INFLUENCE OF GRIST MINERALS AND STONES ON SOIL FEATURES

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Abstract

The alginate and perlite (5t ha^{-1}) minerals were examined on different soil types in the Institute of Agricultural Chemistry and Soil Science. The experiments were set up in the greenhouse of the Institute (small-pot experiment), and in the botanical garden of the University (microparcel - 1,5m^2 experiment). The effects of minerals were studied on some physical, chemical, and microbial features of soils. The applied soil types were the blownsand soil, brown forest soil with „kovárvány", calcareous chernozem and meadow solonetz in the field experiment. In pot experiment humous sandy soil from Debrecen-Pallag was applied.

Neither alginate, nor perlite had influences on the soil pH statistically. The available nutrient content was influenced positively by mineral treatments; the nitrate-N content increased on humous sandy soil, the two clay minerals increased the soil phosphorus and potassium content.

The mineral treatments had changeable positive effect on soil examined microbiological properties. Due to examined microbial properties of soils more positive effect was caused by alginate. The minerals had more positive effects on those soil types - brown forest soil (with "kovárvány"), humous sandy soil - which had very low colloid content. Perlite primarily increased the population dynamics of microorganisms on humus sandy soil.

Our results proved that the application of mineral grist can fit into the sustainable land use system.

Key words: alginate, perlite, physical, chemical, microbial features of soils

INTRODUCTION

The requirement for sustainable development is to preserve crop yields during crop production and to produce high quality feed and food raw materials. The objectives of production and the environment should be realized so that crop production is adapted to the site conditions and the nutrient supply of the plants is carried out with minimal environmental loads, yet it must be economical (Loch, 2004). The fulfillment of the above objectives depends on the natural ecological factors, the applied agrotechnical factors and the genetic specificity of the cultivated plant. Among the ecological factors, the physical, chemical and biological properties of soils are of outstanding importance (Kátai, 1992).

During plant production there are many opportunities to maintain soil fertility or improve soil properties using natural or near-natural, organic or inorganic material. Such materials are grist minerals and rocks (Lazányi, 2003; Sorin et al., 2014.). According to the environment-friendly approach of the sustainable agricultural production, it is very important to investigate the effect of applied grist minerals and rocks on changes the dynamic and activity of microorganisms and the fertility of soils.

In our previous papers (Kátai et al., 2016; Tállai et al., 2017) we have already reported the effects of bentonite and zeolite minerals and rocks on soil properties. The objective of this study was to evaluate the soil chemical and microbiological consequences of the used alginate and perlite.

Alginate consists of fossil biomass and from weathering basaltic and lime, high-organic content rock. Composition: 10-12% organic matter, 20-25% lime, significant amounts of clay, phosphorus, potassium and various microelements. Perlite is highly silicide, structurally containing many fixed water, volcanic rock (Regenhart, 2001; Szendrei, 2005; Vermes, 2012).

MATERIAL AND METHOD

The alginate and perlite minerals were examined on different soil types in the Institute of Agricultural Chemistry and Soil Science. The experiments were set up in the greenhouse of the Institute, it was a small-pot experiment in controlled conditions. In the Demonstration Garden of the Faculty, there were field experiments with microparcels (1,5 m^2). The effects of minerals were studied on some physical, chemical and microbial features of soils. The applied soil types were as follows: the blownsand soil, brown forest soil with „kovárvány”, calcareous chernozem and meadow solonetz turning into steppe formation; the test plants were *Festuca pratensis L.; Festuca arundinacea L.* In pot experiment the applied soil was a humous sandy soil from Debrecen-Pallag, the test plant was *Lolium perenne L.*

The field experiments was set up in 1993 (Kátai, 1994), the small-pot experiments carried out in year 2017. This publication is summarising the experimental results, and studying the effects of alginate and perlite minerals on soil properties. The minerals in the fields were mixed into 20 cm layers of the soils. The treatments on humous sandy soil was output in three kg bottom perforated pots. Water content of treatments was kept on the same level, which is 70% of the maximum water-holding capacity. The pots were irrigated in every day to the same mass. Basic treatments: 50 mg nitrogen – as $Ca(NO_3)_2$ solution – 50 mg P_2O_5 and 50 mg K_2O as potassium dihydrogen orthophosphate and potassium sulphate solution were given to every pot.

In both experiments the applied dose of alginate and perlite minerals were 5 t ha^{-1}. Treatments are shown in the *Table 1.*

Table 1

The treatments and the applied doses in the experiments (Debrecen, Hungary)

Soil type	**Treatments**	**Doses**	**Soil type**	**Treatments**	**Doses**
Blownsand (calcareous)	control	ø	Humous sand	control	ø
	alginate	5 t ha^{-1}		perlite	5 t ha^{-1}
Brown forest soil (with „kovárvány”)*	control	ø	Calcareous chernozem	control	ø
	alginate	5 t ha^{-1}		perlite	5 t ha^{-1}
Humous sand (non calcareous)	control	ø	Meadow-solonetz**	control	ø
	alginate	5 t ha^{-1}		perlite	5 t ha^{-1}

exact name of soil type: *brown forest soil with alternating thin layers of clay substance „kovárvány”, ** meadow solonetz turning into steppe formation

Among the soil physical parameters the silt and clay content, the bulk desity (Filep, 1995), moisture content and the moisture in pore space were determined by Klimes-Szmik, 1962.

