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Research article

Monitoring of pesticide residues from fish feed, fish and vegetables in Bangladesh by GC-MS using the QuEChERS method

Matiur Rahman [a], Md. Sazedul Hoque [b], Shuva Bhowmik [c,*], Shahnila Ferdousi [a], Meera Probha Kabiraz [d], Martin L. van Brakel [e]

[a] National Food Safety Laboratory, Institute of Public Health, Mohakhali, Dhaka 1212, Bangladesh
[b] Department of Fisheries Technology, Faculty of Fisheries, Patuakhali Science and Technology University, Dumki, Patuakhali 8602, Bangladesh
[c] Department of Fisheries and Marine Science, Faculty of Science, Noakhali Science and Technology University, Noakhali 3814, Bangladesh
[d] Department of Biotechnology and Genetic Engineering, Faculty of Science, Noakhali Science and Technology University, Noakhali 3814, Bangladesh
[e] WorldFish Bangladesh and South Asia Office, Banani, Dhaka 1213, Bangladesh

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ABSTRACT

The use of pesticides in agricultural sectors is rising due to the growing demand for food in the world, but the presence of pesticide residues in agricultural commodities has become a major health concern for consumers and is associated with problems of food safety. Thus, the present study determined pesticide residues (17 organochlorine, 5 pyrethroid and 3 organophosphate) in 77 fish feed, 112 fish and 135 vegetables samples (total of 324) from the different locations in Bangladesh, using quick easy cheap effective rugged and safe (QuEChERS) extraction followed by gas chromatography-mass spectrometry (GC-MS) analysis. The 77 fish feed samples analyzed with this method appeared to be free of pyrethroid pesticide residues. Organochlorine pesticide residues aldrin (0.03 ± 0.01 mg/kg) and pyrethroid pesticide residues permethrin (0.08 ± 0.01 mg/kg) were detected in fish samples of catla (*Catla catla*) from Rajshahi Durgapur and bata (*Labeo bata*) from Satkhira Kaligonj, respectively. Among 135 vegetable samples (country bean, green chili, tomato, eggplants and red amaranth), 27.4% were found positive for organophosphate pesticide residues of which 89.2% exceeded maximum residue limits (MRLs) set by the Codex Alimentarius Commission. The study revealed that few fish (catla and bata) but the majority of vegetable samples tested positive for pesticide residues exceeding MRLs. Finally, the study suggests that an effective management strategy is needed for strict regulation and regular monitoring of pesticides in fish feed, fish and vegetables to make aware the farmers and consumers about the harmful effect of pesticides on human health.

1. Introduction

Pesticides are rigorously used worldwide in agriculture to ensure high crop production (Nicolopoulou-Stamati et al., 2016). Numerous studies reported that farmers apply pesticides in different agricultural crops, amongst which vegetables in Bangladesh (Hossain et al., 2015), seasonal vegetables in India (Kumari et al., 2002), fruits and vegetables in Kuwait (Jallow et al., 2017), Brazilian fruits pulps (Paz et al., 2016) and tomato in Brazil (Filho et al., 2006), rice and fish in China (Chen et al., 2007) are common. In Bangladesh, farmers' knowledge about safe and judicious use of pesticides is generally inadequate. Pesticides are used before harvesting, particularly for the prevention of crop contamination before their products are placed on the market (Jallow et al., 2017). Farmers use pesticides widely in vegetable production, most likely because of their perception that no superior alternatives are existing, and pesticides are cost-effective (Hossain et al., 2015). However, pesticide residues persist in vegetables and are responsible for environmental contamination. The accumulation of pesticide residues in the aquatic environment being returned to humans' body through consumption of reared livestock including aquatic organisms or fish (Thundiyil et al., 2008; US Environmental Protection Agency 2009). Due to their persistence in the aquatic environment and bioaccumulation, it is very important to measure pesticide residues in fish in order to detect potential risks to human health from these compounds (Brondi et al., 2011). In addition, consumer exposure to pesticide residues due to consumption of raw and semi-cooked vegetables has been reported to be higher than other plant

* Corresponding author.
E-mail addresses: shuva_bhowmik@yahoo.com, shuva@nstu.edu.bd (S. Bhowmik).

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foodstuffs like cereal food (Claeys et al., 2011). Human health risks are associated with these residues if these products are consumed (Solecki et al., 2005). Apart from this, replacement of fish ingredients with plant ingredients such as rice bran, maize, wheat flour, mustard cake etc. in fish feeds also introduces pesticides most commonly used in terrestrial agriculture into fish feeds (Olsvik et al., 2019).

