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Review Article

PESTICIDE POISONING IN URBAN ENVIRONMENTS

[*]Rajat Mohan Bhatt and Suraj Mehrotra

Department of Entomology, College of Agriculture, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, U.S. Nagar, Uttarakhand

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ABSTRACT

Pesticides, including both natural and synthetic variants, have become an integral component of modern agriculture and urban pest management. They are crucial in mitigating crop losses by targeting a variety of pests, diseases, and weeds, thereby ensuring food security. However, the indiscriminate and rising use of pesticides globally, particularly in developing nations like India, raises significant environmental and health concerns. India is among the largest producers and consumers of pesticides, with unique usage patterns dominated by insecticides rather than herbicides. This paper explores the extensive classifications of pesticides based on chemical composition, toxicity, pest targets, modes of action, and points of entry. Furthermore, it examines the widespread issue of pesticide poisoning, highlighting causes such as self-poisoning, occupational hazards, and misuse in urban pest control. The rising trend of pesticide poisoning in both rural and urban areas underscores the urgent need for stricter regulations, improved training, and integrated pest management practices to mitigate health risks and promote environmental sustainability.

Keywords: Pesticides, Poisoning, Environment, Urban pest control.

INTRODUCTION

Pesticides, encompassing both natural and synthetic substances, play a vital role in modern agricultural practices by controlling pests, weeds, and plant diseases, thereby ensuring optimal crop yields. The various types of pesticides, including herbicides, insecticides, fungicides, rodenticides, and nematicides, are crucial in minimizing crop losses, which are substantial in both developing and developed countries (Dhaliwal *et al.*, 2015). Effective pest management, encompassing disease and weed control, is essential to mitigate these losses. Pesticides have become indispensable in safeguarding plants and boosting agricultural productivity, contributing significantly to global food security (Sharma *et al.*, 2019).

Globally, crop losses due to pathogens and pests are alarming, with estimates suggesting that wheat, rice, maize, potatoes, and soybeans suffer losses ranging from 10-28%, 25-41%, 20-41%, 8-21%, and 11-32%, respectively (Savary *et al.*, 2019). To address these challenges, the intensity of crop protection measures has increased dramatically, reflected in a 15- to 20-fold rise in global pesticide use. This surge aims to enhance agricultural productivity and profitability. However, despite this substantial increase, overall crop losses have not decreased significantly over the past four decades (Oerke, 2006), highlighting the need for sustainable and integrated pest management strategies to optimize pesticide use and minimize environmental impacts. Poisoning has become a pressing global health concern over the past decade, affecting India and worldwide populations. A poison is any substance that can harm or make a living being sick when it comes into contact with or enters the body (WHO,2016). As developing countries like India experience rapid urbanization and population growth, the increased use of chemical-based products has led to a rising incidence of pesticide poisoning. Chemical pesticides, used in diverse sectors such as households, agriculture, industry, and healthcare, provide numerous advantages but also carry significant risks of accidents and poisoning if not handled properly.

A comprehensive examination of pesticide usage patterns reveals a disturbing trend: the global agricultural and industrial sector is resorting to increasingly larger quantities and more frequent applications of these

*Corresponding Author: Rajat Mohan Bhatt, Department of Entomology, College of Agriculture, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, U.S. Nagar, Uttarakhand Email: rajatmohanbhatt@gmail.com.

chemicals. Data from the FAOSTAT database indicates a striking 46% increase in global pesticide use, measured in tons of active ingredients, between 1996 and 2016 (WHO, 2019). Pesticides function by targeting specific pests, but their impact varies across species, often inadvertently harming non-target organisms. The most widely utilized insecticides belong to three primary classes: organophosphates, carbamates, and pyrethroids (Gilbert, 2012). On a global scale, approximately four million tons of pesticides are applied annually, with herbicides accounting for the largest share (56%), followed by fungicides (25%), insecticides (19%), and other specialized types, such as rodenticides and nematicides (FAO, 2018). This substantial pesticide usage raises concerns about environmental pollution, human health risks, and the development of pesticide-resistant pest populations. The escalating reliance on pesticides underscores the need for sustainable agricultural practices, integrated pest management strategies, and rigorous regulatory frameworks to mitigate adverse effects on ecosystems and human well-being. Effective stewardship of pesticide use is crucial to ensuring food security while protecting the planet's ecological integrity.

