Exposure to wood dust, endotoxins and terpenes in Norwegian sawmills

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Introduction:

Sawmill workers are exposed to wood dust, endotoxins and terpenes that may cause allergic and inflammatory responses in airways, eyes, and skin. Detailed exposure characterization of all components by different wood species, seasons and departments is necessary for the study of exposure-response relationships, and for identification of exposure reducing interventions.

Objectives: To characterize the occupational exposure to wood dust, endotoxin and terpenes in Norwegian sawmills.

Methods:

Full shift personal sampling of monoterpenes and sesquiterpenes, thoracic and inhalable wood dust and endotoxins were performed two consecutive days summer and winter in 11 Norwegian sawmills (n=199 workers, 1-4 repeated measurements).

Results:

Table 1. Exposure measurements

Component	n	GM	GSD
Wood dust (mg/m³)			
Thoracic fraction	474	0.09	2.6
Inhalable fraction	87	0.67	2.9
Endotoxin (EU/m³)			
Thoracic fraction	476	2.6	4.9
Inhalable fraction	91	17.0	4.3
Monoterpenes (µg/m³)			
α-pinen	393	544	8.2
β-pinen	393	103	6.9
3-karen	371	127	9.9
p-cymen	393	19	6.0
limonen	393	60	6.9
Σ monoterpenes	393	927	7.6
Sesquiterpenes (ng/m³)			
α-longipinene	50	1343	5.0
Σ sesquiterpenes[a]	50	29437	5.6

[a]equivalents of α-longipinene

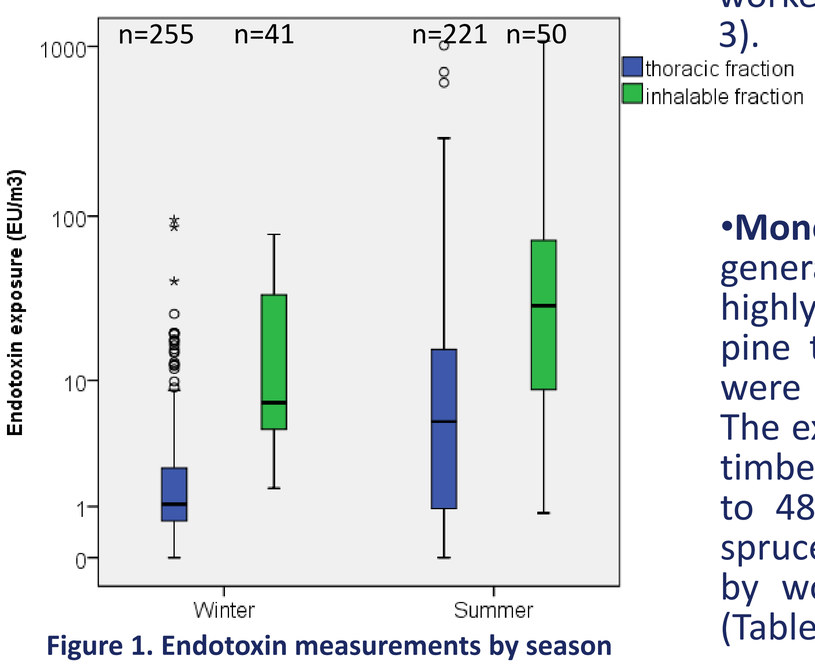


Figure 1. Endotoxin measurements by season

•**Wood dust:** Both the thoracic and inhalable wood dust exposure were low (Table 1) compared with the Norwegian OEL of 2 mg/m³ total wood dust, and did not differ between seasons or wood species (not shown). The thoracic wood dust exposure was highest in maintenance, sorting of dry timber and drying of timber (Table 2). Work in different departments explained 23 % of the between worker exposure variance (Table 3).

