https://doi.org/10.48047/AFJBS.6.14.2024.9669-9683

African Journal of Biological Sciences

Journal homepage: http://www.afjbs.com

Research Paper Open Access

An Overview of the Organophosphate Pesticide Use Scenario in India.

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Volume 6, Issue 14, Aug 2024

Received: 15 June 2024

Accepted: 25 July 2024

Published: 29 Aug 2024

doi: 10.48047/AFJBS.6.14.2024.9669-9683

Abstract:
India's pesticide consumption ranks it third in Asia and 12th globally, behind China and Turkey. For the current study, information on different types of pesticides, usage trends, and precise pesticide consumption in India and globally was collected, organised, and summarised. The 1960s brought pesticides to India, where they remain a staple of the nation's agriculture and are still widely used. The Indian economy is primarily driven by the agriculture sector, which employs almost 70% of the labour force. Nevertheless, in India, the majority of pesticides used are insecticides. Less than 1% of all pesticides are used worldwide, including in India. Apart from posing a threat to the environment, an over reliance on pesticides has also been connected to the presence of organophosphate residues in tea, sugars, fruits, vegetables, and other agricultural products throughout India. The residues found in human and animal tissues, blood, milk, honey, and other physiological fluids are evidence of their excessive use and bioaccumulation potential. The current study highlights the numerous occasions in which different organophosphates have been discovered to be over their corresponding MRL limits. Because some of the discovered organophosphates are so harmful, the WHO has categorised them into hazardous categories 1a and 1b. Their intentional or unintentional intake causes serious health impacts and hundreds of deaths per year. Most of the poisoning cases that are displayed here were caused by substances consumed during suicidal attempts. This illustrates how easily these harmful medications might be located on the market.
Keywords: Pesticides, Organophosphates, Chemical Pesticides, Bio-Pesticides, Indian Agriculture, Toxicity

Introduction

A vast variety of substances are included under the umbrella word "pesticide," such as fungicides, herbicides, rodenticides, molluscicides, nematocides, and plant growth regulators. Among them, most technologically sophisticated nations outlawed or restricted the use of organochlorine (OC) pesticides after the 1960s, despite their effectiveness in combating a variety of illnesses, including typhus and malaria. The introduction of herbicides and fungicides in the 1970s and 1980s, along with other synthetic insecticides including carbamates, pyrethroids, and organophosphate (OP) insecticides in the 1960s, 1970s, and

1980s, significantly increased agricultural productivity and pest control [1]. The Indian government has taken action to guarantee the safe application of pesticides.
In order to reduce dangers to humans or animals, the Insecticides Act was enacted in 1968 and went into effect on August 1, 1971, in India. Its purpose is to govern the import, manufacturing, sale, transit, distribution, and use of insecticides, as well as things related thereto. In order to guarantee the safe use of pesticides for the benefit of society, it was desired to assess the extent of pesticide pollution in the nation and the associated health risks prior to the enforcement of the Insecticides Act. The Indian Council of Medical Research's National Institute of Occupational Health (NIOH), Ahmedabad, along with a number of other national laboratories, agricultural universities, and other research and development organisations, have been involved in the toxicological assessment of pesticides, the creation of safer compounds, and the assessment of pesticide-related environmental contamination. During the last three decades, India has seen an increase in both pesticide output and usage. But India consumes these chemicals in a different way than the rest of the globe [2] Approximately 76% of the pesticides used in India are utilised domestically, compared to 44% worldwide [3] (ICMR Bulletin, September 2001). Seventy percent of all pesticides are used, and small farmers continue to favour the three widely used pesticides—HCH (only gamma-HCH is permitted), DDT, and malathion—because they are accessible, affordable, and exhibit a broad range of bioactivity [4]. Eighty percent of all pesticides consumed are insecticides, fifteen percent are herbicides, fourteen percent are fungicides, and fewer than three percent are other types. By contrast, the global usage of herbicides is 47.5%, insecticides is 29.5%, fungicides is 17.5%, and other chemicals makes up just 5.5% of the total. Given that manual weeding is the primary method of weed management in India, the country's pesticide use is most likely modest [4].

Among the many different types of pesticides are herbicides, insecticides, fungicides, and rodenticides [5,6]. Pesticides can be categorised based on their chemical makeup, mechanism of action, degree of toxicity, and application technique [7]. However, categorising pesticides based on their chemical makeup is the most consistent approach. This is thought to allow for a synergistic interaction between toxicity, structure, degradation mechanism, and activity [8]. Pesticides are commonly categorised into four groups based on their chemical composition: pyrethroids, carbamates, organochlorine, and organophosphate [9].

