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SOIL EROSION IN UKRAINE

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Abstract. *Erodibility of agricultural grounds has already arrived at 40%. The complete damage of erosion has arrived to more, then 10 blln US dollars per year. The specific features of climate, topography Ukraine were highlighted. The basic groundwater withdrawal and analyzed soil structure shelter for soil-climatic zones. Agricultural lands occupy 70.3% of the total area of the country; cultivated lands occupy 81% of the agricultural area. The most widespread soils under agricultural land use are chemozem (60.6%) and dark grey forest soil (21.3%). Nineteen million hectares (about 50%) of agricultural land in the Ukraine are a subject to wind erosion, including 16.6 million hectares of arable land. The next step for the Ukraine towards land conservation development would be the creation of a Soil Conservation Service.*

Key words: water erosion, wind erosion, soil cover, soil protection.

Introduction. The area of the Ukraine is 603,700 km^2. Its territory is spread 1300 km eastwards (from the longitude of 22 to 40 degree East), and near 900 km southwards (from the latitude of 52 to 45 degree North). It is located in Central and South-Eastern Europe and borders with Hungary, Slovakia and Poland in the West, Belarus in the North, Russia in the North and East, Romania and Moldova in the South. The Black and Azov Seas wash its most southern part.

The territory of the Ukraine is mostly flat: near 90% of the whole area is plain; the average elevation of the flat area is 170 m. Mountainous areas occupy near 5% of the territory, they are the Carpathians (20,000 km^2, some peaks 1700-2000 m above sea level) in the west and the Crimean Mountains in the south (5,000 km^2, over 1500 m above sea level).

Purpose. Explore the natural factors of soil Ukraine, their influence on the formation and development of soil erosion. Analyze the structure of the soil shelter area. Determine the necessary anti-erosion measures.

Results. The climate of most the Ukrainian is continental, varying from low continental in the West and Northwest to medium continental in the East and Southeast. Only narrow strip in the Southwest of the Crimean Peninsula is characterized by subtropical climate. Annual precipitation on the flat part of the territory is from 300 mm to 350 mm in the South, from 700 mm to 750 mm in the Northwest, over 1200 mm in the Carpathian Mountains, and from 800 mm to 1000 mm in the Crimea. Average relative air humidity is from 63% to 70%, in summer it is from 55% to 60%, in the eastern areas it may decline to 45%-50% and even 30%. In Ukraine, erosionally hazardous climatic events sometimes occur. Thus, since 1971 maximum rainfall events were observed at weather stations in Poltava (rainfall intensity - 4.65 mm/min, rainfall duration - 2 min), Lubny (4.2 mm/min, 2 min), Kamenets-Podolskiy (3.17 mm/min, 3 min), etc. Seasonal distribution of erosionally dangerous events is as follows: 58% (>10 nun) and 66% (>20 mm) during summer season, 23% (>10 mm) and 16% (>20 mm) in spring, 19% (> 10 mm) and 18% (>20 mm) in autumn. During spring – autumn in the Southeast and Southern parts of the country there sometimes occur droughts, dry winds (25 - 30 days per year), and dust storms (3-8 days per year) The duration of dust storms varies from a few minutes to a few days. In the North (Polissya area), rainfall and snowmelt soil erosion are comparable. In the Forest Steppe area the ratio between the rainfall and snowmelt soil erosion is 2:1. In the South, the contribution of snowmelt erosion annual soil erosion loss is less: in the Arid Steppe, snowmelt erosion is negligible. Overall, the erosive effect of rainfall is ten times greater than of snowmelt.

Topsoil of the Ukraine is very diverse. According to the national soil classification, it includes 650 types and the total number of soil varieties is as large as several thousands. The distribution of soil types over the territory is closely related to the other elements of environment, like physical geography of the location, climate, and vegetation. Agro-pedological zoning of the Ukraine reflects the most general features of the main agro-pedological groups, as described below (all names of soil types are given according to the national naming system) [Soils of the Ukraine. 1988].

