AEROMYCOFLORA OF DHAKA CITY, BANGLADESH.

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DEDICATED

TO

MY BELOVED PARENTS

AND

THE REVERENT TEACHERS

CERTIFICATE

*This is to certify that the research work embodying the results reported herein this thesis entitled "**Aeromycoflora of Dhaka City, Bangladesh**" has been carried out in the Department of Botany, University of Dhaka, under our supervision and guidance. It is further certified that the work presented here is original and suitable for submission in partial fulfillment of the **Master of philosophy degree in Botany.***

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The Author

ABSTRACT

The air influences every aspect of life and the activities of organisms affect the air. Sources of air borne microorganisms are everywhere. They are in food, water, on utensils and on bed sheets. The indoor and outdoor air is an important source of aeroallergens and pathogens.

During the present investigation, monthly sampling of air borne mycoflora of Dhaka Metropolitan City, during February 2013 to January 2014 was recorded. The fungal colonies developed in PDA media were isolated from five different locations in the morning and evening in monthly intervals. The total number of counted fungal colonies were 6648 out of which in the morning was 3268 and in the evening it was 3380 and 156 colonies were sterile mycelia. The sampling sites were Sher-e Bangla Agricultural University, Gulistan, Dhaka Medical College, Sadarghat and DOHS, Mohakhali. The qualitative nature of the mycoflora, their mean, standard deviation, percent frequency and correlations to the total mycoflora, monthly periodicity have been described in this investigation. In this study, fifteen genera have been recorded *viz*. *Alternaria, Arthrinium, Aspergillus*, *Bipolaris, Chaetomium, Cladosporium, Colletotrichum, Curvularia, Fusarium, Nigrospora, Penicillium, Pestalotia, Rhizopus, Syncephalastrum* and *Trichoderma* under the class Ascomycetes, Zygomycetes and Deuteromycetes. Local fluctuations of the air borne fungi in relation to some meteorological parameters were also studied.

The three most dominant fungal species were *Aspergillus*, *Cladosporium* and *Penicillium* contributing 30.71, 18.10 and 12.79% in the evening and in the morning it was 28.82, 15.78 and 11.53% in twelve months counting

of the total colonies, respectively. *Aspergillus* was found in the highest frequency in the present investigation among the identified genera. In the present study *Cladosporium* was found 2nd position in term of its percent frequency.

Maximum number of fungal colonies were found in Gulistan and Sadarghat in the morning and evening. During the twelve months investigation maximum fungal colonies were found in August and September as all the climatic factors were favorable for the fungal growth, their dispersal and survival.

Among the fungi, found in the present investigation *Alternaria, Aspergillus, Chaetomium, Cladosporium, Curvularia, Fusarium, Penicillium* and *Rhizopus* were reported as pathogenic to plants and/or human and strongly allergenic to human. *Bipolaris, Colletotrichum,* and *Pestalotia* were reported as only plant pathogens. The present study contributes to our knowledge of air borne spores in the Dhaka City. Regular monitoring of air borne fungi can be helpful in the prevention of fungal allergic diseases in the city.

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CHAPTER 1

INTRODUCTION

INTRODUCTION

Earth consists of an atmosphere full of airborne microbes such as virus, bacteria fungal spores and others. These micro organisms show significant correlation with air pollution and weather. Some of them are viable. The air we breathe in is full of thousands of fungal spores, which in certain compositing environments can easily exceed $10^9/m^3$ (Aimanianda *et al*. 2010). Exposure of fungal spores occurred mostly in indoor air nevertheless outdoor air is an important source of both aeroallergens and pathogens (O'Gorman and Fuller 2008).

Most spores are viable airborne particles, which are to some extent suited for survival in such an environment for a limited period of time. Most of the airborne microbes originate from natural sources like soil, water bodies and animals including man (Proctor 1935, Zobell 1964). Not only the spores of fungi, myxomycetes, bryophytes and pteridophytes but also pollen grain, moss gemmae, propagules of lichens, cells of algae, vegetative cells of plants constitute the air spores. The air spore comprises cells, which have entered the atmosphere at various places and various means. Thus the interpretation of the spores in a given air mass requires an understanding of the probable movements that brought it there. It is therefore necessary to consider some physical aspects of the atmosphere.

The study of aerobiology is thus important in understanding the distribution and ecology of fungi and also to relate their interactions with plants, human and their products. Some may be harmless to other forms of life. Others cause diseases of plant, human and yet others

cause deterioration of food staffs and manufactured products. The ecology of an area exerts a major influence on its "air-spora" through local flora and microclimate (Lacey 1964). Information of the component of the air-spores collected so far from different parts of the world indicate how local conditions influence the different components to a certain extent.

Two aspects need to be distinguished in considering the horizontal distribution of spores in the air firstly the behavior of clouds of spores arising from a single restricted source and secondly the background concentration of spores from a myriad distance of sources. The concentration of spores in the atmosphere decreases rapidly with distance from a source with time from the moment of release. More than 90% of spores from near ground sources are often deposited within 100 meters.

Air movements readily transport particulate matter over considerable distance, e.g. spread of foot and mouth disease virus, pollen deposits at the earth's poles and transfer of stem rust disease from Mississippi valley (where it was epidemic) to the northern regions of Canada (Cox 1995). Such ubiquitous fine biological particles of diameter 0.05-100 μm are termed as 'Bioaerosols' (Pelczer *et al*. 2004) However, the abilities of air-borne microbes to cause disease also depend in their surviving and remaining infective for susceptible hosts (Cox 1995). Outdoor rain action, air turbulence and diffusion, spray irrigation, sewage treatment, breaking of waves, busting of bubbles, crop spraying etc. ensure that multi-component bioaerosols are formed continuously and travel downwind.

Fungal spores in the air is markedly seasonal because of their sensitivity to weather changes (Hjelmroos 1993, Kurkela 1997, Corden and Millington 2001, Stepalska and Jerez 2005). Fungi produce various forms

of spores which are actively or passively released. The occurrence of fungal spores in air is also associated with ecological dependences of the parasite host type (Chakraborty *et al*. 2003). Air borne fungal counts increased with temperature and decreased with rainfall and relative humidity (Kasprzyk 2008) and have many implications in the spread of human and plant diseases. Weather conditions affect the sporulation, dispersal and deposition of spores and their elements correlate with each other (Kasprzyk 2008). In spite of these complicated dependences, the effect of weather conditions being taken into consideration. Warm and dry weather favors the development, sporulation and dispersal of *Cladosporium*, *Epicoccum* and *Alternaria* conidia and the greatest daily concentration of conidia of these genera usually occurs at noon and in the afternoon hours, when the highest temperature prevails and the lowest values of humidity are recorded (Kasprzyk 2008).

Air borne dispersal of spores out of the doors has considerable biological and economic importance. Numerous plant diseases are caused by air borne fungi. The rapid spread of some such diseases may be the result of many successive acts of dispersal and infection rather than long individual journeys but long distance is very important in the epidemiology of some diseases. Human and animal pathogens spread from host to host directly being unable to multiply in the non-living environment. Outdoor air is not a serious source of infection. It is noteworthy that the principal exceptions to this generalization are fungal diseases such as plasmosis and coccidiomycosis, both of which are caused by organisms able to multiply in the soil. Many sorts of air borne biological particles, particularly pollen grains and spores of certain fungi are, however, important causes of allergies in man (Hawker and Linton 1971). Thus, it is increasing evidence that fungal growth is a risk factor

for the development of mycotoxicity, biodeterioration and infections of man and animals.

Moreover, sources like sewage treatment (Napoletane and Rowe 1966, Adam and Spendlore 1970), animal rendering fermentation processes (Casida 1968), agricultural activites (Christensen and Kaufman 1969, Dickinson 1981, Ramalingam and Nanjundaiah 1983) and vegetation around contribute a lot to the microbial population of the atmosphere. Air borne microbes are one of the component of men's environment and undoubtly are of potential economic and health implications (Gregory 1961, Tsuchiya and Brown 1964, Hashimoto 1986). Moreover, viable microbes in extramural air may be responsible for men's illness during certain seasons of the year and may have serious consequences (Contane *et al*. 1954, Maestreet *et al*. 1986).

Adhikari *et al*. (2004) on outdoor air sampling in a rural agricultural area of India reported the ranges of total fungal spore concentration were 82-2365 spores/m^3 in the first sampling year and 156-2022 spores/m^3 in the second sampling year. The concentration ranges of viable fungi were 72-1796 colony forming units per cubic meter of air CFU/m^3 in the first sampling year and 155-1256 CFU/m^3 in the second sampling year. Devkota and Sharma (1990) reported the atmosphere fungal spores of *Alternaria, Aspergillus, Curvularia, Cladosporium, Helminthosporium, Mucor etc.*

The earliest aerobiological survey in this sub-continent was carried out by Cunningham in 1973. Since then a number of surveys on this aspect has been made in India (Ramalingam 1971, Janaki-Bao 1979, Patil and Vyavahare 1981, Singh *et al*. 1981, 1985, 1987, Narayan *et al*. 1982, Geyer and Khala 1984, Sandhu and Singh 1985, Tilak and Saibaba 1985,

Kumar 1986) and other areas of the world (Maunshell 1985, Richard 1954, Prince and Marrow 1969, Long and Kumar 1973, Al-doory *et al*, 1980, Cherila *et al.* 1981, Americo *et al*. 1983, Ballero *et al*. 1984, Anderson 1985, Beaumont *et al*. 1987).

Shrestha *et al*. (2010) recorded that fungi were the most prevalent in Katmandu, Nepal. Shrestha and Sharma (2010) recorded the highest number of mycoflora in the spring followed by a decrease up to autumn season and increasing tendency afterwards, with the agricultural areas comprising the highest number of genera (24 genera) while least in the airport. Similarly, Bangladesh is one of the developing countries of the world, but is not poor by the abundance of microorganisms (Anonymous 1997), Raanjhanaa (1997) reported 21 genera belonging to Zygomycetes, Ascomycetes and Deuteromycetes in Bangladesh. The frequency of *Aspergillus niger* increased in rainy season with significant prevalence during autumn but gradually decreased in winter.

Air borne spores of some fungi may be associated with acute toxic effects, allergies and asthma (Burge 2002). There is increasing evidence that fungal growth is a risk factor for the development of mycotoxicity, biodeterioration and infections of man and animals. A precise quantitative and qualitative analysis of the content of fungal spores in this type of space and their description of collected materials permit the estimation of the degree of imminent biodegradation, undertaking of proper protection measures which aids in the conservation of the artistic heritage (Nugari and Roccardi 2001). The wide spread use of immuno suppressive drugs for cancer patients and recipients of solid organ and bone marrow transplants has led to a major increase in the incidence of invasive. Often lethal infections are caused by opportunistic fungi (VandeWoude *et al*.

2006). Molds of the genus *Aspergillus* produce many of these infections, nearly half in some instances, and *Aspergillus fumigatus* is by far the most prominent species especially in leukemia (incidence 5 to 25%) and in patients transplanted with solid organs, where the incidence is 1 to 10% (Denikus 2005, Denning *et al*. 2006).

Dhaka Metropolitan city is over-crowded as well as highly polluted due to different pollutants. Fungal spore is one of the most important factor for this pollution. It is assumed that fungal spores are produced from the degradation of garbages and other sources of the city. They flow with the air current around the city. Human being is constantly inhaling these fungal spores from the air during inhalation. As a result respiratory organ of human is being infected due to fungal spores causing physiological disorders. To overcome this waste situation it is essential to detect the qualitative and quantitative estimation the fungal spores which are found with in the air of Dhaka city.

Gravity slide method (Frankland 1989) and Gravity plate method (Colakoglu 1996, Hedayati *et al*. 2005) are the most commonly used methods for the isolation of the air borne mycoflora. Similarly, a sampling device aero scope can be used for collecting air borne mycoflora (Frankland 1989) but in Bangladesh and Nepal conventional methods are used for the identification of fungus.

Limited study on aerobiology has been done in Bangladesh (Khan and Ali 1984, Pasha and Hossain 2011 and Ahmed *et al*. 2013). However, no aeromycological investigation of the external air particularly of Dhaka Metropolitan city has been made in Bangladesh. The air mycoflora of a place varies with season, temperature, humidity and activity of people and this need to be revised every year.

The survey of literature indicates that there is scarcity sporadic report on the survey of aeromycoflora but the no detailed study on the aeromycoflora of Dhaka Metropolitan city has not been done so far. The present study have been conducted to know the distribution pattern of aeromycoflora of this city. This investigation may help us to know the present position of air pollution by fungal spores. The following aspects have been studied in detail:

- Selection of study area of Dhaka Metropolitan city.
- Monthly isolation of air borne mycoflora from the selected area on PDA culture media.
- Identification of air borne mycoflora following standard literature.
- Study the density of population of air borne fungi from different locations in different months at different intervals.
- Find out the correlation between the number of mycoflora and environmental factors.

CHAPTER 2

REVIEW OF LITERATURE

REVIEW OF LITERATURE

A brief review of literature pertinent to the present investigation was made from the work carried out by different workers are presented below.

Al-doory *et al.* (1980) surveyed the air borne fungi and pollens of the Washington DC Metropolitan area. They found that molds and pollen allergies were common in Washington DC Metropolitan area. Air borne fungi and pollen grain were studied throughout 1977 weekly sampling for determination of prevalence of fungi. Dominant fungi were *Hormodendrum* sp. (June) and *Aureobasidium* sp. (March).

Calvo *et al*. (1980) investigated air borne fungi in the air of Barcelona, Spain. During two years survey of the fungal flora, the species of yeast's were isolated. These were *Sporobolomyces roseus et* Van Niel, *Candida albicans* (Robin) Berkhout, *Rhodotorula gentinis* (Fres) Hornison var. *glutinis* and *Rhodororula munuta* (Saito) Harrison. Annual and seasonal incidences were also reported.

Harrington (1980) conducted an experiment on the release of air borne basidiospores from *Cryptoporus valvatus.* He observed air borne basidiospores released from field produced basidiocarps of *C. valvatus* (Pk) Shear and collected by placing a funnel, equipped with a collection vial, below each of 7-11 days until spore released, ceased (average-71 days) and the volva allows production of air borne spore during the periods of low rainfall and relative humidity often associated with beetle flights in areas of Western North America where this fungus was most common.

Hartill (1980) investigated the aerobiology of *Sclerotinia elerotionum* and *Botrytis* emerge spores in Newzeeland tobacco (*Nicotiana tabacum*) crops. He showed the seasonal abundance of ascospore of *S. sclerotioum* in the air depended on rainfall moisture of the soil. No other climatic factors related to the trapping pattern. Ascospore of *S. sclerotioum* and conidia of *B. cinerea* both showed markedly diurnal distribution patterns.

Sing *et al*. (1980) studied the intensity of airborne fungi of Lucnow city using culture plate exposure method for a period of one year that from March 1977 to February 1978. The species of *Aspergillus*, *Cladosporium*, *Alternaria*, *Curvularia*, *Penicillium*, and *Fusarium* were found abundant throughout the year. Some of the fungal types, that is *Aureobasidium* sp., *Myrothecium* sp., and *Cuninghamella* sp. were detected for the first time in the atmosphere of Lucnow city. Some of these fungal antigens have shown significant positive skin response in allergy patients.

Cherila *et al*. (1981) investigated the relationship between air borne fungal spore and *Dermatophagoides pteronyssinus* in house dust. The prevalence of mold general and their association with house dust mite were investigated in the homes of 192 asthmatic patients and 125 healthy people in a Romanian Town with a relatively high degree of humidity. The dominant molds that developed in the culture media exposed on the bedroom floors were *Cladosporium* sp., *Penicillium* sp., and *Aspergillus* sp. Living *D. pteronyssinus* and their eggs were present mostly in the colonies of *Cladosporium* sp. In those of *Penicillium* sp. the house dust mites were dead and disintegrated.

Holtmeyer *et al.* (1981) surveyed the incidence and distribution of air borne spores of *Aspergillus flavus* in Missouri, USA. *Aspergillus flavus* showed that it produced aflatoxin. The percentage of spores were at each site differed from year to year but was never below 17% in 1976 and 1977.

Han *et al.* (1981) observed air borne fungal spore count daily from 1975-1979 at six different stations in the Taipei area. The spore season was May- October in the Taipei area. The count month during this period reached 632/cm². A 311/cm²/ month count was only found from November to April.

Klabusching *et al.* (1981) reported influence of aerobiology and weather on symptoms in children with asthma. They investigated local and central European weather pollen and spore of *Alternaria* sp. and *Cladosporium* sp. counts and asthmatic complains and drug requirements were correlated in a group of 40 asthmatic children during a summer holiday camp for six weeks.

Patil and Vyavahare (1981) surveyed the aeromycoflora of the Ganeohkhind area, India. The aeromycoflora was investigated by exposing petriplates with lactose-yeast extract days over a period of three months starting from 1st November 1980 until 31st January 1981. 24 genera and 38 spp. were recorded. Colonies belonging to *Cladosporium* sp., *Curvularia* sp., *Alternaria* sp., *Aspergillus* sp. and *Fusarium* sp. were frequently recorded and constituted the major components of the air spora.

Singh *et al.* (1981) investigated allergenic significance of air borne fungal spores of allergy patients residence of Lucnow City in India. *Aspergillus* sp., *Cladosporium* sp., *Penicillum* sp., *Alternaria* sp., and

Curvularia sp. showed significant abundance in most of the houses along with some other fungal types. *Aspergillus* sp. showed its maximum abundance (39.3%) affecting about 89.3% houses.

Tilak *et al*. (1981) investigated allergenicity of certain air borne fungal spore of a hospital ward. *Aspergillus flavus*, *A.niger*, *A.fumigatus*, *A. tamari*, *Alternaria* sp., *Curvularia* sp., *Helminthosporium* sp., and *Rhizopus* sp. were tested on allergy patients. The spores of *Aspergillus* spp. *Alternaria* sp. and *Curvularia* sp. showed a maximum number of positive skin reactions.

Anita *et al*. (1982) conducted a survey of the aerial mycoflora of Bomby over a period of 12 months. It was found that species from the genera *Aspergillus, Penicillium* and *Cladosporium* together accounted for 50 to 75% of the total spore load. Organisms from the genera *Alternaria* sp. and *Curvularia* sp. were the other major forms encountered along with the yeasts.

Abdel and Swelim (1982) studied the air borne thermophilic fungi at Qena, Egypt. *Aspergillus* sp. was the only air borne fungus identified at 45ºC. *Aspergillus fumigatus* was extremely dominant.

Narayan *et al*. (1982) investigated aeromycology of the atmosphere of Malleos warm market, Bangalore (India). They surveyed atmospheric fungal spores of Malleos warm market, a vegetable market situated in the northern part of Bangalore City. Species of fungi (87) distributed in 47 genera and two sterile forms were identified during the study. Among the trapped fungi, *Aspergilli, Penicillia*, *Fusaria*, Zygomycetes, *Alternaria* sp. and *Cladosporium* sp. were the most dominant groups. The total spore count was maximum during the summer months of March and April. Tseng and chingehen (1982)

reported air borne fungal spores of *Teuapola aristata*, *T. ellisii* and *Spegagginia lessarthra* from Taiwan.

Vittal and Ponnusamy (1982) in their study noticed significant differences in the percentage contribution of different species of the same genus. For example *Aspergillus niger* was the most abundant among the nine species recordrd. *Cladosporium cladosporioides* was found to be dominant among the three species of the genus recorded. *Drechslera hawwanensis* was found to be the second dominant species.

Americo and Wilma (1983) studied the fungal air borne spore pollution in the city of Recife, Brazil. They reported 73 genera of fungi. *Aspergillus* sp., *Penicillum* sp., *Cladosporium* sp., *Candida* sp., *Rhodotorula* sp. and *Phoma* sp. were among the 299 fungi identified.

Morring *et al*. (1983) carried out an investigation on the sampling for air borne fungi. A statistical comparison of media they observed four broad spectrum media employed for enumeration of fungi from air were compared to determine which could yield the highest number of colony forming units when simultaneously sampling air from the same environment.

A 15 months survey of air borne fungi (Meyer *et al* . 1983) at 14 geographical stations was conducted to determine the incidence of different fungal genera. Five of these stations were surveyed 25 year earlier, many survey have been made of aerobiological populations in different areas of the USA in an effort to determine the presence of airborne fungi involved in respiratory allergic diseases and to demonstrate their seasonal distribution. A comparison between

previous studies fluctuation and present surveys revealed similar organisms at each station with slight fluctuation in frequency of dominant genera.

Sheridam *et al*. (1983) investigated aeroallergens in the homes of Wellington, New Zealand. They studied available fungi present inside the homes of 35 asthmatics in the Wellington area during 1980 using the settle plate method. Fifty species were identified. *Aspergillus* sp., *Cladosporium* sp., *Penicillium* sp. and unidentified basidiomycetes were present in all homes and *Alternaria* sp.in 91%. There were little difference in the types and frequency of occurrence of fungi in house of asthmatics and non-asthmatics.

Satpute *et al*. (1983) in their aerobiological studies of Shillong, India observed the seasonal variation of atmospheric pollen and fungal spores. They recorded total air spora, pollen grains, fungal spores and other biological materials which constituted 22, 72 and 6% respectively. The frequency of the fungal spores was maximum during September and minimum in March with two peak periods in June, and September.

Abdel (1984) surveyed of air borne fungal spores at Taif, Saudi Arabia. Fifty eight species and one variety belonging to 25 genera were collected from the atmosphere of Taif during August 1981 to July 1982 on glucose and cellulose agar plates at 28ºC.

Blamquist *et al*. (1984) studied the methods of collection of air borne fungi. Survey method developed for determining air borne fungi particles in environments highly contaminated with mold fungi was

discussed. The collection of air borne fungi consists of two silt samplers. These sampling devices gave the highest values out of the three different types tested simultaneously.

Ballero *et al*. (1984) surveyed air borne spores in the atmosphere of Cagliari, Italy. The purpose of this work was to give original and useful data for the systematic identification of ethnological air borne agents which may caused different types of clinical allergy. Data have been elaborated which refereed to two genera of mycophytes found to be the most diffused in the atmosphere of Cagliari, Sandinia, Italy. These were *Alternaria* sp. and *Cladosporium* sp.

Ghosh *et al*. (1984) studied a preliminary aero-biological survey on a Virginia tobacco during harvesting. A preliminary environmental survey was carried out on a tobacco farm at Rajahmundry, Southern India. Sixty-eight samples were taken and 304 slides were exposed to fungal spores and pollen grains which were studied by the gravity-slide method. Many*Cladosporium* sp. isolates were counted from the field. Field samples always showed a higher number of pollen grains. Usually the central part of the field registered higher numbers of pollen grains and fungal spores. These findings may be related to the occurrence of allergic reaction, in tobacco farmers.

Geyer and Khala (1984) investigated an aerobiology of Himalayan alpine zone Rudranath, India. The atmospheric particulate were analyzed by exposing adhesive coated slides, at inter also of 24 h, on a gravity sampling device. The aerobiological composition was found to be 65.5% fungal spores, 23.9% pollen and 10.4% miscellaneous biotic objects.

Khan and Ali (1984) made an aerobiological study of the Dhaka city and its suburban areas. The most frequently isolated bacteria and their percentage of occurrence were *Bacillus* sp. (56), *Staphylococcus* sp. (20), *Micrococcus* sp. (6), *Sarcina* sp. (1) and *Corynebacterium* sp. (1). The number of hemolytic bacteria was found to be more in the hospital wards than in the outdoor samples.

Lawande *et al*. (1984) studied air borne fungi during harmattan in Zaria, Nigeria. They observed that nasal and other respiratory allergies are common in Zaria, Nigeria during the dusty harmattan period. A survey of air borne fungi was therefore carried out during four months of the harmattan period by the culture plate exposure methods. Fungi belonging to 13 genera namely *Fusarium* sp., *Alternaria* sp., *Curvularia* sp., *Chaetomium* sp., *Epicoccum* sp., *Geotrichum* sp., *Mucor* sp. and *Trichoderma* sp. were recovered during the survey. They highest colony count was during the month of December and January.

Lyon *et al*. (1984) observed variation of air spora in the atmosphere due to weather conditions. A backward culmination multiple regression analysis was used to variation measured in concentrations of allergenic for three years (1976-1978) with volumetric sampler. Adequate moisture is probably the most important variable in spore production. In the imperfect fungi, once the spores are produced, release is often influenced by wind velocity. In the Ascomycetes, radiation, minimum humidity, changes in humidity, and minimum wind velocity were all directly correlated with air borne ascospores. While in the Basidiomycetes, precipitation was the most important variable directly correlated with basidiospores in the atmosphere.

Sima *et al.* (1984) studied Aspergilli in air over Calcutta using the culture plate method. The genus *Aspergillus* sp. constituted one of the important components of the fungus population of air. The prevalence of *Aspergillus* spp. was greatly affected by climate conditions and this genus was favored by warm and humid climate conditions. Aspergilli formed 11.5% of the total air spore. In total 12 species were identified of which *A. niger* and *A. parasiticus* were the most common ones.

Vijayalakshmi and Rao (1984) observed an aeromycological study over a sunflower field during seed development. They observed that Deuteromycetes ranked first among the 30 spores types of spore recorded in field plate. The majority of fungi recorded on developing seeds belong to Deuteromycetes.The occurrence and abundance of *Alternaria* sp., *Aspergillus* sp., *Cladosporium* sp. and *Curvularia* sp. on seed samples varied in the same way as their count in the air.

Buck *et al*. (1985) studied the air borne fungi of Sao Paulo, Brazil, during a period of one year by means of 156 exposure of Petridishes with culture medium at different locations in the city. Thirty genera of fungi were isolated. Most of them presented higher frequencies in spring and lower in autumn. The genera *Monascus* sp., *Neurospora* sp., *Trichothecium* sp. and *Gyptococcus* sp. occurred with higher frequency different from the observed on the other Brazillian cities. The genus *Alternaria* sp. was different from the values observed in other Brazilian cities.

Kumar (1985) investigated aero-allergenic pollen and spores in the urban environment of Basally, India. In all seven fungal spore types have been reported as aero-allergens at Bareilly. The fungal

taxa namely *Alternaria* sp., *Cladosporium* sp., *Curvularia* sp. and *Helminthosporium* sp. occurred throughout the year. For the occurrence of fungal spores there were three major seasons namely spring-summer (March-June) rainy (July-October) and winter (November-February). The highest number of spores have been recorded during post rainy season and spring-season closely followed to it.

Sandhu and Singh (1985) investigated air borne thermopilous fungi at Amritrar, India by the Petridish exposure method. *Aspergillus* spp. was commonest (76.34%) followed by *Thermomyces lanuginas* (6.29%) and *Mucor pasillus* (5.37%). Seasonal variations were recorded with maximum numbers appearing in August and minimum in December. Twelve thermopiles fungal were reported from the atmosphere for the 1st time.

Singh and Shrivasava (1985) studied the atmospheric allergenic fungal spores at Rena, India. A total of 4389 fungal spores belonging to 11 categories were observed. The spores of *Alternaria* sp., *Cladosporium* sp., *Curvularia* sp. and *Cercospora* sp. were trapped mostly. Maximum number of fungal spores were recorded in the month of July and minimum in January.

Tilak and Saibaba (1985) investigated indoor airborne fungal spore, flora of various indoor environments. Altogether 81 fungal spore types were collected by using conventional Rotorod samples and Tilak's volumetric spores trap.

Vital and Glory (1985) studied the air borne fungal spores in a manuscript library in Madrass, India for a four month period from Ist August till 30 November 1982. *Aspergillus* sp. were found

to be predominant in the library atmosphere followed by *Cladosporium* sp. and *Nigrospora* sp.

Berta *et al.* (1986) observed an air borne Basidiomycetes in the lily of Turin, Italy. During a survey of airborne in the city of Turin, basidiomycetous mycelia were isolated. Cultural, microscopic and ultra structural characters were studied. Their data compared with that in the literature lead to the probable identification of isolates as a species of *Aphyllophorales* sp.

Hashimoto (1986) investigated distribution of air borne fungi in the homes of children with bronchial asthma. The fungi detected from the sampling area were comprised of two genera of Zygomycetes, seven of Ascomycetes and thirty five of Deuteromycetes. The total number of colonies were 10,106. Among the detected fungi *Cladosporium* sp. accounted for the greatest part, about 25.4% followed by *Penicillium* sp., *Arthrinium* sp., *Aspergillus* sp. and *Alternaria* sp. and *Penicillium* sp. *Aspergillus* sp.were detected throughout the air, with an increase of *Cladosporim* sp. in autumn. Cells of *Alternaria* sp., which has only minor component indoors were detected in great numbers outdoor in May and July.

Kumar (1986) reported 92 fungi by culture method from *Alternaria alternata* has contributed the highest. *Alternaria* sp. was present throughout the year but was abundant during summer.

Maestreet *et al.* (1986) observed that air borne fungal spores was a risk factor in the hospital environment. The contamination of the air by filamentous fungi in different locations were *Aspergillus* sp. followed by *Penicillium* sp., *Alternaria* sp., *Cephalosporium* sp. and *Rhizopus* sp.

Banerjee *et al*. (1987) studied the air borne fungi of some residences in Durham, North Carolina, USA. During frost free periods (May-August), the most frequently isolated genera were *Mucor* sp., *Cladosporium* sp., *Aspergillus* sp., *Penicillium* sp., *Rhizopus* sp., *Alternaria* sp., *Aureobasidium* sp., *Fusarium* sp., *Heterosporium* sp., *Amblyosporium* sp. and other fungi.

Singh *et al*. (1987) surveyed air borne fungal spores at Dhera Dun, India. The survey of air borne fungal spores were carried out using a gravity seteing device in 1980 and 1981. Among the fungal types *Cladosporium* sp., *Alternaria* sp., smut spores *Curvularia* sp., *Ascospores* sp., *Nigrospora* sp., *Aspergillus* sp., *Penicillum* sp. and *Epicoccum* sp. dominated the indoor atmosphere of their prevalence.

Majumdar and Chanda (1989) carried out a systematic survey of fungal spores at Cooch Behar district, West Bengal from 3rd October, 1985 to 2nd September, 1986 by using gravitational sampler. Analysis of the exposed slides revealed 48 spore types, several species of aeromycoflora, with an overall dominance of *Alternaria padwickii*. The major types identified were the species of *Cladosporium*, *Curvularia*, *Pheatrichoconis*, *Cochliobolus nodulosa*, *Tetrapola*, *Pyrenphora*, *Pithomyces*, *Periconia*, *Helminthosporium*, *Fusarium* and others. It was further observed that the fungal spores showed a marked correlation with the corresponding meteorological parameters.

Li and Kendrick (1995) studied airborne fungal spores inside and outside 15 residences in Kitchener-Waterloo, Ontario, Canada in 1993. The dominant indoor fungal propagules recorded were *Cladosporium* (38.8%), *Aspergillus/Penicillium* (19.8%), *Leptosphaeria* (7.9%),

unidentified basidiospores (6.5%), unidentified ascospores (2.8%), *Ganoderma* (2.6%), *Alternaria* (1.9%), *Coprinus* (1.8%) and *Epicoccum* (0.3%).

Hedayati *et al*. (2005) performed an experiment on airborne fungi in indoor of asthmatic patients' home, living in the city of Sari. In this work, ninety patients were randomly selected from the asthmatic patients who had been referred to respiratory disease center of Emam Hospital of Sari, north of Iran. The airborne fungal spores were collected by sedimentation method from January 1 to March 30 in the year 2004. A total of 1876 colonies with 31 genera of fungi were identified from indoor air of asthmatic patients' home, respectively. The most common fungi isolated were *Cladosporium, Aspergillus* and *Penicillium. Stachybotrys*, *Oedocephalum* and *Stemphillium* showed the least frequencies among the isolated fungi. *Cladosporium*, *Aspergillus*, *Penicillum*, sterile mycelium, *Rhodotorula*, Yeast, *Fusarium, Oedodendrone*, *Botrytis, Menispora, Trichosporon* and *Geotrichum* were isolated from all of the rooms of asthmatic patients' home. *Cladosporium* was the most abundant genus in bathroom, bedroom and living room; whereas, *Aspergillus* had the highest frequency in kitchen. It is well known that spores of *Aspergillus*, *Cladosporium* and *Penicillum* generated in damp building can cause bouts of asthma and rhinitis among atopic occupants; as well as having a role in such individual cases of allergic disease.

Stryjakowska-Sekulska *et al*. (2007) investigated on indoor air microbiological contamination in various rooms of university buildings in Poznan, Poland. Investigation were conducted in the period of September to October 2002 and the same period in 2003. Air samples were taken twice a day: in the morning and in the afternoon. In all of the tested places a significant increase of mould spores was observed in afternoons.

The predominant moulds *Aspergillus* spp., *Penicillium* spp., *Rhizopus* spp., *Cladosporium* spp. and *Alternaria* spp. The total number of fungi in 2002 ranged from 130 to 1100 cfu/m³ and in 2003 it varied from 90 to 800 cfu/m³, respectively. In mornings fungal air contamination was always lower than in afternoons. Quality characteristics of fungal flora isolated from the air of educational rooms showed dominating contributions of such species of fungi like; *Cladosporium* sp. (e.g. *Cladosporium herbarum*), *Penicillum* spp. (e.g. *P. chrysogenum*, *P. viridicatum* and *P. expansum*) and *Aspergillus* spp. (e.g. *A. niger* and *A. flavus*). *Cladosporium herbarum*, *Alternaria alternata*, *Mucor* spp., *Rhizopus nigricans* and *Epicoccum* spp. prevailed in a canteen and a corridor. In afternoons, microbiological composition of the air in the canteen was dominated by other typical ‘’indoor moulds’’ genera like *Penicillium* spp., *Aspergillus* spp., *Mucor* spp. and “outdoor mould” *Cladosporium* spp. Also a second typical “outdoor mould” *Alternaria* spp. appeared in the air of investigated halls in afternoons. These spores of both genera *Cladosporium* and *Alternaria* emerging and raising in the course of the day in the air of lecture halls and other rooms occupied by many people are evidence of continuous input of microorganisms from outside via visiting people.

Ulea *et al*. (2009) surveyed the indoor airborne fungi in Romania. The aim of this investigation was to monitor the densities and distribution of indoor airborne fungal spores that can cause an allergic response in three educational institutions placed in different locations of Iasi City, Romania. Areas monitored were two lecture halls and one laboratory from the university campus, one classroom from a primary school and one from high school. Samples were collected from April to May 2009. Air samples from all location were taken using the Koch sedimentation

method. A total of 333 fungal colonies were counted on 90 plates. Identification of these showed 11 genera and 10 colonies of indeterminate spores from the indoor air samples. In this investigation, the results showed that in all three locations were differences in the distribution of fungal genera, but *Penicillium, Cladosporium* and *Aspergillus* were the most prevalent with 43.8, 22.2 and 18.0% of the total, respectively. Other fungi genera included *Alternaria*, *Botrytis*, *Trichoderma*, *Verticillium*, *Fusarium, Stemphyllium*, *Rhizopus* and *Mucor*. *Aspergillus* and *Penicillum* spores are the most frequent and predominant aeroallergens in the world. *Penicillium, Cladosporium* and *Aspergillus* spores represent the highest average counts in school buildings. The most common indoor fungus are *Cladosporium*, *Alternaria*. *Aspergillus* and *Penicillium*. The air contamination in educational rooms was measured and the results varied from 120.8 to 862.0 cfu/m³. For clean areas the normal level of airborne fungi should be under 550 cfu/m³. Rooms with airborne fungi between 550 and 700 cfu/m³ are regarded as contaminated, while those with cfu/m³ greater than 700 were regarded as hIghly contaminated (Macher *et al*. 1995).

Bhatia and Vishwakarma (2010) studied the quality and quantity of airborne mycoflora in two major hospitals, the Chaitainya Hospital and District (Tilli) Hospital in Sagar City, Madhya Pradesh, India. Four wards *viz*. children ward, general ward, casuality and I.C.U of these two hospitals were chosen to comparatively enumerate colony count and to obtain biodiversity of aeromycoflora using settling plate technique. In second set of study, microbial load of indoor air was recorded by "Hi-Air" Air Sampler, during three duration (morning, afternoon and evening) of the day. Microbial aero biodiversity as well as microbial load was enumerated in indoor environment of four different wards of these two

hospitals. Microbial load was highest in general ward and lowest in I.C.U in both the hospitals. *Aspergillus* spp. were the most common fungal isolate in the unit studies, along with *Fusarium* sp., *Mucor* sp., *Verticillium* sp., *Rhizopus* sp., *Penicillium* sp. and *Candida* sp. The concentration of fungal population in the air of the general ward was recorded high during afternoon sampling between time 1pm and 2 pm, with values ranging from 0.12 x 102cfu/m^3 to 1.00 x 102 cfu/m^3.

