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EXPOSURE TO WOOD DUST IN CROATIAN WOODWORKING INDUSTRY

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ABSTRACT

Wood dust from work atmosphere can cause allergic phenomenon and asthma on woodworkers and apart from that, it represents a risk of affection of nose and nasal cavity cancer. Apart from chemical compounds from wood material, the substances from board materials and non-wood auxiliary materials such as glues, lacquers, protection mediums and alike, also contribute to hazardous activity.

In Croatian wood industry comprehensive research of woodworkers exposure to wood dust was carried out. Mass concentration of respirable particles (*N*=253) and total wood dust (*N*=259) is being determined by the method of personal collectors.

Results are ranked in groups of mass concentrations of respirable particles and total wood dust for hardwood species, softwood species and boardlike materials. Obtained values were compared with maximal permissible concentrations for dusts according to the Croatian Draft By-Law on Maximum Permissible Concentrations (MPC) of Hazardouos Material and Biological Limit Values (BLV) in Workplace Environment. Concentration of respirable particles of hardwood species (beechwood and oakwood) higher than MPC is measured on 33 out of 137 samples (24%) while exceeding of MPC for boardlike materials is measured on 16 out of 92 samples (17%). Exceedings of MPC of beechwood and oakwood total dust is measured on 46 out of 141 samples (33%) and of boardlike materials on 33 out of 93 samples (36%). Values of mass concentrations of respirable particles and total dust for softwood species do not exceed MPC values.

According to the results of presented research and taking in consideration hazardous effect of wood dust, by Croatian legislative it is possible to accept European standards but moreover it is recommended to prescribe stricter limit values for inhalable fraction of hardwood and specially softwood species with goal to woodworker protection.

KEY WORDS: wood dust, carcinogenicity, method of personal collectors, maximal permissible concentration

INTRODUCTION

Exposure of woodworkers to wood dust can cause allergies and asthma because of hazardous substances in pinewood, sprucewood and oakwood (Hinnen et al. 1995, Hessel et al. 1995; Malo et al. 1995). Longterm exposure to beechwood and oakwood as well as to birch, walnut and exotic wood dust represents the risk of developing adenocarcinoma of the nasal cavity (Klein et al. 2001; Kubel et al. 1988, Demers 2007). Also, among woodworkers, a significant trend of increasing risk of lung cancer with increasing duration of exposure was observed (Stellman 1998, Barcenas et al. 2005). Wood dust of oakwood and beechwood together with exotic wood was categorised as carcinogenic by the European Union in 1999 based on classifications of International Agency for Research on Cancer (IARC) of 1995.

Because of that engineering control and industrial hygiene are mandatory for dusty activities in woodworking should be at last aslow 2 $mg.m^{-3}$.

In Croatia, 40,000 workers are exposed to the influence of wood dust in wood industry and more than 2,500 cutters in forestry. It is significant for the Croatian woodworking industry and forest activity that beech and oak are the two most common species in the growing stock of Croatia, accounting for up to 60% in total wood supply. In spite of lower share of sprucewood and firwood in total wood supply (11.2%), exposure to dust of softwood species must not be disregarded. Various skin irritators and dermatites are situated in firwood resin (monotherpenes, resin acids, collophonium), which cause firwood to develop skin allergies (pinen-allergies), skin blush, eczema as well as skin and mucus irritations (Hausen 1981). Asthma, non-asthmatic airflow obstruction, and both upper and lower respiratory symptoms have been associated with exposure to both 'allergenic' and 'non-allergenic' softwood dusts, and an association with increasing intensity of exposure has been observed (Demers et al. 1998).