Classification of Pesticides: -

The pesticides show the toxicity in the living systems on the basis of their chemical formulations and quantity in an instance. Pesticides are a broad category of products that include antiseptics, disinfectants, anti-bacterial, fungicides, algicides, rodenticides, and herbicides [10](Garcia et al., 2012). Pesticides are classified into two major categories based on their physical and chemical properties. Pesticide classification by nature of pesticide (synthetic and natural) and acting on pest type is illustrated in Figure 1. Organic chemicals made up the majority of synthetic pesticides, which were grouped into the following four groups: Organophosphates, organochlorines, carbamates, and pyrethroids. Some widely used pesticides and their structures are shown in Table 2. Naturally occurring pesticides, also known as biopesticides, are formed by living creatures such as plants, bacteria, and fungus

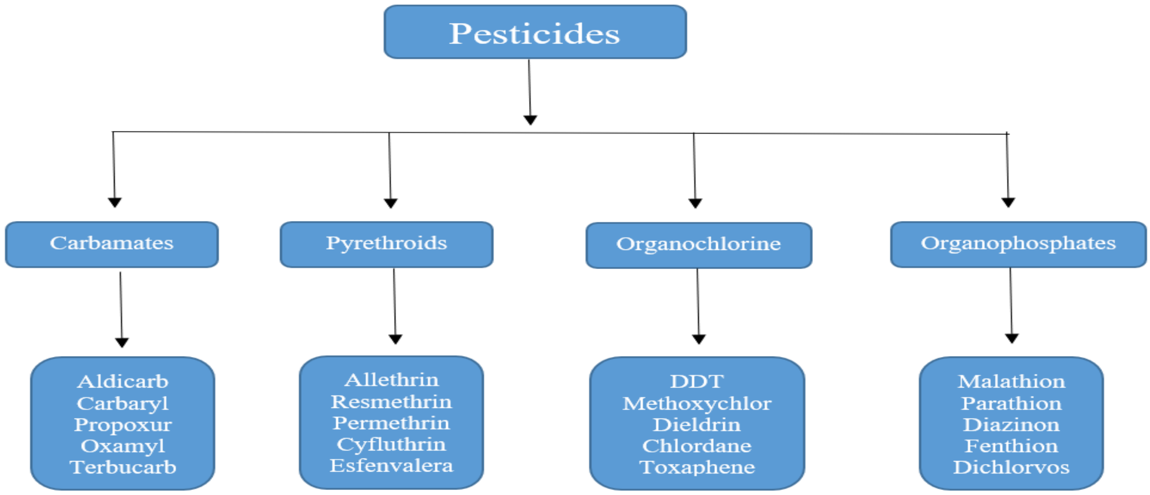


Fig. 1. Pesticide classification based on their chemical composition (Fig. 1) [11]

Classification of pesticides according to its toxicity: Pesticide toxicity is primarily determined by two factors: dose and time. Thus, the amount of this chemical (dose) is involved and how often (time) the material is exposed to lead to two different kinds of toxicity, acute and chronic. Table 1 Pesticides classification on the basis of its Toxicity.

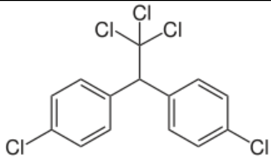
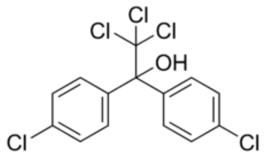
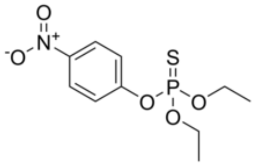
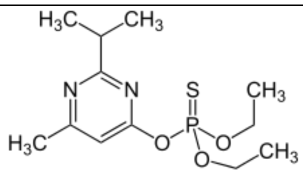
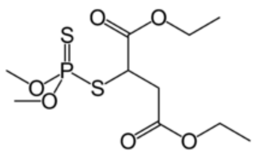
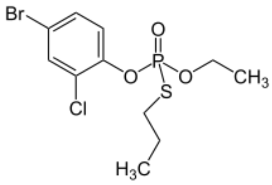
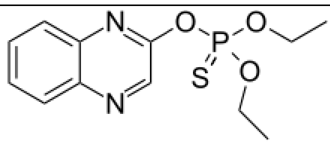
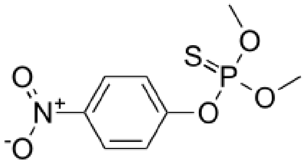
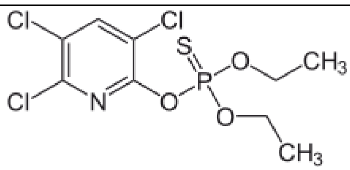
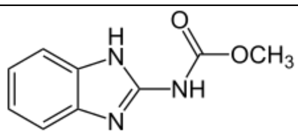
Table 1: The WHO recommended classification of Organophosphates by hazard which are registered in India (World Health Organisation 2009)

