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Review Article

BIOINDICATION IN ECOLOGICAL ASSESSMENT OF ERODED SOILS IN MOUNTAIN AREAS

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Abstract
In the article it is provided a material on determination of quantitative and qualitative composition, as well as invertebrates' distribution in the profile of various types of the eroded mountain soils; on determination of regional regularities of alterations in the morphogenetic structure, agrochemical and agrophysical indicators of eroded mountain and foothill (typical sierozem soils, dark sierozem soils, mountain brown carbonate, mountain brown typical, mountain brown weakly leached) soils; on determination of the correlative relationship between soil fauna (earthworms, mollusks, nematodes, ticks, collembolans) and soil properties.

Keywords: erosion, mountain soils, pedofauna, humus, earthworms, mollusks, nematodes, ticks, collembolans

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INTRODUCTION

To date, the main part of mountain soils is subjected to erosion and research has been conducted using modern technologies. But along with research of the of eroded arid soils' properties, insufficiently studied a role of pedofauna in soil formation processes, the fertility formation, as well as in changing environmental conditions among various environmental factors.

The goal of research is a complex study of soil properties and quantity, the seasonal dynamics of pedofauna of the eroded mountain soils, and development of criteria for the indicator of soil erosion on pedofauna.

RESEARCH OBJECTIVES

Determination of morphogenetic, agrochemical, chemical and agrophysical properties of mountain soils of the region; study of the erosion effect; determination of fauna (earthworms, mollusks, collembolans, nematodes and ticks) of eroded soils in conditions of vertical zonality; determination of the correlative relationship between the basic properties of the soil and pedofauna; development of criteria for the indicator of soil erosion on pedofauna of mountain and foothill soils.

MATERIALS AND METHODS

The researches were carried out in the mountain conditions of Turkestan Range, where 25 basic soil sections were laid, with considering the types and subtypes of the soils, as well as the degree of their erosion. The object of study was selected eroded typical sierozem soils, dark sierozem soils, mountain-brown carbonate, and mountain-brown typical, mountain-brown weakly leached soils. The scheduled tasks found their solution based on the use of comparative-geographical, comparative analytical and expeditionary methods for study of eroded mountain and foothill soils. In the course of the research, morphological, agrochemical, general physical properties were determined in relation to the zoological activity of the soils of the supporting layers. Selection of soil samples of scientific investigations from genetic horizons, observations and analyzes were carried out on the basis of "Methods of agrochemical, agrophysical and microbiological studies in irrigated cotton areas" of UzSIIC, "Guidance on chemical soil analysis" by E.V. Arinushkina, soil-zoological analyzes based on "Methods of soil and zoological research" by M.S. Gilyarov, a mathematical-statistical analysis of research results was performed by the method of B. Dospekhov using the Microsoft Excel software program.

RESULTS AND DISCUSSION

The confinement of the studied soils to the mountain and foothill zones, vegetation cover thinness, low humus content on the slopes, development of degradation processes are reflected in the soil exposure to erosion processes, as well as in the morphological, physical, chemical and biological properties of soils. Morphological indicators of the studied mountain soils (typical sierozem soils, dark sierozem soils, mountain brown carbonate, and mountain brown) depend on the erosion degree. In all types and subtypes of eroded soil slopes, weak humus layer thickness is observed, the carbonates of carbonates accumulating to the soil surface, compaction, relief of the mechanical composition of the upper layers of the soil and a decrease in the activity of the soil fauna. It was noted that soils that are washed as a result of erosion differ from non-eroded and, especially from eroded soils, by the relatively dark color of the soil, the thickness of the humus layer, the gradual decrease from surface to bottom of the humus accumulation horizon, the deep CO2 carbonate horizon.

In the studied area, a mechanical composition of soils spread along vertical zonality is weighted from typical sierozem soils to dark sierozem soil, mountain brown carbonate, mountain brown typical and mountain brown weakly leached soils, their composition increases the amount of fine dust and clay (the amount of physical clay from 35,4-42,9% to 45,2-53,2%). There is a greater amount of dust fractions, especially coarse dust (up to 50, 0-63,4%), there is a slight decrease in its content from typical sierozem soil to mountain-brown weakly leached soils (up to 46,7-53,4%). In the middle part of the soil profile, it is observed an intensification of the claying process from sierozem soils to brown soils; an increase in the fractions of fine dust and clay in the alluvial horizon. It was noted influence of erosion processes on the mechanical composition of all soils: there is relief from the upper layers of eroded soils compared to non-eroded soils (due to fractions of fine silt and clay), a decrease in the content of physical clay. It was determined loading of the mechanical composition of washed-off soils.

Depending on the above-mentioned data, the agrophysical properties of eroded mountain soils were studied with regard to the elements of the slopes. It is determined alteration in the general physical properties of the soil by the vertical zoning.

