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The content of mobile lithium in the plow layer of soils of slopes and its relationship with NDVI and soils properties

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Abstract. A comparative analysis of the content of mobile lithium in the plow layer of soils located on different relief elements: the top of watershed slopes and hollow has been carried out. According to received regression model and the spatial distribution of the vegetation index NDVI, the spatial variability of the content of mobile lithium in the plow layer of soils on slopes has been mapped. Results of present study demonstrated, that an assessment of accuracy the forecast of the content of mobile lithium in the plow layer of soils was good (an error of 16.9%)

1. Introduction

At present the literature contains little information about the spatial variability of the content of mobile lithium in anthropogenically transformed soils. According to research [1], the content of lithium of the soil has a rigid connection with the underlying parent materials, but more controlled of level of soil formation than its initial content in the parent materials. The content of mobile lithium is usually about 5% of the total content [2].

Comparative analysis of the content of mobile lithium in the plow layer of the soils located on different relief elements (the top of the watershed, erosion dangerous slopes and hollow), and examination of the relationship with different soil properties and vegetation parameters allow to determine regularities of the spatial variability of the studied parameter.

Studies have found that vegetation index NDVI has positive correlation with the parameters of productivity of the vegetation [3, 4, 5], which is known to depend on soil properties. Therefore, NDVI can be used as an indirect indicator, as well as for the compilation of digital maps of soil properties.

The aim of this study is to perform predictive mapping of the content of mobile lithium in the plow layer of soils with the use of NDVI calculated from Landsat 8 images (30-m resolution) as an indicator and to compare the properties of the plow layer of soils located on the top of a watershed, erosion dangerous slopes and in the hollow.

2. Objects and methods

Field studies were performed in July 2013 on the Cis-Salair Plain in the south of Western Siberia (Novosibirsk oblast, Toguchin district, Ust’-Kamenka settlement), where agricultural soils are most susceptible to erosion. The investigated 2-km-long plot (100 ha) is found within the Irba and Khairuzovka river catchments. The soil on the top of watershed refers to eluviated clay-illuvial saturated high-humus heavy loamy agrochernozem (Luvic Greyzemic Chernozems (Aric, Pachic, Siltic)). Soils on erosion dangerous slopes, and the hollow have been represented by the following types: eluviated clay-illuvial saturated medium-humus heavy loamy agrochernozem (Luvic Greyzemic Chernozems (Aric, Pachic, Siltic)), dark tonguing clay-illuvial saturated medium-humus heavy loamy agrochernozem (Haplic Chernozems (Aric,Pachic, Siltic)) and eluviated saturated medium-humus heavy loamy dark agrogray (Luvic Greyzemic Phaeozems (Aric, Siltic)) soil. At the time of our study, the investigated cropland was under the oats-pea mixture (oats (Avena sativa) of the Rovesnik cultivar, green pea (Pisum sativum) of the Yamalskii cultivar).

Soil samples (n = 39) were taken from the plow layer (0-30 cm) following an irregular grid. The coordinates of sampling points were determined with a Garmin eTrex Vista GPS (5-m accuracy). The sampling density corresponded to the soil survey on a scale of 1 : 5000. The humus content in the samples was determined by the wet combustion method according by Tyurin; particle size distribution, by the Kachinskii procedure; pH of water suspension, by potentiometry; and the soil water content, by the gravimetric method with the soil drying in a thermostat [6]. The mobile lithium was extracted by the acetate-ammonium buffer (1M CH_3COONH_4, pH 4.8) with further determination on an atomic absorption spectrometer. The NDVI of the oats-pea mixture was used as a predictor of the content of mobile lithium of the soils. NDVI was calculated on the basis of Landsat 8 image (July 14, 2013) in the ENVI 4.0 program. The accuracy of the regression modeling was estimated via calculating the mean absolute percentage error (MAPE).

3. Results and discussions

It was established positive correlation between the content of mobile lithium in the plow layer and NDVI (Fig.1). In regression model, NDVI explains 28% of variance in the content of mobile lithium. According to the regression model, a positive correlation between the studied parameters indicates higher the content of mobile lithium in areas with higher NDVI values. Various indices have been applied to assess the quality of the model (Table 1).

