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# Seasonal distribution pattern of outdoor airborne fungi in Basrah city, southern Iraq

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***Abstract***

An assessment of air quality by examining outdoor airborne fungi among three sites over four seasons of the year 2009 in Basrah city (Iraq) was made. Gravitational setting method using Petri plates containing agar medium was applied. The results showed that nine fungal genera including 16 species besides the yeasts were prevalent in air samples. The most predominant fungi belonged to the genera *Cladosporium*, *Penicillium*, *Alternaria and Aspergillus*. Highest counts of the fungal isolates were recorded for *C. cladosporioides* (31.3 % frequency) followed by *P. notatum* (11.9 % frequency), *A. alternata* (10.0 % frequency) and *Asp. niger* (5.8 % frequency). A significant difference
($P < 0.001$) in the fungal populations over the four seasons was detected. Winter and summer exhibited higher fungal total isolates than spring and autumn at the studied sites. A correlation coefficient analysis revealed negative values between air temperature and total fungal counts and positive values between air humidity and fungal total counts over seasons. This study provided some information regarding the outdoor air borne fungal composition at Basrah city and suggesting a further investigation to correlate between the common human allergies among the population of Basrah and the high incidence of airborne fungi in outdoor environment of this city.

**Key words**: Airborne fungi, Basrah city, climate factors, seasonal variations

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## *Introduction*

Fungi are widely distributed over the world and are affected by various environmental factors such as temperature, moisture, wind and geographical location. It has been reported that airborne fungi are the most common microorganisms that have adverse effect on human health causing asthma, rhinitis and dermatitis besides they are considered as a source of plant and animal pathogens (McGinnis, 1980; Al-Doory, 1984; Agrawal *et al*., 1996; Burge *et al*., 2000). During the last decade more attention has been given by researchers to study the outdoor and indoor airborne fungi, this is mainly due to their importance to the human health, agriculture and food spoilage (Pieckova and Jeseneska, 1999; Shelton *et al*., 2002; Curtis *et al*., 2004). In the Middle East region, so far, a number of studies on airborne fungi have been carried out (Abdel Hafez, 1984; Yousif and Karam El-Din, 1988; Halwagy, 1989; Bahkali and Parvez, 1999), however, in Iraq a scattered data on airborne mycota is available. Therefore, the present study was conducted to elucidate the distribution pattern of outdoor airborne fungi over four seasons of the year 2009 in relation to some metrological parameters in Basrah city, southern Iraq.

## *Materials and Methods*

### *A Study area*

The city of Basrah is the second largest city of Iraq, located on latitude (30◦ N) and longitude (47◦ N) with an area of 19000 $km^2$. Three sites were selected for collecting samples of airborne fungi over four seasons during the year 2009; Winter (January-February), Spring (March-April), Summer (July-August) and Autumn (October-November). Site I (Zubair dstrict) is featured by a desert land with sandy soil and only some desert wild herbs and shrubs are growing in spring, Site II (Abulkhasib district) is located near Shatt Al-Arab River, dominated by date palm plantations and some other plant trees. While the site III (Basrah University Campus) is also located near Shatt Al-Arab River, with East side part covered with date palm plantations while the west side is a bare land. The distance between one site and another is about 25 km. The climate conditions of Basrah city mostly humid during summer and winter (35-85 % humidity), warm in summer (30-45°C), mild in spring and autumn (20-28 °C) and becoming somehow cool in winter (10-18°C). The wind velocity ranges (1.0-25 km/hr) and may carry dust in summer while in winter shows some rainy days.

