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Agrochemical and Ecological Conditions of Brown Forest Soils Determined by Degradation Factors by the Example of Bazum Community of Lori Region

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ABSTRACT

The article presents the direction of degradation processes in eroded forest brown soils based on the example of the Bazum community of the Lori region. It also shows the qualitative characteristics of these soils, the thickness, the degree of humus content, and the availability of nutrients. New technologies and methods of resource-saving tillage and plant care are proposed to mitigate erosion processes, degradation, and desertification of soils based on the research conducted.

Introduction

One of the global problems facing human society today is land degradation and desertification. The land is very precious and essential to everything in this world. The Sustainable Development Goals (SDGs) are one of the ways proposed by the United Nations in 2015 to achieve a better and more sustainable future for all. An increase in pressure on land is very likely to happen in order to achieve the SDGs related to food, health, water and climate (www.sdgs.un.org).

Soil erosion is a growing problem that threatens soil quality and soil's ability to provide environmental services. Soil detachment, deposition, and transport processes occur simultaneously during erosive rainfall. As a result, nutrients, soil organic carbon, and valuable soil biota are transported. At the same time, the species diversity of plants, animals, and microbes is significantly reduced (www.fao.org). The off-site impacts of eroded soil and runoff, primarily eutrophication of water bodies, sedimentation of gravel-bedded rivers, loss of reservoir capacity, and flooding of roads and communities, are increasingly recognized and the costs estimated (Ascough and Flanagan, 2011). Against the background of climate change and accelerated human activities, changes in natural rainfall regimes have taken place and erosion processes will be expected to become more pronounced in future decades (United Nations, 2000; www.fao.org). Long-term shifts may challenge cultivation systems worldwide and eventually alter land use and topography spatiotemporal patterns. All these changes will increase pressure on soil erosion processes, making accurate erosion prediction and control harder. Thus, improved knowledge and understanding of the soil-erosion process will be essential for dealing with forthcoming challenges regarding soil-conservation practices (Flanagan, 2002).

Being located in the dry and terrestrial part of the subtropical climate zone the Republic of Armenia, represents a drought risk zone (Kroyan, et al., 2022). Desertification processes, which became more active, especially during the socio-economic crisis, with their special manifestations, currently cover most of the republic's territory (Markosyan, 2007). Although desertification phenomena are very diverse and multifaceted, one of the main factors contributing to land degradation and desertification processes in RA is soil erosion (Kroyan, et al., 2022).

Materials and methods

The object of research was the brown forest soils of the Lori region. Comparative studies were conducted on non-eroded, slightly, and moderately eroded arable and uncultivated soils of the Bazum community. To assess the agrochemical and ecological conditions of the mentioned soils, soil sampling was done according to soil layers (0-10; 10-20; 20-40; 40-60 cm). The studies were carried out through field experiments and laboratory research.

Field investigations were conducted on brown forest soils. All soil samples were taken using the Burkle Soil Sampling Kit. After being transported to the laboratory, the stones and plant remains were removed from the samples, then dried under room conditions (20-22 ^{0}C). After drying samples were ground and passed through a 2 mm sieve (soil was not crushed only for humus determination). Soil agrochemical and physicochemical indicators (*pH*, humus content, carbonates, mobile nutrients, water-resistant aggregates, absorbed cations, concentration of the mobile form microelements, and mechanical composition) have been determined. The *pH* of the soil was estimated by dipping the pH electrode meter in the saturation paste (ISO 10390:2005 Soil quality – Determination of pH). Total carbonate content was quantified by acid dissolution and subsequent release of titrimetric CO_2 (ISO 10693:1995 Soil quality – Determination of carbonate content). The sample content of humus substances was determined by Turin's method for the determination of organic carbon (using titration with phenyl anthranilic acid). The mechanical composition was determined by the classical pipette method and evaluated according to the Kachinsky classification scale. The easily hydrolyzable nitrogen in the samples was extracted and determined using the method of Tiurin and Kanonova, which is considered to be an indicator of mobile nitrogen compounds, mobile phosphorus was determined using Machigin's method, which is based on the principle of removing them by a 1 % $(NH_4)_2SO_4$ solution, while the exchangeable potassium was quantified using Maslova's method (USSR scientists), the quantity of exchangeable calcium (Ca^{2+}) and magnesium (Mg^{2+}) according to Arinushkina method (1962). The mobile or leachable microelements fraction was extracted using an acetic acid–ammonium hydroxide as a buffer solution adjusted for *pH* 4.8. The samples were left at room temperature in the buffer solution for 24/h soaking and shaken 5-7 times during the soaking period.

