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Original Article

Tecnologia e Utilização de Produtos Florestais

Evaluation of Airborne MDF Dust Concentration in Furniture Factories

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ABSTRACT

High concentrations of airborne dust are observed during the cutting of medium density fiberboard (MDF) boards. This dust, at first considered just uncomfortable for workers, may be harmful to their health. The objective of this work was to evaluate the concentration of airborne dust during the cutting of medium density fiberboard (MDF). The experiment was developed in the MDF cutting sector of three furniture factories located in the city of Lavras/MG. The results showed that the mean concentrations of total dust suspended in these three furniture factories were above the tolerance limit set by the American Conference of Governmental Industrial Hygienists (ACGIH), giving evidence of a serious problem in these companies related to this type of risk agent.

Keywords: occupational safety, occupational hygiene, wood panels.

1. INTRODUCTION

Inhalation is the most common form of entry of dust into the body. Excessive inhalation of dust may cause various effects on the human body, as it overloads the protection and cleaning systems of the body. These effects are determined by several elements such as chemical components present, their concentration in the air, the place of deposition in the respiratory system and the exposure time of workers (Santos, 2001).

According to Nefussi (1979) dust is defined as solid particles, with diameter larger than 1 μm in general, and resulting from the mechanical disintegration of organic or inorganic substances of the processed material. They are created by the simple handling of these substances or in consequence of crushing, grinding, sieving, drilling, polishing, detonation, among other factors.

According to FUNDACENTRO (2007), there are three classifications of greater relevance in occupational hygiene regarding particle size and its relation to the deposition site: inhalable (smaller than 100 μm: penetrate through nose and mouth), thoracic (smaller than 25 μm: penetrate beyond the larynx) and respirable (smaller than 10 μm: penetrate into the alveolar region). Particles deposited in the upper airways or lungs have greater potential to cause damage to health.

Field surveys have shown that in most of the wood furniture factories, no control over the emission of airborne wood particles exist. Locations with high concentrations of these agents generate discomfort and may cause dermatitis, irritation, respiratory allergies and cancer in workers (ACGIH, 2008). It is estimated that more than half a million US workers who were employed in the wood-based products industry (US Census Bureau) and 3.6 million in 25 EU member states are exposed to wood dust during their professional activities (Kauppinen et al., 2006).

Exposure to wood dust implies non-malignant respiratory diseases, including obstructive lower airway disease and reactive upper airway disease (Enarson & Chan-Yeung, 1990). Contrary to this information, the International Agency for Research on Cancer (IARC) has found evidence of carcinogenicity of wood dust in humans. Thus, wood dust was classified as a human carcinogen (IARC, 1995). Furthermore, The Industrial Injuries Advisory Council in the United Kingdom has found an association between exposure to wood dust and nasopharyngeal cancer (IIAC, 2007).

FUNDACENTRO (2007) emphasizes the importance of information on the location and intensity of sources of particulate matter to the monitoring of the exposure of workers for epidemiological records and studies, and to obtaining samples for analytical and toxicological investigations.

Despite the widely known harmful effects of wood dust in workers, occupational safety and hygiene standards in Brazil do not set any limits for this risk agent. In this context, the objective of the present work was to carry out a quantitative evaluation of the concentration of airborne dust produced during the cutting of medium density fiberboard (MDF) in furniture factories. For this, we used technical procedures of hygiene and occupational standards to collect and analyze the particulate matter suspended in the air and diagnose air quality in these industrial units.

2. MATERIAL AND METHODS

The experiment was carried out in three companies producing wooden furniture located in the city of Lavras/MG, specifically in the medium density fiberboard (MDF) cutting sector of these companies. These companies have similar constructive characteristics, installed masonry sheds, with rustic cement floors and roofing made up of fibro cement tiles. The procedures defined by NHO 03 (FUNDACENTRO, 2001) and NHO 08 (FUNDACENTRO, 2007) were adopted for collection and analysis of suspended dust.

We used collectors of PVC membrane filter type, 37 mm of diameter with 5 µm-pores. In the Wood Technology Laboratory (DCF/UFLA), collectors were placed in a petri dish (Figure 1a) and stored in the desiccator for 3 hours to stabilize moisture