Colakoglu and Karalti (2011) carried out an experiment on monthly fungal flora of Marmara University Hospital and Goztepe Education and Research Hospital in Istanbul between 2005 and 2006. Total 175 mould colonies were isolated in Marmara University Hospital and allergenic ones were speciated. Maximal mould isolation was occurred in May and minimal in February. Mostly isolated species was *Cladosporium* (42.9%). Which were followed by *Alternaria* (18.9%), *Penicillium* (12.6%), *Aureobasidium* (11.4%), *Aspergillus* (6.9%), Mycelia sterilia (4.6%), *Scopulariopsis* (1.7%), *Rhizopus* (0.6%) and *Ulocladium* (0.6%). Maximally isolated species in this hospital during the study was *Cladosporium cladosporioides* (36.6%) and this one was followed by *Penicillium commune* (12.6%), *Aureobasidium pullulans* (12.0%), *Alternaria alternata* (6.3%), *Cladosporium herbarum* (4.6%), *Aspergillus niger* (2.9%), *Penicillium citrinum* (2.9%). Total 182 mould colonies were isolated in Goztepe Education and Research Hospital and allergen ones was specified. Maximal mould isolation was occurred in May and minimal in January. Isolated species were; *Cladosporium* (32.4%), *Alternaria* (24.2%), *Penicillium* (15.9%), *Aspergillus* (7.1%), *Scopulariopsis* (3.8%), *Ulocladium* (3.3%), Mycelia Sterilia (2.7%), *Rhizopus* (0.5%) and *Paecilomyces* (0.5%). Maximally isolated species in this Hospital during study was *Cladosporium cladosporioides* (23.6%)

and this one was followed by *Alternaria alternata* (19.8%), *Penicillium glabrum* (11.90%), *Aureobasidium pullulans* (9.3%), *Cladosporium herbarum* (6.0%) and *Alternaria tenuissima* (4.4%).

Pathak (2012) from Madhya Prodesh, India found abundance of *Aspergillus* by using particle sampler. The abundances of the fungi was quite higher in the present investigation. Sedimentation method does not permit exact quantitative determination; some earlier observations reported that results of sedimentation method are usually higher than numbers obtained with the use of air samplers (Fleischer *et al.* 2006). However, data collected by sedimentation method allow the drawing of correct conclusions on types of fungi present in the air and can give a rough approximation of fungal concentration.

Ahmed *et al*. (2013) investigated on the aeromycoflora of Dhaka University Campus during February 2011 to January 2012. In this study, 2106 fungal colony forming units were settled within ten minutes on one square meter area at noon from the air of Dhaka University campus. Ten different locations of the Dhaka University Campus (23°42'0" N and 90°22'30" E) were selected for the sampling of airborne fungi. Among these locations five were inside the buildings of Arts Faculty, University Medical Centre, Science Library, Shahidullah Hall, Mycology and Plant Pathology Laboratory of the Botany Department. In this investigation, *Aspergillus* was one of the most dominating genus in all the stations over the study period. The second was *Penicillium* followed by *Cladosporium*, *Curvularia*, *Alternaria*, *Fusarium*, *Trichoderma*, *Pestalotia*, *Rhizopus* and *Colletotrichum*. In the dry winter (December-February), *Alternaria*, *Cladosporium*, *Curvularia* and *Rhizopus* showed its peak. Hot humid summer (April) is the most favourable season for the occurrence of *Colletotrichum*.

CHAPTER 3

MATERIALS AND METHODS

MATERIALS AND METHODS

Various locations of Dhaka Metropolitan city were selected for the sampling of air borne fungal spores. Depending on the population and importance of the city five sampling sites were selected.

Sampling Sites: The sampling sites were Sher- e Bangla Agricultural University, Gulistan, Dhaka Medical College, Sadarghat and DOHS, Mohakhali (Figs. 2). Sampling area of Dhaka Metropolitan City is in 23°42'0" North latitude and 90°22'30" East longitude in the district of Dhaka (Figs. 1). The city lies on the lower reaches of the Ganges delta and covers a total area of 360 square kilometers (140 sqml).

Sher- e Bangla Agricultural University is in Dhaka, the heart of Bangla with a solid green covering area, with fresh air, residential buildings and a number of land for crop cultivation and other related facilities. It is situated east of Election Commission Secretariat, Planning Commission, west of Shaheed Suhrwardy Medical College Hospital, north of National Library of Bangladesh and south of Bangobandhu International Conference Center, Gono Bhaban and Chandrima Uddyan.

Gulistan is an overcrowded street of Dhaka city in Bangladesh. The street is full of roadside shops. There is a major bus-stand situated in Gulistan. Jatrabari flyover has recently established to bypass the outgoing traffic from Dhaka. It is situated north of Baitul Mokkaram Masjid, GPO, south of Gulistan shopping complex, east of Maulana Bhasani Hockey Stadium, Gulistan park and west of Osmani Uddyan, Police Head quarters and Dhaka south city corporation.

Dhaka Medical College is situated east of Carzon Hall, Asiatic Society, Tuberculosis Hospital, west of Bangladesh University of Engineering and Technology, north of Central Shaheed Miner, Bangle Academy, Secretariat road and south of Hossanidalan, Chankhar pool.

Shadarghat part, the Dhaka city river front, located in the southern part of Dhaka, on the river Buriganga, is one of the most dynamic places in Dhaka. Sadarghat launch terminal is one of the largest river parts in the world. It is situated north of Bahadursha Park and Jagannath University, south of Buriganga river, east of Lalkuthi and west of Ahsan Monzil.

DOHS is an upscale residential area in Dhaka, Bangladesh. It is located on the east of Gulshan Baridhara lake, west of British American Tobacco, north of Govt. Titumir College and south of International Centre for Diarrheal Diseases Research, Bangladesh.

Methods

Culture plates were exposed for 5 minutes time in a day from 7-9 am and 4-5 pm separately during the months of February-April (spring), May-July (summer), August-October (autumn) and November-January (winter). The sampling was done during the twelve months starting from February 2013 to January 2014.

Isolation of air borne mycoflora: Gravity plate sampling method was followed for the isolation of fungi from the selected locations as described by Colakoglu (1996) and Hedayati *et al*. (2005). The Petri plates (9 cm) containing sterilized PDA medium with a drop of lactic acid to inhibit the growth of bacteria (Basilico *et al*. 2007) was exposed

horizontally. The Petri plate was exposed for five minutes in the morning and evening of the same day to avoid the over load of fungal spores on the surface of the culture medium (Frankland 1989).

Potato Dextrose Agar (PDA) medium was used for the isolation of fungi at monthly intervals where 50% lactic acid was added to cheek the bacterial contamination. The Petri plates containing culture medium were exposed at the height of 1.5 meters from the ground level on a tripod stand. Five replications were maintained for each culture medium. The exposed Petri plates containing PDA media were taken into the laboratory and incubated at 25 ± 2ºC for five days. The growth of the mycoflora on the culture plates were examined daily and the colonies which born spores were examined after further incubation. These fungi which did not produce reproductive spores within 7 days were incubated for 10 days or more. The colonies developed on the culture media were counted. The isolation was done by transferring a bit or a single spore into the sterile Petri plates containing PDA medium for further study. The purification of isolates was done by dilution plate method and single spore culture technique. The pure cultures were stored at 4ºC in slant medium for further studies.

Characterization and identification of air borne mycoflora:

The morphology of fungal colony was studied by observing the size, color and nature of colony, margin of colonies, presence or absence of moisture on the surface, pigmentation on front and back of the culture, presence or absence of concentric ring etc. for identification. The structure and color of mycelia, shape and size of spores or conidia and sporangiophores or conidiophores were studied under the microscope. Visual identification of spores and colony developed on gravity plate were done under low and high power of the microscope.

The adhesive side of the tape was touched on to the surface of the colony at point intermediate between the center and periphery. Then adhesive side of the tape was adhered over an area on a glass slide with a drop of lacto-phenol and cotton blue. It was then examined microscopically for characteristic arrangement of spores under 10, 40 and 100X power of compound microscope (Nikon SE, Motic SFC-18 Series).

A small portion of the colony was taken on a glass slide with the help of a needle. It was stained in a normal cotton blue (0.05 gm cotton blue in 100 ml lacto-phenol) and was covered with a cover slip then examined microscopically. Photomicrographs of fungal colonies and spores were also taken. The generic identity of each colony was recorded and identification up to species level was tried wherever possible with the help of standard mycological books and manuals (Rapper and Thom 1945, Gilman 1957, Rapper and Fennell 1965, Booth 1971, Subramanian 1971, Ellis 1971,1985, Barnett and Hunter 1972, Barron 1977 and Alexopoulos and Mims 1979). The identified pure cultures were stored for one month in culture medium or for several months at 4°C in sterile water for later use.

Sterile mycelium of sub-cultures which failed to sporulate at the end of three months was designated as a sterile mycelium. Some fungi imperfecti which did not produce spores on potato dextrose agar medium were also treated as sterile mycelia.

Determination of percent frequency of isolated airborne mycoflora and statistical analysis

Details regarding the qualitative nature of the mycoflora, their frequency and the percentage contribution of the mycoflora and monthly incidence were recorded in the present investigation. The percentage contribution of

each species was calculated on the basis of the number of individual colonies of each species against the total number of colonies of all the species under a genus during the entire twelve months sampling period.

Per cent frequency of the occurrence of the fungal isolates was calculated by adopting the following formula of Spurr and Welty (1972).

Total number of individual colonies were recorded

$$\% \text{ frequency} = \frac{\text{Total number of individual colonies were obtained}}{\text{Total number of colonies}} \times 100$$

To do statistical analysis, an online software was used. To determine mean, Standard Deviation and Correlation, "Pearson Correlation" (an online statistical) was also used.

Determination of climatic factors of sampling sites

Three climatic factors were determined to study the mycoflora of the Dhaka Metropolitan City as the factors were highly responsible for their amount and per cent frequency. The factors were temperature, relative humidity and precipitation. Temperature and relative humidity of the sampling sites at twelve months were determined by a digital Hygro-thermometer machine (Mextech-1). Monthly precipitation was collected from the official website of Bangladesh Meteorological Department.

Fig 1 : Geographical Map of Dhaka City.

A

B

C

D

E

Fig. 2. Sampling sites of Dhaka Metropolitan City, Bangladesh.

A. Sher-e-Bangla Agricultural University
B. Gulistan
C. Dhaka Medical College
D. Sadar ghat
E. DOHS, Mohakhali.

Preparation of fungal slides, chemicals and culture media

A. Preparation of slides

A suitable portion of culture plate of different colony from PDA media was selected under a stereomicroscopic binocular microscope and was taken out with the help of forceps and needles and put in 1 or 2 drops of lacto phenol on clean slides. It was then gently warmed by heating and cooling over low flame of sprit lamp for 6 to 8 times, but was never allowed to boil. Whenever needed, the material was stained with small quantity of cotton blue. A clean cover slip then placed over the material, excess fluid was removed by soaking with blotting paper and examined under compound microscope.

B. Preparation of chemicals

I. Lactophenol

Lactophenol solution used as mounting medium consisted of the following composition (Aniswarth 1963).

Phenyl crystals	20.00 gm
Lactic acid	20.00 ml
Glycerol	40.00 ml
Distilled water	20.00 ml

After weighting the constituents were taken in a conical flask to which distilled water was added. The flask was shaken well till a homogenous solution was obtained.

II. Lactophenol-cotton blue stain

One gram of cotton blue added to 100 ml of lacto phenol and shaken well till it was dissolved. The prepared solutions of lacto phenol and lacto phenol-cotton blue were stored in a cool dark place.

III. Clearing agent

Throughout the present investigation, the glassware's and chemicals supplied by E. Mark and BDH were used. All glassware's were cleaned with a solution of potassium dichromate and sulphuric acid in the following proportions.

Potassium dichromate	60.00 gm
Sulphuric acid	60.00 ml
Water (Tap)	1000 ml

C. Preparation of culture media

The Potato Dextrose Agar (PDA) culture medium was used for the isolation of air borne mycoflora from different locations of the selected sites of Dhaka Metropolitan City.

Potato Dextrose Agar (PDA) medium:

Peeled and sliced potatoes	20.00 gm
Dextrose	15.00 gm
Agar	20.00 gm
Distilled water	1000 ml

Medium was autoclaved at 15 lb/inch^2 for 20 minutes. In case the medium contained any substance liable to decomposition or denaturation ion, it was subjected to fractional sterilized for three successive days. Petri plates and other glassware's were sterilized two hours in hot air oven at 160^{o}C.

CHAPTER 4

RESULTS AND DISCUSSIONS

RESULTS AND DISCUSSION

During the present investigation, monthly sampling of air borne mycoflora of Dhaka Metropolitan City, during February 2013 to January 2014 was recorded. The fungal colonies developed in PDA medium were isolated from five different locations in the morning and evening in monthly intervals (Plates 1-12). In this study, the total number of counted fungal colonies were 6648 out of which in the morning was 3268 and in the evening it was 3380 and 156 colonies were sterile mycelia.

The identified fungi belonged to fifteen genera under the class Ascomycetes, Zygomycetes and Deuteromycetes. Regarding the qualitative nature of the mycoflora, their frequency and percentage contribution to the total mycoflora, monthly periodicity have been described in this investigation.

Incidence and percent frequency of fungi from different locations during the morning of February 2013 to January 2014 is presented in Table 1. The table showed that a total of 3268 fungal colonies were isolated out of which maximum number of colonies are *Aspergillus* spp.(942) followed by *Cladosporium* (516) and *Penicillium* (418). Lowest number of fungal colonies were recorded in case of *Chaetomium* (50).

Table 2 showed the results of evening isolation. A total of 3380 fungal colonies were recorded from five different locations. Out of 3380, highest number was recorded in case of *Aspergillus* (1038) followed by *Cladosporium* (612) and *Penicillium* (390). *Arthrinium* sp. (48) was lowest in number of colony. Highest number of fungal colony was

recorded in Gulistan area in both the cases of isolation which was followed by Sadar ghat (Tables 1 and 2).

The culture plate technique was employed in the present investigation for the isolation of mycoflora from different locations. Most of the workers used culture plate technique, because of its simplicity and availability of a large body of comparable data (Oren and Baker 1970). Moreover, spores of several fungi are morphologically similar and cannot be identified up to their generic level from Gravity Slide Method (D' silva and Freitas 1984). Hence, culture plate method was followed in this investigation.

Paramasiveam and Gnanarethinam (1986) conducted a preliminary survey of the atmospheric fungal flora of Tiruchirapalli, India. The air mycoflora of Tiruchirapalli was investigated by exposing Petri plates with PDA in alternate days over a period of 24 months starting from 1st January 1980 to 3rd December 1981. It was found that species of *Aspergillus*, *Penicillium*, *Cladosporium* and *Drechslera* accounted for nearly 80% of the total load. They were frequently recorded (Plates 1-12).

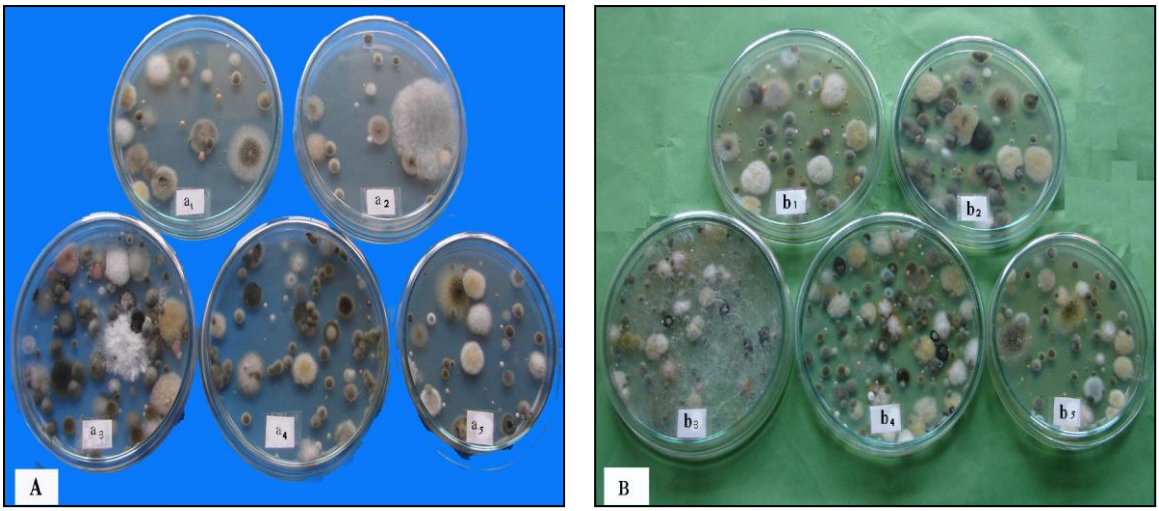


Plate 1. Air borne mycoflora in the morning (A) and evening (B) during the month of February, 2013.

a_1,b_1 = Sher-e Bangla Agricultural University
a_2,b_2 = Gulistan
a_3,b_3 = Dhaka Medical College
a_4,b_4 = Sadar ghat
a_5,b_5 = DOHS, Mohakhali

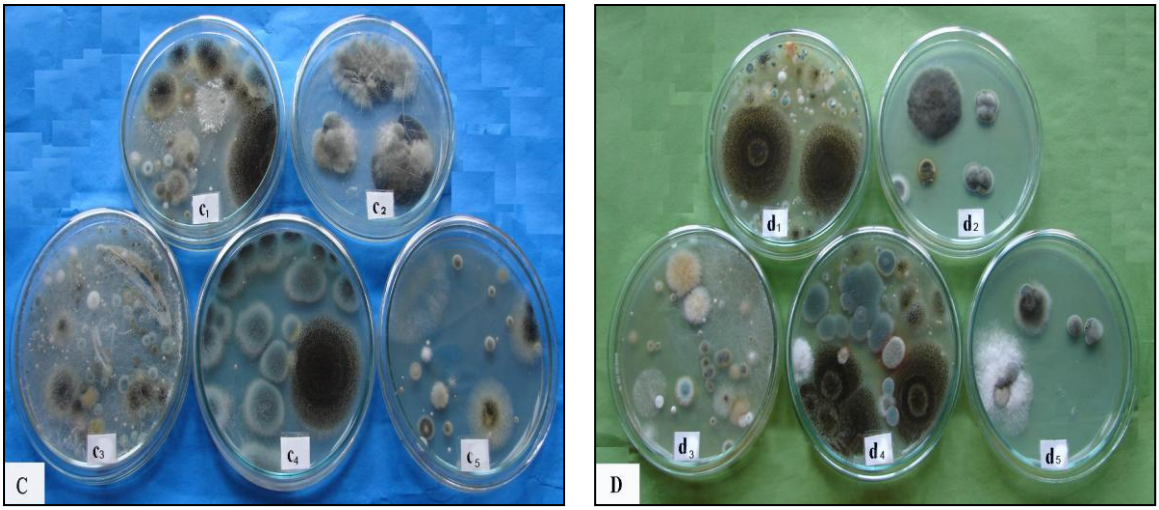


Plate 2. Air borne mycoflora in the morning (C) and evening (D) during the month of March, 2013.

c_1,d_1 = Sher-e Bangla Agricultural University
c_2,d_2 = Gulistan
c_3,d_3 = Dhaka Medical College
c_4,d_4 = Sadar ghat
c_5,d_5 = DOHS, Mohakhali

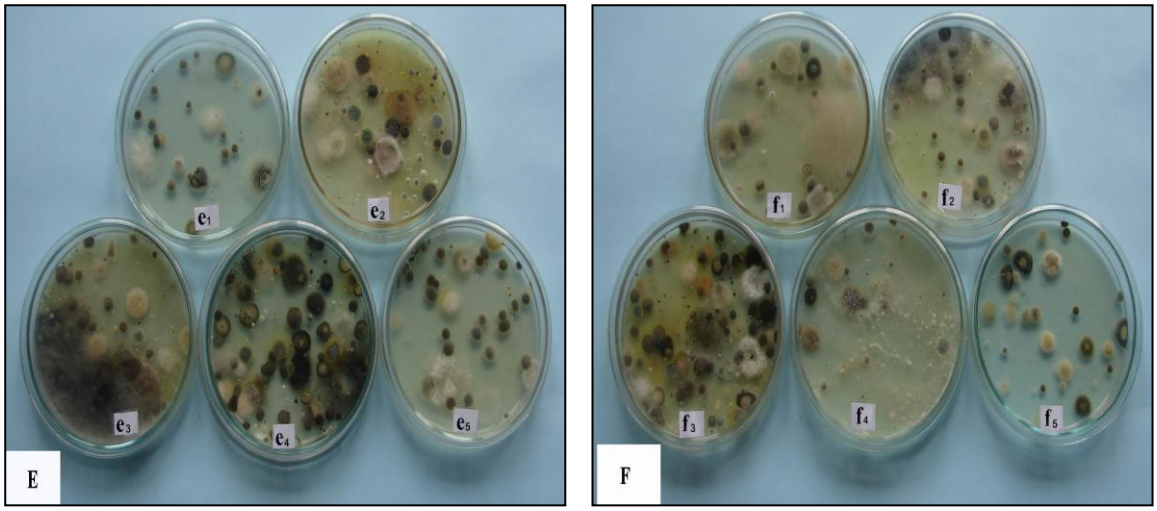


Plate 3. Air borne mycoflora in the morning (E) and evening (F) during the month of April, 2013.

e1,f1 = Sher-e Bangla Agricultural University
e2,f2 = Gulistan
e3,f3 = Dhaka Medical College
e4,f4 = Sadar ghat
e5,f5 = DOHS, Mohakhali

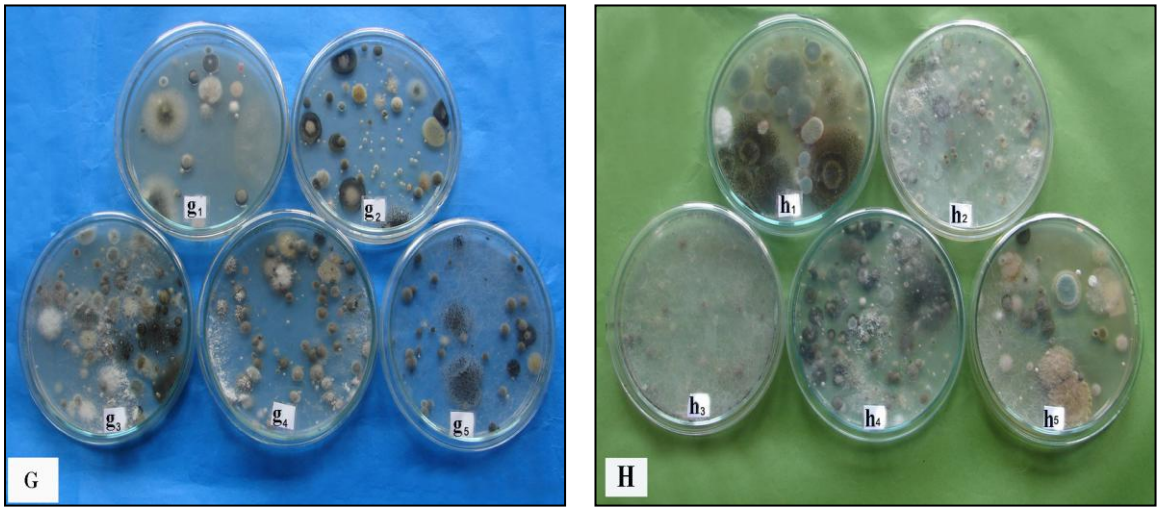


Plate 4. Air borne mycoflora in the morning (G) and evening (H) during the month of May, 2013.

g1,h1 = Sher-e Bangla Agricultural University
g2,h2 = Gulistan
g3,h3 = Dhaka Medical College
g4,h4 = Sadar ghat
g5,h5 = DOHS, Mohakhali

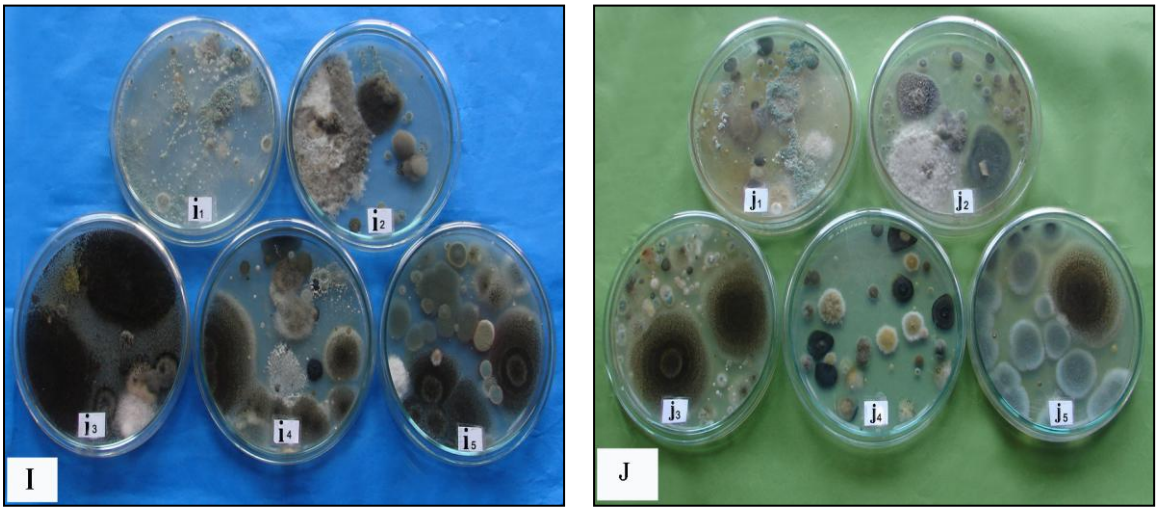


Plate 5. Air borne mycoflora in the morning (I) and evening (J) during the month of June, 2013.

i1, j1 = Sher-e Bangla Agricultural University
i 2, ji = Gulistan
i 3, j 3 = Dhaka Medical College
i 4, j 4 = Sadar ghat
i 5, j5 = DOHS, Mohakhali

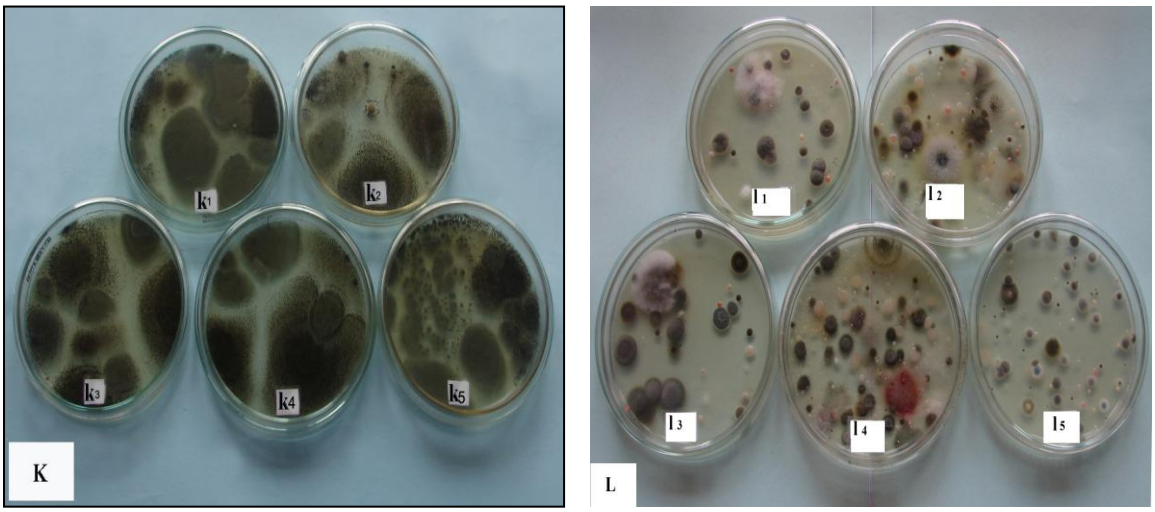


Plate 6. Air borne mycoflora in the morning (K) and evening (L) during the month of July, 2013.

k1,l1 = Sher-e Bangla Agricultural University
k 2,l2 = Gulistan
k 3,l3 = Dhaka Medical College
k4,l4 = Sadar ghat
k5,l5 = DOHS, Mohakhali

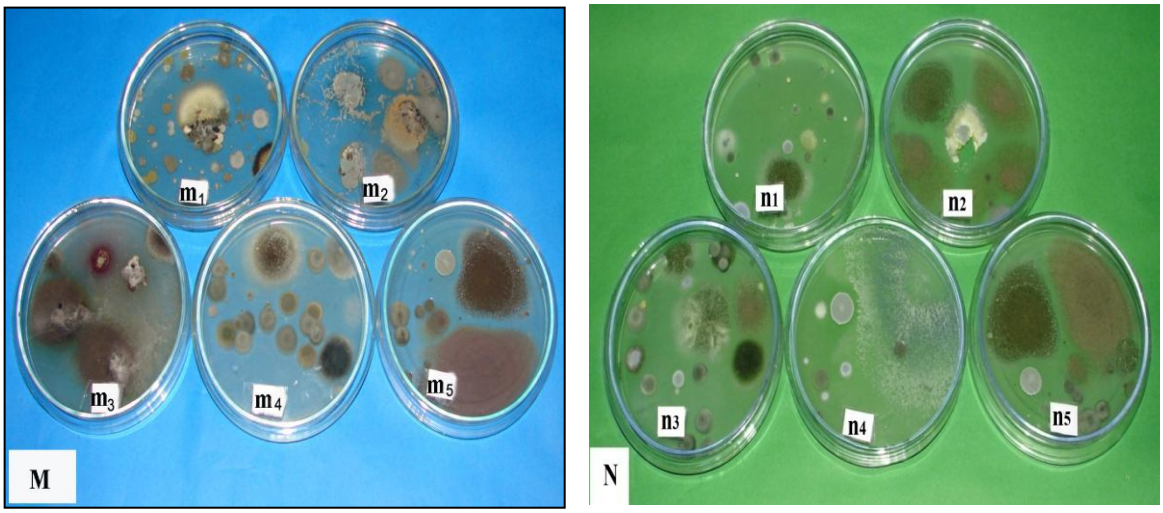


Plate 7. Air borne mycoflora in the morning (M) and evening (N) during the month of August, 2013.

m_1,n_1 = Sher-e Bangla Agricultural University
m_2,n_2 = Gulistan
m_3,n3= Dhaka Medical College
m_4,n_4 = Sadar ghat
m_5,n_5 = DOHS, Mohakhali

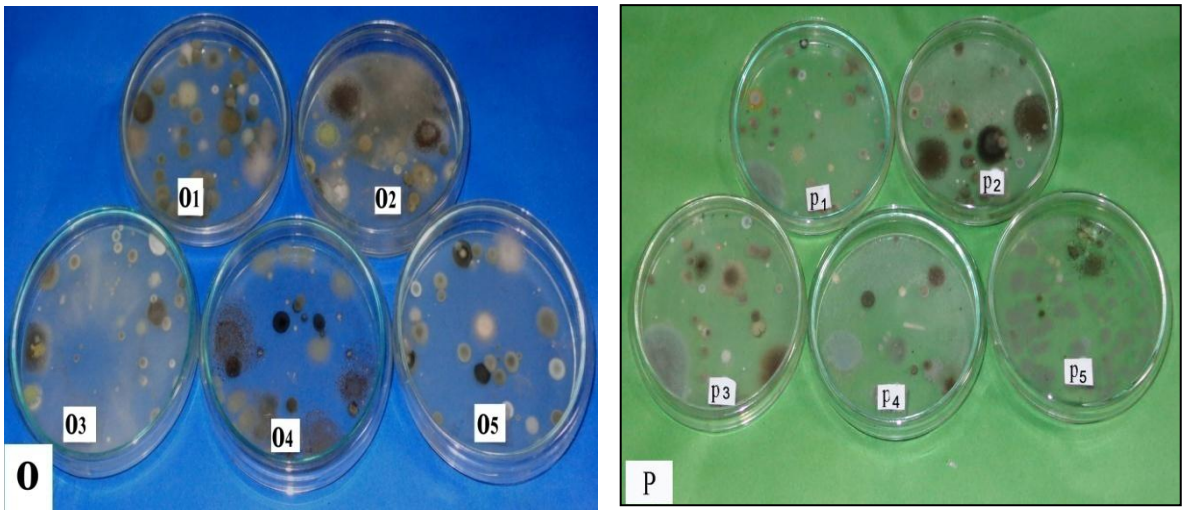


Plate 8. Air borne mycoflora in the morning (O) and evening (P) during the month of September, 2013.

o_1,p_1 = Sher-e Bangla Agricultural University
o_2,p_2 = Gulistan
o_3,p_3 = Dhaka Medical College
o_4,p_4 = Sadar ghat
o_5,p_5 = DOHS, Mohakhali

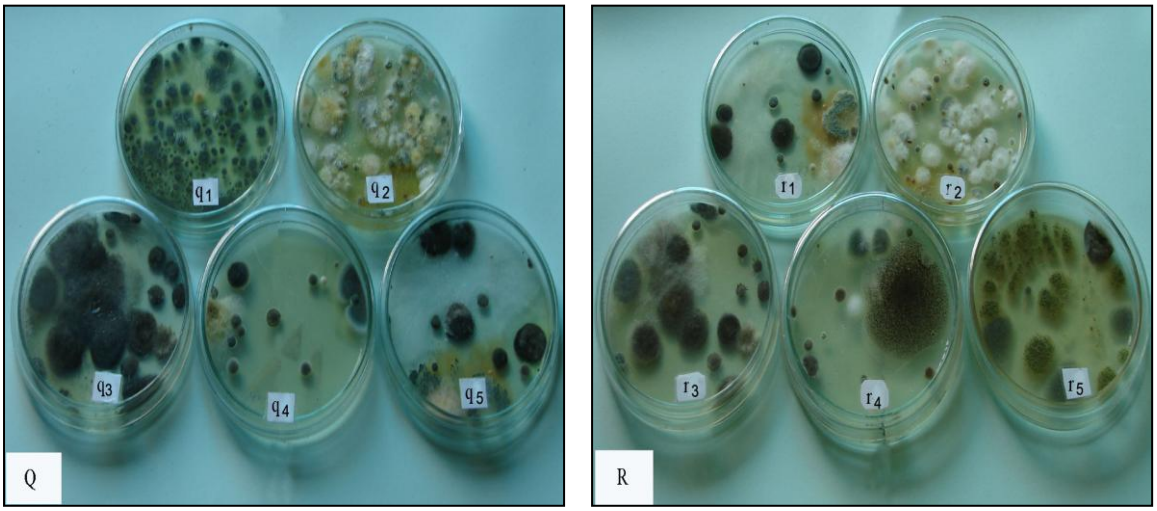


Plate 9. Air borne mycoflora in the morning (Q) and evening (R) during the month of October, 2013.

q_1,r_1 = Sher-e Bangla Agricultural University
q_2,r_2 = Gulistan
q_3,r_3 = Dhaka Medical College
q_4,r_4 = Sadar ghat
q_5,r_5 = DOHS, Mohakhali

