Chromium and Nitrogen Behavior in High-Mn Soils Fertilized with by-Products of the Intermediate Processes of Tanning

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Sponsored by CAPES, CNPq and FAPEMIG

ABSTRACT

Chromium occurs in various oxidation states in nature, although only Cr(III) and Cr(VI) are known to occur naturally in soils. The presence of Cr(III) in the diet of humans and animals is important because of its essentiality to mammals. However, Cr(VI) is toxic, mutagenic, and carcinogenic to humans and animals. Because of its high toxicity, Cr(VI) is becoming increasingly regulated and very restrictive limits concerning concentrations of Cr(VI) in the environment are being established. The objective of this work was to study changes in the forms of Cr(III) and Cr(VI), as well as ammonium and nitrate in A and B horizons of two soils containing high contents of manganese oxides (up to 75,000 mg kg^{-1}) and/or Cr (up to 18.000 mg kg^{-1}), which were incubated with a by-product of the tannery industry, used as a nitrogen fertilizer (total N ~ 12%, total Cr ~ 2.5%). Overall, the incubated soils had higher levels of total nitrogen, ammonium, and nitrate, especially in A horizons. Changes in the contents of Cr(III) and Cr(VI) following the application of the by-product in the soils were not directly related to their content of Mn oxides.

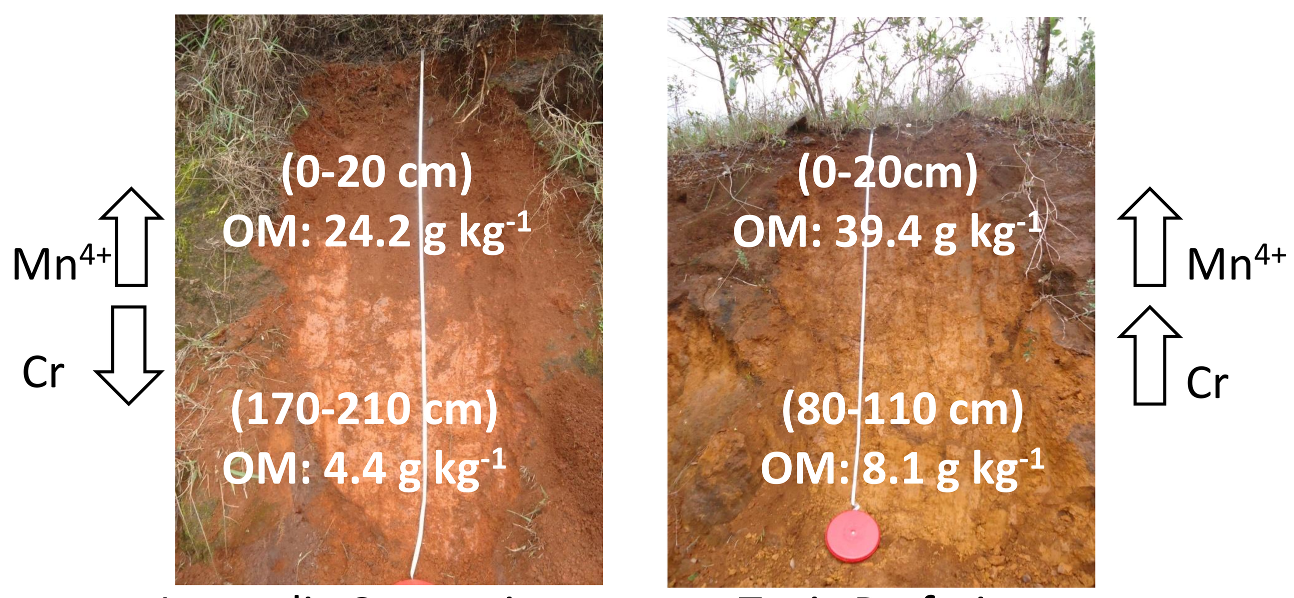
INTRODUCTION

Chromium (Cr) is a natural element in the earth's crust and occurs in soils at concentrations of 10 to 150 mg kg^{-1} (Adriano, 1986). Anthropogenic sources, including ore refining, electroplating industry, tanning, paper making, steel production, and automobile manufacturing, contribute greatly to Cr pollution in the environment (Zayed and Terry, 2003). The lack of appropriate disposal facilities has led to severe Cr pollution in water and soils throughout the world (Loyaux-Lawniczak et al., 2001). Reduction of Cr(VI) to Cr(III) is an effective means of Cr immobilization in soil. The reduction/oxidation of Cr depends largely on soil properties, such as organic matter (OM), Fe(II)-bearing minerals (Buerge and Hug, 1997), Mn(II), Mn(IV) oxides, and pH (Kozuh et al.,2000).

