Available online at www.medicinescience.org

ORIGINAL ARTICLE

Medicine Science International Medical Journal

Medicine Science 2025;14(4):1090-6

Assessment of autopsy findings and pathological analyses in pesticide poisoning cases

Servet Birgin Iritas[1], Ahmet Hakan Dinc[2], Aybike Dip[3], Bedirhan Sezer Oner[4], Nevriye Tezer[5], Lutfiye Tutkun[6]

[1]*Ankara Yıldırım Beyazıt University, Faculty Medicine, Department of Forensic Medicine, Ankara, Türkiye*
[2]*Türkiye Radio and Television Supreme Council, Advisory Department of the Supreme Council President, Ankara, Türkiye*
[3]*Adana Metropolitan Municipality, Department of Environmental Protection and Control, Adana, Türkiye*
[4]*Amasya University, Faculty Medicine, Department of Forensic Medicine, Amasya, Türkiye*
[5]*The Council of Forensic Medicine, Department of Morgue, Ankara, Türkiye*
[6]*The Association of Industrial Toxicology and Occupational Hygiene, Ankara, Türkiye*

Received 22 April 2025; Accepted 16 June 2025
Available online 31 October 2025 with doi: 10.5455/medscience.2025.04.105

Abstract

Pesticide poisoning cases contribute significantly to morbidity and mortality in developing countries, especially in rural areas. In our country, usage of total pesticide increased by 4.5% in 2022 compared to 2021 and reached 55.374 tons. The increasing usage of pesticides due to population growth, their role as an toxic agent in approximately one-third of all suicides worldwide, and their easy accessibility in rural areas make pesticides an important part of forensic research in examinations of suspicious death cases. This study aims to establish and document pathological databases for tissue and organ changes observed in fatal pesticide poisoning cases. For this purpose, a total of 10.390 cases were retrospectively examined by the autopsied at the Council of Forensic Medicine of Ankara. Among these, 31 cases confirmed to have pesticide poisoning after toxicological analyses were included in the study. Blood, urine and tissue samples obtained from autopsies were evaluated together with the hospital treatment documents and available investigation data. In a total of 31 pesticide cases, 56% Organophosphate, 10% Carbamates, 10% DNOC, 6% Organochlorines, 3% Paraquat, 3% Penoxsulam, 3% Pyrethroid were determined after toxicological analysis whereas just crime scene investigation data were used as pesticide poisoning evidence in 9% of the cases. Although pesticide poisoning has been mentioned in many studies, there are limited data regarding histopathological effects. In suspected death cases with limited analysis information, the determined histopathological database are useful sources in developing preventive strategies for public health, when evaluated with crime scene investigations and treatment documents, if any, are important in developing comprehensive surveillance systems that integrate forensic data.

Keywords: Postmortem, histopathology, pesticides, organophosphates, 4.6-Dinitro-o-cresol (DNOC), suicide

Introduction

Each year, a variety of toxic chemicals are produced in many areas around the world. While most of these toxic chemicals are used in the production of other substances, some of them, called pesticides, are used directly as toxic products. Pesticides are used to remove or destroy any plants, animals, microorganisms and pests that damage the products during the storage, consumption or growing process of agricultural products. These chemicals are grouped as insecticide (to kill insects), herbicides (to kill weeds), rodenticide (to kill rodents) and fungicide (to kill fungi) according to their effects on living organisms.

In 2022, usage of total pesticide increased to 55.374 tons in Türkiye. The 35.1% of the total amount of pesticides used in our country are fungicides as well as all over the world. In the rest of them 26.3% were herbicides, 22.0% were insecticides, 4.5% were acaricides, 0.5% were rodenticides and 11.6% were others (plant activators, plant growth regulators, insect attractants, fumigants, nematocides, sulfur, mineral oils [1].

