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Environmental Pollution from Injudicious Application of Pesticides: Bangladesh Context

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Abstract: The recent trend of Pesticide use is accelerating for agricultural production purposes. Its importance is immense for controlling pests in developing countries like Bangladesh. But the imprudent application is increasing at an alarming rate due to which environmental degradation is increasing, which is not still under investigation. Despite the various pest control methods, chemical pesticides (hereafter pesticides) are more popular among Bangladeshi farmers because of their low cost and rapid action. The continuous popularity of pesticides application adversely affects the environment, and eventually, human throughout the country. Hence a systematic review was initiated utilizing the secondary information to overview the hazardous impact or prevailed pollution due to the application of pesticides in the context of the environment, related organisms, and human health. The analysis revealed that pollution-related problem arises mostly due to the unregulated use of pesticides. Therefore, excessive pesticide usage such as pollutes the air, soil, and water and kills non-target organisms, causing an ecological imbalance. Lack of protection exposes farmers to acute illnesses, toxic compounds in the food cycle, and the mass population to chronic health issues. Thus, to minimize pesticides' environmental, and health effects, concerns should be given on the judicious application of pesticides, raising awareness regarding pesticide use. Policymakers should focus on raising awareness regarding the use of pesticides, implementing effective pesticide usage laws at the root level, optimizing reasonable use, participatory program implementation for farmers' training, good governance and regulatory mechanisms, frequent inspection at the field level, and appropriate actions and strategies for promoting eco-friendly methods.

Keywords: Air pollution; Diseases; Pesticides; Soil pollution; Water pollution.

INTRODUCTION

Pesticides are chemical substances used to manage pests belonging to the group of weeds, insects, mites, rodents, and other animals that cause significant damage to crops. The ramifications of pesticides are significant globally as pesticide usage is on the rise. In modern agriculture, pesticides are a cost-effective and efficient way to provide food security by increasing crop output and quality (Sharma et al., 2019). Its use has become widespread due to beneficial effects comprising lower infestation, protection of crops from significant yield loss, and farmer profitability (Damalas, 2009).

Pesticide usage is rapidly growing in Asia's emerging countries like as Nepal, India, Pakistan, China, and Bangladesh (Sharma et al., 2019). Growing pesticide uses are a major concern for developing countries, as up to 30% of pesticides in developing countries fail to fulfill internationally accepted safety criteria; (Parveen and Nakagoshi, 2001; Bradish et al., 2012). In addition, unregulated intensive usage could harm the ecology by

polluting the air, soil, and water and accumulating in the food chain (Sharma et al., 2019). Pesticides are detrimental to the environment because of their persistent nature and tendency to accumulate quickly (Nie et al., 2020). Toxic chemical compounds harm targets and non-target animals, such as beneficial insects, microorganisms, birds, animals, and human health (Pimentel, 2009) while contaminating the environment (Tudi et al., 2021). Chemical exposure, directly and indirectly, influences the health of agricultural sector workers and the general population in various ways (Rani et al., 2021).

In Bangladesh, pesticides are widely utilized for rice (Parveen and Nakagoshi, 2001) and vegetable crops (Sabur and Molla, 2001). Among the pesticides, insecticides are used intensives which are more than 95% of total used pesticides, whereas the remaining 5% of pesticide use comprises weedicides, fungicides, and rodenticides (Rahman et al., 1995). The yearly pesticide use pattern in Bangladesh is shown in Figure 1. Bangladeshi farmers depend highly on chemical pesticides to manage insect pests and related diseases (Rahman et al., 2014). Most cannot decide on controlling pests and pesticide handling (Biswas et al., 2014). They have been discovered to overuse pesticides on beans, eggplant, rice, potato, sugarcane, and mango (Dasgupta and Meisner, 2005). Thus, pesticide residues were identified in irrigated field water, pond water, lake water, river water, tube-well water, vegetable field soil, paddy field soil, marine sediment, pond sediments, canal sediment, and foodstuffs above the acceptance level, which possess a significant threat. Concerns about pesticide focus on insecticide resistance-but persistent changes to our intact diverse community could have more serious consequences (Ali 2014).

