Tree cutters' exposure to oakwood dust – A case study from Croatia

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Belastung der Forstarbeiter durch Eichenholzstaub – Eine Fallstudie aus Kroatien

1 Introduction

Apart from being under noise and vibration stress, workers engaged in forest cutting by use of chain-saws are also exposed to hazardous effects of exhaust gases as well as floating particles of mineral oils and airborne wood dust. Apart from cases of allergy and asthma, caused by hazardous substances from pine, spruce and oak wood (HINNEN et al., 1995; HESSEL et al., 1995; MALO et al., 1995), the most serious problem lies in the risk of developing nose and sinus adenocancer due to exposure to beech and oak wood dust (KUBEL, 1988; KLEIN, 2001). Nasal cavity adenocancer is diagnosed much more frequently with wood-processing workers than with the rest of the human population, where this malignant disease is very rare and only accounts for 0.25 % (HAUSEN, 1981). The same author points out that due to a long-term exposure to wood dust, the chemical components of wood can have a very serious biologic effect on human health already at low concentrations.

In 1999 the European Union proclaimed wood dust as carcinogenic based on the classification of the International Agency for Research on Cancer (IARC) issued in 1995, and classified woodworking and forestry workers into groups according to the degree of their exposure to wood dust at their workplace and based on the reliability of evidences of the developed disease. The damage that wood

Zusammenfassung

Die Arbeit befasst sich mit der täglichen Belastung der Forstarbeiter durch Holzstaub bei der Fällung und Aufarbeitung von Eichenholz im Tiefland Kroatiens. Die Studie differenziert zwischen dem Gesamtstaub und der einatembaren Staubfraktion.

Die Arbeitsbedingungen und die unmittelbare Arbeitsumgebung zeigen einen wesentlichen Einfluss auf die Konzentration der einatembaren Partikel, während sie die Gesamtkonzentration nur gering beeinflussen.

Die mittlere Konzentration der einatembaren Partikel bei der Brennholzaufarbeitung im Sommer lag bei 0,62 ± 0,22 mg/m^3 Luft. Im Vergleich dazu wurden bei einer Endnutzung im Winter Werte von 0,29 ± 0,19 mg/m^3 gemessen.

Schlüsselwörter: Eichenholz, Holzstaub, Massenkonzentration, Forstarbeiter, Arbeitsumgebung.

Summary

This paper shows the daily portion of tree cutters' exposure to total dust or respirable fraction of oakwood during its cutting and processing. The research was carried out in a low-land part of Croatia in summer during processing fuel wood in thinning operations, and in winter during final cut of pedunculate oak stand.

The measurements show that work conditions and the state of the immediate working environment have a considerable impact on mass concentration of respirable particles but not on total dust concentration. Thus the mean value of mass concentration of respirable particles collected in summer during processing fuel wood is 0.62 ± 0.22 mg/m^3 and of those collected in winter during final cut it is much lower and namely 0.29 ± 0.19 mg/m^3.

Key words: Oak-wood, wood dust, mass concentration, cutter, working environment.

dust can cause to forestry and saw-mill workers and the risk of their developing nose cancer, nasal cavity cancer and lung cancer is very small, but still there are grounds to worry. The connection between the impact of wood dust and mortality of saw-mill and forest workers caused by lung cancer has been observed in the USA, England and Sweden (KOHLER, 1995).

More than 2,500 cutters are employed in the Croatian forestry (plus 40,000 in wood-processing industry), and according to the growing stock data, beech and oak trees account for as much as 60% (HRVATSKE ŠUME, 2002).

In Croatia, according to the proposal of the Regulatory Act on maximum permissible concentrations (MPC) of hazardous substances in the working atmospheres and biological limit values (BLV), maximum permissible concentration of wood dust of hard-wood species (beech and oak) at the workplace is 1 mg/m^3 for respirable particles, and 3 mg/m^3 for total dust. The said Regulatory Act is used in Croatia just as a general Technical Regulation, while the acceptance is under way of the Regulatory Act complying with the European Union Directive, which prescribes the limit value of 5 mg/m^3 for inhalable fraction of hard-wood species (EU 99/38/EC).

