A POLLUTANT OF ENVIRONMENT: QUALIFICATION, QUANTIFICATION AND CHARACTERIZATION OF AIRBORNE PARTICULATES

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The study of mineral components in repairable particles is important in improving the quality of air. Airborne particulate (ABP) were collected from various industrial, commercial, residential, combined industrial cum residential and commercial cum residential localities of Faisalabad city in the months of June and July and subjected to quantitative phase analysis by X-ray powder diffraction method using flushing technique. Various minerals were detected in the samples. Results revealed that Illite was the dominant constituent in ABP sample and hence the major contributor to air borne pollution with wt percentage in the range 70.4%-80.4wt%. The other air polluting phases found were albite, calcite quartz, clinochlore, gypsum and talc bearing weight percentages in the range 8.4% to 15.8%, 5.1% to 11.7%, 1.1% to 3.5%, 4.4% to 21.5%, 0.1%-1.3 and 1.76%-5.3% respectively. Fine particles of quartz not utilized in microphysical processes in the atmosphere, stay in air for long periods of time. These pollutants affect human health and may become cause of bronchitis, asthma etc. since the fine particles go deep into lungs and find no way to escape from there.

Keywords: Airborne particulate, flushing technique, quartz, pollutants

INTRODUCTION

The atmosphere of a locality is a dynamic system that continuously absorbs a wide range of substances such as solids, liquids and gases from both natural and man-made sources. These substances travel through air, disperse and react with one another and with the other substances, both physically and chemically. That portion of these substances, which interact with the environment to cause toxicity, diseases, aesthetic distress is known as pollutant (Stern and Athur, 1976). The pollutants fall into two groups: primary and secondary. The substances, which are directly emitted from source, are primary pollutants, which include oxides of sulfur, nitrogen and carbon, particulates like dust, smoke, ash, fumes etc. These pollutants when exist in substantial amounts in air can photo-chemically interact with each other and with the other substances in air. The pollutants produced by these interactions are known as secondary pollutants, namely acid vapors, ozone, sulfur trioxide, nitrogen dioxide, sulphates etc. (Hussain, 1998).

The term pollutants mean an undesirable change in the physical, chemical and biological characteristics of air, water and soil that may harm our lives, living conditions and cultural assets. Air pollution is a situation, when ambient atmosphere contains materials in such concentrations which are harmful to man and other living beings (Hamid, 1994). The airborne particulate matter present in the air stream whose individual particle size varies from less than 1 µm to approximately 10 µm can suspend in air for long periods of time. These are inhale-able, if their size reaches to a value of 15 µm (Kenneth and Cecilf, 1981). Airborne particulate matter creates increased risk either directly or indirectly to human health, when inhaled these penetrate deep into the lungs and cause sicknesses of upper respiratory tract (runny or stuffy nose, sinusitis, sore throat, wet cough, head colds, hay fever, red eyes etc,) and lower respiratory tract (wheezing, dry cough, phlegm, shortness of breath etc.) (Miller, 1999). An overall group of air pollutants may cause increased illness, contamination of surface water, impaired growth of agricultural crops, deterioration of materials and loss of amenity through malodor and reduced visibility (Qureshi, 1999).

The soil-dust component is, therefore, an essential part of the total atmospheric aerosol burden (Schutz *et al.*, 1987). Thus, soil-dust is the source of airborne particulate matter caused by uncontrolled disposal of solid waste and chemical in open lands and fields which go to air as a result of erosion of soil by strong winds etc. (Hamid, 1994).

Study of phase analysis of airborne particulate matter is an active field of research (Schutz *et al.*, 1987). The behaviour of airborne particulate matter can best be understood, if its chemical composition is known and for this purpose powder x-ray diffraction technique was applied (Hussain, *et al.*, 1997) to study the chemical composition of airborne particulate matter in the samples collected from selected site of Faisalabad city.

MATERIALS AND METHODS

Materials

Powder x-ray Diffractometer (Rint 2000 series Rigaku), airborne particulate and soil samples collected from selected sites of Faisalabad city. Cotton sieve and steel sieve were used for making the sample free from some unwanted fibrous material. The sieved samples wee ground into a very fine powder by agate mortar and pestle.

Methods

It included sample collection, preparation, loading in the machine, qualitative and quantitative phase analysis.

Sample collection

Airborne particulate matter samples were collected from the air conditioner's filters running at the selected localities in the pre-monsoon months, namely June and July when Punjab experiences dust raising wind storms. Air conditioner filters were cleaned and washed, before these were employed for sample collection. Sampling was carried out for the known periods of weeks. The airborne particulate matter commonly known as dust was collected in the filters. To get the airborne particulate matter, the dusty filters were jolted and the dust was collected and strained for the removal of fibrous material, if any. The samples were stored in clean, dry and capped bottles. Dust samples were collected from industrialized and thickly populated urban areas. The sample collection sites were divided into zone; industrial, industrial cum commercial, commercial, commercial cum residential and exclusively residential areas. The sample collection sites and their locations are given in Table 1.

