THE EFFECT OF THE TAR EXPOSURE OF A LIVING AREA ON THE MANGANESE TRANSFER FROM SOIL TO PLANTS AND HUMANS

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ABSTRACT

Manganese (Mn) is essential both for plants, animals and humans. Manganese deficiency does usually not occur in humans since the Mn offer exceeds the Mn requirement. The Mn transfer in the food chain was also investigated within the framework of the systematic analysis of the effects of tar exposure in the living area of Rositz. The Mn content in the soil on the tar-exposed site of the factory (n 27) up to a depth of >4m varied insignificantly between 248 and 338 mg/kg air-dried soil. Tar-decontaminated soil (1200°C) (n 6) contained 368 mg/kg (SD 29) on an average. Its Mn content decreased again up to a depth of 3 m. The tar-exposed "upper soil", which was also used in 3 pot trials with oats, mustard and spinach, contained significantly less Mn than the control soil. oats, mustard and spinach stored significantly less Mn than the control variants. Oats on tar-exposed soils fell ill with the "grey speck" disease and withered. Several fruit and vegetable varieties from the living area of Rositz were also Mn-poorer than those from geologically comparable loess sites without tar exposure (n 92). Though the Mn intake of men and women from Rositz with spices and vegetables from house gardens met the requirements with 2.0 and 2.7 mg/day, it was significantly lower than that of the control population from Jena, which amounted to 3.2 and 4.4 mg Mn/day. Tar exposure impairs the bioavailability of Mn in the food chain from soil to plant.

Key words: tar exposure- manganese transfer

INTRODUCTION

Manganese is one of the most abundant trace elements in the lithosphere. It is presumed that the mean manganese concentration in the earth's crust amounts to approximately 0.1%. The earth has a medium manganese content of 550 mg/kg with a widespread scattering from < 1 to over 7000 mg/kg. Manganese is essential both for plants, animals and humans. On a world scale, the range of these manganese average content in soil units varies from 270 ppm (podzols) to 525 ppm (cambiosols). The manganese content shows remarkable variation depending on plant species, stage of growth, and different organs as well as on different ecosystems. World-wide background contents of manganese range from 17 to 334 ppm in grass and 25 to 119 ppm in clover. The response of plants to excessive manganese levels is highly controlled by differences between genotypes.

Deficiency causes growth disturbances in plants and yellowing of needles of coni-
MATERIALS AND METHODS

The manganese analysis was carried out by means of the optical emission spectroscopy with inductively coupled plasma (ICP-OES).

All samples were dried to constant weight at 105 °C and dry-ashed afterwards at 450 °C. The samples were brought in solution through mineralization with 25% hydrochloric acid. The soil samples were prepared with aqua-regia.

RESULTS AND DISCUSSION

The manganese transfer in the food chain was investigated within the framework of the systematic analysis of the effect of tar in the living area of Rositz. The research primarily focused on obtaining fruit, vegetable and spice standard samples from the local inhabitants in order to study the duplicates of Rositz and of control territory of Jena and Erfurt. 10 women and 10 men who were between 20 and 70 years old took part in experiments. They collected all they had taken in as a duplicitate and the daily faeces and urine.

Manganese content of the Rositz soils

Soil samples from the most charged placed with residual substances (where industrial plants were located) were collected from a depth of 4 meters (tab. 1). The mean content of these samples was < 500 mg Mn/kg.

Table 1: Manganese content of the contaminated soil from Rositz depending on depth (mg/kg air-dry matter)

<table>
<thead>
<tr>
<th>Depth, m (n)</th>
<th>X (mg/kg)</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 1 (9)</td>
<td>263</td>
<td>137</td>
</tr>
<tr>
<td>1 - 3 (5)</td>
<td>335</td>
<td>117</td>
</tr>
<tr>
<td>2 - 4 (3)</td>
<td>348</td>
<td>189</td>
</tr>
<tr>
<td></td>
<td>222</td>
<td>67</td>
</tr>
<tr>
<td>X</td>
<td>281</td>
<td></td>
</tr>
<tr>
<td>S</td>
<td>133</td>
<td></td>
</tr>
<tr>
<td>Fp</td>
<td>&gt; 0.05</td>
<td></td>
</tr>
</tbody>
</table>