The upper limit of the aerodynamic diameter of inhalable particles ranges between 10–15 mm depending on the intensity of workers' breathing. The value of aerodynamic diameter of respirable or inhalable particles has been agreed. The Technical Report ISO/TR 7708-1995 proposes the size smaller than 10 mm. For evaluating wood dust risk, it is crucial to determine wood dust suspended in air before sedimentation, made of floating particles of maximum 5 mm in aerodynamic diameter.

According to researches of mass concentration of respirable particles and total dust at different workplaces in the Croatian plants and carpentry works (N = 408), in wood-processing industry exceeded limit values of wood dust mass concentrations have been recorded in 1/3 of samples (KOS et al., 2002; KOS et al., 2004).

Since the share of wood species, beech and oak, related to the risk of developing cancer is considerable in the Croatian forestry, the aim of this research is to start showing the actual level of dustiness or exposure of tree cutters to airborne wood particles in the working atmosphere. Determination of daily dose of inhaled wood particles and comparison of obtained mass concentrations of total dust/respirable particles and the Croatian maximum permissible concentrations (MPC) for hard-wood species would help finding the answer to the question – to what extent are forest workers actually exposed to the risk of developing the cancer of respiratory organs due to the impact of wood dust from the working atmosphere.

2 Methods and site of measurement

The mass concentration of respirable particles and total dust at the workplace was determined by the method of personal collectors (EN ISO 10882-1:2001). Personal collectors (manufactured by Casella) are fixed by straps on the operator's overall so that the inlet part of the device is positioned in the breathing zone (Figure 1 and 2). The separators of non-respirable particle fraction (cyclons) operate in a way similar to the separation of respirable particles in the respiratory system of a healthy adult, with a medium efficiency (50%) for aerodynamic diameter of 5 mm.

Wood dust mass concentration was determined by gravimetric method (ZH 1/120.41, 1989). Weighing was carried out by use of a METTLER-TOLEDO MX-5 micro scale. In collecting wood particles the selected flow of the suction head was 2 l/min.

Daily samples for the determination of mass concentration of wood dust were collected in summer during thinning operations and processing fuelwood in a management unit of an area of 43.3 ha. Fuelwood was processed to 1-m long pieces by use of STIHL 064 chain saws and then cut by axes and piled. The compartment was overgrown with a low-land pedunculate oak forest, 101-year-old, of a wood volume of 383 m^3/ha. Pedunculate oak accounts for 79 % of wood volume, and field ash for 18 %.

In winter, samples were collected during final cut of a pedunculate oak stand of an area of 57.7 ha. The air temperature ranged between 5 and 15 °C, and relative air moisture between 65 and 98 %. The compartment was covered with a low-land pedunculate oak forest, 119-year-old, of a wood volume of 443 m^3/ha. Pedunculate oak accounts for 81 % of wood volume and horn beam for 15 %. STIHL 064 chain saws were used. Only industrial roundwood was processed (veneer and saw logs).

During the measurement, records were made of the temperature, pressure and air moisture. The results of these measurements are shown in Figure 3.

