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PESTICIDE RESIDUES IN SELECTED VEGETABLES IN SEVERAL GROWING AREAS BY GC/MS USING QuEChERS TECHNIQUE

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ABSTRACT

Growing concerns over food safety and the expanding world agricultural trade have led to the enforcement of strict pesticide regulations including in Sri Lanka. Thus, this study was undertaken to evaluate the Maximum Residue Levels (MRL) of selected vegetables in the open market in three locations. For the evaluation of pesticide residues, a total of 90 samples of vegetables including tomato (*Solannum lycopersicum*), capsicum (*Capsicum annuum*) and cabbage (*Brassica olerecea*) were collected during the period of 2016 March to 2016 November from different vegetable markets in Nuwara Eliya, Puttlam and Matale districts. Samples were extracted according to the QuEChERS, AOAC code 2007.01 by application of a single step buffered acetonitrile extraction and salting out liquid-liquid partitioning from the water in the sample with $MgSO_4$ and clean-up is done by dispersive solid phase extraction. Concentrated samples were analyzed by GC/MS in Selective Ion Mode (SIM) and presence of pesticides was confirmed with Retention Time (RT) and Mass Spectrum (MS). Matching of RT and MS data of the sample peak with that of the CRM gave unambiguous identification of the pesticides present in the sample. Recovery studies at three spiking concentration levels, namely, 1 LOQ, 5 LOQ and 10 LOQ varied from 80.7 to 99.1 % with Relative Standard Deviation (RSD) below 20%. Out of 90 samples tested, 30 samples were contaminated with pesticide residues. The results of this study provide important information about contamination of pesticide residues in tomato, capsicum and cabbage available at markets of Nuwara Eliya, Puttlam and Matale districts and recommend that monitoring studies should be expanded to other districts in order to come out with a strong national policy on safer use of pesticides in vegetable cultivation in Sri Lanka.

Key words: LOQ, Pesticide residues, QuEChERS,

INTRODUCTION

Pesticides are extensively used in agricultural production to control pests, diseases, weeds and other plant pathogens in an effort to reduce or eliminate yield losses and extend the storage life food commodities. However, indiscriminate use of pesticides which has become a common practice of present day agriculture leads to the accumulation of pesticide residues in agricultural produce, and causes numerous health and environmental impacts. The prescribed pre-harvest intervals in pesticide applications are neglected by majority of vegetable farmers due to high demand of fresh vegetables (Latif *et al.*, 2011). Pesticides contamination is a worldwide public health concern and also a one of the crucial issue in international. Several pesticides can persist in the environment for a long time. Therefore, in the context of health, it is necessary to control or minimize the application of pesticides on crops.

Agriculture is the cornerstone of Sri Lanka's economy which accounts for 1.7 million farm families in a population of about 22 million. Agriculture sector contribute 11 % to Gross Domestic Product in Sri Lanka. Arable land, percentage of total land area is 19.1 and permanent cropped land, percentage of agricultural land area is 37.4. (Central Bank Report, 2014).

Sri Lanka produces around 710,000 metric tons of vegetables and around 540,000 metric tons of fruits annually (Esham *et al*. 2006). In Sri Lanka, many types of vegetables are grown in various regions. Up country region is ideal for temperate crops such as carrot, leeks, cabbage, chinese cabbage, cauliflower, salad leaves, beet, bean, bell pepper, salad cucumber, tomatoes, cherry tomatoes and strawberries while the Low Country areas are suitable for a variety of tropical fruits and vegetables ranging from green chilli, red onion, pumpkin, cucurbits, bitter gourd, melon, sweet and sour banana types, Cavendish banana, queen pineapple, papaya, mango, lemon and gherkins etc. (Hanif *et al*,2006)

Sri Lanka is ranked 4th amongst Asian countries on pesticide use (1,695 tons of active substances). There are approximately 114 active substances and nearly 440 agricultural pesticides in commercial use. The data

available in year 2014 indicate that an abrupt decline in pesticide imports by about 30% than the previous year (2013) due to stringent control over high volume pesticides such as chlorpyrifos, carbaryl, carbofuran and propanil. Further reduction is imminent due to banning of glyphosate, which accounts for approximately 25% reduction (of weedicide formulations) and/or 18% reduction (of all pesticides formulations) of imports in to the country (Department of Agriculture, 2015). Imported quantities of pesticides during year 2012-2015 are presented in Table 1.

Given the potential risk of pesticides for public health, the use of pesticides in fruit and vegetable production is subjected to constant monitoring. Pesticide residues are specified substances in food, Agricultural commodities or animal feed resulting from the use of a pesticide.

