THE MICROBIAL AND CHEMICAL CONTENTS OF STREET DUST UNDER THE SIZE OF 45 MICRONS

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ABSTRACT: Street dust collected from three different sites in greater Cairo was examined for microbial (bacteria, mold and actinomycetes) and chemical contents (SO_4^{2-}, Cl^- and NO_2^-) of dust ≤45 µm in size. Lead contents of the collected samples were determined using atomic absorption spectrophotometry (AAS). The maximum level of lead was detected at the city Center site (588µg/g). The major source of lead in street dust was automobile emission. The bacteria and molds were the predominant organisms. Most of these organisms are allergenic. The results also show that the chemical compounds influenced the survival of attached microorganisms. The dust compounds may adsorb air pollutants and cause genetic effects. So that the microorganisms may be modified to more pathogenic or more environmental factor resistant.

KEY WORDS: Airborne microorganisms, airborne chemicals, street dust

INTRODUCTION

Street dust is a source of toxic substance, especially heavy metals and viable organisms. Dust is locally generated and dispersed from unpaved and cleanless roads by effects of traffic movement, rain, wind disturbance, and human activities. Contaminated dust may represent a significant pathway of lead and other compounds intake in the exposed people, especially children. Abdel Salam (1977) reported that the particles of a size larger than 20 µm deposited and has direct damage effects upon water resources, land, vegetation, and indirect effects on human health. Airborne lead finds its way into human in the form of settled dust that contaminates food. Young children through their ordinary hand to mouth activities directly ingest dust and thus take in large amounts of lead by this route through street dust. Pica (the habit of eating non-food items) is considered the most common mechanism of lead intoxication in children. Ingestion or inhalation of heavy metals through contaminated food soil surface dust and air has definite hazard effects on human health. The toxicity of street dust will be highly dependent upon the chemical form of the pollutant present.

Airborne microorganisms are also most dangerous to human health and damage of food. The severity of infection depends on the degree of individual and community cleanliness, as well as on the atmospheric content of particulate matter and

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gases (Abdel Salam, 1977). Many respiratory and other health problems associated with bioaerosols (Welch, 1991). Lacey and Dutkiewicz (1994) reported also that airborne fungal spore causes adverse health effects and respiratory symptoms.

Many studies were carried out to determine the relationship between the quantity of suspended dust and viable organisms (Lee et al., 1973; Clark et al., 1983). In contrast, few studies were concerned with the relationship between the microbial and chemical contents of the dust. Dossow and Muller (1988) showed that, agriculture dust Ca^{2+}, CO_3^{2-}, NH_4^+ and humidity influenced the survival of microorganisms. Thorne et al. (1992) reported that components of dust serve as a protectant or absorbers for gases and vapors and affecting microbial life conditions. Moreover, Abdel Hameed (1996) attributed the negative relations between the rate of settled dust and airborne organisms at Cairo city Center to the chemical components of dust and surrounding environment.

The present investigation is aimed to underline the problems of street dust ≤45 µm. The microbial and chemical compounds are examined at different residential and urban areas. The concentrations measured are analyzed statistically to examine the relationship between microbial and chemical contents. Also, to calculate the penetration rate of dust particles that has a potential risk.

MATERIALS AND METHODS

Street dusts have been sampled at three different sites in Cairo, Egypt, in vicinity of *i)* schools (Maadi) *ii)* a hospital (I mbaba) and *iii)* downtown (Galaa street). Collection was by means of gentle sweeping. All samples were passed through a 45 µm sieve to remove particles >45 µm (about 50% road dust samples had size < 45 µm). The physical diameter and the constituent percentages of particles ≤45 µm were measured microscopically according to Stern (1976). The penetration rate was calculated using the following equation according to JAWEM (1991):

$$P = 1 - \frac{D^2}{D_0^1} \ (D < D_o \ \& \ D_o = 7.07\ \mu m)$$

$$P = 0 \quad (D > D_o)$$

where D = particle size.

