American Journal of Environmental Sciences 6 (2): 184-190, 2010
ISSN 1553-345X

Associated Health Effects among Residences Near Jeleeb Al-Shuyoukh Landfill

[1]K. Schrapp and [2]N. Al-Mutairi
[1]Marshall University Joan C. Edwards School of Medicine,
1600 Medical Center Drive, Huntington, WV 25701
[2]Department of Civil Engineering, Kuwait University, P.O. Box 5969, Safat 13060, Kuwait

Abstract: Problem statement: There is growing concern about landfill adverse health effects from exposure to landfill emissions. **Approach:** Airborne dust samples from houses near Jeleeb Al-Shuyoukh landfill and control residences were analyzed for molds and bacteria and Volatile Organic Compounds (VOCs) each month for one year. **Results:** The number of mold species was greater in the residences close to Jeleeb Al-Shuyoukh landfill than in the control. A number of additional VOCs irritating to the skin, eyes, or respiratory tract were also found. **Conclusion:** The results from this pilot study illustrated the diversity of microorganisms and VOCs present in Jeleeb Al-Shuyoukh environment and suggested that analysis of airborne dust may help assess human exposure to microorganisms and chemical compounds. In addition, a cross-sectional study was explored in Jeleeb Al-Shuyoukh and Al-Jahra residence, through a series of door-to-door survey of 451 residents. The findings of the health survey indicated a higher prevalence of dermatological, neuromuscular, respiratory and gastrointestinal symptoms among people living in the area surrounding the landfill than among the control group's participants. Furthermore, the hygienic survey indicated a high amount of airborne dust, bacteria and fungi within the breathing zone of the residences near the landfill.

Key words: Airborne microorganisms, volatile organic compounds, health, landfill

INTRODUCTION

Jeleeb Al-shuyoukh landfill site is approximately 5.5 km^2 and is located in Al-Farwanyah, Kuwait, an area that is primarily rural. There are 5000 residences located within one-kilometer of the northwest of the landfill. This site is considered to be the largest existing landfill in Kuwait. Industrial, commercial and Municipal Solid Wastes (MSW) are generally mixed throughout the fill area, with the exception of construction and demolition and sludge waste which were generally restricted to the south eastern half of the landfill. In 1992, the Jeleeb Al-Shuyoukh landfill received about 58% of the total domestic waste in Kuwait, equivalent to about 180 collection trips per day (Al-Mutairi, 2004).

Jeleeb Al-Shuyoukh landfill, which is a government owned, was licensed by Kuwait Municipality to dispose MSW from 1980-1992. In October 1992, the representative of Jeleeb Al-Shuoukh and its governor presented to Kuwait's National Assembly and the Municipality of Kuwait a complaint regarding the hazardous effects of the landfill site. The public's discomfort from the bad odors emanating from the landfill site had motivated them to act and to request the prevention of improper disposal operations which would cause great health complications in the near future. The main environmental effects are the uncontrolled emission of landfill gases and the migration of gases and leachate beyond the landfill site's boundaries, which may cause problems in the groundwater or nearby housing structures. Such public/government reaction and the growing concern of the society towards improper disposal operations are positive indications of the need for an effective environmental systems (Al-Mutairi, 2004).

Health impact of landfills: Due to a growing awareness of landfills impact on the environment together with the introduction of more stringent regulations, uncontrolled open dumps commonly found two decades ago are disappearing and being replaced by well engineered sanitary landfills. With increasing research and engineering input devoted to landfill design and management, modern sanitary landfilling is fast becoming a state-of-the-art technology.

In the past, a number of uncontrolled open-spaces were used as landfill sites in Kuwait. These locations,

Corresponding Author: K. Schrapp, Marshall University Joan C. Edwards School of Medicine, 1600 Medical Center Drive, Huntington, WV 25701

which were poorly managed by unprofessional municipality staff, constituted breeding grounds for vermin and flies. Such operations are banned nowadays and currently, modern mechanized vehicles transport wastes to somewhat controlled landfills. According to United Nations Development Programme (1991), it is estimated that 5 million people die annually from the improper disposal of society's wastes.

