

One-Year pollen and spore calendars of Saudi Arabia: Al-Khobar, Abha and Hofuf

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Abstract

Airborne Pollen grains and Spores of three different cities viz., Al-Khobar (1987–1988), Abha (1991–1992) and Hofuf (1992–1993) in Saudi Arabia were studied using Burkard Volumetric Seven-Day Spore Trap. The data were analyzed in relation to their allergenic capability and one-year pollen and spore calendars were designed to correlate the patients' symptoms as well as for selection of appropriate allergen extracts for diagnosis and treatment of allergic diseases. Amongst pollen group, *Amaranthus viridis*, *Plantago* spp., *Chenopodium album*, *Ricinus communis*, *Rumex vesicarius*, *Juniperus* spp., *Parkinsonia aculeata*, *Prosopis* spp., and *Phoenix dactylifera* were some of the frequent types. Amongst the fungal spores group *Cladosporium*, Smuts spores, Colored basidiospores, *Alternaria*, *Ulocladium* and *Drechslera* were the dominant types.

1. Introduction

Airborne bio-particles are a major cause of respiratory diseases in humans, causing allergies, asthma and pathogenic infections of respiratory tract. Airborne bio-particles include pollen grains from wind-pollinated plants, viruses, bacteria, spores of fungi, mosses, ferns, fungi hyphal fragments, algae and other plant fragments. Biological pollutants and the concentration of airborne allergens vary according to location, altitude, time of the day, season of the year and fluctuate with climatic conditions (e.g. rain, temperature, humidity and wind velocity etc.) (Al-Doory et al., 1980). Therefore, regional influences are more important in the elicitation of allergic symptoms.

An allergen calendar compiled for each region of a country can be used in allergy clinics and hospitals for symptoms correlation and

subsequent selection of allergens panel for diagnosis and treatment. This also serves primary goal towards the prevention and control of environmental allergens. These calendars can be prepared by sampling one or more locations for at least 12-month period. Yearly variations in airborne allergens of a region can be displayed by allowing the sampler to run for a longer period (i.e. two or more years) at one location.

Aerobiological and clinical studies are generally conducted simultaneously to establish the prevalence and possible contribution of allergens of outdoor and indoor origin in the etiology of allergic disorders, particularly bronchial asthma. In this regard some studies have already been conducted in Saudi Arabia (Sorenson et al., 1985; Al-Frayh et al., 1992, 1995, 2000, 2001; Hasnain et al., 1999a, b, 2004a, b; Al-Suwaine et al., 2001) and its neighboring countries: Kuwait

(Davies, 1969; Moustafa and Kamal 1976; Halwagy 1988, 1989, 1994), Iran (Hariri et al., 1978), Iraq (Al-Tikriti et al., 1980) and Egypt (Youssef and El-Din 1988).

This study is a part of series of studies conducted in different regions of Saudi Arabia and is first of its kind to be published as preliminary study in the area. The paper summarizes pollen and spores data in a format of one-year calendars for three regions viz., Al-Khobar (AKH), Abha (ABH) and Hofuf (HOF).

2. Materials and methods

2.1. Sampling locations

Atmospheric samplings at three major cities viz. Al-Khobar and Hofuf (Eastern region) and Abha (Southwestern region) were conducted using Burkard Volumetric Seven-Day Spore Traps. The traps were operated continuously for more than 12-months period and one-year data were included for each site viz., AKH (August 1987–July 1988), ABH (July 1991–June 1992) and HOF (August 1992–July 1993).

(a) Al-Khobar (AKH): A coastal city by the Arabian Gulf in the Eastern province of Saudi Arabia. The distance from capital city Riyadh to Al-Khobar is 400 km towards the East, with comparatively hot and humid weather. It is comparatively newly developed city, with major oil fields located in the region due to which it has become the commercial hub of the eastern province.

(b) Abha (ABH): The city of Abha lies in the Southwestern part of the Arabian Peninsula about 1100 km from Riyadh with generally moderate climate, heavy rainfall, green pasture and agricultural plateaus. The region abounds in mountains, valleys, and fertile plains and surrounded by dense forests.

(c) Hofuf (HOF): It lies in the Eastern province close to Dammam and Al-Khobar and about 350 Km from capital city Riyadh. Hofuf is now an agricultural market center for the processing of agricultural products (dates and rice) for textile industries and for cement manufacture.

