SOIL EROSION ON THE BOTTOM OF HOLLOWS IN STEPPE ZONE OF UKRAINE

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Soil erosion, undoubtedly, is one of the main ecological and agricultural problems in the world. Quantity of eroded lands in Ukraine achieves 10.5 millions ha. Annual losses of soil constitutes about 600 millions tons in the country.

Gully erosion and other kinds of soil degradation are very extended in east party of Ukraine. Often forming of gullies begin in the links of primary hydro-graphical network, i.e. on the bottom of the hollows.

In the countries of the former USSR the application of so-called “measures of constant action” (the soil-protection ground hydrotechnical constructions, runoff-regulating forest shelterbelts and other linear boundaries) are the most recognized way of the soil protection.

The aims of the our work are:

1) to define quantitative indicators of soil loss due to water erosion; 2) to study the soil protection role of MCA on the slopes with hollows.

Since 1982 we have been studying the soil erosion processes in the agricultural enterprise “Udarnik”. It situated near town Lugansk. In 1980-1990 there were created 153 ha of forest plantations; 19 ha of gullies were made flat, the terraces were located on 20 ha of strong eroded steep slopes; 61.9 km of bank-trenches were created in soil-protective crop rotations; pastures were improved on the area of 373 ha. Except this, banks-terraces with wide base were ploughed on 76 ha of arable lands. More than 2.1 km of water-retaining and water-diverting banks, 5.5 km of trenches including 3.5 km in combination with forest belts, grassland establishment on 24 ha of hollows were made.

The soil cover is middle and hard loamy ordinary chernozemes.

For 22 years there were 26 times of runoff events from snow melting water and rainstorms. Noticeable soil erosion processes were 18 times. Erosive losses of soil have take place at snow melting in 1985, 1986, 1994, 1996-1999, 2002, 2003, 2005 at downpours twice in 1987, in 1989, 1992, 1996, 1998, 2002 and 2003 years. Maximum soil loss from rainstorms achieved 295 t\ha, from the snow melting runoff – 44 t\ha.

The year 1992 was abundant on storm precipitation. On May 23-26 May it fell up to 207 mm in the southern part of Lugansk region. The territories of 13 farms with daily precipitation from 35 to 141 mm (that corresponds to their probability P% of exceeding for 40 to 1%) were inspected.

The inspection shows that the thalwegs of the elementary channel network (hollows) are the most damaged places of the fields. There were rills on the fields with young tilled crops almost in all farms. Rills appeared in winter crops when the daily precipitations was >70 mm (P<3%). Rills were out of hollows (even in the tilled crops) when precipitations were more 115 mm (P<1%). The soil losses under postemergence harrowing of tilled crops along a slope of 3,5º steepness and length 300 m ran up to 295 tons /hectare.

Spatial regularities of soil losses (V, m^3/hectare) are characterized by the next equation (1):

$$V = 1{,}47 I_\pi^{1{,}18} L^{0{,}75} K_o \quad (1)$$

I_π slope steepness in the places of calculation of soil losses, degrees;

L slope length, m;

K_o coefficient of impact of direction of harrowing after sowing. K_o is 1 when harrowing is executed along the slope, and K_o is 0,23 when harrowing is executed crosswise it.

At poor protective action of vegetation the rills may appear on the hollow bottom (stream-channel erosion) when layer of storm precipitation is 25-30 mm, i.e. annually.

On the fields with tilling along slope the rills appear out of the hollow bottom (slope erosion) when probability of precipitations P% is less then 40%. Under contour-parallel organization of the territory, the rills display out of the hollow bottom when probability of precipitations P% is less then 10-15%.

On the fields with tilling along slope the mass appearance of slope erosion is observed on tilled and winter crops under storm precipitations of 1% probability. The transverse direction of sowing and tilling makes the soil losses 2,4-4 times less.

It is revealed, that degree of erosion risk realization on the slope lands depends not only on their length and steepness, but on steepness of the elementary watersheds across its thalwegs.