1. The main characteristics of soils

Soil type	pH	Cation exchange, Mgeq*100g^{-1}	Hydrolytic acidity, Mgeq*100g^{-1}	Base-saturated degree, %	Humus, %	Apparent, g*cm^{-3}	Density, g*cm^{-3}
Polissya							
Turf-podzol soil	6.3	4.4	2.3	75	1.3	1.5	2.6
Turf soil	5.7	3.3	2.0	62	2.2	1.5	2.6
Forest Steppe							
Light grey soil	5.1	16.5	3.2	81	4.2	1.35	2.6
Grey soil	4.5	20.0	3.5	85	2.0	1.4	2.7
Dark grey soil	7.0	31.5	3.9	89	7.3	1.1	2.6
Podzol chernozem	7.0	22.3	3.3	88	5.2	1.2	2.6
Typical chernozem	7.0	36.3	0.7	98	5.5	1.2	2.6
Steppe							
Common chernozem	7.2	37.1	1.1	97	5.0	1.2	2.7
South chernozem	6.9	36.4	1.6	96	3.6	1.0	2.6
Chestnut soil	7.4	26.5	1.8	95	3.4	1.2	2.6

Polissya, which occupies 14.5% of total area, is the area ofsod-podzol soils lying on the flat, run off subjected territories. In the Forest Steppe, the topsoil structure is determined by the diversity of plant formations, of climate and geomorphological conditions, as well as by the differences in land use and land management practices. In the Steppe climate conditions and plant cover basically determine area the heterogeneity of topsoil.

In the Crimean Mountains, vertical zoning and connected with it heterogeneity of soil forming factors, determine noticeable complexity of soil cover. The basic soil in the steppe foothills is chernozem lying on the eluvium of various dense carbonate parent material and clay. The Foothill Forest Steppe is represented by sod carbonate and grey forest steppe soils. In the forest mountain area brown soils are developed, on the tablelands meadow chernozem-like soils are spread. The subtropic southern area is occupied by brown soils.

Agricultural lands occupy 70.3% of the total area of the country; cultivated lands occupy 81% of the agricultural area. The most widespread soils under agricultural land use are chemozem (60.6%) and dark grey forest soil (21.3%). The steepness of agricultural land is differentiated as follows: from 0° to 1.3° 78%, from 1.3° to 3° – 17%, from 3° to 6° – 0.9%, from 6° to 12° – 2.1%, from 12° to 20° – 1.8%, 20° – 0.2%. Varieties of the natural and economic conditions determine different land use practices and regional specialisation in agriculture. Polissya, the most part of which is covered by forests and shrubbery, is characterised by large areas under rangelands, while the portion of cultivated lands is relatively small. In the Forest Steppe, where natural conditions are very favorable for agriculture, portion of cultivated lands and hayfields is very high. In the Steppe area, which occupies 41.5% of the whole territory, agricultural lands occupy over 76%, cultivated lands occupy near 63%.

General losses of organic carbon of humus sphere in our Earth at the expense of Quaternary badland forming (20 mln.km^2) and contemporary tilled of agricultural lands (15 mln.km^2) equal 313000 mln.t. or 15.8% of the initial world stock:

1) 10000 years – 31/13 mln.t*yr^{-1};
2) during the last 300 years – 300 mln.t*yr^{-1};
3) During the last 50 years – 760 mln.t*yr^{-1} (in 24/3 times rather then average in history)

Erosion is a disaster that did not appear in the Ukraine from nothing, but is the natural and inevitable result of mismanagement of agriculture production systems. This diesis for the Ukraine is based on the examples, which show a set of causes and factors leading to the development of erosion processes for the main agricultural regions of the former USSR. The Ukraine possessed 2.7% of its territory, had 15.1% of the total arable land and accounted for 25% of the total agricultural production in the former USSR.

According to data obtained from the Ministry of Agriculture, about 500 million tons of soil on average are lost from the Ukrainian arable land yearly (Fig. 1).

Simultaneously, 23.9 million tons of humus, 964 000 tons of nitrogen, 676 000 tons of phosphorous, and 9.7 million tons of potassium are lost. The yearly soil loss averages 7.7 to 2.7 $t*ha^{-1}$ depended on region.

