Analysis of pesticide load on agricultural land and the effect of chemicals on ecosystems

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Abstract. The article analyzes the pesticide load on agricultural land using the example of the agroecosystem of Moscow region, in particular, the concentration of a wide range of pesticides in soil samples at the beginning and end of the growing season of the model crop, the content of pesticides in agricultural crops at the beginning and end of the growing season and residual pesticides in crop products. The research revealed an excess of the concentration of a number of pesticides in soil samples and agricultural crops. It was noted that the concentration of DDT and its analogues in the herbage at the end of the growing season was 0.031 mg/l, that is three times higher than the MPC level.

1. Introduction
Currently, successful farming is extremely difficult without the use of fertilizers and pesticides [1-5]. From the economic point of view, the use of pesticides pays off in yield increases. In addition, the number of mechanical operations in the tillage system is reduced. On the other hand, the use of pesticides can lead to a number of adverse effects, both for the environment and for humans [6-7].

According to State Report "On the State and Protection of the Environment of the Russian Federation", more than 900 pesticide preparations are registered in Russia, based on 240 active substances.

Researchers have established the following characteristic features of the cycle of pesticides. So, firstly, such a technogenic cycle of pesticides is characterized by the inevitability of circulation, which means the direct entry of a substance into the environment and its presence in it until its decay. In addition, the high biological hazard of pesticides and their constant entry into agroecosystems create an even greater threat to both the surrounding biota and humans through their entry into food chains and products. The high persistence of pesticides, which is one of the characteristic features of this group of chemicals, also contributes to the widespread distribution of preparations along the food chain. Another important property of pesticides is the possibility to accumulate, that also increases their toxic properties [6-10]. All of these characteristic properties of pesticides contribute to their negative impact on the environment.

So, even in the research of N.N. Melnikov, it is indicated that pesticides enter the atmosphere both directly and as a result of evaporation from the surface of soil, plants and water. It was noted that in drier climates and with high groundwater levels, the likelihood of secondary contamination with pesticides and their metabolites is significantly increased [9].

According to various authors the side effects of pesticides include the development of resistance of pest organisms to pesticides, the effect of pesticides and their residues on the biota and abiotic
environment, their accumulation and transfer along food chains, that leads to the appearance of significant amounts of pesticides in food.

When pesticides enter the environment, in addition to their direct effect, they also affect other components, for example, beneficial entomophagous insects. So, E.A. Ivantsova, studying the effect of pesticides on the soil microflora and beneficial biota in agrocenoses of Sarepta mustard, revealed a decrease in the number of entomophages and pollinators by more than 1.5-2 times when the test plant was treated with chemical reagents [8]. The restoration of their numbers occurs rather slowly, since there is a damage of biological objects, contributing to their accumulation.

One of the most famous OCPs is DDT or Dichloro-diphenyl-trichloroethane ("dust"), the use of which was officially banned in the USSR by the end of the 1970s, since its destructive effect on living organisms and extreme toxicity were proven. [8; 10]. Nevertheless, this preparation still circulates through food chains in quantities exceeding the established standards, which is most likely due to the high resistance of the preparation to external influences.

This preparation is currently used in Africa and the Asia Pacific region. According to the IPEN Working Group on POPs / Pesticides, DDT is listed in Appendix B of the Stockholm Convention on Persistent Organic Pollutants (POPs), that means this substance is recognized POP globally and its use should be reduced with a view to its final elimination [8].

2. Materials and methods

The analysis of the pesticide load on agricultural land was carried out on gray forest medium loamy soils with a humus content of 2.08 %. Soil was studied in accordance with GOST. The collection of pooled samples on agricultural land was carried out twice a year: 1) in spring, after the snow melted and before the introduction of pesticides; 2) in autumn, after harvest.

In the course of the study, soil and climate were characterized, the phenetic analysis was provided, which consisted in drawing up a phenological calendar of the studied agricultural crop. There was a study of damaging biological agents, justification of the choice of various groups of pesticides, as well as analysis of the degree of environmental pollution with pesticides, which consists in assessing the content of pesticides in soils and agricultural plants, and analyzing the content of residual amounts of pesticides in plant products.