The major chronic health effects namely malignant tumors, blood disorders, endocrine disruption, reproduction effects and nerve disorders are caused by chemical pesticides, i.e., organophosphates, organochlorines, pyrethroids, triazines, carbamates and neo-nicotinoids. Farmers in Bangladesh use even banned pesticides like organochlorine, organophosphates, pyrethroids and carbamates in agricultural products (Jallow et al., 2017). In addition, exposure of pesticide residues is further metabolized, excreted, stored, or bioaccumulated in human body fat (World Health Organization 1990; Nicolopoulou-Stamati et al., 2016). Moreover, the intentional or accidental exposure of pesticides to the human body can cause serious illness or even death (Gunnell et al., 2007).

Internationally agreed maximum residue limits (MRLs) for pesticides to ensure consumer food safety are expressed in mg/kg content legally allowable to be present in food (FAO/WHO, 1996; Kumari et al., 2002; Filho et al., 2006; EFSA, 2013; Codex Alimentarius Commission 2013; Kariathi et al., 2016). Various methods have been established for analyzing pesticides in food including vegetables and fish. Among the analytical methods, the quick easy cheap effective rugged and safe (QuEChERS) extraction method is gaining popularity for sample processing. The QuEChERS method uses gas chromatography-mass spectrometry (GC-MS) and liquid chromatography-tandem mass spectrometry (LC-MS/MS) for the quantification of pesticide residues (Cunha et al., 2007). Considering food safety and public health, the

