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Detection and quantification of pesticide residues in selected vegetables of Bangladesh

M. W. Islam[1], K. M. G. Dastogeer[1*], I. Hamim[1], M. D. H Prodhan[2], M. Ashrafuzzaman[1]

[1]Department of Plant Pathology, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh
[2]Entomology Division, Bangladesh Agricultural Research Institute, Gazipur Bangladesh

Abstract

A survey was conducted in intensive vegetable growing area in the Narsingdi district of Bangladesh regarding pesticides used by farmers on three major vegetables like eggplant, cauliflower, and country bean. On the basis of questionnaires, 23 farmers were interviewed and it was noted that fourteen pesticides belonging to different groups were found to be commonly used on the selected vegetables by the respondent farmers to control the major pests. In two selected locations of Narsinghdi 8.33 to 45.00 percent farmers were recorded to apply different pesticides every day and in some cases even twice in a day on vegetables. A total of 42 samples were collected from fields and markets and multiple pesticide residue analysis was done by Gas Chromatography (GC) with Flame Thermionized Detector (FTD) and Electron Capture Detector (ECD). Out of 42 samples, 27 had pesticide residue. Among these 27 samples, 14 samples had pesticide residues above the Maximum Residue Limit (MRL). The detected pesticides were Diazinon, Malathion, Quinalphos, Fenitrothion, Cypermethrin, Fenvalerate and Propiconazole.

Key words: detection, quantification, pesticide, residue, vegetables

Introduction

Pesticides are human-made and naturally occurring chemicals that control insects [Xiao et al., 2010; Clarke et al. 1997], weeds, fungi and other pests that destroy crops. Prudent use of pesticides considered by and large to be indispensable for controlling agricultural pests in order to enhance adequate food supply for the increasing world population. In a country like Bangladesh, the application of pesticides has become inevitable to uphold and improve the existing stage of harvest production by shielding the crop from pests. The climate of Bangladesh as being a subtropical, observes varying temperatures and humidity profile throughout the year, which brings a vast array of pests to be tackled. A number of pests are found to assault multiple objects (various crops) and have been attained resistance from the prolonging application of common pesticides. Presently, it is estimated that almost 45% of the world crops have been destroyed by plant pests and diseases. Therefore, to meet the demand, it is essential to apply pesticides to protect the crops, both during development and their consequent storage and transportation. Probably 2.5 million tons of pesticides are being applied globally each year and keep on rising with the passage of time (FAO/WHO, 2002). Pesticides create several adverse effects not only on the human health, but also on the environment.

* **Corresponding author:** dastogeer.ppath@bau.edu.bd

The harmful pesticides are dissolved in our water system and ultimately enter into the human ecosystem, fishes and many other animals and cause severe damage to their health (Khandakar, 1990). The sole reliance on pesticide applications has shown many side effects and limitations (Aktar et al., 2009). At present, inappropriate and irrational use of pesticides for the control of insect pest and diseases of vegetables is the common practice in Bangladesh (Kabir et al., 1996). Serious consequences of indiscriminate overuse and misuse of pesticides results in a disruption in the agro-ecosystem, human health hazard and environmental pollution (MacIntyre et al., 1989).

As crop production and pesticides are closely related and their left over residues might or might not persist in the environment that should be carefully examined and monitored. Modern pesticide residue analysis in developed countries is focusing more and, more on subtle problems, such as looking for very low concentrations of pesticides in the environment. This complicated and expensive equipment is being used. The detection and monitoring of pesticide residues, particularly in vegetable and fruits is being done in regular fashion in many countries (Kumari et al., 2004), but in Bangladesh it is just on the way to start. However, knowledge of the withholding period becomes important, even for less persistent pesticides, specifically in fruits and vegetables since these crops are harvested/picked shortly after pesticide application. The problem of food contamination with pesticide residues is a cause of concern for almost everyone and everywhere. Pesticide residues above the Maximum Residue Limit (MRL) in the crop at harvest are a globally and nationally cause of great concerns. The gravity of the problem of residues is augmented by untimely, uneconomical and unscrupulous spraying of pesticides. These residues make food commodities hazardous for consumption and export and they also pollute the environment (FAO/WHO, 1996). Maclntyre et al., (1989) reported that low level exposure of food products containing pesticide residues to consumers over time might cause cancer, teratogenesis, genetic damage and suppression of the immune system. Pesticide residues in food have become a consumer’s safety issue and the consumers have the right to know how much pesticide gets incorporated in the food they eat. The detection and quantification of pesticides in the food are a problem of increasing public interest. For that matter, in many countries, integrated pest management (IPM) system of agriculture is being encouraged as part of good agricultural practice (GAP). Besides, consumers are showing more and more interest in organic agricultural commodities.