After 24/h, the solution was shaken again and filtered. The mobile or leachable forms of microelements (*Cu, Pb, Cd, Zn, Mo*) in the filtrate were quantified using an atomic absorption spectrophotometer (AAS-1) (He, et al., 1979; Taylor, 2001).

Results and discussions

Field experiments were conducted in 2021–2022 on the brown forest soils of the Lori region at Bazum community, which is 1615 m high above sea level. Preparatory activities were implemented per trial patterns presented in appropriate tables and figures. Forest brown soils are of medium strength and have a medium and heavy loamy-sandy mechanical composition. The structure is grainy-lumpy, porous, and carbonate-free.

The results of field and laboratory research have indicated that along with the depth of the soil layer, a certain weighting of mechanical components is observed. The content of physical clay in the 40-60 cm layer reaches 55.1 % (Table 1). The soils are saturated with alkaline-earth metals, where Ca^{2+} predominates. Its amount in the upper layer reaches 41.27 mg/eq per 100 g soil. The Mg^{2+} content is 6.22 mg/eq per 100 g soil. Table (2) shows that in uncultivated, non-eroding soils, the amount of water-proof aggregates is quite high, which ensures favorable hydrophysical properties of these soils. Particles with diameters of 3-5 mm and 1-3 mm prevail in water-proof aggregates. In the soils upper horizons, the water-resistant aggregates content is 64.58-71.3 %, and in the lower horizons, a noticeable decrease in their content is observed (Table 2).

The slightly and moderately eroded uncultivated areas are weakly, moderately and strongly rocky at the surface. The lower horizons appear rocky. Humus content is quite high, 7.4 % in the 0-10 cm layer. Humus-accumulating horizons in eroded plots range from 20-40 cm. The humus content in the upper horizons of slightly eroded uncultivated soils is 2.6-6.0 %. In the same horizons of moderately eroded soils, this indicator is 2.1-4.2 % (Table 2). The composition of alkaline earth metals is dominated by Ca^{2+}, whose content in the upper layer of slightly disturbed soils is 29.08 mg/eq per 100 g soil, and 19.07 mg/eq per 100 g soil in medium/moderately disturbed soils (Table 1).

Table 1. Physico-Chemical Characteristics of Test Site Soils (Lori Region. Bazum Community)*

The State of the soil. Degree of Erosion	Sampling depth. cm	Absorbed cations. mg eq in 100 g soil			< 0.01 mm – the sum of particles (phys. clay). %	$CaCO_3$ according to CO_2. %
		Ca^{2+}	Mg^{2+}	Total		
Uncultivated. Non-Eroded	0-10	41.27	6.22	47.49	43.6	-
	10.0-20	14.19	2.11	16.3	48.3	-
	20-40	15.38	0.83	16.21	42	-
	40-60	21.72	2.05	23.77	50	-
Uncultivated. Slightly Eroded	0-10	29.08	6.01	35.09	42	5.38
	10.0-20	26.1	6.11	32.21	44.1	5.53
	20-40	25.35	6.27	31.62	36.8	7.04
	40-60	-	-	-	47.9	10.8
Uncultivated. Moderately Eroded	0-10	19.07	10.1	29.17	40.7	0.32
	10.0-20	18.2	12.2	30.22	46	0.33
	20-40	17.2	10.43	27.63	51	0.33
	40-60	-	-	-	55.1	0.83
Arable land. Slightly Eroded	0-10	23.01	2.08	25.09	54	6.44
	10.0-20	24.2	2.79	26.99	40.5	6.03
	20-40	34.36	2.19	36.55	36	6.49
	40-60	-	-	-	51	6.79
Arable land. Moderately Eroded	0-10	22.29	3.1	25.39	32	-
	10.0-20	23.28	4.01	27.29	34.5	-
	20-40	23.07	4.05	27.12	44	-
	40-60	-	-	-	46.3	-

