Soil degradation in the process of agricultural activities

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Abstract. The key characteristic of agricultural land is its fertility. It consists of different components (chemical composition, moisture content, insolation level, etc.), but in the end only the general characteristic matters. Unfortunately, modern farming practices are such that they inevitably lead to soil degradation. Land degradation is the process when soil quality deteriorates, occurring due to improper land use, agriculture and grazing, urban or industrial uses. The process is associated with the deterioration of the physical, biological and chemical condition of the planet's cover. The article deals with the problem of land cover pollution. Characterization of the main types of anthropogenic impact on agricultural soils and methods of protection against them are provided.

1 Introduction

Soils are the most valuable natural resources that have emerged under the action of light, air, moisture, plant and animal organisms, and human activity on the surface layer of the earth's crust [1, 4, 5].

The most important component of economic biocenoses is soil. Unlike rocks, soil has a special property: fertility. The condition and character of the soil cover, its water and salt regimes, bioproductivity have a decisive influence on the yield of agricultural structures. It also accumulates and purifies fresh water, providing nutrition for green plantations.

Soil is a boundary layer between the atmosphere and the biosphere part of the lithosphere. It is not just a mixture of living and non-living components of nature, but their interaction within the soil ecosystem. The main purpose of this ecosystem is to ensure the cycle of substances in the biosphere. Soil is a living system, and it is necessary to treat it in such a way as not to cause irreparable damage to it.

The main property of soil is fertility. Fertility is understood as the ability of soil to provide plants with nutrition elements, water, air and other factors of life during the entire vegetation period to maximize yield [1].

The upper part of the lithosphere, which directly acts as the mineral basis of the biosphere, is subjected to increasing anthropogenic impact every year. Human economic activity is currently becoming a dominant factor in the destruction of soils, reduction and increase of their fertility [1].

Soil degradation is a gradual deterioration of its properties, which is accompanied by a decrease in humus content and fertility. There are different approaches to the definition of "soil degradation". Therefore, according to methodological recommendations on identification of degraded and polluted lands, this concept is defined as a set of processes. They lead to changes in the functions of soil as an element of the natural environment, quantitative and qualitative deterioration of its properties and regimes, reduction of natural and economic significance of lands.

Causes of land degradation are as follows:

- physical factors that alter the natural composition and structure of the soil. Rainfall, surface runoff, floods, wind erosion, tillage and mass movements cause loss of fertile topsoil, which deteriorates soil quality;
- biological factors that are directly influenced by human and plant activities, due to which the quality of the land is reduced. Certain forks of bacteria and fungi have a strong influence on soil microbial activity through biochemical reactions. For this reason, the yield and productive suitability of the soil is reduced. Human activities, such as poor farming practices, can also deplete nutrients in the soil, thereby reducing its fertility. Biological factors mainly affect the reduction of its microbial activity;
- chemical factors. Due to excessive alkalinity, acidity or waterlogging, nutrients in the soil are reduced. Because of this, its chemical properties, which determine the availability of nutrients, change. This is caused by salt accumulation and nutrient leaching, which degrade soil quality by causing undesirable changes in the major chemical components of the soil. These chemical factors usually cause irreversible loss of soil nutrients and productivity, such as the hardening of clay soils rich in iron and aluminium up to stiff troughs.

Main types of anthropogenic impact on soils are:

- erosion (wind and water);
- contamination;
- secondary salinization and waterlogging;
- desertification;

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• alienation of land for industrial and communal construction.

2 Materials and methods

There are two types of land use: industrial and agricultural. Any type of land use leads to the destruction of landscape and soils.

Agricultural land use leads to the destruction of natural ecosystems. Agriculture provides sustainability in food production, but it is environmentally dangerous because agro-ecosystems destabilize the environment through the application of large doses of mineral fertilizers and pesticides. This leads to intensive pollution of soil and water bodies. Therefore, the main task is to create sustainable agro-systems that not only provide high productivity of agricultural lands, but also reduce their destabilizing role.

The area of arable land per capita has become smaller and is projected to continue to decline. In general, the Earth's soil resources suitable for farming are now exhausted by about 40%. The areas occupied by chernozems, as well as loamy soils, located in areas with the most favorable conditions for farming, are almost completely economically developed [1–5, 10].