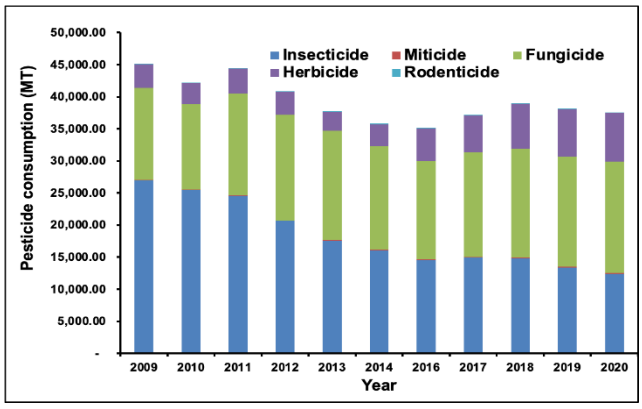

Figure 1. Yearly pesticide use pattern in Bangladesh. Data source: Bangladesh Crop Protection Agency.

The perception by pesticide use of Bangladeshi farmers is poor, and they don't follow the proper protection during the application of pesticides in crop fields (Ali et al., 2020). Farmers handling chemical pesticides without proper protective measures exposed them to serious human health issues (Miah et al., 2014; Akhter et al., 2016). Pesticide residue concentrations were found above the acceptance level in foodstuffs from local markets, which pose a significant threat to the mass population (Chowdhury et al., 2014; Ahmed et al., 2019; Begum et al., 2019). Ignorance of farmers' roles, weak regulatory mechanisms, lack of effective phytosanitary management, and incorrect handling resulted in widespread pesticide contamination in foodstuffs (Sarker et al., 2021). Considering the significance of this issue in Bangladesh, we combined and highlighted evidence regarding different kinds of pesticide compounds polluting air, water, and soil and the destruction of non-target organisms. Moreover, we identified different socio-economic factors affecting farmers' pesticide use and possible actions for managing chemical pesticide use.

METHODOLOGY

The study was carried out following the systematic review. Secondary data were gathered using Google Scholar, PubMed, and Scopus databases. To the chosen database in the context of Bangladesh, the terms "pesticide in Bangladesh," "pesticide impact on water," "soil pollution and pesticide," "water pollution and pesticide," "pesticide and environmental degradation," and "pesticide influence on air," and "pesticide and ecosystem" were entered. The most pertinent papers were chosen using the obtained secondary data, and a systematic review was conducted.

Environmental and Health Impact of Using Chemical Pesticides

Pesticides perceive the potentiality to contaminate soil, water, and air, while non-direct use trigger toxicity to non-target life (plants, fish, birds, and beneficial insects); thus, the negative impact on human wellness and the ecosystem is quite evident (Zhang et al., 2015).

Air pollution

Transmission of pesticide agents occurs from crop-growing localities to the atmosphere (Bozlaker et al., 2009). During application, pesticide spray drift may spread out from the application area due to climatic conditions atmosphere (Bozlaker et al., 2009; Khan et al., 2022). The evaporation of droplets from plant and soil ground transportation by the influence of wind and wind erosion also transports pesticides containing soil particles; hence pollution of atmospheric phases, namely, gaseous aerosol particles and rainwater, occurs (Bedos et al., 2002). Under high temperatures, the organochlorine may go through the gas phase, and wind speed and wind direction influence the atmospheric gas phase level of the POPs atmosphere (Bozlaker et al., 2009).

Water pollution

Water quality issues in Bangladesh's irrigated areas may have arisen due to intensive agricultural practices, especially increased usage of chemical pesticides and fertilizers (Chowdhury et al., 2010). Agrochemicals, which are mostly generated from farming activities, are one of the sources of freshwater contamination (Sarkar et al., 2019). Pesticide residues persist, terminate, and volatilize in soil, water, and air due to improper pesticide treatment, resulting in surface

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water degradation (Chowdhury et al., 2015). Pesticide residual runoff is a common cause of water contamination, with surface water being the most often polluted (Hasan et al., 2019).