Table 2. Agrochemical Characteristics of Test Site Soils (Lori Region, Bazum Community)*

The state of the soil, degree of erosion	Sampling Depth, cm	*pH*	Humus, %	Water-resistant aggregates, %
Uncultivated, Non-Eroded	0-10	6.8	7.4	-
	10.0-20	7.1	5	64.58
	20-40	7.2	2.4	71.3
	40-60	7.6	1.6	50
Uncultivated, Slightly Eroded	0-10	7.3	6	-
	10.0-20	7.9	3.8	57
	20-40	7.8	2.6	65.4
	40-60	7.9	1.3	74.6
Uncultivated, Moderately Eroded	0-10	7.2	4.2	-
	10.0-20	7.2	3.5	67.1
	20-40	7.6	2.1	69.9
	40-60	7.6	0.89	71.52
Arable land, Slightly Eroded	0-10	7.9	4.1	-
	10.0-20	8.4	2.8	54.92
	20-40	8.6	2	52
	40-60	8.7	1.1	52
Arable land, Moderately Eroded	0-10	7.2	3.9	-
	10.0-20	7.6	3.2	38.32
	20-40	7.6	2.6	40.2
	40-60	8	1.8	32.4

*Composed by the authors.

Research results show that there is a significant difference between uncultivated, non-eroded, slightly, and moderately eroded soils and cultivated variants. That difference is particularly evident in the hummus content. If it is 7.4 % in the upper horizon of uncultivated soils, it decreases to 6.0 % in weakly eroded soils, and 4.2 % in moderately eroded versions (Table 2). Significant differences are also felt in absorbed Ca^{2+} and Mg^{2+}. The content of Ca^{2+} in uncultivated non-eroded plots of land is higher (41.27 mg/eq per 100 g soil) than in arable soils subjected to different degrees of erosion, where it is 29.08 mg/eq per 100 grams of slightly eroded soils and 19.07 mg/eq in per 100 grams of moderately eroded soils. In contrast to Ca^{2+}, *Mg* content in soils exposed to different degrees of erosion significantly increases (Table 1). From the analysis of the water-resistant aggregate data, it becomes clear again that there is a big difference between the uncultivated non-eroded versions and the cultivated eroded plots. Thus, if the indicated index in the upper layer of uncultivated soils is 64.58 %, then in the arable layer of slightly eroded soils it is 54.92 %, and in moderately eroded versions it is 38.32 % (Table 2). According to Tables 1 and 2, the humus content in the upper layers of the soil (0-10 cm) varied from 3.9-7.4 % depending on the degree of erosion, the reaction of the soil solution (*pH*-6.8-7.9) varies between neutral and alkaline, they have a loamy-sandy medium and heavy mechanical composition.

A similar pattern is also observed from the point of view of the content of mobile nutrients-nitrogen (*N*), phosphorus (P_2O_5), and potassium (K_2O) in the soil. Thus, the highest amounts of these elements were recorded in the A horizon of the untreated, non-eroded version: *N*-7.0, P_2O_5-4.7, and K_2O-35.6 mg/100 g of soil, decreasing with depth (Figure 1).

