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CHANGES IN THE GRANULOMETRIC COMPOSITION OF EROSIONED MOUNTAIN GRAY-BROWN SOILS IN THE GOBUSTAN REGION DEPENDING ON THE DEGREE OF EROSION

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The soils of the study area are mainly mountain gray-brown type soils, and the resistance of these soils to erosion is quite weak. Therefore, it is important to take preliminary measures to increase the resistance of these soils to erosion. The morphological structure and morphometric indicators of mountain gray-brown soils formed in complex relief conditions are diverse. Basically, these indicators vary depending on the slope and other geomorphological parameters. These characteristics of the soils were observed in all areas of the study area. These characteristics vary depending on the degree of soil erosion. Our studies have considered these issues.

The granulometric composition of ordinary mountain gray-brown (chestnut) soils is heavy, mainly clayey and heavy clayey types prevail. The amount of silt particles in the upper layer is 27±3.2%, and the amount of physical clay is 60±4.5%. In some regions, the amount of physical clay increases to 72%. The amount of silt particles is higher in the middle part of the profile, which causes the appearance of signs of clay formation in this horizon. The mineralogical composition of the soils has similar characteristics to other subtypes.

***Keywords**: mountain gray-brown soils, erosion, granulometric composition, diagnostic indicator.*

INTRODUCTION

The relief of the southeastern slope of the Greater Caucasus is very complex, and steep slopes are widespread here. The rocks distributed in this area are mainly of sedimentary origin, with a marine-derived silty, clayey, and sandy granulometric composition [1, p. 309], [7, p. 340].

The erosion process affects the morphological structure of soils, their diagnostic indicators [6, p. 38]. It is known that each size of granulometric composition indicator has its own physicochemical properties [4, p. 388-396]. The amount of these sizes also changes the fertility properties of the soil. Many studies have already shown that granulometric indicators, along with the physicochemical properties of the soil, play an important role in the formation of its agronomic properties [8, p. 137].

The increase in the amount of large particles in the soil typically leads to a reduction in humus and biogenic elements, as coarser particles have a lower capacity to retain organic matter and nutrients compared to finer particles. Consequently, the granulometric composition becomes a key factor influencing the progression of the erosion process, and it changes in response to the degree of exposure to erosion. As erosion intensifies, larger particles tend to be more easily removed, leaving behind finer particles that are more resistant to transport.

On the other hand, an increase in the proportion of fine silt particles within the soil can enhance its fertility. Fine silt particles have a greater surface area, which allows for better retention of nutrients, water, and organic matter, all of which contribute to soil fertility. However, it is not only the granulometric composition that determines soil fertility. The presence of humus, as well as biogenic elements like nitrogen, phosphorus, and potassium, are essential components that further enhance soil fertility.

Therefore, both the physical structure of the soil, reflected in its granulometric composition, and the chemical properties, such as the amount of humus and biogenic elements, play a vital role in determining the overall fertility and productivity of the soil. Researchers have determined that the physical and water-physical properties of clay soils are often considered unfavorable [2, p. 344], [11, p. 416]. Therefore, soils with a heavy granulometric composition are considered to be poorly fertile soils.

The high carbonate content of soils in the study area plays a pivotal role in shaping their physical and chemical properties. These carbonates, which have a lithogenic origin, are primarily derived from the parent rock material, meaning they are inherited directly from the surrounding bedrock through weathering and mineral transformation processes. Lithogenic carbonates, such as calcium carbonate ($CaCO_3$), are often present in high concentrations in regions where the underlying rock is rich in carbonate minerals.

As the distance from the parent rock decreases, the concentration of carbonates in the soil increases. This is a key feature of lithogenic carbonate-rich soils, where the proximity to the bedrock directly influences the amount of carbonates present in the soil profile. The greater the amount of carbonate material in the soil, the more it affects the soil's structure and erosion resistance.

The presence of this composition, especially in the development of ravine erosion, increases the likelihood of erosion processes [5, p. 626-629].

The composition of the soil is a mixture of elementary particles consisting of various minerals and small amounts of organic residues. These particles are elements present within the soil structure and are called granulometric composition. These elementary particles, which have different sizes, are considered the main indicator of the granulometric properties of the soil. Granulometric particles are divided into categories such as stone, sand, dust and silt according to their size [10, p. 162-163]. These composition indicators, in addition to affecting various properties of the soil, are one of the factors that play a major role in its erosion.

