ZESZYTY PROBLEMOWE POSTĘPÓW NAUK ROLNICZYCH 1992 z. 398, 43-46

THE INFLUENCE OF OXYGEN CONDITIONS ON SORPTION OF Pb^{2+}, Co^{2+} AND Cd^{2+} CATIONS IN MINERAL SOILS

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A b s t r a c t. The course and range of sorption and leaching with water of cations Pb^{2+}, Co^{2+}, and Cd^{2+} in mineral soils (sandy, loessial and loamy) were studied under different oxygen conditions. It was found that in the state of oxygen deficiency only the sandy soil responded with an increased sorptive capacity in relation to the investigated cations.

INTRODUCTION

The processes of assimilation of nutrients from the soil, including assimilation of trace elements (micronutrients) constitute the basis for plants' biological life. These elements are vital in the metabolism of all plants. They are also nutritive for vertebrates as well as for humans. However, the influence of lead and cadmium on metabolic processes occurring in plants has not been explained satisfactorily yet, although their harmful effect at higher concentrations has been widely accepted. Therefore, only toxic doses of these elements have been established so far [5].

Lead reaches the soil due to its admixture as tetraethyl lead in petrol. In the vicinity of roads it settles on soil and plant surfaces and accumulates there. Then together with plant food it reaches both animal and human organisms. It should be stressed that a level of only 10 mg kg^{-1} Pb in plant fodder creates a health hazard for animals [6].

Groenewold and Gross [2] have stated that maximum accumulation of lead in the surface soil layer can rise up to 3 800 mg kg^{-1} due to emission of dusts from steel works, while Hildebrand and Blum [3] found even higher contents, i.e., 4 600 mg kg^{-1}.

Another source of contamination by heavy metals is sewage sludge which may contain higher amounts of these elements, especially lead, cadmium, cobalt and nickel. After increased use of sludges for soil fertilization, we may observe their accumulation in the soil as well as their passing into the food chain: soil-plant-animal-man [4,5].

MATERIALS AND METHODS

This study on the sorption of cations Pb^{2+}, Co^{2+}, and Cd^{2+} was performed on soil material originating from three mineral soils and at two oxygen conditions. All the characteristic features of the examined soils as well as a full description of the methods applied are given in detail in the authors' previous paper [1].

RESULTS

Percolation through the soil columns of solutions containing the Pb^{2+}, Co^{2+}, and Cd^{2+} cations and their desorption by water showed that the obtained sorption degrees

were very differentiated and depended on both the soil kind and oxygen condition.

The removal of oxygen from sandy material caused an increase in the sorption degrees of all three cations studied (Table 1). An increase was also noted for Co^{2+} and Cd^{2+} cations in loessial material and for Pb^{2+} cation in loamy material.

Table 1 also reveals that the highest sorption capacity for the cations investigated was apparent in loamy soil which is to be expected since this soil contains the highest amounts of fine fractions (52 %) from among the soils tested and shows the highest value of the specific surface area (59 m^2/g). Sandy soil shows the lowest sorption capacity and is characterized by the lowest content of fine fraction (only 6 %), low humus content (0.5 %), and the lowest value of the specific surface area (13 m^2/g).

It follows, then, that the conditions of oxygen deficiency led, in most cases, to stronger binding of the studied heavy metal cations. This binding is connected with many factors, such as their fixation mostly in the upper soil horizons, less availability to plants and weak water migration [4].

The course of sorption of Pb^{2+}, Co^{2+}, and Cd^{2+}cations in soil material shows that a state near saturation was already reached in the case of lead at the lowest content of this element (Fig. 1). The two remaining cations, i.e., $Co^{2+}$and Cd^{2+}, reached the saturation state at a content of about 0.6 mmol in sand and loess and at about 0.3-0.5 mmol in loam (Figs 2 and 3).

Leaching the heavy metal cations out of the soil with water has also shown that Pb^{2+} cation in loessial material and Cd^{2+} and Co^{2+} in loessial and loamy material were bound with the exchangeable adsorption forces that are stronger than those responsible for the physical adsorption.

