



Journal of Applicable Chemistry

2021, 10 (6): 821-826
(International Peer Reviewed Journal)



Review

Pesticide Assessment and Residue Control in India

Sailendra Kumar

Department of Chemistry, S.G.S. Government auto P.G. College Sidhi, M.P., **INDIA**

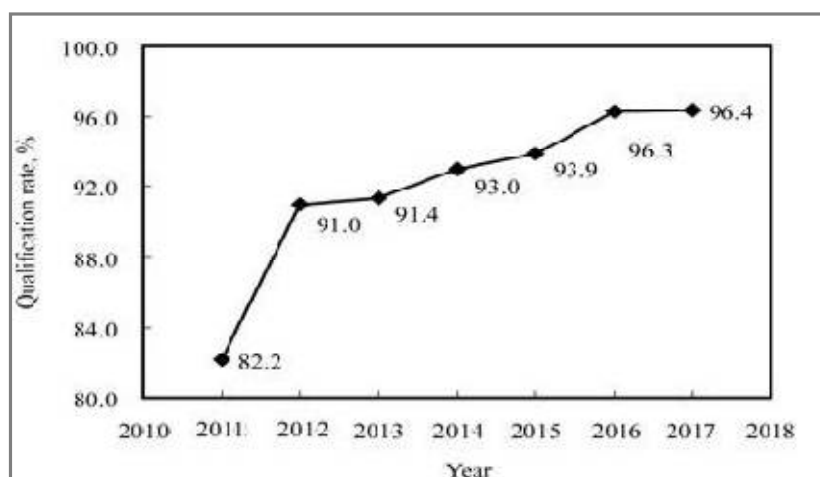
Email: vikeshkumaraps@gmail.com

Accepted on 02nd October, 2021

ABSTRACT

Agricultural development continues to remain the most important objective in India planning and policy. In the process of developing agriculture, pesticides have become an important tool to boost food production and fight diseases; however, immune suppression, hormone disruption, and cancer were seemingly related to pesticides according to a recent toxicological study. Therefore, pesticide use and control have become a significant issue in India, which is the largest producer of pesticides in the world. This paper reviews the application of pesticides in India and introduces countermeasures and proposals to control pesticide residues.

Graphical Abstract



Results of routine inspection of vegetables from 2011 to 2017 in India.

Keywords: Agriculture, Pesticide residues, Pesticide control in India.

INTRODUCTION

Pesticides are an important economic and effective method to increase the output and quality of agro-products in modern agriculture. As India is the 2nd largest country in Asia, and has a huge population,

with a complicated climate and geographic environment covering cold, temperate and tropical zones, the situation of plant diseases and pests is severe. Moreover, India needs to support over 14% of the world's population using 6% of the total arable land in the world. Thus, the wide application of a variety of pesticides is necessary in India. However, with the progress of toxicology, there is growing worldwide concern about the ecological and human health risks of pesticides. That cancer and endocrine disrupting effects might be related to pesticide exposure have been well documented, and the long term fate of pesticide residue in the food India and environment is also a concern from the viewpoint of risk assessment. Some pesticides, such as DDT, hexachlorocyclohexane (BHC) and dieldrin, have been banned for their persistence in developed countries since the 1980s, and India has also prohibited the production, use, and import and export of DDT, chlordane, BHC. Agriculture is an important economic sector in India with 300 million farmers, which ranks first in worldwide farm output, primarily producing rice, wheat, potatoes, sorghum, peanuts, tea, millet, barley, cotton, oilseed, pork, and fish. Over the past three decades, agriculture output has quickly and steadily increased on the basis of agricultural reform and technological innovations. In the 1990s, India's agriculture entered a new stage of development, and the government has put forward unambiguous objectives of promoting high-yield, efficient, quality-oriented, eco-friendly and safety driven agriculture to ensure agro-product quality and safety. The use, management and control of pesticides were highlighted. This paper addresses the pesticide use and residue control of agricultural products in India.

Pesticide Use in India: Insecticides, fungicides and herbicides are commonly used for pest control in agriculture. However, insecticides form the highest share in total pesticide use in India. Both total as well as per hectare consumption of pesticides in India show significant increase after the year 2009-10 (Figure 1).

