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Pesticide Use, Health Risks, and Environmental Implications: A Case Study of Farmers' Practices in Bapatla and Guntur Districts, Andhra Pradesh

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ABSTRACT

Pesticide use remains a major concern in agricultural regions of India, where indiscriminate application, unsafe handling, and poor disposal practices contribute significantly to health and environmental risks. This study investigates pesticide usage patterns, farmer attitudes, safety practices, and health implications in Bapatla and Guntur districts of Andhra Pradesh. Findings reveal that while pesticide use per campaign is substantial, awareness regarding safe handling remains limited. Only a minority of farmers consistently use protective equipment, citing discomfort and impracticality as barriers. Knowledge of label information and hazard classification is also low, underscoring the need for simplified risk communication. Improper disposal of pesticide containers, including burning and reuse, highlights gaps in hazardous waste management, with no formal collection systems in place. Health impacts are evident, as farmers reported acute symptoms such as headaches, dizziness, and nausea following application, while hospital records indicate cases of acute pesticide poisoning, though likely underreported due to diagnostic and record-keeping limitations. These findings emphasize the urgency of training programs, improved regulatory enforcement, and integrated pesticide management systems to reduce risks. Strengthening farmer education and local governance mechanisms is critical to safeguarding public health and ensuring environmental sustainability in the region.

Keywords: Pesticide use, Farmer health, Environmental risk, Protective practices, Hazardous waste management, Andhra Pradesh agriculture.

Introduction

In India, agriculture is one of the most significant productive activities and holds immense social and cultural value, as it involves millions of farming families who cultivate traditional crops such as rice, wheat, maize, pulses, and various cereals, tubers, and oilseeds. At the economic level, agriculture continues to be a primary source of livelihood, with production supporting both household

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consumption and trade in local as well as regional markets. This applies to small, marginal, medium, and large-scale farmers alike (1).

From an environmental perspective, however, the prevailing agricultural practices have contributed to increasing levels of pollution due to the indiscriminate use of chemical fertilizers and pesticides, as well as the reduction of natural vegetation cover. These practices negatively affect soil fertility, water quality, and air purity, while also disturbing biodiversity and reducing populations of wild species. In addition, exposure to toxic substances used for pest control has been linked to multiple health problems among rural populations directly engaged in farming (2). The widespread adoption of high-input agricultural models, particularly those introduced during the Green Revolution, has encouraged monoculture systems heavily dependent on agrochemicals. This reliance has resulted in ecological imbalances, reduction of natural pest regulators, the emergence of resistant pest species, soil degradation, and increased production costs (3–5).

Among the most commonly used pesticides in India are organophosphates; however, residues of banned organochlorines—classified as persistent organic pollutants (POPs) since their prohibition in the early 1990s—continue to be detected in soils, crops, and even human tissues. These substances are highly persistent in the environment and pose serious risks to human health (6).

The World Health Organization (WHO) has classified pesticides based on their hazard potential, with emphasis on their capacity to produce acute health effects following single or multiple short-term exposures. This classification primarily relies on the median lethal dose (LD50) values obtained through oral or dermal administration in rats (7).

The health impacts of pesticide use among Indian farmers are aggravated by unsafe handling practices, lack of protective measures, and the high toxicity of certain chemicals. Such conditions often lead to acute poisonings, which have been documented in several case studies across different states (8). Furthermore, long-term exposures have been linked to chronic illnesses such as cancers of the skin, stomach, prostate, and brain, as well as testicular cancer, leukemia, multiple myeloma, and non-Hodgkin's lymphoma. Numerous epidemiological studies also indicate a higher incidence of soft tissue sarcomas and other health complications among farmers exposed to herbicides such as phenoxy acids (9–20).

The objective of the present study is to analyze the patterns of pesticide use in selected regions of India, assess the potential risks faced by farmers, and highlight the role of pesticide sales outlets, along with a review of reported poisoning cases in rural communities.

The Study

A descriptive study was conducted between April and June 2024 in two agriculturally intensive districts from Andhra Pradesh (Bapatla and Guntur) of India. One of the districts had a rural population of about 37%, while in the other the rural share was around 55%. The primary crops cultivated in these areas included rice, maize, wheat, barley, and pulses, reflecting the region's dependence on agriculture and its significant demand for staple food crops.

This study focuses specifically on pesticide use, management practices, final disposal, and the incidence of pesticide poisoning cases. It was carried out as part of a larger initiative supported by government agencies such as the State Agriculture Department, the Directorate of Plant Protection,

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Quarantine and Storage, the Krishi Vigyan Kendras (KVKs), irrigation committees, local panchayats, and municipal bodies.

