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J. Geogr. Inst. Cvijic. 63(4) (29-36)

*Original scientific paper*

UDC: 911.2:627.5
DOI: 10.2298/IJGI1304029S

# THE RISK OF SURFACE WATER CONTAMINATION BY OIL PRODUCTS

*Dagmar Samešová *[1], Helena Hybská *, Jozef Mitterpach **
* Technical University in Zvolen, Faculty of Ecology and Environmental Sciences, Slovakia

Received 26 September 2013; reviewed 22 October 2013; accepted 27 November 2013

**Abstract:** The aim of this paper is to assess the surface water contamination by oil substances in forest. The usage of forest mechanisms for felling, loading, and wood transportation belong to the activities which affect small but long-term natural environment contamination caused by mineral oil substances. These substances impact negatively on all components of the forest ecosystem. The oil substances were determined as non-polar extractable substances (NES) by spectrophotometric method in infrared spectrum. The progress of NES concentrations and harvest intensity in all sampled locations shows evident connection with harvest intensity and season of the year. We tested biodegradability of selected petroleum products for better understanding the interaction of hydrocarbons in forest ecosystem.

**Key words**: water contamination, petroleum products, biodegradability, harvest

## Introduction

In the European Union is implementation of two directives concerned with birds and biotopes, and creation of the net of protected areas - Natura 2000 fundamental for the nature protection. All associated EU candidate countries are obliged to bring forward the list of protected species and biotopes; and to implement within two years suggested management precautions which should secure their protection. The usage of the forest mechanisms for felling, loading and transportation belong to the activities which affect small but long-term natural environment contamination caused by mineral oil substances. It is inevitable to prevent this phenomenon from the aspect of the long-term nature preservation. Legislation of some European countries enacted obligatory use of biologically soluble oils. This attention is also one of the criteria for the environmental assessment of the companies involved in the certified felling, e.g., in Sweden (Athanassiadis, 2000). Slovak Republic lacks this kind of legislation, and the system of effective control and monitoring is not implemented, yet. Even though the negative effects of the mineral oil substances on water and

[1] Correspondence to: samesova@tuzvo.sk

forest ecosystem are known in generally and studied most of all from the acute toxicity point of view (Kazantseva, 1993). Negative impact of increase oil substances content in surface water is showed as (Bienik, 1986):

- the change of organoleptic properties of water (odour, taste, colour),
- the change of chemical composition of water (as a result of emulsification, change of re-aeration),
- the change of biological activation of water (toxic effect at organisms, change of bacteriological flora),
- the change of physical properties of water (surface tension, oil films).

Because of low dissolubility of the most of oil substances, the emulsified and clear oil substances are dominated in water. Generally, more oil substances are emulsified in the water. Toxicity of emulsified form of oil substances is higher than non-emulsified form (Rothschein, 1997) and one is in the rate of order unit mg/l (Martoň, 1991).

The free oil substances form the oil film at surface which inhibits the oxygen movement into the water, photosynthesis process is fluctuating what is unfavourable for water organisms, for example Algae could be strong influenced and also other plankton (e.g. 1 l of mineral oil covers with its film about 0.5 hectare of water surface). The surface of minor organisms shape is protected with membrane which is abhorrent the water, membrane consists of mainly of lipids. Hydrophobic components of oil substances are easy retained on the membrane forming oil films and hereby infiltrating organisms bodies where they prohibits oxygen reception. Biochemical decomposition of oil substances is passed off mainly in upper layers of surface water in the presence of nutrients and oxygen and at appropriate temperature on the bottom of the fluvial flow this process is 10 times slower than on the top because the chemical oxidation through solar radiation is processing (Hyánek, 1991). The activity of microorganisms decreases with the loss of temperature (Tajč, 1990).

Oil substances affect the most of plants species as total herbicide (Srnský, 1992). In fields target only petroleophobic plants survive (they are lower sensitive to oil substances), for example Stinking Nettle and European Elder. The most of plants and wood species (Mosses, Lichens, Grass, Birch, Lombardy Poplar) are high sensitive, so they are petroleophilic. After attack of oil substances, plants die or respond with delayed growth. One of the reasons of plant necrosis is progressive soil infiltration. Oil substances cover plants roots and inhibit absorption of moisture then the plant begins to dry. When the escape of oil substances is impulsive and small in amount, the oil substances are absorbed at particles surface in ground medium, eventually they rate by capillary powers in

the ground. The ground is able to receive precise quantity of oil substances which can be decomposed by biological processes in the soil with access of air so they do not pollute groundwater.

The risk of contamination increases during emergency situations such as extremely large timber, for example we had monitored territory of the Poľana Biospheric reserve after violent storm which caused so called "100 year" calamity (Samešová, 2008). The disposal of the calamity consequences brought up the environment contamination caused by the mineral oil substances which is connected with the utilization of used mechanisms. We found contamination by mineral oil in 88 % samples of surface water.