Regrettably, pesticide misuse extends beyond agricultural settings. In urban areas, pest control services often employ pesticides indiscriminately, exacerbating risks to human health and the environment. Untrained personnel, inadequate equipment, and lack of regulation can lead to excessive pesticide applications, improper chemical handling, and contamination of water sources. This can result in pesticide poisoning through inhalation of household pesticides, posing serious health risks to residents, especially children, the elderly, and pets. Common symptoms of pesticide poisoning include headaches, dizziness, nausea, and respiratory issues. Severe cases can lead to neurological damage, organ failure, or even death. To mitigate these risks, strengthening regulations, training pest control professionals, and promoting Integrated Pest Management (IPM) practices are essential. This includes using alternative methods, such as baiting, sealing entry points, and sanitizing, to minimize pesticide use. Raising public awareness about safe pesticide handling and use is also crucial to preventing accidental poisonings and ensuring a safer, more sustainable environment for urban dwellers.

Classification of pesticides

Pesticides are classified based on a variety of criteria, such as toxicity levels, target pest organisms, functional mechanisms, chemical composition, mode of entry, action mechanism, timing of efficacy, formulations, and origin sources. This multifaceted approach offers a thorough understanding of pesticide properties, helping researchers, policymakers, and users evaluate their effectiveness, safety, and environmental impact (Yadav and Devi, 2017; Akashe *et al*., 2018; Freedman, 2018; Hassaan and Nemr, 2020; Nayak *et al*., 2020; Tudi *et al*., 2021). By taking these various factors into account, stakeholders can make well-informed decisions regarding pesticide use and management.

Classification by Chemical Composition - Pesticides are often categorized by their chemical structure. Below are examples of chemical-based classifications for various pesticides:

1. Insecticides: Include types like Carbamates (e.g., Carbaryl), Organochlorines (e.g., Endosulfan), Organophosphates (e.g., Monocrotophos), Pyrethroids (e.g., Permethrin), Neonicotinoids (e.g., Imidacloprid), and others such as Spinosyns (e.g., Spinosad).

2. Fungicides: Examples include aliphatic nitrogen fungicides (e.g., Dodine), amide fungicides (e.g., Carpropamid), aromatic fungicides (e.g., Chlorothalonil), and dicarboximide fungicides (e.g., Famoxadone).

3. Herbicides: Types include anilide herbicides (e.g., Flufenacet), phenoxyacetic herbicides (e.g., 2,4-D), and chlorotriazine herbicides (e.g., Atrazine).

4. Rodenticides: Can be inorganic (e.g., Zinc Phosphide) or organic coumarin-based (e.g., Bromadiolone).

Classification of Pesticides Based on Toxicity- Pesticide toxicity is influenced by two main factors: the dose and the frequency of exposure. These factors contribute to different types of toxicity—acute and chronic. Pesticide Classification by Toxicity Level (LD50 for rats in mg/kg of body weight)

1. Class I_a: Extremely Hazardous (Oral & Dermal: <5)

2. Class I_b: Highly Hazardous (Oral: 5–50, Dermal: 5–200)

3. Class II: Moderately Hazardous (Oral: 50–2000, Dermal: 200–2000)

4. Class III: Slightly Hazardous (Oral & Dermal: >2000)

5. Class V: Unlikely to Present Acute Hazard (Oral: ≥5000)

Classification by Pest Target and Function - Pesticides can be categorized based on the specific pests or organisms they target. This classification system includes various types of pesticides, each designed to combat particular pests. For instance, insecticides target insects and other arthropods, while fungicides target fungi and acaricides target mites and ticks. Additionally, algicides control algae, herbicides eliminate unwanted plants, and antifeedants prevent feeding behavior in pests. Other specialized pesticides include avicides, which kill birds, bactericides, which control bacteria, and larvicides, which prevent larval growth. Repellents deter pests, desiccants dry plant tissues, virucides control viruses, ovicides inhibit egg development, and nematicides control nematodes. Termiticides specifically target termites, chemosterilants induce sterility in pests, and plant growth regulators modify plant growth and reproduction. This diverse range of pesticides enables targeted control of various pests and organisms, helping to protect crops, human health, and the environment.