Among the chemical parameters of soil the pH of soil in suspension of distilled water and M KCl [$pH_{(H2O)}$; $pH_{(KCl)}$] were measured (Buzás, 1988), and the organic carbon-, the total nitrogen content was determined, also (Székely et al., 1960). To concern to the soil nutrient content the nitrate nitrogen-N (Felföldy, 1988), the ammonium lactate-acetate soluble phosphate and potassium content of soil was determined (Egnér et al., 1960). Among the microbiological parameters the total number of bacteria (in meat soup agar), the number of microscopic fungi (in peptone glucose agar) according to Szegi, (1979), the soil respiration (Witkamp, 1966. cit. Szegi,1979), the activities of saccharase (Frankenberger & Johanson,1983), dehydrogenase enzymes (Schinner et al., 1996) were determined.

Statistical calculations by SPSS 13.0 for Windows and Microsoft Office Excel programs were carried out (*Duncan – test; OneWay ANOVA*).

RESULTS AND DISCUSSION

In the alginate experiment, soils with low clay and organic matter, firstly sandy textured soils (blown sand, brown forest soil with “kovárvány”, humous sand) were coined. The effect of the perlite on both sandy, loamy and clay loamy textured soil was investigated.

The soils with sandy texture have low moisture content. The smallest moisture content was in the brown forest with “kovárvány” soil. With allocation of the minerals into the soils, the bulk density decreased – exept on brown forest soil. On blownsand and humous sand soil the moisture content slightly increased. The bulk density became smaller, so the moisture content in soil pore space also decreased (*Table 2*).

In the perlite experiment the silt + clay content increased in te following order: humuos sand, calcareous chernozem and meadow solonetz.

In this experiment with the mineral allocation into the soil the bulk density in all three experimental soil types decreased, also. The moisture content increased, and parallel with the moisture in pore space decreased in soils. (*Table 3*).

Due to the effect of perlite treatments, especially in the case of calcareous chernozem and meadow solonetz, there was a greater decrease in moisture content in the soil pore space than in alginates treatments. Alginate and perlite had similar effects but in the case of larger clay and organic soil, the effect of perlite on the moisture content of the soil pore was more pronounced.

Table 2

Effect of alginate on some soil physical features

Soil types and treatments	**Silt and clay (%)**	**Soil texture**	**Bulk density (g cm^3)**	**Moisture content (m/m%)**	**Moisture in pore space (%)**
Blownsand soil (calcareous)					
control	8.5	sand	1.48	11.10	37.21
alginate	11.5		1.40	11.94	35.45
Brown forest soil with „kovárvány”					
control	4.3	coarse sand	1.59	6.26	24.88
alginate	4.1		1.60	5.86	23.69
Humous sand					
control	10.0	sand	1.68	14.62	37.31
alginate	10.5		1.63	17.61	35.38

Table 3

Effect of perlite on some soil physical features

Soil types and treatments	**Silt and clay (%)**	**Soil texture**	**Bulk density (g cm^3)**	**Moisture content (m/m%)**	**Moisture in pore space (%)**
Humous sand (non calcareous)					
control	10.0	sand	1.68	14.62	37.31
perlite	11.5		1.59	20.37	34.62
Calcareous chernozem					
control	41.7	loam	1.46	22.45	72.99
perlite	40.9		1.28	25.79	63.85
Meadow solonetz					
control	58.2	clay loam	1.50	28.85	99.70
perlite	60.4		1.40	29.55	87.70

In the alginate experiment the blown sand soil was weakly alkaline, while the brown forest soil and the humous sandy were acidic. In these treatments the alginate did not influence the soil pH significantly. The slightly increasing of soil pH could be not proved statistically. The amount of organic-C and the available nutrients - mainly phosphorus and potassium - content increased significantly in the blown sand and humous sand soil.

Alginate showed less positive effect in the brown forest with "kovárvány" soil. Primarily only the organic matter and nitrate content increased statistically (*Table 4*).

Table 4

Effect of alginate on some soil chemical features

Soil types and treatments	pH (H2O)	pH (KCl)	Organic-C ($g\ kg^{-1}$)	Total-N ($g\ kg^{-1}$)	NO_3-N	AL-P_2O_5	AL-K_2O
					($mg\ kg^{-1}$)		
Blownsand (calcareous)							
control	8.10a*	7.70a	1.7a	0.14a	18.6a	59.2a	125a
alginate	8.20a	7.70a	4.7b	0.16a	20.2a	105.5b	148b
Brown forest soil (with „kovárvány")							
control	5.15a	4.00a	1.6a	0.11a	65.5a	102.6a	100a
alginate	5.35a	4.20a	2.2a	0.11a	72.2a	99.2a	75a
Humous sand							
control	5.60a	4.20a	4.1a	0.70a	23.9a	160.0a	98a
alginate	5.75a	4.60a	5.2a	0.90a	33.7b	191.2b	123b
* *Oneway* ANOVA *Duncan[a]-test (Significance level =,05) n=3*							