### *Samples collection and data analysis*

A total of 360 samples were collected during this study. Samples were taken in the morning (8.00-10.00) using the gravitational setting method with Petri dishes containing an autoclaved Potato Dextrose Agar (PDA) and Sabourauds Dextrose Agar (SDA) media supplemented with Chloramphenicol (250 ug/L) to prevent bacterial growth. Five plates (three times a month per site) were exposed to the outdoor air at a height 2-2.5 m above the ground for 20 min, plates were recovered with the lids, brought to the laboratory immediately and incubated at 25 C. Fungal growth was examined at intervals for 7 days of incubation. Fungal pure culture was made for each of the isolated fungi and identified according to the literatures (Rapper and Fennell, 1969; Ellis, 1971; McGinnis, 1980; Hoog and Guarro, 1995). Number of fungal colonies of each species per sample for each collecting times and sites were calculated according to Muhsin (1987). The data were statistically analyzed using the Analysis of Variance (ANOVA) to compare the fungal populations among the sites and over the

collecting seasons. A correlation coefficient (r- values) between the number of fungal colonies and the metrological parameters was also applied. The metrological data (air temperature, wind velocity and relative humidity) of the studied area were provided by the Metrological Station in Basrah city.

***Results***

The present study revealed that the outdoor air of Basrah city harbors a fungal populations consisted of a cosmopolitan airborne fungal species have been isolated elsewhere over the world. Nine genera including 16 species of airborne fungi were isolated in this study besides the black and white yeasts (Table 1). Among the recovered fungi, *Cladosporium cladospoiroides* was the most dominant species with a total of 505 isolates and 31.3 % frequency in air samples collected from the studied sites over four seasons. *Penicillium notatum* also exhibited a high number of isolates in the outdoor air samples represented by 193 isolates with 11.9 % frequency followed by *Alternaria alternata* (173 isolates with 10.0 % frequency) (Table 1). *Aspergillus niger* was the most frequent species among the genus recovered from the outdoor air samples with a frequency of 5.8 % (95 isolates). A comparison of airborne fungal assemblages among the selected sites showed a similarity in the fungal species composition. However, the total number of fungal isolates was slightly higher in site I (614 isolates with 37.7 % frequency) followed by site III (525 isolates with 32.3 % frequency) and site II (480 isolates with 30.0 % frequency) (Table 1).

The seasonal distribution patterns of the outdoor airborne fungi among the studied sites in Basrah city were similar with some variations among the isolated species (Fig.1). Highest number of isolates was accounted for *C. cladospoiroides* (131 isolates) in winter at site I, in autumn (66 and 60 isolates) at site II and III, respectively. Similarly, *P notatum* showed a relatively high number of isolates (41 isolates) at site I in winter and site III (33 isolates) in the summer, however, its counts were low at site II over four seasons (Fig.1). *A. alternata* isolates were greater in counts at site I than the other sites during summer. The white yeasts revealed an increase of isolates number during winter at both site I and II (56 and 81 isolates, respectively). Nevertheless, the number of isolates of the rest of fungal species fluctuated over the seasons for each site (Fig.1). Generally, the outdoor air samples collected in winter rendered highest total number of fungal isolates at each of the collecting sites showing a significant differences ($P< 0.001$) between the total number of fungal isolates in this season compared with other seasons (Fig.2). However, no significant differences were observed between the total number of fungal isolates in air samples collected from site I during winter and summer as well as between spring and autumn seasons. Apparently that spring season exhibited the lowest total number of isolates of airborne fungi at the three sites (Fig.2).Whereas, at site II the total number of isolates was significantly greater ($P< 0.001$) in autumn than in spring and summer.

Regression analysis showed a negative correlation ($r = -0.48$, $r = -0.69$ and $r = -0.56$) between total fungal isolates and air temperature of site I, II and III, respectively. While a positive correlation ($r = 0.64$, $r = 0.68$ and $r = 0.65$) was found between the total fungal isolates with the air relative humidity. Wind velocity, on the other hand, negatively correlated ($r = -0.31$ and $r = -0.14$) with the total number of isolates at site II and III, respectively, and positively correlated ($r = 0.11$) at site I.