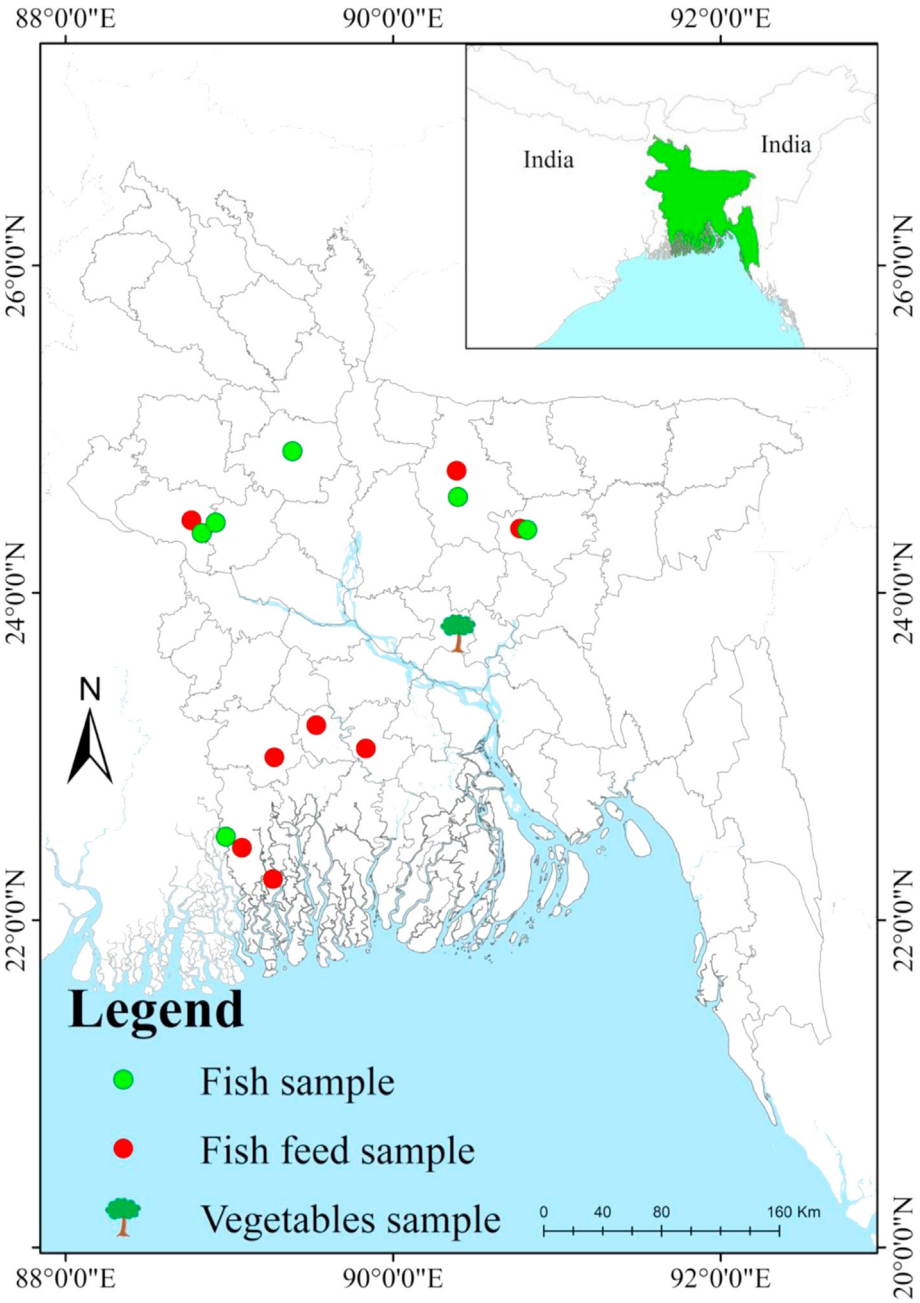


Figure 1. Sampling sites of different locations in Bangladesh.

quantification and calculation of total remaining pesticide residues in food have become a great concern. Limited work associated with the existence of pesticides in fish feed, fish and vegetables has been done in Bangladesh (Shoeb et al., 2016). Therefore, in view of local and global food safety concerns, the current study was designed to determine and quantify pesticide residues in fish feed, fish and vegetables samples from the different locations in Bangladesh using QuEChERS extraction method followed by GC-MS analysis.

2. Materials and methods

2.1. Sample collection

A total of 324 fish feed (77), fish (112) and vegetable (135) samples were collected from eleven districts (Bogora, Dhaka, Gopalgonj, Jessore, Khulna, Kishoregonj, Mymensingh, Natore, Narail, Rajshahi, and Satkhira) in Bangladesh (Figure 1). Fish feed, fish and vegetable samples were collected randomly from local markets. The weight of each sample ranged between 0.5 to 1 kg. To avoid contamination and deterioration, all the samples were packed in labelled sterile polythene bags and placed in an ice box for transport to the laboratory.

2.2. Chemicals and reagents

Standard pesticides of 98–99% purity were collected from Dr. Ehrenstorfer GmbH (Augsburg, Germany). Acetonitrile, toluene, sodium chloride, PSA Bond silica (primary and secondary amine), graphite carbon black (GCB), triphenylphosphate (TPP) and anhydrous magnesium sulphate were obtained from Sigma-Aldrich (St. Louis, MO, USA). For analysis, high performance liquid chromatography (HPLC) grade organic solvents were used.

2.3. Sample preparation, extraction and determination of pesticide residues

Pyrethroid and organophosphate (OP) pesticides residues with their different metabolites were evaluated in fish feed and vegetable samples, respectively. Both organochlorine (OC) pesticides and pyrethroid pesticides with their metabolites were analysed for fish samples. OC, OP and pyrethroid groups were run separately for the analysis of the respective samples following the method of QuEChERS and quantification and detection of pesticides by GC-MS analysis. The extraction and clean-up were done based on the QuEChERS sample preparation method for pesticides (Anastassiades et al., 2003). The collected fish feed, fish and vegetables samples were chopped and blended separately in an electric blender with microcutters (Preethi Steel Max MF-212, Preethi Kitchen Appliances Pvt. Ltd. India) to obtain an isolated homogenous composite of fish feed, fish and vegetables. In a 50 mL centrifuge tube, an aliquot of 10 g homogenized sample and 10 mL of acetonitrile was mixed. The mixture was vortexed for one minute followed by adding 4 g of magnesium sulphate and 1 g of sodium chloride. The sample was centrifuged at 5000 rpm for 5 min and the supernatant was removed for clean-up. During clean-up, 2 mL supernatant was transferred into another tube that contained 50 mg of primary and secondary amine (PSA), 50 mg of graphite carbon black (GCB) and 150 mg of magnesium sulphate. After proper agitation and centrifugation at 10000 rpm for 5 min, the aliquots of the extract were evaporated through nitrogen system and reconstituted with 1 mL toluene for GC-MS analysis.

Further, each pesticide standard solution (1 mg/mL) was prepared by diluting acetonitrile at a different concentration for standard curve preparation. A 2% triphenylphosphate (TPP) solution in acetonitrile with 1% acetic acid was used as quality control (QC) standard for the GC-MS analysis. A Shimadzu (GC-MS QP 2010 Ultra, Japan) gas chromatograph equipped with mass selective detector and analytical column setup was a Restek (Bellefonte, PA) Rxi-5MS with fused silica (30 m long x 0.25 mm internal diameter x 1.0 μm film thickness) used for analysis.