The wastes were left uncovered and untreated in all Kuwaiti dump sites, leaving the refuse open to the full effects of the elements. Often, neither the existence nor the use of the dump was authorized and there was no government supervision. There was little or no effort made to compact or cover the waste and no regard was given to pollution control measures or aesthetics. In addition, fire could occur spontaneously, but more often, the fire was purposely set in an attempt to reduce the volume at a dump or destroy the food that attracts rodents and insects.

There are two major sources of contaminants in municipal landfills and dumpsites: leachate and landfill gas. Each is composed of different contaminants and each poses its own set of management burdens for the development of a landfill. Together, they can affect the soil, ground water and air in and around the landfill sites, many times years after the landfill has been closed. In addition to these, there are also buried materials which may also contribute to contamination. The organic strength of landfill leachate can be greater than 20-100 times the strength of raw sewage. This could be potentially a potent polluter of soil and groundwater. The majority of open dumps and old sanitary landfills in Kuwait do not have liners or proper drainage systems to divert the leachate. The leached material could be absorbed into the ground and then possibly move into groundwater (Al-Mutairi, 2004).

Furthermore, the landfill odor that many people recognize from older landfill sites is the result of landfill gases. Emissions of potentially carcinogenic organic chemicals and airborne bacteria and fungi have been detected from landfills. Benzene and vinyl chloride have been detected at landfills sites in California, Wisconsin and New Jersey (Harrison, 2001). At landfills, concentrations of these bio-aerosols can be hundreds to thousands times higher than that of clean environments (Shusterman, 1992). Elevated concentrations of bacteria and fungi in the air at municipal waste landfills pose a health risk to inhabitants of the neighboring areas. Most of these micro-organisms are infectious and affect the respiratory tracts of exposed persons. The immunotoxic and allergic mechanisms responsible can therefore cause the organic dust toxic syndrome and allergic alveolitis (Dolk *et al*., 1998).

Recent epidemiological research has suggested a probable link between living within 2-3 km of a landfill site and the occurrence of some diseases (Gergen and Weiss, 1992). The nature of these diseases (Down's syndrome and some birth defects) has given this study a high profile. A number of other epidemiological studies have shown that the incidence of allergic and other hypersensitivity conditions has increased over the last 30-40 years, particularly in developed countries (Kimber, 1998). The reasons for this increase are not clear. There is a rising concern about the role of environmental factors (Pope *et al*., 1993).

Numerous studies have observed that particulate air pollution can be associated with respiratory symptoms (Salvaggio, 1994) and that indoor dust particles may be associated with mucous membrane irritation and odor annoyance (Lebowitz *et al*., 1992). One potential cause for this may be that dust particles adsorb great quantities of gases and other volatile compounds from the air (Cooley *et al*., 1998), which may be irritating and cause odor aggravation. Both molds and bacteria have been linked to adverse health effects in several studies (Koskinen *et al*., 1999; Garrett *et al*., 1998). Alternaria, Penicillum and Aspergillus have been associated with asthma and atopy (Larsen, 1994) and allergens such as Alternaria, Ulocladium, Stemphylium, Cladosporium and Aspergillums have been recognized in several molds ordinarily found in the indoor environment (Burrell, 1991). Mold spores can cause acute conditions such as aspergillosis in immuno-compromised patients (Gelberg, 1997). Bacteria, too, present a danger since they contain toxic cell wall components such as endotoxin and peptidoglycan.

There are numerous studies published on the microbiological exposure of workers who have direct contact with solid waste during its collection, processing and disposal (Lopez and Salvaggio, 1987). However, data on indoor bio-aerosols and health risks to nearby residences to municipal waste landfills is insufficient. The current study was undertaken by the authors to measure Jeleeb Al-Shuyoukh landfill emissions over a full annual cycle and therefore provide improved information on the presence of compounds which could possibly impact on local residents. Therefore, the goal of this study was to evaluate the influence of a municipal waste landfill on microbiological air quality in buildings located nearby to Jeleeb Al-Shoukh landfill area. The second goal of this study was to evaluate the severity and frequency of current health-related symptoms incurred by an exposed population and compared to those of an unexposed control population.

