INVESTIGATING INDOOR SUSPENDED PARTICULATE MATTER AS SOURCE OF AIR POLLUTION IN RESIDENTIAL, COMMERCIAL AND INDUSTRIAL AREAS OF FAISALABAD CITY

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Suspended particulate matter (SPM) is one of the important sources of air pollution that can affect human health. A study was conducted to determine the mineral phases present in the SPM collected from commercial, industrial and residential areas of Faisalabad city. X-ray diffraction technique was employed for the characterization and quantification of mineral phases. The results showed that Illite was the dominant constituent where as the other minerals phases found were quartz, albite, calcite, clinochlore, gypsum and talc in the SPM samples. Statistical analysis revealed that all the pollutants were homogeneously diffused equally in the investigated areas of Faisalabad city.
Keywords: Suspended particulate matter, pollution, quantification, pollutants

INTRODUCTION

The ambient air normally we breathe in pure form is a mixture of nitrogen (78.03%), oxygen (20.99%), argon (0.94%), CO_2 (0.03%), hydrogen (0.01%). But the situation in which the ambient air contains certain materials other than its natural constituents in such concentrations which are harmful to man and other living organism, the normal air is known as polluted air (Hamid, 1994). By air pollution means the suspended particulate matter (SPM) present in the air stream whose individual particle size varies from less than 1 µm to approximately 100 µm and these particles are inhalable if their size reaches to a value of 15 µm (Kenneth and Cecilf, 1981). Suspended particulate matter is frequently classified into fine dust (less than 100 µm), coarse dust (above 100 µm), fumes (0.001-1 µm) and mist (0.1-10 µm) in diameters. Fumes are particles formed by condensation, sublimation or chemical reaction and sometimes are also designated as smoke. Mist is comprised of liquid particles formed by condensation and is fairly large in diameter compared to fumes or smoke (Kenneth and Cecilf, 1981).
The SPM creates increased risk either directly or indirectly to human health, cultural resources and atmospheric visibility. These particulates alone or in combination with other pollutants can cause health problems. When inhaled, these can penetrate deep into lungs and cause sickness of upper respiratory tract (runny or stuffy nose, sinusitis, sore throat, wet cough, head colds, hay fever and red eyes) and lower respiratory tract (wheezing, dry cough, phlegm, shortness of breath and chest pain) (Miller, 1999). As an overall group, SPM may cause increased illness, contamination of surface water, impaired growth of agricultural crops, deterioration of materials and loss of ammunity through malodour and reduced visibility (Qureshi, 1999).
In this study XRD technique (Esteve and Rius, 1997; Davis and Jixiang, 2000) was employed for the identification and characterization of mineral phases present in SPM samples collected from various places at commercial, industrial and residential areas of Faisalabad city.

MATERIALS AND METHODS

Samples of SPM were collected within the municipal range from residential area (Ghulam Muhammad abad, Narwala road), commercial area (Peoples Colony, Satiana road), and industrial area (Sugar Mills, Jhumra road). SPM samples (in the form of dust) were collected from the air conditioner filters running at the selected localities in the months of June and July at defined time periods. The filters were cleaned and washed before these were employed for sample collection. To obtain the SPM samples, the dusty filters were jolted at clean surfaces, and then dust was collected and strained for the removal of fibrous material, if any. The collected samples were stored in cleaned, dried and capped bottles.
Sample preparation was the most important requirement in the analysis of powder samples by x-ray diffraction (XRD). The collected and sieved samples were dried before they were ground by mortar and pestle for a long period until homogenized to powder. To obtain homogenized powder in 1-5 µm range was important to ensure enough particle participation in the diffraction process, especially if quantification of various phases is required (Klug and Alexander, 1974; Cullity, 1978). Each sample was loaded into the specific aluminum sample holder of the diffractometer (Rint 2000 series Rigaku). Prior to this, the sample holder was thoroughly washed with acetone to make it free from any contamination and then dried. Next, the loaded sample holder was placed in the goniometer of the diffractometer.
Every crystalline material gave unique X-Ray diffraction pattern lines, which is the characteristic of the material according to Bragg's law (Mckelvey and John, 1966). For qualitative phase analysis, Hanawalt method was employed in which the 'd' values and 'integrated intensities' of the reflections in XRD pattern were used (Cullity, 1978). For quantitative phase analysis, matrix-

flushing method was employed (Chung, 1974) and the working equation was:

$$X_i = \left[\frac{K_i}{I_i} \sum_{i=1}^{n} \frac{I_i}{K_i} \right]^{-1} \times 100$$

This equation gives the percentage composition of a component 'i' in a mixture of 'n' components. In this equation I_i is the integrated intensity and K_i is the relative intensity ratio given by $K_i = I_i/I_{KCl}$ calculated by mixing the component 'I' with a standard material KCl in a ration of 1:1. Relative intensity of a mineral was calculated by the ratio of the intensity of that mineral to the intensity of KCl. Relative intensities of Illite, Quartz, Albite, Calcite, Clinochlore, Talc and Gypsum are 0.20, 0.85, 0.36, 0.74, 0.23, 0.32 and 0.83 respectively. The integrated intensity (I_i) of each of the mineral was calculated by multiplying maximum intensity (I_{max}) and FWHM (full width at half maximum). Using the values of K_i and I_i in the above Equation, the weight percentage of the phases present in a sample was calculated.

RESULTS AND DISCUSSION

Table 1 shows the different types of minerals present were illite, quartz, albite, calcite, clinochlore, talc and gypsum which are found in SPM samples. The mineral phases identified in this study are broadly in agreement with those found by Davis and Jixiang, 2000.

