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Research Paper

A Review on Frequency and Prevalence of Pyrethroid Poisoning in India (2018-2024)

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ABSTRACT

Pyrethroid is a synthetic version of pyrethrin, which naturally occurs in pyrethrum. The oleoresin extract of pyrethrum is extracted from chrysanthemum flowers. The insecticidal properties of these products are derived from pyrethrin, which is highly lipophilic, has a rapid penetration rate, and paralyzes insects as quickly as it penetrates. A pyrethroid can be classified into two types: a first-generation pyrethroid (Type I) and a second-generation pyrethroid (Type II) These toxins affect the central nervous system in both intended and unintended organisms. They work by interfering with the normal function of voltage-gated sodium channels in nerve cells. Specifically, they act as axonic excitotoxins, meaning they disrupt the signals that travel along nerves. By keeping these channels open, the toxins prevent nerve cells from resetting properly, leading to continuous nerve activation. This ultimately results in paralysis, as the affected nerves can no longer function normally. Pyrethroid is known to cause growth retardation, liver enlargement, increased liver enzyme activity, immune suppression, and neurological damage in mammals.

There has been a remarkable rise in the production, sale, and use of this class of pesticides in India. This has led to a shift in the pesticide usage pattern and instances of poisoning and suicidal and homicidal use of pyrethroids. This review study is aimed at assessing the prevalence of pyrethroids in India and also attempts to quantitate the number of poisoning cases related to pyrethroids in India during the period 2018-2024. This study can aid in understanding the extent of usage and instances of poisoning and help understand its future outlook.

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1. INTRODUCTION

Poisoning is one of the most ancient crimes among humanity and one that will never fade in society. From heavy metals to specially designed designer drugs man has found a criminal way of poisoning and getting away with the crime (Bhasker. E, 2010). Common poisons that are employed have evolved during time. The common factors for the evolving trends in choice of poisons are:

- To make it difficult to detect in criminal cases
- Due to availability of the poison in households and occupational areas
- Due to its effectiveness in poisoning, etc.

The intentions of poisoning, however, range from accidental, homicidal, and suicidal. The choice of poisons also differs across intentions of poisoning. For example, a suicidal poison choice would be an easily available yet effective poison, whereas an accidental or homicidal poison may go unnoticed (less effective) for many days.

Common poison choices are heavy metals, plant/animal poisons, pesticides, etc. Pesticide use in poisoning has been highlighted in much research in the recent past due to the scale of increase in its use for both homicidal and suicidal purposes.

Traditional pesticides are the organophosphates, organochlorines, and carbamates, which are commonly used in pest management in the agro-business.

- **Organophosphates:** Mostly used as insecticides, these chemicals interfere with the nervous system by blocking an enzyme responsible for regulating neurotransmitters, leading to nerve signal disruption.
- **Organochlorines:** Once widely used, these insecticides have now been banned in many countries due to their long-lasting presence in the environment and harmful effects on human health. Examples include DDT, chlordane, and toxaphene.
- **Carbamates:** Similar to organophosphates, carbamate pesticides also disrupt nerve function by interfering with enzyme activity. However, their effects are usually temporary, as the body can recover from the disruption over time.

Pyrethroids are a new and emerging class of pesticides that have gained attention in forensic science due to their misuse in poisoning cases, including both suicides and homicides. These chemicals are synthetic versions of pyrethrin, a natural insecticide found in chrysanthemum flowers. They are designed to be more stable in the environment while retaining the insect-killing properties of natural pyrethrins. Since they are highly lipophilic (fat-soluble), pyrethroids quickly enter an insect's body, attacking its nervous system and causing paralysis (Thatheyus, A., 2013).

Chemical Composition: Pyrethrins consist of six structurally related insecticidal esters, formed by combining two acids (*chrysanthemic* acid and pyrethric acid) with three alcohols (*pyrethrolone, cinerolone*, and *jasmolone*). These chemicals act as axonic excitotoxins, meaning they interfere with normal nerve function. They do this by keeping voltage-gated sodium channels open, preventing nerve cells from resetting. As a result, nerve signals continue firing uncontrollably, leading to permanent nervous system overstimulation and paralysis in the affected organism.

This present study attempts to understand the frequency and prevalence of pyrethroid poisoning in India by understanding the production, sale, and number of poisoning cases reported during the 2018-2024 period in India.

Research Gap

A study to understand India-specific data with relation to production, sale, and poisoning occurring in India is missing. A study with such an objective can give a picture of the frequency and prevalence of pyrethroid poisoning in India.

2. OBJECTIVES

The study was performed with the following objectives:

- To estimate production capacity of pyrethroids in India
- To identify sales of pyrethroids in India
- To identify the number of poisoning cases involving pyrethroids in India
- To estimate the number of fatalities involving pyrethroids in India

3. MATERIALS AND METHODS

The study took place during the period 2018-2024. The study adopted a meta-analysis and data acquisition process. The information on production & import of pyrethroid pesticides was collected from published online sources. The data was collected from a comprehensive list of online portals that detail and list the production and import details of chemical pesticides in India.

