Agronomy Research **13**(3), 759–764, 2015

Dust pollution in University offices

P. Kic

Czech University of Life Sciences Prague, Faculty of Engineering, Kamycka 129, CZ-16521 Prague 6, Czech Republic; e-mail: kic@tf.czu.cz

Abstract. The aim of this paper is to present results of microclimatic research focused mainly on dust pollution in several offices of Departments in the Faculty of Engineering at Czech University of Life Sciences Prague. The attention is paid to the dimensions of the room, floor covering, furniture, equipment, ventilation, frequency of the use and period of the year. In the frame of this research the concentration of air dust was measured by special exact instrument Dust-Track aerosol monitor. After the installation of different impactors the PM_1, $PM_{2.5}$, PM_4, PM_{10} size fractions were also measured. The obtained results of measurements were evaluated by the statistical instruments and concentrations of different size of dust particles were analyzed. Results of different indoor conditions were generalized. Based on the results of measurements practical recommendations for the design, use, cleaning and ventilation of these types of rooms and buildings were summarised in the conclusions.

Key words: air, dust fractions, floor, indoor environment, measurement.

INTRODUCTION

Dust is one of the most common pollutants, which people face in everyday life and in their work activities. By dust we understand air pollution particles of matter that dispersed in the air create aerosols. Dust is characterized by a concentration, size and properties of dispersed particles. On all of those characteristics depends the influence on health. The harmful effect of dust on humans is very wide. Evaluation of dust depends on the origin, nature and size of the dust particles, on its concentration in the air, but also on the length and conditions of action, and on the human individual sensitivity to dust. The attention to dust is paid in many research works, e.g. Skulberg et al.(2004), Bouillard et al. (2005), Mølhave (2008), Mølhave et al. (2009), Buchholz et al. (2011), Nõu & Viljasoo (2011), Brodka et al. (2012).

Particles of internal dust are generated primarily by internal surfaces and devices of buildings, textile materials used in the interior, sloughing skin cells from people, etc.; part of household dust comes from atmospheric dust outside.

Over many years of research, it was found that the effect of solid dust particles on health depends mainly on their size. Particles bigger than 100 µm have relatively little importance for human health, because due to its considerable weight quickly settle. The size of dust particles is 1 to 100 µm, particles larger than 30 µm, are known as coarse dust in the environment and in normal conditions also quickly settle. In terms of human respiratory tract larger particles do not cause major problems, since they are recorded on the hairs in the nose and do not penetrate further into the airways (Hollerova, 2007).

Inhalable fraction of dust means a set of airborne dust particles that can be inhaled through the nose or mouth. Respirable fraction means the weight fraction of inhaled particles which penetrates into the respiratory tract where is no *ciliated epithelium* and in alveoli.

Particles smaller than 10 μm (Particulate matter PM_{10}) are of great biological importance because they can penetrate behind the larynx into the lower airways. Therefore these particles are called inhaled particles or thoracic particles. These particles can settle in the bronchial tubes ($PM_{2.5}$), or penetrate into the alveoli (PM_1) or to the blood (nanoparticles) and cause health problems (Hollerova, 2007).

Fromme et al. (2007) evaluated indoor air quality and dust particle fractions (PM_{10} and $PM_{2.5}$) in 64 schools during the winter and summer. The winter concentrations PM_{10} = 91.5 μg m^{-3} and $PM_{2.5}$ = 19.8 μg m^{-3} were significantly reduced in summer PM_{10} = 64.9 μg m^{-3} and $PM_{2.5}$ = 12.7 μg m^{-3}. Heidorf et al. (2009) measured PM_{10} in classrooms with objective to study impact of cleaning. Intensified cleaning showed a significant decrease in all classrooms from 79 ± 22 μg m^{-3} to 64 ± 15 μg m^{-3}.

Problems of dust inside the houses and rooms are also as the dust can be source of house dust mites which are present indoors wherever humans live. Positive tests for dust mite allergies are extremely common among people with asthma. According to the WHO (2000) and Hurley et al. (2005) long-standing increased concentration of dust particles PM_{10} results in an increase in total mortality.

As the university staff spend a large portion of days in the internal environment of buildings and rooms, it is important to know what the situation inside their offices is. The aim of this paper is to present results of microclimatic research focused mainly on dust pollution in several offices of Departments in the Faculty of Engineering at Czech University of Life Sciences Prague.

