Introduction

Biologically associated heavy metal contamination in soils is difficult to assess. In most environmental studies, the total effect of heavy metals has been related to total soil contamination or some operationally defined extractable fractions. Leaching procedures are often used for determination of metal concentrations in soils. e.g. leaching with sodium nitrate is used for determination of the bioavailable part of metal in soils [1]. But these processes do not usually provide information about fractions really available to plants, interception or soil fauna. Therefore new approaches, which could characterize concentrations and transport of bioavailable forms of metals (forms of metals which are available to living organisms) and instead of organic forms of metals in soils much better, have been found.

The DGT (Diffusive Gradient in Thin Films) technique has proved to be a very useful tool to determine the kinetics of metal uptake and the bioavailability of metals to plants. Like plant root, DGT locally decreases the metal concentration of the soil solution and triggers complex by diffusion from the soil solution and solid phase. The kinetics of this process determine the availability of metals to plants (Fig. 1). The DGT technique was used for determination of the bioavailable part of selected metals in soils. Then for the assessment of the degree of metal release from the soil solid phase to the soil solution, two types of diffusive gels with a different pore size (d) were used for determination of inorganic (ion) and organic forms of heavy metals in this experiment.

The DGT technique principle

This technique uses two polyacrylamide gel layers placed in a plastic unit. The first layer is formed by a hydrogel containing a specific ion-exchange resin (Chelex, Na-form). The second one is for med by a clear permeable hydrogel, so-called diffusive gel, which covers the resin layer. The outer surface of the diffusive gel is covered by a 0.45 μm nano-filter to prevent the leaching from adhering particles.

Metal cations diffuse across the filter and diffusive layer and they are immobilized and concentrated by sorption in the resin. Trapped metal ions are released from the resin and move into the gel layer and they are determined by ETAAS, ICP AES or ICP MS. When a linear concentration gradient is established across the diffusive layer, the flux of trace metals from the solution to the resin is governed by Fick’s law of diffusion [12].

\[
\frac{\partial C}{\partial t} = D \frac{\partial^2 C}{\partial x^2}
\]

where \( C \) is the concentration of metal ion in solution, \( D \) is the diffusion coefficient, \( t \) is the deployment time.

\( C(g-m^{-2}) \) is thickness of diffusion gel layer, \( D \) is diffusion coefficient, \( t \) is deployment time

Solute transport in a diffusion media is described by the Fick’s law of diffusion [12] and can be adapted to describe the solute transport across a diffusion media.

The DGT technique provides the possibility of determination of heavy metals in plants [2].

Materials and methods

Soil samples characterization:

Czech arable soils, neutral, middle type, fertilized by sewage sludges in 1980s, examined within the bounds of the project INCO Copernicus: Fertility requires the sustainable management of agricultural soils. Fertility requires the sustainable management of agricultural soils. Fertility requires the sustainable management of agricultural soils. Fertility requires the sustainable management of agricultural soils. Fertility requires the sustainable management of agricultural soils. Fertility requires the sustainable management of agricultural soils. Fertility requires the sustainable management of agricultural soils.

Three sampling sites in South Moravia - Zlin, Chrlice, Tesely chosen as experimental points. The soil characteristics of these sites are different: dry matter, nutrient content, oxidable organic nitrogen amount, carbonat content and pH value were determined. Further the total decomposition of samples was performed following the sample cleaning by aqua regia. EDTA, nitric acid, sodium nitrate, aqua and IBA [6].

DGT unit deployment:

- Soil and water mixture, equilibration 24 h, temperature 25±2°C, DGT unit deployment time 48 h (see Fig. 2)
- Intimate contact of the capillary funnel with the mixture
- Water / soil phase ratio: Tafel 6.6 mg/l, Zln 6.6 mg/l, Chrlice 8.3 mg/l, means of mixture of soil samples: Tafel 6.3%, Zln 6.8%, Chrlice 7.5%.
- Constant moisture of the soil

The DGT technique for assessment of metal bioavailability in soils

The DGT technique is a new method for assessment of metal bioavailability in soils. In this technique the metal concentrations in the vicinity of the DGT unit with the deployment time are determined. Measured concentrations are influenced by the metal ions resupply from the solid phase to the soil solution. The DGT technique is not usually provide information about fractions really available to plants. The DGT technique was used for determination of the bioavailable part of selected metals in soils. Then for the assessment of the degree of metal release from the soil solid phase to the soil solution, two types of diffusive gels with a different pore size were used for determination of inorganic (ion) and organic forms of heavy metals in this experiment.

Determination of metals:

Cadmium was the most mobile metal among the three ones mentioned above and thus the most available one, particularly in 0-10 cm depth profile. End of the metal concentration in the soil solution (C is measured by an inductively coupled plasma mass spectrometry) is slower than in case of cadmium.

Comparison of the DGT technique and leaching procedure:

The comparison of the DGT technique and leaching with sodium nitrate is shown in Fig. 3.

Table 1. Ratio of values.

<table>
<thead>
<tr>
<th>Soil</th>
<th>Cd</th>
<th>Ni</th>
<th>Cu</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tafel</td>
<td>0.10</td>
<td>0.10</td>
<td>0.24</td>
</tr>
<tr>
<td>Zln</td>
<td>0.10</td>
<td>0.10</td>
<td>0.24</td>
</tr>
<tr>
<td>Chrlice</td>
<td>0.10</td>
<td>0.10</td>
<td>0.24</td>
</tr>
</tbody>
</table>

Concluding

The DGT technique provides the possibility of determination of heavy metals in soils and thus their availability to the plant root system because of DGT units locally reduce this system. It can be also used for assessment of the degree and rate of the metal reactivity from the soil solid phase to the soil solution. By the value of the pore size of diffusive gel the proportionality of organic (inorganic) forms and small organic molecules of metals can be determined.

References