Review Article

Pesticide use in Bangladesh: A Review on Potential Impacts

ABSTRACT

Bangladesh is a densely populated agricultural country. A wide range of products of pesticides being used in Bangladesh is already considered a health and environmental concern by different international agencies including the World Health Organization (WHO). Excessive, irrational use of pesticides in agriculture, and lack of knowledge on pest management have caused widespread pesticide pollution which is now posing a substantial threat to the environment and local people. In this review, we assessed and analyzed previous literature systematically to map a complete scenario of pesticide pollution in Bangladesh, covering soil, water, and foods. Most of the previous studies indicated that soil, water, and different seasonal vegetables are contaminated with organophosphorus, pyrethoid and exceeded the FAO/WHO maximum residual limits. But the persistence of organochlorines in the environment is limited and meets the maximum residue level (MRLs). The study will help in formulating a predictive model on pesticide efficacy and cutting off the exacerbation of pesticide pollution. Regular monitoring along with the educational program for farmers is essential to limit the pesticide pollution load in the environmental matrices.

KEYWORDS: Pesticides, Environmental pollution, Overdose, Residue, Soil, Vegetables, Water.

1. INTRODUCTION

Environmental contamination by pesticides is a concern worldwide, and pesticide is a chemical hazard responsible for food adulteration. Pesticides refer to insecticides, fungicides, herbicides, disinfectants, and any other substance or mixture of substances intended for preventing, destroying, or controlling any pest that causes harm during cultivation or interfering with production, processing, storage, transport, or marketing of food [1]. Bangladesh has to feed a large population from its small landscape, so pesticides are used extensively in Bangladesh to combat the rapid multiplication of pests and avoid crop loss.

Farmers use pesticides during harvesting and before distribution to the market. Pesticides are extensively misused in Bangladesh due to the high demand for crops, growth of newly introduced high-yielding crops, incompetent labeling, and limited knowledge of farmers [2,3,4]. Farmers are immediate victims of these dangerous substances as most of them do not even care about reading the labels or wearing protective gears while applying pesticides in fields. The cultivators depend on chemical pesticides due to the insufficiency of competent alternatives to pesticides and safer pest management. Currently, about 84 pesticides are registered with 242 trade names in Bangladesh [5]. Bangladesh had imported 15,106 tons of active ingredients to formulate 37,187 tons of pesticides in 2017, which was 6% higher than the immediately previous year [6].

Crop production, pesticides, and environmental issues are closely related as leftover pesticide residue might persist in the environment. Pesticide residues have been detected in various metrics (soil, water, air), and their discarded residues in food produce an adverse effect when the concentration exceeds the maximum permissible limit. When pesticides enter into the soil, they may be taken up by the plants' roots, while it has the potential to spread toxicity to plants, their products and contaminate the food chain. People are concerned about the quality of surface and groundwater due to the increasing reliance on groundwater for irrigation and drinking water. Groundwater covers 68% of irrigation of cultivating land in Bangladesh because of its technical and cost benefits. Surface runoffs from agriculture fields, industrial effluent are the prime sources of surface water pollution. The surface water quality is also deteriorating for the disposal of untreated wastewater and saline drainage effluent from agricultural areas [7]. Pesticides and agrochemicals reach the groundwater from the land surface through leaching, percolation, surface runoffs, and thus coupling the intensity of drinking water scarcity and environmental contamination.

Nowadays, the dietary pattern is changing from traditional foods to high-value food commodities like vegetables, spinach, fruits, etc. About 100 types of vegetables comprising both local and exotic are grown in Bangladesh [8], and vegetable production has increased five times over the past 40 years [1]. In the first decade of this century, toxic pesticide consumption in agriculture has increased tremendously. Pesticide residues in foods and vegetables result from the direct application of pesticides in the field and indirectly from the remaining pesticide in the soil [9]. The problem becomes compounded when misuse of pesticides coupled with illiteracy and a low level of awareness on the toxicity of pesticides to health [10]. Consumers might take an uncontrolled level of pesticides residues unknowingly with food and vegetables leading to severe health complexity [11]. Therefore, soil, food, and other environmental samples require intensive monitoring for pesticide residues. Already, remnant pesticide residue of food and environmental samples in Bangladesh has received worldwide attention, but no review dedicated to pesticide residues has been found. So, the health or environmental impacts of pesticides were never studied robustly in Bangladesh. However, to the best of our knowledge, there exists no comprehensive review which covers all existing data of pesticide residues in soil, water, and vegetable samples collected from different parts of the country. This paper aims to summarize the results of those studies systematically to evaluate the pesticide pollution status in recent decades and predicts the real picture of pesticide contamination in Bangladesh. Based on these data major pathways of local people to pesticide exposure are denoted which help government and environmental researchers understand the status of pesticide pollution while planning for preventive measures to cut down environmental pollution.

2. PESTICIDES POLLUTION TO SOIL AND ITS IMPACT

Once being applied onto agricultural crops or directly to the soil, pesticide may be washed off by irrigation or rain water and reaches to nearby surface water through surface runoff, volatilization to the atmosphere and percolates through the soil to groundwater (Fig. 1). Pesticide undergoes number of degradation, transport and adsorption/desorption process in soil. Incorrectly applied pesticide interacts adversely with the natural essential micro-organisms like predators and parasitoids [12]. Pesticides also affect pollinators

negatively which are prerequisite for crop production. Inappropriately applied pesticide inhibits soils' microbial proliferation, affects enzymatic behaviour and biological reactions including nitrogen fixation, redox, methanogenesis and ammonification [13]. These alterations of soils' microbes and biomass disturb soil ecosystem and eventually the soil loses its fertility. In the same way, excessive applications of pesticide demineralize soil organic substance which is the key to soil fertility and productivity [14].