In North-west Bangladesh (Sumon et al., 2018), a study was conducted to quantify residues and assess ecological risk for aquatic organisms where the researchers discovered chronic RQs for chlorpyrifos, malathion, diazinon, fenitrothion, and quinalphos in water and soil ((surface), confirming threats for aquatic insects, macro and micro-crustaceans, as well as indirect effects on macrophytes and algae, population digestion, macro-invertebrates, and rotifers. Chlorpyrifos and carbofuran were found in water from a paddy field and a lake in Rangpur, indicating contaminated water sources with high environmental risk (Chowdhury et al., 2012). The concentrations of malathion in the Rangpur district ranged from 2 ppm to 221 ppm, above the pesticide contamination limit (Ara et al., 2014). According to a study conducted in Mymensingh (Uddin et al., 2016), summathion (high dose and low dose) harmed benthic invertebrates and aquaculture ponds. Diazinon, carbaryl, chlorpyrifos, and carbamate were detected in pond water of coastal regions below WHO acceptable limits, but those residues in the surface water body are problematic (Uddin et al., 2014). Farmers of Khulna and Bagerhat districts were found to use organophosphorus, and carbamate widely, including carbofuran, malathion, diazinon, carbosulfan, chlorpyriphos, cyhalothrin, cypermethrin, thiomax and accumulation of excessive pesticides is responsible for fish mortality along with disruption of physiological and behavioral changes of fish (Hasan et al., 2014). Organophosphorus and organochlorine were found in higher concentrations near Dhaka city's lake water (Khatun et al., 2008). In the Savar and Dhamrai, water bodies were proved to be extremely contaminated with carbaryl residues, as well as major residues of malathion, diazinon, and carbofuran, with gross residues crossing the EEC's allowable limit (Chowdhury et al., 2012). Dhamrai upazila's water source was found to be polluted with malathion and diazinon levels that surpassed the recommended level, posing a risk to health (Rahman and Salam, 2017). Despite being suspended, HCB, DDT, and other POPs were found in the water source in the Narayanganj and Dhaka districts, and the elevated levels of concentration posed a major threat to ground and surface water contamination (Hasan et al., 2012). Pesticide residue was tested in the water of paddy field, pond, and tube well in Tangail and Manikganj, and large concentrations of malathion, chlorpyrifos, and diazinon were identified in paddy field water and tube well water above the acceptable limits (Hasanuzzaman et al., 2018). Malathion was discovered to be commonly used in Daudkandi upazila, with concentrations beyond the appropriate limit and posing a major hazard to aquatic and terrestrial species (Hasanuzzaman et al., 2019). Major levels of malathion, carbofuran, and cypermethrin were found in pond water in the Brahmanbaria district, indicating a risk to water quality (Uddin et al., 2013). Diazinon, chlorpyriphos, and carbofuran were found in pond water in the Meherpur district, and although residual levels were found to be within reasonable limits in certain situations, water contamination posed a serious threat to the ecosystem (Uddin et al., 2013). In Dhaka, Magura, Sylhet, Chadpur, Shariatpur, Bogura, Noakhali, and Chittagong, pesticide toxic residues were detected in irrigated agricultural water fields (Islam et al., 2007). Heptachlor and DDT concentrations in irrigated field water were above the WHO allowable level in Nator, Bandarban, Sunamganj, Madaripur, and Feni, Nawabganj, Kumilla, Sunamganj (Chowdhury et al., 2013).

Soil pollution

In Bangladesh, pesticide misuse has become more common, posing a significant threat to soil ecology. The intensive use harms soil health as pesticide toxicity destroys soil microorganisms, and long-term application disrupts biochemical equilibrium, disrupts nitrogen fixation, and inhibits the activity of soil enzymes (Hussain et al., 2009). The plate count data revealed the adverse impact of respective pesticides on fungi, heterotrophic bacteria, and nitrogen transportation bacteria (Cycon and Piotrowska-Seget, 2007). The long-term persistence impact could affect soil microflora by causing negative effects on soil function and properties (rhizodeposition, soil organic carbon, pH, moisture, enzyme activity) (Prashar and Shah, 2016). Pesticides form stable complexes of vital metal ions (Mn^{2+}, Fe^{3+}, Co^{2+}, Ni^{2+}, Ca^{2+}, Zn^{2+}) in water and soil, and these complexes are insoluble in water, difficult to decompose, and unable to be transported in plant and animal bodies, resulting in a reduction in soil fertility (Kaur et al., 2017). Pesticide residues (DDE, DDT, carbofuran, carbaryl, diazinon) were detected in the soil of vegetables and paddy fields in the Narshingdi (Uddin et al., 2016) and Feni (Uddin et al., 2018) districts in 2016 and 2018, respectively, and concentrations were within the limit of IAEA/FAO/Codex Alimentarious Guideline values. However, a recent analysis from the Lakshmipur district in 2020 discovered the prevalence of carbofuran, carbaryl, and diazinon in soil sediments that exceeded the EEC allowable level, indicating a major hazard (Uddin et al., 2020).

