http://www.trakya.edu.tr/Enstituler/FenBilimleri/Dergi/net/index.htm
Trakya Üniversitesi Bilimsel Araştırmalar Dergisi
B Serisi Fen Bilimleri, 4(1): 1-8, 2003
ISSN 1302 647X
DIC: 83AHAAGE/4106030703

Original Article/Orijinal Makale

AIR-BORNE PARTICULATE MATTER AND ITS VIABLE FRACTION DURING SEVERE WEATHER CONDITIONS IN CAIRO, EGYPT

Abdel Hameed A. AWAD
Air Pollution Department, National Research Center, Dokki, Giza, EGYPT, e-mail: hameed_33@yahoo.com

Received : January 30, 2003
Accepted : March 3, 2003

Abstract: Exposure to high levels of particulate matter (PM) has been occurred during severe weather and normal conditions at urban environment. Suspended dust and its viable fraction and smoke concentrations were detected over Cairo during severe weather and normal conditions. During smog episodes, smoke and suspended dust were detected at mean values of 276 μgm^{-3} and 347 μgm^{-3}, respectively, whereas during winter dust storm they were detected at mean values of 117.5 μgm^{-3} and 1074 μgm^{-3} (time weighed average) for the corresponding pollutants, respectively. Surprisingly, during normal conditions smoke was recorded at mean value of 199 μgm^{-3} that exceeded the limit value of smoke recommended by the Egyptian environmental law No 4 (150 μgm^{-3} / 24hrs), whereas suspended dust was detected at mean value of 185.9 μgm^{-3} that was lower than the limit value recommended by the Egyptian environmental law (230 μgm^{-3} / 24hrs). Sulphates and nitrates were recorded at higher mean values during smog episode and normal conditions than those recorded during winter storm. The lowest culturable viable fraction associated with suspended dust, including environment /bacteria, fungi and streptomycetes was recorded during smog episodes, whereas the highest viable fraction was recorded during winter dust storm. Daily exposure to air pollution depresses immune system and increases of airway responsiveness to aeroallergens.

Key words: Episodes, smog, viable fraction, winter dust storm.

Kahire (Mısır)'da Sert Hava Şartlarında Havayla Taşınan Partiküler Maddeler ve Bunların Üzerindeki Mikroorganizmalar

Özet: Partiküler maddelerin yüksek dozlarına maruz kalma, şehir ortamlarındaki sert hava ve normal şartlarda oluşabilmektedir. Havadaki asılı tozlar, bunların üzerindeki canlı mikroorganizmalar ve duman konsantrasyonu, sert hava ve normal şartlarda Kahire'de tesbit edilmiştir. Dumanlı sis ve havada asılı tozların olduğu dönem boyunca, ortalama değerler sırasıyla 276 μg^{-3} ve 347 μg^{-3} olarak tesbit edilmiştir. Oysa kış fırtınaları boyunca bu değerler, sırasıyla onların yerine geçen kirleticiler için, 117.5 µg-3 ve 1074 µg-3 (Süre ağırlık ortalaması) olarak bulunmuştur. Sürpriz olarak, normal duman şartları boyunca ortalama değer, Mısır Çevre kanunu No 4 tarafından önerilen (150 μg^{-3}/24h) duman limit değerinin üstü olan 199 μg^{-3} olarak kaydedilmiştir. Oysa havadaki asılı toz miktarı, Mısır Çevre Kanunu tarafından önerilen (230 μg^{-3}/24h) limit değerden düşük olan 185.9 μg^{-3} olarak tesbit edilmiştir. Sülfatlar ve nitratların ortalama değerleri, kış fırtınalı dönemlere göre, dumanlı dönemler ve normal şartlar boyunca yüksek bulunmuştur. Havada asılı tozların üzerindeki çok az kültüre edilebilir bakteri, fungus ve Streptomyces gibi canlı mikroorganizmalar, dumanlı dönemler boyunca kaydedilmiştir, oysa bu mikroorganizmalar kış toz fırtınaları döneminde havadaki asılı tozlar üzerinde daha fazla sayıda bulunmuşlardır. Günlük olarak hava kirliliğine maruz kalmak, immun sistemi zayıflatır ve aeroallergenlerin etkisini arttırır.

Anahtar kelimeler: Dumanlı sis, kış toz fırtınaları, hava tozlarındaki mikroorganizmalar.