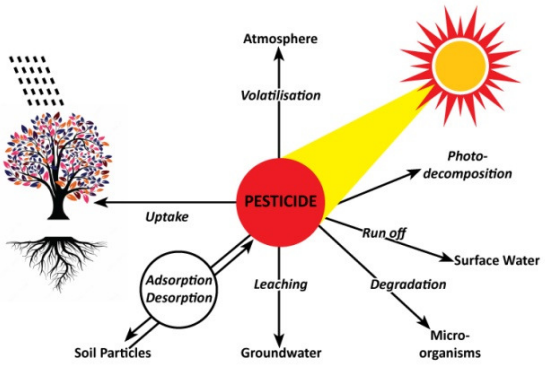

Figure 1: Fate of pesticide in the environment

In Bangladesh, farmers apply synthetic pesticides repeatedly with 8-10 times higher dosages than recommendation [15] which aggravate soils' pesticide accumulation capacity and degrade fertility. Farmers mostly use organophosphorus and carbamate pesticides in Bangladesh as the organochlorinated pesticides have been banned in 1993 [16] due to its persistent and easily bioaccumulation nature and toxicity to wildlife and humans [17]. A total of 40% soil sediment samples, collected from pond and canal of Lakshmipur district, found contaminated with organophosphorus and carbamate pesticides but no trace of organochlorines are detected [18]. This excessive amount of pesticides contamination is caused chiefly by the farmers for their absence of adequate knowledge and proper instruction on pesticides usages [19]. Organophosphorus pesticides exposure disrupts humans' reproductive health, interferes sperm chromosome segregation, and increase the risk for genetic syndrome [20]. [21] Analyzed nine vegetables and paddy field soil samples and found two samples contained organochlorines, namely DDT and DDE ranging from 0-0.726 and 0.404-0.563 μ g/kg, respectively, though these were banned. A remnant of organochlorines is a great concern but its elevated concentrations have not yet detected in agricultural soil in Bangladesh. Pesticides washed down to nearby canals, tributaries, rivers and finally find their way into the coastal area [22], and it was reported that 25% used pesticides in Bangladesh might pollute the sea [23]. Marine sediments of Chittagong coast are found slightly contaminated by organochlorines [24], but soil of Sonagazi, Feni found free of DDT and its metabolites DDD and DDE which indicates growing awareness of the coastal people against its harmful effects [25].

Table 1: Pesticide pollution in soil (μg/L)

Sampling Time/ Sample Number	City	Sampling site	Organophosphorus pesticide			Carbamate pesticide		Reference
			Chlorpyrifos	Diazinon	Malathion	Carbofuran	Carbaryl	
August, 2016/	Sadar upazila, Lakshmipur	Soil samples of ponds	ND	0.147-0.759	ND	0.167-1.851	1.047-.0998	[18]
		Soil samples of canals	ND	0.222	ND	1.069-1.732	ND	
/21	Sonagazi upazila, Feni	Soil samples from vegetable and paddy field	ND	0.01 – 0.235	ND	3.08-3.21	0.381-2.52	[25]
/9	Narsingdi	High land vegetables and low land paddy field	BDL	BDL	BDL	BDL	BDL	[21]
/10	All over Bangladesh	Selected soil samples	ND			ND	ND	[26]

3. PESTICIDES POLLUTION OF WATER AND ITS IMPACT

Water is considered the primary route of environmental pollution and water contamination by pesticides, well documented worldwide, poses a major concern in local, regional and global scale [19]. After application of pesticide in fields, gardens, parks, and other places, a percentage of pesticide is degraded by the soil microorganisms and a fraction moves to the surface and ground water obligatorily [27]. Pesticide residues are transported to the nearby surface water body through agricultural and rain water runoff, leaching and careless disposal of empty containers and washing etc. Eventually this runoff moves in streams, lakes and rivers posing critical source of contamination by pesticides [28]. The amount of pesticides moves with the runoff depends on several factors including soil type, topography, rainfall, agricultural practices, and chemical and environmental properties of the individual pesticide [29]. Sometimes, higher water flow due to incompactness of soil and increased solubility of pesticides conveys more toxicity to surface water. Moreover, if the pesticide is resistant enough to degradation and sufficiently soluble in water, it trend to move to surface water in greater amount. Heavy and sustained rainfall causes water movement in the soil. Runoff immediately after application has been considered to be the major source of pesticides in water bodies [30].

In Bangladesh, government promotes farmers for widely cultivated high yielding varieties to achieve food independency. The high-yielding crops are more vulnerable to pest and diseases [31] and irrigation water quality affects the high-yielding crops. Thus optimal harvesting inputs including quality irrigation water need to be kept for quality production [32]. Rice is the staple food here and it mainly grows in winter along with other seasonal vegetables. Eighty different insects outbreak were reported in this period. About 70% of the total pesticides are used in rice cultivation to ensure food securities. Farmers spray verities of harmful pesticide excessively which remain in the paddy field and are drained to the nearby canal, lake and river. Agriculture extension service was very limited (3.6%) in Bangladesh while majority (60.6%) of the rice cultivators sprayed pesticides without counseling with agriculture officer [33] and 69.16% of them sought advice from dealers or retail sellers[27]. Organophosphorus and carbamate pesticides are widely used in paddy field [11] along with some synthetic pyrethoids. [34] Found 48% sample water, collected from Sonagazi upazila, contaminated with organophosphorus and carbamate pesticides and higher concentration of diazinon and chlorpyriphos than Malaysia and USA. Between 2009 to 2010 rice cultivators of Ghior upazila of Manikganj district were found to use mostly organophosphorus pesticides namely Dioxathion, Diazinon, Chlorpyriphos, Malathion, and fewer extent of pyrethoids, and carbamate pesticides [19]. [19] Analyzed paddy field and Kaliganga water samples of Ghior upazila and detected the presence of chlorpyriphos, diazinon and cypermethrin. Diazinon was not found in Kaliganga river water (Table 2) and the presences of pesticide residues in river water were below the maximum residue limit (MRL) value of drinking water proposed by FAO/WHO Codex Alimentarius Commission. Organophosphorus pesticides degrade quickly in between 1-2 weeks [35], thus the accurate concentration of pesticides in water is more than the detected value. Besides, water sample collected in autumn had more time to degrade pesticides than in monsoon when rain washed away the pesticides to the nearby ditch. Water sample collected in the dry season from a lake, adjacent to the agricultural field in Savar, found fenitrothion, parathion, fenthion but their concentration was below the detection limit [36]. However pond water had higher pesticides residues than lake or canal water in Bangladesh. Excessive use of pesticides in fish farming might be a cause for that [37]. Cypermethrin is a synthetic pesticide which absorbs in sediments and causes long term aquatic pollution [38]. Major sources of cypermethrin include agricultural and urban runoff from rainstorms, spraydift, and release of agricultural trail waters [39]. 95% paddy field water of Manikganj sadar upazila found contaminated with cypermethrin [19], and cypermethrin level in the water samples of agriculture field ranged from 54.36-80.5$\mu g/L$ in Savar upazila [40].

Ground water covers 80% drinking water demand in rural area and 95% in Dhaka city [8]. Some pesticides are not taken up by the plants, adsorbed by soil or broken down by soil microorganisms or chemical reactions, and eventually leach to the groundwater contaminating drinking water source. The leaching of pesticides depends upon the nature of soil, depth to groundwater, chemical properties of pesticide, and the amount and timing of precipitation or irrigation. During heavy rainfall or in sandy soils pesticides move faster through the ground. Malathion concentration in tubewell water sample was lower (4-56 ppm) in Taraganj [41], because the sample was collected in the dry season when the water bearing aquifers went down. But in the recent years underground water in Bangladesh has been found to be free from the organophosphorus and carbamate pesticides (Table 2).

