Journal of Biomedical and Pharmaceutical Research
Available Online at www.jbpr.in
CODEN: - JBPRAU (Source: - American Chemical Society)
NLM (National Library of Medicine): ID: (101671502)
Index Copernicus Value 2023: 85.86
Volume 14, Issue 5; 2025, 30-39

ISSN (Online): 2279-0594
ISSN (Print): 2589-8752

Review Article

A Review on the Estimation of Pesticides Residue in Human Breast Milk: India Versus China"

Juned Ali, Anurag Joshi, Mahipal Garg, Naresh Meghwal, Niraj Shrimali, Seema Wadhwani

Sunrise College of Pharmacy, Udaipur (Raj.)

Article Info: Received: 15-07-2025 / Revised: 27-08-2025 / Accepted: 28-09-2025
Corresponding Author: Seema Wadhwani
DOI: https://doi.org/10.32553/jbpr.v14i5.1372
Conflict of interest statement: No conflict of interest

Abstract: The widespread use of pesticides in agriculture has led to significant concerns regarding environmental contamination and public health. This review provides a comprehensive analysis of global pesticide usage, with particular emphasis on India and China—two major agricultural nations with differing regulatory frameworks and residue patterns. Persistent organic pollutants (POPs) such as DDTs, HCHs, and HCBs are present in human breast milk, highlighting alarming exposure levels, especially among infants. The review critically examines the extent of pesticide residues, regional disparities, factors influencing contamination, and the implications on human health. It further outlines analytical methods used for detection and emphasizes the need for improved regulatory enforcement, public education, and sustainable agricultural practices to mitigate exposure risks.
Keywords: Pesticide residue, Breast milk contamination, DDT, HCH, Public health

Introduction

Pesticides are chemical compounds that are used to kill pests, including insects, rodents, fungi and unwanted plants (weeds). Over 1000 different pesticides are used around the world.

Pesticides are used in public health to kill vectors of disease, such as mosquitoes, and in agriculture to kill pests that damage crops. [1]

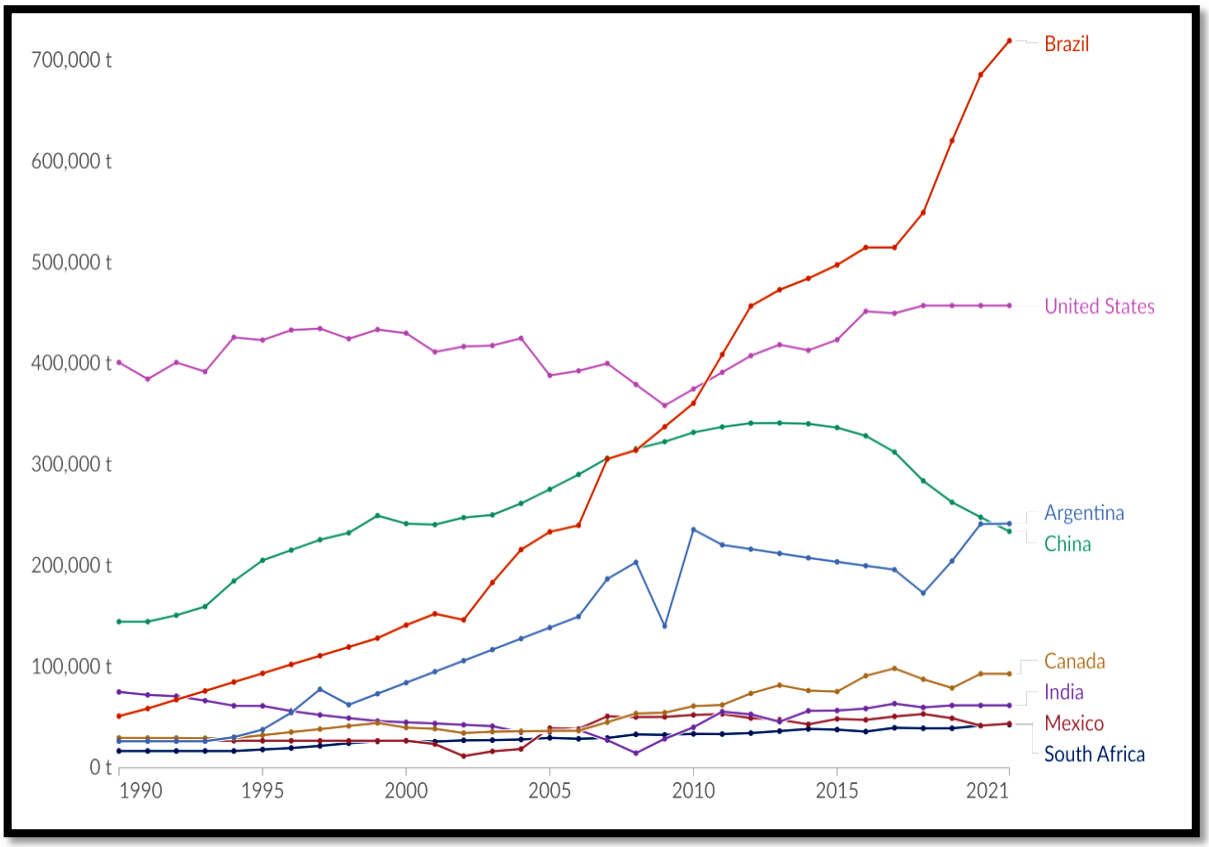
Table 1: WHO classification of pesticides

