Research of fir-wood dust concentration in the working environment of cutters

Horvat, Dubravko; Čavlović, Ankica; Zečić, Željko; Šušnjar, Marijan; Bešlić, Ivan; Madunić-Zečić, Velimira

Research of fir-wood dust concentration in the working environment of cutters

Dubravko Horvat, Ankica Čavlović, Željko Zečić, Marijan Šušnjar
Ivan Bešlić, Velimira Madunić-Zečić

Abstract – Nacrtak

This paper shows the results of measurement of daily exposure of cutters to respirable particles and total fir-wood dust during cutting and processing of dead standing fir-trees. The separators of non-respirable fraction (cyclones) are designed so as to imitate the separation of respirable particles in the respiratory system of a healthy adult person, with a medium efficiency (50 %) with aerodynamic diameter of 5 μm. The mean value of mass concentration of total fir-wood dust was (1.29 ± 0.419) mg/m^3 and of respirable fraction (0.564 ± 0.154) mg/m^3. The results of this research show that no measured value (N = 26) in cutting and processing fir-trees exceeds the Croatian limit values (maximum permissible concentrations) for wood dust of softwood broadleaved species and conifers.

Key words: *firwood, wood dust, mass concentration, cutter, working environment*

1. Introduction – *Uvod*

Ergonomic researches show very hard work conditions of forest cutters. Among other stresses and strains, they are also considerably exposed to hazardous effects of airborne wood dust from the working environment. 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).

Beech and oak wood dust are connected to the risk of developing nose and nasal cavity cancer, and the share of these two wood species is the highest in the domestic forest activities, amounting up to 60 % of the growing stock (Kunstić and Dundović, 2002). Continuous exposure to fir or spruce wood dust is also considerable, regardless of the fact that the share of spruce and fir is lower in the total growing stock (11.2 %). To be specific, fir resins contain different chemical irritants and dermatitis (monoterpenes, resin acids, cholophonium) due to which fir-wood dust causes skin allergies (pinen-allergies), skin redness, eczemas and irritation of skin and mucous membrane (Hausen, 1981). Considering a large share of conifers in Scandinavian countries, for the last 23 years Finish researchers have been collecting information on the connection between the effects of wood dust and development of allergic dermatoses, usually caused by hardwood dust but also caused by wood dust of softwood species (Estlander et al., 2001). Researches in most Scandinavian countries show that irritations and allergies occur, more frequently in summer than in winter, regardless of the fact that the measured values of wood dust concentration are within limit values of the domestic laws and regulations (Rosenberg et al., 2002).

In Croatia, according to the proposal of the Regulatory Act on maximum permissible concentrations (MPC) and biological limit values (BLV) of hazardous substances in the working premises and working environment, maximum permissible concentration of wood dust of softwood broadleaved species and conifers in the working environment is 3 mg/m^3

for respirable particles, and 10 mg/m^3 for total dust. The Directives of the European Union do not prescribe the limit value for inhalable fraction of softwood species and conifers but only the limit value of 5 mg/m^3 for hard-wood species (EU 99/38/EC). In 1999 the European Union proclaimed wood dust of hard-wood species as carcinogenic based on the classification of the International Agency for Research on Cancer (IARC) issued in 1995 (Kohler, 1995). Unlike the European Union, the American regulations are stricter and the American Conference of Governmental Industrial Hygienists (ACGIH) prescribes a maximum limit value of 1 mg/m^3 for inhalable fraction of hard-wood species and also 5 mg/m^3 for softwood species (Kopecký and Pernica, 2004).

According to IARC researches, the mean aerodynamic diameter of most wood particles is larger than 5 μm (Kohler, 1995). The upper limit of aerodynamic diameter of inhalable particles ranges between 10 and 15 μm depending on the intensity of the worker's respiration. The value of aerodynamic diameter of respirable particles has been agreed in accordance with the health criteria. The technical Report ISO/TR 7708–1995 proposes the value lower than 10 μm.

For evaluating the hazard of wood dust, interest should be focused on dust suspended in the air before sedimentation made of floating particles of maximum 100 μm in aerodynamic diameter. To date mass concentrations of respirable particles and total dust of oak-wood have been determined with workers in cutting and processing cordwood, whereby according to the Croatian standards none of the measured values exceeded the maximum permissible concentrations for hard-wood species (Horvat et al., 2005A; Puntarić et al., 2005). At different workplaces in the Croatian plants and carpentry shops, maximum permissible values were exceeded in 1/3 out of 408 samples (Kos et al., 2002, 2004).

