Czech University of Life Sciences Prague
Faculty of Forestry and Wood Sciences
Department of Forestry Harvesting

Dispersion of Biodegradable Oil Used in Chain Saw Lubrication on Soil Surface During Delimbing

DIPLOMA THESIS

By Eng:

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Submitted to

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Department of Forest Harvesting

Faculty of Forestry and Wood Sciences

DIPLOMA THESIS ASSIGNMENT

Cunha Ana Catarina

Thesis title

Dispersion of Biodegradable Oil Used in Chain Saw Lubrication on Soil Surface During Delimbing

Objectives of thesis

Process the data obtained by measuring thedispersion of oil when branching under earlier research grants and comment it using the literature sources.

Methodology

Review the available literature on the subject search and process relevant sources.
Use the methodology proposed for oil dispersion in earlier research grants and perform statistical analysis of the results.
Use a diary with daily results of your own work and the results of consultations.

Schedule for processing

Literature search process to the end of February.
Other results should be discussed on the agreed weekly consultations.
Submit a manuscript to 15 March.

The proposed extent of the thesis

ca 40 pages, figures included

Keywords

Degradable oils, Dispersion, Chain Saw, Delimbing

Recommended information sources

-ATHANASSIADIS, D., LIDESTAV, G. and WÄSTERLUND, I. 1999. Fuel, Hydraulic Oil and Lubricant Consumption in Swedish Mechanized Harvesting Operations, 1996. Journal of Forest Engineering 10, (1), p. 59-66.

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Prague January 25, 2013

Statutory declaration

I hereby certify that I have elaborated my thesis independently, only with the expert guidance of my thesis director Doc. Ing. Alois Skoupý, CSc.

I further declare that all data and information I have used in my thesis are stated in the reference.

In Prague …………. ....……...……………………………….

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“Going to the woods is going home”

John Muir

ABSTRACT

Considerable amounts of oils are used for lubrication of power saws and most of that oil gets into the forest environment. The dispersion of these oils in the natural environment is pointed out as the cause of soil and water pollution. Czech Republic, as other countries, particularly European ones, try to prevent the pollution by applying laws, on the obligatory use of biodegradable oils. This diploma thesis deals with oil dispersion and his selected technical aspects. The analysis is about oil dispersion, and its possible concentration on the soil surface, as well as distribution on its work clothes. There are original methods with particular parameters that were proposed to determine oil dispersion in delimbing, using chain saws. The aim is to guarantee the state of the oil, when ecologically more suitable oils are characterized at the same time, by technical parameters. And Thus, reduce the possible negative effects of forest machines too, on the natural environment.

As a conclusion of the results of the procedures, is possible to conclude that delimbing operation don't disperses so much oil on stand as other operations. Also, was possible to confirm that oil dispersion on work clothes is related with work position. Nevertheless, these values don't cause negative effects on the environment and on the health of machine operators.

Keywords

Chain saw; Lubrication; Degradable oils; Dispersion; Delimbing;

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I might not know where the life's road will take me, but walking with God in my heart, through this journey has given me strength.

José Diogo you are my room neighbour, my friend and my lovely brother. Thanks for taking care of mom, dad and my car.

Mom, you have given me so much, thanks for your faith in me, and for teaching me that I should continue no matter what.

Daddy, you always told me "you have to be engineer." So, now I am. Thanks for inspiring my love for forest.

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ABBREVIATIONS AND SYMBOLS

C_6H_5Br – Bromobenzene

e.g.- for example

i.e.- that is

IAEA - International Atomic Energy Agency

imp.- impulses

p./pp.- page/pages

± - minus or plus

γ – radiation

° C - degree Celsius

m – meter

m/s – meter per second

cm – centimetre

mm - millimetre

mm^2/s – square millimeter per second

cm^2- square centimetre

cm^3- cubic centimetre

cm^3 /hour – cubic centimiter per hour

L – liter

l/m^3 – liter per cubic meter

ml – mililiter

ml/min – mililier per minute

Kg – kilogram

g – gram

$g.m^{-2}$ – gram per meter

g/h – gram per hour

h – hour

min – minute

s – second (time)

J- joule

CHAPTER 1

Introduction

Society impact on the environment is known. The lubricants use can affect plants, animals and human life. Recently, the idea that lubricants should cause less harm to the environment has been promoted in order to preserve the sustainable development of forest in Central and Northern Europe (Kržan, B. and Vižintin, J., 2004).

When operating forest machines the lubrication of chains in power saws contributes to the introduction of oils into the natural environment. When in large values it can be considered an important element with a possible negative impact on the forest ecosystem, particularly contaminating the surface and underground waters. Up to 60% of oil used for the lubrication of chains in power saws getting into the water either directly or through soil infiltration (Skoupý, A. and Klvac, R., 1999).

In Germany, Austria and Sweden the use of mineral lubricants was forbidden. They have been substitute by substances of natural origin that led to the development of vegetable-based technical oils. And in the Czech Republic research task was started in 1992 in by the Ministry of Agriculture, concerning the substitution of mineral oils with vegetable oils (Skoupý, A. and Klvac, R., 1999).

This study deals with the oil dispersion in forest stands. And once detected any lost to the environment, is the concentration enough to harm forest and humans.

OBJECTIVE

- Process data obtained by measuring the dispersion of oil when branching under earlier research grants and comment it using the literature sources.

CHAPTER 2

Literature Review

Increasing attention to the environmental issues drives foresters to increase the ecological friendliness of harvesting techniques and methods.Timber harvesting has a bigger impact on the environment than any other forestry operation (Lauhanen et al. 1998, 1999).

There are two different methods broadly used to harvest in forest management. Originally, the common motor-manual cutting with chain saws, and furthermore the mechanized with harvesters. Mechanised wood harvesting process have become widely used in many European countries (Figure 2) such as Sweden (98%), Ireland (95%) and Finland (91%) compared to motor-manual harvesting. However, highest level of productivity for mechanized harvesting can be reached only if the stands are as even as possible, and regarding the tree species as well as the class diameter (Karjalainen et al., 2001).

Figure 1 - Main elements of Chain Saw (Chainsaw.com. 2013)

All mechanized forestry operations are associated with oil consumption and as a consequence of that, releases to the environment. Environmental impact from mechanized harvesting operations is primarily due to fuel, hydraulic oil and lubricant consumed by the forestry machinery (Athanassiadis, et al., 1999).

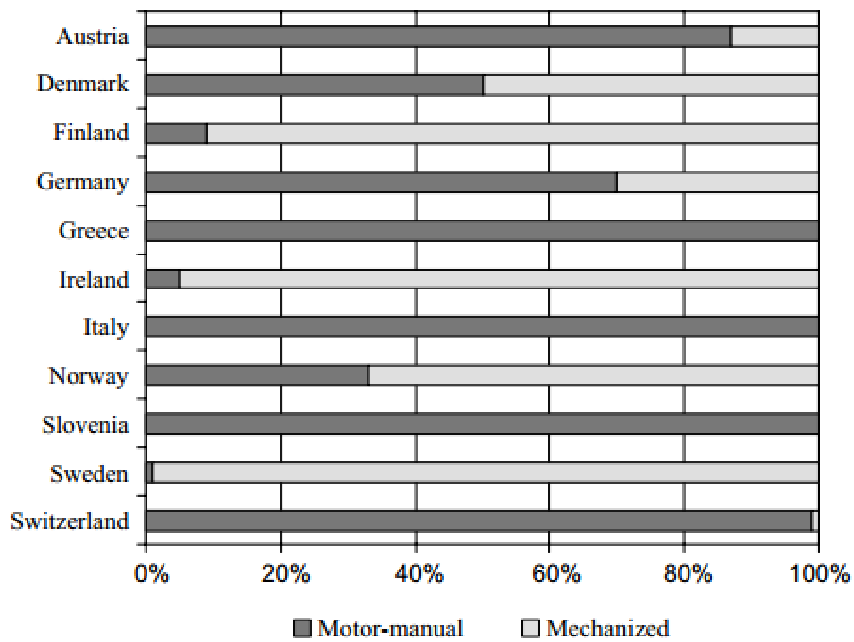

Figure 2 - Share of different harvesting process in European countries (Karjalainen, et al., 2001).

Although, fuel is the higher part of energy used in the mechanised harvesting system. Thus some authors related the fuel consumption to the energy used according to the volume of timber harvested. For example, in 2000 Athanassiadis et al. reported 82 MJ m^{-3} fuel energy use calculated from the assessed fuel for the mechanised harvesting system (Athanassiadis et al., 2000). In Sweden was reported mean energy input of fuel as 85.5 and 97.3 MJ m^{-3} for Ireland (Klvac, et al.,2003).

Increasing attention to the environmental issues drives foresters to increase the ecological friendliness of harvesting techniques and methods.Timber harvesting has a bigger impact on the environment than any other forestry operation (Heikkilä, et al., 2006).

An initial survey to assess the consumption of fossil fuels was performed by Berg (1996). Despise this study as insufficient data on lubricant consumption and oil spillage (Athanassiadis, et al., 1999).

Oils are used by forest machines for both for operational filling of their engines, gearboxes and hydraulic mechanisms, and for lubrication of cutting parts of power saws (Figure 1) and other machines employed in timber felling. Oil used for idle lubrication in motor- manual harvesting gets into forest environment directly and completely (Skoupý, A., 2004).

A saw-bar with a saw-chain is a conventional tool in both mechanized and motor-manual felling trees and crosscutting stems in harvesting operations. In mechanized harvesting, saw-bar is used on harvesting or felling heads; in motor-manual harvesting it is used on chain-saws (Figure 1) (Nordfjell, et al., 2007).

