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Eswaran Rangasamy, Palanisamy Sundarabalan and Muniasamy Muniyandi

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Research Review

Emerging Pesticide Residues in Global Tea Garden Ecosystems: A Review

Eswaran Rangasamy[1], Palanisamy Sundarabalan[2] and Muniasamy Muniyandi*[3]

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A B S T R A C T

The essence of pesticides application is for the control of varieties of weeds, disease-causing organisms, and pests that are capable of causing damage to plants. But unregulated pesticides usage in frequently it's highly harm for surrounding environment and agriculture products. Pesticides are used to increase crop productivity especially in tea garden because the tea plant is harvested numerous times each year, the time between pesticides application and tea plucking is shorter than for compared to other crops. As a result, residues of organochlorine, organophosphorus and synthetic pyrethroids pesticides residues will be accumulated in plant parts, water, soil, air, and biota. It stays in the soil, water and plant eventually enters the food chain threatening humans, and create loss of soil biodiversity, degradation of aquatic community. It's also decreased the tea consignment exporting the key objective of this review paper is to examine different types of research works about the effect of pesticides on tea garden soil, water and tea plant. This study as well focused in addition which pesticides compounds frequently detected in tea gardens. The need maintainable approaches, new innovative ideas such information should be provided the tea farmers. Strictly follow pesticides stringent rules & regulations (maximum residues level). It is more help full for decrease the pesticides residues. Hence further study will be essential in this field to regulate the use of pesticides and to overcome the problems relating to the use of chemical fertilizers and pesticides in the tea gardens.

Key words: Pesticide residues, Global tea garden, Fresh tea leaves, Soil, Water pollution

After water, tea is one of the most widely consumed beverages on the planet. It is crucial for intestinal microbiota, as well as immunity against intestinal diseases and cell membrane protection from oxidative damage. Although the growing circumstances for tea favor disease transmission, pesticides play an important role in pest management and are used to regulate and assure the quality of the tea plants [1]. The use of pesticides to prevent the attack of tea plants has become a widespread practice, but their excessive usage causes major injury and adverse consequences to the health of consumers [2]. Pesticide consumption has increased globally over the last decade as a result of rising population and fast urbanization [3]. Because the tea plant is harvested numerous times each year, the time between pesticide application and tea plucking is shorter than for other crops, and tea fresh leaves are created right after plucking and without washing [4]. During the cultivation of tea, pesticides have been employed to increase the quantity of tea by controlling pests. As a result, several pesticide residues have been found in both raw and processed tea [5].

Improper use of pesticides and other persistent organic pollutants in agricultural soils has devastating consequences for the future. The persistent and ubiquitous nature of various pesticides and other organic pollutants has been harmful to humankind due to their bioaccumulation and high toxicity [6]. Pesticides are used to increase crop productivity, but over time they accumulate in plant parts, water, soil, air, and biota. It stays in the plant and eventually enters the food chain, threatening humans [7-8]. Deposition of pesticides in soil releases soil organisms directly, increasing risk to other higher organisms through nutrition, and can have serious impacts on soil ecosystems, aquatic environment, plants, and human health [9-10]. Certain pesticides such as Chlorpyrifos, glyphosate, copper oxychloride, Dicofol, harm human health and the environment [11-14]. Contamination is also increasing globally, four-hundredth of chemical use is herbicides, terrorist organization square measure pesticides and 100 percent square measure fungicides. Farmers will save cash by victimization pesticides to make sure most yields. Of the sample tons within the world, the ten countries with the best annual chemical use square measure China (1806), the US (386), Argentina (265), Thailand (87), Brazil (76), and European nation (63), France (62), North American nation (54), Japan (52), Asian country (40) (http://www.worldatlas.com/articles/world prime chemical

* **Muniasamy Muniyandi**
munis@buc.edu.in

[1-3] Marine Ecology and Conservation Laboratory, Department of Environmental Sciences, Bharathiar University, Coimbatore - 641 046, Tamil Nadu, India

client of the world). Aquatic organisms are seriously threatened by pesticide-contaminated water. This has a dramatic impact on aquatic plants. It reduces the DO content in water and results in changes in physiology [16]. Aquatic plants provide about 80% of the dissolved oxygen needed to sustain marine life. The destruction of aquatic plants by herbicides causes a decrease in oxygen levels, which has a dramatic impact on fish productivity. For example, atrazine is toxic to certain fish and indirectly affect the immunogenic system of certain amphibians [17].