All types of pesticides can be toxic to all living things, depending

CITATION
Iritas SB, Dinc AH, Dip A, et al. Assessment of autopsy findings and pathological analyses in pesticide poisoning cases. Med Science. 2025;14(4):1090-6

Corresponding Author: Servet Birgin Iritas, Ankara Yıldırım Beyazıt University, Faculty Medicine, Department of Forensic Medicine, Ankara, Türkiye
Email: sbiritas@aybu.edu.tr

DOI: 10.5455/medscience.2025.04.105

on the exposure route and extent of exposure. Some pesticides can be carcinogenic after long-term exposure or neurotoxic after acute exposure for humans. The toxicity of a pesticide can be acute or chronic depending on the exposure route, exposure time and exposure dose. Fatal or detrimental pesticide poisoning often results from neurotoxic or cardiotoxic effects of acute exposure. Poisoning may occur due to careless and uncontrolled use of pesticides or suicidal use. Self-poisoning with pesticides is a widely used method of suicide. Approximately one-third of all suicides in the world occur in low- and middle-income countries where people living in rural areas are involved in small-scale agriculture [2].

According to their toxicity mechanisms or chemical structures, pesticides were classified as organophosphates / carbamates, organochlorines and pyrethrins / pyrethroids pesticides, DNOC, paraquat and penoxsulam in the current study.

Organophosphates

Organophosphates (OPs) are generally esters, amides or thiol derivatives of phosphoric, phosphonic, phosphorothioic or phosphonothioic acids and are used in invertebrates [3]. OPs can be toxic to humans via inhalation, ingestion or skin contamination. Due to their lipophilic structure, they are rapidly absorbed, accumulate in fatty tissue and can cross the blood-brain barrier [4].

Their toxicity is due to the inhibition of the enzyme acetylcholinesterase (AChE), which causes acetylcholine accumulation in the synaptic cleft. This results in overstimulation of the autonomic nervous system, central nervous system and musculoskeletal system, causing muscarinic and nicotinic effects. Deaths usually occur shortly after OP ingestion due to acute respiratory failure due to hypotension and bradycardia [5].

Widely used types of OP insecticides include azinphosmethyl, bromophos, chlorpyrifos, diazinon, dichlorvos, malathion, methamidophos, meviphos and parathion.

Carbamates

Carbamates are N-methyl carbamates derived from carbamic acid (NH2COOH) and have similar mechanisms to organophosphates. Like OPs, carbamates also inhibit AChE, however, instead of phosphorylating, they carbamoylate the serine enzyme in the active site. Contrary to organophosphates, this is a reversible mechanism, therefore less toxicity may be seen at early hospitalization with low dose. Although the symptoms are like OPs, their effects on the CNS are less. [6].

Carbamate group includes methomyl, triallate, aldicarb, carbaryl, carbofuran, carbosulfan, dioxicarb, ecarbendazim, ethinenocarb, fenobucarb, oxamyl, pirimicarb, propoxur, and trimethacarb.

Organochlorines

Organochlorine pesticides (OCs), whose exact toxic effects are still unclear, persist in the environment for a long time and bioaccumulate due to their high lipophilic properties [7]. OCs have been widely used in agriculture and forestry to control pests and insect vectors of human diseases.

OCs can be divided into three main groups: dichlorodiphenylethanes (e.g. dichloro-diphenyl-trichloroethane (DDT), dichlorodiphenyldichloroethylene (DDE), cyclodienes (e.g. endosulfan, aldrin, chlordane) and benzenes/cyclohexanes (e.g. lindane, toxaphene) [8].

Pyrethroids

Pyrethroids are synthetic insecticides based on pyrethrins isolated from the heads of Chrysanthemum cinerariaefolium plants. In humans, pyrethroid toxicity can result from occupational exposure through skin contact, inhalation of sprays, or ingestion of pyrethroid containing substances. The mechanism of pyrethroid toxicity is intricate due to its effects on various channels and proteins, primarily by influencing sodium and chloride channels targeting excitable cells such as nerve and muscle cells [9]. Widely used type of Pyrethrin/syrethroids group includes Cyhalothrin, Cypermethrin, Deltametherin and Permetherin.