In motor-manual operations, the chain-saw is also used for forest operation: delimbing. Thus, are some studies about the comparison between productivity and costs of cutting whole-trees and delimbed trees made by Heikkilä (2006). The study showed that the forest energy potential is increased and procurement costs are reduced. Quality of chips made of delimbed operation is high. Low size variation of stem-wood chips prevents blocks in the fuel receiving and handling systems. Delimbing tree stems have also the ability to dry better than undelimbed ones, thus nutrient loss is lower since the nutrient rich branches are left in the stand (Heikkilä, et al., 2006).

Therefore, the accelerated loss of nutrients from forest soils must be clearly taken into account in the stand selection and in the development of harvesting methods. The productivity in cutting of delimbed energy wood using the multi-tree-handling technique was 10 to 40%

lower compared to cutting of whole trees due to lower average stem volume. However, the handling time per tree was at the same level (Figure 3) (Heikkilä, et al., 2006).

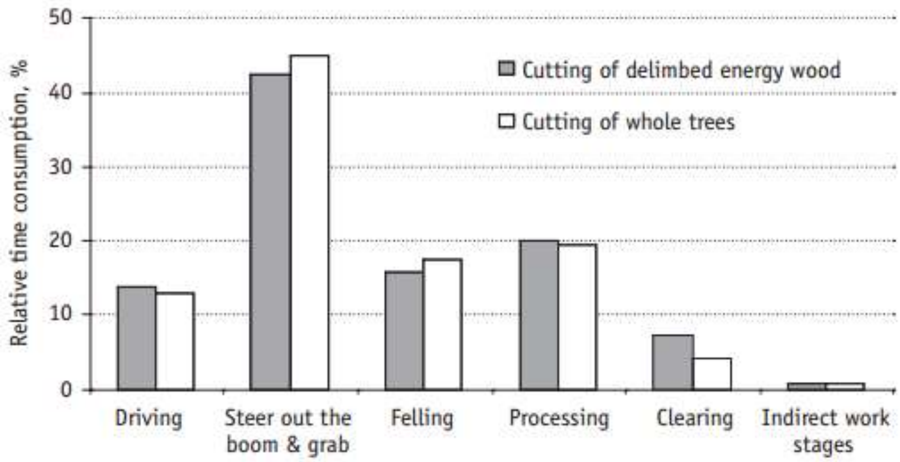

Figure 3 - Time consumption by working elements and cutting methods (Heikkilä, et al. 2006).

In North of Europe a Swedish investigation from 1996, found that the amount of oil used for harvester saw-chain lubrication was about 34 L/1000 m^3 harvested volume. Furthermore, Hydraulic oil spillage by both harvesters and forwarders during forest activities as felling the trees and logging the logs to the roadside was 1 150 m^3. However, spillage is even more significant taking into consideration that 1 920 m^3 of chainsaw oil were released (Figure 4) during the operations (Athanassiadis, D., 1996).

When the hydraulic oil is released during breakdowns (hose breakage) will concentrate in small spots (Hultman, S. G., 1972). The oil that falls into the ground is not uniform spread but falls on rather limited spots. For instance, clear-cutting but rather falls on surfaces in precise places. Although, the quantity of oil spread on forest surfaces depends on: duration of chainsaw operation, position of the guide, type of chainsaw and kind of oil (Wojtkowiak, R. and Tomczak, R. J., 2003).

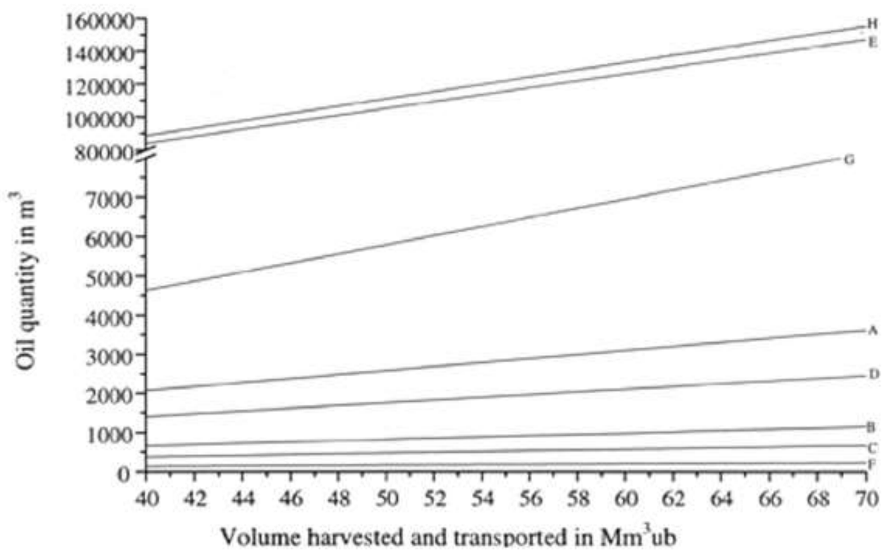

Figure 4 - Estimation of fuel, hydraulic oil and lubricant consumption in harvesting and forwarding operations in Sweden under different harvested volumes A: Total hydraulic oil consumption, B: Total motor oil consumption, C: Total transmission oil consumption, D: Total chainsaw oil consumption, E: Total diesel consumption, F: Total grease consumption, G: Total lubricant consumption, H: Total fuel and lubricant consumption (Athanassiadis, D. 1996).

The knowledge about where this oil ends up for mechanised harvesting is limited. Studies on motor-manual chainsaws show that 50 to 85% of the oil is absorbed in the sawdust (Figure 5), 3 to 15% is deposit on the logs, 0.5% is trapped on the work clothes, and up to 33% ends up on the ground (Skoupý, et al., 1990, Skoupý, A., 1998, .Skoupý, A. and Ulrich, R. 1994, Skoupý, A., 2004).

The velocity of a chain of a chain-saw and harvester or felling heads is 20-25 $m.s^{-1}$ and 40-45 $m.s^{1}$, respectively (Helgesson, T. and Söderqvist, A., 1985, Hallonborg, U., 2003). A high velocity of chain is essential for adequate productivity and for the production of timber without fractures (Hallonborg, U., 2003). It is essential reduce the friction; otherwise, the temperature rises rapidly and destroys both the saw-bar and the chain.In order to reduce this friction between the saw-bar and the saw-chain must be used lubrication. A correct oil flow control can reduce the amount of oil used (Nordfjell, et al., 2007). It is essential that the oil reaches the surfaces on the saw-chain rivets and has a high adhesive capacity to stick onto the rotating saw-chain (Helgesson, T. and Söderqvist, A., 1985).

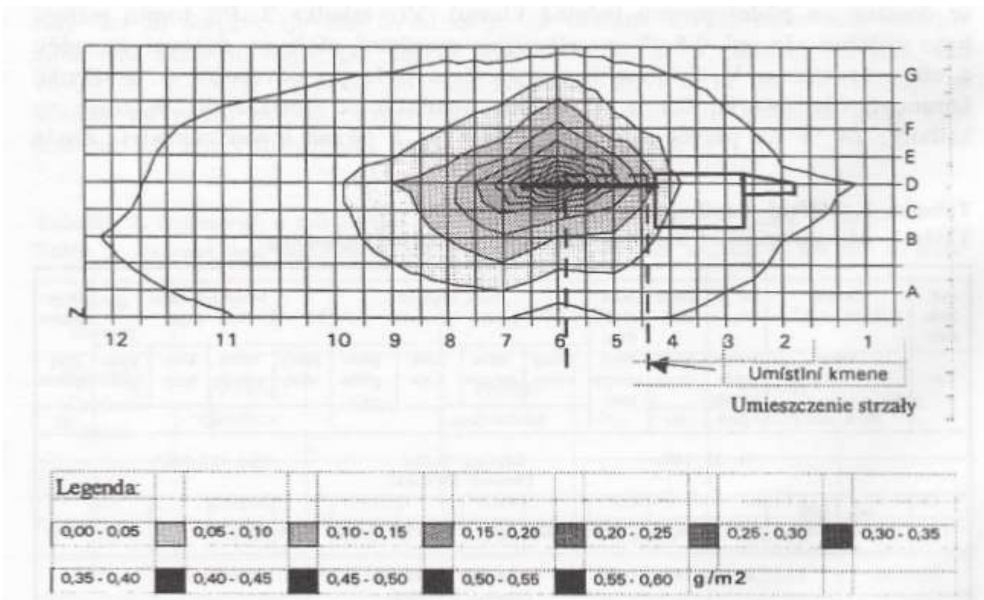

Figure 5 – Concentration (g.m^{-2}) of oil on the surface of the soil (Skoupý, A., 1998).

Although it is possible reduce the amount of oil used for saw-chain lubrication by precise control of the oil flow. Around 1990 an improved oil control system for harvester heads was introduced and only 20 % of the oil was used compared to the old system. In addition, it is than possible reduce the frequency of saw-chain cracks (Anon, 1991).

Since, chainsaw and spilled hydraulic oil are discharged to the environment. Within the lubrication of chains in power saws, contributes to the introduction of oils into the natural environment (Skoupý, A., 1998). Thus the values are so high that they can be considered as having a negative impact on the forest ecosystem. The contamination affects particularly the soil surface of the forest and underground waters (Skoupý, A. and Klvac, R., 1999).

It was found as well that both biodegradable and mineral oils affect negatively on the health of the operator, and that mineral oil were more toxic to plants than bio-degradable oils (Lauhanen, et al., 2000).

Since, forest machines use oil both for lubrication by filling their engines, gearboxes and hydraulic systems, as well for the lubrication of the chain cutting parts of power saws employed in the timber felling. On the other hand, oils used in the fillings will end up at some point into the natural environment due to the filling leakage or sometimes in case of machine crash. It applies particularly to hydraulic systems particularly in cases of defects of hydraulic hoses when an uncommon flow can release several litres of pressure fluid out (Skoupý, A., 2000).