Farmers one habituated in using pesticides for controlling the crop pest need awareness to be developed about the whole affair. Awareness should be developed in the common consumers. But references are hardly available on the presence of residual pesticides in the marketed vegetables in Bangladesh. Considering the above perspectives, the present investigation was undertaken to identify the pesticides present in the randomly collected samples of vegetables from farm gates and marketed samples and to quantify the amount of detecting pesticide residues in those samples and compare with maximum residue limit (MRL) set by FAO/WHO (2002).

Materials and methods

Survey and collection of pesticide data used by vegetable farmers: The survey was conducted in two important growing areas of country bean, cauliflower and eggplant such as Shibpur & Baroicha in Narsingdi. To document pesticide use on the vegetables concerned, thirteen farmers from Shibpur Upazilla and ten farmers from Baroicha were taken as sample respondent, So that the total numbers of respondents were twenty three as a whole from the two locations. These sample respondents were interviewed randomly during January to March, 2011, using objectives oriented redesigned questionnaire to document the use pattern of pesticides (types of pesticides, direction of the pesticide doses, method of selecting time to spray pesticides and interval of applying insecticides, pre-harvest interval etc.) and the major pests attacking the selected vegetables. Farmers who involved growing of above mentioned vegetables over the last couple of years were selected as a respondent sample. In order to get valid and reliable data, these were verified, corrected and rationalized by repeating questions, asking neighboring farmers, interviewer's own judgment in evaluating the accuracy of responses. The interview schedule was designed to collect information on local units. Farmers' practices related data were collected at two levels: directly from the sample farmers by administering pre-designed and pre-tested questionnaires and recording of data in pre-formatted register at 1 month interval from the sample farmers' crop fields through field and crop inspection. The collected data were coded, analyzed and presented in the tabular form. Data were collected from farmers to find out different pesticides used in a season, different intervals of spraying pesticides and marketing vegetables at different intervals after spray.

Pesticide Residue Analysis

Sample collection: A total of 42 samples was collected from different locations like Shibpur, Baroicha, in Narshindhi and Gazipur farmers' field and vegetable market of Gazipur and Shibpur during the survey period from January to June 2011. At first, 12 country bean fruit samples, 10 eggplant fruit samples, 4 cauliflower samples were collected from different farmers' field and 6 country bean fruit samples, 6 eggplant fruit samples and 4 cauliflower samples were collected from the different vegetable market of Shibpur and Gazipur. During sample collection, several fresh polythene bags were used for each sample to avoid cross contamination. Polythene bags were tied and labeled properly, then kept in a chilling box carefully.

Extraction procedure: The frozen samples were kept at room temperature for 5-6 hours to bring to lab temperature. The methodology prescribed by William and George (2005) with necessary modification was adopted for extraction, separation and cleanup of the sample.

Field collected samples (≥250g) were taken for the extraction. Country bean, cauliflower and eggplant fruit, each of the sample taking 250g chopped by sterilizing knife on the chopping board. 20 g of the chopped sample was taken into a 250ml conical flask measuring by electric balance. Then 100 ml of hexane was added to it. Sodium sulphate (Na2SO4) was also added to the sample until the water was removed from the sample. The mixture was then macerated with high-speed homogenizer (Ultraturax, IKA T18 basic, Germany) for 2 minutes. The homogenized material was then placed into a shaker (Orbital Shaking Incubator, Rexmed, Sweden) for 12 hrs continuous shaking. After shaking, the slurry was filtered through a Buchner funnel with suction. The flask and filter cakes were rinsed with 8-10 ml of acetone/hexane each. The filtrate was then transferred into a 250 ml round bottom flask and was dried to 5-7 ml by evaporation using a rotary vacuum evaporator. The concentrated filtrate was then transferred into 500 ml separatory funnel making 10 ml volume with hexane. For color removal, around 20 ml methanol was added with 10 ml filtrate and shook vigorously for 3-5 minutes. After shaking, the separatory funnel was set on the stand and kept undisturbed for 3-5 minutes. Then the clear part of the solution from the bottom of the separatory funnel was collected in a vial which was then centrifuged at 12000 rpm for 5 minutes (Laboratory Centrifuges, Sigma-3K30, Germany). After centrifugation, the supernatant was cleaned up by the SPE cartridge. Then the final volume was adjusted to 10 ml. This volume was used for injection.

