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MAGNESIUM (II) AS A FACTOR ELIMINATING HEAVY METAL IONS FROM SOILS

I. Jackowska, R. Gąszczyk

Department of General Chemistry, University of Agriculture, Akademicka 15, 20-033 Lublin, Poland

Abstract. Samples taken from level A_1 of grey-brown podzolic soil and brown soil formed from weakly loamy sand, loess and heavy loam have been tested. The studies were carried out in laboratory conditions in soils of acid and neutral reaction. Acid soil was made neutral through liming. Ions of the following metals: Fe^{2+}, Mn^{2+}, Ni^{2+}, Cu^{2+}, Co^{2+}, Cd^{2+}, Zn^{2+}, Fe^{3+}, Cr^{3+} were introduced into the samples by means of dynamic method. They all were in form of chloride solutions except Pb^{2+} which was in the form of nitrate solution. Then, metal ions not eluted with distilled water, i.e., sorbed by soil samples were desorbed by the use of 0.05 mol/dm^3 solution of magnesium chloride. The content of particular metal ions was determined in the effluent by classical flame method with the use of atomic absorption spectrophotometry (AAS). It was found that the acidification of soils causes, in general, the increase of tested metal ion desorption by Mg^{2+} with the exception of Fe^{2+}, Mn^{2+}, and Ni^{2+} in loess soil and Fe^{3+} in sandy soil.

Keywords: magnesium, heavy metals, soils, sorption complex

INTRODUCTION

The resources of particular chemical constituents in soil are modified by a number of environmental factors and not only by soil environment [3-5,7-9]. The use of various industrial wastes in agriculture for fertilizing or deacidification of soil may lead to excessive accumulation of some elements in soils [2]. Some chemical compounds can be neutralized in the soil environment by means of agrotechnical measures [1,7]. One of the factors intensively changing the content of chemical constituents in soil is water irrigation, which also constitutes one of the most important agrotechnical measures increasing plant yields, together with the lack of resupplying of these elements during vegetation. As a result of degradation caused by natural soil processes and various agrotechnical negligences the decrease in soil magnesium resources occurs [6]. Depending on the degree of soil degradation, plants show the symptoms of magnesium deficiency, they are ill or even die. Therefore, cultivated soils need magnesium fertilization.

The aim of the study was to show how magnesium ions Mg^{2+} do behave when introduced into the sorption complex saturated with other metal ions: Pb^{2+}, Cu^{2+}, Co^{2+}, Cd^{2+}, Zn^{2+}, Fe^{2+}, Ni^{2+}, Mn^{2+}, Cr^{3+}, and Fe^{3+} from soils of acid and neutral reaction.

MATERIALS AND METHODS

The samples collected from A_1 horizon of grey-brown podzolic and brown soils formed from weakly loamy sand, loess and heavy loam were tested (Table 1). The studies were carried out in laboratory conditions in soils of acid and neutral reaction. Acid soil was limed with $CaCO_3$ and made neutral. The soil pH was measured with electrometric method by pH-meter. Into the soil samples weighing 100 g the following metal ions were introduced by means of

Table 1. Characteristics of the soils used in the experiment

Soil	Percent of soil size fractions (mm)				$N_{tot.}$ (%)	$C_{org.}$ (%)	pH		Specific surface area (m^2/g)	Available forms (mg/kg soil)		
	1.0-0.1	0.1-0.02	0.02-0.002	<0.002			H_2O	KCl		P_2O_5	K_2O	Mg
Grey-brown podzolic soil from weakly loamy sand	80	14	2	4	0.04	0.50	5.5	4.7	13	12.8	10.7	1.0
Grey-brown soil from loess	1	63	27	9	0.10	2.13	4.8	4.3	24	40.0	22.7	4.1
Brown soil from heavy loam	29	19	34	18	0.12	1.70	6.2	5.9	59	11.8	6.7	3.4

dynamic method: Fe^{2+}, Mn^{2+}, Ni^{2+}, Cu^{2+}, Co^{2+}, Cd^{2+}, Zn^{2+} in the form of chloride solutions with concentration 0.05 mol/dm^3, while Fe^{3+} and Cr^{3+} in 0.03 mol/dm^3 concentration and Pb^{2+} in the form of 0.05 mol/dm^3 nitrate solution. Next, metal ions not eluted with distilled water, adsorbed by soil samples were eliminated by 0.05 mol/dm^3 magnesium chloride solution.