The operating condition of pyrethroid and organophosphate pesticides were splitless injection mode, 250 °C injector and interface temperature, 1 min sampling time, helium gas as a carrier with flow rate 0.75 mL/min, linear velocity in flow control mode, 71.2 KPa pressure, 14 mL/min total flow rate, 1 mL/min column flow, 37 cm/s linear velocity, 3 mL/min purge flow and injection volume of 1 μL. The temperature was programmed for organophosphate pesticide from an initial value of 90 °C, ramped to 180 °C at 25 °C/min, and to 270 °C at 3 °C/min, and was increased to 300 °C at 20 °C for 3 min and total run time was 40 min. Likewise, the operating condition of organochlorine pesticide was split mode, split ratio 10, 250 °C injection port temperature, 1 min sampling time, helium gas as carrier with flow rate 0.75 mL/min, linear velocity flow of control mode, 124.6 KPa pressure, 19.5 mL/min of total flow, 1.5 mL/min of column flow, 46 cm/s of linear velocity 3 mL/min of purge flow and injection volume was 1μL. The initial value of 120 °C, ramped up to 200 °C at 45 °C for 3 min, and to 240 °C at 5 °C for 10 min, and finally raised to 310 °C at 10 °C for 3 min and total run time was 34 min. For the detection of all analytes, analysis was performed in selected ion monitoring (SIM) mode and a minimum of four ions were considered for each pesticide. The quantified ion for the detected pesticides is presented in Table 1. The organochlorine pesticides and their metabolites were analyzed with GC-MS: α-BHC, δ-BHC, β-BHC, γ-BHC, Heptachlor, Aldrin, Heptachlor epoxide, γ-Chlordane, α-Chlordane, α-Endosulfan, 4,4′-DDE, Dieldrin, Endrin, 4,4′-DDD, β-Endosulfan, 4,4′-DDT and Endosulfan sulphate. Similarly, the organophosphate pesticides (Dimethoate, Chlorpyrifos and Quinalphos) and pyrethroid (Fenvelrate, Permethrin, Cypermethrin, Deltamethrin, Esfenvalerate) were analysed with validated GC-MS method.

2.4. Ethical considerations

All procedures performed in this study were approved by the ethical research committee of Noakhali Science and Technology University (Reference no. NSTU/2020/18).

2.5. Data analyses

All the experiments results are expressed as the mean of three measurements and the data were presented as mean ± standard deviation (SD).

3. Results and discussion

3.1. Method validation

The linearity of the calibration curves was assessed at 10, 40 and 200 ng/mL (equivalent to 0.01, 0.04 and 0.2 mg/kg) for all by duplicate analysis by using six concentrations levels. The obtained coefficient of determination (R^2) was higher than 0.97 for all the pesticides. The accuracy and precision parameters of the study method were obtained over the entire procedure by recovery analysis. Fish feed (commercial feed), fish (catla and bata) and vegetables (country bean, green chili, tomato, egg plant and red amaranth) samples were spiked with the pesticides at 0.01, 0.04 and 0.2 mg/kg spiking levels. The recoveries were between 80 and 120%, RSD for precision was <10% and RSD for intermediate precision was <15%. The results of the study indicate that the method had acceptable reproducibility and satisfactory. Therefore, present study method provided a good possibility to quantify the pesticide residues in fish feed, fish and vegetables. The limit of detection (LOD) and limit of quantification (LOQ) values for the different types of pesticides residues are presented in Tables 2, 3 and 4.

3.2. Pesticide residues in fish feed samples

All collected fish feed samples underwent analysis for pyrethroid pesticide residues and their metabolites. Tables 2 and 5 show that

Table 1. List of quantified ions for the detected pesticides.

Pesticides	Retention time (min)	Qualitative ion (m/z)	Quantitative ion (m/z)
Aldrin	14.8	66, 79, 103, 263, 293	263
Permethrin	18.8	91, 163, 181, 209	163
Chlorpyrifos	20.38	97, 197, 258, 314	197
Dimethoate	14.05	87, 93, 125, 229	87
Quinalphos	22.87	90, 118, 146, 157, 298	146

Table 2. Pesticide residues in fish feed samples.

Pyrethroid pesticides	LOD (mg/kg)	LOQ (mg/kg)	Detected residue (mg/kg)	MRLs (mg/kg)
Fenvalerate	0.01	0.12	ND	0.01
Permethrin	0.02	0.17	ND	0.05
Cypermethrin	0.01	0.14	ND	0.01
Deltamethrin	0.01	0.14	ND	0.02
Esfenvalerate	0.01	0.15	ND	0.02

ND = Not detected.

Table 3. Pesticide residues in fish samples.