Table 1. Imported pesticide quantities during the period of 2012-2015

	2012 Volume (mt)	**2013 Volume (mt)**	**2014 Volume (mt)**	**2015 Volume (mt)**
Formulation				
Insecticide	959.37	1243.46	702.91	1759.06
Herbicide	4753.01	5958.32	4081.83	2862.74
Fungicide	776.44	981.15	935.92	1233.8

Monitoring of pesticide residues in food stuffs have been carried out for decades in most developed countries even though such initiatives are not in the routine agenda of relevant agencies of Sri Lanka. Therefore, the objective of present study was to assess the concentration of pesticide residues in fruits and vegetables from markets in Nuwara Eliya, Puttlam and Matale districts

Table 2. Details of pesticide selected for the study *

Pesticide	CAS No	Chemical type	Main use	ADI mg/kg b.w	Hazard class AI	A I LD_{50} rat oral mg/kg
Cadusafos	95465-99-9	Organophosphate	I	0.0005	1b	37
Deltamethrin	52918-63-5	Pyrethroid	I	0.01	11	135
Diazinon	333-41-5	Organophosphate	I,A	0.005	11	300
Chlorpyrifos	2921-88-2	Organophosphate	I	0.01	11	135
Phenthoate	120068-37-3	Organophosphate	I	0.001	11	400
Prothiofos	34643-46-4	Organophosphate	I	0.005	11	925
Oxyfluorfen	42874-03-3	Diphenyl ether	H	0.01	IV	>5000
Tebuconazole	107534-98-3	Triazole	F	0.03	11	1700

Note: *WHO recommended classification of pesticides by hazards and guideline to classification 2009. International programme on chemical safety

Table 3. Different Maximum Residue Levels

	Cordex MRL			Global MRL			EU MRL		
	Tom	Capsi	Cabb	Tom	Capsi	Cabb	Tom	Capsi	Cabb
Cadusafos	-	-	-	-	-	-	0.01	-*	0.01
Deltamethrin	0.3	-	-	0.2	-	-	0.3	-*	0.5
Diazinon	0.5	-	0.5	-	-	-	0.01	-*	0.05
Chlorpyrifos	-	-	1	-	-	1	0.01	-*	0.01
Phentoate	-	-	-	-	-	-	-*	-*	-*
Prothiofos	-	-	-	-	-	-	-*	--*	-*
Oxyfluorfen	-	-	-	-	-	0.05	0.05	-*	0.05
Tebuconazole	0.7	-	1.0	1.3	-	-	0.9	-*	-*

Note: *A general default MRL of 0.01 mg/kg applies where a pesticide is not specifically mentioned; -Not available; Tom=Tomato; Capsi=Capsicum; Cabb=Cabbage

MATERIALS AND METHODS

Selection of Pesticide

At present, Organochlorine pesticides are not used due to their bioaccumulation ability. The pesticide categories currently registered in Sri Lanka belongs to hazard classes II, III, and IV of the WHO hazard classification. Cadusafos, Deltamethrin, Diazinon, Chlorpyrifos, Phenthoate, Prothiofos, Oxyfluorfen and Tebuconazole have been selected for the study

due to their extensive usage, toxicological effects and available analytical facilities. Cadusafos is currently registered under the restricted category and Chlorpyrifos is already banned since 2013. These two were selected for the study due to presence of counterfeits in the markets in selected districts

Certified Reference Materials (CRM)

Certified reference materials were obtained from Sigma Aldrich for all the pesticide used in the study. Percent purity of each CRM is given in Table 4.

Table 4. Present purity of chemical standards.

Pesticide	Purity %
Diazinon	98.5
Chlorpyrifos	99.7
Oxyfluorfen	98.7
Tebuconazole	99.3
Cadusafos	99.5
Prothiofos	99.8
Deltamethrin	99.4
Phenthoate	99.4

Instrument Details and Operating parameters

Concentrated samples were analyzed by GC/MS in selective ion mode. Presence of pesticides was confirmed with Retention time (RT) and Mass spectrum (MS). Matching of RT and MS data of the sample peak with that of the CRM gave unambiguous identification of the pesticides presented in the sample (Lehotay *et al.*, 2007). Agilent 6890/5975B GC-MSD (Mass selective Detector) equipped with DB 35 MS fused silica capillary column (Agilent J & W GC column, 5% phenylated methyl siloxane, 30 m length, 0.25 mm internal diameter and 0.25 μm film thickness was used for analysis of pesticide. Analysis was carried out using temperature programming of initial temperature 80 °C for 1 min followed by a ramp rate of 10°C min^{-1}up to a temperature of 160 °C with a hold time of 1 min followed by 6°C min ramp to a temperature of 250 °C with a hold time of 1 min, followed by 10°C min ramp to a temperature of 300 °C with a hold time of 5 min. The injector was operated in splitless mode at 280 °C temperature. The interface, ion source and

quadrapole temperatures were set at 280 °C and 250°C and 150 °C respectively. The instrument was operated at electron impact mode (EI) with electron energy 400 ev. Helium was used as carrier gas at a flow rate of 1 ml/min. Solvent delay time was given as 6.5 min. (Lehotay *et al*., 2005).