MATERIALS AND METHODS

Airborne dust was sampled in forty residences. Control residences were ordinary residences in Jahra City with no problems or complaints from their inhabitants and were selected so that the sampling could be done simultaneously with one control for each affected residence. Jeleeb Al-Shuyoukh landfill is one of the largest in Kuwait was selected for this study. Bioaerosol measurements were made at forty indoor and forty outdoor sampling locations. Outdoor sampling was conducted in the houses area near the landfill. Sampling was performed three times monthly during the summer and winter season. Outdoor samples were taken downwind during dry days.

Air samples were taken for 5 min, using a six-stage Andersen impactor. This sampler separates particles by aerodynamic diameter into six fractions that are impacted onto the surface of agar plates. Each of the fractions relates to the determined part of the human respiratory system. The “respirable fraction” (particles smaller than 5 µm) is able to penetrate into the alveoli. The sampler can distinguish respirable fraction of diameter smaller than 4.7 µm. Airborne bacteria were collected on trypcase soy agar and airborne fungi on 2% malt extract agar. Petri dishes were incubated for 7 days at room temperature. The microbiological concentration levels were calculated as CFU m^{-3} after correction using the positive whole conversion table. The identification of bacterial strains was conducted using BIOLOG tests.

The dust samples were extracted with sterile particle free 0.01% Tween-80 solution for 3 min at 23°C. The extract was then analyzed for total, viable and metabolically active-esterase-positive micro-organisms. The total bacterial and fungal biomass was determined as alcidine orange-stained particles, while the viable fraction was determined as colony-forming units on malt extract agar for fungi and on tryptone glucose extract agar for bacteria. The esterase positive fraction was determined as fluorescent cells after staining with fluorescent dictated. In addition, volatile organic compounds adsorbed on the dust were analyzed using GC-MS. Dust samples (5-10 mg) were transferred to glass tubes and secured with silica wool plugs. The Sigma Stat version 2.03 program was applied (SPSS Inc, Chicago, IL, USA). The t-test was used to show the probability that the two samples had a significant difference ($p<0.05$) in means.

RESULTS AND DISCUSSION

Table 1 show the total number of molds and bacteria as well as colony-forming units and esterase positive cells in the airborne dust samples from Jeleeb Al-Shuyoukh and control residences. There was a significant differences between the two types of residences ($p<0.05$ in all cases). A larger number of microbial genera and species were found in the samples from houses near the landfill (n = 40) than from the controls (n = 40). The fungal species identified in each sample were shown in Table 2. Overall, *Apergillus*, *Penicillin*, *Candida* and *Mucor* dominated. Three species were found in both type of residences, but more than seven mold genera were found only in residences near the landfill. The bacteria found in all the residences were similar except *Pasteurella*, *Streptomyces* and *Bacillus mycoides*, which was found only in residences near the landfill (Table 2). Some species of bacteria and fungi isolated in this study are known to induce extrinsic allergic alveolitis such as *Aspergills* sp., *Circinella* sp., *Fusarium* sp. and *Mucor* sp. (Lacey, 1975). Other fungi are also known to be potentially pathogenic for mankind. These include *Aspergillus* sp., *Scopulariopsis* sp., *Mucor* sp. and *Candida* sp. (Gelberg, 1997).

Volatile organic compounds: Twenty random existing boreholes in Jeleeb Al-Shuyoukh landfill was chosen for sampling. Various VOCs were detected at relatively high concentrations at each borehole. They included: Acetone, benzene, ethyl benzene, methane, toluene, 1, 1, 1-trichloroethane, vinyl chloride and total xylenes. In addition, many other chlorinated aliphatic compounds were detected. The presence of many of these compounds suggests that solvents and petroleum products were contained within the waste (Table 3). Other VOCs detected may be the end products of degradation of organic waste fractions. For instance, vinyl chloride is commonly detected in landfill gases and is a recognized degradation by-product of various chlorinated aliphatic compounds used as solvents.

