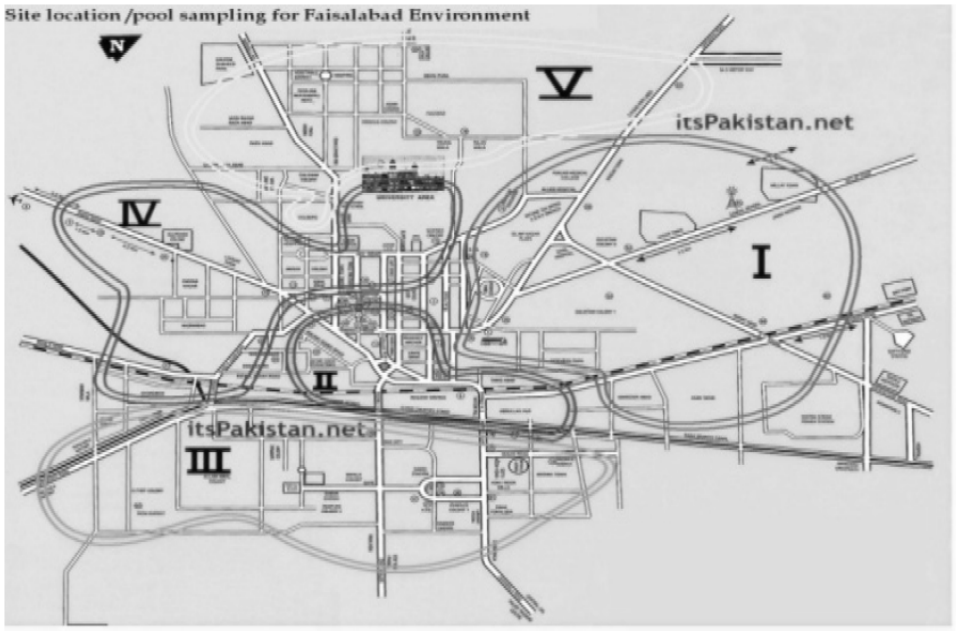

Figure 1: Pool Classification of the Faisalabad city.

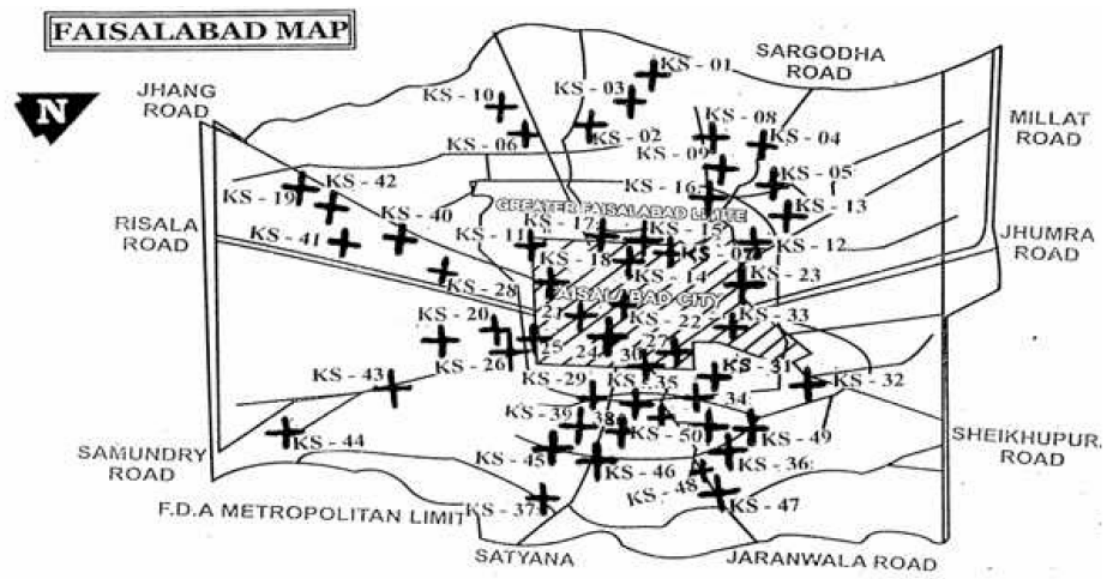

Figure 2: Sites selection of the Faisalabad city.

