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The model for assessment of health risks of dust connected with wood manufacturing in Estonia

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Abstract. The Estonian woodworkers' exposure to wood dust is investigated. The measurement equipment HazDust EPAM-5000 was used and the particle size was determined with the microscope Axiolam ICc 3. On the basis of these measurements and literature data on wood dust hazardousness the model for determination of wood dust risk levels is worked out. The risk level of wood dust in the Estonian wood-processing industry is III to IV on the five levels scale. The maximum wood dust concentration in the workplace air was 4.27 mg $(m^3)^{-1}$ and registered by the polishing of window details. The better work conditions in the industry have been gained with effective ventilation and consistent cleaning of the workrooms. On the basis of the investigation it has been concluded that the working conditions in the wood processing industry in Estonia in 2012 have been improved considerably over the years 1990–2000.

Key words: wood manufacturing, wood dust, health risks.

INTRODUCTION

Occupational exposure to wood dust is widespread in the 25 member states of the EU. The proportion of the exposed population ranged from 1.2% in Belgium to 4.5–4.6% in Estonia and Latvia (data from 2000–2003) Liukkonen et al. (2005).

This paper investigates the relation between wood dust exposure in the wood manufacturing industry and occupational hygiene variables. Wood is manufactured and used in many ways (like sawmill operations, furniture manufacturing, paper manufacturing and construction of residental and commercial buildings), but always it is connected with formation of dust of different particle size (Brosseau et al., 2001; Liukkonen et al., 2005; Blumberga et al., 2012). Workers are exposed when wood is sawed, chipped, routed, or sanded. The health risks of sawdust depend on the particle size and the type of wood (Lehmann & Fröhlich, 1988; Mikkelsen et al., 2002). Some types of wood might be carcinogenic for humans (Innos et al., 2000; Report, 2011), wood dust causes irritation of the eyes, nose and throat. Skin irritation caused by wood is often mechanical. Some wood itself contains chemicals that are irritants, like teak, mansonia and radiata pine which can cause eye irritation, skin dermatitis, resulting in redness and blistering.

Glues and wood preservatives might be used in the manufacturing of wood and dust from such sources may release formaldehyde and organic solvents. Common wood preservatives are arsenic, chromium, copper, creosote, and pentachlorophenol. Wood also contains many endogenous chemicals that are responsible for its biological actions (Liukkonen et al., 2005). Cedar wood dust has been associated with the development of occupational asthma. Pine has been known to cause irritation and allergic contact dermatitis. Chronic exposure to hardwood dusts in the furniture trade has been linked to the development of adenocarcinoma of the nasal sinuses (Mikkelsen et al., 2002; Schlünssen et al., 2002). Some of the wood species have been shown to cause nasopharyngeal carcinoma, or nasopharyngeal cancer (Report, 2011). Wood dust has been found to be almost four times as irritating as plastic dust in the same concentration (Imbus, 2002).

There were 2 large furniture factories in the capital of Estonia during 1968–1995 (Dujeva & Lang, 1996; Innos et al., 2000), where the workers' exposure to wood dust and additionally formaldehyde was investigated. The cancer incidences of 7,412 workers were followed. The sinonasal cancer risk had the greatest numbers; the increased risk of colon and rectal cancer was associated with the length of employment. The risk for workers having wood dust in the workplace air for developing cancer was higher compared with the conditions where the workers were exposed at the same time to supplementary formaldehyde. The numbers for developing cancer caused by formaldehyde were higher in developing stomach and rectal cancer. Formaldehyde stays in the sawdust or plywood for months. Relative risk for oncological illnesses was determined. The results were that the workers with a long history in the furniture industry had 8 times more risk of cancer than the control group (Dujeva & Lang, 1996). Formaldehyde concentration in the plywood industry was registered from 0.007–0.6 mg $(m^3)^{-1}$ (Threshold exposure limit value (TLV) 0.5 mg $(m^3)^{-1}$).