Detection and quantification of pesticide residues

Cypermethrin and Fenvalerate residues: The concentrated extracts were subjected to analysis by GC-2010, Shimadzu Corporation, Japan with Electron Capture Detector (ECD) and Flame Thermionized Detector (FTD). The capillary column used was AT-1, length 30m, ID 0.25mm and film thickness 0.25µm. Nitrogen was used as carrier and make up gas in ECD. But in case of FTD Helium was used as carrier and makes up gas.

Instrument parameters for GC-ECD for the quantification of Cypermethrin and Fenvalerate residues:

[Injection Port SPL]

Injection Mode: Split, Temperature : 280^{o}C

Flow Control Mode: Linear Velocity, Split Ratio: 10

[Detector Channel 1 ECD]

Temperature: 300^{o}C Stop Time : 18 min

Current: 1.00 pA Makeup Flow: 30 ml/min

[Column Oven]

Initial Temperature: 1500C

Column Oven Temperature Program:

Total Program Time: 18.00 min

Rate (^{o}C/min)	Temperature (0C)	Hold Time (min)
-----	160.0	1.00
10.0	270.0	6.0

The instrument parameters for detecting Quinalphos, Diazinon, Fenitrothion, Propiconazole and Malathion:

[Injection Port SPL]

Injection Mode :	Split
Temperature:	250.0 0C
Linear Velocity:	40.0 cm/sec
Purge Flow:	3.0 ml/min

[Column Oven]

Initial Temperature:	150.0 0C
Equilibration Time:	1.0 min

Column Oven Temperature Program

Total Program Time: 10.00 min

Rate (^oC/min)	Temperature (^oC)	Hold Time (min)
-----	150.0	1.00
10.0	220.0	2.0

Calibration curve preparation: Prior to the injection of the sample extract, standard solutions of different concentrations of each pesticide group was prepared and injected with suitable instrument parameters. The samples were calibrated (retention time, peak area, etc.) against three to four pointed calibration curves of standard solution of concerned pesticide (Figure 1). Each peak was characterized by its retention time. Sample results were expressed in ppm automatically by the GC software which represented the concentration of the final volume injected. From this value, the actual amount of pesticide residue present in the sample was determined by using the following formula:

Residue in sample (ppm) =

$$\frac{\text{Conc. obtained in injected volume (ppm)} \times \text{Quantity of final volume (L)}}{\text{Amount of sample taken (Kg)}}$$

Results

Commonly used pesticides against different pests of vegetables in survey areas: On the basis of questionnaire, 23 farmers were interviewed concerning different type of pesticides used like insecticides, fungicides to control the pests that were suggested by Sub Assistant Agricultural Officer (SAAO) and dealer of the locality during the growing season is shown in Table 1.

Table 1: Commonly used pesticides on country bean, eggplant and cauliflower in different location of Narsingdi district.

Insecticides		Sampled farmers (%)
Common name	Trade name	
Cartap	Suntap 50SP	16.67
Carbofuran	Furadan 5G	25.00
Carbaryl	Sevin 85SP	16.67
Chloropyrifos	Dursban 20EC	8.33
Cypermethrin	Ustaad 10EC	33.33
Thiomethoxam	Actara 25WG	8.33
Quinalphos	Korulux 25EC	58.33
	Kinalux 25EC	80.00
Malathion	Fyfanon 57EC	16.67
Diazinon	Basudin 10GR	17.5
Fenvalerate	Fentox 20EC	16.50
Fenitrothin	Corfen 50 EC	11.20
Fungicide		
Propiconzole	Tilt 250EC	75.00
	Protaf 250EC	10.00

Direction of pesticide rates used by the farmers: In the two selected locations of Narsingdi region, 23.25 percent farmers used pesticides according to the label's di-rection and 34.30 percent farmers used pesticides according to the dealer's advice. In those study areas, 27.15 percent farmers used the higher rate, whereas 15.30 percent farmers used lower rate. It was also opined by the farmers in some areas that they used the higher rate of pesticides than the label's direction due to apparent inactivity of spray pesticides to kill the target pest in their vegetables (eggplant, cauliflower and country bean) field while some farmers used lower rate due to high price of pesticides (Figure 2).