The details on sales of pyrethroid pesticides were collected from published online sources as well as information gathered from vendors. A comprehensive list of online stores that deal with pesticide sales as well as market vendors was used to collate data on sales of pyrethroid pesticides in India.

The incidences of poisoning cases involving pyrethroid pesticides were collected from state crime records, medical hospital records, and indices from poison control centers (PCCs) across India. All PCCs were taken into consideration for this information.

The details on fatalities by pyrethroid poisoning were collected from medical hospital records across India. Different databases were reviewed, and written communications were employed to collect this information.

For the last 2 parameters, the region-wise zone was tabulated for comparison to ensure easy understanding of the data. For purposes of this study, India was split in 6 regions, as tabulated below.

Table 1: Zone-wise distribution of India used for the study.

Region number	Region name	States in the region
1	North zone	Jammu & Kashmir, Himachal Pradesh, Harayana, Uttarakhand, Uttar Pradesh and Punjab.
2	West zone	Rajasthan, Goa, Gujarat,and Maharashtra.
3	East zone	Orissa, Bihar, Jharkhand and West Bengal.
4	North East zone	Tripura,Assam, Sikkim, Nagaland, Meghalaya, Manipur, Mizoram, and Arunachal Pradesh.
5	Central zone	Madhya Pradesh, Chhattisgarh.
6	South zone	Andhra Pradesh, Karnataka, Kerala, Tamil Nadu

4. FINDINGS AND ANALYSIS

Production of pyrethroids in India

- Cypermethrin - In 2021, India had the capacity to produce around 24,000 metric tons of cypermethrin. However, since 2009, this chemical has been restricted from public access, limiting its availability to authorized users.

- Deltamethrin - Mostly imported. 20 thousand metric tons were imported in 2018. Data of import since then is not available.
- Fenvalerate - 200 metric tons (2019)
- Permethrin - 1000 kilograms per year (as on 2019)

Sale in metric tons per year in India

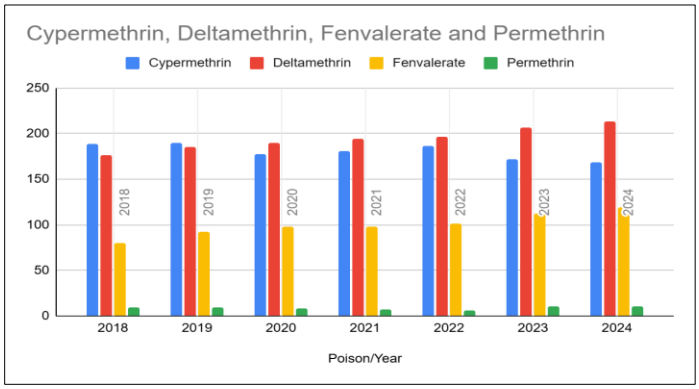

Table 2: Year wise sales of pyrethroids from 2018-2024

Poison/Year	Cypermethrin	Deltamethrin	Fenvalerate	Permethrin
2018	189	176	80	9
2019	190	185	92	9.1
2020	178	190	98	8
2021	181	194	98	7
2022	186	196	101	6.5
2023	172	207	113	10.4
2024	168	213	119	10.9

Common use of pyrethroids in India (farming practices)

- **Cypermethrin:** Commonly used to protect cotton, fruits, and vegetables from pests, as well as to control ectoparasites that infest cattle, sheep, and poultry. Major crops include cotton, sugarcane, maize, groundnut, cabbage, cauliflower, okra, brinjal, and mustard.
- **Deltamethrin:** A highly effective synthetic pyrethroid insecticide, known for its photo stability (resistance to sunlight). It targets a wide range of pests, including Lepidoptera, Homoptera (like aphids and Psylla), Coccidia, Cicadellinea, and Heteroptera. It is widely used on cotton (against bollworm), tomato and okra (for fruit borer), rice (for leaf folder), and chilli (for fruit borer).
- **Fenvalerate:** Particularly effective against pests that have developed resistance to organochlorine, organophosphorus, and carbamate insecticides. It is used in public health and animal husbandry as well as for protecting crops like cotton, cauliflower, okra, vines, and fruits.
- **Permethrin:** A versatile insecticide applied to food and feed crops, ornamental plants, lawns, livestock, and pets. It is commonly used on cotton, wheat, maize, and alfalfa to prevent pest infestations.