MATERIAL AND METHODS

The research work was carried out on mountain gray-brown soils in the Gobustan region, which is part of the economic region of the Upper Shirvan region, at an absolute altitude of 650-840 m. In 2017, sections were made in the soil area where we conducted the experiment and soil samples were taken. Analysis of morphological profiles of eroded mountain gray-brown soils shows that leaching creates an unfavorable environment in the soils. In particular, the granulometric composition, water-physical properties, porosity, aggregate composition are significantly transformed. Moisture indicators, density and many other properties are changed. The granulometric composition was determined using the N.A. Kachinsky scale by decomposition with sodium pyrophosphate.

RESULTS AND DISCUSSION

According to the granulometric composition, clayey and heavy clayey types prevail in mountain dark gray-brown (chestnut) soils and the differentiation of the profile is clearly observed [9, p. 31]. Signs of clay formation are clearly visible in the middle parts of the profile (B2, B/C horizons). Clay formation has metamorphic properties and montmorillonite and hydromica minerals are dominant in the composition of clay minerals in these soils.

These soils do not show signs of salinization. Although the general chemical composition of the genetic layers is close to each other, the amount of oxides is somewhat higher. Most of the dark mountain gray-brown (chestnut) soils are located outside the irrigation zone and are mainly used for rainfed agriculture (grain, orchards, vineyards) [9, p. 30-31]. However, only a small part of these soils is located in the plume zone and is used under irrigated crops.

In the experimental field, a consistent trend is observed regarding the change in granulometric composition of the soils along the profile, which remains relatively the same regardless of the degree of erosion. This trend shows a clear and noticeable increase in the amount of physical clay as the soil depth increases. This observation is evident across all soil sections examined, and it strongly suggests a relationship between the soil’s granulometric composition and the underlying geological formations.

The increase in clay content with depth points to a natural process of soil development influenced by the parent rocks. In the region of the Greater Caucasus, including its southeastern slope, clayey rocks are dominant in the bedrock. The soil's characteristics, therefore, appear to be a direct result of the composition and texture of these parent rocks. Clay minerals, being fine-grained and highly weatherable, tend to accumulate in the soil profile over time, particularly as deeper horizons form and the soil undergoes various processes of mineral weathering and leaching. The clay content increases with depth likely due to the fine particles of clay being less mobile compared to coarser particles such as sand or silt. As water moves through the soil profile, the finer clay particles tend to remain in place, while larger particles are often transported downward or removed by water movement. This results in a higher concentration of clay at greater depths, which can also be influenced by the slow process of clay illuviation — the downward movement of clay from upper soil layers to lower horizons.

It can thus be concluded that the changes in the soil's granulometric composition along the profile are strongly linked to the parent rocks of the region. The predominance of clayey rocks in the Greater Caucasus and its southeastern slope is a key factor in determining the texture and structure of the soils in the area. The accumulation of clay in the deeper soil horizons is a direct reflection of the lithological characteristics of the bedrock, which has a lasting influence on soil formation processes in this region [3, p. 216]. Thus, as the depth increases along the profile, the amount of physical clay also increases. The ratio of the amount of physical clay in the rocks to the amount of physical clay in the soil was 1.15 in non-eroded soils, 1.58 in slightly eroded soils, and 1.36 in moderately eroded soils [5, p. 626-629].

Table

The change in granulometric composition of soils in the study area depending on the degree of erosion

Degree of erosion	Genetic layers, in cm	Hygroscopic moisture, in %	Particle size (mm)						
			1-0,25	0,25-0,05	0,05-0,01	0,01-0,005	0,005-0,001	<0,001	<0,01
Non-eroded N40^{0}31′ 31′,0″ E48^0 53′ 28,2″	AYca0-22 ABca22-46 Bca 46-72 BCca72-98 Cca98-135	5,11 5,06 6,31 6,78 5,95	0,78 0,84 0,21 2,26 0,17	23,62 25,16 20,99 9,34 17,03	23,60 23,20 11,60 12,80 22,40	15,20 14,40 25,60 19,20 11,60	17,60 16,00 23,20 30,40 30,00	19,20 20,40 18,40 26,00 38,80	52,00 50,80 67,20 75,60 70,40
Slightly eroded soil N40^{0}31′ 35′,9″ E48^0 53′ 38,8″	AYca 0-16 ABca16-30 Bca 30-51 Bcca51-68 Cca68-98	4,92 5,06 5,00 6,91 7,03	0,65 0,65 0,74 0,16 0,50	23,75 21,35 18,46 9,44 4,70	25,20 25,60 29,20 17,20 15,60	21,20 20,80 21,20 15,20 12,40	17,60 17,20 16,40 13,60 14,80	12,60 14,40 14,00 24,40 32,00	45,40 43,40 50,60 65,20 62,10
Moderately eroded N40^{0}31′ 04′,5″ E48^0 53′ 56,0″	AYca 0-10 ABca10-20 Bca 20-44 BCca 44-68	4,85 5,23 6,05 6,13	0,69 0,52 2,00 3,35	25,31 22,28 7,60 7,85	24,40 24,80 25,20 21,60	20,00 21,20 12,40 14,80	17,20 17,60 37,60 15,20	9,40 10,60 10,20 16,20	34,60 32,40 43,20 53,20
Moderately eroded N40^{0}31′ 46′,2″ E48^0 53′ 53,4″	AYca0-8 ABca 8-18 Bca 18-29 Bcca29-40	4,48 4,95 6,07 6,98	1,18 1,56 1,83 0,35	34,82 13,24 6,17 7,65	20,00 36,00 25,20 20,80	17,20 17,20 6,00 11,60	13,20 18,80 21,20 22,40	7,60 10,20 10,60 17,20	32,00 30,20 42,80 51,30