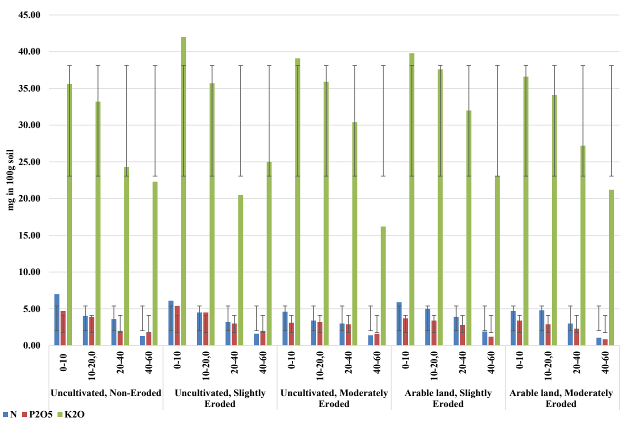

Figure 1. Mobile nutrient content of test site soils *(composed by the authors)*.

The mobile content of microelements, depending on the degree of soil erosion, the amount of humus, mechanical composition, and other factors, varies in the upper 0-20 cm layer: *Cu*-2.8-16.4, *Pb*-2.8-25.10, *Cd*-0.26-1.80, *Zn*-6.3-25.3, *Mo*-0.60-5.6 mg/kg (Figure 2). In Figure 2, microelements are mostly found in the humus horizon (0-10), which proves the correlation between humus and microelements, and the content decreases with depth. To compare the content of microelements, the MPC* indicators (maximum permissible concentration) were used (Chernykh and Sidorenko, 2003).

Conclusion

Based on the studies and analysis, we can say that, along with the increase in the degree of erosion of brown forest soils, the capacity of soil shear, the amount of humus and essential nutrients, the amount of water – resistant aggregates of high value from an agronomic point of view (>0.25 mm) decreases, the specific and volumetric weights increase, the overall porosity decreases, the background contents of microelements decrease along with the depth, which ultimately leads to a decrease in the efficiency of agricultural land types.

It is recommended:

• To fight against erosion phenomena and the degradation of these lands, it is necessary to practice farming agriculture according to the outline-landscape principle. i.e., to carry out all the agricultural works (tilling, sowing, fertilization, etc.) according to the contours of the slope, to perform fertilization at high rates (organic fertilizer: 30-35 t/ha, the purpose of fertilization with such a dose is to bind

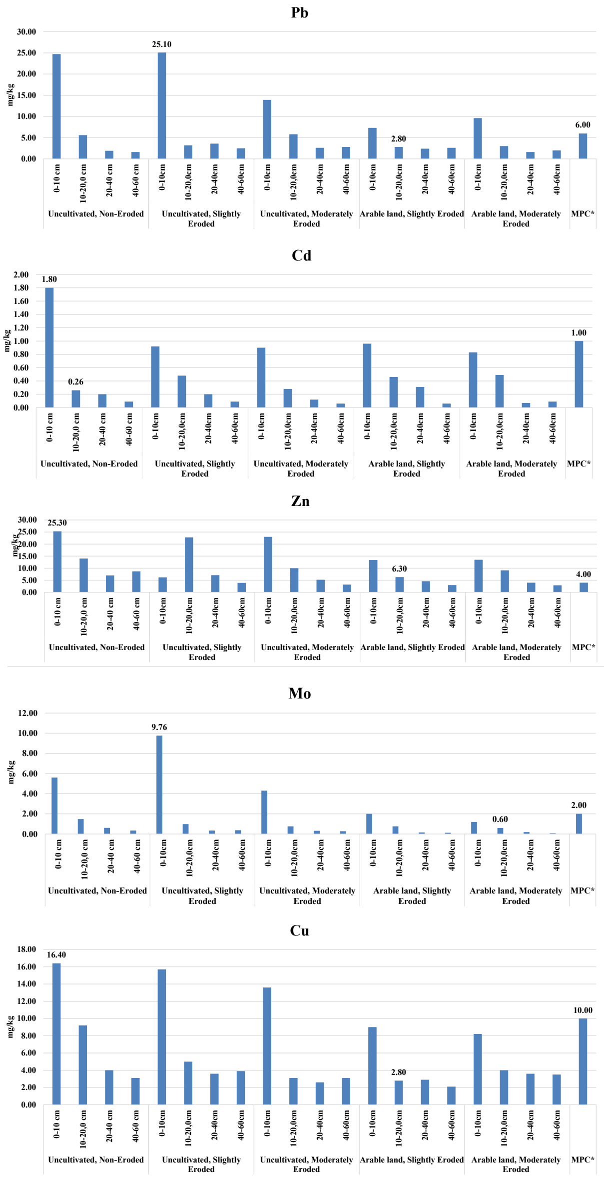

Figure 2. The concentration of the mobile form microelements (*Pb, Cd, Zn, Mo, Cu*) in different degrees of forest brown soils (Lory Region, Bazum Community) *(composed by the authors)*.

microelements in the soil and is to make them available for further use by plants).

