Influence of erosion on the mechanical composition and physical properties of serozems on rainfed soils, Tashkent province, Uzbekistan

Influence of erosion on the mechanical composition and physical properties of serozems on rainfed soils, Tashkent province, Uzbekistan

M Juliev[1, 2, 3, *], B Matyakubov[1], O Khakberdiev[1], X Abdurasulov[1], L Gafurova[4], O Ergasheva[4], U Panjiev5 and Chorikulov B[6]

[1]Tashkent Institute of Irrigation and Agricultural Mechanization Engineers, Kori Niyoziy street, 39, 100000, Tashkent, Uzbekistan
[2]Akfa University, Milliy Bog' Street, 264, 111221, Tashkent, Uzbekistan
[3]Turin Polytechnic University in Tashkent, Little Ring Road street, 17, 100095 Tashkent, Uzbekistan
[4]National University of Uzbekistan, University street, 4, 100174 Tashkent, Uzbekistan
[5]Uzbek National Institute of Metrology, Farobiy street, 333 «A», 100174, Tashkent, Uzbekistan
[6]Tashkent State Technical University, University street 2, 100095 Tashkent, Uzbekistan

E-mail: mukhiddinjuliev@gmail.com

Abstract. The problem of soil protection from erosion is relevant for many countries in the arid zone of the world, including the territory of Uzbekistan. In the republic, the main arrays of crops are located on rainfed lands, where the crop is created only due to moisture in precipitation. The amount of porosity (duty cycle) of soils is determined mainly by specific and bulk mass, mechanical composition, and humus content. Porosity of soils decreases from unwashed soils to washed away and down the profile. In the arable horizons of unwashed rainfed soils, it is 52%, washed out - 47.49%. Deeper in the profile, in horizons transitional to soil, due to a sharp increase in density and a decrease in the humus content in all soils, regardless of erosion, Porosity sharply drops to 48-50%. Thus, with a small bulk mass, the overall porosity of rainfed typical serozems is generally satisfactory, since it provides good soil aeration and the use of precipitation, only on highly washed away soils the porosity decreases markedly and the absorption of precipitation is slightly worsened.

1. Introduction

The problem of soil protection from erosion is relevant for many countries in the arid zone of the world, including the territory of Uzbekistan [1,2]. In the republic, the main arrays of crops are located on rainfed lands, where the crop is created only due to moisture in precipitation. According to our estimates, soils of rainfed lands are eroded to varying degrees on an area of more than 700 thousand ha. For this reason, determining the properties of rainfed soils formed in various soil and climatic conditions of the republic, preventing erosion processes that occur under the influence of factors limiting soil fertility, improving methods for assessing soil fertility, evaluating their quality and determining the degree of soil fertility are of great importance [3–7].

The mechanical composition of soils is one of the main indicators that determine the most important physical and physicochemical properties of soils, as well as their resistance to erosion. Typical serozems on loesses contain an increased the amount of dusty particles that are easy to wash off. It should be noted that the soils under consideration of varying degrees of erosion are mainly represented by medium loamy varieties, they contain a large amount of coarse dust fraction (0.05-0.01 mm), usually called the "loess fraction"[2].

2. Study area

The Tashkent province is situated in the Chirchik-Angren climatic region, which includes the Pri-tashkent loess plain and the ridge Western Tien Shan, irrigated by the Chirchik and Angren rivers. The climate of the territory is sharply continental, which is expressed by a sharp temperature drop, both daily and annual [8,9]. The territory is open in the west and southwest in the direction of movement of air masses, so the district is richer in precipitation than most foothill-mountain districts of Uzbekistan. There are 6 meteo (observation) stations collecting meteorological data in the project area: Angren, Almalyk, Bekabad, Tashkent, Yangiyul and Sukok close to the project sites. The amount of precipitation is growing from 260-300 mm in the extreme southwest to 800- 1000 mm in the northeast. The average maximum temperature varies from 40-42ºC in Tashkent, Almalyk, Yangiyul and Bekabad until 38ºC in Angren (Figure 1). The maximum wind intensity and speed are observed in Bekabad city, the speed of wind reaches 33 m/s, for other cities wind speed is observed between 18 and 28 m/s [9,10].