Despite the prohibition of organochlorines, organochlorinated pesticides were found in various matrices in surface water. [16] Detected 19.6$\mu g/L$ of DDT in the surface water sample collected from Begumganj, Bangladesh. Presences of organochlorines were detected in the range of 0.20 to 6.95 $\mu g/L$ in Meghna-Dhangoda irrigation canal water [42], indicating the limit of detection varies from region to region. Irrigated water of sixteen different districts found contaminated by the organochlorines in different levels (Table 3). This was a huge threat for drinking water quality as this pesticide could reach to ground water through leaching, percolating and direct drift. But in the recent year's agriculture field and adjacent pond water found free of organochlorines [36,41,43,44]. Most importantly drinking water of different locations in Bangladesh were found below the detection limit or free from the organoclorinated pesticides [41,43-45].

Table 2: Pesticides pollution in water (μg/L)

Sampling Time/ Sample Number	City	Source of water	Organophosphorus pesticide			Carbamate pesticide		Reference
			Chlorpyrifos	Diazinon	Malathion	Carbofuran	Carbaryl	
October 2009/ 25	Taraganj upazila, Rangpur	Tubewell	ND	ND	4-5.6	NA	NA	[41]
		pond	ND	ND	2-6.4	NA	NA	
		paddy field	ND	ND	1-2.21	NA	NA	
/ 25	Sonagazi upazila, Feni	Irrigation canal	ND	0.336-0.488	ND	0.546	0.095-0.714	[34]
		Fishing pond	ND	0.320-0.631	ND	0.684-4.820	0.149	
February to March 2012/ 12	Savar upazila, Dhaka	Lakes adjacent to agricultural field	3.27-9.31	7.86	23.1-59.9	43.2	4.6-6.3	[40]
/ 30	Dhamrai upazila, Dhaka	Fish pond	ND	31.5	261.6-922.8	ND	ND	[43]
		Cultivated land	ND	ND	475.36	ND	ND	
		Tubewell	ND	ND	42.58	ND	ND	
May to July 2009/ 27	Savar and Dhamrai upazila, Dhaka	Paddy and vegetable field	ND	0.9	105.2	105.2-198.7	14.1-18.1	[10]
/21	Ghior and sadar upazila, Manikganj	Paddy field	0.06 ± 0.001	0.039 ± 0.002	NA	NA	NA	[19]
		Kaliganga river water	0.012 ± 0.0006	ND	NA	NA	NA	

Sampling Time/ Sample Number	City	Source of water	Organophosphorus pesticide			Carbamate pesticide		Reference
			Chlorpyrifos	Diazinon	Malathion	Carbofuran	Carbaryl	
/40	Nagarpur upazila, Tangail Saturia upazila, Manikganj	Pond	BDL	4.11-257.91	84.64	NA	BDL	[44]
		Paddy field	37.3	8.03-134.95	BDL	NA	BDL	
		Tubewell	ND	ND	ND	NA	ND	
/25	Nabinagar upazila, Brahmanbaria	Pond of five union	ND	ND	24.1-46.3	30.2-62.9	ND	[46]
/20	Meherpur	pond	10-47.1	33-79	ND	0.0143-0.0387	ND	[47]
May to July, 2010/ 29	Pirgacha upazila, Rangpur	Paddy field	0-1.189	NA	NA	0-3.395	0-0.163	[11]
		Lakes	0.544-0.895	NA	NA	0.949-1.671	0-0.195	
/30	Daudkandi upazila, Comilla	Pond	31	651	1000-6200	NA	NA	[45]
		Ditch	BDL	BDL	1000-8200			
		Tubewell	BDL	BDL	BDL			
May, 2011	Jamalpur and Gazipur	Paddy field	NA	300-1260	NA	ND	1800	[48]

Sampling Time/ Sample Number	City	Source of sample	Organochlorinated pesticide							Reference
			Aldrin	Dieldrin	DDE	DDT	Endrin	Lindane	Heptachlor	
June to August, 2011/25	Feni Sadar	Irrigated water	ND	ND	ND	4.16	ND	ND	ND	[49]
	Nawabganj sadar		ND	ND	ND	3.01	ND	ND	ND	
	Putia, Rajshahi		ND	ND	ND	0.133	ND	ND	ND	
	Natore Sadar		ND	ND	ND	NA	ND	ND	5.24	
	Burichang, Comilla		ND	ND	4.06	8.29	ND	ND	ND	
	Sikderpara, Bandarban		ND	ND	ND	NA	ND	ND	5.08	
	Chatak, Sunamganj		ND	ND	ND	5.6	ND	ND	5.04	
	Rajoir, Madaripur		ND	ND	ND	NA	ND	ND	5.14	
October to March, 2005-2006/48	Savar, Dhaka	Irrigated water	ND	ND	NA	ND	ND	1.8235	0.243	[50]
	Hazrapur, Magura		ND	ND	NA	ND	ND	ND	0.109	
	Gopalgng, Sylhet		ND	ND	NA	ND	ND	0.4385	ND	
	Chadpur, Rajbari		ND	ND	NA	0.1149	ND	ND	ND	
	Jajira, Shariatpur		ND	ND	NA	ND	ND	ND	1.5929	
	Bogura Sadar, Bogura		ND	ND	NA	0.5401	ND	ND	ND	
	Bahadurpur, Noakhali		ND	ND	NA	ND	ND	0.2482	ND	
	Halishahar, Chattrogram		ND	ND	NA	ND	ND	ND	0.1214	

4. PESTICIDES POLLUTION TO VEGETABLES AND ITS IMPACT

Pesticides are widely applied during cultivation, vegetation and postharvest storage to increase quantity and quality of crops and to control many diseases transmitted by insects [51]. In Bangladesh, pest infestation is the main obstacle to increase vegetable production and farmers use chemical pesticides daily or each alternative day to protect their vegetable crop [15]. A major portion of these pesticides are intercepted by the plants leaves and roots during and after application. [52] Have demonstrated that vegetable absorbed pesticide internally which can create adverse effect as they are consumed by human and animals. In Chuadanga, brinjal plant was treated with cartap to minimize pest infestation, in return brinjal samples were found contaminated of cartap residue which was above MRL [53]. However, farmers apply pesticide extensively as they are unaware about the fact of pesticide residues in finished crops, even they don't know dosage and period of pesticides application. These are the root cause of pesticide residue problems [54]. In the name of crop productivity, Bangladesh has an unplanned pesticide mechanism and exercising rampant overdosing in the field [55]. Vegetables like brinjal, cauliflower, country bean, cabbage, potatoes, bitter gourd, and lady's finger receive higher doses of pesticides. Most of the farmers lack sufficient knowledge and perception on the chemical nature of the pesticide and their effect on health by consuming left over pesticide residues. Moreover, calcium carbide, oxytocin are added for artificial ripening of immature fruits and vegetables in the southern part of Bangladesh [56]. Therefore presence of pesticides residues in vegetable poses serious concern as these is consumed fresh [57].