WHO Class		LD50 for the rat (mg/kg body weight)	
		Oral	Dermal
Ia	Extremely hazardous	< 5	< 50
Ib	Highly hazardous	5–50	50–200
II	Moderately hazardous	50–2000	200–2000
III	Slightly hazardous	Over 2000	Over 2000
U	Unlikely to present acute hazard	5000 or higher	5000 or higher

Worldwide pesticide usage:

Pesticides are extensively used in modern agriculture and are an effective and economical way to enhance the yield quality and quantity, thus ensuring food security for the ever-growing population around the globe. Approximately, 2 million tons of pesticides are utilized annually worldwide. [2,3] However, by the year 2020, the global pesticide usage has been estimated to

increase up to 3.5 million tones. Although pesticides are beneficial for crop production point of view, extensive use of pesticides can possess serious consequences because of their bio-magnification and persistent nature. Diverse pesticides directly or indirectly polluted air, water, soil and overall ecosystem which cause serious health hazard for living being. In the present manuscript, an attempt has been made to critically review the global usage of different pesticides and their major adverse impacts on ecosystem, which will provide guidance for a wide range of researchers in this area. [4, 5]

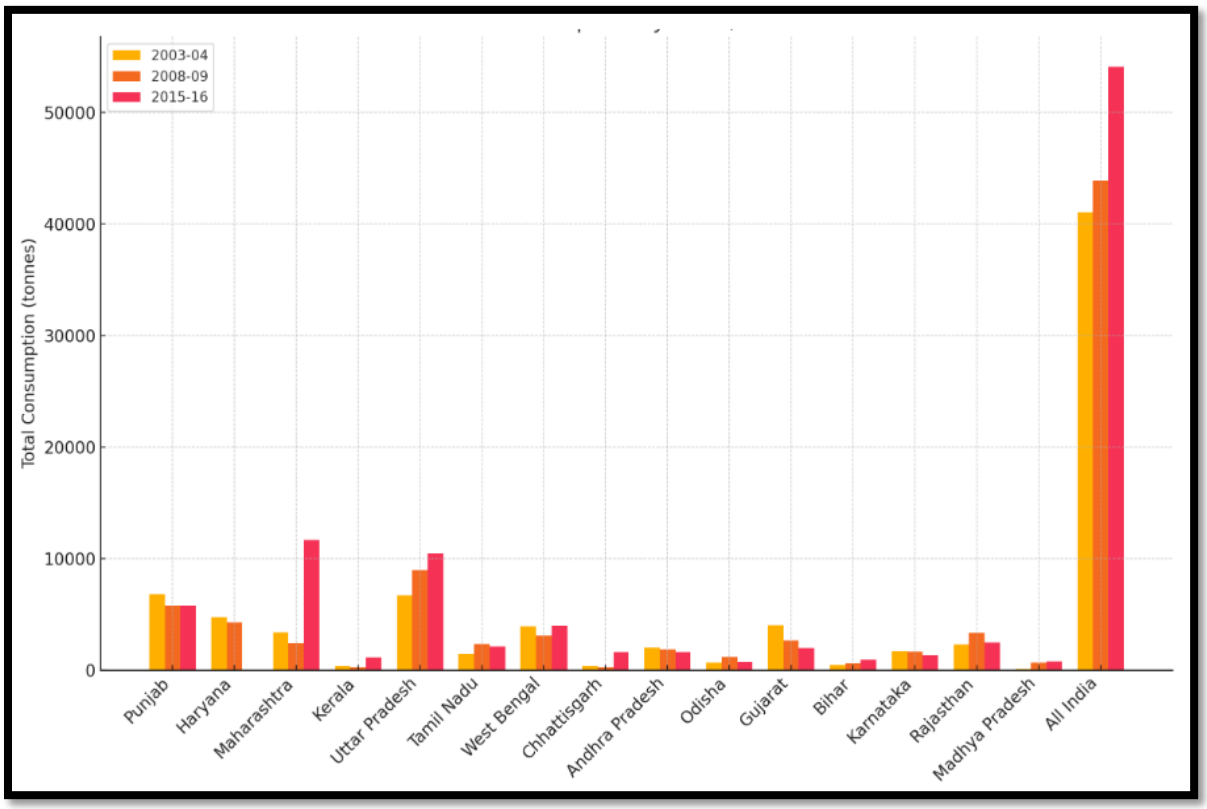