According to the norm (HRN EN 481:2007) total airborne particles (total wood dust) are all particles in given volume of surrounding air. Inhalable fraction is mass fraction of total airborne particles which is inhaled through the nose and mouth. Respirable fraction is mass fraction of inhaled particles which penetrate to the unciliated airways. In Croatia, Draft By-Law on Maximum Permissible Concentrations (MPC) of Hazardouos Material and Biological Limit Values (BLV) in Workplace Environment prescribes maximum permissible mass concentration of hardwood dust of 1 $mg.m^{-3}$ for respirable particles, and 3 $mg.m^{-3}$ for total dust. Maximum permissible mass concentration for respirable particles of softwood amounts to 3 $mg.m^{-3}$, and for total dust to 10 $mg.m^{-3}$. EU Directives 99/38/EC prescribe limit value for the inhalable fraction of wood dust, but only for harwood that amounts to 5 $mg.m^{-3}$. Most European countries have already set their own limit values, some of which are stricter than those posed by EU guidelines (Giesen 1998). In Republic of Slovenia allowed limit values for the inhalable fraction is 5 $mg.m^{-3}$ for hardwood and softwood species.

The American Conference of Governmental Industrial Hygienists (ACGIH) prescribes a maximum limit for the inhalable fraction of 1 $mg.m^{-3}$ for hardwood species and 5 $mg.m^{-3}$ for softwood. The available evidence seems to indicate that to prevent non-malignant effects of softwood dust, the level of exposure should be at least as low

2 $mg.m^{-3}$, and a standard of 1 $mg.m^{-3}$ may be more appropriate to provide a safety margin to protect more sensitive workers (Demers et al. 1998).

Past researches of workers' exposure to respirable and total wood dust at different workplaces in the Croatian wood processing plants have shown that the influence of woodworking material is important but not as much as the influence of parameters related to working machines (Kos et al. 2004). Workers' health effects as well as permissible mass concentrations differ by the type of dust in most regulations, and hence the goal of this research was to establish and analyse the actual level of workers' exposure to hardwood and softwood dust as well as dust of boardlike materials in relation to permissible concentrations. Namely, the comparison of mass concentration of dust (daily doses of workers' exposure to wood dust in workplaces) to MPC or other applicable regulations shows the level of the need to improve engineering measures for minimizing the emission or necessity of use of personal protection devices.

Also, the aim was to compare mean values and standard deviations of measured mass concentrations of softwood and hardwood dust and dust of boardlike materials.

MATERIAL AND METHODS

In several woodworking companies in Croatia, in the period from 1996 to 2005 respirable and total mass concentration was investigated in workplaces by the personal sampling method. The workers carried personal samplers attached with props to his working uniform so that the inhaling part was located in the worker's breathing zone according to ISO 10882-1:2001 method.

253 samples were collected of respirable particles and 259 samples of total wood dust in five factories and three joineries. During sampling at workplaces of mechanical woodworking, various kinds of wood material were processed - domestic softwood and hardwood species and boardlike materials. Collecting was performed during processing of wood and wood materials at different woodworking machines and working quality of suction devices (apart from log band saws, cabinet band saws, circular saws, belt sanders, spindle moulders, jointers, drills, hand tool machines), in furniture montage rooms, plywood production, sander rooms and paintshops, in industrial furniture trade, as well as behind the controls of fork-lift truck. At workplaces and in the rooms where the mass concentration is measured only defined working material was processed.

Mass concentration of respirable particles and total dust was determined by gravimetric method according to the standard ZH 1/120.41. Sampling was carried out with collectors produced by Casella (Bedford UK). Separators of unrespirable fractions of particles (cyclones) imitate the separation of respirable particles in the respiratory system of an adult person, with a medium efficiency of 50% with aerodynamic diameter of 5 μm according to British Medical Research Council Standard criteria. The suction flow rate in wood particle sampling was set at 2 $L.min^{-1}$ according to ISO 10882-1:2001 method. Weighing was performed by microscales Cahn type G.2 (Paramount, California) and METTLER-TOLEDO MX-5 (Greifensee, Switzerland). Descriptive statistics (mean, standard deviation) was made for all analysed variables. The differences between mass concentrations, taking into consideration the species of worked material, were tested by Mann-Whitney U-test, as the condition of homogeneity of variance was not fulfilled (McClave and Dietrich, 1988). The error type I (α) of 5% was considered as statistically significant. All statistical analyses and graphs have been made by use of the statistics software - STATISTICA 6.0.