3. Results

For the ecological justification of the use of pesticides in protecting plants from damaging effects of biological agents, annual sunflower (Helianthus annuus), which is one of the main oilseeds of the country, was chosen as a model agricultural crop.

Considering the phenological calendar of the crop, it can be noted that the annual sunflower (Helianthus annuus) has 10 main phases of vegetation, which reflect the characteristic features of its growth and development, that is of fundamental importance when choosing chemicals and plant protection products.

In the course of the study, the following damaging biological agents were identified that negatively affected the growth and development of the studied crop: Agriotes (Agriotes sputator), Sclerotinia stem blight of sunflower (Sclerotinia sclerotiorum), prickly grass or barnyard grass (Echinochloa crus-galli), wild spin (Chenopodium album).

Evaluating the recommended list of pesticides of different directions in terms of such indicators as specificity, duration of protective action, rate of decomposition in the environment, safety for humans and farm animals, preference was given to Maxim (against Sclerotinia stem blight of sunflower), Dual Gold (species-specific herbicide) and Iskra Zolotaya (long-acting insecticide).

When studying the effect of pesticides on biotic and abiotic components of the agroecosystem, comprehensive studies of the degree of soil and plant pollution were carried out. The following pesticides were determined in the selected soil samples: DDT and its analogues, HCCH, Treflan, Zineb, Phosphamide, Atrazine-simazine (tables 1 and 2).
Table 1. Pesticide content in soil samples, mg/kg.

| Sampling time          | Atrazine-simazine | Phosphamide | HCCH   | DDT and its analogues | Treflan | Zineb |
|------------------------|-------------------|-------------|--------|------------------------|---------|-------|
| The beginning of vegetation | -                 | 0.013       | 0.0066 | 0.0018                 | 0.0767  | 0.37  |
| The end of vegetation  | 0.0297            | 0.011       | 0.046  | 0.0031                 | 0.0063  | 0.54  |
| MPC                    | 0.01              | 0.3         | 0.1    | 0.1                    | 0.1     | 0.2   |

Table 2. Pesticide content in agricultural crops, mg/kg.

| Sampling time          | Phosphamide | Chlorophos | HCCH   | DDE    | DDH    | HPC | Treflan | Zineb |
|------------------------|-------------|------------|--------|--------|--------|-----|---------|-------|
| The beginning of vegetation | 0.015       | 0.019      | 0.0008 | 0.001  | 0.00061| 0.0053| 0.053   | 0.52  |
| The end of vegetation  | 0.034       | 0.01       | 0.003  | 0.0031 | 0.00102| -   | 0.19    |       |
| MPC                    | 0.3         | 0.1        | 0.01   | 0.01   | 0.01   | 0.1 | 0.1     |       |

Studies revealed an excess of the content of Zineb in crops compared to the MPC by 5.2 times at the beginning of vegetation and by the end of vegetation the concentration of the preparation decreased, but still exceeded the MPC (0.19 versus 0.1 mg/kg).

It should be especially noted that the content of such a pesticide as DDT in the herbage of the studied agricultural crop by the end of vegetation increased from 0.001 to 0.031 mg/l, that was three times higher than the MPC level.

To assess the level of accumulation of pesticides in food, comprehensive studies of the content of residual amounts of pesticides in crop products were carried out (table 3). The following agricultural products were studied: winter wheat, barley, carrots, cabbage, beetroot, potatoes, apples.

Table 3. Residual amounts of pesticides in crop products

| Crop          | Pesticide | Active substance     | Residual amounts | MRL |
|---------------|-----------|----------------------|------------------|-----|
| Winter wheat  | dospekh   | tebuconazole         | 0.09±0.0045      | 0.2 |
|               | raxil     | tebuconazole         | <0.015           | 0.2 |
|               | hezaguard | prometrine           | 0.01±0.0001      | 0.02|
|               | acetic    | pyrimiphos-methyl    | <0.0005          | 0.5 |
|               | pilot     | metamitron           | 0.009±0.005      | 0.03|
|               | butizan   | metazachlor          | <0.0005          | 0.02|
|               | acetic    | pyrimiphos-methyl    | 0.0005           | 0.2 |
|               | reglon super | diquat                    | 0.0083±0.00083 | 0.05|
|               | titus     | rimsulfuron           | <0.0005          | 0.01|
|               | prestige  | imidocloprid          | 0.004±0.0002     | 0.05|
|               | ridomil gold | mancozeb               | 0.01±0.0005     | 0.02|
|               | shar-pei  | cypermethrin          | 0.021±0.00110.05 | 0.05|
|               | abiga-peak | copper chloroxide    | 0.24±0.08        | 5.0 |
|               | skor      | difenoconazole       | <0.0005          | 0.1 |
|               | fufanon   | malathion            | 0.0005           | 0.5 |