Graph 1: Total pesticide use measured in tones of pesticide consumption per year from 1990 to 2021 around worldwide

Status of Pesticides in India:

Agriculture is one of the most important enterprises in India feeding more than a billion people. With increasing population and diminishing land and water resources, agriculture forms the backbone of Indian economy contributing 20% of national income and providing employment to 60% of the population especially in rural areas. The advent of green revolution in 1950's brought about a complete turnaround in Indian agriculture and changed its face forever. [6, 7]

The success of green revolution was primarily driven by the abundant use of high yielding crop varieties, chemical fertilizers and plant protection chemicals which resulted in a two-three folds increase in productivity and helped India achieve self-sufficiency in food grain production. There was a paradigm shift from traditional agricultural methods relying on use of organic manures, local varieties and low pesticide inputs to the technology driven modern agriculture which exists today. [8]



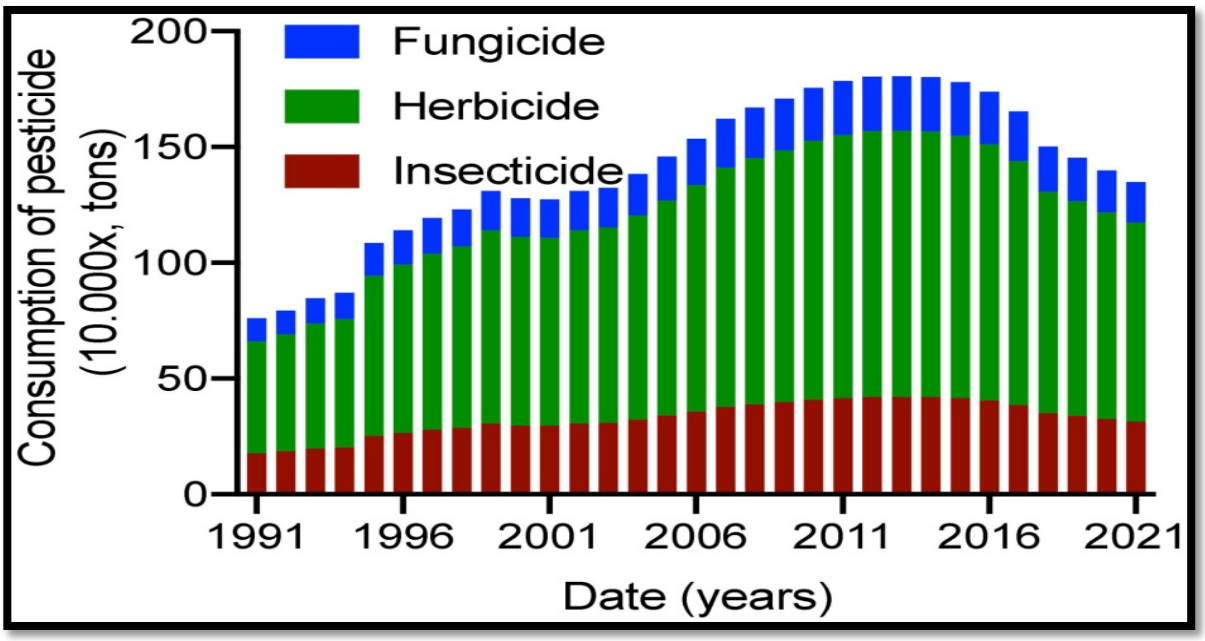
Graph 3: Here is a bar graph illustrating the fertilizer consumption (in tonnes) across different States/UTs in India for the years 2003-04, 2008-09, and 2015-16