Pesticides are released by flushing, venting, air waste treatment, and spills into surface waters. When pesticides are released into the atmosphere by the above routes, they have transported miles away, affecting nearby flora and fauna. Pesticides are absorbed by wind-eroded soil particles during dry deposition, causing rapid leaching and soil erosion. Drinking water can be a source of human exposure to pesticides [18]. Overuse of pesticides around the world this review outlines the use of pesticides in tea-growing countries and their various environmental impacts. For nutritional and environmental reasons, most countries around the world have legislated to set maximum pesticide residue levels in crops. Management of pesticide residues in crops is based on the Maximum Pesticide Residue Limit (MRL). MRL is the highest residual level expected in foods when pesticides are used according to approved agricultural practices [19].

Generally, in the range of 0.01 mg/kg to 10 mg/kg, MRL is a useful tool for implementing acceptable pesticides and is not a good guide to the risk to human health due to residues. Regulators are concerned with consumers and the environment because pesticide residues below MRL set by the European Commission, Codex Digestion Commission, US EPA, are significantly lower than concentrations that adversely affect human health and health. We do not consider it to pose a risk. The environment can be demonstrated in regulated pesticide safety tests conducted as part of the pesticide approval process [20].

Organochlorine pesticides (OCP)

Organochlorine pesticides (OCPs) are persistent organic pollutants (POPs) extensively used in agriculture to control insect pests in a broad variety of crops. POPs are a cluster of toxics, bio-accumulative, bio-magnified, and persistent compounds with a likelihood of long-distance movement in the environment [21]. OCPs, including hexachlorocyclohexanes (HCHs), DDTs, Aldrin, dieldrin, endrin, chlordane, heptachlor, and hex chlorobenzene (HCB), have been related to causing cancer injury to the nervous system, generative disorders, and disturbance of the immune system in humans [22].

Organophosphorus pesticides (OP)

Organophosphates, compounds are used as a replacement for organochlorine due to their less persistent nature, but their extensive and non-regulated use has caused a major threat for our environment and life [23]. OP pesticides is associated with the effects of cholinesterase enzymes on function [24], decreased insulin secretion, disruption of normal cellular metabolism of proteins, carbohydrates, and fats [25], and the effects on mitochondrial function doing oxidative stress. Population-based studies suggest a possible link between exposure to organophosphorus pesticides and serious health effects such as cardiovascular disease [26] and adverse effects on the male reproductive system [27]. For the nervous system [28-30].

Synthetic pyrethroids pesticides (SP)

Pyrethroids are a type of synthetic organic insecticide derived from pyrethrins. It has been used worldwide since the 1980s due to its higher efficacy and lower toxicity compared to other pesticides such as organophosphorus and carbamic acid ester compounds [31]. Based on their molecular structure, they can be divided into agricultural pyrethroids (alpha, addictive) and urban pyrethroids (non-alpha, low toxicity), which are mainly used for agricultural and non-agricultural pest control, respectively. Pyrethroids also play an important role in personal care products such as shampoos and mosquito repellent perfumes. In recent years, cypermethrin, deltamethrin, fenpropatrin, fenvalerate, bifenthrin, permethrin, cyhalothrin, and cyfluthrin have become widely used [32].

Pesticides residues effects in soil and water and their health effects

High nutrient soils and water bodies have been encouraged not only for healthy plant growth but also to supply quality and quantity to tea producing countries [33]. the use of pesticides to prevent the attack of tea plants has become a widespread practice, but their excessive usage causes considerable injury and adverse effects on the health of consumers. Some of the negative health impacts linked to pesticide exposure include vomiting, headaches, skin irritation, dizziness, neurological disorders, and toxic effects that include interfering with reproductive systems and foetal development, as well as the potential to cause cancer and asthma. These traditional management practices, when combined, have resulted in soil deterioration and erosion, water pollution, and decreased tea productivity, as well as raising environmental and human health concerns [34-35].