Destruction of non-target organisms

The excessive dosage of pesticide application impairs crop growth, development, and yield with excessive accumulation in crops; it also causes the effect on non-target crops, including chemical sensitivity, and enhances crop damage (Pimentel, 1996). Rapid pesticide exposure also negatively affects honey bees through their excessive accumulation in honey bee colonies (Pettis et al., 2013). Higher fungicide concentrations that accumulated in pollen increased the occurrence of infection (Nosema) in bees (Pettis et al., 2013). Pollinator reduction influences agricultural productivity as both botanical and synthetic pesticides can potentially negatively impact beneficial insects, including natural enemies (Ndakidemi et al., 2016). The broad range of carbamate, organophosphates, and pyrethroid poses a significant threat to terrestrial biodiversity as beneficial insects, including bees and beetles, declined due to the increased use of those pesticides (Mahmood et al., 2016).

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Pesticide Exposure, Food Contamination, and Related Health Problems

Pesticides are unique among environmental contaminants due to high toxicity and biological activity, which can affect humans, livestock, other living species, and the atmosphere if used improperly (Yadav and Devi., 2017). Pesticides expose to the human body through inhalation exposure (breathing contaminated air as vapor, aerosol, and dust), oral exposure (eating poisonous food, drinking contaminated water), and dermal exposure (direct contact) (Sacramento, 2008). Acute exposure showed symptoms like headaches, nausea, rashes, body aches, low concentration, dizziness, panic attacks, in severe cases, coma or death (Yadav and Devi, 2017).

Chronic exposure induces various disease symptoms, including bone marrow, cancer, fertility, cytogenetic effects, neurotoxicity, enzyme induction, immunological effects, and skin effects (World Health Organization, 1990). Owing to different risk factors (e.g., greater body surface in comparison to weight, variations in metabolism, faster growth rate, and continued production of the body's organs), not all groups of people experience the same degree of health danger (Bradish, 2012). The path of intake and absorption determines pesticide toxicity, the form of pesticide used, also its accumulation and longevity in the body (World Health Organization, 1990). Dermal absorption of pesticides depends on skin characteristics (wetness of skin, Sores and abrasions, vascularization part on the body), environmental factors (Temperature, humidity), and pesticide characteristics (pH, vehicle, physical state, concentration of active ingredient) (World Health Organization 1990). Mainly Agriculture workers are vulnerable because they are exposed to chemicals directly daily, but the general public is also affected by polluted food or consumer goods or chemical drift from fields (Bradish, 2012).

Bangladeshi farmers rely heavily on pesticide use to control various insect pests and diseases (Rahman et al., 2014). The majority of them were not conscious of making decisions on pest management through pesticide application (Biswas et al., 2014). They are unaware of chemical pesticide toxicity and take no precautions when treating, transporting, mixing, storing, or disposing of pesticides that cause serious health issues (e.g., Rahman et al., 2014; Miah et al., 2014; Akhter et al., 2016). They work in the same field right after pesticide application, resulting in direct inhalation and dermal touch exposure (Bhattacharjee et al., 2013). They smoke, drink, or eat something while applying chemicals, causing both acute and chronic health issues (Miah et al., 2014). Since they only use chemical pest control techniques and cannot read the prescribed dosage of pesticide bottles/packets, most use pesticides in greater concentrations than recommended (Akhter et al., 2016). The uncontrolled, extreme, and non-selective use of pesticides are quite evident in Bangladesh's leafy vegetables and another crop (Islam and Hoque, 2013). Chemical pesticide residues indicate contamination, whereas extreme concentration makes the produce hazardous for consumption. Determining pesticide concentration in food production is essential as absorption is mostly responsible for poisoning and toxicity (Koh and Jeyaratnam, 1996). Recent studies in Bangladesh discovered that farm products are contaminated with chemical pesticide residues that crossed the EU's MRLs, posing a serious health risk.