Subsequently, some studies report as much as up to 60% of oil used for the lubrication of chains in power saws getting water flow both direct or through soil infiltration (Bublinec, E., Šimek, M., 1989). Researches were done in Central Europe and Sweden aimed to substitution of mineral lubricants with substances of natural origin and led to the development of vegetable-based oils (Skoupý, A., and Klvac, R., 1999).

The traditional saw-chain lubrication oils are mineral oils of petroleum hydrocarbons (Makkonen, I., 1994). The use of environmentally friendly, biodegradable vegetable-based oils has increase over the last several years (Mercurio, et al. 2004). In Finland during 1997 from 10 to 15% of chain oils used were biodegradable chain (Lauhanen, et al. 2000).

During the year of 2000 Lauhanen, et al., measured possible harmful effects of mineral oils on forest site and calculated that for a Moto-manual felling of 200 m^3 of Derbholz (timber to the top of 7 cm over bark) per hectare a power saw will require 20 litres lubricating oil which will be deposit into the forest environment.

Biodegradable lubricants, hydraulic oils and other functional fluids are especially important for users of equipment exposed to the environment (Padavich, A. and Honary, L., 1995) (Douglas 1992) (Randles, J. and Wright, M., 1992) (Battersby, et al. 1992). However, if these oils are to become a full-value replacement of mineral oils, their technical parameters have to be at least as good as those of mineral oils (Skoupý, A. and Klvac, R., 1999). In spite of, there was found that a mean value of 35 litres per cubic metre under bark of chainsaw oil for single grip harvester was required during operations of timber felling and crosscutting (Athanassiadis, et al.1999).

In the Czech Republic, is prohibited the use of mineral oils for dissipation lubricating and as pressure fluids in hydraulic systems by Forest law No. 289/1995 Gaz (Skoupý, A. and Klvac, R., 1999).

Despise there being a prohibition, to the use of mineral or other types of oils (viz. used gear, hydraulic and kitchen oils) in forest operations such as timber harvesting operations still continues. In Germany was calculated that the annual consumption of oils for logging exceeded the volume sold by a two million litres, which means that oils applied are considered to be toxic may have been used (Hartweg, A. and Keilen, K., 1989).

Within the implementation of the new regulations some firms carrying out logging operations in the forests field had to deal with sudden economic and technical problems. For that reason as necessary achieve a condition when the biologically degradable oils have equal technical parameters at adequate price (Skoupý, A., 2004).

The matter about the harmful impact of oils on natural environment was studied in detail by many authors. Subsequently in this sense can be highlighted works dealing with the comparison of mineral and rape oils or other vegetable oils. Likewise, test the biological degradability and other some technical properties (Battersby, N. S. and Morgan, P., 1997; Wightman, et al. 1999; Asadauskas, et al., 1997).

Therefore, has been considerable interest in the application of vegetable oils (VO) as environmentally warm-hearted lubricants. Before wider recognition as biodegradable lubricants, vegetable oils low-temperature properties need improvement. In fact, as prove that low-temperature performance of vegetable oils limits their prospect as biodegradable lubricants. However well-balanced usage of pour point depressant (PPD) and diluents can deliver a readjustment (Table 1) (Asadaukas, S. and Erhan, S. Z., 1999).

Table 1- Viscosities and pour points of major lubricating base stocks (Asadaukas, S. and Erhan, S. Z., 1999).

Fluid	Viscosity, cSt at 40°C	Pour points, °C	Storage at −25°C, days	
			No additives	With 1% PPD[a]
Soybean oil	31.5	−9	0	0
90% Oleic Sunflower oil	40.3	−12	0	0
Di i−C_{13} adipate	27.2	−54	7+	7+
PAO 4[b]	17.4	−63	7+	7+
Mineral oil	71.2	−21	0	7+

[a] Poly alkyl methacrylate copolymer of ~8000 amu, canola oil carrier 1:1.
[b] Poly-alpha olefin (kinematic viscosity 4 mm^2/s).

The potential of vegetable oils is wiser than goal of energy independence and security since they are a renewable resource. In addition, other advantages of vegetable oils are low volatility (esters of long chain fatty acids) due to the high molecular weight of the triglyceride molecule and excellent temperature-viscosity properties (Erhan, et al., 2006).

The vegetable-based chain oils are usually based on rape-seed oils (HETG) some results were already publish in recent years by Rousek (2000) and pine (tall) oil. It’s possible improving the environment conditions and decreasing the level of pollution by substitution of mineral oils with both rapeseed and pine oil since both are fatty acids made of monoenoic and dienoic acids but with different proportions (Holmbom, B. and Ekman, R., 1978; Peterson et al., 1991). Pine oil also contains smaller amounts of trienoic pinolenic acid (Holmbom, B. and Ekman, R., 1978).

A study as arranged by Nordfjell, et al. 2007 in order to evaluate the lubrication characteristics at different oil flows of two vegetable-based and one mineral-based saw-chain oil (Table 2). The temperature of the saw-bar was used as an indicator of the lubrication efficiency (Nordfjell, et al., 2007).

Table 2 - Characteristics of the saw-chain oils (Nordfjell, et al., 2007).

Characteristics	ASTM-D[a]	Type of oil and brand name		
		Mineral Chain-way LT	Rapeseed Chain-way Bio	Pine Chainway Bio Pine
Density at 15°C (kg/m^3)	4052	910	922	966
Viscosity at 40°C (mm^2/s)	445	69.8	64.0	84.0
Viscosity at 100°C (mm^2/s)	445	7.4	14.6	13.2
Viscosity index	2270	50	242	158
Melting point (°C)	97	–36	–39	–51
Flash point (°C)	92	180	250	--
Flash point (°C)	93	--	--	200

[a] Test standard according to the American Society for Testing and Materials (ASTM). Numbers indicates the ASTM-D standard used (ASTM 2006).

In conclusion, an oil flow of 2 ml/min (Figure 6) is sufficient to prevent high temperatures for all kinds of oil, although pine oil produced higher temperatures than mineral and rapeseed oils at this oil flow (Nordfjell, et al., 2007).

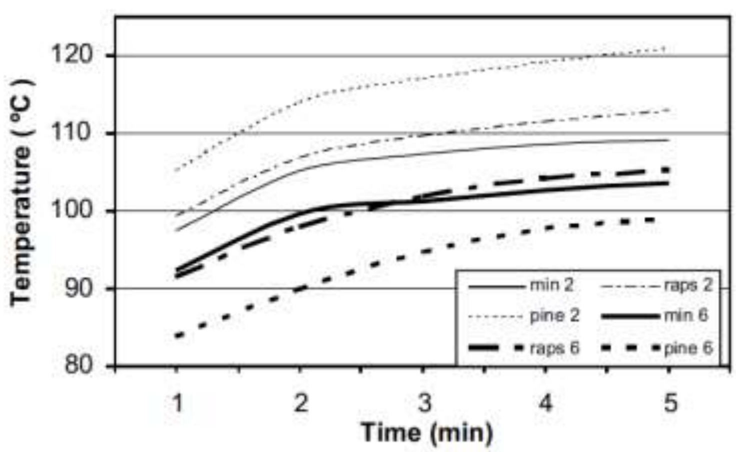

Figure 6 - Saw-bar temperature as a function of time for mineral, rapeseed, and pine oils at oil flows rates of 2 and 6 ml/min (Nordfjell, et al., 2007).

Currently, are available on the market several biodegradable oils with some characteristics that are similar or sometimes even better than those mineral oils (Lauhanen et al., 2000). The use of these oils is based on factors such as price, lubrication characteristics, accessibility, adhesive properties and low temperature pumping characteristics (Klvac, et al., 2002).

Although biodegradable oils have been found to be better lubricants than mineral oils, and they have the ability of degrade faster than mineral oils (Lauhanen et al., 2000), these oils still present several fundamental problems (Klvac, et al., 2002). As example when exposed to air thin layers of rapeseed oil easily oxidize. Once oxidized rapeseed oil will have a viscous texture and left on a chain of a chainsaw, it may result in the ceasing of the chain. This eventually may cause difficulties in the operation of grease removal from the chain. Other restrictions of oxidized oil residuals are the restriction on the movement of the piston during oil pumping that can result in damage in drive wheels of the transmission system. In addition, oil dispersed in the air will create a mixture of impurities (such as dust particles) and settle on cylinder walls, leading decrease in the engine cooling, and if not checked may lead to engine seizure (Klvac, et al., 2002). For this reason the use of biodegradable oils in vehicles, based on loss-making lubrication properties is not approve by many users (Skoupý et al., 1995).

A study (Gulko, L., 1970) was performed in order to investigate the effect of friction caused by the cutting mechanism of a power chainsaw. The aim was measuring the temperature of the guide bar during operation using guide bar had six channels for oil application, and six thermal points. The guide bar had six channels for oil application, and six thermal points for measuring the temperature of the guide bar during operation. The results were positive, performance was achieved when the chainsaw operated at a rate of 200 g/h, a speed of 8 to 20 m/s, and when the oil was added from the top or bottom of the guide bar (Gulko, L., 1970).

Years before was showed that the increment of the flow rate of lubrication oils (up to 200 cm^3 /hour) decreased the temperature of the guide bar. Although, the use of more than 200 cm^3/hour of oil showed no significant influence on the temperature of the guide bar (Szepesi, L., 1968). The minimum amount of oil required for sufficient guide bar lubrication was established 5 ml per 60 seconds (Navrátil, S., 1995).

The complexity of attributes may also affect the pumping characteristics of the oils, especially at low temperatures. The suitability of oils for use in chainsaws obligates constant pumping of specified amounts of oil to the grooves of the guide bar at low temperatures. The minimum temperature required to pump oils is related to the freezing temperature (Klvac, et al. 2002). In 2002 eleven different types of oils were studied (one mineral oil, one mixture of mineral and biodegradable oil, and nine biodegradable oils).