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 them 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 times 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 indicates 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 was carried out by Hanawalt Method.

Qualitative and Quantitative analysis were performed by Hanawalt Method and by Matrix-flushing methods. Qualitative phase analysis of the samples showed 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), Barium phenolsulfonate (7) the relevant codes specified in brackets 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) in amounts ranging between (33.76→7.29)% in Pool (1→2), Sodium hippurate (2) in amounts ranging between (27.78→6.64)% in Pool (1→4), Sodium-GA-naphthylamine-4-sulfonate tetrahydrate (3) in amounts ranging between (43.76→1.48)% in Pool (5→3), Potassium phenoxide (4) in amounts ranging between (60.07→18.12)% in Pool(4→2), Bismuth salicylate (5) in amounts ranging between (61.81→8.48)% in Pool(2→4), Cadmium salicylate hydrate (6) in amounts ranging between (39.395→4.287)% in Pool(1→2),Barium phenolsulfonate (7) in amounts ranging between (6.54→1.82)% in solid aerosols of Pool(3→5). Following the pool wise Identification of compounds in solid aerosols trend given in Tables **1-20**.

These phases are of metallic, semi metallic and of non metallic nature. Therefore their study becomes very critical because they when combined with Oxygen, Sulphate (SO_4^{-2}) and carbonate (CO_3^{-2}) radicals result's formation of complex compounds indicating that the interaction of Industrial and transportational dust, fumes with solids aero sols and pollute the environment, this aspect is evident from Gray / Black and Yellow color of most of the selected samples along with non identified phases [21, 22]. Therefore they are polluting environment adversely by changing the Physico-chemical process occurring in the Environment and disturbing radiation budget creating global cooling and global warming along with health hazard see Figures **3**, **4**.

The major sources of solid aerosols include Coal burning, Auto mobile exhaust, high temperature Industrial processes, fugitive dust, de-odourization of waste gases, detoxification of dust from steel plants, unpaved roads, municipal waste combustion etc along with some natural processes as forest fires, decaying

Table 1: Identified Chemical Analysis with integrated intensities for Aerosol Sample Collected from Crescent Textile Mills Faisalabad Pool (1) Sample # 02

Peak No.	2θ (degree)	d-value	Integrated Intensities (I_i)	Chemical Name	Chemical Formula
1	8.9246	9.90885	2.66	GB-Naphthylbismuth dioxide	$C_{10} H_7 Bi O_2$
2	14.0114	6.32079	4.12	Sodium hippurate	$C_9 H_8 N Na O_3$

Table 2: Identified Chemical Analysis with Integrated Intensities for Aerosol Sample Collected from Sahil Hospital and East Inn Faisalabad Pool (1) Sample # 05

Peak No.	2θ (degree)	d-value	Integrated Intensities (I_i)	Chemical Name	Chemical Formula
1	8.9357	9.89656	5.5	GB-Naphthylbismuth dioxide	$C_{10} H_7 Bi O_2$
2	12.5888	7.03171	1.71	Sodium hippurate	$C_9 H_8 N Na O_3$
3	22.1327	4.01644	1.46	Bismuth salicylate	$C_{21} H_{15} Bi_2 O_9$
4	24.397	3.64856	1.49	Cadmium salicylate hydrate	$C_{14} H_{10} Cd O_6$! $H_2 O$

Table 3: Identified Chemical Analysis with Integrated Intensities for Aerosol Sample Collected from Outside General Bus Stand Faisalabad Pool (1) Sample # 07