•**Endotoxins:** The thoracic and inhalable endotoxin exposure were low (Table 1) compared with the health based inhalable OEL of 90 EU/m³, but were higher in summer than in winter (Figure 1). Significant interactions were observed between seasons and departments. In winter, work in maintenance and saw had the highest exposure of all departments (Table 2). In summer, the exposure were higher in all departments, but particularly in sorting of green timber (28×), saw (8×) and sorting of dry timber (8×) (Table 2). Work in different seasons and departments explained both between worker and within worker endotoxin exposure variance; 57% in total (Table 3).

•**Sesquiterpenes:** The exposure to sesquiterpenes was significantly higher in the saw department compared with the planing department (Figure 3).

•**Monoterpenes:** The GM exposure to monoterpens was in general low compared with the OELs of 140 mg/m³, but highly variable (Table 1), and higher when working with pine than with spruce (Figure 2). Significant interactions were observed between wood species and departments. The exposure level was highest in the saw, sorting of green timber, maintenance and the planing department, and up to 48× higher when working with pine compared with spruce (Table 2). 48 % of the total variance was explained by work with different wood species and departments (Table 3).

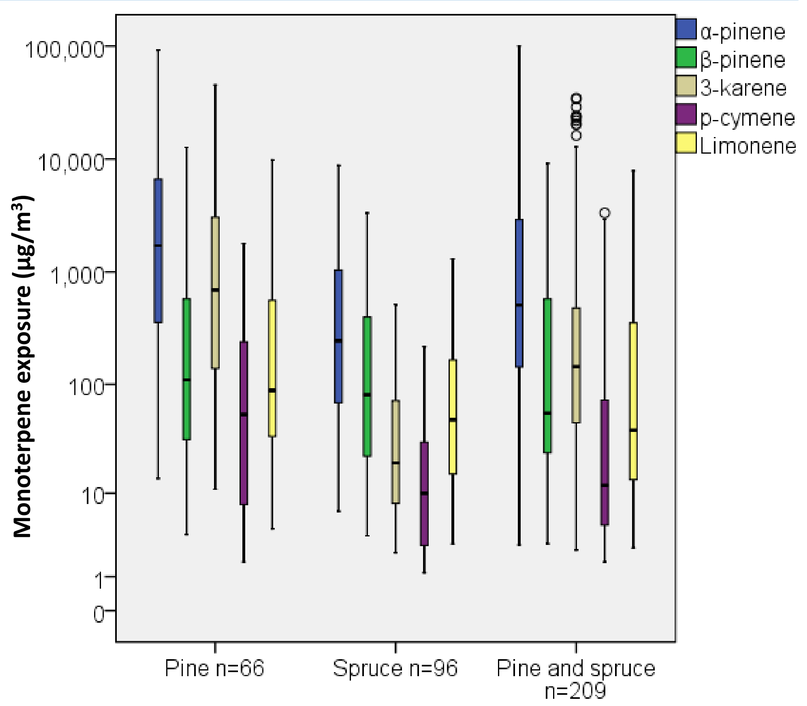


Figure 2. Monoterpene measurements by wood species

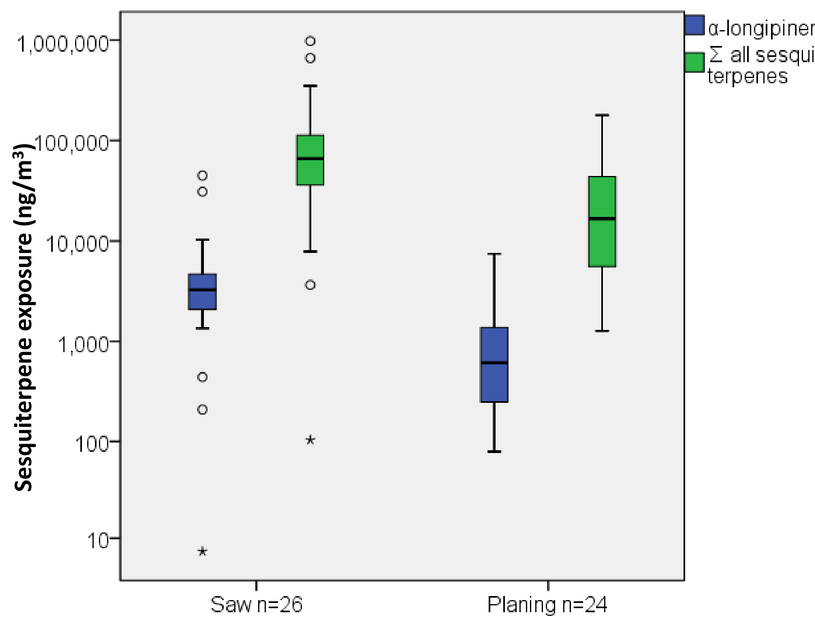


Figure 3. Sesquiterpene measurements by departments

Table 2. Exposure levels in sawmill departments estimated from mixed models

	Thoracic wood dust[b]		Thoracic endotoxin[c]				Σ Monoterpenes[d]					
			Winter		Summer		Pine		Spruce		Pine and spruce	
	n	mg/m³	n	EU/m³	n	EU/m³	n	µg/m³	n	µg/m³	n	µg/m³
Saw	63	0.08	36	2.1	27	18.4	6	21807	11	1958	20	9997