A study in china reported for a tea farming industry, long term conventional tea cultivation has been considered as the main driver of severe soil acidification, soil nutrient imbalance and nutrient leaching in tea plantations [36].

Tea plantations in China are expected to lose up to 4000 tonnes per kilometer per year due to erosion. Soil erosion causes soil organic matter and nutrient losses reduced soil water holding capacity, subsoil acidification, and poor fertility, all of which contribute to soil health degradation [37-39]. Soil erosion is a continual and challenging concern in Vietnam, where 80% of tea farms are located in high rainfall, hilly regions with steep slopes [40].

In China reported to fully understand the pollution status of pesticide residues in the soil of Chinese tea plantations, an ecological risk assessment was conducted in tea plantations in Taiwan, Tibet, Guangdong, and Fujian. Among the pesticides analyzed during this study, methamidophos and imidacloprid were detected altogether sites. Imidacloprid concentration in Guangdong was significantly higher than in other sites. HCHs was solely detected at low concentrations in Xizang and Anxi typical tea plantations whereas bifenthrin was found in Taiwan, Fuzhou, and Anxi typical tea plantations Showing the great pollution index values of soil chemical residues within the tea plantations of Taiwan, Tibet, Anxi organic and Anxi typical were thought-about delicate pollution. According to the standards, soils from Guangdong and Fuzhou were classified as slight pollution. The concentration of methamidophos within the soil of Anxi standard plantation was the best and this could be closely associated with the native farmers' spraying habits [41].

In light of the government's proposed conservation and restoration programme for the Citarum River, monitoring synthetic pyrethroids in the soil of tropical tea plantations, notably in the Citarum Watershed, Indonesia, is difficult. The goal of this study was to see how hazardous pyrethroids left in tea plantation soil were when they leached into surface water. The introduction of pyrethroids into surface water via runoff and leaching could have a harmful impact on aquatic life. The highest permethrin concentration retained in the soil of a tea plantation indicating the safe limit for aquatic creatures populating the Upper Citarum River was estimated to be 136 g g 1 for algae, 0.84 g g 1 for Daphnia sp., and 366 g g 1 for fish, according to the research. In the meantime, the maximum Deltamethrin concentration indicating the safe limit for Daphnia sp. was 8.0 g g 1 and 0.27 g g 1 for fish. In the series, pyrethroids permissible concentration above the MRL it is highly dangerous for aquatic organisms and soil contamination [42].

The results of residue tests of three commonly used pesticides in water samples, sediment, and fish muscles from river Deomoni flowing through tea gardens in the Terai region were published by [43]. The mean pesticide residues of chlorpyriphos, Dicofol, and ethion in the water sample were 0.0091 0.0020 ppm, 0.0180 0.0071 ppm, and 0.0892 0.0375 ppm, respectively, whereas the mean concentrations of Chlorpyriphos, Dicofol, and Ethion in the sediment sample were 0.0513 0.0085 ppm, 0.0414 0.0045 ppm, and Chlorpyriphos, Dicofol, and Ethion residue concentrations in fish muscles were reported to be 5.0371 1.4236 ppm, 3.7700 0.6391 ppm, and 2.9599 0.4027 ppm, respectively. Interestingly, the concentration of chlorpyriphos in fish muscle was greater in the winter (11.6709 0.4332 ppm). When we compared the concentrations of the three pesticides in fish muscle to those in sediment and water, they discovered that fish muscle had higher concentrations than sediment and water, with water having the lowest concentration. The lower amounts of pesticide residues discovered in water than in sediment may be attributable to the fact that pesticide intake in water is a function of suspended particle concentrations, where the residues were absorbed and transported, as [44]. Have pointed out [45]. Because sediments are important sinks for various pollutants like pesticides and also play a significant role in the remobilization of contaminants in aquatic systems under favorable conditions and in interactions between water and sediment, higher levels of pesticides were found in sediments than in water.