A study conducted in the local market of Dhaka city expressed that a significant concentration of organophosphate, namely dimethoate, was found in coriander and lettuce, which exceeded the permissible limit of EU guidelines (Ahmed et al., 2019). Again, the detected concentration of dimethoate in tomatoes was found beyond MRLs in the Rajshahi district (Begum et al., 2019). The concentration of dimethoate, both acephate and fenitrothion detected in brinjal, were above the MRLs values in Rajshahi and Gazipur districts, respectively (Chowdhury et al., 2014; Begum et al., 2019). Meanwhile, the concentration of ethion in the lady's finger exceeded the recommended MRLs value in the Gazipur district after analyzing for organochlorine, organophosphorus, carbamate, and pyrethrum (Chowdhury et al., 2014). Management of chemical pesticide use needs to be accomplished as significant concentrations of chlorpyrifos, diazinon, and carbaryl were observed in Dhaka city brinjal and tomatoes (Chowdhury et al., 2010) and different regions of Bangladesh (Fardous et al., 2007). The study in Dhaka revealed that organophosphorus pesticides, namely dimethoate, and quinalphos, were above MRLs in some country bean samples (Hasan et al., 2017), indicating a significant threat to country bean consumption. The substantial amount of mancozeb and imidacloprid in cucumber and spinach, respectively, indicate significant chemical contamination in those respective vegetables of Mymensingh (Islam et al., 2015). In Narsingdi, the chemicals, namely diazinon, quinalphos, malathion, cypermethrin, fenitrothion, fenvalerate, and propiconazole, were detected in field crops where maximum analyzed chemicals found above MRL value (Islam et al., 2014).

Similarly, 12% of the analyzed cabbage tested was contaminated with pesticide residues of diazinon and chlorpyrifos in Dhaka, and interestingly, all detected concentrations were above the MRLs of EC (Islam et al., 2019). Organochlorine residues aldrin and pyrethroid residues permethrin were detected in fish samples of catla (*Catla catla*), where 27.4% were found positive for organophosphate pesticide toxic residues, of which 89.2% exceeded MRLs set by the CAC in different location of Bangladesh (Rahman et al., 2021). Pesticide contamination was found in a great percentage of tomatoes (60%) and brinjals (50%) from the Narayanganj district, with all levels exceeding the EC regulation's MRL where diazinon was the most prevalent chemical pesticide identified in the samples of vegetable (35%) (Alam et al., 2015). A conducted study in the retail market of Savar explicated pesticide residue contamination in bitter gourds where 12.3 percent of food samples were detected tinted with toxic residues, which surpassed the value of MRL set by EC (Islam et al., 2019).

Akhter et al., (2016) interviewed 80 farmers in Jhenaidah districts and found that the farmers who were more involved in agricultural practices suffered most various kinds of health

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issues where Gastrointestinal diseases (84%), skin diseases (60%), eye diseases (64%), and sexual and urinary diseases (54%). Bhattacharjee et al., (2013) examined 512 farmers in the Manikgonj district and found Excessive sweating, burning, itching eyes Fatigue, Dizziness, Nausea, Skin redness, burning nose, cough, diarrhoea, and wheezing were the most common effect on health. Ahmad et al., (2016) examined the effects of a sprayed organophosphate pesticide, where hazardous impacts were observed nausea and vomiting (36.3%), blurred vision (55.0%), headache (55.0%), excessive lacrimation (48.3%), excessive salivation (50.0%), excessive sweating (58.3%), and dyspnea and chest tightness (43.3%). Dasgupta and Meisner. (2005) revealed that 49% of the farmers' frequent health symptoms were generally associated with acute pesticide poisonings, such as headaches, eye irritation, dizziness, skin effects, and vomiting. Sultana et al., (2011) conducted a study in Gazipur and found the common physical problems were excessive lacrimation (88.7%), salivation (81.1%), difficulty breathing (68.6%), blurring of vision (57.9%), excessive sweating (52.8%), anorexia (49.1%), and nausea (26.4%). Also, some chronic illnesses observed by Sultana et al., (2011) are attributable to pesticide toxicity; the illnesses were weakness, loss of appetite, insomnia, headache, lethargy, and muscle fasciculation, where most of the illness symptoms were significant among Non-IPM workers.