Excessive pesticide utilization with time in vegetables has been manifested in the increased concentration of their left over residues in vegetable samples. Some vegetable samples (brinjal, yard long bean, bitter gourd, snake gourd, pointed gourd, okra, tomato, hyacinth bean and cabbage) were collected between 2010 to 2011 from several district of Bangladesh and 21.8% were tested contaminated, in which 18.26% were above the MRL [58]. [59] Detected pesticide residue in 27.4% sample vegetable (country bean, green chili, tomato, eggplants, red amaranth) of which 89.2% exceeded MRL. This is due to the famer's dependency on organophosphorus, carbamate and pyrethoid pesticides and lack of bio-pesticides. Though chlorinated pesticides are restricted in Bangladesh due to their spread occurrence, persistence, bio-accumulation and toxicity to humans, some vegetables (potato, tomato, red amaranth and spinach) of Dhaka new market revealed contaminated with chlorine compounds [60]. Later experiments found vegetables unadulterated from organochlorines, its metabolites [59,61] and carbamate pesticides [61]. Sometimes pesticides might be converted to their metabolites; hence they remain below the detection limit. Short soil degradation time of fenitrothion (4 days) and dimethoate (7 days) contribute to their relatively lower residue level in tomato and eggplant of Narayangonj district; on the contrary diazinon was the most detected pesticide due to its relatively high soil degradation time (40 days) and low water solubility [63]. But farmers don't let the pesticides degrade or wash away before harvesting for sale. 18.60 to 29 percent farmers of Narsingdi and Gazipur district sold their harvested country bean, eggplant and cauliflower after 3-4 days of pesticide application where 8.33 to 16.67 percent sold after 5-7 days of

pesticides application [64]. Quinalphos, fenitrothion, acephate concentration in cauliflower exceeded MRL after 7 days of spraying; diazinon and cypermethrin after 5 days, and Malathion after 3 days of spraying [65]. Lack of proper guidance and education on pesticide application may be another cause of high percentage of vegetables having higher pesticide residues. For better productivity farmers used “cocktail” (mixture of 3-5 pesticides) in Jessore at daily or every alternative day [66]. This type of whimsical and injudicious use of pesticides results in the presence of multiresidue in vegetable. Acephate was detected as multiple products with chlorpyrifos in two sample of snake gourd from Narsingdi which were above MRL, and the detected multiresidue (chlorpyrifos and quinalphos) level in brinjal and snake gourd of Jessore were also above MRL. About 23.53% contaminated brinjal and tomato samples of Narayangonj district found to have multiple residues [63]. [67] Collected 210 samples of eight different vegetables from different region of Bangladesh and revealed 10.47% vegetables contained multiple residues.

Exposure to pesticide residue *via* dietary ingestion of contaminated food products causes a spectrum of health complexities that varies with the nature of pesticide and duration of exposure [68]. Symptoms of exposure to organophosphorus such as diazinon, dimethoate, fenitrothion, parathion and chlorpyrifos include meiosis, urination, diarrhea, excitation, irritation, salvation [69]. Exposure to carbofuran and carbamate leads to overstimulation of the nervous system. Symptoms of overexposure to carbofuran include headache, blurred vision, nausea, abdominal cramp, tremor, coma, and convulsion [70]. Farmers and workers in Bangladesh spray pesticides in the crop field without taking proper protection are mostly vulnerable to pesticide exposure. About 20% user wear only partial protective clothing and 6.7% don’t take any protective measure in Chittagong [2] where as 40% workers reported to feel bad headache and vomiting tendency after long time exposure with pesticides [15]. About two third pesticide users are suffering from dermal problems including skin diseases, eye irritation, itching; 63% pesticide exposed people suffering from eye problems; and 85% operators suffering from stomach, indigestion problem, loss of appetite, vomiting during or after pesticide application [2]. Washing, peeling and cooking removes extent of pesticides from vegetables. But studies indicated that these were not enough to reduce the residue level below MRL. Several methods including advanced oxidation, UV photolysis, photo catalysis (Hydrogen peroxide and ozone) and radiolysis of water can be used for the removal of various classes of pollutant from the environmental samples. Despite food safety concern, gamma irradiation is one of the popular technologies in food industry for the preservation of fruits and vegetables, and to reduce pathogenic microbes.

Table-3: Pesticides vegetable contamination

Sampling Time/ Sample Number	Sampling site	Vegetables	Name of pesticides detected	Residue level (mg/kg)	MRL (mg/kg)	Contaminated sample (%)	Samples exceeding MRL (%)	Reference
September 2009 to October 2012/210	Dhaka, Narayangonj, Comilla, Mymensingh, Kushtia, Rajshahi, Faridpur, Chittagong, Jessore and Sylhet (Middle to southern part of Bangladesh)	Eggplant	Malathion	0.008-0.040	0.02	3	1	[67]
			Carbofuran	0.005-0.050	0.020	3	2	
			Diazinon	0.005-0.700	0.010	4	1	
		Tomato	Chlorpyrifos	0.040-0.70	0.50	5	2	
			Malathion	0.010-0.060	0.020	2	1	
			Phenthoate	0.040	NE	1	-	
			Carbofuran	0.004-0.050	0.020	4	3	
		Cauliflower	Chlorpyrifos	0.62-0.080	0.50	2	2	
			Carbaryl	0.020-0.10	0.050	4	2	
		Cabbage	Endosulfan	0.010-0.120	0.050	3	1	
			Carbofuran	0.013-1.0	0.020	5	3	
		Potatoes	Diazinon	0.013-0.240	0.010	3	3	
			Endosulfan	0.070-0.20	0.050	3	3	
			Carbaryl	0.012-0.30	0.050	3	1	
			Dimethoate	0.031-0.140	0.020	2	2	
		Cucumber	Chlorpyrifos	0.018-0.270	0.050	6	3	
			Carbaryl	0.020-0.30	0.050	4	3	
			Diazinon	0.007-0.060	0.010	4	2	
		Carrot	Fenvalerate	0.011-0.060	0.020	3	1	
			Chlorpyrifos	0.030-0.40	0.10	7	3	
/72	Comilla, Bogura, Rangpur, Rajshahi, Khagrachari, Cox's Bazar, Barisal, Jamalpur, Dhaka	Hyacinth bean	Dimethoate	0.192-0.961	0.01	6	6	[71]
			Chlorpyrifos	0.082	0.05	2	2	
		Brinjal	Dimethoate	0.032-0.217	0.01	2	2	
			Quinalphos	0.081	0.01	1	1	
June, 2019/ 65	Seven retail markets adjacent to Jahangirnagar University, Savar, Dhaka	Bitter gourd	Chlorpyrifos	0.023-0.159	0.01	6	6	[72]
			Diazinon	0.058-0.101	0.01	4	4	
			Dimethoate	0.062-0.095	0.01	3	3	
/10	Kapasia, kaligonj Upazila, Gazipur	Brinjal	Acephate	0.19	0.02	1	1	[61]
			Fenitrothion	0.166	0.01	1	1	
		Lady's finger	Fenitrothion	0.17	0.01	1	1	
			Ethion	1.8	0.01	1	1	