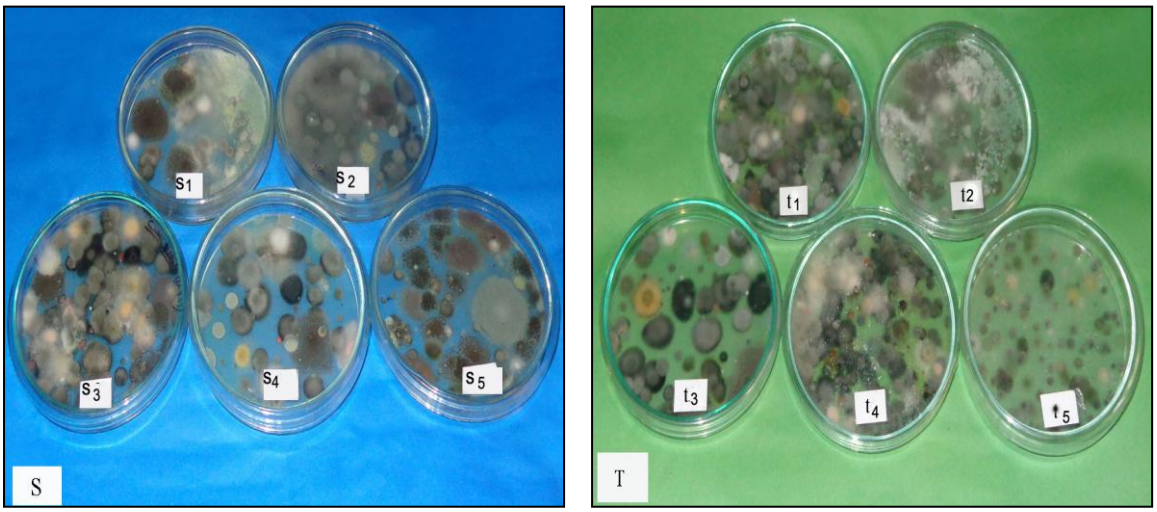


Plate 10. Air borne mycoflora in the morning (S) and evening (T) during the month of November, 2013.

s_1,t_1 = Sher-e Bangla Agricultural University
s_2,t_2 = Gulistan
s_3,t_3 = Dhaka Medical College
s_4,t_4 = Sadar ghat
s_5,t_5 = DOHS, Mohakhali

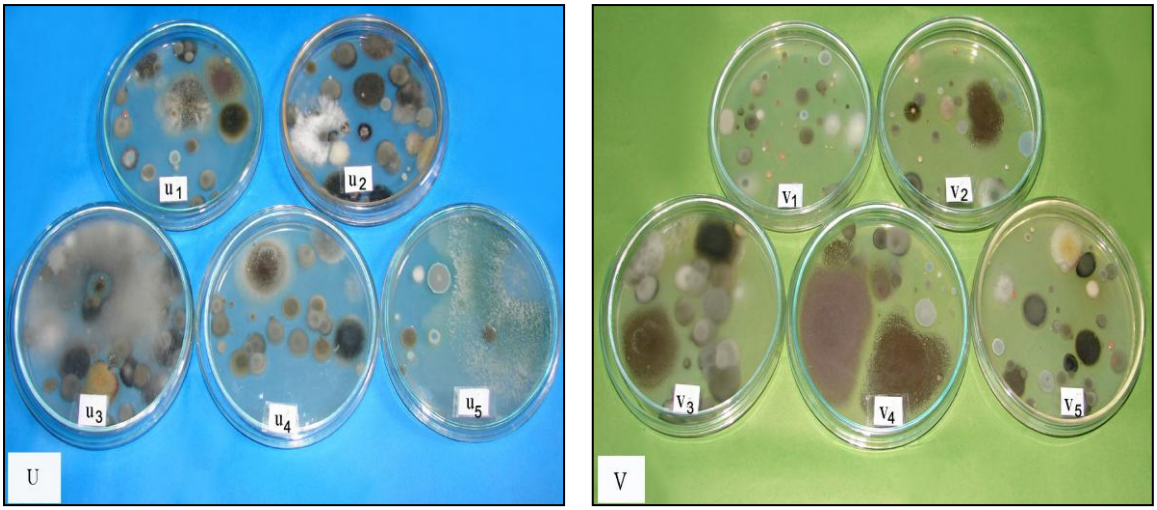


Plate 11. Air borne mycoflora in the morning (U) and evening (V) during the month of December, 2013.

u1,v1 = Sher-e Bangla Agricultural University
u2,v2 = Gulistan
u3,v3 = Dhaka Medical College
u4,v4 = Sadar ghat
u5,v5 = DOHS, Mohakhali

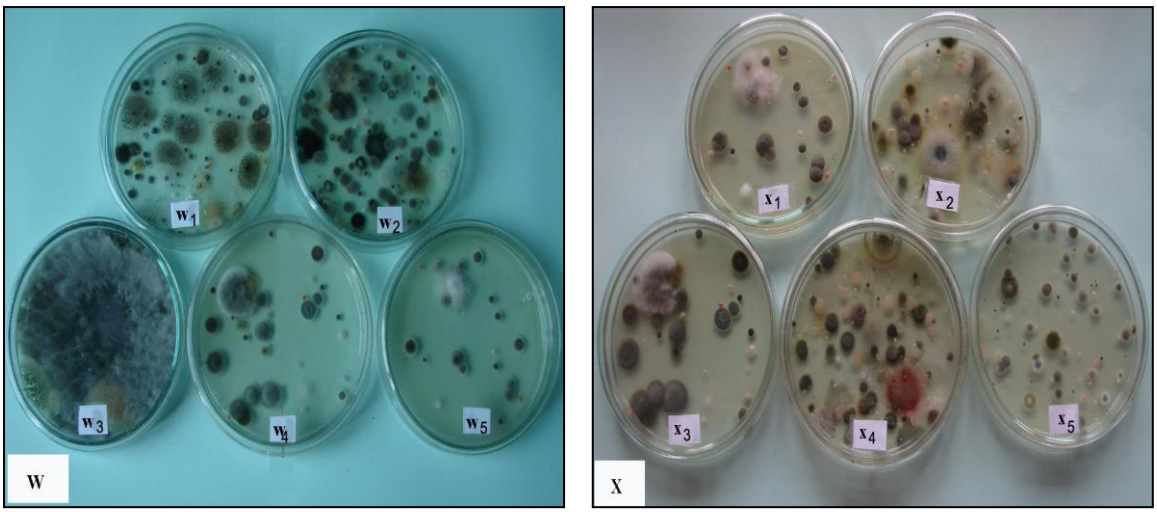


Plate 12. Air borne mycoflora in the morning (W) and evening (X) during the month of January, 2014.

w1,x1 = Sher-e Bangla Agricultural University
w2,x2 = Gulistan
w3,x3 = Dhaka Medical College
w4,x4 = Sadar ghat
w5,x5 = DOHS, Mohakhali

Among the identified fungi *Aspergillus* spp. was the most dominating fungi (Table 1, Fig. 5) showed that a total of 942 colonies of *Aspergillus* spp. was isolated from the five different locations of Dhaka City in the morning. The percent frequency of *Aspergillus* spp. was 28.82. Highest number of colony (242) of the fungus was isolated from Gulistan which was followed by Sadar ghat (213), DMC (178) and Sher-e Bangla Agricultural University (172). Least number of *Aspergillus* spp. (137) was recorded from DOHS, Mohakhali. Similar observation was also recorded in case of evening time. Out of 3380 fungal colonies *Aspergillus* spp. (1038) was recorded from the five selected locations. Highest number of *Aspergillus* colonies was observed in Gulistan (268) which was followed by Sadar ghat (210), DMC (198) Sher-e Bangla Agricultural University (187). Lowest (175) count was recorded from DOHS, Mohakhali. The percent frequency in the evening was 30.71 (Table 2, Fig. 5). Maximum number of total count of *Aspergillus* spp. was noticed in the evening (1038) than that of morning (942) (Table 5, Fig. 36).

Highest number of *Aspergillus* colonies was recorded in the morning of September 2013 (184) which was followed by August (169) (Table 3, Fig. 21). Least number of the fungus was observed in the month of January (15). Similar observation was also noticed in the month of September evening. Maximum count of *Aspergillus* colony (208) was observed in September evening followed by August (193). Least number (14) was recorded in the evening of December, 2013 (Table 4, Fig. 21).

Maximum number of *Aspergillus* colonies recorded in the month of September might be due to suitable temperature (29ºC), relative humidity (72.5%) and rainfall (12.6mm) (Table 5, Fig. 35). Maximum number of *Aspergillus* colonies in Gulistan might be due to various types of

contamination from the bus, CNG, footpath shops and over crowdedness of human.

Aspergillus genus is widely distributed from the arctic region to the tropics. The air and soil, contains the spores of these organisms. Several species grow on leather and cloth fabrics, reducing their commercial value and imparting a musty odor to shoes and clothing. Some species of *Aspergillus* produce mycotoxins, the most important of which is aflatoxin. It may cause liver cancer in humans and animals. Other species are animal and human pathogens that cause Aspergillosis. Aspergilli also cause considerable trouble as common contaminants of cultures in bacteriological and mycological laboratories (Alexopoulos and Mims 1979).

Cladosporium spp. ranked second and it contributed 516 fungal colonies (Table 1) of the total counts from five different locations of Dhaka city in the morning. The percent frequency of *Cladosporium* spp. was 15.78. Highest number of colony (118) of the fungus was isolated from Sher-e Bangla Agricultural University which was followed by Sadar ghat (113), Gulistan (104) and DMC (97). Least number of *Cladosporium* spp. was recorded from DOHS, Mohakhali. Similar observation was also recorded in case of evening time (Table 1, Fig. 8). Out of 3380 fungal colonies 612 *Cladosporium* spp. was recorded from the five selected locations (Table 2, Fig. 8). Highest number of *Cladosporium* colonies was observed in Gulistan (142) which was followed by DMC (137), Sadar ghat (129), and Sher-e Bangla Agricultural University (106). Lowest (98) count was recorded from DOHS, Mohakhali. The percent frequency in the evening was 18.10 (Table 2). Maximum number of total count of *Cladosporium* was noticed in the evening (612) than that of morning (516) (Table 5, Fig. 36).

Highest number of *Cladosporium* colonies (136) was recorded in the morning of January which was followed by December (108) (Table 3, Fig. 24). Least number of the *Cladosporium* was observed in the month of July. Similar observation was noticed in the month of January evening also. Maximum count of *Cladosporium* colony (159) was observed in January evening followed by December (113). Least number was recorded in the evening of June and July (Tables 4, Fig. 24).

Cladosporium are cosmopolitan in distribution and commonly encountered on all kinds of plant, fungal and other debris, are frequently isolated from soil, food, paint, textiles and other organic matters or colonies as secondary invaders of leaf lesions caused by plant pathogenic fungi (Ellis 1971, 1976).With their small conidia, usually formed in branched chains, they are well adapted to be spread easily in large numbers over long distances. Few species of this genus are plant pathogenic. They are the causal agents of leaf spots and other lesions (Schubert 2005), or they occur as hyperparasites on other fungi (Heuchert *et al*. 2005). *Cladosporium* species are also known to be common endophytes (El-Morsy 2000) as well as phylloplane fungi (Levetin and Dorseys 2006).

Cladosporium is one of the common airborne fungi. The number of spores in the air usually differs depending upon the pattern of rain. Numbers of conidia decrease dramatically just after rain, while ascospores increase. Time of day, temperature and place of collection are other variables that have been found to affect spore trapping (Alexopoulos *et al*. 1995).

In the present investigation *Penicillium* spp. ranked third and it contributed 418 fungal colonies (Table 1, Fig. 13) of the total counts from

five different locations of Dhaka City in the morning. The percent frequency of *Penicillium* spp. was 12.79. Highest number of colony (98) of the fungus was isolated from Gulistan which was followed by DOHS (88), DMC (82), and Sher-e Bangla Agricultural University (76). Least number of *Penicillium* spp. was recorded from Sadar ghat. Similar observation was also recorded in case of evening time. Out of 3380 fungal colonies 390 *Penicillium* spp. was recorded from the five selected locations (Table 2, Fig. 13). Highest number of *Penicillium* colonies was observed in Gulistan (104) which was followed by Sadar ghat (81), Sher-e Bangla Agricultural University (72) and DMC (68). Lowest (65) count was recorded from DOHS, Mohakhali. The percent frequency in the evening was 11.53 (Table 2). Maximum number of total count of *Penicillium* was noticed in the morning (418) than that of evening (390) (Table 5, Fig. 36).

Maximum number of *Penicillium* colonies was recorded in the morning of September which was followed by May (Table 3, Fig. 29). Least number of the fungus was observed in the month of June. Similar observation was also noticed in the month of September evening. Maximum count of *Penicillium* colony (77) was observed in September evening followed by January (51). Least number of the fungus was recorded in the evening of November 2013 (Table 4, Fig. 29). Maximum number of *Penicillium* colonies recorded in the month of September might be due to suitable temperature (29ºC), relative humidity (72.5%) and rainfall (12.6 mm) (Table 5, Fig. 35).

Penicillium spp. can act as an allergen and an asthma inducer. It is an active allergen that triggers histamine responses in the epithelial cells of lungs (Manisha and Panwar 2012). It is rarely pathogenic except in extenuating circumstances such as people with severely suppressed

immune systems, like those with Human Immunodeficiency Virus (HIV). The most common avenue for the implementation of infection by *Peniciliium* spp. in the eye is by penetrating trauma. *Penicillium* may cause lesions and abscesses in the skin and can become disseminated to lymph nodes, lungs, other organs and bone. Although the disease can be fatal, it usually is treatable if diagnosed early (Kwon-Chung and Bennett 1992).

The next genus was *Alternaria* sp. and it contributed 221 fungal colonies of the total counts from five different locations of Dhaka City in the morning (Table 1, Figs. 3). The percent frequency of *Alternaria* sp. was 6.76. Highest number of colony (57) of the fungus was isolated from Gulistan which was followed by Sadar ghat (48), DMC (43), and Sher-e Bangla Agricultural University (38). Least number of *Alternaria* spp. was recorded from DOHS, Mohakhali. Similar observation was also recorded in case of evening time. Out of 3380 fungal colonies 216 *Alternaria* sp. was recorded from the five selected locations (Table 2, Fig. 3). Highest number of *Alternaria* colonies was observed in Gulistan (52) which was followed by Sadar ghat (48), DMC (43) and Sher-e Bangla Agricultural University (37). Lowest (36) count was recorded from DOHS, Mohakhali. The percent frequency in the evening was 6.39 (Table 2). Maximum number of total count of *Alternaria* was noticed in the morning (221) than that of evening (216) (Table 5, Figs. 36).

Highest number of *Alternaria* colonies was recorded in the morning of September which was followed by December and February (Table 3, Fig. 19). Least number of the fungus was observed in the month of July. Similar observation was noticed in the month of January evening. Maximum count of *Alternaria* colony (27) was observed in January evening followed by April (24). Least number was recorded in the

evening of June 2013 (Table 4, Fig. 19). Maximum number of *Alternaria* colonies recorded in the month of September might be due to suitable temperature (29ºC), relative humidity (72.5%) and rainfall (12.6 mm) (Table 5, Fig. 35).

Alternaria is a large universally occurring genus. Several form-species are found as saprobes on dead and dying plant parts in the soil from which the conidia are picked up by the wind, and they invade laboratories where they are troublesome as contaminants of cultures (Alexopoulos and Mims 1979). *Alternaria* species are known as major plant pathogens. They are also common allergens in humans, growing indoors and causing hay fever or hypersensitivity reactions that sometimes lead to asthma.

The next genus was *Curvularia* spp. and it contributed 214 fungal colonies of the total colonies from five different locations of Dhaka City in the morning (Table 1, Fig. 10). The percent frequency of *Curvularia* spp. was 6.54. Highest number of colony (68) of the fungus was isolated from DMC which was followed by Sadar ghat (42), Gulistan (39) and Sher-e Bangla Agricultural University (33). Least number of *Curvularia* spp. was recorded from DOHS, Mohakhali. Similar observation was also recorded in case of evening time. Out of 3380 fungal colonies 170 *Curvularia* spp. was recorded from the five selected locations (Table 2, Fig. 10). Highest number of *Curvularia* colonies was observed in DMC (48) which was followed by Gulistan (40), Sadar ghat (36) and Sher-e Bangla Agricultural University (24). Lowest (22) count was recorded from DOHS, Mohakhali. The percent frequency in the evening was 5.02 (Table 2). Maximum number of total count of *Curvularia* was noticed in the morning (214) than that of evening (170) (Table 5, Fig. 36).

Highest number of *Curvularia* colonies was recorded in the morning of June which was followed by July (Table 3, Fig. 26). Least number of the fungus was observed in the month of October. Similar observation was also noticed in the month of July evening. Maximum count of *Curvularia* colony (31) was observed in July evening followed by August (27). Least number was recorded in the evening of May 2013 (Table 4, Fig. 26). Maximum number of *Curvularia* colonies recorded in the month of July might be due to suitable temperature (28.2ºC), relative humidity (76.5%) and rainfall (18.9mm) (Table 5, Fig. 35). Shrestha and Chauhan (2003) reported *Curvularia* around various historical monuments of Agra, in India.

Fusarium spp. contributed 172 fungal colonies of the total counts in five different locations of Dhaka City in the morning (Table 1, Fig. 11). The percent frequency of *Fusarium* spp. was 5.26. Highest number of colony (42) of the fungus was isolated from Sadar ghat which was followed by Gulistan (36), DMC (34) and DOHS, Mohakhali (32). Least number of *Fusarium* spp. was recorded from Sher-e Bangla Agricultural University. Similar observation was also recorded in case of evening time. Out of 3380 fungal colonies 145 *Fusarium* spp. was recorded from the five selected locations (Table 2, Fig. 11). Highest number of *Fusarium* colonies was observed in Sadar ghat (40) which was followed by Gulistan (32), DOHS, Mohakhali (29), and DMC (28). Lowest (16) count was recorded from Sher-e Bangla Agricultural University. The percent frequency in the evening was 4.28 (Table 2). Maximum number of total count of *Fusarium* was noticed in the morning (172) than that of evening (145) (Table 5, Fig. 36).

Highest number of *Fusarium* colonies was recorded in the morning of August which was followed by September (Table 3, Fig. 27). Least

number of the fungus was observed in the month of January. Similar observation was noticed in the month of August evening. Maximum count of *Fusarium* colony (37) was observed in August evening followed by July (28). Least number was recorded in the evening of October 2013 (Table 4, Fig. 27). Maximum number of *Fusarium* colonies recorded in the month of August might be due to suitable temperature (29.2ºC), relative humidity (77.85%) and rainfall (15.6 mm) (Table 5, Fig. 35).

Bipolaris spp. contributed 150 fungal colonies of the total counts in five different locations of Dhaka City in the morning (Table 1, Fig. 6). The percent frequency of *Bipolaris* spp. was 2.90. Highest number of colony (48) of the fungus was isolated from Sher-e Bangla Agricultural University which was followed by Sadar ghat (32), DMC (18) and DOHS, Mohakhali (16). Least number of *Bipolaris* spp. was recorded from Gulistan (20). Similar observation was also recorded in case of evening time. Out of 3380 fungal colonies (114) *Bipolaris* spp. was recorded from the five selected locations (Table 2, Fig. 6). Highest number of *Bipolaris* colonies was observed in Sher-e Bangla Agricultural University (51) which was followed by DMC (18), Sadar ghat (18) and Gulistan (15). Lowest (12) count was recorded from DOHS, Mohakhali. The percent frequency in the evening was 2.01 (Table 2). Maximum number of total count of *Bipolaris* was noticed in the morning (150) than that of evening (114). (Table5, Fig. 36).

Highest number of *Bipolaris* colonies was recorded in the morning of December (31) which was followed by November (22) (Table 3, Fig. 22). Least number of the fungus was observed in the month of April. Similar observation was noticed in the month of December evening. Maximum count of *Bipolaris* colony (24) was observed in December evening followed by November (23). Least number was recorded in the evening

of May, 2013 (Table 4, Fig. 22). Maximum number of *Bipolaris* colonies recorded in the month of December might be due to suitable temperature (19ºC), relative humidity (65.2%) and rainfall (1.7 mm) (Tables 5, Fig. 35).

Pestalotia sp. contributed 128 fungal colonies of the total counts in five different locations of Dhaka City in the morning (Table 1, Fig. 14). The percent frequency of *Pestalotia* sp. was 3.91. Highest number of colony (32) of the fungus was isolated from Gulistan which was followed by DOHS, Mohakhali (30), Sadar ghat (28), and Sher-e Bangla Agricultural University (24). Least number of *Pestalotia* sp. was recorded from DMC (14). Similar observation was also recorded in case of evening time. Out of 3380 fungal colonies (110) *Pestalotia* sp. was recorded from the five selected locations (Table 2, Fig. 14). Highest number of *Pestalotia* colonies was observed in DMC (28) which was followed by DOHS, Mohakhali (25), Gulistan (22) and Sadar ghat (21). Lowest (14) count was recorded from Sher-e Bangla Agricultural University. The percent frequency in the evening was 3.25 (Table 2). Maximum number of total count of *Pestalotia* was noticed in the morning (128) than that of evening (110) (Table 5, Fig. 36).

Highest number of *Pestalotia* colonies was recorded in the morning of March which was followed by April (Table 3, Fig. 30). Least number of the fungus was observed in the month of May and June. Similar observation was noticed in the month of August evening. Maximum count of *Pestalotia* colony (22) was observed in August evening followed by September (18). Least number was recorded in the evening of May and June 2013 (Table 4, Fig. 30). Maximum number of *Pestalotia* colonies recorded in the month of March might be due to suitable

temperature (25.2ºC), relative humidity (65.6%) and rainfall (6.7 mm) (Table 5, Fig. 35).

In the present investigation *Colletotrichum* sp. contributed 74 fungal colonies of the total counts in five different locations of Dhaka City in the morning (Table 1, Fig. 9). The percent frequency of *Colletotrichum* sp. was 2.26. Highest number of colony (24) of the fungus was isolated from Sadar ghat which was followed Sher-e Bangla Agricultural University (16), DMC (14), and Gulistan (11). Least number of *Colletotrichum* sp. was recorded from DOHS, Mohakhali (9). Similar observation was also recorded in case of evening time. Out of 3380 fungal colonies (99) *Colletotrichum* sp. was recorded from the five selected locations (Table 2, Fig. 9). Highest number of *Colletotrichum* colonies was observed in Sadar ghat (26) which was followed by DMC (22), Sher-e Bangla Agricultural University (21) and Gulistan (18). Lowest (12) count was recorded from DOHS, Mohakhali .The percent frequency in the evening was 2.92 (Table 2). Maximum number of total count of *Colletotrichum* was noticed in the evening (99) than that of morning (74).

Highest number of *Colletotrichum* colonies was recorded in the morning of November which was followed by December (Table 3, Fig. 25). Least number of the fungus was observed in the month of August. Similar observation was noticed in the month of December evening. Maximum count of *Colletotrichum* colony (22) was observed in December evening followed by November (13). Least number was recorded in the evening of May, 2013 (Table 4, Fig. 25).

Trichoderma sp. contributed 76 fungal colonies of the total counts from five different locations of Dhaka city in the morning (Table 1, Fig. 18). The percent frequency of *Trichoderma* sp. was 2.32. Highest number of

colony (25) of the fungus was isolated from Sadar ghat which was followed by Gulistan (18) and DMC (13). Least number of *Trichoderma* sp. was recorded from DOHS and Sher-e Bangla Agricultural University. Similar observation was also recorded in case of evening time. Out of 3380 fungal colonies 85 *Trichoderma* sp. was recorded from the five selected locations (Table 2, Fig. 18). Highest number of *Trichoderma* colonies was observed in Sadar ghat (23) which was followed by Gulistan (21), DMC (15) and DOHS, Mohakhali (14). Lowest (12) count was recorded from Sher-e Bangla Agricultural University. The percent frequency in the evening was 2.51 (Table 2). Maximum number of total count of *Trichoderma* was noticed in the evening (85) than that of morning (76). (Table 5, Fig. 36).

Highest number of *Trichoderma* colonies was recorded in the morning of August which was followed by July (Table 3, Fig. 30). Least number of the fungus was observed in the month of April. Similar observation was noticed in the month of August evening. Maximum count of *Trichoderma* colony (13) was observed in August evening followed by May and June (12). Least number was recorded in the evening of April 2013 (Table 4, Figs. 30). Maximum number of *Trichoderma* colonies recorded in the month of August might be due to suitable temperature (29.2ºC), relative humidity (77.85%) and rainfall (15.6 mm). (Tables 5, Fig. 35).

The sterile mycelium contributed 66 fungal colonies of the total colonies from five different locations of Dhaka City in the morning (Table 1, Fig. 16).The percent frequency of sterile mycelium was 2.01. Highest number of colony (18) of the fungus was isolated from Sadar ghat which was followed by Sher-e Bangla Agricultural University (16), and Gulistan (12). Least number of sterile mycelium was recorded from DOHS and DMC. Similar observation was also recorded in case of evening time. Out

of 3380 fungal colonies (90) sterile mycelium was recorded from the five selected locations (Table 2, Fig. 16). Highest number of sterile colonies was observed in Gulistan (26) followed by Sher-e Bangla Agricultural University (18), DOHS (17) and Sadar ghat (15). Lowest (14) count was recorded from DMC. The percent frequency in the evening was 2.66 (Table 2). Maximum number of total count of sterile fungus was noticed in the evening (90) than that of morning (66) (Table 5, Fig. 36).

Highest number of sterile colonies was recorded in the morning of March which was followed by April (Table 3, Fig. 32). Least number of the fungi was observed in the month of July. Similar observation was also noticed in the month of October evening. Maximum count of sterile colony (17) was observed in October evening followed by February (14). Least number was recorded in the evening of September and June, 2013 (Table 4, Fig. 32).

Rhizopus sp. contributed 70 fungal colonies of the total counts from five different locations of Dhaka City in the morning (Table 1, Fig. 15). The percent frequency of *Rhizopus* sp. was 2.14. Highest number of colony (25) of the fungus was isolated from Gulistan which was followed by Sher-e Bangla Agricultural University (15), Sadar ghat (11) and DMC (10). Least number of *Rhizopus* sp. was recorded from DOHS (9). In case of evening time out of 3380 fungal colonies (78) *Rhizopus* sp. was recorded from the five selected locations (Table 2, Fig. 15). Highest number of *Rhizopus* colonies was observed in Sadar ghat (20) which was followed by Gulistan (18) and DMC (16). Lowest (12) count was recorded from DOHS, Mohakhali and Sher-e Bangla Agricultural University. The percent frequency in the evening was 2.30 (Table 2). Maximum number of total count of *Rhizopus* was noticed in the evening (78) than that of morning (70) (Table 5, Fig. 36).

Highest number of *Rhizopus* colonies was recorded in the morning of June which was followed by March (Table 3, Fig. 32). Least number of the fungus was observed in the month of December and January 2014. Maximum count of *Rhizopus* colony (16) was observed in January evening followed by December (9). Least number was recorded in the evening of June and July 2013 (Table 4, Fig. 32).

Nigrospora sp. contributed 62 fungal colonies of the total colonies in five different locations of Dhaka City in the morning (Table 1, Fig. 12). The percent frequency of *Nigrospora* sp. was 1.89. Highest number of colony (14) of the fungus was isolated from DMC and Gulistan (14) which was followed by Sadar ghat (13) and Sher-e Bangla Agricultural University (11). Least number of *Nigrospora* sp. was recorded from DOHS, Mohakhali. Similar observation was also recorded in case of evening time. Out of 3380 fungal colonies 65 *Nigrospora* sp. was recorded from the five selected locations (Table 2, Figs. 12). Highest number of *Nigrospora* colonies was observed in Gulistan (22) which was followed by DMC (16), Sadar ghat (10), and Sher-e Bangla Agricultural University (9). Lowest (8) count was recorded from DOHS, Mohakhali. The percent frequency in the evening was 1.92 (Table 2). Maximum number of total count of *Nigrospora* was noticed in the evening (65) than that of morning (62) (Table 5, Fig. 36).

Highest number of *Nigrospora* colonies was recorded in the morning of March which was followed by April (Table 3, Fig. 28). Least number of the fungus was observed in the month of February and July. Similar observation was noticed in the month of December evening. Maximum count of *Nigrospora* colony (14) was observed in December evening followed by August (11). Least number was recorded in the evening of February and July, 2013 (Table 4, Fig. 28).

Chaetomium sp. contributed 50 fungal colonies of the total counts from five different locations of Dhaka city in the morning (Table 1, Fig. 7). The percent frequency of *Chaetomium* sp. was 1.52. Highest number of colony (15) of the fungus was isolated from Sadar ghat which was followed by DMC (12), Gulistan (10) and Sher-e Bangla Agricultural University (7). Least number of *Chaetomium* sp. was recorded from DOHS, Mohakhali. Similar observation was also recorded in case of evening time. Out of 3380 fungal colonies 62 *Chaetomium* sp. was recorded from the five selected locations (Table 2, Fig. 7). Highest number of *Chaetomium* colonies was observed in DMC (18) which was followed by Gulistan (14) and Sadar ghat (12). Lowest (9) count was recorded from DOHS and Sher-e Bangla Agricultural University (9). The percent frequency in the evening was 1.83 (Table 2). Maximum number of total count of *Chaetomium* was noticed in the evening (62) than that of morning (50) (Table 5, Fig. 36).

Highest number of *Chaetomium* colonies was recorded in the morning of March 2013 which was followed by November (Table 3, Fig. 23). Least number of the fungus was observed in the month of May and June. Similar observation was noticed in the month of April evening. Maximum count of *Chaetomium* colony (12) was observed in April evening followed by July (8). Least number was recorded in the evening of May (Table 4, Fig. 23).

Syncephalastrum sp. contributed 52 fungal colonies of the total counts from five different locations of Dhaka city in the morning (Table 1, Fig. 17). The percent frequency of *Syncephalastrum* was 1.59. Highest number of colony (15) of the fungus was isolated from DOHS, Mohakhali which was followed by Gulistan (13), Sher-e Bangla Agricultural University (10) and Sadar ghat (9). Least number of

Syncephalastrum sp. was recorded from DMC. Similar observation was also recorded in case of evening time. Out of 3380 fungal colonies (58) *Syncephalastrum* sp. was recorded from the five selected locations (Table 2, Fig. 17). Highest number of *Syncephalastrum* colonies was observed in Sadar ghat (17) which was followed by DOHS (12), Gulistan (11) and Sher-e Bangla Agricultural University (10). Lowest (8) count was recorded from DMC. The percent frequency in the evening was 1.71 (Table 2). Maximum number of total count of *Syncephalastrum* was noticed in the evening (58) than that of morning (52) (Table 5, Fig. 36).

Highest number of *Syncephalastrum* colonies was recorded in the morning of May which was followed by April (Table 3, Fig. 33). Least number of the fungus was observed in the month of December and February. Similar observation was also noticed in the month of December evening. Maximum count of *Syncephalastrum* (16) was observed in December evening followed by September (13). Least number was recorded in the evening of January, February and June 2014 (Table 4, Fig. 33).

Arthrinium sp. contributed 57 fungal colonies of the total counts from five different locations of Dhaka City in the morning (Table 1, Fig. 4). The percent frequency of *Arthrinium* sp. was 1.74. Highest number of colony (18) of the fungus was isolated from DMC which was followed by Gulistan (15), Sadar ghat (9) and Sher-e Bangla Agricultural University. Least number of *Arthrinium* sp. was recorded from DOHS, Mohakhali. Similar observation was also recorded in case of evening isolation. Out of 3380 fungal colonies 48 *Arthrinium* spp. was recorded from the five selected locations (Table 2). Highest number of *Arthrinium* was observed in DMC (17) which was followed by DOHS (10), Gulistan (9) and Sadar ghat (7). Lowest (5) count was recorded from Sher-e Bangla Agricultural

University.The percent frequency in the evening was 1.42 (Table 2, Fig. 4). Maximum number of total count of *Arthrinium* was noticed in the morning (57) than that of evening (48) (Table 5, Fig. 36).

Highest number of *Arthrinium* colonies was recorded in the morning of March which was followed by July and November (Table 3, Fig. 20). Least number of the fungus was observed in the month of April and August. Similar observation was noticed in the month of September evening. Maximum count of *Arthrinium* colony (9) was observed in September evening followed by March and May (6). Least number was recorded in the evening of April and November 2013 (Table 4, Fig. 20).

Meteorological data of low and high temperature, average relative humidity and a very little to heavy rainfall in the month of February 2013 to January 2014 which was very closely associated with the incidence of these fungi (Table 5, Fig. 35).

In agreement with Ahmed *et al*. (2013) *Aspergillus* was found in the highest frequency in the present investigation among the identified genera. In the present study *Cladosporium* was found 2nd position in term of its percent frequency which is differs from the findings of Ahmed *et al*. (2013). They also isolated *Trichoderma*, *Pestalotia* and *Colletotrichm* from Dhaka University campus. Pathak (2012) recorded *Aspergillus* in the highest frequency (95.85%) followed by *penicillium* (84.80%), *Alternaria* (83.30%), *Cladosporium* (54.15%), *Curvularia* (41.70%), *Rhizopus* (41.66%), *Fusarium* (39.15%), *Mucor* (33.35%), *Epicoccum* (33.3%), *Phoma* (29.15%), *Nigrospora* (21.15%) and *Trichoderma* (16.65%). The variation in aeromycoflora and its frequencies with the present study might be due to the variation of meteorological parameters of the study area and methods used in the investigations.

Among the fungi, found in the present investigation *Alternaria, Aspergillus, Chaetomium, Cladosporium, Curvularia, Fusarium, Penicillium* and *Rhizopus* were reported as pathogenic to plants and/or human and strongly allergenic to human. *Bipolaris, Colletotrichum,* and *Pestalotia* were reported as only plant pathogens. The present study contributes to our knowledge of air borne spores in the Dhaka City. Regular monitoring of air borne fungi can be helpful in the prevention of fungal allergic diseases in the city.

The value of correlation of different places to different fungi

Correlation (r1) values of ranges between 0.981 to -0.307 indicate that there were highly significant relationship between different places and different times of same fungi (Table 1and 2).

Correlation (r2) values of ranges between 0.9918 to 0.9669 indicate that these were not highly significant between different times and different fungi of same place (Table 1and 2).

The value of correlation of different months to different fungi

Correlation (r1) values of ranges between 0.985 to -0.67 indicate that there were highly significant relationship between different places and different times of same fungi (Table 3 and 4).

Correlation (r2) values of ranges between 0.993 to 0.718 indicate that these were not highly significant between different times and different fungi of same place (Table 3 and 4).

Table 1. Incidence and percent frequency of fungal genera in PDA medium from different locations during February 2013 to January 2014 (morning)

Fungal genera	No. of fungal colonies developed in culture medium from different locations						(%) Frequency	Mean	Standard deviation	Correlation (r1)
	SAU	Gulistan	DMC	Sadar ghat	DOHS Mohakhali	Total				
Alternaria	38	57	43	48	35	221	6.76	44.2	75.7	0.981
Arthrinium	9	15	18	9	6	57	1.74	11.4	24.3	0.687
Aspergillus	172	242	178	213	137	942	28.82	188.4	1624.3	0.927
Bipolaris	48	20	28	32	22	150	4.59	30	124	0.945
Chaetomium	7	10	12	15	6	50	1.52	10	13.5	0.593
Cladosporium	118	104	97	113	84	516	15.78	103.2	180.7	0.206
Colletotrichum	16	11	14	24	9	74	2.26	14.8	33.7	0.898
Curvularia	33	39	68	42	32	214	6.54	42.8	215.7	0.863
Fusarium	28	36	34	42	32	172	5.23	34.2	28.2	0.935
Nigrospora	11	14	14	13	10	62	1.89	12.4	3.3	0.814
Penicillium	76	98	82	74	88	418	12.79	83.6	94.8	0.571
Pestalotia	24	32	14	28	30	128	3.91	25.6	50.8	-0.307
Rhizopus	15	25	10	11	9	70	2.14	14	43	0.277
Sterile mycelium	16	12	10	18	10	66	2.02	13.2	13.2	-0.116
Syncephalastrum	10	13	5	9	15	52	1.59	10.4	14.8	0.247
Trichoderma	10	18	13	25	10	76	2.35	15.4	38.3	0.929
Total fungal colonies	631	746	640	716	535	3268	100			
Correlation (r2)	0.9899	0.9894	0.9688	0.9918	0.9669					

Correlation (r1) = Correlation between different places and different times of same fungi.

Correlation (r2) = Correlation between different times and different fungi of same place.

