Grassland stress effect on the macroelements dynamics in soil-plant system

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Abstract. High rate of litter mineralization in steppe and forest-steppe zones facilitates litter macroelements release and their involvement in open cycles with further migration through the soil profile. Grassland stress initiates mineralization processes that enable macroelements to get rapidly involved in the process of organic matters re-synthesis. Grassland transferring into reserve state leads to litter accumulation in upper soil layer and degradation processes to slow down.

1. Introduction
Biosphere macro- and microelement balance in relation to live organisms activity is one of global scientific problems connected with the problems of climate changes, human nutrition, agriculture etc. Macro- and microelements simulation is based on the single observations that are analysis of live organisms and soil elements composition. Such observations first of all of phytomass fraction and soil element composition are, as a rule, laborious and expensive and there fore there are very few of them that is the researches are very often carried out with small number of repetitions. At the same time, it is well-known that both plant cover and soil one are characterized with great spatial and time variability even within the same biogeocenosis. That includes variability of species composition and plant species abundance, of soil horizons thickness and chemism as well as variability of macro- and microelements volumes per square unit. On modeling balances of the main macro- and microelements, a simple results estrapolation on larger territories can lead to great mistakes.

Pedogenesis processes and soil development are tightly connected with ecosystem dynamics and functioning as soils are open dynamic systems bound up with other ecosystem components, matter and energy flows. Quantitative characteristics of soil nutrients are controlled by destruction component of carbon cycle providing return into atmosphere the carbon taken from it during photosynthetic assimilation and macroelements return into soil profile. Macrolelements such as P, K, Ca and others take a great part in soil fertility. These components content level in specific ecosystems corresponds to the difference between their coming into soil with dead plant residues and their release during destruction process. Thus, long-term uncontrolled grazing leads to plant community degradation and biodiversity decrease. Studying of effect degree of long-term grazing stress on steppe ecosystems species composition, plant matter productivity and structure is an urgent problem [1-4].
2. Materials and methods
Grassland stress effect on the macroelements dynamics in soil-plant system was investigated for steppe catenas within steppe part of Il'men state reserve located on the Southern Ural east slope in trans-Ural peneplain. The territory is of hill-plain kind with 390-350 m above sea level. The main forming soils are dealluvial ones, often loams of carbonate formation and rarely light brown, dark brown and yellow-brown clays. Carbonates content in those soils is up to 2-3%. There chernozems and meadow chernozems are formed. When groundwaters are deposited high enough, dealluvial sediments become saline and half-hydromorphic saline soils are formed [5].

The climate of investigated territory is of acutely continental kind and its main characteristics are stipulated with interaction between atmospheric circulation and relief of the Urals southern edge. The climate is characterized as driest and warmest. January average temperatures are of 16-20 °C. Temperature conditions are rather changeable, severe frosts in all winter months can alternate with thaws up to +3°C in January and +18° in November. Winer period in the region can last from 100 to 154 days. Average depth of ground frost penetration is 135 cm. Average snow cover height is of 25 cm, snowmelmting lasts 15-20 days on average though it can fluctuate from 6 to 30 days and more. July average temperatures are +18 +20°C. The period of air temperature over 15°C is 95 days. Precipitation amount of accumulated above ground mortmass storage means low rates of destruction processes. Great storage of green mass and roots indicates high rate of production. Changing of the rate of plant matter formation and destruction can be judged from storages ratio changing. Above-ground mortmass storage (standing dead and litter) depends on live mass amount and mortmass degradation rate. The higher is production with maximum live plant matter storage as relative measure and the lower destruction rate, the more is amount of accumulated above-ground mortmass. Mortmass storage of investigated catenas is higher than phytomass storage. It fluctuates within 1020-2800 g/m² (Table 1).

3. Results
Plant matter storage structure/composition is one of the most significant ecosystem characteristics. Great storage of green mass and roots indicates high rate of production processes, great dead matter storage means low rates of destruction processes. Changing of the rate of plant matter formation and destruction can be judged from storages ratio changing. Above-ground mortmass storage (standing dead and litter) depends on live mass amount and mortmass degradation rate. The higher is production with maximum live plant matter storage as relative measure and the lower destruction rate, the more is amount of accumulated above-ground mortmass. Mortmass storage of investigated catenas is higher than phytomass storage. It fluctuates within 1020-2800 g/m² (Table 1).