Descriptive statistics (mean, standard deviation) was made for all analysed variables, and the error of type I (a) of 5 % was considered as statistically significant. The differences between mass concentrations of respirable fraction and

Figure 1: Cutters with attached dust samples
A – Processing of fuelwood in summer thinning
B – Final cut in winter

Abbildung 1: Forstarbeiter mit Staubsammelbehältern
A – Brennholzaufarbeitung bei der Durchforstung im Sommer
B – Endnutzung im Winter

Figure 2: Filter holders for collecting total dust and respirable particles
Abbildung 2: Filterbehälter zum Sammeln von Gesamtstaub und einatembaren Partikeln

total dust with respect to types of felling (summer – thinning, winter – final cut) were tested by Student's t-test, under assumption that the condition of homogeneity of variance was met (McClave J and Dietrich FH II, 1988). All statistical analyses and graphs have been made by use of the statistics software – STATISTICA 6.0. (StatSoft, 2003)

3 Results and discussion

The diagram in Figure 4 shows mass concentrations of respirable particles and total dust of oakwood for pairs of samples collected in two stands during different forest operations, in summer and in winter. This figure shows clearly that no measured mass concentration exceeds maximum permissible concentrations for hardwood species (MPC).

The mean value of mass concentration of total oakwood dust collected in summer was 1.56 ± 0.16 mg/m^3, and of respirable fraction 0.62 ± 0.22 mg/m^3. The mean value of mass concentration of total oakwood dust collected in winter was 1.45 ± 0.43 mg/m^3, and of respirable fraction, it was considerably lower – 0.29 ± 0.19 mg/m^3. This descriptive statistics is shown in Figure 5.

As clearly shown in Fig. 5, there is a significant difference between mass concentrations of respirable particles in winter during the final cut and on thinning in summer, while the difference between mass concentrations of total dust is not so conspicuous. Since the homogeneity of variance condition was met, the differences between mass concentrations of total and respirable fractions for these two types of felling were tested by Student's t-test as shown in Table 1.

Mass concentrations of respirable fraction collected in summer, during felling of fuelwood, are considerably higher than those collected in winter during final cut. This result is also interesting because in final cut cutters use the chain saw full time in their work, while in processing fuel wood a lot of time is dedicated to cutting and piling the processed wood, as shown in Figure 6.

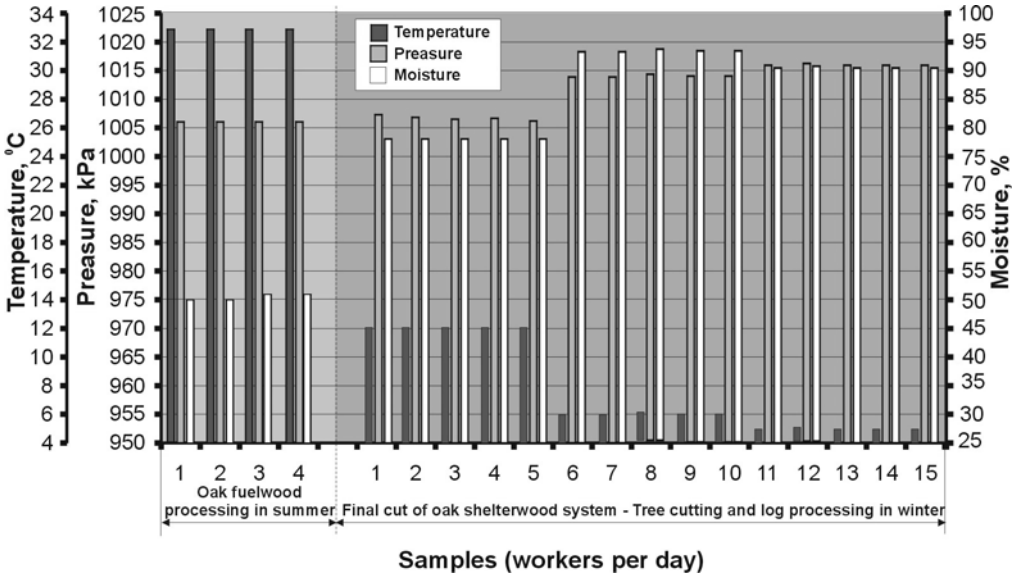

Figure 3: Physical characteristics of the surrounding air
Abbildung 3: Physikalische Eigenschaften der Umgebungsluft