The manganese content of the contaminated soil from Rositz varied insignificantly between 248 and 338 mg/kg air-dried soil. A comparison was made between contaminated and decontaminated soil (tab. 2). Tar-decontaminated soil (1200 OC) contained 268 and 29 mg Mn/kg on average. The manganese concentration in contaminated soil is lower. Tar-decontaminated soil from 281 mg/kg.

Table 2: Manganese content of the contaminated and decontaminated soil from Rositz (mg/kg)

<table>
<thead>
<tr>
<th></th>
<th>contaminated</th>
<th>decontaminated</th>
<th>p</th>
<th>%</th>
<th>( x )</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>s</td>
<td>s</td>
<td>&lt;0.01</td>
<td>131</td>
<td></td>
</tr>
<tr>
<td>27 : 6</td>
<td>133</td>
<td>268</td>
<td>281</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Transfer of manganese in the food chain

The transfer of manganese in the food chain was analysed in green houses in three types of plants, grow under controlled conditions and was repeated six times. Besides, controlling soil with 50% contaminated soil and 50% residual decontaminated substance were analysed (tab. 3).

Table 3: Manganese content in the pot trial with different soils (mg/kg dry matter, n=30)

<table>
<thead>
<tr>
<th>Kind of soil</th>
<th>X</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control soil</td>
<td>489</td>
<td>32</td>
</tr>
<tr>
<td>Contaminated soil</td>
<td>274</td>
<td>13</td>
</tr>
<tr>
<td>Decontaminated soil</td>
<td>364</td>
<td>23</td>
</tr>
<tr>
<td>50% contaminated soil + 50% control soil</td>
<td>414</td>
<td>17</td>
</tr>
<tr>
<td>50% decontaminated soil + 50% control soil</td>
<td>&lt; 0.001</td>
<td></td>
</tr>
</tbody>
</table>

In this case the contaminated soil contained significantly less manganese than control soil. The tar-exposed "upper soil", which was also used in the pot trials with oats, mustard and spinach, contained significantly less manganese than the control variants (tables 4, 5, 6, 7).
Table 4: Fresh matter production of oat grown on different kinds of soil (g/wet weight/pot, n=30)

<table>
<thead>
<tr>
<th>Kind of soil</th>
<th>X</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control soil</td>
<td>390</td>
<td>23</td>
</tr>
<tr>
<td>Contaminated soil</td>
<td>149</td>
<td>28</td>
</tr>
<tr>
<td>Decontaminated soil</td>
<td>16.1</td>
<td>14</td>
</tr>
<tr>
<td>50% contaminated soil + 50% control soil</td>
<td>255</td>
<td>7.2</td>
</tr>
<tr>
<td>50% decontaminated + 50% control soil</td>
<td>276</td>
<td>18</td>
</tr>
<tr>
<td>Fp</td>
<td></td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>% (%)</td>
<td>38</td>
<td></td>
</tr>
</tbody>
</table>

*control soil △ 100%: contaminated soil △ X %

The leaves were yellow in the pots with contaminated soil. Plant species differ in their susceptibility to manganese deficiency with the most sensitive being oats. The free biomass obtained from contaminated soil and especially from decontaminated soil was very low. The best growth was registered for oats on control soil.

