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Pesticides Residues In, Vegetables and Fruits: A Review

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ABSTRACT: To feed the growing global population, it is essential to increase agricultural production. Due to health consciousness and prosperity, the consumption of fruits and vegetables, particularly in developing countries, has increased manifold in the last 50 years. To achieve these, the use of pesticides is one of the tools. Pesticides are also used for public health protection (to protect from vector-borne diseases). About 1000 compounds (organic and inorganic) are used as active ingredients of pesticides. Organochlorine and organophosphate pesticides are not only highly toxic but persist for decades. Those organochlorine pesticides which were banned 40 years ago are still found in vegetables and fruits. The pesticides from soil and water are accumulated in fruits and vegetables, and some of the vegetables are often consumed raw. Consumption of pesticide-contaminated fruits and vegetables by humans causes adverse health effects to humans. The short-term adverse effects on humans are asthma, sore throat, eye and skin irritation, and diarrhea, while long-term effects are cancer, neurological disorders, reproductive problems, diabetes, etc. This review aims to report the concentration of the commonly used pesticides in fruits and vegetables and their impact on humans. The present study will provide data for policymakers to formulate guidelines for the reduction of health risks to humans caused by the consumption of pesticide-contaminated fruits and vegetables.

KEYWORDS: Environment, Fruits, Humans, Pesticides, Vegetables

INTRODUCTION

Vegetables and fruits, an important part of the human diet, are one of the major sources of carbohydrates, lipids, vitamins (A, B complex, C, E), minerals, antioxidants, dietary fibers and other essential nutrients. Medical experts to minimise the chances of major non-communicable diseases such as cancer, cardiovascular diseases, and obesity, to prevent micronutrient and vitamin deficiency recommend a high intake of fruits and vegetables [1,2]. As per estimation in the year 2023, the global production of fruits and vegetables was 2.1 billion tonnes. India, the second largest producer of vegetables, produces 12% of world vegetable produce. The global market of fruits in 2023 was 714 billion US dollars.

To feed the rapidly growing world population, which is expected to be 8.6 billion by 2030 (from 7.6 billion in 2024), it is the compulsion of agricultural scientists to find a way to increase agricultural productivity, especially in tropical regions. To increase the agricultural products, the first step is to manage pests and crop invaders, i.e., herbs and fungi (approximately 23% of crop growth is affected by pests), for which fertilisers and pesticides have been widely and indiscriminately used. Pesticides are also widely used in public health protection to protect humans from vector-borne diseases like malaria and dengue fever [3, 4]. It is reported that in the year 2024, the global pesticide production was 4.3598 million metric tonnes of 26.22 billion US dollars. The agrochemical market in 2025 is expected to reach 311.48 billion US dollars. Though globally DDT and BHC are banned due to their low cost and wide spectrum activity, they are still used in developing countries, including India. Pesticides that are sprayed directly on the crops/vegetables and the soil surface undoubtedly increase crop productivity and food security, but indiscriminate use, inappropriate spraying equipment and incorrect application techniques cause accumulation of the persistent pesticide residues in crops and soil. The accumulation in vegetables is more than the grain crops. Health experts suggest consuming fresh fruits and vegetables, but the presence of pesticide residues causes food safety and health issues, particularly for those vegetables which are mostly consumed in their raw form or semi-processed form [5].

A major pathway of human exposure to the pesticides is consumption of farm produce. Several health problems such as cancer, endocrine disruption, neurological effects, genotoxicity, birth defects, and impaired fertility are linked with pesticides or their metabolites present in the human body, as pesticides in the human body impact xenobiotic metabolism by deregulating the enzymes that affect growth, reactive oxygen species and cause cell and DNA damage. Dizziness, headaches, rashes and nausea are also

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exerted by pesticides. The negative impacts of pesticides are more pronounced in children. The objective of this review is to make policy for minimising the negative health risks to humans caused by the consumption of fresh fruits and vegetables.

Major classes of pesticides used are:
Organochlorine pesticides (e.g., DDT, HCH, aldrin, dieldrin, endosulfan, heptachlor, dicofol, chlordane, and methoxychlor); Organophosphorus pesticides (parathion, malathion, diazinon, dimethoate, chlorpyrifos, dichlorvos, fenthion and glyphosate); Carbamate and dithiocarbamate pesticides (carbaryl, oxamyl, carbofuran, aminocarb, aldicarb, propoxur, thiram, disulfiram, ziram, and ferbam); Pyrethrins and pyrethroids pesticides

Routes of contamination of fruits, vegetables, etc.:
The major route of accumulation of pesticides in fruits and vegetables is via absorption by the plants with water and minerals from soils. Plants absorb the pesticides which are washed into soil or water bodies and applied to crop plants for protection from pests. As the pesticides are not easily decomposing, their biomagnifications occur.