**Table 1. Total numbers of isolates of airborne fungal species at three sites in Basrah city.**

| Fungal species | Site I | Site II | Site III | Total isolates | Frequency % |
|---|---|---|---|---|---|
| ***Alternaria alternata*** | 78 | 37 | 58 | 173 | 10 |
| ***A. chlamydospora*** | 21 | 22 | 5 | 48 | 2.9 |
| ***A. dennisii*** | 5 | 2 | 0 | 7 | 0.4 |
| ***Aspergillus flavus*** | 42 | 10 | 4 | 56 | 3.4 |
| ***A. fumigatus*** | 18 | 5 | 18 | 41 | 2.6 |
| ***A. niger*** | 24 | 21 | 50 | 95 | 5.8 |
| ***A. terreus*** | 11 | 4 | 6 | 21 | 1.3 |
| ***Cladosporium cladospoiroides*** | 123 | 144 | 238 | 505 | 31.3 |
| ***C. herbarum*** | 17 | 25 | 35 | 77 | 4.8 |
| ***Fusarium proliferatum*** | 6 | 5 | 6 | 17 | 1.1 |
| ***F. moniliforme*** | 11 | 5 | 10 | 26 | 1.5 |
| ***Mucor hiemalis*** | 10 | 18 | 5 | 33 | 2.1 |
| ***Penicillium notatum*** | 92 | 45 | 56 | 193 | 11.9 |
| ***Phoma glomerata*** | 26 | 10 | 0 | 36 | 2.3 |
| ***Rhizopus stolonifer*** | 19 | 7 | 10 | 36 | 2.3 |
| ***Ulocladium atrum*** | 8 | 9 | 9 | 26 | 1.5 |
| **Black yeasts** | 16 | 40 | 5 | 61 | 3.8 |
| **White yeasts** | 80 | 87 | 10 | 177 | 10.9 |
| **Total isolates** | **614** | **489** | **525** | **1628** | **100** |