Currently, India is home to a diverse number of agricultural and horticultural crops which in turn are attacked by a number of biotic and abiotic stresses Among the biotic factors, pest and diseases alone cause around 46% losses in production with roughly about one third of the world's agricultural production lost every year due to these biotic agents Although several physical, cultural and biological management optics exist for disease control, chemical management has always been the foremost choice for farmers primarily due to ease of its use and apparently effective results achieved in short course of time. [9]

Current Status of Pesticides in China:

Pesticide use has experienced a dramatic increase worldwide, especially in China, where a wide variety of pesticides are used in large amounts by farmers to control crop pests. While Chinese farmers are often criticized for pesticide overuse, this study shows the coexistence of overuse and underuse of pesticide based on the survey data of pesticide use in rice, cotton, maize, and wheat production in three provinces in China. A novel index amount approach is proposed to convert the amount of multiple pesticides used to control the same pest into an index amount of a referenced pesticide. We compare the summed index amount with the recommended dosage range of the referenced pesticide to classify whether pesticides are overused or underused. Using this new approach, the following main results were obtained. Pesticide overuse and underuse coexist after examining a total of 107 pesticides used to control up to 54 crop pests in rice, cotton, maize, and wheat production. In particular, pesticide overuse in more than half of the total cases for 9 crop pest species is detected. In contrast, pesticide underuse accounts for more than 20% of the total cases for 11 pests. [10-13] We further indicate that the lack of knowledge and information on pesticide use and pest control among Chinese farmers may cause the coexistence of pesticide overuse and underuse.

Our analysis provides indirect evidence that the commercialized agricultural extension system in China probably contributes to the coexistence of overuse and underuse. To improve pesticide use, it is urgent to reestablish the monitoring and forecasting system regarding pest control in China. China is a major producer and consumer of pesticides, with consumption volumes reaching approximately 1.5 million metric tons in 2018. [14,15]



Graph 4: Pesticide use measured in tones of pesticide consumption per year in China [12]

Pesticides Present in Human Breast Milk:

The presence of pesticide residues in breast milk is a growing concern due to the potential health risks for nursing infants. These residues can accumulate in the body from exposure to contaminated food, water, and air, as well as occupational or environmental contact. Persistent organic pollutants (POPs) like organochlorines, commonly used in pesticides, are of particular concern as they are lipophilic, meaning they dissolve in fats and can accumulate in fatty tissues, including breast milk. While breastfeeding remains highly recommended for its numerous health benefits, prolonged exposure to pesticide residues may pose developmental, neurological, and immune system risks to infants. Efforts to minimize this exposure include promoting organic farming, regulating pesticide use, and educating mothers on safe food choices. Continued monitoring and research are essential to address this public health issue. [6]

Amount of Pesticides Present in Human Breast Milk in India:

The presence of pesticides in human breast milk in India is a growing concern, influenced by several critical factors**. A lack of comprehensive data and surveys** on pesticide contamination hinders the understanding of its prevalence and impact. [15, 16] Additionally, **a lack of education** among farmers and the general population about the harmful effects of pesticides contributes to improper handling and excessive usage. [17,18] Weak enforcement of **rules and regulations** allows the continued misuse of harmful pesticides, including those that are banned. Moreover, the **use of banned pesticides** persists due to inadequate monitoring and limited awareness of their long-term health effects. Finally, the **overuse of pesticides** in agriculture, driven by the pursuit of higher yields, significantly increases the risk of contamination in the environment, food chain, and ultimately, human breast milk. These factors

collectively highlight the urgent need for stricter regulations, awareness campaigns, and sustainable agricultural practices to safeguard maternal and infant health. [19-21]