Sampling Time/ Total Sample Number	Sampling site	Vegetables / Sample number	Name of pesticides detected	Residue level (mg/kg)	MRL (mg/kg)	Contaminated sample (%)	Samples exceeding MRL (%)	Reference
January to June, 2011/ 42	Gazipur, Narsingdi	Eggplant/ 16	Fenvalerate	0.09	0.02	1	1	[64]
			Diazinon	0.035-0.708	0.01	10	10	
			Quinalphos	0.016-0.344	0.01	5	5	
			Malathion	0.014-0.630	0.02	11	8	
			Cypermethrin	0.077-0.531	0.5	2	1	
		Country bean/ 18	Malathion	0.014-0.082	0.02	7	6	
			Fenvalerate	0.116-0.804	0.02	5	5	
			Diazinon	0.054-0.789	0.01	8	8	
			Quinalphos	0.012-0.287	0.01	7	7	
			Fenitrothion	0.027	0.01	1	1	
		Cauliflower / 8	Malathion	0.043-0.655	0.02	4	4	
			Diazinon	0.093-0.156	0.01	4	4	
			Quinalphos	0.026-0.033	0.01	4	4	
March to December, 2011/140	Rupgonj, Sonargaon, Arihajar upazila, Narayangonj	Eggplant/ 10	Diazinon	0.453-4.514	0.01	2	2	[63]
			Linuron	0.657-1.073	0.05	2	2	
			Dimethoate	1.806	0.02	1	1	
		Tomato/ 10	Carbofuran	0.673	0.02	1	1	
			Diazinon	1.88-3.612	0.01	4	4	
			Fenitrothion	0.657-1.88	0.01	2	2	
			Parathion	0.116	0.05	1	1	
/16	Markets in Gulshan-2 area, Dhaka	Eggplant/ 16	Dimethoate	0.183	0.02	1	1	[62]
			Phenthoate	0.311-0.077	0.01	2	2	
			Carbofuran	1.86	0.02	1	1	
June, 2019/ 78	Seven retail markets adjacent to Jahangirnagar University, Savar, Dhaka	Eggplant/ 78	Diazinon	0.045-0.059	0.01	4	4	[73]
			Chlorpyrifos	0.043-0.049	0.05	3	-	
			Dimethoate	0.048-0.058	0.02	2	2	
January to September, 2016/50	Five different markets of Dhaka city	Country bean/ 50	Dimethoate	0.009-0.120	0.02	8	3	[74]
			Quinalphos	0.033-0.045	0.01	2	2	
December 2015 to January 2016/50	Ten markets of Mymensingh sadar, Mymensingh	Eggplant/ 50	Diazinon	0.014-0.023	0.01	3	3	[75]
			Dimethoate	0.054-0.109	0.02	2	2	
			Chlorpyrifos	0.045-1.617	0.05	7	6	
			Quinalphos	0.018-0.363	0.01	2	1	
January to June, 2006/ 18	Different region of Bangladesh	Tomato/ 18	Chlorpyrifos	0.107-0.342	0.5	4	-	[76]
			Diazinon	0.31-0.381	0.01	4	4	
			Carbaryl	0.1-0.32	0.05	4	4	

Sampling Time/ Total Sample Number	Sampling site	Vegetables / Sample number	Name of pesticides detected	Residue level (mg/kg)	MRL (mg/kg)	Contaminated sample (%)	Samples exceeding MRL (%)	Reference
2011 t0 2012 seasons/ 170	Jessore, Comilla, Narsingdi, Tangail, Rangpur, Gazipur, Jamalpur, Dhaka	Brinjal/30	Quinalphos	0.069-0.326	0.01	2	2	[58]
			Chlorpyrifos	0.420-0.445	0.05	2	2	
		Hyacinth bean/15	Chlorpyrifos	0.196-0.407	0.05	2	2	
			Quinalphos	0.260	0.01	1	1	
		Cabbage/6	Quinalphos	0.098-0.143	0.01	2	2	
			Chlorpyrifos	0.063-0.406	0.05	2	2	
		Bitter gourd/20	Chlorpyrifos	0.094-0.441	0.05	5	5	
			Quinalphos	0.065-0.226	0.01	4	4	
		Pointed gourd/10	Chlorpyrifos	0.267-0.302	0.05	2	2	
		Snake gourd/23	Chlorpyrifos	0.035-0.120	0.05	3	2	
			Acephate	0.066-0.236	0.01	2	2	
			Quinalphos	0.094	0.01	1	1	
		Long Yard bean/16	Chlorpyrifos	0.368	0.05	1	1	
			Quinalphos	0.096-0.247	0.01	3	3	
			Cypermethrin	0.563	0.5	1	1	
/15	Savar bazar, Dhaka	Tomato/5	Malathion	0.33	0.02	1	1	[40]
			Parathion	0.31	0.05	1	1	
			Carbaryl	1.6	0.5	1	1	
		Lady's finger/5	Chlorpyrifos	0.14	0.5	1	-	
			Fenitrothion	0.19	0.01	1	1	
			Ethion	0.98	0.01	1	1	
/135	Bogura, Dhaka, Khulna, Gopalgonj, Jessore, Kishoregonj, Natore, Rajshahi, Mymensingh, Narail, Satkhira	Country bean/ 27	Dimethoate	ND-0.424	0.05	9	8	[59]
			Chlorpyrifos	ND-0.064	0.05	2		
		Green chili/27	Dimethoate	ND-0.201	0.05	9	7	
		Tomato/27	Quinalphos	ND-0.321	0.01	4	3	
		Eggplant/ 27	Quinalphos	ND-0.128	0.01	12	12	
		Red amaranth/ 27	Chlorpyrifos	ND-1.535	0.05	3	3	
Winter season/ 12	Four vegetable market of Dhaka city	Brinjal/ 4	Acephate	0.27	0.01	1	1	[77]
			Parathion	0.32	0.05	1	1	
		Tomato/4	Parathion	0.23	0.05	1	1	
			Carbaryl	1.52	0.5	1	1	
		Lady's finger/ 4	Ethion	1.76	0.01	1	1	
			Fenitrothion	0.13	0.01	1	1	

Sampling Time/ Total Sample Number	Sampling site	Vegetables / Sample number	Name of pesticides detected	Residue level (mg/kg)	MRL (mg/kg)	Contaminated sample (%)	Samples exceeding MRL (%)	Reference
September 24, 2017 to April 21, 2018/ 30	Kawran bazar and Jatrabari bazar, Dhaka. Khetlal bazar, Joypurhat. Jessore sadar bazar. Mithapukur bazar, Rangpur. Narsingdi sadar bazar	Brinjal/ 5	Quinalphos	0.020-0.325	0.01	3	3	[78]
		Country bean/ 5	Dimethoate	0.386-0.449	0.05	2	2	
		Tomato/ 5	Quinalphos	0.085	0.01	1	1	

