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Viscoelastic Profile of Solid Aerosols (Soft Matter) Generated From Different Industries of Faisalabad

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Abstract

The physical and viscoelastic profile of industrial aerosols generated from different industries of Faisalabad were investigated not only to improve the industrial setup efficiency but also to reduce the environmental pollution generated due to these industries. XRPD technique was employed to study these samples which showed the presence of illite, Quartz, calcite, dolomite, gypsum and chlorite as major phases. From the overall study of viscoelastic profile of solid aerosols, it looks quite evident that solid aerosols collected from specially selected sites showed mixed behavior. 2KMS-P_1 and 2KMS-P_4 are showing warming trend. On the other hand 2KMS-P_2 and 2KMS-P_3 are showing cooling trend while 2KMS-P_5 is the only pool showing approximately neutral trend. On the average, the behavior of environment is nearly neutral and global warming decreases in the order 2KMS-P_1>2KMS-P_4>2KMS-P_5>2KMS-P_3>2KMS-P_2 as we move from highly polluted industrial areas to cleaner residential areas. The SEM analysis of solid aerosols showed the presence of a variety of patches but confirms the dominance of industrial cum transportational aerosol's interlocking and soot particles solid aerosol concentration and hence friction will act as main environmental adjuster and pollution controller through the adjustment of viscoelastic profile like softness and hardness on behalf of variations in climatology and ecological disturbance. Finally comprehensive research and administrative based solution to tackle the issue without affecting the development process is suggested.

Key Words: ***Industrial solid aerosols, mix behaviour, industrial cum transportational interlocking, soot particles, over all neutral trend, friction the main adjuster, pollution controller, viscoelastic profile and ecological disturbance.***

ISSN: 2348 9510
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Volume 2, Issue 1, April 2015

1. Introduction

A gaseous blanket, called atmosphere surrounds the earth. The atmosphere consists of mixture of gases and small particles collectively called air. Natural air differs from place to place around the globe because air is not a single chemical compound like water. The atmosphere is 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 interacts with the environment to cause toxicity, disease, aesthetic distress is known as "pollutant". By air pollution it means the Suspended Particulate Matter (SPM) present in the air stream whose individual particle size varies from less than 1µm to approximately 100 µm. These particles suspended in air for long periods of time and become inhale if their size reaches to a value of 15 µm [1]. Particulate matter, which causes air pollution, includes dust, dirt, soot, smoke and liquid droplets. These are given out directly from their sources into the atmosphere. Particles in the air are very important source of air pollution. There are 2×10^6 dust particles in every cubic foot of air. With every breathers man inhale 2×10^4 to 7×10^4 dust particles. Particulate matter is frequently divided in subclasses, which include fine dust (less than 100 µm in diameter), coarse dust (above 100 µm in diameter), fumes (0.001- 1.0 µm in diameter) and mist (0.1-10 µm in diameter). Fumes are particles formed by condensation, sublimation or chemical reactions and sometimes are designated as smoke. Mist is comprised of liquid particles formed by condensation and is fairly large in diameter compare to smoke or fumes [2-13].

The study of solid aerosols is necessary not only for its physical viscoelastic profile but also for their effects on human health, vegetation and its acidic effects on the soil. Particles of size 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 [14-17].

Solid aerosol aggregates composed of cross linked suspended particulate matter cemented through organic or inorganic matter in the presence of water through dipoles during this process then compresses or relaxed making them closer and hence can be packed to effective volume fraction much greater than the random close packing limit for hard spheres even at such close packing thermally activated solid aerosols rearrange still exist allowing the aggregates to accommodate stress applied from outside. How even the complete understanding of such types of arrangements is still unprictedable and it is very difficult to guess internal properties like deformability, compressibility, rigidity, stability, flexibility, elasticity and plasticity.

Faisalabad, the Manchester of Pakistan, is the biggest industrial city of the country. Textile

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Volume 2, Issue 1, April 2015

related industry is spread in and around all parts of the city without the distinction of locality. This heavy industry in the SPM samples in the industrial areas of Faisalabad. Measurement of the minerals present in the samples along with thermal events taking place during formation and deformation of solid aerosols aggregates may give us a chance to compare our results with national and international studies along with the investigation effects of these pollutants on human health. This study will help in strategic planning in order to reduce the injurious effects of pollution [18-22].

2. Materials And Methods

Solid aerosol samples were collected from the randomly selected industrial areas of Faisalabad city. The dust present in the environment of the selected sites will be collected by jolting from the filters of the air conditioners, which ran during the season under observation. The dust samples were strained to remove fibrous material after that the sample was dried to reduce humidity. The samples were grind to make them homogenous before XRD analysis. The analysis of the samples was carried out by means of X-ray diffractometer and industrialization was found to be the major fact to cause air pollution in general and solid aerosol as specific pollution in Faisalabad. During past decade different techniques have been developed which enable the research to study the particulate matter and soil.