RESULTS AND DISCUSSION

Each value of measured mass concentration is compared with referred MPC taken from proposed Croatian Draft By-Law on Maximum Permissible Concentrations of Hazardouos Material and Biological Limit Values in Workplace Environment. The shares of samples whose dust concentration is higher than limit values are shown in Tab. 1.

Tab. 1: The share of samples whose dust concentration is higher than limit values

TYPE OF DUST	Share of samples exceeding limit values (n) in total number of collected samples (N)					
	respirable particles			total dust		
	MPC $mg.m^{-3}$	n/N	%	MPC $mg.m^{-3}$	n/N	%
Hardwood (beechwood, oakwood)	1	33/137	24	3	46/141	33
Boardlike material (fiberboard, chipboard)	1	16/92	17	3	33/93	36
Softwood (firwood)	3	0/24	0	10	0/25	0

The arithmetic average value and intervals of measured mass concentrations of respirable particles and total wood collected by personal samplers at workplaces during working of hardwood, softwood and boardlike materials are shown in Tab. 2.

Tab. 2: Arithmetic average value and intervals of measured mass concentration of respirable (c_r) and total wood dust (c_{tot})

Type of dust	Mass concentration									
	Respirable particles					Total dust				
	N	MPC	c_r	c_{min}	c_{max}	N	MPC	c_{tot}	c_{min}	c_{max}
		mg. m^{-3}					mg. m^{-3}			
Hardwood (beechwood, oakwood)	137	1	0.82	0.03	5.64	141	3	2.61	0.33	16.11
Board material (fiberboard, chipboard)	92	1	0.69	0.11	3.94	93	3	2.82	0.39	15.57
Softwood (firwood)	24	3	0.59	0.18	1.46	25	10	1.80	0.55	4.29

Although the mean values of measured mass concentrations of respirable particles for hardwood are 0.82 $mg.m^{-3}$, exceedences of MPC (1 $mg.m^{-3}$) of respirable oakwood and beechwood particles have been measured in 33 out of 137 samples (24%). Mass concentration of total oakwood and beechwood dust higher than MPC (3 $mg.m^{-3}$) has been measured in 46 out of 141 samples (33%). Exceedences have been measured when working oakwood and beechwood by sanders and circular saws, while other observed machines show no exceedences of limit values.

Exceeding of MPC for boardlike materials is measured on 16 out of 92 samples (17%) for respirable wood dust and on 33 out of 93 samples (36%) for total wood dust. Exceedences have been measured when working boardlike materials by hand tool machines.

Measured mean values of mass concentrations of respirable softwood particles (firwood) amount to 0.59 $mg.m^{-3}$ and total dust to 1.80 $mg.m^{-3}$. Not in one out of 49 samples of firwood dust, exceedence has been recorded of MPC of 3 $mg.m^{-3}$ for respirable particles and 10 $mg.m^{-3}$ for total dust.

Fig. 1 shows the distribution diagram of mean values and data dissipation of measured mass concentration of respirable particles and total dust for hardwood and softwood species and boardlike material.

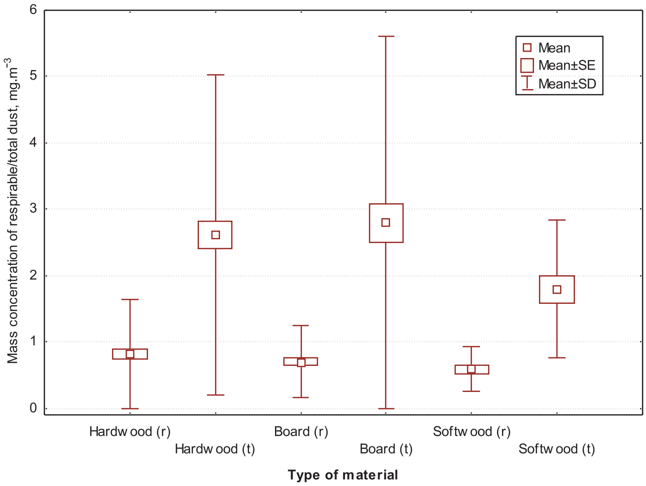

Fig. 1: Distribution diagram of mean values and data dissipation of respirable mass concentration and total mass concentration for different workpiece material (SD-standard deviation, SE-standard error of mean)

It is obvious that mass concentrations of hardwood and boardlike material exceed limit values, while all measured mass concentrations of softwood meet the limit values prescribed by the Croatian regulations.