Table 2. Incidence and percent frequency of fungal genera in PDA medium from different locations during February 2013 to January 2014 (evening)

Fungal genera	No. of fungal colonies developed in culture medium from different locations						(%) Frequency	Mean	Standard deviation	Correlation (r1)
	SAU	Gulistan	DMC	Sadar ghat	DOHS Mohakhali	Total				
Alternaria	37	52	43	48	36	216	6.39053	43.2	47.7	0.981
Arthrinium	5	9	17	7	10	48	1.42012	9.6	20.8	0.687
Aspergillus	187	268	198	210	175	1038	30.7101	207.6	1308.3	0.927
Bipolaris	51	15	18	18	12	114	3.373	22.8	254.7	0.945
Chaetomium	9	14	18	12	9	62	1.83432	12.4	14.3	0.593
Cladosporium	106	142	137	129	98	612	18.1065	122.4	376.3	0.206
Colletotrichum	21	18	22	26	12	99	2.92899	19.8	27.2	0.898
Curvularia	24	40	48	36	22	170	5.02959	34	120	0.864
Fusarium	16	32	28	40	29	145	4.28994	29	75	0.959
Nigrospora	9	22	16	10	8	65	1.92308	13	35	0.814
Penicillium	72	104	68	81	65	390	11.5385	78	247.5	0.571
Pestalotia	14	22	28	21	25	110	3.25444	22	27.5	-0.307
Rhizopus	12	18	16	20	12	78	2.30769	15.6	12.8	0.277
Sterile mycelium	18	26	14	15	17	90	2.66272	18	22.5	-0.116
Syncephalastrum	10	11	8	17	12	58	1.71598	11.6	11.3	0.247
Trichoderma	12	21	15	23	14	85	2.51479	17	18.5	0.920
Total fungal colonies	603	814	694	713	556	3380	100			
Correlation (r2)	0.9899	0.9894	0.9688	0.9918	0.9665					

Correlation (r1) = Correlation between different places and different times of same fungi.

Correlation (r2) = Correlation between different times and different fungi of same place.

Table 3. Monthly incidence and percent frequency of air borne fungal genera in PDA medium in different months during February 2013 to January 2014 (morning)

Fungal genera	No. of fungal colonies developed in culture media in different months																
	February	March	April	May	June	July	August	September	October	November	December	January	Total colonies	(%) Frequency	Mean	Standard deviation	Correlation (r1)
Alternaria	27	11	22	23	8	7	15	28	16	23	27	14	221	6.763	18.42	56.81	0.15
Arthrinium	3	10	0	6	3	7	0	5	6	7	5	5	57	1.744	4.75	8.38	0.30
Aspergillus	28	26	85	94	108	162	169	184	32	20	19	15	942	28.82	78.5	4173.5	0.99
Bipolaris	10	4	3	11	10	8	15	4	18	22	31	14	150	4.589	30	124	0.95
Chaetomium	4	9	3	0	0	5	5	2	5	8	4	5	50	1.53	4.167	7.424	0.10
Cladosporium	77	24	6	6	4	3	5	18	61	68	108	136	516	15.79	43	2115.2	0.97
Colletotrichum	5	6	6	7	5	11	0	5	7	11	9	2	74	2.264	6.167	10.515	0.41
Curvularia	24	17	15	17	35	25	22	18	6	8	15	12	214	6.548	17.83	62.696	0.30
Fusarium	7	8	9	12	18	25	32	31	6	11	9	4	172	5.263	14.33	96.42	0.87
Nigrospora	0	13	12	7	2	0	5	8	4	6	3	2	62	1.897	5.167	18.15	0.12
Penicillium	52	36	17	61	6	23	27	89	11	16	42	38	418	12.79	34.83	568.15	0.91
Pestalotia	10	21	18	0	0	17	5	13	14	13	13	4	128	3.917	10.67	48.42	0.01
Rhizopus	4	10	9	7	13	3	3	7	8	5	0	1	70	2.142	5.833	14.87	-0.67
Sterile mycelium	7	13	9	5	7	0	3	3	6	3	6	4	66	2.02	5.5	11.36	-0.23
Syncephalastrum	0	5	8	10	5	6	5	1	6	1	0	5	52	1.591	4.333	10.24	-0.27
Trichoderma	3	4	0	7	4	12	18	6	4	9	1	8	76	2.326	6.333	24.96	0.60
Total fungal colonies	261	217	222	273	228	314	329	422	210	231	292	269	3268	100			
Correlation (r2)	0.95	0.71	0.95	0.97	0.95	0.99	0.98	0.98	0.90	0.96	0.95	0.98					

Correlation (r1) = Correlation between different months and different times of same fungi.

Correlation (r2) = Correlation between different times and different fungi of same months.

Table 4. Monthly incidence and percent frequency of air borne fungal genera in PDA medium i different months during February 2013 to January 2014 (evening)

Fungal genera	No. of fungal colonies developed in culture media in different months																
	February	March	April	May	June	July	August	September	October	November	December	January	Total colonies	(%) Frequency	Mean	Standard deviation	Correlation (r1)
Alternaria	18	22	24	12	11	15	17	21	14	19	16	27	216	6.391	18	23.45	0.15
Arthrinium	3	6	0	6	5	4	4	9	5	0	4	2	48	1.42	4	6.54	0.31
Aspergillus	42	38	68	87	113	171	193	208	43	33	14	28	1038	30.71	86.5	4732.2	0.99
Bipolaris	9	4	7	3	13	9	10	2	4	23	24	6	114	3.373	22.8	254.7	0.95
Chaetomium	7	5	12	0	6	8	4	4	6	4	1	5	62	1.834	5.167	9.78	0.10
Cladosporium	95	19	11	5	0	0	18	22	61	109	113	159	612	18.11	51	2980	0.98
Colletotrichum	4	6	5	0	9	11	5	7	9	13	22	8	99	2.929	8.25	30.38	0.49
Curvularia	13	9	7	4	11	31	27	15	14	5	22	12	170	5.03	14.17	71.96	0.31
Fusarium	6	12	5	9	11	28	37	17	3	8	5	4	145	4.29	12.08	110.08	0.87
Nigrospora	0	5	4	1	3	0	11	6	6	9	14	6	65	1.923	5.417	18.62	0.12
Penicillium	47	26	16	42	14	21	19	77	26	13	38	51	390	11.54	32.5	367.90	0.91
Pestalotia	12	3	5	0	0	7	22	18	9	8	12	14	110	3.254	9.167	46.51	0.01
Rhizopus	9	5	7	4	2	3	8	5	4	6	9	16	78	2.308	6.5	14.09	-0.67
Sterile mycelium	14	3	5	7	0	10	9	0	17	12	8	5	90	2.663	7.5	27.90	-0.23
Syncephalastrum	0	3	8	2	0	4	7	13	5	0	16	0	58	1.716	4.833	28.33	-0.27
Trichoderma	11	3	0	12	12	8	13	7	5	8	0	6	85	2.515	7.083	20.26	0.61
Total fungal colonies	290	169	184	194	210	330	404	431	231	270	318	349	3380	100			
Correlation (r2)	0.95	0.71	0.95	0.97	0.95	0.99	0.99	0.99	0.91	0.96	0.96	0.99					

Correlation (r1) = Correlation between different months and different times of same fungi.

Correlation (r2) = Correlation between different times and different fungi of same months.

Table 5. Climate factors and total number of fungal colonies in different months.

Months	Temperature (°C)			Relative Humidity (%)			Precipitation (mm)	Total fungal colonies	
	Maximum	Minimum	Mean	Maximum	Minimum	Mean		Morning	Evening
February	26.2	11.6	18.9	79.4	52.8	66.1	0.0	258	290
March	32.8	17.6	25.2	82.6	48.6	65.6	6.7	209	188
April	33.4	22.6	28	84.5	50.1	67.3	8.3	169	180
May	33.2	23.2	28.2	89.6	53.4	71.5	5.9	196	177
June	34.2	26.8	30.5	91.3	59.1	75.2	16.1	219	225
July	30.6	25.8	28.2	92.4	60.6	76.5	18.9	266	275
August	32.2	26.2	29.2	94.3	61.4	77.85	15.6	309	301
September	32.7	25.3	29	88.3	56.7	72.5	12.6	218	249
October	30.7	20.5	25.6	85.6	54.6	70.1	2.0	206	187
November	28.9	18.7	23.8	83.4	52.9	68.15	1.3	284	289
December	24.6	13.4	19	80.7	49.7	65.2	1.7	373	350
January	23.3	10.7	17	74.6	47.1	60.85	0.0	403	374

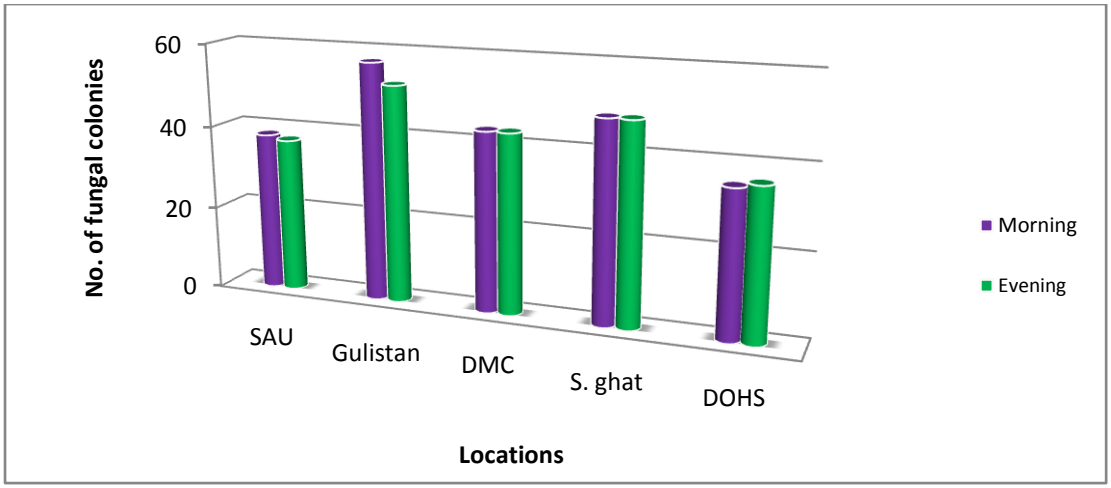


Fig. 3. Number of colonies of *Alternaria* sp. in the morning and evening from different locations.

SAU: Sher-e Bangla Agricultural University
DMC: Dhaka Medical College
S. ghat: Sadar ghat
DOHS: Defense Officers Housing Society (Mohakhali)

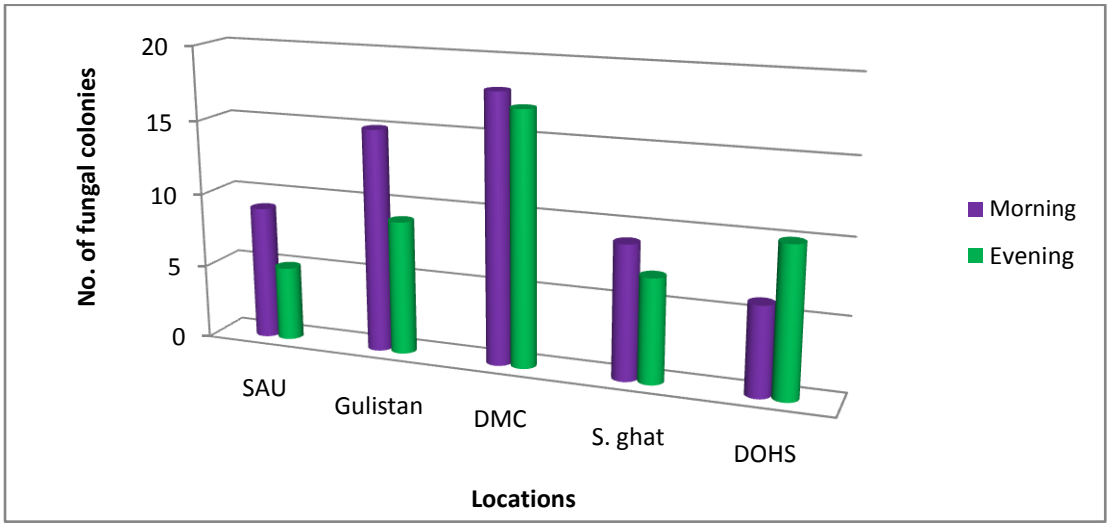


Fig. 4. Number of colonies of *Arthrinium* sp. in the morning and evening from different locations.
(Abbreviations are same as in Fig. 3).

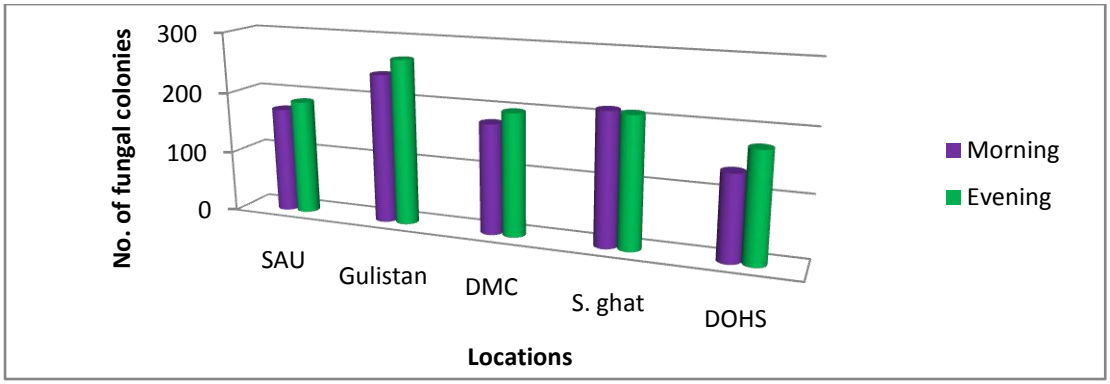


Fig.5. Number of colonies of *Aspergillus* spp. in the morning and evening from different locations.
(Abbreviations are same as in Fig. 3).

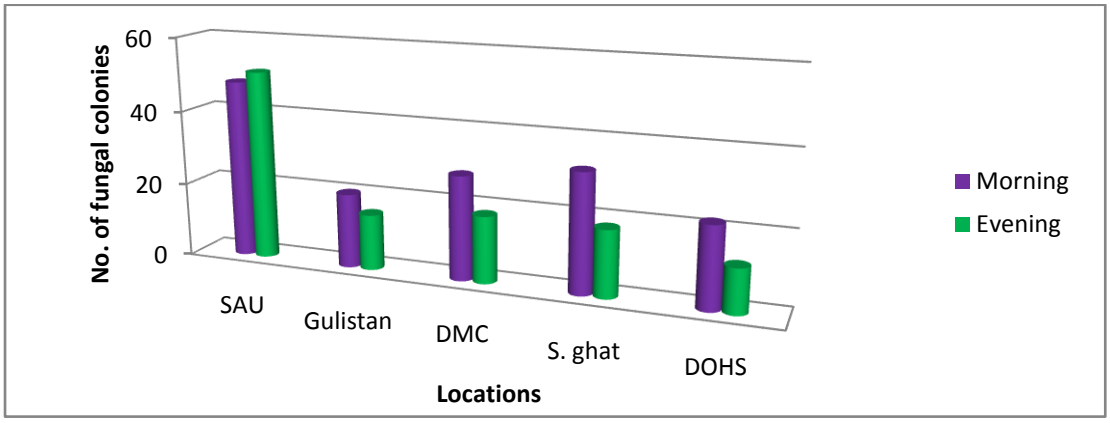


Fig.6. Number of colonies of *Bipolaris* spp. in the morning and evening from different locations.
(Abbreviations are same as in Fig. 3).

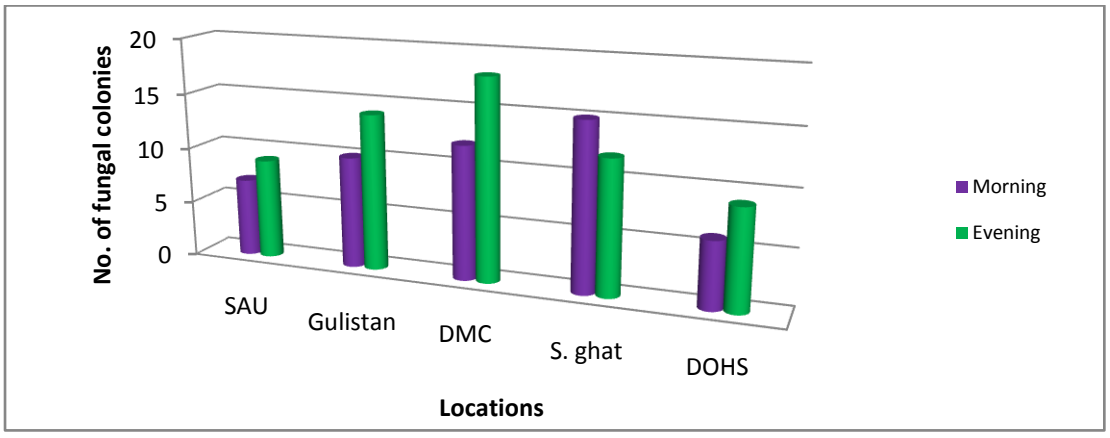


Fig.7. Number of colonies of *Chaetomium* sp. in the morning and evening from different locations.
(Abbreviations are same as in Fig. 3).

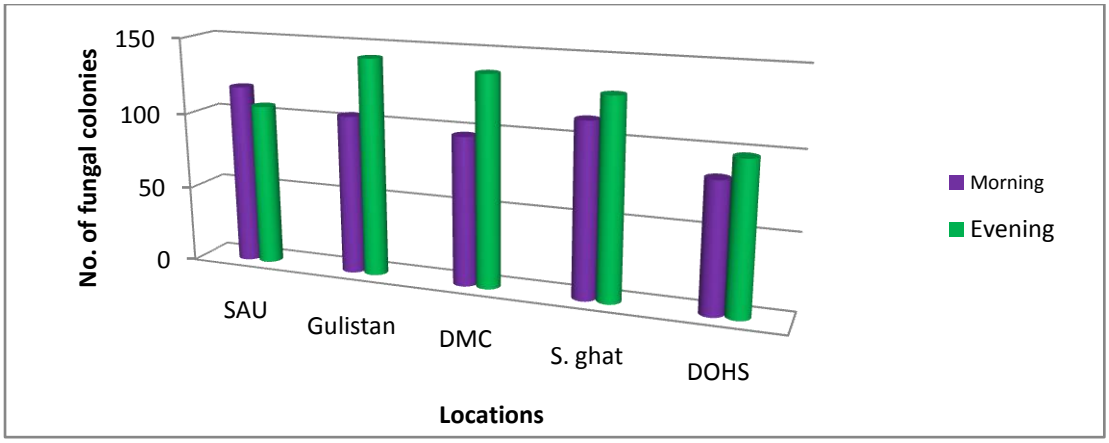


Fig. 8. Number of colonies of *Cladosporium* spp. in the morning and evening from different locations.
(Abbreviations are same as in Fig. 3).

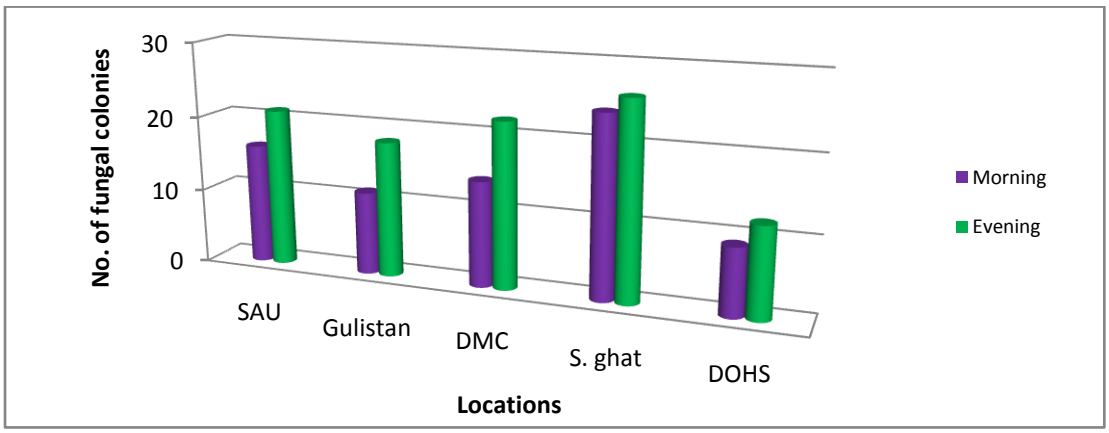


Fig .9. Number of colonies of *Colletotrichum* sp. in the morning and evening from different locations.
(Abbreviations are same as in Fig. 3).

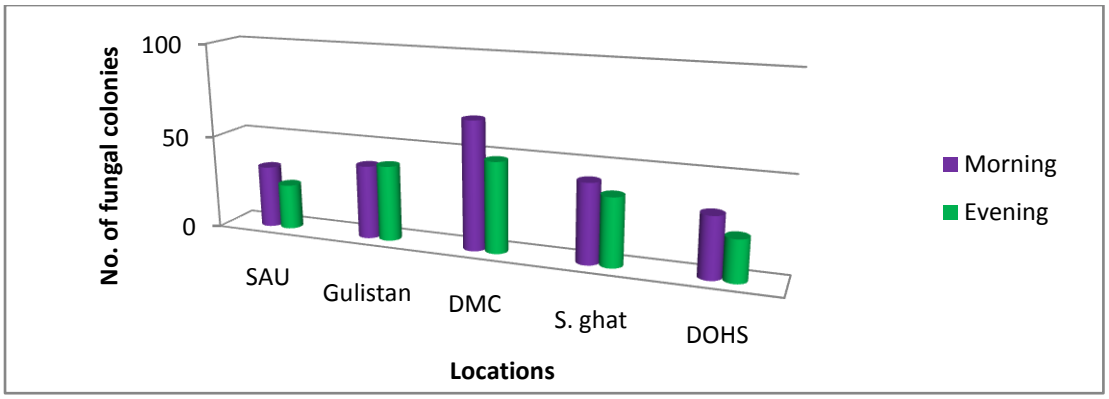


Fig.10. Number of colonies of *Curvularia* spp. in the morning and evening from different locations.
(Abbreviations are same as in Fig. 3).

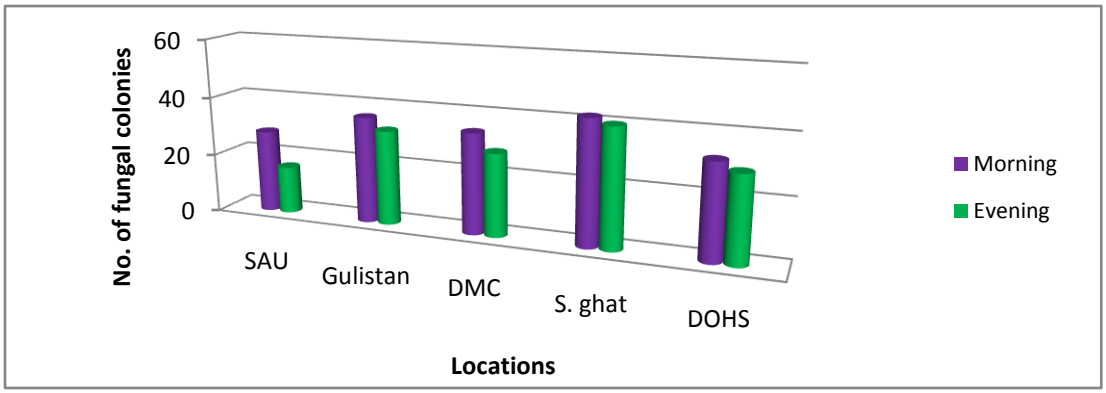


Fig. 11.Number of colonies of *Fusarium* spp. in the morning and evening from different locations.
(Abbreviations are same as in Fig. 3).

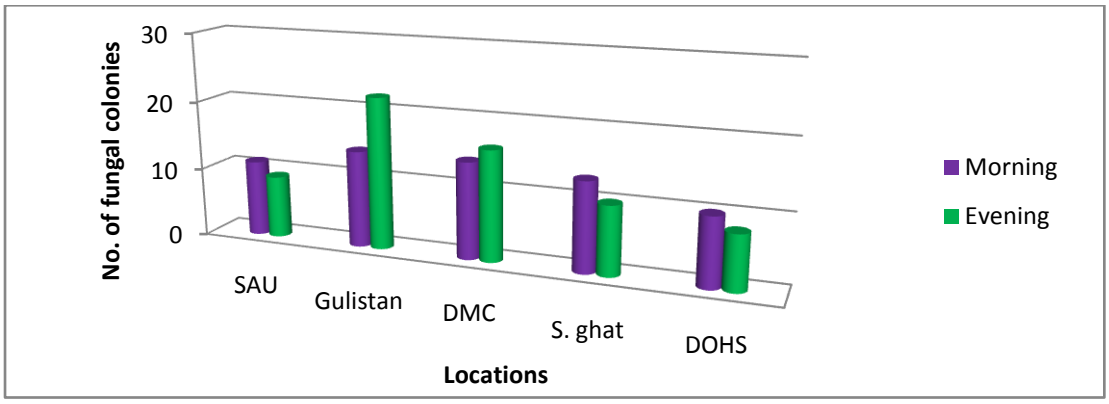


Fig.12. Number of colonies of *Nigrospora* sp. in the morning and evening from different locations.
(Abbreviations are same as in Fig. 3).

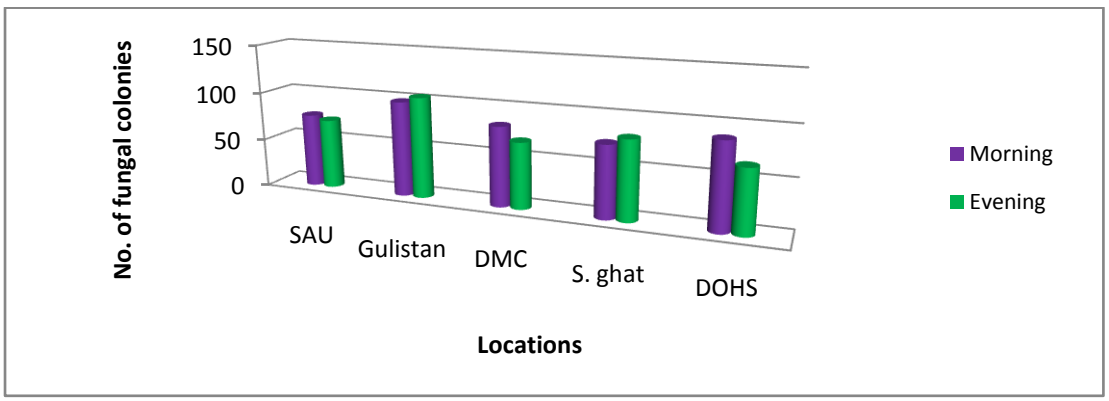


Fig.13.Number of colonies of *Penicillium* spp. in the morning and evening from different locations.
(Abbreviations are same as in Fig. 3).

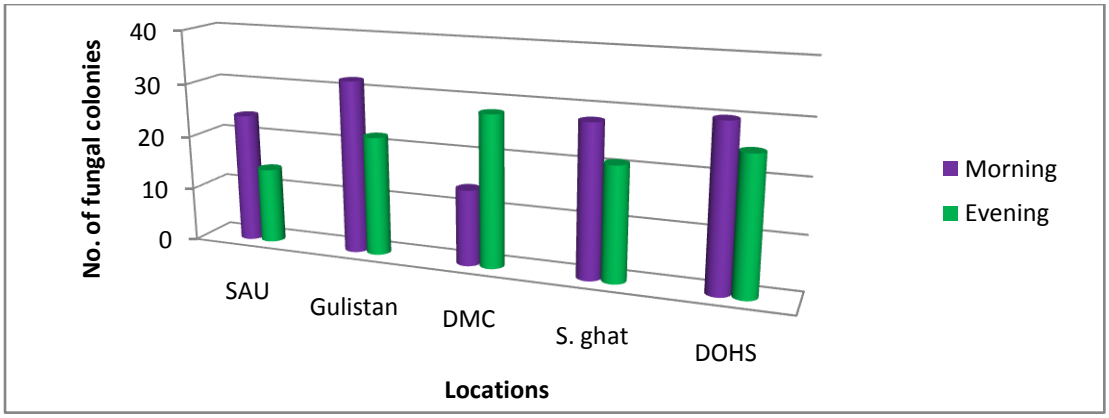


Fig.14. Number of colonies of *Pestalotia* sp. in the morning and evening from different locations.
(Abbreviations are same as in Fig. 3).

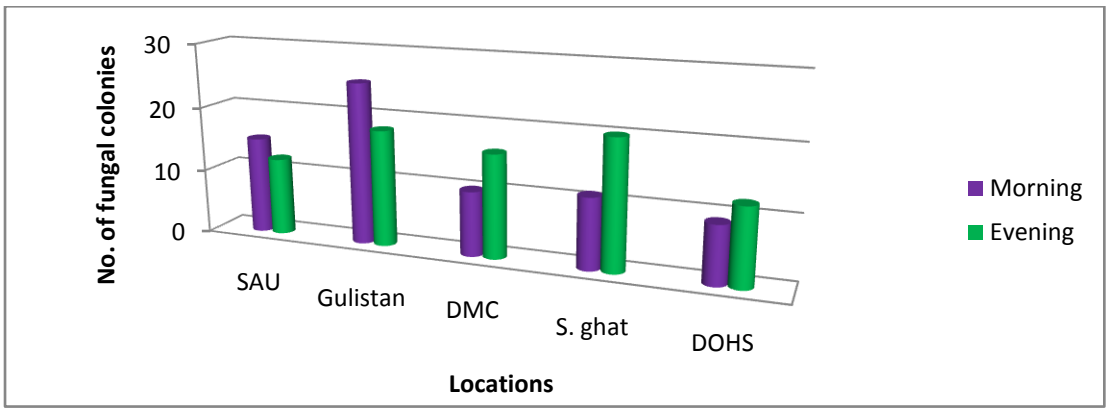


Fig.15.Number of colonies of *Rhizopus* sp. in the morning and evening from different locations.
(Abbreviations are same as in Fig. 3).

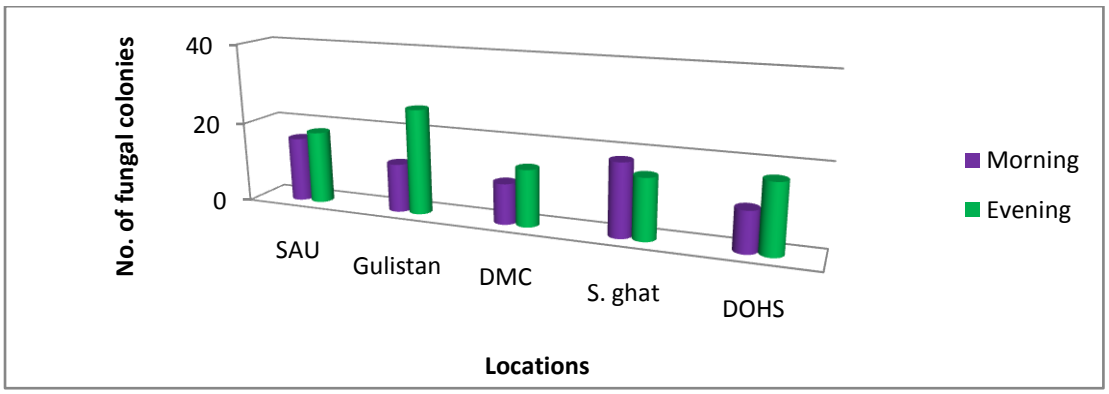


Fig.16.Number of colonies of Sterile mycelium in the morning and evening from different locations.
(Abbreviations are same as in Fig. 3).

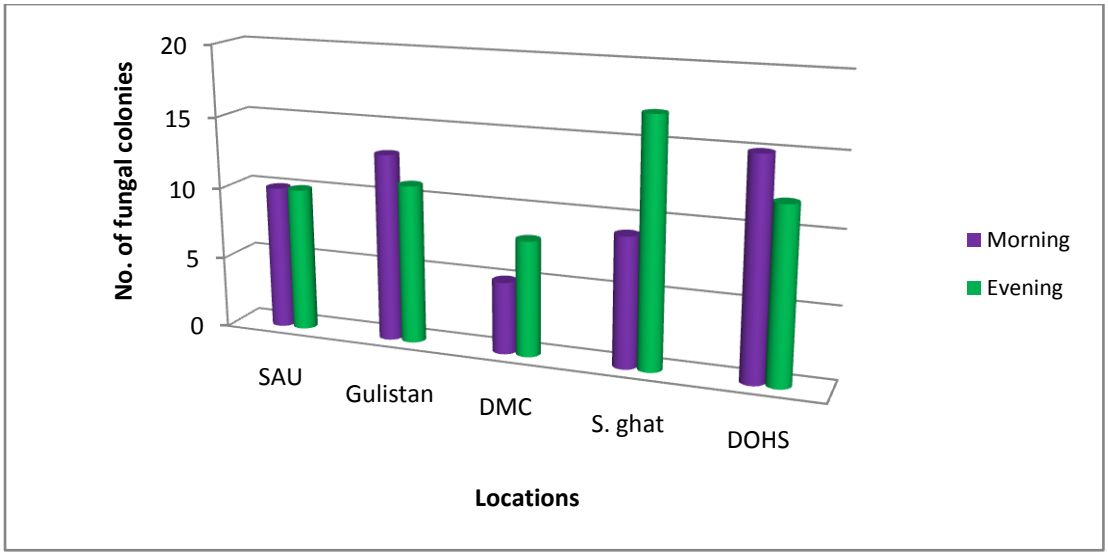


Fig.17. Number of colonies of *Syncephalastrum* sp. in the morning and evening from different locations.
(Abbreviations are same as in Fig. 3).

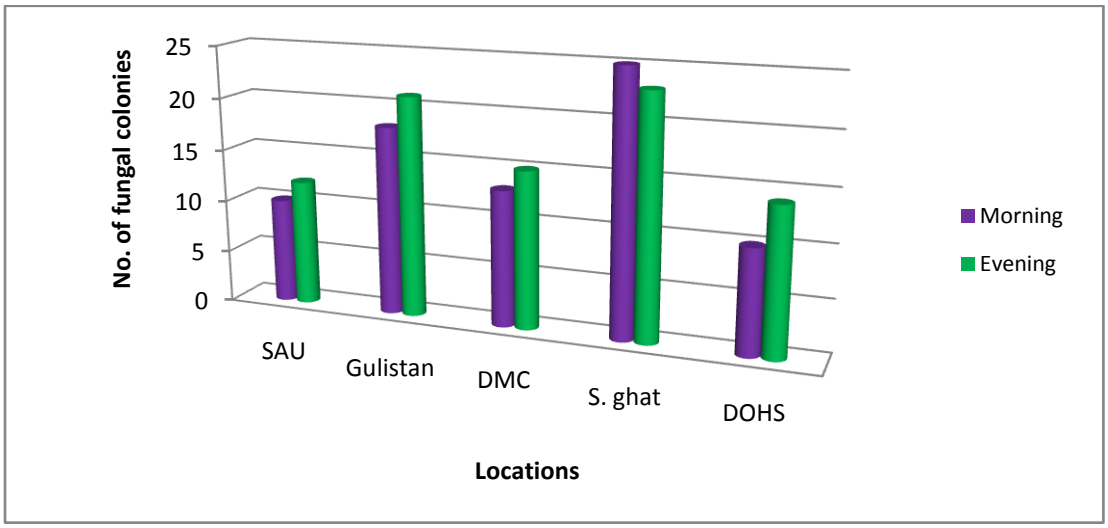


Fig.18. Number of colonies of *Trichoderma* sp. in the morning and evening from different locations.
(Abbreviations are same as in Fig. 3).