2.2. Burkard volumetric seven-day sampler

The Burkard Volumetric Samplers were operated continuously for one-year or more at each location, in order to complete the data for 12 month-period. The intake orifice of the samplers was approximately 10 m above the ground level. Samplers were set for seven day sampling onto Melinex tape. The tapes were changed weekly and cut into one-day (24 h) segments, which were mounted with gelvatol–phenol mixture onto a microscopic slide. Identification and counting were undertaken in 10 random fields for each bi-hourly counts (4 mm traverse) for each 24-h period (= 120 fields). Slides were scanned at a magnification of $\times 400$ for counting and, where necessary, $\times 1000$ under oil immersion for identification. The trap operates on the principle of “impaction through suction” with 2-mm movement of the drum each hour. Spores counts were converted to cubic meter of air by a factor obtained by applying the formula: concentration propagules $m^{-3} = N_T A_E / n \times a \times V_a$, where N_T is the total number of spores counted in “ n ” areas, n is the number of fields counted (= 10 field areas), a is a field area, mm^2 (= $0.15205 mm^2$); V_a is the air volume sampled, $m^{-3}(0.6^3)$ and A_E is the total effective area, mm^2 (i.e. long axis of orifice \times distance tape moves in hour, = $14 \times 2 = 28 mm^2$) (Hasnain et al., 1984, 2004b). Based on the above equation, each hour counts were added to calculate daily mean/ m^{-3} and monthly mean/ m^{-3} of air.

2.3. Pollen & Spore calendars

The pollen and spore calendars presented for the three regions are based on one-year data each (12 months period). The calendars are based on the frequencies of airborne Pollen/Spore concentrations per cubic meter of air (m^{-3}) and are grouped differently for pollen grains and fungal spores. The frequencies for pollen grains are grouped as “Sporadic/Rare” ($1-10 m^{-3} = +$), “Occasional” ($11-25 m^{-3} = ++$), “Frequent” ($26-50 m^{-3} = +++$), and “Very Frequent” ($> 50 m^{-3} = ++++$). The frequencies of fungal spores are grouped as follows: “Sporadic/Rare” ($1-50 m^{-3} = +$), “Occasional” ($51-100 m^{-3} = ++$), “Frequent” ($101-200 m^{-3} = +++$) and “Very Frequent” ($> 201 m^{-3} = ++++$). The

Table 1. One-year calendar of airborne and allergenic pollen grains Al-Khobar (1987–1988), Abha (1991–1992) and Hofuf (1992–1993)

Pollen types	Site	Months											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Trees: <i>Acacia</i> spp.	AKH	-	-	-	-	-	-	-	-	-	-	-	-
	ABH	-	-	-	+	+	+	+	-	-	-	+	-
	HOF	-	-	-	-	-	-	-	-	-	-	-	-
Betulaceae	AKH	-	-	-	-	-	-	-	-	-	-	-	-
	ABH	+	+	+	+	+	-	-	-	-	-	+	++
	HOF	+	+	+	-	-	-	-	-	-	-	-	++
<i>Casuarina equisetifolia</i>	AKH	+	+	+	+	-	-	-	+	+	-	+	+
	ABH	-	-	-	-	-	-	-	-	-	-	-	-
	HOF	-	-	-	-	-	-	-	-	-	-	-	-
<i>Eucalyptus</i> spp.	AKH	+	+	+	+	+	+	+	+	+	+	+	+
	ABH	+	+	+	+	++	++	-	-	-	-	+	+
	HOF	-	-	-	-	-	-	-	-	-	-	-	-
<i>Fraxinus</i> spp.	AKH	-	-	-	-	-	-	-	-	-	-	-	-
	ABH	-	-	-	-	-	+	+	-	+	+	+	-
	HOF	-	-	-	-	-	-	-	-	-	-	-	-
<i>Juniperus</i> spp.	AKH	-	-	+	+	+	+	-	-	-	-	-	-
	ABH	-	+	++	++	+	-	-	-	-	-	+	-
	HOF	-	-	-	-	-	-	-	-	-	-	-	-
<i>Morus</i> spp.	AKH	-	+	+	+	+	+	-	-	-	-	-	-
	ABH	-	-	-	-	-	-	-	-	-	-	-	-
	HOF	-	-	-	-	-	-	-	-	-	-	-	-
Oleaceae	AKH	-	-	-	+	+	+	-	-	-	+	+	+
	ABH	-	+	+	-	-	+	+	-	+	+	-	-
	HOF	+	-	-	-	-	-	+	+	+	-	-	+
<i>Parkinsonia aculeata</i>	AKH	-	+	+	-	+	+	-	-	-	-	-	-
	ABH	-	-	-	-	-	-	-	-	-	-	-	-
	HOF	-	-	-	-	-	-	-	-	-	-	-	-
<i>Phoenix dactylifera</i>	AKH	+	+	+	+	+	-	+	-	+	-	+	+
	ABH	-	-	-	+	-	-	-	-	-	-	-	-
	HOF	-	-	+	+	-	-	-	-	-	-	-	-
<i>Pinus</i> spp.	AKH	-	-	-	-	-	-	-	-	-	-	-	-
	ABH	-	-	+	-	-	-	-	-	-	-	-	-
	HOF	-	-	-	-	-	-	-	-	-	-	-	-
<i>Populus</i> spp.	AKH	-	-	-	-	-	-	-	-	-	-	-	-
	ABH	-	-	+	-	-	-	-	-	-	-	-	-
	HOF	-	-	-	+	++	+	-	-	-	-	-	-
<i>Prosopis</i> spp.	AKH	+	+	+	+	+	+	+	+	+	+	+	+
	ABH	-	-	-	-	-	-	-	-	-	-	-	-
	HOF	-	-	-	-	-	-	-	-	-	-	-	-
<i>Tamarix</i> spp.	AKH	-	-	-	-	-	-	-	-	-	-	-	-
	ABH	-	-	-	-	-	-	-	-	-	-	-	-
	HOF	-	-	-	-	-	-	-	-	-	-	-	-
Weeds: <i>Amaranthus viridis</i>	AKH	++	++	+	+	++	+	+	+++	+++	+++	+++	+++
	ABH	-	-	-	-	-	-	-	-	-	+	-	-
	HOF	-	-	-	-	-	-	-	-	+	-	-	-
<i>Artemisia</i> spp.	AKH	-	-	-	-	-	-	-	-	-	-	-	-
	ABH	-	-	-	-	-	-	-	-	+	+	+	+
	HOF	-	-	-	-	-	-	-	+	+	+	+	+