Peak No.	2θ (degree)	d-value	Integrated Intensities (I_i)	Chemical Name	Chemical Formula
1	8.9712	9.85748	12.34	GB-Naphthylbismuth dioxide	$C_{10} H_7 Bi O_2$
2	12.6395	7.00362	8.97	Sodium hippurate	$C_9 H_8 N Na O_3$
3	20.9916	4.23213	30.46	Potassium phenoxide	$C_6 H_5 K O$
4	22.1818	4.00765	4.16	Bismuth salicylate	$C_{21} H_{15} Bi_2 O_9$
5	26.7619	3.33127	100	Cadmium salicylate hydrate	$C_{14} H_{10} Cd O_6 H_2 O$

Table 4: Identified Chemical Analysis with integrated intensities for Aerosol Sample Collected from Tariq Abad Inside Faisalabad Pool (2) Sample # 02

Peak No.	2θ (degree)	d-value	Integrated Intensities (I_i)	Chemical Name	Chemical Formula
1	8.9238	9.90973	7.1	GB-Naphthylbismuth dioxide	$C_{10} H_7 Bi O_2$
2	12.5841	7.03431	1.65	Sodium hippurate	$C_9 H_8 N Na O_3$
3	20.9661	4.23721	22.69	Potassium phenoxide	$C_6 H_5 K O$
4	22.1373	4.0156	11.37	Bismuth salicylate	$C_{21} H_{15} Bi_2 O_9$
5	23.0921	3.8517	1.26	Cadmium salicylate hydrate	$C_{14} H_{10} Cd O_6 H_2 O$

Table 5: Identified Chemical Analysis with integrated intensities for Aerosol Sample Collected from Flying Coach Stand Faisalabad Pool (2) Sample # 06

Peak No.	2θ (degree)	d-value	Integrated Intensities (I_i)	Chemical Name	Chemical Formula
1	8.8338	10.01048	6.19	GB-Naphthylbismuth dioxide	$C_{10} H_7 Bi O_2$
2	20.8709	4.25633	34.6	Sodium hippurate	$C_9 H_8 N Na O_3$
3	25.3321	3.51596	1.7	Potassium phenoxide	$C_6 H_5 K O$
4	26.6787	3.34147	100	Bismuth salicylate	$C_{21} H_{15} Bi_2 O_9$
5	27.4592	3.24824	11.22	Cadmium salicylate hydrate	$C_{14} H_{10} Cd O_6 H_2 O$

Table 6: Identified Chemical Analysis with integrated intensities for Aerosol Sample Collected from Jaranwala Road out Side Kohinoor Mills Faisalabad Pool (2) Sample # 09

Peak No.	2θ (degree)	d-value	Integrated Intensities (I_i)	Chemical Name	Chemical Formula
1	8.886	9.95172	1.84	GB-Naphthylbismuth dioxide	$C_{10} H_7 Bi O_2$
2	17.877	4.96181	1.01	Sodium hippurate	$C_9 H_8 N Na O_3$
3	25.6947	3.46715	1.87	Potassium phenoxide	$C_6 H_5 K O$
4	26.7304	3.33513	100	Bismuth salicylate	$C_{21} H_{15} Bi_2 O_9$
5	28.0154	3.18501	2.88	Cadmium salicylate hydrate	$C_{14} H_{10} Cd O_6 H_2 O$

Table 7: Identified Chemical Analysis with Integrated Intensities for Aerosol Sample Collected from Madina Town/ Kohinoor Mills Faisalabad Pool (3) Sample # 03

Peak No.	2θ (degree)	d-value	Integrated Intensities (I_i)	Chemical Name	Chemical Formula
1	8.9954	9.83103	4.73	GB-Naphthylbismuth dioxide	$C_{10} H_7 Bi O_2$
2	12.68	6.98137	3.15	Sodium hippurate	$C_9 H_8 N Na O_3$
3	17.8871	4.95904	2.03	Barium phenolsulfonate	$C_{12} H_9 Ba O_7 S_2$
4	21.0228	4.22592	18.86	Potassium phenoxide	$C_6 H_5 K O$
5	23.2321	3.8288	2.25	Cadmium salicylate hydrate	$C_{14} H_{10} Cd O_6 H_2 O$

