Extractability And Bioavailability Of Cd In Soil Treated With Cd-enriched Sewage Sludge

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ABSTRACT

The effect incubation time and application of Cd-enriched sewage sludge on Cd availability in soil and bioavailability to rice (*Oryza Sativa* L.) were investigated. Soil was treated with 20 g kg\(^{-1}\) of sewage sludge and it had been enriched with different amounts of CdSO\(_4\) to obtain Cd concentrations ranging from 10 to 90 mg Cd kg\(^{-1}\). Soil was extracted with DTPA after 1 and 120 days. Availability of Cd in soil and Cd concentration in rice shoots at two incubation times, increased with increasing levels of Cd in soil. Incubation time had a significant effect on Cd concentration in rice it was significantly higher at 120 days of incubation than at first day of incubation probably due to degradation of organic matter and release of the Cd in soil. Shoot Cd concentrations correlated with DTPA-extractable Cd in the soil. Therefore, DTPA-extractable Cd could be successful in predicting Cd bioavailability and toxicity in rice plant.

Keywords: DTPA-extractable Cd; rice; Cd concentration; Cd-enriched sewage sludge

Introduction

Sewage-sludge improves soil fertility and soil physical properties (Planquart et al., 1999). However, it may also contain undesirably high concentrations of heavy metals which may have adverse effects on crops and consumers (Bose and Bhattacharyya, 2008). Residence time directly relates to the bioavailability of heavy metals in soils (Alexander, 2000). DTPA is more suited to extract soluble, exchangeable and organically-chelated metals in soil (Lindsay and Norvell, 1978). DTPA extraction method provided good information about metal availability and correlated with metal uptake by plants (Hooda and Alloway, 1994). Knowledge of soil-plant interactions is important for the safety of the environment and reducing the risks of trace metals. This study was conducted to investigate availability of Cd in soil incubated with Cd-enriched sewage sludge in different incubation time and to study the relationship between Cd in soil and Cd uptake by rice plant.

Material and Methods

A soil sample was collected from surface horizon of Typic Xerorthents soils in Bajgah Agricultural Station of Shiraz University. Sewage sludge was collected from sewage sludge Industry of Zarghan, Fars province, Iran. Selected properties of soil and sewage sludge are given in Tables 1. A 5 × 2 factorial experiment as a completely randomize design with three replications were used. Treatments consisted of two incubation times (0, and 120 days) and five Cd-enriched sewage levels. Soil was treated with 20 g kg\(^{-1}\) of sewage sludge and it had been enriched with different amounts of CdSO\(_4\) to obtain Cd concentrations ranging from 10 to 90 mg Cd kg\(^{-1}\) soil. After incubation times, DTPA-extractable Cd was measured. Rice plants (Ghasrodashti cultivar) were harvested and Cd concentration was measured by atomic absorption spectrophotometer.

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Table 1. Soil and sewage sludge properties

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<th></th>
<th>pH</th>
<th>texture</th>
<th>EC</th>
<th>OM</th>
<th>Fe</th>
<th>Cu</th>
<th>Mn</th>
<th>Zn</th>
<th>Cd</th>
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</thead>
<tbody>
<tr>
<td>Soil</td>
<td>7.5</td>
<td>loam</td>
<td>0.79</td>
<td>0.50</td>
<td>4.89</td>
<td>1.55</td>
<td>7.76</td>
<td>0.86</td>
<td>nd</td>
</tr>
<tr>
<td>Sewage sludge</td>
<td>6.79</td>
<td>-</td>
<td>3.1</td>
<td>40.2</td>
<td>1419</td>
<td>60</td>
<td>367</td>
<td>532</td>
<td>9</td>
</tr>
</tbody>
</table>

Results and Conclusion

The DTPA-extractable concentrations of Cd in soil were tended to increase over Cd-enriched sewage sludge application in two times of incubation, but incubation time did not significantly affect Cd extractability in soil (Fig. 1). Antoniadis et al., (2008) indicated that sewage sludge application increased Cd extractability in soil and Cd uptake in ryegrass. Mahdy et al.,

![Figure 1. DTPA-extractable Cd in soil treated with Cd-enriched sewage sludge](image1)

Figure 1. DTPA-extractable Cd in soil treated with Cd-enriched sewage sludge

Cadmium concentration in rice shoot increased with increasing levels of Cd-enriched sewage sludge in two incubation time (Fig. 2). Moreover, concentration of Cd was significantly higher at 120 d of incubation than at first day of incubation probably due to degradation of organic matter and release of the metals, which were complexes with sludge at the beginning of incubation. Bose and Bhattacharyya (2008) showed that Cd concentration in wheat grain enhanced with increase in percentage of waste application in soils.

![Figure 2. Cd concentration in rice plant as affected by Cd-enriched sewage sludge](image2)

Figure 2. Cd concentration in rice plant as affected by Cd-enriched sewage sludge
Cd concentration in rice shoot was correlated with available Cd in sludge amended soil and Cd applied in soil (Table 2). Therefore, DTPA-extractable Cd in soil could be used as an indicator of bioavailability and toxicity of Cd for rice plant. A positive correlation between Cd concentration in wheat plant root and available-Cd in waste amended soil was observed by Bose and Bhattacharyya (2008).

Table 2. Correlation coefficient between DTPA-extractable Cd in soil, Cd concentration in rice shoot, and Cd applied from Cd-enriched sewage sludge (mg kg$^{-1}$)

<table>
<thead>
<tr>
<th></th>
<th>DTPA-extractable Cd</th>
<th>Cd concentration in rice</th>
<th>Cd applied in soil</th>
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<tr>
<td>DTPA-extractable Cd</td>
<td>-</td>
<td>0.72***</td>
<td>0.91***</td>
</tr>
<tr>
<td>Cd concentration in rice</td>
<td>-</td>
<td>-</td>
<td>0.61***</td>
</tr>
<tr>
<td>Cd applied in soil</td>
<td>-</td>
<td>-</td>
<td>-</td>
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</table>

***Significant at P≤0.05

References