5. CONCLUTION

The study demonstrates a correlation between pesticides management and impacts on environmental contents. Several studies showed that chronic exposure to pesticides has been linked to a range of diseases and conditions that certain pesticides can persist in the environment for decades posing threat to the entire ecological system on which food production depends. As the pesticide operators care the least about the health and ecological risks; excessive use of pesticides by farmers contaminates soil, water, and food causing loss of biodiversity and destroying the natural enemies of pests. Many shreds of evidence showed that pesticide impacts strongly involve their agro-ecosystem scale and it requires the development of appropriately scaled monitoring or experimental systems. The regulatory body should set experimental database from the combination of knowledge about chemical properties, fate, and behaviour of pesticide and establish a predictive model indicating on how a pesticide will behave in a given set of soil conditions. To reduce of pesticide pollution, the authority should arrange workshops and training for the sellers and applicators informing them about the health effects, environmental concerns, and the importance of a greener agro-ecosystem.

Consent

It is not applicable.

Ethical Approval

It is not applicable.

References

1. Roser, M. *Pesticides,* Our World in Data. 2019. Accessed 12 August 2021.
Available: https://ourworldindata.org/pesticides

2. Miah, S., Hoque, A., Paul, D., & Rahman, D. Unsafe Use of Pesticide and Its Impact on Health of Farmers: A Case Study in Burichong Upazila, Bangladesh, *IOSR Journal of Environmental Science, Toxicology and Food Technology. 2014;8*(1):57-67.

3. Shammi, M., Sultana, A., Hasan, N., Rahman, M., Islam, M., Bodrud-Doza, M., et al. Pesticide exposures towards health and environmental hazard in Bangladesh: A case study on farmers' perception, Journal of the Saudi Society of Agricultural Sciences. 2020;19:161-173.

4. Lekei, E. E., Ngowi, A. V., & London, L. Farmers' knowledge, practices and injuries associated with pesticide exposure in rural farming villages in Tanzania, *BMC public health. 2014;14:389*.

5. Pesticide Association of Bangladesh. *Pesticides consumption report for the year 1999/2000* Dhaka, Pesticide Association of Bangladesh. 2000

6. Imran Hossain, Hazardous pesticides in wide use in Bangladesh, The new age newspaper. 14 September 2018. Accessed 7 August 2021
Available:https://www.newagebd.net/article/50556/hazardous-pesticides-in-wide-use-in-bangladesh

7. Iram, S., Ahmad, I., & Ahad, K. Analysis of pesticides residues of Rawal and Simly lakes, *Pakisthan Journal of Botany. 2009;4:*1981-1987.

8. Banglapedia*, Water Resources*. 18 June 2021. Accessed 13 September 2021
Available: https://en.banglapedia.org/index.php/Water_Resources

9. Puri, P. Food safety assurance through regulation of agricultural pesticide use in India: perspectives and prospects*, Indian Journal of Life Science. 2014;3*(2):123-127.

10. Chowdhury, M. Z., Banik, S., Uddin, B., Moniruzzaman, M., Karim, N., & Gan, S. Organophosphorus and Carbamate Pesticide Residues Detected in Water Samples Collected from Paddy and Vegetable Fields of the Savar and Dhamrai Upazillas in Bangladesh, *Environmental R*esearch and Public Health. 2012*;9:*3318-3329.

11. Chowdhury, A., Jahan, S., Islam, M., Moniruzzaman, M., Alam, M., Zaman, M., et al. Occurrence of Organophosphorus and Carbamate Pesticide Residues in Surface Water Samples from the Rangpur District of Bangladesh*, Bulletin of Environmental Con*tamination and Toxicology. 2012*;89*:202-207.

12. Ware, G. W. Effect of pesticides on non-target organisms*, Residue Reviews. 1980;76*:173-201.

13. Hussain, S., Siddique, T., Saleem, M., Arshad, M., & Khalid, A. Impact of pesticides on soil microbial diversity, enzymes, and biochemical reactions, *Advances in Agronomy. 2009;102*:159-200.

14. Yadav, I. C., & Devi, N. L. Pesticides Classification and Its Impact on Human and Environment. In I. C. Yadav, & N. L. Devi*, Environmental Science and Engineering* (Vol. 6: Toxicology, pp. 140-158); 2017

15. Chowdhury, M., Rahman, M., Miaruddin, M., Khan, M., & Rahman, M. Assessment of pesticides and ripening chemicals used in selected vegetables at different locations of Bangladesh, *Bangladesh Journal of Agricultural research. 2019;45*(2):44(2),261-279.

16. Matin, M., Malek, M., Amin, M., Rahman, S., Khatoon, J., Rahman, M., et al. Organochlorine Insecticide Residues in Surface and Underground Water from Different Regions of Bangladesh, *Agriculture, E*cosystems and Environment. 199*8;69*:11-15.

17. Tanabe, S., Prudente, M. S., Kan-Atireklap, S., & Annamalai, S. Mussel watch: Marine pollution monitoring of butyltins and organochlorines in coastal waters of Thailand, Philippines and India, *Ocean and Coastal Management. 2000;43*:819-839.

18. Uddin, M., Chowdhury, N., Rahman, M., Rashid, M., Chowdhury, M. Z., & Fardous, Z. Identification and Quantification of Soil pesticides in Coastal Lakshmipur District of Bangladesh, *Journal of Asiatic Society Bangladesh. 2020;Science 46*(2):191-200.

19. Bhattacharjee, S., Fakhruddin, A., Chowdhury, M., Rahman, M., & Alam, M. Monitoring of Selected Pesticides Residue Levels in Water Samples of Paddy Fields and Removal of Cypermethrin and Chlorpyrifos Residues from Water Using Rice Bran, *Bulletin of Environmental Contamination and Toxicology. 2012;89*:348-353.

20. Recio, R., Robbins, W., Ocampo-Gómez, G., Borja-Aburto, V., Moran-Martinez, J., Froines, J., et al. Organophosphorous Pesticide Exposure Increases the Frequency of Sperm Sex Null Aneuploidy, *Environmental Health Perspectives. 2001;109*:12.

21. Uddin, M., Chowdhury, M., Fardous, Z., & Hasanuzzaman, M. Quantification of Pesticide Residues in Some Soils of Narshingdi Area, *Bangladesh Journal of Scientific Research. 2016;29*(1):85-88.

22. Islam, M., Khan, Y., & Choudhury, S. Effects of organophosphorous pesticides on the behavioral pattern and mortality of Apocryptes bato (Bellder, 1874), *Bangladesh Journal of Zoology. 2001;29*(2):151-157.