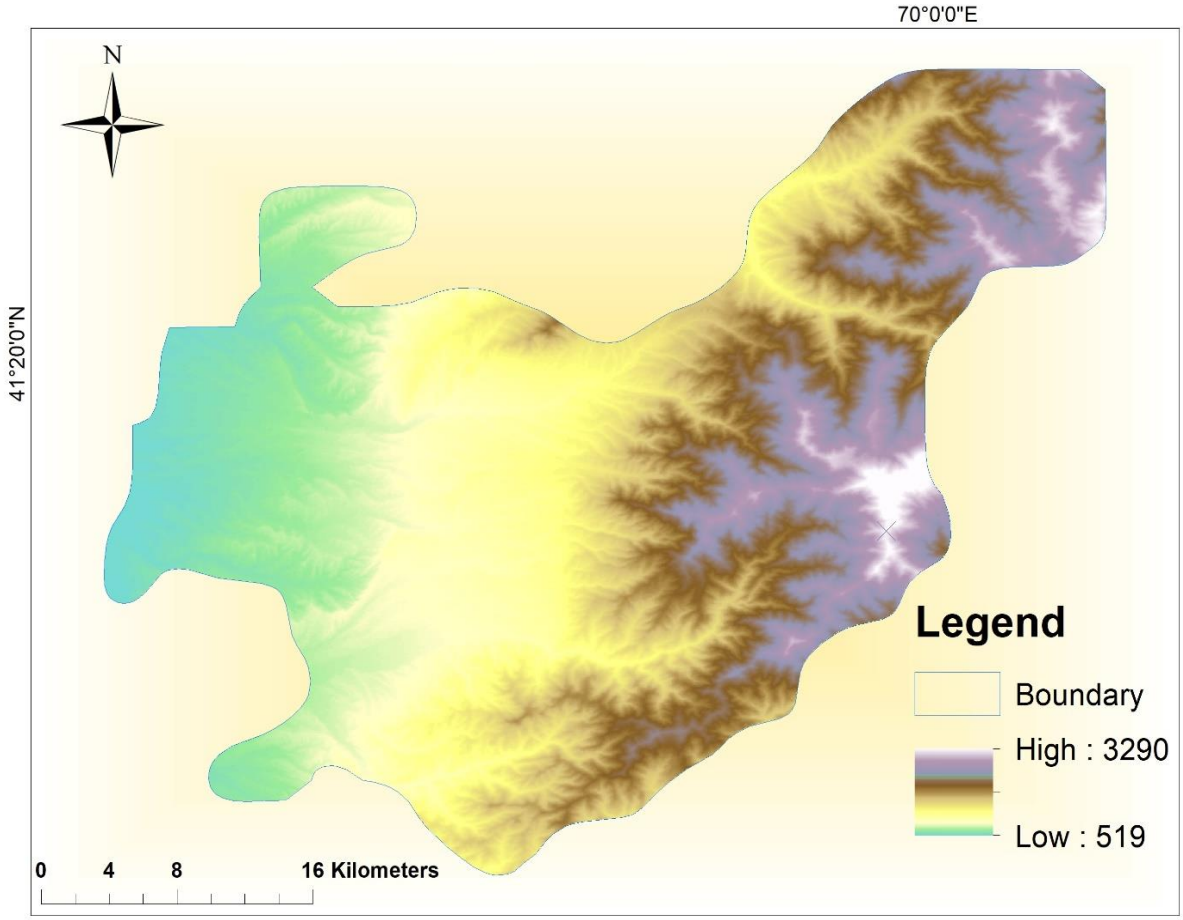

Figure 1. Digital elevation model of Parkent district.