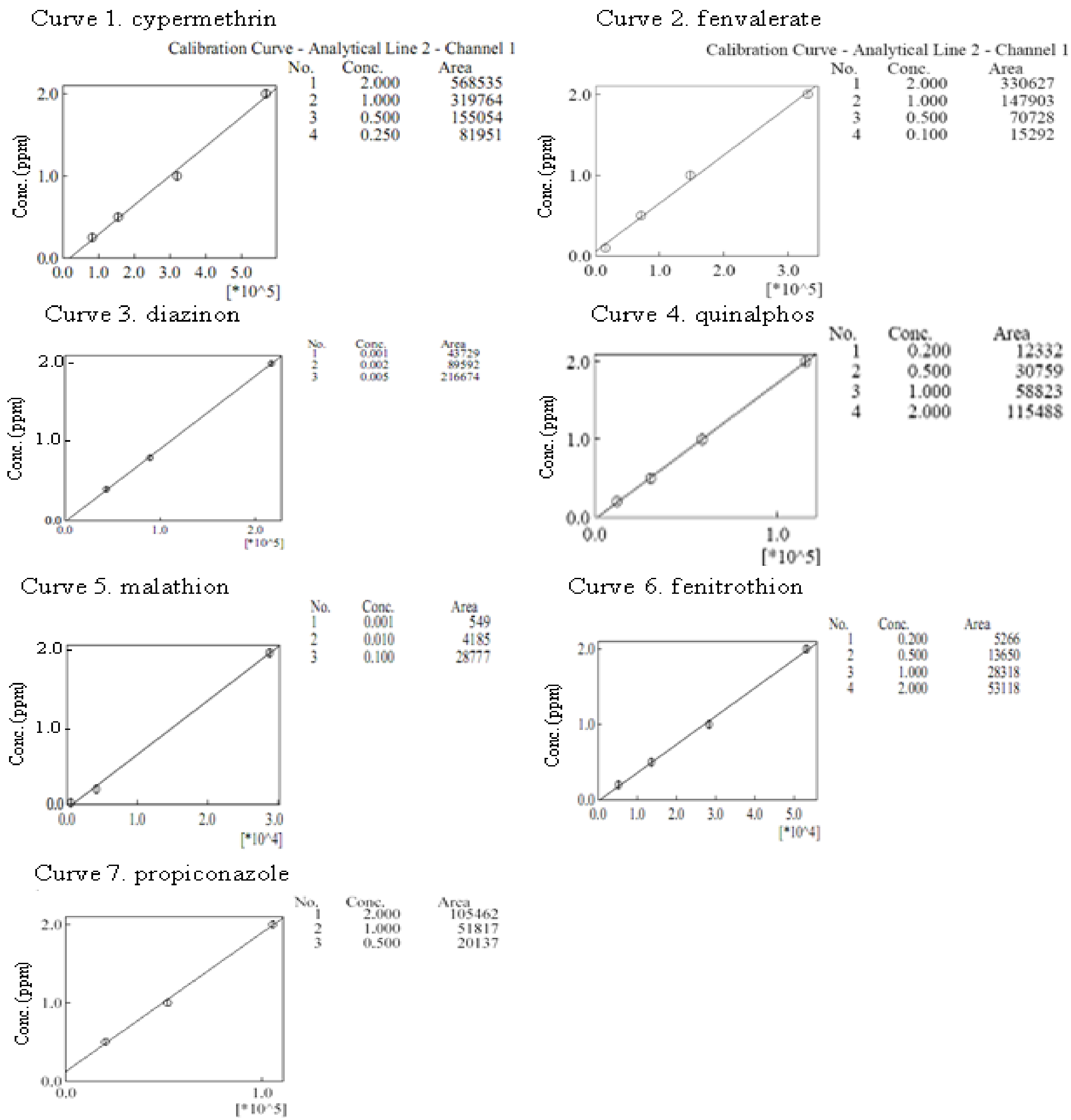

Figure 1: Calibration curve made of different concentrations of pesticides standard (Curves 1 to 7).