Table 1: Median numbers of molds and bacteria per 10^{-7} g in airborne dust from Jeleeb Al-Shuyoukh residences and controls

	Molds		Bacteria	
Number 10^{-7} g dust	Jeleeb Al-Shuyoukh	Control	Jeleeb Al-Shuyoukh	Control
Total number	100±15	14±3.0	151±26	21±5
Colony forming units	41±9	3±0.5	60±6.0	29±6
Esterase positive cells	52±3	7±2.0	40±2.6	ND

Table 2: Colony-Forming Units per g dust (CFU per g) of major molds in airborne dust from residences near the landfill and control residences

	CFU per g			CFU per g	
Molds type	Residences near the landfill	Control residences	Bacteria type	Residences near the landfill	Control residences
Aspergills sp.	3×10^7	2×10^3	*Acinetobacter* calcoaceticus	2×10^6	2×10^2
Circinella sp.	9×10^4	1×10^3	*Pseudomonas* sp.	6×10^5	5×10^3
Fusarium sp.	4×10^2	ND	*Moraxella* sp.	2×10^3	4×10^2
Candida sp.	7×10^6	ND	*Pasteurella* sp.	4×10^7	ND
Mucor sp.	4×10^6	ND	*Streptomyces*	2×10^7	ND
Penicillium sp.	2×10^7	2×10^3	*Bacillus mycoides*	2×10^4	ND
Scopulariopsis sp.	4×10^2	ND	*Bacillus*	3×10^6	4×10^2
Others	2×10^2	ND	Others	1×10^3	2×10^2

Table 3: Average VOCs (ppbv) and methane (% by volume) detected inside the boreholes Jeleeb Al-Shuyoukh landfill for the summer and winter seasons

Compound	"Summer" concentration	"Winter" concentration
Acetone	68300.0	37100.0
1, 1-Dichloroethylene	1200.0	1000.0
Ethylbenzene	821.0	420.0
Methylene Chloride	5178.0	198.0
Styrene	519.0	282.0
Trichlorofluoromethane	1120.0	960.0
Trichloroethene	220.0	100.0
Toluene	17333.0	12000.0
Tetrachloroethene	240.0	180.0
4-Methyl-2-Pentanone	6398.0	5842.0
Vinyl Chloride	5691.0	4719.0
Benzene	767.0	490.0
Chlorobenzene	1028.0	210.0
Chlorethane	670.0	429.0
Methane	21.1	25.5

Table 4: MVOCs (ppbv) present in airborne dust from residences near the landfill and control residences

MVOC	Residences near the landfill (n = 40)	Control (n = 40)
1, 3-octadiene	95	25
1-Hexanol	35	25
1-Octanol	96	10
1-Octen-3-ol	18	0
2, 3, 5-Trimethylfuran	24	0
2-Ethyl-1-hexanol	31	61
2-Hexenal	84	41
Acetic acid	99	70
Acetone	100	32
Benzaldehyde	89	51
Cyclopentanone	41	12
Heptane	30	35
Hexanal	0	24
Methyl acetat	51	0
Nonanal	92	0
Octanal	89	0
Pinene	0	25

The observed spatial variations among emission rate measurements at Jeleeb Al-Shuyoukh Landfill site was presented along a landfill surface. These variations can be attributed to differential landfill settlement, diversity in volunteer vegetation species, erosion, surface pounding and rooting of wild animals. In order to measure total landfill gas emissions, therefore, a needs of point data integration must be developed. The results indicate that there is also a variation in emission rates over time at the twenty boreholes. Increased precipitation may temporarily reduce the soil permeability of a landfill cover. The change in permeability of the landfill cover may be highly variable from place to place due to the heterogeneous nature of the surface. Areas which are rendered more impervious will experience a decrease in emissions at the surface while the emissions seek the path of least resistance and thus vent out in the better drained areas of the landfill surface.