MATERIALS AND METHODS

This research work and measurements of the actual values were carried out in three offices of Departments in the Faculty of Engineering at Czech University of Life Sciences Prague. All rooms are situated in the same building, two of them in the same corridor in the third floor, one in the second floor. The rooms have the same dimensions: floor area about 20 m^2, volume 66 m^3 and inside is one person.

The first office (A) is equipped with 12 upholstered chairs and the floor covers PVC flooring, the second office (B) is furnished with 8 upholstered chairs and the floor covers carpet covering from wall to wall, the third office (C) is equipped with 5 upholstered chairs and the floor covers PVC flooring.

Offices A and B were during the measurement within normal operating conditions (relatively well organised and clean), two days after cleaning. Office C was also two days after cleaning, but the lockers were opened, taking out a lot of books, research reports, papers, etc., (total chaos, disarray). There was also measured in this office another day (C_2), immediately after cleaning (wiping down the floor).

The total concentration of air dust was measured by special exact instrument Dust-Track aerosol monitor. After the installation of different impactors the PM_{10}, PM_4, $PM_{2.5}$, PM_1 size fractions of dust were also measured. Measured dust inside the offices is not aggressive, it has properties as house dust, therefore, as a criterion for evaluation of the measured values was selected the limit level of outdoor dust, which is 0.050 mg m^{-3} (50 µg m^{-3}).

The 90 data of dust concentration for total dust as well as of each fraction size in each room were collected. The obtained results of dust measurements were processed by Excel software and verified by statistical software Statistica 12 (*ANOVA* and *TUKEY HSD Test*).

RESULTS AND DISCUSSION

Principal results of dust measurement are summarized and presented in the Figs 1–4 and Tables 1, 2. The Fig. 1 presents results of measurement inside the office A. The average concentration of total dust pollution was lower than limit level 0.050 mg m^{-3}. About 15% are large particles of dust over PM_{10}, which is not so dangerous from the human health point of view. About 54% of dust was size fraction PM_1 which can cause health problems.

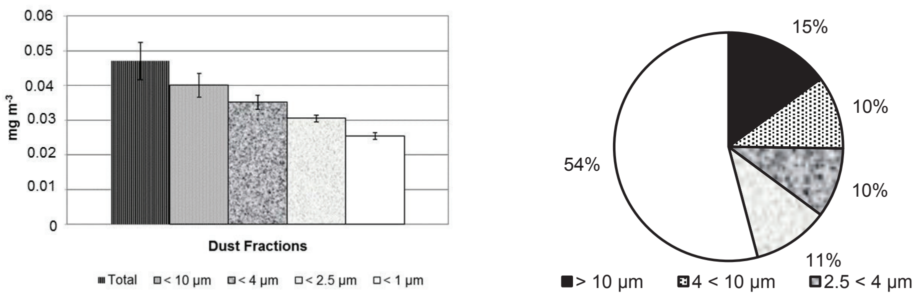

Figure 1. Concentrations and percentage of size distribution of dust fractions inside the office A.

Fig. 2 presents results of measurement inside the office B. Average concentration of total dust pollution was lower than limit level 0.050 mg m^{-3}. About 55% of dust was size fraction PM_1 which can penetrate into the alveoli and cause health problems. The smallest percentage of dust fractions about 8% is the large particle of dust over PM_{10}. It can be supposed, that the biggest dust particles are fixed in the carpet.

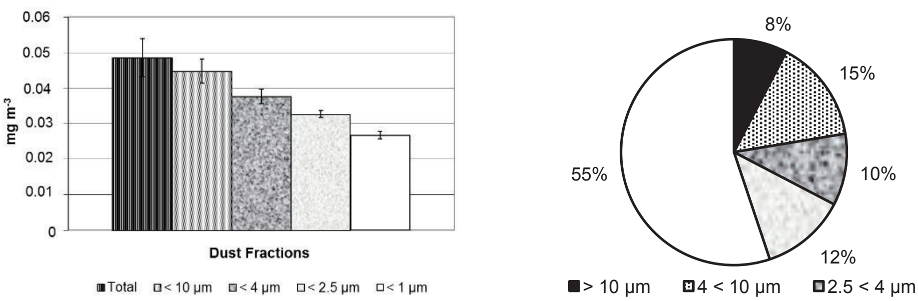

Figure 2. Concentrations and percentage of size distribution of dust fractions inside the office B.

