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Wood Dust Exposure in Wood Industry and Forestry

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ABSTRACT

The aim of the study was to determine occupational exposure in Croatian wood processing industry and forest workers to harmful effects of wood dust on the risk of nose, nasal cavity and lung carcinoma. Mass concentrations of respirable particles and total wood dust were measured at two wood processing plants, three woodwork shops, and one lumbering site, where 225 total wood dust samples and 221 respirable particle samples were collected. Wood dust mass concentration was determined by the gravimetric method. Mass concentrations exceeding total wood dust maximal allowed concentration (MAC, 3 mg/m^3) were measured for beechwood and oakwood dust in 38% (79/206) of study samples from wood processing facilities (plants and woodwork shops). Mass concentrations of respirable particles exceeding MAC (1 mg/m^3) were recorded in 24% (48/202) of samples from wood processing facilities (mean 2.38±2.08 mg/m^3 in plants and 3.6±2.22 mg/m^3 in woodwork shops). Thus, 13% (27/206) of work sites in wood processing facilities failed to meet health criteria according to European guidelines. Launching of measures to reduce wood dust emission to the work area is recommended.

***Key words**: wood dust, carcinogenicity, wood industry, forestry, Croatia*

Introduction

About 3.5 million cubic meter wood volume are manufactured in Croatia *per* year. More than 2,500 forest wood cutters and 40,000 wood industry workers are exposed to various wood dust concentrations[1]. Wood dust from the work area can induce allergic reactions and asthma in these workers. While the opinion on wood dust carcinogenicity differs among European countries, wood processing activities are definitely associated with the risk of nose and nasal cavity carcinoma[2–5]. In 1995, the International Agency for Research in Carcinoma (IARC) classified wood dust in group 1 carcinogens, and divided workers exposed to wood dust effects into groups according to the level of work site dustiness and validity of evidence for disease development. Group 1 includes workers in furniture industry and woodwork shops, who are at an increased risk of developing nose and nasal cavity carcinoma. There is definite evidence for detrimental effects of wood dust in this group at risk. Group 2 includes carpenters and construction (rough) carpenters in whom harmful effects of wood dust have only been postulated based on inadequate evidence and lower values compared with those recorded in furniture industry; yet, the data available suggest an association with the development of nose and nasal cavity carcinoma. As these workers also work with processed wood, adverse effects of pentachlorophenol and other substances can also be presumed. In group 3, which includes forest and sawmill workers, the risk of detrimental effects of wood dust and development of nose, nasal cavity and lung carcinoma is very low, however, yet suspected[2]. In some countries, e.g., USA, England and Sweden, an association was recorded between wood dust exposure and lung cancer mortality among forest and sawmill workers[2].

In Croatia, according to the 1993 Draft By-law on maximal allowed concentrations (MAC) of harmful substances and biological borderline values (BBV) in work areas, the mass MAC in work area is 1 mg/m^3 of respirable particles and 3 mg/m^3 of total wood dust for hard-

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woods (beechwood, oakwood and exotic woods). For soft deciduous wood and conifers, these figures are 3 mg/m^3 and 10 mg/m^3, respectively[5]. According to the European Union (EU) guidelines, a borderline value of 5 mg/m^3 has been set for hardwood inhalable fraction[6]. Most European countries have already set their own borderline values, some of which are more strict than those posed by EU guidelines[7].

Data on the prevalence of respiratory system carcinoma in wood industry and forestry laborers in Croatia are not available. The measurement of wood dust mass concentration in the respective work areas in Croatia was performed in order to assess the level of exposure in these workers. The results thus obtained should indicate the work sites with wood dust exposure exceeding regulatory MAC in Croatia and associated with an increased risk of cancer development. Once the risk sites have been identified, target engineering and administrative measures to reduce wood dust emission into the work area can be introduced, with special reference to the use of personal protective devices.

Subjects and Methods

A total of 202 samples of respirable particles and 206 samples of total dust were collected by use of personal samplers. Nineteen paired samples were collected during wood cutting. The samplers were carried by forest laborers during wood cutting and oakwood chainsawing (Figure 1).