Figure 2: Direction of pesticide rates used by the farmer of Narsingdi region.

Method of selecting time to spray pesticides: On average, 71.05 percent farmers in two study areas selected the time to spray pesticides according to their own decision and 28.95 percent farmers followed the dealer's suggestion. It was recorded in the study that, in case of some highly toxic pesticides, the dealers suggested the farmers not to go in the field within 1 week after spray, but the farmers did not maintain the interval and they sprayed their crop according to their own decision, almost every day or 1-2 days interval.

Harvesting of eggplant, country bean and cauliflower after pesticide application: In the survey area of Narsingdi, 8.33 to 45.00 percent farmers harvest and sold country bean, eggplant and cauliflower immediately after pesticide spray. The majority of the interviewed farmers indicated that they did not care about the residual effects. They sprayed the field in the afternoon and pick the eggplants, country bean and cauliflower early in the morning for selling in the market. Some of the farmers sold their harvested eggplant, cauliflower, and country bean after 1-2 days of pesticide application (Table 2). Among farmers in Shibpur 29.00 percent and in Baroicha 18.60 per cent farmers sold their harvested country bean, eggplant and cauliflower after 3-4 days of pesticide application. Only 8.33 to 16.67 percent farmers sold eggplant, cauliflower and country bean after 5-7 days of pesticide application which was also not safe for consumers because of the residue persistency of pesticides in eggplant, country bean and cauliflower.

Table 2: Harvesting of eggplant, country bean and cauliflower after pesticide spray from farmer's field of Narsingdi (2011).

Location	Days after application	Farmers harvested country bean, eggplant, cauliflower after spraying pesticides (%)
Shibpur	0	17.67
	1-2	45.00
	3-4	29.00
	5-7	8.33
Baroicha	0	24.37
	1-2	40.00
	3-4	18.60
	5-7	16.67

Safety measures taken by the farmers during spraying pesticides: On an average 13.46 percent farmers used mask, 22.88 percent farmers covered their heads and face during pesticide spray, 89.54 percent farmers washed their hands, faces and body after spray and 8.33 percent farmers took all these safety measures in a sample collected locations in Narsingdi region. Only 2.04 percent farmers used spectacles during spraying pesticides. In those study areas, 8.29 percent farmers did not take any safety measure during spraying (Table 3). The majority of the respondents reported that they felt giddiness and sometimes vomiting, headache, sneezing, nausea, skin and eye irritations, weakness and chest discomfort after spraying pesticides without having protective clothing.

Table 3: Safety measures taken by the farmers during spraying pesticides in Narsingdi

Safety measures taken	Farmer's opinion percent (%)
Using mask	13.46
Covering head and face	22.88
Washing hand, face and body after spray	89.54
All of the above	8.33
Using spectacles	2.04
No safety measure	8.29

Residue of pesticides in country bean, cauliflower and eggplant of Narsingdi and Gazipur regions: A total of 42 samples of country bean, cauliflower and eggplant fruit were collected from two selected locations of Narsingdi region viz., Shibpur, Baroicha, Sripur and Gazipur then brought to the Pesticide Analytical Laboratory, Entomology Division of BARI for pesticide residue analysis. Multiple pesticide residue analysis was done by GC-2010. All of the collected samples were analyzed against commonly used pesticides (i.e., Diazinon, Malathion, Quinalphos, Fenitrothion, Cypermethrin, Fenvalerate and Propiconazole). The maximum residue limit for the vegetables is given in Table 4 and the analytical results of farm gates and market samples are given in the table 5 to 10.