Pesticides Organochlorine pesticides	LOD (mg/kg)	LOQ (mg/kg)	Detected residue (mg/kg)	MRLs (mg/kg)	Comments
α-BHC	0.01	0.14	ND	0.01	Aldrin was detected in catla fish collected form Rajshahi Durgapur and permethrin detected in bata fish collected from Satkhira Kaligonj
δ-BHC	0.01	0.17	ND	0.01	
β-BHC	0.02	0.13	ND	0.03	
γ-BHC	0.01	0.16	ND	0.01	
Heptachlor	0.01	0.14	ND	0.01	
Heptachlor epoxide	0.03	0.14	ND	0.02	
γ-Chlordane	0.01	0.13	ND	0.01	
α-Chlordane	0.01	0.18	ND	0.01	
α-Endosulfan	0.01	0.19	ND	0.02	
4,4′-DDE	0.02	0.19	ND	0.01	
Dieldrin	0.02	0.14	ND	0.01	
Endrin	0.03	0.17	ND	0.05	
4,4′-DDD	0.01	0.13	ND	0.01	
β-Endosulfan	0.01	0.14	ND	0.02	
4,4′-DDT	0.01	0.17	ND	0.01	
Endosulfan sulphate	0.01	0.19	ND	0.01	
Aldrin	0.02	0.16	0.03 ± 0.01	0.02	
Pyrethroid pesticides					
Fenvalerate	0.01	0.22	ND	0.01	
Cypermethrin	0.01	0.22	ND	0.01	
Deltamethrin	0.01	0.22	ND	0.02	
Esfenvalerate	0.01	0.22	ND	0.02	
Permethrin	0.03	0.21	0.08 ± 0.01	0.05	

ND = Not detected.

pyrethroid pesticide residues (Fenvelrate, Permethrin, Cypermethrin, Deltamethrin, Esfenvalerate) were not detected in the fish feed samples, i.e. the result revealed that fish feed ingredients were pyrethroid pesticide residues free. Generally, fish feed ingredients are mostly of animal origin, like fish meal, meat and bone meal, and contain less ingredients of plant origin such as rice bran, soy bean meal and mustard oil cake. Among the different organic or natural pesticides, pyrethroids (Fenvelrate, Permethrin and Sumithrin) are the most commonly used for agricultural and public health purposes (Chen and Wang, 1996; Nicolopoulou-Stamati et al., 2016). As a consequence, no pyrethroid pesticides were detected in fish feed samples in our study. Similar findings reported by Nahar et al. (2008) and Shoeb et al. (2009) who stated fresh fish, dried fish and poultry feeds samples, DDT and its metabolites (DDE and DDD) were identified and quantified but no pyrethroid residues were detected.

3.3. Pesticide residues in different fresh fish samples

Organochlorine and pyrethroid pesticide residue and its metabolites were analysed for fish samples collected from different locations in Bangladesh are presented in Tables 3 and 6. Among the organochlorine pesticides residues analyzed, the catla (*Catla catla*) fish sample collected from Rajshahi Durgapur was identified to contain aldrin at the level of 0.03 ± 0.01 mg/kg. Except aldrin, no other organochlorine pesticide

Table 4. Pesticide residues in vegetables collected from different locations in Bangladesh.

Vegetables	Sample size	Pesticides	Number of Contamination	LOD (mg/kg)	LOQ (mg/kg)	Detected ranges of residues (mg/kg)	MRLs (mg/kg)
Country bean	27	Dimethoate	9	0.02	0.56	ND-0.424	0.05
	27	Chlorpyrifos	2	0.01	0.16	ND-0.064	0.05
Green chili	27	Dimethoate	9	0.01	0.25	ND-0.201	0.05
Tomato	27	Quinalphos	4	0.01	0.37	ND-0.321	0.01
Egg plant	27	Quinalphos	12	0.01	0.23	ND-0.128	0.01
Red amaranth	27	Chlorpyrifos	3	0.04	1.82	ND-1.535	0.05

ND = Not detected.