Table 1. Continued

Pollen types	Site	Months											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
<i>Atriplex</i> spp.	AKH	-	-	-	-	-	-	-	-	-	-	-	-
	ABH	-	-	-	-	-	-	-	-	-	-	-	-
	HOF	-	-	-	-	-	-	-	+	+	+	-	-
<i>Chenopodium album</i>	AKH	+	+	-	+	+	+	+	+	+	+	+	+
	ABH	-	-	+	-	-	-	-	-	-	-	-	-
	HOF	-	-	+	-	+	-	-	-	+	+	+	-
Chenopodiaceae	AKH	-	-	-	-	+	-	-	+	+	+	-	-
	ABH	+	-	+	+	+	+	+	+	+	+	+	+
	HOF	+	+	+	-	+	+	+	+	+	+	+	+
Compositae	AKH	-	-	-	-	-	+	+	-	-	-	+	+
	ABH	+	-	-	-	-	-	-	-	-	-	-	-
	HOF	-	-	-	-	-	+	+	-	-	-	+	+
<i>Cyperus rotundus</i>	AKH	+	+	+	+	+	+	+	+	+	+	+	+
	ABH	-	-	-	-	-	+	-	-	-	-	-	-
	HOF	-	-	+	+	+	+	-	-	-	-	-	+
<i>Ephedra</i> spp.	AKH	-	-	+	+	+	+	+	-	-	-	-	-
	ABH	-	-	-	-	-	-	-	-	-	-	-	-
	HOF	-	-	-	-	-	-	-	-	-	-	-	-
<i>Plantago</i> spp.	AKH	+	++	++	++	+	+	+	-	+	-	-	-
	ABH	-	-	-	+++	+	-	-	-	-	-	-	-
	HOF	-	-	-	-	-	-	-	-	-	-	-	-
<i>Reseda</i> spp.	AKH	+	+	+	+	-	-	-	+	+	-	+	+
	ABH	-	-	-	-	-	-	-	-	-	-	-	-
	HOF	-	-	-	-	-	-	-	-	-	-	-	-
<i>Ricinus communis</i>	AKH	+	+	+	+	+	-	+	+	+	+	+	+
	ABH	-	-	-	-	-	-	-	-	-	-	-	-
	HOF	-	-	-	-	-	-	-	-	-	-	-	-
<i>Rumex vesicarius</i>	AKH	+	-	+	+	+	+	+	-	-	+	+	-
	ABH	-	-	-	+	-	+	-	-	-	-	-	-
	HOF	-	-	-	-	-	-	+	-	-	++	+	+
<i>Salsola</i> spp.	AKH	-	-	-	-	-	-	-	-	-	-	-	-
	ABH	-	-	-	-	-	-	-	-	-	-	-	-
	HOF	-	-	-	-	+	+	+	+	+	+	-	-
Ulmaceae	AKH	-	-	-	-	-	-	-	-	-	-	-	-
	ABH	-	-	-	+	++	+	-	-	-	-	-	-
	HOF	-	-	-	-	-	-	-	-	-	-	-	-
Umbelliferae	AKH	-	-	-	+	+	+	+	-	+	-	-	-
	ABH	-	-	-	-	-	-	-	-	-	-	+	-
	HOF	-	-	-	-	-	-	-	-	-	-	-	-
Grasses: <i>Cynodon dactylon</i>	AKH	+	+	+	+	+	+	+	+	+	+	+	+
	ABH	-	-	+	+	+	+	+	+	+	-	+	+
	HOF	-	-	-	-	-	-	-	-	-	-	-	-
Poaceae	AKH	-	-	-	-	-	-	-	-	-	-	-	-
	ABH	-	-	+	+	+	+	-	-	-	-	+	-
	HOF	-	-	-	+	+	+	+	+	+	+	+	+
Unidentified particles	AKH	+	+	+	+	+	+	+	+	+	+	+	+
	ABH	+	+	+	+	+	+	+	+	+	+	+	+
	HOF	+	+	+	+	+	+	+	+	+	+	+	+

