Ecological problems of tillage

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Abstract. The main consequences of human economic activities include: soil erosion, pollution, exhaustion of soil, impoverishment of soil with mineral substances and dehumification. Anthropogenic impacts usually affect all components of the geosystem. As a result of erosion processes, the soil structure changes, its water-physical properties deteriorate; the use of heavy agricultural machinery on the fields contributes to the formation of a plowing shoe with an increased density, which prevents free infiltration of moisture in the soil; contamination of agricultural land leads to the accumulation of heavy metals (HM), radionuclides, benz(a)pyrene, industrial pollutants of organic and inorganic origin, soil pollution with transport and municipal waste. They penetrate in the soil in different ways. Not only soils but also plants growing on them are polluted, through which they enter the body of animals and humans causing various diseases.

1. Introduction
Undesirable processes occur in agriculture - erosion, destruction, arable land degradation. Today the world uses 1.5 billion hectares of arable land; annual losses of 6-7 million ha; world reserves amount to about 4 billion. In our country, 130 million hectares 32 million hectares are withdrawn from circulation, 80 million hectares are re- compacted. The annual increase in land under ravines is 40 thousand ha, desertification occurs on an area of 50-60 thousand ha per year.

Around the world, about 6 million hectares of arable land is annually lost from agricultural use, 24 billion tons of humus is lost, which, when converted to standard tuks, is 2 times higher than their quantity brought in with mineral fertilizers [1-3].

The total area of Russian chernozem is 153 million hectares, which is 48% (almost a half) of the world's chernozem soils. Russia is the richest country by the availability of chernozem fertile land. Chernozems of Russia are experiencing a colossal ecological load. Almost a half of the Russian population lives on this territory. 80% of grain and other agricultural products are produced here. An extensive reproduction of the soil fertility of chernozems is needed to preserve and continue using this precious soil type. The need for this lies in the following.

The first reason is ecological and demographic. B. Rozanov [4-21] wrote that 40 years ago, when the world population was 4 billion people, there were 37.5 hundred square meters of arable land per capita, 15 years ago, when the population reached 5 billion, there were 30 hundred square meters per capita, and now, when there are over 6 billion of us - only 25 hundred square meters. In the USSR 40 years ago, there was over 1 hectare of arable land per capita, 15 years ago - 0.81 hectares. The downward process is on: there is a population growth, on the one hand, and a loss and alienation of land, on the other hand.
The second reason why we need an extended reproduction of humus and soil fertility is socio-economic. It is economically much more efficient and profitable to get more products from a smaller area than to scatter labor and funds in large areas. Intensive farming at this development stage is the only reasonable alternative to the previous extensive way of developing agriculture, which completely exhausted itself in all its aspects - social, economic, ecological.

The third reason is a rather sad state of fertility of most of our arable soils, which resulted from several centuries of extensive farming aimed at the exhaustion of natural fertility.

2. Intensive farming and soil
According to V.M. Volodin [22-24], in the conditions of intensive farming, potential fertility should transfer into the real one in the volumes necessary to maintain the developing energy balance of the ecosystem. An increase in the productivity of agriculture at the maximum preservation of the production potential is the most important problem of our time. Preservation of the soil cover is also necessary from the planetary point of view, since the biosphere cannot exist without soil-ecological systems and without biomass reproduction [4,5,6,7,15,16,23].

The statement of American scientist Eu. Odum dealing with this subject [20] is of interest. He notes that such a prudent consumer, as an individual, should not seek to receive more than 1/3 of the gross or 1/2 of the net output if he/she is not ready to supply energy to replace those "service mechanisms" that have developed in nature to ensure maintaining of primary products in the biosphere. And further he writes: "So, before trying to gather as much as possible of the "crops of the sun", we must remember the first law of thermodynamics (conservation of energy). By removing the flow from one path, we reduce some other flow, which may be more important for the ecosystem."