The goal of this report is to assess the surface water contamination by oil substances during routine management in forest, except this to determine biodegradability and toxicity of the selected mineral oils.

## Methods and materials

### *Surface water sampling*

Contamination of surface water was studied in the University forest management enterprise during the years 2010 – 2013. Full range of conditions was monitored on selected localities. Flows mentioned above were monitored in profiles chosen according to the places of intensive exploitation. Near town Zvolen were selected four forest plots (no. 511, 518, 522, 736). Water samples were taken from places situated along to outflow from the whole area into stream. Places were selected to represent the whole outflow. Water samples were took as a dot samples into fairly flushed glass bottles and processed next day.

### *Determination of oil substances*

Oil substances were determined by spectrophotometric method in infrared spectrum as non-polar extractable substances (NES). The method is based on the extraction of oil substances from acidified water sample with trifluorotrichloromethane then the residual of polar substances is removed by adsorption at silica gel. Measurement was done in spectrum with wave number in the range from 3150 cm-1 to 2750 cm-1 and valence vibrancies typical for CH groups are evaluated by the assistance of empiric formula (Horáková, 2000).

*Biodegradability*

Simple method comparing concentration of biodegradable organic substances to the total concentration of organic substances was used for evaluation of biodegradability of selected petroleum products (Fargašová, 2009). Selected were the most commonly used petroleum products in the forest management:

- hydraulic oil OT HP3
- biohydraulic oil HLP SYNTH 46
- chain lubrication oil for chainsaw BioPlus
- motor oil Tirman.

Biodegradability was determined by chemical oxygen demand (COD) and biochemical oxygen demand (BOD5). Except this, we used also determination of aerobic biodegradability by manometric respirometry (OECD, 1992).

## Results and discussion

The research was done at four sites – forest stand no. 511 – Pole Niva (Niva Field), stand no. 518 Blatá 1, stand no. 522 – Blatá 2 and stand no. 736 – Šteflíkova lúčka (Šteflíkova Meadow), which are under the management of VšLP – Lesná správa Budča (University Forest Enterprise - Forest Office Budča). Water samples were taken in each forest stand before, during and immediately after the harvest. Stands are still monitored. In all four forest stands was done deliberate regeneration harvest according to Forest Management. The highest concentrations in water samples were connected with the forest stands where had been used the oldest means of transport and mechanization.

Results from tests in the forest stand no. 511 did not reveal any positive NES before the harvest. The highest amount of NES was found during intensive harvest, value was 4.279 mg/l NES. High concentrations of NES lasted until May. The concentrations of NES in samples taken during the entire monitoring period are recorded in Figure 1

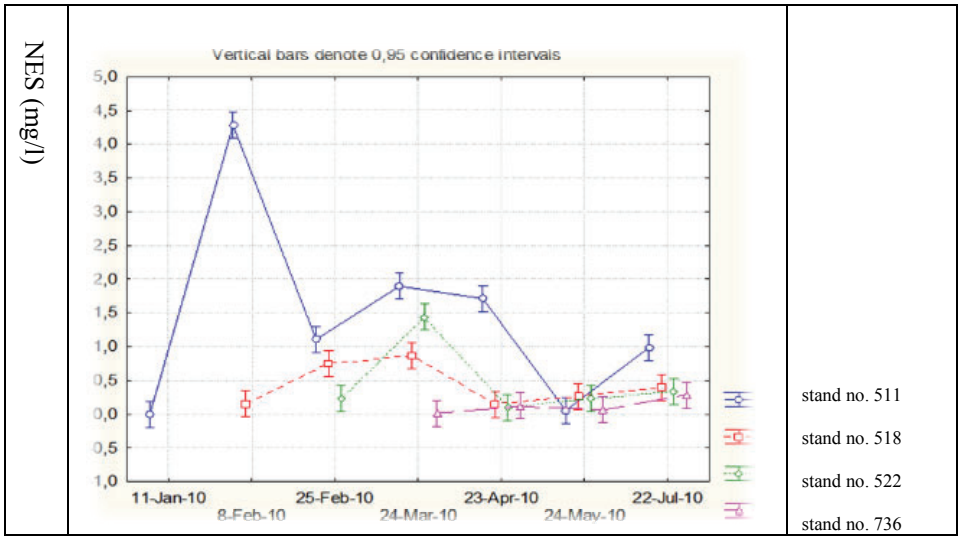


Figure 1 Course of NEL concentrations in the water samples

The course of NEL concentrations and harvest intensity in all sampled locations shows evident connection with harvest intensity and season of the year. During the winter biochemical decomposition stops and flow of oil substances is easier on frozen soil. Microorganisms are capable of aerobic hydrocarbons degradation as well as anaerobic degradation. Aerobic conditions occur in the most cases of natural microbiological degradation of water and soil contaminants. Results determining biodegradability of monitored products are stated in Table 1.