The present research work will include the study of phsyico-chemical characterization and viscoelastic profile of the compounds present. [23,24].

2.1 Sample Collection

Samples were collected from selected industrial areas of Faisalabad city keeping in view all the types of industries having dominant effect on the Faisalabad environment covering (5×5) Km grid using SRS technique and space syntax map method. The detail is given in Table 1:

2.2 Sample Loading

The samples were loaded at the Goniometer one by one and XRD patterns were obtained under controlled experimental conditions.

2.3 Qualitative Phase Analysis

In the present paper we have described the well established experimental technique. This is suitable for determining the viscoelastic properties of solid aerosols capable of retaining their shapes for considerable length of time in the absence of thermo dynamical disruptive forces making the environment stable. To date we have found no published method for the same purpose. Moreover this novel technique can also be utilized for measuring the other viscoelastic quantities of solid aerosols. Viscoelastic aerosols combine the features of solid aerosols with those of liquids. They may be pure elastic bodies and follow Hook's law or they

ISSN: 2348 9510
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Volume 2, Issue 1, April 2015

may be pure liquids and follow Newton's law of flow. In this way solid aerosols were closely linked with the said dual behavior and may disturb the ecological balance. The most important physical quantities required for characterizing the viscoelastic aerosols are particle size, stress, strain and yield strength. As each crystalline material gives a unique X-ray diffraction pattern. Qualitative phase analysis was used for study of crystal structure and unknown phases of material. In XRPD pattern there were two parameters (Bragg's angle and integrated intensities). Bragg's equation is used to find the d-value corresponding to Bragg's angles. The d-values which were obtained from samples were compared with standard values. This was done by employing the Joint Committee Powder Diffraction Standard (JCPDS) file method. With the help of JCPDS, the existence of different minerals in the sample was confirmed.

Table 1: Sample Location & Coding

Type of Industry	Codes
Arzoo Textile	$2KAR_T$ 01
Fatime Textile	2 KF_T 02
Sitra Chemical	$2KS_c$ 03
Masood Textile	$2KM_T$ 04
Happliac Paints	2KHp 05
Ahsan Yousaf Textile	$2KAY_T$ 06
Zeenat Textile	$2KZ_T$ 07
Rasheed Textile	$2KR_T$ 08
Crescent Textile	$2KC_T$ 09
Industrial Free Area	2KIFA 10
2K Special1	2K Mix 01 (1-5)
2KSpecial2	2 K Mix 02 (6-10)

2.4 The Hanawalt Method

The principle of identification of substances by powder x-ray diffraction is based on the fact that every crystalline material gives its own characteristics pattern. This pattern of material in a mixture form is independent of others. The powder data of crystalline material is now published by ICDD (International Center for Diffraction Data) in the form of cards. Each card contains the name of material studied by the powder x-ray diffraction and corresponding miller planes of reflections belong to the materials. A search manual (index book) is also published by the ICDD which contains maximum intensity reflections of all the identified crystalline materials.

ISSN: 2348 9510
International Journal Of Core Engineering & Management (IJCEM)
Volume 2, Issue 1, April 2015

2.5 Quantitative Phase Analysis

2.5.1 Matrix Flushing Method

This method provides the exact relationship between intensity and concentration free from matrix effects. This method is very useful because amount of amorphous phase content present in the other crystalline phases can also be detected. The maximum error in quantifying a phase in a mixture by the matrix flushing method had been estimated to be 80% relative. This method was applicable when all phases in the mixtures were in crystalline form. In this method a fundamental matrix flushing concept was introduced.
Let xi be the weight fraction of a component "i" in the mixture of "n" components then basic intensity equation could be written as

Ii = KiXi ……………………. (1)

Where K is a constant.