Pesticides in vegetables:
Unregulated, indiscriminate excessive use of the pesticides during the sowing and growth stages of vegetables and fruits results in the accumulation of these persistent toxic pollutants in the vegetables and fruits. The review of literature denotes [6, 7] that globally more than 50% of vegetables and fruits are contaminated by one or more pesticides. The pesticide concentration in about 30% of the vegetables and fruits was beyond the permissible limit. Research studies made by Foster [8] revealed that in the United States (USA), 20% of vegetables and fruits contain high concentrations of pesticides (one or more). The 'Dirty Dozen' list of fruits and vegetables with the most pesticides includes strawberries, apples, cherries, spinach, nectarines, blueberries, green beans, potatoes, peppers and kale. During the research work on 30,000 samples of fruits and vegetables, Gillam [9] found that strawberries, blueberries, green beans, potatoes and peppers accumulate more concentration of pesticides, and in 8% of studied samples, the concentration of pesticides was beyond their allowable limit. As per the report of The Hindu Daily newspaper dated 23 July 2024, out of 195 samples of 19 vegetables and 12 fruits, 16% of the sample's pesticide concentration was much beyond their permissible limits. Li et al. [6], during their studies, found that almost 90% of the samples of fruits and vegetables from ten countries are contaminated with pesticides chlorpyrifos, profenofos, dimethoate, and fenitrothion. The maximum concentration was in the samples of the United Arab Emirates (UAE). Maximum accumulation of the pesticides was in root vegetables [10]. The concentration of the pesticide chlorpyrifos in the fruits and vegetables grown in China, India, Ghana, Thailand and the UAE exceeds the maximum allowable limits, and in the samples from Ghana, the concentration was 30 times the UK standards [6]. Dinede et al. [11] assessed the concentration of pesticides in 232 samples of tomatoes, cabbage and Swiss chard and found that almost 50% of samples contain at least one pesticide and 20% contain two or more pesticides, and 155 of the total samples are contaminated with pesticides whose concentration exceeds the allowable limits. The concentration of the chlorpyrifos pesticide in the fruit and vegetable samples of the UAE, China, India, Ghana and Thailand was beyond permissible limits [12-14]. About 47.5% of the samples of vegetable tomatoes, onions, watermelon, cucumbers, sweet peppers and Chinese cabbage grown in Tanzania contain commonly used pesticide residues beyond their permissible limits, and one pesticide residue was present in 49.1% of samples; two pesticide residues were in 31.1% of samples and three types of pesticide residues were in 11.7% of samples, was the finding of Kapeleka et al. [15]. They also reported that organophosphate pesticides were present in 95.2% of total samples, followed by organochlorine (24%); pyrethroids (17.3%); and carbamate pesticides (9.2%). The concentration of DDT, HCH and heptachlor in cabbage and tomatoes and aldrin in lettuce grown in Ghana was beyond the recommended permissible limit [16]. El-Sheikh et al. [17] found that the pesticide residues in 40.7% of vegetables and 38.9% of fruits exceeded MRLs. The USA Environmental Working Group reported that in the USA, more than 90% of samples of strawberries, apples, cherries, spinach, nectarines, and kale are contaminated with two or more pesticides. They also found that more than two types of pesticides are present in 50% of studied samples. A maximum of 18 pesticides were tested by them in a few samples of kale [18]. In the fresh fruits and vegetables grown in Uganda, Ssemugabo et al. [19] reported twenty-one classes of pesticides, including organophosphates, carbamates, dithiocarbamates, pyrethroids, and neonicotinoids. They also found that all the samples contained at least one pesticide; 64% of samples contained 2-9 pesticides, and 25.6% were contaminated by more than 10 pesticides. Farshidi et al. [20], during their studies on the pesticides DDT, malathion, diazinon, tebuconazole, trifloxystrobin, bioallethrin and cypermethrin residue in leafy vegetables, lettuce, tomato and cucumber grown in Iran, found that residual concentrations of diazinon, tebuconazole, trifloxystrobin,

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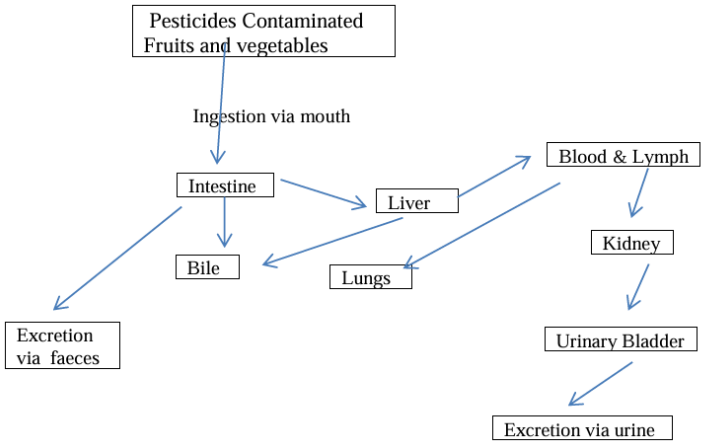
bioallethrin and cypermethrin exceed the permissible limits. Organophosphate and carbamate pesticide residues within permissible limits were reported by Fatunsin et al. [21] in food grown in Nigeria. In the Middle East, almost 90% of fruits and vegetables are contaminated with insecticides, and the concentration of insecticides in 61% of produce exceeds the allowable limit [22]. Kazar Soydan et al. [23], during their research studies on 16 commodities of fruits and vegetables grown in Turkey, found that 12% of the studied samples contain pesticides beyond their permissible limit. Ahmed et al. [24] reported that the concentration of the pesticides chlorpyrifos and fenitrothion in 15% of tomato samples and 27.5% of eggplant samples grown in Bangladesh was beyond the EU maximum limit. The concentration of the pesticide imidacloprid in spinach, beetroot, mustard plant, bitter gourd and guava was 2-12 times the permissible limit, while the pesticide difenoconazole in oranges, guavas, mustard plant and lemons was 6-1533 times higher than the permissible limits [25]. Out of 211 samples of vegetables collected from Saudi Arabia Ramadan et al. [26] found pesticide residues in 145 samples, and in 44 samples the pesticide concentration was beyond the maximum residue limit. The pesticides detected were methomyl, metalaxyl, imidacloprid, and cyproconazole. In the vegetables pepper, garden egg and okra grown in Ghana, the banned pesticides DDT, lindane, and hexachlorocyclohexane residues were beyond the limit [27]. They also conclude that DDT and lambda-cyhalothrin hinder seed germination and seedling vigour. The concentrations of pesticides in vegetables and fruits grown globally are summarised in Tables 1 and 2.

Impacts of pesticides on Humans:

Undoubtedly globally all humans are exposed to pesticides, while the exposure and adverse health effects of pesticides are more prevalent in developing countries. Infants and children, due to their developing bodies, are more susceptible to the adverse effects of pesticides. Pesticide intake by humans via vegetables and fruits causes neurological disorders, DNA damage, excessive salivation, skin and eye irritations, haematological abnormalities, infertility, miscarriages and foetal malformation, hearing loss, psychiatric effects, diabetes, cancer, etc.[52-54] Organochlorines (OCs) and organophosphates (OPs) affect the nervous system and can lead to damage to organs and cancer. Exposure to carbamate and dithiocarbamate pesticides causes respiratory problems and developmental problems. Pyrethrins and pyrethroids cause systemic impacts. WHO has estimated that globally, unintentional, acute pesticide poisoning occurs in about 385 million people annually, with 220,000 deaths.