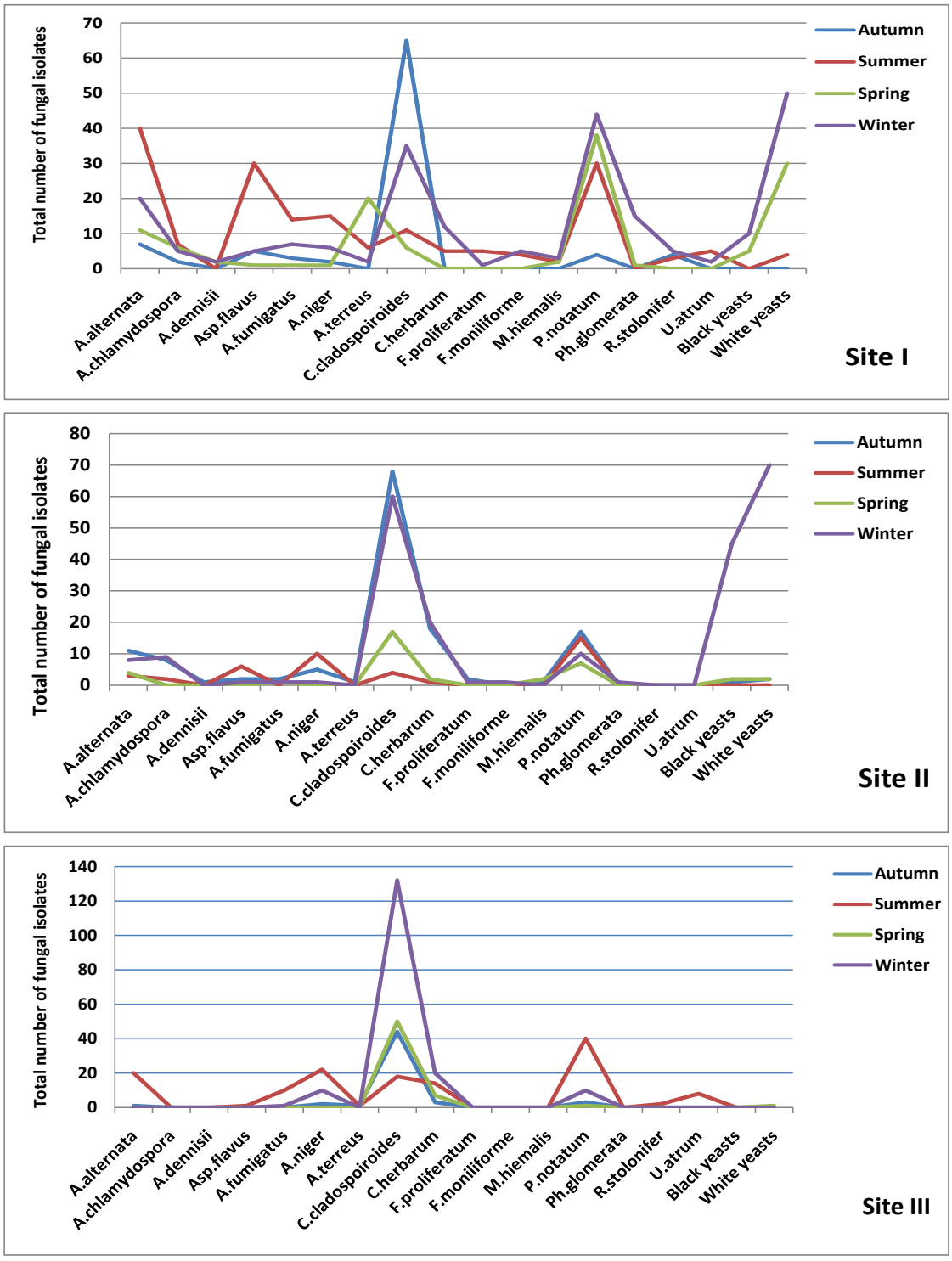


**Fig.1. Seasonal variations of the total isolates of airborne fungi among three sites over four seasons in Basrah city.**

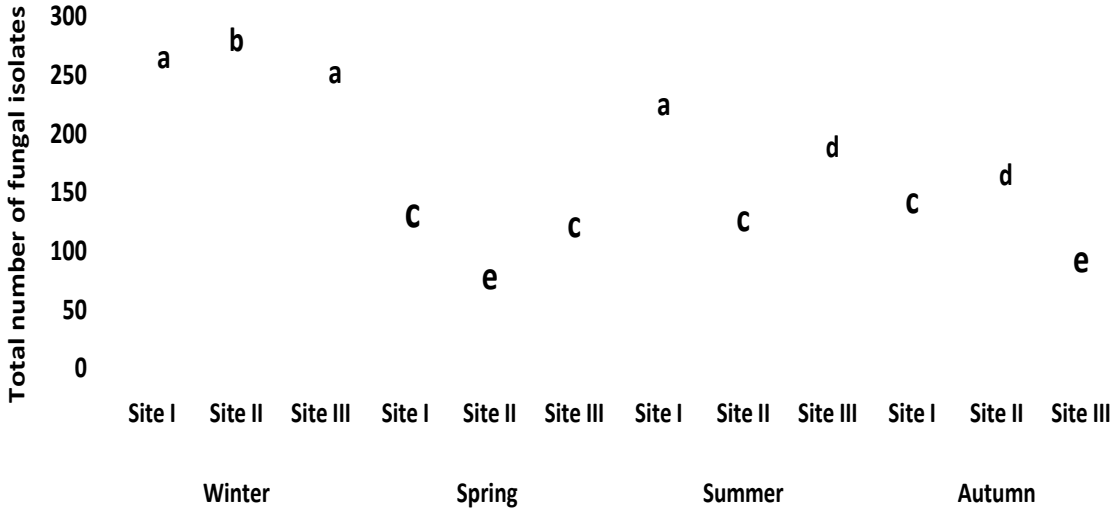


**Fig.2. Total numbers of isolates of airborne fungi in three sites over four seasons in Basrah city. Different letters above the bars indicates significant differences at $P < 0.001$.**