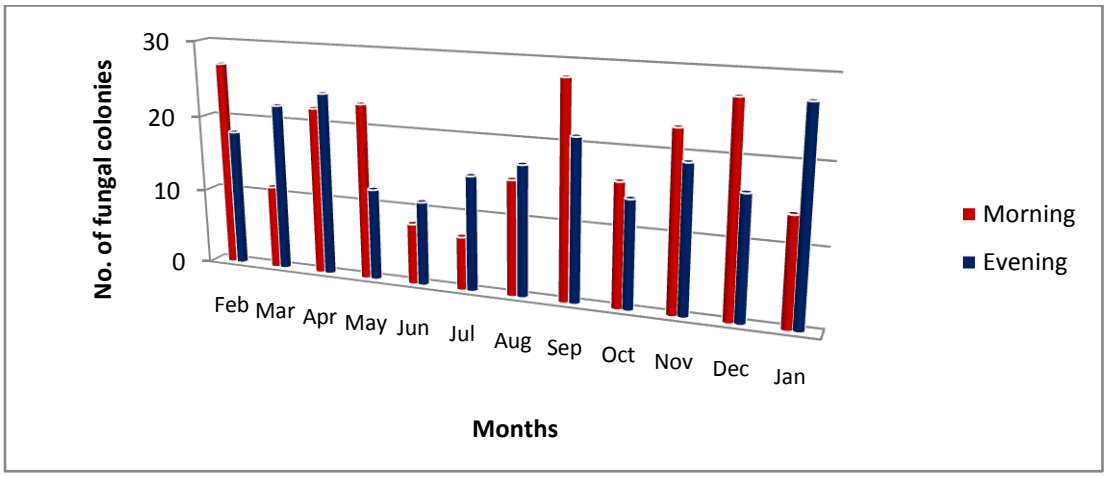


Fig. 19. Number of colonies of *Alternaria* sp. in the morning and evening in different months during February 2013 to January 2014.

Feb : February	May : May	Aug : August	Nov : November
Mar : March	Jun : June	Sep : September	Dec : December
Apr : April	Jul : July	Oct : October	Jan : January

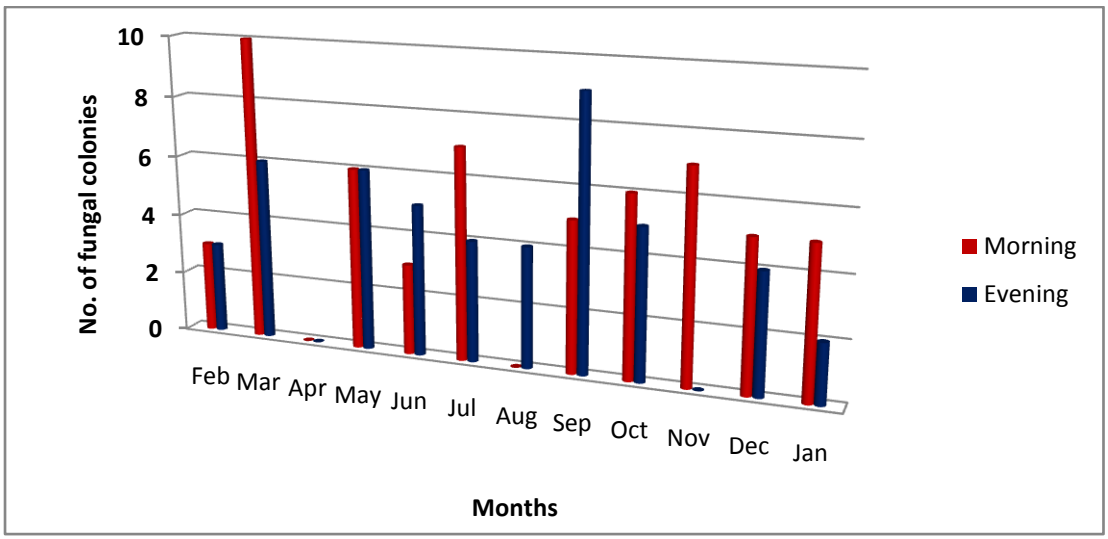


Fig. 20. Number of colonies of *Arthrinium* sp. in the morning and evening in different months during February 2013 to January 2014.
(Abbreviations are same as in Fig. 19).

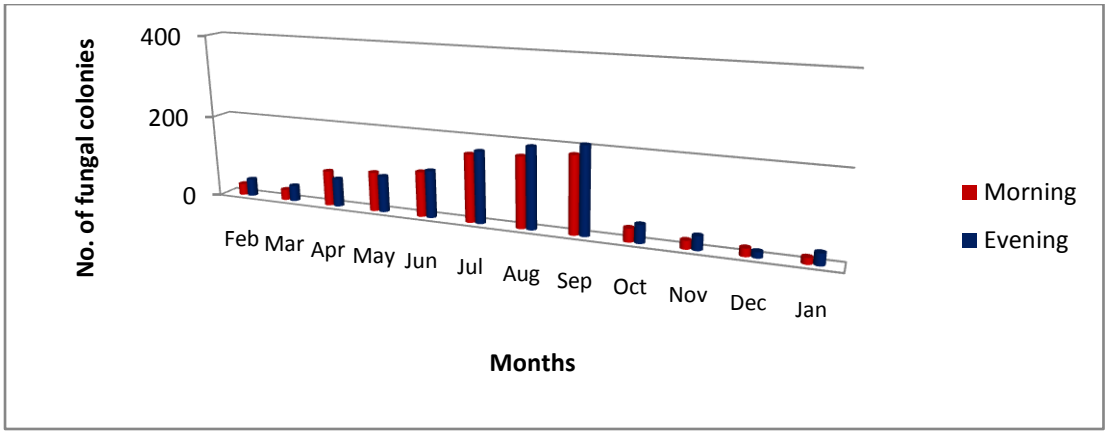


Fig. 21. Number of colonies of *Aspergillus* spp. in the morning and evening in different months during February 2013 to January 2014. (Abbreviations are same as in Fig. 19).

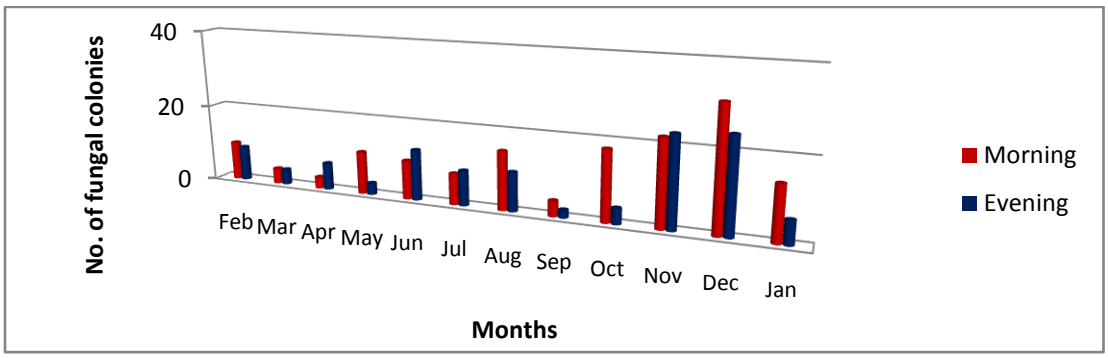


Fig. 22.Number of colonies of *Bipolaris* spp. in the morning and evening in different months during February 2013 to January 2014. (Abbreviations are same as in Fig. 19).

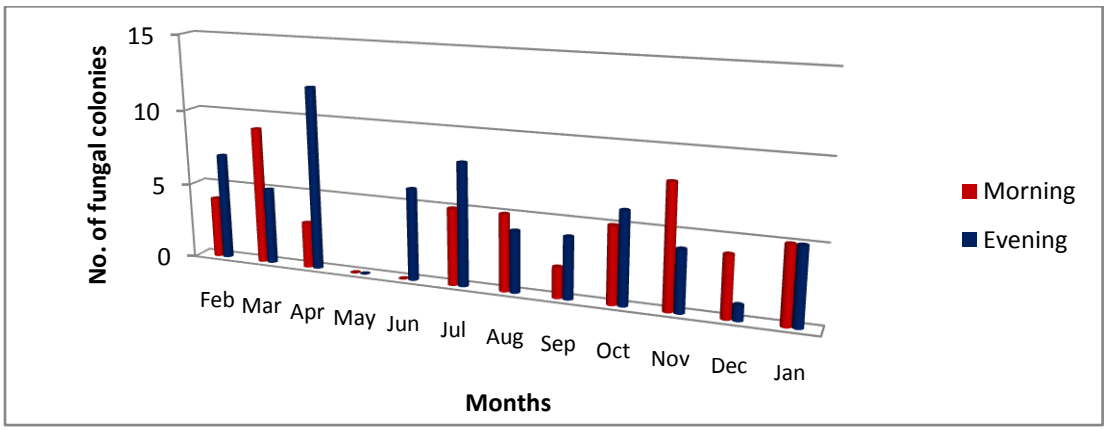


Fig. 23. Number of colonies of *Chaetomium* sp. in the morning and evening in different months during February 2013 to January 2014. (Abbreviations are same as in Fig. 19).

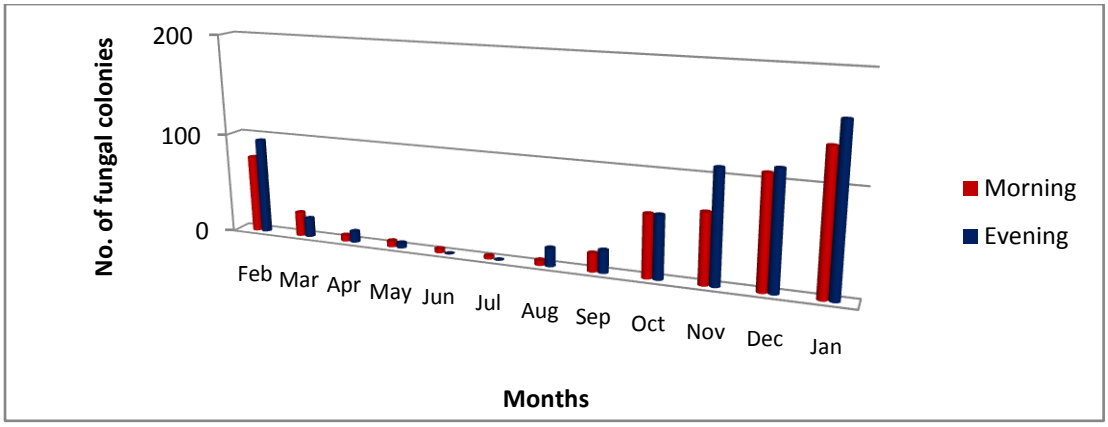


Fig. 24. Number of colonies of *Cladosporium* spp. in the morning and evening in different months during February 2013 to January 2014. (Abbreviations are same as in Fig. 19).

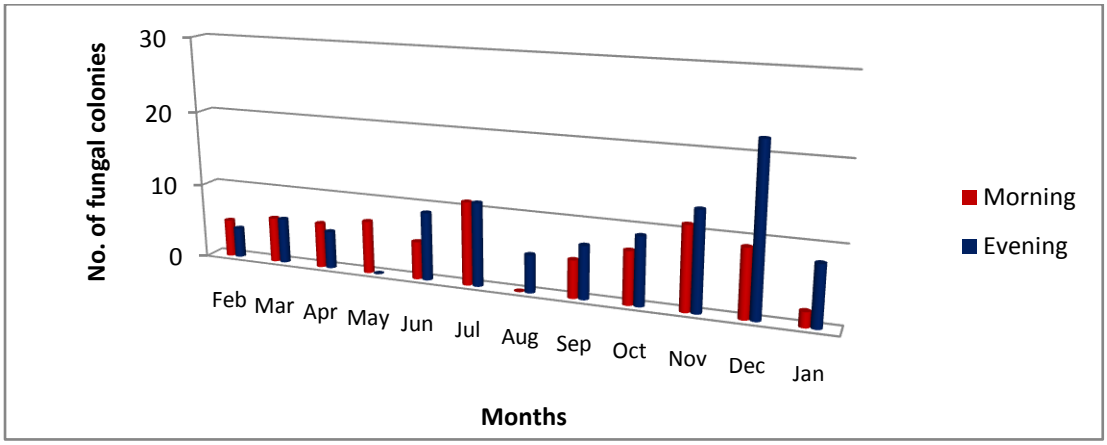


Fig. 25. Number of colonies of *Colletotrichum* sp. in the morning and evening in different months during February 2013 to January 2014. (Abbreviations are same as in Fig. 19).

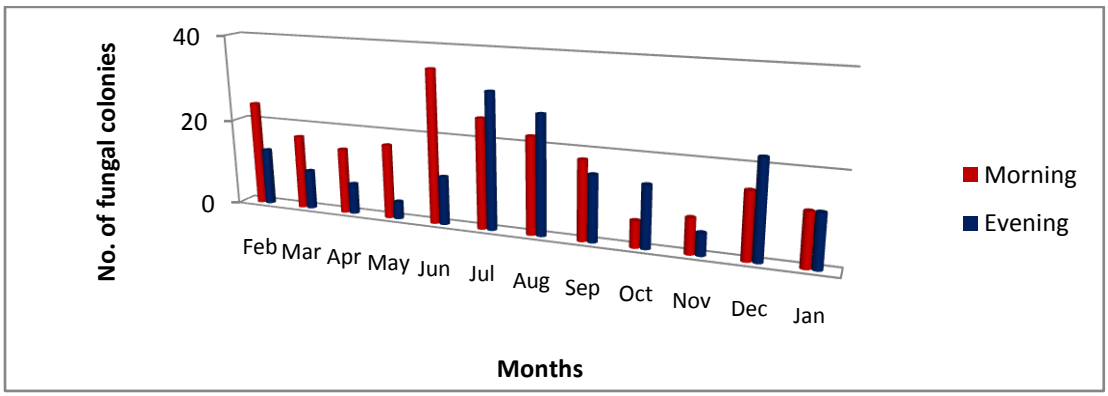


Fig. 26. Number of colonies of *Curvularia* spp. in the morning and evening in different months during February 2013 to January 2014. (Abbreviations are same as in Fig. 19).

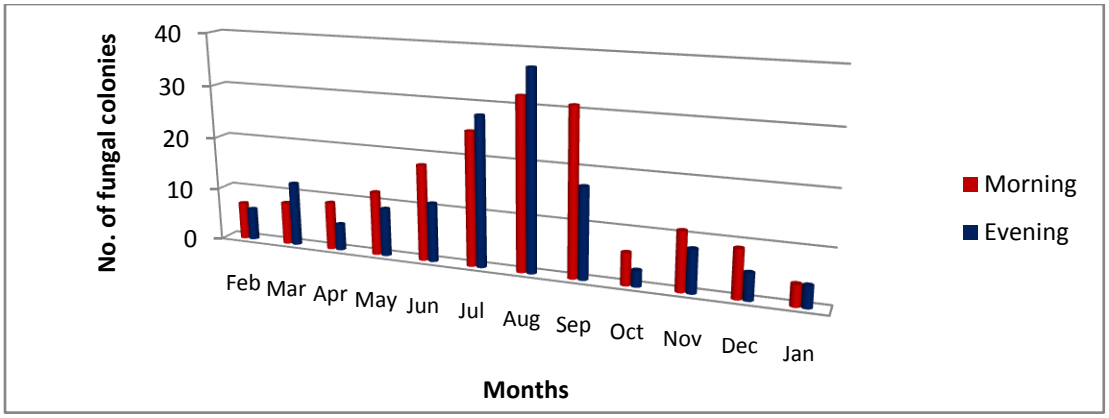


Fig.27. Number of colonies of *Fusarium* spp. in the morning and evening in different months during February 2013 to January 2014.
(Abbreviations are same as in Fig. 19).

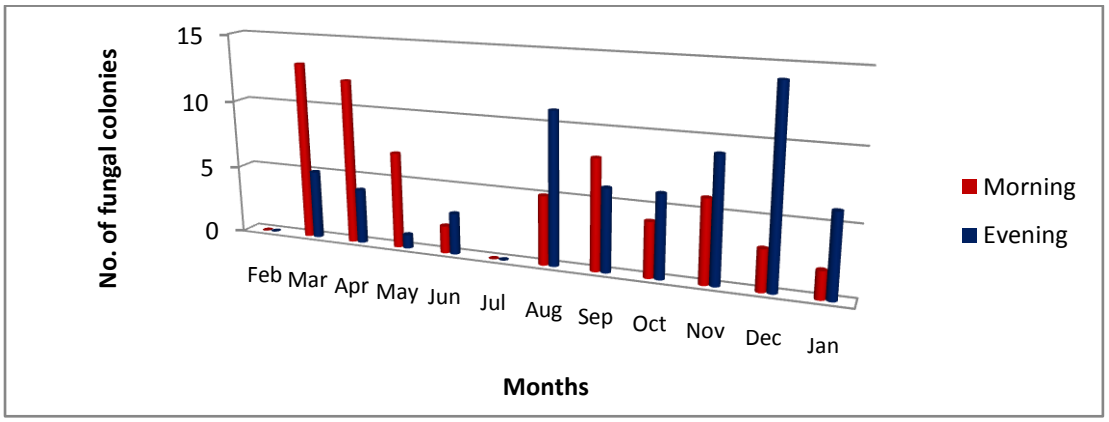


Fig. 28. Number of colonies of *Nigrospora* sp. in the morning and evening in different months during February 2013 to January 2014.
(Abbreviations are same as in Fig. 19).

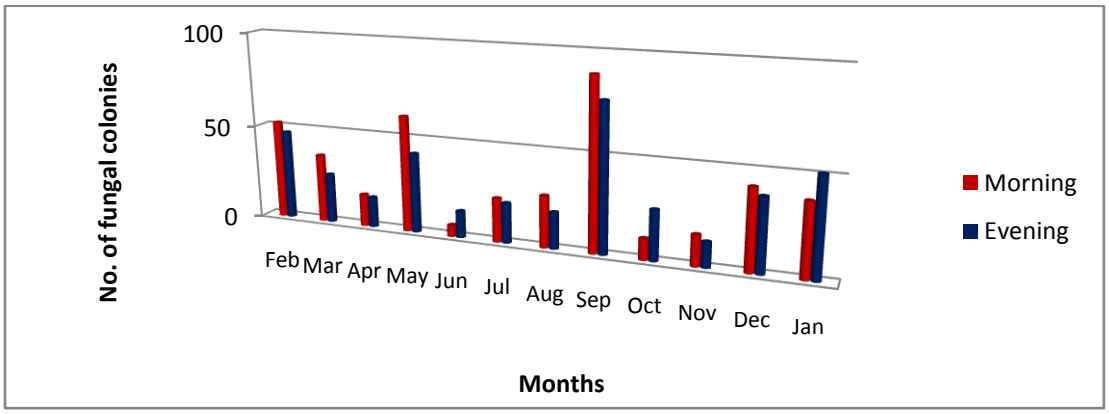


Fig. 29. Number of colonies of *Penicillium* spp. in the morning and evening in different months during February 2013 to January 2014.
(Abbreviations are same as in Fig. 19).

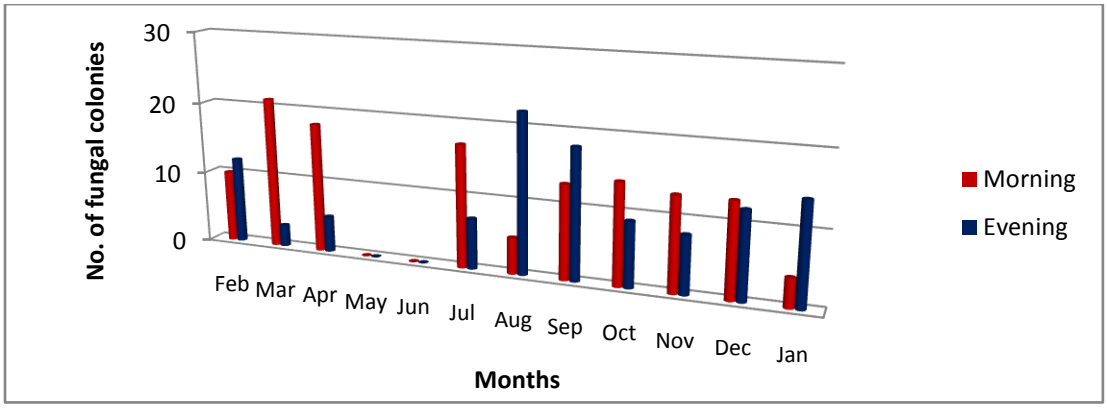


Fig. 30. Number of colonies of *Pestalotia* sp. in the morning and evening in different months during February 2013 to January 2014.
(Abbreviations are same as in Fig. 19).

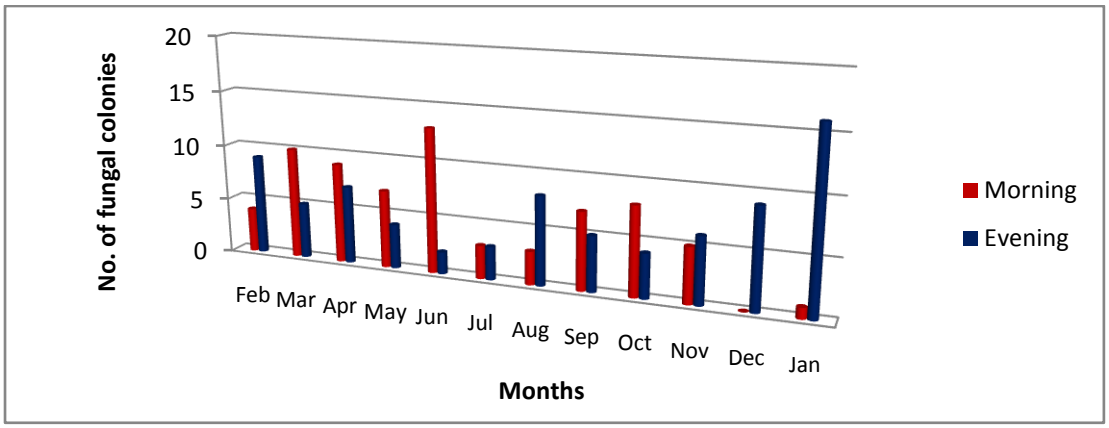


Fig. 31.Number of colonies of *Rhizopus* sp. in the morning and evening in different months during February 2013 to January 2014.
(Abbreviations are same as in Fig. 19).

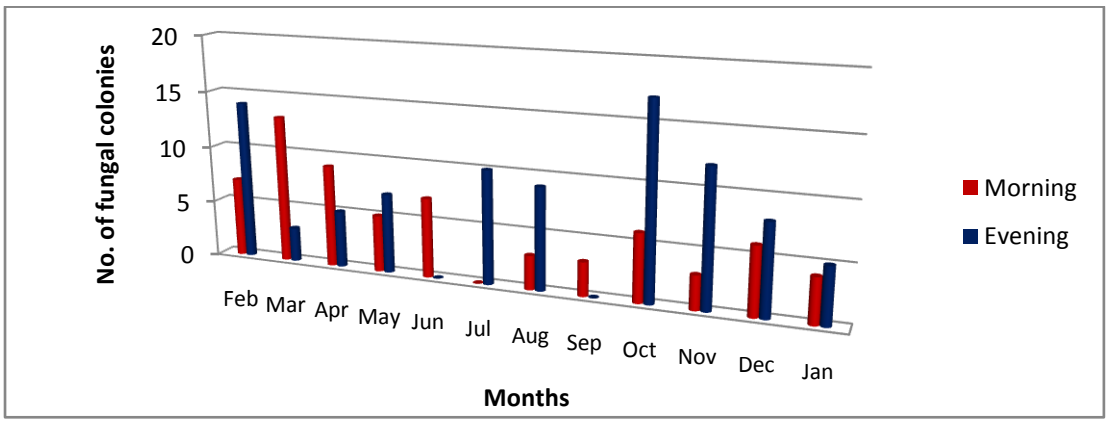


Fig. 32. Number of colonies of Sterile mycelium in the morning and evening in different months during February 2013 to January 2014.
(Abbreviations are same as in Fig. 19).

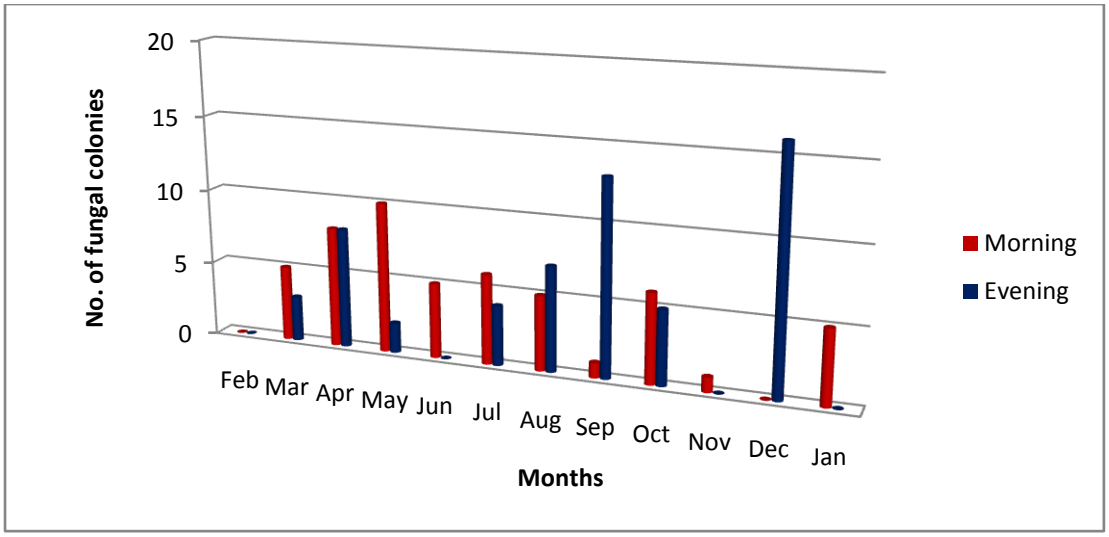


Fig. 33. Number of colonies of *Syncephalastrum* sp. in the morning and evening in different months during February 2013 to January 2014. (Abbreviations are same as in Fig. 19).

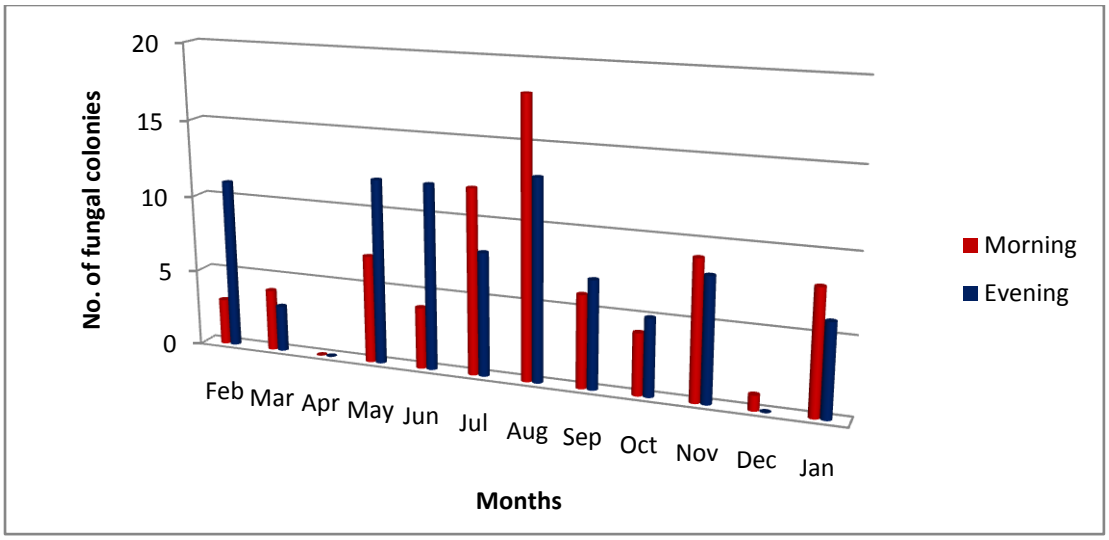


Fig. 34. Number of colonies of *Trichoderma* sp. in the morning and evening in different months during February 2013 to January 2014. (Abbreviations are same as in Fig. 19).

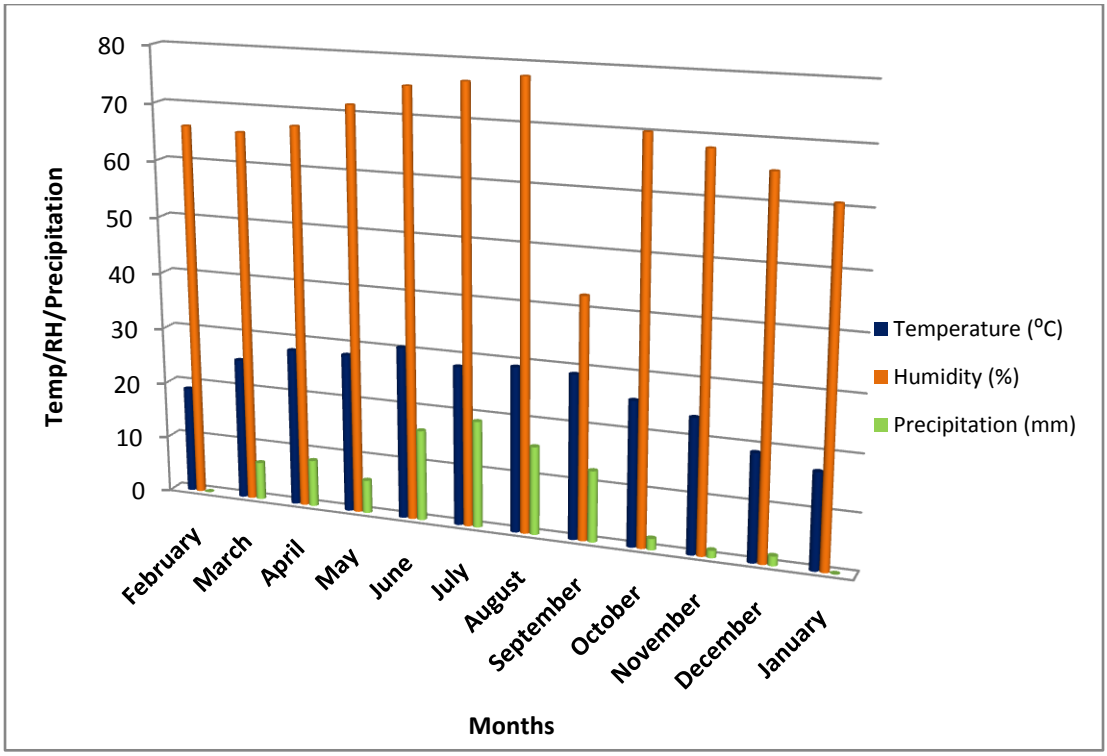


Fig. 35. Monthly mean temperature (°C), relative humidity (%) and precipitation (mm) of five locations in Dhaka Metropolitan City during the twelve months.

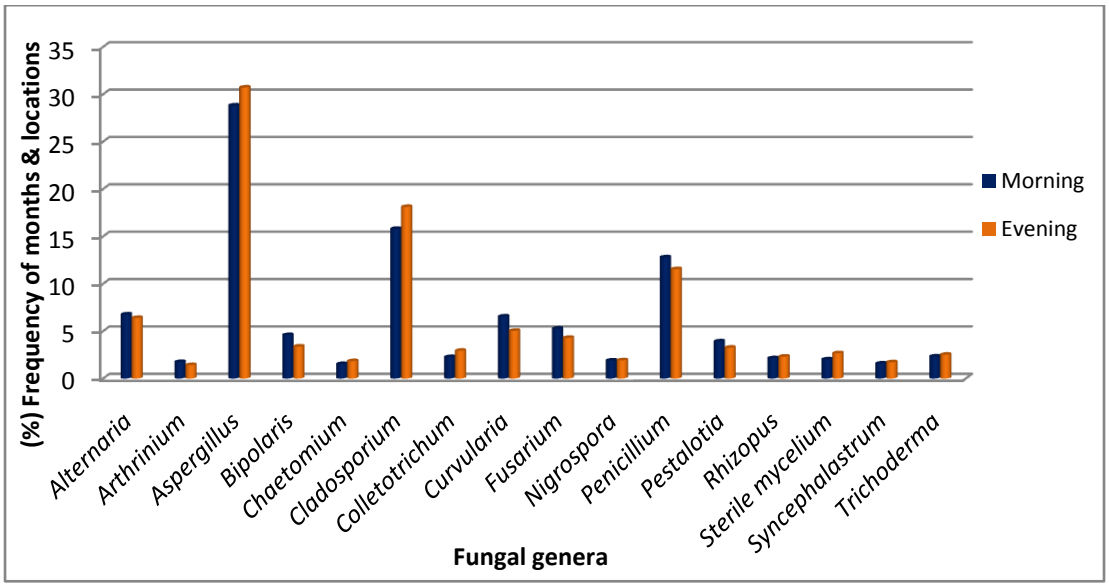


Fig: 36. Percent frequency of air borne fungi of five locations and twelve months in the morning and evening during January 2013 to February 2014.

The frequency peaks for most of the fungal types recorded of "diffused" nature, probably due to the occurrence of successive sources or substrates for the major part of the year (Singh *et al*. 1987). The saprophytic fungi i.e. the species of *Aspergillus*, *Penicillium*, *Rhizopus*, *Cladosporium*, *Curvularia*, *Alternaria*, *Trichoderma* and others depend on the vegetative matter from crops and seasonal weeks, whereas parasitic forms like *Aspergillus* and *Fusarium* which were recorded in this study, can be attributed, largely depended on the availability of the host and suitable weather conditions. As for example, *Alternaria* is known parasites responsible for leaf spot and glume discoloration on rice. *Fusarium* sp. is pathogenic which causes wilt and other diseases to many vegetables and crops.

The fungal spores of atmosphere gradually increase with the increase of temperature and reach its maximum in September to October with high atmospheric humidity. From the present investment, maximum fungal colonies were found in August and September due to high atmospheric humidity and temperature (Table 5, Fig. 35). It was observed that the spore contents decreased after November till December, January and February. It might be due to down fall of temperature in winter season. The spore contents were reported to increase with the increase in average mean of atmospheric temperature from March to May. Therefore, the concentration decrease because of rain, as continuous rain water usually washes out the spores. However, the spore counts were found high after long rain. The rain water enhance sporulation. From the result it can be concluded that the distribution of fungal spores varied with seasons.

Month to month aerofungal frequency have also been reported from other countries (Agarwal and Shivpuri 1979, Janaki- Bao 1979, Beaumont *et al*. 1987). A follow up program has already been under taken to check and verify the seasons of incidence of these fungi, recorded in different months and different places in Dhaka Metropolitan City (Fig. 36).

CHAPTER 5

TAXONOMIC ENUMERATION OF THE ISOLATED FUNGI

TAXONOMIC ENUMERATION OF THE ISOLATED FUNGI

During the process of isolation of fungi from different locations in culture media, the Petri plates were kept open for ten minutes. The isolated fungi were transferred to PDA slant media. Fungal slides were prepared and observed under microscope at different magnifications. Most of them were identified by observing the characteristics of the fungal colony, conidia, conidiophores and pigmentation of the fungi. Generic identification of all the fungi was done following standard literatures.

Fifteen genera have been isolated from five different locations of Dhaka Metropolitan City during the tenure of the present investigation. Colony, conidiophores and the morphological characteristics of the isolated fungi were observed to identify the fungal genera.

The generic description of the isolated fungi are given below:

ALTERNARIA

Alternaria Nees ex Fr.; Nees, 1816, Syst.

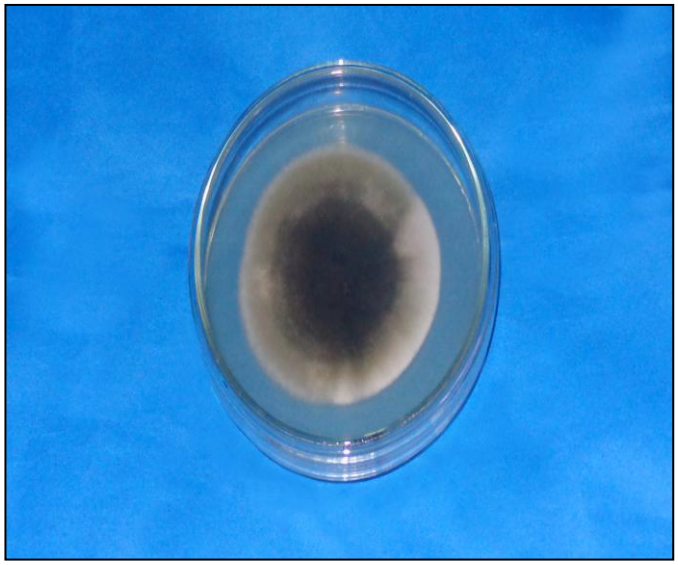
Pilze Schwamme: 72; Fries, 1821, Syst. Mycol., **1**: XLVI

Type Species: Alternaria alternata (Fries) Keissler, syn. A. tenuis Nees ex Pers. Elliot, J. A., Am. J. Bot., **4**: 439-476, 1917.