Table 6: The table below summarizes pesticide levels in breast milk samples across different regions in India

Region/State	Detected Pesticides	Concentration (ng/g lipid weight or µg/kg)	Key Findings
Punjab [15]	β-HCH, γ-HCH, p,p'-DDD, p,p'-DDE, p,p'-DDT, endrin	90.7 - 1574.1	β-endosulfan, endosulfan sulfate, cypermethrin, and chlorpyrifos detected for the first time.
Lucknow, Uttar Pradesh [20]	DDT, HCH	High levels reported	Linked to neonatal deaths and developmental concerns due to elevated levels of organochlorines.
Ahmedabad, Gujarat [16]	o,p'-DDT, p,p'-DDD	53.43	No PCBs detected; highlights ongoing pesticide exposure.
Haryana [17]	Organochlorine, organophosphate, and pyrethroid pesticides	25	Cyfluthrin detected in 25% of samples.
Chennai, Tamil Nadu [19]	HCHs, DDTs	~90	Increased pesticide levels over the last decade; significant public health concerns.
West Bengal [19]	DDT, HCH	~120	Pesticide residues exceeded permissible daily intake values for some infants.
Kerala [21]	DDT, HCH, endosulfan	~85	Endosulfan found to have developmental toxicity effects in infants.

Amount of Pesticides Present in Human Breast Milk in China:

The presence of pesticides in human breast milk in China has been a significant concern, linked to various factors such as agricultural practices, diet, and population density. The government's regulatory measures play a crucial role in controlling pesticide use, but challenges persist due to inadequate enforcement and improper disposal of chemical residues. Education on safe agricultural practices and the risks associated with pesticide exposure has been instrumental in raising awareness among rural populations. [22,23] Moreover, the consumption of non-vegetarian diets, which often involves the intake of livestock fed with contaminated feed, further contributes to the accumulation of pesticides in breast milk. The future vision involves strengthening government policies, improving monitoring systems, and increasing public awareness through targeted education campaigns to reduce pesticide exposure in vulnerable populations like nursing mothers. [24-26]

Table 7: Mean Pesticide Residue in Human Breast Milk across Regions different regions in China [28]

Region	Mean HCHs (µg/kg)	Mean DDTs (µg/kg)	Mean HCB (µg/kg)	Overall Mean (µg/kg)
Heilongjiang	1.48	1.29	0.23	1.00
Liaoning	2.49	3.52	0.31	2.10
Hebei	1.19	2.62	0.17	1.33
Shanxi	0.52	2.93	0.26	1.24
Henan	1.48	3.36	0.22	1.69
Ningxia	1.03	1.21	0.27	0.84
Shanghai	2.41	5.64	0.19	2.75
Fujian	1.47	4.61	0.20	2.09
Jiangxi	0.99	5.58	0.14	2.24
Hubei	2.41	8.49	0.29	3.73
Sichuan	1.04	3.92	0.20	1.72
Guangxi	1.06	2.64	0.08	1.26

The analysis of pesticide residues in human breast milk from 12 provinces in China reveals the presence of three major pesticides: HCHs (Hexachlorocyclohexanes), DDTs (Dichlorodiphenyltrichloroethane), and HCB (Hexachlorobenzene). DDTs dominate, accounting for approximately 75% of the total pesticide residues, reflecting their historical use as insecticides despite their ban in many regions. [27], HCHs contribute 16%, often linked to agricultural practices, while HCB, associated with industrial processes and fungicides, represents 9%. The highest contamination is observed in Jiangxi, where DDT levels are significantly elevated, likely due to agricultural and industrial activities. In contrast, Ningxia exhibits the lowest contamination, with minimal levels of all pesticides, suggesting better environmental management or lower exposure sources. This disparity underscores the need for targeted interventions in high-contamination areas and stricter regulations to reduce exposure to persistent organic pollutants in breast milk. [29-31]

Comparison between India & China

Pesticide Use & Regulation:

Aspect	India	China
Agricultural Reliance High:	Agriculture contributes ~20% of national income and employs ~60% of the population.	High: China is one of the largest pesticide producers and consumers.
Pesticide Use Trends	Rising, especially herbicides post-2009 due to labor cost increase. High per-hectare usage in Punjab and Haryana.	Steady increase till 2011, followed by a decline and stabilization due to improved regulations and pest control practices.
Regulatory Framework	Weak enforcement, banned pesticides still in use. Lack of education among farmers.	Some overuse and underuse observed. Regulatory challenges persist, especially due to commercialized advisory systems.
Main Pesticides	Organochlorines (DDTs, HCHs), Organophosphates, Pyrethroids	Predominantly DDTs (75%), HCHs (16%), and HCB (9%) in breast milk samples.