Involvement of new lands in agricultural turnover occurs mainly at the expense of deforestation, which in itself carries the threat of a global ecological catastrophe. The development of these lands cannot solve the problem of increasing food production.

Preservation and multiplication of soil fertility are the key problems of human survival. Meanwhile, increased exploitation of the most fertile soils leads not only to their depletion, although this problem is quite solvable owing to fertilizers and agricultural techniques. But it also leads to soil erosion: the process of soil destruction due to the movement and dispersion of soil particles under the action of wind and surface water runoff [11].

3 Results and discussion

Soil erosion is the destruction and removal of the upper most fertile horizons and underlying rocks by wind (wind erosion) or water flows (water erosion). Land that has been destroyed by erosion is called eroded land. Erosion has a significant negative impact on the state of the soil cover and in many cases destroys it completely. The biological productivity of plants decreases, yields and quality of grain crops, cotton, tea are reduced [12, 13].

Wind erosion is characterized by the wind carrying away the smallest soil particles. The intensity of wind erosion depends on wind speed, soil stability, vegetation cover, relief features and other factors. Anthropogenic factors have a huge impact on its development. For example, destruction of vegetation, unregulated grazing, improper application of agrotechnical measures sharply activate erosion processes. There is a distinction between local wind erosion and dust storms.

The most dangerous is water erosion, washing away of soil by melt, rain and storm water. As in the case of wind erosion, the conditions for water erosion are created by natural factors, and the main cause of its development is industrial and other human activities. In particular, the emergence of new heavy tillage equipment, which destroys a soil structure, is one of the reasons for the intensification of water erosion in recent decades. Other negative anthropogenic factors are destruction of vegetation and forests, overgrazing, and moldboard tillage [1, 8, 9].

Technogenic intensification of production contributes to soil pollution. Main soil pollutants are pesticides (pesticides); mineral fertilizers; production wastes and waste products; gas and smoke emissions of pollutants into the atmosphere; oil and petroleum products [14].

More than one million tons of pesticides are produced annually in the world. Among pesticides, the most dangerous ones are persistent organochlorine compounds (DDT, HCB, HCCH), which can persist in soils for many years and even small concentrations of which, as a result of biological accumulation, can become dangerous to life organisms. The impact of pesticides is very negative not only for humans, but also for all fauna and flora. Pesticides can penetrate into plants from contaminated soil through the root system, accumulate in the biomass and subsequently contaminate the food chain.

Soils are also polluted by mineral fertilizers, if they are used in excessive quantities, lost during production, transportation and storage. Nitrogen, superphosphate and other types of fertilizers migrate nitrates, sulphates, chlorides and other compounds into the soil in large quantities [15–19].

Industrial wastes and waste products lead to intensive soil pollution. Huge areas of land are occupied by dumps, ash dumps, tailing dumps, which intensively pollute soils, which are known to have limited self-purification ability.

Gas and smoke emissions from industrial enterprises are extremely harmful to the normal functioning of soils.

According to numerous studies, soil has the ability to accumulate pollutants that are very dangerous to human health, such as heavy metals.

Causes of pollution are accidents on main and in-field oil pipelines, imperfect oil production technology, accidental and technological emissions, etc. [20–22].

A separate problem in this regard is abandoned agricultural land, i.e. areas where, for various reasons, human economic activity has completely ceased. No soil is cultivated there, and no agricultural plants are grown on arable land, no grazing or haying is carried out on hayfields and pastures. Such areas are heavily overgrown with weedy herbaceous and woody shrub vegetation. And only decades later, there is a probability that they will return to their natural state corresponding to the soil-climatic zone [5].

In the process of economic activity, man can increase natural salinization of soils. Such phenomenon is called secondary salinization, and it develops with inordinate irrigation of irrigated lands in arid areas. Salinization of soils weakens their contribution to the maintenance of the biological cycle of substances. Many species of plant organisms disappear, new plants halophytes appear. The

gene pool of terrestrial populations decreases due to deterioration of living conditions of organisms, migration processes intensify [23].

Soil waterlogging is accompanied by degradation processes in biocenoses, appearance of signs of gleying and accumulation of undecomposed residues on the surface. Waterlogging worsens agronomic properties of soils and reduces forest productivity.