Route of Impact on Human body



Effects of pesticides on human health:

1. Neurological disorders:

Several research studies have shown a relationship between pesticide exposure and neurological disorders, e.g., Parkinson's and Alzheimer's diseases, neurotoxic effects and cognitive effects. If exposure to organochlorine pesticides occurs for a long period, it causes brain damage which leads to Alzheimer's disease and dementia [55, 56]. The mental function of those schoolchildren who are exposed to organophosphate pesticides at the prenatal stage is compromised [57]. Parkinson's disease is caused when pesticides or their metabolites disrupt mitochondrial activities and alter xenobiotic metabolism. Organophosphate pesticide exposure and Parkinson's disease are linked [58, 59], as organophosphate pesticides enhance reactive oxygen species production, causing oxidative injury. Most of the carbamate pesticides and a few organophosphate pesticides inhibit the acetylcholinesterase enzyme activities, resulting in hyperstimulation of cholinergic receptors in the nervous system. Lindane and endosulfan in the human body

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affect the central nervous system, increase lipid peroxidation, and damage DNA in brain tissue, cause seizures and lead to neuronal hyperexcitability. Pesticides of the pyrethroid class and organophosphate cause damage to neurones and change the way cells function by inducing oxidative stress [60-62]. Exposure to organochlorine and organophosphate pesticides increases the chances of cognitive impairment. Lower IQ and poor memory are reported in those children who are exposed to organophosphate pesticides at the prenatal stage [60, 63.

2. Diabetes

Exposure of humans to pesticides is one of the causes of the occurrence of diabetes. The literature review on epidemiological studies denotes that organochlorine and organophosphate pesticides enhance the chances of glycaemic control impairment leading to diabetes [64, 65]. The organochlorine and organophosphate pesticides interfere with the normal functioning of the endocrine system, resulting in diabetes. The metabolites of organochlorine pesticides increase the number of type 2 diabetes and other associated complications [66, 67]. Miranda et al. [67] also reported that a higher concentration of DDT and/or heptachlor epoxide in blood enhances the probability of diabetic neuropathy.

3. Respiratory disorders

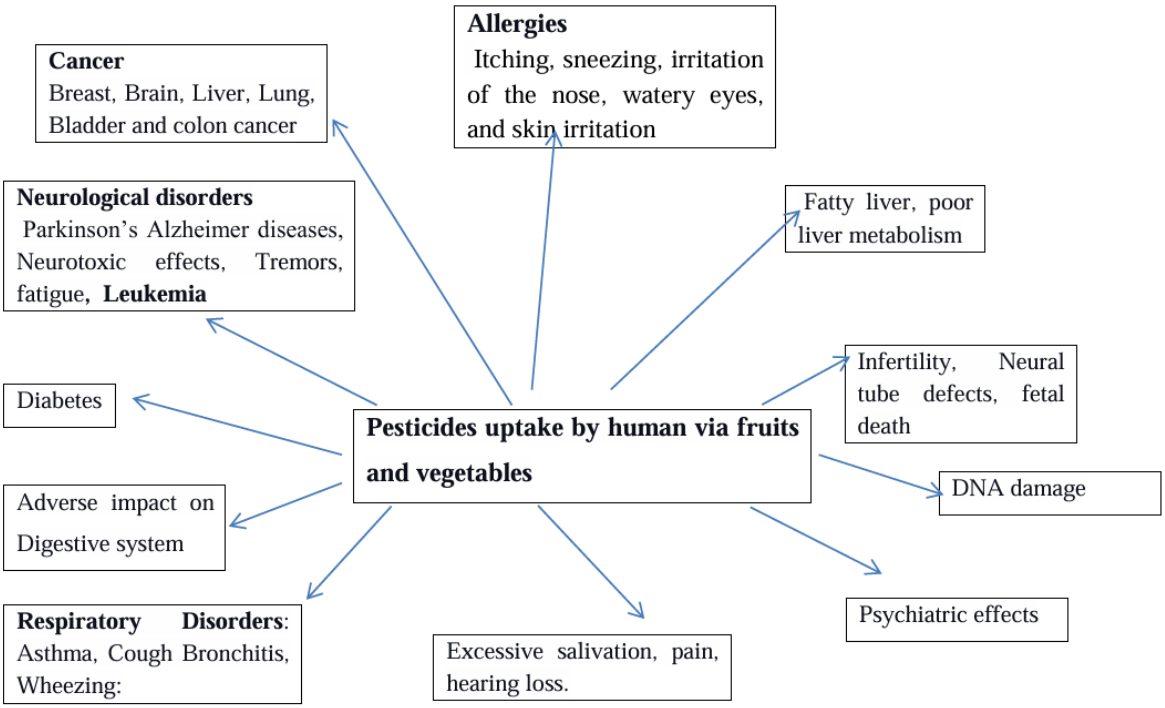
Several respiratory disorders in humans are caused by pesticide exposure. Developing asthma is closely associated with pesticide exposure. Pyrethroids and organophosphate pesticides increase the risk of asthma**,** mainly in children [68, 69]. The bronchial mucosa is damaged by making airways very sensitive to pollutants.

4. Impact on reproduction:

The accumulation of pesticides in the human body disrupts hormonal signalling and semen quality and negatively impacts the fertility of humans (both men and women). Hood et al. [70] reported that the accumulation of organophosphate pesticides is directly correlated with erectile dysfunction. Accumulation of organochlorine pesticides causes neural tube defects (NTDs) [71, 72]. Exposure to pesticides also causes limb disorders, urogenital anomalies, ocular anomalies and orofacial clefts [73, 74]. Accumulation of pesticides also causes natural abortion, foetal death and neonatal death [75].