The investigation of daily exposure to wood dust of cutters engaged in seed cutting of a 109-year old beech stand (Horvat et al., 2005B), showed that neither total nor respirable fractions reached the limit values, except several samples when the air flow was slower. Although due to a small number of samples this fact could not be statistically confirmed, assumption remains that the surrounding air flow has a considerable impact on dustiness.

2. Objectives of research – *Ciljevi istraživanja*

The objective of this research is to determine the actual level of exposure of tree cutters to airborne fir-wood particles in the working environment. By the comparison of the measured mass concentrations of respirable particles and total dust with the Croatian maximum permissible concentrations for softwood broadleaved species and conifers, the estimate can be made of the risk to which forest workers are exposed for developing skin allergies or asthma. The results of this research could be of help in choosing adequate protection measures against the hazardous effects of fir-wood dust in the cutters' working environment.

3. Methods and site of research – *Metode i mjesto istraživanja*

The mass concentration of respirable particles and total dust were determined by gravimetric method in compliance with the standard ZH 1/120.41, 1989, by use of personal collectors defined by the standard EN ISO 10882-1:2001. Personal collectors manufactured by Casella (produced in Bedford, UK, 2001) were fixed by straps on the cutter's body so that the suction parts, cyclones equipped with filters were positioned in the breathing zone (Figure 1), and the driving device (electric pump) on its back (Figure 3), so as not to stand in the way of cutting and processing. The separators of non-respirable particle fraction (cyclons) operate in a way similar to the separation of respirable particles in the medium effective (50 %) respiratory system of a healthy adult, with an aerodynamic diameter of 5 μm. The measurement was performed by use of a micro-scale METTLER-TOLEDO MX-5 (produced in Greifensee, Switzerland, 2000) capable of precise measurement and reading of values to 10^{-6} gram, with measurement error of ± 10^{-4} gram. In the process of sampling, the air flow rate at the suction head was 2 L/min (EN ISO 10882–1:2001).

Figure 1 Cutter with attached dust samplers
Slika 1. *Sjekač s pričvršćenim uređajima za skupljanje uzoraka prašine*

Figure 2 Site of research
Slika 2. *Prikaz mjesta istraživanja*

Figure 3 Cutter going to the felling site with driving device on its back
Slika 3. *Odlazak sjekača u sječinu s pogonskim uređajem na leđima*

The research was carried out in the mountainous part of Croatia (Litorić, Gorski Kotar) as shown in Figure 2 at an altitude of 750 m. The compartment is of an area of 22.77 ha with 70 % coverage. This stand is made of fir and beech with a total growing stock of 306 m^3/ha of which fir accounts for 48.4 %, beech for 39.1 % and other hard-wood broadleaved species for 12.5 %. In the compartment 465 trees were marked for felling with a mean volume of 1.71 m^3, and the mean volume of fir was 1.81 m^3.

The measurements were carried out in summer (late July and early August 2004), when the average air temperature was 22.6 °C (ranging between 16 °C and 27 °C). The relative air humidity was 75.6 %,

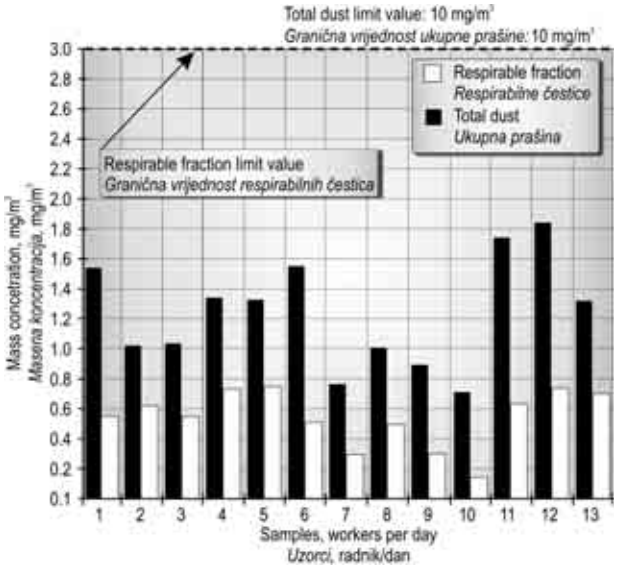

Figure 4. Comparison between the obtained mass concentrations of respirable particles/total dust and maximum permissible concentrations (limit values)
Slika 4. *Usporedba masenih koncentracija respirabilnih čestica i ukupne prašine s maksimalno dopuštenim vrijednostima*

ranging between 64 % and 95 %. The air pressure at the working site was 977.5 hPa. Through 13 workers/day the same number of sample pairs of total and respirable wood dust were collected.