3. Results and discussion

According to mechanical analysis, rainfed eroded differences of a typical serozem on loesses in the upper horizons contain about 33-43% of physical clay, that is, particles less than 0.01 mm in size; at the same time, on indelible soils in the same horizons of physical clay contains 46-47%. The data presented in the table show, although a small, but clear and characteristic tendency to increase the content of physical clay by 2-8% in the upper part of the horizons. Some weighting of its mechanical composition, which is associated with oglification of the middle part of the profile of rainfed serozem (Table 1).

Table 1. The mechanical composition of eroded rainfed typical serozems.

Relief elements and soil washout	Depth, cm	Particle size (mm) and their content (%)							The amount of fraction of physical clay, %
		>0,25	0,25-0,1	0,1-0,05	0,05-0,01	0,01-0,005	0,005-0,001	<0,001	
Section 55, Parkent, Tashkent province									
Dividing part, flat area, unwashed soil	0-25	0,83	1,07	5,81	46,20	16,58	15,53	13,98	45,99
	25-50	0,59	0,45	4,57	47,79	14,30	17,41	15,10	46,90
	50-80	0,60	0,40	5,76	45,82	14,70	15,82	16,90	47,42
	80-105	0,40	0,21	6,64	48,90	14,60	15,55	13,61	43,85
	105-120	0,56	0,27	5,69	52,32	14,02	13,34	13,80	41,16
Section 56, Parkent, Tashkent province									
The second third of the slope, steepness 5 °, medium-washed soil	8-22	0,31	0,32	8,81	53,34	14,16	12,08	10,98	37,22
	22-42	0,65	0,31	5,00	56,56	13,90	12,94	11,44	37,28
	42-75	0,46	0,32	4,04	53,78	12,96	14,62	13,82	41,48
	75-85	0,25	0,31	3,12	53,52	12,36	14,98	15,46	42,80
	85-110	0,42	0,23	4,75	56,88	13,60	12,10	12,02	37,72
Section 57, Parkent, Tashkent province									
Middle third of the slope 7 °, heavily washed soil	0-20	0,70	0,80	10,03	55,26	11,24	12,10	9,80	33,14
	20-30	0,44	0,35	8,19	56,08	11,16	11,22	12,65	35,04
	50-60	0,65	0,31	5,00	56,76	11,90	11,94	13,44	37,28
	85-95	0,57	0,68	9,84	55,20	10,96	12,12	10,63	33,71
	120-130	0,82	0,58	6,75	56,88	11,12	12,10	11,80	35,02
Section 58, Parkent, Tashkent province									
Slope plume, reclaimed soil	0-26	0,41	0,71	1,72	47,78	12,42	18,28	18,88	49,58
	26-40	0,51	0,23	2,02	46,16	11,52	18,04	21,88	51,44
	40-63	0,17	0,20	1,85	47,74	11,98	15,94	22,12	50,04
	63-101	0,45	4,40	2,17	41,23	10,78	14,54	26,38	51,70
	101-135	2,83	2,86	4,57	38,66	10,46	16,86	23,76	51,08

On the slope plumes (section 58), the content of physical clay reaches 50-51%, it is mainly associated with the accumulation of small soil particles brought from the upstream sections of the slope.

Field studies and soil analysis results reveal a relationship between the mechanical composition and the degree of erosion: medium and heavily washed soils are depleted in silt and fine dust and enriched in coarse. The difference between unwashed and washed soils is that the washed one contains more silt and sand in the upper and lower horizons. So, while in the watershed waters that are not affected by erosion, the content of physical clay in the upper meter soil layer fluctuates mainly in the range of 44-47%, then in the plume soils it significantly increases and amounts to about 49-52%. The same

regularity is observed when comparing the content of silt fraction (less than 0.001 mm) in soils on different elements of the relief with different degrees of erosion.

Among soils of varying degrees of erosion and sedimentation, the most enriched mud fraction is reclaimed soil on the slope plumes. The content of fine particles of 0.001 mm in them is from 19-22% in the upper horizons and up to 22-26% in horizon B. With an increase in the degree of erosion with an increase in the steepness of the slope, the mechanical composition of the soil is facilitated, the content of silty particles <0.001 mm is noticeably reduced and amounts to 9 -fifteen%. Due to the absence of erosion, the content of silt particles on the soils of the watersheds is slightly higher than on the slopes and they occupy an intermediate position in terms of the size of this fraction. Studies of the mechanical composition of solid runoff on medium loamy soils under different crops showed that flushing of particles larger than 0.05-0.01 mm was observed on spring wheat crops, slightly on alfalfa. Most particles were washed off with a size of less than 0.01-0.005 mm (from 50 to 68%).