Breast Milk Contamination:

Criteria	India	China
Main Concern	Persistent organic pollutants (POPs) in breast milk due to environmental and agricultural exposure.	High DDT and HCH presence; dietary factors (e.g. meat) and industrial exposure also contribute.
High-Risk Regions	Punjab (up to 1.574.1 μg/kg), Lucknow, Chennai, West Bengal.	Jiangxi (up to 5.58 μg/kg DDTs), Hubei, Shanghai
Low-Risk Regions	Ahmedabad (0.05343 μg/kg), Haryana (0.025 ng/kg).	Ningxia (0.84 μg/kg overall mean).
Residue Types	DDTs, HCHs, endosulfan, cypermethrin, chlorpyrifos, etc.	DDTs, HCHs, and HCB dominate.
Overall Residue Levels	Ranges from ~0.025 μg/kg to ~1.574 μgk/g depending on region.	Ranges from ~0.84 μg/kg to ~3.73 μg/kg (i.e. ~840–3730 ng/g). Some areas exceed Indian highs.

Health Implications:

India:

- Linked to neonatal deaths, developmental toxicity (esp. endosulfan in Kerala).
- Breast milk exceeds WHO safety levels in several states.
- Highlights urgent need for public awareness and stronger policy implementation.

China:

- Higher average pesticide burden in breast milk.
- Industrial activities and non-vegetarian diets (through contaminated feed) aggravate accumulation.
- Better surveillance and education starting to show effects, but regional disparities persist.

Policy & Recommendations:

India	China
Public education campaigns for safe pesticide use	Strengthening of forecasting systems for pest outbreaks
Regulatory enforcement to prevent illegal/banned pesticides	Better agricultural extension and advisory systems
Promotion of organic farming and safe handling	Regulation of pesticide residues in animal feed and food supply
State-specific interventions for high-risk zones (e.g., Punjab, West Bengal)	Targeted interventions in high-residue regions (e.g., Hubei, Jiangxi)

Results:

This study aimed to assess and compare the concentration of pesticide residues in human breast milk between India and China, with a focus on persistent organic pollutants (POPs) such as HCHs, DDTs, and HCB. These chemicals are known to accumulate in fatty tissues and pose long-term health risks to infants.

India:

- Highest Residues: Punjab reported the highest levels of pesticide residues (up to 1574.1 ng/g lipid weight), including β-HCH, γ-HCH, DDT derivatives, and endosulfan.
- Moderate to Low Levels: Regions like Kerala (~85 ng/g), Chennai (~90 ng/g), and Gujarat (53.43 ng/g) showed moderate

contamination. Haryana showed the lowest levels (~25 ng/g).

- Common Pesticides: Organochlorines (DDTs, HCHs), organophosphates (chlorpyrifos), pyrethroids (cypermethrin), among others.
- Sampling and Testing: GC-MS with LLE, SPE, and QuEChERS methods provided high-accuracy results.

China:

- Highest Residues: Hubei (3.73 µg/kg) and Jiangxi (2.24 µg/kg) exhibited the highest concentrations, primarily due to DDT contamination.
- Lowest Residues: Ningxia (0.84 µg/kg) and Shanxi (1.24 µg/kg) recorded the lowest.
- Residue Composition: DDTs dominated (75%), followed by HCHs (16%) and HCB (9%).
- Observations: Despite improvements, some provinces still show high pesticide burden due to legacy pollution, industrial discharges, and meat-based diets that amplify bioaccumulation.