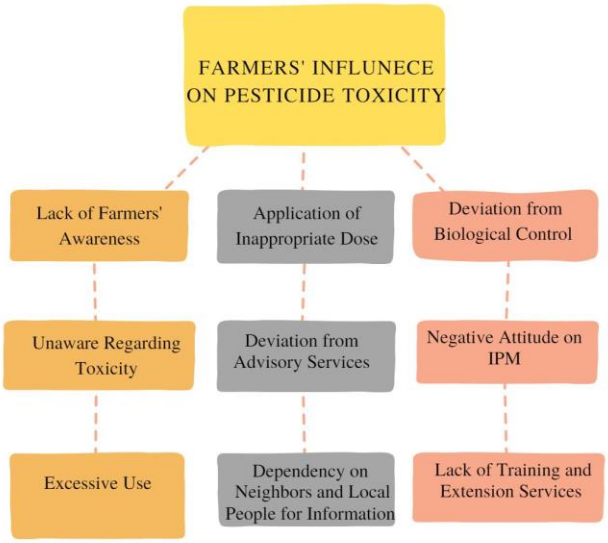

Figure 2. Factors of Pesticide Use and Toxicity Dissemination by Farmers (Khan et al., 2020).

Awareness and Factors Associated with Chemical Pesticide Uses by Farmers

Farmers acknowledged the negative aspects of pesticides, which include health, food, and environmental concerns (Rashid et al., 2003; Kabir and Rainis, 2012; Sultana and Muhammad, 2018; Rahaman et al., 2018; Shammi et al., 2020) initiating from farmers' level (Figure 2)

Several studies argued that farmers are not aware of pesticide toxicity; thus, they spray hazardous chemicals without taking any protective measures (Bhattacharjee et al., 2013; Miah et al., 2014; Hasan et al., 2015; Akhter et al., 2016) and use excessive amounts of pesticides (Dasgupta and Meisner, 2005), which results in pesticide sprayer exposing themselves to serious health risks (Bhattacharjee et al., 2013). They were observed spraying pesticides based on the dose recommended by village leaders and neighbors (Ali et al., 2020). Farmers lacked awareness of IPM practices, held a negative attitude about IPM, and failed to implement it properly (Kabir and Rainis, 2015; Kamal et al., 2018). Farmers' attitudes and perceptions of biological risk were influenced by age, education, experience, income, off-farm income, agricultural credit, and interaction with extension staff (Islam et al., 2021). Their perceptions of pesticide effects were found to be considerably affected by extension media, experience in vegetable production, education, and training in IPM (Kabir and Rainis, 2012). The analysis expressed that communication exposures indirectly influenced IPM practice, while mass extension contacts, risk orientation, and knowledge about predators and pests had a direct influence (Rahman, 2010).

Management of Environmental and Health Impact

Figure 3 represents the steps of Pesticide use management to limit injudicious application.

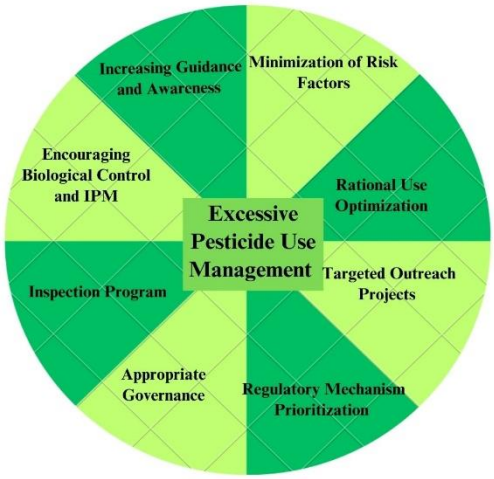

Figure 3. Management of Injudicious Application of Pesticides.