5. Cancer

Many studies have concluded that there is a positive correlation between pesticide exposure and multiple myeloma, breast, bladder, colon, brain and liver cancer [76-79]. Pesticides, particularly organophosphates, damage breast tissue DNA with disruption in the oestrogen receptors, causing DNA mutation and boosting malignancy [80-81].



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Effects of pesticides on human

If chlorpyrifos accumulates in the breast, it impacts the redox mechanism and negatively affects the antioxidant defence mechanism [82]). Organochlorine pesticides (DDT, chlordane, and heptachlor) affect mammary cells by producing oestrogen, which enhances the probability of breast cancer [83, 84]. Accumulation of the pesticides imidazolinone, imazaquin, and imazethapyr is related to bladder and colon cancer [85, 86]. Some organophosphate pesticides harm brain DNA and contribute to the development of cancer cells by harming the brain DNA and impairing hormonal balance [87, 88] (Leonel et al., 2021; Feulefack et al., 2021). Several studies have shown a direct relationship between organochlorine pesticide accumulation and liver and pancreatic cancer [86, 89-90].

6. Other Impacts:

Cano et al. [91] (2020) during their studies found that some pesticides, particularly organochlorine pesticides, facilitate the progression of non-alcoholic fatty liver disease (NAFLD as pesticides affect the gut microbiota and lipid metabolism and induce oxidative stress and inflammation [10,92]. Allergies like itching, sneezing, irritation of the nose, watery eyes, and skin irritation (blisters, rash, and rhinitis) are also caused by pesticides [93]. Leukaemia and non-Hodgkin's lymphoma development in humans are linked with pesticide, particularly organophosphate pesticide exposure [94-97].

CONCLUSIONS

• To feed and provide a nutritional diet to a growing population and to protect humans from vector-borne diseases, the use of pesticides in the agriculture field and public health sector is indispensable. However, unregulated and indiscriminate applications in agriculture and public health sectors over the last 60 years and due to their persistence have resulted in serious negative health impacts on humans. Organophosphates, carbamates, dithiocarbamates, and pyrethroids with banned organochlorine (DDT, BHC, heptachlor, aldrin) pesticides are present in fruits and vegetables.

• Globally, more than 60% of vegetables and fruits are contaminated by one or more pesticides. Contamination in about 25% of samples is beyond their permissible limits. The contamination is more (65-70%) in the developing countries.

• In the human/animal body, the pesticides are bioaccumulated in the adipose tissues, and they persist for a longer period. Consumption of pesticides via contaminated vegetables and fruits causes allergies, neurotoxic effects, damage to the central and peripheral nervous system, allergies, disruption of the immune system, DNA damage, reproductive disorders, endocrine disruption, diabetes, obesity, cardiovascular diseases, and psychiatric effects.

Suggestions for minimising the negative impacts of pesticides:

• Scientists must focus on the development of alternate ways for pest management.

• To protect consumers' health, there must be regular monitoring for a long period of pesticide residues in fruits and vegetables.

• As the pesticide concentration in vegetables and fruits varies according to the country's climatic conditions and vegetable/fruit type, effective convenient guidelines according to climatic conditions must be framed, and those should be implemented to minimise the negative impact of the pesticides on humans and the environment.

• There must be seminars and meetings in the local language to make farmers and consumers aware of the negative impacts of pesticides and how those can be minimised. Consumers must also be advised to consume fruits and vegetables after washing and peeling.

• Strict steps must be taken to stop the use of banned pesticides.

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ISSN: 2581-8341
Volume 08 Issue 04 April 2025
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ISSN: 2581-8341
Volume 08 Issue 04 April 2025
DOI: 10.47191/ijcsrr/V8-i4-18, Impact Factor: 8.048
IJCSRR @ 2025
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Table1: Concentration of different pesticides (mg/kg) in vegetables

Pesticide	Vegetables & Fruits	Leafy vegetables	Tomato	Cucumber	Lettuce	Lemon	Carrot /Radish	Pepper	Spinach	Cauliflower	Green onion	Potatoes	Egg plant	Others food/ celery	Cabbage	Green Peas	Green Beans	Okra
Acehate	0.0463-1.237	0.019-0.028 [13,14]	0.0001 [19; 0.02-			0.001 [19]	0.0-0.324 [29]			0.122-1.555		0.013-0.084	0.0002 ([19];	0.001	0.00008[19]; 0.12		0.003-0.	0.011-3.3

International Journal of Current Science Research and Review
ISSN: 2581-8341
Volume 08 Issue 04 April 2025
DOI: 10.47191/ijcsrr/V8-i4-18, Impact Factor: 8.048
IJCSRR @ 2025
www.ijcsrr.org

	[15] ; 0.0008-0.0178 [19]; 0.092-0.114 [13,14]		1.219[28); 0.012-0.137 [26]							[28]		[28]	0.123-1.197[28; 0.01-0.39 [24]	[19]	2-1.169[28]		004 [13, 14]	48[28]
Acetamiprid	0.009-0.058[19]		0.008[19]; 0.008-0.023[17]; 0.005-0.02 [30] ; 0.01-0.13 [31]; 0.015 - 0.49 [32]	0.008-0.022 [17]; 0.07-0.32 [32]		0.004 [19)		0.099 - 0.221 [17]; 0.031 - 0.054 ([26]; 0.022 [33]	0.011 [17]				0.001[19]; 0.01-0.014 [17]	0.002 [19]]	0.005[19]			
Aldrin			0.35-0.45 [16] ; 0.0016[34]	0.0035[34]	0.23-2.55 [16]		0.45-0.71 [16]; 0.0054 [34]	0.001 [34]; 0.0001[27]		0.0027 [34]		0.0 - 7.1 - 26.8[35]	0.0011 [34] ; 0.0001 [27]	0.139-3.219 [36]	0.55 - 1.28 [16]; 2.41 - 26.8 [35]; 0.027[34]		0.00020 [34]	0.00014 [27]
BHC			0.02-0.027 [37]; 0.0-0.054 [38]; 0.00-0.07 [16]; 0.002 [34]	0.0-0.009 [38] 0.0015 [34]	0.13-0.20 [16]		0.002[39] ; 0.0-0.054 [38] ; 0.11 - 0.26[16]; 0.0016 [34]	0.0 - 0.069 [38]; 0.0011[34]; 0.00115 [27]	0.233 [39]	0.0019 [34]	0.018-0.029[37] ; 0.0 - 0.054 [38]	0.0 -1 [35]	0.0-0.027 [38]; 0.0029 [27]	0.028-0.146 [36]	0.0-0.069 [38]; 0.11 - 0.375[16]; 1.5-4.2 [35]; 0.0029[34]		0.00012 [34]	0.00006 [27]

