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Redistribution of Ag in Two Calcareous and Noncalcareous Spiked Soils  
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With best regards,
Prof. Giancarlo Renella, Conference chair of the 11th ICOBTE

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Redistribution of Ag in two calcareous and noncalcareous spiked soils

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Key words: Ag, contamination, fractionation, soil.

Abstract
Review of literature clearly shows that environmental data are scarce on the behavior of silver (Ag) in soils. Ag toxicity and its fate in the environment are currently being debated and are important as challenging research topics. Even though there are several studies on its total content in soils, fractionation of Ag, especially in calcareous soils has not been investigated. Therefore, our objectives

Introduction
Ag⁺ as one of the most toxic forms of silver, has been categorized to the highest toxicity class (Ratte, 1999) and mainly is released into the aquatic environment from domestic, agricultural, and industrial sources (Wood et al, 1996). Ag⁺ has harmful effects on the soil microbial population and biochemical processes. In general, the Ag content of surface soils ranges from 0.01 to 5 mg kg⁻¹, with most reported values being 1 mg kg⁻¹ (Alloway, 1995). Nowadays, soil pollution with Ag is a matter of concern as silver contamination and reported in several cases, such as Thailand from radiographic film wastes (Khanprasert et al, 2008), silver contamination in San Francisco Bay (Flegala et al, 2007), and also current applications of nanosilver containing materials in human life (Blaser et al, 2008). Even though there are many studies on the total content of Ag in soils, fractionation of Ag especially in calcareous soils has not been investigated. Therefore, our objectives were to provide fundamental information on the chemical behavior and the fate of Ag in polluted soils, and to quantify redistribution processes of Ag in contaminated soils.

Materials and methods
We studied 8-step chemical fractions (Krishnamurti, 1995) of Ag (i.e., EXCH, CARB, Me-Org, re-MeOx, H₂O₂-Org, am-MeOx, cr-FeOx, and RES) following 30 and 60 days incubation in a calcareous and noncalcareous soil amended with Ag (0 and 15 mg kg⁻¹). Experimental results showed that Ag in nonamended soils was predominantly in the forms H₂O₂-Org > Me-Org > RES > CARB. These four fractions contributed more than 5% of total Ag concentration in noncalcareous soil. Redistribution of Ag in spiked noncalcareous soil was EXCH (34%), H₂O₂-Org (33%) and RES (17%). After 30 days incubation in contaminated noncalcareous soil, EXCH-Ag increased whereas CARB- and H₂O₂-Org-Ag decreased. However EXCH-Ag decreased and H₂O₂-Org-Ag increased after 60 days incubation (P < 0.05). In calcareous soil after 30 days, EXCH- and RES-Ag increased but at the end of 60 days H₂O₂-Org-Ag increased. From our data we may conclude that addition of Ag results in increase of Ag mobility in soils but incubation may have adverse effect on its mobility. In general, chemical behavior of Ag, in terms of its redistribution into labile fractions in calcareous soil differed from noncalcareous soil.

Table 1 Some physical and chemical properties of soils.

<table>
<thead>
<tr>
<th>Soil</th>
<th>noncalcareous</th>
<th>calcareous</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth (cm)</td>
<td>0-30</td>
<td>0-30</td>
</tr>
<tr>
<td>Clay (g kg⁻¹)</td>
<td>220</td>
<td>250</td>
</tr>
<tr>
<td>Silt (g kg⁻¹)</td>
<td>280</td>
<td>230</td>
</tr>
<tr>
<td>Sand (g kg⁻¹)</td>
<td>500</td>
<td>520</td>
</tr>
<tr>
<td>EC (dS m⁻¹)</td>
<td>3.6</td>
<td>2.5</td>
</tr>
<tr>
<td>pH</td>
<td>7.1</td>
<td>7.6</td>
</tr>
<tr>
<td>OC (g kg⁻¹)</td>
<td>5.5</td>
<td>4.7</td>
</tr>
<tr>
<td>CEC (cmol c kg⁻¹)</td>
<td>13.91</td>
<td>11.09</td>
</tr>
<tr>
<td>CaCO₃ (g kg⁻¹)</td>
<td>29.8</td>
<td>208.0</td>
</tr>
<tr>
<td>Total Ag (mg kg⁻¹)</td>
<td>0.2</td>
<td>0.6</td>
</tr>
</tbody>
</table>

Ag in nonamended noncalcareous soil occurred predominantly in the forms H₂O₂-Org > Me-Org > RES > CARB and other fractions were negligible (<5%) (Fig.1.a). Experimental results showed that addition of Ag to noncalcareous soil resulted in increase of EXCH-Ag whereas, CARB- and Me-Org-Ag decreased (P<0.05). After 30 days incubation, relative distribution of Ag in H₂O₂-Org fractions decreased but after 60 days incubation increased. In noncalcareous soil, RES-Ag did not change significantly. After incubation, Me-Org-Ag in nonamended soil increased. In contrast, H₂O₂-Org-Ag decreased after 60 days (P<0.05). Distribution of Ag in other fractions among control and spiked soils did not significantly alter. In amended noncalcareous soil, EXCH-Ag decreased with time while H₂O₂-Org increased (P<0.05). Incubation did not influence Ag distribution in other fractions. Although there are several studies on silver total content in soils, fractionation of Ag in soils has not been extensively studied. Hou et al. (2005) found average distribution of Ag in H₂O₂-Org > Me-Org > RES fractions in Fluvisol loaded with Ag. However our results showed that Ag in spiked soil was found in the following fractions EXCH > H₂O₂-Org > RES fractions. This may be due to the variation of incubation time in two studies. Jones et al (1986) reported that in contaminated soils, nearly half of the total Ag was in...
residual fraction. Time redistributed Ag to OM fractions which have high affinity for Ag (Ratte, 1999). This behavior was similar to Cu, as Ma and Uren (1998) observed that EXCH- and CARB-Cu transformed to OM and FeOx fractions with time.

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Figure 1. Percent distribution of Ag among various fractions in natural and metal loaded soils as affected by time in (a) noncalcareous soil, (b) calcareous soil.

**References**