The research was structured into three major components based on the units of analysis: farmers, agrochemical sales centers, and cases of pesticide poisoning.

Farmers: According to the State Agricultural Directorate, there were over 2,000 registered irrigation users in each of the two districts. Based on a 95% confidence level, a 5% sampling error, and an expected utilization rate of 82%, the minimum number of interviewees required was approximately 206 and 208 in the two districts. However, in practice, 225 and 210 farmers were randomly selected and surveyed, respectively.

The questionnaire used for data collection covered six areas: demographic details of respondents, crop and pesticide use characteristics, conditions of application and safety measures, environmental conditions in the farming area, knowledge and training regarding pesticide use, and finally, farmers' perceptions of health and environmental risks. The survey instrument was prepared with expert input and validated through discussions and workshops with farmers, who were not part of the final sample.

Agrochemical sales centers: For this component, 31 of the 57 authorized pesticide outlets in the study region, including those in the district headquarters, were included. Trained personnel from the agricultural department conducted structured interviews with shop owners and attendants.

Cases of pesticide poisoning: With the cooperation of the State Health Department, access was granted to records of pesticide poisoning cases reported at local health centers during the years 2022, 2023, and 2024.

Data analysis: The data were compiled in Microsoft Excel® and analyzed using SPSS version 12. Both absolute and relative frequencies were employed for categorical variables.

FINDINGS

A total of 435 farmers were surveyed, of whom 65% were men. In one district, 36% of respondents had secondary education, 32% had primary education, and 32% had higher education. In the other district, 50% had completed secondary education, 26% had higher education, and 24% had primary education.

According to official agricultural sources, 57 agrochemical sales outlets were registered in the study area—10 in one district, 9 in the other, and 38 in the nearby city, which served as a central hub. Of the 31 outlets visited, nearly half were located in close proximity to food businesses such as restaurants, poultry shops, grocery stores, fruit and vegetable vendors, and local markets.

Use of pesticides: Survey results indicated that metaminodophos was the most commonly used pesticide, marketed under commercial names such as *Tamaron*® and *Monitor*®. In one district, the fungicide propineb (*Antracol*®) was not used at all, while in the other it was frequently reported. Alarmingly, ethyl parathion (*Parathion*®), a pesticide banned for agricultural use, was still being used by nearly 5% of farmers in both districts. According to the World Health Organization (WHO) classification, most of the pesticides reported in use fall into the categories of "extremely hazardous" and "highly hazardous."

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Results and discussion

The estimated volume of pesticide use per agricultural season was 25,423 kg in Bapatla and 9,655 kg in Guntur, based on farmer reports and cultivation area of major crops. An important finding is the persistence of banned organochlorine residues in the region. Field inspections revealed that some agrochemical outlets were still selling prohibited products such as aldrin. Reports from the Directorate of Plant Protection, Quarantine and Storage, the Andhra Pradesh Pollution Control Board, and the Ministry of Environment indicated that, in 2022, 3 kg of DDT, 70 kg of aldrin, 7 kg of heptachlor, and 10 kg of mirex were seized from local warehouses and outlets, showing the challenges of enforcing pesticide bans.

Table 1 presents the frequency of use of various pesticides in the two districts studied. It can be observed that monocrotophos is the most frequently used pesticide, followed by carbofuran and cypermethrin. In addition, mancozeb was reported only in a small proportion of cases in both districts. Alarmingly, ethyl parathion continues to be used by nearly 1 in 20 farmers in both Bapatla and Guntur, despite being officially banned in India. According to the World Health Organization (WHO) classification, the majority of pesticides reported here, including monocrotophos, phorate, and carbofuran, fall into the category of extremely and highly hazardous chemicals, underscoring the significant risks posed to human health and the environment.

Table 1. Use of Pesticides in Two Agricultural Districts of Andhra Pradesh, India (District A: Bapatla; District B: Guntur)

Pesticide Use	Bapatla (n=210)	Guntur (n=225)
Use of pesticides	86%	89%
Monocrotophos*	44.6%	39.5%
Phorate*	5.6%	5.8%
Carbofuran*	15.6%	15.1%
Cypermethrin**	15.2%	14.7%
Chlorpyrifos**	9.2%	14.2%
Mancozeb**	5.2%	3.5%
Parathion (Ethyl)***	4.9%	4.5%

*Highly and extremely hazardous; **Moderately hazardous; ***Banned/Prohibited in India

Attitudes towards pesticide application: Table 2 presents the most common attitudes of farmers regarding pesticide application, including the use of protective measures, preventive practices during and after spraying, and disposal of empty containers. Most applications were reported to occur in the morning hours. With regard to storage, 53% of farmers in Guntur and 54% in Bapatla reported keeping their products in what they described as safe storage facilities.