Fig. 1. Wood cutter on wood processing.

Sampling was performed during wood machining at different quality levels of suction system operation (along with band-saws, circular saws, grinders, molders, planing and drilling machines, manual machine tools) in furniture manufacture facilities, grinding and varnishing facilities, plant furniture shop, and at the forklift truck wheel. Different kinds of wood, i.e. hardwoods, softwoods and fiberboard, were processed.

Upon comparison of passive monitors and method of personal sampling[8,9], the method of respirable particle and total wood dust collection by use of personal samplers (dosimeters) manufactured by Casella (Bedfort, England, 2001) worn by the workers throughout the work hours was chosen (Figure 2).

The design of the nonrespirable particle fraction separators (cyclones) imitates separation of respirable particles in the respiratory system of a healthy adult human at mean efficacy (50%) *per* 5 μm aerodynamic diameter.

Wood dust mass concentration was determined by gravimetric method[10,11]. The value of aerodynamic diameter of respirable or inhalable particles was arbitrarily determined. Dust is mostly composed of solid particles greater than 1 μm in diameter[12]. According to IARC investigations, most wood dust particles are of medium aerodynamic diameter of >5 μm. The upper limit of inhalable particle aerodynamic diameter is 10–15 μm, depending on the workers' breathing intensity[2]. The ISO/TR 7708-1995 Technical Report proposes the size below 10 μm[13].

The instruments were standardized, and the method of wood dust particle sampling met the Croatian and international standards[14,15]. Wood dust samples were collected by use of Whatman glass fiber filters characterized by efficient particle separation from air stream, low resistance, high purity, and chemical inertia. Considering the material hygroscopy, the filters were conditioned to permanent exicator humidity for 24 h before weighing (before and after sampling). Weighing was done by use of a Mettler-Toledo microscale (Greifensee, Switzerland, 2000), characterized by precise measurement and reading-off values of 10^{-6} g, with measurement uncertainty of 10^{-4} g. The suction flow rate was set at 2 l/min on wood particle sampling. Mass concentration of wood dust was determined by the following equation:

$$c = \frac{(m_2 - m_1)}{V} = \frac{m_u}{V}, \frac{\text{mg}}{\text{m}^3} \tag{1}$$

where:
c = mass concentration of wood dust (mg/m^3);
m_1 = filter mass before sampling (mg);
m_2 = filter mass with sample (mg);
$m_2 - m_1$ or m_u = sample mass (mg);
V = total air volume from which the sample was obtained (m^3).

Air volume (V) from which the sample was obtained was calculated from the measured time of the device operation during which the environmental air flowed through the device at the preset flow rate:

$$V = Q \cdot t, \text{ m}^3 \tag{2}$$

where:
V = sampled air volume (m^3);
Q = air flow rate through the device (m^3/min);
t = time of device operation (min).

Fig. 2. Holders of filters sampling respirable particles (a) and total wood dust (b).

According to European guidelines[6], when oakwood and beechwood particles are present in the mixture of wood particles along with other wood types, the borderline value of mass concentration for hardwood applies to the overall mixture, i.e. 5 mg/m^3 for inhalable fraction. Therefore, maximal allowed values for hardwood were taken for comparison of the measured values of mass concentration. According to Croatian regulatory provisions, these values are 1 mg/m^3 for respirable particles and 3 mg/m^3 for total wood dust. Only total wood dust samples were considered when the measured mass concentrations were compared with the borderline values as recommended by European guidelines. None of the samples of respirable particles showed >5 mg/m^3, however, it should be considered that the comparison was approximate because the total wood dust sampler input is only approximated to the respective input of the standard inhalable fraction sampler.

Results

Values exceeding MAC of respirable particles of 1 mg/m^3 were measured in 26 of 120 (22%) samples from wood processing plants and 22 of 82 (27%) samples from woodwork shops. A higher rate of values exceeding the maximal allowed mass concentration of 3 mg/m^3 was recorded for total wood dust, i.e. in 32 of 123 (25%) samples from wood processing plants and 47 of 83 (57%) samples from woodwork shops (Table 1).