Table 8: Identified Chemical Analysis with Integrated Intensities for Aerosol Sample Collected from Madina Town/ Kohinoor Mills Faisalabad Pool (3) Sample # 06

Peak No.	2θ (degree)	d-value	Integrated Intensities (I_i)	Chemical Name	Chemical Formula
1	9.2092	9.60323	3.24	GB-Naphthylbismuth dioxide	$C_{10} H_7 Bi O_2$
2	21.2003	4.19092	22	Sodium hippurate	$C_9 H_8 N Na O_3$
3	28.3174	3.15172	9.23	Potassium phenoxide	$C_6 H_5 K O$
4	29.7858	2.9996	9.12	Bismuth salicylate	$C_{21} H_{15} Bi_2 O_9$
5	30.1763	2.96167	4.35	Cadmium salicylate hydrate	$C_{14} H_{10} Cd O_6 H_2 O$

Table 9: Identified Chemical Analysis with Integrated Intensities for Aerosol Sample Collected from Over Head Bridge Opposite Both Cinema Sides Faisalabad Pool (3) Sample # 09

Peak No.	2θ (degree)	d-value	Integrated Intensities (I_i)	Chemical Name	Chemical Formula
1	8.9653	9.86394	3.68	GB-Naphthylbismuth dioxide	$C_{10} H_7 Bi O_2$
2	20.8824	4.25401	19.63	Sodium hippurate	$C_9 H_8 N Na O_3$
3	22.085	4.025	2.1	Sodium-$GA-naphthylamine-4-sulfonate tetrahydrate	$C_{10} H_8 N Na O_3 S$!$_4$ $H_2 O$
4	26.7628	3.33116	100	Potassium phenoxide	$C_6 H_5 K O$
5	27.701	3.22043	5.97	Bismuth salicylate	$C_{21} H_{15} Bi_2 O_9$
6	27.9773	3.18925	9.91	Cadmium salicylate hydrate	$C_{14} H_{10} Cd O_6 H_2 O$

Table 10: Identified Chemical Analysis with Integrated Intensities for Aerosol Sample Collected from Model Town Inside Faisalabad Pool (4) Sample # 04

Peak No.	2θ (degree)	d-value	Integrated Intensities (I_i)	Chemical Name	Chemical Formula
1	8.993	9.8336	3.36	GB-Naphthylbismuth dioxide	$C_{10} H_7 Bi O_2$
2	11.8216	7.4863	3.56	Sodium hippurate	$C_9 H_8 N Na O_3$
3	26.8121	3.32514	100	Potassium phenoxide	$C_6 H_5 K O$
4	28.0222	3.18424	14.42	Bismuth salicylate	$C_{21} H_{15} Bi_2 O_9$
5	29.2929	3.04894	6.34	Cadmium salicylate hydrate	$C_{14} H_{10} Cd O_6 H_2 O$

Table 11: Identified Chemical Analysis with Integrated Intensities for Aerosol Sample Collected from New Graveyard, Hang Road, Faisalabad Pool (4) Sample # 06

Peak No.	2θ (degree)	d-value	Integrated Intensities (I_i)	Chemical Name	Chemical Formula
1	8.8263	10.01891	1.04	GB-Naphthylbismuth dioxide	$C_{10} H_7 Bi O_2$
2	13.6434	6.49046	1.54	Sodium hippurate	$C_9 H_8 N Na O_3$
3	26.6573	3.34411	100	Potassium phenoxide	$C_6 H_5 K O$
4	27.9529	3.19198	3.8	Bismuth salicylate	$C_{21} H_{15} Bi_2 O_9$
5	29.478	3.03021	1.62	Cadmium salicylate hydrate	$C_{14} H_{10} Cd O_6 H_2 O$