4. Results and discussion – *Rezultati s diskusijom*

Figure 4 presents the comparison between measured mass concentrations of respirable particles and total dust for sample pairs collected in felling dead standing fir-trees and maximum permissible concentrations for fir-wood (3 mg/m^3 for respirable particles and 10 mg/m^3 for total dust). The mean value of mass concentration of total dust of fir wood was (1.29 ± 0.419) mg/m^3 and of respirable fraction (0.564 ± 0.154) mg/m^3.

This research shows that none of the measured values exceeded the Croatian maximum permissible values of mass concentration of softwood broadleaved species and conifers. Despite the fact that the measured values are as much as 10 times lower than the permissible ones, in accordance with previous researches (Rosenberg et al., 2002) where the concentrations within limit values did not preclude the occurrence of dermatoses, asthma and allergies, it is only partly possible to defuse doubts on the risk of exposure of tree cutters to fir-wood dust in the working environment.

In order to acquire better understanding of these issues further researches with forest cutters are planned involving a larger number of samples, determination of mass concentrations of wood dust of other species of wood, also present in cutting and processing, along with the definition of the factors of the measuring site affecting the sedimentation of airborne particles – characteristics of the felling site, season and conditions of the working environment (air flow, temperature and relative air humidity) along with monitoring the daily efficiency of cutters in the process of cutting and processing.

5. Conclusion – *Zaključak*

This research gives no ground for defusing the dilemma related to the risk of exposure of tree cutters to wood dust during thinning of dead standing fir-trees despite the fact that the measured concentration values of respirable particles and total wood dust in the working environment of cutters do not exceed the maximum permissible values set for softwood broadleaved species and conifers. The results of measurement would only be completely satisfying if they showed no presence at all of airborne wood particles in the cutters' working environment. The reason lies in the result of researches carried out by Scandinavian industrial medicine experts, who have established the development of dermatoses and allergies even though the measured concentrations of coniferous wood dust were within the limit values. Further research will be focused on investigation of dustiness of the cutters' working environment during felling and processing in the regions of Croatia with characteristic methods of management of naturally regenerated forests along with monitoring the main components of stand conditions, characteristics of the surrounding air, applied technologies, organisation and productivity. The basic aim is to define the conditions under which and where the exposure of cutters is increased to airborne wood particles from the working environment.

6. References – *Literatura*

Anonymus, 1989: Hauptverband der gewerblichen Berufsgenossenschaften, Zentralstelle für Unfallverhütung und Arbeitsmedizin, ZH 1/120.41.

Anonymus, 1993: Prijedlog Pravilnika o maksimalno dopustivim koncentracijama štetnih tvari u atmosferi radnih prostorija i prostora MDK i o biološkim graničnim vrijednostima BGV (1993), ANT-Zagreb, ISBN 953-96075-0-7.

Anonymus, 1999: Councile directive 1999/38/EC of 29 April 1999 amending for the second time Directive 90/394/EEC on the protection of workers from the risk related to exposure to carcinogens at work and extending it to mutagens. Official Journal L 138, 01/06/1999 P 0066–0069.

EN ISO 10882–1:2001, Health and safety in welding and allied processes – Sampling and gases in the operators breathing zone – Part 1: Sampling of airborne particles.

Estlander, T., Jolanki, R., Alanko, K., Kanerva, L., 2001: Occupational allergic contact dermatitis caused by wood dusts. Contact Dermatitis, 44, p. 213–217.

Hausen, B., 1981: Woods Injurius to Human Health: a manual. Universitätsbibliothek Hannover und Technische Informationsbibliothek, de Gruyter.

Hessel, P. A., Herbert, F. A., Melenka, L. S., Yoshida, K., Michaelchuk, D., Nakaza, M., 1995: Lung health in sawmill workers exposed to pine and spruce. Chest, 108 (3), p. 642–646.