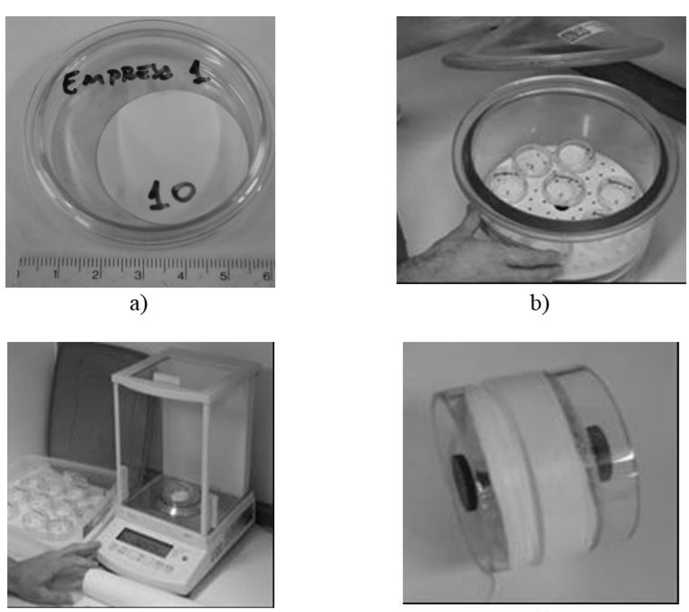

Figure 1. Methodology for dust collection: (a) PVC membrane filters; (b) storage of filters; (c) weighing of filters and (d) cassette with stored filter. Source: Field research.

(Figure 1b). Subsequently, the petri dishes and filters were weighed on a precision balance (0.0001g) (Figure 1c). This procedure was also performed in two treatments used as reference, which were the control in this study. After the mass measurement, the PVC membrane filters were conditioned in receptacles, called cassettes, properly identified (Figure 1d).

The cassettes with the PVC membrane filters were connected to the flow pump and calibrated with a digital flow gauge (Figure 2a). The pump flow rate was calibrated for an average air suction of 1.80 L * min^{-1}, with average collection time for each cassette of 30 minutes, resulting in a mean volume of contaminated air collected of 54 Liters, considering the indication of NIOSH nº 500 (NIOSH, 2010). Thereafter, the cassettes were stored within a receptacle suitable for transportation (Figure 2b).

The collection time was defined as a function of the digital pump calibration and calculated by Equation 1.

$$T = \frac{V}{Q} \quad (1)$$

where: T = collection time, in minutes; Q = flow delivered by the pump, in L * min^{-1}; V = volume of air collected, in Liters.

According to NHO 03 (FUNDACENTRO, 2001), the digital gravimetric pump and the cassette with PVC membrane filter were placed on the worker's body, meaning individual collection (Figure 3).

After collection in the companies, the sets of cassettes/PVC membrane filters with the retained particulate matter were re-calibrated, following the same methodology previously described (Figure 2). Then the membranes were placed in the respective petri dishes, stored in the desiccator for 3 hours and weighed on the precision balance (0.0001g).

For final calculation of the individual concentrations, the mass of particles collected according to NHO 3 (FUNDACENTRO, 2001) was corrected and individual concentrations of each sample were calculated (Equation 2).

$$C = \frac{m}{V} \quad (2)$$

where: C = sample concentration, in mg*m^{-3}; M = mass of the sample, in mg; V = volume of air sampled, in m^3.

The time-weighted average concentration of each collection was calculated according to Equation 3.

$$C_{MPT} = \frac{C_1 t_1 + C_2 t_2 + ... + C_n t_n}{t_{total}} \quad (3)$$

on what: C_{MPT} = time-weighted average concentration in mg*m^{-3}; C_{1-n} = concentration of particulate material obtained in sample n, in mg*m^{-3}; T_{1-n} = sample collection in time n, in minutes; T_{total} = total collection time ($= t_1 + t_2 + ... + t_n$), in minutes.

Considering that all evaluated companies had less than eight employees, the number of collections per company was seven, according to Leidel et al. (1977). In order to investigate the efficiency of the gas and particle exhaust systems of the industrial sheds, samples were collected with exhaust fans in operation and deactivated.

According to Brief & Scala (1975), the Threshold Limit Values (TLV) were corrected for a 44-hour workweek (Equation 4).

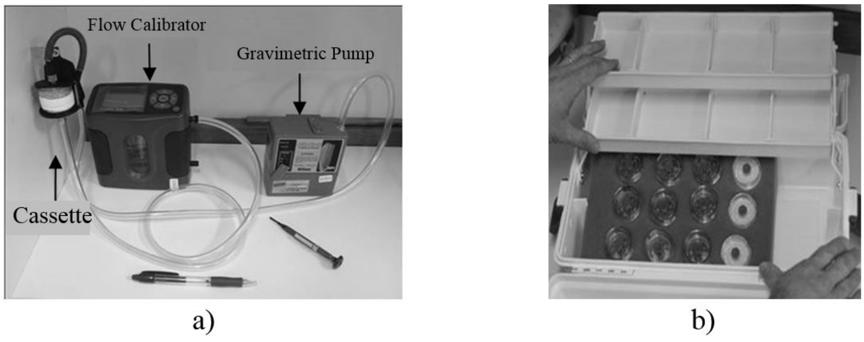

Figure 2. Calibration of the flow and time of collection of the field collectors: (a) gravimetric pump and flow calibrator and (b) storage of cassettes for field collection. Source: Field research.

$$FR = \frac{40}{h} * \frac{168 - h}{128} \quad (4)$$

where: FR = reduction factor; h = working day (weekly) in hours.