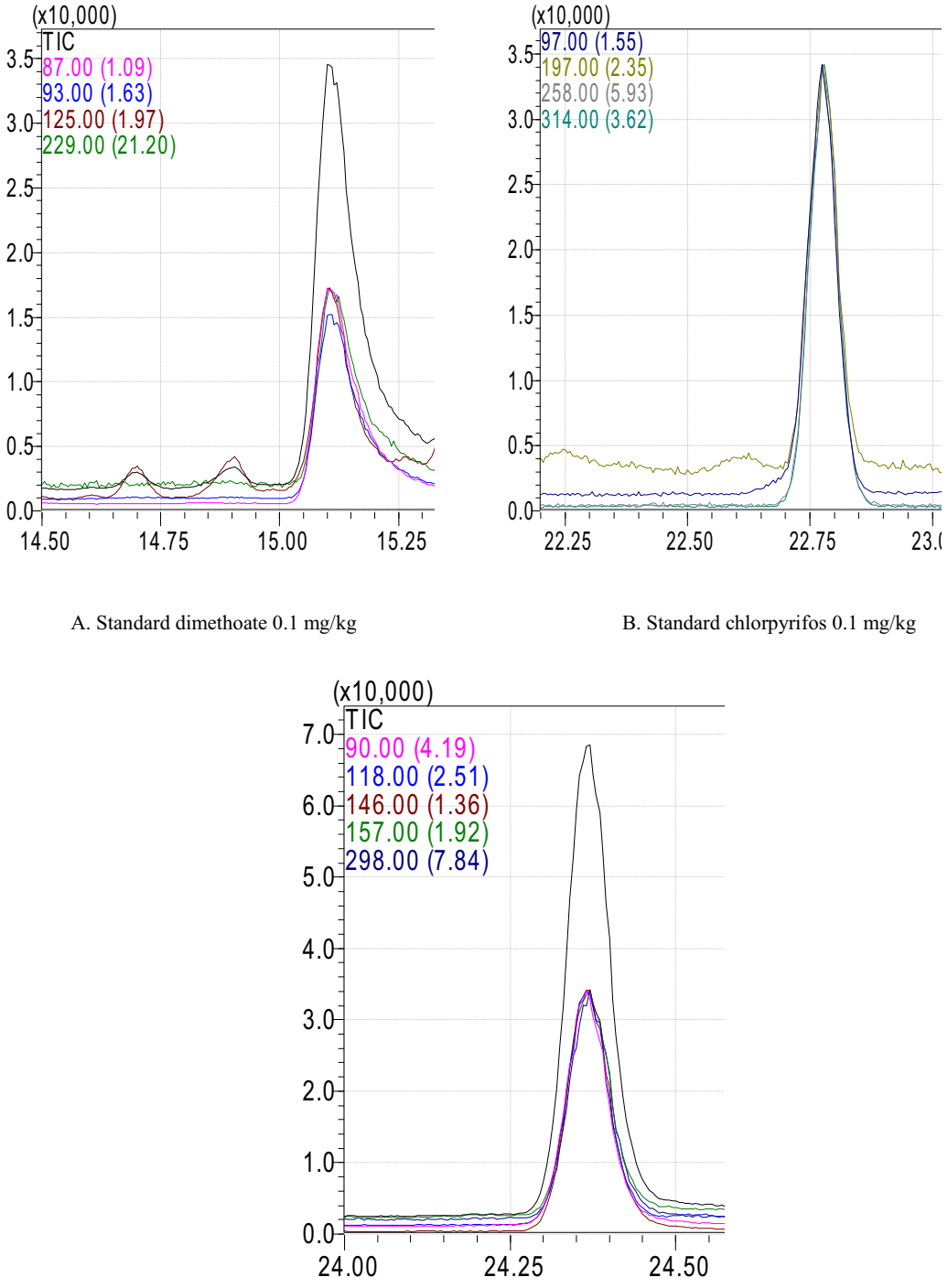
Table 5. Details of fish feed samples from different locations in Bangladesh.

Sample type	Sample size	Sources of fish feed samples	Quantity	Physical appearance
Fish feed	77	Mymensingh Fulpur, Kishorganj Sadar Kishorganj Kotiadi, Rajshahi Putia, Rajshahi Bagatipara, Rajshahi Durgapur, Khulna Rupsha, Jessore Avoynagar, Jessore Monirampur, Jessore Sadar, Gopalganj Sadar, Khulna Dumuria, Satkhira Kaliganj, Narail Sadar	App. 1000g	Fresh

Table 6. Details of fish samples collected from different locations in Bangladesh.