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Table 2. Common Attitudes of Farmers in Both Districts (Bapatla and Guntur) Regarding Pesticide Application

Practice	Bapatla (n=210)	Guntur (n=225)
Time of day when application is carried out		
Morning hours	71%	74%
Protective material used during pesticide application		
Use of cloth mask/scarf	47%	52%
Use of gloves	13%	22%
Use of long-sleeved shirt	61%	58%
Use of trousers/long pants	67%	64%
Use of goggles	6%	8%
Use of gumboots	2%	4%
Application practices		
Spraying against wind direction	81%	86%
Spraying along wind direction	19%	14%
Cleaning clogged nozzles with mouth	8%	12%
Changing work clothes after spraying	86%	89%
Bathing immediately after spraying	80%	84%
Washing clothes used for spraying separately	71%	74%
Handling and disposal of pesticide containers		
Disposing containers in open fields	32%	36%
Burning empty pesticide containers	21%	25%
Burying containers in soil	11%	9%
Reusing pesticide containers at home	13%	18%
Selling empty containers as scrap	23%	28%
Triple-rinsing containers before disposal	7%	6%

Level of information on pesticides: Table 3 summarizes farmers' knowledge and training on pesticide use. In Guntur, 70% of farmers reported reading pesticide labels regularly compared to 79% in Bapatla. However, only 31% in Guntur and 40% in Bapatla could recognize hazard classifications based on container colors. Training opportunities remain limited: 22% in Guntur and 27% in Bapatla had attended programs on pesticide-related health and environmental risks, provided mainly by agricultural agencies, private companies, or NGOs.

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Table 3. Cases of Pesticide Poisoning Reported in Health Centers of Bapatla and Guntur Districts (2023–2024)

Causative Product	2023 Bapatla	2023 Guntur	2024 Bapatla	2024 Guntur	2025 Bapatla	2025 Guntur
Carbamates	1	1	1	0	0	0
Organophosphates	22	23	22	25	11	12
Synthetic Pyrethroids	1	1	2	2	3	2
Total	24	25	25	27	14	14

Perceptions of health risks: In Guntur, 79% indicated that pesticide use affected their health, associating it with cancer (68%), poisoning (53%), and birth defects (52%), along with nervous system and gastric disorders. In Bapatla, 83% acknowledged health risks, most frequently citing cancer (61%), poisoning (58%), and nervous system disorders (42%), while others mentioned sterility, miscarriages, skin problems, and stomach ailments.

Mild acute pesticide poisoning: Immediate discomfort following pesticide application was reported by 58% of farmers in Guntur and 60% in Bapatla. Common symptoms included headaches, dizziness, nausea, and blurred vision, with smaller numbers reporting chills, fainting, or skin reactions.

Acute pesticide poisoning in hospitals: Hospital records showed a rising trend in pesticide poisoning cases over four years. The number of patients treated increased steadily from 28 in 2023 to 52 in 2024, although hospital data did not specify the exact chemicals involved.

Acute pesticide poisoning in health centers: Table 5 shows the number of cases reported at primary health centers between January 2024 and April 2024. In Guntur, 61 cases were recorded, with women representing the majority (38 cases). In Bapatla, 66 cases were reported, of which 35 involved women. These findings highlight both widespread exposure and the particular vulnerability of rural women to pesticide-related illnesses.

Discussion

According to reports from the Directorate of Public Health in India, pesticide poisoning continues to be a major public health concern. National estimates indicate thousands of reported cases annually, with a significant proportion linked to the use of organophosphate and carbamate compounds, which account for more than half of all pesticide-related health impacts. Beyond indiscriminate application, factors such as poor sanitation practices, unsafe handling, and improper disposal of containers aggravate the risks. This study has sought to analyze these issues within the broader framework of pesticide management and its implications for farmer health and environmental sustainability.

One of the most critical concerns relates to the location of pesticide sales centers. In many urban and semi-urban areas of Andhra Pradesh, agrochemical outlets are often situated close to restaurants,

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grocery shops, or vegetable markets. This co-location poses health hazards due to inadequate storage, contamination risks for nearby food items, and the danger of fire, spill, or explosion. Several studies have highlighted these risks and stressed the responsibility of municipal authorities and local governance institutions in enforcing zoning and storage regulations (8, 22–24).