3. RESULTS AND DISCUSSIONS

The concentration values of particulates collected in the air during MDF cutting in the three timber companies from Lavras/MG are shown in Table 1. The Company 1, with the exhaust system turned off, presented the highest value of airborne particulate concentration, 120.18 mg*m^{-3}. After the exhaust system installation, an improvement in the environment was observed, with reduction of the particulate concentration to a minimum value of 1.52 mg*m^{-3}.

The comparison of the particulate concentration in the companies 1 and 2 (Table 1) showed lower percentages of reduction with the exhaust system in the company 1. The particulate concentration in the company 3 were the lowest observed, which reached the value of zero in one of the samples collected (Table 1). This can be explained by the efficiency of the exhaust system in the cutting sector of this company.

The threshold limit for airborne dust concentrations defined by ACGIH (2010) corrected for the Brazilian working day was 0.88 mg*m^{-3}. Notably, the sample 6 of the company 3 was the only one below this limit

Figure 3. Placement of the individual collection of airborne dust showing details of the cassette with PVC membrane filter and the gravimetric pump position on the worker. Source: Field research.

Table 1. Concentration of airborne particulates during MDF cutting in three timber companies from Lavras/MG.

Sample	Company 1		Company 2		Company 3
	Without exhaustion	With exhaustion	Without exhaustion	With exhaustion	With exhaustion
1	31.95	-	-	33.95	3.55
2	120.18	-	-	48.90	1.77
3	38.03	-	-	15.24	8.87
4	15.21	-	-	43.65	1.72
5	-	9.13	40.65	-	1.77
6	-	9.13	66.99	-	0.00
7	-	1.52	68.59	-	2.66
8	-	9.13	-	-	-

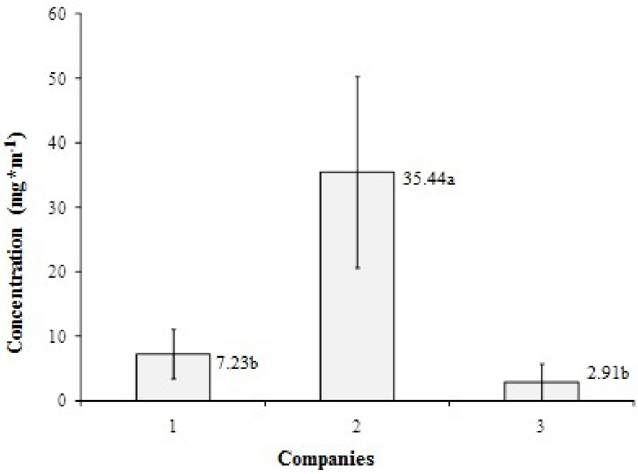

Figure 4. Multiple comparison of the mean airborne particulate concentration with exhaust system in the three companies from Lavras/MG. Means followed by the same letter do not differ from each other at 5%, according to t-test.

(Table 1). Based on the SWEA (2005), which establishes a tolerance limit of 2 mg*m^{-3} for furniture industries in Sweden, the sample 7 of company 1 and samples 2, 4 and 5 of company 3 can be considered acceptable.

Figure 4 shows the multiple comparison of mean concentrations of airborne particulates with exhaust system in operation in the three companies studied. Statistical equality was observed at 5% of significance between the airborne particulate concentration in the companies 1 and 3. Company 2 differed from the others. Moreover, this later company had the highest standard deviation of data.

A reduction of airborne particulate concentration around 86% was observed with exhaust system in the company 1. In company 2, the reduction was smaller, around 39%. This fact can be attributed to low efficiency and size of the exhaust system or even lack of system maintenance, such as internal cleaning of hoses and frequent discharges of residues. It was also observed in the companies 1 and 2 that the circular saws had collected particulate only in the lower portion of the table and had no system of upper collection of particles.

Thus, projection of particulates in the air during MDF cutting was observed, even with the exhaust system in operation. One possible solution to reduce the emission of these particulates in the air is the implementation of upper hood systems connected to the exhaust system. Company 3 presented the lowest values of airborne particulate concentration, since the MDF was cut by the section cutters with a lower and upper particle suction system to the panel support table. The analysis of the weighted mean concentrations resulted in values of 7.23; 35.44 and 2.91 mg*m^{-3} for companies 1, 2 and 3, respectively. None of these values meet the tolerance limit established by ACGIH (2010), which is 0.88 mg*m^{-3}, corrected for a 44-hour workweek. These values also do not meet the limit established by the Swedish standard, which is 2 mg*m^{-3} (SWEA, 2005).

4. CONCLUSIONS

- ✓ The threshold limit values (ACGIH, 2010) of airborne particulate concentration were exceeded in all companies;
- ✓ The quality of air in these companies during the MDF cutting can pose a health risk to workers;
- ✓ Even with the presence of exhaust systems, occupational safety standards indicate the mandatory use of masks or respirators with filters, according to the models and types set by Environmental Risk Prevention Programs (PPRA), which are mandatory for all companies;
- ✓ Projects, implementation and maintenance of exhaust systems and particulate collectors must be carried out by specialized companies in order that systems work properly.

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