Occupational Exposure to Hazardous Chemicals in Logging Operations

R.Cabella, M.Gherardi, A.Gordiani

ISPESL, Department of Occupational Hygiene, Via Fontana Candida 1, 00040 Monte Porzio Catone (Rome), Italy

Introduction

Exhaust emissions from two-stroke chain saws contain hazardous chemical agents emitted both as fuel-air mixture unburned and as incomplete combustion products. The two-stroke chain saw engine exhaust contains hydrocarbons (HC), carbon monoxide (CO), nitrogen oxides (NO_x) and aldehydes; the relative percentage distribution is mainly affected by gasoline composition, fuel-air mixture ratio and catalyst presence [1]. In Italy loggers number approximately 22.000 during 1996. Very few data on exposure to exhaust emissions from chain saws have been published. The aim of this study was to evaluate the exhaust inhalation exposure of chain saw operators in logging operations. Benzene and formaldehyde were regarded as the most important hazardous chemical agents owing to their toxicological properties. Benzene and formaldehyde meet the criteria for EU classification as a category 1 carcinogen (R45) and as a category 3 carcinogen (R40) respectively (Annex VI of Directive 67/548/EEC).

Subjects and methods

Two field monitoring studies were conducted during the winter of 2001. The aim of the first one was to evaluate operator exhaust inhalation exposure during representative logging operations while the second one was conducted to confirm the unexpected results obtained during the first field monitoring study. The two studies were conducted in a coniferous forest stand located in Luserna (Trento, Italy). Four different chain saws were tested using a commercial lead-free gasoline with a benzene content minor than 2 % (volume): two chain saws were equipped with catalytic converters (Stihl Type 046C, Stihl Type 044C) and two without (Stihl Type 026, Stihl Type 044). One chain saw (Usqvarna 351) was tested using a special gasoline with a benzene content minor than 0.01 % (volume).

First field study

In the first field study five professional loggers chain saw operators were monitored during two working days by using personal sampling according to NIOSH methods. Measurements were carried out during the felling of trees. Working hours were divided into two periods during each day ranging from 1.5 to 2.5 hours. The daily operator exhaust exposure period was about four hours. Four operators made us of a customary commercial lead-free gasoline (benzene content minor than

2 % v/v) and one operator made use of a special gasoline (benzene content minor than 0.01% v/v). The temperature ranged from 13-21°C with humidity between 40 and 71%. Personal samples were collected during morning and afternoon working periods from the time the saw was started until it was switched off. Short breaks during logging operations were included in the sampling period too. The five professional loggers have used the same chain saws during the two days monitoring study. Four remote area samples were also collected to evaluate the contribute of possible different benzene and formaldehyde sources. Eighteen personal breathing zone air samples were collected on 100-mg charcoal tubes using personal air sampling pumps calibrated at a flow rate of 0.20 L/min. After desorption of the active charcoal tubes with 1 mL carbon disulphide (CS_2), hydrocarbons were analysed and benzene was quantified by gas chromatography-mass spectrometry (GC/MS). Sixteen personal breathing zone air samples were collected on 300-mg silica gel coated with 2,4 dinitrophenylhydrazine using personal air sampling pumps calibrated at a flow rate of 0.20 L/min. After desorption with acetonitrile, aldehydes were analysed by high performance liquid chromatography (HPLC) with UV detection as their 2,4-dinitrophenylhydrazones.

Second field study

In the second study four professional loggers chain saw operators were monitored during controlled bucking operations. Bucking is sawing felled trees into sections called logs. The same chain saws utilized in the first study and the same procedure was followed by each professional logger in order to compare exhaust emissions from the four different chain saws tested. Personal samples were collected during morning and afternoon working periods from the time the saw was started until it was switched off. Eight personal breathing zone air samples were collected on 100-mg charcoal tubes using personal air sampling pumps calibrated at a flow rate of 0.20 L/min. Four personal breathing zone air samples were collected on 300-mg silica gel coated with 2,4 dinitrophenylhydrazine using personal air sampling pumps calibrated at a flow rate of 0.20 L/min. Samples were analysed for benzene and formaldehyde content as previously described.