Fig. 3 presents results of measurement inside the office C. The average concentration of total dust pollution was lower than limit level 0.050 mg m^{-3}. About 54% of dust was size fraction PM_1 which can cause health problems. About 14% are the large particles of dust over PM_{10}, which are not so dangerous for the human health.

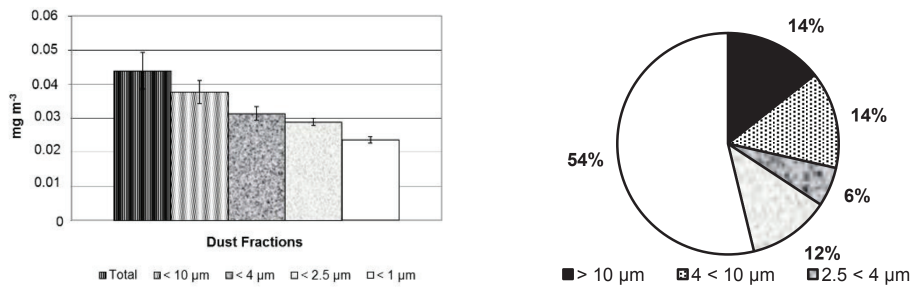

Figure 3. Concentrations and percentage of size distribution of dust fractions inside the office C.

The results of dust measurements were compared by statistical analyse (Table 1). The total dust concentration in the room C was significantly lower than the concentrations in the rooms A and B. Concentrations in the rooms A and B could be considered as equal (*TUKEY HSD Test*, P = 0.43). The other all differences between concentrations of fractions in all offices were statistically significant (*TUKEY HSD Test*, $P \leq 0.05$).

Table 1. Mean values in μg m^{-3} of total dust concentration and concentration of dust fractions PM_{10}, PM_4, $PM_{2.5}$ and PM_1 in offices A, B and C. Different letters (a, b, c) in the superscript are the sign of high significant difference (*ANOVA; Tukey HSD Test*; $P \leq 0.05$)

Office	Concentration total	Concentration of dust fractions			
		PM_{10}	PM_4	$PM_{2.5}$	PM_1
A	47 ± 5^a	40 ± 3^a	30 ± 2^a	30 ± 1^a	25 ± 1^a
B	48 ± 5^a	45 ± 4^b	38 ± 2^b	33 ± 1^b	27 ± 1^b
C	44 ± 7^b	38 ± 4^c	31 ± 1^c	29 ± 1^c	24 ± 1^c

The floor covering in the rooms A and C enables easy cleaning by wiping the floor with a wet rag. To know the effect of wiping, the measurement of dust was repeated in the room C two hours after the wiping of the floor. The results of the measurement (C_2) are presented in the Fig. 4.

These results were compared with the measurement before the wiping and statistically evaluated (Table 2). The all differences between total dust concentrations and all fractions in both measurements were statistically significant (*TUKEY HSD Test*, $P \leq 0.05$).

All dust concentrations (total dust as well as size fractions) in the room C after the wiping C_2 were significantly lower than before the cleaning. It is obvious from the Fig. 4 that mainly the percentage of largest particles was reduced from 14 to 5%. On the contrary, the percentage of the smallest particles increased from 54 to 72%.

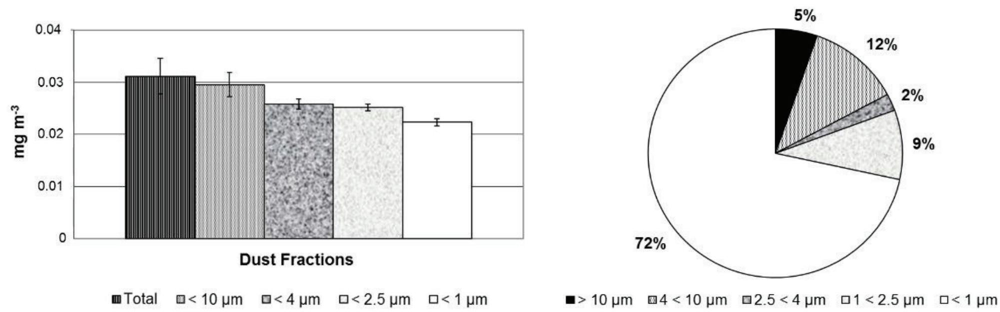

Figure 4. Concentrations and percentage of size distribution of dust fractions inside the office C after the wiping of the floor C_2.