Table 1. Location of air borne particulate matter sample collection sites

Location
Ghulam Muhammad Abad (Narwala Road)
Kohinoor Flats (Jaranwala Road)
Gulfishan Colony (Jhang Road)
Crescent Sugar Mills (Jhumra Road)
Nazimabad, near old vegetable market
Coca-Cola Factory (Samundry Road)
Zeenat Textile Mills (Sargodha Road)
Peoples Colony (Sityana Road)

Sample preparation

Sample preparation is the most careful and important requirement in the analysis of powder samples by x-ray diffraction particularly for the soils that contain finely divided colloids that are poor reflectors of x-rays. The collected and sieved samples were dried before they were ground by mortar and pestle for long periods until their homogeneous consistent was achieved. Reduction of powders to fine particles ensures enough particle participation in the diffraction process. The recommended size range is 1-5 µm (Kluge and Alexander, 1974; Cullity, 1978) especially if quantification of various phases is required.

Sample loading

Prior to loading into the specific aluminum rectangular sample holder of the Diffractometer, it was thoroughly washed with acetone and cleaned with Kleenex and dried. The samples were pressed gently into the aluminum holders before loading each of them onto the XRD Goniometer.

Qualitative phase analysis

The diffraction patterns of all the samples were obtained along with printout of the diffraction data. The comparison of the observed 'd' values (from XRD data) and calculated 'd' values (from JCPDS cards), mineral phases were identified by applying Hanawalt method (Cullity, 1978).

Quantitative phase analysis

All the samples were also quantitatively analyzed by Chung's matrix Flushing Method (Chung, 1974). The working equation for quantification of different phases in the mixtures was:

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

where Xi is the weight percentage of the mineral, K_i is the relative intensity of the mineral $\left(\frac{I_i}{I_{KCl}} \right) 1:1$ and I_i is the integrated intensity of the mineral.

RESULTS AND DISCUSSION

The phases such as Illite ($K_{0.7}$ Al_2 (Si, Al)$_4$ O_{10} H_2O), Quartz (SiO_2), Albite (NaCl Si_3 O_8), Calcite ($CaCO_3$), Clinochlore ((Mg, Al)$_6$ (Sr, Al)$_4$ O10 (OH)$_8$), Talc (Mg_3 Si_4 O_{10} $(OH)_2$), and Gypsum ($CaSO_4.2H_2O$) were found. The minerals identified in this study are in line with those found by Smith *et al.*, 1996 and Hussain *et al.*, 1997 who had also used X-ray diffraction technique while investigating airborne particulates for the air samples collected from Lahore, Pakistan.

The weight percentage of the identified phases of all the samples was calculated. The results (Table 2) show that Illite was the dominant constituent having weight percentage varying in the range from 70.4%-81.6%. The second largest phase found was albite having weight percentage varying in the range from 8.4% to 15.8%. The third major constituent was calcite with its weight percentage ranging from 5.1% to 11.7%. Quartz was the fourth major phase varying in its weight percentage from 1.1% to 3.5%. Fifth highest phase obtained was Clinochlore having weight percentage varying from 4.4% to 21.5%. Concentration of Gypsum and Talc in air sample was very low lying in the range 0.1%-1.3 and 1.76%-5.3% respectively.

All the minerals present in the airborne particulate samples are injected into the air through wind erosion of soil while presence of gypsum and talc in the air particulates possible comes from remote areas of our surrounding environment (Hussain *et al.*, 1997). Quartz is an important rock-forming mineral that occurs as a subordinate constituent of many igneous metamorphic and sedimentary rocks and hence is the principal constituent of sand stone. Calcite is also an important rock-forming mineral like calcite marbles, carbon entities and pure limestones. Gypsum is the most

Table 2. Weight percentage of phases in the airborne particulate matter

Phases	Ghulam Muhammad Abad	Koh-e-Noor Flats	Gulfishan Colony	Crescent Sugar Mills	Nazim Abad	Coca Cola Factory	Zeenath Textile Mills	Peoples Colony
Illite	75.6	80.4	71.9	77.2	81.6	71.1	70.4	74.4
Albite	8.4	8.9	15.8	9.08	9.0	8.5	8.46	9.38
Calcite	8.2	7.2	11.7	5.1	6.98	6.8	6.04	7.6
Quartz	2.4	2.0	3.5	1.1	2.3	1.1	2.51	1.5
Clinochlore	0	0	21.5	4.4	0	8.93	9.76	5.2
Gypsum	0	1.3	0	0.9	0	0	0.1	0
Talc	5.3	0	4.5	1.9	0	3.3	1.76	0

common of sulphates minerals. Talc is silicated and hydrated magnesium. Illite is mica-type clay minerals. The soil compounds detected in the air particulate samples are poor nucleant of ice in the atmosphere; they stay suspended in the atmosphere long depending on their size. The smaller the size of the particle, the longer will be its residence in the atmosphere. If the air borne particles is poor nucleant, they will not be utilized and hence not washed out from the atmosphere and stay as pollutant (Hussain *et al.*, 1997). Since the detected particles are poor nucleant, they are behaving as pollution for the Faisalabad environment.

The study of airborne particulate matter is necessary for its effects not only on human health but also on vegetation and its acidic effects on the soil it lands on. Particulate of sizes greater than 16 µm are filtered out in upper respiratory system. Approximately 30% of the particles from 3 µm to 5 µm are deposited in lower respiratory system while about 70% of particles from 0.02 µm to 0.2 µm are deposited in the pulmonary system. Further, the elderly and those with heart and lung disease are at a greater risk of premature mortality due to particulate air pollution (Ferron *et al.*, 1988). Quartz is very dangerous as on inhaling its fine particles go deep into the lungs and trapped there causing bronchitis, pneumonia etc. a health threat to Faisalabadies.

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