Table 1. Results determining biodegradability of chosen oil products in surface water

| Name of products | BOD5 (mg/l) | CODCr (mg/l) | Biodegradability (%) | BOD5/CODCr (%) |
|---|---|---|---|---|
| chain lubrication oil for chainsaw BioPlus | 210 | 519 | 61.9 | 0.41 |
| hydraulic oil OT HP3 | 243 | 675 | 33.0 | 0.36 |
| bio-hydraulic oil HLP SYNTH 46 | 317 | 516 | 92.0 | 0.61 |
| motor oil Tirman | 169 | 669 | 27.0 | 0.25 |
| Diesel | 172 | 352 | 50.6 | 0.49 |

Based on the results, acquired using described laboratory methods, conclusions were determined as follows:

- the best biodegradability was achieved in water samples contaminated by chain saw lubricating oil BioPlus, where biodegradability reached value 61.9 % in 28 days,
- the worst biodegradability was achieved in water samples contaminated by motor oil Tirman, biodegradability reached value 27 % (Fig.2). Based on criteria BOD5/CODCr rate, oil Tirman is in class 3 (slow degradable substance).

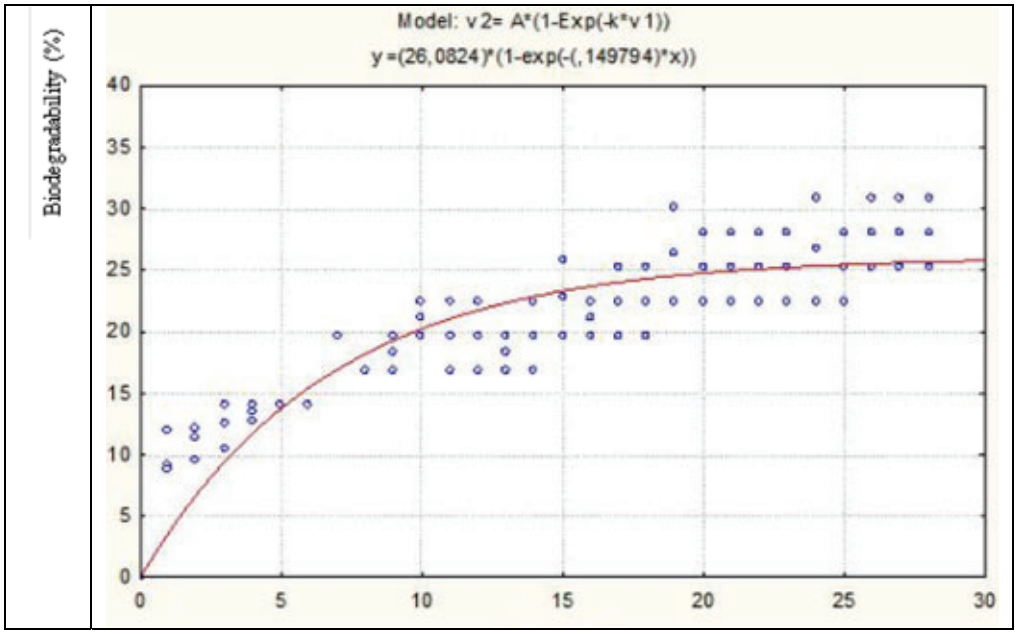


Figure. 2 Statistical model of biodegradability of motor oil Tirman by time

## Conclusion

Results of analytical testing show that oil substances contamination occured in time of intensive exploitation of wood. In all monitored forest stands was done deliberate regeneration harvest according to Forest Management Plan. We found that non-polar extractable substances (NES) did not answer the legislative tolerable value (0.1 mg/l). The highest concentrations in water samples (4.279 mg/l) were connected with the forest stands where had been used the oldest means of transport and mechanization.

Results show that significant influence on biodegradation process of tested oil products (in permanent conditions) has time for the most part. The chain oil for chain saw Bioplus and bio-hydraulic oil HLP SYNTH 46 had the highest percentage of biodegradation. On the contrary, the lowest percentage had hydraulic oil OTHEP 3 and motor oil Timan.

In conclusion is possible to state that the approach to the wood exploitation and work management is necessary to change, because there is a danger of multiplying damages in environment. Using of naturally degrading oils, vehicles with good technical conditions and technology discipline has to be secured with high priority in valuable localities.

**Acknowledgements**
This paper was published under support of grant VEGA 1/1275/12): Semi-natural forest phytocoenoses in Praecarpaticum and its contamination by harmful substances

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