VOC dust analysis: A total of 112 chemical compounds were recognized in the dust samples through GC-MS library searches. Among the compounds thus found, two groups of particular interest: (i) compounds characterized as of microbiological origin (MVOCs) by Sunesson *et al*. (1995), presented in Table 4 and (ii) compounds identified as irritants by skin, eye, or respiratory route. MVOC's have been determined to be an indicator of mold growth because their presence is associated with actively growing mold. Most of the MVOC identified were present in dusts of both types of residences. However, 1-octen-3-01, 2, 3 and 5-trimethylfuran, methyl acetate, Nominal and Octane were found only in dust from residences near the landfill. By contrast, hexane and pinned were found only in samples from control residences (Table 4).

The concentration of molds and bacteria was elevated in airborne dust from residences near the landfill than from the controls. In addition, the samples from residences near the landfill and controls differ also with regard to numbers of colony forming units or esterase-positive cells. On the other hand, the number of genera and species in the dust from residences near the landfill was higher than in controls, indicating that high microbial content in a residence air promotes a more diversified microbial flora. Seven mold genera and species were found only in residences near the landfill but four was present in all of the control.

Furthermore, nineteen compounds classified as irritants by skin, eye, or respiratory route were identified on airborne dust (Table 5). Apparently, the amounts of irritants were sufficiently high to have an impact on the residents. There were also differences between both type of residences with respect to irritant patterns in the dust. Some irritants were found in all residences, e.g., Hexanal, Nonane, Benzaldehyde, Hexanoic acid and Octanoic acid compound originating from the common industrial and human origin (Table 5).

Two hundred and forty residents were selected from houses around the landfill and from the control participated in the survey. Out of residents approached to participate in this study (more than 590 residents), 240 responded, yielding a 50% response rate. The main age for residents living near the landfill was 37 years; for the control group it was 34 years. Demographic data revealed that there significant differences were detected between past and current smoking levels for both groups. Table 6 summarizes the demographic data for both groups.

The survey instrument employed in this study was developed from Gelberg's questionnaire (Gelberg, 1997). The survey examined participants' health-related symptoms. Descriptive statistics were computed to identify sample characteristics. Reported symptoms were combined into five composite variables based on previous research: dermal, gastrointestinal, neurologic, neuromuscular and respiratory.

Chi-squared tests were used to assess differences between the symptoms reported by both groups. The odds Ratios (ORs) and 95% Confidence Intervals (CIs) were calculated to compare the prevalence of specific symptoms in the two groups. Chi-squared analyses revealed significant variation in the frequency of specific symptoms reported between both group; this finding pertained to all five characteristics (Table 7; $c^2 = 3.21$, $p = 0.04$). Odds ratios calculated for each specific symptom showed that symptoms were more prevalent among people living in the area surrounding Jleeb Al-Shoukh landfill (Table 7). The people living close the landfill reported more respiratory, neuromuscular, neurologic and dermatologic symptoms.

The data showed that there was a significant relation between living close to Jeleeb Al-Shoukh landfill and Nausea, OR = 13.3 (95% CI 3.48-50.7); Recurring headaches, OR = 1.48 (95% CI 0.73-3.0); daily tiredness, OR = 1.75 (95% CI 0.45-6.15); trouble concentrating, OR = 11.3 (95% CI 2.48-40.7) and muscle weakness, OR = 1.28 (95% CI 0.84-2.0). In addition, the association were positive and significant for all respiratory symptoms, OR range from 1.2-13.3.

