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Article

The Impact of Pesticides on the Environment and Animal Organisms

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Abstract: The article analyzes the comprehensive impact of pesticides on animal and human organisms as well as on the natural environment, based on modern scientific data. The main routes of entry of toxicants into the organism, their mechanisms of action, and the long-term consequences of chronic exposure are examined. Particular attention is paid to the degradation of aquatic and terrestrial ecosystems, as well as to the reduction of biodiversity. The author substantiates the need for a transition to balanced pesticide management strategies, including strengthening regulatory control and developing alternative methods of plant protection. In addition, the toxic effects of herbicides (among pesticides) on animals, humans, and edible plants were studied using modern diagnostic methods to assess toxicity levels.

Keywords: Pesticides, toxicological, herbicide, neurotoxic, ecosystem, carcinogenesis, ecotoxicology, sustainable agriculture, subacute toxicological method.

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Introduction

Pesticides are an integral component of modern agricultural production because they reduce losses caused by insects, weeds, fungi, rodents, and other harmful organisms. Their use can support crop productivity and food security; however, the same biological activity that makes pesticides effective against target organisms can create risks for non-target organisms and humans when exposure is excessive or poorly controlled [1], [2]. The World Health Organization notes that pesticides are potentially toxic and that the magnitude of risk depends on the chemical, dose, and route of exposure. Therefore, pesticide management requires a balance between agricultural benefits and toxicological and ecological safety.

The environmental significance of pesticide use is related not only to direct toxicity but also to persistence, mobility, bioaccumulation, and transfer through food chains. Once released into soil and water, some pesticide compounds can remain for prolonged periods and may affect organisms beyond the treated area [3], [4]. Soil contamination can influence microorganisms, plants, and invertebrates, while aquatic contamination can affect fish and other aquatic organisms. Reviews of pesticide pollution have also emphasized that environmental fate, degradation, bioconcentration, and biomagnification are important determinants of ecological risk .

The toxicological consequences of pesticide exposure are likewise dependent on the chemical class and exposure conditions. The manuscript emphasizes synthetic pyrethroids, organophosphorus compounds, and organochlorine compounds and notes that their persistence and toxicological profiles differ. Pesticides may enter the organism through ingestion, inhalation, and dermal contact. These pathways are especially relevant for agricultural workers, livestock, laboratory animals, and other organisms exposed directly or indirectly during pesticide application. Veterinary toxicology literature further demonstrates that accidental or inappropriate exposure can result in poisoning in domestic animals and that species differences and dosage are important when evaluating toxic effects.

In the Republic of Uzbekistan, pesticide use is closely connected with crop protection and agricultural productivity. The source manuscript reports that Fergana and Andijan were among the leading regions in pesticide application in the cited comparison period, followed by Khorezm region. It also describes the persistence of pesticide residues in soil and their interaction with soil colloids and humic substances. These observations highlight the need for systematic monitoring and scientifically based management of pesticide residues in agricultural ecosystems.

Another important issue is the analytical identification and quantification of pesticide components. Chromatographic techniques, including liquid chromatography and high-performance liquid chromatography, are widely used for pesticide residue analysis because they enable separation, identification, and quantitative assessment of compounds in complex matrices [5]. Modern analytical reviews demonstrate the continuing importance of chromatographic sample preparation, separation, identification, and quantification for reliable residue monitoring.

The present study therefore focuses on the toxicological assessment of the herbicide VINTOPIC under laboratory conditions using rabbits as experimental animals and on the chromatographic characterization of its active component. The objective is to describe the exposure design, assess the toxicological significance of the tested preparation, and interpret the analytical results in the broader context of pesticide safety for animals and the environment. The work also contributes to the practical need for safer pesticide management, residue monitoring, and reduction of unnecessary exposure.

Currently, the global production volume of pesticides exceeds 3,000 tons per year. Through the implementation of measures aimed at the safe use of modern pesticides in livestock farming and veterinary medicine, it is possible to achieve the production of environmentally friendly food products. However, at present, their use without knowledge of their pharmacological composition leads to poisoning of many animals and humans.

At present, in our republic, synthetic pyrethroids, which belong to the group of pesticides, occupy a key position in protecting plants and animals from pests and diseases. Pyrethroids are distinguished by their low toxicity and rapid degradation in the external environment.

Pesticides are an integral part of the modern agro-industrial complex. They protect crops from pests and diseases, thereby directly contributing to global food security. However, their widespread and often uncontrolled use has posed serious risks to humans and the biosphere. Non-selectivity, persistence (stability), and the ability to bioaccumulate allow pesticides to spread far beyond treated areas, contaminating soil, water, air, and food chains.

