Physico-Chemical Analysis of Solid Aerosols Generated from Different Industries of Faisalabad

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Abstract: The physical, chemical and electrical characteristics of industrial aerosols generated from different industries of Faisalabad were investigated not only to improve the industrial setup efficiency but also to reduce the environment 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. The values of resistivity of solid aerosols are in high range (0.07×10^7 to 4.0×10^9 Ωm) conversely the electrical conductivities are in lower range (0.21-13.30Mho), may be due to high components of Fe_2O_3 and CaO. Coal fly ash and foundry aerosols do precipitate well in the electrostatic precipitator given their operational temperature and moisture content so it is recommended that by changing the temperature and moisture content of the precipitator its cleaning action and hence the industrial efficiency may be improved. The most of the solid aerosols are alkaline therefore acidic rain probability in near future is completely ruled out. 80% basic (Dark color), 20% acidic (light color) of particulate matter confirms our experimental findings. The SEM analysis of particulate matter showed the presence of a variety of patches but confirms the dominance of industrial cum transportational aerosols interlocking and soot particles. Finally comprehensive research and administrative based solution to tackle the issue without affecting the development process is suggested.

Keywords: Industrial solid aerosols, high resistively, low conductivity, industrial cum transportational interlocking, soot particles.

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 there 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 SPM is necessary for its 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].

Faisalabad, the Manchester of Pakistan, is the biggest industrial city of the country. Textile related industry is spread in and around all parts of the city without the distinction of locality. This heavy industry is the root cause of the air pollution in Faisalabad. So industrialization is the major fact to cause air pollution in general and SPM pollution in Faisalabad. (During past decade different techniques have been developed which enable the research to study the particulate matter and soil).

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The present research work will include the study of phase analysis and the characterization of the compounds present in the SPM samples in the industrial areas of Faisalabad. Measurement of the minerals present in the samples 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 [1, 18-22].

2. MATERIALS AND METHODS

Suspended Particulate Matter (SPM) 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 [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 method. The detail is given in Table **1**:

Table 1: Sample Location & Coding

Type of Industry	Codes
Arzoo Textile	$2KAR_T$ 01
Fatime Textile	$2KF_T$ 02
Sitra Chemical	$2KS_C$ 03
Masood Textile	$2KM_T$ 04
Happliac Paints	$2KH_P$ 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	2K Mix 02(6-10)

2.2. Sample Preparation

All the samples were taken from the filters of the air conditioners. A square disk of glass and a disk of Al with hole was taken the specimen was fitted in the hole and then pressed to remove extra material.

2.3. Sample Loading

The samples were loaded at the Goniometer.

2.4. Qualitative Phase Analysis

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.

2.5. 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.

2.6. Quantitative Phase Analysis

2.6.1. 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:

$I_i = K_i X_i$ ………………… (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:

$X_i = [K_i/I_i\ ({}^{n}\sum_{j=1} I_j/K_j)]^{-1} \times 100$…………………. (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

$$K_i = [I_j/I_{kcl}]_{50/50}$$

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**:

In the present study, quantitative phase analysis of solid aerosols was carried out by powder x-ray diffraction method to identify the phase of the compounds.

2.7. Determination of pH and EC

The pH value of each sample was determined by using Orion research pH meter model 701- A. The pH meter was dipped in a beaker having (SA +H_2O 1:1) solution and values were noted for each sample. EC of each sample was measured by using L.F.90 Conductivity meter model (SA +H_2O 1:1) taken in a beaker & properly calibrated. Conductance meter rod was dipped into the beaker and conductance was noted.

2.8. Determination of Mechanical Properties of Atmospheric Solid Aerosols

The investigation of mechanical properties 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 mechanical properties of solid aerosols. The formulae used in these theories are very complex and require rigorous experimental set up for their execution. In this study an attempt has been made to use very simple and well-established empirical relations which give the same results as the actual ones generated by applied