The content of particular metal ions was determined in the effluent by means of a classical flame method, i.e., atomic absorption spectrophotometry. All the processes were carried out at a temperature of 293 °K ±2°.

RESULTS AND DISCUSSION

The amount of sorbed metal ions from the solution by a soil sample was calculated from the difference between metal concentration in the input solution and in the effluent. Then, the content of metal ions in the effluent was computed. The results were elaborated according to the programme based on the method of least squares adopted for the study. The amount of metal ions which remained in the soil samples after the elution with distilled water was assumed as 100 %. The amount of ions eliminated by Mg^{2+} ions is shown in Fig. 1.

In the samples of loess soil the change of reaction from neutral to acid caused greater desorption of ions Pb^{2+}, Cu^{2+}, Co^{2+}, Cd^{2+}, Zn^{2+}, Fe^{3+}, and Cr^{3+}. Moreover, from the samples of acid reaction Mg^{2+} ions eliminated three times as many Cr^{3+} ions (the increase from 12.51 to 39.98 %) and two times as many Pb^{2+} ions (from 17.74 to 43.81 %), Cu^{2+} (from 33.84 to 76.64 %), Co^{2+} (from 43.52 to 96.58 %) and Fe^{3+} (from 1.19 to 2.89 %) as from the samples of neutral reaction. On the other hand, from the loess samples of acid reaction Mg^{2+} ions eliminated less Fe^{2+} ions (decrease from 25.09 to 15.59 %), Mn^{2+} (from 27.60 to 8.09 %), and Ni^{2+} (from 62.82 to 58.01 %) than from neutral samples.

From sandy soil of acid reaction Mg^{2+} ions eliminated more Pb^{2+}, Ni^{2+}, Cu^{2+}, Co^{2+}, Cd^{2+}, Zn^{2+}, Fe^{3+}, and Cr^{3+} ions. In case of Cr^{3+} ions the increase was ten times higher than in soils of neutral reaction (from 4.61 to 54.65 %), while the change for other ions was as follows: Fe^{3+} ions (from 17.0 to 0.87 %), Zn^{2+} (from 36.12 to 61.58 %), Cd^{2+} (from 55.47 to 92.88 %), and Pb^{2+} (from 16.43 to 32.22 %). For Fe^{2+} ions it was slightly less (from 3.66 to 3.38 %), but in case of Mn^{2+} ions it was already three times less then in neutral samples (from 16.44 to 5.73 %).

From the acid samples of loamy soil Mg^{2+} ions eliminated more ions of Pb^{2+}, Ni^{2+}, Cu^{2+}, Co^{2+}, Cd^{2+}, Zn^{2+}, and Cr^{3+}. In case of Pb^{2+} the increase was thirteen-fold (from 2.06 to 26.97 %), for Cr^{3+} it was ten-fold (from 2.95 to 34.82 %), and seven times more for Cu^{2+} (from 7.88 to 59.86 %) in comparison with the neutral samples. The magnesium ions eliminated two times less Fe^{2+} ions (from 33.07 to 20.02 %) and Mn^{2+} ions (from 48.7 to 17.25 %) as well as three-times less Fe^{3+} (from 7.17 to 1.79 %) from acid samples of loamy soil than from the same soil of neutral reaction.