Table 3 - Different pumpability levels for oils (Klvac, et al. 2002).

Group 1 $-15°C > \theta_{60}$	Group 2 $-15°C \leq \theta_{60} < -10°C$	Group 3 $-10°C < \theta_{60} < -8°C$	Group 4 $-8°C < \theta_{60}$
Biomil P70	Ekolube Cut 80 P/1	Biomil P35	Lespol
Biosol	Shell Kettensägenöl Super Bio	Bipol	OA M6A
Ekolube Cut 80 P/2		Clear-refined Oil	
Husqvarna Veg Oil			

The oils were then classified into four different levels (Table 3), based on established temperature limit for the pump ability (Table 3) of the oils at low temperatures (Klvac, et al. 2002).

The results also show that biodegradable oils are more suitable for winter use than mineral oils. Representative of each group is shown in Figure 7 (Klvac, et al. 2002).

A Biologically easily degradable hydraulic fluid is product which is able to be biologically degraded and which is not toxic (both the fluid and products of its degradation) for flora and fauna (Rousek, M., 2003).

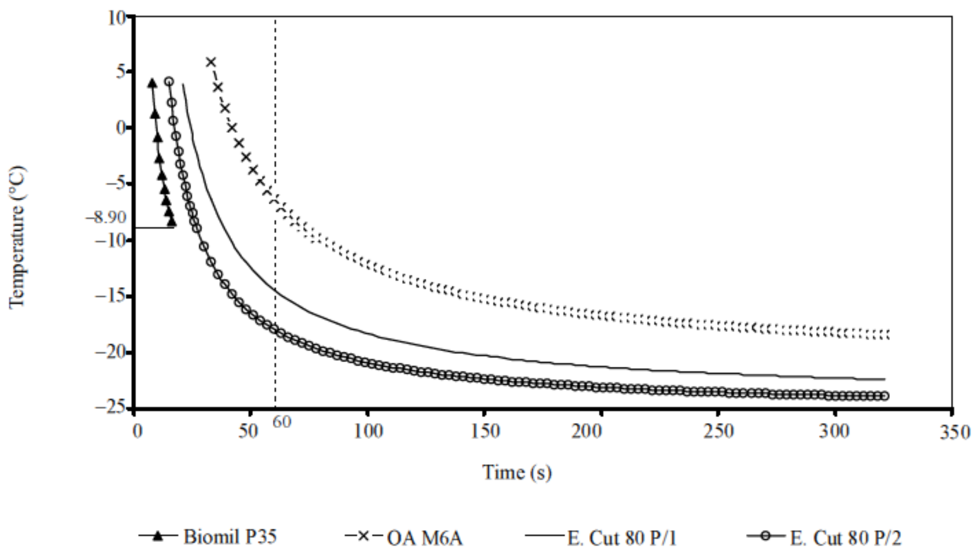

Figure 7 - Relationship between suction time and oil temperature for representative oils from each group of pump ability level (Klvac, et al. 2002).

The processes of degradation of carbonaceous substances, aerobic and anaerobic are known. Figure 8 shows the results of decomposition both plant and synthetic origin which are to be substituted for mineral fluids. The fluids are based on polyalkyleneglycols and synthetic esters which are degradable after a period of 21 days, according to a type from 10 to 100 %. On the other hand, natural rape-seed oils degradable from 75 to 100 %. As compared with mineral oils which are degradable only from 10 to 30 % a promising shift is evident (Rousek, M., 2003).

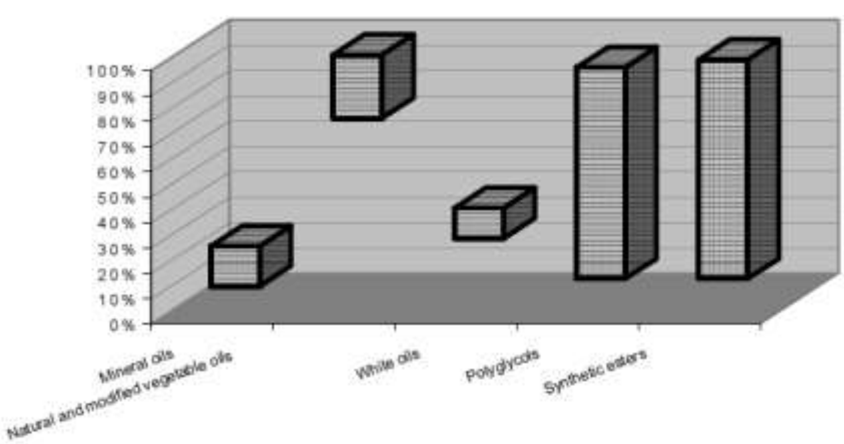

Figure 8 - Biological decomposability according to CEC–L–33–T 82 (Rousek, M., 2003).

In conclusion, biodegradable lubricants may have good lubricating and viscosity-temperature properties, resistance to corrosion (low water content), tolerance to materials of hydraulic circuits, low setting temperature, stability of a liquid with a limited creation of sludge and sticky substances rank in order to be suitable as a fluid use in hydrostatic mechanisms (Rousek, M., 2003).

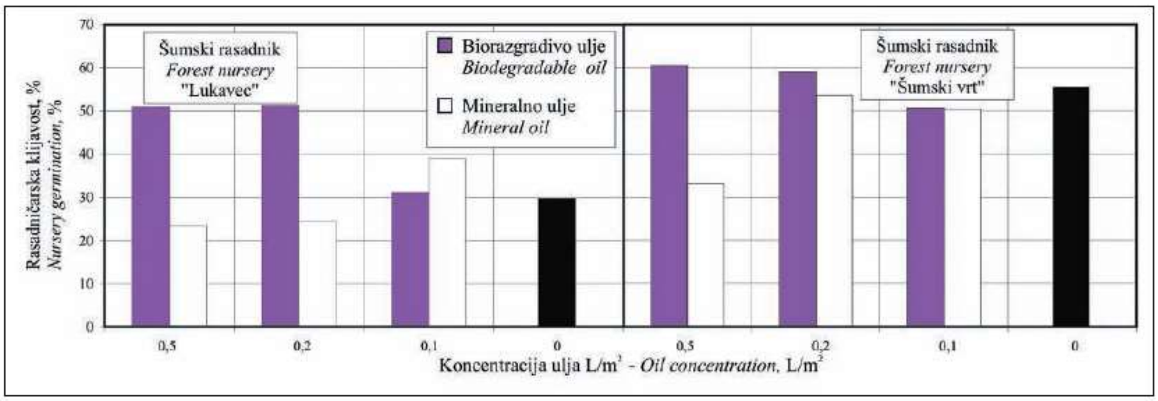

Figure 9 - Nursery germination of pedunculate oak (Quercus robur L.) on the test plots (Orsanic, et al. 2008).

The effect of different concentrations of mineral and biodegradable lubricants for chainsaws upon seedling growth in the particularly case of initial growth of pedunculate oak (*Quercus robur L.*) was study as well. The results (Figure 9) showed that the increased concentration of mineral oil may decrease seedling germination; on the contrary, the bio-decomposable oil can increase it (Orsanic, et al. 2008).

Table 4 - Physiographic soil properties (Orsanic, et al. 2008).

Šumski rasadnik *Forest nursery*	Dubina tla *Soil depth* (cm)	Krupni pijesak *Coarse sand* 2,0 – 0,2 mm	Sitni pijesak *Potty sand* 0,2 – 0,02 mm	Prah *Silt* 0,02 – 0,002 mm	Glina *Clay* <0,002 mm	Teksturna oznaka *Texture mark*	C org (g kg^{-1})	pH /H_2O	pH /$CaCl_2$
Lukavec	0-10	9,6	37,6	31,2	21,6	glinovita ilovača *clay loam*	18,4	7,54	7,04
	10-30	10,9	34,3	30,2	24,6	glinovita ilovača *clay loam*	17,5	7,73	7,19
	30-50	0,8	41,9	31,8	25,5	glina *clay*	13,3	7,57	7,09
Šumski vrt	0-10	3,0	39,9	36,5	20,6	glinovita ilovača *clay loam*	17,2	7,16	6,85
	10-30	2,9	37,6	41,2	18,3	glinovita ilovača *clay loam*	11,8	7,27	6,82
	30-50	1,1	35,9	36,8	26,2	glina *clay*	4,5	6,82	6,52

Based on pedological research (Table 4), it is possible to conclude that the soil of weedy plots is biologically more active, which results in faster oil degradation. Still five months after treatment it was found oil remnants in the soil (Table 5) (Orsanic, et al. 2008).

Table 5 - Oil remains in the soil five months after treatment (Orsanic, et al. 2008).