The value of specific gravity is noted in the range of 2,56–2,72 g/cm3. It was noted an increase in the specific gravity of eroded typical and dark sierozem soils, mountain brown carbonate, typical and low-alkaline mountain brown soils with alteration in soil types and subtypes along the vertical zoning, as well as under the influence of erosion processes.

The volumetric mass of the soil varies within 1,21-1,42 g/cm3, and increases down the profile (1,50-1,58 g/cm3). Eroded soils have higher rates than non-eroded soils. From typical sierozem soils to dark soils, mountain brown carbonate, mountain brown typical, mountain brown low-alkaline soils, in accordance with changes in specific and volumetric mass, it was noted an alteration in soil porosity to 45,1-53,5%.

On the basis of conducted research, it was noted a relationship between the content of gross quantities of nitrogen, phosphorus and potassium in the of eroded soils composition, depending on the degree of their erosion. In all the studied soils, it is determined the maximum content of humus and nitrogen is observed in the arable and upper soil layers, and the direct connection of the dynamics of the plant nutrient, nitrogen, with the content of humus in soils. The same regularities is characteristic for mobile forms of phosphorus and potassium in soils. In the washed soils, the humus profile differs from the non-washed, and especially from the washed-away soils, and the humus content gradually decreases down the profile (Fig. 1)

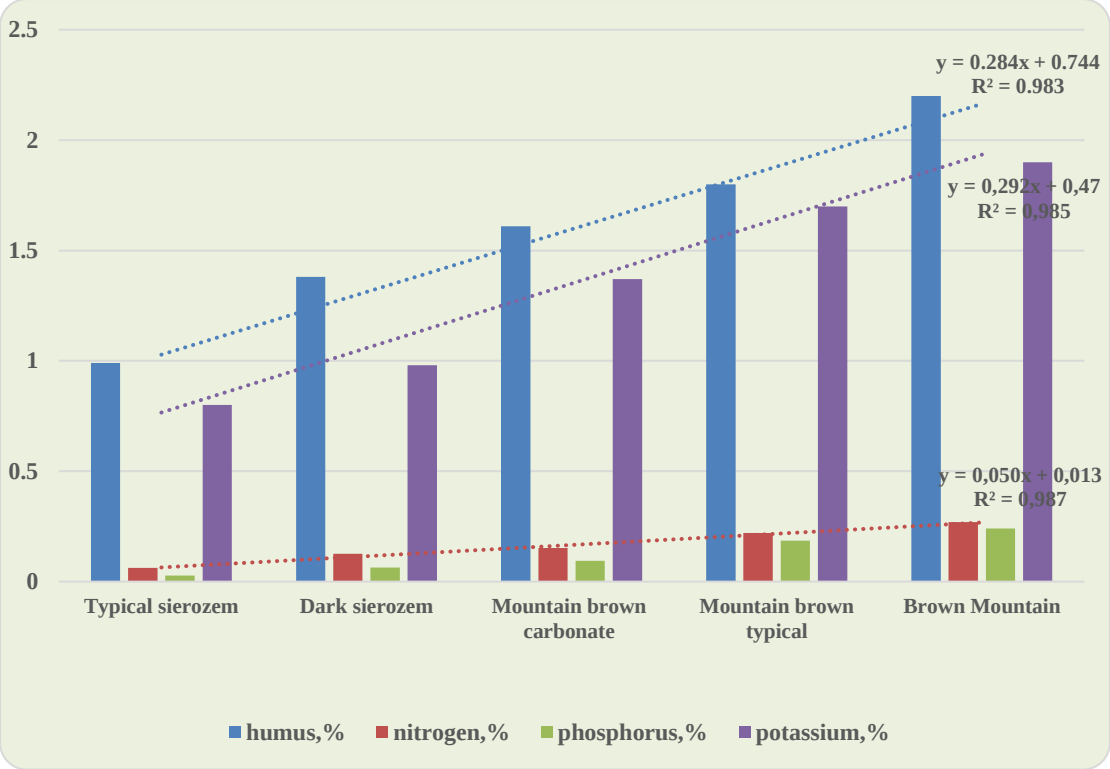

Figure. 1. Agrochemical indicators of eroded foothill and mountain soils

The content of CO2 carbonates from typical sierozem soils to mountain brown typical soils of the study area is 6,3–9,2%, and in mountain brown, low-leached soils, CO2 carbonates are 4,2–5,1%. In eroded soils, the carbonates content from the upper layers of soils have high rates, and in washed soils, on the contrary, low rates (Fig. 2)