The basis for the existence of soil as a natural resource is the reproduction of the organic matter in it. However, as a result of the economic use and the impact of erosion processes, the content of humus in soils is decreasing, which leads to a decrease in the yield of agricultural crops.

Worsening of the state of the soil cover can be connected both with natural and anthropogenic factors. The main consequences of human economic activities include: soil erosion, pollution, densification, depletion and acidification of soils, impoverishment with mineral substances and dehumification.

Soil erosion in many regions of Russia is the most serious problem of agriculture. It includes water and wind erosion (deflation).

Wind erosion, or deflation, as well as water erosion, leads to the destruction of the soil cover. The most important conditions for its development are: strong and constant winds; climatic conditions with insufficient moisture throughout a year or a season; destruction of natural vegetation, which leads to the fact that easily blown soil comes to the surface [12,16,17,25].

Water erosion is a process of interaction of inflows and soil, it depends on the nature of the flow and its transporting capabilities, it is closely connected with the water content, morphological conditions of the surface and the properties of the underlying rocks [2,8,9,25]. Its initial stage is surface slope erosion.

Water droplets falling on the surface of soil destroy soil aggregates, i.e., erode the soil structure. Due to the impact force of the droplets, the smallest soil particles move down the slope. The ablation activity increases with an increase in the surface slope. The formation of erosive furrows, i.e., a plurality of parallel washaways on the slopes is a transition from flat to linear ablation.

Overcompaction of soils, i.e., a decrease in its inter-aggregate and aggregate porosity and an increase in density to 1.4 g/cm³. The main reason for this is the use of heavy agricultural machinery in the fields, which leads to the formation of a plowing shoe with an increased density. This prevents free infiltration of moisture in the soil and leads to its overmoisturing.

An alternative way to resolve the contradictions between the intensification of the production activity of modern society and the preservation of the environment from destruction is the justification and development of environmentally adaptive systems and technologies based on scientific and technological achievements. In the field of agricultural production, these can only be regulated
agroecosystems implemented in the form of waste-free biotechnological complexes for year-round production of high-quality plant products, which are essentially a prototype of the industries of the noosphere.

The organization of a regulated agroecosystem entails the solution of a complex of complex tasks, among which the leading one is the creation of non-waste technological cycles in which production waste can be completely disposed of, for example, as soil fertilizer in agroecosystems of an agricultural field. Thus, it is possible to harmonize the interaction of a regulated agroecosystem with the natural environment and ultimately reduce the negative anthropogenic impact on the biosphere and prevent the harmful effects of technogenesis [10]. The principles of creating large-scale biotechnological complexes based on a controlled agroecosystem should take into account the ecological function of the biota of the root habitat (soil and its physical models - soil substitutes) as a regulator of the dynamic state of organic substances during the functioning of the autotrophic and heterotrophic blocks of any ecosystem. Agroecosystems in industrial production are the basis for obtaining food products and raw materials for industry, and the organization of managing their productivity is aimed at the maximum use of radiant energy in the formation of plant products [19].

3. Soil pollution

*Land pollution* results from the penetration of untypical substances into the soil. Sources of pollution are: industry (organic and inorganic waste, heavy metals); transport (petroleum products, benz(a)pyrene, heavy metals); municipal and domestic economy (solid and liquid waste); agriculture (pesticides, mineral fertilizers in excess quantities, livestock drains).

The most dangerous land polluter is heavy metals. Their penetration into the soil through the atmosphere, together with atmospheric precipitation, from soil-forming rocks, as a result of the technogenic transfer. Heavy metals are accumulated in chernozems mainly in the upper part of their profile in connection with the presence of a geochemical barrier here [9,15,20]. Mg, Na, Sr, Mn, Cu, Zn, Mo, Co, As, Hg, Ba, Pb and other microelements are accumulated due to the biogenic accumulation [1,24]. Heavy metals get into soil not only with emissions of motor vehicles and industry, but also with fertilizers and pesticides [11,13,22].