## *Discussion*

Biological air quality assessment is essential since it is related to the human health, food industry and animals and plants pathogenicity. In the last decade, an increasing interest by researchers was given to investigate the outdoor and indoor airborne fungi due to their adverse effects on human health (Burge *et al*., 2000; Shelton *et al*., 2002; Horner *et al*., 2004). The present study examined the culturable fungi from outdoor air over four seasons of the year in the vicinity of Basrah city, Iraq. It appeared that most of the recovered fungal species are cosmopolitan and widely spread in atmosphere over the world. The isolated species of the genera *Alternaria, Aspergillus, Cladosporium,Fusarium* and *Penicillium* were frequently reported in outdoor and indoor air elsewhere, for examples, from United States (Al-Doory *et al*., 1980; Bush, 2001; Shelton *et al*., 2002; Horner et al., 2004), Canada (Li and Kendrick, 1995), Australia (Garrett *et al*., 1998), Italy (Marchisio *et al*., 1992) and Turkey (Tobas *et al*., 2006). These fungal genera were also reported from different locations in the Middle East region (Yousif and Karam El-Din, 1988; Abdel-Hafez, 1984; Halwagy, 1989). Seemingly, these fungi are also prevalent in air samples collected from Basrah city. as *C. cladospoiroides* was the most dominated fungus amongst the isolated species from the examined air samples. This is in concomitant with other studies (Flannigan *et al*., 1987; Halwagy, 1989; Shelton et al., 2002; Helbling and Reimers, 2003). This species is considered as xerophilic, xerotolerant and psychrophilic and capable of producing of various enzymes (Domsch *et al*., 1980). This may explain it prevalence in air over all parts of the world. Moreover, *C. herbarum* was also found in air samples of Basrah city, this fungus has been reported as causative agent of allergies (Bush, 2001).

*Alternaria* spp. were also reported from air samples examined by many investigators from different regions over the world (see Al-Doory, 1984). *A. alternata* was frequently isolated in the present study mainly at site I during summer season. A previous study (Muhsin and Daraj, 1993) reported that *A. alternata* is a common fungus associated with moribund desert plants at summer season in Basrah area (represented by site I). Hence, it can be speculated that the moribund desert plant may be the source of the high incidence of this fungus in outdoor air of the studied sites, particularly in site I (Fig.1). It is worth mentioning here that the coincidence of asthma and other allergic symptoms among the population of Basrah city during summer season

perhaps is related to the increase of propagules of *A. alternata* or some other species present in the air during summer season. A further study regarding this postulation is needed. Nevertheless, it has been stated that *A. alternata* is a main cause of allergy and asthma elsewhere (Halonen *et al*., 1997; Downs *et al*., 2001).

In this study, the seasonal distribution pattern of outdoor airborne fungi was significantly varied. Winter exhibited highest total counts of fungal isolates at the studied sites. The increase of fungal propagules in winter can be related to the elevation of humidity and rainfall at Basrah area. This result agreed with another study (Halwagy, 1989) conducted on airborne fungi in a similar climate region. However, our results are contrary with some other studies (Shelton *et al*., 2002; Tobas *et al*., 2006) that reported maximum fungal counts in summer season. Despite of an increase in temperature in summer at Basrah, however, an increase of airborne fungal population during this season was noticeable specially at site II and III and can be mainly related to an increase of humidity level that encourage in the spores germination and fungal growth, in addition to the adaptations of fungal spores to tolerate the sun light at summer season by having dark pigments that reduces the light intensity. Moreover, these two sites are often exposed to a dusty wind storms in summer that may carry more fungal propagules from different sources such as soils and plants. Nonetheless, some of the fungal species are considered as xerophilic or thermotolerants which are adapted and can thrive well in a warm climate (Domsch *et al.*, 1980). Site II, however, is featured by high density of date palm plantations and some other trees are grown. Consequently, an increase of plants litter during autumn may be considered as a source which leads to a relative increase of outdoor airborne fungal population (due to air dwelling) at this site compared with the other two sites. Spring season revealed the lowest counts of airborne fungal isolates at the studied sites. No explanation can be stated in this regard, however, a calm wind velocity and less humidity in spring might be the reason of such decline in total fungal isolates based on the setting method applied in this study. A similar fungal distribution trend was also found in outdoor air of Turkey, northern Iraq (Tobas *et al*., 2006).

In conclusion, the present study provided some information regards the air quality in this part of the world using biological approach as an indicator of air pollution which may be useful for a further investigation to correlate the outdoor/ or and indoor airborne fungi with the human allergenic responses.

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