Six series of 0.1 gm from each sample were dissolved in 100 ml sterilized distilled water. Shaking for about 30–60 min one ml of stock solution was diluted. The surface technique and plate count agar, malt extract agar and starch casein agar (Difco) media were used to determine the counts of bacteria, mold, and actinomycetes, respectively (APHA, 1995). The bacterial plates were incubated at 37 °C for 48 hrs, whereas mold and actinomycetes plates were incubated at 28 °C for 7 days. Thermophilic fungi were incubated at 45 °C for 48 hrs. The mold species were identified microscopically.

Twenty-five ml of stock solution was used to determine lead level. The samples were extracted by a (1:3) mixture of HCl and $HN0_3$. Metal analysis was carried out by using Atomic Absorption Spectrophotometer, flame, at wavelength 283.3 nm, AAS 33000 Parkin Elemer (SCOPE, 1975). The remaining 74 ml of stock solution was filtered. Sulfates, chloride and nitrite ions were determined in the water-soluble portion according to Harrison and Perry (1986).

Statistical analysis

Linear correlation coefficient (r) and correlation significant t test ($P = 0.05$) were determined by Alternative method of calculation according to Gregory (1963). Log transformation of each value x was made as Log $(x + 1)$ (Snedecor and Cochran, 1980).

RESULTS AND DISCUSSION

The microbial and chemical contents of street dust <45 μm collected from the three sampling sites are shown in *Table 1*. The bacterial counts ranged between 10^4–10^6 cfu/g, with a mean value of 10^5 cfu/g. The mold counts varied between 0–10^5 cfu/g. However, the highest mold count was recorded near the hospital site (a mean value of 4.2×10^4 cfu/g), whereas the minimum mold count was found at El Maadi (a mean value of 1.6×10^4 cfu/g). In contrast, the highest count of actinomycetes was detected at El Maadi site, whileas it was not detected in dust collected from Imbaba. Generally, actinomycetes were recorded in low counts, they ranged between 0–10^4 cfu/g. These results are in agreement with Jones and Cookson (1983) who detected fungi in lower levels than bacteria in Washington. Clark et al (1983) stated that the viable fraction of bacteria and fungi are associated with larger dust particulate, which settled easily on roadsides. Dust particles carry microorganisms which reenter the atmosphere and may deposit themselves on the upper respiratory system (Jawetz et al., 1987). So, airborne organisms are most dangerous to human health.

The types and percentages of mold dominant of dust particle ≤45 μm are summarized in *Table 2*. *Cladosporium* (34.6%) is the predominant mold spore. *Penicillium* and *Aspergillus niger* constituted 19.2% and 15%, respectively. Moreover, *Aspergillus fumigatus* (invasive fungal agents), *Aspergillus versicolor, Alterneria* and *Monosporium* were found in percentages of 7.6%, 3.8%, 3.8%, and 15%, respectively. This finding is in agreement with Reponen (1995) who stated that *Cladosporium* mainly originates from outdoors. In contrast, *Penicillium* and *Aspergillus* are of indoor sources (Flanknigan et al., 1991). Generally, *Cladosporium, Alterneria,* and *Aspergillus* are allergenic agents (Juozaitis et al., 1994).

Table 1 shows the concentrations of SO_4^{2-}, Cl^-, NO_2^- and Pb^{2+}. Sulfates were found to be the major constituent of street dust. Sulfates concentrations were ranged between 6–38 mg/g. The Highest concentrations were detected at Imbaba and El Galaa sites (a relatively mean value of 24 mg/g), whilst the lowest level was detected at El Maadi site (a mean value of 13.7 mg/g). This finding is in agreement with Shakour (1992) who recorded high levels of SO_4^{2-} and NO_3^- at urban areas. She added that the industrial and combustion processes are the main sources of

SO_4^{2-}. Autoexhaust is a major source of sulfate, since 2% of the fuel sulfur burned in diesel engines emitted is in the form of sulfate (Truex et al., 1980). Sulfate is formed from oxidation of atmospheric H_2S and SO_2 in the presence of NH_3 (Radojevic and Harrison, 1992). Zeki (1985) found a positive relationship between SO_4^{2-} and SO_2 in foggy conditions. Shakour and Zekey (1998) reported that both types of SO_2 oxidation, i.e. aqueous droplet and photochemical reaction may take place in Cairo atmosphere.