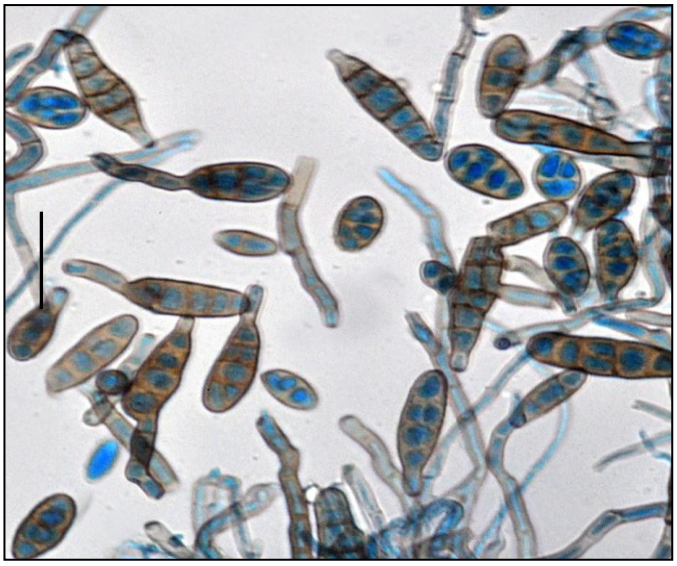
Colonies effuse usually grey, dark blackish or black. Mycelium immersed or partly superficial; hyphae colorless, olivaceous brown or brown, stroma rarely found. Setae and hyphopodia absent. Conidiophores macronematous, micronematous, simple or irregularly and loosely branched, pale brown or brown, solitary or in fascicles. Conidiogenus cells integrated, terminal becoming intercalary, polytetric, sympodial or sometimes monocentric, cicatrized. Conidia catenate or solitary, dry, typically ovoid or obclavate, often rostrate, pale or mid olivaceous brown or brown, smooth or verrucose, with transverse and frequently also oblique or longitudinal septa (Ellis, 1976).

Alternaria alternata (Fr.) Keissler, 1972, Beih. Bot. Zbl., **29**; 434.

Colonies usually black or olevaceous black, sometimes grey. Conidiophores arising singly or in small groups, simple branched, straight or flexuous, sometimes geniculate, pale to mid olevaceous or golden brown, smooth up to 28-99µm long and 3-5µm thick with 1 or several conidial scars. Conidia formed in long, often branched chains, obclavate, with a short conical or cylindrical beak, sometimes up to but not more than one third the length of the conidium, pale to mid golden brown, smooth or verruculose, overall length 22.5-52.2µm, 4.5-16.3µm thick in the broadest part; beak pale, 2.5-5µm thick (Plate 13).



A



B

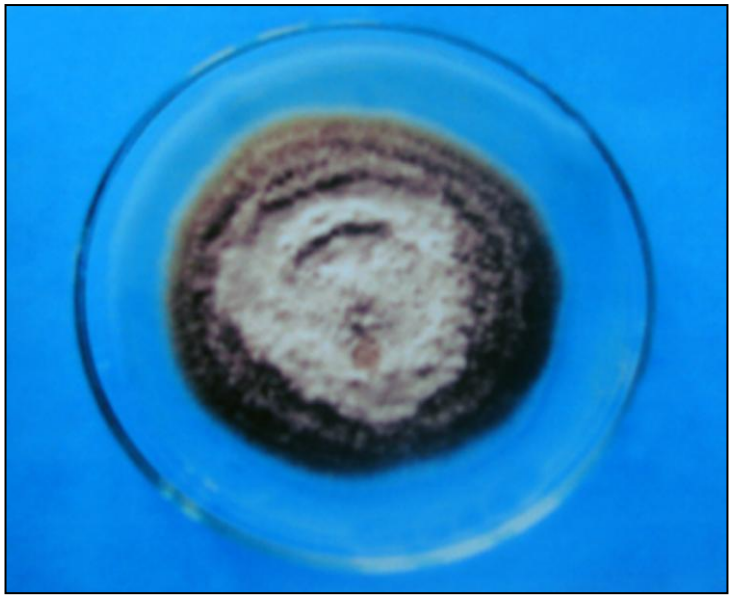
Plate 13. Colony on PDA medium (A), conidia and conidiophores (B) of *Alternaria alternata.* (Bar = 45µm).

ARTHRINIUM

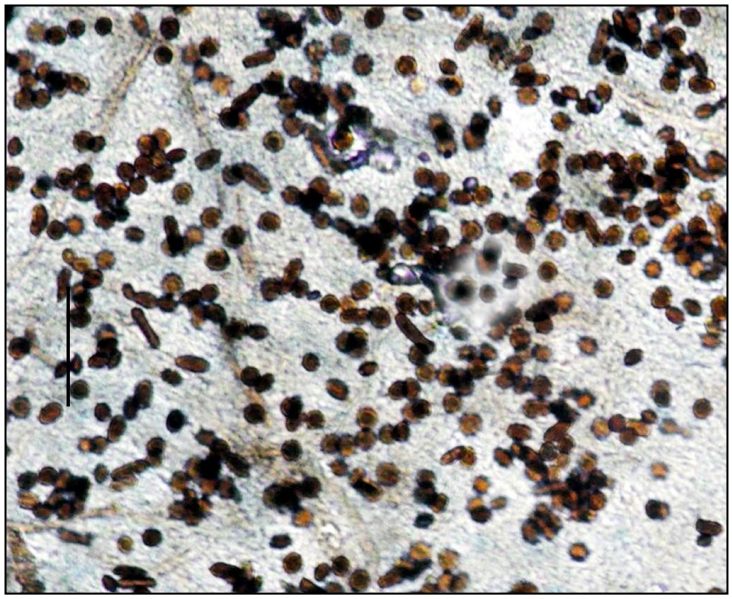
Arthrinium Kunze ex Fr., 1821; Kunze in Kunze & Schmidt, 1817, Mykol.

Colonies compact or widely effused, black or dark blackish brown, fructifications occasionally erumpent but usually superficial and frequently pulvinate. Mycelium partly superficial, partly immersed, often with connecting hyphae which become very narrow where they pass through the host cuticle. Stroma none. Setae and hyphopodia absent.

Conidiophores macronematous, mononematous, arising singly from subspherical, ampulliform, barrel-shaped or broadly clavate conidiophores mother cells, simple, often narrow, more or less cylindrical, usually colorless except for the thick transverse septa which may be highly refractive and are often brown or dark brown. Conidiogenous cells integrated, terminal and intercalary, polyblastic, denticulate; pegs usually very short, cylindrical, truncate. Conidia solitary, lateral and sometimes also terminal, distinctively shaped, frequently flattened and with a hyaline rim or germ slit, brown or dark brown, smooth as a rule, 0-septate, sterile cells when present terminal or sub terminal in place of conidia, usually smaller, polar and not the same as conidia, often containing one or more highly refractive cubical bodies (Plate 14).



A



B

Plate14. Colony on PDA medium (A) and conidia (B) of *Arthrinium* sp. (Bar = 45µm).

ASPERGILLUS

Aspergillus Micheli ex Fries; Micheli, 1729, nova Pl. Gen.: 212-213; Fries, 1821, Syst. Mycol., **1**: XLV.

The genus *Aspergillus* consists of about 100 or more species (Rapper and Fennel 1965) from those many species are saprophytic on a wide variety of substrata and a few parasitic species.

Colonies effuse, variously colored, often green or yellowish, sometimes brown or black. Mycelium well developed, septate, partly immersed, partly superficial and profusely branched which produces abundances of conidiophores. While still young and vigorous, the mycelium of *Aspergillus* produces an abundance of conidiophores macronematous. Often with a foot cell, straight, colorless, smooth, swollen at the apex into a spherical of clavate vesicle the surface of which is covered by short branches or in some species by phialides. These usually arise singly from the somatic hyphae. The hyphal compartment or cell that branches to give rise to conidiophores is called the foot cell. stroma none. Conidia catenulate, dry, semiendogenous or acrogenous, spherical, variously colored, smooth and nonseptated (Plate 15-22).

Aspergillus flavus Link (Plate 15)

Colonies effuse, greenish. Mycelium well-developed, septate, profusely branched and hyaline. Cells are multinucleate. Conidiophores are long. This species produce sclerotium which is well developed. The sclerotia contribute to an accumulation of inoculumns in the soil when they produce conidia at the beginning of the next growing season. Conidia catenulate, dry, usually globose, smooth, green in color.

Aspergillus fumigatus Frsenius. 1863. (Plate 16)

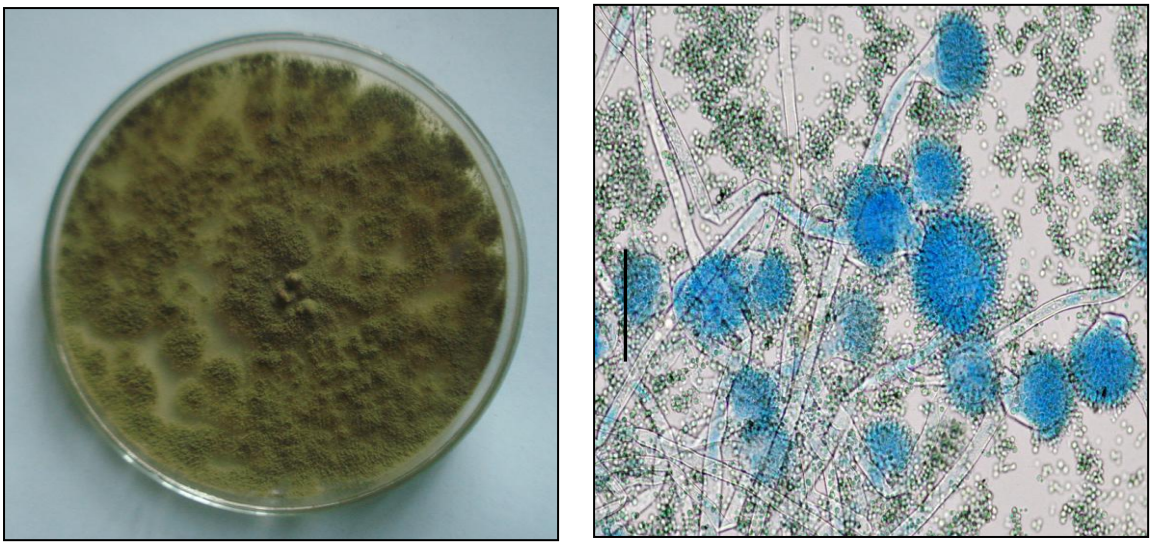
Colonies flate, pest to pale greenish. Mycelium well-developed, septate, profusely branched and hyaline. Conidiophores long, often with a foot cell, straight or flexuous, swollen at the apex in to a spherical vesicle. Surface of vesicle covered by closely packed more or less clavate branches. Conidia catenulate, dry, usually globose, echinulate and dark brown in color.

Aspergillus niger van Teighem, 1867, *Annls Sci*. nat (Bot.), Ser. 5, **8**: 240. (Plate 17)

Colonies effuse, blackish brown to black. Mycelium hyaline, well-developed, septate, profusely branched. Conidiophores very long, often with a foot cell, straight or flexuous, swollen at the apex into a spherical vesicle. Surface of vesicle covered by closely packed more or less clavate branches. Conidia catenulate, dry, usually globose, echinulate, dark brown in color.

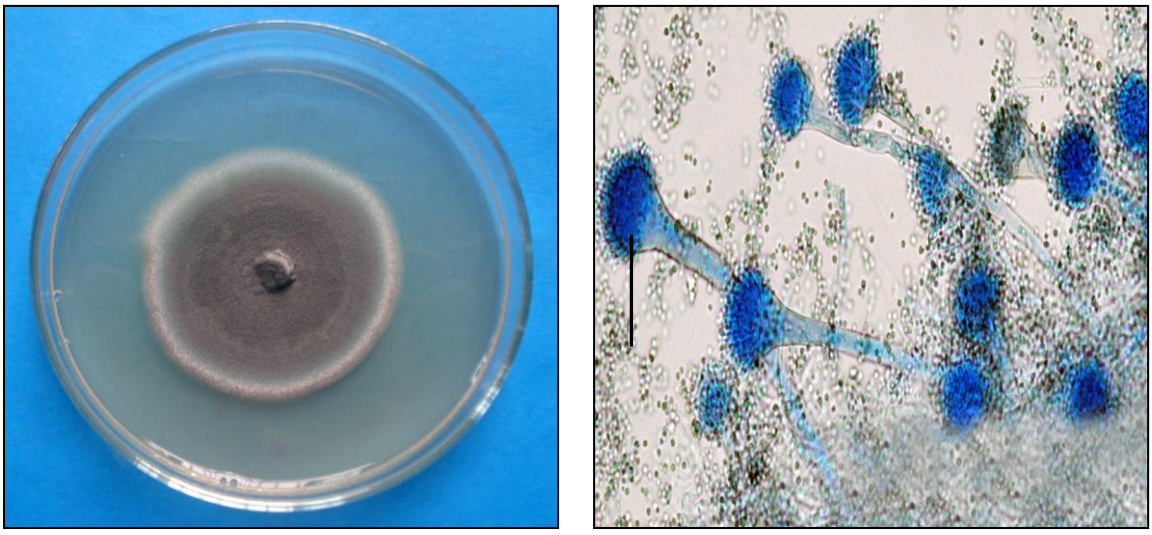
Aspergillus terreus var. floccosus Shih. In Lingnan Sci. Jour. 15:372.P1. 16, 1936.

Colonies pure brown or ocharaceous brown in age and brighter than. Mycelium well-developed, aseptate, non branched. Conidiophores very long, conidial heads are less abundant, develop late and are borne almost entirely upon aerial hyphae, are frequently encountered. The variety is considered by the writres as a strongly floccose. *A. terreus* in which the head is commonly less compact & lighter in color, but with the basic morphology of the conidial apparatus remaining that of the species proper (Plate 18).



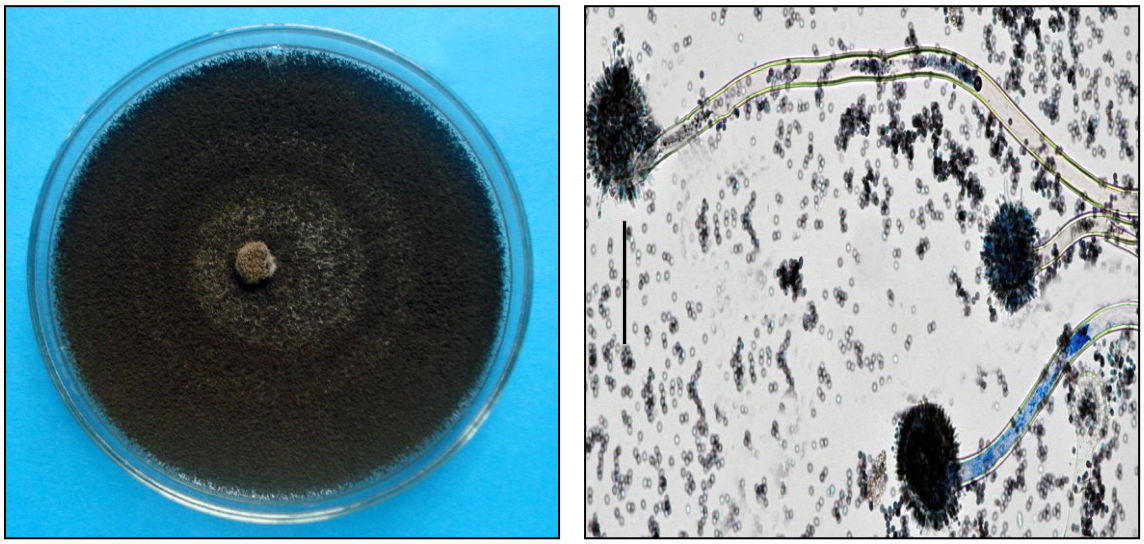
A B

Plate15. Colony on PDA medium (A), conidia, vesicles and conidiophores (B) of *Aspergillus flavus.* (Bar = 45µm).



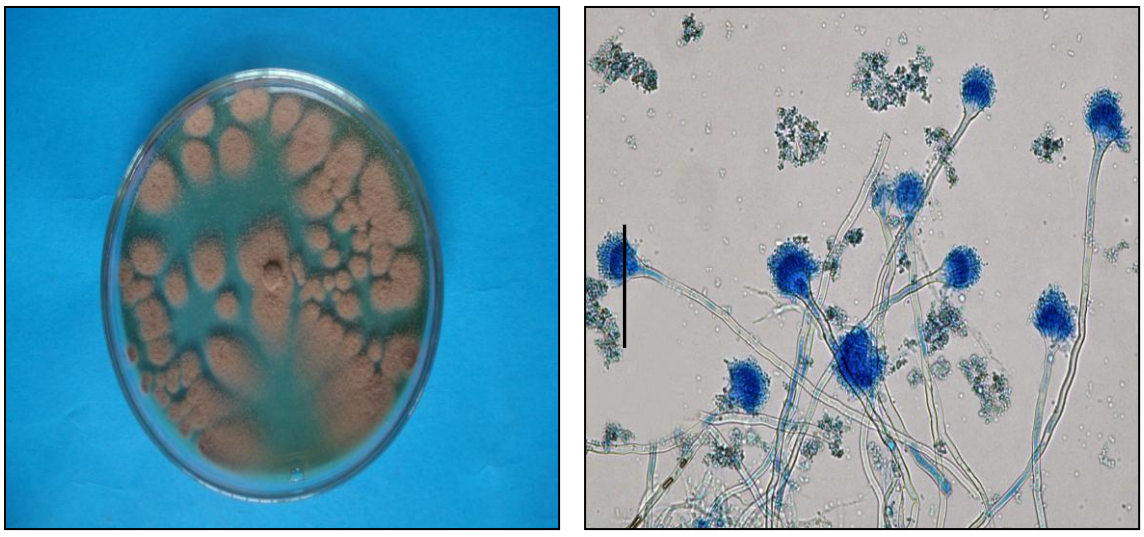
A B

Plate16. Colony on PDA medium (A), conidia, vesicles and conidiophores (B) of *Aspergillus fumigatus.* (Bar = 45µm).



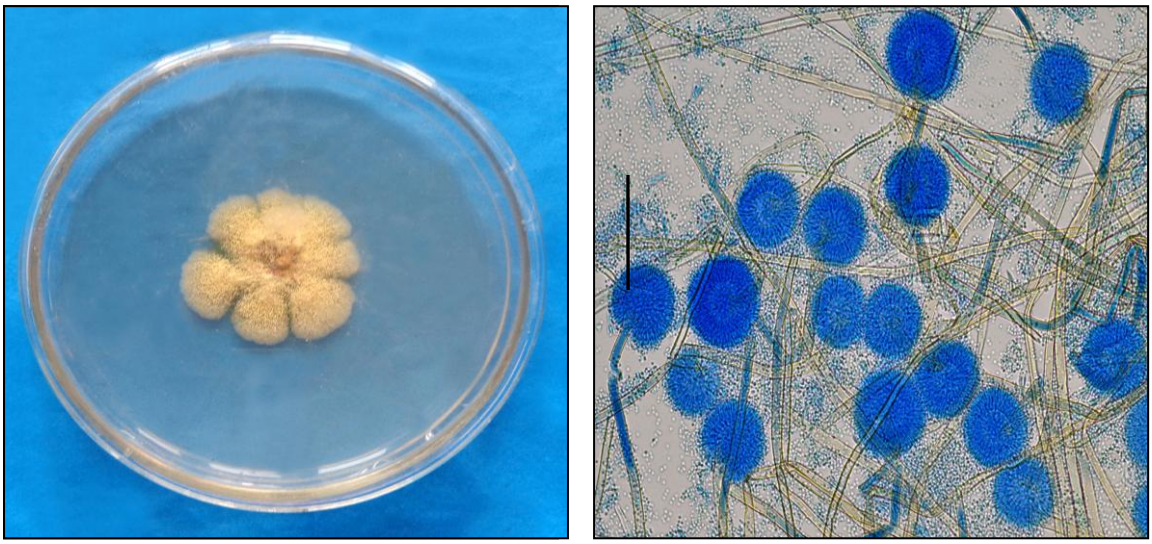
A **B**

Plate 17. Colony on PDA medium (A), conidia, vesicles and conidiophores (B) of *Aspergillus niger*. (Bar = 45µm).



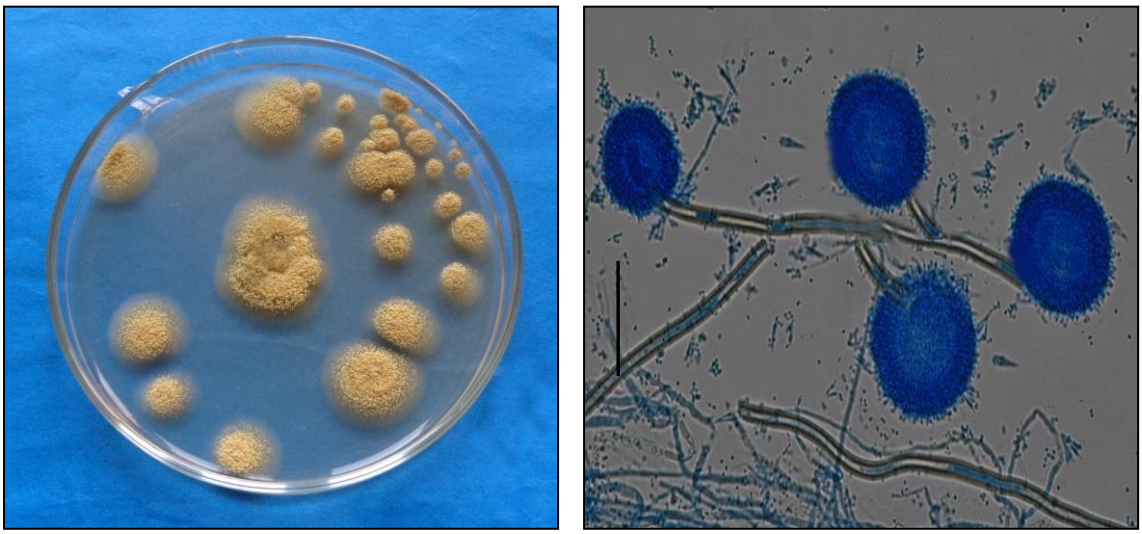
A B

Plate 18. Colony on PDA medium (A), conidia, vesicles and conidiophores (B) of *Aspergillus terreus*. (Bar = 45µm).



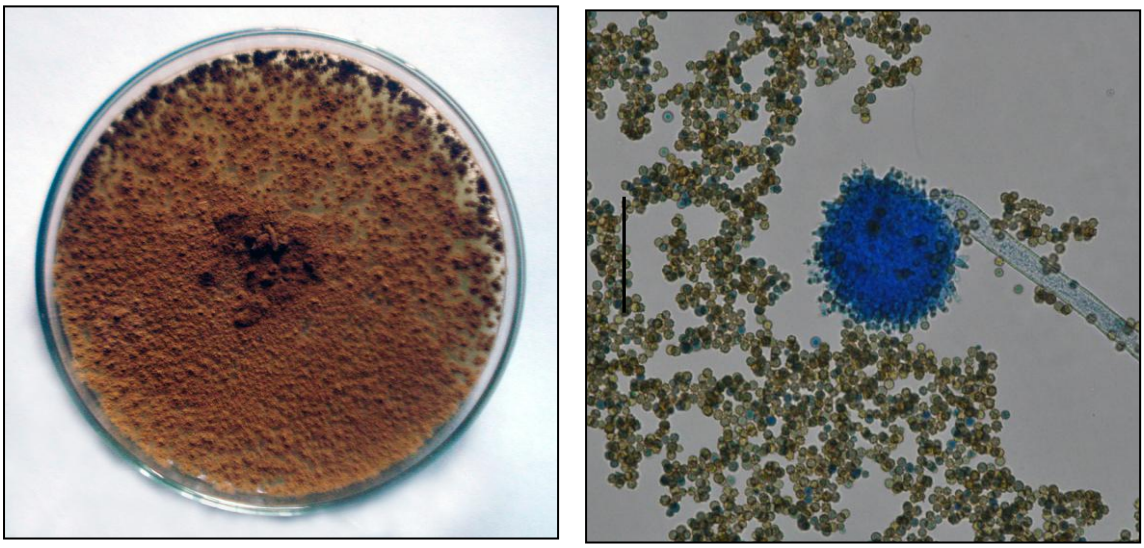
A B

Plate 19. Colony on PDA medium (A), conidia, vesicles and conidiophores (B) of *Aspergillus* sp.1 (Bar = 45µm).



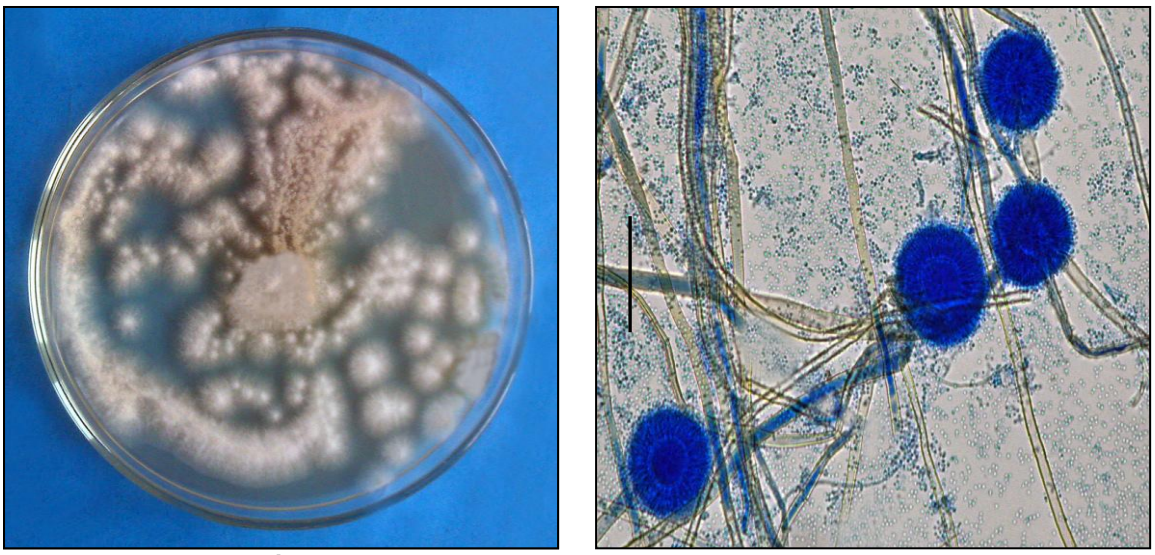
A B

Plate 20. Colony on PDA medium (A), conidia, vesicles and conidiophores (B) of *Aspergillus* sp.2 (Bar = 45µm).



A B

Plate 21. Colony on PDA medium (A), conidia and conidiophores (B) of *Aspergillus* sp.3 (Bar = 45µm).



A B

Plate 22. Colony on PDA medium (A), conidia, vesicles and conidiophores (B) of *Aspergillus* sp.4 (Bar = 45µm).

BIPOLARIS

Bipolaris shoemaker, Canadian Journal of Botany **37**: 882 (1959)

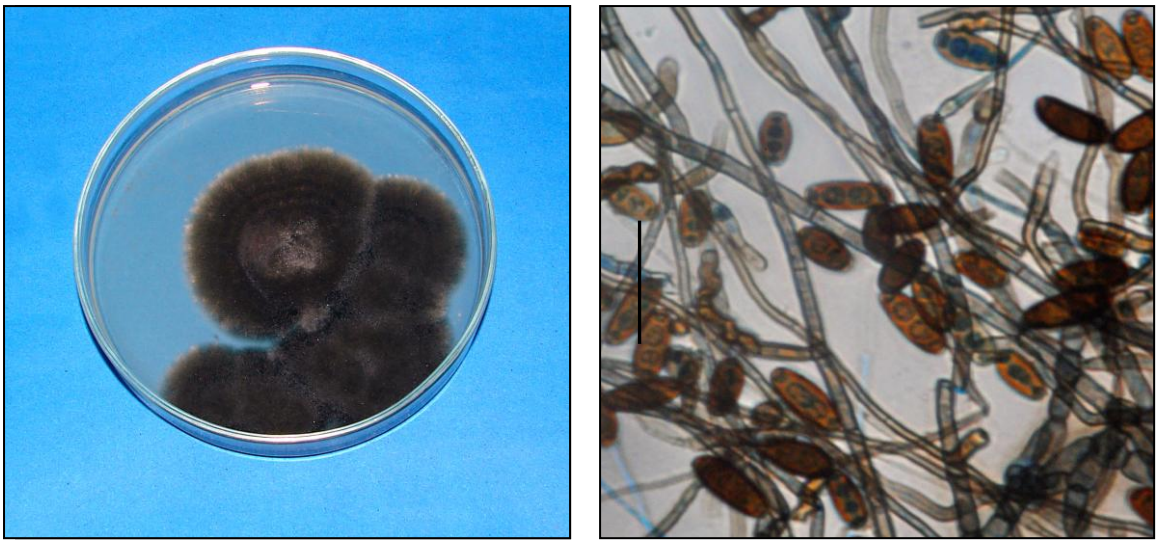
Colonies are moderately fast growing, effuse, grey to blackish brown, reverse black. Microscopic, morphology shows sympodial development of pale brown pigmented, pseudoseptate conidia on a geniculations or zigzag rachis. Conidia are produced through pores in the conidiophores wall (poroconidia) and are straight, fusiform to ellipsoidal, rounded at both ends, smooth to finely roughened and germinating only from the ends (bipolar).

Bipolaris spicifera (Bainier) Boedijn, 1933, *Bull*. *Jard.bot*. *Buitenz*., 111, **13**(1): 127 (Plate 24)

Conidiophores solitary or in small groups, flexuous, repeatedly geniculate with numerous well-defined scars, often torsive, mid to dark brown, up to 300um, long or sometimes longer, 4-9µ thick. Conidia straight, oblong or cylindrical rounded at the ends, when mature golden brown except for a small area just above the dark scar which remains hyaline or very pale, smooth, constantly 3-pseudoseptate, 9.0-13.5 x 19.8-32.4µ : hilum 2-3µm wide.

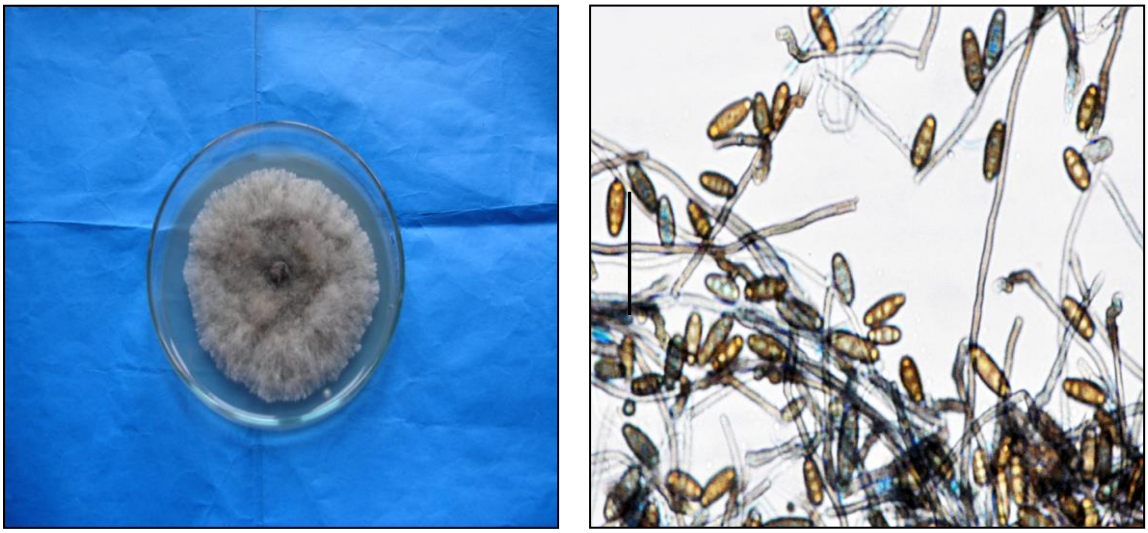
Bipolaris hawaiiensis (Bugnicourt) Subram. & Jain ex M.B. Ellis; Subram. & Jain, 1966, *Curr*. *Sci*., **35**: 354 (Plate 23)

Colonies effuse, grey, dark blackish brown or black. Stromata sometimes formed in culture, erect, straight, cylindrical, black. Hyphae pale to mid brown, smooth, septate, 1-3µ thick. Conidiophores solitary, flexuous or geniculate, septate, pale to mid brown, up to 120µ long but usually much shorter, 2-7µ thick. Conidia straight, ellipsoidal, oblong or cylindrical, rounded at the ends, pale to mid brown, 2-7(mostly 5-) pseudoseptate, 4.5-9.9 x 8.1-34.2 µm.



A B

Plate 23. Colony on PDA medium (A), mycelium, conidia and conidiophores (B) of *Bipolaris hawaiiensis.* (Bar = 45µm).



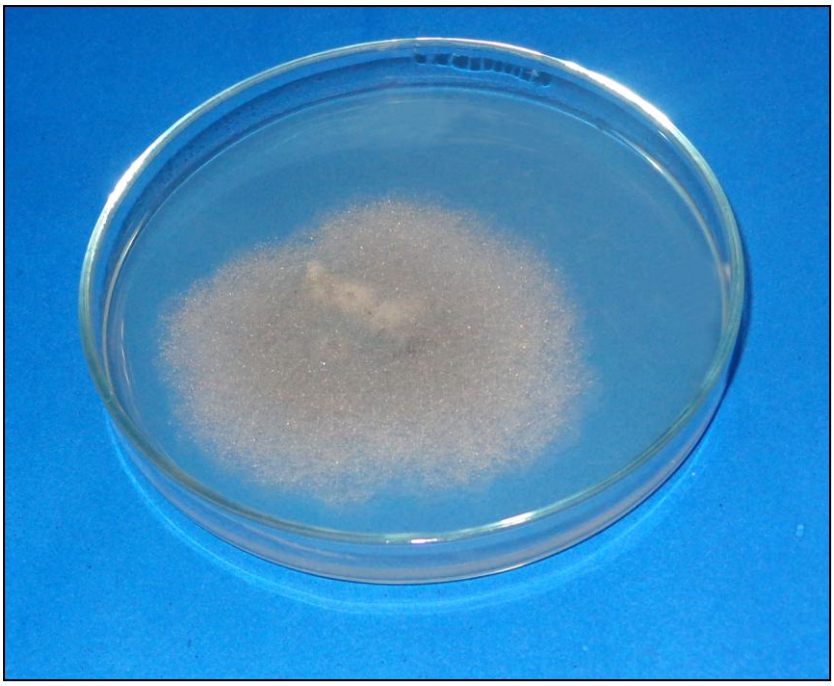
A B

Plate 24. Colony on PDA medium (A), mycelium, conidia and conidiophores (B) of *Bipolaris spicifera.* (Bar = 45µm).