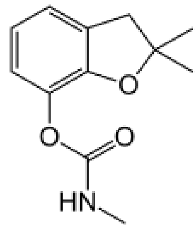
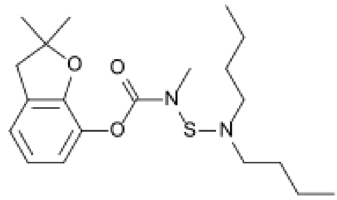
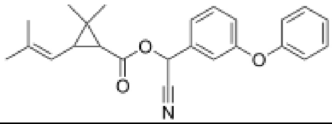
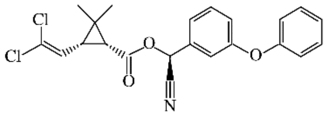
Extremely hazardous (class Ia)	Highly hazardous (class Ib)	Moderately hazardous (class II)	Slightly hazardous (class III)
Parathion-methyl	Fenamiphos	Acephate, anilophos	Chlorpyriphos-methyl
Phosphamidon	Monocrotophos	Chlorpyrifos, diazinon,	Malathion
Terbufos	Oxydemeton-methyl	Dichlorvos, dimethoate,	Temophos
	Propetamphos	Ethion, fenitrothion,	
	Triazophos	Fenthion, phenthoate,	
		Phosalone, phorate,	
		Pirimiphos-methyl,	
		Profenofos, quinalphos,	
		Trichlorfon	

Table 1 Pesticides classification on the basis of its Toxicity.

Table 2: Major classes of pesticides

	Examples	Name	Structure

Organochlorine pesticides	DTT	1,1′-(2,2,2-trichloroethane-1,1 diyl)bis(4-chlorobenzene)	
	Dicofol	2,2,2-trichloro-1,1-bis(4 chlorophenyl)ethanol	
Diethyl 2-dimethoxy	Parathion	O,O-diethyl O-(4-nitrophenyl) phosphorothioate	
	Diazinon	O,O-diethyl O-[4-methyl-6 (propan-2-yl)pyrimidin-2-yl] phosphorothioate	
Diethyl 2-dimethoxy	Malathion	2[(dimethoxyphosphorothioyl) sulfanyl]butanedioate, diethyl	
	Profenofos	O-(4-bromo-2-chlorophenyl) O-ethyl S-propyl phosphorothioate	
	Quinalphos	O,O-diethyl O-quinoxalin-2-yl phosphorothioate	
	Methyl parathion	O,O-dimethyl O-4 nitrophenyl phosphorothioate	
	Chlorpyrifos	O,O-di ethyl-O-(3,5,6-trichloro-2 pyridinyl)- phosphorothioate	
	Carbendazim	Methyl 1H-benzimidazol-2 ylcarbamate	

Carbamate pesticides	Carbofuran	2,2-dimethyl-2,3-dihydro-1 benzofuran-7-yl methylcarbamate	
	Carbosulfan	2,2-dimethyl-2,3-dihydro-1 benzofuran-7-yl [(dibutylamino)sulfanyl] methylcarbamate	
Pyrethroid pesticides	Cyphenothrin	Cyano(3-phenoxyphenyl) methyl 2,2-dimethyl-3-(2 methylprop-1-en-1-yl) cyclopropanecarboxylate	
	Cypermethrin	[Cyano-(3-phenoxyphenyl) methyl]3-(2,2-dichloroethenyl) 2,2-dimethylcyclopropane-1 carboxylate	

The amount of pesticides used (dose) and exposure period (time) are the two most important factors for pesticide toxicity that define the acute and chronic toxicity of pesticides. Acute toxicity refers to a pesticide's toxicity to animals, plants, and humans following a definite short-term exposure of pesticide. A pesticide with a high acute toxicity is fatal, even if only a tiny quantity is absorbed into body. The World Health Organization (WHO) recognizes only acute toxicity for pesticide categorization and based on lethal dosage (LD50) divided into two types, i.e., acute cutaneous (dermal) toxicity (e.g., extremely: less than 50-mg/kg body weight of rat; highly: 50-200-mg/kg body weight of rat; moderately: 200-2,000-mg/kg body weight of rat, etc.) and acute oral toxicity (e.g., extremely: less than 5-mg/kg body weight of rat; highly: 5-50-mg/kg body weight of rat; moderately: 50-2,000-mg/kg body weight of rat, etc.) are shown in Table 2 (World Health Organization, 2009).

The deadly impact of pesticide exposure that persists over time is known as chronic toxicity. Chronic toxicity of pesticides is a worry for the general population and those who work with pesticides directly because of possible exposure to pesticides. Pesticides are now classified into "WHO Hazard classifications" according to the widely used Frontiers in Microbiology "WHO Recommended Categorization of Pesticides by Hazard." Following a change in 2009, such a classification was merged with the "Globally Harmonized System (GHS) Acute Toxicity Hazard Category" shown in Table 3 [12]

Pesticides generally vary in how they work, but because they inhibit acetylcholinesterase, an enzyme that hydrolyses acetylcholine at brain cholinergic synapses and neuromuscular junctions, organophosphate pesticides are known to be especially neurotoxic [13,14]. Organophosphate insecticides have the advantageous dual purpose of reducing post-harvest crop losses by controlling pests and lowering the prevalence of illnesses carried by vectors [15]. While certain organophosphate insecticides are effective in preventing insect infestation on stored goods, others are employed as fumigants to manage domestic pets [16]. Organophosphate insecticides have lower environmental half-lives than other pesticide types [17].