Erosion totaled 200 $t*ha^{-1}$ during one storm and even greater losses are common. The area of agricultural land in 1991 with erosion to a variable degree was 12.1 million ha (30.7% of total agricultural land). There were included 9.4 million ha of arable land (29.2% of arable land). The area of eroded land increases at a rate of 80 000 $ha*yr^{-1}$. Moreover, wind erosion processes also occur in the Ukraine. Nineteen million hectares (about 50%) of agricultural land in the Ukraine are a subject to wind erosion, including 16.6 million hectares of arable land. 5.9 million ha of the agricultural land are already eroded to a variable extent, including 5.4 million ha of arable land. According to the data obtained from the Institute of Soil Conservation (Lugansk), the total shortage of grain production resulting from this soil degradation is 8.6 million t/yr. This results in a total ecological and economical sacrifice of USS20-30 million/yr [On the system of natural accounts, 1994]. There is an evidence to contend, that the intensity of erosion is accelerating. This occurs in spite of considerable attention of technical specialists and the public to the erosion problem [Formation of ecologically balances agrolandscapes: the problem of erosion. Kharkov, 1999].

For each information unit, which is an administrative region, the average weighted values were estimated the runoff length, slope, soil credibility, crop management factor parameters involved in the hydromechanical soil erosion model of Mirtskhoulava [The engineering methods of water soil erosion calculation and prediction.,1970]. This model was modified and adapted to the task of the estimation of erosion process development [Theoretical and applied basis for the engineering of soil protecting agrolandscapes.,1992, Estimation of geographical environment and land use optimization., 2002].

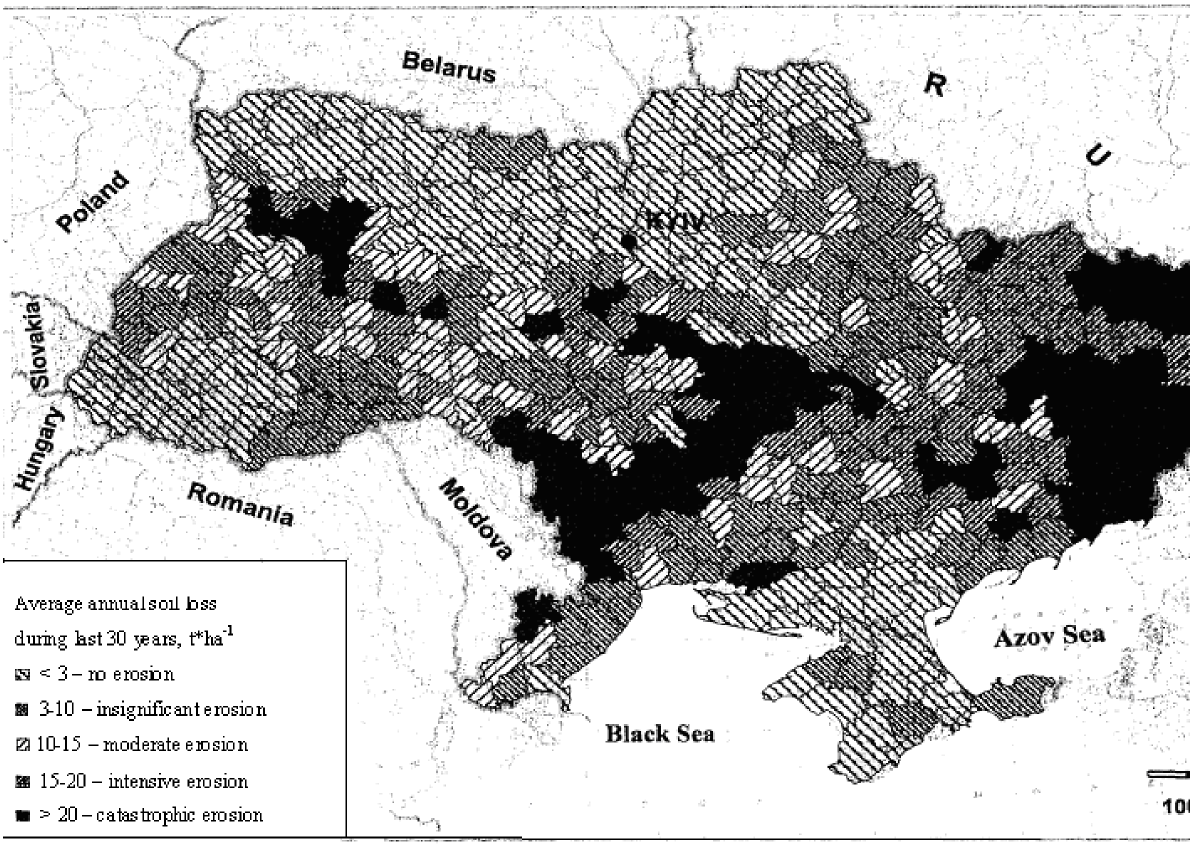
According to the data, there is no soil erosion risk in the Polissya and Dry Steppe areas. On the map the areas of the Carpathian and Crimean Mountains are also shown as the areas with no soil erosion risk. This happens because the mapping methodology is not appropriate because of the differentiation of soil formation factors. The greatest soil erosion risk in the Ukraine exists in the areas including the Southern Forest Steppe and Northern Steppe. The data represented on the map are verified by the experimental data obtained from runoff plots during a number of studies by Ukrainian scientists. A set of maps exists for the estimation of eroded lands, however these maps cannot be seriously considered because they were built using an erroneous method (comparison of soils on slopes with the analogous soils on plains).