Classification by Mode of Action - In urban pest control, pesticides can be classified based on their mechanism of action, specifically how they affect pests at the biological level. This classification includes:

1. Physical Poisons: Cause physical harm or damage to pests, disrupting their bodily functions.
2. Protoplasmic Poisons: Precipitate proteins, disrupting cellular processes.
3. Respiratory Poisons: Inhibit essential respiratory enzymes, impairing pests' ability to breathe.
4. Nerve Poisons (Neurotoxins): Block nerve impulse transmission, disrupting pests' nervous systems.
5. Chitin Inhibitors: Prevent chitin synthesis, crucial for insect exoskeleton formation.

Classification by Mode of Entry - Pesticides can penetrate pests through various routes of entry, depending on their formulation and mode of action. There are several primary methods by which pesticides enter pests:

1. Systemic Pesticides: These chemicals are absorbed and distributed throughout plant or animal tissues, providing internal protection (e.g., 2,4-D and glyphosate). This type of pesticide is often used to control pests that feed on plant sap or tissues.
2. Contact Pesticides: These pesticides act when pests come into direct physical contact, causing immediate harm or death (e.g., Paraquat). Contact pesticides are typically applied to plant surfaces or soil.
3. Stomach Poisons: Pests ingest these toxins through contaminated food or water sources (e.g., Malathion). Stomach poisons are often used to control pests that feed on treated plants or materials.
4. Fumigants: These pesticides enter pests through respiration, typically as vapor, and are commonly used to control soil-dwelling or airborne pests.
5. Repellents: Instead of killing pests, repellents deter them from approaching treated areas, reducing infestation risks.

Pesticide usage in India and world

India's pesticide industry began with the introduction of synthetic pesticides in 1948-49, specifically DDT for malaria control and BHC for locust control. The country's pesticide production industry took off with the establishment of a BHC technical plant at Rishra near Kolkata in 1952 (Gupta, 2004). Hindustan Insecticides Ltd. subsequently set up two units to manufacture DDT. In 1969, Union Carbide established a pesticide formulation plant in Bhopal, contributing to India's Green Revolution. The plant produced various pesticides, including Sevin and Temik, until the 1984 Bhopal disaster (Lallas, 2001).

India is one of the few remaining countries that continues to engage in the large-scale manufacture, use, and export of certain toxic chlorinated pesticides, including p,p'-dichlorodiphenyltrichloroethane (DDT), hexachlorocyclohexane (HCH), and pentachlorophenol (PCP). Notably, even in the 1990s, more than 70% of the gross tonnage of pesticides utilized in agricultural applications within India consisted of formulations that have been banned or subjected to severe restrictions in both Eastern and Western countries (Subramanian *et al*., 2007). According to a Greenpeace report, India produces 90,000 metric tons of pesticides, making it the largest pesticide producer in Asia and the twelfth largest globally. By 1985, India had cumulatively used 575,000 tons of hexachlorocyclohexane (HCHs), with an additional 45,000 tons being used annually since then (Voldner and Li, 1995). By 1985, India had used a total of 575,000 tons of the pesticide hexachlorocyclohexane (HCHs), and approximately 45,000 tons have been used each year since(Gupta, 2006). The use of DDT and HCH in India continued until recently. Besides the U.S., India is the only country to have applied over 100,000 tons of DDT, primarily for agricultural purposes and in malaria control programs, until its agricultural use was banned in 1989 (Kannan *et al*.,1995). Although technical HCH was completely banned in 1977, the Government of India is promoting its replacement with Lindane (γ-HCH), an isomer that shares the hazardous characteristics of HCH (Kannan *et al*.,1997). While DDT has been prohibited for agricultural use, India has requested an exemption under the Stockholm Convention to permit the use of 10,000 tons of DDT for restricted public health purposes. In 2001, the National Malaria Program (NAMP) utilized 3,750 tons of DDT for residual spraying in rural and peri-urban regions (Gupta, 2004).