Poisoning cases reported (zone-wise data) in India

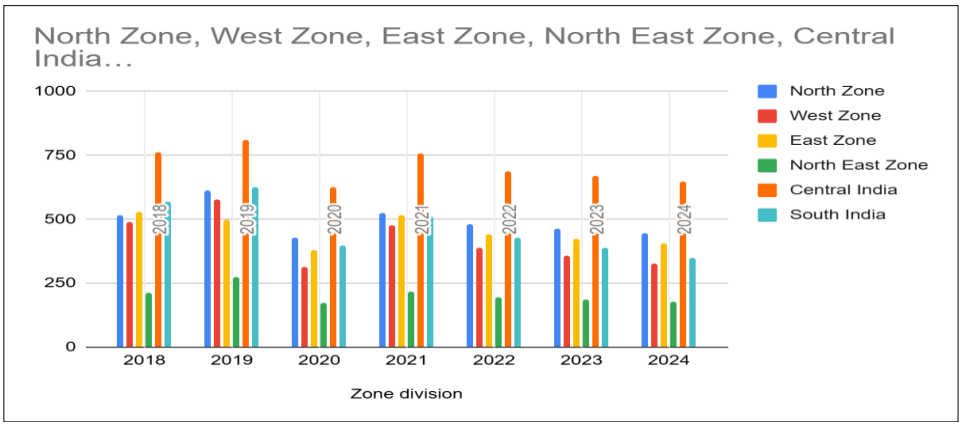

Table 3: Zone wise poisoning cases reported of pyrethroids from 2018-2024

Zone division	North Zone	West Zone	East Zone	North East Zone	Central India	South India
2018	516	490	528	214	764	567
2019	614	578	497	276	812	624
2020	429	314	378	175	624	398
2021	524	476	515	216	759	512
2022	480	388	440	196	689	427
2023	464	357	424	187	668	388
2024	448	326	408	177	646	349

Fatalities reported (zone-wise data) in India

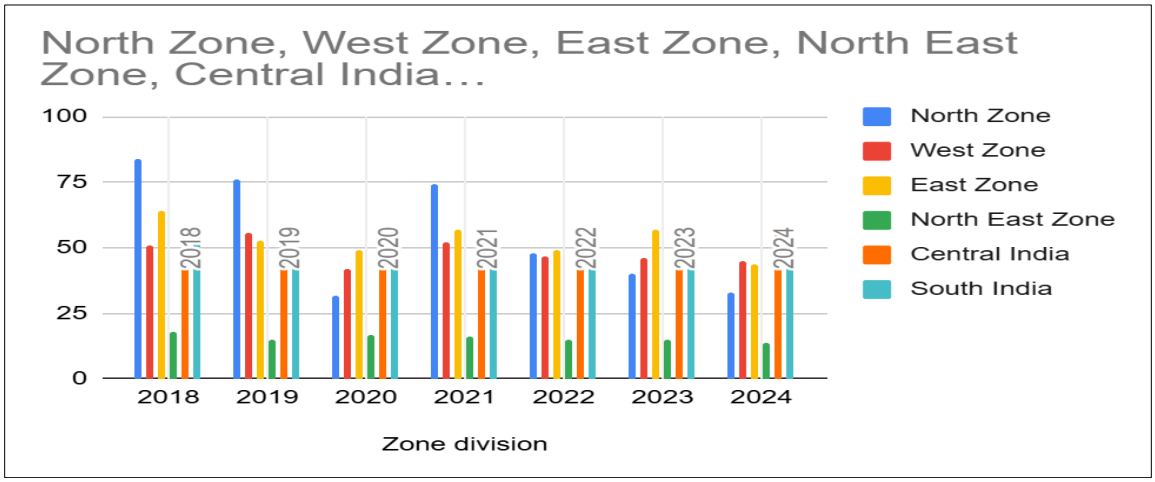

Table 4: Zone wise fatalities cases reported of pyrethroids from 2018-2024

Zone division	North Zone	West Zone	East Zone	North East Zone	Central India	South India
2018	84	51	64	18	43	57
2019	76	56	53	15	56	46
2020	32	42	49	17	48	57
2021	74	52	57	16	50	51
2022	48	47	49	15	52	51
2023	40	46	57	15	53	50
2024	33	45	44	14	55	49

5. CONCLUSION AND FUTURE SCOPE

The study shows a steady rise in the import, production, sales and incidences of poisoning involving pyrethroid pesticides in India. The covid pandemic served as a disruption to the study's findings. But it is safe to say that overall, there seems to be an increasing dependence by the farming community on pyrethroid pesticides. There is also an overall increase in poisoning and fatality cases involving pyrethroid pesticides in India.

The feeling that pyrethroid pesticides only caused environmental pollution, is no truer if this trend continues. Pyrethroids have been thought of as environmental poisons, more than animal and human poisons in the past. Many studies have an environmental concern in their objectives. This preliminary study shows the impact of pyrethroids use and abuse among humans in India.

The trend is not clear, due to the pandemic disruption in the period of study. But overall, there seems to be an increase in the number of poisoning and fatalities of pyrethroids in India. This trend is indicative of the rise of pyrethroid pesticides as the new class of toxins - for both suicidal and homicidal purposes.

This study can further be strengthened by taking into consideration the number of suicidal poisonings, homicidal poisoning and accidental poisoning. This can give indication as to its abuse pattern. A more definite statistical study can provide insights as to whether the pattern is similar in other countries or is it individual in India alone. This can give an indication of regional use/abuse.

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