

EROSION AND DEFLATION CONTROL

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Summary

Soil erosion and deflation occur worldwide, annually eliminating up to 5–7 000 000 ha (5–70 000 km²) of fertile lands from intensive use. The ruin and depletion of soils accelerated greatly in the twentieth century due to excessive plowing of vast areas, extermination of forests, greatly increased mechanization of soil management and crop farming, and the paucity of measures to protect soil.

This article considers features of the anthropogenic erosion and deflation, including wash off, wash out, and blow out of soil on agricultural lands; damage from different erosion and deflation processes; the area of spread, recurrence frequency and intensity; and the ecological effects of erosion and deflation.

Practical measures of erosion and deflation control are considered. On gentle slopes of cropland, narrow water-preserving forest belts, with border ditches in the lower inter-row space and ridge terraces can prevent soil loss; thinly planted wind-breaking forest belts are recommended to protect soil from deflation,. The construction and parameters of forest belts, their placement, and efficiency are considered only briefly.

On steeper slopes that are damaged by rills and gullies, it is recommended that shallow rills be completely filled and gullies leveled. The technologies involved are described. The article also describes the various methods of building terraces on steep slopes, creating forest and fruit stands, and achieving a surface and fundamental improvement in the grass stand on steep eroded slopes while using them as hay- and pasturelands.

Much of the article is devoted to the reinforcing of active gullies and preventing scouring on leveled gullies, using water-retention and water-diversion banks, drops, flumes and steep channels, cantilevered extensions, and bottom dikes. It is noted that projects such as the creation of forest belts, leveling gullies, building terraces and gully-reinforcing constructions are best handled as part of a comprehensive planned project.

1. Introduction

Of all the forms of degradation of agricultural lands, erosion and deflation currently present the greatest hazard, because of the size of the areas affected by them and the harm they inflict. Data provided to the 1992 UN Conference on Environment and Development in Rio de Janeiro indicated that erosion accounts for 56% of the total area of degraded soils, deflation accounts for 28%, and chemical and physical degradation account for 12% and 4% respectively (see *Erosion and Soil Conservation*).

According to various expert estimates, since human beings began to practice agriculture, erosion and deflation have damaged about 5×10^8 ha of fertile soils. For comparison, about 15×10^8 ha are now cropped worldwide. The rates of soil damage and depletion due to erosion and deflation have accelerated notably during the last two or three centuries, owing to the intensive growth of the planet's population, which has encouraged the clearance of forests and the cultivation of crops on the cleared lands. The invention of the plow, the tractor, and other tillage machines and tools accelerated the plowing-up of new areas, increased disturbance to the soil structure, and intensified soil wash out and blow out (see *Protection of Soil Against Erosion* and *Erosion Science*). Good examples of the scale and harmfulness of erosion and deflation are found in the United States, which began to be settled intensively by emigrants from Europe in the seventeenth century. Before the first settlers lay a vast country with great natural riches: impenetrable forests, boundless prairies with huge herds of bison, and an abundance of rivers and lakes. The native inhabitants mainly hunted and fished. Crop farming was primitive and covered comparatively small areas, because Native Americans had neither horses nor plows.

To survive, the settlers had to cut down the forest to build houses and farm buildings, and plow up more and more land for planting crops. Within 100 to 150 years (a very short period from the historical point of view), hundreds of millions of hectares of virgin forests were destroyed and prairies were plowed up. For many years the same crops were grown on the agricultural land that was created in the south-east: primarily corn, tobacco, and cotton. These barely protected the soil surface from erosion during rain showers, which resulted in intensive outwash and soil loss. Because of the intensive growth of gullies the so-called "badlands" were formed on millions of hectares within a short period. Where formerly fertile lands suffered the greatest degradation, farmers were forced to leave settled places and move to the western states (see *Ecology and Our*

Endangered Life-Support Systems). Luckily there was a great amount of wild uninhabited territory still available at this time.

In the 1920s and 1930s intense dust storms broke out on the Great Plains. The storm winds raised the tiniest particles of dust and silt 2–3 km high and carried them towards the Atlantic Ocean. During only one day—May 11, 1934—about 3×10^8 t of fertile soil were raised up into the air and the layer of outblown soil amounted to 25 cm. Nearly 13×10^7 ha in the United States were badly affected by the dust (“black”) storms, a quarter of which had to be removed completely from arable farming. At present 34% of cropped land in the United States is to some extent affected by erosion and deflation, and the annual economic damage is estimated at several billions of dollars.

Considerable areas of agricultural lands are damaged by erosion and deflation in many other countries. For example, in Hungary and Poland eroded soils cover from 30 to 40%, in Australia and Cuba about half, and in Bulgaria nearly three-quarters of the agricultural territory. Soil erosion is widely spread all over the continents except Antarctica, and in all climatic zones. Unlike other kinds of degradation, which are generally found only in specific zones, erosion is an azonic phenomenon.

Erosion has a number of negative social and ecological effects. The main ones are:

- A reduction in the area of arable land because of its destruction by the linear forms of scour (gullies and rills). Research data indicate that 1 ha of gully area eliminates from intensive use another 3–5 ha of fertile land.
- A decrease in the thickness of the soil layer, and a fall in the humus reserve, as a result of erosion of the most fertile top horizons.
- A fall in crop yield on eroded soils (compared with uneroded soils) of 30–60% or more. The total yield loss because of erosion is many times greater than the total yield loss caused by such kinds of soil degradation as increased acidity, alkalinity, and excessive moistening.
- Gully growth can cause landslides that damage housing and industrial constructions, roads and other infrastructure.
- There is irretrievable loss of a great amount of organic matter and biogenic elements.
- Watercourses are silted up and water polluted.
- Outwashed water is not only a water loss, but also carries away mineral fertilizers, herbicides, and other chemicals applied in the fields to control weeds, pests, and crop diseases. Scientists from different countries report that the loss of fertilizers and other chemicals along with the runoff and outwashed soil can be up to 20–30 percent of the amount applied.