Introduction

Air pollution is created by emissions from natural and non-natural sources. Fine particles, particulate material of 2.5 micrometers (µm) in diameter (PM2.5 µm) result from many different sources, including combustion sources, vehicle emissions and they are formed secondarily from gaseous precursors such as SO_2 and NO_2. Coarse particles, particulate material of 10 to 2.5 µm in diameter (PM10-2.5 µm) have many sources including wind blown dust, vehicles travelling on unpaved roads, materials handling, crushing and grinding operations (Friedlander and Lippman, 1994). Smog episodes always occur in urban environment as a result of high concentrations of combustion particles and other combustion related pollutants during extraordinary meteorological conditions (high humidity, low wind speed and low lying inversion layer). The greater air pollution smog episodes were occurred in London 1952 (Anonymous, 1954); the

Meuse valley in Belgium in 1930 (Firket, 1936) and Donora, PA, USA in 1948 (Shrenk et al., 1949). On the other hand, episodes of coarse particles are associated with dust storms during atmospheric instability. There are three kinds of dust storms attacking Egypt namely: khamasin, winter and like winter type. Khamasin is the major storm contributor to the problem of natural dust and sand in Egypt (Abdel Salam and Sowelim, 1976). Moreover, Egypt suffers from high ambient concentration of atmospheric pollutants (Sturchio et al., 1997), including particulate matter, carbon monoxide, ozone, nitrogen and sulphure oxides.

Microorganisms enter and disperse into the atmosphere from various natural and unnatural sources (Gregory, 1961). Biological aerosols, including pollen, spores, protozoa, bacteria, fungi and viruses, are ubiquitous components of atmosphere (Schnell and Tan-Schnell, 1982). Windstorms are convective and lead to release and redistribution of bacteria on or near the ground (Lighthart and Shaffer, 1995) and their occurrence is correlated with dust from soil, agriculture and human activities (Sen and Asan, 2001).

Many studies have been conducted to determine factors that are affecting the survival of air microorganisms. Lighthart et al. (1971) found that, concentrations of toxic gases (CO, O_3, SO_2 and HCs) were deleterious to the survival of ambient microorganisms. Open air factor (O_3 + olefins) is the most pollutant causing damage to air microorganisms (Cox, 1987). Thorne et al. (1992) reported that, chemical components of dust are affecting the microbial life. Also, Lighthart (1998) concluded that, precipitation, wind direction, time of day, season and atmospheric inversion conditions are affecting the survival of total culturable bacteria associated with particles.

High levels of air pollution disasters have major short term effects on mortality and morbidity in London in 1952 (Anonymous, 1954), the Mesue valley (Firket, 1936) and Donora, PA, USA (Shrenk et al., 1949). Several studies have shown the adverse health effects of air pollution on respiratory diseases (Keiding et al., 1995, Holgate et al., 1999). Microorganisms or their by-products can act as antigens and may cause various allergic reactions. The inhalation of microbial components of dust is associated with pulmonary diseases (Merchant, 1987). Dust, sand, ash, soot and hydrocarbons are found besides pollen grains and fungal spores. These particles contribute to increase respiratory tract problems either as agents that cause illness themselves (D'Amato et al., 1994) or as the adjuvant effect that is provoked in people suffer from respiratory allergies (Santra et al.,1991). Moreover, aeroallergens such as those derived from pollen grains and fungal spores lead to bronchial obstruction in predisposed allergic subjects (D'Amato et al., 2000; Brunekreef et al, 2000).

During the periods of 20 to 25 Nov, 1999 and 24 to 30 Nov, 2002, Cairo were covered by smoke clouds as a result of slow movement of humid air from the north-east across the Delta into the Cairo atmosphere combined with atmospheric inversion conditions. Combustion particles emitted from different man-made sources, vehicle emissions and open burning of agricultural wastes in the Delta created smog episodes over Cairo during these periods. On the other hand, a case of atmospheric instability, occurred in the upper atmosphere and extended downwards to the earth's surface was attacked Egypt on 18 January, 2000. The front of this layer has active strong energy, which leads to severe wind speeds (~15 m/s) that flatten huge amounts of natural (sand and soil) dust into Cairo atmosphere.

The present study was directed to evaluate the concentrations of particulate matter (suspended dust and its viable fraction) and smoke at an urban area during severe and normal weather conditions. In addition, try to pay attention to the occurrence of the viable fraction associated with suspended dust as a pollutant that may play a role of respiratory complaints during different weather conditions.

Materials and methods

Sampling Site

Air samples were collected during smog (20 to 25 Nov.1999 and 24 to 30 Nov, 2002) and winter storm (18, Jan, 2000) episodes and normal weather conditions at only one sampling site, located at National Research Center, Dokki, Giza province, Egypt. It is an urban area, characterizes with high vehicle traffic and locates south-west of an industrial area. Samples of normal conditions (control) were collected on some days when episodes did not occur (some days in January and February 2000 and in January 2003).

Smoke sampling

The smoke samples were collected on cellulose nitrate membrane filters (pore size 0.45 μm, diameter 25 mm). Consecutive 24 hrs samples were collected using an open face filter holder (open face oriented downwards) and sampling pump calibrated to draw 1 l min^{-1}. The amount of light reflected from black stain was measured using reflectometer, which was checked continuously to measure 100% reflectance for the clean membrane filter. Using the smoke concentration table constructed by the British Warren Laboratory (Anonymous, 1965) and the stain reflectance readings, average smoke levels in $\mu g/m^3$ were obtained. As smoke in Cairo atmosphere is lighter in colour than that in Britain, the results were multiplied by 1.18 according to Appleton (1974).