India's pesticide management is a pressing concern, with 293 registered pesticides, and 104 of them still in use despite being banned in multiple countries globally (Goi, 2021). Alarmingly, half of all insecticides used in India are dedicated to cotton pest management, accounting for approximately 50% of total usage (Mooventhan et al., 2020). This excessive reliance on insecticides has severe consequences, including pesticide residues on plants, increased insecticide resistance, secondary pest outbreaks, pollution of natural resources, and health risks to both humans and wildlife. To mitigate these issues, experts advocate for eco-friendly pest control alternatives (Birthal and Sharma, 2004). Notably, India's pesticide use per hectare remains relatively low at 0.31 kg, compared to countries like Saint Lucia (19.6 kg/ha), Hong Kong (16.59 kg/ha), Ecuador (13.9 kg/ha), Taiwan (13.3 kg/ha), and China (13.07 kg/ha), while the United States has made progress in reducing pesticide use by 2.54 kg/ha (Roser, 2019). This underscores the need for India to adopt sustainable practices and reduce its pesticide dependency to minimize environmental and health hazards.

India's pesticide usage patterns diverge significantly from global trends. Unlike the worldwide pattern, where herbicides account for the largest share, insecticides dominate India's pesticide usage, followed by herbicides and fungicides, and then other types. Specifically, the current usage pattern in India is characterized by insecticides making up the majority, followed by herbicides, then fungicides and bactericides, and finally other pesticides. In contrast, the global pattern consists of herbicides making up the largest share, followed by fungicides and bactericides, then insecticides, and lastly other pesticides. Notably, India has emerged as the world's fourth-largest pesticide producer. The Indian pesticide market was valued at Rs 214 billion in 2019 and is projected to reach Rs 316 billion by 2024, growing at a compound annual growth rate of 8.1 percent, according to Research and Markets (TAAS, 2020). India's pesticide usage has seen significant growth in recent years, with Chlorpyrifos emerging as the most extensively used insecticide. Its consumption skyrocketed from 471 metric tons in 2014-15 to 1,431 metric tons by 2019-20. Sulfur takes the lead as the most widely used fungicide, with its usage more than doubling from 1,548 metric tons in 2014-15 to 3,878 metric tons in 2019-20. Additionally, 2,4-D amine salts have become increasingly popular as a herbicide, with consumption rising dramatically from just 1 metric ton in 2014-15 to 1,067 metric tons by 2019-20. Zinc phosphide remains the go-to rodenticide, with usage fluctuating between 65 and 200 metric tons from 2014 to 2020 (GOI, 2020).

In terms of insecticide categories, organophosphates are the clear frontrunners, followed closely by neonicotinoids and pyrethroids. Interestingly, cotton tops the list of crops with the highest pesticide use, accounting for a staggering 93.27% of total usage. Vegetables come in second at 87.2%, followed by wheat at 66.4%, millet at 52.6%, and mustard at 12.6% (Maurya and Malik, 2016; Yadav and Dutta, 2019; Nayak *et al.*, 2020). These statistics highlight the growing reliance on pesticides in Indian agriculture and underscore the need for sustainable practices to mitigate environmental and health risks.

Pesticide Poisoning

Pesticide poisoning occurs when non-target entities, such as humans, wildlife, plants, or bees, are inadvertently affected by chemicals intended for pest control (Gupta, 2011). There are three primary forms of pesticide poisoning.

- Acute poisoning results from brief, high-level exposure, commonly affecting individuals who ingest pesticides for suicidal purposes or those handling pesticide formulations.
- Chronic high-level exposure typically impacts pesticide manufacturers and formulators, leading to prolonged health risks.
- Low-level exposure over an extended period affects the broader population through residual pesticide contact via food, air, water, soil, and contaminated plants and animals (Hamilton, 2004).