TABLE 1. The range and the mean concentrations of microbial and chemical contents of dust at sampling sites.

	Microbial parameters			Chemical parameters			
	TVBC cfu/g	Mold cfu/g	Actino cfu/g	SO_4^{2-} mg/g	Cl^- mg/g	NO_2^- µg/g	Pb^{2+} µg/g
El Maadi	8.5×10^4–1.5×10^6 (4.9×10^5)	0–5×10^4 (1.6×10^4)	0–5×10^4 (8.3×103)	6–20 (13.7)	4–7 (5.7)	13–22 (16)	152–500 (375)
Imbaba	2.8×10^5–1×10^6 (4.9×10^5)	0–7.5×10^4 (4.16×10^4)	0 (0)	17–38 (24.8)	5–7 (6)	0–11 (5)	115–349 (215.7)
El Galaa	4×10^4–5.1×10^5 (2.2×10^5)	0–1.2×10^5 (3×10^4)	0–1.6×104 (2.6×103)	17–32 (24)	6–11.2 (8.3)	0–8 (3.6)	200–588 (354)

–: range
( ): mean
cfu: colony forming unit
TVBC: total viable bacterial counts
Actino: Actinomycetes

TABLE 2. Identification of mold isolates

Isolate	No.	%
Alternaria	1	3.8
Aspergillus niger	4	15
Aspergillus versicolor	1	3.8
Aspergillus fumigatus	2	7.6
Monosporium	4	15
Cladosporium	9	34.6
Penicillium	5	19.2
Total	26	

Chlorides were the minor constituents of street dust. The mean concentration of chloride ranged between 8.3–5.7 mg/g. The highest levels were recorded at El Galaa and Imbaba sites with high traffic density. These results are in agreement with Shakour (1992), who found chloride in high percentages at urban region compared with rural area.

Nitrite was recorded in low concentrations compared with the other previous components. It ranged between 0–22 μg/g *(Table 1)*. The highest level was found at El Maadi (a mean value of 16 μg/g), whereas the lowest levels were detected at Imbaba (a mean value of 5 μg/g) and El Galaa (a mean value of 3.6 μg/g). It is suggested that the low concentration of NO_2^- may be due to the fact that it is an intermediate oxidation state, and the half-life of NO_2^- is very short. Nitrites are generated in the atmospheric from oxidation of NO_2. Autoexhaust is the main source of NO_2 in Cairo city atmosphere. Oxidants, hydrocarbons and photochemical reactions accelerate the oxidation of NO_2^-. This finding confirms the lower concentration of NO_2^- in the city center. In addition, Khoder (1997) stated that ozone and oxidants lead to speed up the oxidation processes of NO_2^- to NO_3^-. Generally, the chemical composition of dust is related to the atmospheric chemistry.

Lead was found in the range of 115–588 μg/g. The maximum mean of lead concentration was recorded at El Maadi (a mean value of 375 μg/g), whereas the lowest one was recorded at Imbaba site (a mean value of 215.7 μg/g). The mean concentrations of lead in Cairo street dust exceed much the levels of sediment collected from Canada but it is still lower than that found in London (Stone and Morsalek, 1996). These data suggest that autoexhaust is an important source of the metal especially at the city center site, meanwhile, at El Maadi traffic exhaust besides the metal emitted from industrial activities and batteriy factories is the main source. This suggestion is confirmed by Yousefi and Rama (1992). They stated that the locality of the site and the surrounding, meteorological, geographical and geological factors are major factors for accumulation of contaminants.