Table 12: Identified Chemical Analysis with Integrated Intensities for Aerosol Sample Collected from G.C. Sammanabad, Faisalabad Pool (4) Sample # 10

Peak No.	2θ (degree)	d-value	Integrated Intensities (I_i)	Chemical Name	Chemical Formula
1	8.865	9.97525	10.11	GB-Naphthylbismuth dioxide	$C_{10} H_7 Bi O_2$
2	12.53	7.06459	2.84	Sodium hippurate	$C_9 H_8 N Na O_3$
3	21.9544	4.04866	1.69	Potassium phenoxide	$C_6 H_5 K O$
4	23.5625	3.77585	1.92	Bismuth salicylate	$C_{21} H_{15} Bi_2 O_9$
5	24.2798	3.66591	1.51	Cadmium salicylate hydrate	$C_{14} H_{10} Cd O_6 H_2 O$

Table 13: Identified Chemical Analysis with Integrated Intensities for Aerosol Sample Collected from Faizabad Market Start, Faisalabad Pool (5) Sample # 03

Peak No.	2θ (degree)	d-value	Integrated Intensities (I_i)	Chemical Name	Chemical Formula
1	8.9913	9.83541	3.94	GB-Naphthylbismuth dioxide	$C_{10} H_7 Bi O_2$
2	20.9038	4.2497	16.59	Sodium hippurate	$C_9 H_8 N Na O_3$
3	27.7299	3.21714	8.41	Bismuth salicylate	$C_{21} H_{15} Bi_2 O_9$
4	28.0045	3.18621	11.65	Cadmium salicylate hydrate	$C_{14} H_{10} Cd O_6 H_2 O$

vegetation, dust storms and volcanic eruptions are almost all are the components of Faisalabad environment.

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 re-appearance of the compounds phases which means that transportation is main contributor of these phases. When compared with the total pooled environment, creation of two new compounds likes Sodium-$GA-naphthylamine-4-

Table 14: Identified Chemical Analysis with Integrated Intensities for Aerosol Sample Collected from Grid Station Sargodha Road, Faisalabad Pool (5) Sample # 07

Peak No.	2θ (degree)	d-value	Integrated Intensities (I_i)	Chemical Name	Chemical Formula
1	9.1057	9.71211	5.01	GB-Naphthylbismuth dioxide	$C_{10} H_7 Bi O_2$
2	18.0098	4.92552	2.12	Sodium hippurate	$C_9 H_8 N Na O_3$
3	22.1895	4.00628	2.12	Barium phenolsulfonate	$C_{12} H_9 Ba O_7 S_2$
4	26.8843	3.31638	100	Bismuth salicylate	$C_{21} H_{15} Bi_2 O_9$
5	28.1456	3.17057	6.71	Cadmium salicylate hydrate	$C_{14} H_{10} Cd O_6 H_2 O$

Table 15: Identified Chemical Analysis with Integrated Intensities for Aerosol Sample Collected from (B. Bazar) Clock Tower of Faisalabad Pool (5) Sample # 10

Peak No.	2θ (degree)	d-value	Integrated Intensities (I_i)	Chemical Name	Chemical Formula
1	8.9905	9.83637	7.14	GB-Naphthylbismuth dioxide	$C_{10} H_7 Bi O_2$
2	15.0616	5.88236	8.44	Sodium hippurate	$C_9 H_8 N Na O_3$
3	20.836	4.26336	53.9	Sodium-GA-naphthylamine-4-sulfonate tetrahydrate	$C_{10} H_8 N Na O_3 S_4 H_2 O$
4	27.9696	3.19012	20.56	Potassium phenoxide	$C_6 H_5 K O$
5	29.6027	3.01774	21.65	Bismuth salicylate	$C_{21} H_{15} Bi_2 O_9$
6	30.3094	2.94897	11.47	Cadmium salicylate hydrate	$C_{14} H_{10} Cd O_6 H_2 O$

Table 16: Identified Chemical Analysis with Integrated Intensities for Aerosol Sample Collected from Residential Pool of Faisalabad