Hinnen, U., Willa-Craps, C., Elsner, P., 1995: Allergic contact dermatitis from iroko [*Milicia excelsa*] and pine [*Pinus*] wood dust. Contact Dermatitis, *33(6), p. 1–428.*

Horvat, D., Kos, A., Zečić, Ž., Šušnjar, M., Bešlić, I., 2005A: Istraživanje koncentracije drvne prašine hrastovine u radnoj okolini sjekača pri izradbi prostornog drva. Šumarski list, 129, 7/8, p. 393–396.

Horvat, D., Kos, A., Zečić, Ž., Jazbec, A., Šušnjar, M., 2005B: Concentration of wood dust in the working envinroment during felling and processing of beech trees, International scientific conference on scientific cooperation for forest technology improvement, FORMEC 2005, Austria-Slovenia, Abstract, p. 1–27.

Klein, R. G., Schmezer, P., Amelung, F., Schroeder, H. G., Woeste, W., Wolf, J., 2001: Cancerogenicity assays of wood dust and wood additives in rats exposed by long-term inhalation. Int Arch Occup Environ Health, 74, p. 109–118.

Kohler, B., 1995: Wood dust and cancer. National Rep – Healt, Safety and Environment, IARC, France.

Kopecký, Z., Pernica, J., 2004: Effects of the dimensional specification of dust on the quality of air. »Trieskove a beztrieskove obrabanie dreva ´04«, Stary Smokovec – Tatry, p. 125–130.

Kos, A., Beljo-Lučić, R., Horvat, D., Šega, K., Bešlić, I., 2002: Čimbenici koji utječu na zaprašenost u drvoprerađivačkim pogonima. Drvna industrija, 53(3), p. 131–140.

Kos, A., Beljo-Lučić, R., Šega, K., Rapp, A., 2004: Influence of woodworking machine cutting parameters on the surrounding air dustiness. Holz als Roh- und Werkstoff, 62(3), p. 169–176.

Kubel, H., Weißmann, G., Lange, W., 1988: Untersuchungen zur Cancerogenität von Holzstaub. Die Extraktstoffe von Buche und Fichte. Holz als Roh- und Werkstoff, 46, p. 215–220.

Kunstić, Đ., Dundović, J., edit.: Godišnje izvješće 2001. Hrvatske šume, Zagreb, 2002.

Malo, J. L., Cartier, A., Desjardins, A., Weyer, R., Vandenplas, O., Vande-Weyer, R., 1995: Occupational asthma caused by oak wood dust. Chest, 108(3), p. 856–858.

Puntarić, D., Kos, A., Šmit, Z., Zečić, Ž., Šega, K., Beljo-Lučić, R., Horvat, D., Bošnir, J., 2005: Dust wood exposure in wood industry and forestry (Izloženost drvnoj prašini radnika drvne industrije i šumarstva). Collegium Antropologicum, Volume 29, Supplement 1, p. 221–225.

Rosenberg, Ch., Liukkonen, T., Kallas-Tarpila, T., Ruonakangas, A., Ranta, R., Nurminen, M., Welling, I., Jäppinen, P., 2002: Monoterpene and Wood Dust Exposures: Work-Related Symptoms among Finnish Sawmill Workers. American Journal of Industrial Medicine (41), p. 38–53.

Sažetak

Prilog istraživanju koncentracije jelove drvne prašine u radnoj okolini sjekača

U radu su prikazani rezultati istraživanja dnevnih izloženosti šumskih sjekača respirabilnim česticama te ukupnoj jelovoj prašini za vrijeme sječe i izradbe jelovih sušaca. Separatori nerespirabilnoga dijela čestica (cikloni) svojom izvedbom oponašaju odvajanje respirabilnih čestica u dišnom sustavu odrasle zdrave osobe, srednje učinkovitosti (50 %) na 5 μm aerodinamičkoga promjera.

Cilj je ovoga istraživanja određivanje stvarne izloženosti šumskih sjekača jelovim lebdećim česticama na radnom mjestu. Usporedbom izmjerenih masenih koncentracija respirabilnih čestica i ukupne prašine s domaćim maksimalno dopuštenim koncentracijama (MDK) za meke listače i četinjače procjenjuje se koliki je rizik obolijevanja šumskih radnika od kožnih alergija i astme.

