Research Article

Effect of Meteorological Factors on the Concentration of Allergenic Pollen Grains in the Atmosphere of Capital Territory Islamabad, Pakistan

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Abstract | The present study is aimed to find meteorological factors affecting pollen concentration in Islamabad. For this purpose, three years data (2009-2011) of pollen concentration and meteorological parameters have been used. Pollen concentration in the atmosphere has been measured using RotoRod sampler. Many plants pollen are allergenic that cause different types of allergenic diseases globally. Pakistan also faces the problem of pollen allergy caused by various plants pollen. Among these allergenic pollen producing plants are Broussonetia papyrifera, Alternanthera pungens, Cannabis sativa, Eucalyptus globulus and Taraxacum officinales pollen grains are dominant. These plants pollen cause different allergies like asthma, rhinitis and hay fever etc. Extremely high pollen concentration in the spring and summer seasons in month of March, April, August and relatively less concentration in winter and autumn season in the month of October, December, January are recorded. These high concentrations are mainly due to Broussonetia papyrifera tree. Meteorological parameters affect pollen concentration in the atmosphere by two ways its production and dispersion. Different meteorological parameters like seasons, mean temperature, rain fall, and wind speed are correlated with total pollen count (TPC) using SPSS 16.0 and MS Excel to draw a relationship between them which are useful for allergy patients. The results showed that mean temperature, wind speed and rainfall are the factors that influence pollen of Broussonetia papyrifera only during the spring seasons and the Dandelion, Cannabis sativa and Eucalyptus globulus pollen grains are influence throughout the year. As a result, the total pollen counts in the atmosphere increased due to Broussonetia papyrifera throughout the year.

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Introduction

Allergy is abnormal reaction of the body caused by hypersensitivity of the immune system to ordinary harmless substances present in the environment called allergens that frequently causes little or no trouble in most people (McConnell, 2007). For the previous four-decade reports reveal that prevalence of allergenic asthma and other allergic diseases increased greatly. In different western countries the incidence of asthma in children is higher and it is expected that the increase may be due to high pollen grains in these countries (Hertzen *et al*., 2005). According to the previous study allergy problems are more common in the populated and industrialized cities as compared to less populated and industrialized societies (Braback *et al*., 2004). An allergy problem increases in those peoples living in cities (Hertzen *et al*., 2005). The variations and incidence of allergy in different parts of the world suggest that environmental factors play an important role in such disorders (Eder *et al*., 2006).

Air pollution and climatic change in environment increase allergenic diseases (Beggs *et al*., 2004). The environmental substances that are linked to allergic diseases are house dust, spores, aeroallergens, pollution and climate (Eder *et al*., 2006). These allergens may originate from natural environment or from chemically contaminated environment. Plants pollen play important role in prevalence of respiratory allergic diseases among these allergies, seasonal allergic diseases are increase due to change quality, quantity and distribution of pollen allergens and the duration of peak pollen time (Beggs *et al*., 2004; Zafar *et al*., 2006). Among these allergens pollen grains of grasses and trees are the important allergens that are responsible for allergic diseases. Pollination processes of trees, weeds and grass species in many regions of the world release allergenic pollen grains, these pollen grains are the most important source of allergy (Anderson and Lidhlom, 2003). The major part of air flora of a region mostly contains pollen grains of wind pollinated plants (Riaz *et al*., 2021). Wind-pollinated flowering plants are significant in allergic diseases then insect-pollinated flowering plants. Wind-pollinated plants pollen is small, smooth and produced in large quantity (Gu, 1993). The sizes of this inhalant pollen are small and microscopic that can easily entered through lower respiratory tract (Perveen *et al*., 2015).

The study of airborne pollen grains provides a continuous monitoring of the pollen on the basis of climate change in environment. High concentration of pollen in the atmosphere directly affects the human health (Haroon *et al*., 2008).

Plants pollen allergy was first described by English physician Charles Harrison Blackly in 1873 in his book experimental researches on causes and nature of catarrhus aestivus. Now this is recognized that pollen contain a number of chemicals such as proteins and glycoprotein's, which cause allergenic reactions in sensitive peoples resulting in symptoms of atopic diseases. Aerobiological study has recognized that which pollen grains cause hypersensitivity reaction and how total pollen count varies throughout the year (Dopazo *et al*., 2000). The increase in number of pollen grains concentration in environment can influence the intensity and prevalence of allergic problems in sensitive people (Smart *et al*., 1979). Some recent studies have found that the increase in airborne pollen may be due to climatic and environmental change especially impact the amount and season of pollen, as well as the distribution of plant and pollen (Oh *et al*., 2012). Airborne pollen study also provides Information about allergenic pollen and their relation to allergenic problem which are important for pollen sensitive individual (Zeb *et al*., 2017). Respiratory allergy diseases belong to seasonal pollen allergy (Ribeiro *et al*., 2009). Airborne pollen concentration in environment play significant role in social issues like pollinosis (Mandal *et al*., 2008). The pollens of plants species are considered the most efficient inhalants for causing asthma, rhinitis and hay fever (Liu *et al*., 2010; Bousquet *et al*., 2008). The prevalence rate 7.3% of allergenic rhinitis and asthma and these problems were mainly caused by pollen grains, spores and dust allergens in the air (Al-Hammadi *et al*., 2010). The allergic patient have irregular episode of asthma attacks, breathlessness, chest pain and wheezing (Pokharel *et al*., 2007). The recent aerobiological studies established huge awareness among the peoples due to their application in allergology (Sahney *et al*., 2008). Local vegetation of region can be represented by pollen grains present in the air mixture (Chaturvedi and Datta, 1995).

In desert and semi-desert areas of the world such as united states of America, Europe, Africa, Iran, Kuwait and Saudi Arabia Amaranthaceae family pollen grains has been documented as a allergenic pollen that cause severe allergic problem (Tehrani *et al*., 2010). In America about 35 million peoples are suffering

from the upper respiratory tract infection that show allergenic symptom to aeroallergens. Most of the pollen allergy commonly known as hay fever is most common in United States. Aeroallergens also cause allergenic asthma and about 11 million in America are affecting from this allergy (U.S. Department, 2003).

Pollen allergy have significant effect all over Europe, evidence show that prevalence of respiratory allergic diseases like asthma, rhino conjunctivitis and eczema are induced by pollen (Asher *et al*., 2006). In UK Children asthmatic symptoms are maximum and twice in European average. Allergic rhinitis symptoms in UK children are more during pollen peak time (Walker *et al*., 2007). Study of allergenic pollen in UAE exposed that 7.3% of asthma and allergic rhinitis are mainly caused by pollen (Al-Hammadi *et al*., 2010). Pollen allergy has significant effect on Iran. Pollen is the most common allergen sensitization in Iran and estimated about (47.0%) of all allergen (Moghtaderi *et al*., 2017). In China airborne pollen produce different health problem like allergic diseases such as asthma, rhinitis, and hay fever. Study shows that there are about 10000000 patients with pollinosis in China (Liu *et al*., 2010).