Table 5

Effect of perlite on some soil chemical features

Soil types and treatments	pH (H2O)	pH (KCl)	Organic-C ($g\ kg^{-1}$)	Total-N ($N\ g\ kg^{-1}$)	NO_3-N	AL-P_2O_5	AL-K_2O
					($mg\ kg^{-1}$)		
Humous sand (non calcareous)							
control	5.60a	4.20a	4.1a	0.70a	23.90a	160.0a	98a
perlite	5.70a	4.30a	4.8a	1.10b	29.16b	191.0b	120b
Calcareous chernozem							
control	6.70a	5.85a	19.8a	1.32a	33.66a	224.5a	425a
perlite	6.70a	5.98a	20.4a	1.36a	35.90a	314.0b	540b
Meadow solonetz							
control	6.50a	5.80a	25.4a	1.69a	13.20a	111.2a	308a
perlite	6.55a	5.80a	27.8a	1.92b	13.61a	228.0b	420b

The humous sandy soil was acidic, the meadow solonetz, slightly acidic and the calcareous chernozem was nearly neutral. The perlite did influence neither the soil pH nor organic carbon content in the examined soils. The total-N increased on meadow solonetz-, the nitrate-N content increased on humous sandy soil, statistically. The perlite positively influenced on the available phosphorus and potassium content in all examined soil types (*Table 5*).

Table 6

Effect of alginate on some soil microbial features

Soil types and treatments	Number of bacteria (*10^6g^-1 soil)	Micros-copic fungi (*10^3g^-1 soil)	CO_2-production of soil (mg 100g^-1 10 days)	Saccha-rase (glucose mg g^-1 24h^-1)	Dehydro-genase INTF (µg/g)
Blownsand (calcareous)					
control	2.55a	9.3a	16.32a	7.13a	42.73a
alginate	1.82a	15.3b	16.70a	6.64a	64.56b
Brown forest soil (with „kovárvány")					
control	1.88a	18.7a	15.68a	3.93a	105.74a
alginate	4.64b	13.3a	16.32b	7.37b	113.21a
Humous sand (non calcreous)					
control	1.85a	11.0a	15.46a	4.66a	104.86a
alginate	3.84b	13.3a	16.02a	3.19a	91.79a

The alginate had significant positive effect on the number of microscopic fungi and dehydrogenase enzyme activity in the blown sand soil. The total number of bacteria, the soil respiration, and the saccharase activity were increased by alginate on brown forest soil. Positive effect of treatment was determined on number of bacteria in humous sandy soil.

Table 7

Effect of perlite on some soil microbial features

Soil types and treatments	Number of bacteria (*10^6g^-1 soil)	Microsc opic fungi (*10^3g^-1 soil)	CO_2-production of soil (mg 100g^-1 10 days)	Saccha-rase (glucose mg g^-1 24h^-1)	Dehidro-genase INTF (µg/g)
Humous sand (non calcareous)					
control	1.85a	11.0a	15.46a	4.66a	104.86a
perlite	3.68b	16.2a	15.82a	3.43a	100.90a
Calcareous chernozem					
control	4.88a	38.7a	17.47a	11.06a	147.46a
perlite	5.24a	15.0b	16.40a	11.91a	146.99a
Meadow solonetz					
control	3.30a	42.6a	17.15a	13.04a	33.44a
perlite	6.91b	30.0b	15.76b	9.59a	34.96a

Some negative effect of alginate were detected in saccharase enzyme activity of blown sand and humous sandy soil but these effects were could not prove statistically (Table 6). At the same time the dehydrogenase activity was increased in blown sand and brown forest soil by alginate.

The number of total soil bacteria showed a significant increase on humous sand and meadow solonetz by perlite treatments. The amount of microcopic fungi decreasead statistically on calcareous chernozem and meadow solonetz soil by the perlite. The perlite did not influence on carbon-dioxid production and enzyme activity of soil. (*Table 7*).

CONCLUSIONS

The effects of alginate, and perlite minerals were studied on different soil types on some physical, chemical, and microbial features of soils.

Neither alginate, nor perlite influenced the soil pH statistically. The organic carbon content was increased by alginate; the amount of total nitrogen was increased by perlite. The available nutrient content was influenced positively by mineral treatments, the nitrate-N content raised in humous sandy soil, and both grist mineral and rocks increased the soil phosphorus and potassium content.

The mineral treatments had changeable positive effect on soil examined microbiological properties. Due to examined microbial features of soils more positive effect was caused by alginate. In view of examined microbial parameters the alginate was the most stimulate on brown forest soil (with "kovárvány"), which had very low colloid content. The more pronounced effect of perlite was prevailed on humous sandy soil, compared with higher loam-containing calcareous chernozem and meadow solonetz soils.

Our results proved that due to the partly changed environment by the application of minerals and grinded rocks, these natural amendments can fit into the sustainable land use system, especially soils having low colloid content.

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