The most common illnesses of wood-workers were of the pharynx, oesophagus, nose and sinuses, bladder, Hodgkin's disease (Innos et al., 2000). The studies in Estonia (1999–2003) showed that in the furniture industry where different wood types were used and formaldehyde as the component of the glue was present, the hazardous factors were formaldehyde, wood dust, carbamide-formaldehyde adhesives and glues. The concentration of formaldehyde registered was from 0 to 6.4 mg $(m^3)^{-1}$ in the inhalable zone, the mean value was 1 mg $(m^3)^{-1}$. Machine manufacturing of wood is connected with wood dust elimination: 1–3.7 mg $(m^3)^{-1}$ – producers of veneer; by the polishing machines (sanding etc.) the concentration of dust (c_{dust}) was 0.7–53.7 mg $(m^3)^{-1}$ (TLV was then 6 mg $(m^3)^{-1}$) (Kauppinen et al., 2006). The mean value for wood dust in veneer manufacturing was 1.6 ± 0.2; the mean dust concentration of the polishing machines was 11.4 ± 0.8. The concentration of formaldehyde was determined by the chemical method. Before 1985 OSHA settled the exposure limit for wood dust 15 mg $(m^3)^{-1}$ (TVL). At the present time TVL in different countries is in the range of 0.5 to 5 mg $(m^3)^{-1}$ for the inhalable dust (Brosseau et al., 2001; Liukkonen et al., 2005). Contaminated with wood dust workplace air is continuously a subject for investigation in many countries (Friesen et al., 2006; Schlünssen, 2002, 2008). The results of wood dust concentration measurements in some EU countries are given in Table 1.

Table 1. Results of investigations of pollution in the work environment with wood dust in some EU countries

Country	Source of investigation, year	Type of industry	Dust concentration, mg $(m^3)^{-1}$	Exposure limit TLV, mg $(m^3)^{-1}$
Denmark	Mikkelsen, 2002	furniture	$C_{mean} = 0.95$ $C_{max} = 1.99$	2.0
Netherlands	Spee, 2007	carpentry, construction work	0.8–11.6 $C_{mean} = 3.3$	2.0
Great Britain	Black, 2007	wood processing	$C_{max} = 15.9$ $C_{mean} = 2.3–2.7$	5.0
Denmark	Schlünssen, 2008	furniture	0.6–0.95	2.0
Poland	Baran, 2007	wood processing	0.59–16.2	4.0

The aim of the study was to explore the working conditions in the wood processing industry in Estonia in 2011–2012. The main question was: are the conditions in the wood processing industry improved compared with 1990–2000 when Estonia took the 1st-2nd place (beside Latvia) in the number of workers (4.5–4.6% of the population) exposed to wood dust?

MATERIAL AND METHODS

Wood souvenir producing small-scale enterprises (juniper and alder used as wood source material), furniture industry (pine), paper finishing, plywood industry, fibre boards manufacturing, office-rooms and the outdoor environment close to industrial premises were investigated. The Haz Dust EPAM 5000 was used. The size of the particle was determined with the microscope Axiolam ICc 3. The list of the health hazards caused by the types of wood used in Estonian manufacturing are as follows: 1) Birch: irritant, sensitiser; causes nausea; 2) Juniper: irritant; headache, nausea; 3) Pine: general irritant, skin irritant; contact dermatitis, rhinitis, asthma; 4) Alder: rhinitis and bronchial problems, dermititis; 5) Aspen: soft, no health damages; 6) Oak: sensitiser, eye and skin irritant; nasal cancer; 7) Larix (larch): allergia, dermatitis; 8) Fir: skin irritation; dermatitis, rhinitis, asthma, possible decrease in lung function (Liukkonen et al., 2005).

For risk assessment mainly BS8800 standard based methods are used. The developments of this method are given by Reinhold et al. (2009), Friesen et al. (2006). The risk assessment method used in the current study is based on the standard EVS-EN 15251 (Fig. 8). The concentrations of wood dust in this risk assessment model are derived from the experimental data of the current investigation.

RESULTS

The results of measurements are given in Table 2. The configuration of dust in the souvenirs factory are given in the Figs. 3, 4 and 5 (juniper and alder are used). The highest dust levels were in window and door manufacturing (enterprise 3 in Table 2) – 4.27 mg $(m^3)^{-1}$. The dust concentration in different procedures during window production are given in Table 3 and Fig. 6 and 7. The dust concentration during processes of the furniture industry (enterprise 5 in Table 2) are lower than in enterprise 3. The low concentrations of dust in enterprise 4 (Table 2) have been gained due to the effective local exhaust ventilation. The dust concentration outdoors close to the industry (No 8 in Table 2) and in the office-rooms (No 7 in Table 2) of these industries were also measured and are presented in Table 2. These two concentrations are under the environmental exposure limits.