Table 4: Maximum Residue Limit (MRLs) in different vegetables (FAO, 2002)

Pesticides	Maximum Residue Limit (MRLs) in different vegetables		
	Eggplant	Country bean	Cauliflower
Fenvalerate	0.2 mg/kg	1 mg/kg	0.2mg/kg
Diazinon	0.5 mg/kg	0.5 mg/kg	0.5mg/kg
Quinalphos	0.2 mg/kg	0.2 mg/kg	0.2 mg/kg
Malathion	0.5 mg/kg	2 mg/kg	0.5mg/kg
Cypermathrin	0.2 mg/kg	0.05 mg/kg	1mg/kg
Fenitrothion	0.1 mg/kg	0.1mg/kg	0.1mg/kg
Propiconazole	0.2 mg/kg	0.1 mg/kg	2mg/kg

Eight eggplant samples (5 from the field and 3 from the market) were collected from Gazipur farmer's field and vegetables market then analyzed for the quantification of pesticide residues. Sample code GPFBj1-GPFBj5 collected from the farmer's field and GPMBj6-GPMBj8 collected from the market. Among these, five samples contained residue of different pesticides and only two samples had above MRL. Among eight samples of Gazipur, one sample contained fenvalerate residue, five had diazinon and malathion residue, one had quinalphos residue and another 2 had no residue (Table 5). Again, eight eggplant samples (5 from the field +3 from the market) were collected from the farmer's field (Shibpur & Baroicha) and market (Shibpur) of Narsingdi and analyzed for the quantification of pesticide residues. Sample code NBFBJ1-NBFBj5 collected from the field and NBMBj6-NBMBj8 collected from the market. Among these, six samples contained residue of different pesticides and only four samples had above the MRL. Among eight samples of Narsingdi, two samples contained Cypermethrin residue, five had Diazinon residue, four had Quinalphos residue, six had malathion residue and the other two had no residue (Table 6).

Six country bean samples (4 fields + 2 markets) were collected from Gazipur fields and vegetable market and analyzed for the quantification of pesticide residues. Sample code GPFBe-1-GPFBe-4 collected from the field and GPMBe-5- GPMBe-6 collected from the market. Among these, three samples contained residue of different pesticides and one sample had above the MRL. Among six samples, two samples contained Cypermethrin residue, one had Diazinon and residue, one had Quinalphos residue, one had malathion residue, two had Fenvalerate and the other three had no residue (Table 7). Besides, twelve country bean samples (8 from field + 4 from the market) were collected from the farmer's field and market of Narsingdi and analyzed for the quantification of pesticide residues. Sample code NBFBe 1- NBFBe 8 collected from fields and NBFBe 9- NBMBe 12 collected from the market. Among these, nine samples contained residue of different pesticides and only six samples had above the MRL. Among twelve samples of Narsingdi, one sample contained Cypermethrin residue, six had malathion residue, four had Fenvalerate residue, five had Propiconzole residue, seven had Diazinon residue, six had Quinalphos residue, one had Fenitrothion residue and the other three had no residue (Table 8).

Four cauliflower samples (2 from field + 2 from the market) were collected from Gazipur fields and vegetable markets and analyzed for the quantification of pesticide residues. Sample code GPFCf-1-GPFCf-2 collected from fields and GPMCf-3- GPMCf-6 collected from the market. Among these, two samples contained residue of different pesticides and no samples had above the MRL. Among four samples, two samples contained Diazinon residue, two had Quinalphos residue, two had malathion residue and other two had no residue (Table 9). Again, four cauliflower samples (2 from the field +2 from the market) were collected from the farmer's field and vegetable market (Shibpur) of Narsingdi and analyzed for the quantification of pesticide residues. Sample code NBFCf-1- NBFCf-2 collected from the field and NBMCf-3- NBMCf-4 collected from the market. Among these, two samples contained residue of different pesticides and only one sample had above the MRL. Among four samples, two samples contained Diazinon residue, two had Quinalphos residue, two had malathion residue and the other two had no residue (Table 10).

Discussion

The use of pesticides was observed to be high, probably because farmers assume that the only solution to pest problems is to spray more frequently and using different types of pesticides (Dinham, 2003). In previous studies conducted in some of the study areas (Ngowi & Partanen, 2002) it was revealed that farmers were not receiving agricultural extension service, hence have attempted various means, especially in pesticide use when dealing with pest problems but were constrained by the lack of appropriate knowledge. However, pesticide usage in the study area seems to be highly influenced by manufacturers and pesticide dealers who were carrying out their business right in the farming communities and very interested in achieving large sales of their pesticides. This is a typical situation in many developing countries where the choice of pesticides to be used by farmers is influenced by the suppliers (Snoo et al., 1997; Epstein and Bassein, 2003). As a result and coupled with the lack of basic knowledge of pesticides, farmers' decisions on what pesticides and how to use do not have a bearing on the health or safety of the environment. Epstein & Bassein, (2003) observed that farmers used more pesticides because they based the applications on calendar spray pesticides program without necessarily giving much priority to health and environmental considerations.