Total Suspended particulate

The samples of suspended dust during smog and winter storm episodes were collected on preweighed cellulose nitrate membrane filters (pore size 0.45µm, diameter 25 mm). Twenty four hours and one hour sequential samples were obtained using an open face filter holder and pump calibrated to draw 6 *l* min^{-1} during smoke and winter storm, respectively. Moreover, only one sample was collected from 1700 to 0800 Cairo Local Time (CLT) during winter dust storm. The filters were weighed under sterilized conditions and the results were calculated and expressed as $\mu g/m^3$. Physical diameter of suspended particles were measured by an optical microscopy (x=400) using calibrated circles of graduated size on an eyepiece (reticule eye piece) (Giever, 1976) and the aerodynamic diameter was calculated from the density, shape and physical diameter of the particles.

Microorganisms associated with dust particles

Suspended particulates collected on membrane filters were washed in 100 ml sterilized distilled water and shaking well for about 30 to 60 min at room temperature. The surface plate technique and trypticase soya agar, 3% malt extract agar and starch nitrate agar media (Difco, Detroit, MI) plates were used for counting of the environment/bacteria, fungi and streptomycetes, respectively (Anonymous, 1989). Bacterial plates were incubated at 25°C for 72 hrs, whereas fungi and streptomycetes plates were incubated at 28°C for 7 and 14 days, respectively. The resultant colonies are expressed as colony forming unit per gram of dust ($cfug^{-1}$). Five isolates of different colony morphology which appear in more than 5 % of trypticase soya agar and malt extract agar were picked up from each plate, purified and subcultured for further identification. Bacterial and fungal isolates were identified to the genus level only according to Vanderzant and Nickelson (1969) and using Barnett's work (1972), respectively.

Sulfates (SO_4^{2-}) and nitrates (NO_3^-) analysis.

The remaining of suspended particulates stock solution was filtered. Sulfate was determined in water soluble fraction turbidimetry according to Harrison and Perry, (1986), whereas nitrate was determined colorimetry according to German Standard Method, DEV (Anonymous, 1984).

Results and discussion

The $\log_{x+1}$ levels of smoke, suspended particulates, SO_4^{2-} and NO_3^- during episodes and normal conditions are shown in figure 1. During smog episode the smoke concentrations varied from 184 to 360 $\mu g/m^3$ with a mean value of 276 $\mu g/m^3$, whereas it varied from 105 to 130 $\mu g/m^3$ with a mean value of 117.5 $\mu g/m^3$ during winter storm. On the other hand, smoke levels ranged from 130 to 250 $\mu g/m^3$ with a mean value of 199 $\mu g/m^3$ during normal weather conditions. The smoke levels exceeded the limit current value of the air quality (150 $\mu g/m^3$ / 24hrs) as given in the Egyptian environmental law No.4 (Anonymous, 1995) during smog episodes and normal weather conditions. These results indicate that, smoke is normally present at high concentrations in Cairo atmosphere during normal days. This means that, smoke is coming from conventional sources which are mainly vehicle emissions. Moreover, open burning of agricultural wastes is still considered another source for higher smoke levels over Cairo during smog episodes.

Suspended dust, which is recognized as the most sensitive indicator of air pollution, ranged from 170 to 515 $\mu g/m^3$ (with a mean value of 346.7 $\mu g/m^3$) during smog episodes, exceeded the limit value of air quality (230 $\mu g/m^3$ / 24 hrs) recommended in the Egyptian environmental law No.4 (Anonymous, 1995) whereas it varied from 154 - 232.1 $\mu g/m^3$ (with a mean value of 189.5 $\mu g/m^3$) during the normal conditions. Extraordinary weather conditions (calm air and thermal inversion) help accumulate dust near the ground level. Higher concentrations of both smoke and suspended dust are found during thermal inversion period, which prevent dispersion of particles, as a result smoke cloud can be seen over Cairo during that period. It should be mentioned that, smoke and suspended dust levels were detected in lower range (184-290 μgm^{-3} and 170-232.1 μgm^{-3}, respectively) during year 2002 than those recorded during year 1999 (200-360 μgm^{-3} and 231-515 μgm^{-3} for the corresponding indicators respectively). Moreover, there was no obvious difference between smoke levels during both periods, in contrast, there was a clear decrease regarding suspended dust levels. Abdel Salam et al., (1980) stated that, aerosols and smoke haze are common over Cairo due to urbanization, rapid industrialization and population growth. Moreover, Siverfsen and Ahmed (1999) reported that, stable atmospheric conditions, temperature inversion and a slow movement of particulate emitted from open burning in the Delta, created the smog episode covered Cairo in October, 1999. However, our findings indicated that, vehicle emissions and other human activities inside Cairo are considered the main sources of particulate matter whereas open burning of agricultural wastes constituted a small percent (~27%) of smoke during smog episodes. This is in agreement with Carińanos et al (1999) who reported that, high atmospheric stability (thermal inversion) might impede the dispersion of particles and consequently accumulation of particles. Also, Osterlee et al.