CONCLUSIONS

These studies on the range and course of sorption processes of heavy metal cations Pb^{2+}, Co^{2+}, and Cd^{2+} in soil material originating from three kinds of mineral soils allow us to draw the following conclusions.

1. The change in oxygen conditions from a state of good oxygenation to a state of oxygen deficiency caused an increase in the sorption of Pb^{2+}, Co^{2+}, and Cd^{2+} cations in sandy soil; in the sorption of $Co^{2+}$and Cd^{2+} in loess; and in the sorption of Pb^{2+} in loamy soil.

2. Loamy soil showed the highest sorption capacity in relation to all the cations investigated in both oxygenation states.

3. The sorption of Pb^{2+} cations in the loess as well as that of Cd^{2+} and Co^{2+} cations in the loess and loam was related to the action of forces typical for the ion-exchangeable sorption.

Table 1. Degree of sorption of heavy metal cations in the soils under two conditions of oxygen status

Soil	Oxygen status*	Pb^{2+}	Co^{2+}	Cd^{2+}
Lessive from weakly loamy sand (Podzoluvisols)	I	23.19	8.36	6.68
	II	27.77	13.57	19.21
Lessive from loess (Orthic Luvisols)	I	90.50	37.30	36.30
	II	82.48	38.04	42.22
Brown soilfrom heavy loam (Eutric Cambisols)	I	79.46	61.67	62.64
	II	95.61	54.52	58.78

* I - good oxygenation; II - oxygen deficiency.

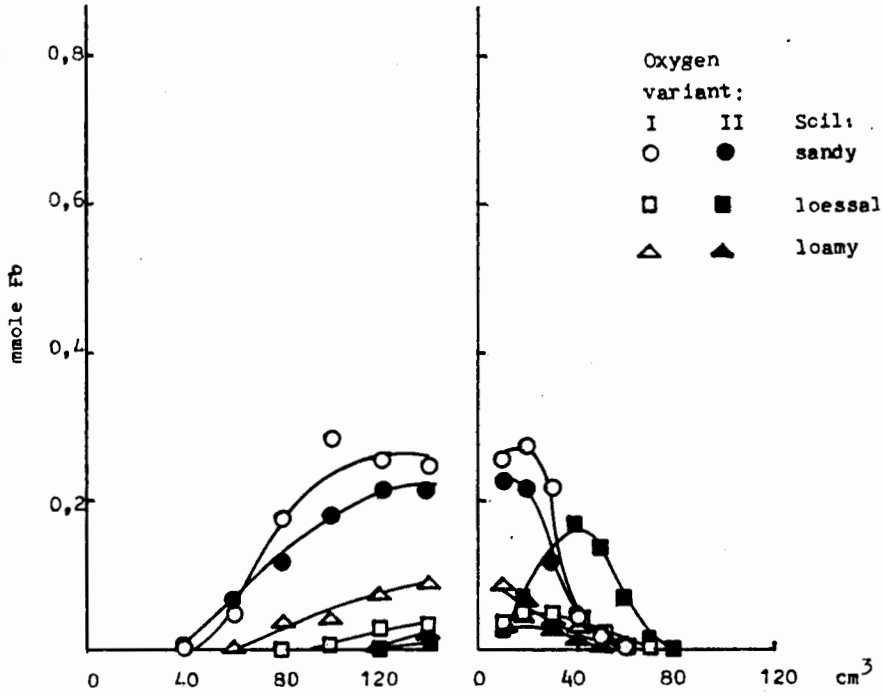

Fig. 1. Course of sorption and leaching out with water of Pb^{2+} cation from the soil under different oxygen conditions.