At present, among all environmental factors, it is soil erosion, and in certain zones deflation, that cause most damage to agricultural production. That is why the protection of soil from their destructive impact should be a priority; in susceptible areas, only crops that can be produced in an anti-erosion and anti-deflationary way should be grown. Anti-erosion and anti-deflationary measures should be worked out in detail, on the basis of the following principles:

- Systematization: that is, a necessary appreciation of the damage caused by erosion and deflation, and of the positive effects of various soil-protecting measures.
- Obligation and generality. Anti-erosion and anti-deflation measures are to be applied continuously and all over the erosion- and deflation-prone area.
- The integrity and irreplaceability of separate elements. Crop farming should be based on a contour (strip) organization of the farmed area. There should be an obligatory combination of agronomic, meadow meliorative, and forest meliorative measures, together with hydrotechnic measures in certain conditions. Attempts to solve the problems of erosion and deflation through farming practices or forest melioration alone have been shown to be unsound.
- There should be differentiated placement of crop rotations on the available agricultural land, taking into account the specific biological and soil-protecting properties of crops, the erodibility and deflatability of soils, the extent to which soils are subject to gully formation, slope steepness, and exposure.

The principle of urgency is also important. Erosion and deflation control should be carried out without delay, because damage once done cannot entirely be repaired by any technological measures, and once erosion has affected crop production levels it may never be possible to regain the lost level of production.

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Biographical Sketches

Victor Mitrofanovich Volodin was born in 1939 in Russkaya Zhuravka, Verkhne-Mamon district, Voronezh province, Russia. After finishing school in 1956 he worked on a collective farm, then entered Voronezh State University from which he graduated in 1965. His specialism subsequently has been soil science and agrochemistry. He obtained a candidate's degree from Tselinograd Agricultural Institute in 1971, then worked as senior teacher and assistant professor.

From 1974 till 2000 he worked at the All-Russian Research Institute of Agronomy and Soil Erosion Control, Kursk as senior scientist, head of a laboratory, a department, deputy director, director. He obtained his doctorate in 1991, and in 1995 he was elected corresponding member of the Russian Academy of Agricultural Sciences.

He was engaged in research work for 30 years. He published 130 papers including five monographs, and was one of the leading scientists in the field of agricultural soil science and agronomy. He founded a new scientific school of agricultural bioenergetics, formulated a conception of the estimation of soil fertility and crop farming systems on the bioenergetic basis, revealed the regularities of the process of the extended soil fertility reproduction, sustainability and stability of crop farming, and suggested new approaches to the crop-farming classification based on the ecosystem theory. He was an author of the fundamental tenets of the conception of forming ecologically balanced agricultural landscapes. He won the State Prize of the Russian Federation for development of the theory and methods of managing ecologically balanced agricultural landscapes. He also lectured on ecology and supervised postgraduate students.

V.M. Volodin died on December 26, 2000.

Grigoriy Nikolayevich Cherkasov was born in 1948 in Konetzpolye, Baryatinsk district, Kaluga province, Russia. He graduated from the K.A. Timiryazev Moscow Agricultural Academy in agronomy in 1971, and obtained his candidate's degree in 1976. He has been occupied in scientific and research work for 25 years, 23 of them in the All-Russian Research Institute of Agronomy and Soil Erosion Control, Kursk, as junior and senior scientist, head of a laboratory and deputy director, and director. He has published more than 90 papers including four monographs

His main research interest is in methods and technologies for the improvement and increase of productivity of natural fodder lands on erosion-prone and eroded slope lands; technologies of reclamation of gully-ruined lands for hay- and pasturelands; regularities of erosion processes on slopes and measures of soil protection from erosion; and scientific principles of forming ecologically balanced agricultural landscapes and soil-protecting farming systems. He obtained his Doctorate in 1996 on the topic "Scientific principles of rational land use and raising productivity of natural fodder lands in the gully and ravine systems of the forest steppe of the Central Chernozem Zone."

G.N. Cherkasov is a winner of the State Prize of the Russian Federation for development of the theory and methods of managing ecologically balanced agricultural landscapes.

Alexander Georgiyevich Rozhkov was born in 1926 in Shatalovo, Oryol district, Oryol province, Russia. He graduated from the Voronezh Institute of Forest Engineering in 1955 with agricultural forest

melioration as his speciality, then studied at the Dimo Moldavian Research Institute of Soil Science and Agrochemistry, obtaining his candidate's degree on the topic "Investigation of the process of plowing terracing of slopes" in 1963. In 1972 he obtained his Doctorate on the topic "Gullies, their melioration and agricultural use."

He has been engaged in scientific and research work for more than 40 years. For about 30 years he has been working at the All-Russian Research Institute of Agronomy and Soil Erosion Control, Kursk, 11 of them as deputy director. He has published more than 200 papers including nine monographs and booklets. His main research interests are in regularities of soil loss and gully formation; effect of natural (precipitation, soil, relief, etc.) and anthropogenic factors on the intensity of erosion processes; development of technologies of slope terracing with different machines; development of technologies of gully leveling and melioration of gully-ruined lands; and the study and estimation of soil-protecting and nature conservational efficiency of different anti-erosion measures (slope terracing, forest-meliorative and agronomical methods, hydrotechnical constructions for gully reinforcing, ecological consequences of soil erosion and others).