Abstract. Desorption of Cd from two Danish soils (loamy sand, sandy loam) previously exposed to low concentrations of Cd was examined in terms of reversibility, effect of changes in solute composition, and effects of aging of the soils for extended time prior to accomplishing the desorption experiments. The loamy sand exhibited full reversibility of Cd sorption in $10^{-3}$ M CaCl$_2$ at pH = 6.0, while the sandy loam at the same conditions exhibited a partial irreversibility of the order of 1/~g Cd g$^{-1}$ soil. However, this partial irreversibility was not caused by any strong binding of Cd since no irreversibility was observed in $10^{-2}$ M CaCl$_2$ at the same pH. Changing the solute composition with respect to Zn, CaCl$_2$, pH and the presence of organic ligands (EDTA) caused significant desorption of Cd from the soils. The degree of desorption was proven with respect to variations in CaCl$_2$ and pH to be governed by the sorption equilibrium conditions independently of the previous distribution of Cd between soil and solute. Aging of the soil at a temperature of 1 °C (after exposure to Cd) for 35 and 67 wk did not reveal any changes with respect to desorption of Cd at pH = 6.0 in $10^{-3}$ M CaCl$_2$.

1. Introduction

The increasing Cd content of agricultural soils due to application of phosphate fertilizers, atmospheric deposition, and disposal of wastes such as sewage sludge and municipal compost (Tjell et al., 1980) has in view of the potential toxicity of Cd to man through contamination of agricultural produce and drinking water given rise to extensive research on the soil chemistry of Cd. However, most of the reported investigations have dealt with excessive Cd concentrations (in excess of 20 $\mu$g (0.18 $\mu$mol) Cd g$^{-1}$ soil or 100 $\mu$g (0.9 $\mu$mol) Cd dm$^{-3}$ solute; Christensen, 1980) and hence are only of minor environmental pertinence. The few reported investigations on the soil chemistry of Cd at low concentrations (Christensen, 1984; Garcia-Miragaya and Page, 1978; Jarvis and Jones, 1980; Mayer, 1978) have revealed that soils have a high capacity for sorbing Cd, that equilibrium is approximately reached within 1 h, that the sorption capacity is highly dependent on pH, and that Ca in the solute may significantly compete for sorption sites.

Evaluation of the environmental problem of Cd addition to soils requires, besides the abovementioned knowledge, information on desorption of Cd from soils previously loaded with Cd. In the long term it is paramount, whether sorbed Cd is readily released from the soil by a decrease in solute Cd concentration or a change in solute composition, or if the soil binds Cd so firmly that the soil, from an environmental point of view, acts as a permanent sink for Cd. The development of firm bonds may however, from a theoretical point of view, require extended time. Hence the question on the effect of aging of the Cd loaded soils must be taken into consideration as well.

Several investigations (Blom, 1974; Ferrell and Price, 1978; Garcia-Miragaya, 1980;
Jarvis and Jones, 1980; John, 1971; Levy and Francis, 1976; Mayer, 1978; Navrot
et al., 1978, Riffaldi and Levi-Minzi, 1975; Singh, 1979; Singh and Sekhon, 1977; Tiller
et al., 1979) have examined the exchangeability of sorbed Cd by accomplishing desorption
experiments with a specific extractant. However, applying most of these results to the
actual problem of Cd addition to agricultural soils is difficult, since most of the investiga-
tions have been accomplished at excessive Cd concentrations. Furthermore, a variety
of extractants has been employed including weak solutions of Ca salts and 1 N ammo-
nium acetate, and every investigation has used its own extraction procedure and hence
defined 'exchangeability' in its own way. Only the approach by Mayer (1978) yields
results of a type directly applicable to prediction of solute Cd concentrations in actual
soil environments: The desorption experiments employed Cd free soil solutions and the
results were expressed in terms of desorption isotherms. In the case of an acid forest
soil loaded with low Cd concentrations full reversibility was observed (Mayer, 1978).

In the present study the release of Cd from two Danish soils loaded with low Cd
concentrations (0.1 to 6 μg g⁻¹ soil and 1 to 50 μg Cd dm⁻³ solute) was examined in
terms of desorption isotherms caused by decreases in solute Cd concentrations and
changes in solute composition. Furthermore, the effect of aging Cd loaded soils was
investigated.

The sorption of Cd at low concentrations onto these soils and the effect of time, Cd
load, pH, and Ca has previously been reported (Christensen, 1984).

2. Materials and Methods

2.1. SOILS

The soils consisted of a loamy sand and a sandy loam sampled in slightly weathered
quaternary deposits (tills) in Jutland, Denmark at depths of 50 to 100 cm.

The soils were air dried and sifted through a 0.5 mm nylon mesh. Employing soil
fractions less than 0.5 mm instead of less than 2.0 mm improved the precision from 11.5
to 3.6% (C.V) (Christensen, 1980) of batch Cd sorption experiments involving 1 to 2 g
of soil.

The soil characteristics, as presented in Christensen (1984), were primarily determined
by standard methods (Christensen, 1980).

2.2. CADMIUM LOADING OF SOILS

The soils were loaded with Cd by equilibrating 0.5 to 4 g of soil with solutes of preset
Cd concentrations in 0.1 dm³ polyethylene reactors, which were shaken for 20 hr.
Cadmium (based on CdCl₂ standards) was added to the solutes as small volumes of
100 mg (900 μmol) Cd dm⁻³ of 10⁻² M HNO₃. A constant pH (6.00 ± 0.03) was
maintained by adding small amounts of HNO₃ or NaOH. The solutes contained 10⁻³
M or 10⁻² M CaCl₂ in the loading experiments.

Solute and soil were separated after equilibration by means of centrifugation corres-
ponding to an equivalent particle diameter of 0.2 μm.