Reference:

1. The World Health Organization (WHO) reference number for the module Pesticides: training for health care providers, second edition is WHO/HEP/ECH/CHE/24.04
2. FAO. 2022c. FAOSTAT: Pesticides trade. In: FAO. Rome. Cited July 2022.http://www.fao.org/faostat/en/#data/RT.
3. United Nations. 2019. Methodology Guide for UN Comtrade User on UN Comtrade Upgrade 2019 [online]. New York. https://comtrade.un.org/data/MethodologyGuideforComtradePlus.pdfs
4. United Nations. 2021. UN Comtrade Database. In: UN. New York. Cited July 2022.https://comtrade.un.org
5. WTO (World Trade Organization). 2020. Trade in medical goods in the context of tackling COVID-19: developments in the first half of 2020. Geneva. https://www.wto.org/english/tratop_e/covid19_e/medical_goods_update_e.pdf
6. "Pesticide Use, Regulation, and Policies in Indian Agriculture"; Publisher: Sustainability 2024; Volume: 16, 7839; Editor: Reddy, A.A.; Reddy, M.; Mathur, V; https://doi.org/10.3390/su16177839
7. "Pesticides and Indian agriculture-are view"; Pblisher: Int. J. Res. Granthaalayah 2021; Edition: 9, 250–263. Editor: Nayak, P.; Solanki, H.
8. [Google Scholar]
9. "Crop losses due to insect pests: Global and Indian scenario"; Publisher: Indian J. Entomol. 2015; Edition: 77, 165–168; Editor: Dhaliwal, G.S.; Jindal, V.; Mohindru, B. [Google Scholar] [CrossRef]
10. "Crop losses due to insect pests: Global and Indian scenario"; Publisher: Indian J. Entomol. 2015; Edition: 77, 165–168; Editor: Dhaliwal, G.S.; Jindal, V.; Mohindru, B. [Google Scholar] [CrossRef]
11. 10 57) DAC&FW (2017). Pesticide Wise Consumption of Indigenous Pesticides during 2010-11 to 2016-17. Directorate of Plant Protection, Quarantine & Storage, Department of Agriculture Cooperation, New Delhi.
12. "Overuse or underuse? An observation of pesticide use in China"; Publisher: Sci Total Environ. 2015; Editon: 15;538:1-6; Editor: Zhang C, Hu R, Shi G, Jin Y, Robson MG, Huang X; PMID: 26296070; doi: 10.1016/j.scitotenv.2015.08.031
13. "Exploring China stepping into the dawn of chemical pesticide-free agriculture in 2050"; Publisher: Crop and Product Physiology 2022; Volume 13; Editor: Wang Xuejiang, Chi Yan, Li Feng; https://doi.org/10.3389/fpls.2022.942117
14. "Pest control practices, information sources, and correct pesticide use: Evidence from rice production in China"; Publisher: Ecological Indicators; Volume 129, 2021; ISSN 1470-160X; Editor: Shengyang Sun, Ruifa Hu, Chao Zhang https://doi.org/10.1016/j.ecolind.2021.1078