Preparation of standard stock solution (Strength approximately 500 mg/L)

The stock solution of 500 mg/L was prepared by certified Reference Materials (CRM) of pesticide having specific purity with traceability. Standards were taken out from freezer (–18 to-20 °C) and kept them till room temperature was reached. 500 mg/L standard stock solutions were prepared by HPLC grade acetone and kept in the refrigerator at 4 - 6 °C.

Intermediate stock solution (Strength approximately 50 mg/L)

Stock solution of 500 mg/L was taken out from the refrigerator and leave to reach room temperature. Intermediate solutions of 50 mg/L were prepared by diluting the stock solution and stored in the refrigerator at 4 - 6 ° C.

Primary working Standards Solution (Strength approximately 5 mg/L)

Intermediate stock solutions were taken out from refrigerator and leave to reach the room temperature. 5 mg/L primary working standard contain all pesticides was prepared by HPLC grade acetone and store in the refrigerator at 4 - 6 ° C.

Preparation of working standards

Primary working standard solutions was taken out (Approximately 5 mg/L) storage bottle from refrigerator and leave it to reach the room temperature. If moisture observed on the storage bottle surface, gently wipe out using a tissue paper. Working standards of 0.2, 0.5, 1.0, 1.5, 2 .0 mg/L was prepared from the Primary working standard.

External standards calibration procedure

Calibration standards were prepared at five concentration levels for each pesticide. The analysed concentration should be within the lowest and highest calibration standards linearity is accepted only if the correlation factor is more than 0.990.

Steps in pesticide residue analysis

Pesticides may occur in food at very low concentrations, usually at ppm levels. A variety of analytical methods are currently used to detect pesticide residues and all contained certain basic steps that include sampling, sample preparation, extraction, clean up and identification (Lesueur *et al.*, 2008)

Table 5. Selected pesticides, retention time and their target ions

Compound Name	Retention Time/min	Target Ion M/Z
Cadusafos	13.983	253,231,233
Deltamethrin	15.275	159,158,127
Diazinon	15.948	304,179,199
Chloropyrifos	19.566	314,197,199
Phenthoate	20.342	274,246,164
Prothiofos	22.308	309,267,162
Oxyfluorfen	22.824	252,302,331
Tebuconazole	26.201	250,125,126

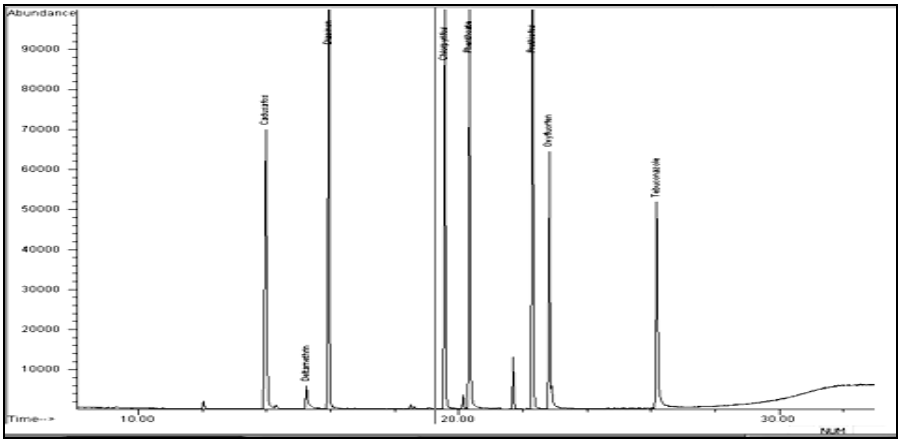

Figure 1. Chromatograms for Standard in GC/MS.

