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THE ROLE OF MICROORGANISMS IN TRANSFORMATION OF ALUMINIUM IN BROWNISH-PODZOLIC GLEIED SOILS OF CISCARPATHIA

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The microbocenoses of brownish-podzolic gleied soils of Ciscarpathia is investigated. The high intensity of processes of release and accumulation of aluminium regardless of depth is established. It is proved that in investigated soils mobilization of aluminium can be accessory under the influence of microflora which is able to dissolve Al-phosphate.
Keywords: aluminium, migration, accumulation, mobilization soil microorganisms, Metallogenium, to the phosphate aluminium

Introduction. Aluminium – one of the most common soil elements. Soil minerals and different aluminium content combinations include it. Transformation of aluminium combinations, their migration and accumulation, are better expressed in the conditions of moist climate [3], including Ciscarpathia [6]. In obedience to traditional conceptions, descending motion of aluminium and fixing in lower horizons depends on physical and chemical factors: the mechanical moving, dissolution or sedimentation is under the influence of change of pH and others [4,7]. There are few scientific hypotheses about biogenic origin of aluminium deposits. But they still are hypotheses because of absence of fact date. That is why establishing of mechanisms of the microbiological accumulation of aluminium in soils with its high maintenance is actual and necessary.

Materials and methods. Researches were conducted on brownish -podzolic gleied soils (Albeluvisols) which are typical for Ciscarpathia. Summarizing formula of investigated soil is: Hegl+Ehgl+Eigl+Igl+Pgl.

The general quantity of microorganisms was determined using the Vinogradski method of direct microscoping [2]; quantity of chemotrophic bacteria – by sowing method using of selective culture media of Aristovska-Zykina, Letena, Kuznetsova-Dubinina etc. [1]; a quantity of bacteria which dissolve aluminium phosphate using the Muromtsev method [2]; microbiological diagnostics and morphological study of microorganisms-accumulators of aluminium were conducted on culture signs; washings of bacterial cells using Aristovska-Zykina method [1]. For verification of possibility of direct microbiological dissolution of oxide of aluminium we used MPA diluted in two times in which Al_2O_3 in the different amount was added. This method is based on principle of areas of dissolution of Muromtseva.

Decomposition of law molecular complexes of fulvoacids (FA) by microorganisms was studied. For this purpose the complexes of aluminium with lactic, citric and vine acids were added to basic solution of mineral salts in an amount 0,25 %. Basic solution contained in the litre of the distilled water: 0,1 *M* $(NH_4)SO_4$ 0,03 *M* $MgSO_4$, 0,03 *M* NaCl and 0,1 *M* KH_2PO_4. Preparations of FA were prepared from explored soil using Ponomariova`s method [1].

Results and their discussions. The specific microorganisms, which would transform especially aluminium, were not found out in explored soils. More frequent this process is provoked by chemotrophic microflora, which takes part also in circulation of iron and manganese. It is established that considerable part of microbocenoses of explored soils takes part in the transformation of aluminium combinations, as well as iron and manganese *(tab.1.*).

Characteristic peculiarity is found to be that 80% of microorganism associations of lower horizons of brownish-podzolic gleied soils are chemotrophes. Exactly they are able to use alumin-

ium as “framework” material. In fact unlike the elements of variable valence, aluminium is not able to take part in the processes of power metabolism. However cells of these microorganisms are often encrusted with aluminium.