| Catena/pc | g/m² | ash | P   | Mg  | Ca   | Na  | K   | Fe  | Al  |
|-----------|------|-----|-----|-----|------|-----|-----|-----|-----|
| Alluv1    | 86,0 | 15,7| 18,4| 0,14| 1,15 | 0,01| 0,13| 0,31| 1,14|
| Trans1    | 135,3| 28,4| 53,7| 0,21| 1,64 | 0,08| 0,22| 0,39| 1,79|
| Trans2    | 195,9| 37,2| 75,5| 0,33| 2,15 | 0,13| 0,31| 0,88| 2,58|
| Trans3    | 204,2| 37,1| 51,2| 0,51| 2,38 | 0,08| 0,31| 1,16| 3,47|
| Trans4    | 263,2| 50,5| 45,6| 0,39| 1,81 | 0,07| 0,23| 1,47| 0,81|
| Akk       | 225,6| 41  | 57,2| 0,45| 2,16 | 0,06| 0,27| 1,28| 3,51|
| C-2/pc    |      |     |     |     |      |     |     |     |     |
| Alluv2    | 151,2| 32,6| 36,2| 0,21| 1,98 | 0,03| 0,28| 0,61| 2,97|
| Trans1    | 133,6| 32,7| 36,8| 0,14| 1,28 | 0,02| 0,2  | 0,76| 1,84|
| Trans2    | 177,2| 30,2| 53,3| 0,26| 1,57 | 0,03| 0,23| 0,63| 2,12|
| Trans3    | 84,8 | 13,7| 30,4| 0,15| 1,06 | 0,02| 0,23| 0,31| 1,45|
| Trans4    | 63,7 | 13,1| 21,9| 0,14| 0,75 | 0,01| 0,12| 0,29| 1,42|
| Akk       | 58,2 | 11,8| 24,7| 0,18| 0,84 | 0   | 0,12| 0,33| 1,34|

C-1 – reserve catena; C-2 – catena under grassland stress; pc- position of the catena
Comparative analysis of quantitative characteristics of catenas dead plant matter shows that it has different peak directions. All fractions storage of reserve catena grows from eluvial position to accumulative one and that of catena under grassland stress decreases from upper position to lower one. Litter fixes live plant matter and soil in biological cycle and consists of dead plant residues of different destruction stages.

Litter amount depends on ecosystem using mode. It has been recorded that on transferring grassland into reserve mode, standing dead is accumulated before litter that, in its turn, leads to macroelements accumulation in the soil upper layer and to destruction processes slowdown. Carbon concentration changes from 15% to 50% and depends on catenas vegetation composition (Table 1). The line of consecutive decrease of ash elements content is the following: P > Ca > Al > Fe > Mg > K > Na. Percents and percents tenth parts belong to Ca, P, Fe and Al. Litter amount is not great under high grassland stress, destruction processes in it go much more quickly that increases system macroelements turnover [7].

4. Conclusions
Studies have shown that grassland ecosystems under the commandments of the value of the stocks of green biomass, rags and litter can fluctuate during the season and from year to year, but the average over the observation period retain a certain value because the processes of formation and decomposition of litter cancel each other out. Grazing stock of dead plant matter first responds to grazing stress: with increasing grazing the amount is reduced, at the termination of grazing is restored to the value characteristic for this type of grasslands.

Great rate of litter mineralization in steppe and forest-steppe zones allows macroelements to be rapidly released from litter and to be included in open cycles with further migration through soil profile. Grassland stress speeds up mineralization processes that enable macroelements to be rapidly included in organic matters re-synthesis processes.

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References
[1] Bazilevich N I And Titlyanova A A 2008 Biotic cycle on five continents: nitrogen and ash elements in natural ecosystems the World ( Novosibirsk: Nauca) (in Russian)
[2] Mordkovich V G and Afanasyev N A 1980 Ecol. (3) 840-9
[3] Titlyanova A A and Shibareva S V 2012 Litter in forest and grass ecosystems (Novosibirsk:Nauca) (in Russian)
[4] Norby R J, Cotrufo M F and Ineson P 2001 Ecol. (127) 153-6.
[5] Levit A I and Mironycheva-Tokareva N P 2005 Steppe and forest-steppe landscapes of the South of the Chelyabinsk region and their transformation (Chelyabinsk:Crocus) (in Russian)
[6] Titlyanova A A 1977 Biological carbon cycle in grass biogeocenoses (Novosibirsk: Nauka) (in Russian)
[7] Bazilevich N I and Semenyuk N V 1986 Soil Science (7) 57-69