Table 5: Quantity of residue of different pesticides estimated from eggplant samples collected from Gazipur

Sample code	Quantity of detected residue (ppm)						
	Fenvalerate	Diazinon	Quinalphos	Fenitrothion	Malathion	Cypermethrin	Propiconazole
GPFBj-1	0.09	0.035	ND	ND	0.018	ND	ND
GPFBj-2	ND	0.708	ND	ND	0.014	ND	ND
GPFBj-3	ND	ND	ND	ND	ND	ND	ND
GPFBj-4	ND	0.038	ND	ND	0.023	ND	ND
GPFBj-5	ND	0.040	ND	ND	0.612	ND	ND
GPMBj-6	ND	0.083	0.016	ND	0.021	ND	ND
GPMBj-7	ND	ND	ND	ND	ND	ND	ND
GPMBj-8	ND	ND	ND	ND	ND	ND	ND

ND= not detected

Table 6: Quantity of residue of different pesticides estimated from eggplant samples collected from Narsingdi

Sample code	Quantity of detected residue (ppm)						
	Cypermethrin	Diazinon	Quinalphos	Fenvalerate	Malathion	Fenitrothion	Propiconazole
NBFBj-1	0.531	0.062	ND	ND	0.017	ND	ND
NBFBj-2	ND	0.153	0.344	ND	0.630	ND	ND
NBFBj-3	ND	0.048	ND	ND	0.031	ND	ND
NBFBj-4	0.077	ND	0.022	ND	0.050	ND	ND
NBFBj-5	ND	0.687	0.048	ND	0.060	ND	ND
NBMBj-6	ND	0.105	0.017	ND	0.028	ND	ND
NBMBj-7	ND	ND	ND	ND	ND	ND	ND
NBMBj-8	ND	ND	ND	ND	ND	ND	ND

ND= not detected

Table 7: Quantity of residue of different pesticides estimated from country bean samples collected from Gazipur

Sample code	Quantity of detected residue (ppm)						
	Cypermethrin	Malathion	Fenvalerate	Diazinon	Quinalphos	Fenitrothion	Propiconazole
GPFBe-1	ND	ND	ND	ND	ND	ND	ND
GPFBe-2	0.114	ND	ND	ND	ND	ND	ND
GPFBe-3	0.264	ND	0.401	ND	ND	ND	ND
GPFBe-4	ND	0.014	0.804	0.069	0.012	ND	ND
GPMBe-5	ND	ND	ND	ND	ND	ND	ND
GPMBe-6	ND	ND	ND	ND	ND	ND	ND

ND= not detected

Table 8: Quantity of residue of different pesticides estimated from country bean samples collected from Narsingdi

Sample code	Quantity of detected residues (ppm)						
	Cypermethrin	Malathion	Fenvalerate	Propiconazole	Diazinon	Quinalphos	Fenitrothion
NBFBe-1	ND	ND	0.102	0.028	ND	ND	ND
NBFBe-2	ND	ND	ND	ND	ND	ND	ND
NBFBe-3	ND	0.036	ND	0.552	0.798	0.023	ND
NBFBe-4	0.239	0.037	ND	0.063	0.084	0.023	ND
NBFBe-5	ND	0.025	ND	ND	0.87	0.017	ND
NBFBe-6	ND	ND	0.116	0.408	0.054	ND	ND
NBFBe-7	ND	0.039	ND	0.081	0.192	0.287	0.027
NBFBe-8	ND	0.030	0.684	ND	0.067	ND	ND
NBMBe-9	ND	0.082	ND	ND	0.069	0.045	ND
NBMBe-10	ND	ND	0.130	ND	ND	0.051	ND
NBMBe-11	ND	ND	ND	ND	ND	ND	ND
NBMBe-12	ND	ND	ND	ND	ND	ND	ND

ND= not detected

Table 9: Quantity of residue of different pesticides estimated from Cauliflower samples collected from Gazipur