1. Description of microbocenoses, that takes part in transformation of Al, Fe and Mn

Genetic horizon	Depth, m^{-2}	Total amount of cells, mln./kg^{-3}			Part of chemotrophes , %
		direct microscoping	medium of Leten	medium of Kyznetsova-Dubinina	
Hegl	4 – 16	2,852	0,025	0,101	4
Ehgl	16 – 31	1,231	0,124	0,412	44
Eigl	31 – 43	1,005	0,254	0,312	56
Igl	43 – 100	0,985	0,341	0,45	80
Pgl	> 100	0,620	0,280	0,218	80

To receive the complex enriched by aluminium, solution of FA was saturated by $Al_2(SO_4)_3$ up to the complete fall of sediment. The received gel was used for preparation of nourishing media (5 *ml/l*). The sterilized medium was inoculated by two-component symbiotic culture of microorganisms, selected from the soil which consisted of unidentified fungi and attached to its mycelium excrescences of Metallogenium. We were not able to separate symbiotic organisms, and that is why we worked with the mixed culture, sowing it on all media listed above. Intensive and rapid growth of culture was observed only on a media with lactoacid-Al. However in all cases its growth was accompanied by the concentration of aluminium on the morphological structures of *Metallogenium*. In course of time the capacity of deposits of aluminium notably increases and fungi myceliym with excrescences of *Metallogenium* became hard and fragile.

To define the amount of aluminium accumulated on the surface of cells of *Metallogenium*, simbionts were separated from the medium, washed from salts and processed by 0,1 *M* HCl for dissolution of deposits of aluminium. Quantitative determination of aluminium was conducted by gravimetric method after its sedimentation from the solution by ammonia (*tab. 2).*

2. Amount of Al, accumulated on the surface of cells of *Metallogenium* in a binary culture (time of cultivation - 21 days)

Genetic horizon	Depth, m^{-2}	Total dry weight of cells-symbionts in 40 ml of medium), mg	Amount of Al accumulated on the surface of cells, mg	Amount of Al accumulated on the surface of cells, mg /kg^{-3} of dry weight of cells-symbionts
Hegl	4 – 16	13,2 ± 0,8	4,8 ± 0,2	363 ± 22
Ehgl	16 – 31	15,8 ± 1,1	4,2 ± 0,1	265 ± 18
Eigl	31 – 43	17,9 ± 0,9	4,7 ± 0,1	262 ± 13
Igl	43 – 100	18,2 ± 0,9	6,8 ± 0,3	373 ± 19
Pgl	> 100	13,7 ± 0,6	3,7 ± 0,1	270 ± 11

On the basis of the presented information it is possible to make conclusion, that intensity of process of release and accumulation of aluminium is high enough, regardless of depth. At the estimation of given ratio between biomass of symbiotic organisms and amount of the accumulated aluminium one has to take into account, that in the process of accumulation of this element only *Metallogenium* took part, weight of which notably scanty in comparing to weight of concomitant to it fungi mycelium. Consequently, we can consider geochemical energy of *Metallogenium* extraordinarily

high. The highest ability to accumulate aluminium was discovered for Hegl and Igl horizons. To our mind this tendency is the result of high contents of SOM which can be used as a power material. The high ability of Igl horizon to accumulate Al can be explained by hemotrophic type of nutrition of it microorganisms associations.

For an extraction from the soil bacteria, which destroy aluminosilicate, we used "silicate agar" (1/10 000 dilution and more). In three days after inoculation a quality test was conducted on potassium by a Peive's indicator. Appearance of potassium in solution served as the clear sign of initial destruction of aluminosilicates, and therefore the proper destructive ability of bacteria.

This ability appeared for bacteria with special form of slime colonies. In addition, another bacterium was found out in explored soils, which formed the smooth (not slime) colonies of dirty-white colour on a nourishing medium. The result of quantitative determination of extracted from aluminosilicates potassium can be used as the evidence of activity of the mentioned above bacteria. Now the identification of received cultures proceeds.

It is established that mobilization of aluminium can be accessory [5], under the influence of microflora, which dissolves an Al-phosphate (*tabl. 3*). During this process aluminium releases in soil solution. Our numeral attempts to identify the microorganisms able to mobilize phosphates were not successful. But obviously one: the same species - *Bacillius polimixa* prevailed among all analyzed colonies, which formed the halo of dissolution of Al-phosphate.