The causes of the accelerating erosion intensity are enumerated below. Economic resources allocated for soil erosion control have been used with little efficiency. The analysis of state investments for soil conservation has shown that during 1976-1985 72.4% of total funds were spent on building anti-erosion hydro technical structures (so called 'anti-erosion ponds', iron-concrete devices and so on), 10.5% – on land recultivation, 5% – on other works (including the planning), and only 12.1% – on erosion control [About contour farming on the slope lands., 1986].

There are 24 mln ton of humus, 1 mln ton of nitrogen, 700 thousand ton of phosphorus, 10 mln ton of potassium are being lost yearly. There are from 8 to 30 t/ha average washing-off from tillage yearly and differ by regions. We can often observe catastrophic influence of erosion, when washing-off 200 t*ha^{-1} and more from field.

Erodibility of agricultural grounds has already arrived at 40%. The complete damage of erosion has arrived to more, then 10 blln US dollars per year, what are approximately equals to the National budget of Ukraine.

Apart, there are near 19 mln ha of deflationary dangerous agricultural grounds, including 16 mln ha of tillage. There are 5.9 mln ha of agricultural grounds, which already have deflated, including 5.4 mln ha of tillage.



There is an extremely high proportion of arable land in the territory of Ukraine: arable land covers 56.9% of the whole territory and 81.1% of the agricultural land. This is the highest proportion of cultivated land in any European country, or in any developed country in the world. With such a high proportion of arable land, it is difficult to protect land from water and wind erosion processes.

Grazing land would provide more feed units in comparison with sloping arable eroded land, improving environmental security and lowering production costs.

The nature-conserving efficiency of field-protecting forestry is obviously underestimated. Today, there is an observed slowing down (and more often a stoppage) in creation of field protecting forest strips and in not caring for them. Imperfection of farm and land protection strategies (principles used on the plains have been used also on slopes). The main mistakes are: use of rectangular-shaped fields and placement of field-protecting forest strips and other stable borders along slopes, ignoring the laws of landscape development and transformation; in particular, ignoring the association of mass and energy exchange between landscape elements. In the Ukraine, with the exception of nature reserves, there are no natural landscapes.

Therefore, only constructing special anti-erosional agro-landscapes, where water and wind erosion processes are common could solve the problem. The agro-landscapes should approximate to the natural landscapes. With rare exceptions the methods used to protect landscape, are not parts of a definite system and are without scientific substantiation. The use of full-scale soil protecting technologies would permit a sharp decline in soil loss caused by erosion.