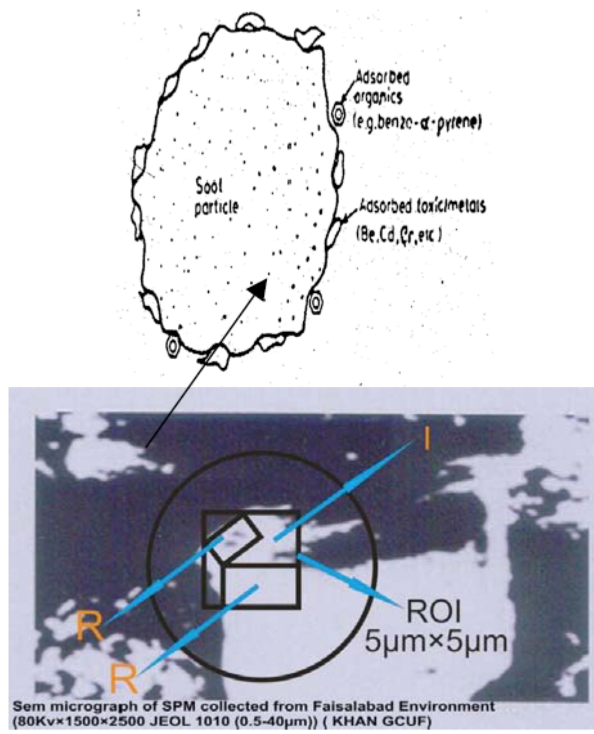
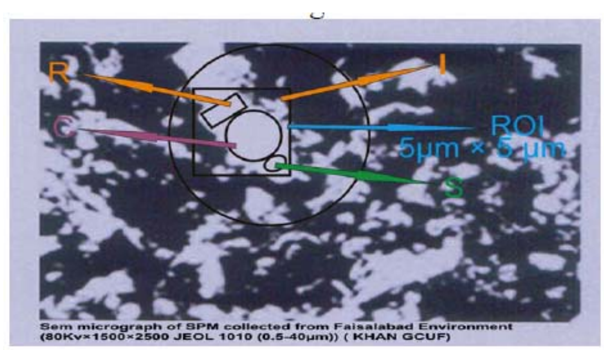


Figure 1: Soot particle from solid aerosols related to Faisalabad environment.



S^3I - 2SEM MICROGRAPH

Figure 2:

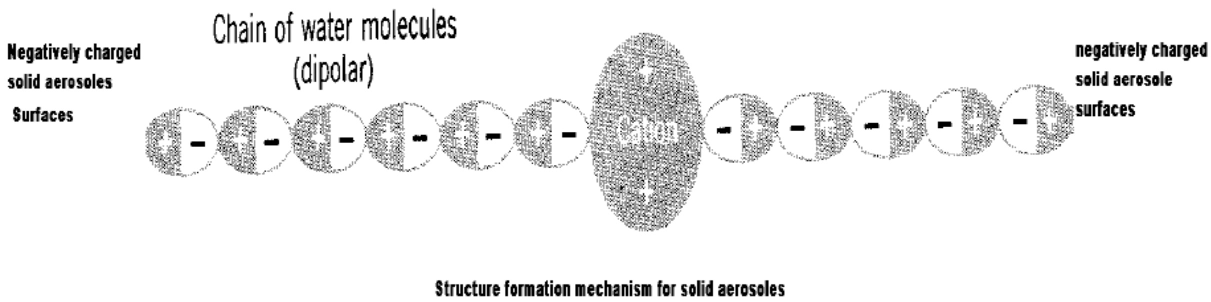


Figure 3:

theories and modern experimental set up. The required formulae for the determination of mechanical properties are given below

2.8.1. Particle Size

Particle size was determined using the famous Debye-Scherrer formula

$$t = \frac{K\lambda}{BCOS(\theta_{avg})}$$

Where

K = 0.92

$\lambda = 1.54056A^{o}$

B = FWHM in radians

$$\theta_{avg} = (\theta_1 + \theta_2)/2$$

2.8.2. 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

$$d_{(obs)} = \frac{\lambda}{2\sin\theta}$$

2.8.3. Strain

Strain was calculated using formula

$$BCOS(\theta_{avg}) = \frac{K\lambda}{t} + 4\eta \sin\theta_{avg}$$

2.8.4. Yield Strength

It is calculated using formula

$$\sigma_y = \sigma_0 + k t^{-1/2}$$

Where σ_0 is the stress required to move dislocations, K is a material constant t is the particle/grain size.

Critically speaking, the field of mechanical properties 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.

3. RESULTS AND DISCUSSION

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 aggregations processes being and ideal colloidal nuclei 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= I_i/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: For 2k mix01 (1-5)

P. No.	20 (degree)	d-values	Integrated intensity I1	Phases
1	20.743	4.2823	124.669	Q
2	20.542	3.3583	691.412	Q, IL
3	29.390	3.0390	513.110	CA
4	39.400	2.2870	133.103	CA, Q
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: For 2kmix 02(6-10)

P. No.	20 (degree)	d-values	Integrated intensity I1	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: Concentration Data in Weight Percentage of Phases in the Ten Solid Aerosols Samples

Phases	Arzoo Textile $2KAR_T$ 01 S-I	Fatime Textile $2KF_T$ 02 S-II	Sitra Chemical $2KS_C$ 03 S-III	Masood Textile $2KM_T$ 04 S-IV	Happliac Paints $2KH_P$ 05 S-V	Ahsan Yousaf Te xtile $2KAY_T$ 06 S-VI	Zeenat Textile $2KZ_T$ 07 S-VII	Rasheed Textile $2KR_T$ 08 S-VIII	Crescent Textile $2KC_T$ 09 S-IX	Industrial Free Area 2KIFA 10 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	30.59	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
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)	5.54	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	2.92	ND	ND	ND	0.29

ND= not detected.