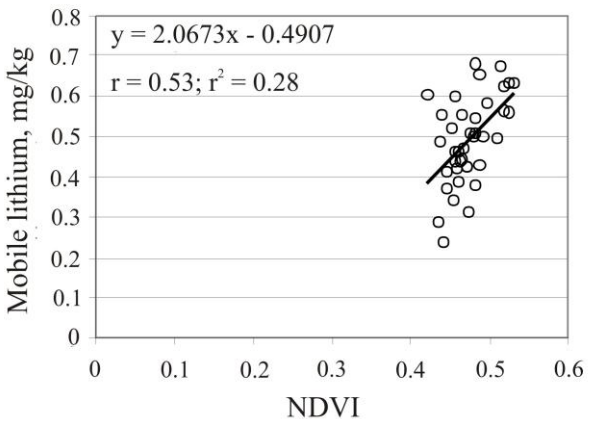

Figure 1. Regression model of the dependence between the content of mobile lithium in the plow layer of soils and NDVI values (n = 39; p < 0.001).

According to F-criterion and its probability (p), the model and its determination coefficient is statistically significant, as $F_{fact} > F_{table}$ (4.08). The statistical significance for regression coefficients (b) of the model is confirmed by the values of t-criterion of regression coefficients above the critical value of 2.02. Student's t-test values for the free term of the equations is higher than 2.02 which points to the statistical significance of the free term. For model, calculated *DW* value is higher than critical *DW* values, which means that the autocorrelation of the residuals is absent. Calculated RS values for the model are within the critical interval (3.67–5.16), which means that the residuals fit the normal distribution pattern. Results of present study demonstrated, that an assessment of accuracy the forecast of the content of mobile lithium was good (an error of 16.9%).

Table 1. Quality indices of regression model «Mobile lithium».

Parameter	Value
Correlation coefficient, r	0.53
Determination coefficient, r^2	0.28
F-criterion	14.6 ($p<5\times10^{-4}$)
t-criterion for regression coefficient (b)	3.82 ($p<5\times10^{-4}$)
Standard error	0.09
t-criterion for the free term of the equation	-2.05 ($p<10^{-5}$)
DW	2.47
RS	4.43
MAPE, %	16.9

DW is the Durbin-Watson criterion (test for autocorrelation of the residuals), *RS*-criterion is the test for normal distribution of the residuals, MAPE is the mean absolute percentage error.

Using the resulting regression equation was constructed a forecast map of the content of mobile lithium on the entire examined field (Fig. 2).

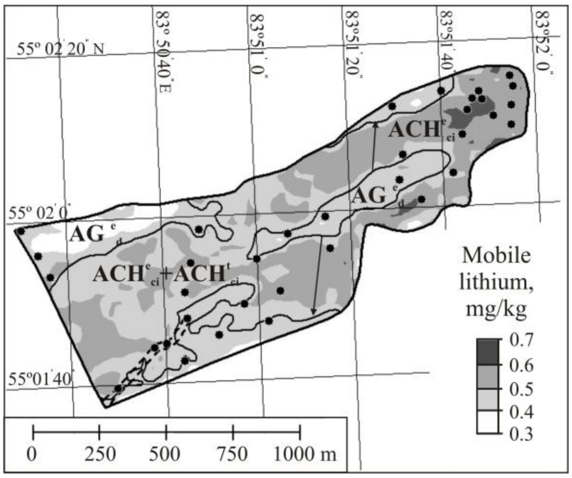

Figure 2. Forecast map of the content of mobile lithium in the plow layer of soils. Solid lines – boundaries between soil polygons; dots – sampling points; dotted line – location of the hollow. Soils: ACH^e_{ci} – eluviated clay-illuvial agrochernozems, ACH^t_{ci} – dark-tonguing clay-illuvial agrochernozems, AG^e_d – eluviated dark agrogray soils.

In soils on the top of a watershed with higher content of humus in comparison to the soils of the slopes and hollow the content of mobile lithium is increased 1.3 and 1.6 times, respectively, which probably indicates more active processes biological accumulation in the soils of the top of a watershed (Tab. 2).

This conclusion can be confirmed by dates according to Table 2 and Table 3. The content of humus in soil of the top of the watershed has had in to 1.6 and 2.5 times higher in compare to soils of slope and hollow. At the same time, the content of mobile lithium has had a positive correlation with the content of humus (r=0.69).