The particle diameters, soil density, and structure shown in table describe the soil characteristics. The sizes of soil particles vary significantly across different degrees of erosion, reflecting the extent to which erosion has impacted the soil's structure. In non-eroded soils, the particle diameters typically range from less than 0.001 mm to 0.25 mm. These values indicate that the majority of the soil consists of fine and small particles, particularly clay, silt, and very fine sand. Such particles are crucial for maintaining soil structure and fertility, as they have a larger surface area that can retain moisture, nutrients, and organic matter.

The predominance of fine particles in non-eroded soils is a key feature that contributes to their high water retention capacity and overall soil health. These fine particles, especially clay and silt, provide the soil with a stable texture that supports plant growth, allows for better aeration, and retains essential nutrients. They also help improve the soil's ability to resist erosion because smaller particles are more likely to stay in place, forming a cohesive structure that can better withstand external forces like wind and water.

As erosion progresses, however, the proportion of these fine particles in the soil decreases, replaced by coarser particles, which can negatively impact the soil's physical properties. The removal of fine particles reduces the soil's ability to retain water and nutrients, leading to a decline in fertility and an increased susceptibility to further erosion. Therefore, understanding the particle size distribution in soils and its relationship to erosion is critical for developing effective soil conservation strategies and ensuring sustainable land use.

In moderately eroded soils, the particle sizes are more diverse, as the erosion process alters the soil structure, leading to the formation of larger particles. In slightly eroded soils, the largest particle size typically ranges between 0.25 mm and 0.05 mm. This is because, in these soils, the erosion process has been minimal, meaning that the finer particles have not been significantly washed away. As a result, the soil maintains a greater proportion of larger particles, such as sand and coarse silt. The relatively larger particle sizes help to preserve the structural integrity of the soil, allowing it to retain its natural texture and composition. These soils tend to be more stable and less prone to the erosion process, which helps in maintaining their fertility and overall soil health.

In contrast, in non-eroded soils, hygroscopic moisture levels are relatively high, ranging between 5.11% and 6.78%. Hygroscopic moisture refers to the water that is tightly bound to soil particles, particularly the fine particles like clay and silt. This high level of hygroscopic moisture indicates that the soil has a strong ability to retain water. The presence of finer particles, such as clay and silt, increases the soil's surface area, allowing it to hold more water compared to coarser soils. Soils with high water retention are more capable of maintaining moisture for plant roots, especially during dry periods, which can enhance soil fertility and support plant growth.

These characteristics are closely linked to the soil's ability to support vegetation. Soils with higher water retention and larger particle sizes typically have better aeration and root development conditions. This is particularly important in non-eroded soils, where the minimal impact of erosion allows for a balance of soil moisture retention and drainage, making it suitable for healthy plant growth. Conversely, slightly eroded soils, with a predominance of larger particles, may not retain water as effectively, requiring more careful management of irrigation and soil moisture.

In moderately eroded soils, the hygroscopic moisture content typically ranges from 4.85% to 6.05%. This is a noticeable decline compared to non-eroded or slightly eroded soils, indicating that as erosion progresses, the soil's ability to retain water decreases. Erosion tends to remove finer particles, such as silt and clay, which are essential for holding water. As a result, the remaining soil becomes coarser, with a higher proportion of sand and larger particles that have a reduced capacity to retain moisture.

