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INTENSITY OF SOIL WASH-OFF FROM THE SURFACE OF MOUNTAIN RIVER BASINS AND THEIR MAPPING

INTENSITY OF SOIL-GROUND FLUSHING FROM THE SURFACE OF MOUNTAIN RIVER BASINS AND THEIR MAPPING

Abstract: The article addresses the issues of changing the intensity of washout from the surface of the river basins of Uzbekistan in altitude zones and their mapping. The river catchments with a natural hydrological regime were chosen as the object of the study. Estimated values of flush modulus for different altitude zones. Mapping of soil washout according to O.P.Shcheglova method on the example of the Chirchik river basin was conducted.

Аннотация: В статье рассматриваются вопросы изменения интенсивности смыва с поверхности речных бассейнов Узбекистана по высотным зонам и их картографирования. В качестве объекта исследования были выбраны водосборы рек с естественным гидрологическим режимом. Рассчитаны значения модуля смыва для различных высотных зон. Составление карты смыва почво-грунтов осуществлено по методике О.П.Щегловой на примере бассейна реки Чирчик.

Keywords: river; river basin; water discharge; suspended sediment discharge; flush module; flush intensity; mapping.

Ключевые слова: река; речной бассейн; расход воды; расход взвешенных наносов; модул смыва; интенсивность смыва; картографирование.

Introduction. Determining long-term values of hydrological parameters characterizing the intensity of soil loss from the surface of mountain river basins, such as the discharge and volume of suspended sediment runoff, the erosion modulus, and the erosion depth, and mapping these parameters are important tasks in mountain hydrology.

Many scientists have studied the issues of quantitative assessment and mapping of the intensity of soil and ground loss from the surface of the mountain river basins of Uzbekistan and adjacent territories. In particular, the issues of soil and ground loss and the formation of suspended sediment runoff (SSR) are considered in the works of B.V. Polyakov, G.I. Shamov, G.V. Lopatin, N.I. Makkaveev, A.V. Karaushev, G.N. Khmaladze, M.N. Zaslavsky, K.S. Kabanova, R.S. Chalov, G.I. Shwebs, A.P. Dedkov, R.E. Horton, H. H. Bennett, A. Barat, N. L. Coleman, J. M. Jansen, V.A. Vanoni, W.D. Ellison, J.N. Holeman, W.H. Wisehmeier and others. These works proposed methods for quantitative assessment of runoff from the surface of river basins and scientific approaches aimed at their mapping [3, 5].

In Uzbekistan, the first fundamental studies on this issue were carried out by V.L. Shultz, O.P. Sheglova and others. Their scientific ideas were subsequently developed in the works of A.A. Khanazarov, H.M. Makhsudov, Yu.N. Ivanov, A.R. Rasulov, S.R. Saidova, Z.S. Sirlibayeva, F.H. Khikmatov and others [5].

The main objective of this study is to evaluate intensity of soil erosion from the surface of mountain river basins and their mapping.

The objectives of the study are as follows:

- improvement of existing methods for quantitative assessment of the intensity of soil erosion from river basins, taking into account the influence of meteorological factors;
- identification of the features of the distribution of the intensity of soil erosion from river basins by altitude zones;
- mapping the intensity of soil erosion from river basins, taking into account the characteristics of their changes according to altitude zones.

Methods and Results of the Study. In this study, erosive activity indicators for both surface and channel runoff were estimated for selected river basins in Uzbekistan using observed suspended sediment runoff data. Specific calculation formulas used in standard hydrological calculations were used.

An analysis of the obtained results revealed changes in the intensity of soil and ground loss from the surface of the studied river basins. It was revealed that the Surkhandarya (Shurchi) River basin is characterized by the most intense soil and ground loss processes. For this river, if the observed average long-term loss moduli are M_R = 504 t/km^{2}per year, then the average loss depth will be h_c = 0,336 mm. At the same time, the annual loss from the surface of this river basin was $4{,}38 \cdot 10^6$. The erosion meter calculated based these data was h_e = 2976 years. This figure indicates that the surface of the Surkhandarya River basin, on average, will decrease by one meter over 2976 years. The Akchasai River basin (Akcha village), located within the Akhangaran River basin, on the other hand, exhibits minimal surface soil loss. The surface loss modulus for this basin was 4,93 t/km^2·. Compared to the Surkhandarya River basin (Shurchi), the difference is more than 100-fold (Table 1).