4.6-Dinitro-o-cresol (DNOC)

DNOC, a dinitrophenolic compound, is among the earliest synthetic organic pesticides, initially developed in the 1890s for the control of tussock moth caterpillars.

Dinitrophenols was first mentioned in medical literature as a drug to be used for weight loss after animal experiments showing that they accelerate basal metabolic rate [10]. Following these reports were published, dinitrophenol—and to a lesser extent, DNOC—became available in drug stores and was prescribed for weight loss. It was banned from sale in pharmacies by the FDA in 1938 due to many side effects associated with long-term use [11]. DNOC is extremely toxic to humans and is rapidly absorbed following inhalation, oral, or dermal exposure and EPA canceled DNOC's registration as a pesticide in 1991 [12].

Paraquat

Paraquat poisoning primarily occurs through intentional, occupational, or accidental exposure, with self-poisoning via oral ingestion being the leading cause of fatal cases worldwide, particularly in developing countries [13]. Paraquat induces toxicity through enzymatic redox cycling, generating reactive oxygen species (ROS) such as superoxide and hydroxyl radicals, and reactive nitrogen species (RNS) like peroxynitrite, leading to oxidative stress, cellular damage, and severe pulmonary toxicity due to its preferential accumulation in the lungs [14]. Paraquat cause also renal failure by affecting kidney. Gastrointestinal toxicity often presents as lesions of the oral mucosa and tongue (paraquat tongue) [15].

DOI: 10.5455/medscience.2025.04.105

Penoxsulam

Penoxsulam is belongs to the triazolopyrimidine sulfonamide class and functions as an acetolactate synthase (ALS) inhibitor, which inhibits essential amino acid synthesis in plants and leading to their death [16]. Penoxsulam is rapidly metabolized and excreted, mainly through urine and feces, without significant bioaccumulation in the human body. Metabolites of penoxsulam are considered non-toxic and are eliminated efficiently, reducing long-term toxicity risk. Absorption after oral ingestion rise up to 80% and accumulation potential is low. It distributes throughout blood, gastrointestinal tract, liver and kidney, respectively [17].

Material and Methods

In our study, a total of 10390 cases autopsied at the Council of Forensic Medicine of Ankara between 2012 and 2015 were retrospectively examined. Among these, 31 cases confirmed to be pesticide poisoning were included in the study, following chemical analyses conducted by the Ankara Group Presidency Chemistry Specialization Department of the Council of Forensic Medicine. Blood, urine, and internal organ tissue samples were analyzed and assessed by the specialists.

The forensic investigation documents and autopsy records were reviewed, and the cases were assessed in terms of age, sex, month, location, origin, detected pesticide types, and autopsy findings.

This study was approved by the Republic of Türkiye Ministry of Justice, Forensic Medicine Institution Education and Scientific Research Commission (Approval:07.6.2016-21589509/239).

Results

Among the 31 fatal pesticide poisoning cases, 22 (70.97%) were male, and 9 (29.03%) were female. 68% of the cases were aged 41 and above. The average age of women is 41.56, while that of men is 50.22. Analysis of seasonal distribution among the cases demonstrated that 11 deaths (35.49%) occurred in summer, 9 (29.03%) in autumn, 7 (22.58%) in spring, and 4 (12.90%) in winter. The age distribution of cases is presented in Figure 1, and the seasonal distribution is presented in Figure 2.