Values exceeding MAC for oakwood and beechwood dust respirable particles of 1 mg/m^3 and for total wood dust of 3 mg/m^3 were measured at all wood processing sites except for forest woodcutters. Nevertheless, the mean mass concentration of respirable particles collected during oakwood (hardwood) cutting exceeded the mean value recorded in one of the woodwork shops (Table 1). Besides wood type, this could have been due to the work with chainsaw, whereby wood cutters are additionally exposed to exhaust gases, dispersed oil particles, ground particles, etc.

Comparison of these results with the borderline value set by European guidelines (5 mg/m^3) yielded excessive total wood dust mass concentration in 8% of wood processing plant samples and 21% of woodwork shop samples (Table 1).

Discussion

The Croatian wood industry and lumbering are expected to adjust to the European standards including work site air quality system. Results of the present study revealed the rate to which the work conditions in Croatian wood industry met the regulations set by the Croatian provisions and respective European guidelines. The Croatian provisions on the maximal allowed concentration of adverse substances in the work area differentiate respirable fraction from total wood dust, whereas European standards refer only to inhalable fraction, i.e. total respirable airborne particles. As some of the study work sites failed to meet the health criteria according to both Croatian provisions and European guidelines, the new legal provisions are expected to require modifications in the Croatian furniture industry.

According to IARC data, highest wood dust exposure in furniture plants and woodwork shops of 5 mg/m^3 is recorded on sanding and similar activities[2]. Total wood dust mass concentration of up to 5.22 mg/m^3 was measured in plant 1 on oakwood sanding with band sander, and of up to 12.52 mg/m^3 in plant 2 on manual sanding in varnish shop. A similar level of wood dust exposure was recorded at the circular saw work site, with total wood dust mass concentration of 16.11 and 15.57 mg/m^3 measured in woodwork shop 2 on beechwood and chipboard sawing, respectively. The work with sanders, manual machines, machines with poor wood dust suction on work with hardwood are the sites associated with high wood dust exposure. High wood dust exposure frequently results from irregular and inappropriate machine and work area cleaning with compressed air and broom instead of workshop vacuum cleaner[16].

In addition to recognizing wood dust carcinogenicity, the standards in various European countries differ according to borderline values of wood dust mass concentration[6,7]. Thus, German standards for borderline

TABLE 1
MASS CONCENTRATIONS OF RESPIRABLE PARTICLES AND TOTAL WOOD DUST MEASURED AT SAMPLING SITES, AND PROPORTION OF SAMPLES EXCEEDING MAXIMAL ALLOWED CONCENTRATION (MAC) AND EUROPEAN GUIDELINES[6]

Sampling site	Mass concentration (mg/m^3) (mean±SD)		Proportion (%) of samples (n) exceeding borderline values in total number of samples collected (N)		
			Croatian regulatory provisions (MAC)		European guidelines
	total wood dust (c_u)	respirable particles (c_r)	total wood dust (3 mg/m^3)	respirable particles (1 mg/m^3)	inhalable particles (5 mg/m^3)*
Plant 1	2.02±1.5	0.7±0.38	20/87 (23%)	16/83 (19%)	6/87 (7%)
Plant 2	2.74±2.65	0.87±0.79	12/36 (33%)	10/37 (27%)	4/36 (11%)
Total	2.38±2.08	0.79±0.59	32/123 (26%)	26/120 (22%)	10/123 (8%)
Woodwork shop 1	4.23±2.61	0.6±0.27	8/11 (73%)	1/11 (9%)	3/11 (27%)
Woodwork shop 2	4.61±3.38	1.2±1.08	37/57 (65%)	21/56 (38%)	14/57 (25%)
Woodwork shop 3	1.97±0.67	0.21±0.06	2/15 (13%)	0/15 (0%)	0/15 (0%)
Total	3.6±2.22	0.67±0.47	47/83 (57%)	22/82 (27%)	17/83 (21%)
Wood industry total	2.99±2.15	0.73±0.53	79/206 (38%)	48/202 (24%)	27/206 (13%)
Wood cutting and processing	1.47±0.39	0.36±0.23	0/19 (0%)	0/19 (0%)	0 (0%)
Wood industry and forestry total	2.84±1.87	0.66±0.47	79/225 (35%)	48/221 (22%)	27/206 (13%)