Cause of pesticide poisoning

1. Self-poisoning/ Suicide - Self-harm through agricultural pesticide poisoning is a significant global public health issue, particularly in developing regions (Bertolote *et al*., 2006). This method of self-injury is prevalent in the Asia-Pacific region, where it accounts for a substantial number of deaths annually (WHO, 2004). The availability of pesticides plays a critical role in the incidence of self-poisoning, as these substances are often used impulsively during stressful periods. Suicide attempts using pesticides have a high fatality rate. In India, pesticides are the most common means of suicide among farmers and students, with a disturbingly high success rate (Sarkar *et al.*, 2013). Approximately 10-20% of pesticide ingestion attempts result in death, making it a particularly lethal method (Gunnel and Eddeleston, 2003). Every year, around 800,000 people worldwide take their own lives, with India bearing a disproportionate share of 180,000 suicides (22.5%). Shockingly, intentional poisoning is responsible for roughly half of India's suicides, primarily due to pesticide consumption (Patel V *et al.*, 2012). According to Jeyaratnam's 1984 study in Sri Lanka, approximately 220,000 pesticide-related fatalities occur globally each year, primarily due to suicidal ingestion. The problem is further exacerbated by underreporting, especially in areas where agricultural workers have limited access to healthcare. Millions of agricultural workers worldwide experience severe pesticide poisoning each year, resulting in a significant number of fatalities.

Addressing this scientific problem requires a multifaceted approach that includes restricting access to highly toxic pesticides, improving pesticide storage and disposal practices, and providing comprehensive support services for individuals in crisis.

2. Occupational/ Industrial urban pest control - Pesticide poisoning poses a significant occupational health risk due to widespread use across various industries, putting numerous worker categories at risk. Agricultural workers are particularly vulnerable due to extensive exposure, with potential health hazards arising from inhalation of fumes in settings like greenhouse spraying operations, tractor cabs, and poorly ventilated areas (Calvert *et al*., 2008). Beyond agriculture, workers in other sectors are also exposed, including retail employees handling pesticide products, emergency responders like firefighters and police officers who may encounter poisoning hazards, and flight attendants subjected to aircraft disinsection procedures (Calvert *et al*., 2007). Occupational exposure varies by job function, primarily occurring through skin absorption, especially on the face, hands, forearms, neck, and chest, often exacerbated by inhalation in enclosed environments (Ecobichon, 2001).

Key factors contributing to pesticide exposure include:

- Pest control service by an untrained and unlicensed pest control company.
- Agricultural spraying operations
- Poor ventilation in greenhouses, tractor cabs, and facilities
- Handling pesticide products in retail settings
- Aircraft disinsection procedures
- Skin absorption and inhalation

Occupational pesticide poisoning in urban areas is often linked to pest control services provided by unlicensed companies offering discounted rates. In an effort to save money, homeowners, businesses, and property managers may hire unregistered pest control operators who use unsafe practices, substandard equipment, and potentially.