Fish Species	Sample size	Sources of fish samples	Range of quantity	Physical appearance
Tilapia	10	Mymensigh Fulpur, Rajshahi Tanore, Mymensingh Fulbaria, Mymensingh Trisal, Mymensingh Bhaluka	App. 550–800g	Fresh
Pangas	12	Mymensingh Fulpur, Kishorganj Sadar, Kishorgonj Kotiadi, Bogora Aditmari, Mymensingh Fulbaria, Mymensingh Bhaluka	App. 600–900g	
Silver carp	7	Kishorgonj Sadar, Natore Boraigram	App. 550–700g	
Catfish	9	Kishorgonj Sadar	App. 650g	
Rui	14	Kishorgonj Kotadi, Rajshahi Putia, Rajshahi Bagmara, Rajshahi Durgapur, Natore Sadar, Natore Boraigram, Bogora Aditmari, Rajshahi Poba, Rajshahi Tanore, Mymensingh Fulbaria, Mymensingh Trisal	App. 600–800g	
Mrigal	9	Rajshahi Putia, Rajshahi Poba, Rajshahi Tanore	App. 550–800g	
Kalibaush	7	Rajshahi Putia, Rajshahi Bagamara, Natore Sadar	App. 550–650g	
Catla	12	Rajshahi Bagamara, Rajshahi Durgapur, Bogora Aditmari, Mymensingh Bhaluka	App. 650–800g	
Mirror carp	6	Rajshahi Poba	App. 550g	
Carpio	9	Mymensingh Trisal	App. 650g	
Puti	8	Mymensingh Trisal	App. 600g	
Bata	9	Satkhira Kaligonj	App. 700g	

compounds were found irrespective of fish species and sampling sites. In addition, among the pyrethroid pesticides (Fenvelrate, Permethrin, Cypermethrin, Deltamethrin, Esfenvalerate) only permethrin was detected at a level 0.08 ± 0.01 mg/kg in bata fish (*Labeo bata*) from Satkhira Kaligonj. The detected pesticide levels in pesticide positive fish samples were much higher than MRLs. The result in this study revealed that different fish species collected from different locations in Bangladesh were mostly organochlorine and pyrethroid pesticide free, except the aforementioned fish samples in the respective sites. The pesticide positive fish sample from the respective site might be due to differences in geographical location and environmental conditions that lead to pesticide leakage into the water body, and as a consequence its ingestion by fish. Our research outcome is similar to the findings of Zamir et al. (2013) who found ΣDDTs residue levels (4,4′-DDT, 4,4′-DDD and 4,4′-DDE) below the MRLs within the range of 0.01–0.279, 0.006–0.669 and 0.008–0.113 mg/kg respectively in rui (*Labeo rohita*), catla (*Catla catla*) and pangas (*Pangasius hypophthalmus*) fresh samples. Another study by Ayas et al. (1997) also detected 6 and 13 different OC residues respectively in liver and adipose tissue of carp *(Cyprinus carpio),* where mean concentrations of endrin and 4,4′-DDT were 1.072 mg/kg and 4.217 mg/kg, respectively were higher than of our findings. Besides, OC residues were also detected in liver and adipose tissue of grey mullet *(Mugil cephalus)*, 6 and 11 different residues, respectively with mean concentrations at 0.066 mg/kg 4,4′-DDE and 0.912 mg/kg 4,4′-DDT. OC concentrations varied with fish species and tissues (Ayas et al., 1997). The study also reported that higher OC concentrations were found in agricultural soil than in non-agricultural soil, water, sediment and fish (Ayas et al., 1997). However, similar results were reported by Chen et al. (2007) and Erkmen and Kolankaya (2006) who stated organochlorine pesticides in grass carp (*Ctenopharyngodon idella*) fish fat were 0.666 mg/kg and in carp (*Cyprinus carpio*) fish fat 0.003–0.052 mg/kg.



A. Standard dimethoate 0.1 mg/kg

B. Standard chlorpyrifos 0.1 mg/kg

C. Standard quinalphos 0.1 mg/kg

Figure 2. GC-MSD chromatogram of dimethoate, chlorpyrifos and quinalphos.

3.4. Pesticide residues in vegetables samples

The chromatogram of standard response in the GC-MS is shown in Figure 2. The concentrations for dimethoate, chlorpyrifos and quinalphos were 0.1 mg/kg. The concentrations of findings in the samples were calculated with the comparison of retention time and concentration of standard.

Different vegetables samples underwent analysis for organophosphate pesticide residues and their metabolites. The result revealed that the collected vegetables were contaminated with different OP pesticide residues (Table 4). All the vegetables were analyzed in the same number (27 each) of samples. Among the vegetable samples, dimethoate was detected in nine samples of country bean and nine samples of green chili, where the amount of dimethoate was higher in country bean (Not Detected 'ND'-0.424 mg/kg) than green chili (ND-0.201 mg/kg). Out of all country bean and red amaranth samples, chlorpyrifos was detected in 2 and 3 samples, respectively. The detected chlorpyrifos was much higher (ND-1.535 mg/kg) in red amaranth and in country bean (ND-