A significant negative impact on soils is caused by their pollution with organic and organometallic compounds associated with technogenic emissions, as well as a widespread use of pesticides. Many of these compounds preserve for a long time in soils (from several months to tens of years) remaining toxic and even forming more toxic metabolites. It is necessary to bear in mind that the soil contaminated with toxicants and their metabolites becomes a source of contamination of plant and animal products, the atmosphere and natural water bodies. Arable land cultivation methods also differently contribute to the accumulation of HMs in soil and the preservation of humus in it [14,18].

The proximity of fields to highways also results in a large accumulation of HMs in the adjacent soils. However, protective forest belts significantly retain dust and thus counteract the intrusion of HMs into arable land. Our studies prove it (Table 1).

**Table 1.** Content of HMs in the 0-30 cm layer 20 m from the highway, mg/kg of soil with and without a protective forest belt.

| Experiment variants | Content of humus, % | Lead | Nickel | Cobalt | Manganese | Cadmium | Chrome |
|---------------------|---------------------|------|--------|--------|-----------|---------|--------|
| Without protective forest belt | 5,23 | 16,2 | 340 | 27,3 | 496 | 0,69 | 74,8 |
| With protective forest belt | 5,76 | 15,8 | 64,7 | 18,6 | 410 | 0,64 | 47,9 |
| MPC according to Kloke | 100 | 50 | 50 | - | 3 | 100 |
| Gross content of HMs in soil according to Boven, mg/kg | 10 | 40 | 40 | 800 | 0,06 | 100 |
A comparison of the content of HMs in the considered variants with their average gross content in soil according to Boven has shown that the excess of the average indicators in both variants included lead, nickel, cobalt and cadmium. Even nickel MPC was in excess according to Kloke (64.7 - 340 vs. 50 mg/kg of soil). This means that crops of cereals and fodder crops are unacceptable near highways due to the danger of their use for humans and animals.

As it has been mentioned earlier, one of the reasons for the appearance of HMs in soil above the background indicators may be mineral fertilizers, or, to be more exact, the ballast introduced into soil together with mineral fertilizers [2,18]. Our studies have shown that in the part of the field where more phosphorus fertilizers were introduced for a long time, the content of some of HMs was higher (Table 2).

| Content of P₂O₅, mg/100 of soil | Soil layers, cm | Heavy metals, mg/kg of soil | Lead | Nickel | Iron | Manganese | Chrome |
|---------------------------------|----------------|---------------------------|------|--------|------|-----------|--------|
| Increased, 10,1 – 15,1          | 0 – 10         |                            | 22.2 | 76.3   | 16350| 416       | 39.3   |
|                                 | 10 – 20        |                            | 18.8 | 71.5   | 13650| 349       | 35.7   |
|                                 | 20 – 30        |                            | 18.4 | 74.6   | 14950| 375       | 38.9   |
|                                 | Average        |                            | 19.8 | 74.1   | 14983| 380       | 38.9   |
| Average, 5,1 – 10,0             | 0 – 10         |                            | 17.9 | 61.3   | 16200| 361       | 34.3   |
|                                 | 10 – 20        |                            | 17.5 | 63.0   | 13650| 348       | 29.2   |
|                                 | 20 – 30        |                            | 18.4 | 58.8   | 12950| 328       | 27.5   |
|                                 | Average        |                            | 17.9 | 61.0   | 14267| 346       | 30.3   |

The content of lead, nickel, iron, manganese and chrome in the plow layer was higher in that part of the field where more fertilizers were added, i.e. at an increased content of P₂O₅ in soil (for comparison: lead at an increased content of P₂O₅ - 19.8 and 17.9; nickel, respectively, 74.1 and 61.0; iron - 14983 and 14267; manganese - 380 and 346, chrome 38.9 and 30.3 mg/kg of soil).

4. Conclusion
Summing up, it can be noted that the accumulation of HMs in soil depends on many factors: the content of humus in soil, its tillage method, the use of chemical means, natural background of the content of chemical elements, technogenic pollution, dispersion of man-made emissions, mobility of chemical elements and many other reasons.

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