ECOTOXICOLOGICAL CHARACTERISTICS OF THERMAL TREATMENT

EKOTOXIKOLOGICKÁ CHARAKTERISTIKA TERMICKÉHO ZÁSAHU

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Abstract:
The paper deals with the effect of thermal treatment on soil properties. A standard soil LUFA 2.2 has been exposed to thermal desorption conditions using two methods of heating – a microwave furnace and an electric furnace. Subsequently, the influence of a thermal action on ecotoxicological properties of soil was studied. The tests were conducted using aqueous leachate crustaceans *Daphnia magna* and green algae *Desmodesmus subspicatus*. Contact reproductive tests on soil invertebrates, enchytraeid *Enchytraeus crypticus* and springtail *Folsomia candida*, were also conducted. The test results showed that a thermal intervention did not have any notable effect on the ecotoxicity of aquatic organisms. In contrast, it produced a substantial effect on toxicity in terms of soil organisms.

Keywords:
Thermal desorption, soil ecotoxicology.

Introduction

Thermal desorption represents an ex-situ recovery technology that may be used to eliminate pollutants such as, e.g., pesticides of the HCG type from contaminated materials. The process consists in heating the material to a high temperature and in the subsequent transition of the contaminants to the gaseous phase. The heating may be conducted using a rotary or microwave furnace (Matějů 2006).

If the decontaminated material is soil, its properties may be expected to change. Thermal intervention causes changes particularly in the organic matter in the soil which degrades at thermal desorption temperatures (Madrnová 2011). Consequently, the resulting effect of thermal desorption is not only the elimination of the pollutant but also possible origin of compounds which may affect living organisms. The aim of the presented work is to establish the extent to which a thermal intervention may affect the ecotoxicological properties of soil.

Methodology

Standard soil LUFA 2.2 was used to assess the effect of the given process on soil. In the first step the soil was dried at a laboratory temperature (dry matter reached roughly 99% at 105°C) and subjected to a thermal intervention – heating in a microwave oven (specimen "M") or a conventional laboratory furnace (specimen "P"). The heating was conducted in batches with a batch mass of 600g. The soil was heated gradually to a temperature of 200°C with a gradient of about 10°C/min. The temperature of 200°C was then kept stable for a period of 15 min. Two specimens of thermally treated soil and one specimen of dry untreated soil (indicated as "LUFA") were thus obtained.

Subsequently, the materials were subjected to ecotoxicological biotests. Following the thermal intervention, aqueous leach of the studied materials - P, M and LUFA (ČSN EN 12457-4) was prepared. A test of freshwater algae growth rate inhibition (ČSN EN ISO 8692) and a test of daphnia mobility inhibition (ČSN EN ISO 6341) were conducted using undiluted aqueous leach. Contact soil tests were conducted directly with treated undiluted specimens, namely springtails and enchytraeid reproduction tests (ČSN ISO 11267 and ČSN ISO 16387, respectively), and springtails and enchytraeid avoidance tests (ISO 17512-2 and Natal-da-Luz 2008, respectively). The Tukey-Kramer comparison test was used in the statistical evaluation of the obtained data.

Results
Table 1 shows that the aqueous leach did not have any toxic effect on any of the tested organisms. In contrast, the tests conducted on soil organisms showed notable changes ecotoxicity of materials.

Table 1: Ecotoxicity tests results: a negative value represents stimulation; ^{ns} represents a result that does not show any statistically significant difference from the LUFA specimen; * indicates a statistically significant difference at the significance level $\alpha = 0{,}05$; ** indicates a statistically significant difference at the significance level $\alpha = 0{,}01$.

Organism, studied effect / Material	Algae, growth rate inhibition (%)	Daphnia, immobilization (%)	Springtail, reproduction inhibition (%)	Springtail, avoidance (%)	Enchytraeid, reproduction inhibition (%)	Enchytraeid, avoidance (%)
LUFA	5	0	0	0	0	0
P	-9 *	0	30 ^{ns}	79 **	98 **	94 **
M	2	0	60 *	66 *	62 **	93 **

Discussion
The obtained results show only minor changes of soil toxicity in an aqueous leach. We may thus conclude that a thermal intervention does not produce toxic substances soluble in water that would have aby inhibiting impact on green algae or small crustaceans. Slight stimulation of the growth rate was observed in the aqueous leach of the specimen treated by way of conventional heating in an electric furnace, which might be due to the mobilization of nutritional substances.

Soil invertebrates migration from a disturbed environment (significant avoidance) confirmed the deterioration of the soil quality in consequence of a thermal intervention. Considerable inhibition of reproduction was also observed. This was most likely due to the decomposition of the soil organic component which produced toxic products. From the ecotoxicological point of view, conventional heating in an electric furnace was more dangerous because it caused a 98% inhibition of enchytraeid reproduction. A similar effect on other segmented worms may be expected, which might cause considerable deceleration of further soil regeneration. In contrast, microwave heating produced only a partial inhibition effect on the reproduction of both enchytraeids and springtails. This phenomenon may be due to the homogeneity of the temperature field in the batch of the treated specimen (Mašín 2011).

Differences in the sensitivity of individual organisms to the same stimulus are common and they are most probably caused by different metabolic processes and possibilities of toxic substances intake (Hopkin 1997; Papáček 2000).

Conclusion
A thermal intervention comparable to a low-temperature thermal desorption causes deterioration of the quality of soil treated in the given way. In spite of a considerable decrease in the reproductive capability of some organisms, the soil may be colonized and thus able to fulfil its function. An aqueous leach of the treated soil does not represent any obvious risk to aquatic organisms.

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