Thus, under the influence of erosion on the dryland, the mechanical composition of soils of varying degrees of erosion sharply changes. The upper part of the profile of unwashed soils is represented by heavy, the lower - by medium loam. Washed soils are medium loamy from the surface, and the stronger the washout, the lighter their mechanical composition. This is evidenced by data on two medium- and highly washed soils, where in the upper soil horizons the amount of physical clay is 33-37%. Part of the demolished fine-grained material is deposited on the slope plume, forming heavier soils. As a result, washed away soils are depleted in silt, fine dust and enriched in coarse dust. Washed soil contains more silt and sand in the lower horizons than unwashed soil. All this characterizes the mechanical composition of the washed away soils as coarser, coarser dust, it is worse sorted in the washed ones, there are more sand and silt particles, which should leave an imprint on the physical properties of the soils.

Obviously, the indicated changes that occurred on the rainfed zones under the influence of erosion affected the physical and water properties of eroded typical serozems. In the process of erosion, when the upper, more fertile, organic layers enriched with organic matter are washed away, poorer and denser horizons come to the surface. Rainfed eroded typical serozems, developed on loesses and loesslike rocks, have small volumetric masses and significant porosity. Bulk mass varies from the mechanical composition, organic matter content, structure, as well as many agricultural techniques, in particular from soil cultivation. The smallest bulk density is observed in the upper cultivated horizons of unwashed soils and amounts to 1.24 g / cm3, the bulk density is lower sharply at first and then gradually increases depending on various factors, reaching the highest values in the subsoil horizons. The increased compaction of subsurface horizons compared to the subsoil is characteristic of rainfed serozems (Table 2).

Table 2. Physical properties of eroded typical serozems on loess.

Section number	Horizon, cm	Bulk density, g/cm3	Specific gravity, g/ cm3	Transparency, %	Degree of soil erosion
	0-25	1,24	2,60	52	Unwashed soil
55	25-50	1,30	2,63	50	
	50-80	1,40	2,66	48	
	80-105	1,30	2,71	49	
	8-22	1,38	2,70	49	Medium washed soil
56	22-42	1,37	2,68	48	
	42-75	1,39	2,71	48	
	75-85	1,43	2,72	47	

	0-20	1,43	2,72	47	Heavily washed soil
57	20-30	1,40	2,67	48	
	50-60	1,39	2,71	48	
	85-95	1,43	2,72	47	

A sharp increase in the density of soils and an increase in its bulk density to 1.30 - 1.37 g/cm3 are observed on serozem with the transition of the arable horizon to the arable one. This, obviously, is caused, on the one hand, by a large number of carbonate precipitates playing the role of cementing material, and on the other hand, by a denser packing of soil particles. With an increase in the degree of washing, the bulk mass of the arable horizon increases to 1.38 - 1.43 g/cm3.

In the subsoil, deep layers of soil-forming loess rock, the volumetric mass is somewhat leveled and is usually 1.39 - 1.43 g/cm3. The specific gravity of the solid phase of soils of different erosion varies little and amounts to 2.70 - 2.72 g/cm3. The specific gravity of the soil, as well as the bulk density, is the smallest in all soils in the arable and subsurface layers, richer in organic matter and devoid of salt formations. With depth, due to a sharp decrease in the humus content, the specific gravity of the solid phase of the soil gradually increases, reaching the greatest value in saline and gypsum interbeds of the parent rock. The specific gravity of the arable layer of unwashed soils and washed away differences varies between 2.60 - 2.72 g/cm3. In the middle part of the profile, the specific gravity of the solid phase increases and amounts to about 2.66 - 2.71 g/cm3. In loess parent soil rock, the specific gravity increases to 2.72 g/cm3, which, apparently, is associated with the mineralogical composition of parent rock.