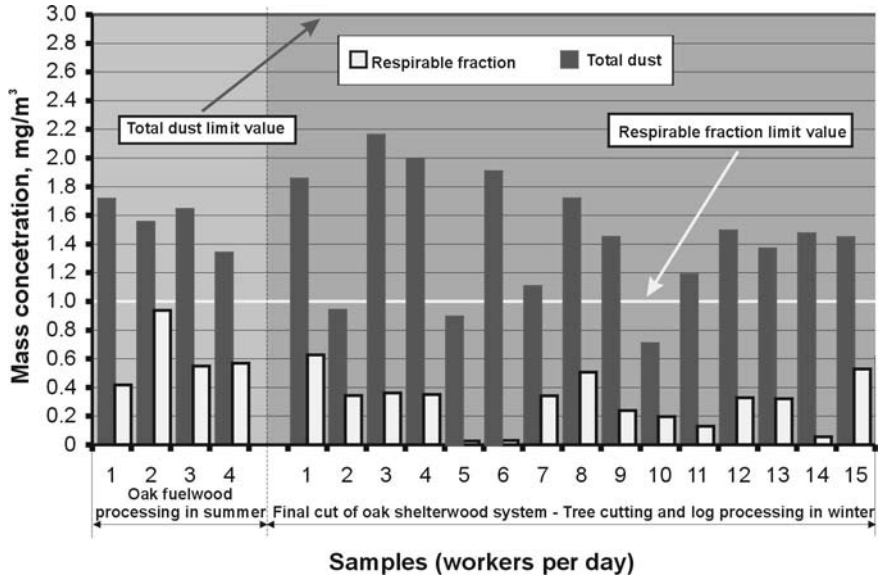

Figure 4: Comparison between limit values and obtained mass concentrations of respirable particles and total dust
Abbildung 4: Grenzwerte im Vergleich zu den gemessenen Massenkonzentrationen der einatembaren Partikel und zum Gesamtstaub

The observed lower dustiness in winter (final cut) can be explained by relatively higher air moisture (frequent fog) when the sedimentation of airborne particles occurs faster. Also in winter, during final cut in an open felling site, the air flow is much stronger than in thinning and in processing fuelwood in summer when the plants are dense (Figure 6).

The measured values of mass concentrations of wood dust have been compared with the Croatian limit values for respirable fraction and total dust. This investigation carried out on a relatively small sample (19 pairs), of which not one measured value exceeded the Croatian maximum permissible values of hardwood dust mass concentration, can only partly defuse the doubt on the risk of exposure of tree cutters to wood dust at their workplace and the risk of their developing cancer of respiratory organs.

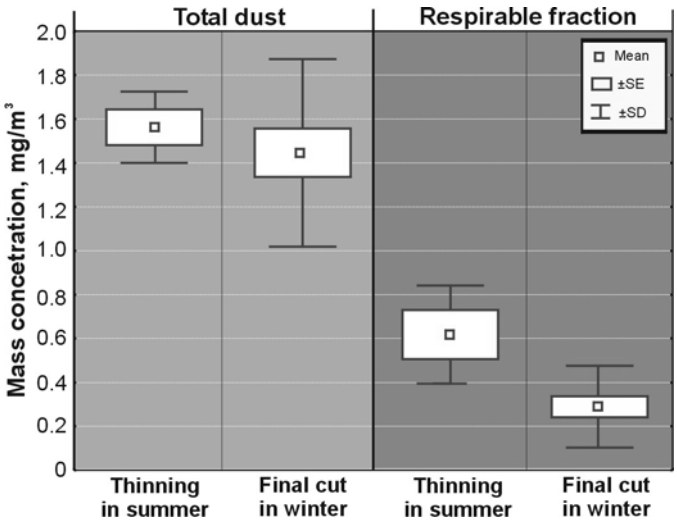

Figure 5: Descriptive statistics of measured mass concentrations
Abbildung 5: Deskriptive Statistik der gemessenen Massenkonzentrationen