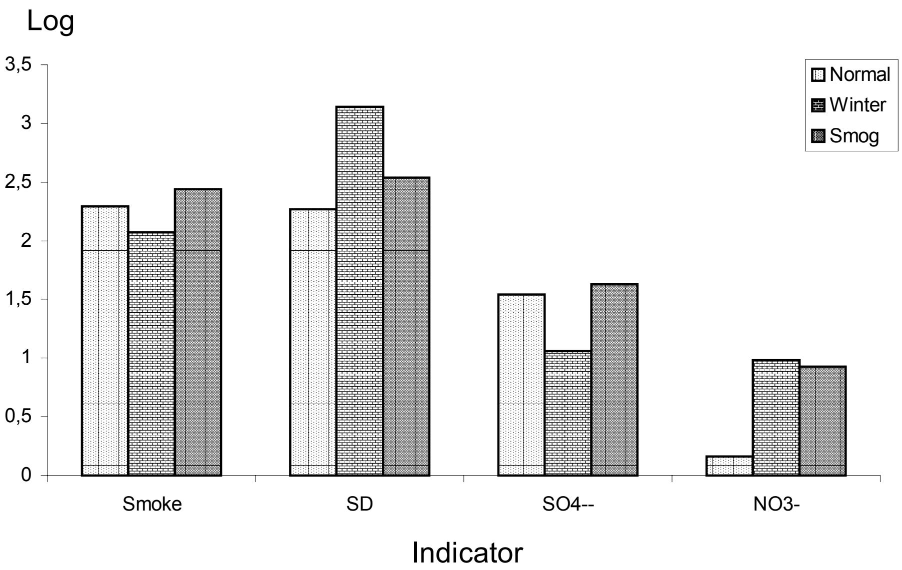

Fig.1. The Logx+1 of the mean levels of smoke, suspended dust (SD),SO4-- and NO3- (µg/m3) during episodes and normal conditions

(1996) reported that, road traffic with its motor emissions is currently the main contributor of air pollution in most urban settings. D' Amato et al (2000) concluded that, some air pollution related episodes of asthma exacerbation are due to climate factors that favour the accumulation of air pollution at ground level and some cities are perennially affected by black smoke caused by motor vehicles.

During the winter dust storm, hourly suspended dust ranged from 667 to 7740 µg/m^3 with a time (24hrs) weighed average of 1403 µg/m^3 (Fig.1) which is about 4 times more than the limit value of air quality as given in Egyptian environmental law No.4 (Anonymous, 1995). The highest level of suspended particulate (7740 µg/m^3) was recorded at the beginning of the storm whereas the lowest level (667 µg/m^3) was recorded during the evening and the night time (between 1700 CLT to 0800 CLT). This is attributed to the increase of stability conditions during evening and night time which leads to fast deposition of storm particulates.

Particulate matter present in wide size ranges. Calculation of aerodynamic diameter without a particle sizer is difficult, and it changes under different conditions. So, particle diameter may be a little bit far from reality. In the present study, aerodynamic diameters varied from 1.2 to 13.8 µm, 1.2 to 28 and 1.2 to >38 µm during smog episode, normal conditions and dust storm, respectively. The most abundant pollutants in urban areas with high frequencies of respirable particulates less than 5 µm were recorded during smog episodes (81.4 %) and normal conditions (74%). This is due to fine particles are emitted from combustion and man made activities from combustion and man made activities. Both coarse and fine particles are of health concern because they can penetrate into the sensitive regions of the respiratory tract (Anderson et al., 1994). The dangerous effect of suspended particles was studied by Wark and Warner (1981) who reported that, particulate matter ranged from 206 to 300 µg/m^3 for 24 hrs may lead to chronic bronchitis. Suspended particles less than 10µm are small enough to inhale and penetrate into respiratory tract that may cause asthma and allergy (Choudhury, 1997; Belong et al., 2000). In addition, coarse particles can aggregate respiratory disease especially asthma (Abby et al, 1995).

In the present study, sulfates and nitrates were found at mean values of 43.5 µg/m^3 and 8.5 µg/m^3, respectively during smog episodes, whereas they were 34.8 µg/m^3 and 0.68 µg/m^3 during normal conditions, respectively (Fig 1). During dust storm time weighed average of SO_4^{2-} and NO_3^- were 11.5 µg/m^3 and 9.7 µg/m^3, respectively. This confirmed that, $SO4^{2-}$ is derived from pollutants emitted from mobile and stationary sources. These results are in agreement with Pritchard et al. (1996) who found higher concentration of SO_4^{2-}, NO_3^- and organic compounds in combustion particles. Also, Cass and Shair (1984) found a correlation between high aerosol sulfates level in Los Angeles and the occurrence of fog episodes.