23. Khan, Y., & Talukdar, A. Pollution in coastal water of Bangladesh, *Journal of Naomi. 1993;10*:7-8.

24. Talukder, A. A., Khan, Y., & Begum, J. Organochlorine Insecticide Residues in Sediments from the Coast of Chittagong, Bangladesh*, Pakistan Journal of Marine Sciences. 1999;8*(1):21-27.

25. Uddin, M., Rahman, M., Nesha, M., Choudhury, M., Fardous, Z., & Rahman, M. Studies on Pesticide Residues in Soils of Some Selected Spots of Coastal Region of Bangladesh, *Nuclear Science and Applications. 2018;27*:1-2.

26. Rahman, M., Chowdhury, M., Rahman, M., & Hasanuzzaman, D. Pesticides Residues in Soils of Some Selected Spots of Bangladesh, *Journal of Asiatic Society of Bangladesh. 2006;32*(2):243-248.

27. Rahman, M., Awal, M., & Misbahuddin, M. Pesticide application and contamination of soil and drinking water, *Drinking Water Contaminants in Bangladesh*. 2020;90-131.

28. Phong, T. K., Yoshino, K., Hiramatsu, K., & Harada, M. Pesticide discharge and water management in a paddy catchment in Japan, *Paddy and Water Environment. 2010;8*:*361*-369.

29. Leonard, R. Movement of pesticides into surface waters, *Soil Science Society of America*. 1990;303-349.

30. Kreuger, J. Pesticides in Stream Water within an Agricultural catchment in southern Sweden, 1990–1996, *Science of the Total Environment.* 1998;*216*:227-251.

31. Ali, M., Sumon, K., Sultana, M., & Rashid, H. Toxicity of Cypermethrin on the Embryo and Larvae of Gangetic Mystus, Mystus Cavasius, *Environmental Science and Pollution Research. 2018;25*:3193-3199.

32. Islam, M., & Shamsad, S. Assessment of irrigation water quality of Bogra District in Bangladesh, *Bangladesh Journal of Agricultural Research. 2009;34*:507-608.

33. Bhattacharjee, S., Chowdhury, M., Fakhruddin, A., & Alam, M. Impacts of Pesticide Exposure on Paddy Farmers' Health, Jahangirnagar University Environmental Bulletin. 2013;2: 18-25.

34. Bhuiyan, M. H., Rahman, M., Uddin, M., Chowdhury, M., Rahman, M., Saha, B., et al. Contamination of pond and canal water by residues of organophosphorus and carbamate pesticides in Feni district, Bangladesh, *Environmental Sustainability. 2021;4*:191-197.

35. Barcelo, D., Garrigues, P., Lacorte, S., & Lartiges, S. Degradation of Organophosphorus Pesticides and their Transformation Products in Estuarine in Water, *Environmental Science and Technology. 1995;29*:431-438.

36. Hossain, M., Chowdhury, M. Z., Pramanik, M., Rahman, M., Fakhruddin, A., & Alam, M. Determination of selected pesticides in water samples adjacent to agricultural fields and removal of organophosphorus insecticide chlorpyrifos using soil bacterial isolates, *Applied Water Science. 2015;5*: 171-179.

37. Islam, S., & Bhuiyan, M. Impact Scenarios of Shrimp Farming in Coastal Region of Bangladesh: an Approach of an Ecological Model for Sustainable Management, *Aquaculture International. 2016; 24*(4):1163-1190.

38. Tomlin, C. *The e-Pesticide Manual, Version 5.1.* Surrey, UK: The British Crop Protection Council. 2010

39. Wang, D., Weston, D., & Lydy, M. Method Development for the Analysis of Organophosphate and Pyrethroid Insecticides at Low Parts per Trillion Levels in Water, *Talanta. 2009;78*:1345-1351.

40. Hossain, M., Fakhruddin, A., Alamgir Zaman Chowdhury, M., Rahman, M., & Khorshed Alam, M. Health Risk Assessment of Selected Pesticide Residues in Locally Produced Vegetables of Bangladesh*, International Food Research Journal. 2015; 22*(1):110-115.

41. Ara, A., Haque, W., & Hasanuzzaman, M. Detection of Organochlorine and Organophosphorus Pesticides Residues in Water Samples of Taragong Thana in Rangpur District in Bangladesh, *Research Journal of Environmental and Earth Sciences. 2014;6*(2):85-89.

42. Alam, M., Malek, M., Rahman, M., & Das, N. Organochlorine Insecticide Residues in Water and Soil of the Meghan Dhonagoda Irrigation Project of Bangladesh, *Journal of the Asiatic Society of Bangladesh. 1999;25*(1):135-142.

43. Hasanuzzaman, M., Rahman, M., & Salam, M. Identification and quantification of pesticide residues in water samples of Dhamrai Upazila, Bangladesh, *Applied Water Science. 2017;7*: 2681-2688.

44. Hasanuzzaman, M., Rahman, M., Islam, M., Salam, M., & Nabi, M. Pesticide residues analysis in water samples of Nagarpur and Saturia Upazila, Bangladesh, *Applied Water Sciences. 2018;8*:*8*.

45. Hasanuzzaman, M., Rahman, M., Sharkar, T., Haque, W., & Uddin, M. Study on Organochlorine and Organophosphorus Pesticide Residues in Surface and Underground Water Samples of Daudkandi Upazila in Bangladesh, *American-Eurasian Journal of Agricultural and Environmental Science. 2019;19*(4):271-278.

46. Uddin, M., Auwal, M., Chowdhury, M., Rahman, M., & Alam, M. Pesticides Residues in Some Pond Water Samples of Bangladesh, *Bangladesh Journal of Scientific Research. 2012;25*(1):93-98.

47. Uddin, M., Saha, M., Chowdhury, M., & Rahman, M. Pesticide Residue in Some Selected Pond Water Samples of Meherpur Region of Bangladesh, *Journal of the Asiatic Society of Bangladesh. 2013; 39*(1):77-82.

48. Shammi, M., Islam, M., Alamgir, M., & Sultana, A. Pesticide Contamination of Rice Field Agroecosystem: Hazard Perspectives of Surface Water Quality and Aquatic Lives from Gazipur District, Bangladesh, *Jahangirnagar University Environmental Bulletin. 2014;3*:xx-xx.

49. Chowdhury, A. Z., Islam, M., Moniruzzaman, M., Gan, S., & Alam, M. Organochlorine Insecticide Residues are found in Surface, Irrigated Water Samples from Several Districts in Bangladesh, *Bulletin of Environmental Contamination and Toxicology. 2013;90*:149-154.

50. Islam, M., Hoque, S., Chowdhury, M., Rahman, M., & Fardous, Z. Monitoring of Organochlorine Pesticide Residues in Surface Water Samples of the Agricultural Field of Bangladesh, *Journal of Subtropical Research Devision. 2007;5*(5):357-360.