Depending on morphogenetic, agrochemical and agrophysical properties, as well as the erosion processes of the mountain and foothill soils, the regularities are determined for distribution of the soil fauna. As the analysis of the obtained data shows, the distribution of 4 species of earthworms (Aporrectodea caliginosa trapezoidae, A. rosea, Aporrectodea caliginosa, Allolobophora kaznakovi), 33 species of nematodes (Cephalobus monus, C.corris, Chiloplacus bibiguelae, Mesodorylaimus bastiani, Eudorylaimus monhystera, E.obtusicandatus, Acrobeloides buetschii, A.emarginatus, Acrobeles innoxius, A. ciliatus, Ektophelenchus tenidens, Eudoraylaimus elegans, Tylenchus davainei, Plectus parietinus, Ironus ignavis, Drepanodorus laetificanus, Cephalobus persegnis, Eucephalobus laevis, Aphelenchoides xyloplilus, Aphelenchus avenae, Aphelenchoides limberi, Aphelenchoides parietinus, Bitylenchus dubius, Ditylenchus dipsaci, Ditylenchus tulaganovi, Helicotylenchus multicinctus, Rotylenchus robustus, Pratylenchus pratensis, Fylenchus filiformus, Prizmatolaimis dolichurus, Mylonchylus solus, Eudorylaimus obtusicaudatus, Eudorylaimus parvis,), 7 species of mollusks (Oxyloma elegans ,Pseudonopaeus sogdianus, Deroceras leave, Candaharia levanderi, C.issatullaevi, Leucozonella crassicosta, Xeropicta candaharica), 20 species of collembolans (Isotomiella minor Schaff, Proisotoma minuta Tullb, Onychiurus procompatus Gis, Folsomia guadrioculata Tullb, Ceratophusella armata Nic, Onychiurus fimatus Gisin, O. armatus Tullb, Jsotoma saltans Nic, Jsotoma hiemalis Schott, Jsotama veridis Bourl, Hypogastrura assimilis, Neanura muscorum, Orchesella flavescens, O. cincta, Tomocerus vulgaris, Pogonognathus plumbens, Sminthurus fuscus,.S.viridis, Tomocerus longicornis, Tetroden tophora bielanensis), and 21 species of ticks (Epilohmannia szanisloe Oudms, Thamnacarus pavlovski B.,Sphaerochthonius splendidus Berl, Damaeolus laciniatus Berl, Passalozetes perforatus Berl, P. variatepictus Mihelcic Berl, Licnoliodes andrei Grandj, Oppia nova Oudms, O.elliptica Berl, O. subpectinata Oudms, O. minus Paoli, Oribatufa venusta Berl, Zygoribatula skrjabini B – Z, Simkinia turanica Kriv, S. schachtachtinskoi kulijan, Scheloribates fimbriatus Thor, Microzetes arenarius Kriv, Protoribates capucinus Berl, Allogalumrna thysanura Crivol, Prothoplophova palpalis Berl, Oribotritia loricata Rathke).

The formation and development of soil fauna is inseverable linked with the type and subtype of soils, the regularities of their distribution, erosion processes and climatic conditions. High humus horizons are environmentally friendly habitat for multiple soil fauna. In the life of the soil fauna organic matter, in particular humus, plays an important role.

Table 1 The number of pedofauna in the soils of the northern spurs of Turkestan Range (pieces/m²)

Pedofauna	Typical sierozem soils	Dark sierozem soils	Mountain brown carbonate	Mountain brown typical	Mountain brown weakly leached
Earthworms, pieces/m²	>2	3-10	3-12	4-13	5-16
Mollusks, pieces/m²	2-4	4-6	6-7	7-8	7-9
Collembolans, pieces/m²	10-15	16-21	16-26	25-28	30-38
Nematodes, pieces/m²	40-50	46-56	55-111	58-90	60-120
Ticks, pieces/m²	35-38	32-36	29-30	28-30	20-30

The quantitative distribution and of soil fauna activity alters in the correlative connection of the humus profile and the distribution of pedofauna in it, which confirms the important role of the biological factor in the process of soil formation: a decrease in the humus content in medium eroded soils and proportionally with it a sharp decrease in the number of soil invertebrates; a gradual decrease in the humus content along the soil profile of the non-eroded and especially washed soils and in proportion with it the decrease in the number of soil invertebrates. In moderately eroded soils, there is no sharp decrease in the number of ticks compared to collembolans, mollusks, and earthworms. It was noted a large number of collembolans and mollusks in washed soils. The number of soil fauna increases in the sequence of the typical sierozem soil - dark sierozem soil - mountain brown carbonate - mountain brown typical - mountain brown low-leached soils (Table 1). The number of earthworms, mollusks and collembolans increases from sierozem soils to mountain brown soils in comparison with the number of ticks and nematodes. The main part of pedofauna along the profile is found at a depth of 0-10 cm: in typical and dark sierozem soil in the 0-10 cm layer is 40,7-60,4%, in mountain brownish carbonate, in typical and weakly leached mountain brown soils – 78,7-82,3%. It was determined a decrease of the amount of soil invertebrates from 13,5–30,5% from 10–20 cm of the layer, and especially from 0,6 to 5,5% from 20–30 cm of the layer and down along the profile, especially in moderately eroded soils. In all soils, invertebrates are noted in spring in a larger quantity except for ticks (April – May), relatively less in summer (July – August) and in autumn. In spring, pedofauna occurred mainly at a depth of 0-10 cm, in summer and autumn mainly at a depth of 10-20 cm. In the profile of eroded soils, the number of pedofauna is sharply reduced, especially earthworms and collembolans relative to ticks and nematodes.