Sri Lanka reported Tea farmers' overuse of herbicides in Sri Lanka has resulted in soil deterioration, compaction, and erosion, resulting in a decline in tea production in the region: The harmful effect of herbicides on soil organisms aggravates the situation. "What we've discovered is that tea farms and large tea estates with degraded soils tend to be more susceptible to natural and climate-change-induced drought, as they experienced in the dry seasons of 2015-2016 and 2016-2017," (Director of the Alliance for Sustainable Landscapes Management in Sri Lanka [46].

Monocrop farming and its related chemical inputs reduce soil biodiversity and organic matter, as well as compact soils (particularly in places where workers and machinery pass over). Compacted soils have a low oxygen content [47].

OCP and OP concentration high level detected in soil November. Study conducted in doors and hill region tea plantation of west Bengal India, the concentration of pesticides residues in soil Heptachlor (0.238mg/kg), Dicofol (0.450) but both residues absent month of April. Simultaneously, OP ethion residue concentration is in November (0.210mg/kg), Chlorpyriphos concentration is (0.141mg/kg) but April ethion concentration is (0.161mg/kg) following chlorpyriphos concentration is (0.110mg/kg) this study revealed banned pesticides like OC pesticides heptachlor and chlorpyriphos detected in soil this may pose serious health effects on soil degradation and loss of soil biodiversity [48]. In the series, a similar study conducted from tea garden of Darjeeling hill. studied two type of soil one is control site soil from (forest land) and second from five different tea garden soil. But here, detected OC pesticides in high level concentration heptachlor (160.70mg/kg), Dicofol (310.50mg/kg), endosulfan sulfate (45.00µg/kg), α, endosulfan (35.20µg/kg) β endosulfan (38.90µg/kg) (138) all OC pesticides residues high level detected in November compared to April and OP pesticides are also detected high concentration in ethion (28.50µg/kg) Chlorpyriphos (257.50µg/kg) November compared to April. After studied result indicate organically managed gardens soil found higher microbial activity with higher physiologically active microorganisms than the conventional tea garden. Study shows the conventionally managed tea garden heavy effect on the soil physio-chemical and biochemical which are important sanctum of soil quality [49].

A long-term study of the tea plantation is anticipated to uncover a slew of new species in addition to the 13 already identified. Since the tree frog, Rhacophorus pseudomalabaricus was discovered and named for the first time in the rain forests of the Indira Gandhi wildlife sanctuary in the year, his ability to offer this confidence. Among the anurans found in Valparai's tea farms, *Bufo melanostictus* and *Rana Limnonectes spp*. and aurantiaca have aquatic larval stages. Surprisingly, these species reproduce prolifically in small watersheds that drain substantial tea growing and are frequently contaminated with fertilizers and pesticides. [50].

Pesticides residues in fresh tea leaves and their health effects

Tea is the most frequently consumed drink in the universe, next to water and recognized as one of the most popular healthy drinks for consumers in 21st century [51]. Tea an important role in intestinal micro flora, as well as immunity against intestinal disorders and protection of cell membranes from oxidative damage [52]. Tea contains polyphenols (catchiness), amino acids, tannic acid and other antioxidants drinking tea is considered beneficial human health, including the prevention of many diseases since it has been proven to prevent Alzheimer’s disease, high blood pressure, cardiac problem and obesity [53]. The environmental conditions in which tea is grown favor the spread of disease but pesticides play important role in pest management and are used to control and ensure quality of the tea plants [54]. Pesticides are used to increase crop productivity especially in tea garden because the tea plant is harvested numerous times each year, the time between pesticides application and tea plucking is shorter than for compared to other crops. As a result, residues of OCP, OP and SP pesticides residues will be accumulated in plant parts, water, soil, air, and biota. It stays in the soil, water and plant eventually enters the food chain threatening humans, and create loss of soil biodiversity, degradation of aquatic community [55]. EU, FAO, CODEX ALIMENTORIOUS COMMISSION, WHO maximum residue limit of (MRL) pesticides in tea mg/kg fixed by international regulator bodies for tea exporting countries recommended residue limit for Aldrin, Chlorpyriphos, Copper oxychloride, Cypermethrin, Deltamethrin, Dicofol, Ethion, Lindane, malathion, Glyphosate, Propargite, Hexacozole, Quinalphos and Fenpropethrin used for the protection of tea crop [56].