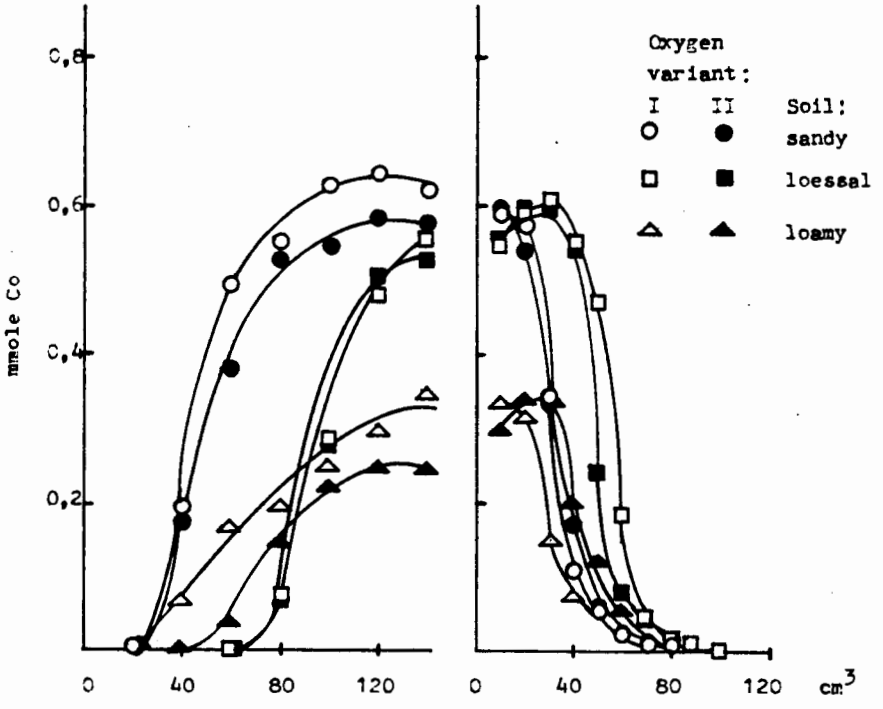

Fig. 2. Course of sorption and leaching out with water of Co^{2+} cation from the soil under different oxygen conditions.

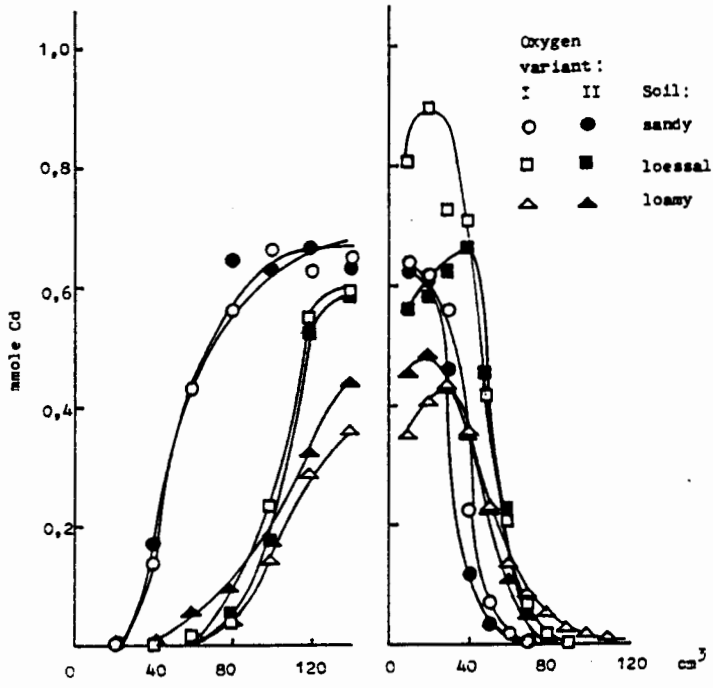

Fig. 3. Course of sorption and leaching out with water of Cd^{2+} cation from the soil under different oxygen conditions.

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WPŁYW WARUNKÓW TLENOWYCH NA SORPCJĘ KATIONÓW Pb^{2+}, Co^{2+} ORAZ Cd^{2+} W GLEBACH MINERALNYCH

Zbadano przebieg i zakres sorpcji oraz wymywania wodą kationów Pb^{2+}, Co^{2+} i Cd^{2+} w glebach mineralnych: piaszczystej, lessowej i gliniastej w warunkach zróżnicowanego natlenienia. Jedynie gleba piaszczysta w warunkach niedotlenienia wykazała zwiększenie własności sorpcyjnych w stosunku do badanych kationów.