Sample code	Quantity of detected residues (ppm)						
	Malathion	Diazinon	Quinalphos	Cypermethrin	Fenvalerate	Propiconazole	Fenitrothion
GPFCf-1	ND	ND	ND	ND	ND	ND	ND
GPFCf-2	0.057	0.156	0.032	ND	ND	ND	ND
GPMCf-3	0.046	0.126	0.026	ND	ND	ND	ND
GPMCf-4	ND	ND	ND	ND	ND	ND	ND

ND= not detected

Table 10: Quantity of residue of different pesticides estimated from Cauliflower samples collected from Narsingdi

Sample code	Quantity of detected residue (ppm)						
	Diazinon	Quinalphos	Malathion	Cypermethrin	Fenvalerate	Propiconazole	Fenitrothion
NBFCf-1	0.108	0.027	0.043	ND	ND	ND	ND
NBFCf-2	0.093	0.033	0.655	ND	ND	ND	ND
NBMCf-3	ND	ND	ND	ND	ND	ND	ND
NBMCf-4	ND	ND	ND	ND	ND	ND	ND

ND= not detected

A total of 7 pesticide residues were detected in the eggplant, country bean and cauliflower samples. This result is in agreement with Ahuja et al., (1998) who reported residues of Hexachlorocyclohexane (HCH) and its isomers, Endosulfan, Dimethoate, Monocrotophos, Quinalphos, Fenvalerate and Cypermethrin were detected in cauliflowers, cabbages, tomatoes, eggplant, okra, field beans and cucumbers were monitored for in most of the samples. However, some pesticides were not detected in some samples analyzed from the two locations. This may be attributed to the fact that decomposition or degradation of pesticide before the analysis was carried out. Diazinon and Malathion residues in eggplant; Fenvelerate, Diazinon and Propiconazole residues in country bean and Malathion residues in cauliflower were above their respective MRL values. Consequently, this study confirms the work of Essumang et al. (2008) regarding the observation that some pesticide residues in vegetables are above the allowed MRLs. However, unlike in this study which focused on cabbage, Assuming studied pesticide residues on tomatoes. Significant levels of Fenvalerate and Methamidophos have been detected in the analysis of pesticide residues in fruits and vegetables in Sweden (Pihlstrom et al., 2007). Prodhan et al., (2008) conducted an experiment at Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur, Bangladesh to detect and quantify the left over residue of Fenitrothion in Brinjal and comparison between the detected residue levels with a Maximum Residue Limit (MRL) set by FAO and the left over residue of concerned pesticide was detected up to 7 days and the quantities were above MRL up to 3 days. Our work appears to contradict the work of Pihlstrom et al., (2007) given that neither Fenvalerate nor Methamidophos were detected in the study. It is important, however; to distinguish that Pihlstrom et al., (2007) based their work on only market-level sampling whereas this study focused on vegetable obtained at the farm gate and market. A similar study in Canada, reported that, pesticide residues in vegetables and fruits; were far below the MRLs (Ripley et al., 2000). EL-Saeid (2003) used Supercritical Fluid Extraction (SFE) in the analysis of pesticide residues unlike in this study where we used Gas Chromatography. Also, EL-Saeid (2003) sampled canned foods, fruits and vegetable, whereas this study sampled fresh vegetables. Ahn et al., (2011) has shown that Diazinon and Chlopyrifos residues were stable up to 30 months and this needs public attention. An integrated approach to pesticide use should be encouraged and this should fit broadly in a framework in which certain criteria are used for pesticide selection, specific instructions are followed for their application on crops and residue analysis is used as one of the tools for enforcement (Damalas & Eleftherohorinos, 2011). Pesticides that are chosen for application on vegetable farming should be biologically effective, user friendly and environmentally safe.

Presence of pesticide residues in vegetables and fruits is an indicative change in use pattern of pesticides in Bangladesh, where shift has taken place from Organochlorines to the easily degradable groups of pesticides over the last few years. Monitoring studies are imperative to know the actual status of contamination due to toxic pesticide residues for future policies as well as to strengthen the confidence of consumers in quality of food. It is, therefore, suggested that such studies may be extended to other vegetables and fruits grown in different agro-climatic regions of Bangladesh. These issues are central to minimizing the risk posed to human health on exposure to pesticides in food.

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