Sample preparation procedure

Tomato, capsicum and cabbage samples collected at local markets from Nuwara Eliya, Puttalam and Dambulla were stored in a refrigerator and taken out to set to room temperature. Samples were cut coarsely with a knife and grinded separately by using a blender. The blender was clean thoroughly before being used for the next sample to avoid cross contamination. A sample of 10 g ± 0.1 g was transferred in to 50 ml Teflon tube and 6 g of anhydrous magnesium sulphate, 1.5 g of anhydrous sodium acetate or 1.5 g of sodium chloride were added. 10 ml of 1 % acetic acid in acetonitrile was added in to the sample tube and vortex for 1 minute and centrifuge 3000 rpm for 3 minutes (Nguyen *et al*., 2008). Aliquot from supernant layer was transferred in to the dispersive 15 ml SPE tube containing 400 mg PSA, 1200 mg magnesium sulphate. In the presence of water magnesium sulphate tends to form lumps, which can harden rapidly. This can be avoided if immediately after the addition of the salt mixture the centrifuge tube is shaken vigorously for a few seconds. SPE (Solid Phase Extraction) tubes were Vortex for 1 minute and centrifuge 3 minutes at 3000 rpm. Finally supernant layer was transferred in to rotary evaporator. Content was evaporated using a rotary evaporator at a temperature below 40^{o} C concentrate the solvent near to dry and add 1 ml of acetone to dissolve. The solution was passing through 0.45 micro meter HDPE filter by using the plastic syringe and transfers the extract to GC vial. Finally extract is subject to GC/MS for quantitative analysis (AOAC, 2007).

Calculation

As the external standard calibration procedure was used, calculate the amount of material injected from the peak response using the calibration curve (Figure 1).

Linearity

All calibration curves were prepared and correlation coefficient (r) values were calculated with each calibration curve. Each calibration curve was prepared with multi-pesticide standard solutions, including the blank standard solution. The analytical calibration should extend over a range appropriate to the lowest and highest nominal concentration of the analysed in relevant

analytical solutions at least ±20%. At trial linearity the linearity criteria of $r^2 \geq 0.98$-0.99 have to be achieved (Yawar, *et al.*, 2011)

Determination of recovery

Replicates of high spiked sample and low spiked sample were analyzed using candidate method and recovery was estimated. Mean recoveries for each level should be in the range 70-110%, with acceptability RSD ≤ 20% (Nguyen, *et al*., 2008). Mean recovery percentages for each pesticide are present in figure 3.

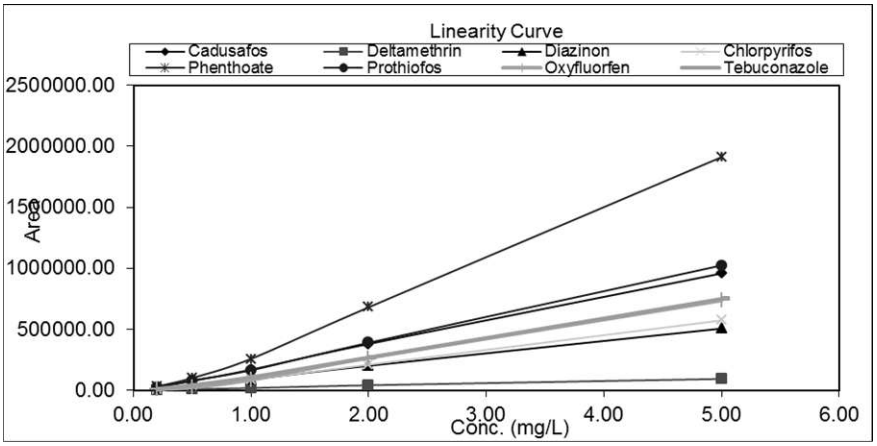

Figure 2. Calibration curve for selected pesticides

Table 6. Correlation coefficient for selected Pesticides

Chemicals	R^2
Cadusafos	0.999
Deltamethrin	0.998
Diazinon	0.999
Chlorpyrifos	0.999
Phenthoate	0.998
Prothiofos	0.994
Oxyfluorfen	0.997
Tebuconazole	0.999

Acceptable Daily Intake (ADI)

ADI of a chemical is the daily intake, which during an entire lifetime, appears to have no appreciable risk to the health of the consumer on the basis of all the known facts at the time of the evaluation of the chemical. It is

expressed in mg/kg of body weight. ADIs are derived from the results of long term feeding studies with laboratory animals.

No Observed Adverse Effect Level (NOAEL)

It is the highest dose of substances that does not cause any detectable toxic effects in experimental animal studied. It is expressed in mg/kg body weight per day.