According to research data, in 2016 compared to 2009, the leading regions in the Republic of Uzbekistan in terms of pesticide application were Fergana and Andijan, followed by Khorezm region. It is known that once pesticides enter the soil cover, they remain undegraded for a long time, accumulating in the soil accumulative layer, being adsorbed by soil colloids, and combining with humic substances to form highly toxic complex compounds. As is known, pesticides form complex chemical compounds in the soil and persist for many years. Since pesticides are mainly organochlorine and organophosphorus compounds, their degradation, i.e., mineralization, ranges from five months to 2–3 years and even over 100 years. Organophosphorus pesticides degrade within 5–6 months, while organochlorine pesticides degrade within 2–3 years.

There are many types of pesticides, and they are classified in various ways according to their application. The most widespread include: insecticides (against insects), fungicides (against plant fungi), defoliants (for defoliation of plants), herbicides (against weeds), bactericides (against bacteria), acaricides (against mites), zoocides (against rodents), and ovocides (against larvae and worms). [5][6][7]

Every year, approximately 385 million cases of acute pesticide poisoning are recorded worldwide, of which about 11,000 result in death [8][9].

As is well known, pesticides enter the human and animal organism through three main routes according to their mechanism of action (through the skin, mucous membranes, perorally, and orally), causing damage and inducing endotoxins.

Methodology

The experimental component was conducted in the vivarium of the Toxicology and Therapy Laboratory. The source manuscript reports the use of 12 rabbits (240 EU) for evaluation of the toxicological effect of the herbicide VINTOPIC. The preparation was diluted at a concentration of 0.01 ml per 1000 ml (1 L) of water and administered through different exposure routes. According to the experimental description, one group received the preparation aerogenously by spraying it on alfalfa grass followed by feeding, a second group was exposed to aerosol in a 1 m^3 cage, a third group received the diluted suspension orally, and a control group was observed without treatment. The experimental allocation reproduced in Table I follows the group and dose information available in the submitted manuscript. For chemical characterization, the active components of the preparation were analyzed using chromatographic equipment with standard solutions and appropriate reagents. Quantitative calculations were based on chromatographic peak areas and the ratio between the test preparation and standard samples. Computer-assisted graphical integration was used to identify the beginning and end of chromatographic peaks, after which the test amount and standard amount were compared according to the chromatographic procedure described in the manuscript. Reversed-phase high-performance liquid chromatography (RP-HPLC) was used for identification and quantitative evaluation. The analytical approach is consistent with established pesticide-residue methodology, in which chromatographic separation, identification, and quantitative determination are used to characterize pesticide compounds. The manuscript also specifies that the number of tested samples in the first batch should be no fewer than three and no more than 30. The resulting chromatographic values were interpreted together with the toxicological classification of the active component to determine the hazard level of the preparation.

Editorial note on the source data: the narrative states that 12 rabbits were used and describes four groups, whereas the original Table 1 contains three rows totaling 9 rabbits. The experimental allocation and animal number should be verified against the laboratory record before final publication.

Table 1. Experimental Grouping And Administration Of The Herbicide.

Group	Number of Rabbits	Preparation	Route of Administration	Dose (ml/kg)
I – Experimental	3	Entopic	Sprayed on feed	0.5
II – Experimental	3	Entopic	Aerosol	0.5
III – Control	3	Entopic	Oral	0.05

Results and Discussion

The toxicological assessment of the herbicide VINTOPIC demonstrated that the preparation contains an active component identified in the manuscript as clodinofop-propargyl. Chromatographic determination indicated that, at the reported dose of 240 EU, the compound corresponds to a Class 3 toxicity hazard. This finding is important because toxicity classification provides a basis for determining the level of precaution required during preparation, application, storage, and disposal of pesticide formulations.

The experimental design considered three principal exposure routes—feed-associated exposure, aerosol exposure, and oral administration—with a control condition. Such route-specific testing is relevant because pesticide toxicity is influenced not only by dose but also by the way in which the chemical enters the organism [10], [11]. Inhalation and dermal or mucosal contact can be particularly important during spraying and preparation of pesticide solutions, while oral exposure is relevant when contaminated feed, water, or food is consumed.

The chromatographic analysis provided a quantitative basis for evaluating the preparation. The manuscript describes the use of standard solutions, appropriate reagents, peak-area comparison, and graphical integration of chromatographic signals. These procedures are consistent with established approaches to pesticide residue analysis, in which extraction and preparation are followed by chromatographic separation and quantitative detection . The use of RP-HPLC is also consistent with the broader development of liquid-chromatographic methods for pesticide analysis, particularly where compound polarity or chemical properties make liquid chromatography advantageous.

The source manuscript reports a final analytical value of 4032 associated with the clodinofop-containing compound. The calibration graph retained from the original manuscript shows a strong linear relationship, with the displayed regression equation $y = 13.016x + 80.184$ and $R^2 = 0.9956$. The high coefficient of determination indicates a strong linear fit within the presented calibration range; however, the units, calibration levels, number of replicate measurements, and validation parameters should be supplied in the final manuscript to permit independent assessment of analytical accuracy and precision.