For quantitative analysis of mixture of n components the above equation became a matrix equation:

[I]= [KX]………………… (2)

The equation had a unique solution if the rank of K was equal to the rank of the (K, 1) matrix. The equation will be of the form:

$Xi= [Ki/Ii (n \sum j=1Ij/Kj)]^{-1} \times 100$ …………………. (3)

The above relation gave the percentage composition of a component i in mixture of n components. In equation (3) Ii is integrated intensity and Ki is relative intensity ratio given by

$Ki= [Ij/I_{kcl}]_{50/50}$

This ratio can be calculated by mixing the component i with the standard material KCl in the ratio 1:1. The relative intensity calculated for the seven minerals are shown in a Table 2:

ISSN: 2348 9510
International Journal Of Core Engineering & Management (IJCEM)
Volume 2, Issue 1, April 2015

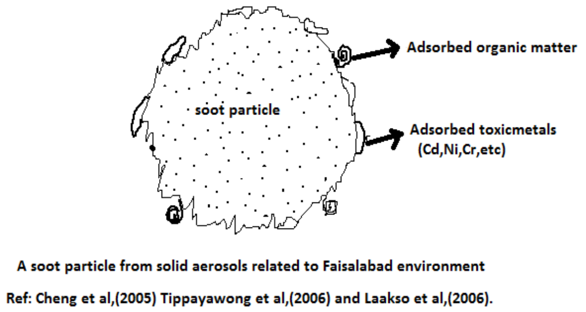

Figure 1: Colloidal composite formation from solid aerosols related to Faisalabad Environment

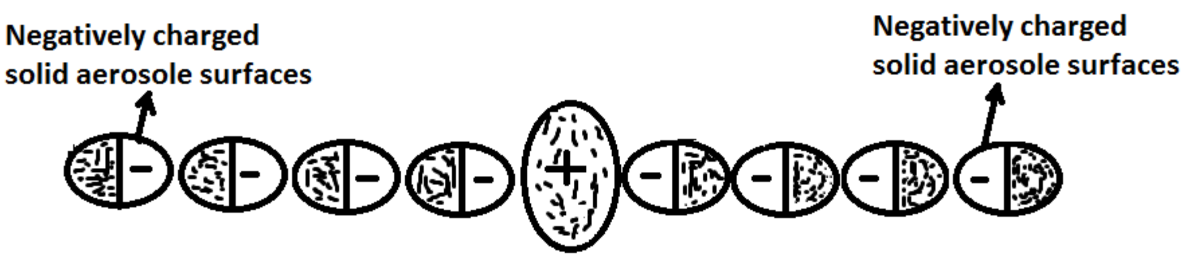

Figure 2: Composite structure Formation for Solid aerosols

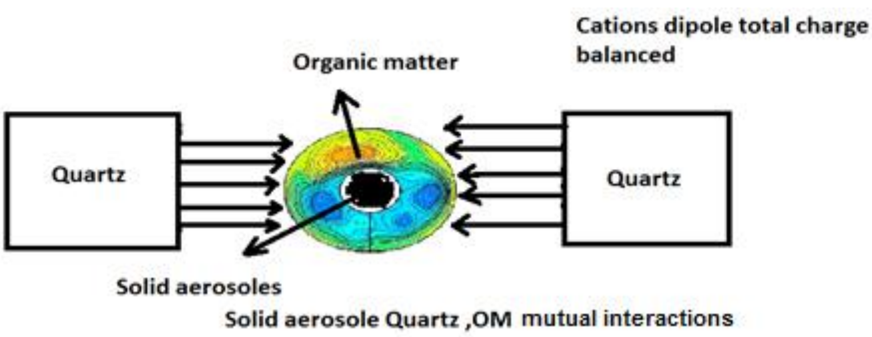

Figure 3: Solid Aerosol quartz, OM mutual interactions

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ISSN: 2348 9510

International Journal Of Core Engineering & Management (IJCEM)
Volume 2, Issue 1, April 2015