A serious obstacle to the introduction of soil protecting technologies into the cropping system is the absence of soil conservation tools for cultivation. Techniques for managing crops on slopes of more, than three degrees (sowing, harvesting and plant care) are practically absent. Also, tractors are not adapted to work across inclined slope surfaces. Therefore, according to the concept of contour-ameliorative agriculture of the Agriculture Institute (Kiev), row crops should be concentrated on lands with slopes up to 3 degrees in the so-called first technological group, thus, providing some protection from degradation [New conception of soil conserving contour reclamation farming and its effectiveness in the Ukraine. 1990]. It seems that such, a “straightforward” recommendation is of a forced character and hardly could be applied everywhere. Absence of a direct monetary interest of land users in soil conservation also affects the attitude towards the land. This is the basis of the contemporary harmful activity of humans, which has a material and political basis. The absence of a land value appraisal has created a paradoxical situation — the means of production have practically no price. Land users have practically no responsibility for the damage to the main production base — the soil. Their work is evaluated by the profitability of the production enterprise. Under such conditions, measures are carried out that increase crop yield in the year of their application. Soil projection is of low interest, as economic considerations are focused on immediate results. This is also a characteristic of Western countries with developed market economics. Economic levers securing reliable and effective 'soil health' are necessary. Especially important is the development of accurate and clear techniques for the estimation of the loss caused by erosion. It follows, that the development of an agro-landscape needs to include reliable protection from degradation processes such as erosion. This statement is strengthened by the obvious fact that halting erosion is a precondition for further improvement or restoration of soils, i.e. without solving the erosion problem, any plans for improving the fertility or other functions of the soil surface are doomed to failure. Development of an erosion resistant and ameliorative agro-landscape at a particular site is an engineering process. Therefore, it must be based on some conceptual agro-landscape model, which must adequately reflect the peculiarities and intensity of the erosion process. An agro-landscape conceptual model is the general scheme of anti-erosion measures in a particular region. The development of a conceptual model seems to be quite conjectural without the preliminary differentiating of the territory by some soil erosion index. Such differentiating has considerable difficulty: traditionally, it is carried out on the basis of maps on which actual soil erosion is indicated. We suggest using a potential erosion danger index for territory differentiation. The map of the potential danger of erosion is radically different from the map of actual soil erosion. If the strategy for erosion is developed only on the basis of actual soil erosion maps, we could only identify the erosion processes to combat against the erosion consequences, but could not work against its causes. If the prevention of erosion is based on an actual soil erosion map, the main efforts will be in regions with highly eroded soil surface. In such an approach, actual erosion frequently does not coincide with the potential danger of the erosion process. As a result, in regions with moderate or low erosion, further intensification of agricultural use is planned, even though there is high potential danger of erosion. There is one more substantial detail that does not permit the management of agricultural lands only on the basis of maps of actual soil erosion. It concerns the difficulties in diagnosis of the erosion grade. This method is based on the choice of control being used in the watershed, for which the thickness of soil is compared with the thickness of soils on slopes. Such a method causes gross errors. For instance, non-eroded weakly developed arable soils at the southern aspect of slopes are diagnosed as eroded, while actually they are non-eroded.

For many years problems of accelerated soil erosion were almost completely ignored by the government. The situation became even worse after land started. Many attempts have been made to attract the attention of members of society, who are indifferent to the state of the Ukrainian lands and to the future of the Ukraine.

Eventually, the efforts succeeded, resulting to the development of the Land Code of the Ukraine, which has been approved on the October 25, 2001. The Land Code is a legal basis, for the land protection and land fertility restoration, which regulates all the main issues related to land conservation management.

Conclusions. The important step for the Ukraine towards land conservation development would be the creation of a Soil Conservation Service, which is currently in progress. This would be a great advance for the Ukraine, which will allow development of a civilized land management system, improve the quality of life and preserve one of the most valuable Ukrainian resources for future generations.

Список літератури

1. Полупан Н. И. (ред.) Почвы Украины и повышение их плодородия. Том 1. К.: Урожай, 1988. – 296 с.

2. Bulygin S. On the system of natural accounts / S. Bylugin / ESSC Newslett. – 1(2). – p. 15-17.

3. Булыгин С. Ю. Формирование экологически сбалансированных агроландшафтов: проблема эрозии / С.Ю. Булыгин, М. А. Неаринг. – Харьков: Эней, 1999. – 272 с.
4. Мирцхулава Ц. Е. Инженерные методы расчета и прогноза водной эрозии. — М.: Колос, 1970. – 240 с.
5. Булыгин С. Ю. Теоретические и прикладные основы конструирования почвоохранных агроландшафтов: почвенный аспект: автореф. дис...д-ра с. – х.наук: 06.01.03 / Булыгин Сергей Юрьевич; Харьковский аграрный ун-т им. В. В. Докучаева. – Х., 1992. – 44 с.
6.. Булигін С. Ю. Оцінка географічного середовища та оптимізація землекористування / С. Ю. Булигін, Ю. В.Думін, М. В. Куценко – Харків: Світло зі Сходу, 2002. –168 с.
7. О культурном земледелии на склоновых землях / [Джамаль В. А., Шелякин Н. М., Медведев Н. В., Белолипский В.А.]// Проблемы почвоохранного земледелия. Почв, ин-т им. В. В. Докучаева. М. 1986. С. 40-46.