These findings should be interpreted in the wider environmental context. Pesticides that persist in soil or water may affect non-target organisms and can enter food chains , [12], [13]. Research on aquatic organisms has documented changes in hematological and oxidative parameters following pesticide exposure, illustrating that ecological effects can occur even when the target pest is absent. Similarly, recent research emphasizes sublethal pesticide effects on insects and other non-target organisms, reinforcing the importance of biodiversity protection in pesticide-management decisions.[14][15]

The practical implication is that toxicological classification should be integrated with exposure prevention and environmental monitoring rather than treated as an isolated laboratory result. WHO and FAO guidance emphasizes lifecycle management, regulatory oversight, worker protection, and monitoring of pesticide residues. For veterinary and agricultural practice, this means that pesticide selection should consider target specificity, application dose, exposure route, persistence, residue limits, and the availability of safer alternatives. Integrated pest-management strategies and reduction of unnecessary chemical application can decrease environmental loading while preserving the agricultural benefits of pest control [16], [17].

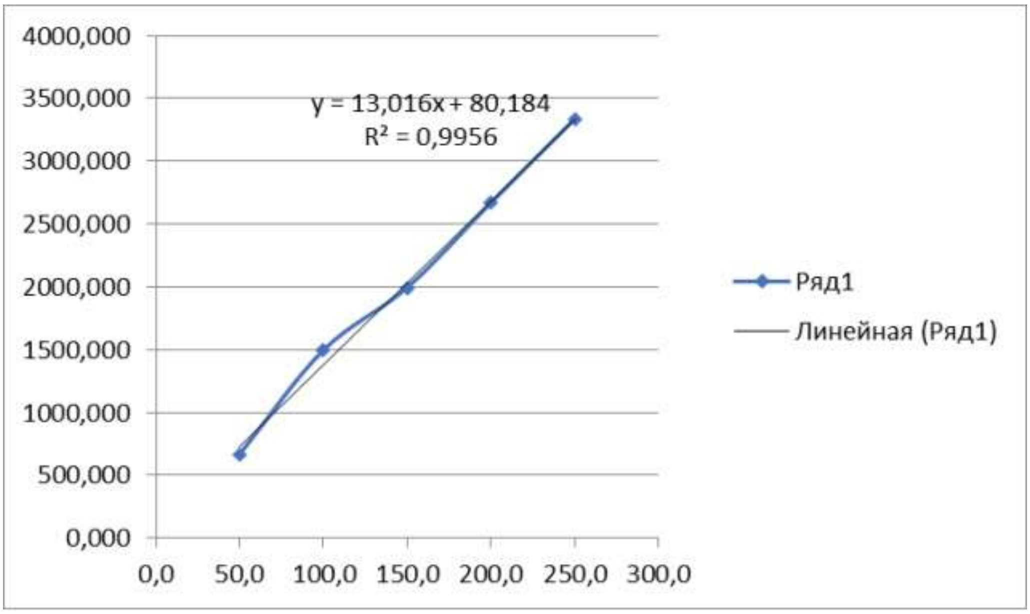

Figure 1. Calibration curve presented for chromatographic quantitative analysis of the tested preparation.

Equation (1):

$V = (m_1 - m_2) / \varrho_{20}$

where V is the filling volume of standard preparations; m_1 and m_2 are the corresponding measured masses; and ϱ_{20} is the density parameter used in the calculation.

Equation (2):

$X = (S_1 \times m_0 \times F_1 \times P_0) / (S_0 \times m_1 \times F_0 \times 100)$

where S_1 is the highest peak of the preparation in RP-HPLC; S_0 is the lowest/reference peak value; F_1 is the dilution factor for the preparation; F_0 is the dilution factor for the standard; m_0 is the mass of the test sample; m_1 is the mass of the standard sample; and P_0 is the standard composition of ingredients in the preparation.[18]

Conclusion

The study demonstrates the importance of combining toxicological observation with instrumental chemical analysis when assessing pesticide safety. The laboratory assessment of the VINTOPIC herbicide described in the source manuscript identified clodinofop-propargyl as an active component associated with a Class 3 toxicity hazard at the reported dose. The experimental design considered different exposure routes, while chromatographic analysis and peak-area calculations provided a quantitative basis for characterizing the preparation. The calibration relationship shown in the manuscript also indicates a strong linear response over the presented range, although additional analytical validation information is required for full reproducibility. From an environmental and veterinary perspective, the results reinforce the need for controlled pesticide application, appropriate protection of workers and animals, residue monitoring, and prevention of contamination of soil, water, feed, and food chains. Future studies should verify the experimental animal allocation, report complete dose-response data and statistical parameters, define the analytical units and validation characteristics, and expand the assessment to biological endpoints and environmental matrices. Such an integrated approach can support safer pesticide management and contribute to sustainable agricultural and veterinary practices.

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