Koncentracija ulja *Oil concentration*	Vrsta ulja *Type of oil*	Plohe sa sadnicama *Plots with seedlings*	Šumski rasadnik "Lukavec" *Forest nursery "Lukavec"*		Šumski rasadnik "Šumski vrt" *Forest nursery "Šumski vrt"*	
			Lipofilne tvari *Lipofil agents*	Uljni hidrougljici *Oil hydrocarbons*	Lipofilne tvari *Lipofil agents*	Uljni hidrougljici *Oil hydrocarbons*
			mg/kg		mg/kg	
0,5 l/m^2	Bio	+	32,9	6,8	37,3	7,6
		-	95,5	7,7	103,2	8,4
	Mineralno	+	1306,3	784,5	1457,2	810,3
		-	621,4	339,4	758,5	419,6
0,2 l/m^2	Bio	+	18,5	4,1	25,1	4,9
		-	75,0	3,5	85,1	4,9
	Mineralno	+	630,5	367,8	697,2	411,8
		-	109,1	61,3	139,7	83,2
0,1 l/m^2	Bio	+	16,3	2,2	15,7	2,4
		-	20,3	2,5	23,5	3,1
	Mineralno	+	56,0	26,7	73,1	38,3
		-	47,5	30,9	59,1	37,4
0	0	+	17,1	1,4	19,3	2,1
		-	19,4	3,2	22,7	3,8

CHAPTER 3

Material and Methods

3.1- Chain Saw Properties

For the measurements was used a chainsaw HUSQVARNA SG 266, serial number 9470048, which was adjusted previously according to the manufacturer's instructions for the pneumatic brake HUSQVARNA. The maximum speed without load was adjusted to 11 000 min^{-1} and engine idling speed to 2500 min^{-1}. Nominal speed was measured at the maximum load and the blower reached 8500 min^{-1}. Speed measurement accuracy is within ± 5% (Skoupý, A., 1994).
At the same rotational pneumatic brake, amount of the oil supply was measured at three positions of set up screw adjustable on the oil pump at different speed rates. In the second level of oil pump supply was 6 ml. min^{-1}, on the third about 7 ml. min^{-1} and fourth level 8.5 ml. min^{-1}. Measurement accuracy was affected by variations in speed and changes in temperature and thus the viscosity measurement reached ± 0.2 ml.min-1 (Skoupý, A., 1994).
The chain saw was fitted with new rail SANDVIK WINDSOR for 15HS58SPNA, 3/8 "- .058" / 1.5 mm and a new chain 56DL Oregon 73LP 56E (3/8 ") (Skoupý, A., 1994).

For the cut test were used notches from spruce and beech bark raw stored at 15 cm above soil surface (Skoupý, A., 1994).

Although, species had different thicknesses and oil supply was resized (6, 7, and 8.5 ml.min^{-1}), three different types of oil were used. It was used mineral oil OA M6A and two vegetable oils PRIMOL Eco-P and QUAKER Greensave. Both vegetable oils were quite different regarding viscosity characteristics. QUAKER oil has a higher viscosity than oil PRIMOL and oil OA M6A highest viscosity of the three (Skoupý, A., 1994).

Every lot of oil was marked of about 1 GBG, i.e. approx. 30 mCi, bromo-benzene with ^{82}Br. This amount was mixed during 30 minutes into 500 ml oil using a laboratory folding. During the mixing oil was placed in a bowl with lead shield. Part of the oil was poured into the saw oil tank, and from which all unmarked oil was previous removed. The remaining oil was used for marked guild measurements. After filling Chain saw tank and before each measurement was necessary reach the operating temperature by increasing speed rotation without load for at least 5 minutes at minimum 20 m distance from the place of measurement. The saw was transferred to the point of measurement with the engine running at idle speed when the chain is not moving. Was used a chain brake. (Skoupý, A., 1994).

At the time measurements were recorded temperature and humidity, wind direction and wind force. If the air temperature was higher than 30° C or lower than 10 ° C, or wind velocity greater than 5 ms^{-1}, the measurement should be discontinued. Significant changes in temperature and high wind speed may greatly influence the results (Skoupý, A., 1994).

The total amount of oil on the soil surface was detected by using paper pad, including a cover sheet that was put together and inserted into the sample under the probe. Composite mat was again wrapped in clean foil (Skoupý, A., 1994).

Before taking any measurements, radiation intensity was measured by a pulse frequency background (paper pads, containers), but also the natural radioactivity of wood and sawdust, so that the value of the natural background was eventually be subtracted from the measured values and thus obtain the actual value of marked oil contained in the measured sample . For background measurement was used the same methodology as in measuring the amount of marked oil. Background was measured again after the finishing the whole measurement series to verify the accuracy of the results (Skoupý, A., 1994).

According to the material, radioactive activity decay pulse was load at 30, 60 or 120 seconds. At lower activities, expressible in thousands of pulses was calculated a statistical error up to 30%, while the activities around 100,000 pulses only 2-3% (not a measuring device) (Skoupý, A., 1994).

3.2 – Oils Dispersion Measurements

When creating a methodology for measuring the oil dispersion is expected that oil used to chain chainsaw lubrication is dispersed into the environment by centrifugal force used in chain movement. It can be assumed that partly of the oil produced during cutting is captured in sawdust, some of the oil remains at both end and immediate kerf surroundings. One last share gets into work clothes of the chainsaw operator and one final part is dispersed into the air in aerosol form, transported off-site air cutting. This spray can also be inhaled later and in small quantities by sawmill operating worker. Probably only a small amount of oil is oxidized due to friction between the chain and bar. The rest of the oil gets on the soil surface. Besides, the concentration of oil will probably be greater near the cut and decrease with the distance from the cut. (Skoupý, A.,1994).

The aim of this methodology was quantify the amount of oil that reach the soil surface and determine is concentration in the cut surrounding area, and determine the maximum level of concentration. To ensure repeatability conditions of measurement is necessary take into account factors affecting the oil dispersion as:

- The length and shape of the bar;
- Bar type;
- Chain type;
- Chain and bar wear, dulling the chain;
- Size of oil supply;
- The type of oil (physical properties);
- Lubricating oil temperature (depends on the design and location of the oil tank and engine warm-up stage);
- Carburetor adjustment;
- Chainsaws working position (cutting part);
- Cutting height from the ground;
- Area surface and shape of the cut;
- Cutting with a pulling and pushing chain;
- Way of cut (gradual, frond or plunge cut);
- Type of wood cut;
- Physical properties and conditions of the species (moisture, density, temperature, state of health);
- Climatic factors (wind direction and speed, temperature, humidity, precipitation);
- Slope of the terrain, section and its micro relief;
- Logger skills and working procedure (Skoupý, A., 1994).

Considering the multiple factors influencing the oil dispersion of the measurement process should be simplified and define in advance. When that is not possible it is necessary measure all factors and after determinate the best method (Skoupý, A., 1994).

3.3 – Radioisotope Method

To evaluate oil dispersion was used the radio-indicator method making possible to quantify oil dispersion immediately after cutting. The method is based on injection of the tracer (marking oil) in the oil tank of the power saw with a suitable liquid radiotracer with this technique is possible detect and quantify it, in any place. (Skoupý et al., 1990).

Tracer response is then used to describe the flow pattern. A model was designed, simulating transverse cutting of the stem placed on 15 cm high stands. This knowledge is important in optimizing oil dispersion (Skoupý et al., 1990).

Most of the information given by the tracer response curves cannot be obtained by means of other techniques (IAEA, 2012). Absolute amounts of oil were measured on the soil surface, in sawdust and on the processed wood (Skoupý et al., 1990).

Was used to mark the lubricating oil the Radiotracer ^{113m}In with radioactive transformation half-life $T_{1/2}$ = 105 min and semi-^{82}**Br** radioactracer with decay time T = 36 hours, the second in the form of C_6H_5Br (Bromo –Benzene) which is soluble in the OA M6A oil (Skoupý, A., 1994).

The ^{113m}In Radiotracer, is widely applied because is consider as simple, safe and effective (Sun Wenhao, et al., 1988). Besides, The tracer ^{82}Br was consider less suitable from the hygienic point of view (active transformation half-life $T_{1/2}$ = 36 hours), it not possible measurements within short time intervals (lapse of time) like with ^{113m}In which the measurement could be repeated in the same place as early as the second day (Skoupý et al. 1990).

To repeat measurements in 24 hours ate the same place the ^{113m}In Radiotracer must be emulsified into OA M6A lubricating oil by means of primary moisture with emulsifying oil (drilling oil). The ratio was approximately 3:6:91 for tracer water solution with emulsifying oil to the proper lubricating oil (Skoupý et al. 1990). The solubility in OA M6A oil is an advantage since do not change its viscosity and higher energetically abundance of y radiation, which is fundamental of accuracy in measurement (Skoupý et al. 1990).

The tracer has been considered before in two different experiments of orientation character, the aim was verify the basic principles of the method suggested (Skoupý et al. 1990).

With this method there was not significant for change of oil viscosity and the results were used only for an approximate assessment of its own methodology, measurement and its possible treatment (Skoupý, A., 1994). In addition to a short half-life of radioactive decay, it was necessary to introduce a correction taking into the account a gradual quick change of the initial tracer activity, based on the Law of radioactive decay:

$$\mathbf{N = N_0 . e^{-k.t}}$$

For the practical calculations it was more appropriate:

$$\mathbf{n = n_0 . 2^{\frac{T}{t}}}$$

Where:

N_0 = Initial number of radioactive atoms;

N = Number of radioactive atoms at time t (s) expressed by the number of pulses;

k = Decay constant (s^{-1});

n = Number of calculated initial impulses (imp);

n_0 = Measured number of impulses (imp);

t = Time interval between the time of measurement and the start of measurement (h);

T = The radioactive decay half-life (h).

It was therefore necessary before measurement specify the "reference time" to the nearest minute, and then record with the same accuracy each individual measurement point (Skoupý, A., 1994).

It was not necessary count with the correction using the ratio indicator ^{82}Br radiotracer for the half-life radio transformation T= 36 hours due at a relatively short duration of the measurement, about tens of minutes which do not affected the results. However, this set of measurements had duration of tens of hours and for this reason the measured values have to be corrected also (Skoupý, A., 1994).

The ^{82}Br tracer is not suitable in terms of hygiene as the first, for both a longer half-life and for higher energy radiation **γ**, representation, but is this property that guarantees higher accuracy. It was ignored the self-absorption of radiation in the material and oil dispersion was evaluated by a single cut. In contrast to the previous radio indicator viscosity remains almost unchanged as ^{82}Br can be dissolved directly in the oil. Was not possible perform two measurements in the same place and in a time interval of less than two weeks, was to be ensured that all the used oil marked during measurement is completely removed (Skoupý, A., 1994).