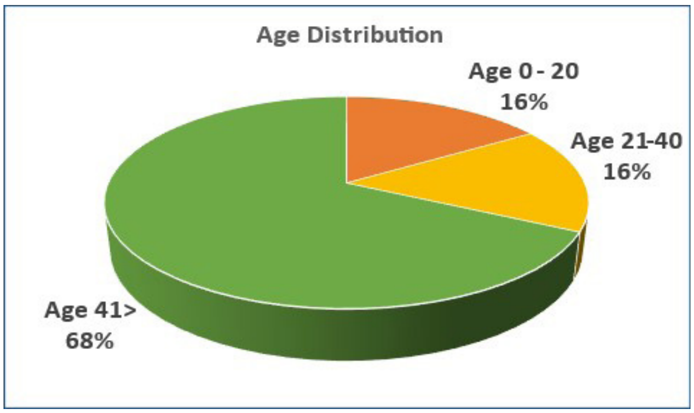

Figure 1. Age distribution of the cases

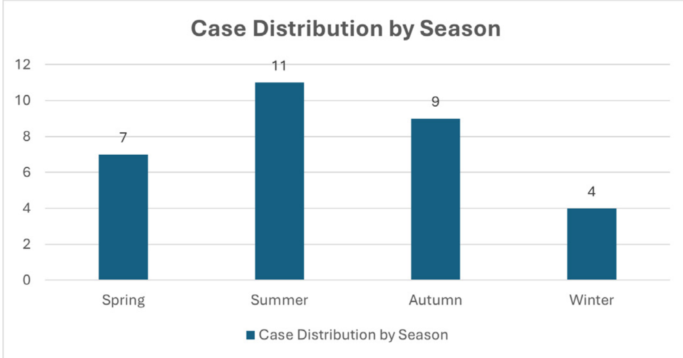

Figure 2. Distribution of cases among seasons

The forensic investigation determined that 17 cases (54.83%) were suicide related. Postmortem examinations and crime scene reports indicated that 28 deaths (90.32%) occurred in rural areas, while only 3 cases (9.68%) were recorded in urban locations. It is noteworthy that all three death cases occurred in the urban area were due to suicide. The distribution of cases by district and origin is presented in Figure 3.

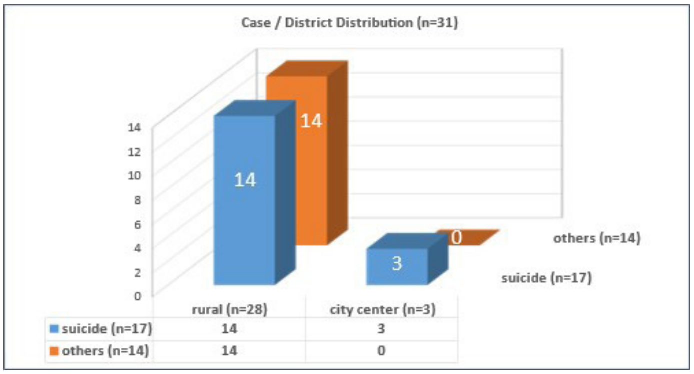

Figure 3. The distribution of cases by district and origin

Toxicological analysis revealed the presence of organophosphates in 56% of the cases, carbamates and DNOC each in 10%, organochlorines in 6%, and paraquat, penoxsulam, and pyrethroids each in 3% of cases. In 9% of the cases, no toxic chemicals could be identified through toxicological examination. The distribution of detected pesticides by groups is presented in Figure 4. No significant difference was found between the type of active substance used and the variables of gender, origin, or location of death. Chemical analyses identified the following substances within the organophosphate group: dichlorvos, methyl parathion, chlorpyrifos, aluminium phosphide, monocrotophos, and cyhalofop-butyl. In the carbamates group, carbofuran, methomyl, and terbucarb were identified; in the organochlorines group, endosulfan and DDT were detected; and in the pyrethrins group, cypermethrin was found.

Histopathological examination of the cases revealed congestion in the brain, cerebellum, and brainstem, as well as pulmonary congestion, edema, and petechial hemorrhages in all cases. Liver congestion was observed in all cases except for one in which DDT was detected. Petechial hemorrhages beneath the scalp were identified in 16 cases (51.61%), and gastric mucosal hemorrhage was found in 6 cases (19.35%).