On the result of the investigations data for the period from 1986 to 1999 from the slopes with the steepness 1.2 – 3.2 degree the mathematical model of the soil loss was elaborated. Model (2) shows the dependence of the soil loss on the parameters of the hollow watersheds and agrotechnical factors.

$$V = Af^{0{,}68} It^{1{,}20} t^{0{,}37} Lp^{0{,}096} \quad (2)$$

V soil losses for a unit of length of a hollow thalweg in all periods of runoff (V, m^3/running meter)

A efficiency of hydrometeorology, soil, agrotechnical, vegetative and other conditions;

f square of a reservoir part of a hollow, which is set above a cross section line that coincides with a scour cut, hectare;

I_t weighted average of the length of thalweg steepness, hail;

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t auxiliary inclination (steep slope of a gully reservoir in the direction towards a thalweg, weighted average to length and edgewise of a hollow watershed, degree);

L length of flow runaway, m (distance from an insulating or inhibiting hindrance). Variability intervals of these factors on a watershed are the follows: f = 0,05-3,0 hectare; It = 1,9-3,5º; t = 0,4-2,4º; Lp = 10-280 m.

Indicators, allowing to estimate run-off regulating effectiveness of soil control hydrotechnical constructions in conditions of complicated relief are proposed.

Methodics of definition of a relief characteristics on topographical maps is elaborated.

Regularities of a hollow net location on the slope lands were studied.

The dependence of most probable parameters of hollows on slopes length, form of their cross profile, slope exposure and other factors is showed in table 1.

The investigations proves that first hollows appear under steep slope of 0,5-1,0º, at 100-150 meters distance from a watershed line. Mass appearance of hollows is observed under steep slope of 1-2º. And 70% of all hollows originated within interval of 0-3º.

Peculiarities of the soil profile on the slopes with hollows was studied. As a result, mathematical models of the soil profile depth in dependence of morphometrical indicators of the slopes, of granulometrical composition of the soil and exposition of the slopes were obtained.

Study of soil profile showed that depth of humus horizon on the bottom of hollows is bigger (as a rule) than on the watersheds between them. On the bottom of a hollow the cases of burying of humus horizon under alluvial layer (that is identical to the cover of hollow slopes) are often observed. The slopes of hollow, on the contrary, often have not humus and even upper transitional horizons. On the hollow bottom the depth of soil profile may be up to 170 cm or more. Total depth (H) of alluvial, humus and upper transitional horizons on hollow bottoms may be expressed by the following equitation (3):

$$H = (0{,}48 + 0{,}059h^3)(1{,}123 - 4710I_t^3) \qquad (3)$$

h – hollow depth, m;

I_t – local inclination of a hollow thalweg.

Taking into account active erosive process on the bottom of hollows, above-stated phenomena prove the presence of active water and agrotechnical erosion on the slopes of hollows.

To increase water-absorbing capacity of MCA the method was elaborated, which includes fan-shaped mole plowing of hollow slopes. An energy-conservation technology of building of anti-erosion banks was proposed (patent of Ukraine #30243A). The technological ways, which will promote to accelerating of introduction of contour-reclamation agriculture and to increase of anti-erosion stability of agrolandscapes in hard relief conditions are proposed.

The elaborated mathematical models could be used for the grounding of practical measures, regulating water erosion as well as accumulation processes in agrolandscapes.

Table 1. Most probable parameters of hollow network.

Slope steepness	Slope length, m	Cross form of a slope	Parameters of hollow network			
			Hollow depth, m	Slope steepness of hollows	Distance between them, m	Width of their watersheds, m
1-3°	100-500	1-3*	0,3-0,55			
	500-1000		0,5-0,65			
	1000-1500		0,6-0,75			
	100-1500	1		0,007-0,018	100-200	85-170
		2		0,005-0,012	150-260	110-185
		3		0,004-0,010	190-320	110-190
3-5°	100-500	1-3	0,3-0,65			
	500-1000		0,55-0,85			
	1000-1500		0,70-1,00			
	100-1500	1		0,012-0,023	70-150	60-125
		2		0,010-0,018	110-180	75-130
		3		0,008-0,014	130-225	80-135
5-7°	500-1000	1-3	0,7-1,2			
		1		0,018-0,030	60-90	50-75
		2		0,014-0,020	90-130	65-90
		3		0,011-0,018	115-150	75-95

Note: 1* – concave slopes, radius of curvature of contour line R = 250 ÷ 1000 m.
2 – direct slopes, R >1000 m, <-1000 м; 3 – convex slopes, R = -250 ÷ -1000 m.