However, the content of mobile lithium could reduce on soils of the slope and hollow due to active flowing of erosion processes on the slope. And significant decrease of the content the physical clay on soils of slopes and hollow and its positive correlation with lithium were fixed at present research (Tab. 2, Tab. 3). In addition, rise of content mobile lithium on soils which have high amount of physical clay (on the soil on the top of a watershed) can provide its more efficient absorption by the different fraction of clay particles. Thus, the causes of the spatial variability of the content of mobile lithium in soils could be diverse.

Table 2. Variation of the properties of soils and NDVI on the different geomorphic positions

Characteristics	Geomorphic positions		
	Top of a watershed (n=16)	Slopes (n=20)	Hollow (n=4)
Mobile lithium, mg/kg	0.57 ± 0.08 0.41–0.68	0.44 ± 0.09* 0.24–0.60	0.37 ± 0.06* 0.32–0.43
Soil moisture, %	21.9 ± 1.5 19.2–24.4	17.7 ± 4.5* 5.0–22.4	16.5 ± 0.7* 15.7–21.4
Humus, %	7.4 ± 1.5 3.7–9.1	4.7 ± 1.2* 2.6–6.8	3.0 ± 1.5* 1.7–3.9
Physical clay, %	49.9 ± 3.0 44.2–57.0	46.7 ± 4.4* 40.1–59.9	43.5 ± 1.9* 41.0–45.6
pH_{H2O}	5.8 ± 0.17 5.5–6.2	5.7 ± 0.17 5.4–6.0	5.8 ± 0.1 5.6–5.9
NDVI	0.494 ± 0.026 0.445–0.531	0.459 ± 0.018* 0.422–0.492	0.470 ± 0.01 0.455–0.479

Above the line – mean value and standard deviation (M; s); under the line – the range of values (min–max); n – is the number of sampling points. * The difference with corresponding values on the top of a watershed is statistically significant (at p<0.01).

Table 3. Pearson's correlation coefficients between the properties of soils and NDVI.

Characteristics (n=39)	Mobile lithium	Soil moisture	Humus	Physical clay	pH_{H2O}	NDVI
Mobile lithium	–					
Soil moisture	0.41	–				
Humus	0.69	0.63	–			
Physical clay	0.63	x	x	–		
pH_{H2O}	0.69	x	x	x	–	
NDVI	0.53	0.54	0.72	x	x	–

n – is the number of sampling points; x – statistically insignificant correlative relationships.

4. Conclusions

4.1. According to received regression model and the spatial distribution of the vegetation index, the spatial variability of the content of mobile lithium in the plow layer of soils has been mapped. In regression model, NDVI explains 28% of variance in the content of mobile lithium. Results of the present study have demonstrated the good assessment of accuracy the forecast of the content of mobile lithium (an error of 16.9%).

4.2. Statistically confirmed that NDVI and contents of mobile lithium, humus, physical clay, in the plow layer of soils situated on erosion dangerous slopes are lower than in soils of the top of the watershed. Was fixed significantly decrease of all investigated soil properties on the hollow in compare with the top of a watershed. While the average value of NDVI on the hollow is comparable to one on the top of the watershed.

4.3. The content of mobile lithium in soils of the top of the watershed is high due to accumulation of this element by humus and physical clay.

References

[1] Akhmetov R M 2009 Lithium in geotechnosphere of the South Ural *Geologychesky sbornik* **8** 248-52 (in Russian)
[2] Michael A, Anderson P M and Bertsch P 1989 Exchange and apparent fixation of lithium in selected soils and clay minerals *Soil Science* V **148** (1) 46-51
[3] Gopp N V 2013 Algorithm for compilation of digital soil maps based on field, laboratory, and satellite data *Issled. Zemli Kosmosa* **3** 58-72
[4] Kashkin V B and Sukhinin A I 2001 Remote sensing of the Earth from space. Digital image processing (Moscow: Logos) p 264 (in Russian)
[5] Gopp N V 2015 Soils of the Southwestern Part of the Dzhulukul Depression in the Altai Republic *Eurasian Soil Science* V **48** (6) 567–77
[6] Agrochemical Methods of Soil Studies 1975 (Moscow: Nauka) p 656 (in Russian)