Therefore, the indicator ^{113m}In was used only for verification of the measurement procedure and the preliminary detection of oil concentration, which clarified and accelerated the procedure to use ^{82}Br indicator. When we know the concentration of oil, we can calibrate measuring instruments for the expected activity of the sample (Skoupý, A., 1994).

Tracer (radionuclide) ^{82}Br was produced artificially, and radiation target material (C_6H_5Br) in the reactor core of the Nuclear Research Institute in Rez near Prague (Skoupý, A., 1994).

In terms of measurements activity of tracer oils in individual objects the content was marked and it was necessary to take into account the fact that none of them can be considered as a point source γ radiation. Hence, it was necessary to design the measuring geometry that guarantees the possibility to place both, sawdust and front trunk as well as any other material in the same position relative to the measuring probe (Skoupý, A., 1994).

This measuring geometry is illustrated in Figure 10, where the radiation detector γ (1), is located in a lead collimator (2), which suppresses interference γ natural background or the effect of other materials used (contaminated) when measured (Skoupý, A., 1994).

The detector (4) as the sample container and a stand (3) fix the correct position of sample container in the detector, since this position must be the same during measurements. The detector is connected to the impulse counter (5) and the sample container has capacity in volume of 2 dm^3. In the impulse centre is placed sawdust material (6), paper sheet (7) that was used as a soil cover (after measurements must be properly folder), and log cut (8) which was cut away with another chain saw not marked (Skoupý, A., 1994).

Before measuring the oil dispersion was first necessary to express the relationship between pulse frequency and sample oil content. For this purpose was necessary creating the calibration curve, which express the relation between the volume of oil and number of impulses. First was measured the oil volume at a specified time in different materials after measure the number of impulses. Step by step was created the calibration curve showing the relation between impulses per period of time (Skoupý, A., 1994).

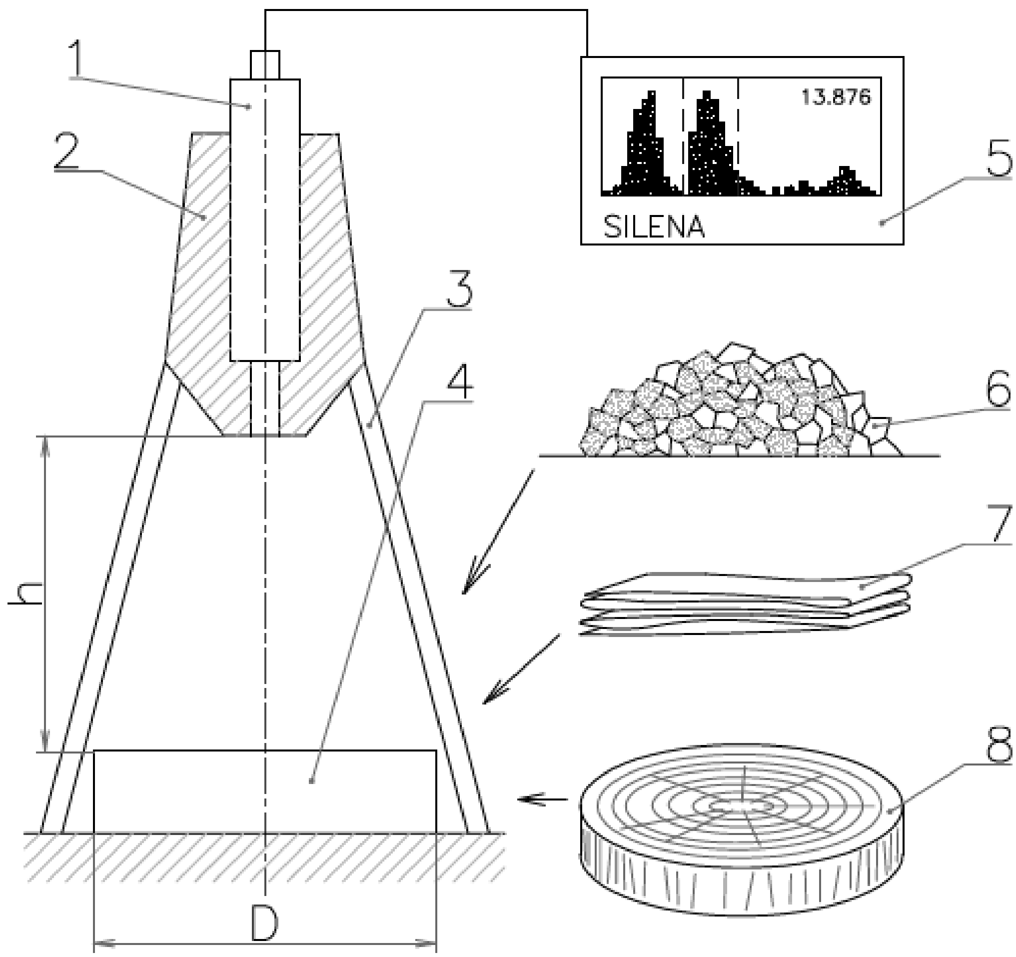

Figure 10 - The geometry of Measurement (Skoupý, A., 1994).

In order to calculate the calibration (impulses/time) correlation was used discs cut off from the wood trunk where was dripped marked oil in quantities of 10, 20, 30, 40 and 50 drops. For each roll with a certain number of oil marked drops was measured number of pulses, thus when obtained from six measurements of the calibration curve was calculated (Skoupý, A., 1994).

This relationship was calculated for each type of marked oil (Skoupý, A., 1994).

3.3 - Dispersion of oil during Delimbing

For delimbing method were prepared two raw spruce trunks with 6 m long tree from the bottom to crown. The notches had in average 25 and 30 cm of thickness. Previously all branches with length under 10 cm from have been removed. In order to decrease the need ti cut a large amount of material which would greatly increase the amount of work involved, and hence the cost of the measurement (Skoupý, A., 1994).

The measured section was 2 meters long in order to match the continuous measurement of branching and not be distorted by changes in scattering and the quantity of oil which is necessarily present in the end section. The test trunk was laying 40 cm above ground insurance by garters (Skoupý, A., 1994).

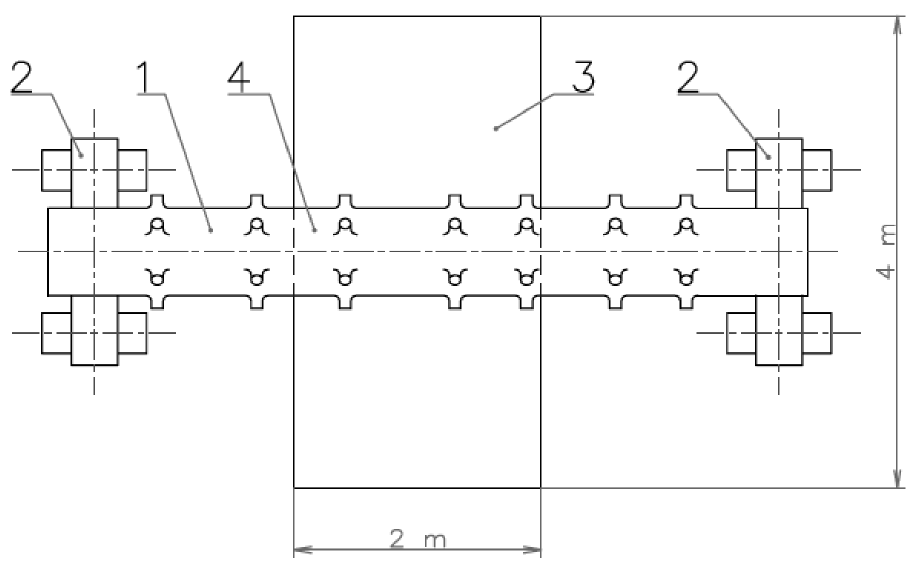

Figure 11 - Cut Placement when delimbing (Skoupý, 1994).

Measurement of oil dispersion was performed under polyethylene sheet with 2 m of length and a width of 4 m. Oil concentration was not measured; it can be assumed that it is lower than during felling. Additionally, it was not expect the creation of a typical oil spill, as is the cases of oil dispersion during cross cutting and felling cases (Skoupý, A., 1994).

The placement of the trunk 1 on underlays 2 is visible on figure 11, where is ground foil 3 also pictured under the middle measured section 4 (Skoupý, A., 1994).

During the delimbing was used OA M6A oil, oil pump set on 4th level and supply about 8, 5 $ml.min^{-1}$. It was performed the classic delimbing "Nordic approach '. The initial cut had 2 m of length in the first section. After the first section cut the garters and branches were collected. The material from the cut of the second section was collected to a polythene bag to the next measurement. Then the delimbing operation was completed. The folia were folder properly to keep sawdust and small debris inside and do not contaminated surface (Skoupý, A., 1994).

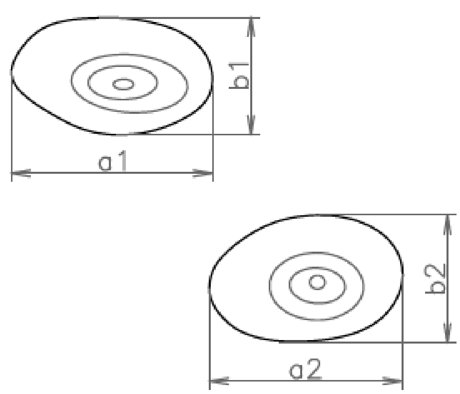

Figure 12 - Measurement of the delimbing (Skoupý, A., 1994).

To express the cut size in surface were measured the delimbing traces in two perpendicular cut dimensions, one axial direction and other in tangential direction, as shown in Figure 12. Area size has been simplified calculated as an ellipse. To calculate each measured section was used relation (Skoupý, A., 1994):

$$\mathbf{A = \frac{\pi . a . b}{4}} \quad (mm^2)$$

Where

a = axial length (mm)

b = radial width (mm)

In order to measure the presence of oil on the surface delimbing trunk were measured all cut sections. The bark was carried in the foil, and together with measured (Skoupý, 1994).