Table 5: Irritants present in airborne dust from residences near the landfill and control residences

	Percentage in airborne dust	
Irritant	Residences near the landfill (n = 40)	Control (n = 40)
2-Methylpropanal	71	0
Acetic acid	11	0
3-Penten-2-one	29	5
Propanoic acid	96	0
1, 2-Propanediol	30	0
Butanoic acid	29	0
Hexanal	71	59
2-Furanmethanol	11	0
Pentanoic acid	29	0
Nonane	95	21
Pinene	20	0
6-Methyl-5-hepten-2-one	56	0
Benzaldehyde	81	31
Hexanoic acid	65	11
2-Ethyl-1-hexanol	32	16
1-Methyl-2-pyrrolidinone	11	0
2-Undecenal	54	0
Octanoic acid	32	72
1-Nonanol	15	0

Table 6: Demographic and behavioral characteristics of residences near the landfill and control group

Age				
Characteristics	Residences near the landfill (n = 270) (%)	Control group (n = 220) (%)	Odds ratio	95% confidence interval
Age				
30	15	11		
31-50	45	44		
51+	40	45		
Ever smoked cigarettes				
Yes	39	49	1.21	0.61-2.00
No	41	39		
Currently smoke cigarettes				
Yes	38	39	0.51	0.42-1.11
No	39	37		
Number of cigarettes				
1-10	9	16	10.2	2.22-19.5
15+	12	9		

Table 7: Prevalence and risk of symptoms among respondents near the landfill and control group, as measured by odds ratio

Characteristics	Residences near the landfill (n = 270) (%)	Control group (n = 220) (%)	Odds ratio	95% confidence interval
Dermal				
Skin rash or hives	61	33	0.90	0.28-3.65
Scaly or itching skin	41	12	0.78	0.53-11.0
Unusual acne	51	23	0.48	0.13-3.00
Skin patches	48	19	0.79	0.45-3.17
Boils, warts, or cysts	72	42	0.63	0.31-1.28
Gastrointestinal				
Nausea	25	12	13.30	3.48-50.7
Diarrhea	61	33	0.77	0.41-9.40
Neurologic				
Recurring headaches	51	23	1.48	0.73-3.00
Daily tiredness	48	19	1.75	0.45-6.15
Dizziness	72	42	0.63	0.31-1.28
Memory problems	55	23	0.92	0.46-10.6
Trouble concentrating	25	12	11.30	2.48-40.7
Balance problems	56	9	0.65	0.36-2.10
Neuromuscular				
Tremors or cramps	41	12	0.95	0.87-1.70
Muscle weakness	51	23	1.28	0.83-2.00
Tingling numbness or whiteness of fingers	48	19	0.90	0.75-1.34
Problems with joints	72	42	0.63	0.31-1.28
Backaches	55	23	0.81	0.79-1.75
Respiratory				
Attacks of bronchitis	61	33	1.27	0.84-1.94
Shortness of breath	41	12	1.21	0.85-1.74
Daily phlegm/cough	48	19	1.64	1.12-2.43
Tightness in chest or difficulty in breathing	72	42	1.63	0.31-1.88
Flulike symptoms	55	23	1.42	0.94-2.13
Nasal stuffiness	25	12	13.30	3.48-50.7
Bloody nose	56	9	1.81	0.71-12.2

According to odds ratios, Jeleeb Al-Shuyoukh residences were more likely to experience shortness of breath, daily phlegm or cough, tightness in the chest or difficulty in breathing and nasal stuffiness. In addition, the prevalence lingling, numbness or whiteness of fingers; problems with joints and backaches; daily tiredness, dizziness and balance problems and recurring headaches were significantly higher among Jeleeb Al-Shuyoukh residences than in the control group.

CONCLUSION

The conclusiveness of the findings are:

- The results demonstrate the elevated concentration of VOCs in airborne dust in all of the residences near Jeleeb Al-Shoukh landfill and suggest that analysis of airborne dust may give important clues to the human exposure to microorganisms and chemical compounds in the indoor environment
- This study clearly demonstrated significant differences in the health symptoms between people living near the landfill and the control
- The people living near the landfill were exposed to higher number of fungi and bacterial concentrations in the dust samples than in samples collected from the control
- The high bacterial concentration in the dust samples in the area surrounding the landfill could explain the significant number of dermatological problems such as unusual acne, warts, cysts and itching skin

REFERENCES

Al-Mutairi, N., 2004. Biological, chemical and physical assessment of Jeleeb Al-Shuyoukh landfill. Final Report. Kuwait Environmental protection agency.