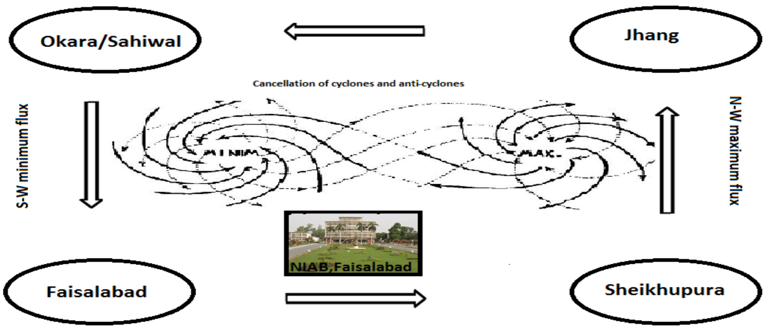
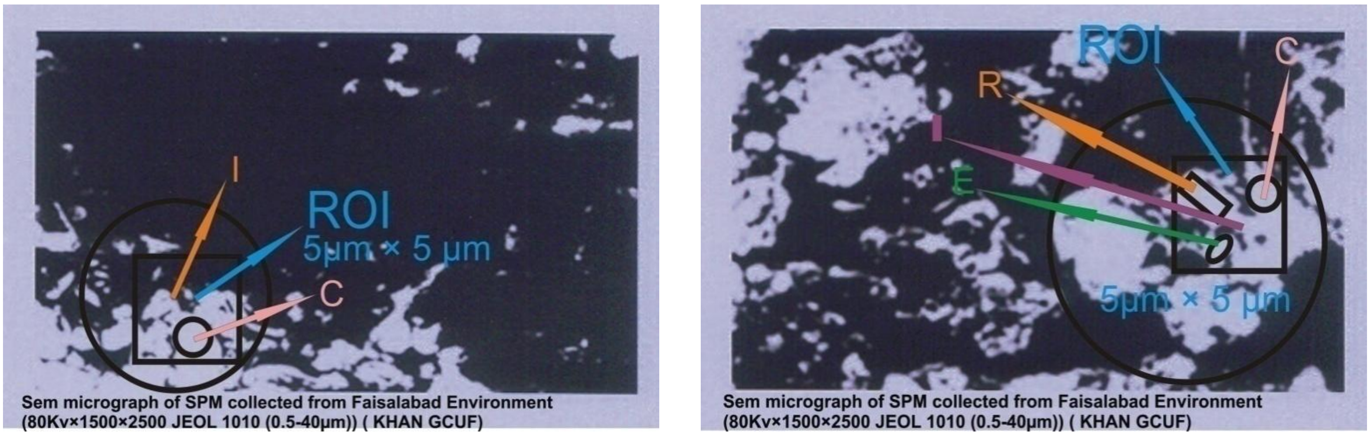


Figure 4: Cyclone and Anti-cyclone mixation and Trend of Identified Pollutant Web

Figure 5: SEM Micrograph of colloidal composites from solid aerosols related to



Faisalabad Environment

2.6 Determination of Viscoelastic profile of Atmospheric Solid Aerosols

The investigation of viscoelastic profile of atmospheric solid aerosols is an important aspect regarding Air pollution and Atmospheric research both scientifically and technologically. It has become the object of prior attention for scientific community due to the understanding of plasticity or elasticity of environment depending upon the size of solid aerosol particles, on behalf of which stability or instability of the environment or atmosphere is checked. According to many present theories, attempt has been made to relate many parameters like particle size, stress, strain, Young's Modulus and yield strength to study viscoelastic profile of solid aerosols. The formulae used in these theories are very complex and require experimental set up for their execution. In this study an attempt has been made to use very

ISSN: 2348 9510
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Volume 2, Issue 1, April 2015

simple and well-established empirical relations which give the same results as the actual ones generated by applied theories and modern experimental set up. The required formulae for the determination of viscoelastic profile are also presented under headings: particle size, stress, strain and yield strength in the form of empirical relations [25-30].

2.6.1 Particle Size

Particle size was determined using the famous Debye-Scherrer formula

$t = \frac{K\lambda}{B\cos\theta_{avg}}$, where $k = 0.92$, $\lambda = 1.54056A_{\circ}$, $B = \text{FWHM in radians}$ and $\theta_{avg} = (\theta_1 + \theta_2)/2$.

2.6.2 Stress

Stress was calculated by using following formula

$S = \frac{d_{(obs)} - d_{(s)}}{d_{(s)}}$, where $d_{(s)}$ is the standard value of d and $d_{(obs)}$ is the value of d calculated from Bragg's Diffraction Law such as $d_{(obs)} = \frac{\lambda}{2\sin\theta}$.

2.6.3 Strain

Strain was calculated using formula $B\cos\theta_{avg} = \frac{K\lambda}{t + 4\eta\sin\theta_{avg}}$.

2.6.4 Yield Strength

It is calculated using formula $\sigma_y = \sigma_{\circ} + Kt^{-1/2}$, where $\sigma_{\circ}$ is the stress required to move dislocations; K is a material constant t is the particle/grain size.

Critically speaking, the field of viscoelastic profile of atmospheric aerosol's research is and should remain a favorable subject for atmospheric research because a very little work has been done in this regard up till now.

3. Results and Discussion

We have presented a novel analytical method based on XRD dirrractometry that allows quantitative analysis of the viscoelastic profile of solid aerosols (soft matter) during suspension in the environment on the basis of their XRD data. We have shown that the said approach will be especially useful and unique for providing not only the phsico-mechanical

ISSN: 2348 9510
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Volume 2, Issue 1, April 2015

information but also the effect of relative humidity during sampling period as a function of peak broadening or peak shortening. We anticipate the approach will be especially useful for quantitative studies of the spatially resolved hygroscopic and hydroscopic properties of solid aerosols with complex mixing states on behalf of structure crystalarity and amorphous contents in the composite sample (soft matter) as the viscoelastic profile are inherently related to stress and strain. Therefore study of viscoelastic profile of solid aerosols (soft matter) is important to the context of both environmental degradation and seasonal abnormalities due to their direct and indirect effect on radiation budget. Moreover such type of studies will also be helpful in estimating global warming, global cooling trends, cloud composition and microphysical phenomena occurring in the atmosphere.