Different techniques are used to solve the problem allergy such as skin prick test and blood test. Skin testing can confirm many common types of allergies. In some cases, skin prick tests can be the most accurate and least expensive way to confirm allergens. For skin prick testing, involves the places a drop of mixture of 25 pollen antigens under the fore arm using sterile needle. They will then lightly prick or scratch on skin. If patient are sensitive to pollen antigens, they will develop redness, swelling and itching at the test site within 15 minutes (Qazilbash *et al*., 1997). The prevalence respiratory allergic diseases and airborne pollen are greatly affected from climatic changes.

Climatic factors such as rainfall, humidity, temperature and wind affect concentration of pollen grains in the air. Between the temperature and pollen concentration has positive correlation and negative correlation of pollen was present with humidity and rainfall (Alwadie, 2008). The influence of temperature on airborne pollen on woody species has been widely studied, that temperature effect pollen especially in flowering tree during spring seasons (Menzel *et al*., 2006). During rainy season observed minor pollen grains concentration because rain water sweeps typically airborne pollen from air (Hong *et al*., 1986). Climatic factors also affect pollen grains dispersal mechanism (Burge, 2002; Jato *et al*., 2002). Pollen dispersal also depend on chemical properties such as (available water content, type of carbohydrate and proteins in pollen) and physical properties such as (pollen morphology, pollination time, its size and weight) during pollen release (Pacini *et al*., 2004). In hot, dry and windy days high pollen grains was seen in the air. Trees pollen usually dominates in spring season and an herbaceous plant pollen is dominates in autumn (Chaturvedi and Datta, 1995). The pollen shows positive correlation with average temperature (Alwadie, 2008).

Islamabad is the capital of Pakistan in which pollen allergy is one of the most emerging health problems. Plants species such as *Broussonetia papyrifera, Alternanthera pungens*, *Cannabis sativa*, *Eucalyptus globulus, Grasses* and *Pinus* species of the area producing pollen that responsible for pollen allergy (Ozturk *et al*., 2013). In Pakistan particularly in two cities Rawalpindi and Islamabad in last few years face a problem of respiratory allergic diseases like asthma due to allergens in atmosphere that initiate allergic responses in susceptible individuals. Pollens, fungal spores, castor bean, house dust mite are the aeroallergens they produce allergic response in the body. About 90% of childhood and 17-80% of adult asthmatics are allergic to aeroallergens (Hussain *et al*., 2013). The most common aeroallergens symptom reported by medical sources is asthma, watery red and itchy eyes, running, itchy or blocked nose, sneezing, itchy ears, as well as, itching of the skin on any area of the body leading to redness. According to Pakistan Institute of Medical Sciences (PIMS) 360 persons suffering from allergy symptoms (Bano *et al*., 1996). The invasive plant species produce new health problems like respiratory diseases such as asthma and rhinitis in development countries like Pakistan (Hussain *et al*., 2013).

Preliminary study of atmospheric pollen in Islamabad has been carried out by Haroon *et al*. (2008), similarly Ghufran *et al*. (2013) conducted studied on airborne pollen grains of paper mulberry under changing climatic condition in Islamabad in relation to allergy. No data was available on airborne pollen grains in Islamabad for the period of December 2008 to October 2011 in relation to environmental conditions. The present study from (2009-2011) exposed the

relationship between the daily pollen count of seven different species with different meteorological perimeters such as (average temperature, rain, wind speed etc.) and its distribution in the air mixture during the study period and reviewing the status of pollen grains caused allergies in Pakistan.

Table 1: *Different plants species pollen count of 2009 and average climatic conditions (average temperature, wind speed and rain fall).*

Date/month	Paper mulberry	Cannabis	Dandelion	Alternanthera	Eucalyptus	Total pollen count (TPC)	Averge temp (°C)	Wind speed meter per second (m/s)	Rain fall in millimeters (mm)
13-17 Dec 08	6	10	5	6	173	205	13.0	2	0.6
18-22 Dec 08	5	5	7	2	95	118	13.5	3.2	16
23-27 Dec 08	5	6	7	1	93	115	13.0	0	0
28-31 Dec 08	5	7	5	3	87	110	12.0	2	0
01-05 Jun 09	6	3	4	0	97	112	10.8	4.8	3.4
06-10 Jun 09	5	11	7	0	73	98	10.7	2	0
11-15 Jun 09	5	30	7	2	83	128	11.8	2.4	0
16-20 Jun 09	4	28	4	2	74	113	12.7	8.2	7.7
21-25 Jun 09	6	92	9	2	65	174	13.9	3.2	0.5
26-31 Jun 09	7	175	14	0	110	310	12.7	1.8	3.2
6-10 Mar 09	16596	176	79	1	50	16904	17.6	9.4	0
11-15 Mar 09	93187	102	53	10	38	93395	18.6	5.4	0
16-20 Mar 09	162230	31	37	6	34	162344	19.6	5	0
21-25 Mar 09	65432	33	54	4	55	65583	16.7	8.8	9.8
26-31 Mar 09	43103	29	103	11	105	43368	16.9	4	4.1
1-5 April 09	10948	40	58	2	155	11213	20.4	12	3.7
6-10 April 09	2059	16	30	2	189	2311	17.7	15.2	17.1
11-15 April 09	6270	27	38	9	336	6692	22.2	11.4	0
16-20 April 09	15291	25	44	13	361	15753	22.5	8.8	2.52
21-23 April 09	5703	20	29	2	96	5857	21.7	12.2	2.4
13-17 Jul 09	26	16	209	6	173	432	32.1	8	0
18-22 Jul 09	10	6	69	7	220	313	31.8	16.8	2.95
23-27 Jul 09	78	14	300	8	225	658	30.5	11.2	3.4
28-31 Jul 09	76	11	208	8	204	498	29.3	13.8	1.4
01-05 Aug 09	1466	32	289	9	213	2009	31.5	5.6	3.55
06-10 Aug 09	4632	132	193	16	157	5131	30.5	16.8	13.8
11-15 Aug 09	14553	19	520	7	186	15285	31.6	5.6	1.12
16-20 Aug 09	1204	18	648	9	156	2036	27.0	15.6	9.5
21-25 Aug 09	1678	24	1191	24	368	3285	28.1	4.4	0.05
26-31 Aug 09	436	27	1495	42	297	2297	28.3	10	0.95
01-05 Sep 09	139	26	831	19	187	1202	26.0	4.4	7.3
06-10 Sep 09	79	21	922	16	206	1245	26.8	4	1.2
11-15 Sep 09	64	16	741	6	190	1017	28.4	5.2	0
16-20 Sep09	49	76	629	19	216	989	26.4	11.4	3.96
21-25 Sep 09	32	50	599	17	226	924	28.5	3.2	0.2
26-30 Sep 09	41	35	471	13	191	751	28.6	5.2	0
01-05 Oct 09	49	19	281	10	139	498	26.9	6.4	1.8
06-10 Oct 09	69	19	199	6	159	452	24.6	4.8	0
11-15 Oct 09	53	12	162	6	120	353	23.3	3.6	0
16-20 Oct 09	38	13	92	5	77	225	21.5	6.8	0

The pollen taxa recovered from rotorode sampler placed on metrology deportment Islamabad.