* Only the group of total wood dust samples were compared, as none of the respirable particle samples exceeded borderline values according to European guidelines.

values of oakwood and beechwood inhalable wood dust prescribe 2 mg/m^3 for new facilities, allowing up to 5 mg/m^3 for old facilities[7]. German standards from 1992 and 1996 recommend the use of substitute wood kinds where possible in order to reduce the use of oakwood and beechwood to 10% in final products. In 1985, the Germany Senate Commission proclaimed oakwood and beechwood dust carcinogenic, based on the research launched in England as early as 1965, during which adenoacarcinoma of the nose was recorded in 15 woodworkers. In 1999, European Community proclaimed wood dust carcinogenic based on the IARC classification from 1995[17]. Following rat studies in Germany[17], the 2001 TRGS 905 standards do not classify untreated oakwood and beechwood dust in the first category of carcinogens anymore[9].

Study results are consistent with the concept of greater wood fragmentation on sawing hardwood (oakwood, beechwood) and fiberboard sawing. Wood dust, especially hardwood dust emission can be reduced by a number of protective measures that are described and recommended in all relevant Croatian and European regulations available. Besides personal protection and proper education of both the employers and employees, workers' exposure to wood dust can also be reduced by appropriate control of dust suction systems at work sites and parameters of the machine operation. Investigating the impact of working practice and wood material properties on respirable particle emission to the work area atmosphere, Palmqvist and Gustafsson conclude that the mean thickness of wood shavings greater than 0.1 mm on wood processing should be determined by regulatory provisions[18], as the work area dustiness with respirable particles would thus be reduced.

In contrast to other countries with a long tradition of wood industry such as Canada, Finland, Denmark and Germany[7,8,19,20–23], in Croatia there are no longstanding and systematic measurements of workers' wood dust exposure according to work sites. On the other hand, there are no data on exposure measurements and respective regulatory standards in the neighboring countries such as Bosnia and Herzegovina, Serbia and Montenegro, Bulgaria and Romania, which, like Croatia, have abundant timer reserves, and quite prominent position in the total world and European wood industry. No data or clear standards are available from Hungary, a new European Union member country either. According to the information available, the issue of standards in wood industry and forestry was regulated in a way similar to that in Croatia in Czech Republic and Poland until their admission to the European Union[7].

The results obtained in the present study have fully justified continuation of the measurements and chemical analysis of the samples collected at work sites in wood industry and forestry. Reliable data on the wood dust level in work areas in the Croatian wood industry will help in taking stand on borderline values as regulated by European guidelines and on determining regulatory mass concentration of inhalable fraction in Croatia.