The Compound phases such as Albite, Quartz, Illite, Calcite, Talc, Gypsum and Clinochlore were present in the almost all the solid aerosols samples as major phases. Clinochlore was found absent in the mixed sample 1 and Gypsum from mix samples 2 and II and VIII and Talc was found only in one sample that is Zeenat Textile Mills, Faisalabad the reason behind that is due to their basic and neutral nature after mixing with Acidic Mineral they have Neutralize themselves and disappear. The second reason may be due to their hydrophobic nature they take part in texture aggregation processes being an ideal colloidal nucleus they will become the part of the major environment and stabilize themselves.

Table 2: Relative Intensity of Solid Aerosols Samples with KCl

Compound/ minerals	**Relative intensity Ki= Ii/I_{kcl}**
Quartz	0.85
Illite	0.20
Talc	0.32
Gypsum	0.83
Chlorite/Chlinochlore	0.23
Albite	0.36
Calcite	0.74

Table 3: Relative intensities and identified phases for 2k mix01 sample (1-5)

P.No.	**20 degree**	**d-value**	**Integrated Intensity I_1**	**Identified Phases**
1	20.743	4.2823	124.669	Q
2	20.542	3.3583	691.412	Q,L
3	29.390	3.0390	513.110	CA
4	39.400	2.2870	133.103	CA,Q

ISSN: 2348 9510
International Journal Of Core Engineering & Management (IJCEM)
Volume 2, Issue 1, April 2015

5	43.382	2.0858	416.654	AL,CA
6	45.448	1.9957	62.301	AL,G
7	47.385	1.9185	81.300	IL,Q
8	50.101	1.8207	169.832	G,Q
9	68.015	1.3772	73.213	Q

Table 4: Relative intensities and identified phases for 2kmix 02 sample (6-10)

P.No.	20 degree	d-value	Integrated Intensity I_1	Identified Phases
1	26.590	3.3524	607.224	Q ,IL
2	29.438	3.0342	240.785	CA
3	39.371	2.2886	95.237	CA,Q
4	43.345	2.0852	337.167	AL,CA
5	50.242	1.8759	52.719	AL,G
6	59.871	1.5449	106.989	CL
7	68.039	1.3768	83.641	CA, Q

Table 5: Weight Percentage of different identified Phases in Solid Aerosol Samples

Identified Phases	Arzoo Textile 2KART01 S-I	Fatime Textile 2KFT02 S-II	Sitra Chemical 2KSC03 S-III	Masood Textile 2KMT04 S-IV	Happliac Paints 2KHP05 S-V	Ahsan Yousaf Textile 2KAYT06 S-VI	Zeenat Textile 2KZT07 S-VII	Rasheed Textile 2KRT08 S-VIII	Crescent Textile 2KCT09 S-IX	Industrial Free Area 2KIFA10 S-X	Average
Illite (IL)	37.87	30.78	32.09	30.65	31.47	31.21	33.81	32.39	31.87	30.597	32.27
Quartz (Q)	15.37	30.78	32.09	30.65	31.47	31.21	33.81	32.39	31.87	30.597	30.02
Albite (AL)	13.39	15.37	10.29	5.04	7.74	9.00	3.29	9.44	12.05	12.77	10.25
Calcite (CA)	15.37	15.37	12.01	14.88	14.52	11.38	10.24	18.21	6.77	12.71	12.97

ISSN: 2348 9510
International Journal Of Core Engineering & Management (IJCEM)
Volume 2, Issue 1, April 2015

Clichlore (CL)	12.44	7.68	5.66	4.29	9.68	8.18	5.63	7.06	7.34	8.43	7.68
Gypsum (G)	5.44	ND	7.84	14.88	5.08	9.00	10.24	ND	10.09	4.94	6.76
Talc (T)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.29

Table 6: Weight Percentage of Identified Phases in mix samples (comparative study)

Identified Phases	2k Mix 01	2k Mix 01	Average
Illite (IL)	28.73	32.27	30.5
Quartz (Q)	28.73	30.02	29.37
Albite (AL)	16.61	10.25	13.43
Calcite (CA)	1855	12.97	15.76
Clichlore (CL)	2.61	7.68	5.14
Gypsum (G)	4.70	6.76	5.73
Talc (T)	ND	0.29	0.14