Table 2: *Pollen count of different plant species 2010 and average climatic conditions (average temperature, wind speed and rain fall).*

Date/month	Paper mulberruy	Cannabi	Dandelion	Alternanthera	Eucalyptus	Total pollen count (TPC)	Total pollen count (TPC)	Averge temp (°C)	Avg Rain fall in millimeters (mm)
13-17 Dec 09	8	0	12	6	69	95	12.5	0.8	0
18-22 Dec 09	6	4	18	2	43	73	11.4	3.2	0
23-27 Dec 09	8	2	20	6	30	66	10.9	3.2	0
28-31 Dec 09	6	1	16	7	26	56	9.7	2.4	0
01-05 Jun 10	6	0	12	6	46	70	10.7	4	0
06-10 Jun 10	6	1	11	4	44	67	11.6	4.6	0
11-15 Jun 10	7	1	14	5	55	82	10.5	2.8	0
16-20 Jun 10	7	1	13	5	42	68	12.3	0.8	0
21-25 Jun 10	7	5	14	6	52	84	13.6	3.2	0
26-31 Jun 10	9	21	30	1	68	129	14.1	11.4	4.3
6-10 Mar 10	9406	101	105	2	77	9696	17.2	8	0.7
11-15 Mar 10	115316	28	67	3	63	115486	19.4	5	0
16-20 Mar 10	172243	44	70	1	84	172452	22.8	4	0
21-25 Mar 10	98375	24	48	0	74	98530	24.9	3	0
26-31 Mar 10	12238	149	106	0	104	12603	23.2	10	4
1-5 April 10	4368	35	27	0	84	5419	22.1	20.0	0.3
6-10 April 10	4454	28	37	0	73	4595	24.4	5.6	0
11-15 April 10	2646	43	27	0	68	2788	26.0	6.4	0
16-20 April 10	1109	27	37	0	63	1237	29.1	10.4	1.0
21-23 April 10	185	7	14	0	206	418	22.5	8.4	1.3
13-17 Jul 2010	114	12	163	5	157	451	31.5	4	0
18-22 Jul 2010	67	10	92	12	162	343	29.6	6.2	20.6
23-27 Jul 2010	816	11	107	6	201	1141	29.7	4	1.2
28-31 Jul 2010	1640	6	59	4	83	1792	25.8	6	68.66
01-05 Aug 10	10772	30	94	5	194	11096	30.0	2	2.9
06-10 Aug 10	836	31	100	4	134	1105	27.7	2	8.9
11-15 Aug 10	362	18	273	5	172	830	29.5	5.2	3.25
16-20 Aug 10	213	13	198	11	161	596	29.4	4.4	15.24
21-25 Aug 10	62	12	152	5	125	356	28.1	6.8	14.78
26-31 Aug 10	246	19	312	7	123	707	12.3	2.4	0.2
01-05 Sep 10	113	13	217	4	158	505	29.5	12.2	14.7
06-10 Sep 10	59	53	206	10	192	520	28.5	0.8	0.6
11-15 Sep 10	77	44	259	10	156	546	26.6	4.4	5.6
16-20 Sep 10	89	42	214	14	146	505	24.84	7.4	4.9
21-25 Sep 10	65	47	191	5	147	455	26.1	3.6	4.9
26-30 Sep 10	74	22	143	4	140	383	24.87	2.4	0
01-05 Oct 10	49	47	218	14	94	422	24.8	1.6	0
06-10 Oct 10	54	34	249	0	108	445	25.5	0.8	0.8
11-15 Oct 10	38	18	151	2	113	323	24.4	9.2	1.4
16-20 Oct 10	27	11	91	0	117	248	24.8	1.3	0

Materials and Methods

Study area

Islamabad is the capital of Pakistan. Its location on the world map at 33° 42' N and 73° 10' E. The temperature of Islamabad varies from an average daily low of 2 °C in January to an average daily high of 40 °C in June. Half of the annual rainfall occurs in July and August, averaging about 255 mm in each of these two months. The remainder of the year has significantly less rain, amounting to about 50 mm per month. Hailstorms are common in the spring.

Table 3: *Pollen count of different plant species 2011 and average climatic conditions (average temperature, wind speed and rain fall).*

Date/month	Paper mulberruy	Cannabis	Dandelion	Alternanthera	Eucalyptus	Total pollen count (TPC)	Averge temp (°C)	Wind speed (m/s)	Avg. rain fall (mm)
13-17 Dec 09	8	0	12	6	69	95	12.5	0.8	0
18-22 Dec 09	6	4	18	2	43	73	11.4	3.2	0
23-27 Dec 09	8	2	20	6	30	66	10.9	3.2	0
28-31 Dec 09	6	1	16	7	26	56	9.7	2.4	0
01-05 Jun 10	6	0	12	6	46	70	10.7	4	0
06-10 Jun 10	6	1	11	4	44	67	11.6	4.6	0
11-15 Jun 10	7	1	14	5	55	82	10.5	2.8	0
16-20 Jun 10	7	1	13	5	42	68	12.3	0.8	0
21-25 Jun 10	7	5	14	6	52	84	13.6	3.2	0
26-31 Jun 10	9	21	30	1	68	129	14.1	11.4	4.3
6-10 Mar 10	9406	101	105	2	77	9696	17.2	8	0.7
11-15 Mar 10	115316	28	67	3	63	115486	19.4	5	0
16-20 Mar 10	172243	44	70	1	84	172452	22.8	4	0
21-25 Mar 10	98375	24	48	0	74	98530	24.9	3	0
26-31 Mar 10	12238	149	106	0	104	12603	23.2	10	4
1-5 April 10	4368	35	27	0	84	5419	22.1	20.0	0.3
6-10 April 10	4454	28	37	0	73	4595	24.4	5.6	0
11-15 April 10	2646	43	27	0	68	2788	26.0	6.4	0
16-20 April 10	1109	27	37	0	63	1237	29.1	10.4	1.0
21-23 April 10	185	7	14	0	206	418	22.5	8.4	1.3
13-17 Jul 2010	114	12	163	5	157	451	31.5	4	0
18-22 Jul 2010	67	10	92	12	162	343	29.6	6.2	20.6
23-27 Jul 2010	816	11	107	6	201	1141	29.7	4	1.2
28-31 Jul 2010	1640	6	59	4	83	1792	25.8	6	68.66
01-05 Aug 10	10772	30	94	5	194	11096	30.0	2	2.9
06-10 Aug 10	836	31	100	4	134	1105	27.7	2	8.9
11-15 Aug 10	362	18	273	5	172	830	29.5	5.2	3.25
16-20 Aug 10	213	13	198	11	161	596	29.4	4.4	15.24
21-25 Aug 10	62	12	152	5	125	356	28.1	6.8	14.78
26-31 Aug 10	246	19	312	7	123	707	12.3	2.4	0.2
01-05 Sep 10	113	13	217	4	158	505	29.5	12.2	14.7
06-10 Sep 10	59	53	206	10	192	520	28.5	0.8	0.6
11-15 Sep 10	77	44	259	10	156	546	26.6	4.4	5.6
16-20 Sep 10	89	42	214	14	146	505	24.84	7.4	4.9
21-25 Sep 10	65	47	191	5	147	455	26.1	3.6	4.9
26-30 Sep 10	74	22	143	4	140	383	24.87	2.4	0
01-05 Oct 10	49	47	218	14	94	422	24.8	1.6	0
06-10 Oct 10	54	34	249	0	108	445	25.5	0.8	0.8
11-15 Oct 10	38	18	151	2	113	323	24.4	9.2	1.4
16-20 Oct 10	27	11	91	0	117	248	24.8	1.3	0