Table 5: Dry matter production of oats on different kinds of soil (g/pot, n=30)

<table>
<thead>
<tr>
<th>Kind of soil</th>
<th>X</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control soil</td>
<td>50</td>
<td>3.4</td>
</tr>
<tr>
<td>Contaminated soil</td>
<td>20.7</td>
<td>4.6</td>
</tr>
<tr>
<td>Decontaminated soil</td>
<td>5.2</td>
<td>4.6</td>
</tr>
<tr>
<td>50% contaminated soil + 50% control soil</td>
<td>45.9</td>
<td>1.7</td>
</tr>
<tr>
<td>50% decontaminated + 50% control soil</td>
<td>41.4</td>
<td>5</td>
</tr>
<tr>
<td>Fp</td>
<td></td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>% (%)</td>
<td>41</td>
<td></td>
</tr>
</tbody>
</table>

*control soil △ 100%: contaminated soil △ X %

Table 6: Manganese content of oat grown on different kinds of soil (mg/kg dry matter, n=30)

<table>
<thead>
<tr>
<th>Kind of soil</th>
<th>X</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control soil</td>
<td>124</td>
<td>9.0</td>
</tr>
<tr>
<td>Contaminated soil</td>
<td>20.7</td>
<td>4.6</td>
</tr>
<tr>
<td>Decontaminated soil</td>
<td>5.2</td>
<td>4.6</td>
</tr>
<tr>
<td>50% contaminated soil + 50% control soil</td>
<td>45.9</td>
<td>1.7</td>
</tr>
<tr>
<td>50% decontaminated + 50% control soil</td>
<td>41.4</td>
<td>5</td>
</tr>
<tr>
<td>Fp</td>
<td></td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>% (%)</td>
<td>41</td>
<td></td>
</tr>
</tbody>
</table>

*control soil △ 100%: contaminated soil △ X %

In addition, manganese concentrations in different fruits, vegetables, and spices grown in the garden of Rositz were analyzed in order to compare them with those grown in the living area of Erfurt (tab. 9). Lower manganese concentrations in pears, carrots, and parsnips as compared to the manganese concentrations of the same species in Erfurt were obtained. This is possible because the bioavailability of manganese in the soil from Rositz is often diminished by the far exposure.

Manganese intake of adults

The manganese intake of adult inhabitants of Rositz was analyzed. It was analytical established with the duplicate method (tab. 10). The control team comes from Jena. The manganese intake by both experimental teams differs significantly. The women and the men from Rositz consume (62% / 61%) less manganese than the population from Jena. In both towns the manganese supply is a reasonable supply in reasonable limits.
Table 9: Manganese content in different fruits, vegetables and spices from the living area of Rositz and Erfurt (mg/kg dry matter, DM)

<table>
<thead>
<tr>
<th>Sort</th>
<th>Erfurt</th>
<th>Rositz</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>S</td>
<td>X</td>
</tr>
<tr>
<td>Apples</td>
<td>0.51</td>
<td>2.4</td>
</tr>
<tr>
<td>Pears</td>
<td>2.9</td>
<td>5.2</td>
</tr>
<tr>
<td>Kohlrabi</td>
<td>4.4</td>
<td>5.3</td>
</tr>
<tr>
<td>Potatoes</td>
<td>5.1</td>
<td>7.5</td>
</tr>
<tr>
<td>Carrots</td>
<td>3.8</td>
<td>12</td>
</tr>
<tr>
<td>Leek</td>
<td>13</td>
<td>13</td>
</tr>
<tr>
<td>Parsley</td>
<td>14</td>
<td>45</td>
</tr>
</tbody>
</table>

¹) Erfurt Δ 100%; Rositz Δ X%

Table 10: Mean manganese intake of adults in Jena and Rositz (mg/day)

<table>
<thead>
<tr>
<th>Living areas</th>
<th>Women</th>
<th>Men</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>s</td>
<td>X</td>
</tr>
<tr>
<td>Jena</td>
<td>1.3</td>
<td>4.4</td>
</tr>
<tr>
<td>Rositz</td>
<td>0.62</td>
<td>2.7</td>
</tr>
<tr>
<td>Fp</td>
<td></td>
<td></td>
</tr>
<tr>
<td>%²</td>
<td>62</td>
<td>61</td>
</tr>
</tbody>
</table>

CONCLUSIONS

The manganese concentration of soils, plants as well as the manganese intake by the Rositz population are not so high as to affect human health. Tar exposure impairs the bioavailability of manganese in the food chain from the soil to plant.

REFERENCES