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Environmental Protection Through the Regulation of Pesticide Use

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Abstract: This article is dedicated to studying the impact of pesticides on the environment. Based on the classification of pesticides in relation to their persistence in the environment, the harmful effects of chemical substances on the soil can be identified and assessed. From the following information, it can be concluded that the use of certain pesticides requires strict regulation under legislation.

Keywords: soil, pesticide, accumulation, tissue, ecology.

Fertile lands given to humans are truly treasures, no less and perhaps even more valuable than coal seams, oil deposits, and gold veins. Protecting soils from pollution is a critical task for society, as any harmful compounds present in the soil will eventually enter the human body. Many compounds harmful to human health have the ability to accumulate in tissues, primarily in the bones. According to researchers, around 20-30 billion tons of pollutants, including pesticides, enter the biosphere annually.

Land resources play a significant role in the agro-industrial complex of Uzbekistan. Currently, land resources are severely depleted due to ecological problems and related issues. This paper attempts to explore one of the most pressing land-use problems today — soil pollution by pesticides — and highlight some possible solutions.

The soil cover, along with its micro-world, serves as a universal biological sorbent, purifier, and neutralizer of pollutants, as well as a mineralizer of various organic substances. The soil cover plays a critical role in ensuring humanity's food supply and providing raw materials for essential industries. Using ocean products, hydroponics, or artificially synthesized substances for these purposes cannot, at least in the near future, replace the products of terrestrial ecosystems (soil productivity). Continuous monitoring of soil conditions is a necessary requirement for obtaining the planned yields in agriculture and forestry.

Soil is the most sensitive to anthropogenic impacts. Of all the layers of the Earth, the soil cover is the thinnest, with the most fertile humus-rich layer, even in black soil, usually not exceeding 80-100 cm, and in many soils of most natural zones, it is only 15-20 cm. Loose soil, when perennial vegetation is destroyed and the land is plowed, is easily subjected to erosion and deflation. Poorly planned anthropogenic impacts and the disruption of balanced natural ecological connections in soils quickly lead to undesirable processes, such as the mineralization of humus, increased acidity or alkalinity, salt accumulation, and the development of reduction processes. All of this sharply worsens soil properties, and in extreme cases, leads to the local destruction of the soil cover. The high sensitivity and vulnerability of the soil cover are due to the limited buffering capacity and resilience of soils to environmental forces foreign to their natural state.

Pesticides – finely dispersed substances – in soil are subject to numerous biotic and abiotic influences, which determine their behavior, transformation, and eventual mineralization. The type and rate of these transformations depend on the chemical structure of the active substance and its stability, the mechanical composition and structure of the soils, the chemical properties of the soils, the composition of soil flora and fauna, the intensity of external impacts, and agricultural practices.

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The breakdown of chemical compounds in soil also occurs under the influence of plants, which can absorb certain substances from the soil and convert them into simpler products or other metabolites that form conjugates with plant compounds. As previously mentioned, soil temperature significantly affects how long pesticides persist in the soil: the higher the soil temperature, the faster the breakdown of substances, whether through chemical factors (hydrolysis, oxidation) or the activity of microorganisms and other soil inhabitants. Air temperature also plays a significant role. At a temperature of 15°C, the half-life of ametryn is 6.0 months, and for bromacil, it is 7.0 months. At a temperature of 30°C, the half-life is 4.5 months for ametryn and 1.5 months for chlor-IFK. Various strains of microorganisms break down pesticides at different rates. Soil aeration is also of great importance. For example, DDT decomposes faster in anaerobic conditions than in aerobic ones due to different degradation mechanisms. DDT (Dichlorodiphenyltrichloroethane) is a synthetic organic pesticide that was widely used in the mid-20th century to control disease-carrying insects (such as those spreading malaria) as well as to protect agricultural crops.

Key features of DDT:

DDT is a chlorinated organic compound, which makes it highly persistent in the environment. It can remain in soil and water for many years.

While it is highly effective in killing insects, DDT also accumulates in the fatty tissues of animals and humans and spreads through the food chain.

Over time, it was discovered that DDT has negative effects on both ecology and health, leading to its ban in most countries. It causes problems for wildlife, especially birds (for example, it weakens the structure of their eggs), and is potentially harmful to humans as it is suspected to be carcinogenic.

Under normal conditions, the first stage of DDT breakdown is the formation of 1,1-dichloro-2,2-bis(4-chlorophenyl) ethylene, while in anaerobic conditions, DDT is reduced to DDD (Dichlorodiphenyldichloroethane), which degrades much more quickly.

Pesticides can be classified into six groups based on their rate of decomposition in the soil:

Substances with an action duration of more than 18 months (most organochlorine pesticides).

Substances with an action duration of about 18 months (some urea derivatives, picloram, simazine, and other triazines).

Pesticides with a persistence in soil of up to 12 months (benzoic acid derivatives, acid amides).

Substances with a persistence in soil of up to 6 months (nitroanilines, acrylic oxyalkanoic acids, and others).

Pesticides with a persistence in soil of more than 3 months (carbamic acid derivatives, aliphatic carboxylic acids, and others).

Pesticide adsorption in soil is a complex process that depends on many factors. It plays an important role in the movement of pesticides and serves to temporarily hold them in vapor, dissolved form, or suspension on the surface of soil particles. Silt and organic matter, which make up the "colloidal complex" of soil, are especially important in pesticide adsorption. Adsorption is reduced to ion-cation exchange involving negatively charged clay particles and acidic humus groups, or anionic exchange due to the presence of metal hydroxides (Al(OH)3 and Fe(OH)3), or it occurs through molecular exchange. The movement of pesticides in soil occurs with soil solution or simultaneously with the movement of colloidal particles, on which they are adsorbed. This process is called migration. It depends on diffusion processes and mass flow (dilution), which represent the usual method of leaching.

During surface runoff caused by rainfall or irrigation, pesticides move in solution or suspension, accumulating in soil depressions. This form of pesticide movement depends on the terrain, soil erosion, rainfall intensity, the extent of vegetation cover, and the time elapsed since pesticide application.

Soil contamination with heavy metals is detected through direct methods of sampling soil from studied areas and conducting chemical analysis to determine the concentration of heavy metals. Indirect methods are also effective, such as visual assessment of phytogenesis conditions, analysis of the distribution and behavior of indicator species among plants, invertebrates, and microorganisms.

The consequences of excessive pesticide use can be highly unexpected and, most importantly, biologically unpredictable; one harmful species may be replaced by another that develops immunity and can survive even the most effective treatments. Overcoming the immunity of resistant species often requires increasing pesticide doses, which amplifies the risk of environmental contamination. Due to pesticide migration through air and water streams, or through the biological cycle of substances, their toxic effects may appear in areas where chemicals were never used.

Protecting soil from contamination by heavy metals is based on improving production methods. For example, one technology consumes 45 kg of mercury to produce 1 ton of chlorine, while another uses 14-18 kg. In the future, this amount could be reduced to 0.1 kg.

A new strategy for protecting soil from contamination by heavy metals involves creating closed technological systems and establishing zero-waste production processes.

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