Table 7: Nature of the origin for Identified Phases

Identified Phase	Wt. % age	Local / Remote	Origin
IL	30.5	Local cum remote	Soil dust; Glass Cum Mica manufacturing Industries
Q	29.37	Local Only	Soil dust; Construction and Building Materials
AL	13.43	Local Only	Soil dust; ceramic and plaster of Paris Manufacturing Industrial Units
CA	15.76	Local Only	Soil dust; constructions & Road Building materials, ceramics manufacturing Industrial Units
CL	5.14	Local cum remote	Soil dust; constructions & Road Building materials, ceramics manufacturing Industrial Units along with fertilizer manufacturing units
G	5.73	Local cum	remote Soil dust; Glass Cum Mica Manufacturing

ISSN: 2348 9510
International Journal Of Core Engineering & Management (IJCEM)
Volume 2, Issue 1, April 2015

		remote	Industries
T	0.14	Remote Only	Plastics; paints and soap manufacturing Industrial Units

Table 8: Weight Percentages of Identified Phases in specially mixed samples (comparative study)

Identified Phases	2k Mix Special 01	2k Mix Special 02	Average
Illite (IL)	27.82	29.64	28.73
Quartz (Q)	27.82	29.64	28.73
Albite (AL)	16.78	16.45	16.61
Calcite (CA)	20.66	16.45	18.55
Clichlore (CL)	ND	5.22	2.61
Gypsum (G)	6.84	2.57	4.70
Talc (T)	ND	ND	ND

To confirm these findings Faisalabad environment was checked by using the microscopic analysis of the solid aerosols shown in the micrograms and was found correct. The possible justification is that due to the presence of fly ash, road dust and pollens present in the Faisalabad environment are synthesized by micro organisms gain positively and negatively charged groups as shown in fig (1-3) have interlocked the identified phases into patches, the oval and irregular shapes of the majority of the samples also support our justification. (Confirmation of Presence of Fibrous Material) which shows semi transparent, semi opaque stack emission of industrial pollutants in the Faisalabad environment with mixed plume behavior i.e. 72 % looping and 28% lofting trend making pollutant web North (N) to West (W) direction has high concentration i.e. maximum load of solid aerosols (Sheikhupura to Jhang, pollutant gradiant = +ve) while South (S) to East (E) direction has low concentration i.e. minimum load of solid aerosols (Sahiwal /Okara to Sheikhupura and converse, pollutant gradient = -ve). In other two directions pollutant gradient =0, due to cancellation of cyclones and anti-cyclones. In a cyclic fashion depending upon geological, geographical, climatogical and meteorological set up of the area under investigation as shown in fig (4) which combines the features of solid aerosols partly pure elastic following Hook's law and partly inelastic following Newton's las of flow, such type of dual viscoelastic behavior may be the cause of ecological imbalance of Faisalabad environment and formation of pollutant web in and around Faisalabad detected by Mr Khan during his PhD project.

Source pattern of SEM micrographs closely related to biomass combustion and natural and man made air pollution sources which are clear indication of the industrial disturbance into

ISSN: 2348 9510
International Journal Of Core Engineering & Management (IJCEM)
Volume 2, Issue 1, April 2015

the environmental set up of the related area and the physiomechanical changes taking place in the environment because of industrial set up. 80% dark color of solid aerosols also confirms our experimental findings that organic matter has been decayed in the environment [25].In micrograph figure 1 and figure 2 (supporting information) it can be shown from these images that all solid aerosol samples were obtained as agglomerate non spherical particles with rough surfaces. XRD patterns analyzed using scherrer equation and other related empirical expressions also showed the same tendency in sample sizes and shapes depending upon thermal energy generated from industrial and transformation in the environment which means that climatology and metrology of the environment plays an important role in the neutrality and homogeneity of the environment mixing and missing of large number of peaks in XRD pattern also showed the mixing of crystalline and amorphous phases of solid aerosols and hence the heterogeneity and complexity of the Faisalabad environment.

In order to check the elasticity and stability of Faisalabad environment, viscoelastic characteristics of solid aerosols like particle size, stress, strain and yield strength have been determined using XRPD patterns along with standard empirical relations. Table 9 shows the viscoelastic profile of sample 2KMS-P_1. It is clear from the table that particle size is varying from 10.13 nm to 21.36 nm with a critical size 15.24nm. 63.64% particles have greater size and expansion thus absorbing incoming radiations giving rise to global warming while 36.36% particles are showing converse behavior [31-35].