3. Profile distribution of microorganisms able to mobilize phosphates

Genetic horizon	Depth, m^{-2}	Total amount of cells, thousand/kg^{-3}
Hegl	4 – 16	186 ± 8,49
Ehgl	16 – 31	102 ± 2,83
Eigl	31 – 43	91,0 ± 15,6
Igl	43 – 100	153 ± 9,90
Pgl	> 100	43,5 ± 3,54

For identification of microorganisms able to mobilize unsolvable complexes of aluminium we used principle of zones of solution as in Muromtsev method. We added different amount of Al_2O_3 powder into MPA diluted in two times and inoculated this medium with soil suspension (1/10000 dilution); cultivated during 30 days at the temperature of 26 ^{0}C. In the majority of petri dishes small quantity of colonies dissolved. That was predefined the toxic effect of aluminium. The changes in media were not observed.

However in the dishes inoculated with soil suspension from Igl horizon negligible quantity of colonies appeared in 40 days around which medium became more transparent (*fig. 1*). In our opinion, this fact is the evidence of dissolution of Al_2O_3 and existence of microorganisms, which are able to release Al from the soil minerals of class of oxides and hydroxides.

We don't have enough data to form global conclusions yet. It is now possible to establish only the fact of existence in brownish-podzolic gleied soils of Ciscarpathia bacteria able to dissolve aluminium complexes. Work with this culture proceeds.

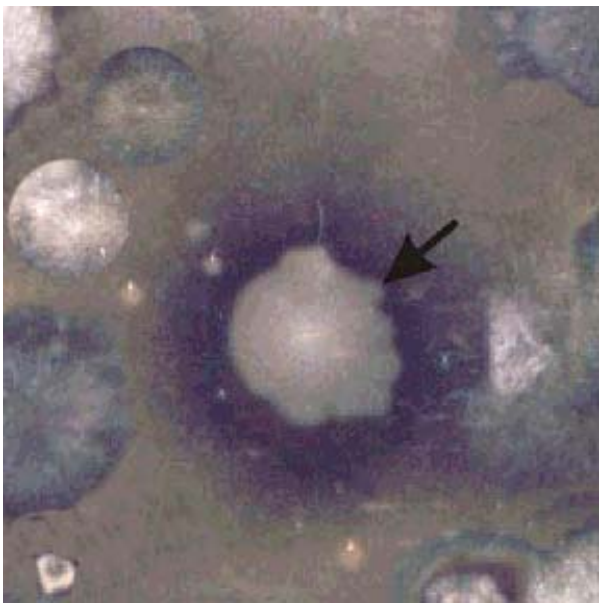

Fig. 1. Colony of the unidentified bacterium with halo of dissolution of oxide of aluminium around it

Conclusions.

1. Special feature of brownish-podzolic gleied soils of Ciscarpathia is the considerable prevailing of chemotrophic microflora (about 80%) in Igl horizon and mother rock.
2. The high intensity of processes of release and accumulation of aluminium regardless of depth is established. The analysis of ratio between biomass of symbiotic organisms and amount of the accumulated aluminium showed that bacterium of genes *Metallogenium* takes part in the processes of accumulation of this element.
3. It is established that in brownish-podzolic gleied soils of Ciscarpathia mobilization of aluminium can be accessory under the influence of microflora which is able to dissolve Al-phosphate.

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РОЛЬ МІКРООРГАНІЗМІВ У ТРАНСФОРМАЦІЇ СПОЛУК АЛЮМІНІЮ В БУРУВАТО-ПІДЗОЛИСТИХ ОГЛЕЄНИХ ГРУНТАХ ПЕРЕДКАРПАТТЯ

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Досліджений мікробоценоз бурувато-підзолистих оглеєних грунтів Передкарпаття. Встановлено, що інтенсивінсть процесу вивільнення та акумуляції алюмінію зростає з глибиною. Показано, що в досліджених грунтах можлива мобілізація алюмінію під впливом мікрофлори, яка здатна розчиняти алюмофосфати.
Ключові слова: алюміній, міграція, акумуляція, мобілізація грунтовими мікроорганізмами, Metallogenium, фосфат алюмінію