Figure 6: In processing fuelwood, considerable time is dedicated to work carried out without the chain saw
Abbildung 6: Bei Brennholzaufarbeitung wird ein Großteil der Zeit ohne Kettensäge gearbeitet

The other European countries set the limit values of mass concentration at workplace before the Directive. However, most of them differ from the limit value set by the European Union Directive. The lowest limit value for inhalable dust of hardwood species (and for new machines) is 1 mg/m^3 and it is set in Sweden, Norway, Spain and France. The measured mass concentrations of total dust would exceed this strict limit value in both stands as well as all samples collected in summer and 12 out of 15 (80 %) in winter.

As the research work on workers' exposure to wood dust has been rare so far, for the sake of comparison we mention the results of measurement at workplaces in the Croatian wood-processing plants and carpentry works, where 153 (76 %) out of 202 samples of respirable particles mass concentration are within the limit value of 1 mg/m^3, and 128 (62 %) out of 206 samples of total dust mass concentration are within the set limit value of 3 mg/m^3 (KOS, 2004). It is significant that according to *IARC*, regardless of the existence of limit values of mass concentration of airborne particles, wood-processing workers are still classified as group 1 of workers based on higher risk of developing nose and nasal cavity adenocancer due to their exposure to dust of hardwood species (KOHLER, 1995). According to its definition, adenocancer develops slowly due to a permanent and long exposure to minor carcinogen and/or mutagen irritance. According to data obtained from patients with diagnosed disease, the latent period for the development of this occupational disease is on average 28 to 45 years (HAUSEN, 1981).

To the end of providing better understanding of this issue, further development of research is planned with tree cutters as well as determination of wood dust mass concentrations of other species of wood, also represented in cutting and processing (beech and fir), taking into account the influencing factors of measurement site affecting sedimentation of airborne particles – characteristics of felling site, season and atmospheric conditions (air flow, temperature and relative air humidity).

4 Conclusions

The investigation of dustiness of the atmosphere, immediately surrounding the cutters in processing fuelwood in thinning operations and assortments after final cut, has shown that the measured concentrations are lower than the limit values allowed by the European Union and Croatian regulations. At the same time it has been observed that work conditions (thinning – final cut), which determine the atmosphere immediately surrounding the cutters and the season of felling (summer – winter), which affect the physical characteristics of air, have a serious impact on the concentration of respirable particles but not on total dust concentration in a working day.

The fuelwood preparation during sommer thinning takes place in a very thick stand where there is practically no air flow at all, while the winter final cut is very open with considerable air flow.

Table 1: Comparison between mass concentrations of wood dust for different types of felling
Tabelle 1: Vergleich der Massenkonzentration des Holzstaubes bei verschiedenen Nutzungsarten

Sampling site	Descriptive statistics			Homogeneity of variances test		t-test	
	N	Mean	S.D.	F	p	t	p
Thinning in summer total dust	4	1.562	0.162	6.92	0.14	0.52	**0.608**
Final cut in winter total dust	15	1.446	0.428				
Thinning in summer respirable particl.	4	0.618	0.223	1.43	0.553	3.05	**0.0076**
Final cut in winter respirable particl.	15	0.289	0.186				

Despite the fact that the measured values are within the limit values for hardwood species, this research gives no grounds for defusing doubts on the risk of exposure of tree cutters to wood dust. The results could only be considered satisfying if they showed no presence at all of airborne wood particles in the cutters' working atmosphere. The reason lies in the claim of the occupational medical experts that the limit values of any carcinogen and/or mutagen is not a guarantee against the illness but rather the guideline for providing an adequate level of protection. Further research should be focused on identifying work conditions with increased exposure to airborne wood particles, where adequate measures should be taken so as to reduce the risk of developing the disease or to use personal protective equipment – respirators and respiratory devices.

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