The $\log_{x+1}$ levels of culturable viable fraction associated with suspended dust (cfu g^{-1}) during both episodes and normal conditions are shown in figure 2. The viable indicators were found at mean values of 1.17x10^5, 4.9 x10^5 and 0 cfu g^{-1} for environment/bacteria, fungi and streptomycetes, respectively during smog episodes, whereas they were 6.96 $x10^5$, $1.72x10^6$ and $1.1x10^5$ cfu g^{-1} for the corresponding indicators, respectively during winter storm. During normal weather conditions bacteria, fungi and streptomycetes were recorded at mean values of $3.2x10^6$, $1.22x10^6$ and $4.9x10^4$ cfu g^{-1}, respectively (Fig. 2). It is clear that, anthropogenic sources produce microorganisms and the lowest viable fraction concentration was recorded during smog episode, whereas the highest fungi concentrations were recorded during winter storm. This is because fungi spores are related to natural dust and wind blown over vegetation. Also, Sreeramulu (1962) concluded that, prevailing wind velocity and especially wind gustiness was the main agent in removing spores from exposed mass in air.

In the present study, actinomycetes (streptomycetes) were recorded in the lowest concentrations and did not detect during smog episodes. This is due to actinomycetes are commonly found in agricultural soil and natural dust. This confirms that, natural and agricultural dusts were flattened over Cairo atmosphere by gustiness storm. Streptomycetes are of health concern because they have been implicated in many diseases and several streptomycetes species stimulate lung macrophage reactions that lead to inflammation of tissue injury (Hirvonen et al., 1997).

Generally, the lowest viable fraction associated with dust particles was detected during smog episode. This may be due to combustion particles associated air pollution contain many of toxic compounds which may kill microorganisms or affect their viability. This conclusion is confirmed by many investigators such as Hood (1973) and Handley and Webster (1995) who reported that, biological decay rate was higher during high level of air pollution (during an inversion layer). Lighthart et al. (1971) found that, concentrations of toxic gases emitted by human activities reached levels conceivably deleterious to the survival of microorganisms. Also, Cadman et al. (1997) recorded fungi spores in low counts during peak season of air pollution.

Table 1 shows the dominant types of bacterial and fungal isolates during different conditions. Gram positive bacteria (*Bacilli, Streptococcus pneumoniae*, *Micrococcus spp* and *Sarcina*) are the common bacterial isolates. Most of these organisms are related to human activities, more environmentally resistance and they are pathogenic according to Scott et al. (1982). Shaffer and Lighthart (1997) found Gram positive bacteria (80.4% with 39.6% of the genus *Bacillus*) was the dominant category of cultural airborne bacteria at four locations in Oregon. There is an increase in *Cladosporium* counts during episodes. *Cladosporium*, *Penicillium* and *Alternaria* were the common fungal isolates during extreme weather conditions. In contrast, many divergent genera such as *Aspergillus, Trichoderma, Fusarium* and *Scopulariopsis* were detected during normal conditions. This indicates that, fungi can live in extreme severe conditions in almost all regions and meteorological conditions affect the predominant genera. Asan et al. (2002) reported that, various meteorological factors affect the type and concentrations of air fungi. Miller (1992) stated that, *Cladospo-*

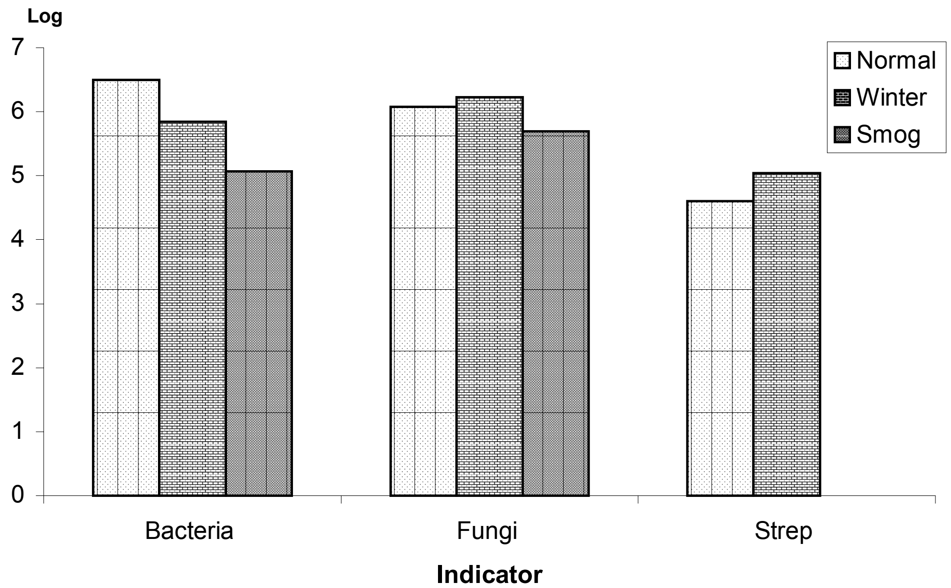

Fig.2. The Logx+1 of the mean values of environment/bacteria, fungi and streptomycetes (cfu/g) during episodes and normal conditions.