Table 3: - Class of Pesticides according to Toxicity

Category		Classification	criteria	
	LD_{50} of rat dermal	Hazardous description	LD_{50} of rat oral	Hazardous description
1	Less than 50mg/kg body weight	Lethal if come in skin contact	Less than 5 mg/kg body weight	Lethal if consumed
2	50-200 mg/kg body weight	Lethal if come in skin contact	5-50 mg/kg body weight	Lethal if consumed
3	200-1000 mg/kg body weight	Toxic in come in skin contact	50-300 mg/kg body weight	Toxic if consumed
4	1000-2000 mg/kg body weight	Harmful if come in skin contact	300-2000 mg/kg body weight	Harmful if consumed
5	2000-5000 mg/kg body weight	Possibly harmful if come in skin contact	2000-5000 mg/kg body weight	Possibly harmful if consumed

Organophosphate pesticides have many benefits, particularly in the fields of agriculture and public health, but when they are used incorrectly, they have a significant negative influence on the environment and human health [18]. Human exposure to these contaminants, whether deliberate or not, may have both short-term and long-term impacts. Panic attacks, cramps, vertigo, blurred vision, nausea, headaches, and skin rashes are a few symptoms of these acute effects, while effects from extended exposure (chronic effects) include effects on reproduction, blood and nerve disorders, genetic alterations, and congenital disabilities [19–21].

Similar to this, the decomposition of organic materials in the soil, the modification of the microbial diversity in the soil, the impact of pesticides on some beneficial soil invertebrates, and the percolation of soil layers to ground water all pose a danger to the sustainability of the environment [18, 22, 23]. Organophosphate pesticide levels have been found in biological matrices such blood serum and urine [17, 24–28], and they have also been found and measured in environmental matrices like soil, sediments, water, and air [29–34] in a number of fascinating contemporary investigations.

But there aren't many thorough evaluations that concurrently cover this persistent organic pollutant's prevalence, sources, benefits, risks, and possible remediation strategies in biological and environmental matrices—especially in the last 10 years. These information gaps are what motivated the current review. This was the first description of the classifications and sources of organophosphate insecticides. Additionally, it was emphasised how often these contaminants appeared in various media. Furthermore, the possible benefits and risks of being exposed to this category of contaminants were clarified. Lastly, a number of corrective measures for eliminating organophosphate pesticides from the environment were covered.

Organophosphate pesticide sources

Application of organophosphate insecticides in agriculture is one of the main ways that they enter the environment. Organophosphate insecticides have a high solubility in water and enhanced adsorption in soils. Pollutants build up as a result of runoff water [35, 36]. Farmers are exposed to these pesticides at work when they spray, endangering aquatic life when runoff water reaches adjacent streams and waterbodies [37]. The entry points for OPPs residues from non-agricultural uses that are found in sewage systems include industrial vegetation control, private home and garden pest control, and grass management practices in parks and golf courses. The wastewater treatment plant (WWTP) effluents and sewage overflows are the two main primary sources of organophosphate pesticide contamination into aquatic systems. Organophosphate pesticides are mostly leaked into sewage systems by farmyards when field sprayers are filled and cleaned on paved surfaces. They can also leak accidentally or be used for purposes other than agriculture. Nevertheless, negligent handling of OPPs and wind drift from nearby spraying activities are other possible sources of OPPs getting into aquatic systems [35,37,38].

Pesticide Usage Pattern: -

There are 293 pesticides registered in India, and it is reported that 104 pesticides are still being produced/used in the country despite being prohibited in two or more nations around the world [39] Goi (2021). Out of total insecticides used for pest management in India, 50% are diverted to cotton pest management. [40] Mooventhan et al. (2020). Due to over dependence and indiscriminate use of insecticides, many ill-effects including residue in plant parts, resistance to insecticides, secondary pest out-break, pollution to natural resources, health complications for human and wild life etc., warrant to switch over to eco-friendly pest management methods