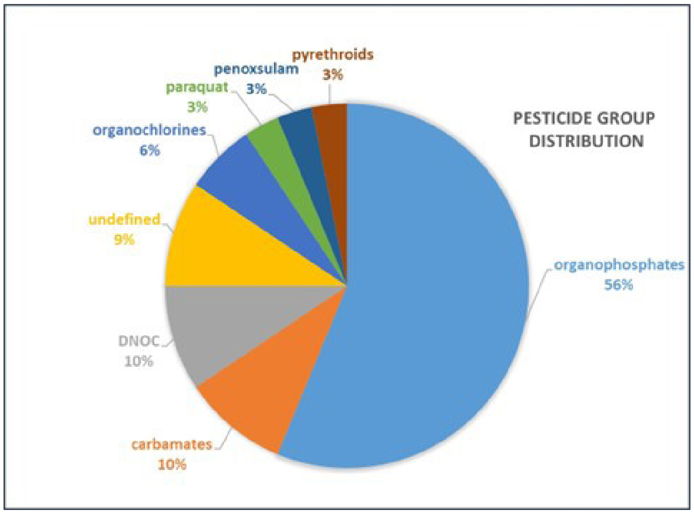

Figure 4. The distribution of pesticides by groups is shown

Discussion

In our study, among 31 cases, 22 (70.97%) were male and 9 (29.03%) were female. These findings are consistent with those reported in previous studies [18-21]. This proportional difference in gender distribution can be explained by the fact that men, who make up the majority of individuals actively involved in agricultural production, are more likely to experience unintentional exposure and have easier access to pesticides for suicide attempts.

In the study, cases aged 41 and above accounted for 68% of all cases. Similarly, a study conducted in Wales and England reported that 80% of the 44-pesticide poisoning-related death cases were aged 44 and above, showing a comparable age distribution to our findings [18]. In the study conducted by Lee et al. in South Korea, which covered a 10-year period and included 25.360 death cases, 57.3% of the cases were found to be over the age of 50 [19]. Conversely, the study by Türkmen et al. in Bursa, conducted on 91 insecticide-related deaths, reported that 52.74% of the cases were between the ages of 20 and 49 [20]. In another study conducted in South Africa, 30% of the cases were under the age of 16, while more than half were between the ages of 17 and 40 [21]. Likewise, a study from India reported that approximately 90% of the cases were under the age of 40 [22]. These regional differences in age distribution may be attributed to the socioeconomic conditions of the region. In low-income countries, factors such as child labor, unregulated working conditions in agriculture, lack of education, and insufficient safety measures may increase the likelihood of chemical exposure among younger populations. Consequently, this may lead to a higher incidence of cases involving lower age groups in such settings.

In our study, the finding that 68% of the cases were aged 41 and above can be associated with several factors: the increasing average age of the agricultural workforce each year, rising life stress, economic difficulties, chronic illnesses, and social isolation within this age group. The lower proportion in younger age groups, on the other hand, may be explained by the tendency of these individuals to migrate from rural areas to cities, distancing themselves from agricultural practices and having less access to pesticides.

According to our study, postmortem examinations and crime scene reports indicated that 28 deaths (90.32%) occurred in rural areas, while only 3 cases (9.68%) were recorded in urban locations. In contrast, a study conducted in India reported that 36% of the cases occurred in rural areas [22], while another study from Bursa, Turkey, found that rural cases accounted for 40% of the total [20].

Due to the Council of Forensic Medicine of Ankara being the one of the main branches with higher number of specialists and high technology and having a wide rural responsibility area in the surrounding provinces, some extra peripheral rural area death cases were autopsied in the Ankara branch. It is the most probable reason why rural area pesticides cases were much higher than in central areas for Ankara.