All tea leaves contained γHCH and βHCH isomers as can be shown, black tea leaves had much lower concentrations of HCH (3.68 ng g^{-1} dry wt.) than herbal tea leaves (6.27 ng g^{-1} dry wt.) and green tea leaves (16.37 ng g^{-1} dry wt.), which had the greatest concentrations of HCH (16.37 ng g^{-1} dry wt.). Similar values for HCH were found in both black and green tea leaves, whereas herbal tea leaves had the lowest concentration.

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A study in Pakistan total seven pesticides residues analyzed in collected 14 tea samples Lamda was detected in total collected samples concentration range is 1.67 – 8.48mg/kg which is greater than the standard value of 1ppm in all of them 12 sample showed the presence of bifenthrin exceeding the MRL of 5 ppm concentration range is 5.25- 35.1 ppm, Glyphosate is 2ppm above the MRL, Dichlorovas detected 0.5ppm above the MRL, Emmamectin is 0.5 ppm above the MRL. The results of the study revealed that in case of Emmamectin one of the samples was found to be having a health risk as well as carcinogenic in nature for consumer. In the series, results of the pesticides detection in different tea brands respectively revealed that imidacloprid was present and its concentration range is 0.01 ppm which was above the MRL, thus imposing thread to human health [61]. Imidacloprid which are associated with reproductive or developmental impacts in animals, as well as affecting bees and other beneficial insects [58]. In Ethiopia reported 14 domestic samples analyzed about 13 domestic samples were contaminated OCPs compounds Heptachlor concentration of (0.107 to 1.242 mg/kg) in domestic tea and imported tea sample Heptachlor concentration of (0.618 to 1.08) mg/kg. This may be contamination of tea sample during transportation or storage to super market and shops. And also seven pesticides residues including Aldrin, hepatachlorepoxide, chlordane, p,p- DDT, endosulfan, dieldrin and methoxychlor were detected in two 40% imported tea samples. This could be owing to the chemicals' use in agricultural fields or their previous use in Ethiopia for malaria control [59].

In the series, A study 2011 in Iran shows 53 samples the presence (OCPs) of endosulfan sulfate in 18.9% of the samples with residues ranged from 5–20 μg/kg and the presence of bifenthrin in 9.4% of the samples with residues ranged from 5–35 μg/kg, these contaminated samples were lower than MRL established by regulation authorities from India and England [60]. In India studied and quantified the residues of six pesticides namely Heptachlor, Dicofol, α endosulfan, β endosulfan, endosulfan, sulfate in fresh tea leaves five pesticides of OCPs is average but Heptachlor is high level of concentration in doors region and Hill region fresh tea leaves summer 0.923mg/l and winter is 0.540mg/l low level in Hill region fresh tea leaves summer 0.11g/l and winter 0.30mg/l but here heptachlor is very below compared to the α endosulfan is 0.387mg/l quantified the residues of six pesticides namely Heptachlor, Dicofol, α endosulfan, β endosulfan, endosulfan, sulfate in tea ecosystems of Dooars regions of West Bengal, India. They found that the residues of banned pesticides like heptachlor in tasted samples may pose health hazard to the consumer [61].

In south India a study by Subbiah Seenivasan and Narayanan Nair Muraleedharan in a large-scale survey of produced tea in the factories of south India had been carried out for a period of three years from 2006 to 2008 and 912 samples were analyzed for the residues of certain pesticides such as Dicofol, ethion, quinalphos, hexaconazole, fenpropathrin, fenvalerate and Propargite. The analytical data showed that only less than 0.5% of samples had residues of reveled pesticides tea samples had residues of ethion and quinalphos very lower level MRL value along with other categories of pesticides [62].