95. (https://www.sciencedirect.com/science/article/pii/S1470160X21005604)
15. "Factors influencing Chinese farmers' proper pesticide application in agricultural products – A review"; Publishetr: Food Control; Volume 122; 2021; Editor: Yingxuan Pan, YingxueRen, Pieternel A. Luning; ISSN 0956-7135, https://doi.org/10.1016/j.foodcont.2020.107788. (https://www.sciencedirect.com/science/article/pii/S0956713520307040)
16. "Pesticide residues in human breast milk: risk assessment for infants from Punjab, India"; Publisher: Sci Total Environ. 2013 Oct; Edition: 1; Page 463-464:720-6; Editor: Bedi JS, Gill JP, Aulakh RS, Kaur P, Sharma A, Pooni PA; doi: 10.1016/j.scitotenv.2013.06.066; PMID: 23850662.
17. "Levels of organochlorine pesticides in human milk in Ahmedabad, India"; Publisher: Int. Arch Occup Environ Heath; Edition: 60; Page: 111–113 (1988); Editor: Jani, J.P., Patel, J.S., Shah, M.P. https://doi.org/10.1007/BF00381490
18. "A mixed-methods study of pesticide exposures in Breast milk and Community & Lactating Women's perspectives from Haryana, India"; Publication: BMC Public Health; Edition: 20; 1877 (2020); Editor: Mehta, R., Sreenivasa, M.A., Mathew, Mhttps://doi.org/10.1186/s12889-020-09966-x
19. "High levels of organochlorines in mothers' milk from Chennai (Madras) city, India"; Publisher: Chemosphere; Volume 68; Issue 5, 2007; Pages 928-939; ISSN 0045-6535; Editor: Annamalai Subramanian, Masako Ohtake, Tatsuya Kunisue, Shinsuke Tanabe; https://doi.org/10.1016/j.chemosphere.2007.01.041. (https://www.sciencedirect.com/science/article/pii/S0045653507001403)
20. "Human exposure to organochlorine, pyrethroid and neonicotinoid pesticides: Comparison between urban and semi-urban regions of India"; Publisher: Environmental Pollution; Volume 270; 2021; 116156; ISSN 0269-7491; Editor: NiharikaAnand, ParomitaChakraborty, Sujata Ray; https://doi.org/10.1016/j.envpol.2020.116156. (https://www.sciencedirect.com/science/article/pii/S0269749120368457)
21. Website: https://health.economictimes.indiatimes.com/news/diagnostics/pesticides-in-breast-milk-led-to-infant-mortality-study/97447131?utm_source=copy&utm_medium=pshare
22. Website: https://timesofindia.indiatimes.com/city/mumbai/pesticides-endanger-health-in-northern-kerala/articleshow/15397440.cms
23. "Pesticide Residues in Breast Milk from Rural and Urban Areas in China: A Public Health Concern"; Publisher: Environmental Pollution (2020); Volume: 267, 115543; Editor: Wang, X., Li, S., Liu, Y., & Zhao, Y.
24. "Persistent organic pollutants in breast milk: A nationwide survey in China"; Publisher: Environment International (2021); Volume: 157, 106863; Editor: Zhang, X., Ma, Y., & Cao, Z.
25. "Contamination of organophosphate pesticides in breast milk from rural and urban areas of China" Publisher: Environmental Pollution (2018); Volume: 243; Page: 767-776. Editor: Yang, J., Li, X., & Zhou, X.
26. Impact of dietary habits and agricultural practices on pesticide exposure through breast milk in rural China"; Publisher: Science of the Total Environment (2019); Volume: 657; Page: 1028-1035; Editor: Liu, J., Wei, S., &Zheng, Y
27. Wang, Q., Li, H., & Du, X. (2019). Risk assessment of pesticide residues in human breast milk in China: A meta-analysis. Chemosphere, 217, 486-496.
28. "Socioeconomic and demographic factors affecting pesticide exposure in rural Chinese populations"; Pblisher: Environmental

Health Perspectives 2020, Edition: 3(128); Editor: Chen, Y., & Sun, G.

29. "Dynamic study on the organic chloride level in human breast milk in Changsha District. Pract"; Publisher: Prev. Medicne; Edition: 7 (2000); Page: 172-174 (in Chinese); Editor: Cao, H.J., Cao, C.H., Hu, X.H., Zhou, X.D., Yang, Y., Wang, W.H., Yuan, C.H., Liu, J.Q., Fang, D., Su, A.X., Hang, T.,
30. "Fourth WHO-coordinated survey of human milk for persistent organic pollutants (POPs): Belgian results"; Publisdher: Chemosphere (2008); Volume: 73; Page: 907-914; Editor: Colles, A., Koppen, G., Hanot, V., Nelen, V., Dewolf, M.C., Noel, E., Malisch, R., Kotz, A., Kypke, K., Biot, P., Vinkx, C., Schoeters, G
31. "Pesticide residues in breast milk and the associated risk assessment: A review focused on China"; Publication: Sci Total Environ (2020); Edition: 20;727:138412. Editor: Kuang L, Hou Y, Huang F, Hong H, Sun H, Deng W, Lin H; doi: 10.1016/j.scitotenv.2020.138412 ;PMID: 32330708.
32. "Effects of Organochlorine Pesticide Residues in Maternal Body on Infants"; Publisher: Front Endocrinol (Lausanne) (2022); Editon:13:890307; Editor: Qi SY, Xu XL, Ma WZ, Deng SL, Lian ZX, Yu K. doi: 10.3389/fendo.2022.890307. PMID: 35757428; PMCID: PMC9218079.