Flora of Islamabad

In Islamabad wild plants and vegetation produce pollen in huge quantity in different time of the year, among them trees produce pollen in spring and grasses produce autumn. The dominant plant species includes *Pinus roxburghii*, *Acacia modesta*, *Acacia arabica*, *Olea ferrugenia*, *Dodonaea viscosa*, *Justicia adhatoda*, *Carisa opaca* (garanda), *Woodfordia fruticosa*, *Morus alba*, *Ficus carica*, while *Broussonetiapa pyrifera* Islamabad (GOP, 1998).

Table 4: *Summarized results of the statistical analysis pollen data in relation to the meteorological parameters for the investigated period (2009–20011).*

Pair of variables	Pearson correlation R	p-level
2009		
Average Temp. & Total Pollen count	-0.096	0.177
Average Temp. & Paper mulberry Pollen	0.411**	0.000
Average Temp. & Cannabis Pollen	0.163*	0.021
Average Temp. & Dandelion Pollen	-0.297**	0.000
Average Temp. & Alternanthera Pollen	-0.111	0.116
Average Temp. & Euclyptus Pollen	0.509**	0.000
Wind speed. & Total pollen count	-0.016	0.824
Rain fall. & total pollen count	-0.060	0.420
2010		
Average Temp. & Total Pollen count	0.242**	0.001
Average Temp. & Paper mulberry Pollen	-0.112	0.115
Average Temp. & Cannabis Pollen	-0.055	0.439
Average Temp. & Dandelion Pollen	0.558**	0.000
Average Temp. & Alternanthera Pollen	0.435**	0.000
Average Temp. & Euclyptus Pollen	0.509**	0.000
Wind speed. & Total pollen count	-0.016	0.824
Rain fall. & total pollen count	0.112	0.126
2011		
Average Temp. & Total Pollen count	0.262**	0.000
Average Temp. & Paper mulberry Pollen	0.0134	0.921
Average Temp. & Cannabis Pollen	0.058	0.420
Average Temp. & Dandelion Pollen	0.718**	0.000
Average Temp. & Alternanthera Pollen	0.332**	0.000
Average Temp. & Eucalyptus Pollen	0.691**	0.000
Wind speed. & Total pollen count	0.052	0.464
Rain fall. & total pollen count	-0.078	0.294

Meteorological data

This project was carried out in collaboration with Federal Metrology department Islamabad. Pollen monitoring was carried out in the years 2009–2011. The rotorod sampler was used for pollen counting. Daily pollen concentration data and meteorological parameters were used in this study. The rod is coated with silicon grease to trap the pollen grains. The pollen grains was analyzed and counted under a microscope. Meteorological data obtained from Pakistan Meteorological Department. The following daily meteorological data were used for the analysis: Average temperature, relative air humidity, rainfall and wind speed.

Statistical analysis

The statistical analyses were carried out using SPSS 16.0 version to find out correlation between the seasons and meteorological parameters such as (average temperature, rain fall, wind speed) and average pollen count of different species. The meteorological data was calculated by Spearman's rank correlation coefficient, multiple regression analysis and related statistical tests were applied on the data to answer our research questions. The relationship between the pollen season and meteorological conditions in different periods was analyzed.

Results and Discussion

In 2009 the mean pollen count shows week negative correlation with average temperature, wind speed. The two variable (mean pollen count and average temp) correlations coefficient is (-096) and the p-value (0.177) (Table 7). The correlation coefficient value of wind speed and mean pollen count is (-.016) and p-value (0.824). The correlation is not significant between the variables. The airborne pollen shows

negative correlation with mean total rain fall in each year. The paper mulberry means pollen count show a medium positive correlation with average temperature. The values of correlation coefficients are (0.411**) and the p-value is (.000) that are less than (0.05).

Table 5: *Total pollen count of 2009 and average temperature correlation.*

Correlations			
		Total pollen count	**Average temp**
Total pollen count	Pearson correlation	1	-.096
	Sig. (2-tailed)		.177
	N	200	200
Average temp	Pearson correlation	-.096	1
	Sig. (2-tailed)	.177	
	N	200	200

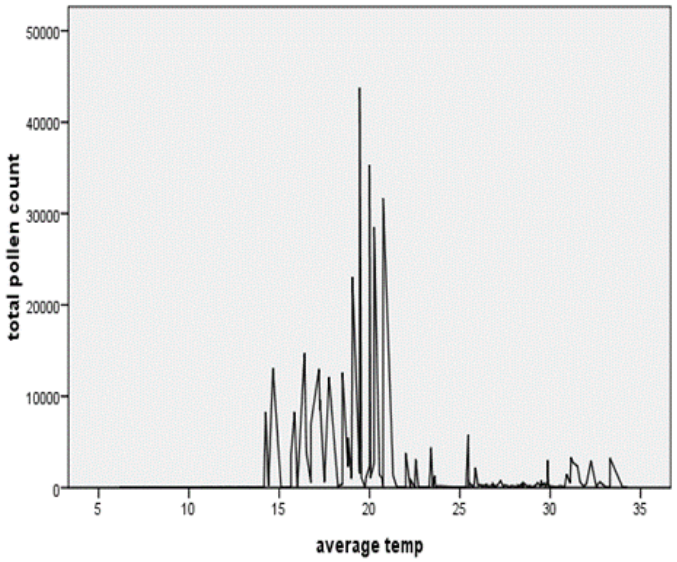

Figure 3: *Graphical representation of total pollen count of 2009 and average temperature correlation.*