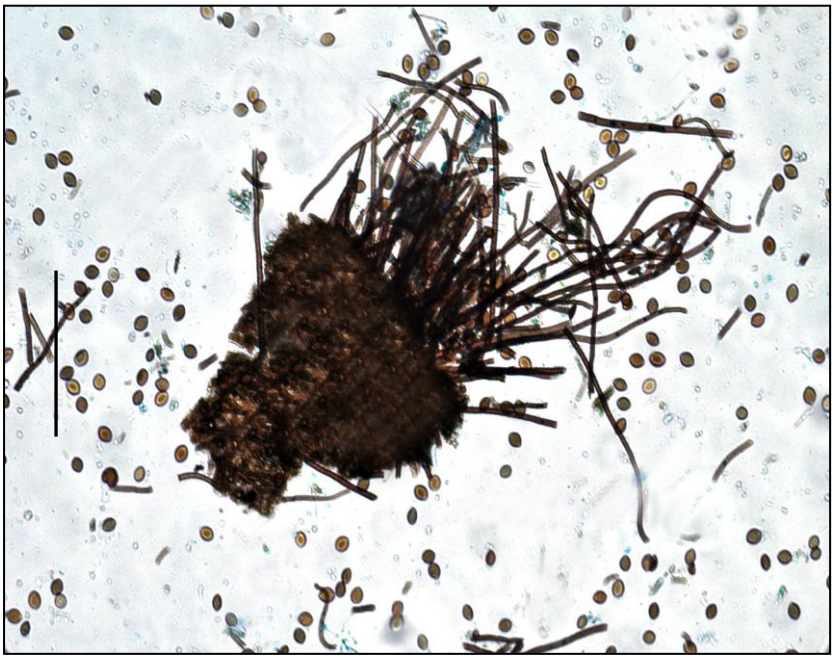
CHAETOMIUM

Chaetomium sp.

Colonies golden brown, mycelium dark. Perithecia dark brown to black and clothed, especially in the upper part, by dark brown setae. There setae may be simple or branched, straight, wavy or spirally coiled, smooth or ornamented in various ways. The lemon-shaped, brown ascosporous are freed from their asci inside the perithecia and emerge through the ostiole to be held by the terminal setae in large, very dark masses (Plate 25).



A



B

Plate 25. Colony on PDA medium (A), ascocarp, asci and ascospores (B) of *Chaetomium* sp. (Bar = 45µm).

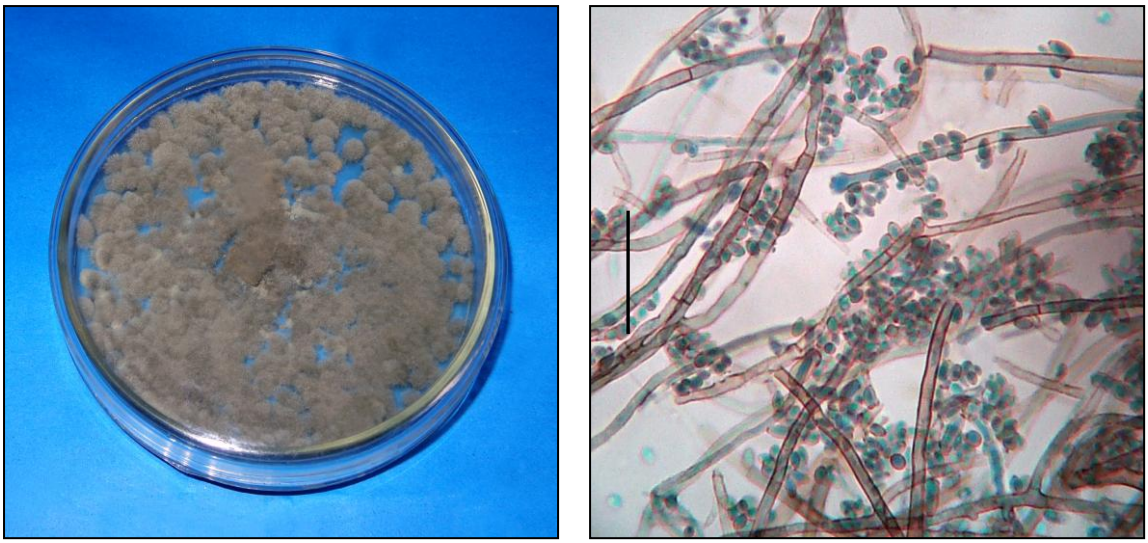
CLADOSPORIUM

Cladosporium Link ex Fries, 1815, Magazine Ges. Naturf. Freunde, Berline, **7**:37-38; Fries, 1821, Syst, mycol., **1**: XLVL.

Mycelium immersed and often also superficial. Stroma sometimes present. Conidiophores arising as scattered, lateral or terminal out growths from the hyphae or as fasciles from stromata, straight or flexuous, mostly unbranched or branched, restricted to the apical region, olivaceous brown, smooth or verrucoise. Ramo-conidia often present. Conidia single or in simple or in branched chains, easily separating, cylindrical, dolliform, ellipsoidal, fusiform, ovoid, spherical or sub spherical often with a distinctly protuberant scare at each end or just at the base, pale to darkly pigmented, smooth, verruculose or echinulate with 0-3 septa.

Cladosporium cladosporioides (Fresen). De vries, 1952, knowledge of the genus

Colony effuse, olive green, or olivaceous brown, valvately reverse on melt agar greenish black. Conidiophores macronematous and micronematous, sometimes upto 350µm long but generally much shorter, 2-6µm thick, pale to olivaceous brown, smooth or verruculose. Ramo-conidia 0-1 septate, up to 30µm long, 2-5thick, smooth or occasionally minutely verruculose. Conidia formed in long branched chains, mostly 0 septate, ellipsoidal or limonform, 4-10 x 2-4µm, pale olivaceous brown, most commonly smooth but verruculose in some strain. A very common cosmopolitan species, it occurs as a secondary invader on many different plants and has been isolated from air, soil, textile etc. So far, it was isolated from wood pulp and conifer wood from Europe (Plate 26-27).



A B

Plate 26. Colony on PDA medium (A), conidia and conidiophores (B) of *Cladosporium cladosporioides.* (Bar = 45µm).

A B

Plate 27. Colony on PDA medium (A), conidia and conidiophores (B) of Cladosporium sp.1 (Bar = 45µm).

COLLETOTRICHUM

Colletotrichum Cda in Sturm, Deutschland's Flora **3**:41 (1831-1832)

Vermicularia Tode fungi Mecklend Sel. **1**:31 (1970)

Vermicularia Todeex Fr., Syst. Orb. Veg.:111 (1825)

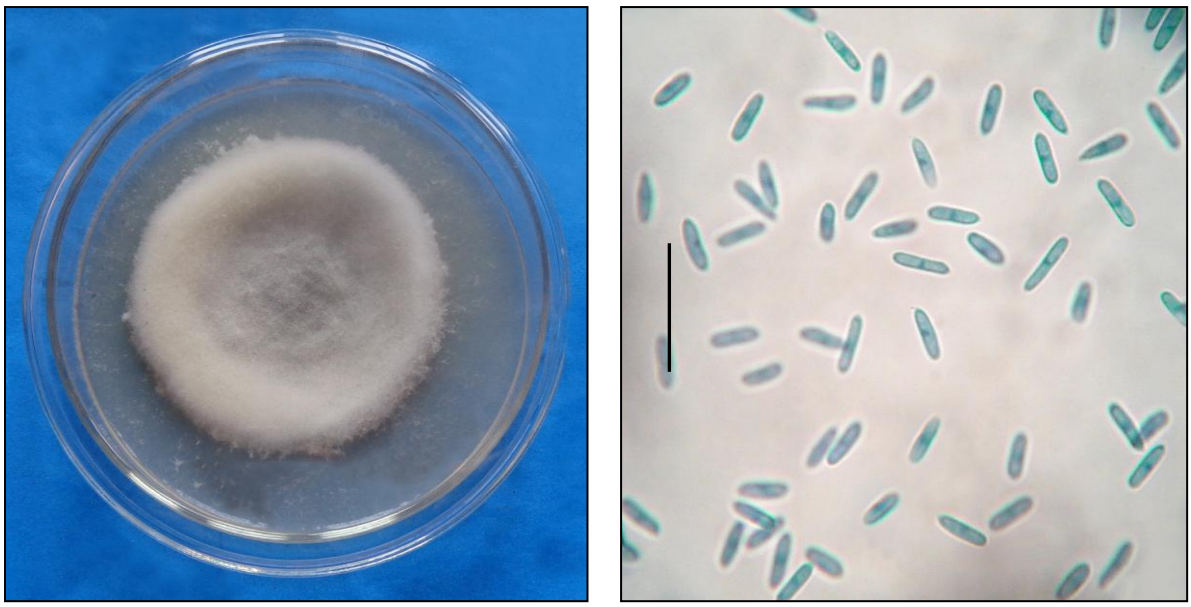
Mycelium immersed, branched, septate, hyaline, pale brown or dark brown. Sclerotia sometimes present in culture, dark brown to black, often confluent, occasionally setose. Setae in or sclerotia, brown, smooth, septate, tapered at the apices. Conidiophores hyaline to brown, septate, branched only at the base, smooth. Conidia hyaline, aseptate, straight to falcate, smooth, thin walled, sometimes guttulate, muticate or with the apex prolonged into a simple cellular appendages. Appressoria brown, entire or with crenate to irregular margins, simple or repeatedly germinating to produce complex columns of several closely connected appressoria.

Colletotrichum gloeosporioides (Penz.) Sacc., *Fung*. *Agrum*. 2:6 (1882).

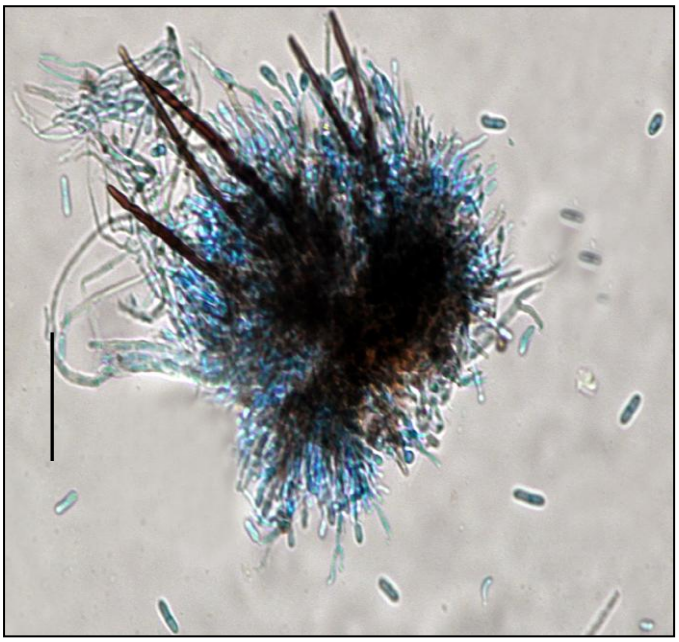
Vermicularia gloeosporioides Penz., *Michelia* **2** : 450 (1880).

Telemorphosis: *Glomerella cingulata* (stomen) spauld. & Schrenk, *Science* Ser. 2, **17**: 751 (1903)

Colony white, sometimes grayish with lighter centre. Sclerotia present, setae absent. Conidia pale to medium brown, circular or slightly irregular. In all the criteria that have been used for differentiating taxa than in *colletotrichum*, it is clear that *colletotrichum gloeosporioides* shows extensively wide variation (Plate 28).



A B



C

Plate 28. Colony on PDA medium (A), conidia (B) and setae (C) of *Colletotrichum gloeosporioides*. (Bar = 45µm).

CURVULARIA

Curvularia Boedijin, 1933, *Bull. Jard.bot.Buitenz*., III, **13**(1): 120-134.

Malustela Batista & Lima 1960, Publcoes Inst. Micol. Recife, **263**: 5-10.

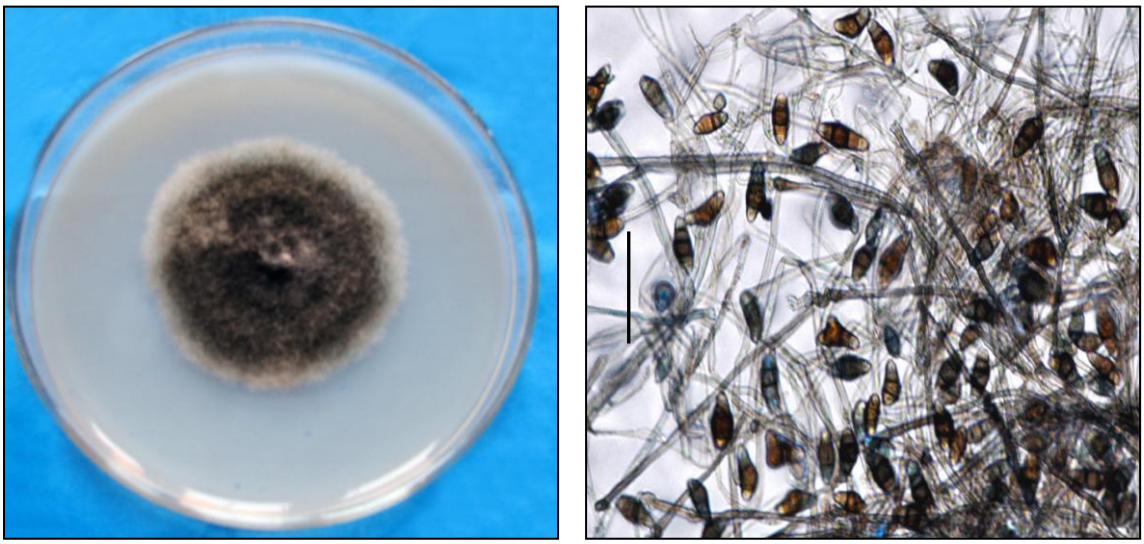
Mycelium immersed in natural substrata. Stomata often large, erect, black, cylindrical, sometimes branched, formed by many species in culture, especially on firm substrata such as rice grains. Conidiophores macronematous, usually smooth. Conidiogenous cells polycentric, integrated, terminal, sometimes later becoming intercalary, sympodial, cylindrical or occasionally swollen, cicatrized. Conidia solitary, acropleurogenous, simple, often curved, elevate, ellipsoidal, broadly fusiform, obovoid or pyriform with 3 or more transverse septa, pale or dark brown, often with some cells, usually the end ones paler than the others, sometimes with dark bands at the septa, smooth or verrucose; hilum in some species protuberant. In many species occasional triradiate stauroconidia are formed at the same time as normal conidia.

Curvularia lunata (Plate 29).

Colonies effuse, brown, grey or black, hairy, cottony or velvety. Conidiophores solitary, mostly unbranched, straight, mostly flexuous geniculate, mid brown, septate up to 250µm. Conidia mostly 3-septate, dark brown, mostly curved, smooth 25.2-14.4 x 7.2-13.5µm.

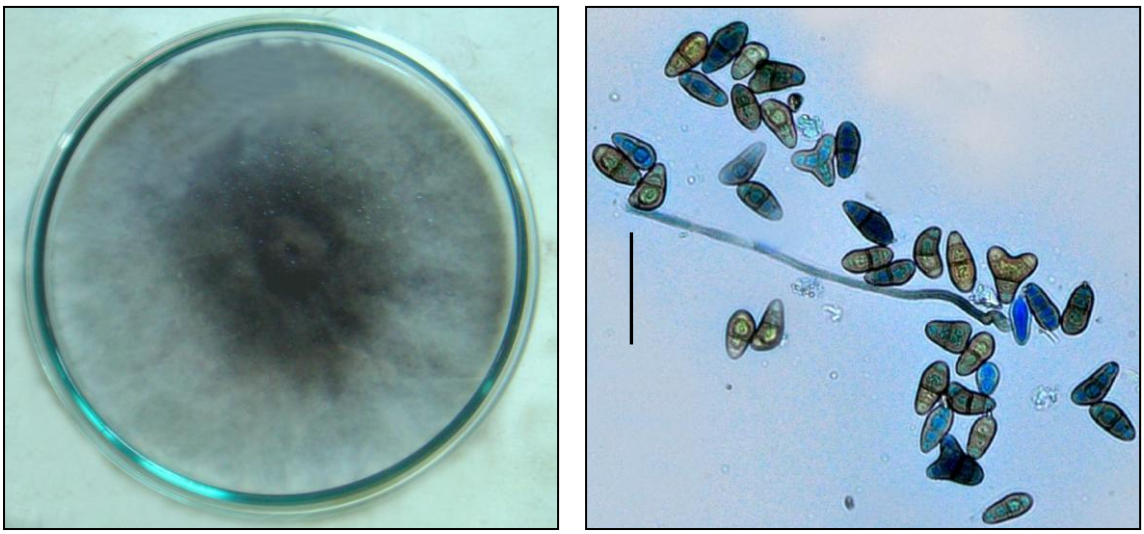
Curvularia lunata var. aeria (Batista, Lima & vasconcelos) M.B. Ellis (Plate 30).

Colonie on p.d.a. effuse, dark brown, cottony or felted. Conidiophores pale to mid brown, up to 150µ long, 4-7µ thick. Conidia catenate and often forming short conidiophores from both apical and basal cells, curved, fusiform or clavate, 2-5 but mostly 4 septate, the broader cells mid brown, other cells paler, smooth, 18-32.4µ long, 8-17µ thick in the broadest part.



A B

Plate 29. Colony on PDA medium (A), conidia and conidiophores (B) of *Curvularia lunata.* (Bar = 45µm).



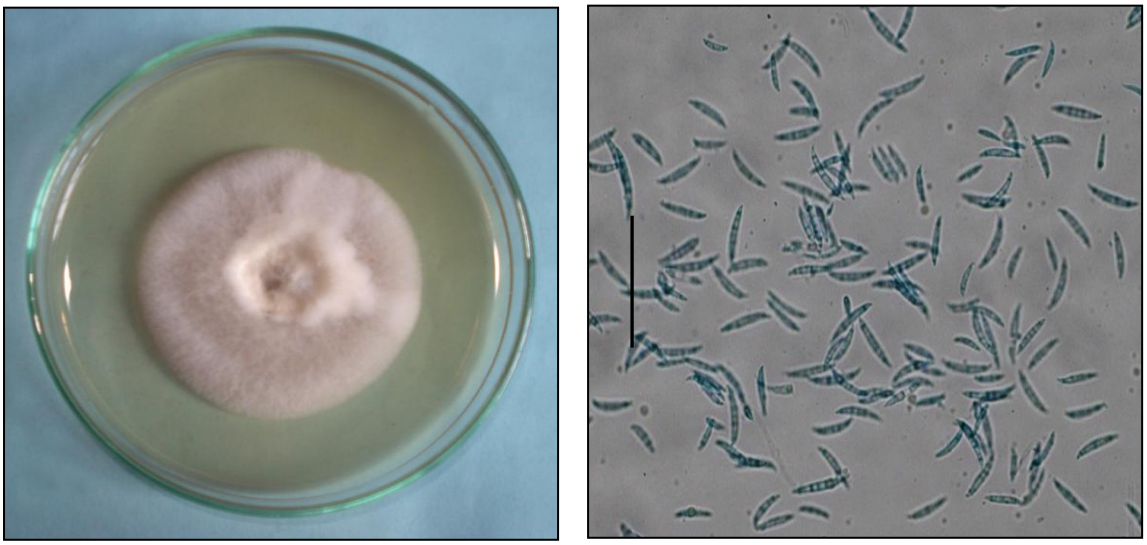
A B

Plate 30. Colony on PDA medium (A), conidia and conidiophores (B) of *Curvularia lunata* var *aerica.* (Bar = 45µm).

FUSARIUM

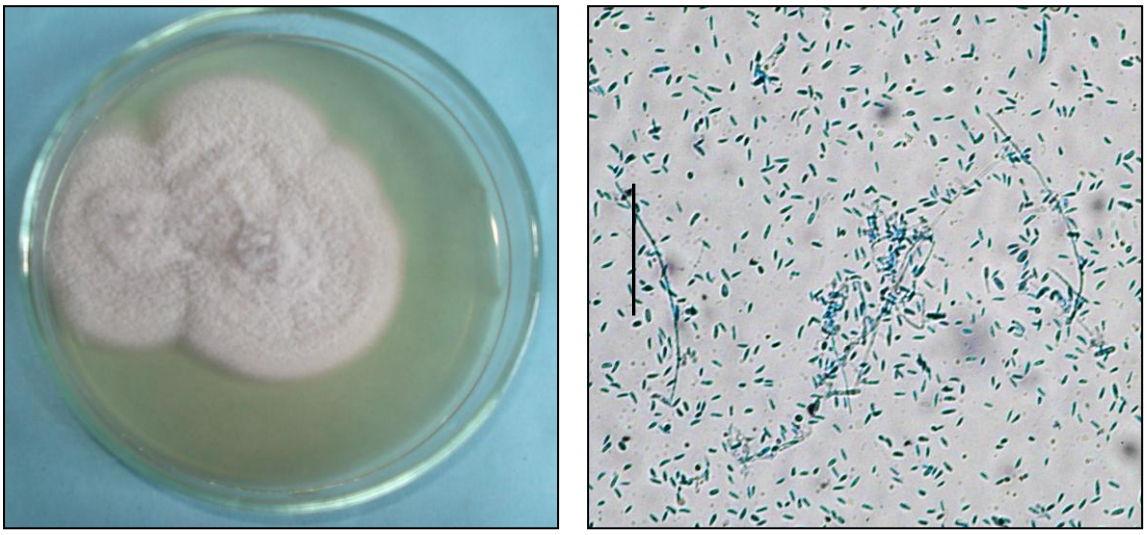
Fusarium Link ex Fr., Syst. Mycol. 1.XLI (introduct), 1891; Link, Mag. Ges. Naturf. Freunde, Berlin **3**:10. 1809.

Mycelium extensive and cotton-like in culture, often with some tinge of pink, purple, or yellow in the mycelium; conidiophores variable, slender and simple or stout, short, branched irregularly or bearing a whorl of phialides, single or grouped into sporodochia; conidia (phialospores) hyaline, variable, principally of two kinds, often held in small moist heads; macroconidia several-celled, slightly curved or bent at the pointed ends, typically canoe shaped; microconidia 1-celled, ovoid or oblong, borne singly or in chains; some conidia intermediate, 2 or 3-celled, oblong or slightly curved; parasitic on higher plants or saprophytic on decaying plant material. A large and variable genus sometimes placed in the Tuberculariaceae because some species produce sporodochia. Thick-walled chlamydospores common in some species (Plate 31-34).



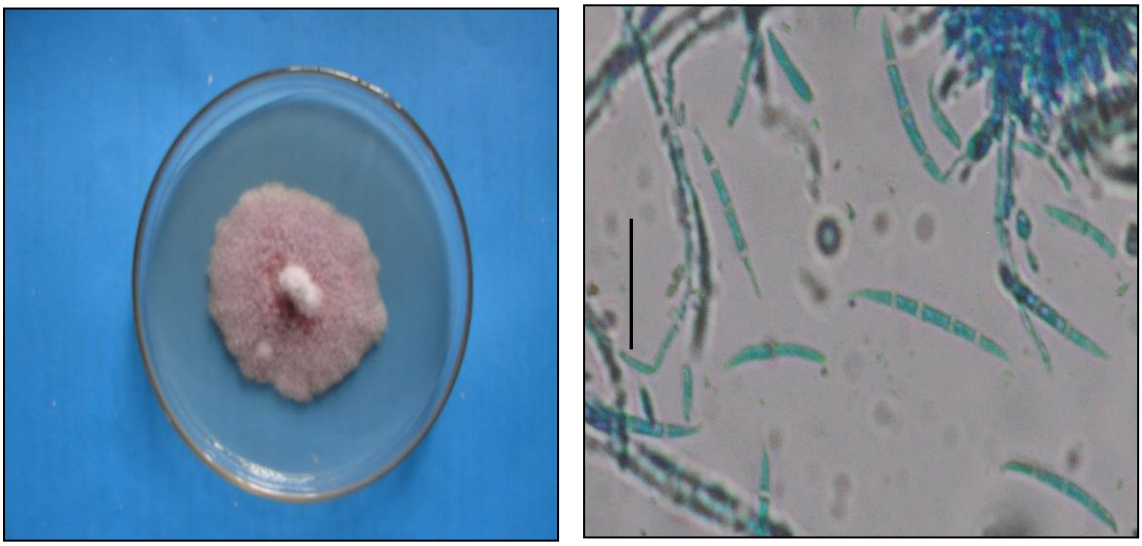
A B

Plate 31. Colony on PDA medium (A) and macroconidia (B) of *Fusarium* sp.1 (Bar = 45µm).



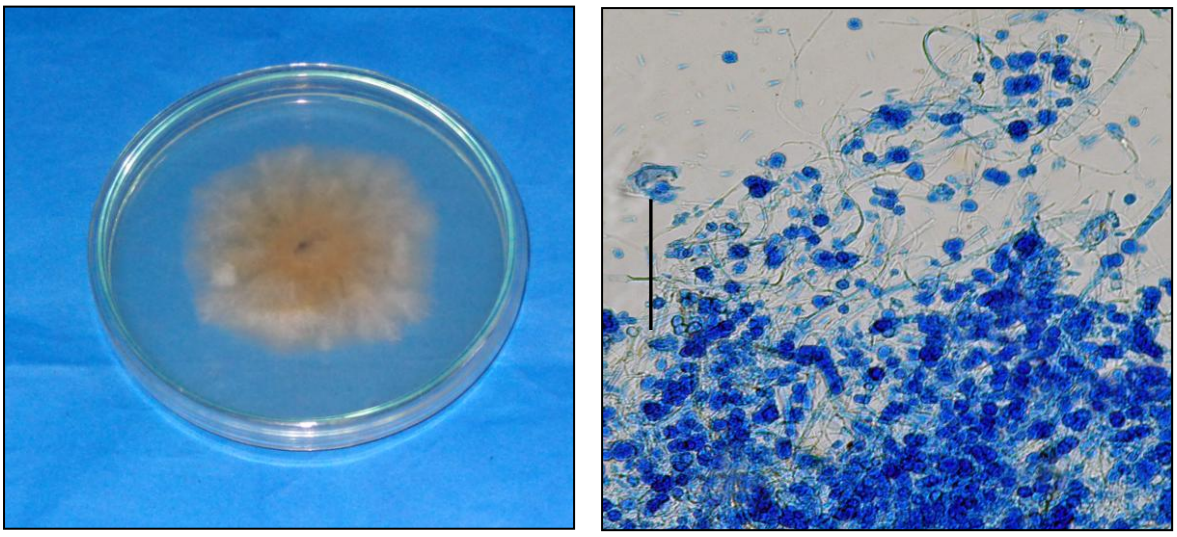
A B

Plate 32. Colony on PDA medium (A) and microconidia (B) of *Fusarium* sp.2 (Bar = 45µm).



A B

Plate 33. Colony on PDA medium (A) and conidia (B) of *Fusarium* sp.3 (Bar = 45µm).



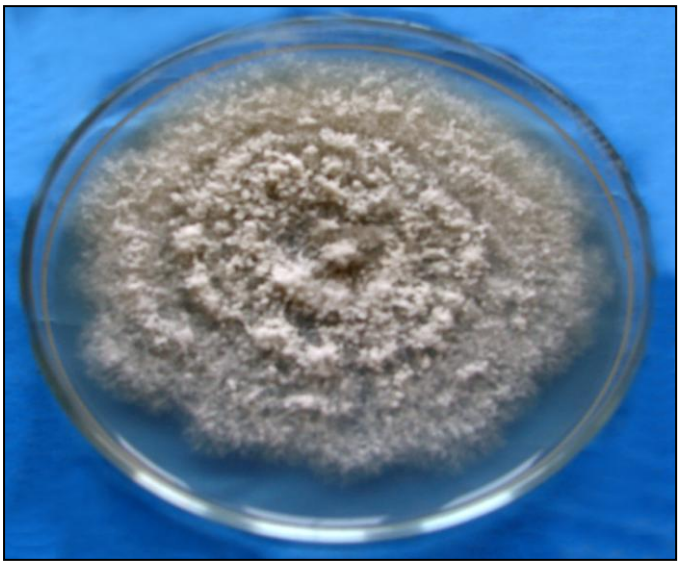
A B

Plate 34. Colony on PDA medium (A) and conidia (B) of *Fusarium* sp.4 (Bar = 45µm).

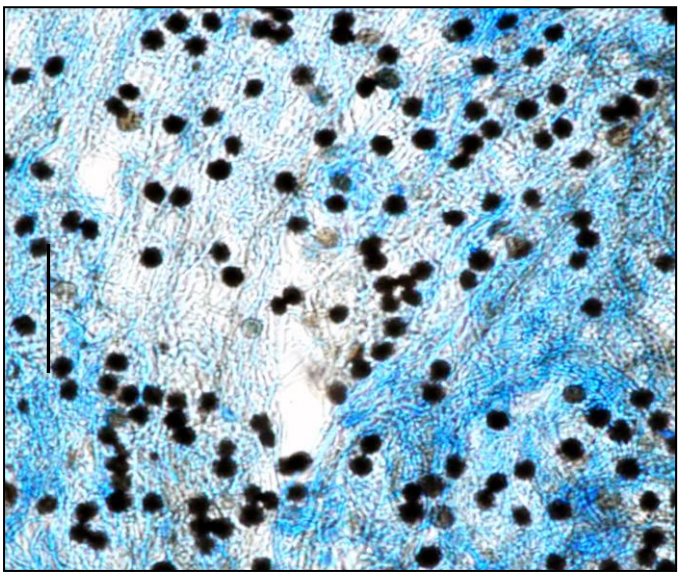
NIGROSPORA

Nigrospora Zimmermann, 1902, Zentbl. Bakt. Parasitekde, Abt.2, **8**:220.

Mycelium all immersed or partly superficial. Stroma none. Setae and hyphopodia absent. Conidiophores micronematous or semi macronematous, branched, flexuous, colorless to brown, smooth. Conidiogenous cells mono-blastic, discrete, solitary, determinate, ampulliform or subspherical, colorless. Conidia solitary, with a violent discharge mechanism, acrogenous, simple, spherical or broadly ellipsoidal, compressed dorsiventrally, black, shining, smooth, 0-septate. Colonies at first white with small shining black conidia easily visible under a low power dissecting microscope, later brown or black when sporulation is abundant. Conidiophores not short, cells somewhat inflated, dark, mostly simple, thick (Plate 35).



A



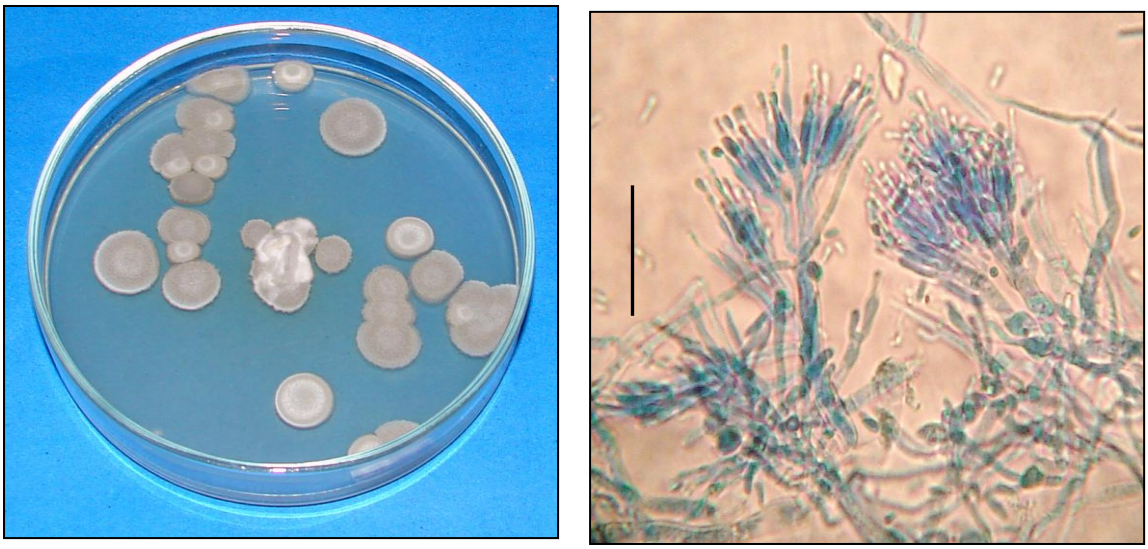
B

Plate 35. Colony on PDA medium (A) and conidia (B) of *Nigrospora* sp. (Bar = 45µm).

PENICILLIUM

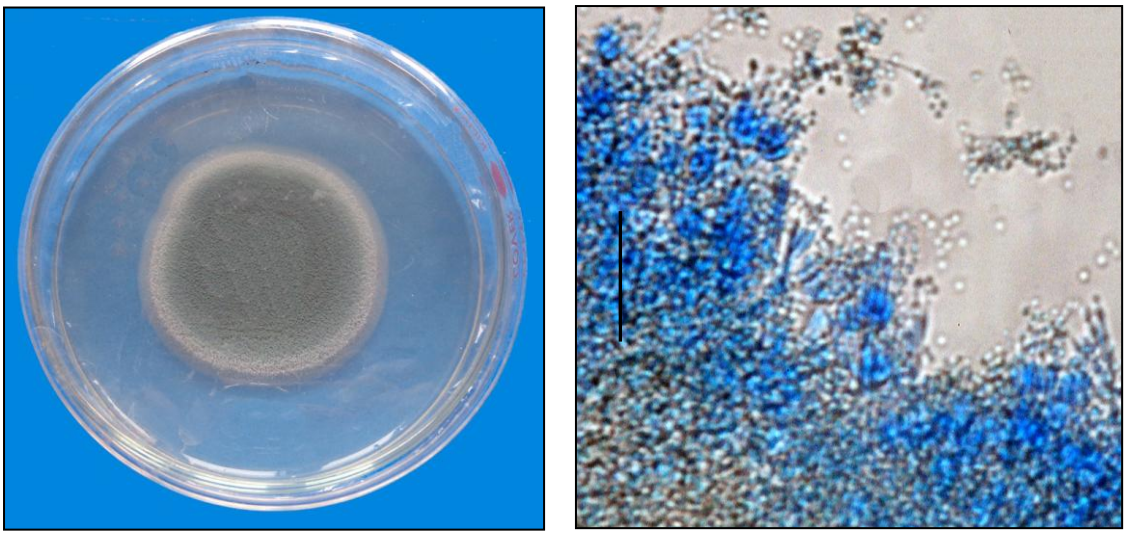
Penicillium Link.

Colony typically exhibits certain striking characteristics. These include color and color change; texture which may be varied, floccose, funiculose or fasioculote or corremiform; and habit which may be restriced or broadly spreading and range from pale to deeply pale to deeply furrowed or wrinkled. Conidiophores arising from the mycelium singly or less often in synnemata, branched near the apex to from a brush like conidia bearing apparatus; ending in halides which pinch off conidia in dry chains. Conidia hyaline or brightly colored in mass, one celled, mostly globes or ovoid, produced basipetally. A large genus containing both parasitic and saprophytic species (Plate 36-39).



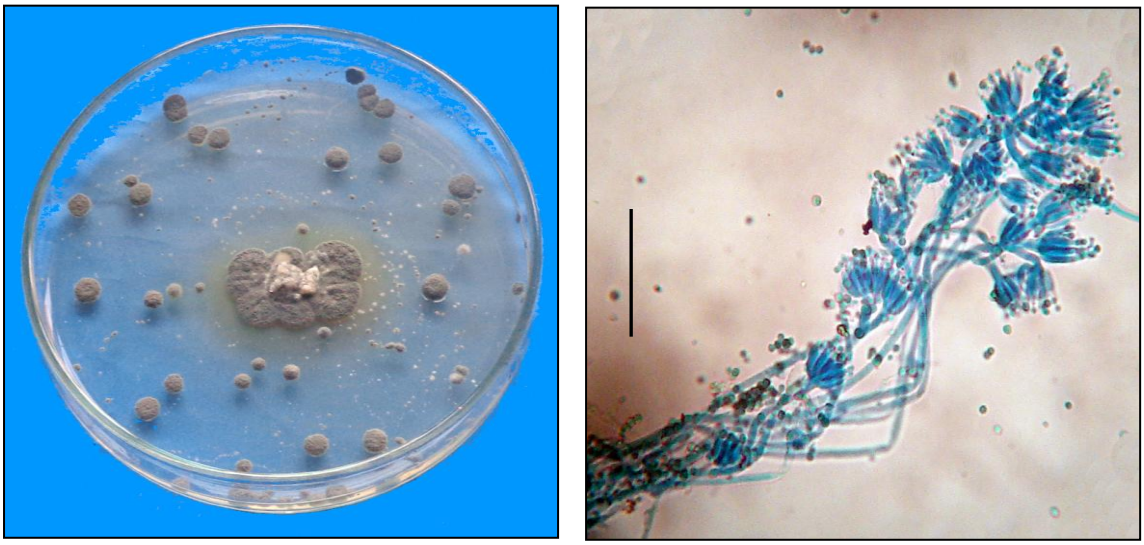
A B

Plate 36. Colony on PDA medium (A), conidia and conidiophores with metulae, sterigmata (B) of *Penicillium* sp.1 (Bar = 45µm).