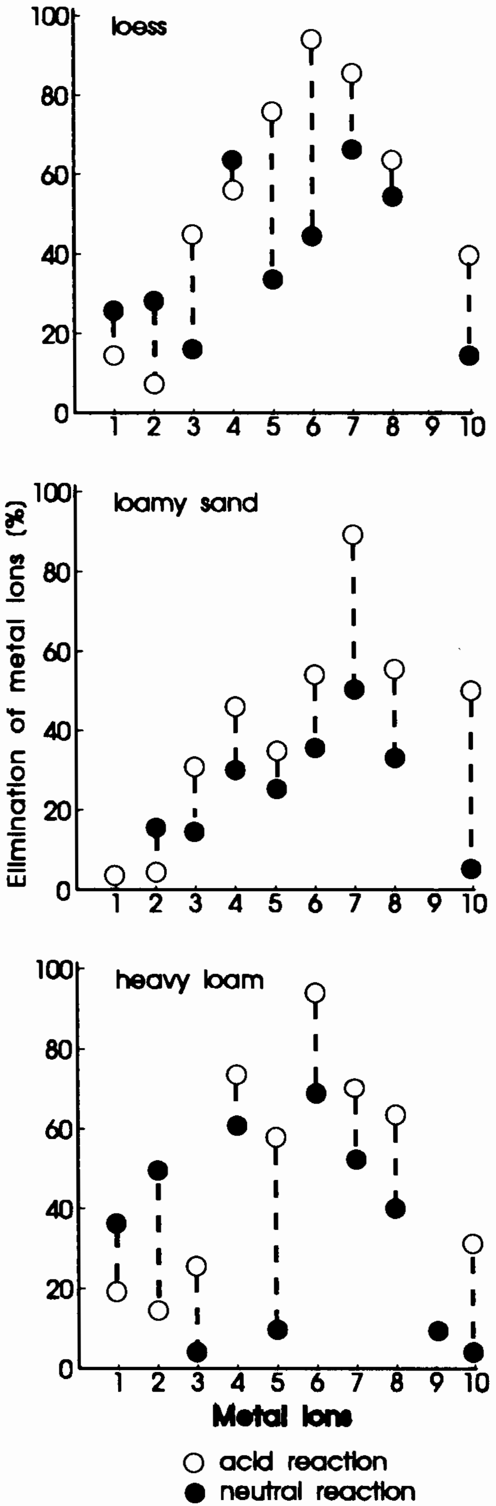

Fig. 1. Elimination of metal ions from soils by Mg^{2+} ions (in %).

In conclusion, it can be stated that from soil of acid reaction Mg^{2+} ions eliminated less Fe^{2+}, Mn^{2+}, and Ni^{2+} ions from loess soil and Fe^{3+} from loamy soil than from soils of neutral reaction. The ions of the remaining metals are eliminated by Mg^{2+} ions in greater amounts from acid soils than from neutral ones.

From the soils of neutral reaction Mg^{2+} ions desorb less Fe^{2+} ions which may testify to their precipitation in the form of insoluble hydroxides. On the other hand, the greater Fe^{3+} ions desorption from loessial and sandy soils and Ni^{2+} ions from sandy and loamy soils with Mg^{2+} ions suggest the occurrence of physical sorption. Different physicochemical properties of the soils tested must influence the type and force of cations binding in the soil sorption complex.

CONCLUSIONS

The results of the study presented above allow us to formulate the following conclusions:

1. Acid soil reaction causes greater elimination of the following ions: Pb^{2+}, Cu^{2+}, Co^{2+}, Cd^{2+}, and Zn^{2+} by Mg^{2+} ions from the soils tested.

2. Acid soil reaction causes smaller elimination of the ions: Fe^{2+}, and Mn^{2+} by Mg^{2+} ions, and Ni^{2+} ions from loessial soil and Fe^{3+} ions from loamy soil.

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MAGNEZ (II) JAKO CZYNNIK RUGUJĄCY JONY METALI Z GLEB

Badaniami objęto próbki pobrane z poziomu A_1 gleb płowych i brunatnych wytworzonych z piasku słabogliniastego, z lessu i z gliny ciężkiej. Badania wykonano w warunkach laboratoryjnych w glebach o odczynie kwaśnym i obojętnym. Glebę o odczynie kwaśnym poprzez zabieg wapnowania doprowadzono do odczynu obojętnego. Do próbek glebowych wprowadzono metodą dynamiczną jony metali: Fe^{2+}, Mn^{2+}, Ni^{2+}, Cu^{2+}, Co^{2+}, Cd^{2+}, Zn^{2+}, Fe^{3+}, Cr^{3+} w postaci chlorkowych roztworów, a Pb^{2+} w postaci roztworu azotanowego. Następnie nie wymyte wodą destylowaną, zasorbowane przez próbki glebowe jony metali desorbowano przy użyciu 0.05 mol/dm^3 roztworu chlorku magnezu. W wycieku oznaczano zawartość poszczególnych jonów metali klasyczną metodą płomieniowej spectrofotometrii absorpcji atomowej. Stwierdzono, że zakwaszenie gleb powoduje na ogół zwiększenie desorpcji badanych jonów metali przez Mg^{2+} z wyjątkiem Fe^{2+}, Mn^{2+} oraz Ni^{2+} w glebie lessowej i Fe^{3+} w glebie piaszczystej.

Słowa kluczowe: magnez, metale ciężkie, gleby, kompleks sorpcyjny.