International Journal of Current Science Research and Review
ISSN: 2581-8341
Volume 08 Issue 04 April 2025
DOI: 10.47191/ijcsrr/V8-i4-18, Impact Factor: 8.048
IJCSRR @ 2025
www.ijcsrr.org

Bioallethrin	0.254[[15]	0.0-0.15[20]			0.0-0.3 [20]													
Bifenthrin	0.103[15]; 0.0005-0.0025 [19]		0.0004 [19]]			0.00002[19]	13.577 [25]		21.67 [25]					0.000004 [19]	0.000005 [19]			
Bromopropylate		0.0-0.021 [20]	0.5[20].															
Buprofezin			0.03[30] ; 0.023-0.124 [26]								0.018 [26]							
Carbaryl	0.021-1.51[15] ; 0.00009-0.0002 [19]	0.0-0.13 [20]			0.0-0.034 [20]						0.009-0.015 [26]				0.005-0.006[26]			
Carbendazim	0.00002-0.0000 [19]		0.016-0.109[17](; 0.005-0.01 [30]	0.008-0.028[17] ; 0.02 [31]; 0.013-0.083[26]	0.16 [40]			0.098-0.33[17]; 0.022-0.098 [26]							0.006-0.158[26]			
Carbofuran	0.0001[15]; 0-0.0001 [19]		0.00003[19]									0.01-0.16[31]						
Chlorantraniliprole		0.25-0.56 [40]	0.07-0.92 [31; 0.017-0.031[26]		0.18 [40]													
Chlordane			0.0-0.021 [38]; 0.0021 [34]	0.0-0.034 [38]; 0.0015 [34]			0.0-0.022 [38];0.001[34]	0.0-0.034 [38]; 0.0008			0.0-0.03 [38]	7.1-25.5 [35]	0.0-0.03 [38] ; 0.037 [34]		0.0-0.037 [34]; (2.41-26.8 [35]; 0.0-16.2			

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ISSN: 2581-8341
Volume 08 Issue 04 April 2025
DOI: 10.47191/ijcsrr/V8-i4-18, Impact Factor: 8.048
IJCSRR @ 2025
www.ijcsrr.org

								[34]							[35]; 0.0009[34]			
Chlopyrifos	0.0004-1.255[15]; 0.068-0.733[41];0.101-0.145[13,14]	2.5[41];0.0167-0.025[13,14]	0.42[20]; 0.052[17]; 0.005-0.38[30];1.8-2[42];0.01-0.37[31] ; 0.27-0.45[24]; 0.08 - 0.107[43]	0.0-0.02[20]; 0.036-0.1[17]; 0.01-0.64[31]			0.0-0.327[29]	0.024[17]; 0.9-1.4[42]; 0.01-0.46[31]	0.01222[17]; 0-0.09[44]	0.029-0.3[28]	0.012[17]	0.013-0.014[17]; 0.013[28]; 1.5[42]	0.011[17; 0.02-0.46[24]; 4.96[45]		0.004-0.01[17]; 0.019-0.291[28];0.097-0.14[41]	0.016[17]	0.008[17]; 0.015-0.0246[13,14]	0.014-0.018[17]; 0.02[28]
Chloropham			0.005-0.04[30]									0.01-3[30]						
Chlorpyriphos-methyl	0.0-0.0027[19]		0.061[26]					0.007-0.051[26]			0.004-0.008[26]				0.005-0.008[26]			
Λ-cyhalothrin	0.0686-1.443[15]; 0.0009 - 0.0025[19]		0.0002[19]; 0.029-0.072[17]; 0.017[26];0.047-0.062[46]	0.008-0.048[17];0.023[26]; 0.062[46]	0.0-0.025[20]; 0.407[46]	0.0002[19]		0.048[46]	0.34-0.521[17]		0.012[17]	0.02-0.256[31]	0.01-0.063[17]; 0.0029[27]	0.034-0.11[46]	0.009-0.019[17]; 0.027-0.031[26]	0.024-.101[17]	0.009-0.015[17]; 0.034[46]	0.039-0.099[17]; 0.0019[27]
Cypermethrin	0.0573-0.064[15]; 0.0-30.295[47]; 0.0015-0.0156[19]	0.0-1.4[20]	0.001[19]; 0.026[17]; 0.037[39];0.005-0.19[30]; 0.039-0.081[46];0.002-	0.029-0.045[17]; 0.017[26]; 0.044[46]	1.514[46]	0.005[1]	0.239[39]	0.111[26]	0.0032[39]		0.307[39]		0.011-0.021[17]	0.028[46]	0.034-0.054[46]; 0.004-0.473[49]			0.013-0.044[17]; 0.005[39]

International Journal of Current Science Research and Review
ISSN: 2581-8341
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IJCSRR @ 2025
www.ijcsrr.org