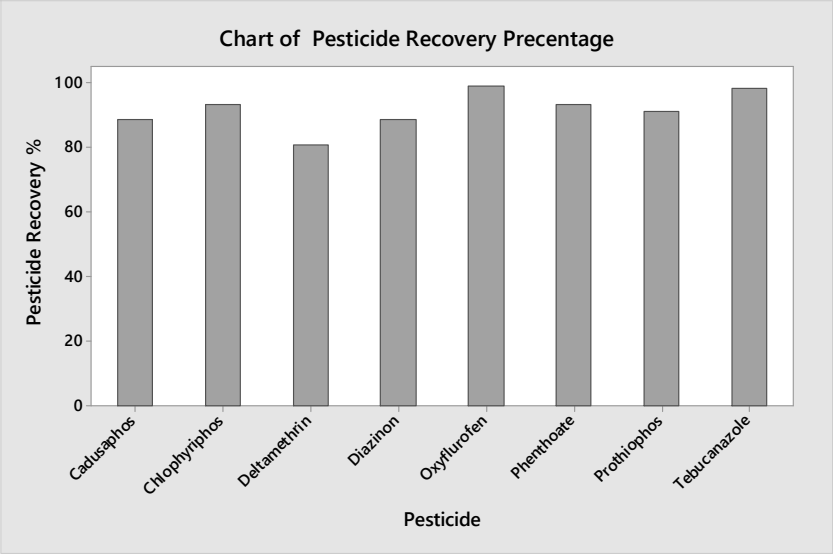

Figure 3. Mean Recovery value for selected pesticides

Maximum Residue Level (MRL)

MRL is the maximum concentration of a pesticide residues (mg/kg) to be legally permitted in or on food commodities and animal feeds recommended by the CORDEX or National Regulatory Authority. During the Study, CORDEX MRL data are compared with the global MRL data and EU MRL data as shown in table 3. According to that EU has most stringent data base and default is set to 0.01 mg/kg and it covers most of the crop and pesticide. Therefore, EU MRL data was used to compare the detectable residue level (CODEX alimentarius, 2015).

Limit of Detection (LOD)

LOD for pesticide residue analysis in vegetable and fruit was 40 ppb. LOD value for the Matrix converted for pesticide residue was presented on table 6. (EU MRL, 2015)

Table 6. Matrix converted LOD Values for selected pesticides

Pesticide	LOD with uncertainty mg/kg
Cadusafos	0.040±0.0061
Deltamethrin	0.040±0.0064
Diazinon	0.040±0.0061
Chlopyrifos	0.040±0.0067
Phenthoate	0.040±0.0068
Prothiofos	0.040±0.0063
Oxyfluorfen	0.040±0.0062
Tebuconazole	0.040±0.0064

RESULTS AND DISCUSSION

Out of 90 samples analyzed, no samples were found to be contaminated with Cadusafos or Deltamethrin. EU has the most stringent MRL data and EU MRL was used to compare the detectable residue level. Each 30 samples of tomatoes, capsicum and cabbage from Nuwara Eliya, Puttalam and Matale districts were collected for the study. Out of 90 samples analysed, 30 were found to be contaminated with the residues of different pesticides. It was determined that 4 samples were found to be contaminated with Diazinon with exceeding EU MRLs. Summary of the results of GC/MS analysis of samples are given in figure 4 and table 8. The highest amount of Diazinon found in cabbage was 0.170 mg/kg, collected from Dambulla.

Table 8. Sample analysis data for Diazinon

Area	Matrix	Total Sample No	No of Contami-nated	No of Sample above EU MRL	Mean mg /Kg	Range mg /Kg
Nuwara Eliya	Tomato	10	-	-	-	-
	Capsicum	10	01	01	0.042	0.042
	Cabbage	10	-	-	-	-
Puttalam	Tomato	10	-	-	-	-
	Capsicum	10	02	02	0.089	0.048-0.130
	Cabbage	10	-	-	-	-
Dambulla	Tomato	10	-	-	-	-
	Capsicum	10	-	-	-	-
	Cabbage	10	01	01	0.170	0.170

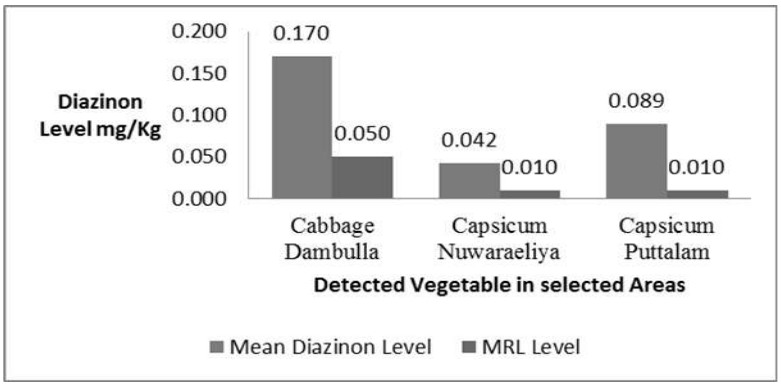

Figure 4. Chart of mean Diazinon level detected in vegetables available at Selected Areas

Of the 90 samples, including 30 samples of tomatoes, 30 samples of capsicum and 30 samples of cabbage, only 7 samples were contaminated with Chlorpyrifos and these 7 samples had residue content more than EU MRL value. Chlorpyrifos contamination was only presented with Nuwara Eliya and Puttalam districts and out of these 7 samples almost 6 samples were found in market located in Puttalam district. Chlorpyrifos has been already banded on 2013 and the contamination may be due to counterfeits of Chlorpyrifos. The highest amount of Chlorpyrifos found in cabbage was 0.130 mg/kg, collected from Puttalam District. Summary of the results of GC/MS analysis of samples are given in Figure 5 and Table 9.