Table 2. Investigated wood manufacturing industries in Estonia

No	Characterisation of investigated firm	Wood types	Dust concentration, mg $(m^3)^{-1}$	Exposure limit TLV, mg $(m^3)^{-1}$	Risk level**
1	Paper processing	pine	0.1–0.2	1–5	III
2	Plywood	pine	1) produce: 1.18 2) + F* = 4.37 3) polishing 2.9	2–5	IV
3	Windows and doors (Fig. 2)	oak, birch, pine, fir	4.27	2–5	IV
4	Wood souvenirs (Figs 1, 3, 4)	juniper, alder	0.09	2–5	III
5	Furniture	pine, birch	0.019–2.058	2–5	IV
6	Fibre boards	pine	0.087	2–5	III
7	Office-rooms		0.012–0.020	0.05	II
8	Outdoors		0.009–0.014	0.05	II

*Formaldehyde concentration: 0.2 mg $(m^3)^{-1}$ (TLV = 0.5 mg $(m^3)^{-1}$)

**Risk level is determined by the risk assessment model (Fig. 8)

Figure 1. Manufacturing of wood.

Figure 2. Manual polishing of wood details souvenirs (juniper, alder) for windows and doors (pine, birch).

Figure 3. Juniper dust from machine planing.

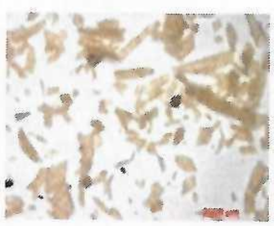

Figure 4. Alder dust from machine planing.

Figure 5. Alder dust from hand polishing.

Table 3. The measurement of wood dust in the manufacturing of windows (enterprise 3) and doors during different operations

Workplace	Wood type	The duration of the measurement (minutes)	Results	
			The measurement results $c_{min}...c_{max}$, mg $(m^3)^{-1}$	c_{mean} ± uncertainty (U= ± 10%) mg $(m^3)^{-1}$
Abrading/ packing. Overall dust	99% pine dust	5	0.017...0.070	0.047 ± 0.005
Wood planing, overall dust	'	5	0.008...0.042	0.017 ± 0.002
Planing, of profile parts (with local ventilation)	'	5	0.010...0.077	0.036 ± 0.004
Polishing of primed details	alder+ aspen	5	0.107...4.237	1.289 ± 0.123
Polishing of undercoated boards	'	3	0.474...4.274	2.988 ± 0.299
Overall dust from polishing	'	3	0.066...0.199	0.149 ± 0.015
Polishing (in the same room with painting)	99% pine	3	0.005...0.948	0.151 ± 0.015
Polishing of a window by 2 workers	'	3	0.029...3.211	1.443 ± 0.144

**2 mg $(m^3)^{-1}$ is the TLV for all dust during 8 h (Resolution, 2007).

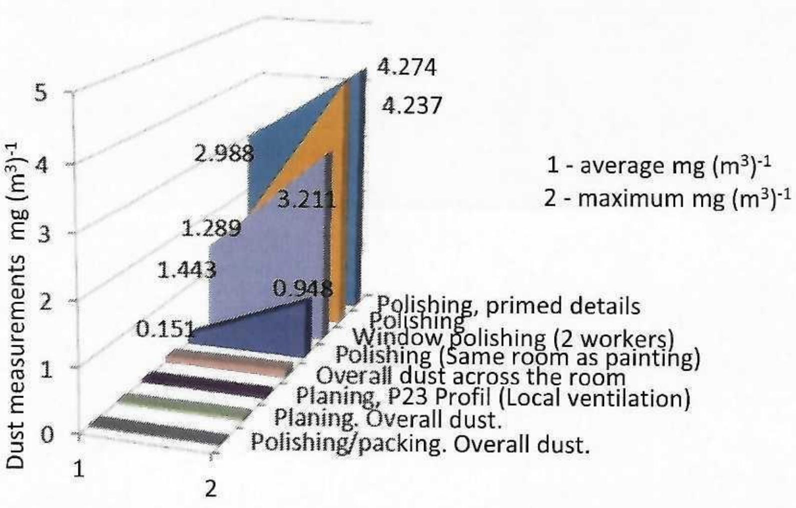

Figure 6. Dust concentration in window manufacturing.