References

1. Polupan, N. (1988) Soils of the Ukraine [Pochvu Ukrainu]. Vol. 1., 29-43. (in Russian).
2. Bulygin, S. (1994) On the system of natural accounts. ESSC Newslett, 1(2), 15-17.
3. Bulygin, S. Yu., Nearing M. A. (1999) Formation of ecologically balances agrolandscapes: the problem of erosion [Formirovanie ekologicheski sbalansirovannux landshaftov: problem erozii]. Kharkov: "Enei", 272 (in Russian).
4. Mirtskhoulava, Ts. (1970) The engineering methods of water soil erosion calculation and prediction [Ingunernue metodu raccheta I prognoziirovaniya erozii pochv]. Moscow, 240 (in Russian).
5. Bulygin, S. Yu. Theoretical and applied basis for the engineering of soil protecting agrolandscapes [Teoreticheskiye i prikladnyye osnovy konstruirovaniya pochvookhrannykh agrolandshaftov:pochvennyy aspekt] : avtoref.dis...d-ra s.-kh.nauk:06.01.03; Khar'kovskiy agrarnyy un-t im. V.V.Dokuchayeva, 44 (in Russian).
6. Bulygin, S., Dumin, Yu., Kutsenko, N. (2002) Estimation of geographical environment and land use optimization [Otsinka heohrafichnoho seredovyshcha ta optymizatsiya zemlekorystuvannya]. Kharkiv: Svitio zi Shodu, 168 pp. (in Ukrainian).
7. Jamal, V., Sheliakin, B., Medvedev, N., Belolipskiy, V. (1986) About contour farming on the slope lands [O kul'turnom zemledelii na sklonovykh zemlyakh] Vol.1, Nauchnyie Trudy Poehvennogo Instituta, Moscow, 40-46 (in Russian).

ЕРОЗІЯ ҐРУНТІВ В УКРАЇНІ

С. Ю. Булигін, Д. Антонюк

Анотація. *Еродованість сільськогосподарських угідь досягла рівня 40%. Повні втрати від пошкодження ерозії досягли понад 10 мільярдів доларів США в рік. У статті висвітлено особливості клімату, рельєфу території України. Наведено основну ґрунтову відмінність та проаналізовано структуру ґрунтового вкриття за ґрунтово-кліматичними зонами. Сільськогосподарські угіддя займають 70,3% від загальної площі країни; орні землі – 81% сільськогосподарських площ. Найбільш поширені ґрунти серед земель сільськогосподарського призначення – чорноземи (60,6%) і темно-сірі лісові ґрунти (21,3%).*

Дев'ятнадцять мільйонів гектарів (близько 50%) сільськогосподарських земель в Україні підлягають вітровій ерозії, серед них 16,6 млн га орних земель. Наступним кроком для України у галузі захисту від водної ерозії повинно бути створення служби охорони ґрунтів.

Ключові слова: водна ерозія, вітрова ерозія, ґрунтовий покрив, захист ґрунтів.

ЭРОЗИЯ ПОЧВ В УКРАИНЕ

С. Ю. Булыгин, Д. Антонюк

Аннотация. *Эродированность сельскохозяйственных угодий достигла уровня 40%. Полные потери от повреждения эрозии достигли более 10 миллиардов долларов США в год. В статье освещены особенности климата, рельефа территории Украины. Приведены основные почвенные различия и проанализирована структура почвенного покрытия по почвенно-климатических зонах. Сельскохозяйственные угодья занимают 70,3% от общей площади страны; пахотные земли - 81% сельскохозяйственных площадей. Наиболее распространенные почвы среди земель сельскохозяйственного назначения – черноземы (60,6%) и темно-серые лесные почвы (21,3%). Девятнадцать миллионов гектаров (около 50%) сельскохозяйственных земель в Украине подлежат ветровой эрозии, в том числе 16600000 га пахотных земель. Следующим шагом для Украины в области защиты от водной эрозии должно быть создание службы охраны почв.*

Ключевые слова: водная эрозия, ветровая эрозия, почвенный покров, защита почв.