Table 9. Sample analysis data for Chlorpyrifos

Area	Matrix	Total Sample No	No of Contaminated	No of Sample above EU MRL	Mean (mg /Kg)	Range (mg /Kg)
Nuwara Eliya	Tomato	10	01	01	0.061	0.061
	Capsicum	10	-	-	-	-
	Cabbage	10	-	-	-	-
Puttalam	Tomato	10	02	02	0.096	0.062-0.130
	Capsicum	10	02	02	0.130	0.130
	Cabbage	10	02	02	0.130	0.130
Dambulla	Tomato	10	-	-	-	-
	Capsicum	10	-	-	-	-
	Cabbage	10	-	-	-	-

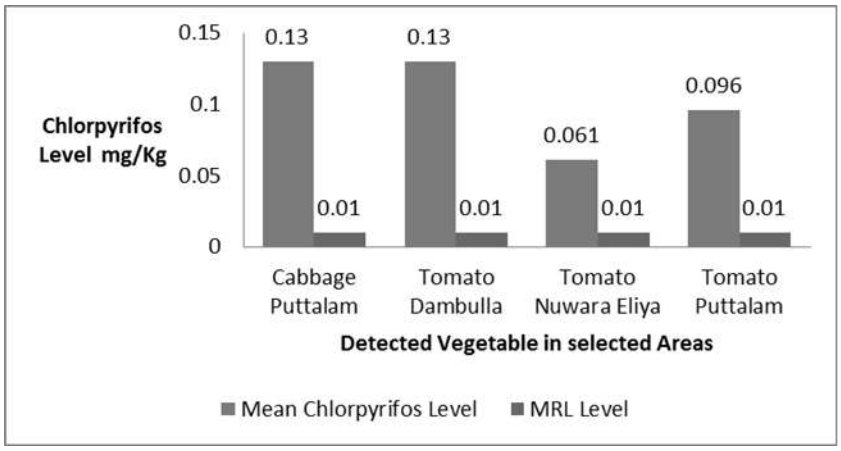

Figure 5. Chart of mean Chlorpyrifos level detected in vegetables available at Selected Areas.

According to the analysis data present in Figure 6 and Table 10, only 04 samples were contaminated with Phenthoate and these 4 samples had residue content more than EU MRL value. The highest amount of Phenthoate found in vegetables collected from Puttalam and Nuwara Eliya districts and the value was 0.200 mg/kg. Summary of the results of GC/MS analysis of samples are given in Figure 6 and Table 10.

Table 10. Sample analysis data for Phenthoate.

Area	Matrix	Total Sample No	No of Contaminated	No of Sample above EU MRL	Mean (mg /Kg)	Range (mg /Kg)
Nuwara Eliya	Tomato	10	-	-	-	
	Capsicum	10	01	01	0.200	0.200
	Cabbage	10	-	-	-	-
Puttalam	Tomato	10	-	-	-	-
	Capsicum	10	01	01	0.180	0.180
	Cabbage	10	01	01	0.200	0.200
Dambulla	Tomato	10	-	-	-	-
	Capsicum	10	01	01	0.180	0.180
	Cabbage	10	-	-	-	-

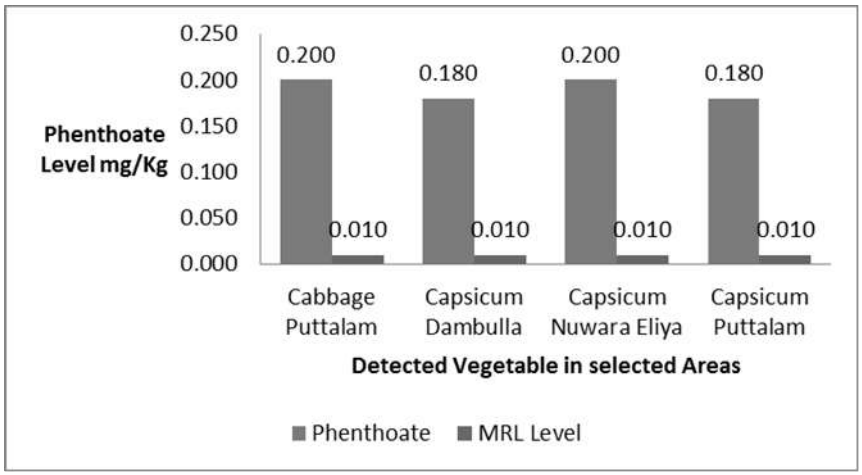

Figure 6. Chart of mean Phenthoate level detected in vegetables available at Selected Areas.