rium and *Alternaria* are mainly of outdoor origin as well as Reponen (1995) found *Cladosporium* and yeasts at higher concentrations outdoor. Fungi are of health concern because many of them are aeroallergens. *Cladosporium, Penicillium, Alternaria* and *Aspergillus* are allergenic agents (Lacey and Crook, 1988; Juozaitis et al., 1994). Moreover, atopy to allergens of the fungus *Alternaria* is strongly associated with allergic disease, particularly with asthma (Halonen et al., 1997).

The relationships between viable aeroallergens and air pollution at urban environment have not been established and appear to be little studied. Generally, daily exposure to air pollution may impair mucociliary clearance, depresses immune system and increases of airway responsiveness to aeroallergens. So, people who live in urban areas tend to become more affected by respiratory problems than those of rural areas. On the other hand, many factors help develop of respiratory problems such as concentrations, duration of exposure, landing site in respiratory tract, and predisposition**.** People with respiratory and heart diseases, elderly and children are the groups most at risk to particulate matter.

Conclusion

High percentages of fine particulate matter were detected during smog episodes and normal conditions whereas coarse particles were dominant during wind storms. Smoke levels exceeded the limit value during the normal conditions. Open burning of agricultural wastes constituted a small part of the total smoke concentration that covered Cairo during smog episodes, but certainly it plays a role of creating smoke clouds over Cairo during these periods. The vehicle emissions are the main source of smoke in Cairo. Smoke contains many of deleterious compounds that may either kill microorganisms or modify their antigenic properties. There is no accurate data about hospital admission visits during episodes; however, hospital visits for respiratory problems were increased after episodes (personnel communication). Particulate matter and viable aeroallergens may trigger respiratory tract problems in susceptible individuals. Less attention has been paid to naturally occurring particles of biological composition, when evaluating air quality, that they may constitute a large percent of total particles and can have serious adverse effects. So, the question that can be raised here is? Do viable fraction or its by-products associated with particulate matter play a role of health problems during air pollution episodes, even if they are found at low levels? It is suggested that, more studies should be focused on the role of particulate matter viable fraction in respiratory problems among people who live in industrial urban areas. Also, information of biological particles (free or associated with dust) should be included in reports when evaluating urban air quality.

Acknowledgements

To the soul of my professor *Dr. M.M. El-Abagy*, professor of microbiology, Water Pollution Department, National Research Centre, Dokki, Giza, Egypt.

Table 1. The types, numbers (cfu/g) and percentages of the bacterial and fungal isolates during different weather conditions.

Type of microorganisms	Smog episode No.	Smog episode %	Winter storm No.	Winter storm %	Normal condition No.	Normal condition %
Bacteria						
Gr + and rods	25	50	40	58.8	38	65.5
Gr + coccus						
Streptococcus pneumoniae	9	18	0	0	8	13.8
Micrococcus spp	8	16	8	11.8	2	3.45
Micrococcus luteus	8	16	8	11.8	2	3.45
Sarcina	0	0	12	17.6	4	6.9
Staphylococcus	0	0	0	0	4	6.9
Total	***50***		***68***		***58***	
Fungi						
Alternaria	7	13.2	12	10.5	2	1.5
Aspergillus spp	0	0	0	0	63	47
Cladosporium	36	67.9	84	73.7	26	19.4
Penicillium	8	15.1	12	10.5	34	25.37
Rhizopus	2	3.8	0	0	3	2.24
Trichoderma	0	0	0	0	2	1.5
Fusarium	0	0	0	0	1	0.75
Scopulariopsis	0	0	0	0	1	0.75
Yeast	0	0	0	0	2	1.5
Total	***53***		***114***		***134***	

References

1 ABBY DE, HWANG BL, BURCHETTE R ET AL. Estimated long term ambient concentration of PM10 and development of respiratory symptoms in non-smoking population. *Arch. Environ. Health*. 50 (2): 139-152, 1995.

2 ABDEL SALAM MS AND SOWELIM MA. Dust fall caused by the spring khamasin storm in Cairo. *Atmosph. Environ*. 1: 221-226, 1976

3 ABDEL SALAM MS, FARAG SA AND HIGAZY NA. Smoke concentration in the greater Cairo atmosphere. *Atmosph Environ*. 15:157, 1980.