3.4 – Oil dispersion on work Clothes

When delimbing there are significant changes in work position of the saw. The saw works mostly to cut out of wood it can be assumed that the lubricating oil will be more disperse during this operation than when felling or cross-cutting. For this reason, this method was selected to control measurements of oil on loggers work clothing (Skoupý, A., 1994).

The Logger in charge of operate chainsaw during delimbing operation was equipped with a special rubber coat permeable and rainproof, rubber gloves, blouse and trousers against rain cover shoes as well. Simultaneously, was equipped with a respirator which contained a paper filter, which was used to capture the oil spread to facial part of the body or used to calculate the amount of oil that could be inhaled during the operation (Skoupý, A., 1994).

All these parts are easily measurable after work using the same geometry as in the previous measurement (Skoupý, A., 1994).

The proper measurement was carried out by the specialist from the department of Radionuclide Methods of the Institute of Development, Production and Utilization of Radioisotopes, Prague.

The material, methods and data was provided by Prof. Ing. Alois Skoupý, DrSc., Department of Forest Harvesting of the Faculty of Forestry and Wood Sciences from Czech University of Life Sciences Prague, Czech Republic.

CHAPTER 4

Results

4.1 – Oil Dispersion during delimbing operations

The oil dispersion during delimbing is recorded in Table 6. Are recorded the initial indicators of oil distribution for delimbing model in logs with thickness of 25 and 30 cm.

Table 6 - Measurement of oil dispersion during delimbing operations**.**

No.	Date and time	Stem diam.	Cut time	Oil pump adj.	Impulse number				Oil quantity				Total
					sawd.	branches	bark	soil	sawd.	branches	bark	soil	
	[h:min]	[cm]	[s]		[imp]				[g.m-^{2}]				g.m-^{2}
	31-05-91		Stem:		**Spruce**		Oil:	**OA M6A**					
17	beg. 11:00	30	20,84	4	44024	554	12575	28054	1,374	0,017	0,393	0,876	**2,660**
	31-05-91		Stem:		**Spruce**		Oil:	**OA M6A**					
18	beg. 14:00	25	32,53	4	25011	376	7501	15636	0,812	0,012	0,243	0,507	**1,574**

According to the proposed methodology were used 6 m long trunk and the pruning cuts were made at the lower part of the spruce crown. They have been previous cut. These strains were divided into 2 m long sections, whose boundaries on the trunk were marked with white chalk. Measurements were focused on the middle section, to which the above results (Table 6).

In Table 6 is possible check the cutting time (s) that was measured in the trunk so that it was not counted waiting at the borders of each section, required by methods, when were collected from branches of just branched section.

The absolute oil dispersion occurrence during delimbing operations is showed in Table 7. The largest amount (g.m^{-2}) of oil was measured in sawdust followed by soil surface and then the bark. The oil dispersion in branches is not representative has lower values (Figure 13).

Table 7 - Absolute oil dispersion during delimbing (g.m-2).

	Oil concentration				
	Sawdust	**Branches**	**Bark**	**Soil**	**Total**
25 cm	0,812	0,012	0,243	0,507	**1,574**
30 cm	1,374	0,017	0,393	0,876	**2,660**

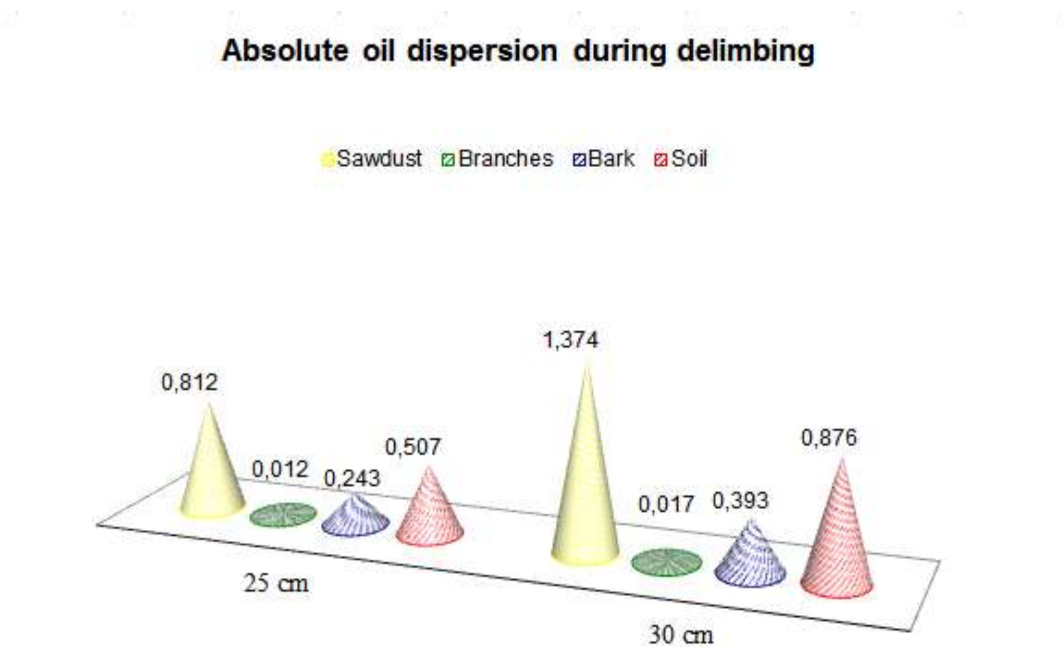

Figure 13 - Absolute oil dispersion during delimbing (g.m^{-2}).

The relative values are shown in Figure 14, which shows that relative proportions are about the same for both measurements. Oil dispersion in sawdust represents 51-52%, only 1% was found on the branches, 15% is disperse on the stem bark and 32-33% on the soil surface.

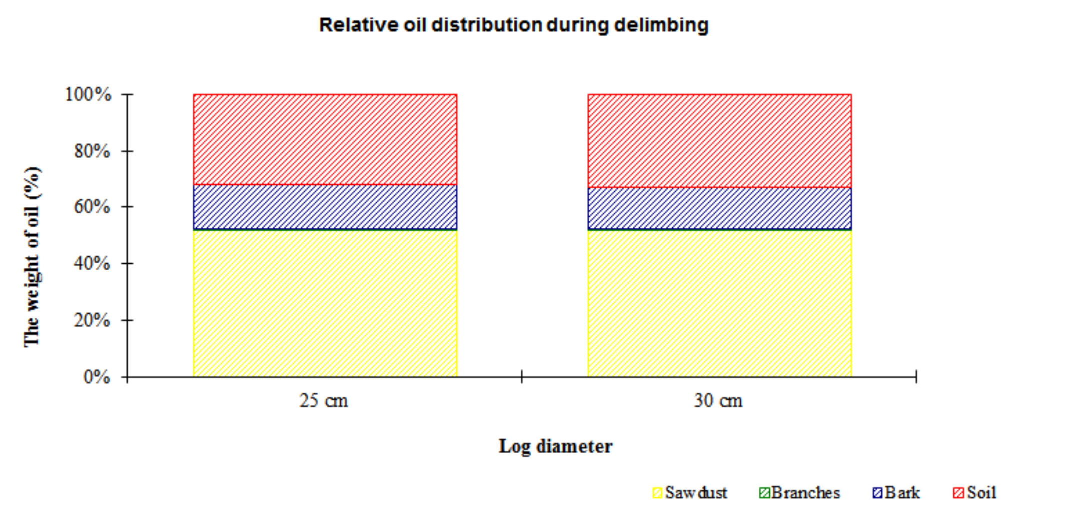

Figure 14 - Relative oil distribution during delimbing.

In order to express the size of the total area cut when delimbing, all traces of cutting wood were measured according to the proposed methodology. These measurements were calculated by area of each section. The results of measurements and calculations are shown in Table 8. Here it is possible count the number of branches and whorls of each section as well all of the area of the cut. When the branch cut was too deep or superficial influenced the oil concentration in that spot.

Table 8 - Cut branches areas during delimbing.