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

Table 17: Identified Chemical Analysis with Integrated Intensities for Aerosol Sample Collected from Complex and Commercial Pools of Faisalabad

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

sulfonate tetrahydrate and Barium phenolsulfonate gave astonishing results from this mixing of the technique it was emitted that these solid aerosols were contributing a lot towards environment pollution of the Faisalabad environment by addition and subtraction of phases and hence modifying the ecosystem. To check

Table 18: Identified Chemical Analysis with Integrated Intensities for Aerosol Sample Collected from Transportational Pool of Faisalabad

Peak No.	2θ (degree)	d-value	Integrated Intensities (I_i)	Chemical Name	Chemical Formula
1	9.043	9.77933	10.41	GB-Naphthylbismuth dioxide	$C_{10}H_7BiO_2$
2	12.6599	6.99236	5.14	Sodium hippurate	$C_9H_8NNaO_3$
3	26.8544	3.32	100	Potassium phenoxide	C_6H_5KO
4	27.8558	3.20289	17.61	Bismuth salicylate	$C_{21}H_{15}Bi_2O_9$
5	29.6634	3.0117	17.48	Cadmium salicylate hydrate	$C_{14}H_{10}CdO_6H_2O$

Table 19: Pool Wise Weight Average Intensities

Sr. No.	Identification of compounds in Solid Aerosols	Chemical Formula	Pool Selections				
			Pool (1)	Pool (2)	Pool (3)	Pool (4)	Pool (5)
1	GB-Naphthylbismuth dioxide	$C_{10}H_7BiO_2$	33.76	7.29	8.197	19.84	8.79
2	Sodium hippurate	$C_9H_8NNaO_3$	27.78	9.064	23.48	6.64	10.39
3	Sodium-GA-naphthylamine-4-sulfonate tetrahydrate	$C_{10}H_8NNaO_3S_4H_2O$	ND	ND	1.48	ND	43.76
4	Potassium phenoxide	C_6H_5KO	19.53	18.12	50.33	60.07	19.595
5	Bismuth salicylate	$C_{21}H_{15}Bi_2O_9$	8.515	61.81	11.62	8.48	40.02
6	Cadmium salicylate hydrate	$C_{14}H_{10}CdO_6H_2O$	39.395	4.287	7.78	4.78	12.53
7	Barium phenolsulfonate	$C_{12}H_9BaO_7S_2$	ND	ND	6.54	ND	1.82

Table 20: Pool Wise Trend Pattern of Compounds in Solid Aerosols

Sr. No.	Identification of compounds in Solid Aerosols	Pool wise Identification of elements in solid aerosols trend				
		Pool (1) Average Conc.(ppm)	Pool (2) Average Conc.(ppm)	Pool (3) Average Conc.(ppm)	Pool (4) Average Conc.(ppm)	Pool (5) Average Conc.(ppm)
1	$GB-Naphthylbismuth dioxide	P1>P4>P5>P3>P2				
2	Sodium hippurate	P1>P3>P5>P2>P4				
3	Sodium-$GA-naphthylamine-4-sulfonate tetrahydrate	P5>P3				
4	Potassium phenoxide	P4>P3>P5>P1>P2				
5	Bismuth salicylate	P2>P5>P3>P1>P4				
6	Cadmium salicylate hydrate	P1>P5>P3>P4>P2				
7	Barium phenolsulfonate	P3>P5				

the stability of the environment statistical analysis was also carried out a large variation in SD's and CV's showed the instability of the Environment [23-40].