Based on this primary objective, this paper further examines changes in the rate of runoff from the surface of river basins across altitudinal zones. The rate of runoff from the surface of river basins, for the purposes of mapping, was assessed based on multifactorial relationships between suspended sediment discharge in rivers and hydrometeorological factors (rainfall, snowmelt, and glacier melt).

Table 1

Indicators of soil loss intensity in river basins

#	River basin	N	Value	Sediment runoff		M_R t/km^2 per year	h_s, mm	h_e, per year
				W_{RG}, 10^3 t	W_{RV}, 10^3 м^3			
1	Chirchik	13	Max	23.02	15.3	406	0, 271	3690
			Min	0.568	0.379	24.4	0.016	62500
2	Akhangaran	12	Max	200	133	159	0.106	9434
			Min	0.631	0.421	4.93	0.003	333333
3	Sanzar + Zaaminsu	7	Max	5.39	3.59	121	0.08 1	12346
			Min	1.51	1.01	10.2	0.007	142857
4	Zeravshan	8	Max	3.34	2.23	133	0.089	11236
			Min	1.48	0.987	5.99	0.004	250,000
5	Kashkadarya	15	Max	248	165	294	0.195	5128
			Min	24.6	16.4	15.7	0.010	100,000
6	Surkhandarya	14	Max	4384	2922	504	0.33 6	2976
			Min	144	96.0	54.1	0.036	27778

Note: N – number of hydrological posts; W_{RG} – sediment runoff, in weight units; W_{RV} - sediment runoff, in volumetric units; M_R - erosion modulus; h_c - erosion layer; h_e - erosion meter.

Normalized regression equations characterizing these multifactorial relationships were obtained. To facilitate calculations of suspended sediment runoff, the values of which enable the calculation of runoff values, special nomograms were compiled based on normalized regression equations (Fig.1).

The accuracy of the calculated nomogram was assessed. For this purpose, the observed suspended sediment discharges ($R_в^ф$) were compared with the values ($R_в^р$), i.e., those calculated using the nomogram. The paired correlation coefficient characterizing the relationship between the observed and calculated suspended sediment discharge values was 0.886 ± 0.046 (Fig.2).

The calculation of washout modules from different altitude zones was carried out using the method of O.P. Shcheglova [6]. Based on the calculated values of washout modules, using modern GIS technologies (Map Info, Arc GIS), a map of soil erosion from the surface of the Chirchik River basin was compiled (Fig. 3).

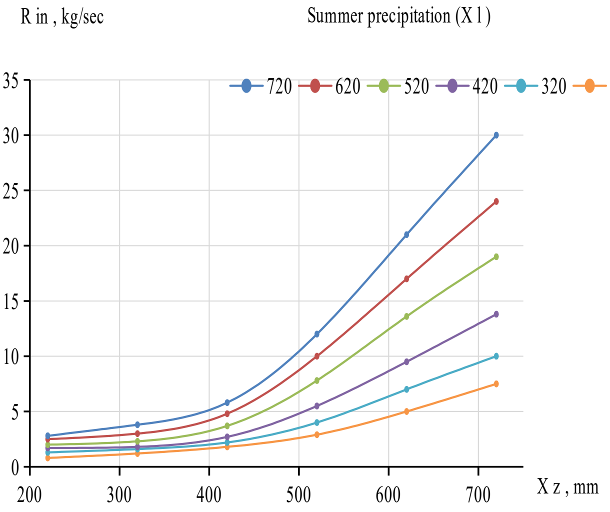

Fig. 1. Nomogram for assessing the suspended sediment discharge of the Akhangaran River
(Iertash village) according to winter ($X_з$) and summer ($X_л$ precipitation

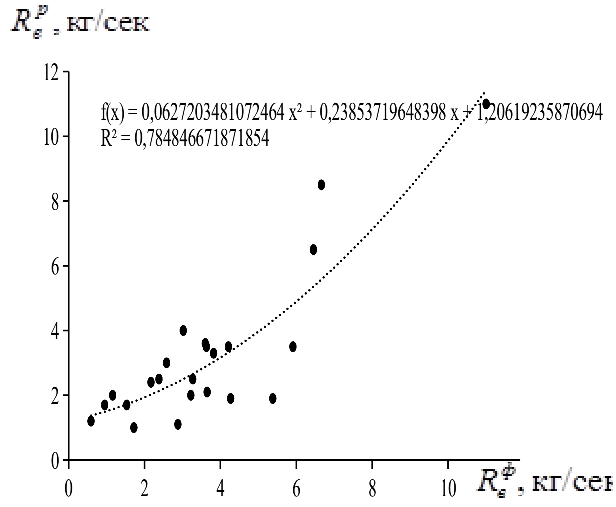

Fig. 2. Graph of the relationship between calculated ($R_в^р$) and actually observed ($R_в^ф$) values suspended sediment runoff