With respect to protective clothing and safety practices, farmers in both Bapatla and Guntur rarely use masks or gloves. The main reasons cited include discomfort, high temperature, and the impracticality of wearing protective gear during prolonged hours in the field. This limited use of protective equipment increases direct exposure to toxic chemicals, particularly since the average pesticide application lasts for about three hours and is repeated multiple times within a cropping season.

The knowledge level of farmers about pesticides is another crucial issue. Although labels provide detailed information about chemical composition, use instructions, hazard classification, and safety precautions, farmers reported difficulty in interpreting the highly technical language. The study emphasizes the urgent need for farmer-friendly communication tools and continuous training programs, led by agricultural extension agencies and supported by civil society, to enhance awareness about pesticide hazards to human health and the environment.

Another pressing issue is the disposal of pesticide containers. Under the Indian Solid Waste Management Rules, discarded containers with residues are classified as hazardous waste. While triple-rinsing is recommended, it is rarely practiced and, even when performed, does not completely eliminate toxic residues. As a result, such containers remain dangerous both for handlers and the environment. Farmers in Bapatla and Guntur dispose of containers in varied ways—burning, burying, or reuse—but there is no organized system for container collection in rural areas. Unlike some countries where agrochemical firms and regulators have introduced take-back schemes, India still lacks such widespread mechanisms, although recent state-level initiatives show promise in addressing this issue.

Cases of acute pesticide poisoning reported at local health facilities were largely confined to severe emergencies, typically presenting with symptoms such as vomiting, respiratory distress, muscle spasms, miosis, and in extreme cases, loss of consciousness. However, the data suggest substantial underreporting due to limited diagnostic capabilities, poor record-keeping in rural health centers, and the tendency of farmers to seek medical attention only in severe cases. Consequently, the recorded numbers do not capture the true burden of pesticide-related morbidity and mortality. Moreover, as highlighted in earlier studies, chronic pesticide exposure has been linked to neurotoxicity, carcinogenesis, hepatotoxicity, and reproductive disorders, raising long-term public health concerns (9–20).

The Food and Agriculture Organization (FAO) has noted that 99% of pesticide poisoning cases occur in countries with weak regulatory, health, and educational systems (22). The main contributing factors include inadequate enforcement of regulations, lack of farmer training, poor communication of risks, limited participation of farmers in decision-making, and improper storage and disposal of agrochemicals (6, 13).

Findings from this study underscore the urgent need to prioritize farmer training, strengthen epidemiological surveillance systems, and implement integrated pesticide management programs in

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Andhra Pradesh. Sectoral agencies, municipal authorities, and local panchayats must play a stronger role in monitoring pesticide trade, ensuring safe storage, promoting protective practices, and developing container disposal systems. Such coordinated measures are essential for reducing the health and environmental risks associated with pesticide use in Bapatla and Guntur districts.

Conclusion

This study highlights the critical challenges associated with pesticide use in the agricultural districts of Bapatla and Guntur, emphasizing both human health and environmental implications. The findings reveal widespread reliance on highly hazardous pesticides, with inadequate awareness and inconsistent use of protective measures among farmers. Despite recognition of the health risks—such as cancer, poisoning, and neurological disorders—preventive practices remain weak, largely due to limited training, low risk perception, and discomfort associated with safety equipment. Improper storage and unsafe disposal of pesticide containers further compound risks, contributing to environmental contamination and potential long-term ecological damage. Acute health effects, including dizziness, nausea, and headaches, were frequently reported, while hospital records show increasing cases of pesticide poisoning, although underreporting remains a serious concern.

Addressing these issues requires a comprehensive, multi-sectoral approach. Strengthening regulatory enforcement, ensuring safer pesticide trade practices, and establishing container collection and disposal systems are essential. Equally important is the expansion of farmer-centered education programs, using simple and practical communication tools to enhance understanding of pesticide risks. Integrating these strategies within local governance and community-based initiatives can significantly reduce health hazards, promote sustainable agricultural practices, and protect both farmers and the environment from the harmful consequences of pesticide misuse.

Future Recommendations

To mitigate the adverse effects of pesticide use, future efforts must focus on strengthening farmer education and awareness programs, particularly through participatory training and demonstration-based approaches. Establishing safer pesticide distribution and storage regulations, alongside structured container collection and disposal systems, is crucial. Local authorities, agricultural agencies, and NGOs should collaborate to enforce strict monitoring of banned substances and promote the adoption of safer alternatives such as biopesticides and integrated pest management (IPM). Furthermore, implementing an epidemiological surveillance system will help track health impacts, ensuring timely interventions and supporting sustainable agricultural practices in rural farming communities.

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