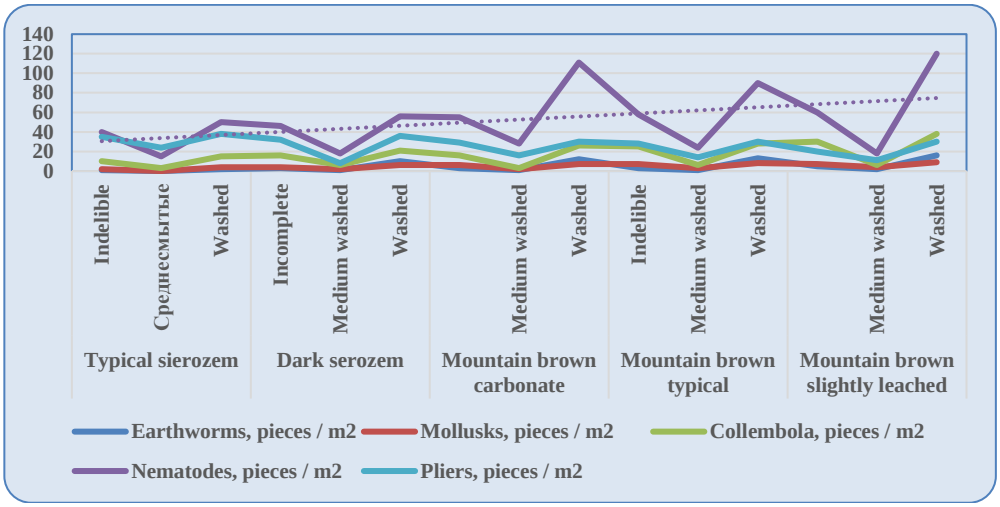

Figure. 2. Distribution of soil fauna in foothill and mountain soils

In washed and non-eroded soils, a correlative relationship was observed between soil invertebrates and humus, nitrogen, phosphorus, potassium, the content of physical clay and soil density: humus, nutrients and nematodes r = 0,63-0,75, ticks r = 0,62-0,70, mollusks r = 0,68-0,76, collembolans r = 0,81-0,90, earthworms r = 0,86-0,93. The correlative relationship is used in determining fertility and soil erosion degree.

Eroded soils on the activity of the soil fauna can be placed in the following descending order: totally washed – non-eroded – medium-eroded (Fig. 2). Based on the soil studies, criteria for the indicator of erosion of mountain soils by pedofauna were developed and soil diagnostics based on them and soil-ecological monitoring were recommended.

CONCLUSION

Confinement of the studied soils to arid mountain and foothill zones, thinning of the vegetation cover, low humus content on the slopes, the development of degradation processes are reflected in soil susceptibility to erosion processes, as well as morphological, physical, chemical and biological properties of soils.

Soils of the territory vary in the pedofauna species composition; in all soils it is observed the superiority of nematodes, collembolans and ticks, their dominance in the upper layers of the soil. The distribution of 4 species of earthworms, 33 species of nematodes, 7 species of mollusks, 20 species of collembolans and 21 species of ticks was determined in the soil composition. Eroded soils by the activity of pedofauna are placed in the following descending sequence: totally washed - non-eroded - medium -eroded. The amount of soil fauna increased in sequence of typical sierozem soil - dark sierozem soil - mountain brown carbonate - mountain brown typical - mountain brown weakly leached soils.

Correlative distribution of the humus profile and pedofauna confirms that the biological factor is an important factor in soil formation process: there is a decrease in the humus content in medium eroded soils and, in proportion with it, a sharp decrease

in the number of soil invertebrates; a gradual decrease in the content of humus along the soil profile of non- eroded, and especially washed soils, and in proportion with it a decrease in the number of soil invertebrates (earthworms, mollusk, collembolans). There is no sharp decrease in the number of ticks in medium eroded soils. Collembolans are expressed in large quantities in the washed soils.

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