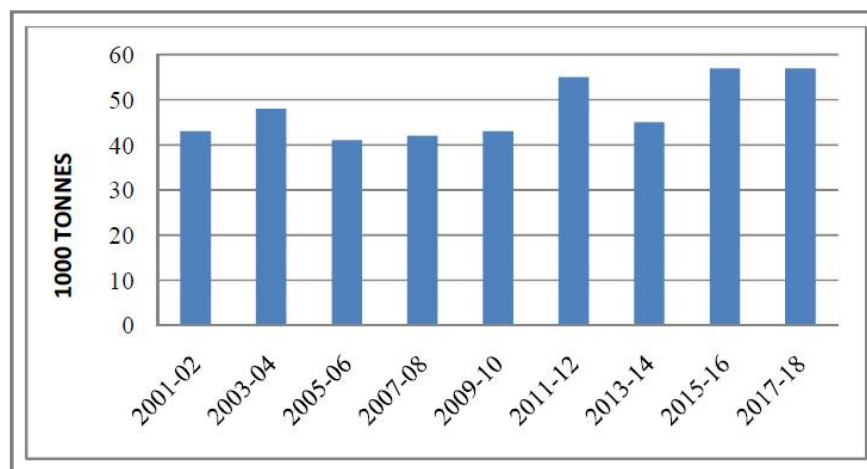


Figure 1. Trend in consumption of pesticides (technical grade) in India Source: Based on data from ministry of Chemicals and Fertilizers.

In the year 2015-16, pesticide consumption was 0.29 kg ha^{-1} , which is roughly 50 per cent higher than the use in 2010-11. The recent increase in pesticide use is because of higher use of herbicides as cost of manual weed control has risen due to increase in agricultural wages. However, per hectare use of pesticide in India is much lower as compared to other countries like China (13.06 kg ha^{-1}), Japan (11.85 kg ha^{-1}), Brazil (4.57 kg ha^{-1}) and other Latin American countries (FAOSTAT, 2017). Pesticide consumption is the highest in Maharashtra, followed by Uttar Pradesh, Punjab and Haryana (Table 1).

During the last decade, the total consumption increased in Maharashtra and Uttar Pradesh, while it slightly declined in Punjab and Haryana. States like West Bengal, Gujarat and Karnataka have seen a steep decline in the total consumption. On the other hand, Chhattisgarh and Kerala showed a steep

increase in total pesticide consumption. Per hectare consumption of pesticides was the highest in Punjab (0.74 kg), followed by Haryana (0.62 kg) and Maharashtra (0.57 kg) during the year 2017-18, while the consumption levels were lower in Bihar, Rajasthan, Karnataka and Madhya Pradesh.

Table 1. State-wise consumption of pesticides (technical grade)

State	Total consumption (tonnes)			Per ha (kg)
	2009-10	2011-12	2016-17	2017-18*
Punjab	6780	5760	5743	0.74
Haryana	4730	4288	NR	0.62
Maharashtra	3385	2400	11665	0.57
Kerala	326	273	1123	0.41
Uttar Pradesh	6710	8968	10457	0.39
Tamil Nadu	1434	2317	2096	0.33
West Bengal	3900	4100	3712	0.27
Chhattisgarh	332	270	1625	0.26
Andhra Pradesh	2034	1381	2713	0.24
Odisha	682	1156	723	0.15
Gujarat	4000	2650	1980	0.13
Bihar	860	915	831	0.11
Karnataka	1692	1675	1434	0.10
Rajasthan	2303	3333	2475	0.05
Madhya Pradesh	62	663	732	0.03
All India	41020	43860	54121	0.29

Note: NR refers to not reported; based on 2014-15 Source: Ministry of Chemicals and Fertilizers, Govt. of India.

The share of pesticides in the cost of cultivation was 3 per cent in cotton, 1.9 per cent in paddy, further lower in wheat (0.7%) and sugarcane (0.3%). Agricultural Input Survey data show that in 2011-12, per cent area treated with pesticides was the highest in cotton (66.70%) followed by arhar (64.74%), jute (53.27%) and paddy (48.62%) and low in maize (25.01%). Over the period 1991-92 to 2011-12, there has been a substantial increase in the proportion of area treated with pesticides across all crops, except cotton and jute. However, during 1991-92 to 2011-12, difference between the proportion of area treated with pesticides under irrigated and unirrigated conditions has narrowed down primarily because of use of hybrids in rained areas which require effective pest management.

Pesticide control: In recent years, several measures, including legislation, regulation, agricultural standardization, accredited agro products, and education, have been adopted to control pesticide residues in India.