One of the global manifestations of soil degradation, and the entire natural environment in general, is desertification. According to B.G. Rozanov, desertification is a process of irreversible change in soil and vegetation and reduction of biological productivity, which in extreme cases can lead to the complete destruction of the biosphere potential and transformation of the territory into a desert [3]. Under the influence of primitive farming, irrational use of pastures, and indiscriminate use of machinery on land, soils turn into deserts [1, 5–7, 10].

Ecological measures can play a special role in soil conservation. They influence the restoration of species and landscape diversity in anthropogenic systems, which is the main condition for increasing the systemic stability of any biocenosis.

In order to avoid blight, trees and shrubs are planted. This work also provides shelter for insect-eating birds. Gullies that have already formed are blocked by dams that hold back the sediment that gradually fills the gully itself [24].

Forest plantations in the form of strips not only reduce soil washing away, provide shelter for birds and prevent the migration of undesirable species. They are the main means of controlling wind erosion.

Only the joint application of organic (manure, humus and compost) and mineral fertilizers, anti-erosion measures and crop rotation (i.e. traditional crop rotation) together with the correct organization of irrigated agriculture can save the basis of life: the soil mass degradation on a planetary scale.

4 Conclusion

Protecting soils from progressive degradation and unjustified losses are the most pressing environmental problems in farming that are far from being solved.

The major links in environmental protection of soils include:

- protection of soils from water and wind erosion (reduction in the degree of plowing of the territory by means of grassing coastal strips along the banks of rivers, gullies and ponds, increasing the area of field-protective forest plantations (including in water protection zones), conservation of degraded lands, etc.);
- optimization of crop rotation organization;
- grassing and afforestation of gully networks;
- planting forest strips along the contours of arable fields, continuous afforestation of steeply sloping and landslide areas [2, 10];
- organization of crop rotations and soil tillage systems in order to increase their fertility;
- optimization of humus content in soils, bringing the content of organic matter to optimal values is possible due to additional (over and above plant residues) application of organic fertilizers in the form of humus [2, 9–11];
- ameliorative measures (control of waterlogging, soil salinization, etc.);
- reclamation of the disturbed soil cover;
- protection of soils from pollution and beneficial flora and fauna from destruction;
- prevention of unjustified withdrawal of lands from agricultural turnover.

Effective methods of soil improvement can be developed and applied exclusively on the basis of comprehensive monitoring, analysis of soil conditions (phytosanitary, sanitary-hygienic and ecological) and individually justified determination of necessary norms for agricultural works [25].

Soil protection should be carried out on the basis of an integrated approach to agricultural lands as complex natural formations with a mandatory consideration of regional peculiarities. The main attention should be paid to activation of internal mechanisms of soil decompaction and maintenance of an optimal level of a soil physical condition.

References

1. E.A. Arustamov et al., *Nature Management*: Textbook (Publishing and Trading Corporation "Dashkov and K", Moscow, 2004) 312 p.
2. I.S. Belyuchenko, *Ecology of Krasnodar Krai (Regional Ecology)* Textbook (FGOU VPO "Kuban GAU", Krasnodar, 2010) 356 p.
3. A.B. Rozanov, B.G. Rozanov Ecological consequences of anthropogenic changes in soils, *Results of Science and Technology. Ser. Soil science and agrochemistry* (Moscow, 1990).
4. L.I. Tsvetkova, *Ecology*: Textbook for Universities (Izd-vo ASV, SPB: Khimizdat, Moscow, 2001) 552 p.
5. R.R. Abdusalamova, Z.M. Balamirzoeva, Soil degradation and its consequences, Vestnik of Social and Pedagogical Institute (2022).
6. M.I. Gerasimova, N.A. Karavaeva, V.O. Targulyan, Soil degradation: methodology and mapping possibilities, Soil Science **3**, 358–366 (2000)
7. V.A. Turkin, I.A. Sarychev, G.V. Ignatenko, Monitoring pollution from ship power plants with laser technologies, IOP Conf. Ser.: Earth and Environ. Sci. **867(1)**, 012177 (2021), DOI=10.1088/1755-1315/867/1/012177
8. M.A. Modina, E.V. Khekert, A.A. Voskanian, Y.V. Pismenskaia, A.I. Epikhin, V.V. Shkoda, Bioindication and biomonitoring assessment of the state of atmospheric air and soil in the study area, IOP Conf. Ser.: Earth and Environ. Sci. **867(1)**, 012072 (2021)