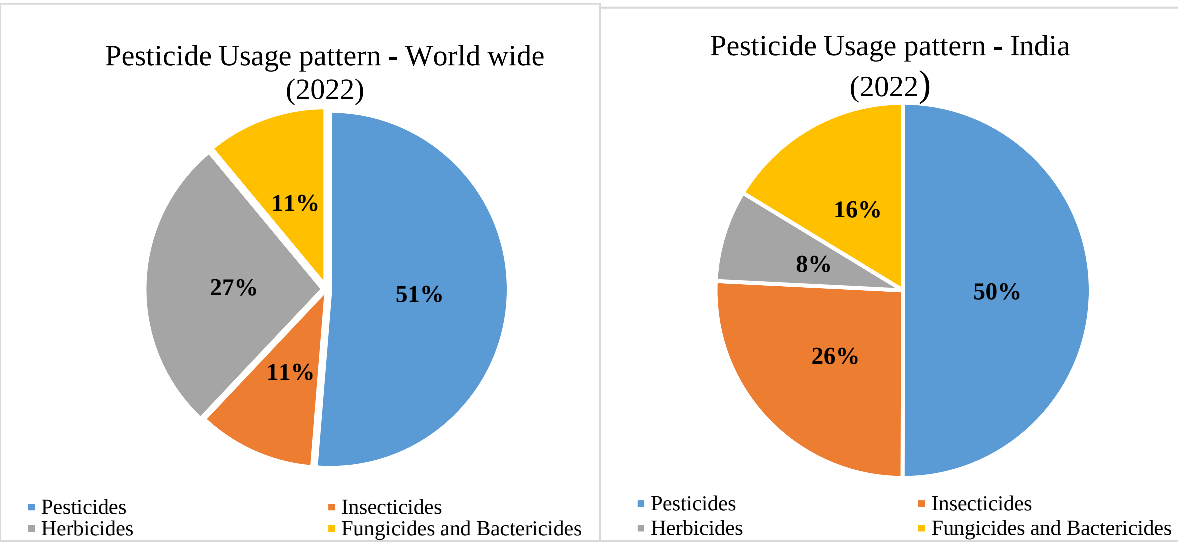


Fig 2 Pesticide use pattern- Worldwide and India (Source: http://www.fao.org/faostat/en/#d ata) FAO (2018)

Pesticide usage patterns in India differ from those in the world as a whole (Figure 2). In India, insecticides, fungicides, and herbicides are used. Insecticides account for the majority of the total. The present pesticide use pattern in India is insecticides>herbicides>fungicides+bactericides>other-pesticides, whereas the global pesticide use pattern is herbicides>fungicides + bactericides>insecticides>other pesticides. Currently, India is the world's fourth largest producer of pesticides. The Indian pesticides industry was worth Rs 214 billion in 2019, according to Research and Markets. The market is expected to reach Rs. 316 billion by 2024, with a compound annual growth rate of 8.1 percent. TAAS (2020).

India started producing pesticides in 1952 when a plant to manufacture BHC was built in Calcutta. Today, the country ranks twelfth globally and is Asia's second-largest producer of pesticides, after China.

The production of technical grade pesticides in India has steadily increased, from 5,000 metric tonnes in 1958 to 102,240 meter tonnes in 1998. It was projected that the demand for pesticides would reach Rs. 22 billion (USD 0.5 billion) in 1996–1997, or around 2% of the total world market. The graph shows that over the preceding seven decades, India's pesticide consumption has increased hundreds of times, from 154 MT in 1953–1954 to 57,000 MT in 2016–17. India utilised 80,000 MT of insecticides in a single year in 1994–1995—the most ever.

Owing to a ban or restriction on the use of organochlorine pesticides, such as DDT, aldrin, and HCH (BHC), a decline was noted between 2000 and 2010. Adoption of the Stockholm Convention with high application levels and creation of integrated pesticide management programs are two reasons for lowering the use of pesticides.

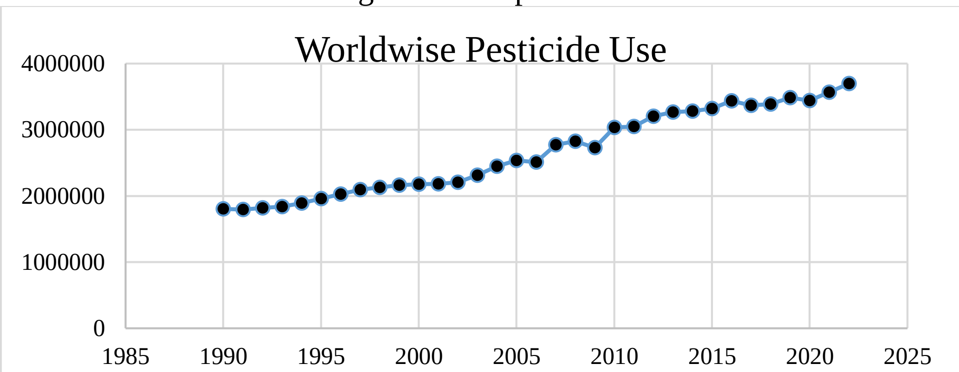


Figure 3 World-wide Pesticide consumption (1990 to 2016)
(Source: http://www.fao.org/faostat/ en/#data/RP/visualize)