Masena koncentracija respirabilnih čestica i ukupne prašine određene su gravimetrijskom metodom prema normi ZH 1/120.41, 1989, pomoću osobnih skupljača definiranih normom EN ISO 10882-1:2001. Vaganje je obavljeno uporabom mikrovage METTLER-TOLEDO MX-5 (proizvedene u Greifenseeu, Švicarska, 2000) koja ima mogućnost preciznoga mjerenja i očitavanja vrijednosti do 10^{-6} grama s mjernom pogreškom od ± 10^{-4} grama. Pri skupljanju uzoraka protok je zraka u ulaznim ušćima iznosio 2 L/min (EN ISO 10882-1:2001).

Istraživanja su provedena u brdskom području Hrvatske (Gorski kotar) na nadmorskoj visini od 750 m. Površina je odjela bila 22,77 ha s obrastom od 0,7. To je jelovo-bukova sastojina ukupne drvne zalihe od 306 m^3/ha s 48,4 % jele, 39,1 % bukve i 12,5 % ostalih tvrdih listača. U odjelu je ukupno doznačeno 465 stabala za sječu sa srednjim obujmom od 1,71 m^3, dok je srednji obujam jele iznosio 1,81 m^3.

Mjerenja su obavljena ljeti (krajem srpnja i početkom kolovoza 2004.), kada je prosječna teperatura zraka iznosila 22,6 °C (od 16 °C do 27 °C). Prosječna je relativna vlaga zraka iznosila 75,6 %, a kretala se od 64 % do 95 %. Tlak je okolnoga zraka na radilištu iznosio 977,5 hPa. U 13 radnik/dana skupljeno je isto toliko parova uzoraka ukupne i respirabilne drvne prašine. Svaki je sjekač nosio par osobnih skupljača, za respirabilnu frakciju i ukupnu prašinu.

Srednja vrijednost masene koncentracije ukupne jelove prašine iznosila je (1,29 ± 0,419) mg/m^3, a respirabilne frakcije (0,564 ± 0,154) mg/m^3. Rezultati istraživanja pokazuju kako ni jedna izmjerena vrijednost (N = 26) pri sječi i izradbi jelovih stabala ne prekoračuje domaće granične vrijednosti masenih koncentracija za prašinu mekih listača i četinjača.

Ovim istraživanjem nije moguće otkloniti dvojbu o štetnosti izlaganja šumskih sjekača drvnoj prašini pri prorednoj sječi jelovih sušaca bez obzira na to što izmjerene vrijednosti koncentracije respirabilnih čestica i ukupne drvne prašine na radnom mjestu sjekača ne prekoračuju maksimalno dopuštene vrijednosti za meke listače i četinjače. Potpuno bi zadovoljavajuće bilo stanje koje pokazuje da lebdećih drvnih čestica u radnoj atmosferi sjekača uopće nema. Razlog su istraživanja skandinavskih stručnjaka medicine rada koji su zabilježili obolijevanja od dermatoza i alergija bez obzira na to što izmjerene masene koncentracije drvne prašine četinjača nisu prekoračivale dopuštene vrijednosti. Daljnjim je planom pokusa predviđeno istraživanje zaprašenosti radne okoline radnika

sjekača pri sječi i izradbi u raznim područjima Hrvatske s karakterističnim načinima gospodarenja prirodno obnavljanih šuma uz praćenje bitnih sastavnica sastojinskih uvjeta, stanja okolnoga zraka, primijenjenih postupaka, organizacije i proizvodnosti. Temeljna je svrha definiranje onih uvjeta pri kojima i gdje se povećava izloženost sjekača drvnim ledbećim česticama iz radne atmosfere.

Ključne riječi: *jelovina, drvna prašina, masena koncentracija, sjekač, radna okolina*

Authors address – Adresa autora:

Assoc. Prof. Dubravko Horvat
Assist. Prof. Ankica Čavlović
Assist. Prof. Željko Zečić
M. Sc. Šušnjar Marijan
Forestry faculty of University of Zagreb
Svetošimunska 25
HR-10 000 Zagreb
CROATIA
e-mail: horvat@sumfak.hr
e-mail: kos@sumfak.hr
e-mail: zecic@sumfak.hr
e-mail: susnjar@sumfak.hr

M. Sc. Ivan Bešlić
Institute for Medical Research and Occupational Health
Ksaverska cesta 2,
HR-10 000 Zagreb
CROATIA
e-mail: ibeslic@imi.hr

dr. med. Velimira Madunić-Zečić
Zagreb Institute of Public Health
Mirogojska 16
HR-10 000 Zagreb
CROATIA

Received (*Primljeno*): August 29, 2004
Accepted (*Prihvaćeno*): November 03, 2005