• To place crops according to soil protection properties, and apply crop rotations. In heavily eroded and uncultivated arable lands it is necessary to cultivate butterfly-flowered and perennial cereal grass mixtures, which will significantly reduce erosion processes, restore the degraded soil structure, increase the reserves of organic matter, improve the agrophysical properties of the soil, making it possible to return it to agricultural circulation.

• To increase the efficiency and productivity of grasslands and pastures (especially near the community), it is necessary to implement radical (fertilization NPK 60:60:60 and sowing with grass mixtures) and surface improvement measures and apply effective pasture rotation/ circulation schemes.

References

1. Ascough, J.C., Flanagan, D.C. (2011). International Symposium on Erosion and Landscape Evolution Abstracts. ASABE Publication N. 711P0311. St. Joseph, Mich. ASABE.
2. Arinushkina. E.B. (1962). Guide to chemical analysis of soils, Publishing house MGU, Moscow, - p.492.
3. Chernykh, N.A., Sidorenko, S.N. (2003). Environmental monitoring of toxicants /toxic substances/ in the biosphere. Monograph. - Moscow. Publishing house of RUDN, - p. 430.
4. FAO (2000). Land Resource Potential and Constraints at Regional and Country Levels. World Soil Resources Report 90. Rome, Italy. United Nations FAO, Land, and Water Development Division. Available at: ftp.fao.org/agl/agll/docs/wsr.pdf (accessed on 12.05. 2023).
5. FAO (2012). Managing Living Soils; Global Soil Partnership International Technical Workshop: Rome, Italy, - pp. 20–25 http://www.fao.org/documents/card/en/c/d018fe5b-59af-454e-8a27-8c75b671ba37/ (accessed 09.05.2023).
6. Flanagan, D.C. (2002). Erosion in Encyclopedia of Soil Science, R. Lal, ed. New York. Marcel Dekker, - pp. 395-401.
7. He, Q., Ren, Y., Mohamed, I., Ali, M., Hassan, W., Zeng, F. (2013). Assessment of trace and heavy metal distribution by four sequential extraction procedures in contaminated soil. - Soil Water Res. 8(2), - pp. 71-76.
8. ISO 10390:2005 Soil Quality-Determination of pH, Edition 2, Technical Committee: ISO/TC 190/SC 3 Chemical and physical characterization.
9. ISO 10693:1995 Soil Quality-Determination of carbonate content—Volumetric method, Edition 1, Technical Committee: ISO/TC 190/SC 3, Chemical and physical characterization.
10. Ivanov, D.N., Lerner, L.A. (1979). Methods for the determination of trace elements in soils, plants. - M., - pp. 242-263.
11. Kroyan, S., Khoyetsyan, A., Khachatryan, S., Sanosyan, G. (2022). Geography of soils based on soil science, book two, geography of soils, ISBN 978 9939-893-0, Yerevan, - p.178.
12. Markosyan, A.O. (2007). Effectiveness of minimal and zero soil tillage for winter wheat in the steppe zone of the Republic of Armenia. Journal of the State Agrarian University of Armenia, international conference, 3, - pp. 77-79.
13. Taylor, H.E. (2001). ICP-MS Practices Techniques, USA, chapter 3, - pp. 15-27.
14. United Nations, (2000). Convention to Combat Desertification, RA Ministry of Environmental Protection, “Dar”, Yerevan, - p. 142.
15. https://sdgs.un.org/gsdr/gsdr2023. Global Sustainable Development Report (accessed 16.05.2023).

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