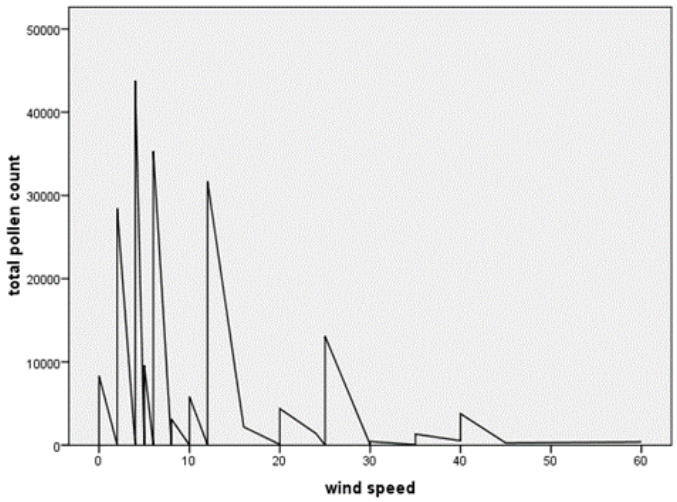

Figure 4: *Graphical representation of total pollen count of 2009 and wind speed correlation.*

Table 6: *Total pollen count of 2009 and wind speed correlation.*

Correlations			
		Total pollen count	**Wind speed**
total pollen count	Pearson correlation	1	-.016
	Sig. (2-tailed)		.824
	N	200	200
wind speed	Pearson correlation	-.016	1
	Sig. (2-tailed)	.824	
	N	200	200

Table 7: *Total pollen count of 2010 and average temperature correlation.*

Correlations			
		Total pollen count	**Average temp**
Total pollen count	Pearson correlation	1	.242**
	Sig. (2-tailed)		.001
	N	200	200
Average temp	Pearson correlation	.242**	1
	Sig. (2-tailed)	.001	
	N	200	200
**. Correlation is significant at the 0.01 level (2-tailed).			

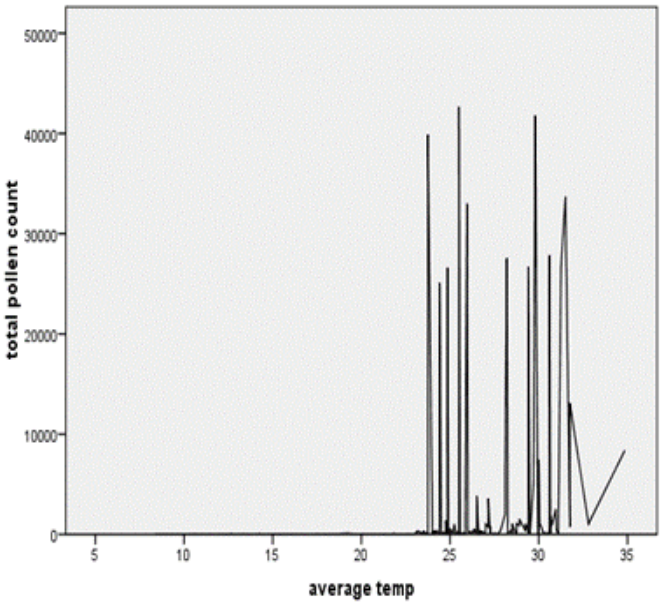

Figure 5: *Graphical representation of total pollen count of 2010 average temp correlation.*

Tables 8 and 9 in 2010 the mean pollen count shows a positive correlation with average temperature and shows negative correlation with wind speed and rain fall. The value of correlation coefficient of total pollen count and average temperature is (0.242**) and p-value

(0.001) that are less than (0.05) thus the correlation is significant between the variables.

Table 8: *Total pollen count 2010 and wind speed correlation.*

Correlations			
		Wind speed	**Total pollen count**
Total pollen count	Pearson correlation	1	-.016
	Sig. (2-tailed)		.824
	N	200	200
Wind speed	Pearson correlation	-.016	1
	Sig. (2-tailed)	.824	
	N	200	200

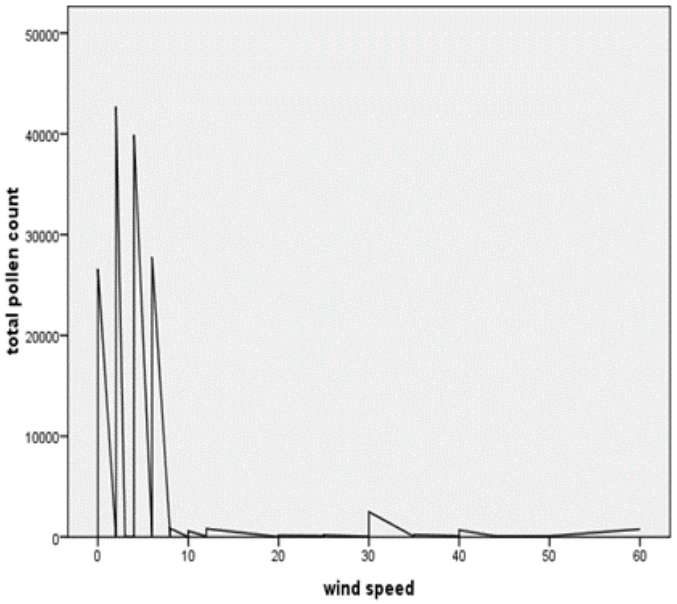

Figure 6: *Graphical representation of total pollen count of 2010 and wind speed correlation.*

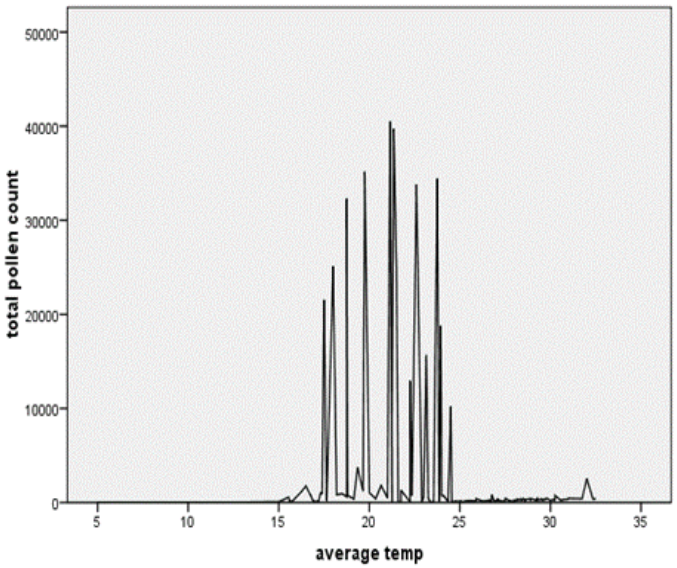

Figure 7: *Graphical representation of total pollen count of 2011 and average temp correlation.*

Table 9: *Correlation between total pollen count of 2011 and average temperature.*

Correlations			
		Total pollen count	**Average temp**
Total pollen count	Pearson correlation	1	.262**
	Sig. (2-tailed)		.000
	N	199	199
Average temp	Pearson correlation	.262**	1
	Sig. (2-tailed)	.000	
	N	199	199
**. Correlation is significant at the 0.01 level (2-tailed).			