Saw/sorting of green timber	36	0.06	12	1.7	22	7.5	0	4402[a]	15	228	12	2018
Sorting of green timber	35	0.06	20	0.9	16	25.5	4	14186	12	1790	16	13360
Sorting of green and dry timber combined	5	0.07	3	0.7	2	4.3	3	2392	0	215[a]	0	1097[a]
Planing	87	0.09	42	1.3	42	3.4	15	9414	2	196	40	1755
Sorting of dry timber	97	0.13	50	1.2	42	10.4	10	1394	26	164	49	228
Storage/finished goods	16	0.03	10	0.7	8	1.4	3	90	5	36	6	90
Maintenance	62	0.19	38	3.2	25	2.6	9	9997	20	450	31	1686
Drying of timber	25	0.10	13	1.2	12	1.6	2	223	10	854	11	821
Transport	50	0.05	31	0.8	17	1.3	12	302	17	150	20	159
Roof timber trusses	6	0.06	0	0.2[a]	6	1.4	0	172[a]	0	15[a]	4	79

[a] no samples, value is estimated from model

[b] $y = \mu + \beta_{department} + u_{company} + u_{companyworkers} + \varepsilon$

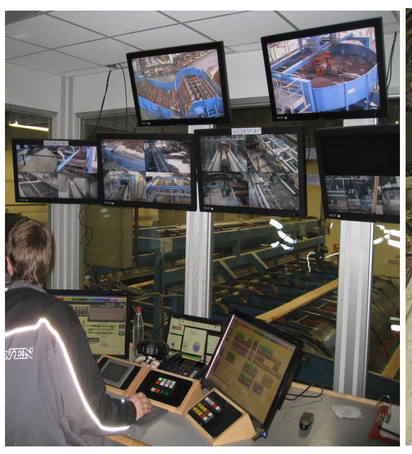
[c] $y = \mu + \beta_{department} + \beta_{season} + \beta_{department \times season} + u_{company} + u_{companyworkers} + \varepsilon$

[d] $y = \mu + \beta_{department} + \beta_{wood\ species} + \beta_{department \times wood\ species} + u_{company} + u_{companyworkers} + \varepsilon$

Table 3. Variance components of exposure

	Thoracic wood dust		Thoracic endotoxin		Σ Monoterpenes	
	Random	Mixed[b]	Random	Mixed[c]	Random	Mixed[d]
Between company δ^2	0.09	0.09	0.19	0.19	0.53	0.56
Between worker δ^2	0.52	0.30	0.73	0.35	2.90	0.92
Within worker δ^2	0.35	0.35	1.53	0.94	0.82	0.73
Total variance explained by fixed effects determinants:		23%		57%		48%

[b,c,d] see footnotes in Table 2.



The saw. In the control room (left) and in the production area (right).

Conclusion:

Although mean exposure levels of wood dust, endotoxins and terpenes seemed low, the variability was high and significantly related to departments, wood species and season. These exposure contrasts may have different impacts on health outcome, and will be subject for further study.

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