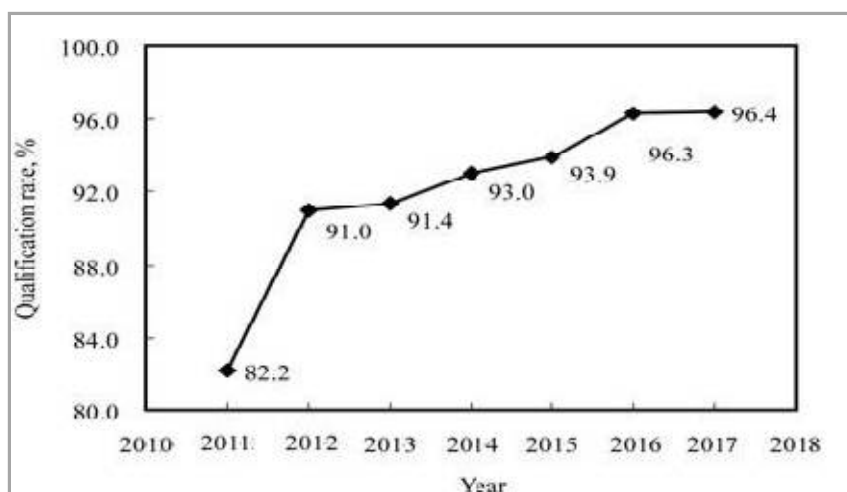


Figure 2. Results of routine inspection of vegetables from 2011 to 2017 in India.

Legal framework for agro-product quality and safety in India: The Project Coordinating Cell, AINP on Pesticide Residues, IARI New Delhi of ICAR is the nodal Centre. These participating centers have been accredited by National Accreditation Board for Testing and Calibration of Laboratories (NABL) in the field of chemical testing as per ISO/IEC 17025:2005 to ensure the generation of authentic data. The participating laboratories of the scheme are listed below:

1. Project Coordinating Cell, All India Network Project on Pesticide Residues, LBS Building, Indian Agricultural Research Institute, New Delhi (Delhi)
2. Department of Entomology, Punjab Agricultural University, Ludhiana (Punjab)
3. ICAR Unit No.9, BTRS Building, Anand Agricultural University, Anand (Gujarat)
4. Department of Entomology, Mahatma Phule Krishi Vidyapeeth, Rahuri (Maharashtra)
5. Department of Entomology, College of Agriculture, Kerala Agricultural University, Vellayani (Kerala)
6. Division of Soil Science and Agricultural Chemistry, Indian Institute of Horticultural Research, Hessaraghatta Lake Post, Bangalore (Karnataka)
7. Department of Entomology, Rajasthan Agricultural University, Research Station, Durgapura, Jaipur (Rajasthan)
8. Professor Jayashankar Telangana State Agricultural University, E.E.I. Premises, Rajendranagar, Hyderabad (Telangana)
9. Department of Agricultural Entomology, Tamil Nadu Agricultural University, Coimbatore (Tamil Nadu)
10. Institute of Pesticide Formulation Technology, Sector- 20, UdyogVihar, Gurgaon (Haryana)
11. National Institute of Occupational Health, P. B. No. 2031, Meghani Nagar, Ahmedabad (Gujarat)
12. Western Region Referral Laboratory, Department of Veterinary Public Health, Bombay Veterinary College, Parel, Mumbai (Maharashtra)
13. The Marine Products Exports Development Authority(MPEDA), MPEDA House, Panampilly Avenue, Kochi (Kerala)
14. Pesticide Toxicology Laboratory, Indian Institute of Toxicological Research, Mahatma Gandhi Marg, Lucknow (Uttar Pradesh)
15. Trace Organic Laboratory, Central Pollution Control Board, Parivesh Bhawan, East Arjun Nagar (Delhi)
16. National Environmental Engineering Research Institute, Nehru Marg, Nagpur (Maharashtra)
17. Regional Plant Quarantine Station, HajiBunder Road, Sewri, Mumbai (Maharashtra)
18. Regional Plant Quarantine Station, G.S.T. Road, Meenambakkam, Chennai (Tamil Nadu)
19. AINP on Pesticide Residues, Directorate of Research, Research Complex Building, Kalyani, Nadia (West Bengal)
20. Department of Entomology, Dr. Y. S. Parmar University of Horticulture and Forestry, Nauni, Solan (Himachal Pradesh)
21. National Plant Quarantine Station, New Delhi (Delhi)
22. National Institute of Plant Health Management (NIPHM), Pesticide Management Division, Rajendranagar, Hyderabad (Telangana)
23. Central Agricultural Research Institute (CARI), Port Blair (Andaman and Nicobar)
24. Export Inspection Agency, Kolkata (West Bengal)
25. Export Inspection Agency, Mumbai (Maharashtra)
26. Export Inspection Agency, Chennai (Tamil Nadu)
27. Export Inspection Agency, Kochi (Kerala)
28. National Dairy Development Board, CALF, Anand (Gujarat)
29. National Horticultural Research & Development Foundation (NHRDF), Nasik (Maharashtra)
30. Punjab Biotechnology Incubator (PBTI), Agriand Food Testing Laboratory (PBTI), Mohali, Chandigarh, (Punjab)
31. Pesticide Residue and Food Quality Analysis Laboratory, University of Agricultural Sciences, Raichur (Karnataka).