TABLE 3. The percentages at sampling sites and the penetration rate of particle size ≤45 μm

Particle size	El Maadi %	Imbaba %	El Galaa %	P
1.20	6.49	9.78	0	0.83
1.70	14.28	13.04	1.25	0.76
2.50	13.00	17.40	5.00	0.65
3.50	10.40	22.80	11.25	0.50
4.95	9.10	16.30	25.00	0.30
7.07	14.28	8.70	12.50	0
10.00	15.60	6.50	17.50	0
14.10	5.20	2.10	8.75	0
20.00	7.80	3.26	5.00	0
>20.00	3.90	0	13.75	0

P: (penetration rate): rate of the particle pass through separator

Lead is a well known toxicant. Lead poisoning leads to disastrous effects on mental development and causes brain damage (Klein, 1974). There is evidence that blood lead even in low level associated with high risk of failure at school and affection of intelligence (Hilxe et al., 1993). Dust particles > 10 μm reach the nose or throat. However, very tiny particles may reach deep into the lung and if absorbed into the blood stream they cause lung and health problems especially for children and patients. Recognizing the significance of penetration of the particles, *Table 3* illustrates the penetration rate. This table shows that the penetration rate increased as particle size decreased. A maximum penetration rate of 0.83 was recorded for a particle size of 1.2 μm, whereas a minimum rate of 0.3 was recorded for particle size 4.95 μm. This table also shows that relatively high percentage concentration of particle size of 3.5 μm was recorded in the collected samples at the three sites which have a penetration rate of 0.5. Disturbance of settled dust by the action of wind or vehicle movement led to dispersion of large amounts of wide range particle sizes. These particles carry many microbial and toxic chemical compounds.

The correlation coefficients between the microbial and chemical parameters are shown in *Table 4*. Negative correlation was detected between chemical and microbial indicators at all sampling sites, except with nitrite and mould at El Maadi site (r = –0.19). The differences of relations may be explained due to the absorbed behavior affinities between components and solid surface adsorption. Nitrite was found in less toxic compounds as well as mold which is more resistant to NO_2^- than bacteria. Another factor is the effects of Open Air Factor, OAF (ozone + olefins) which is photochemical smog (Cox, 1987). This factor is found in high levels at downtown and Imbaba site, due to high hydrocarbon emission from vehicle exhaust. The results in the present study are confirmed by many investigators. Won and Ross (1969) found that the increase of SO_2 gas in urban area leads to the formation of a toxic and lethal compounds of H_2SO_4. Also Thompson (1987) stated that, SO_4^{2-} in air increases acidity and leads to decreased activity of microorganisms. Chlorides react with many pollutants such as gases, heavy metals, hydrocarbons, olefins and ketons to form very toxic chlorinated hydrocarbon compounds (Abdel Hameed, 1996). Moreover, the degree of inhibition of CO_2 evaluation (respiration) from microorganisms depends on the degree of toxicity of a metal (Hattori et al., 1992).

TABLE 4. The correlation coefficients (r) between bacterial, mold counts and concentration of chemical components at sampling sites

Site:	El Maadi		Imbala		El Galaa	
Parameter	Bact.	mold	Bact.	mold	Bact.	mold
SO_4^{2-}	–0.71	–0.26	–0.28	–0.34	–0.125	–0.89*
Cl^-	–0.50	–0.01	–0.89*	–0.50	–0.05	–0.27
NO_2^-	–0.57	+0.19	–0.80	–0.60	–0.96*	–0.14
Pb^{2+}	–0.04	–0.19	–0.48	–0.66	–0.64	–0.23

* Significant (p < 0.05)

CONCLUSION

Microbial and chemical constituents of dust particles are distributed throughout the atmosphere. Smaller particles with a size less than 45μm remain airborne for a considerable time in turbulent air, which can enter the body by inhalation. It can be concluded that autoexhaust is the major source of street dust components. The components of dust affect the survival of microorganisms. The type of components not their levels effect the survivability. The adsorption of air pollutants by dust particles may cause undesirable effects or altered allergenic potential of airborne microorganisms. The chemical components may modify an organism to an environmentally more resistant and pathogenic one. Moreover, the locality of the site and the surrounding environment affect the magnitude of contaminants. Street dust is a nuisance to human health, and it is recommended that continuous washing and removing as well as street pavement should be realized. These will decrease the dust resuspension and dispersion.

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