Table 9: Viscoelastic profile of 2KMS-P_1

Sr. No.	Size(t) A^o	strain	Stress	Yield Strength
1	201.7545	0.000825	-0.44745	37704.7
2	105.9046	-0.0015	-0.405	30783.2
3	106.554	-0.00145	-0.22544	12856.7
4	145.1576	-0.00018	-0.22832	14532.3
5	163.9325	0.000225	-0.38298	30487.7
6	101.354	-0.0017	-0.35563	25629.6
7	152.4398	-2E-07	-0.34684	26584.8
8	166.8308	0.0003	-0.38587	30845.3
9	162.2754	0.0002	-0.38443	30592.7
10	213.5965	0.000975	-0.40888	34046.1
11	212.503	0.00095	-0.4009	33230.3

Table (10) shows the viscoelastic profile of sample 2KMS-P_2. It is clear from the table that particle size is varying from 7.99nm to 31.08nm with a critical size 12.77nm. 25% particles have greater size and expansion thus absorbing incoming radiations giving rise to global warming while 75% particles are showing converse behavior.

ISSN: 2348 9510
International Journal Of Core Engineering & Management (IJCEM)
Volume 2, Issue 1, April 2015

Table 10: Viscoelastic profile of 2KMS-P_2

Sr. No.	Size (t) A^o	strain	Stress	Yield Strength
1	79.99075	-0.0028	-0.45745	34563.7
2	105.0969	-0.0011	-0.42944	33189.2
3	106.4469	-0.001	-0.44107	34415
4	143.2659	0.0004	-0.41198	32843
5	108.7164	-0.0009	-0.3105	21458.8
6	116.9947	-0.0005	-0.17588	8343.23
7	127.7381	-0.0001	-0.41614	32766.4
8	310.7695	0.0026	-0.38192	32519.9

Table (11) shows the viscoelastic profile of sample 2KMS-P_3. It is clear from the table that particle size is varying from 5.84nm to 24.87nm with a critical size 14.26nm. 30.77% particles have greater size and expansion thus absorbing incoming radiations giving rise to global warming while 69.23% particles are showing converse behavior.

Table 11: Viscoelastic profile of 2KMS-P_3

Sr. No.	Size (t) A^o	strain	Stress	Yield Strength
1	100.7486	-0.00163	-0.28419	18456.2
2	58.43296	-0.00548	-0.3118	18097.9
3	139.0917	-0.00015	-0.31189	22710.1
4	208.2648	0.001125	-0.24984	18054.9
5	141.5322	-0.0001	-0.22795	14389
6	85.85828	-0.00255	-0.25334	14541.3
7	146.3327	0.000025	-0.27087	18820.8
8	115.8563	-0.00093	-0.31837	22546
19	137.3289	-0.0002	-0.30489	21955.6
10	248.6783	0.00155	-0.25893	19551.4
11	142.6252	-0.00005	-0.22357	13984.1
12	131.625	-0.00038	-0.22996	14279.6
13	191.6573	0.0009	-0.25281	18058.1

Table (12) shows the viscoelastic profile of sample 2KMS-P_4. It is clear from the table that particle size is varying from 10.93nm to 27.13nm with a critical size 12.85nm. 57.14% particles have greater size and expansion thus absorbing incoming radiations giving rise to global warming while 42.86% particles are showing converse behavior.

ISSN: 2348 9510
International Journal Of Core Engineering & Management (IJCEM)
Volume 2, Issue 1, April 2015

Table 12: Viscoelastic profile of 2KMS-P_4

Sr. No.	Size (t) A^o	Strain	Stress	Yield Strength
1	170.4892	0.00025	-0.45204	37545
2	122.6703	-0.00088	-0.4552	36490.9
3	109.2669	-0.00135	-0.43168	33601.7
4	218.7239	0.0009	-0.40532	33769.9
5	111.8508	-0.00125	-0.27247	17791.7
6	114.6614	-0.00115	-0.22525	13185.8
7	261.3862	0.00125	-0.28823	22637.7
8	128.5127	-0.00068	-0.34119	25298.1
9	166.6357	0.0002	-0.39023	31276.4
10	200.299	0.000675	-0.39311	32244.9
11	123.9633	-0.00083	-0.3898	29998.1
12	255.3186	0.001225	-0.38318	32059.4
13	195.7354	0.000625	-0.36241	29093.5
14	271.2773	0.001325	-0.35888	29817

Table (13) shows the viscoelastic profile of sample 2KMS-P_5. It is clear from the table that particle size is varying from 6.21nm to 16.53nm with a critical size 10.79nm. 44.44% particles have greater size and expansion thus absorbing incoming radiations giving rise to global warming while 55.56% particles are showing converse behavior.