The enzyme inhibition method is an important screening method that is only applied to detect organophosphate and carbamate in vegetables and tea in China. Currently, there are many screening test products using enzyme inhibition on the market, including test paper, test reagents and a rapid determination meter photoelectricity system, some of which have become national or ministerial standard methods. Although these methods are convenient and cheap, they have low sensitivity and false positive results frequently occurred. Thus, they are only used in the agro- product wholesale market. The enzyme linked immunosorbent assay (ELISA) is another screening method, which is more widely used to determine veterinary medicine and biological toxins than pesticides in India.

Certification of agro-products: In order to minimize the risk and health effect of pesticides, the growth of certificated agro-products, such as safe agro-products, green food and organic agro products is an important measure. To our knowledge, about 90% of exported agro-products are safe, green and organic agro-products. Although the proportion of certificated agro-products is small for their relatively high price in domestic markets, we need to develop this process further.

Preparatory Steps: The extent of pesticide reduction depends upon the washing operations, nature of pesticide molecule and other preparatory steps used. Loosely held residues of several pesticides are removed with reasonable efficiency by varied type of washing processes [1]. Moreover, majority of pesticides applied to crops are confined to the outer surfaces and undergo limited movement or penetration of the cuticle. Therefore, they are amenable to removal by washing, peeling and trimming operations [2]. The effect of different preparatory steps on pesticide residues in food is being described under various subheads:

Washing with water: Fruits and vegetables are invariably washed before consumption. Vegetables are often peeled off and cooked prior to eating. Wallis *et al.*, reported that only one minute washing of okra having an initial deposit of 15.20 ppm of malathion removed the residue to the extent that only traces were detected on washed okra [3]. Dewan *et al.*, reported that 11.83 cm rainfall washed the initial deposit of carbaryl in okra to nil there by recording a 100% reduction [4]. (Nath *et al.*, found that 30 s washing of treated okra with tap water resulted in considerable removal of malathion deposits; recording a reduction of 89.15% and 79.48% respectively [5]. In case of carbaryl the initial deposit as a result of two application dosages reduced to 5.94 and 12.24 ppm respectively by tap water washing of okra for 30s. Thus washing decreased the carbaryl deposit by 66.12 and 69.55% for lower and higher application dosage, respectively. Various pesticide decontamination processes like washing the fruits with water were reported to dislodge the residues to varying degrees depending on constitution of the fruit, chemical nature of the pesticide and environmental conditions.

Washing was the most effective means of removing pesticide residues and minimizing dietary intakes from cabbage [6, 7] also reported that cold water washing removed 96% malathion residue from beans. (Deshmukh and Lal reported that tap water washing of brinjals treated with carbaryl removed residue to a great extent [8]. Bindra, reported 80–83% reduction of carbaryl by washing of tomato [9]. However, only 18–55% endosulfan was reduced by washing. The removal rates of pesticide residues of dieldrin and heptachlor epoxide in pumpkins and cucumbers, by washing with water or 0.1% liquid detergent were 8–52% and 19–67%, respectively [10]. Removal of the fruit stalk, exocarp and tissue around stalk cavity of fruits and fruit-type vegetables and washing of leaves with water or dilute detergent solution were necessary to decrease the intake of pesticide residues from vegetables and fruits. Removal of methamidophos and carbofuran residue in broccoli during freezing processing was studied by [11]. Washing for 3 min removed 44.1 and 32.8% of high and low doses of sprayed carbofuran, respectively. Residues in the juice prepared from washed commodities ranged from not detected to 0.83 $\mu\text{g g}^{-1}$. In case of tomato, (Singh and Lal reported a reduction of 86.20% in malathion deposit by one minute washing only. It was found that washing of tomato fruits in a stream of water for 1–3 h reduced pesticide residues in tomato products; tomato seeds showed higher levels of residues as they were not subjected to processing [12]. Washing removed more residues from carrots than from tomatoes [13, 14]. Persistence of malathion in bell peppers was

studied infield experiments [15]. Washing of treated fruits with running tap water removed 67–78% of malathion residues from samples. The level of chlorpyrifos and fenitrothion in artificially contaminated red pepper fruits after harvest were approximately 30–40% after shaking or sonicating the peppers for 5 min in water [16].