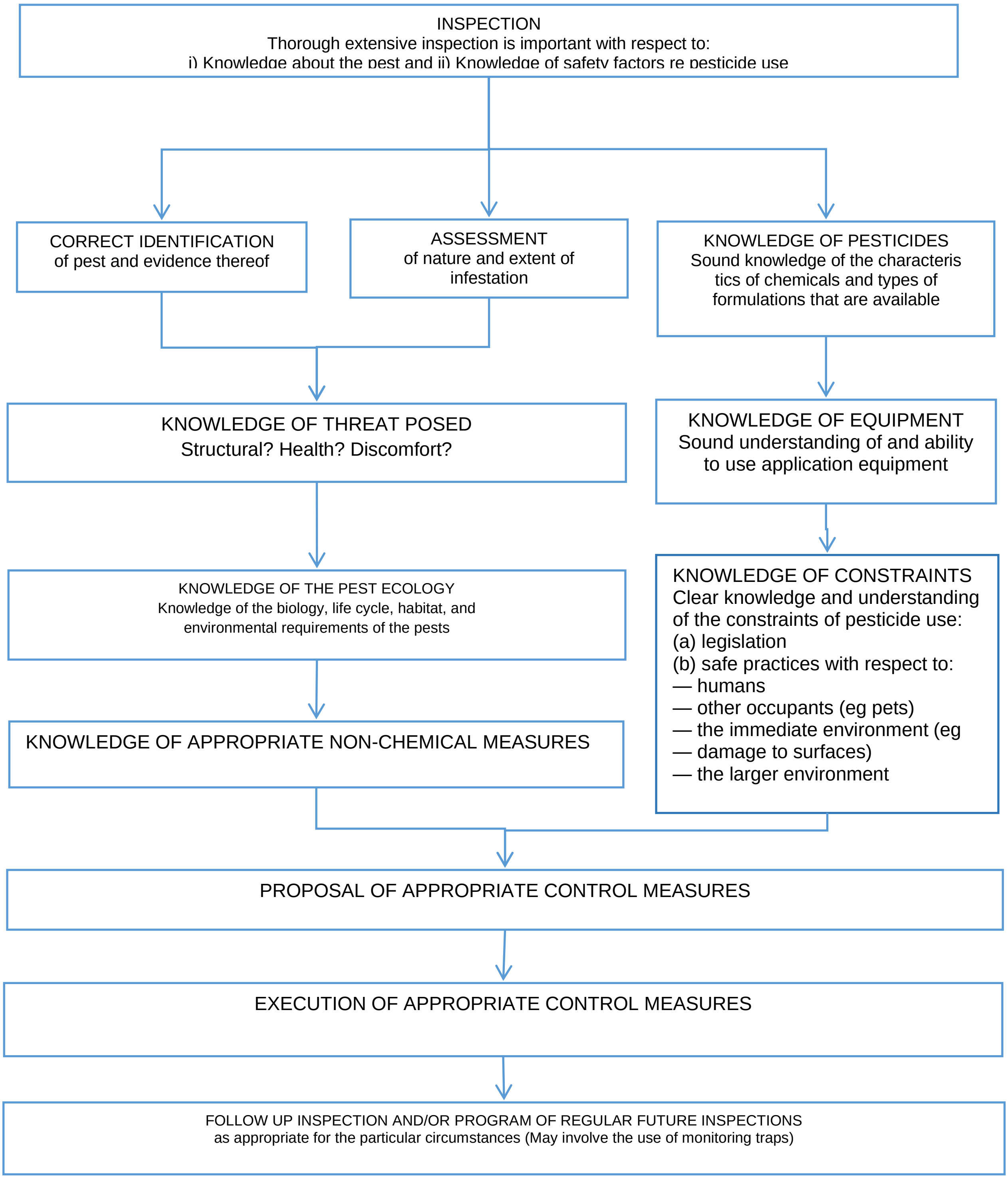

Figure 1. Flow chart of approach of a urban pest problem.

harmful pesticides. These unlicensed providers often lack proper training, disregarding safety protocols and handling pesticides irresponsibly, which puts workers, residents, and bystanders at risk of exposure. Furthermore, unauthorized pest control services may employ ineffective or counterfeit products, exacerbating infestations and necessitating repeated treatments, thereby increasing the likelihood of pesticide-related illnesses.

How to approach a urban pest problem

A pest control operator's job demands a diverse skill set, ranging from carpentry abilities, such as cutting floor traps to access areas under flooring, to climbing skills for challenging bird control tasks. Operators also need to be familiar with electrical, plumbing, and general building practices to prevent accidents, and they sometimes need psychological skills to comfort clients facing significant damage to their property or dealing with imagined pest issues. Generally, though, the primary steps and requirements for addressing pest issues are outlined.

The most crucial initial step in tackling any pest problem is a thorough inspection, which helps with:

1. Accurate identification of the pest(s) involved (for example, borer damage might result from the furniture beetle, powderpost beetle, or European house borer, each requiring a different control approach).
2. Evaluating the nature and scale of the infestation.
3. Becoming acquainted with the control environment to ensure safe practices, such as removing pets and protecting food from contamination.