			0.085 [48]															
Cyproconazole								0.008-0.541 [26]							0.043-0.255[26]			
DDT		0.0-0.11 [20]	0.009-0.0017 [37]; 0.0-0.056 [38];0.538-2.41[16]; 0.0049 [34]	0.0-0.02 [20]; 0.0 -0.009 [38]; 0.001 [34]	0.0.0-0.345 [16]		0.0-0.056 [38]; .341-0.74516]; 0.0039 [34]	0.0-0.087 [38]; 0.0007 [27]		0.0039 [34]	0.008-0.011 [37]; 0.0-0.056 [38]	21.7-32.9[35]	0.0-0.015 [38]; 0.0059 [34]; 0.0044 [27]	0.0-2.255 [36]	0.0-0.06 [38]; .628-0.948[16]; 2.41-26.8 [35]; 0.00049 [34]		0.0023 [34]	
Diazinon	0.015-0.046[13, 14]	0.063-0.82[20];(0.017-0.233 [13,14]	0.25[24]	0.004-0.009 [26]	0.0-0.18 [20]			0.013-0.026 [26]					0.0-0.5[20]; 0.12-0.37 [24]		0.009[26]			
Dichlorvas	0.004-0.115[19]		0.0001 [19]			0.003 [19]	0.0-0.027[29]						0.0007[19]	0.007[19]	0.00002 [19]			
Dimethoate	0.0-23.2 [19];0.057 -0.074 [13,14]	0.018-0.038 [13,14]	0.031-0.047[28](); 0.005-0.02[30]	0.052-0.059 [41]							0.0037-0.146 [28];0.005-0.007 [26]	0.0046 [28]	0.142[28]		0.012[28]		0.006-0.182 [13, 14]	0.01[28]
Dieldrin	0.001-0.527[15]													0.026-0.059 [36]				

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DOI: 10.47191/ijcsrr/V8-i4-18, Impact Factor: 8.048
IJCSRR @ 2025
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Difenoconazole	0.0-15.443 [47]		0.02-0.05[30]															
Diniconazole			0.068[20]															
Dinotefuran			0.07-0.38[31]	0.06-0.16 [31]														
Dithiocarbamate	0.0014-0.0032 [19]		0.0002 [19]			0.001 [19]							0.0004 [19]	0.0007 [19]	0.00006 [19]			
Endosulfan	0.109[15]		0.264[39]; 0.0066 [34]	0.0022 [34]		0.00002 [34]	0.243[39];0.0047 [34]	0.0021[34]	0.664 [39]	0.0008 [34]	0.576 [39]		0-1.09 [45]					0.208[39]
Ethion			0.052-0.59[28]					0.007-0.06[26]				0.055-0.064 [28]			0.055-0.061[28]			0.026-0.057[28]
Fenhexamid						0.01 [19]							0.009[19]	0.07 [19]	0.03 [19]			
Fenitrothion	0.024-0.08 [15]; 0.063-0.505 [19]; 0.01-0.093 [13,14]	0.014-0.057 [13,14]	0.01[19]			0.02 [19]							0.03[19]	0.004 [19]	0.03 [19]			
Fenothiocarb	0.0001 [15]																	
Fenthion	0.014-0.037[15]		0.1[24]										0.31[24]					
Fenvalerate			0.012[17]	0.055-0.08[17]			0.011-0.053[29]											0.009-0.05[17]
Fipronil	0.0-3.71[47]			0.011 [17]														0.026[17]
Glyphosphate							0.289[25]		0.931 [25]									

International Journal of Current Science Research and Review
ISSN: 2581-8341
Volume 08 Issue 04 April 2025
DOI: 10.47191/ijcsrr/V8-i4-18, Impact Factor: 8.048
IJCSRR @ 2025
www.ijcsrr.org

Heptachlor			0.0-0.13[16]		0.13-0.55 [16]		0.38-0.73[16]					18.2-22.3[35]	0.0027 [27]	0.083-0.758 [36]	0.63-1.85 [16]; 0.0-121.6[35]			0.003[27]
Hexythiazox													0.013[17]		0.005-0.007[26]			
Imazalil	0.003-0.0076 [19]		0.0001 [19]	0.0-0.05 [20]		0.04-0.542 [1]												
Imidacloprid	0.0011-0.0075 [19]		0.0004 [19]; 0.011-0.03 [17]; 0.07-0.61 [49]; 0.005 - 0.12 [30]; 0.043-0.116 [26]	0.012-0.032[17]; 0.06-0.62[49];0.071-0.199 [26]		0.0007 [19]		0.009-0.022 [17]	0.06-0.83 [49]; 1.964 [25]	0.019-0.62[49]		0.07-0.34 [49]	0.002 [19]; 0.08-1.3[49]	0.00008 [19]; 0.01 [30]	0.00004[19]; 0.09-0.36 [49]; 0.014-0.051[26] ; 0.013-0.052[48]			0.008-0.03[17]
Lufenuron			0.005-0.03[30] ; 0.09-0.36 [31]				0.025-0.099[17]					0.06-0.12[17]	0.017-0.034[17]			0.04-0.096[17]	0.233-0.453 [17]	
Malathion	0.036-0.192[15];0.0-0.0023 [19]	0.0-0.11 [20]	0.005-0.02 [30]	0.0-0.024[20]; 0.011-0.273 [26]											0.007-0.013[26]			
Metalaxyl	0.01[15]( ]); 0.0 - 0.0014 [19]]	0.0-0.18 [20]]	0.01[30] ; 0.01-0.03 [31] ; 0.023 -	0.013-0.083 [26]	0.0-0.067 [20]			0.02[31]; 0.033 -										

International Journal of Current Science Research and Review
ISSN: 2581-8341
Volume 08 Issue 04 April 2025
DOI: 10.47191/ijcsrr/V8-i4-18, Impact Factor: 8.048
IJCSRR @ 2025
www.ijcsrr.org

			0.419[26]					0.103[26]										
Methamidophos	0.023-0.039 [13,14]	0.055-0.654 [13,14]																
Methiocarb	0.0035-0.048[15];0 .0001-0.0003 [19]														0.00005 [19]			
Methomyl	0.00009-0.0005[19]		0.00003[19]; 0.005-0.01[30]; 0.005-0.008[26]	0.048[17]; 0.009-0.222([26]		0.00006[19]		0.009-0.06[17]; 0.005-0.199[26]			0.009-0.054[26]		0.00003[19]	0.00003[19]	0.006-0.071[26]			
Methoxychlor			0.009-0.0136 [37]								0.007-0.0111[37]	0.0-104.5[35]		0.098[36]	0.0-77 [35]			
Monocrotophos	0.0226[15]; 0.2-0.5 [19]		0.0001[19]; 0.029-0.207[28]			0.0003 [19]				0.01-0.145[28]	0.036([28]	0.041-0.134[28]	0.00002[19]; 0.046-0.159[28]	0.000004[19]	0.00003[19]; 0.055-0.09[28]			
Omethoate	0.06-0.08 [13,14]	0.089-0.138 [13,14]	0.0003[19]; 0.005-0.03 [30]			0.0004 [19]							0.00007[19]	0.00002[19])			0.006-0.182[13,14]	
Oxamyl	0.0001 [15]			0.017 [17]														