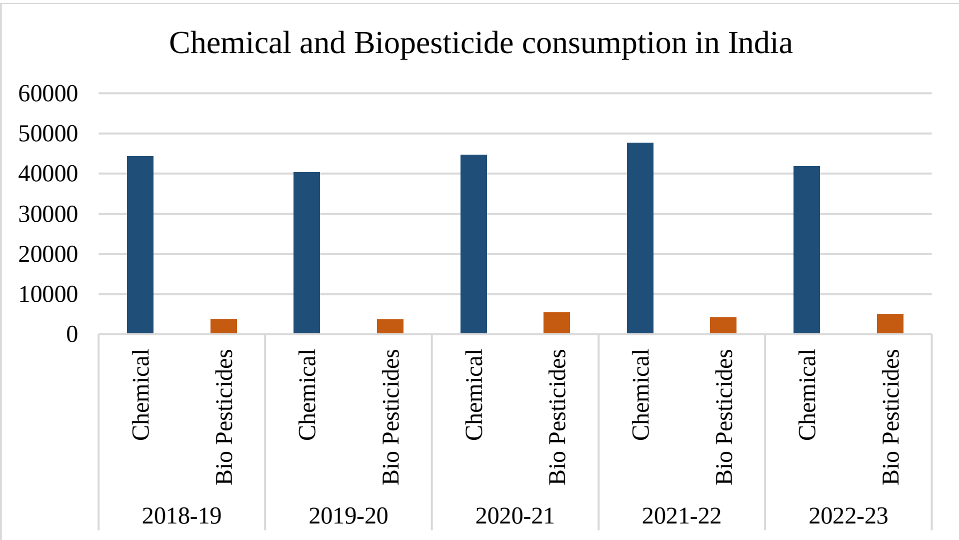


Figure 4 Chemical and Biopesticide consumption of last six years in India (Source: GOI (2024))

These days, a lot of people are more concerned about the environment and their own health and choose natural alternatives to synthetic chemicals. Biopesticides are becoming more and more popular because to their advantages in terms of target specificity, effectiveness, biodegradability, and suitability for use in integrated pest management (IPM) programs.

Biopesticides are acknowledged to have safe use in the environment. The demand for organic food has been rising, thus emphasis has been increased.
Biopesticides are insecticides made from natural materials including plants, animals, microorganisms, and certain minerals. Microorganisms, regulators of biochemical plant growth, natural pests (biochemical pesticides), and pesticide control (microbial pesticides) are all included in the category of biopesticides. Since the 17th century, when more dangerous synthetic pesticides were first developed and widely used to regulate agriculture, biopesticides have advanced significantly.

The graph (Figure 4) shows how the usage of chemical and biological insecticides has changed over the previous six years. In India, the share of biopesticides in total pesticide usage is around 9%. The usage of biopesticides is declining. Data, however, show that India's usage of biopesticides has increased dramatically over the past few decades.

The Central Insecticides Board and Registration Committee (CIBRC), the main body in India that regulates the use of biopesticides of all kinds, presently has 970 biopesticide products registered with them. Of all the biopesticides produced, bacterial, fungal, viral, and other (plant-based, pheromones) biopesticides make up 29, 66, 4, and 1 percent, respectively. Bioinsecticides are still in high demand compared to other products like bionematicides, biofungicides, and bioherbicides. About 70% of the market is made up of bioinsecticides, which are a key focus for producers since they offer better control and food safety.
Only 12 distinct biopesticide types have been identified in India as per the Insecticide Act of 1968.Bacillus thuringensis, NPV, Trichoderma, and neem-based insecticides are the principal biopesticides produced and applied in India. However, there are more than 230 synthetics on the registry for use as chemical insecticides.With a few exceptions for agricultural application, the majority of biopesticides are utilised in public health. In India, beneficial organisms referred to as bio-agents and transgenic plants are also employed in pest control.

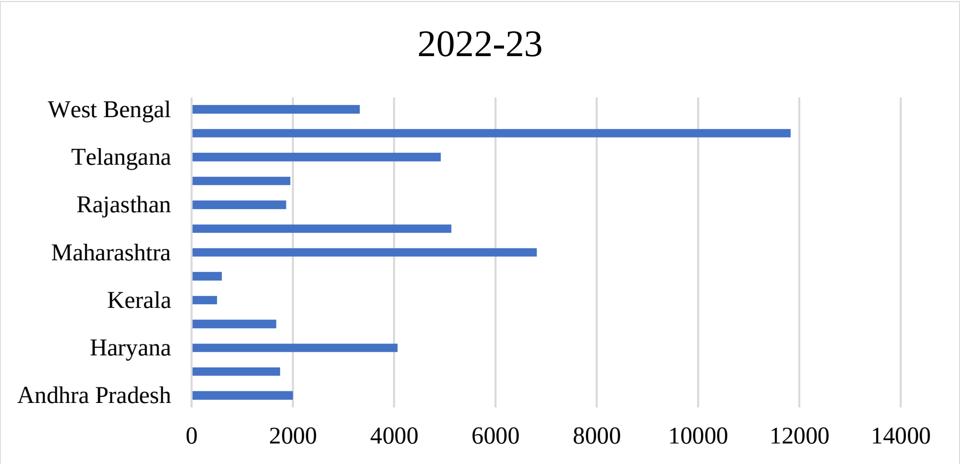
Table 4: Top states in India for pesticide use from 2018 to 2023 (based on government statistics from the Directorate of Plant Protection, Quarantine and Storage) [41]Source:http://ppqs.gov.in/PMD.htm#variousPest

STATE-WISE CONSUMPTION OF CHEMICAL PESTICIDES						
	As on 13.07.2023	Total pesticides consumed (in metric tons)				
S. No.	**States/UTs**	**2018-19**	**2019-20**	**2020-21**	**2021-22**	**2022-23**
1	Andhra Pradesh	1689	1559	1559	1759	2001
5	Gujarat	1608	1784	1573	1869	1750
6	Haryana	4015	4200	4050	4066	4066
9	Karnataka	1524	1568	1930	2224	1669
10	Kerala	995	656	585	532	504
11	Madhya Pradesh	540	540	691	654	598
12	Maharashtra	11746	12783	13243	13175	6814
14	Punjab	5543	4995	5193	5376	5130
15	Rajasthan	2290	2088	2330	2104	1865
16	Tamil Nadu	1901	2225	1834	1851	1952