SEM analysis of most of the solid aerosols showed that the identified organic compounds occurred as patches rather than single grains, so the heterogeneity and complexity of the Faisalabad environment is confirmed being the dominating factor in our experimental findings which may be the main cause of formation of organic compounds in the environment because the environment of the Faisalabad is more favorable for photolysis process, being more humid than that of other environments and hydroscopic and hygroscopic nature of solid aerosols also favours our experimental findings through condensation after oxidation of precursor compounds already present in

Table 21: Statistical Analysis of Major Identified Phases of Organic Compounds by XRD

Identification of compounds in Solid Aerosols	Phases	Max	Min	Mean	S.D	CV
GB-Naphthylbismuth dioxide	1	33.76	7.29	20.525	10.01	48.77
Sodium hippurate	2	27.78	6.64	17.21	7.99	46.43
Sodium-GA-naphthylamine-4-sulfonate tetrahydrate	3	43.76	1.48	22.62	21.14	93.46
Potassium phenoxide	4	60.07	18.12	39.095	15.85	40.54
Bismuth salicylate	5	61.81	8.48	35.145	20.15	57.34
Cadmium salicylate hydrate	6	39.395	4.287	21.841	13.27	60.76
Barium phenolsulfonate	7	6.54	1.82	4.18	1.78	120.27

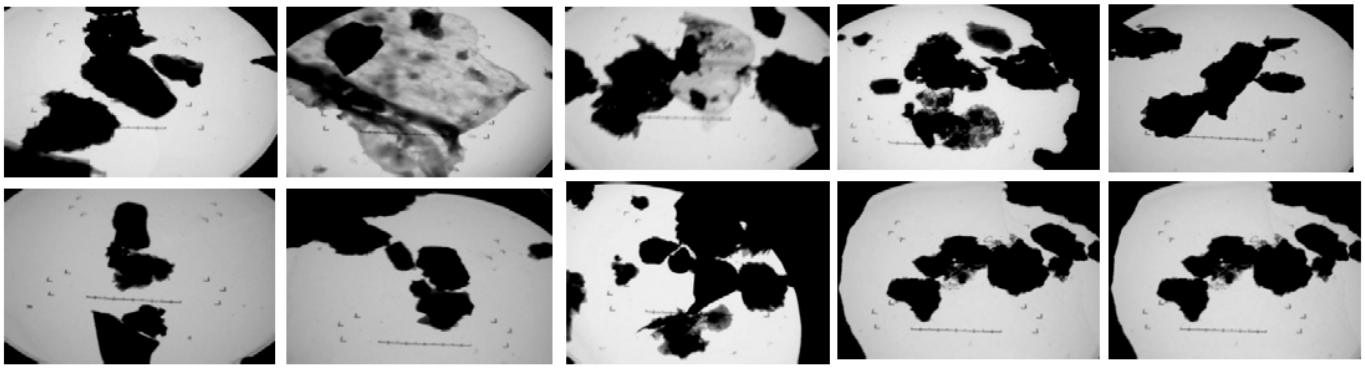

Figure 3: Digital SEM Micrographs (Confirmation of fibrous material).

Figure 4: Digital Camera Photographs (Showing fibrous material in different pools of the Environment).

the environment. The symmetry between digital photographs and SEM micrographs confirmed not only this state of affairs but also transport and industrial involvement towards atmospheric pollution Figures **3**, **4**. Similar impact will be observed on human beings when these aerosols were inhaled or digested by them through food chain and food web of the concerning environment. No doubt the gas particle conversion process is still debatable but the present study will definitely provide not only data but also guidelines in the positive direction.

4. CONCLUDING REMARKS

It is concluded that the solid aerosols samples collected from various pools in Faisalabad contained steadily the organic compounds namely GB-Naphthylbismuth dioxide, Sodium hippurate, Sodium-GA-naphthylamine-4-sulfonate tetrahydrate, Potassium phenoxide, Bismuth salicylate, Cadmium salicylate hydrate, Barium phenolsulfonate as pollution components mixing techniques showed addition and subtraction of compound phases and hence modification of the environment and consequently are generating relevant health hazards. The sources of these organic compounds are both local and remote [41-53].

5. FUTURE PERSPECTIVES

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 theoretical modeling defective, relevant to meteorological conditions of the environment. Because of this complexity characterization of these solid aerosol, 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 Faisalabad environment. However 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 [54-57].

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