Table 6: Weight Percentage of Identified Phases

Phase	2K Mix 01	2K Mix 02	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)	18.55	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 Identified Phases

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

Table 8: Weight Percentages of Identified Phases

Phase	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 secondary electron microscopic analysis of the solid aerosols shown in the micrograms was carried out 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 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.

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 the environmental set up of the related area and the physiochemical 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 delayed in the environment [25].

Mechanical properties of materials define its elasticity and stability. So, elasticity and stability of Faisalabad environment is checked by determining the mechanical properties of solid aerosols like particle size, stress, strain and yield strength using XRPD patterns along with standard empirical relations. As environment is a thermodynamic system so due to temperature gradient and different climatological and meteorological parameters, mechanical properties of solid aerosols undergo variations. It was observed in almost all the samples that there was a critical particle size of solid aerosols beyond which they have been deformed. This deformation was both in form of contraction and expansion. Particles with smaller sizes showed negative values of strain undergoing contraction and particles with larger size showed positive values of strain undergoing expansion while stress in both the cases was found to be negative representing compressive nature. The contraction in size and strain due to compressive stress is easier to understand but a paradox arises when particle size and strain increases due to compressive stress. It happens due to the hygroscopic and hydroscopic nature of solid aerosols due to heterogeneity of Faisalabad environment as indicated by the presence of gypsum and quartz as identified phases in these aerosols. Both of these phases are hydrous and contain water molecules. This presence of water is the main cause of

Table 9: Physical Parameters of Collected SPM

Code	Color	Code	Color
2K01	Dull Yellow	2K26	Dull Green
2K20	Light Gray	2K27	Dull Green
2K03	Green Tinge	2K28	Dull Green
2K04	Green Tinge	2K29	Dull Green
2K05	Green Tinge	2K30	Dull Green
2K06	Green Tinge	2K31	Light Green
2K07	Light Green	2K32	Light Green
2K08	Light Green	2K33	Yellow Tinge
2K09	Brown	2K34	Brown
2K10	Black Tinge	2K35	Black
2K11	Black Tinge	2K36	Black
2K12	Black Tinge	2K37	Black
2K13	Black Tinge	2K38	Black
2K14	Blackish Brown	2K39	Black
2K15	Light Gray	2K40	Black
2K16	Light Gray	2K41	Muddy Gray
2K17	Light Gray	2K42	Muddy Gray
2K18	Light Yellow	2K43	Muddy Gray
2K19	Dull Green	2K44	Shining Gray
2K20	Dull Green	2K45	Shining Gray
2K21	Black	2K46	Dark Gray
2K22	Light Yellow	2K47	Dark Gray
2K23	Light Gray	2K48	Dark Gray
2K24	Light Green	2K49	Dark Gray
2K25	Dull Green	2K50	Blackish Gray
Code	Color	Code	Color
2K51	Blackish Gray	2K76	Blackish Brown
2K52	Blackish Gray	2K77	Blackish Brown
2K53	Blackish Gray	2K78	Blackish Brown
2K54	Black	2K79	Gray
2K55	Black	2K80	Gray
2K56	Black	2K81	Gray
2K57	Black	2K82	Yellow
2K58	Black	2K83	Yellow
2K59	Blackish Brown	2K84	Yellow
2K60	Blackish Brown	2K85	Yellow
2K61	Blackish Brown	2K86	Light Gray
2K62	Blackish Brown	2K87	Light Gray
2K63	Blackish Brown	2K88	Light Gray
2K64	Blackish Brown	2K89	Light Gray
2K65	Blackish Brown	2K90	Gray Tinge
2K66	Blackish Brown	2K91	Gray Tinge
2K67	Brownish Black	2K92	Dull Green
2K68	Brownish Black	2K93	Light Gray
2K69	Brownish Black	2K94	Light Yellow
2K70	Black	2K95	Light Yellow
2K71	Black	2K96	Light Yellow
2K72	Black	2K97	Black
2K73	Black	2K98	Blackish Brown
2K74	Black	2K99	Brownish Brown
2K75	Black	2K100	Brownish Brown