The comparison of the results of this research show that measured mass concentrations of hardwood do not differ significantly from mass concentration of softwood and boardlike material (Tab. 3, 4 and 5). However, as health effects of softwood and hardwood dust are highly different, values of MPC are also different and hence greater importance is given to workers' exposure to oakwood and beechwood dust than to the exposure to softwood dust.

Tab. 3: Comparison between mass concentrations of hardwood and softwood dust

Sampling site	Descriptive statistics			Homogeneity of variances test		U test
	N	Mean	SD	F	p	p-level
Hardwood – total dust	141	2.61	2.42	80.1	p<0.01	0.24
Softwood – total dust	25	1.80	1.03			
Hardwood – resp. particles	137	0.82	0.83	66.6	p<0.01	0.45
Softwood – resp. particles	24	0.59	0.33			

N-number of samples; SD-standard deviation; F-test of variance; p-significance level

Tab. 4: Comparison between mass concentrations of hardwood and boardlike material dust

Sampling site	Descriptive statistics			Homogeneity of variances test		U test
	N	Mean	SD	F	p	p- level
Hardwood – total dust	141	2.73	2.42	248.11	p<0,01	0.95
Board – total dust	93	2.82	2.81			
Hardwood – resp. particles	137	0.82	0.83	237.43	p<0,01	0.86
Board – resp. particles	92	0.7	0.54			

N-number of samples; SD-standard deviation; F-test of variance; p-significance level

Tab. 5: Comparison between mass concentrations of softwood and boardlike material dust

Sampling site	Descriptive statistics			Homogeneity of variances test		U test
	N	Mean	SD	F	p	p - level
Softwood – total dust	25	1.80	1.03	65.0	p<0,01	0.26
Board – total dust	93	2.82	2.81			
Softwood – resp. particles	24	0.59	0.33	121.56	p<0,01	0.49
Board – resp. particles	92	0.7	0.54			

N-number of samples; SD-standard deviation; F-test of variance; p-significance level

What is more important, the dissipation (standard deviation) of measured values of mass concentration of hardwood dust and boardlike material is significantly greater than data dissipation of softwood dust mass concentration, which indicates the necessity of researching factors affecting environmental air pollution in processing of hardwood and boardlike materials. The conducted research shows that in some cases when processing hardwood and boardlike materials dust mass concentration is very low while in other cases it exceeds significantly the limit values. These fluctuations are much smaller in processing softwood for both respirable dust and total dust.

Limit values of carcinogens in regulations are determined in accordance with health criteria and they merely play an orientation role in providing adequate measures of workers' protection. Wood dust emission and workers' exposure especially to hardwoods, can be reduced with the aid of a large number of protection measures as described and recommended in all applicable regulations, both Croatian and European. Apart from personal protection devices and adequate training of employees and employers, workers' exposure to wood dust can also be reduced by the control of workplace exhaustion system and working machine parameters (Beljo Lučić et al. 2005, Hemillä et al. 2003, Palmqvist and Gustafsson 1999; Kopecky and Pernica 2004).

CONCLUSION

In Croatian woodworking industry, by the method of personal samplers has been measured the exceedence of MPC of total wood dust in one third of researched workplaces and the exceedence of MPC of respirable wood dust in nearly one fifth of researched workplaces. Personal protection devices (respirators) are nearly out of use. Obviously, workplace air quality according to the health critera in woodworking and furniture industry are not satisfactory, especially near the sanders, circular saws, hand tool machines and machines with shoddier solutions of wood dust suction. Processing of hardwood species and boardlike materials should be primarily considered but processing of softwood should not be disregarded, too.

According to the results of presented research and taking in consideration hazardous effect of wood dust, by Croatian legislative it is possible to accept European standards but moreover it is recommended to prescribe stricter limit values for inhalable fraction of hardwood and specially softwood species with goal to woodworker protection.