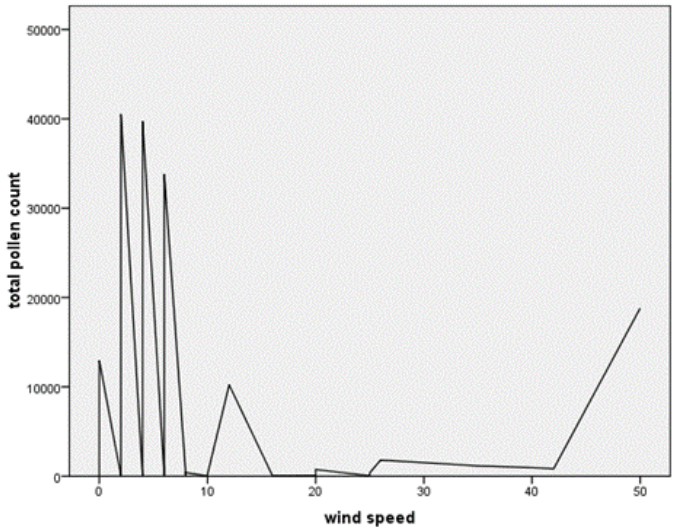

Figure 8: *Graphical representation of total pollen count of 2011 and wind speed correlation.*

Table 10: *Total pollen count of 2011 and wind speed correlation.*

Correlations			
		Total pollen count	**Wind speed**
Total pol-len count	Pearson correlation	1	.052
	Sig. (2-tailed)		.464
	N	199	199
Wind speed	Pearson correlation	.052	1
	Sig. (2-tailed)	.464	
	N	199	199

Table 10 the paper mulberry and cannabis shows negative correlation and the dandelion, Eucalyptus and Alternanthera pollen shows a positive correlation with average temperature.

The correlation coefficient value of dandelion, Eucalyptus and Alternanthera is (0.558**), (0.509**),

(0.435**) and its p-values (0.000), (0.000), (0.000) respectively. And this pollen shows negative correlation with wind speed. The correlation coefficient value of total pollen count and wind speed are (-0.016) and p-value (0.824) which are greater than (0.05) so the correlation is not significant between the variable.

Table 11: *Correlation between total pollen count and total rain fall.*

Correlations			
		Total pollen	**Total rain**
total pollen	Pearson correlation	1	-.772
	Sig. (2-tailed)		.438
	N	3	3
total rain	Pearson correlation	-.772	1
	Sig. (2-tailed)	.438	
	N	3	3

Table 13: *Comparing three years peak spring data of pollen grains from (2009 to 2011) with average temperature.*

Correlations			
		Pollen	**Temp**
pollen	Pearson correlation	1	.032
	Sig. (2-tailed)		.696
	N	147	147
temp	Pearson correlation	.032	1
	Sig. (2-tailed)	.696	
	N	147	147

Table 14: *Comparing three years peak summer data of pollen grains from (2009 to 2011) with average temperature.*

Correlations			
		Pollen	**Temp**
Pollen	Pearson correlation	1	.213**
	Sig. (2-tailed)		.009
	N	150	150
Temp	Pearson correlation	.213**	1
	Sig. (2-tailed)	.009	
	N	150	150
**. Correlation is significant at the 0.01 level (2-tailed).			

Tables 1, 10, 11 in 2011 the total pollen count shows medium positive correlation with average temperature and negative with wind speed and rain fall. The value of correlation coefficient between the total pollen count and average temperature is (0.262**) and p-value (0.000). The value is significantly correlated. Paper mulberry and Cannabis pollen shows no correlation with average temperature but Dandelion, Alternanthera and Eucalyptus pollen shows positive correlation with average temperature. The values of correlation coefficient between these pollen and average temperature are (0.718**), (0.332**), (0.691**) respectively and P- values is (0.000). These values show significantly positive correlation between the variables. The total pollen count increases up to optimum range (15-26 °C) of temperature, as the average temperature increases from January to August and again decrease as the average temperature decreases from September to December.

Table 15: *Comparing three years peak autumn data of pollen grains from (2009 to 2011) with average temperature.*

Correlations			
		Pollen	**Temp**
Pollen	Pearson correlation	1	.581**
	Sig. (2-tailed)		.000
	N	150	150
Temp	Pearson correlation	.581**	1
	Sig. (2-tailed)	.000	
	N	150	150
**. Correlation is significant at the 0.01 level (2-tailed).			

Table 16: *Comparing three years peak winter data of pollen grains from (2008 to 2011) with average temperature.*

Correlations			
		Pollen	**Temp**
Pollen	Pearson correlation	1	.440**
	Sig. (2-tailed)		.000
	N	150	150
Temp	Pearson correlation	.440**	1
	Sig. (2-tailed)	.000	
	N	150	150
**. Correlation is significant at the 0.01 level (2-tailed).			

In 2010 maximum spring pollen record in 16-March with average temperature 21.8°C and minimum spring pollen record in 6-Mar 2010 with average temperature 17.5°C and in 2011 maximum pollen record in 24-March with average temperature 25°C and minimum pollen in 6-Mar 2011 with average temperature 13.5°C, respectively. Result also indicates

that temperature increase each year. The most dominant pollen grains during this three years spring date are paper mulberry and second most prominent are Cannabis, Eucalyptus and Dandelion, respectively.

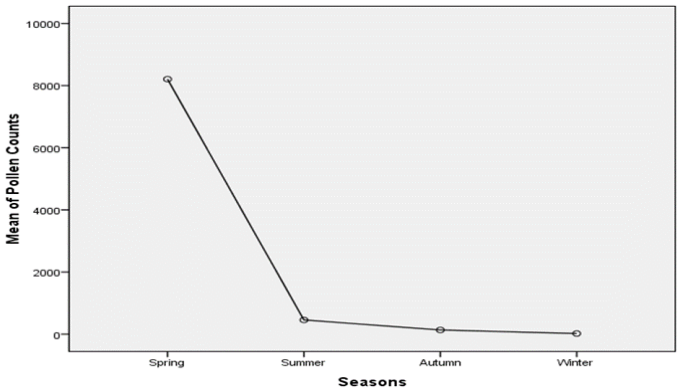

Figure 9: *The highest mean pollen count observed in spring seasons than summer, autumn and winter, respectively. The lowest mean pollen count observed in winter seasons. Result shows that mean pollen count totally depend on flowering seasons.*