International Journal of Current Science Research and Review
ISSN: 2581-8341
Volume 08 Issue 04 April 2025
DOI: 10.47191/ijcsrr/V8-i4-18, Impact Factor: 8.048
IJCSRR @ 2025
www.ijcsrr.org

Permethrin	0.0009-2.453[15]		0.023[17]															
Phorate	0.003-0.01 [13,14] ; 0.02[50]	0.003-0.028[13,14]					0.033-0.081[29]											
Phosphimidon	0.00005-0.0003 [19]																	
Piperonyl butoxide		0.0-0.023 [20]		0.0-0.05 [20]	0.0-0.05 [20]													
Primiphos methyl	0.0003-1.409[15]	0.0-0.34 [20]	0.185[41]													0.35 [41]		
Profenofos	0.0176-2.138[15] ;0.0112-0.406[19] ; 0.055-0.066 [13,14]	0.007-0.011 [13,14]	0.04([19]; 0.016-0.161[28]; 0.095-0.231[26]			0.003 [19]		0.035 [17] ; 0.007 - 0.041 [26]	0.0-5.184 [44]	0.012 [28]	0.951 [17]; 0.244-0.331 [28]	0.037-0.164[28] ; 0.01 - 0.26 [31]	0.005[19]; 0.025 [28]	0.00002 [19]	0.003[19]; 0.029-0.157[28]; 0.007-0.496[26]		0.059-0.126 [13, 14]	0.014-0.374[28]
Propargite		0.0-0.018 [20]	0.088-0.219[17]; 0.020-0.31[30]									0.0 - 0.5 [20]	0.011[17]					0.014[17]
Propetamophos	0.0236-0.363[19]																	
Pyrimethanil				0.054 [17]		0.057-0.078 [1]												
Pyriproxyfen			0.033-0.167[26]					0.043 - 0.056 [26]										
Thiacloprid				0.009-0.013[17]				0.009 [26]										

International Journal of Current Science Research and Review
ISSN: 2581-8341
Volume 08 Issue 04 April 2025
DOI: 10.47191/ijcsrr/V8-i4-18, Impact Factor: 8.048
IJCSRR @ 2025
www.ijcsrr.org

Thiamethoxam				0.017-0.04[17]		0.007-0.009[1]		0.04-0.12[31]				0.02-0.08[31]						
Tebuconazole	0.0-3.594[47]	0.0-0.65[20]		0.091-0.159[26]				0.017[26]										
Tetramethrin	0.033-1.373[15]																	
Thiacloprid									0.009-0.031[17]						0.006-0.017[17]			
Thiamethoxam			0.01-0.035[48]	0.008-0.017[48]											0.009-0.048[48]			
Thiophanate methyl			0.12-0.21[17]; 0.005-0.03[30]	0.066-0.1[17]				0.017-0.060[17]				0.01[30]						
Triadimenol	0.012-0.437[15]		0.017-0.044[26]	0.009][26])]				0.027[26]			0.005-0.008]				0.004-0.007[26]			
Triazophos	0.004-0.007[13,14]																0.012[28]	
Trichloroform	0.0001-1.485[15]																	
Tridimefon	0.0011-1.605[15]																	
Trifloxystrobin	0.0-0.593[47]	0.0-0.74[20]		0.016-0.063[26]				0.014-0.035[26]										
Vamidothion	0.0086-0.256[15]																	

International Journal of Current Science Research and Review
ISSN: 2581-8341
Volume 08 Issue 04 April 2025
DOI: 10.47191/ijcsrr/V8-i4-18, Impact Factor: 8.048
IJCSRR @ 2025
www.ijcsrr.org

Table2: Concentration of different pesticides (mg/kg) in vegetables and fruits

Pesticide	Apricot	Herbal Products	Dates	Grapes	Pomegranate	Guva	Banana	Mango	Strawberry	Watermelon	Apple	Orange	Passion fruit	Cantaloupe/ Pear	Kaki/ Peach
Acehate	0.03-0.12[17]			0.068-1.588[28]			0.0.132-0.904[28]	0.022-0.1[28]		0.001[19]	0.009-0.048 ([17]; 0.013-0.891 [28]		0.001[19]		
Acetamiprid	0.015[1]			0.009-0.028[17]; 0.02-0.1[30]						0.004[19]	0.018-0.057[1]	0.01-0.05 [30]	0.002[19]	0.007-0.111[17]; 0.011[1]	0.008[1]
Aldrin				0.0009[34]			0.0011[34]			0.0037 [34]					
Azoxystrobin	0.003-0.146[1]														0.01[1]
BHC				0.0009[34]			0.001[34]			0.0007 [34]					
Bifenthrin	0.013[1]			1.35[25]		2.225[25]				0.00002 [19]			0.00004 [19]		
Boscalid	0.047[1]			0.02-0.55 [30]; 0.009-0.012[1]							0.081[1]			0.159[1]	
Buprofezin	0.09-0.199 [17]														
Carbendazim	0.131-0.34([17]		0.005-0.071[17]	0.04-0.569 [17] ; 0.01-0.62 [30]		0.014-0.061[17]		0.017-0.023[17]	0.065-0.269[17]		0.041-0.125[17]	0.005-0.11[30]			
Chlopyrifos	0.086-0.311[17]; 0.002-0.02[1]		0.014 [17]	0.018-0.024 [17]; 0.016-0.29 [28]; 0.01	0.231[1]	0.018[17]	0.003[1]	0.012[17]; 0.025 [28]	0.111-0.301[17]		0.0-0.24[20]; .012-0.394 [17]; 0.013-0.09 [28]	0.011[17]; 0.005-0.08[30]; 0.002[1]		0.124[1]	0.123[17]; 0.002[1]