Cut a thickness of 24 cm						Cut a thickness of 30 cm					
Section Number	Trunk Number	Serial Number	Dimensions		Calculated Area	Section Number	Trunk Number	Serial Number	Dimensions		Calculated Area
			a	b					a	b	
			(mm)	(mm)	(cm2)				(mm)	(mm)	(cm2)
I.	1.	1	45	34	12,02	**I.**	1.	1	31	36	8,76
		2	36	55	15,55			2	67	68	35,78
		3	37	29	8,43			3	51	45	18,02
	2.	4	39	45	13,78			4	23	19	3,43
		5	25	27	5,30			5	85	84	56,08
		6	160	61	76,65			6	75	93	54,78
		7	10	15	1,18		2.	7	34	32	8,54
	3.	8	121	112	106,43			8	62	39	18,99
		9	43	64	21,61			9	15	16	1,88
		10	60	39	18,38			10	15	13	1,53
		11	150	13	15,31			11	34	39	10,41
		12	17	20	2,67			12	22	23	3,97
	4.	13	131	60	61,73		3.	13	44	34	11,75
		14	140	28	30,79			14	102	30	24,03
		15	40	29	9,11		4.	15	94	81	59,80
		16	27	24	5,09			16	145	127	144,63
		17	90	17	12,02			17	30	31	7,30
		18	9	13	0,92			18	84	91	60,03
Total Section I					**416,97**	**Total Section I**					**529,74**
II.	5.	1	47	66	24,36	**II.**	5.	1	117	71	65,24
		2	79	45	27,92			2	47	60	22,15
		3	43	36	12,16			3	58	79	35,99
		4	9	6	0,42			4	23	23	4,15
		5	72	63	35,62			5	76	29	17,31
		6	16	13	1,63			6	76	15	8,95
		7	81	60	38,17		6.	7	111	23	20,05
		8	25	29	5,69			8	89	63	44,04
	6.	9	33	28	7,26			9	32	35	8,80
		10	22	42	7,26			10	33	45	11,66
		11	51	103	41,26		7.	11	77	100	60,47
		12	66	61	31,62			12	76	59	35,22
		13	17	113	15,09		8.	13	81	41	26,08
		14	75	27	15,90			14	51	48	19,23
		15	7	7	0,38			15	96	21	15,83
	7.	16	49	52	20,01						
		17	72	15	8,48						
		18	45	22	7,78						
		19	16	14	1,76						
		20	184	70	101,16						
Total Section II					**403,93**	**Total Section II**					**395,17**
III.	8.	1	35	37	10,17	**III.**	9.	1	78	83	50,85
		2	9	7	0,49			2	70	101	55,53
		3	81	61	38,81			3	43	56	18,91
		4	54	56	23,75		10.	4	58	52	23,69
		5	37	34	9,88			5	63	50	24,74
		6	9	8	0,57			6	37	53	15,40
	9.	7	28	28	6,16		11.	7	124	100	97,39
		8	83	49	31,94			8	43	37	12,50
		9	33	41	10,63			9	22	17	2,94
		10	48	44	16,59		12.	10	82	83	53,45
		11	52	44	17,97			11	41	33	10,63
	10.	12	58	76	34,62						
		13	142	23	25,65						
		14	72	47	26,58						
		15	38	43	12,83						
		16	60	43	20,26						
		17	27	29	6,15						
Total Section III					**293,04**	**Total Section III**					**366,01**
Total Cut					**1113,94**	**Total Cut**					**1290,92**

4.2 - Oil Dispersion in particular pieces of working clothes

During delimbing was also investigated the occurrence of oil in work clothes. For this purpose, the trunk used during measurements had a medium of 25 cm thickness. Delimbing operation occurred in a fluently way. Measurements took place on June 5th, 1991 have been launched at 10 hours. The designed methodology was strictly followed.

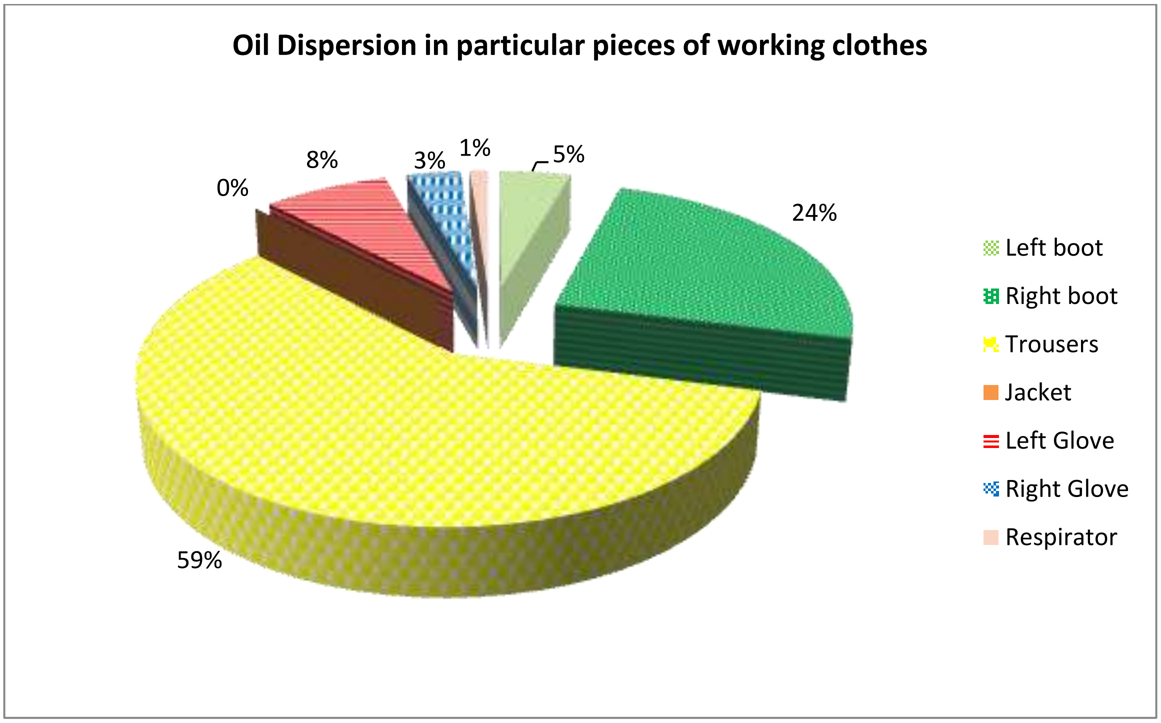

Figure 15 - Oil Dispersion in particular pieces of working clothes.

It’s easy to conclude for the Figure 15 that the highest concentration of oil dispersion occurs in the trousers of the logger (59%). The piece of work clothes most affected after trousers is the right boot (24%) this condition is explain by the wok position since the feet must be firmly planted slightly apart in a balanced position. Left glove has 8% of concentration more 5% than right glove once again is related with working position. Left boot has a small share of concentration together with respirator 5% and 1% respectively. In the work jacket, or on the helmet was not found oil. In conclusion the Total weight of oil is 0, 09 g.m^{-2}.

Table 9 - The spots of oil stain on the particular pieces of working clothes.

	Left Boot	**Right Boot**	**Trousers**	**Jacket**	**Left Glove**	**Right Glove**	**Respirator**	**Total**
[pulses]	139	704	1724	0	244	105	48	
[g.m^{-2}]	0,004	0,022	0,053	0,000	0,007	0,003	0,001	**0,090**

The headpiece is not included in the results intentionally, because it is the only element that could not be placed in the same measurement geometry as other items of clothing. The results correspond exactly to the assumptions. The trousers accumulate during delimbing more oil since the saw is placed on the left side of the trunk creating a directed stream on the right foot and left glove. Respirator was measured as a whole, because the paper filter all the air we breathe, although measured values, which would be less expressible amount only 0.001 g.m^{-2}.

Was also made an attempt to measure the incidence of oil on the work clothes in the transverse cutting, but after 10 consecutively cuts at one point (cutting blade) to cut the 30 cm thick spruce. Was not found in any part of work clothes measurable values

CHAPTER 5

Discussion

It is possible to make a statement that oil concentration on forest soil surface at normal work with the chain power saw in the stand is lower than the values found in sawdust. This observation could mean that oil dispersion on forest soil surface during normal work with chain saw have no significant impact on the soil flora and fauna. Since, germination capacity is decreased from 95 % to 13-47 % under conditions of oil dispersion (Lauhanen, R. and Kolppanen, R., 2003).

Neither it is possible to detect of any influence on timber production. The oil dispersion values found in branches and bark aren't expressible.

Delimbing was an operation that was expected not triggers a major oil spill, which could be viewed in previous cases as in felling that 75–77% of oil was absorbed by sawdust, 7–13% adhered to the surface of cut timber, and 12–16% got onto the soil surface (Skoupý, A., 1994). Or in cross-cutting method where can be seen that 55 – 85% of oils are retained in sawdust, 3 - 15% log surface of cut wood and 10 - 35% of oil get into the soil surface and its conclude that oil dispersion into sawdust is higher than in any other place and increase with the log diameter (Skoupý, A., 1994). The assumption was correct since the values of oil dispersion were lower than in the other methods. Oil dispersion in sawdust represents 51-52%, only 1% was found on the branches, 15% is disperse on the stem bark and 32-33% on the soil surface (Figure 13).

It does easy conclude that no matter the pruning operation used the oil dispersion will have simillar pattern of distribution. Although, the relative values of distribution can change. This difference in the concentration is related with the cutting technique, and oil properties and cutting time (Skoupý, A., 1994).

Contamination of groundwater in particular is only considered in the case of concentrated oil leakages or spills have been observed in previous cases (Skoupý, A., 1994). The more serious cases of water threaten contamination happen only in water-logged soils or at cutting timber right above the water surface (Skoupý, A., 1994). Further, research has been done in this field of study in order to prove the assumption.

So the size of the total cut area of delimbing was calculated by measured all branches of cutting wood and summarizing the total (Table 8). It is necessary take into account that some of the values show higher concentrations, which is related with cut performance. The cut branch can be cut more or less deeper what will influence the oil concentration in that specific spot.

The work clothes more affected with oil dispersion were trousers and right boot this distribution is related to the work position during the pruning (Figure 15). The amount of oil in the 0.001 $g.m^{-2}$ respirator (Table 9) was very low that means all the air breathed, during the operation was not expressible of making any risk for human health. The present results are corresponding exactly to the assumptions and previous study cases (Skoupý, A., 1994).

The method of measuring oil dispersion on the stand and work clothes during delimbing give us an interesting knowledge of oil distribution. The provided information can be therefore fitted for direct practical use and considered used in different forest fields. Has an example production of new forest garment and reduce the oil dispersion during forest harvesting.

CHAPTER 6

Conclusion and Recommendations

Generality during delimbing operation with chain saw in the forest stand the oil concentrations on the soil surface cannot reach values that have a negative influence on environment.

The negative impacts on the timber production were not found at all.

Besides, any water contamination, particularly the underground water reservoirs, comes into consideration when exposed at these low oil concentrations. The risk of environment contamination exists only on the condition of a massive oil leakage during operations.

I assume that a more serious contamination of water can result only when working on water-logged soils or cutting right above the water surface. However, is recommended the use of biologically degradable oil such as the vegetable oil in all forest stands in order to preserve the natural environment conditions.

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