4 ANDERSON M, SVARTENGREN M, PHILIPSON K, CAMNER P. Regional human lung deposition studied by repeated investigations. *J Aerosol Sci*. 25: 567-581, 1994.

5 ANONYMOUS. Public Health Service Reports. Mortality and morbidity during the London fog of December 1952. London Her majesty's stationary office 1954 (Her majesty's Public Service Report No.95 on Public Health and Medical Subjects). (PHS Bulletin No.306).

6 ANONYMOUS. Warren Spring Laboratory, National survey of atmospheric pollution. Tables for calculation of smoke and sulphur dioxide concern. England, 1965.

7 ANONYMOUS. German Standard Methods, DEV, Deutsche Einheitsver Fahren Zur-Wasser-Abwasser und Schalmmuntersung Verlag Chemie, Weinheim, 1984.

8 ANONYMOUS. APHA, American Public Health Association. Standard methods for the examination of water and wastewater 17th ed; APHA Inc. Washington. D.C, 1989.

9 ANONYMOUS. EEAA, Egyptian Environmental Affairs Agency Environmental, Protection Law No.4,1994; EEAA, Cairo,1995.

10 APPLETON JM. Warren spring Lab. Personnel communication 1974.

11 ASAN A, SEN B, SARICA S. Airborne fungi in urban air of Edirne city, Turkey. Biologia 57: 59-68, 2002.

12 BARNETT HL. Illustrated Genera of Imperfect Fungi. Burgess Publishing Company, Minneapolis, Minn, USA, 1972.

13 BELONG CHO, JAEWOOK CHOI AND YOUNG-TAE YUM. Air pollution and hospital admission for respiratory diseases in certain areas of Korea. J.Occup. Health 42: 185-191, 2000.

14 BRUNEKREEF B, HOEK G, FISCHER P, SPIEKSMA FTHM. Relation between air pollen concentrations and daily cardiovascular and respiratory disease mortality. Lancet 335:1517-1518, 2000.

15 CADMAN A, DAMES JF, TERBLANCHE PS AND NEL R. The AIRKEM study in Gauteng South Africa: The role of the airspora in an industrial urban environment. Grana 36:175-179, 1997

16 CARIŃANOS P ,GALAN C, ALCAZAR P AND DOMINGUEZ E. Diurnal variation of biological and non biological particles in the atmosphere of Cordoba, Spain. Aerobiologia; 15: 177-182, 1999.

17 CASS GR AND SHAIR FH. J Geophys. Res.; 89:1429-1438, 1984.

18 CHOUDHURY AH, GORDIAN ME AND MORRIS SS. Association between respiratory illness and PM_{10} air pollution. Archives of Environmental Health 52 (2) :113-117, 1997

19 COX CS. The aerobiological pathway of microorganisms. A Wiley Interscience Publication, John Wiley and Sons Inc., NY, 1987.

20 D` AMATO G, LICCARDI G, CAZZOLA M. Environment and development of respiratory allergy I. Outdoors. Monaldi Arch Chest Dis; 49: 406-411, 1994.

21 D'AMATO G, LICCARDI G, D'AMATO M AND CAZZOLA M. Outdoor air- pollution, climatic changes and allergic bronchial asthma. *European Respiratory Journal*. 30:763-776, 2000.

22 FIRKET J. Fog along the Meuse valley. *Trans Faraday Soc*. 32:1192-1197, 1936.

23 FRIEDLANDER SK, LIPPMAN M. Revising the particulate ambient air quality standard. *Environ. Sci.Tech*. 28: 148-150., 1994.

24 GIEVER PM. Analysis of number and size of particulates. Chapter 21, in A. C. Stern, Air Pollution, 3rd ed., Academic Press, NY, 1976

25 GREGORY DH. The microbiology of the atmosphere. Interscience Publication Inc., N. Y. 20, 1961

26 HALONEN M, STERN DA, WRIGHT AL, TAUSSING LM AND MARTINEZ FD. *Alternaria* as a major allergen for asthma in children raised in a desert environment. *Am. J.of Respiratory and Critical Care Medicine*. 1997, 155: 1356-1361.

27 HANDLEY BA AND WEBSTER AJF. Some factors affecting the airborne survival of bacteria outdoors. *J Appl Bact*. 79: 368, 1995.

28 HARRISON RM AND PERRY R. Handbook of air pollution analysis. 2nd ed., London, NY, Chapman and Hall, 1986.

29 HIRVONEN MR, NEVALAINEN A, MAKKONEN M, MONKKONEN J AND SAVOLAINEN K. Streptomyctes spores from mouldy houses induce nitric oxide, TNFx and IL-6 secretion from RAW264.7 macrophage cell line without causing subsequent cell death. *Environ Toxicol Pharmacol*. 3: 57-63,1997

30 HOLGATE S, SAMET JM, KOREN HS, MAYNARD RL. Air pollution and health. Academic Press, London 1999.

31 HOOD A.M. In fourth International Symposium on Aerobiology, J. F. Ph. Hers and K.C.Wiakler (eds) Oosthoek ,Utrecht ,The Netherlands, pp : 149-151, 1973

32 JUOZAITIS A, WILLEKE K, GRINSHPUN SA AND DONNELY J. Impaction onto a glass slide or agar versus impingement into a liquid for the collection and recovery of airborne microorganisms. Appl. Environ. Microbiol. 60:861, 1994

33 KEIDING LM, RINDEL AK AND KRONBORG D. Respiratory illness in children and air pollution in Copenhagen. Arch Environ Health; 50(3): 20, 1995.