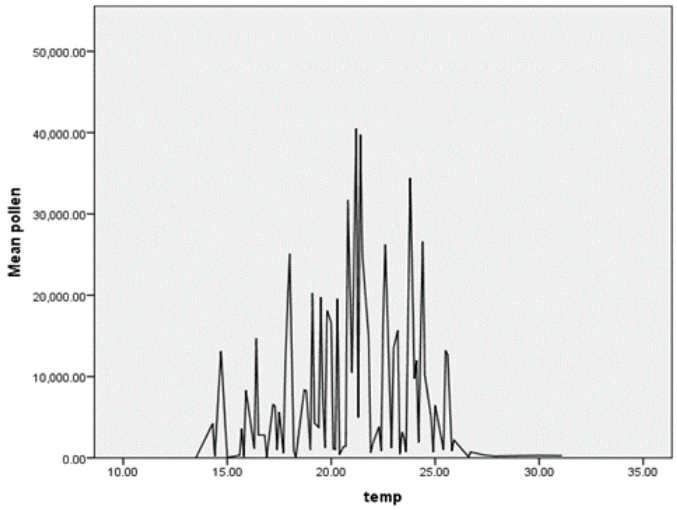

Figure 10: *Graphical representation of three years spring mean pollen count of and average temp.*

Figure 11 three summer season's data of daily pollen count compare with daily average temperature, pollen grains show positive correlation with temperature. Maximum pollen in 2009 observes in 11-Aug with average temperature 31.2°C and minimum pollen in 20-Jul with average temperature 32.6°C, in 2010 maximum pollen record in 2-Aug with average temperature 29.7°C and minimum pollen in 23-Jul 52.5°C and in 2011 maximum summer pollen record in 13-July with average temperature 32.0°C and minimum pollen in 16-Jul with average temperature 26.8°C, respectively. The most dominant pollen during this three years summer date are paper mulberry and Dandelion, Eucalyptus and Cannabis, respectively.

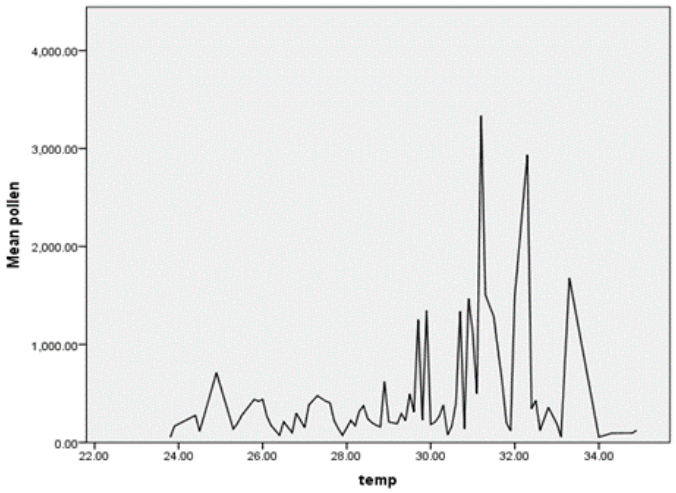

Figure 11: *Graphical representation of three years summer means pollen count of and average temp correlation.*

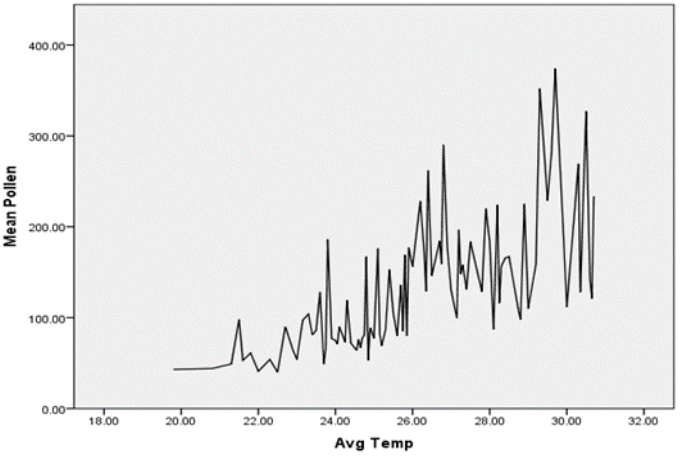

Figure 12: *Graphical representation of three years autumn means pollen count of and average temp correlation.*

Figure 12 three autumn seasons data of daily pollen count compare with daily average temperature pollen grains show positive correlation with temperature, as decrease occur in average temperature pollen concentration also decreased. Highest pollen observes in 5-Sep-2009 with average temperature 25.4 °C and minimum pollen recorded in 18-Oct-2009 with average temperature 22.5 °C, maximum pollen in 14-Sep 2010 with average temperature 26.75 °Cand minimum pollen record in 18-Oct 2010 with average temperature 25.0 °C and 2011 maximum and minimum record in 6-Sep 2011 with average temperature 29.5°C and on 19-Oct 2011 with average temperature 21.3°C, respectively. The most dominant pollen grains during this three-year autumn date are Dandelion than paper mulberry, Eucalyptus and cannabis, respectively.

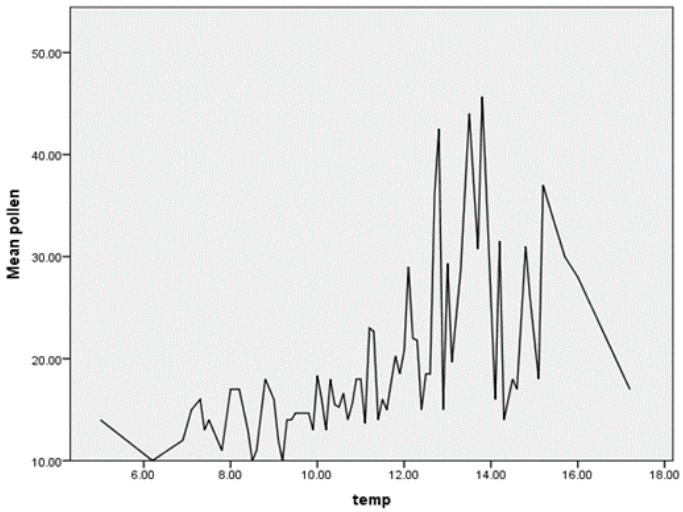

Figure 13: *Graphical representations of three years winter mean pollen count of and average temp correlation.*

Figure 13 three winter seasons data of daily pollen count compare with daily average temperature pollen grains show positive correlation with temperature as daily temperature decreased air born pollen concentration also decreased. Highest pollen observes in 29-Jun-2009 with average temperature 13, 3 °C and minimum pollen recorded in 5-Jun-2009 with average temperature 6.2 °C, in 2010 maximum pollen 29-Jun 2010 with average temperature 15.2 °C and minimum pollen record in 8-Jun 2010 with average temperature 9.9 °C and 2011 maximum and minimum record in 31-Jun 2011 with average temperature 11.5 °C and on 8-Jun 2011 with average temperature 8.5 °C, respectively. The most dominant pollen grains during this three years winter date are Eucalyptus and Cannabis.