Table 10: pH & Electrical Conductivity of SMP Samples

Code	pH	Ec (ds/m)
2K01	8.0	4.12
2K20	8.0	3.52
2K03	8.0	3.02
2K04	7.0	3.61
2K05	7.0	3.17
2K06	8.0	3.23
2K07	8.0	3.09
2K08	8.0	3.13
2K09	7.0	2.86
2K10	7.0	3.19
2K11	7.0	5.70
2K12	7.0	1.99
2K13	8.0	2.39
2K14	7.0	2.14
2K15	8.0	4.87
2K16	10.0	5.25
2K17	9.0	4.25
2K18	7.0	2.93
2K19	9.0	2.93
2K20	10.0	4.16
2K21	10.0	3.18
2K22	7.0	3.32
2K23	8.0	3.04
2K24	8.0	4.18
2K25	8.0	2.09
2K26	7.0	2.35
2K27	7.0	5.29
2K28	7.0	5.19
2K29	7.0	3.97
2K30	8.0	4.33
2K31	9.0	5.29
2K32	8.0	1.06
2K33	8.0	2.37
2K34	8.0	2.61
2K35	8.0	2.21
2K36	8.0	2.62
2K37	8.0	2.21
2K38	9.0	4.28
2K39	9.0	1.74
2K40	9.0	3.98
2K41	9.0	1.67

(Table 10). Continued.

Code	pH	Ec (ds/m)
2K42	7.0	1.74
2K43	7.0	3.71
2K44	9.0	3.61
2K45	8.0	3.56
2K46	8.0	3.61
2K47	9.0	4.01
2K48	9.0	3.60
2K49	8.0	3.62
2K50	8.0	4.01
2K51	8.0	2.84
2K52	8.0	2.71
2K53	8.0	1.24
2K54	8.0	2.62
2K55	8.0	2.51
2K56	8.0	2.04
2K57	8.0	2.04
2K58	8.0	3.91
2K59	8.0	3.56
2K60	8.0	3.57
2K61	8.0	3.59
2K62	8.0	3.59
2K63	8.0	3.55
2K64	8.0	2.84
2K65	8.0	1.06
2K66	8.0	2.37
2K67	8.0	1.08
2K68	8.0	3.59
2K69	8.0	3.58
2K70	8.0	3.54
2K71	9.0	1.40
2K72	9.0	1.14
2K73	8.0	1.59
2K74	8.0	1.14
2K75	8.0	2.56
2K76	8.0	2.59
2K77	8.0	2.59
2K78	8.0	2.58
2K79	8.0	7.09
2K80	8.0	3.71
2K81	8.0	1.79
2K82	8.0	3.12
2K83	8.0	2.21

(Table 10). Continued.

Code	pH	Ec (ds/m)
2K84	8.0	1.62
2K85	8.0	3.51
2K86	7.0	11.7
2K87	7.0	13.3
2K88	8.0	5.00
2K89	8.0	9.50
2K90	7.0	11.50
2K91	8.0	9.30
2K92	7.0	9.90
2K93	8.0	7.30
2K94	7.0	9.90
2K95	7.0	6.60
2K96	8.0	6.30
2K97	7.0	11.40
2K98	7.0	7.00
2K99	7.0	5.4
2K100	7.0	14.3

Table 11: Probability of Acidic Rain

Zone	PH Value	Probability
N Zone	7-8	49.42%
H Zone	8-9	41.86%
VH Zone	9 & above	8.72%

Table 12: Probability of Acidic Rain with Respect to Color

Color	Probability
Light Color (Acidic)	20%
Dark Color (Basic)	80%

Key ----------- N = Normal H = High VH = Very High.

expansion under compressive stress. 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. The acidic rain probability may however be completely ruled out in H and VH zone because of the high resistive capacity i.e., alkaline nature of most of the solid aerosols to completely neutralize the acidity of the environment at present. N zone is within safe limit but due to the change in industrial and transportational set up it may be treated in to sensitive zone and acidic rain may happen in future. Wide range values of EC (1.06 for 2K32) to (11.50 for 2K90) indicate the effect of geological formations and degree of anthropogenic involvement. Low values of EC mean clear environment and conversely more resistivity which indicates the rigidity and stability of the Environment. However further work is suggested to reconcile satisfactorily the techniques used in this study and their co-relationship with Morphological structure studies.

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.
- Acidic rain probability due to alkaline nature of identified phases is ruled out for the time being as indicated by Electrical Conductivity (EC) values.
- Wide range variations in EC values confirm anthropogenic involvement, low values of EC and study of mechanical properties confirms the stability of the environment.
- 80% dark (Basic) and 20% light (Acidic) nature along with 72% looping and 28% lofting trend not only confirms the industrial involvement in physico-chemical reactions but also complexity of the Faisalabad environment.

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-chemical 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-chemical changes taking place in the environment can be minimized.

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