Burrell, R., 1991. Microbiological agents as health risks in indoor air. Environ. Health Perspect., 95: 29-34. PMID: 1669959

Cooley, J.D., W.C. Wong, C.A. Jumper and D.C. Straus, 1998. Correlation between the prevalence of certain fungi and sick building syndrome. Occup. Environ. Med., 55: 579-584. PMID: 9861178

Dolk, H., M. Vrijheid, B. Armstrong, L. Abramsky and F. Bianchi, 1998. Risk of congenital anomalies near hazardous-waste landfill sites in Europe: The EUROHAZCON study. Lancet, 352: 423-427. PMID: 9708749

Garrett, M.H., P.R. Rayment, M.A. Hooper, M.J. Abramson and B.M. Hooper, 1998. Indoor airborne fungal spores, house dampness and associations with environmental factors and respiratory health in children. Clin. Exp. Allergy, 28: 459-467. PMID: 9641573

Gelberg, K., 1997. Health study of New York City department of sanitation landfill employees. J. Occup. Environ. Med., 39: 1103-1110. PMID: 9383721

Gergen, P.J. and K.B. Weiss, 1992. The increasing problem of asthma in the United States. Am. Rev. Respir. Dis., 146: 823-824. PMID: 1416404

Harrison, R.M., 2001. Health risks of Residence in the Vicinity of a Landfill Site. Evidence Prepared for Submission to a Public Inquiry to Consider Proposals by Minosus Ltd for a Waste Disposal Facility at Winsford Salt Mine, Bostock, Middlewich, Cheshire, pp: 18.

Kimber, I., 1998. Allergy, asthma and the environment: an introduction. Toxicol. Lett., 102-103: 301-306. PMID: 10022270

Koskinen, O.M., T.M. Husman, T.M. Meklin and A.I. Nevalainen, 1999. The relationship between moisture or mould observation s in houses and the state of health of their occupants. Eur. Respir. J., 14: 1363-1367. PMID: 10624768

Lacey, J., 1975. Potential hazards to animals and man from microorganisms in fodders and grains. Trans. Br. Mycol. Soc., 65: 171-184. DOI: 10.1016/S0007-1536(75)80001-5

Larsen, L., 1994. Fungal Allergens. In: Air Quality Monographs, Health Implications of Fungi in Indoor Environments, Samson, R.A., B. Flanningan, M.E. Flanningan, A.P. Verhoe, O.C.G. Adan and E.S. Hoekstra (Eds.)., Elsevier, Amsterdam, pp: 215-220.

Lebowitz, M.D., J.J. Quackenboss, M. Krzyzanowski and M.K. O'Rourke, 1992. Multipollutant exposures and health responses to particulate matter. Arch. Environ. Health, 47: 71-75. PMID: 1540007

Lopez, M. and J. Salvaggio, 1987. Epidemiology of hypersensitivity pneumonitis/allergic alveolitis. Monogr. Allergy, 21: 70-86. PMID: 3317002

Pope, A.M., R. Patterson and H. Burge, 1993. Indoor Allergens. National Academy Press, Washington DC.

Salvaggio, J.E., 1994. Inhaled particles and respiratory disease. J. Allergy Clin. Immunol., 94: 304-309. DOI: 10.1016/0091-6749(94)90090-6

Shusterman, D., 1992. Critical review: The health significance of environmental odor pollution. Arch. Environ. Health, 47: 76-87. PMID: 1540008

Sunesson, W., C. Nilsson, G. Blomquist, B. Andersson and R. Carlson, 1995. Identification of volatile metabolites from 5 fungal species cultivated on two media. Applied Environ. Microbiol, 61: 2911-2918. PMID: 16535095

United Nations Development Programme, (UNDP), 1991. Annual Report.