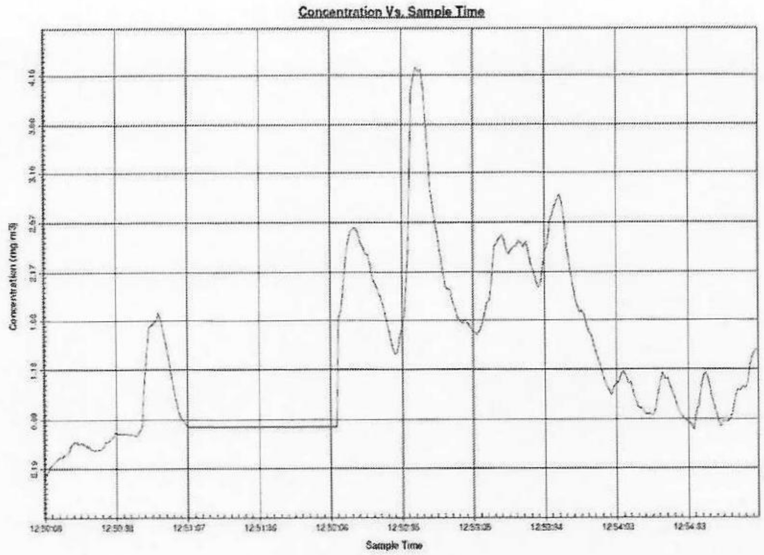

Figure 7. Dust concentration changes during machine polishing of wooden parts of windows.

Dust concentrations in the inhalable zone of workers during different manufacturing processes in window production are given in Fig. 6. The highest concentration of wood dust is during the polishing of primed details. The dust concentration is not constant during the polishing process; it depends on the angle between the work tool and the wood detail (Badescu et al., 2011) and other factors (Fig. 7).

RISK LEVELS

The risk assessment model is given in Fig. 8. Four risk levels are determined.

< 300	300	500	1,000–1,500	Lighting, lx
< 4	< 4	> 7	> 10	Ventilation, l/s per person
< 20	> 20	> 25	> 30	Humidity, %
10	5	2	1	Wood dust, mg $(m^3)^{-1}$
more	19–27	20–26	21–23.5	Operative temperature, °C
0.25…10	0.25…10	<0.25 >10	<0.25 >10	Particle size, μm

5th level of risk: Restricted demands for IC	4th level of risk: Restricted demands for IC	3rd level of risk: Moderate demands for IC	2nd level of risk: Optimal demands for IC	1st level of risk: Special demands for IC

Figure 8. The levels of risk for different hazardous factors of indoor climate (IC). Health consequences on 5 levels of risk are given by Reinhold and Tint (2009).

DISCUSSION

The conditions in the wood processing industry in Estonia have been improved compared with the period 1968–1995. The toxic hardwoods (mahagony, etc.) are not manufactured in Estonia. From the investigated wood types juniper has a strong smell, but it is used only in small amounts for making souvenirs. The highest dust concentration measured, was 4.27. The exposure limit for all inhalable dust in Estonia is 5 mg $(m^3)^{-1}$ (Resolution, 2007), although for wood dust it is 2 mg $(m^3)^{-1}$. The effective measures for workers health protection are: effective local exhaust ventilation by all woodworking machines; automatively working machines; rooms should be cleaned every day, ventilation should be balanced by an intake of fresh air.

CONCLUSIONS

The Estonian woodworkers' exposure to wood dust was investigated. On the basis of these measurements and literature data on wood dust hazardousness the model for determination of wood dust risk levels is worked out. The risk level of wood dust in the Estonian wood-processing industry is III to IV in the five levels scale. The maximum wood dust concentration in the workplace air was 4.27 mg $(m^3)^{-1}$ and connected with the polishing of windows details.

The better work conditions in the wood processing industry in 2012 (compared with the conditions in the period of 1990–2000, literature data analysis) have been gained with more effective ventilation systems and careful surveillance of these ventilation devices; consistent cleaning of the workrooms.

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