REFERENCES

1. ANONYMOUS: Annual Report 2001. (Hrvatske šume, Zagreb, 2002). — 2. KOHLER, B.: Wood dust and cancer. National Report – Health, Safety and Environment. (IARC, Lyon, 1995). — 3. RUETZE, M., D. NOACK, C. SCHUMACHER, Holz Roh. Werkstoff, 48 (1990) 229. — 4. RUETZE, M., U. SCHMITT, D. NOAK, S. KRUSE, Holz Roh. Werkstoff, 52 (1994) 87. — 5. ANONYMOUS: Draft By- Law on Maximal Allowed Concentrations of Harmful Substances and Biological Borderline Levels in Work Areas 1993. ISBN 953-96075-0-7. (ANT, Zagreb, 1993). — 6. ANONYMOUS: 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 risk related to exposure to carcinogens at work and extending it to mutagens. (EC, Strassbourg, 1999). — 7. GIESSEN, E. G., MDF Magazin, 98 (1998) 20. — 8. SCHLÜNSSEN, V., P. S. VINZENTS, A. B. MIKKELSEN, I. SCHAUMBURG, Ann. Occup. Hyg., 45 (2001) 157. — 9. HENKEL, M., K. JENTSCH, Holz Zentralbl., 96 (2001) 1200. — 10. ANONYMOUS: Hauptverband der gewerblichen Berufsgenossenschaften. (Zentralle für Unfallverhütung und arbeitsmedizin, Holzstaub – Grav ZH 1/120.41, 1989). — 11. ANONYMOUS: Determination of mass concentration of air particles. (SDČVJ, Smjernica SDČVJ 203, 1987). — 12. ANONYMOUS. Characteristics of particles and particle dispersoids. (Stanford Research Institute Journal, Menlo Park, California, 1961). — 13. ISO 7708:1995; Air quality – particle size fraction definition for health-related sampling. — 14. ANONYMOUS. Neue Technische Regeln für Gefahrstoffe. Technik und Recht. Gefahrstof. Remhalt. Luft, 50 (1996) 255. — 15. ISO 10882-1:2001; 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. — 16. KOS, A., R. BELJO-LUČIĆ, D. HORVAT, K. ŠEGA, I. BEŠLIĆ, Drvna industrija, 53 (2002) 131. — 17. KLEIN, R. G., P. SCHMEZER, F. AMELUNG, H. G. SCHROEDER, W. WOESTE, J. WOLF, Int. Arch. Occup. Environ. Health, 74 (2001) 109. — 18. PALMQVIST, J., S. I. GUSTAFSSON, Holz Roh. Werkstoff, 57 (1999) 164. — 19. ROSENBERG, C., T. LIUKKONEN, T. KALLAS-TARPILA, A. RUONAKANGAS, R. RANTA, M. NURMINEN, I. WELLING, P. JÄPPINEN, Am. J. Ind. Med., 41 (2002) 38. — 20. HALL, A., K. TESCHKE, H. DAVIES, P. DEMERS, S. MARION, Am. Ind. Hyg. Assoc. J., 63 (2002) 709. — 21. RAPP, A. O., R. D. BRANDT, U. SCHMITT, Holz Roh. Werkstoff, 55 (1997) 141. — 22. TESCHKE, K., C. HERTZMAN, B. MORRISON, Am. Ind. Hyg. Assoc. J., 55 (1994) 205. — 23. VINZENTS, P. S., V. SCHLÜNSSEN, H. FEVEILE, I. SCHAUMBURG, Ann. Occup. Hyg., 45 (2001) 603.

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IZLOŽENOST DRVNOJ PRAŠINI RADNIKA DRVNE INDUSTRIJE I ŠUMARSTVA

SAŽETAK

Cilj rada bio je prikazati razinu izloženosti drvodjeljskih radnika i šumskih sjekača štetnom utjecaju zaprašenosti na radnom mjestu zbog rizika obolijevanja od karcinoma nosa, nosne šupljine i pluća. Mjerenjima masene koncentracije *respirabilnih čestica* i *ukupne drvne prašine* obuhvaćena su radna mjesta u dvije tvornice, tri stolarije te radno mjesto šumskog sjekača pri čemu je sakupljeno 225 uzoraka ukupne prašine i 221 uzorak respirabilnih čestica. Masena koncentracija drvne prašine određivana je gravimetrijskom metodom. Prekoračenja (MDK) masene koncentracije drvne prašine bukovine i hrastovine za *ukupnu prašinu* (3 mg/m^3) izmjerena su u 38% uzoraka (79 od 206) u drvodjeljskim tvrtkama (tvornicama i stolarijama). Izmjerena masena koncentracija *respirabilnih čestica* preko MDK (1 mg/m^3) utvrđena je u 23,76% (48 od 202) uzoraka u drvodjeljskim tvrtkama (prosječno 2,38±2,08 mg/m^3 u tvornicama i 3,6±2,22 mg/m^3 u stolarijama). Tako 13,11% (27/206) istraživanih radnih mjesta u tvornicama i u stolarijama ne zadovoljava zdravstvene kriterije prema Europskim Smjernicama od 5 mg/m^3 inhalabilnih čestica. Sve potrebne mjere zaštite trebaju ishoditi usklađivanju s europskim standardima kakvoće zraka na radnom mjestu.