Access to pesticides is easy in rural areas where agricultural activities are intensive. Therefore, it should be considered that pesticide use in suicide attempts may be higher in these regions, safety measures may be insufficient, and the likelihood of improper pesticide use may increase the risk of unintentional exposure.

A study conducted by Wang et al. in China reported a comparable rate, with organophosphates identified as the most common pesticide in 60.2% of the cases, with methamidophos and dichlorvos accounting for the majority of pesticide poisoning incidents [23]. Similarly, in a study conducted in India, aluminum phosphide was the most frequently detected pesticide, found in 76.92% of the cases [24]. On the contrary, a study conducted in Tunisia reported that carbamate pesticide were the main identified pesticides, accounting for 50% of the cases, while organophosphate insecticides were detected in 31.5% of the cases. The three identified organophosphates were dichlorvos, parathion, and Quickphos [25]. In our study as well, organophosphates were identified as the most frequently detected compounds, accounting for 56% of the cases.

This finding points to the widespread agricultural use of organophosphates and their high toxicity potential. Its similarity to studies conducted in different countries supports the notion that organophosphates are a significant global risk factor in pesticide-related deaths.

In our study, paraquat was detected in one case, which showed congestion in the brain, cerebellum, brainstem, liver, and lungs, along with pulmonary edema and petechial hemorrhages, as well as submucosal hemorrhage in the stomach. Similarly, a four-year study conducted in Thailand reported seven deaths due to paraquat poisoning, in which significant pulmonary and gastric mucosal findings were observed, consistent with the findings of our study [26].

DOI: 10.5455/medscience.2025.04.105

Pyrethroids (cypermethrin) were detected in one case, which showed congestion in the brain, cerebellum, brainstem, liver, and lungs, along with pulmonary edema and petechial hemorrhages. Similarly, in the study conducted by Nozawa et al., a fatal case involving pyrethroids (tetramethrin and resmethrin) revealed internal examinations showing congestion in several organs, particularly in both lungs, consistent with the findings of our study [27].

Beside determined pesticides in toxicological analysis, in 9% of the cases no pesticide could be identified. Similarly, a study conducted in Bursa reported that the causative agent could not be determined in 17.58% of the pesticide poisoning cases [20]. In these cases, the presence of pesticides was inferred from crime scene investigation reports and, in treated individuals, from hospital medical records indicating pesticide poisoning. This inability to detect the toxic agent is thought to be related to the extended time between ingestion and death, during which the substance may have been metabolized or eliminated, especially in those who received medical treatment. As with all forensic death investigations, these findings underscore the critical importance of thorough crime scene examinations in cases of suspected poisoning.

Histopathological examination of the cases revealed congestion in the brain, cerebellum, and brainstem, as well as pulmonary congestion, edema, and petechial hemorrhages in all cases. Liver congestion was observed in all cases except for one in which DDT was detected. Petechial hemorrhages beneath the scalp were identified in 16 cases (51.61%), and gastric mucosal hemorrhage was found in 6 cases (19.35%). Similar to our findings, the study conducted in Tunisia reported pulmonary edema and acute bronchopneumopathy in the majority of cases, along with multi-organ congestion in more than half of the cases [25]. Likewise, a study from India found cerebral edema in all cases and significant pulmonary edema in 55.77% of the cases, further supporting the consistency of these pathological findings across different regions of the world.

Strength and Limitations of the Study

One of the most significant strengths of this study is its multidimensional analysis, achieved by evaluating forensic autopsy findings, toxicological analysis results, and crime scene investigation data together of pesticide intoxication. The integration of these data allows for a more accurate and comprehensive interpretation of the circumstances surrounding the pesticide deaths. Additionally, assessments based on cases supported by both histopathological and toxicological data strengthen the cause-and-effect relationship and enhance the reliability of the findings. Comparisons with existing literature contribute significantly to the scientific validity of the study by contextualizing the results at both national and international levels in pesticide intoxication.