Results and Discussion

First field study

Individual operator inhalation exposure to benzene and formaldehyde are reported in Table 1 as time-weighted average (TWA) values taking into account the four working periods monitored during two working days. Arithmetic mean benzene operator exposure level of 259 $\mu g/m^3$, ranging from 72 to 491 $\mu g/m^3$ (n=4), and arithmetic mean formaldehyde operator exposure level of 251 $\mu g/m^3$, ranging from 69 to 528 $\mu g/m^3$ (n=4) are calculated as far as the logging activity performed by using the commercial lead free gasoline is concerned. The results obtained by using the special

lead free gasoline have shown an average benzene operator exposure level of 17 µg/m^3. Surprisingly the mean levels of exposure were not correlated with the presence of catalytic converters on the chain saw. Remote area samples results were all below method detection limits for benzene (1 µg/m^3) and formaldehyde (2 µg/m^3).

Second field study

Exposure monitoring results are reported in Table 2 for each operator. Time-weighted average (TWA) values are calculated taking into account the two working periods monitored. The results confirm those obtained during the first field study. Particularly higher exposure levels were measured for those operators using chain saw models Stihl 044C and Stihl 044 and lower exposure levels were measured for operators using chain saw models Stihl 046C and Stihl 026.

TABLE 1
Benzene and formaldehyde inhalation exposure during manual felling of trees

Operator	Chain saw model	Gasoline type	Benzene		Formaldehyde	
			TWA (µg/m^3)	Range (µg/m^3)	TWA (µg/m^3)	Range (µg/m^3)
1	Stihl 046C	Commercial lead-free	72	50-92	69	48-79
2	Stihl 044C	Commercial lead	491	397-731	528	407-652
3	Stihl 026	Commercial lead	100	66-153	119	75-152
4	Stihl 044	Commercial lead	373	276-545	288	123-409
5	Usquarna 351	special *	17			

* benzene content minor than 0.01 % (volume)

TABLE 2
Benzene inhalation exposure during controlled bucking *

Operator	Chain saw model	Gasoline type	Benzene	Formaldehyde
			TWA (µg/m^3)	TWA (µg/m^3)
1	Stihl 046C	Commercial lead-free	108	103
2	Stihl 044C	Commercial lead	630	492
3	Stihl 026	Commercial lead	137	144
4	Stihl 044	Commercial lead	261	171

* The same procedure was followed by each professional logger in order to compare the exhaust emissions from the four different chain saws tested

In order to properly compare exposure results with occupational exposure limits it should be noted that operator exhaust exposure usually takes four hours a day, whilst occupational exposure limits generally refer to an eight/hours working period: no exposure to benzene and formaldehyde usually occurs during working activities other than logging. The so calculated time weighted average (8

hours TWA) exposure values using the commercial lead free gasoline were approximatively 119 μg/m^3 for benzene and 121 μg/m^3 for formaldehyde. All the measured individual benzene exposure levels were well below the Italian regulatory limit (3.25 mg/m^3); however due to the carcinogenic properties of benzene the use of a special lead free gasoline, with a benzene content minor than 0.01% (volume), is strongly recommended. At the moment there is no Italian regulatory limit for formaldehyde. TWA formaldehyde values are below the OSHA PEL value (922 μg/m^3) but above the NIOSH REL value (20 μg/m^3 8-hr TWA).

Conclusions and Recommendations

This study revealed a significant difference between operator exposure to exhaust emissions from different chain saws. Unexpectedly operator exposure values were not correlated with tested chain saw types. No significant exhaust exposure differences were observed among loggers equipped with chain saws with a catalyst converter and loggers equipped with chain saws without a catalyst converter. In view of the measured benzene and formaldehyde exposure levels it is recommended that action should be taken to reduce exposure. The use of special lead free gasoline, with a benzene content minor than 0.01% (volume), and a periodic check of catalyst converter efficiency are strongly recommended. Moreover, exhaust pipes on each machine shall be located so exhaust gases are directed away from the operator.

References

[1] Nilsson, C.A., R. Lindahl, and A. Norström: Occupational exposure to chain saw exhausts in logging operations. *Am. Ind. Hyg. Assoc. J.* 48:99-105 (1987)