The soil loss map constructed using the above-mentioned sequence made it possible to identify water erosion hotspots, i.e., areas with the most intense loss processes. This, in turn, will serve as the basis for developing targeted action plans to prevent erosion processes on the surface of river catchments.

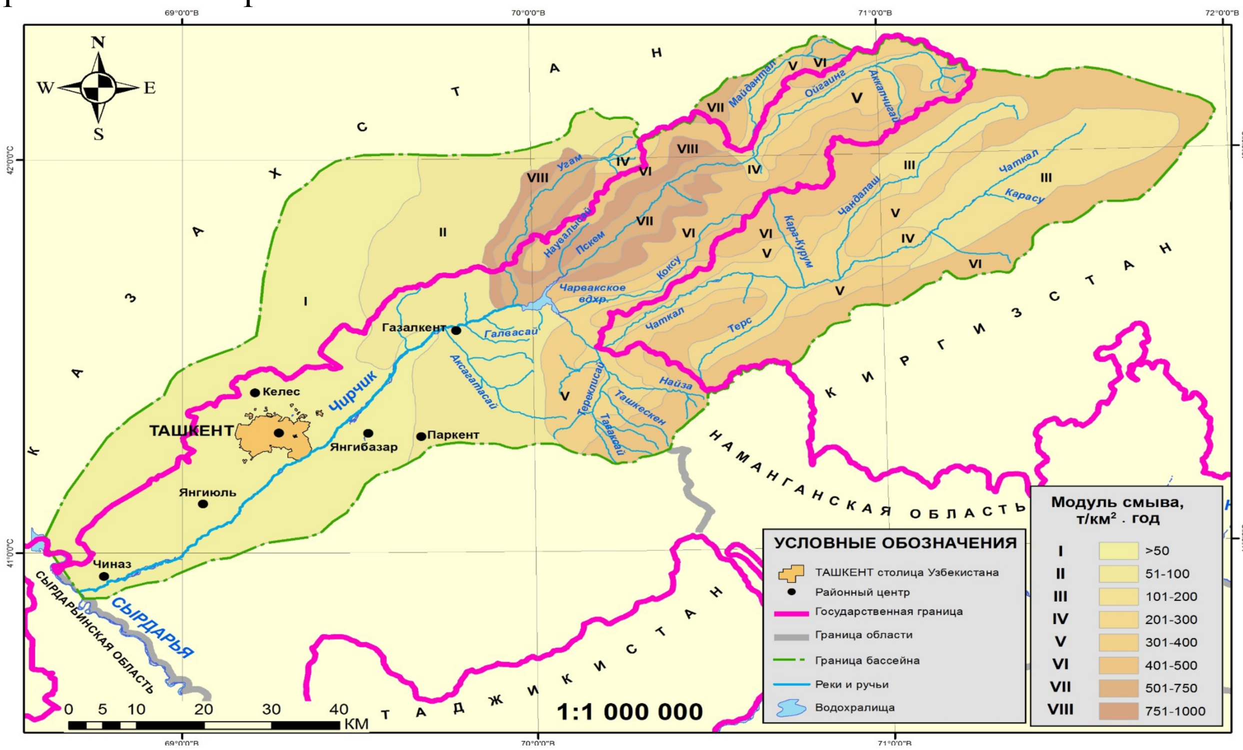

Fig. 3. Map of soil erosion from the surface of the Chirchik River basin

Conclusions. In conclusion, quantitative characteristics of soil loss from the surface of river basins by elevation zones were calculated using O.P. Shcheglova's method. To map soil loss from the surface of river basins, hydrometeorological factors that shape water erosion processes were also taken into account in the calculations. The soil loss moduli calculated for different elevation zones made it possible to compile soil loss maps from the surface of river basins. The soil loss map was compiled using modern GIS technologies (MapInfo, ArcGIS) using the Chirchik River basin as an example.

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