However, the study also has certain limitations. Firstly, the relatively small sample size (n= 31) reduces the generalizability of the findings. Moreover, in 9% of the cases, pesticides could not be identified in biological material, which may hinder the full interpretation of some cases. The fact that the data were obtained from the Ankara Council of Forensic Medicine, which has jurisdiction over many rural areas apart from Ankara provincial border, may have led to a higher proportion of pesticide poisonings from rural regions. This should be considered a potential source of data selection bias. Additionally, the lack of data on sociodemographic variables such as educational status, psychiatric history, and economic condition limited the ability to examine causes of death within a broader social context. Taking these limitations into account, future studies with larger sample sizes, multicenter data collection, and systematic recording of sociodemographic information would make valuable contributions to the field.

Conclusion

This study highlights the ongoing public health problem posed by pesticide poisoning, particularly in rural areas where access to these substances is less regulated and forensic examination is limited. The majority of the cases occurred in agricultural regions and involved commonly used organophosphates, reflecting the widespread availability and misuse of such compounds. Our findings, in line with previous national and international studies, underline that pesticide-related deaths proportionately affect rural areas where people having lack of knowledge and awareness about pesticide usage, unregulated labor conditions, and insufficient safety measures increase vulnerability—especially among younger age groups.

Histopathological examinations revealed consistent organ involvement, particularly pulmonary and cerebral congestion and edema, confirming the toxicological burden of these compounds on vital systems.

Since toxic substances may not always be detectable in poisoning cases, crime scene investigations and case histories carry great importance. This highlights the significance of multidisciplinary collaboration in forensic medicine practices. We believe that developing guideline documents on pesticide-specific histopathological findings and implementing training programs on the forensic evaluation of such cases would be beneficial for medical professionals.

To prevent the uncontrolled use of pesticides, strict regulations should be imposed on their commercial sale and distribution, and legal frameworks should be established to ensure they are used only by individuals who have received training and certification. In particular, awareness campaigns in rural areas should focus on teaching the safe use of pesticides, recognizing symptoms of poisoning, and providing education on available healthcare services in case of emergencies.

Consequently, preventing pesticide-related deaths requires not only medical and forensic interventions, but also educational activities and broader legal and policy-level reforms aimed at reducing environmental and occupational exposures.

Conflict of Interests
The authors declare that there is no conflict of interest in the study.

Financial Disclosure
The authors declare that they have received no financial support for the study.

Ethical Approval
This study was approved by the Republic of Türkiye Ministry of Justice, Forensic Medicine Institution Education and Scientific Research Commission (Approval:07.6.2016-21589509/239).