OBJECTIVE

To evaluate changes in Cr and N forms in the soil following the application of a by-product (hydrolyzed leather) supplied as a nitrogen fertilizer

MATERIALS AND METHODS



Latosolic Concretionary Petric Plinthosol | Typic Perferic Red-Yellow Latosol

Figure 1 Soil profiles

Figure 2 Experimental setup

Experimental Setup
144 plots = 2 soils x 2 horizons x 3 reps x 6 sampling times (0, 15, 45, 75, 105, 135 d) x 2 N rates (0 and 300 mg N kg^{-1}, from the by-product: hydrolyzed leather, 12% N; 8876 mg kg^{-1} labile Cr; 0.8 mg kg^{-1} Cr(VI))

Total N: ISO 11261: Soil quality – Determination of total nitrogen – Modified Kjeldahl method.
Inorganic N (nitrate & ammonium): ISO 14256-2: Soil quality – Determination of nitrate, nitrite and ammonium in field-moist soils by extraction with potassium chloride solution – Part 2: Automated method with segment flow analysis
Labile Cr: S.O. Gazzetta Ufficiale n.248 de 21/10/1999, Método ufficiale n.XII.5.
Hexavalente Cr: Gazzetta Ufficiale del 21/05/03 n. 116, DM 08/05/03, Suppl. n. 8.

RESULTS

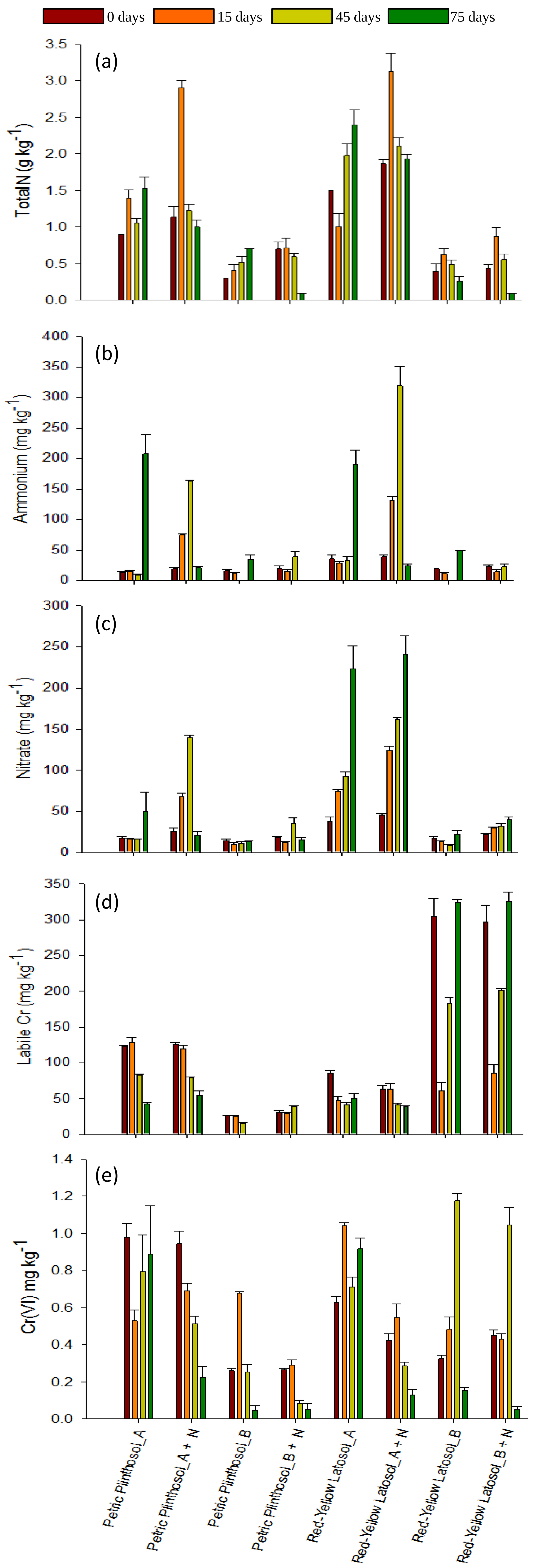


Figure 3 (a) Total N, (b) N-NH_4^+, (c) N-NO_3^-, (d) labile Cr, (e) Cr (VI)

CONCLUSIONS

The application of the by-product (hydrolyzed leather), supplied as a nitrogen fertilizer, increased soil contents of total N, nitrate, and ammonium.

The nitrogen concentration and consequently its transformation into inorganic forms (ammonium and nitrate) is directly related to the organic matter content in the soil. Thus, there was a greater increase in these forms in A horizons, especially in the Red-Yellow Latosol (Oxisol), which has the highest OM content.

The Cr(III) content was greater in the B horizon of the Oxisol, a soil that naturally has a higher concentration of chromium, which did not change much following the addition of the hydrolyzed leather.

Soil OM fosters the reduction of Cr(VI) to Cr(III). This explains the higher content of Cr(VI) in the A horizon of the Petric Plinthosol compared with the Oxisol.

Both soils have a high concentration of Mn^{4+}, which acts as an electron acceptor that favors the conversion of Cr(III) to Cr(VI). This was not observed in the study. Nor is it possible to establish a relationship between the application of the hydrolyzed leather and an increase in the concentration of Cr(VI) in the soil.

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ACKNOWLEDGMENTS