REFERENCES

1. Beljo Lučić, R. et al., 2005: Properties of chipped wood generated during mechanical wood processing. Drvna industrija 56(1): 11-19
2. Barcenas, C. H. et al., 2005: Wood dust exposure and association with lung cancer risk. American Journal of Industrial Medicine 47(4): 349-357
3. Demers, P.A. et al., 1998: What to do about softwood? A review of respiratory effects and recommendation regarding exposure limits. American Journal of Industrial Medicine 31(4): 385-398
4. Demers, P.A. et al, 2007: Wood dust and sino-nasal cancer: Pooled reanalysis of twelve case-control studies. American Journal of Industrial Medicine 48(2): 151-166
5. Giesen, E.G., 1998: Umweltaspekte bei der Arbeit mit MDF. MDF Magazin 1998, 20-23
6. Hausen, B., 1981: Woods Injurius to Human Health. Universitätsbibliothek Hannover und Technische Informationsbibliothek, de Gruyter, 67 pp.
7. Hemillä, P. et al., 2003: Effect of cutting parameters to dust and noise in wood cutting, laboratory and industrial tests. 16th International Wood Machining Seminar. Matsue, Japan. Pp. 375-384
8. Hessel, P.A. et al., 1995: Lung health in sawmill workers exposed to pine and spruce. Chest 108(3): 642–646
9. Hinnen, U. et al., 1995: Allergic contact dermatitis from iroko [Milicia excelsa] and pine [Pinus] wood dust. Contact Dermatitis 33(6): 428
10. Klein, R.G. et al., 2001: Cancerogenicity assays of wood dust and wood additives in rats exposed by long-term inhalation. International Archives of Occupational and Environmental Health 74: 109–118
11. Kopecký, Z., Pernica J., 2004: Effects of the dimensional specification of dust on the quality of air. IV. Medzinárodná vedecká konferencia "Trieskové a beztrieskové obrábanie dreva ´04", Stary Smokovec – Tatry, Pp. 125–130
12. Kos, A. et al., 2004: Influence of woodworking machine cutting parameters on the surrounding air dustiness. Holz als Roh- und Werkstoff 62(3): 169–176
13. Kubel, H. et al., 1988: Untersuchungen zur Cancerogenität von Holzstaub. Die Extraktstoffe von Buche und Fichte. Holz als Roh- und Werkstoff 46: 215–220
14. Malo, J.L. et al., 1995: Occupational asthma caused by oak wood dust. Chest 108(3): 856–858
15. McClave, J., Dietrich, F.H., 1988: Statistics II. Dellen Publishing Company, 4th ed.
16. Palmqvist, J., Gustafsson S.I., 1999: Emission of dust in planing and milling of wood. Holz als Roh- und Werkstoff 57: 164-170

17. Stellman, S.D., 1998: Cancer mortality and wood dust exposure among participants in the American Cancer Society Cancer Prevention Study-II (CPS-II). American Journal of Industrial Medicine 34(3): 229-237
18. Laboratory for Analytics and Toxicology (ANT), 1993: Draft By-Law on Maximum permissible concentrations (MPC) of hazardous material and Biological limit values (BLV) in workspace environment. Table 5. ANT, Zagreb, Croatia. ISBN 953-96075-0-7
19. The Council of the European Communities: Council Directive 1999/38/EC of 29 April 1999 amending for the second time Directive 90/394/EEC on the protection of workers from the risks related to exposure to carcinogens at work and extending it to mutagens. Official Journal L 138, (1. June 1999). Pp. 66-69
20. World Health Organization, International Agency for Research on Cancer (IARC), 1995: Wood dust and formaldehyde. IARC Monographs, 62 pp.
21. Zentralstelle für Unfallverhütung und Arbeitsmedezin, 1989: Holzstaub-Grav (ZH 1/120.41) Hauptverband der gewerblichen Berufsgenossenschaften
22. CEN, EN 481, 1993: Air quality – Particle size fraction definition for health-related sampling. (HRN EN 481:2007)
23. EN ISO 10882-1:2001 E : Health and safety in welding and allied processes – Sampling and gases in the operators breathing zone – Part 1: Sampling of airborne particles

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