In slightly eroded soils, the hygroscopic moisture content varies between 4.92% and 7.03%. This range is slightly higher than in moderately eroded soils, reflecting the still-present influence of fine particles like clay and silt, which contribute to the soil's higher water retention capacity. Despite the erosion, these soils still maintain a better balance of particle sizes, allowing them to hold more moisture than their more eroded counterparts.

The decrease in water retention capacity in eroded soils suggests that erosion not only affects the physical structure of the soil but also its hydrological properties. As the finer particles are removed by erosion, the soil becomes less capable of retaining water, which can lead to reduced soil fertility and diminished plant growth. This loss of water retention capacity further exacerbates the impacts of erosion, as the soil becomes more prone to drying out during periods of low rainfall. Consequently, soil conservation measures become even more critical in eroded areas to mitigate water loss, restore soil structure, and maintain agricultural productivity.

CONCLUSION

According to the table, soil erosion has a significant impact on the physical properties of the soil. Non-eroded soils have the highest productivity and water retention capacity, while moderately and slightly eroded soils lose these characteristics, resulting in decreased soil fertility. Combatting erosion, implementing effective soil conservation measures, and reducing the adverse effects of erosion are crucial steps in maintaining soil health and ensuring long-term agricultural productivity. As discussed earlier, changes in the granulometric composition of soils are deeply tied to the soil formation process, which in turn is influenced by the granulometric composition of the parent material. The interaction between the parent material and the weathering processes that shape the soil over time determines the proportions of sand, silt, and clay particles in the final soil profile.

Given this direct relationship between the parent material and the resulting soil texture, it becomes evident that when soil cultivation and land management practices are carried out, a comprehensive understanding of the key indicators of the granulometric composition is essential. These indicators, which include the relative amounts of sand, silt, and clay, should be carefully assessed and taken into account during soil preparation, tilling, and cropping decisions.

By considering the granulometric composition of the soil, agricultural practices can be tailored to the soil's specific texture, enhancing its capacity for water retention, nutrient uptake, and overall resilience against erosion. For example, finer soils with higher clay or silt content may benefit from specific erosion control techniques, such as contour plowing or the use of cover crops, to prevent soil loss and enhance fertility. Meanwhile, coarser soils may require different approaches, such as the addition of organic matter or the use of mulching, to improve moisture retention and protect against wind erosion.

REFERENCES

1. Aliyev, G.A. Soils of the Greater Caucasus within the Azerbaijan Republic / G.A.Aliyev. - Baku: Elm, - 1994, - 309 p.
2. Babayev, M.P. Modern Soil Cover of the Greater Caucasus / M.P.Babayev, A.M.Jafarov – Baku: - 2017, - 344 p.
3. Babayev, M.P. Land Degradation and Protection in Azerbaijan / M.P.Babayev, E.A.Qurbanov, V.H.Hasanov - Baku: Elm, - 2010, - 216 p.
4. Carullayev, A.Sh. Comparative Study of the Gobu-Yargan Network in the Desert Landscape // Proceedings of the 4th Scientific and Practical Conference on the Perspectives of the Development of Geodesy and Cartography in Azerbaijan, - 2012, - p. 388–396.
5. Gafurova, L.A., Nabieva, G.M., Jalilova, G.T. Modern Methods for Studying the Properties of Soils Affected by Erosion Processes // Soil Science in Russia: Contemporary Challenges and Main Directions of Development, - 2012, - p. 626–629.
6. Khalilov, T.A. On Brown-Gray (Chestnut) Soils // News of Baku State University, - 2009, No. 2, 31, - 38 p.
7. Mammadov, Q.Sh. Soil Erosion and Protection / Q.Sh.Mammadov, S.Z.Mammadova, J.A.Shabanov - Baku: Elm, - 2009, - 340 p.
8. Musayev, M.A. Landscapes of the Azerbaijan Republic / M.A.Musayev. - Baku: AGU, - 2003, - 137 p.
9. Nabiyeva, F.Kh., Huseynov, A.A., Huseynov, A.M. Reinforcement of Eroded Pastures with Perennial Grasses in the Ismayilli District // Proceedings of the Scientific and Technical Conference of Young Scientists and Specialists on ―Production, Processing, and Storage of Agricultural Products‖. Baku, - 1991, - 30–31 p.
10. The Effect of Perennial Grasses on the Structure and Aggregate Composition of Eroded Mountain Meadow Soils // Proceedings of the Azerbaijan Society of Soil Scientists, Vol. VIII. Baku, - 2001, - 162–163 p.