Table 13: Viscoelastic profile of 2KMS-P_5

Sr. No.	Size (t) A^o	Strain	Stress	Yield Strength
1	69.54373	-0.00275	-0.51079	39087.7
2	140.6739	0.001125	-0.35717	27285.6
3	71.08303	-0.00258	-0.34795	22933.8
4	107.9259	-0.00002	-0.32278	22652.4
5	87.54956	-0.00118	-0.32197	21509.6
6	111.3046	0.000125	-0.31803	22324.3
7	90.47914	-0.00098	-0.32909	22396.4
8	77.05627	-0.002	-0.33882	22490.3
9	118.1768	0.0004	-0.36455	27255.9
10	97.76285	-0.00052	-0.36417	26303.6
11	165.2887	0.0017	-0.3529	27511.4
12	63.99156	-0.00342	-0.36567	24066.6
13	134.0833	0.00095	-0.38402	29766

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14	62.14853	-0.00365	-0.35619	22934.6
15	145.7693	0.00128	-0.33465	25182.6
16	106.194	-0.0001	-0.35724	26020.2
17	144.9579	0.00125	-0.367	28394.6
18	127.1095	0.000725	-0.34723	25852.8

From the overall study of viscoelastic profile of solid aerosols, it looks quite evident that solid aerosols collected from specially selected sites showed mixed behavior. 2KMS-P_1 and 2KMS-P_4 are showing warming trend. On the other hand 2KMS-P_2 and 2KMS-P_3 are showing cooling trend while 2KMS-P_5 is the only pool showing approximately neutral trend. On the average, the behavior of environment is nearly neutral and global warming decreases in the order 2KMS-P_1>2KMS-P_4>2KMS-P_5>2KMS-P_3>2KMS-P_2 as we move from highly polluted industrial areas to cleaner residential areas as shown in the table (14).

Table 14: Global Warming and Global Cooling trend on the basis of Viscoelastic profile of Solid Aerosols

Pool Sample	**Global Warming Trend**	**Global Cooling Trend**	**Overall Trend of the Pool**
2KMS-P_1	63.64%	36.36%	Warming
2KMS-P_2	25%	75%	Cooling
2KMS-P_3	30.77%	69.23%	Cooling
2KMS-P_4	57.10%	42.90%	Warming
2KMS-P_5	44.44%	55.56%	Approximate neutral

This suggests that the softness and hardness of the colloidal solid aerosols play an important role in the relaxation mechanism as described by power law and hooks law. This expansion leads to increase in particle size and absorption of light giving rise to global warming. It is also evident from our findings that the presence of gypsum in atmosphere of Faisalabad is due to anthropogenic activities hence causing pollution. On the other hand hydroscopic phases are also present giving rise to contraction of particles causing scattering of light and global cooling. However further work is suggested to reconcile satisfactorily the techniques used in this study and their co-relationship with Morphological structure studies [36-40]. The method described in this study not only provides a simple way for characterizing viscoelastic character of solid aerosols but also can be utilized for a number of applications related to atmospheric dynamics by developing empirical relations between them. In this way our method can serve as valuable tool for the formulation necessary for the environmentalists and atmospheric researchers to develop exact relationships between the physicochemical composition and viscoelastic characteristics and their nucleonic adaptability. We are pursuing active research on the above said lines and we hope to report the novel and valuable results of our investigations in subsequent publication very soon [51-60].

4. Conclusion

From the said discussion we arrived on the following important conclusions.

- Quartz, illite, calcite, talc and gypsum were identified as major phases with soil derived origin.
- Hydroscopic nature and presence of microorganisms in the environment is the main reason for colloidal nature of solid aerosols confirmed through SEM micrographs.
- Solid aggregates exhibits a transition from elastic behavior as the concentration of solid aerosols increases and shape of the aggregate is deformed in other words more be the aerosols more be the friction more be the deformation and converse.
- Briefly speaking friction controls the dynamics of aerosol rearrangements, viscoelastic behavior along with ecological balance disturbance and formation of pollutant web detected by Mr. Khan in his PhD project. Hence by controlling friction i.e. reducing the amount of microorganism we can control the atmospheric pollution and presence of pollutant web.

5. Future Recommendation

The present study is a humble attempt on the subject. It is the need of the hour that concerned departments and agencies must take keen interest and put more efforts for aerosol monitoring on a large scale to find out the physico-mechanical changes taking place in the environment due to abnormal expansion of industry and transport in and around residential cum commercial areas of Faisalabad. Small township schemes along with all basic necessities of life should be launched to reduce the migration of population burden towards the industrial city like Faisalabad so that the physico-mechanical cum ecological changes taking place in the environment can be minimized.

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