Effective pest control requires operators to possess comprehensive knowledge in several key areas. This includes:

1. Understanding the risks posed by various animals in and around buildings, enabling informed assessments of potential threats.
2. Familiarity with pest ecology, crucial for developing targeted control strategies.
3. In-depth knowledge of available chemicals, formulations, and application equipment.
4. Awareness of government regulations and legislation governing pesticide use.
5. Understanding of safe pesticide handling practices.

By combining these expertise areas, pest control operators can design and implement control measures that are: Safe for humans and the environmen, Effective in eliminating pests and efficient in terms of resources and costs. This integrated approach enables operators to provide well-informed guidance, such as determining whether termites found in a woodpile pose a threat to nearby buildings, and tailor control strategies accordingly.

Residential

In Canada, pesticide use is widespread among households engaging in gardening activities. With 96% of households having a lawn or garden, approximately 56% of these households utilize fertilizers or pesticides. This common practice may contribute to long-term low-level pesticide exposure, posing health risks through various sources:

- Residues in food
- Air and water contamination
- Soil and sediment pollution
- Contact with contaminated plants and animals

This type of exposure, accounting for the third category of pesticide poisoning, can have cumulative health effects.

History of Pesticides poisoning

Pesticide poisoning is a significant concern in India, accounting for a substantial number of acute human poisonings. Unfortunately, there's a lack of systematic and authentic data on poisonings, making it challenging to grasp the full extent of the issue. India's first documented pesticide poisoning incident occurred in Kerala in 1958, resulting in over 100 fatalities. The tragedy was caused by consumption of wheat flour contaminated with parathion, a highly toxic pesticide (Karunakaran, 1958). The introduction of ethyl parathion (Folidol E 605) by Bayer led to a devastating pesticide poisoning incident in Kerala, India, in 1958, resulting in 102 deaths. This incident was followed by numerous cases of human and animal poisoning, as well as environmental damage, highlighting the importance of proper pesticide handling and storage (Sethuraman, 1977; Banerjee, 1979). Between 1967-1968, Indore reported 35 cases of malathion (diazole) poisoning, resulting in five fatalities. Electrocardiogram (ECG) abnormalities were observed in all cases. Post-mortem and histopathological examinations revealed myocardial damage, highlighting the severe cardiac effects of malathion exposure (Sethuraman, 1977). In Madhya Pradesh, a disturbing incident unfolded where 12 individuals consumed contaminated wheat laced with aldrin dust and gammexane for 6-12 months, leading to severe poisoning symptoms. These symptoms included sudden muscle spasms (myoclonic jerks), full-body convulsions (generalized clonic convulsions), and weakness in the limbs. Tragically, the contamination didn't only affect humans. Two dogs and two bullocks also suffered from similar symptoms, experiencing generalized seizures and myoclonic jerks. This incident highlights the devastating consequences of pesticide contamination in food and the importance of ensuring safe agricultural practices (Gupta, 1975). In 1977, a tragic incident occurred in a village in Uttar Pradesh, where eight people suffered from grand mal seizures after unintentionally consuming wheat contaminated with hexachlorocyclohexane (HCH) (Nag *et al.*, 1977). Periodic incidents of poisoning have been reported in humans and livestock, highlighting the ongoing risks. In 1978, six people lost their lives in Bhopal due to exposure to phosgene gas. Additionally, there have been numerous suicidal deaths resulting from the consumption of aluminum phosphide, although documented reports are scarce. The most devastating incident, however, remains the 1984 Bhopal disaster, one of the world's worst industrial tragedies (Gupta, 1986). Generally it has been observed that Organophosphorus pesticides are responsible for over 70% of pesticide-related deaths, primarily due to intentional poisonings, mainly suicide attempts. In some developing countries, suicides account for a significant proportion of acute pesticide poisonings. For instance, in Indonesia, Malaysia, and Thailand, suicide attempts comprise 62.6%, 67.9%, and 61.4% of acute pesticide poisonings, respectively. These alarming statistics highlight the critical need for stricter regulations and public health interventions to address pesticide misuse and prevent tragic losses (Jeyaratnam, 1987).