11. Vadyunina, A.F. Methods of Studying the Physical Properties of Soils / A.F.Vadyunina, Z.A.Korchagina - Moscow: Agropromizdat, - 1986, - 416 p.
12. Viles, H.A., Goudie, A.S. Soil erosion and its impact on soil composition in mountain regions // In Soil erosion and its environmental impact. Wiley-Blackwell., - 2014, - p. 96-112.
13. Zhang, J., & Wang, H. Changes in granulometric composition and soil fertility under erosion conditions in the Loess Plateau of China // Catena, - 2012, - p. 81-89.
14. Zhao, X., & Lu, Y., Erosion effects on soil texture and fertility in the mountainous regions of Central Asia // Geoderma, - 2010, 157(3-4), - p. 138-145.

QOBUSTAN RAYONUNDA EROZİYAYA UĞRAMIŞ DAĞ BOZ-QƏHVƏYİ TORPAQLARIN QRANULOMETRİK TƏRKİBİNİN EROZİYA UĞRAMA DƏRƏCƏSİNDƏN ASILI DƏYİŞİLMƏSİ

Ü.R. Qədiyeva

Tədqiqat ərazisinin torpaqları əsasən dağ boz-qəhvəyi (kaştanozems) tipli torpaqlardır və bu torpaqların eroziyaya qarşı davamlılığı olduqca zəifdir. Buna görə də bu torpaqların eroziyaya qarşı davamlığını artırmaq üçün ilkin tədbirlər görülməsi vacibdir. Mürəkkəb relyef şəraitində formalaşan dağ boz-qəhvəyi torpaqların morfoloji quruluşu və morfometrik göstəriciləri müxtəlifliyə malikdir. Əsasən bu göstəricilər meyillik və digər geomorfoloji parametrlərdən asılı olaraq dəyişir. Tədqiqat ərazisinin bütün sahələrində torpaqların bu xüsusiyyətləri müşahidə edilmişdir. Bu xüsusiyyətlər torpaqların eroziyaya məruz qalma dərəcəsindən asılı olaraq dəyişir. Bizim apardığımız tədqiqatlar bu məsələləri nəzərdən keçirmişdir.

Adi boz-qəhvəyi (şabalıdı) torpaqların qranulometrik tərkibi ağır olub, əsasən gilli və ağır gillicəli növlər üstünlük təşkil edir. Üst qatdakı lil hissəciklərinin miqdarı 27±3,2%, fiziki gilin miqdarı isə 60±4,5%-dir. Bəzi bölgələrdə fiziki gilin miqdarı 72%-ə qədər yüksəlir. Lil hissəciklərinin miqdarı profilin orta hissəsində daha yüksəkdir, bu da həmin horizontda gilləşmə əlamətlərinin yaranmasına səbəb olur. Torpaqların mineraloji tərkibi digər yarımtiplərlə oxşar xüsusiyyətlərə malikdir.

Açar sözlər: *dağ boz-qəhvəyi torpaqlar, eroziya, qranulometrik tərkib,diaqnostik göstərici.*

ИЗМЕНЕНИЕ ГРАНУЛОМЕТРИЧЕСКОГО СОСТАВА ЭРОЗИОННЫХ ГОРА СЕРО-БОРОЧНЫХ ПОЧВ В ЗАВИСИМОСТИ ОТ СТЕПЕНИ ЭРОЗИИ В ГОБУСТАНСКОМ РАЙОНЕ

У.Р. Гадиева

Почвы района исследований представлены в основном гора серо-коричневыми (кастанoземами) типами, эрозионная устойчивость этих почв довольно слабая. Поэтому важно принять предварительные меры по повышению устойчивости этих почв против эрозии. Морфологическое строение и морфометрические показатели гора серо-бурых почв, сформировавшихся в сложных рельефных условиях, разнообразны. В основном эти показатели меняются в зависимости от наклона и других геоморфологических параметров. Данные характеристики почв наблюдались на всех участках исследуемой территории. Эти характеристики изменяются в зависимости от степени эрозии почвы. Наше исследование решило эти вопросы.

Гранулометрический состав обыкновенных гора серо-бурых (каштановых) почв тяжелый, преобладают преимущественно глинистые и тяжелозернистые типы. Количество илистых частиц в верхнем слое составляет 27±3,2%, количество физической глины – 60±4,5%. В некоторых регионах количество физической глины возрастает до 72%. Количество илистых частиц выше в средней части профиля, что обуславливает признаки заиливания этого горизонта. Минералогический состав почв имеет сходные характеристики с другими подтипами.

Ключевые слова: *гора серо-бурые почвы, эрозия, гранулометрический состав, диагностический индекс.*