Table 2. Mean values in µg m^{-3} of total dust concentration and concentration of dust fractions PM_{10}, PM_4, $PM_{2.5}$ and PM_1 in office C before and after wiping C_2. Different letters (a, b) in the superscript are the sign of high significant difference (*ANOVA; Tukey HSD Test*; $P \leq 0.05$)

Office	Concentration total	Concentration of dust fractions			
		PM_{10}	PM_4	$PM_{2.5}$	PM_1
C	44 ± 7^a	38 ± 4^a	31 ± 1^a	29 ± 1^a	24 ± 1^a
C_2	31 ± 3^b	30 ± 2^b	26 ± 1^b	25 ± 1^b	22 ± 1^b

CONCLUSIONS

The results of measurements in the University offices showed that:

- average concentrations of dust in offices was not over the level 0.050 mg m^{-3},
- the biggest percentage of dust particles are small size particles PM1,
- rather bigger influence on the indoor pollution by dust has floor covering, especially the carpets are the source of dust,
- floor PVC covering is more suitable for the floor than the carpet, as it enables easy cleaning of floor by wiping, which is important for reduction of dust inside the rooms,
- the equipment which is used inside the room, especially the cloth seats furniture, rather increases the indoor air pollution by dust,
- previous factors are more important than the total chaos and disarray inside the room.

ACKNOWLEDGEMENT. Author is grateful and expresses many thanks to the colleagues who enabled him to carry out all measurements inside their offices.

REFERENCES

Bouillard, L., Michel, O., Dramaix, M. & Devleeschouwer, M. 2005. Bacterial contamination of indoor air, surafaces, and settled dust, and related dust endotoxin concentrations in healthy office builgings. *Ann. Agric. Environ. Med*. **12**, 187–192.

Brodka, K., Sowiak, M., Kozajda, A., Cyprowski, M.& Szadkowska-Stanczyk, I. 2012. Biological contamination in office buildings related to ventilation/air conditioning system. *Medycyna Pracy* **63**(3), 303–315. (in Polish).

Buchholz, S., Krein, A., Junk, J., Gutleb, A.C., Pfister, L. & Hoffmann, L. 2011. Modelling, measuring, and characterizing airborne particles: Case studies from southwestern Luxembourg. *Critical reviews in environmental science and technology* **41**(23), 2077–2096.

Hurley, F., Hunt, A., Cowie, H., Holland, M., Miller, B., Pye, S. & Watkiss, P. 2005. *CBA methodology for the Clean Air for Europe (CAFE). Volume 2: Health Impact Assessment.* AEA Technology Environment, Didcot, 133 pp.

Fromme, H., Twardella, D., Dietrich, S., Heitmann, D., Scierl, R., Liebl, B. & Rüden, H. 2007. Particulate matter in the indoor air of classrooms – exploratory results from Munich and surrounding area. *Atmospheric Environment* **41**, 854–866.

Heudorf, U., Neitzert, V. & Spark, J. 2009. Perticulate matter and carbon dioxide in classrooms – The impact of cleaning and ventilation. *Int. J. Hyg. Environ. Health.* **212**, 45–55

Hollerova, J. 2007. Prasnost na pracovisti. *http://www.szu.cz/tema/pracovni-prostredi/prasnost-na-pracovisti.* Accessed 29.1.2015 (In Czech).

Mølhave, L. 2008. Inflammatory and allergic responses to airborne office dust in five human provocation experiments. *Indoor air*. **18**(4), 261–270.

Mølhave, L., Pan, Z., Kjærgaard, S.K., Bønløkke, J.H., Juto, J., Andersson, K., Stridh, G., Löfstedt, H., Bodin, L. & Sigsgaard, T. 2009. Effects on human eyes caused by experimental exposures to office dust with and without addition of aldehydes or glucan. *Indoor air*. **19**(1), 68–74.

Nõu, T. & Viljasoo, V. 2011. The effect of heating systems on dust, an indoor climate factor. *Agronomy Research* **9**(1), 165–174.

Skulberg, K., Skyberg, K., Kruse, K., Eduard, W., Djupesland, P., Levy, F. & Kjuus, H. 2004. The effect of cleaning on dust and the health of office workers: an intervention study. *Epidemiology* **15**(1), 71–78.

World Health Organisation (WHO). 2000. Air Quality Guidelines for Europe. WHO regional Publications, European Series, No. 91. Copenhagen, 273 pp.