9. *On the state of nature management and environmental protection in Krasnodar Krai in 2022*, Report
10. V.P. Kazachinsky, S.V. Lazovskaya, Ecology of Kuban (YuIM Publishing House, Krasnodar, 2012) 134 p.
11. A.A. Velichko, To estimate changes in the state of vegetation and soil cover of the Eastern European Plain in the XXI century due to anthropogenic climate change, Problems of ecological monitoring and modeling of ecosystems **18,** 208–220 (2002)
12. N.B. Khitrov, Degradation of soil and soil cover: concepts and approaches to obtaining estimates, Anthropogenic degradation of soil cover and measures for its prevention **1.M,** 20–26 (1998)
13. K. Szoszkiewicz, J. Zbierska, S. Jusik, T. Zgoła, *Makrofitowa Metoda Oceny Rzek. Podre˛cznik metodyczny do oceny i klasyfikacji stanu ekologicznego wo´d płyna˛cych w oparciu o ros´liny wodne. Bogucki Wydawnictwo Naukowe* (Poznan, 2010), 82 p.
14. K. Szoszkiewicz, T. Ferreira, T. Korte et al., European river plant communities: the importance of organic pollution and the usefulness of 128 existing macrophyte metrics, Hydrobiol. **566(1)**, 211–234 (2006)
15. K. Szoszkiewicz, K. Karolewicz, A. Ławniczak, F.H. Dawson, An assessment of the MTR aquatic plant bioindication system for determining the trophic status of Polish rivers, Pol. J. Environ. Stud. **11(4)**, 421–427 (2002)
16. C. Vis, C. Hudon, R. Carignan, P. Gagnon, Spatial analysis of production by macrophytes, phytoplankton and epiphyton in a large river system under different water-level conditions, Ecosyst. **10(2)**, 293–310 (2007)
17. A.S. Yakovlev, M.V. Yevdokimova, Environmental regulation of soils and their quality management, Soil sci. **5**, 582–597 (2011)
18. A. Klimkowicz-Pawlas, B. Maliszewska-Kordybach, B. Smreczak, Triad-based screening risk assessment of the agricultural area exposed to the long-term PAHs contamination, Environ Geochem Health **41**, 1369–1385 (2019)
19. K. Alef, Soil respiration, In: K. Alef, P. Nannipieri (eds), *Methods in Applied Soil Microbiology and Biochemistry* (Academic Press, London, 1995), pp. 214–219
20. T.V. Bardina, M.V. Chugunova, V.V. Kulibaba, Yu.M. Polyak, V.I. Bardina, L.P. Kapelkina, *Applying bioassay methods for ecological assessment of the soils from the brownfield sites. Water Air Soil Pollut* (2017), pp. 228–351, DOI: I10.1007/s11270-017-3521-3
21. C. Blasé, Canadian application of microbiotest to assess the toxic potential of liquid and solid media, In: *Microbiotests for Routine Toxicity Screening and Biomonitoring* (Kluwer Academic, New York, 2000), pp. 3–12
22. F. Abbondanzi, A. Cachada, T. Campisi, R. Guerra, M. Reccangni, A. Iacondini, *Optimisation of a microbail bioassay for contaminated soil monitoring: bacterical inocum standartisation and comparison with Microtox® assay, Chemosphere* (2003)
23. Z. Prokop, I. Holoubek, The Use of a Microbial Contact Toxicity Test for Evaluating Cadmium Bioavailability in Soil, J. Soils and Sediments **1**, 21–24 (2001)
24. A. Galuszka, Z. Migaszewski, R. Podlaski et al., The influence of chloride deicers on mineral nutrition and the health status of roadside trees in the city of Kielce, Poland, Environ. Monit. Assess **176** (2011)
25. V.A. Ershov, I.A. Sysoev, V.V. Kondrat'ev, Determination of aluminum oxide concentration in molten cryolite-alumina, Metallurgist **57(3–4)**, 346–351 (2013)