According to the analysis data present in Figure 7 and Table 11, of the 90 samples tested, The highest amount of prothiofos found in vegetables collected from Puttalam and Nuwara Eliya districts and the value was 0.200 mg/kg Summary of the results of GC/MS analysis of samples are given in Figure 7 and Table 11.

Table 11. Sample analysis data for Prothiofos

Area	Matrix	Total Sample No	No of Contami-nated	No of Sample above EU MRL	Mean (mg /Kg)	Range (mg /Kg)
Nuwara Eliya	Tomato	10	-	-	-	-
	Capsicum	10	-	-	-	-
	Cabbage	10	-	-	-	-
Puttalam	Tomato	10	-	-	-	-
	Capsicum	10	-	-	-	-
	Cabbage	10	01	01	0.170	0.170
Dambulla	Tomato	10	02	02	0.146	0.052-0.240
	Capsicum	10	-	-	-	-
	Cabbage	10	-	-	-	-

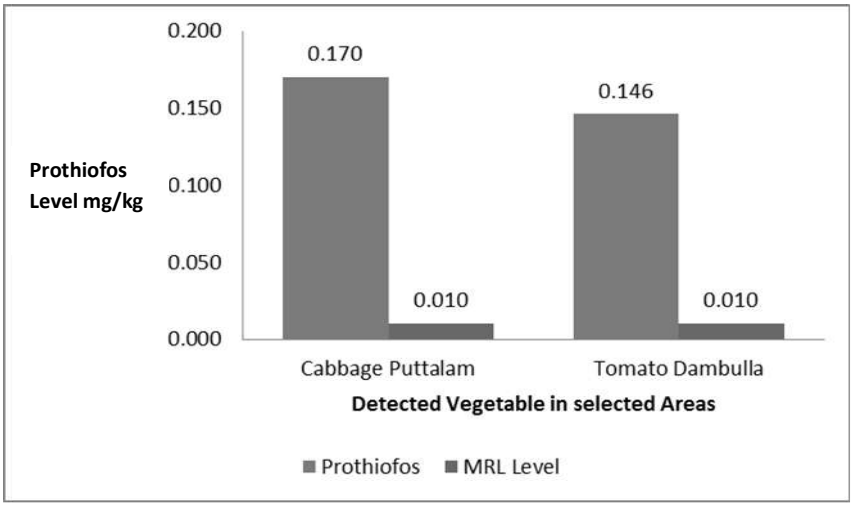

Figure 7. Chart of mean Prothiofos level detected in vegetables available at Selected Areas.

Of the 90 samples tested, only 4 samples were contaminated with Oxyfluorfen and these 4 samples had residue content more than EU MRL value. The highest amount of Oxyfluorfen found in tomato was 0.490 mg/kg, collected from Matale District. Summary of the results of GC/MS analysis of samples are given in Figure 8 and Table 12.

Table 12. Sample analysis data for Oxyfluorfen

Area	Matrix	Total Sample No	No of Contami-nated	No of Sample above EU MRL	Mean (mg /Kg)	Range (mg /Kg)
Nuwara Eliya	Tomato	10	-	-	-	-
	Capcicum	10	02	02	0.139	0.078-0.200
	Cabbage	10	-	-	-	-
Puttalam	Tomato	10	01	01	0.200	0.200
	Capcicum	10	-	-	-	-
	Cabbage	10	-	-	-	-
Dambulla	Tomato	10	01	01	0.490	0.490
	Capcicum	10	-	-	-	-
	Cabbage	10	-	-	-	-

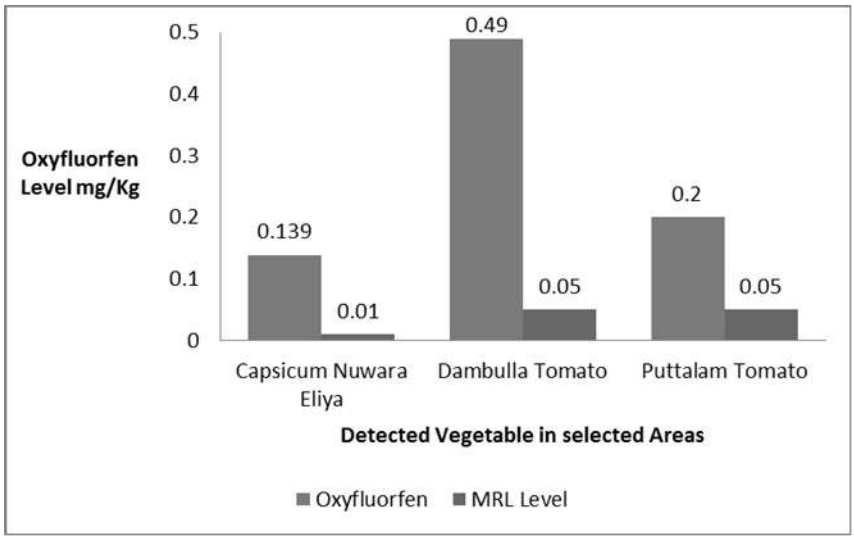

Figure 8. Chart of mean Oxyfluorfen level detected in vegetables available at Selected Areas