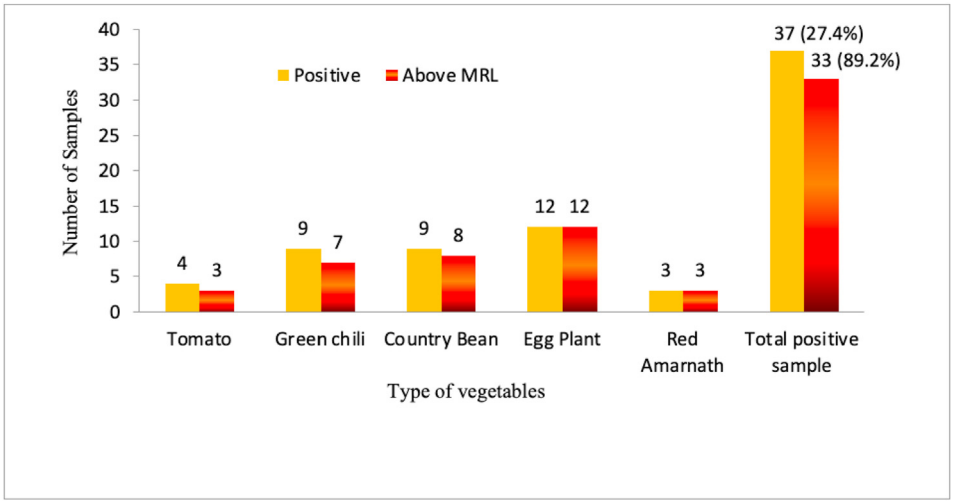


Figure 3. Pesticide residues positive in fresh vegetables sample comparing with sample above MRLs.

0.064 mg/kg). In addition, quinalphos was detected in 15% and 45% of tomato and eggplant samples containing ND-0.321 mg/kg and ND-0.128 mg/kg, respectively. In this study chlorpyrifos contamination was comparatively less than other pesticides identified. The positively detected level of all pesticide's residues in vegetables were higher than the MRLs. The detected pesticide residues levels were higher than MRLs in 75%, 78% and 89% of tomato, country bean and green chili samples, respectively (Figure 3). In the cases of eggplant and red amaranth, all positive samples (100%) exceeded the MRLs. In addition, about 33 (89.2%) samples out of 37 (27.4%) positive samples, contained pesticide residues that exceeded the MRLs. Similar results were reported by Aktar et al. (2017) who applied the same method (QuEChERS extraction) to analyze 50 eggplant samples and found diazinon, dimethoate, quinalphos, and chlorpyrifos pesticide residues in 22% of analyzed samples, of which 10% samples contained residue above MRLs. In the studied area, the eggplant samples contained chlorpyrifos as the most used pesticide. Besides, Hossain et al. (2015) also identified two organochlorines, seven organophosphorus, two carbamate and one pyrethroid pesticide residues in 15 tomato, lady's finger and brinjal samples. Among the pesticides, chlorpyrifos and cypermethrin residues were exceeded MRLs in the all-vegetables samples.

4. Conclusion

The present study revealed that most of the vegetable samples were contaminated with OP pesticides and the level of pesticide residues was high, which ultimately causes harmful effects on the health of consumers. In view of food safety and public health concerns, it is concluded that in Bangladesh, the potential health risk from consuming vegetables contaminated with organophosphate pesticide residues is high. The potential health risk from organophosphate pesticide residues in fish is less, however, not negligible. Although, the study indicated that no fish feed samples and few fish samples were contaminated with pyrethroid and OC pesticide residues respectively, environmental contamination might be a potential source of occasional occurrence of aldrin and permethrin residues in fish in the study area where such pesticides are applied in crops. Therefore, a holistic, systematic and effective risk management strategy should be taken by the risk manager (government and other appropriate regulatory authorities) to regularly monitor pesticide residues in fish and vegetable samples to aware farmers for safe and efficient use of pesticides. However, during this study a moderate number of sample size was considered for pesticides analysis because of limited resources, thus more research is needed to assess pesticide residues in fish feed, fish and vegetables with a large sample size across the country.

Declarations

Author contribution statement

Matiur Rahman; Shahnila Ferdousi: Conceived and designed the experiments; Performed the experiments; Contributed reagents, materials, analysis tools or data.

Md. Sazedul Hoque; Shuva Bhowmik: Conceived and designed the experiments; Analyzed and interpreted the data; Wrote the paper.

Meera Probha Kabiraz; Martin L. van Brakel: Analyzed and interpreted the data; Wrote the paper.

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Data availability statement

Data included in article/supplementary material/referenced in article.

Declaration of interests statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

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