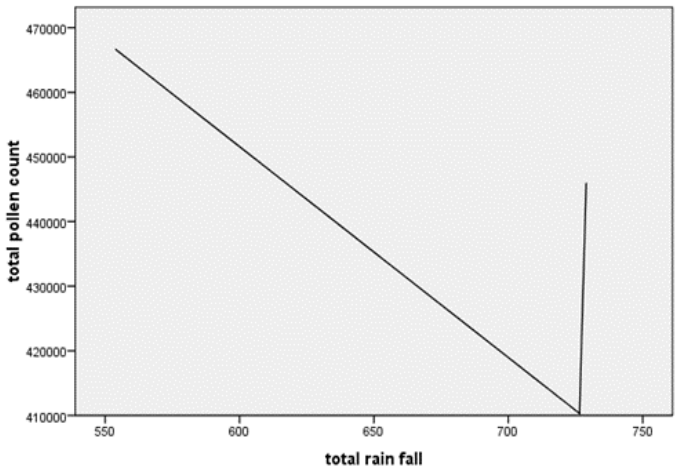

Figure 14: *Graphical representation of correlation between total pollen count and total rain fall.*

In the present study Paper mulberry, Cannabis, Alternanthera, Dandelion and Eucalyptus are the abundant pollen type, and representive vegetation of capital territory Islamabad. The meteorological parameters analyzed did not show significant variations in pollen trends. We analyzed the influence of several meteorological parameters.

According to the present daily total pollen concentration data was correlated to the daily meteorological data throughout the study period. Temperature is one of the main factors affecting the start of flowering in tree species that bloom at the beginning of spring season. For the development of every pollen there must be a particular temperature, if this particular temperature is not available pollen growth will be suffer thus affect life cycle of a plant. The same result obtained by (Sicard *et al.*, 2012) that the mean temperature in February plays an important role in determining reproductive growth and anthesis. The mean pollen count shows positive correlation with average temperature and negative correlation with wind speed and rain fall.

In the present study throughout the year average temperature did not affect the daily mean pollen counts but only affect the flowering seasons in some plants as the temperature rises from optimum level pollen concentration also decrease. But according to (Ghufran *et al.*, 2013) meteorological factors such as average temperature affect the concentration of daily pollen count shows positive significant correlation and negative correlation with humidity, rain fall and wind speed.

According to the present study maximum pollen count observed in the spring season (March and April) and second highest pollen count in the summer during (July and August) and lowest in the winter season in (December and January). The same result obtained by (Ghufran *et al.*, 2013) high concentration of observed in the month of April, March and second highest peak value of pollen count was observed in the month of August, October. The lowest concentrations of pollen grains were found in January.

According to the present result of the study area the climatic factor affects the flowering season and daily pollen counts concentration for example as the temperature increases gradually in the spring that result in an increase in the pollen concentration. In the spring high concentration of pollen are due to paper mulberry. The production and dispersion

of pollen depend upon the season of year. But the pollen shows no significant correlation with average temperature throughout the year. Same result observed by (Rodríguez-Rajo *et al*., 2004) that the variation in temperature is one of the main climatic factors that affecting the flowering season of plants in the beginning of spring and (Haroon *et al*., 2008) Concentration of airborne pollen is extremely high due to paper mulberry tree in the month of March. Meteorological factors such as (relative humidity, max temperature, min temperature and precipitation) affect pollen concentration its production and dispersion. These factors affect the production of paper mulberry tree pollens in March-April. According to (Weryszko *et al*., 2006) climatic factors such as temperature and relative humidity are the most the most important factors for the concentration of pollen in the air.

According to the present result the analysis of the relationships between the season parameters shows that the highest correlation was present between the season start date and peak date. The seasonal peak occurred earlier when the season started earlier. The seasons show significant correlation with the mean pollen count. In spring seasons, the mean pollen count is higher due to flowering period than summer, the summer mean pollen count is higher than autumn and in autumn higher from winter seasons respectively. The same result was observed by (Weryszko *et al*., 2006) the relationships between the season parameters shows strong correlation between the seasons start date and peak date (a positive correlation). The seasonal peak occurred earlier when the season started earlier. A high positive correlation was also found between the peak value and SPI (seasonal pollen index) as well as between the peak date and the season end date. Season that started later had shorter duration and that the peak value and SPI (Seasonal Pollen Index) were higher in a shorter season.

According to the present study the annual rain fall shows negative correlation with mean pollen count in each year. The increasing of annual rain fall result in decreases of mean pollen counts. Same result was observed by (Sicard *et al*., 2012) the environmental factor such as rainfall shows great influence in determining the arrival and final date of pollination. The accumulated rainfall amount during the pollination period has a negative effect on the pollen index. This may be interpreted as the wash out of airborne pollen by raindrops.

Relations between daily pollen concentrations and weather conditions such as temperature, humidity, precipitation and wind have been reported by many workers i.e., (Moseholm *et al*., 1987; Agashe *et al*., 1989) but most studies have been of single regions or under similar types of climates. However, relationships found in one area cannot always be applied to a different area because meteorological parameters are interred correlated and are dependent on a particular site (Moseholm *et al*., 1987).

So from the above discussion it is clear that climatic factors positively affect the daily air born pollen concentration in the atmosphere of the studied area.

Conclusions and Recommendations

The present studied sets out to explain the correlation of airborne pollen with the climatic factors and seasons to draw up guidelines for pollen occurrence from data collected over a period of three years. This study clarified that daily pollen count throughout the year depending on climatic factors. In the spring seasons the daily pollen count shows strong positive correlation with average temperature and negative correlation with rainfall as the occurrence of rain result of disappearing of pollen from atmosphere but in summer seasons the daily pollen concentration did not shows positive correlation excepting some herbaceous plants pollen. We also conclude that optimum wind speed in the atmosphere is responsible for the production and dispersion of airborne pollen. In the present study flowering seasons of plant influence the daily pollen concentration as the specific flowering seasons goes away as a result decrease occur in daily pollen concentration.

The present research covers the allergenic pollen bearing species of capital city Islamabad and it will help in controlling the pollen allergy and will help in improving the health condition of the inhabitants of the area. Future research area of pollen study should be expanded in Pakistan in order to improve health conditions in the context of allergy problems. For this research proposals should be submitted to Federal government, provincial government and HEC to provide funding for relevant lab tools, so as to control allergy problem in Pakistan.

Novelty Statement

This work is novel as it is related to the effects of allergies causing pollen grains in the atmosphere of the capital of Pakistan.

Author's Contribution

Farooq Jan: Conducted the study
Abdu Rauf: Experimental design
Ikramullah Khan: Field supervision
Muhammad Yasin: Data analysis
Muhammad Qayash: Software applications
Hazrat Wali: Fieldwork data collection
Muhammad Luqman: Fieldwork data collection
Fayaz Asad: Hypothesis testing statistics
Muhammad Khalid: Proof reading corrections

Conflict of interest
The authors have declared no conflict of interest.

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