Pesticide residues have adverse effects on human health, so adequate precautions must be taken. Farmers should receive guidance and motivation on pesticide prevention measures and rational usage, as well as wear protective garments (masks, glasses, hand gloves, full jacket, full coat, etc.) prior to applying pesticides to reduce health risks (Alam and Chowdhury, 2004; Dasgupta and Meisner, 2005; Biswas et al., 2014; Miah et al., 2014; Ahmad et al., 2016; Akhter et al., 2016). Vegetables must be frequently washed and cooked before eating to remove pesticides and prevent pesticide-contaminated foods (Miah et al., 2014). Risk

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zones, at-risk populations, and risk factors (e.g., the availability of potentially toxic pesticides and the introduction of preventive measures) should be identified using increased data collection to minimize, decrease, or remove risk factors in risk areas (Bradish, 2012). In agricultural communities, targeted outreach projects such as farmer field schools and participatory farmer studies are required (Dasgupta and Meisner, 2005). It is necessary to prioritize the implementation of regulatory mechanisms and to devote to field-level agricultural administration (Rahman and Debnath, 2015). Agricultural courts must be formed in each district to execute agricultural laws and governance at all levels of agricultural administration (Rahman and Debnath, 2015). To avoid, regulate, and mitigate contamination, as well as to decrease health risks, routine inspection programs for toxic residues in foods are needed (Hossain et al., 2015; Ahmad et al., 2016). The Ministry of Agriculture should take the lead in encouraging farmers to limit pesticide use by judicial action, transitioning from conventional pesticides to bio-pesticides and organic farming, thus reducing emissions and health threats (Miah et al., 2014; Rahman et al., 2014). Using of IPM (Dasgupta and Meisner, 2005; Bhattacharjee et al., 2013; Biswas et al., 2014), natural products and biological agents are required to manage the negative effect of agrochemicals (Biswas et al., 2014). Hence, the injudicious application requires consideration of guidance application regarding Pesticide use, awareness raising, risk factors minimization, optimization of judicious use, participatory program implementation, good governance, and regulatory mechanisms, frequent inspection at the field level, and IPM dissemination should be implemented

CONCLUSION

The evidence from previous research showed significant pesticide contamination in Bangladesh's air, water, and soil. Drifting and transporting pesticides from applied areas through wind contaminate the air. Meanwhile, soil and water are significantly polluted through direct and non-direct pathways. As a result, living organisms, including targets and non-target associated with environmental resources, are being affected. The information generated in this review exposed the contamination of soil, air, water, and ecosystem due to the hazardous impact of chemical substances of pesticides. The overall environmental elements are filled with toxic elements of pesticides. The exposure reaches the extreme and results in environmental degradation. Along with environmental alteration, toxic compounds enter the food chain. Consumption of pesticide-affected foodstuffs causes people to be exposed to various serious health hazards. The farmers lack awareness of using protective measures, leading them to suffer from acute and chronic health problems due to pesticide exposure. It is crucial to enforce the judicious application of pesticides. As a result, the study suggests implementing specific measures. The prudent application must be enforced at the farmer level by taking actions ranging from raising awareness to implementing regulatory mechanisms. Farmers ought to have enough direction. Risk factors should be kept to a minimum, and administrative regulations should be properly adhered to. It is important to promote the use of IPM and uphold regulatory standards. Above all, farmers must receive adequate training through collaborative projects based on prudent pesticide application. Bangladesh must establish proper plans and policies regarding i) increasing the suitability of eco-friendly pest control methods to farmer levels, ii) increasing the awareness level of farmers on using chemical pesticides, iii) implication of rules and regulations for pesticide use to the root level effectively.

Appendix

Abbreviations/Acronym			
EU	European Union	WHO	World Health Organization
FAO	Food and Agriculture Organization	IAEA	International Atomic Energy Agency
CAC	Codex Alimentarius Commission	EEC	European Economic Community
MRLs	Maximum Residue Limits	EC	Electrical Conductivity
RQ	Respiratory Quotient	POPs	Persistent Organic pollutants
IPM	Integrated Pest Management	DDE	Dichlorodiphenyldichloroethylene
DDT	Dichlorodiphenyltrichloroethane	HCB	Hexachlorobenzene

Data availability

All necessary data is included in the article.

Conflicts of Interest

The authors declare that there is no conflict of interest exists.

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