EFFECT OF LONG-TERM FERTILIZATION ON THE AVAILABLE TOXIC ELEMENT CONTENT OF DIFFERENT SOILS

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ABSTRACT

The National Long-Term Fertilization Trials were set up more than 30 years ago and in that time soil and water protection and environmental relations of fertilization had not been the direct aim of research. From the agricultural load the use of phosphate fertilizers gets outstanding attention because of the accumulation of toxic heavy metals. The aim of our research was to study the influence of long-term, intensive fertilization on the available toxic element content and accumulation in different soils. Samples were collected from 8 experimental sites with equal treatments from the depth of 0-20 cm.

The so-called available, 0,1M KCl + 0,05M EDTA extractable element content was determined. In the paper the results of Cd, Pb, Cr, are discussed in details. The experimental results of toxic elements show that the 28-year old constant fertilization treatments did not result higher values than the accepted concentration level, even they did not approach it.

KEYWORDS: long-term trials, fertilization, available, toxic elements, soil
INTRODUCTION

Soil fertility decreases due to extreme physical, chemical and biological conditions, e.g. lack or surplus of nutrients, water, organic or mineral colloids, low or high pH, accumulation of toxic (metal) elements, anaerobe conditions, salt accumulation, narrow A horizon, environmental load, etc.

There are many possible ways for heavy metals to get into the soil and to the soil-plant system and all through this the food chain. It can happen by air-pollution; by natural conditions, salt accumulation, narrow A horizon, pH, accumulation of toxic (metal) elements, anaerobe conditions, etc.

The agricultural load has the widest extent and affects the whole biosphere. Fertilization changes the nutrient status, pH, etc. of soils. Some heavy metals may accumulate in the soil or the solubility change. From the agricultural load the use of phosphate fertilizers gets outstanding attention because of the accumulation of toxic heavy metals. The effect of toxic concentration appears through the ion uptake of plants, though it may influence the biological and physical-chemical properties of soils. The trace element content of soils may be different due to their origin and geology, however anthropogenic effects like fertilization may have further influence.

The so-called available, 0,1M KCl + 0,05M EDTA extractable element content was determined. In the paper the results of Cd, Pb, Cr, are discussed in details. The experimental results of toxic elements show that the 28-year old constant fertilization treatments did not result higher values than the accepted concentration level, even they did not approach it.

MATERIALS AND METHODS

The National Long-Term Fertilization Trials were set up more than 30 years ago and in that time soil and water protection and environmental relations of fertilization had not been the direct aim of research. Since then more and more demand have arisen from environmental point to get knowledge of macro, micro and toxic element content of soils. The acidification of soils increases the solubility of metal elements, which through unwanted concentration levels may result toxicity. Acid soils are therefore more sensitive to contamination and this kind of agricultural load. The effect of toxic concentration appears through the ion uptake of plants, though it may influence the biological and physical-chemical properties of soils. The trace element content of soils may be different due to their origin and geology, however anthropogenic effects like fertilization may have further influence.

The importance of long-term experiments has increased significantly proportional to their age. The accumulated effect of external environmental load from atmospheric sediments and fertilizers on the biomass production, quality of crops, soil fertility, utilization and losses of nutrients can be measured in these trials and compared to earlier periods.

In the paper experimental results on the change of Pb, Cd and Cr concentrations of soils in different agricultural regions are presented. The effect of long-term fertilisation (28 years) on these element concentrations is presented in relation to some important fertilizer treatments (NPK doses).
Experimental Sites

<table>
<thead>
<tr>
<th>Properties</th>
<th>NH</th>
<th>IR</th>
<th>BL</th>
<th>K. O.</th>
<th>KA</th>
<th>PU</th>
<th>KE</th>
<th>HB</th>
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</thead>
<tbody>
<tr>
<td>Soil type  (FAO)</td>
<td>Calcaric</td>
<td>Calcaric</td>
<td>Calcaric</td>
<td>Phaeosem</td>
<td>Calcaric</td>
<td>Phaeosem</td>
<td>Luvic</td>
<td>Phaeosem</td>
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<tr>
<td>Soil type  (USDA)</td>
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<td>Mollisol</td>
<td>Mollisol</td>
<td>Mollisol</td>
<td>Mollisol</td>
<td>Alfi sol</td>
<td>Vertisol</td>
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<tr>
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<td>Loam</td>
<td>Loam</td>
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<td>Clay loam</td>
<td>Clay loam</td>
<td>Sandy loam</td>
<td>Clay loam</td>
</tr>
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<td>Soil OM, %</td>
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<td>2.4</td>
<td>2.4</td>
<td>2.7</td>
<td>2.4</td>
<td>2.4</td>
<td>2.7</td>
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<tr>
<td>Soil pH</td>
<td>7.2</td>
<td>7.4</td>
<td>7.4</td>
<td>7.2</td>
<td>7.4</td>
<td>7.4</td>
<td>7.4</td>
<td>7.4</td>
</tr>
<tr>
<td>Clay %</td>
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<td>5.0</td>
<td>5.0</td>
<td>5.0</td>
<td>5.0</td>
<td>5.0</td>
<td>5.0</td>
<td>5.0</td>
</tr>
</tbody>
</table>