Note: AKH, Al-Khobar; ABH, Abha; HOF, Hofuf.

Frequency: Pollen ranging from: 1 to 10 m⁻³, (+); 11 to 25 m⁻³, (++); 26 to 50 m⁻³, (+++); > 50 m⁻³, (++++); Absent, (-).

Table 2. One-year calendar of airborne and allergenic fungal spores Al-Khobar (1987–1988), Abha (1991–1992) and Hofuf (1992–1993)

Pollen types	Site	Months											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
<i>Alternaria</i>	AKH	+	+	+	+	+	+	+	+	+	+	+	+
	ABH	+	+	+	+	++	+	+	+	+	++	+	+
	HOF	+	++	+	++	+++	++	+	++	+	+	++	++
<i>Arthrimum</i>	AKH	+	+	+	+	+	+	+	+	+	+	+	+
	ABH	-	-	-	-	-	-	-	-	-	-	-	-
	HOF	-	-	-	-	-	-	-	-	-	-	-	-
<i>Cladosporium</i>	AKH	+++++	+++++	+++++	+++++	+++++	+++++	+++++	+++++	+++++	+++++	+++++	+++++
	ABH	+++++	+++++	+++++	+++++	+++++	+++++	+++++	+++++	+++++	+++++	+++++	+++++
	HOF	+++++	+++++	+++++	+++++	+++++	+++++	+++++	+++++	+++++	+++++	+++++	+++++
Colored basidiospores	AKH	+	++	++	++	++	++	++	+	++	++	++	++
	ABH	+	++	++	++	+++	+++	++	+	++	++	++	++
	HOF	+++++	+++++	+++++	+++++	+++++	+++++	+++++	+++++	+++++	+++++	+++++	+++++
<i>Curvularia</i>	AKH	+	+	+	+	+	+	+	+	+	+	+	+
	ABH	-	-	-	-	-	-	-	-	-	-	-	-
	HOF	-	-	-	-	-	-	-	-	-	-	-	-
<i>Drechslera</i>	AKH	+	+	+	+	+	+	+	+	+	+	+	+
	ABH	+	+	+	+	+	+	+	+	+	+	+	+
	HOF	+	+	+	+	+	+	+	+	+	+	+	+
<i>Epicoccum</i>	AKH	+	+	+	+	+	+	+	+	+	+	+	+
	ABH	-	-	-	-	-	-	-	-	-	-	-	-
	HOF	-	-	-	-	-	-	-	-	-	-	-	-
<i>Pleospora</i>	AKH	+	+	+	+	+	+	+	+	+	+	+	+
	ABH	-	-	-	-	-	-	-	-	-	-	-	-
	HOF	-	-	-	-	-	-	-	-	-	-	-	-
Rust spores	AKH	-	+	+	+	+	+	+	+	+	+	+	+
	ABH	-	-	-	-	-	-	-	-	-	-	-	-
	HOF	-	-	-	-	-	-	-	-	-	-	-	-
Smut spores	AKH	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++
	ABH	++	++	++	+++	+++	++++	++	+	+	++	++++	++
	HOF	+	+	++	++	+++	++++	++++	++	+++	+++	++	+
<i>Sporomiella</i>	AKH	+	+	+	+	+	+	+	+	+	+	+	+
	ABH	-	-	-	-	-	-	-	-	-	-	-	-
	HOF	-	-	-	-	-	-	-	-	-	-	-	-
<i>Stemphylium</i>	AKH	+	+	+	+	+	+	+	+	+	+	+	+
	ABH	-	-	-	-	-	-	-	-	-	-	-	-
	HOF	-	-	-	-	-	-	-	-	-	-	-	-
<i>Ulocladium</i>	AKH	+	+	+	+	+	+	+	+	+	+	+	+
	ABH	+	+	+	+	+	+	+	+	+	+	+	+
	HOF	++	+	+	+	+	+	++	++	+	+	+	+
<i>Venturia</i>	AKH	+	+	+	+	+	+	+	+	+	+	+	+
	ABH	-	-	-	-	-	-	-	-	-	-	-	-
	HOF	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified particles	AKH	+	+	+	+	+	+	+	+	+	+	+	+
	ABH	+	+	+	+	+	+	+	+	+	+	+	+
	HOF	+	+	+	+	+	+	+	+	+	+	+	+