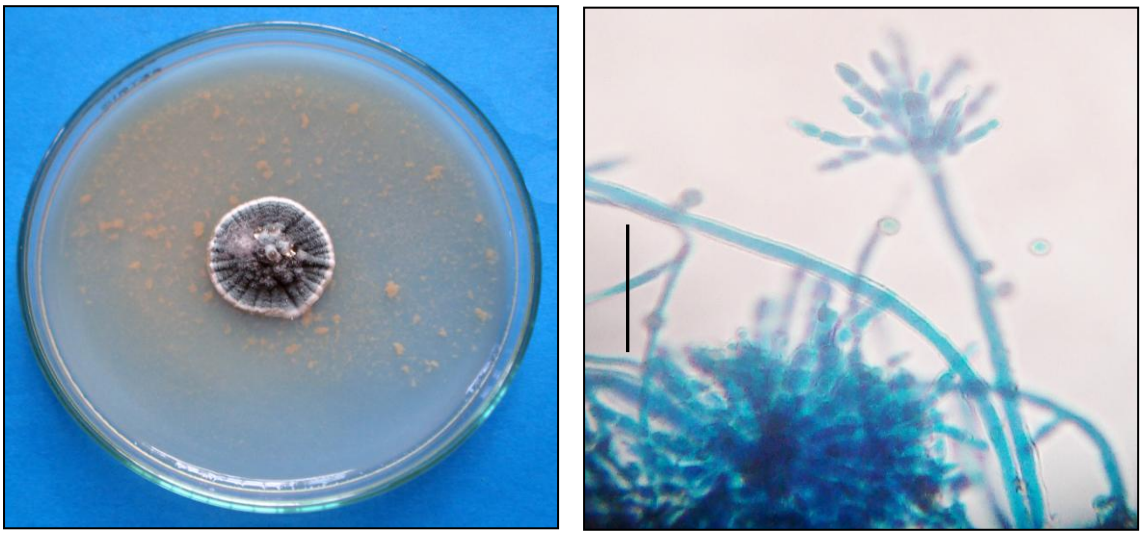
A B

Plate 37. Colony on PDA medium (A), conidia and conidiophores with metulae, sterigmata (B) of *Penicillium* sp.2 (Bar = 45µm).



A B

Plate 38. Colony on PDA medium (A), conidia and conidiophores with metulae, sterigmata (B) of *Penicillium* sp.3 (Bar = 45µm).



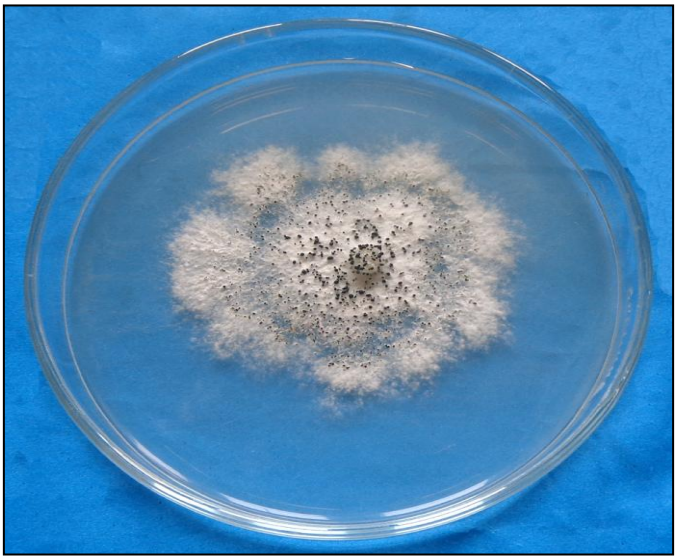
A B

Plate 39. Colony on PDA medium (A), conidia and conidiophores with metulae, sterigmata (B) of *Penicillium* sp.4 (Bar = 45µm).

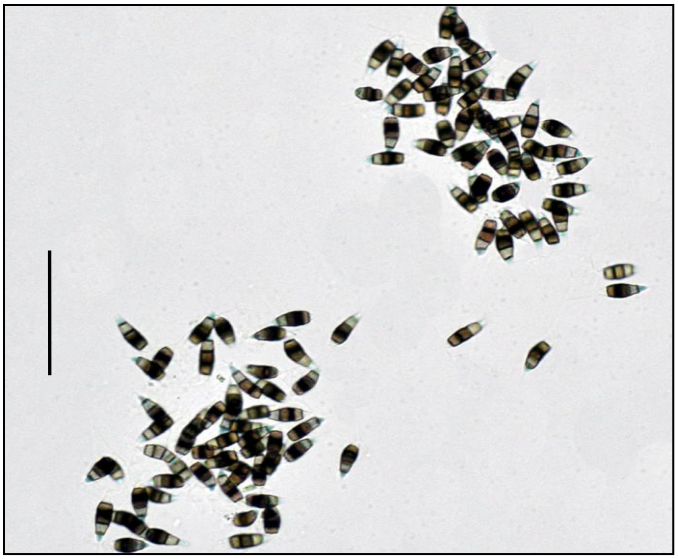
PESTALOTIA

Pestalotia sp. de Not.

Mycellium immersed, branched, septate, hyaline to pale brown. Colonies white, compact with black, small scattered acervulus. Conidia blackish brown, several celled with hyaline pointed end celled, ellipsoidal with two or more apical appendages. Acervuli dark, discoid or cushion shaped, sub epidermal; Conidiophores short, simple; Conidia dark, several celled, with hyaline pointed end cells, ellipsoidal to fosoid, with two or more hyaline, apical appendages. Conidiogenous cells holoblastic, annellidic, intermediate, intefrated, cylindrical, hyaline, smooth with several percurrent proliferations. Conidia fusiform, straight or slightly curved, 4 euseptate (Plate 40).



A



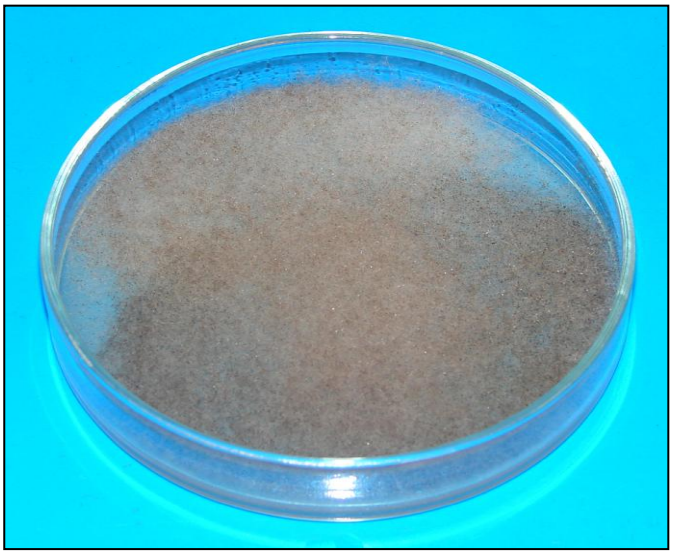
B

Plate 40. Colony on PDA medium (A) and conidia (B) of *Pestalotia* sp. (Bar = 45µm).

RHIZOPUS

Rhizopus stolonifer PL.

Mycelium coenocytic, well developed, branched and fluffy. Mycelium produces many aerial stolons that develop rhizoids at certain points. Directly above the rhizoids, one or more sporangiophores are produced. The top of each sporangiophores become swollen as the latter reaches maturity and a sporangium is developed. The central portion of sporangium becomes highly vacuolated and it eventually surrounted by a wall that separates it from the peripheral zone. The central portion is the columela. Sporangium may produces non-motile sporangiophores (Plate 41).



A

B

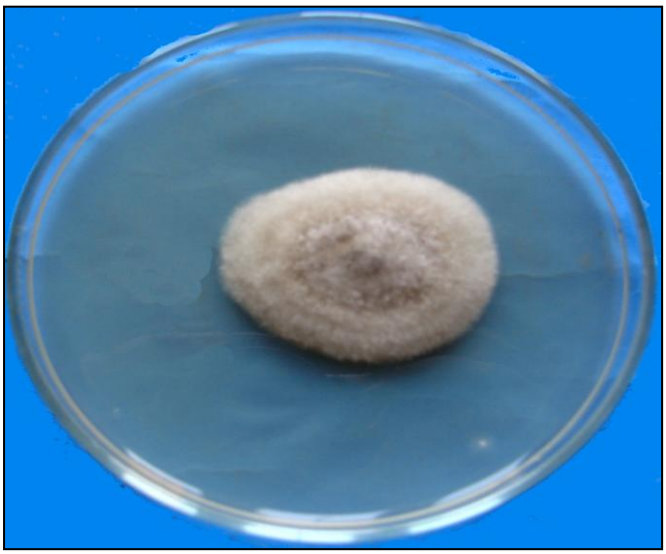
Plate 41. Colony on PDA medium (A), conidia and conidiophores with stolon (B) of *Rhizopus* sp. (Bar = 45µm).

SYNCEPHALASTRUM

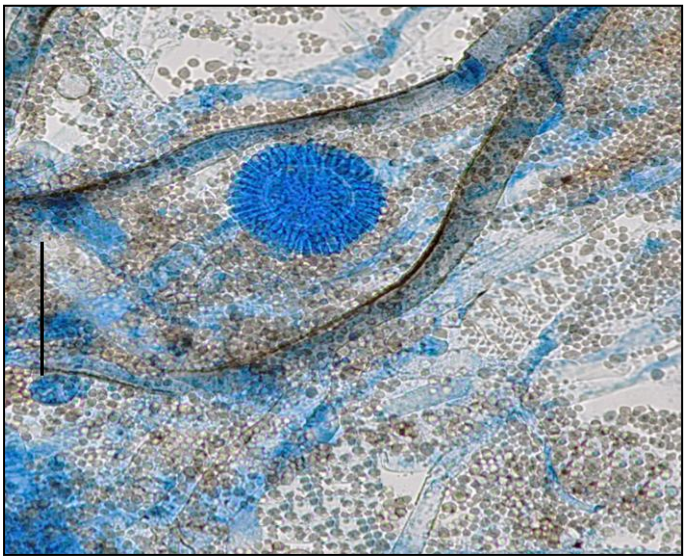
Syncephalastrum Schroet

Mycellium growing rapidly, abundantly branched conidiophores (sporangiophores) erect, branched tips enlarged bearing a head of rod-shaped sporangioles (merosporangia), each producing a row of nearly spherical spores, resembling a chain of conidia. Wall of sporangiole dissolved to release spores. Species of the genus Syncephalastrum is saprophytic (Barnet 1972).

This genus is the only number of the family Syncephalautraceae (Benjamin 1959). The merosporangia of *S.racemosum* are multispored (Schipper and Stalpers 1983); a second Species, *S.monosporum* (Zheng *et al*. 1988) has unispored sporangiola. Species of Syncephalastrum can be isolated from dung and soil.



A



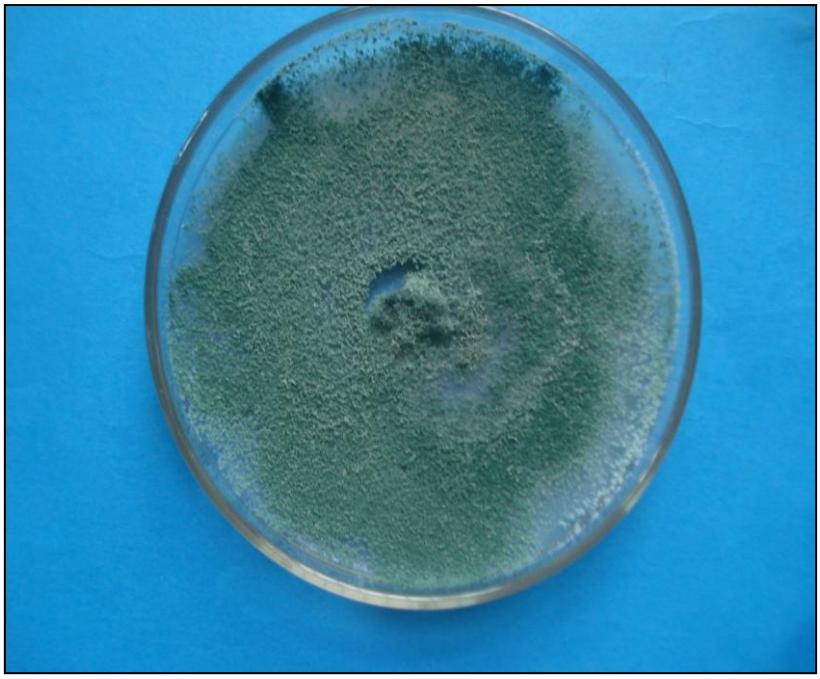
B

Plate 42. Colony on PDA medium (A), conidia and conidiophores (B) of *Syncephalastrum* sp. (Bar = 45µm).

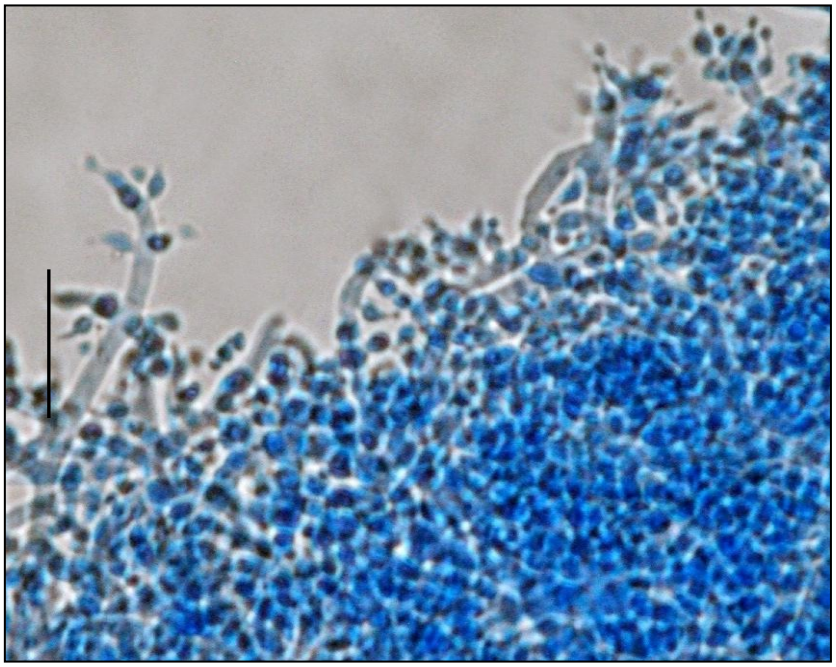
TRICHODERMA

Trichoderma Pers.

Trichoderma produces white, yellowish or green colonies when cultured. Conidiophores hyaline, upright, much branched, not vercilliate; phialides single or in groups. Conidia hyaline, one celled, borne in small terminal cluster; usually easily recognized by its rapid and green patches or cushions of conidia (Plate 43).



A



B

Plate 43. Colony on PDA medium (A), conidia and conidiophores (B) of *Trichoderma* sp. (Bar = 45µm).

CHAPTER 6

CONCLUSION

CONCLUSION

A total number of counted fungal colonies were 6648 out of which in the morning was 3268 and in the evening it was 3380 and 156 colonies were sterile mycelia in monthly sampling of air borne mycoflora of Dhaka Metropolitan City, during February 2013 to January 2014. The fungal colonies developed in PDA media were isolated from five different locations in the morning and evening at monthly intervals. These locations were Sher-e Bangla Agricultural University, Gulistan, Dhaka Medical College, Sadar ghat and DOHS, Mohakhali. Fungal colony forming units were settled within five minutes on one square meter area at morning and evening from the air of Dhaka city.

Among the identified fungi, *Aspergillus* was one of the most dominating genus in all the stations over the study period. The second fungus was *Cladosporium* followed by *Penicillium*, *Alternaria*, *Curvularia*, *Fusarium*, *Bipolaris, Pestalotia*, *Colletotrichum, Trichoderma*, *Rhizopus*, *Nigrospora*, *Chaetomium, Syncephalastrum* and *Arthrinium*. In the dry winter (December-February), *Alternaria*, *Bipolaris*, *Cladosporium*, *Curvularia*, *Nigrospora* and *Rhizopus* showed their peak. In the rainy monsoon (June-September), *Aspergillus*, *Chaetomium*, *Fusarium*, *Penicillium, Pestalotia*, and *Trichoderma* shwoed its peak. Hot humid summer (April) was the most favourable season for the occurrence of *Arthrinium, Colletotrichum* and *Syncephalastrum.* Maximum fungal colonies were found in Gulistan and Sadarghat in the morning and evening. During the twelve months investigation maximum fungal colonies were found in August and September as all the climatic factors were favorable for the fungal growth, their dispersal and survival.

The identified fungi belonged to fifteen genera under the class Ascomycetes, Zygomycetes and Deuteromycetes. Regarding the qualitative nature of the mycoflora, their frequency and percentage contribution to the total mycoflora, monthly periodicity have been described in this investigation. Among the fungi, found in the present investigation *Alternaria, Aspergillus, Chaetomium Cladosporium, Curvularia, Fusarium, Penicillium* and *Rhizopus* were reported as pathogenic to plants and/or human and strongly allergenic to human. *Bipolaris, Colletotrichum,* and *Pestalotia* were reported as only plant pathogens. The present study contributes to our knowledge of air borne spores in the Dhaka city. Regular monitoring of air borne fungi can be helpful in the prevention of fungal allergic diseases in the city.

REFERENCES

REFERENCES

Abdel FHM and Swelim MA 1982. Studies on air borne fungi at Qena, Egypt. 3. Thermophilic fungi. Mycopathologia **80**(2): 107-112.

Abdel HS 1984. Survey of air borne fungus spores at Taif, Saudi Arabia, Mycopathologia **88**(4): 39- 44.

Adam AP and Spendlore JC 1970. Coliform aerosols emitted sewage treatment plants. Science **169**: 1218-1220.

Adhikari A, Sen MM, Gupta-Bhattacharya S and Chanda S 2004. Air borne viable, non-viable, and allergenic fungi in a rural agricultural area of India: a 2-year study at five outdoor sampling stations. Sci. **326**: 123-141.

Agarwal MK and Shivpuri DN 1979. Fungal spores, their role in respiratory allergy. Adv. Pollen Spores Res. **1**: 78-128.

Ahmed J, Hossain KS and Bashar MA 2013. Aeromycoflora of the Dhaka University Campus. Bangladesh J. Bot. **42**(2): 273-278.

Aimanianda V, Bayrz J, Bozza S, Kniemeyer O and Perruccio K 2010. Clover cloak prevents immune recognition of air borne fungal spores. 4th advances against Aspergillosis. Asp Newsl. **460**: 1117-1123.

Al-doory, Yousef Donsen, Howard WA and Sly RM 1980. Air borne fungi and pollens of the Washington. DC, USA Metropolitan Area. Ann. Allergy. **45**(5): 265-269.

Alexopoulos CJ and Mims CW 1979. Introductory Mycology. 3rd Ed. John Wiley and Sons, Inc. USA.

Alexopoulos CJ, Mims CW and Blackwell M 1995. Introductory Mycology. 4th ed. John Wiley and Sons, Inc., New York, USA.

Americo DL, Jose and Gadelha W 1983. Fungal air borne spore pollution in the city of Recife, Pernembuco, Brazil, Rev. Latinoam Microbial. **25**(4): 243-252.

Anderson JH 1985. Allergenic air borne pollen and spores in anchorage, Allasska, USA, Ann. Allergy. **54**(5): 390-399.

Anita M, Silva D and Freitas YM 1982. A survey of the aerial mycoflora of Bombay, India. J. Microbial. **22**(1): 27-33.

Anonymous 1997. The incidence of aeromycoflora (Fungi and Bacteria) in the indoor and outdoor environments of Dhaka city, M.Sc. Thesis, Dept. of Botany, Jahangirnagar University, Savar, Dhaka, Bangladesh.

Ballero M, Carbecco A, Piu G and Camba G 1984. Survey of air borne spores in the atmosphere of Cagilliri, Sardinia, Italy. : *Alternaria* sp. and *Cladosporium* sp. Folia. Altergol Inmunal. Clin. **31**(6): 423-428.

Banarjee V, Weber CP, Ruffin J and Banerjee S 1987. Airborne fungi survey of some residences in Durham. North Carolina, USA. Grana. **26**(1): 103-108.

Barnett HL and Hunter BB 1972. Illustrated genera of imperfect fungi, Burgess Publishing Company, Minneapolis, Minnesota.

Barron GL 1977. The nematode-destroying Fungi. Can. Biol. Publ. Ltd. Guelph, Ontario. Topics in Mycology **1**: 140.

Basilico ML, Cheiricatti C, Aringoli EE, Althaus RL and Basilico JC 2007. Influence of environmental factors on air borne fungi in houses of Santa Fe City, Argentina, Sci. **376**: 143-150.

Beaumont F, Kaufman HF, Monehy JGRD, Sluiter HJ and Varies KD 1987. Volumetric aerobiological survey of conidial fungi in the Northest Netharlands: 2. Comparison of aerobiological data and skin tests with mold extracts in an asthmatic population. Allergy. **40**(3): 181-18.

Berta G Putzalu P and Marchialo VF 1986. An air borne basidiomycetes in the city of Turin, Italy. Allionia. **27**: 42-52.

Bhatia L and Vishwakarma R 2010. Hospital indoor airborne mycoflora in private and government owned hospitals in Sagar City, India. World Journal of Medical Sciences **5**(3): 65-70.

Blamquist G, Storm G and Stromquist L 1984. Sampling of high concentrations of airborne fungi. Scand. J. Work Environ. Health. **10**(2): 109 -114.

Booth C 1971. The Genus *Fusarium*. Commonwealth Mycological Institute. Kew, Surrey, England.

Buck P and Levetin E 1985. Air borne pollen and mold spores in a subalpine environment. Ann. Allergy. **55**(6): 794-801.

Burge HA 2002. An update on pollen and fungal spore aerobiology. J.Allerg, Clin. Immunol. **110**: 544-552.

Calvo MA, Guarro J, Suarez G and Raminez C 1980. Air borne fungi in the air of Barcelona, Spain, 5. The Yeasts. Ann. Allergy. **45**(2): 115-116.

Casida LEJ 1968. Industrial Microbiology. John Wiley, New York.

Chakraborty PS, Gupta-Bhattacharya and Chanda S 2003. Aeromycoflora of an agricultural farm in West Bengal, India. Grana. **42**: 248-254.

Cherila Maria, Capelti E and Banercu D 1981. The relationship between airborne fungal spores and Dermatophagoides Pteronyssinus in house dust. Rev. Roum Med. Interne. **19**(1): 73-78.

Christensen CM and Kaufman HM 1969. Grain storage: The role of fungi in quality loss. University of Minnesota Press, Minnepolia.

Colakoglu G 1996. The variability of fungal flora in the air during morning and evening in 1994. J. Basic Microbial. **36**: 393-398.

Colakoglu G and Karalti 1 2011. The determination of airborne fungal flora of two different hospitals in Istanbul (Turkey). Advances in Environmental Biology **5**(11): 3645-3652.

Contane NF, Smith DT, Baker RD, Callaway JL and Martin DS 1954. Manual of Clinical Mycology. 2nd ed. Saunders. Philadelphia.

Corden J and Millington W 2001. The long-term trends and seasonal variation of the aeroallergen *Alternaria* in Derby. UK. Aerobiol. **17**: 127-136.

Cox CS and CM Wathes 1995. Bioaerosols Handbook. Lewis Publishers, New York.

Cunningham DD 1983. *In*: "Microscopic Examination of Air" superintendent of Govt. Printing, Calcutta.

Denikus N 2005. Fungal antigens expressed during invasive aspergillosis. Infect. Immun.**73**: 4704- 4713.

Denning DW, O'Driscoll BR, Hogaboam CM, Bowyer P and Niven RM 2006. The link between fungi and severe asthma: a summary of the evidence. European Respiratory Journal **27**: 615- 626.

Devkota SR and Sharma AP 1990. 'Atmospheric fungi of Kathmandu'. J. Inst. Med. **12**: 115-124.

Dickinson CH 1981. Microbial Ecology of the Phylloplane. Academic Press London.

D'Silva AM and Freitas YM 1982. A survey of the aerial mycoflora of Bombay. Indian. J. Microbiol. **22**: 27-33.

Ellis MB 1971. Dermatiaceous Hyphomycetes. Commonwealth Mycological Institute, Kew, Surrey, England.

Ellis MB 1976. More Dematiaceous Hyphomycetes. Commonwealth Mycological Institute, Kew, Surrey, England.

Ellis MB 1985. More Dematiaceous Hyphomycetes. Commonwealth Mycological Institute, Kew Survey, England.

El-Morsy EM 2000. Fungi isolated from the endorhizosphere of halophytic plants from the Red Sea Coast of Egypt. Fungal Diversity **5**: 43-54.

Frankland PE 1989. A new method for the quantitative estimation of the microorganisms present in the atmosphere. Phil. Trans. B. **178**: 113-152.

Geyer RD and Khala SP 1984. Aerobiology of a Himalayan alpine zone, Rudranath. India. Aret. Alp. Res. **16**(2): 173-174.

Ghosh SK, Gokani VN and Thakker M 1984. A preliminary aerobiology survey on a Virginia tobacco farm during harvesting. Indian J. Med. Res. **79**: 566-570.

Gilman JC 1957. A Manual of Soil Fungi. Lowa State. Univ. Press.

Gregory PH 1961. The Microbiology of Atmosphere. Inter Science Publishers, NY.

Han Chunang YC, Hingmeishiong, Chao HY and Chang LY 1981. A follow-up survey on airborne fungal spore counts in the Taipei Area. Taiwan. Chin. J. Microbial. Immunal. **14**(4): 213-221.

Harrington TC 1980. Release of air borne Basidiospores from the pouch fungus, *Cryptoporus valvatus*. Mycologia **72**(5): 926-936.

Hartill WFT 1980. Aerobiology of *Sclerotinia sclerotium*. and *Botrytis cineria* spores in New Zealand tobacco (*Nicotinia tabacum*) crops. N.Z.J. Agric. Res. **23**(2): 256-262.

Hashimoto S 1986. Study on air borne fungal flora. The distribution of air borne fungi in the homes of children with bronchial asthma. J. Tokyo Womens Med. Chall**. 56**(10/1): 969-980.

Hawker LE and Linton AH 1971. Microorganisms: Function, form and Environment. Edward Arnold Ltd., London. 391p.

Hedayati MT, Mayahi S, Aghili R and Goharimoghadam K 2005. Air borne fungi in indoor and outdoor of asthmatic patient's home, living in the city of sari. Iran J. Allergy Asthma Immunol. **4**: 189-191.

Heuchert B, Braun U and Schubert K 2005. Morphotaxonomic revision of fungicolous *Cladosporium* species (hyphomycetes). Schlechtendalia **13**: 1- 78.

Hjelmroos M 1993. Relationship between airborne fungal spore presence and weather variables. Grana. **32**: 40-47.

Holtmeyer MG and Wallin JR 1981. Incidences and distribution of air borne spores of *Aspergillus flavus* in Missouri. USA. Plant Dis. **65**(1): 58-60.

Janaki-Bao A 1979. The air spore of Vishakhaptanam (Ph.D. Thesis). Andhra University, Waltair, India.

Kasprzyk 1 2008. Aeromycology-main research fields of interest during the last 25 years. Ann. Agric. Environ. Med. **15**: 1-7.

Khan MR and Ali S 1984. An aerobiological study of the Dhaka City and its sub-urban areas, Bangladesh. J. Bot. **13(**2): 214-219.

Klabusching A, Goety F, Horak S, Jaeger A, Machaler C, Popow F, Haschke and Turek RS. 1981. Influence of aerobiology and weather on symptoms in children with asthma. Respiration **42**(1): 52-60.

Kumar R 1986. A two year study of aeromycospora of Dehra Dun, **India**. J. Mycol. PL. Pathol. **14**(3): 260-265.

Kurkela T 1997. The number of *Cladosporium* conidia in the air in different weather conditions. Grana. **36**: 54-61.

Kwon-Chung KJ and Bennett JE 1992. Medical Mycology. Lea and Febiger, Philadelphia, PA.

Lacey J and ME 1964. Spore concentration in the air of farm buildings. Trans. Br. Mycol. Soc. **47**: 547-552.

Lawande RV and Onyemelukwe GC 1984. Air borne fungi during Harmattan in Zaria, Nigeria. Ann. Allergy **52**(1): 47- 49.

Levetin E and Dorseys K 2006. Contribution to leaf surface fungi to the air spora. Aerobiologia **22**(1): 2-12.

Li DW and Kendrick B 1995. A year-round comparison of fungal spores in indoor and outdoor air. Mycologia **87**(2): 190-195.

Long DL and Kumar CL 1973. Air spora of two contrasting ecological sites in Kanasas. J. Allergy Clin. Immunology **49**: 255-266.

Lyon FL, Bramer CL and Eversmeyer MG 1984. Variation of air spora in the atmosphere due to weather conditions. Grana. **23**(3): 177-181.

Maestreet JR, Picazo JJ, Fereres J, Jurrado LAL and Balaneooria M 1986. Airborne fungal spores as a risk factor in the hospital environment. Infectoloia **7**(3): 27-28.

Manisha K and Panwar N 2012. Morpho-Pathological Effects of Isolated Fungal Species on Human Population. **1**: 521. doi: 10.4172/scientific reports.521.

Maunshell K 1985. Respiratory Allergy to fungus spores. P. Allergy. **4**: 457 (New York: S. Karger Bawel).

Meyer GH, Prince HE and Raymer WJ 1983. Air borne fungi. A resurvey. Ann. Allergy **51**(1): 26-29.

Morring KL, Sorenson WG and Attfield MD 1983. Sampling for air borne fungi. A statistical comparison of media. Ann. Ind. Hyg. Assoc. J. **44**(9): 662-664.

Napoletane PJ and Rowe R 1966. Microbial content of air near sewage treatment plants. Water Sewage Works. **113**: 480-482.

Narayan M, Jayaprakash C, Ravichandran V and Sullia SB 1982. Aeromycology of the atmosphere of Malleeswarm market Banglore (India). Acta. Bot. Indica. **10**(2): 169-200.

Nugari M and Roccardi A 2001. Aerobiological investigations applied to the conservation of cultural heritage. Aerbiol. **17**: 215-223.

0'Gorman CM and Fuller HT 2008. Prevalance of culturable airborne spores of selected allergenic and pathogenic fungi in outdoor air. Atmos. Environ. **42**: 4355- 4368.

Oren J and Baker CES 1970. hlolds in hlanoa: A study of prevalent fungi in Hamiian homes. Ann. Allergy **28**: 472- 480.

Paramasivam M and Gnanarethinam JL 1986. A preliminary survey of the atmosphere fungal flora of Tiruchira Palli. India. J. Microbial. **26**(1 & 2): 117-119.

Pasha MK and Hossain MS 2011. Airborne bio-particulate objects at Chittagong University campus. Ban. J. Bot. **40**(2): 189-191.

Pathak K 2012. An extramural aeromycological investigation of dental college hospital associated environment. Int. J. Env. Sci. **2**(4): 1952-1961.

Patil SD and Vyavahare VB 1981. Aeromycoflora of the Ganesh Khind area (India). Maharashtra Vidnyan Mandir Patrika. **16**(1/2): 1- 4.

Pelczar MJ Chan ECS, Kreig NR and Pelczar MF 2004. Microbiology. Tata McGraw-Hill Publ. Co. Ltd., New Delhi.

Prince HE and Marrow MB 1969. Logical approach to mold allergy. Ann. Allergy. **2**: 77-79.

Proctor BE 1935. The Microbiology of upper air. J. Bacteriol. **30**: 363-375.

Raanjhanaa M 1997. Studies on aeromycoflora of Rajshahi Metropolitan, M.Sc. Thesis, Dept. of Botany. University of Rajshahi, Rajshahi, Bangladesh.

Ramalingam A 1971. Air-spora of Mysore. Proc. Indian Acad. Science. **74:** 27.

Ramalingam A and Nanjundaiah D 1983. Air borne spores; A source of seed and soil borne inoculum. *In:* Proceeding of the national seminar on seed pathology (Eds. N. Shanmugan and R. Jayaraj) Tamil Naru Agric. University.

Raper KB and Fennell DI 1965. The Genus *Aspergillus*. The Williams and Wilkins Co., Baltimore. USA. Pp. 1- 686.

Rapper KB and Thom C 1945. A Manual of the Aspergilli. Williams and Wilkins, Baltimore.

Richard M 1954. Atmospheric molds in and out of doors. J. Allergy. **25**: 429.

Sandhu DK and Singh SS 1985. Air borne thermophilous fungi at Amritsar, India. Br. Mycol. Soc. **84**(1): 41- 46.

Satpute M Dutta BK and Rao RR 1983. Contributions to the aerobiology of Shillong. I. Studies on the seasonal variation of atmospheric pollen and fungal spores. Proc. Indian Natl. Sci. Acad. Part B. Biol. Sci. **49**(6): 675-686.

Shrestha AK and Chauhan SVS. 2003. Aeromycoflora around various historical monuments of Agra. Ind. J Aerobiol. **16**: 23-27.

Shrestha G, Mridha AU and Gauging W 2010. Study of allergens produced by *Aspergillus flavus* and *Aspergillus fumigatus* isolated from the atmosphere of Kathmanda, 4th Advances Against Aspergillosis, Rome, Italy. Pp. 98.

Sima S Chakraverty R and Mishra AK 1984. *Aspergilli* in air over Calcutta. Indian J. Microbiol. **24**(2): 35-38.

Singh BP, Singh AB, Nair PKK and Gangal SW 1987. Survey of airborne pollen and fungal spores at Dehra Dun, India. Ann. Allergy **59**: 229-234.

Singh P Nath P and Mukherjee P 1980. Air borne fungi of Lucknow City. A study of two sites. India. Allied Sci. **22**(4): 199-203.

Singh VK and Shrivasava GP 1985. Study of atmospheric allergic fungal spores at Rewa, India. Acta Bot. Indica. **13**(2): 218-220.

Spurr HWJ and RE Welty 1972. Incidence of tobacco leaf mycoflora in relation to brown spot disease and fungicidal treatment. Phytopathol. **62**: 616-920.

Stepalska D and Jerez W 2005. Variation in fungal spore concentrations of selected taxa associated to weather conditions in Cracow, Poland in 1997. Aerobiol. **21**: 43-52.

Stryjakowska, Sekulska M, Piotraszewska-Pajak A, Szyszka A, Nowicki M and Filipiak M 2007. Microbiological quality of indoor air in University room. Polosh J. Env. Stud. **16**(4): 623- 632.

Subramanian CV 1971. Hyphomycetes. Indian Council of Agricultural Research, New Delhi.

Tilak ST and Saibaba M 1985. Indoor aeromycology. Acta Bot. Indica. **13**(2): 203-210.

Tseng His-yen and Zuci-chingehen 1982. Interesting air borne fungal spores. Taiwan. **27**(10): 48-51.

Tsuchiya HM and Brown AH 1964. Proceeding of the atmospheric Biology Conference. University of Minnesota, Minneapolos.

Ulea E, Lipsa FD, Irimia N and Balau AM 2009. Survey of indoor airborne fungi in different educational institutions from Iasi, Romania. University of Agricultural and the Veterinary Medicine Sciences "Ion Ionescu de la Brad" Iasi **52**: 518-523.

VandeWoude, Vogelaers KHD and Blot SI 2006. Aspergillosis in the ICU – The new 21st century problem. Med. Mycol **44**: 71-76.

Vijayalakshmi M and Rao AS 1984. An aeromycological study over a sunflower field during seed development. Indian Bot. Rep. **3**(1): 27-31.

Vital BRR and Glory AL 1985. A air borne fungus spores of a library in India. Grana. **24**(2): 124-132.

Vittal BPR and Poonnusamy P 1982. Species composition of the atmospheric fungal flora of Madras.-Indian. J. Microbiol. **22**: 79-81.

Zobell CF 1964. Marine Microbiology, Chronic Botanica, Waltham, Mass.