In the series a same related study extensively carried out in numerous survey were conducted from 2009 to 2011in south India. 468 samples surveyed Even though ethion, quinalphos, hexaconazole, Dicofol, Propargite, and fenpropathrin residues were the most often discovered, just one sample went over the MRL set for hexaconazole by a significant amount of European Union. [63]. Hexaconazole above the MRL it causes harmful for soil microorganisms and may reduce the soil quality and increase the loss of nitrogen loss in soil [64]. A study in north India, west Bengal region OPs like quinalphos and ethion detected higher in fresh tea leaves than the made tea leaves [65].

Japan reported all of seven neonicotinoid pesticides examined were detected in Japanese tea leaves The detection frequency and maximum concentration of neonicotinoid insecticides were highest for dinotefuran (100%, 3004 ng/g), imidacloprid (92%, 139 ng/g); thiacloprid (79%, 910 ng/g) with thiamethoxam (79%, 650 ng/g); clothianidin (74%, 233 ng/g) acetamiprid (67%, 472 ng/g) and nitenpyram (3%, 54 ng/g). Were simultaneously detected in Japanese tea leaves. In addition to the 100% detection of dinotefuran, imidacloprid, and thiamethoxam/clothia- nidin, thiacloprid, and acetamiprid are also commonly used, as well as nitenpyram. Concentrations of neonicotinoid insecticides in tea leaves from Japan were below the Maximum Residual Levels (MRL) recommended by Japan. However, there could be health concerns due to the high intake of tea in the Japanese population because human health risk assessment does not only depend on the concentration of the target chemical in food, but also on the consumption rate [66]. The MRL set in Japan for fruits, tea leaves were higher than recommended levels from other countries. There, detected neonicotinoid pesticides residues levels are below the Japan MRL regulations but compared to all detected residues above the EU permissible limit.

In a recent investigation in China, 102 distinct pesticide residues were discovered in tea leaves [67]. Similarly, discovered pesticide residues in 198 out of 232 harvested tea samples of green tea, Oolong tea, and black tea, with residue levels in 39 samples above the European Union's maximum residual standards. It is commonly known that only the hot water extract of black [68].

Tea (tea brew) and not the black tea itself is used for human consumption. As a result, the tea brew is a potential source of pesticide residues. The true cause is determined by the number of residues leached from black tea into the tea brew, not by the existence of residues. Black tea infusion because black and green tea are traded commodities, all regulatory bodies have established maximum pesticide residue limits. Pesticide residue concentrations in tea samples are shown to vary with the season, it is posing a risk to users. The largest pesticide amounts in tea samples were detected easily during the winter season, which could build in a person's body harm and lead to lethal repercussions in the long term. Although only Chlorpyriphos poisoning causes various signs and symptoms, based on plasma cholinesterase (ChE) inhibition and possible clinical signs, a few studies suggest that humans are similar and possibly more sensitive than animals following acute and short-term oral exposure and acute dermal exposure [69].

Reduced tendon reflexes, cranial nerve palsies, weakness in the face, neck, and proximal limb muscles, and partial respiratory paralysis are some of the other symptoms seen in humans. After an acute chlorpyriphos exposure, signs and symptoms usually appear within minutes to hours. Increased heart rate, unconsciousness, loss of control of the urine, convulsions, respiratory depression, and paralysis are indicators of severe poisoning, as are weakness or tremors, lack of coordination, vomiting, abdominal cramps, diarrhea, and pupil constriction. Anxiety, despair, disorientation, stupor, odd conduct, and restlessness are some of the psychiatric symptoms associated with acute exposure [70]. People direct contact with organophosphate pesticides can inhibit the enzyme acetylcholinesterase and this enzyme inactivates neurotransmitter acetylcholine in the body, which cause neurological problems [71].

Different pesticides were discovered in dried tea leaf samples in research conducted in other countries. Fenpropathrin and lambda-cyhalothrin, for example, were the most common pesticides in Chinese tea samples [72]. The most prevalent pesticides discovered in tea samples from India were phosphamidon, monocrotophos, malathion, methyl parathion, quinalphos, and chlorpyriphos, according to [73], whereas difenoconazole, azoxystrobin, and triflumizole residues were found in tea samples from Korea [74]. The research was carried out in Germany. The results showed that the transfer rate varied by pesticide; hexaconazole (23.79 percent) had the highest mean transfer rate during brewing, followed by triflumizole (22.35 percent) and chlorpyriphos (11.7 percent), while ibuprofen (8.33 percent) had the lowest. In tea infusion, however, the quantities of ethalfluralin and quintozene, as well as residues, were below the detection limit [75].