34 LACEY J AND AND CROOK B . Review fungal and actinomycetes spores as pollutants of the workplace and occupational allergens. Ann.Occup. Hyg.32 (4):515-533, 1988.

35 LIGHTHART B, HIATT VE AND ROSSANO AT JR. The survival of airborne *Serratia marcescenes* in urban concentrations of sulfur dioxide. *APCA*. 21(10), 639, 1971.

36 LIGHTHART B AND SHAFFER BT. Airborne bacteria in the atmospheric surface layer: Temporal distribution above grass seed field. *Appl Environ Microbiol*. 61 (4) 1492, 1995.

37 LIGHTHART B. Mini-Review of the concentration variations found in the Alfresco atmospheric bacterial populations, Fourth Joint workshop on Stand of Detection for Chemical and Biological Defence. 26-30 Oct., 1998. Williamsburg,VA, USA; and the 6th International Congress on Aerobiology, 31 Aug-5 Sept., Perugia, Italy.15, 1998

38 MERCHANT JA. Agricultural exposure to organic dusts. *Occup Med. State of the Art Rev*. 2: 409-426, 1987

39 MILLER JD. Fungi as contaminants in indoor air. *Atmosph Environ*. 26A: 2163-2172, 1992.

40 OSTERLEE A, DRIJVER M, LEBRET E, BRUNKEKREEF B. Chronic respiratory symptoms in children and adult living along street with high traffic density. *Occup. Environ.Med*. 53:241-247, 1996.

41 PRITCHARD RJ, GHIO A J AND LEHMANN J R. Oxidant generation and lung injury after particulate air pollutant exposure increase with the concentrations of associated metals. *Inhal Toxicol*. 8: 457-477, 1996.

42 REPONEN T. Aerodynamic diameters and respiratory deposition estimates of viable fungal particles in mold problem dwellings. Aerosol Sci and Tech. 22:11-25, 1995.

43 SANTRA SC, GUPTA S, CHANDA S. Air pollutants and aeroallergens interaction. *Grana*. 30: 63-66, 1991.

44 SCHNELL RC, TAN-SCHNELL SN. Kenya tea litter: a source of ice nuclei. *Tellus*. 34:92-95, 1982.

45 SCOTT E, BLOOMFIELD SF AND BARLOW CG. An investigation of microbial contamination in the home. *J Hyg*. 89:279-293, 1982.

46 SHAFFER BT AND LIGHTHART B. Survey of culturable airborne bacteria at four diverse locations in Oregon: Urban, rural, forest and coastal. *FEMS Microbial Ecol*. 34: 167-177, 1997

47 SEN B, ASAN A. Airborne fungi in vegetable growing areas of Edirne, Turkey. Aerobiologia 17: 69-75, 2001.

48 SHRENK HH, HEIMANN H,. CLAYTON GD, et al. Air pollution in Donora, PA: epidemiology of the unusual smog episode of October, 1948. Preliminary report. Washington DC :US Public Health Service 1949

49 SIVERFSEN B AND AHMED H. Air quality in Egypt: As seen from the EEAA/ EIMP programme. Environment 99, The Second International Conference and Trade Fair for Environmental Management and Technologies, 24-26 Nov: 519-533, 1999.

50 SREERAMULU T. Aerial dissemination of barely loose smut (*Ustilago nudo*). *Trans.Br. Mycol.Soc*.45,373-384, 1962.

51 STURCHIO N, SUTTAN M, SHARKAWAY ME, MAGRABY AE, TAHER A. Concentration and isotopic composition of lead in urban particulate air, Cairo, Egypt, 1996 Argonne National Laboratory, Argonne, IL and Centre for Environmental Hazard Mitigation, Cairo Univ., Egypt, 1997.

52 THORNE PS, KIEKHAEFER MS, WHITTEN P AND DONHAM KJ. Comparison of bioaerosol sampling methods in barns housing swine. *Appl Environ Microbiol*. 58 (8):25, 1992

53 VANDERZANT C AND NICKELSON RI. A microbiological examination of muscle tissue of beef, pork and lamb carcasses. *J Milk and Food Tech*. 32 :357-361, 1969

54 WARK K AND.WARNER CF. Air Pollution, 2nd ed,; p.19. Harper and Row Publishers, NY. 1981.