The following pesticides were determined in the selected soil samples of food products: dospekh, raxil, hezaguard, acetic, pilot, butizan, acetic, reglon super, titus, prestige, ridomil gold, shar-pei, abiga-peak, skor, fufanon and others.

As a standard, the maximum residues level (MRL) was applied, which, according to regulatory documents, means the maximum concentration of pesticide residues in a food product or on its
surface, recognized by law as acceptable, provided that pesticides are used correctly in accordance with principles of good agricultural practice.

As can be seen from Table 3, the residual amounts of pesticides in food did not exceed the standard indicators.

4. Discussion

The human right to a comfortable and favorable living environment is one of the basic principles of the Constitution of the Russian Federation.

The main components of the environment include atmospheric air, surface and ground waters, soils, landscapes, phyto- and zoocenoses. Monitoring of their state in order to develop measures to counter the massive anthropogenic pressure is the goal of this research.

Nowadays, successful farming is extremely difficult without the use of pesticides. From the economic point of view, the use of pesticides pays off in yield increases. In addition, the number of mechanical operations in the tillage system is reduced. On the other hand, the use of pesticides can lead to a number of adverse effects, both for the environment and for humans.

When assessing the effect of pesticides on agroecosystems, it is necessary to analyze the content of their residues not only in soil samples, but also in crops, as well as in food. The following pesticides were determined in the soil samples taken: DDT and its analogues, HCCH, Treflan, Zineb, Phosphamide, Atrazine-simazine. The analysis of the data obtained indicates that the maximum permissible concentration of pollutants in the soil has been exceeded for the following types of plant protection chemicals: Atrazine-simazine (the excess was 97 % compared to the norm) and Zineb (the excess was 170 %). The concentration of the last preparation exceeded the norm already at the beginning of vegetation (excess of 85 %). Such a picture indicates an insufficiently clear understanding of the tasks of environmental protection and greening of agriculture in particular.

It should be especially noted that the content of such a pesticide as DDT in the herbage of the studied agricultural crop by the end of the growing season increased from 0.001 to 0.031 mg/l, that is three times higher than the MPC level. Thus, the studies have confirmed the fact that this preparation is extremely resistant to destruction and transformation in the environment.

Nevertheless, the assessment of the level of accumulation of pesticides in food products showed that the residual amounts of pesticides in crop products did not exceed the established standards. Thus, one can conclude that the aftereffect of the studied pesticides is minimized and will not have any significant effect when these products are consumed.

5. Conclusion

In the environmental substantiation of the use of pesticides to protect plants from the damaging effects of biological agents, annual sunflower (Helianthus annuus) was chosen as a model agricultural crop. The following damaging biological agents were identified that negatively affected the growth and development of the studied crop: Agriotes (Agriotes sputator), Sclerotinia stem blight of sunflower (Sclerotinia sclerotiorum), prickly grass or barnyard grass (Echinochloa crus-galli), wild spin (Chenopodium album).

It was found that the content of Zineb in plant raw materials was 5.2 times higher than the MPC at the beginning of vegetation. The concentration of the preparation decreased by the end of vegetation, but still exceeded the MPC (0.19 versus 0.1 mg/kg). The content of such a pesticide as DDT in the herbage of the studied agricultural crop by the end of vegetation increased from 0.001 to 0.031 mg/l, that was three times higher than the MPC level. Residual amounts of pesticides in crop products (winter wheat, barley, carrots, cabbage, beetroot, potatoes, apples) did not exceed the established norms.

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