References

1. Republic of Türkiye Ministry of Environment, Urbanization and Climate Change. Pesticide use. Available from: https://cevreselgostergeler.csb.gov.tr/tarim-ilaci-pestisit-kullanimi-i-85834 access date 01.03.2025
2. World Health Organization (WHO). Safer access to pesticides for suicide prevention: experiences from community interventions. Available from: https://www.who.int/publications/i/item/WHO-MSD-MER-16.3 access date 14.03.2025
3. Malhat FM, Loutfy NM, Greish SS, Ahmed MT. A review of environmental contamination by organochlorine and organophosphorus pesticides in Egypt. J Toxicol. 2018;4:013.
4. Vale JA. Toxicokinetic and toxicdynamic aspects of organophosphorus insecticide poisoning. Toxicol Lett. 1998;102–103:649–52.
5. Eddleston M. Applied clinical pharmacology and public health in rural Asia--preventing deaths from organophosphorus pesticide and yellow oleander poisoning. Br J Clin Pharmacol. 2012;75:1175-88.
6. Pillay VV. Pocketbook of pesticide poisoning for physicians. New Delhi: CBS Publishers and Distributors; 2001.
7. Hafeez M, Nawaz MA, Gulzar A, et al. Extensive use of organochlorine pesticides in agriculture: environmental and health concerns: A review. Acad J Environ Sci. 2019;7:132–48.
8. Taiwo AM. A review of environmental and health effects of organochlorine pesticide residues in Africa. Chemosphere. 2019;220:1126–40.
9. Soderlund DM. Molecular mechanisms of pyrethroid insecticide neurotoxicity: recent advances. Arch Toxicol. 2011;86:165–81
10. Cutting WC, Tainter ML. Metabolic actions of dinitrophenol with the use of balanced and unbalanced diets. JAMA. 1933;101:2099–102.
11. Colman E. Dinitrophenol and obesity: an early twentieth century regulatory dilemma. Regul Toxicol Pharmacol. 2007;48:115–21.
12. Agency for Toxic Substances and Disease Registry. Toxicological Profile for Dinitrocresols (DNOC). Atlanta (GA): ATSDR; access date: January 2018
13. Gunnell D, Eddleston M, Phillips MR, Konradsen F. The global distribution of fatal pesticide self poisoning: systematic review. BMC Public Health. 2007;7:357.
14. Robb EL, Gawel JM, Aksentijević D, et al. Selective superoxide generation within mitochondria by the targeted redox cycler MitoParaquat. Free Radic Biol Med. 2015;89:883–94.
15. Shabrina LS, Ahmad A, Fadrian F. Diagnosis and management of paraquat intoxication. Bioscientia Med. 2023;7:3478–99.
16. US Environmental Protection Agency (EPA). Memorandum: Penoxsulam. Washington (DC): Office of Chemical Safety and Pollution Prevention access date 05.09.2018
17. European Food Safety Authority, Álvarez F, Arena M, Auteri D, Batista F, et al. Peer review of the pesticide risk assessment of the active substance penoxsulam. EFSA J. 2024;22:e9055.
18. Thompson JP, Casey PB, Vale JA. Deaths from pesticide poisoning in England and Wales 1990–1991. Hum Exp Toxicol. 1995;14:437–45.
19. Lee WJ, Cha ES, Park ES, et al. Deaths from pesticide poisoning in South Korea: trends over 10 years. Int Arch Occup Environ Health. 2009;82:365–71.
20. Türkmen N, Fedakar R, Çetin V, Durak D. Evaluation of acute insecticide poisoning cases with postmortem examination in Bursa. Bull Leg Med. 2002;7:28–32.
21. London L, Ehrlich RI, Rafudien S, et al. Notification of pesticide in the Western Cape, 1987–1991. S Afr Med J. 1994;84:169–71.
22. Singh D, Jit I, Tyagi S. Changing trends in acute poisoning in Chandigarh zone; a 25 year autopsy experience from a tertiary care hospital in Northern India. Am J Forensic Med Pathol. 1999;20:203–10.
23. Wang N, Jiang Q, Han L, et al. Epidemiological characteristics of pesticide poisoning in Jiangsu Province, China, from 2007 to 2016. Sci Rep. 2019;9:8604.
24. Kanani J, Sheikh MI, Jain S, Mesuriya S. Histopathological changes in human tissues in various types of poisoning: a cross sectional autopsy study. Toxicol Rep. 2024;13:101771.
25. Mlayeh S, Annabi K, Daly AB, et al. Pesticide poisoning deaths: a 19 year retrospective study of medicolegal autopsies in central Tunisia. Egypt J Forensic Sci. 2020;10:26.
26. Nuwongsa I, Markmee T, Pholpo N, et al. Paraquat poisoning: insights from autopsy, histology, and liquid chromatography with tandem mass spectrometry in multidisciplinary forensic toxicology practice. Toxics. 2024;12:675.
27. Nozawa H, Minakata K, Hasegawa K, et al. A fatal case involved in pyrethroid insecticide ingestion: quantification of tetramethrin and resmethrin in body fluids of a deceased by LC–MS/MS. Forensic Toxicol. 2022;40:189198.