Table 1. Uses of pesticide in urban environment.

Category	Purpose
Agriculture	Managing pests, weeds, and rodents to protect crops and enhance productivity.
Public Health	Controlling diseases like malaria, filariasis, dengue, Japanese encephalitis, cholera, and louse-borne typhus.
Industrial	Controlling unwanted vegetation in forests and factory premises; fumigating buildings and ships.
Domestic	Household and garden pest control; managing ecto-parasites in animals and birds.
Personal	Applying pesticides to clothing and skin for protection; controlling ecto-parasites like fleas and lice.
Material/Building	Incorporating pesticides in paints, timber, glues, plastics, sheeting, and building foundations for protection.

Regulatory Framework for Pesticides in India: Ensuring Health and Safety

India's pesticide regulations, established in 1968, are outdated and inadequate, posing significant health risks to farm workers and the environment. Despite ongoing efforts since 2008 to update the law, the government has yet to implement necessary reforms (Prakash & Donthi 2022). The existing Insecticides Act of 1968 and Insecticides Rules of 1971 provide a legal framework for pesticide manufacture and use, but lack critical provisions to prevent deaths, minimize risks to farm workers, and protect against environmental and food contamination (Reddy, 2016).

The Pesticide Management Bill (PMB), 2020, which was recently returned to the Lok Sabha by the Standing Committee with recommendations, aims to replace the current pesticide regulations. However, the current regulatory framework has several shortcomings, including:

- ➢ Inadequate Protection for Farm Workers: No robust mechanisms exist to prevent pesticide exposure, which results in approximately 6,600 farmer deaths annually in India (Bonvoisin *et al.*, 2020).
- ➢ Environmental Contamination: The regulations fail to address the harmful impact of pesticides on the environment and food safety.
- ➢ Lack of Transparency and Accountability: Pesticide companies are not held accountable for misleading information, and there is no mandatory disclosure of pesticide usage and its effects.
- ➢ Ineffective Labelling and Packaging: Labels often lack essential information, and packaging does not meet international standards.

Legislation for Human Health Safeguard

The Indian regulatory framework outlines a procedure for companies to register chemicals and obtain licenses for the manufacture, import, and sale of pesticides. The Central Insecticides Board has the authority to approve or deny these applications. While the act includes a registration process, it lacks a clear mechanism for challenging granted registrations (Bonvoisin *et al.*, 2020). State governments have limited powers over pesticide regulation, including issuing or revoking licenses for the manufacture, sale, stocking, display, or distribution of pesticides for a specified time. The act allows states to ban a pesticide for up to 60 days if safety concerns arise, with possible 30-day extensions. This means that even if a pesticide poses an immediate risk to farmers' lives, it may still be available for 60 days. Additionally, enforcing such short-term bans presents its own challenges.

CONCLUSION

The pervasive use of pesticides, while essential for agricultural productivity, presents substantial risks to human health and the environment. In India, where pesticide usage is primarily insecticide-focused, the agricultural sector relies heavily on these chemicals, which has led to various issues including resistance development, secondary pest outbreaks, and health hazards due to pesticide residues. Pesticide poisoning is a serious concern, particularly among farmers, urban pest control operators, and vulnerable populations. Addressing this issue requires a multifaceted approach: implementing stricter regulatory frameworks, promoting sustainable agricultural practices, and raising public awareness about the risks associated with improper pesticide use. Encouraging eco-friendly pest management solutions and enhancing training for pesticide application can significantly reduce the environmental impact and health risks posed by pesticides. By advancing towards a more sustainable and regulated pesticide use, we can protect ecosystems, ensure safer agricultural practices, and safeguard human health on a global scale.

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CONFLICT OF INTERESTS

The authors declare no conflict of interest

ETHICS APPROVAL

Not applicable

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