Tanzania reported by survey shows that (tea garden) workers huge in tea companies are exposed to pesticides, presently most of the tea workers are still under the working pesticides contamination environment. According to survey Occupational hazards such as pesticide exposure and poisoning have been identified in tea nurseries and farms using a red blood cholinesterase test and risk and exposure assessment. Data revealed the Pesticide poisoning signs and symptoms among 37 workers [76].

Tea sample residues and their impact on exporting tea major producing countries

Over the last two decades, notably after 2000, China's exports to key European partners have declined dramatically. This drop will be ascribed to an increase in the number of pesticides used by tea farmers that are regulated by EU laws, as well as lower default MRL values for older pesticides. Furthermore, tea shipments from China to the Netherlands, Poland, and the United Kingdom decreased dramatically after 2008, owing to tougher controls and lower default values. Even though Vietnamese tea production and export volumes have steadily expanded over the last two decades, due to low quality, Vietnamese tea products have primarily been shipped to lower-value markets such as Taiwan, Pakistan, Iran, Indonesia, and Russia [77-78]. Pesticides and fungicides are used extensively on tea plantations in various Asian and African countries, according to research. This puts the health of tea growers and consumers in danger [79].

Pesticides management in tea plantation

Research into fertilizer and pesticide management is not only excellent for lowering the cost of tea production, but it is also beneficial for reducing the risk of environmental pollution in tea plantations. to investigate the effects of various organic fertilizer replacement ratios on soil properties, nutrient inputs to runoff water, and tea yield and quality to demonstrate the environmental effects of various pesticide reduction ratios on pesticide residues in tea leaves, soils, and runoff water; and to reveal the potential effects of interactions between dual fertilizer and pesticide reductions on tea yield and quality [80] because tea is a consumable product, pesticide residue in produced tea is detrimental to human health. In terms of integrated pest management (IPM) of insect pests, a heavy reliance on insecticides has not been performed successfully. It is critical to discover some environmentally friendly alternatives to tea pest treatment. Many countries are attempting to reduce the usage of toxic insecticides by employing indigenous plant products, implementing IPM strategies, using biodegradable materials [81], and employing insect growth regulators [82]. Bio pesticides are seen as ecologically friendly, selective, biodegradable, cost-effective, and renewable alternatives for use in IPM programmes [83]. Botanical pesticides are derived from a variety of plant parts (leaves, stems, seeds, roots, bulbs, rhizomes, unripe fruits, and flower heads, among others). Botanical pesticides are praised for their broad spectrum of activity, ease of processing and application, brief residual activity, and lack of accumulation in the environment or in warm-blooded animals' fatty tissues [84]. Some plants have been scientifically studied for pesticide qualities and to be effective. Bonkalmi, Bazna, Bishkatali, Datura, Durba, Eucalyptus, Ghora-neem, Hijal, Karanja, Mahogoni, Marigold, Neem, Nishida, Pithraj, and a variety of other botanicals may be used. Farmers may cultivate it for a low cost and extract it using traditional ways [85]. Neem (*Azadirachta indica* A. Juss.) is extensively recommended and used to combat many tea pests [86-87]. Different quantities of aqueous extracts of neem seed kernels (NKAE) were tested for antifeedant action against the tea mosquito bug, H. the ivory [88]. Numerous studies conducted outside of Vietnam have shown the benefits of agro ecological management practices such as organic fertilizers [89-90], bio fertilizers [91- 92], bio pesticides [93], mulching, intercropping [94-96], and integrated pest and disease control strategies are all examples of effective pest and disease management [97].