Table 1: Soil Properties of the Eight Sites of the Long-Term Field Experiment Network “OMTK”

Samples were collected from 8 experimental sites with equal treatments from the depth of 0-20 cm. The so-called available, 0.1M KCl + 0.05M EDTA extractable Pb, Cd and Cr content was determined [2]. These elements have been determined from samples collected in the 28th year of the trial.

Mathematical statistical analysis of the experimental data was done by ANOVA using of SPSS for Windows statistical program.

RESULTS

The available Pb content of the experimental soils has mainly shown site dependence in the eight places (Table 2). The difference between soils in available Pb content is 4-5 fold. Pb load originated in the greatest content from traffic, thus the highest value(s) came from Keszthely due to the close main road.

The 200-250 kg N ha⁻¹ year⁻¹ and the 150 – 500 kg P₂O₅ ha year⁻¹ treatments have slightly increased the Pb content of acid soils (Kompolt, Putnok, Keszthely) contrary to calcareous soils (Nagyhörcsök, Iregszemcse), as it can be found in literature, CaCO₃ decreases the availability of Pb. Experimental results even do not approach the accepted concentration level of Pb.

The available Cd content of the experimental soils varied between 0.06 – 0.16 mg kg⁻¹. The highest values were measured at Hajdúböszörmény and Karcag sites, while the lowest values came from Putnok, Iregszemcse and Nagyhörcsök. Statistically significant treatment effect in the upper 20 cm soil layer could not be found in none of
The increasing amounts of P fertilizers applied for 28 years have not influenced significantly the available Cd content of soils. The Cd content of P fertilisers is influenced by the raw material and the method of preparation as well. In Hungary, because of the very low Cd content of fertilizers (1 mg kg\(^{-1}\)) even under the intensive fertiliser application of the seventies and eighties, less than 0.3-0.5 g ha\(^{-1}\) year\(^{-1}\) Cd contaminated the soil [8, 4].

Unfortunately, the original heavy metal content of the experimental soils, from 1968 is unknown, since the environmental load was not in focus in that time. The results of Cd measurements show that Cd concentration even does not approach the accepted level in the experiment soils.

The third element of this study is the Cr. The available Cr content shows significant differences due to the soils and nutrient supply as well (0.05 – 0.28 mg kg\(^{-1}\) soil). There was no treatment effect except the Karcag site. In seven experimental sites significantly higher Cr content was found in plots where lower fertilizer doses had been applied. Our results can strengthen the opinion from literature that phosphorus content of soils may great importance on the availability of Cr. In our experiment lower available Cr content was measured from soils where higher P\(_2\)O\(_5\) fertilizer treatments occurred.

It can be stated that in the 28-year long-term fertilization trial the effect of treatments in case of Cr content of soil could be detected in the greatest extent.

DISCUSSION

Primarily the site conditions of the eight experimental soils have influenced the available Pb content. The increasing doses of NPK fertilizer treatments applied equally for 28 years have not resulted statistically significant differences in the 0-20 cm depth of the experimental soils.

The available Cd content of the experimental soils varied between 0.06 – 0.16 mg kg\(^{-1}\). The increasing amounts of P fertilizers applied for 28 years have not influenced significantly the available Cd content of soils. The extremely toxic Cd content did not increase due to the P fertilization treatments. There are geo-chemical differences between the Cd content of experimental soils. In our experiment lower available Cr content was measured from soils where higher P\(_2\)O\(_5\) fertilizer applications occurred.
treatments occurred. The effect of long-term fertilization in case of Cr content of soil could be detected in the greatest extent. The long-term fertilization experiments are the most reliable means to follow the process of soil pollution, accumulation of heavy metals in soils as a function of fertilization. The experimental results of toxic elements show that the 28-year old constant fertilization treatments did not result higher values than the accepted concentration level, even they did not approach it.

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