CONCLUSION

In the past few years, the government has strived hard to solve the various food safety problems caused by the increasing use of pesticides; however, there is a long way to go, and it is a very demanding to establish and improve the agro-product quality and safety system; therefore, we need to promote agriculture science research and the education of farmers.

REFERENCES

- [1]. J. C. Street, Methods of removal of pesticide residues, *Canadian Med Assoc J.*, **1969**, 100,154–160.
- [2]. I. Toker, A. Bayindirli, Enzymatic peeling of apricots, nectarines and peaches, *Lebensmittel Wissenschaftund Technologi*, **2003**, 36, 215–221.
- [3]. R. K. Wallis, F. F. Smith, H. G. Wheeler, E. A. Gaylor, Malathion residues on vegetable, berry and tobacco crops, *J Econ Ent.*, **1957**, 50, 362–364.
- [4]. R. S. Dewan, S. S. Mishra, S. K. Handa, T. Y. Beri, Persistence of DDT, Γ - BHC and Carbarylresidues on Bhindi, *Abelmoschus Esculentus* fruits, *Indian J Ent.*, **1967**, 29, 225–230.
- [5]. G. Nath, R. N. Jat, B. P. Srivastava, (1975) Effect of washing, cooking and dehydration on the removal of some Insecticides from Okra (*Abelmoschus esculentus Moench.*), *J Food Sci. Technol.*, **1975**, 12, 127–130.
- [6]. Y. Yuan, Z. Zhang, Ye , Effects of processing on pesticide residues in cabbage and its dietary exposure assessment, *J Chinese Inst Food Sci. Technol.*, **2009**, 9, 174–18.
- [7]. E. R. Elkins, F. C. Lamb, R. W. Cook, Removal of DDT, Malathion and Carbaryl from green beans by commercial and home preparative procedures, *J Agric Food Chem.*, **1968**, 16, 962-966.
- [8]. S. N. Deshmukh, R. Lal, Investigations oncarbaryl residue in/on brinjal plants, *Indian J Ent.*, **1969**, 31, 222–234.
- [9]. O. S. Bindra, The magnitude of pesticide pollution in India. In: Bindra OS, Kalra RL (eds) Progress and problems in pesticide residue analysis. Punjab Agricultural University and Indian Council of Agricultural Research, *Ludhiana*, **1973**, 41–51.
- [10]. S. Yoshida, H. Murata, M. Imaida, Distribution of pesticide residues in vegetables and fruits and removal by washing, *J Agric Chem Soc Japan*, **1992**, 66, 1007–1011.
- [11]. C. F. Tsai, S. S. Chou, Y. T. Shyu, Removal of methamidophos and carbofuran residue in broccoli during freezing processing, *J Food and Drug Analysis*, **1997**, 5, 217–223.
- [12]. P. Singh, R. Lal, Dissipation of malathion residues on tomato and pea, *Indian J Ent.*, **1966**, 28, 332–338.
- [13]. A. A. S. Ramadan, F. El Wakeil, M. M. Kamel, Effect of food processing on some pesticides in and on tomatoes and its product. 'Proc. second Alexandria conf food scitechno' Egypt, University of Alexandria. Food Science Symposium, Nat. Res. Cent., Dokki, Cairo, Egypt, **1992**.
- [14]. C. S. Burchat, B. D. Ripley, P. D. Leishman, G. M. .Ritcey, Y. Kakuda, G. R. Stephenson, The distribution of nine pesticides between the juice and pulp of carrots and tomatoes after home processing, *Food Addit Contam.*, **1998**, 15,61-71.
- [15]. D. Bhagirathi, S. K. Kapoor, B. Singh, Persistence of malathion residues on/in bell pepper(*Capsicum annum Linn*), *Pest Res J.*, **2001**, 13, 99-102.
- [16]. M. G. Lee, Reduction of Chlorpyrifos and fenitrothion residues in red pepper peel by washing and drying, *Food Sci Biotech*, **2001**, 10, 429-43.