Agroecology can help promote food production, nutrition, and food security while also restoring ecosystem services and biodiversity, which are critical for agriculture's long-term viability [98-99]. Furthermore, agroecology offers a realistic solution for repairing soil quality that has been harmed by traditional management approaches (100). It has been extensively proven that agroecology tea management has an impact on soil physical qualities. Tea residue mulches, when used in conjunction with bio fertilizers containing various beneficial microorganisms. Resulted in a significant decrease in soil bulk density and an increase in soil moisture content, according to a study conducted in tea fields in Vietnam [101]. Organic fertilizers application, such as sheep manure, greatly reduced soil acidity and enhanced soil nitrogen content in tea growing [102-103]. Found that organic mulches (straw, chopped grass, legumes) significantly increased soil organic matter and nitrogen status [104].

Organic carbon, pH, accessible P, and total N concentration in the soil [105]. Tea pruning mulches and bio fertilizers (*Bacillus spp*., *Lactobacillus spp*., *Streptomyces spp*., *Saccharomyces spp*.) were added to tea plantation soils, resulting in a significant increase in soil organic matter content, exchangeable cation concentrations ($Al3+$, $Ca2+$, and $Mg2+$), and a decrease in soil acidification [106] . In terms of soil fauna, a Chinese study found that organic tea growing increased common species diversity, species richness, and trophic diversity of nematodes in both the surface and subsurface layers of the soil, compared to conventional tea farming [107].

Regulating body

The use of pesticides on this cash crop has largely been guided by the Commission of European Communities (CEC), the Environmental Protection Agency (EPA), the Food and Agricultural Organization (FAO), the Food Control (FC), and the Codex Alimentarius Commission's Maximum Residue Limits (MRLs) and tolerance limits (CAC). Alternative control tactics are gaining traction among these regulatory agencies as a way to minimize or limit the use of expensive pesticides, as well as the health risks associated with residues.

The present food safety rules and trade interactions in the setting of MRLs were examined in this study. Tea regulations are not universally coordinated, however, there are guidelines (CODEX, OECD), regional regulations (EU), and national regulations. MRL incidences have been reported over the years, particularly on vegetable goods, according to the EFSA report, while MRL incidents for tea have been rather rare. However, like with many other food safety concerns, these instances are becoming more widely reported as food safety standards tighten and worldwide production levels rise to meet rising demand. Furthermore, severe laws may have hampered the penetration of traditional tea into EU markets.

Administrative actions (returning to the exporter) or market withdrawals are usually used to deal with MRL-related consignments. These measures would hurt exporters, as they would increase transportation and storage expenses, particularly when consignments were directed to new markets. As a result, large tea exporters should monitor consignments during the production stage to avoid mishaps [108]. Pesticide residues have become more of a concern for consumers in these countries. In this regard, the Environmental Protection Agency (EPA), the Codex Commission/FAO, the World Health Organization (WHO), Japan, and German law, among others, have imposed limits on the production and procurement of pesticide-contaminated tea [109]. Because black and green tea are traded commodities, all regulatory bodies have established maximum pesticide residue limits.

Kenya uses pesticides in a completely different way than other major tea-producing countries. Because their crops have less added value and preservatives, they enjoy a good crop trade ration. This maintains a positive market relationship in terms of bulk tea exports. Majority of developing countries must also consider such examples and concentrate on how to increase crop output and what they can do to make crops grow healthier using more natural rather than artificial methods [110].

CONCLUSION

Pesticide pollution is a major issue for all tea plantation environments, and it is damaging to all organisms that live there. As a result, reducing pesticide use necessitates new procedures and approaches for analyzing the impact of extensive pesticide use on tea plantation ecosystems and surrounding rivers. Efforts must be made to increase public awareness of dangerous insecticides. Implement new agriculture policies aimed at long-term development and consumer health protection. Using transgenic techniques, various pest-resistant crop types have been developed, allowing pesticides to be avoided. As a result, encouraging the use of bio insecticides rather than chemical pesticides is critical. Pesticides have been used in tea plantations to reduce pesticide application by following maximum residue levels (MRLs-Permit) defined by the EU, Codex Alimentarius Commission, US EPA, and various country legislation. As a result, more research is needed to regulate pesticide use and to solve concerns associated with the use of chemical fertilisers and pesticides in tea gardens around the world.

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