51. Fenik, J., Tankiewicz, M., & Biziuk, M. Properties and determination of pesticides in fruits and vegetables, *Trends in Analytical Chemistry. 2011;30*:6.

52. Kumari, B. Effects of Household Processing on Reduction of Pesticides Residues in Vegetables, *ARPN Journal of Agricultural and Biological Science. 2008;3*:4.

53. Alam, M., Mondal, M., Paul, D., Samad, M., Mamun, M., & Chowdhury, M. Determination of Pesticide Residue (Cartap) in Brinjal, *Proceedings of the Pakistan Academy of Sciences. 2011;48*(2):89-93

54. Zhou, J., & Jin, A. Safety of Vegetable and the Use of Pesticides by Farmers' in China: Evidence from Zhejiang Province, *Food Control. 2009;20*(2):419-422.

55. Rahman, M., & Alam, M. Risk Assessment of Pesticides Used in Bangladesh, *Journal of Civil Engineering. 2007;25*(1):97-106.

56. Sultana, R., Ahmmed, R., Khan, M., Hoque, M., & Sabuj, A. Quality Analysis of Fruits, Vegetables and Fish Available in Local Market of Southern Districts in Bangladesh, *DUET Journal. 2018;4*(1):59-67.

57. Chen, C., Qian, Y., Chen, Q., Tao, C., Li, C., & Li, Y. Evaluation of pesticide residues in fruits and vegetables from Xiamen, China, *Food Control. 2011;22*:1114-1120.

58. Ahmed, M., Begum, A., Rahman, M., Akon, M., & Chowdhury, M. Extent of Insecticide Residue Load in Vegetables Grown under Conventional Farming in Bangladesh, *The Agriculturists. 2016;14*(2):38-47.

59. Rahman, M., Hoque, M., Bhowmik, S., Ferdousi, S., Kabiraz, M., & Brakel, M. Monitoring of Pesticide Residues from Fish Feed, Fish and Vegetables in Bangladesh by GC-MS Using the QuEChERS Method, *Heliyon. 2021;7*:e06390.

60. Chowdhury, M., Razzaque, M., & Khan, M. Chlorinated Pesticide Residue Status in Tomato, Potato and Carrot, *Journal of Experimental Sciences. 2011; 2*(1):1-5.

61. Chowdhury, A., Hasan, M., Karim, N., Fakhruddin, A., Hossain, S., Chowdhury, A., et al. Contamination and Health Risk Assessment of Pesticide Residues in Vegetables from Agricultural Fields of Gazipur District, Bangladesh, *American-Eurasian Journal of Agricultural and Environmental Science. 2014;14*(5):421-427.

62. Chowdhury, M. Z., Jahan, I., Karim, N., Alam, M., Rahman, M., Moniruzzaman, M., et al. Determination of Carbamate and Organophosphorus Pesticides in Vegetable Samples and the Efficiency of Gamma-Radiation in Their Removal, *BioMed Research International. 2014*;9.

63. Alam, M., Chowdhury, M. Z., Hossain, M., Rahman, M. M., Rahman, M., Gan, S. H., et al. Detection of Residual Levels and Associated Health Risk of Seven Pesticides in Fresh Eggplant and Tomato Samples from Narayangonj District, Bangladesh, *Journal of Chemistry. 2015*;7.

64. Islam, M., Dastogeer, K., Hamim, I., Prodhan, M., & Ashrafuzzaman, M. Detection and Quantification of Pesticide Residues in Selected Vegetables of Bangladesh, *Journal of Phytopathology and Pest Management. 2014;1*(2):17-30.

65. Ahmed, M., Sardar, M., Ahmad, M., & Kabir, K. Detection of the Amount of Residue Degradation Rate of Six Commonly Used Insecticides in Cauliflower under Supervised Field Trial, *Asian-Australasian Journal of Food Safety and Security. 2018;2*(2):109-114.

66. Rashid, M., Alam, S., Rouf, F., & Talekar, N. Socio- economic parameters of eggplant pest control in Jessore district of Bangladesh, *AVRDC Technical Bulletin*. 2003;1-54.

67. Chowdhury, M. Z., Fakhruddin, A., Islam, M., Moniruzzaman, M., Gan, S., & Alam, M. Detection of the residues of nineteen pesticides in fresh vegetable samples using gas chromatography mass spectrometry, *Food control. 2013;34*:457-465.

68. Gupta, R. Carbofuran Toxicity, *Journal of Toxicology and Environmental Health. 1994;43*(4):383–418.

69. Moore, P. *Children and Pollution: Why Scientists Disagree.* Oxford, UK: Oxford University Press. 2009.

70. Tenenbaum, D. Pesticides: Carbofuran under Review, *Environmental Health Perspectives. 2008;116*(10):A425.

71. Ahmed, M., Begum, A., Prodhan, M. D., & Sarker, D. Analysis of Pesticide Residue in Vegetables Collected from Nine Different Regions of Bangladesh Using Gas Chromatography, *Asian-Australasian Journal of Food Safety and Security. 2019;3*(1):23-26.

72. Islam, M., Prodhan, M. D., & Uddin, M. Analysis of the Pesticide Residues in Bitter Gourd Using Modified QuEChERS Extraction Coupled With Gas Chromatography, *Asia Pacific Environmental and Occupational Health Journal. 2019;5*(3):6-15.

73. Islam, M., Prodhan, M., & Uddin, M. Determination of Major Organophosphorous Pesticide Residues in Eggplant using Quechers Extraction and Gas Chromatography, *International Journal of Innovative Science and Research Technology. 2019;4*(8):212-219.

74. Hasan, R., Prodhan, M., Rahman, S., Khanom, R., & Ullah, A. Determination of Organophosphorus Insecticide Residues in Country Bean Collected from Different Markets of Dhaka, *Journal of Environmental & Analytical Toxicology. 2017;7*(4):489.

75. Aktar, M., Khatun, R., & Prodhan, M. Determination of Pesticide Residues in Eggplant Using Modified QuEChERS Extraction and Gas Chromatography, *International Journal of Agronomy and Agricultural Research. 2017;11*(2):22-31.

76. Fardous, Z., Islam, M., Hoque, S., Choudhury, M., & Rahman, M. Determination of Some Selected Pesticide Residues in Tomato from Different Locations of Bangladesh, *International Journal of Sustainable Education and Technology. 2007;3*(6):4-7.

77. Hossain, M., Hossain, M., Rahman, M., Islam, M., Rahman, M., & Adyel, T. Health Risk Assessment of Pesticide Residues via Dietary Intake of Market Vegetables from Dhaka, Bangladesh, *Foods. 2013;2*:350-351.

78. Hasan, M., & Rahman, M. Pesticide Residues In Selected Vegetable Collected From Wet Markets Of Bangladesh, *Advances in Social Sciences Research Journal. 2019;6*(5):15-23.