17	Telangana	4894	4915	4986	4920	4920
18	Uttar Pradesh	11049	12217	11557	11688	11824
20	West Bengal	3190	3630	3630	3630	3321
Grand Total		**50984**	**53160**	**53161**	**53848**	**46414**

Source: Statistical Database | Directorate of Plant Protection, Quarantine & Storage | GOI (ppqs.gov.in)

The top state in India for consumption of Pesticides is Andhra Pradesh which consumes about 2002 metric tons of total pesticides, followed by Gujarat, Haryana, Karnataka,Kerala,Madhya Pradesh, Maharashtra And Punjab. West Bengal stands to be least consumed Pesticide State.



Uses of organophosphate insecticides and the extent of pollution

Because they are less persistent than organochlorines, organophosphate compounds are utilised in lieu of those chemicals; nonetheless, their widespread and uncontrolled usage poses a serious risk to human health and the environment. Since a few decades ago, they have been extensively utilised in agriculture for crop protection and pest management; hundreds of these compounds have undergone screening, and more than 100 of them have been put on the market for these uses [42] (Kumar et al. 2010). Organophosphates including malathion, methyl parathion, dichlorvos, diazinon, fenitrothion, phorate, and monocrotophos are often used in India (Table 3). Under the Ministry of Agriculture and Farmer Welfare, the Central Insecticides Board and Registration Committee (CIBRC) is in charge of registering pesticides for use on crops to manage weeds and pests. Table 4 lists the organophosphates registered for usage in the nation under Section 9(3) of the Insecticides Act, 1968.
Reported contamination of different samples with residues of organophosphates

Sample type	Study site	Detected Organophosphates	MRLa/ Permissible blimit	reference
Soil from paddy-wheat, paddy-cotton,and sugarcane fields	Hisar,Haryana	Chlorpyriphos,malathionandquinalphos	Above	[42]

Soils from tea fields	West Bengal	Ethion and chlorpyrifos	Belowto moderate	[43]
Soil from Cardamom field	Idukki,Kerala	Chlorpyriphos,quinalphosandet hion	Above	[44]
Seasonal vegetables	Nanded,Mahar ashtra	Chlorpyriphosandmonocrotoph os	Below	[45]
Vegetable from farmers' field	Andhra Pradesh	profenofos,chlorpyrifos,Dimeth oate,malathion,Quinalphos,Met hyl parathion,Ethion,andPhorate	Belowtoabo ve	[46]

[a] The MRL value (only for the different crops) has been given by the European Union and WHO/FAO joint standard programme. The latest report of this came in 2008 entitled BREPORT OF THE FORTIETH SESSION OF THE CODEX COMMITTEE ON PESTICIDE RESIDUES^ www.codexalimentarius.org/input/download/report/701/al31_24e.pdf

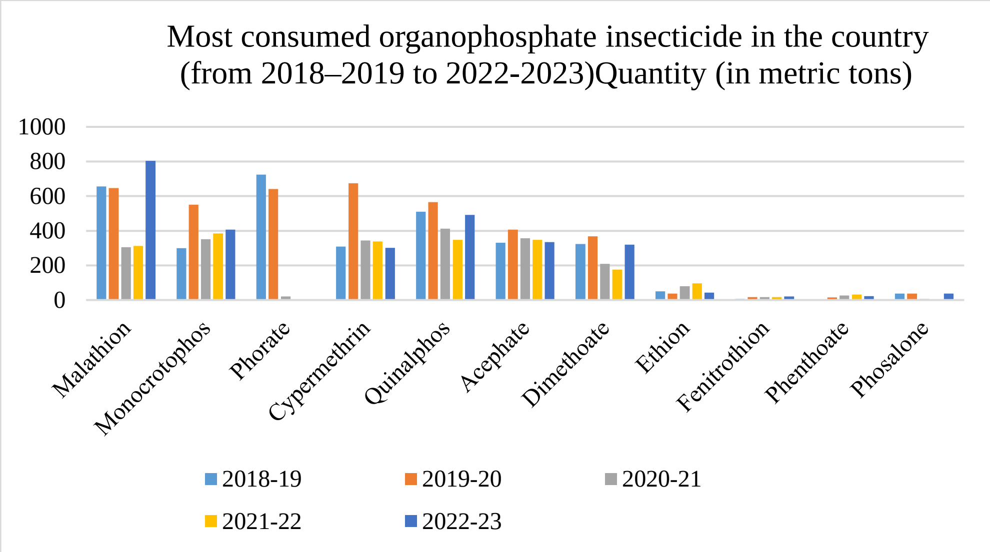
[b] BIS Permissible limit of pesticides in water is 0.001 mg/l but there is no any prescribed/permissible limit set for soil or sediment. So any alteration in this limit in water or any trace detection in the soil can be treated as contamination