International Journal of Current Science Research and Review
ISSN: 2581-8341
Volume 08 Issue 04 April 2025
DOI: 10.47191/ijcsrr/V8-i4-18, Impact Factor: 8.048
IJCSRR @ 2025
www.ijcsrr.org

				-0.14 [30]											
Chlorfenapyrl				0.03-0.172[17]				0.021[17]							
Cyfulthrin				0.01-0.27 [30]											
Λ-cyhalothrin	0.022-0.101[17]; 0.007-0.033[1]			0.01[17]				0.001-0.07 [17]	0.046-0.066[17]	0.0002 [19]	0.023-0.025 [17]	0.00008[17]; 0.005-0.6[30]		0.009-0.031[17]; 0.023[1]	0.044-0.126[17]; 0.019[1]
Cypermethrin	0.109-0.261 [17]			0.01-0.05 [17]; 0.005 - 0.17 [30]	0.005[1]			0.025-0.061 [17]		0.0002 [19]	0.09-0.362[17]	0.005-0.47[30]; 0.003-0.005[1]			
Deltamethrin	0.017[1]				0.064[1]									0.039[1	
DDT							0.0033[34]			0.0006[34]					
Diazinon					0.006[1]						1.467[28]	0.0-0.5 [20]			
Dichlorvas				2.09([25]						0.003[19]			0.007[19]		
Difenoconazole	0.048[1]			0.005-0.13 [30]										0.005[1]	0.007[1]
Dimethoate	0.014[17]			0.032-0.108 [17]; 0.144 [28]; 0.005-0.17 [30]			0.143-0.147 [28]				0.033-0.146[28]	0.01-0.09 [30]			0.52-0.99[17]
Dithiocarbamate										0.001[19]			0.0007 [19]		
Endosulfan							0.0009[34]			0.009[34]					

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ISSN: 2581-8341
Volume 08 Issue 04 April 2025
DOI: 10.47191/ijcsrr/V8-i4-18, Impact Factor: 8.048
IJCSRR @ 2025
www.ijcsrr.org

Ethion							0.058[28]	0.063[28]			0.059-0.071[28]				
Fenhexamid										0.01 [19]			0.07[19]		
Fenitrothion										0.02 [19]			0.004[19]		
Fipronil						0.017[17]					0.012[17]				
Fludioxonil	0.965[1]				0.006[1]						0.005-0.458 [1]			0.142-1.807[1]	0.036([1]
Fonophos										0.03 [19]			0.2[19]		
Glyphophate						0.57 [25]						1.1-1.4 [25]			
Imazalil	0.027[1]									0.0005 [19]		0.07-0.24 [20]; 0.39-1.29[30] ; 0.044-0.619[1]			
Imidacloprid	0.012-0.391[17]; 0.239 [1]		0.15-0.25[49]		0.06-0.123 [17];0.08-0.32 [49] ; 0.04-0.62 [30]	0.0091 [25]			0.09-0.33 [49]	0.0007[19]; 0.06-0.56 [49]	0.012-0.061[17]; 0.19-0.83[49]	0.01-0.05[30]	0.0008[19]	0.07-0.61 [49]	
Lufenuron					0.01-0.06[30]							0.09-0.216[17]		0.011[17]	
Malathion					0.005-0.01[30]							0.005-0.06[30]			0.003[1]
Metalaxyl									0.0-0.067 [20]		0.009-0.02[17]				
Methiocarb			0.0003-0.0013 [51]												
Methomyl			0.0002-		0.01[30]	0.124[17]				0.00006 [19]			0.00003 [19]		

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ISSN: 2581-8341
Volume 08 Issue 04 April 2025
DOI: 10.47191/ijcsrr/V8-i4-18, Impact Factor: 8.048
IJCSRR @ 2025
www.ijcsrr.org

			0.0017[51]												
Monocrotophos					0.153[28]		0.049-0.167[28]	0.027-0.212[28]		0.00003[19]			0.00004[19]		
Myclobutanil	0.037[1]				0.01-0.07 [30]		0.006[1]								
Omethoate			0.053[17]		0.01-0.044 [17]; 0.014-0.09 [30]					0.00004 [19]		0.009[17];0.02-0.04 [30]	0.0002 [19]		
Permethrin					0.006-0.021[17]			0.018 [17]			0.017[17]			0.013-0.022[17]	
Phenmedipham			0.0001-0.0042 [51]												
Pirimicarb			0.0002-0.004 [51]								0.018-0.268[1]				
Profenofos	0.086-0.23[17]				0.023[28]; 0.01-0.03 [30]		0.155[28]			0.003[19]	0.029-0.032[28]	0.018-0.248[28]; 0.02 [30]	0.0002 [19]		
Propargite					0.005[30]						0.0-0.5[20]); 0.016-0.02[17]	0.005-0.04[30]			
Propoxur			0.0007-0.0061[51]								0.0-0.07[20]				
Pyrimethanil	0.005-0.244[1]										0.019-4[1]	0.052-		0.007-0.055[1]	2.233[1]

International Journal of Current Science Research and Review
ISSN: 2581-8341
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IJCSRR @ 2025
www.ijcsrr.org

												0.09[1]			
Tebuconazole	0.005[1]										0.031-0.099 [17]			0.028[1]	
Thiabendazol	0.006[1]						0.004[1]				0.011[1])	0.07-0.22[30]; 0.027-0.043[1]			
Thiacloprid	0-0.0002 [19]				0.09-0.3 [17]										
Thiamethoxam					0.01-0.096 [17]; 0.01 [30]		0.01[17]								
Thiophapanate methyl			0.041-0.06[17]		0.086-0.635 [17]; 0.01-0.94 [30]	0.018[17]			0.066-0.31 [17]		0.02-0.044[17]				0.008-0.025[17]

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