Through qualitative analysis (Table 1), the minerals identified were illite, quartz, calcite, albite, gypsum and Clinochlore. The quantitative analysis (Table 2) revealed that illite was the dominant constituent found in all the samples with its average weight percentage varied from 78.6%, 74.95% and 73.8% in residential, commercial and industrial areas respectively. The second largest phase found was albite having average weight percentage 8.7% (residential), 10.34% (commercial) and 8.77% (industrial), The other constituent phases were: calcite having average weight percentage 7.59% (residential), 10.05% (commercial) and 5.57% (industrial); clinochlore having average weight percentage 4.1% (residential), 11.0% (commercial) and 5.57% (industrial); quartz having its weight percentage 2.35% (residential), 2.75% (commercial) and 1.80% (industrial) whereas the concentration of talc and gypsum in air for all the three selected sites was in lower limits and this may be attributed to their source away from the Faisalabad city. Our results are almost in agreement with those obtained by Smith et al., 1996 for the air samples collected from Lahore, Pakistan.

Table 2. Average weight percentage of phases in SPM (air) samples

Areas/Phases	Residential	Commercial	Industrial
Illite	78.6	74.95	73.8
Quartz	2.35	2.75	1.80
Albite	8.7	10.34	8.77
Clinochlore	4.1	11.0	7.08
Calcite	7.59	10.05	5.57
Talc	2.65	0	1.83
Gypsum	0	1.56	0.5

Table 1. Qualitative phase analysis of the suspended particulate matter (SPM) distribution in residential, commercial and industrial area

Peak	Residential			Commercial			Industrial		
	d-value (A^o)	Integrated Intensities (I_o)	Identified mineral phases	d-value (A^o)	Integrated Intensities (I_o)	Identified mineral phases	d-value (A^o)	Integrated Intensities (I_o)	Identified mineral phases
3	-	-	-	4.48	45.18	IL	-	-	-
4	4.66	52.24	T	4.26	100.95	Q	4.66	22.13	T
5	4.43	43.06	IL	4.03	40.94	IL	4.43	42.36	IL
6	4.26	63.11	Q	3.86	48.73	CA	4.22	114.37	CA
8	3.86	53.65	CL	3.53	55.77	CL	3.50	91.07	AL
9	3.67	25.93	IL	3.34	499.14	Q	3.32	540.10	IL
10	3.50	102.30	AL	3.20	57.93	AL	3.18	114.37	AL
11	3.32	465.96	IL	3.03	133.43	CA	3.01	132.72	CA
12	3.18	93.89	AL	2.88	37.41	G	2.86	27.31	G
13	3.01	186.38	CA	2.57	82.32	AL	2.54	36.00	CL
14	-	-	-	2.45	24.02	CL	2.44	50.12	CL
15	2.81	55.77	CA	2.27	34.38	AL	2.27	54.77	CA
16	2.49	30.14	CA	-	-	-	-	-	-
17	2.45	25.43	AL	1.87	25.41	CA	1.86	33.88	CA
18	2.27	50.12	AL	1.81	50.83	Q	1.81	33.91	Q
19	2.08	23.07	CA	1.54	49.42	Q	1.66	20.25	Q

Legend: T (Talc); **IL** (Illite); **Q** (Quartz); **CA** (Calcite); **AL** (Albite); **G** (Gypsum); **CL** (Clinochlore)

ANOVA technique was employed to the data for each mineral for the samples collected from residential, commercial and industrial areas focusing on four dominant phases, namely illite, quartz, albite and calcite and the results obtained are presented Table 3. The p-values obtained (0.495; 0.744; 0.273; 0.249) show that the minerals illite, quartz, albite and calcite cannot be considered significantly different for all the three different areas. Thus, these results provide a base to make an assessment that the indoor environment at all the three investigated areas, the pollution level is almost same and can behave similar towards the health of local dwellers regarding the investigated pollutants. It is argued that the existing level of pollution may be due to the dump of wastage in an undisciplined way of local cottage industry which lowers the impact of existing plantation.

Table 3. Analysis of variance for mineral phases found in the air samples collected for residential, commercial and industrial areas

Pollutants	DF.	MS	MSE	P-Values
Illite	2	12.6	14.0	0.495
Quartz	2	0.45	1.37	0.744
Albite	2	1.635	0.791	0.273
Calcite	2	10.07	4.40	0.249

It is suggested that the volume of existing plantation is too insufficient to suffice favourable environment free from pollutant in residential, commercial and industrial area. Further, similar studies are highly recommended for cottage industry crowded cities like Multan, Sialkot and Gujranwala etc.

Moreover, this study proposes that the identified minerals at all the selected sites were injected into the air of Faisalabad city possibly through wind erosion and human related activities. The homogeneity in the identified phases at all the selected sites leads to infer that the indoor environment carried particulate matter that is well mixed in air as a result of continuous deposition and uptake from the ground.

Moreover, air particulate existing in the air other than its normal constituents is highly dangerous to the health of children and adults particularly those who are asthma patients since it causes severeness in symptoms like coughing, wheezing, chest discomfort and burning feeling in the lungs (Anonymous, 2007).

Thus the controlling of the particulate matter in the air is highly desired. For this, it is recommended that the government must designate and certify safe dumping sites and strictly enforce the regulations against illegal dumping of wastes. A central disposal depot should be made well outside the city. The industries situated in the urban and residential areas of the city should preferably be shifted outside the municipal city and the installation of any new industry should be allowed only in the industrial estate. There should be a lot of tree plantation for the eradication of the unnecessary addition of dust in the atmosphere of Faisalabad city since trees are the best antidote for the cleaning of air. The concerned authorities, the corporate sector and general public must fight together against the demon of pollution as this the real threat to the human health.

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