4. Conclusion

The amount of porosity (duty cycle) of soils is determined mainly by specific and bulk mass, mechanical composition, and humus content. Porosity of soils decreases from unwashed soils to washed away and down the profile. In the arable horizons of unwashed rainfed soils, it is 52%, washed out - 47.49%. Deeper in the profile, in horizons transitional to soil, due to a sharp increase in density and a decrease in the humus content in all soils, regardless of erosion, Porosity sharply drops to 48-50%. Thus, with a small bulk mass, the overall porosity of rainfed typical serozems is generally satisfactory, since it provides good soil aeration and the use of precipitation, only on highly washed away soils the porosity decreases markedly and the absorption of precipitation is slightly worsened.

References

[1] Gafurova L and Juliev M 2021 Soil Degradation Problems and Foreseen Solutions in Uzbekistan *Regenerative Agriculture* ed D Dent and B Boincean (Cham: Springer International Publishing) pp 59–67

[2] Mirzabaev A, Goedecke J, Dubovyk O, Djanibekov U, Le Q B and Aw-Hassan A 2016 Economics of Land Degradation in Central Asia *Economics of Land Degradation and Improvement – A Global Assessment for Sustainable Development* ed E Nkonya, A Mirzabaev and J von Braun (Cham: Springer International Publishing) pp 261–90

[3] KussaiNova M, Spaeth K E and Zhaparkulova E 2020 Efficiency of using the rangeland hydrology and erosion model for assessing the degradation of pastures and forage lands in Aydarly, Kazakhstan *EURASIAN JOURNAL OF SOIL SCIENCE (EJSS)* **9** 186–93

[4] Mukanov Y, Chen Y, Baisholanov S, Amanambu A C, Issanova G, Abenova A, Fang G and Abayev N 2019 Estimation of annual average soil loss using the Revised Universal Soil Loss Equation (RUSLE) integrated in a Geographical Information System (GIS) of the Esil River basin (ERB), Kazakhstan *Acta Geophys.* **67** 921–38

[5] Aralova D, Kariyeva J, Khujanazarov T and Toderich K 2018 Drought Variability and Land Degradation in Central Asia: Assessment Using Remote Sensing Data and Drought Indices *Vegetation of Central Asia and Environs* ed D Egamberdieva and M Öztürk (Cham: Springer International Publishing) pp 15–47

[6] Karnieli A, Gilad U, Ponzet M, Svoray T, Mirzadinov R and Fedorina O 2008 Assessing land-cover change and degradation in the Central Asian deserts using satellite image processing and geostatistical methods *Journal of Arid Environments* **72** 2093–105

[7] Nurbekov A, Akramkhanov A, Kassam A, Sydyk D, Ziyadaullaev Z, Lamers J P A, and 1 International Center for Agricultural Research in the Dry Areas (ICARDA) Central Asia and the Caucasus Regional Office, Tashkent, Uzbekistan 2016 Conservation Agriculture for combating land degradation in Central Asia: a synthesis *AIMS Agriculture and Food* **1** 144–56

[8] Belolipov I V, Zaurov D E and Eisenman S W 2013 The Geography, Climate and Vegetation of Uzbekistan *Medicinal Plants of Central Asia: Uzbekistan and Kyrgyzstan* ed S W Eisenman, D E Zaurov and L Struwe (New York, NY: Springer New York) pp 5–7

[9] Gerts J, Juliev M and Pulatov A 2020 Multi-temporal monitoring of cotton growth through the vegetation profile classification for Tashkent province, Uzbekistan *GeoScape* **14** 62–9

[10] Aw-Hassan A, Korol V, Nishanov N, Djanibekov U, Dubovyk O and Mirzabaev A 2016 Economics of Land Degradation and Improvement in Uzbekistan *Economics of Land Degradation and Improvement – A Global Assessment for Sustainable Development* ed E Nkonya, A Mirzabaev and J von Braun (Cham: Springer International Publishing) pp 651–82