Most consumed organophosphate insecticide in the country (from 2018–2019 to 2022-2023)

S. No. Organophosphate insecticide Quantity (in metric tons)

Pesticides	**2018-19** (As on 30.11.19)	**2019-20** (As on 13.04.20)	**2020-21** (As on 28.05.21)	**2021-22** (As on 25.04.23)	**2022-23** (As on 13.07.2023)
Malathion	656.41	647.14	305.41	312.55	802.73
Monocrotophos	299.44	551.02	351.91	385.07	406.19
Phorate	723.7	641.49	19.86	4.55	4
Cypermethrin	308.54	674.65	343.91	338.41	300.99
Quinalphos	509.84	564.61	412.6	347.28	491.1
Acephate	330.6	405.91	356.9	348.11	334.57
Dimethoate	323.64	367.51	209.59	175.76	319.86
Ethion	50.04	36.83	79.14	96.59	42.62
Fenitrothion	5	17.41	16.45	17.55	20.73
Phenthoate	3.08	14.5	26.9	31.53	22.52
Phosalone	37.66	37	6	4	37

Source: http://ppqs.gov.in/statistical-database



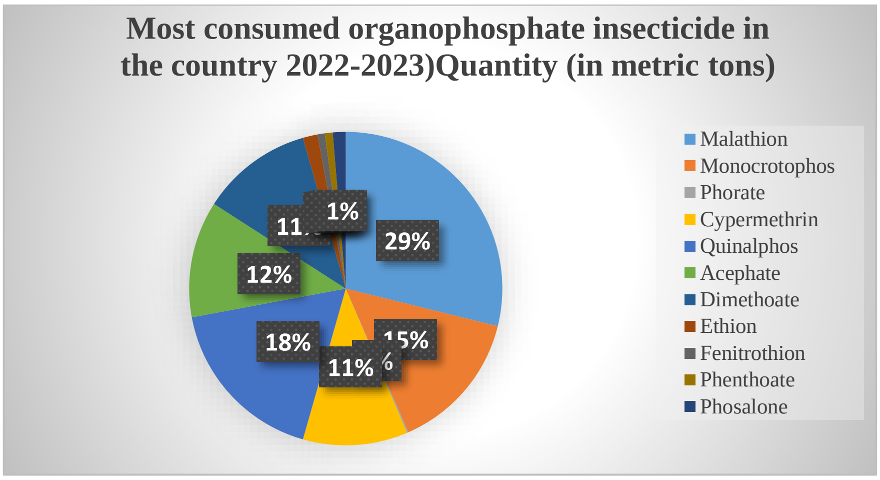


Figure 6: Pesticides classification according to WHO guidelines (World Health Organization ,2009).

According to the reports the most consumed pesticide (in metric tons) according to the WHO is Malathion, which is 29% reported in 2022-2023.The other pesticides most commonly used are Monocrotophos, Cypermetrin, Acephate, Dimethoate etc.
It is being seen that the consumption of Malathion was 656.41 MT in year 2018-19 which is been increased to 802.73 MT in year 2022-2023.

Conclusion

Over the past few years, India has seen a gradual increase in both pesticide output and use. Organophosphorus pesticides are now the main and most commonly used group of pesticides used in India, out of all the other types. While organophosphate chemicals are frequently utilised in place of organochlorides, their widespread, uncontrolled usage and accessibility pose a serious risk to both living things and the environment. Organophosphates, most of which are classified as highly to moderately dangerous by the WHO, have been used widely in India. These include monorotophos, phorate, methyl parathion, malathion, chlorpyrifos, diazinon, phorate, quinalphos, ethion, etc. It's interesting to note that a large number of the organophosphates listed under Section 9(3) of the Insecticides Act, 1968 for use in India are highly restricted or outright forbidden in a number of nations, including the USA and Europe. Although their environmental persistence is lower, several researchers have found evidence of their remains in soil, water, vegetables, and specific food products.Furthermore, traces of certain organophosphates have also been discovered in human blood, urine, breast milk, and other bodily fluids, indicating that they do remain in the body for a considerable length of time. There are guidelines for applying particular organophosphates to particular plants, but in several situations in our study, they were completely careless.

Due to these chemicals' accessibility, people in India routinely use them to try suicide; some of these individuals have recovered successfully after receiving targeted therapy and an early diagnosis. There are guidelines for their sale, application, and crop-specificity, but effective execution and awareness are required. Minimising the number of fatalities and casualties from these potentially deadly substances requires early detection and effective treatment of very acute poisoning. Although they naturally decompose, improved degrading techniques are still required to reduce the likelihood of their buildup and the associated health risks.

Funding

No Funding for this Project.

Acknowledgments

The author is thankful for the guidance and support of Principal Dr. Anagha Joshi; and Vice-Principal Dr.D.M. Kannur for providing all necessary Facilities at SCES's Indira College of Pharmacy, Pune.

Conflicts of Interest

"The authors declare no conflict of interest."

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