Note: AKH, Al-Khobar; ABH, Abha; HOF, Hofuf.

Frequency: 1 to 50 m⁻³, (+); 51 to 100 m⁻³, (++); 101 to 200 m⁻³, (+++); >201 m⁻³, (++++); Absent, (-).

unidentified/damaged pollen and spores are grouped as "Unidentified particles"

3. Results

The one-year calendar of airborne and allergenic pollen grains of Al-Khobar, Abha and Hofuf are presented in Table 1. The pollen calendar is divided under three categories as Trees, Weeds and Grasses. A total of 31 pollen types were considered common for all the three sites. Among weeds pollen, *Amaranthus viridis*, *Plantago* spp., *Chenopodium album*, *Cyperus rotundus*, *Ricinus communis* and *Rumex vesicarius* were most frequently encountered pollen types, where as, *Juniperus* spp., *Populus* spp., Betulaceae, Oleaceae, *Prosopis* spp., *Parkinsonia aculeata*, *Eucalyptus* spp., and *Phoenix dactylifera* were among the frequent tree pollen types. Among the grass pollen group *Cynodon dactylon* and other Poaceae were found to be less frequent/sporadic in the airspora of the three regions.

The frequencies of various fungal spores in three regions showed that *Cladosporium* followed by Smut spores and coloured basidiospores were found to be very frequent types almost throughout the year (Table 2). *Alternaria*, *Ulocladium* and *Drechslera* were the other frequent types recorded. Spores that were recorded occasionally to sporadic are *Curvularia*, *Epicoccum*, *Sporomiella*, *Pleospora*, *Arthrimum*, Rust spores, *Stemphylium* and *Venturia*.

4. Discussion

The aerobiological investigation to record the airborne pollen and spores and to compile one-year pollen and spores calendars for each region in Saudi Arabia was conducted using Burkard Volumetric samplers. The pollen calendars show the distribution of frequently occurring taxa, particularly those having allergenic importance.

The frequencies of major pollen categories in three regions displayed the dominance of weeds pollen. The weeds pollen were found to be present almost throughout the year but declined during Jan–March, when the tree pollen dominated. The grass pollen although present throughout the year were less frequent. Frequencies of various

fungal spores in the three regions clearly exhibited *Cladosporium* spores as the dominant category followed by Smut spores and colored basidiospores. Solomon and Mathews (1978) reported that *Cladosporium* species probably occur more abundantly worldwide than any other spore type and are the dominant airborne spores in many areas, especially in temperate climates. *Ulocladium*, *Alternaria* and *Drechslera* were fairly encountered. A number of other spores with casual or sporadic appearances were *Curvularia*, *Epicoccum*, *Pleospora*, Rust spores, *Sporomiella*, *Stemphylium*, *Venturia* and *Arthrimum*.

The one-year calendars clearly show that weeds pollen at all sites were prevalent throughout the year. The findings also revealed that fungal spores comprise the greatest portion of the airspora compared to pollen grains and other biological particles. It has also been recorded that airborne fungal spores are present in the airspora almost throughout the year. Similar findings have been reported earlier (Salvaggio and Aukrust, 1981; Horner et al., 1995). The results are comparable to those from previous study in Saudi Arabia (Hasnain et al., 1989, 1995; Al-Nahdi et al., 1989) and other studies from some of the Middle East countries (Hariri et al., 1978; Youssef and El-Din 1988; Moustafa and Kamal 1976; Halwagy, 1994).

5. Conclusion

It is hoped that the data presented in these one-year calendars will help the health professionals of these regions to correlate the patients' symptoms in order to select precise allergen extracts for diagnosis and treatment of allergic diseases and to implement prevention or avoidance strategies in the region.

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