Out of 90 samples only 13 samples were contaminated with Tebuconazole and from these 13 samples, only 9 samples had residue content more than EU MRL value. The highest amount of Tebuconazole found in vegetable was 0.370 mg/kg, collected from Dambulla. Summary of the results of GC/MS analysis of samples are given in Figure 9 and Table 13.

Table 13. Sample analysis data for Tebuconazole.

Area	Matrix	Total Sample No	No of Contaminated	No of Sample above EU MRL	Mean (mg /Kg)	Range (mg /Kg)
Nuwara Eliya	Tomato	10	03	-	0.093	0.061-0.150
	Capsicum	10	03	03	0.090	0.060-0.150
	Cabbage	10	02	02	0.060	0.060
Puttalam	Tomato	10	-	-	-	-
	Capsicum	10	01	01	0.150	0.150
	Cabbage	10	01	01	0.058	0.058
Dambulla	Tomato	10	01	-	0.370	0.370
	Capsicum	10	-	-	-	-
	Cabbage	10	02	02	0.138	0.084-0.330

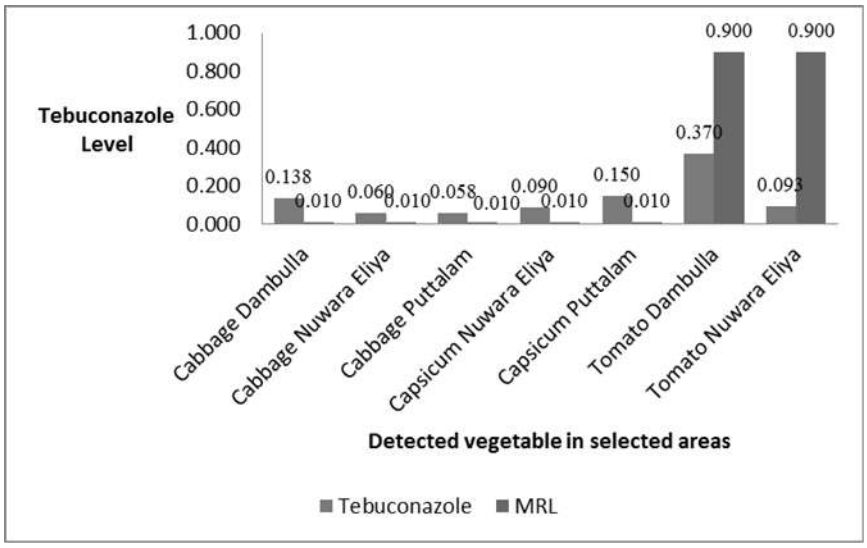

Figure 9. Chart of mean Tebuconazole level detected in vegetables available at Selected Areas.

The mean concentrations and range of pesticide residues found in tomato, capsicum and cabbage available at Nuwara Eliya, Puttalam and Dambulla local markets are summarized in table 14.

Table 14. Mean concentration of pesticide detected.

Area	Matrix	Mean Pesticide Residue detected (mg/Kg)							
		Cadusafos	Deltamethrin	Diazinon	Chlorpyrifos	Phenthoate	Prothiofos	Oxyfluorfen	Tebuconazole
Nuwara Eliya	Tomato	-	-	-	0.061	-	-	-	0.093
	Capsicum	-	-	0.042	-	0.200	-	0.139	0.090
	Cabbage	-	-	-	-	-	-	-	0.060
Puttalam	Tomato	-	-	-	0.096	-	-	-	
	Capsicum			0.089	0.130	0.180	-	-	0.150
	Cabbage				0.130	0.200	0.170	-	0.058
Dambulla	Tomato	-	-	-	-	-	0.146	0.490	0.370
	Capsicum	-	-	-	-	0.180	-	-	-
	Cabbage	-	-	0.170	-	-	-	-	0.138

Overall the data revealed that, the high presence of pesticide residues was appeared in Puttalam . Capsicum and cabbage available at Puttalam market have high frequency of contamination with pesticide residues. The highest level of contamination was found to be 0.490 mg/kg of Oxyfluorfen on tomato presence in Dambulla Economic Centre. The result of the study indicates that Tebuconazole has higher possibility for contamination in all Districts. Mean level of detected pesticide in Nuwara Eliya, Puttalam and Matale Districts were presented by the Figure 10.

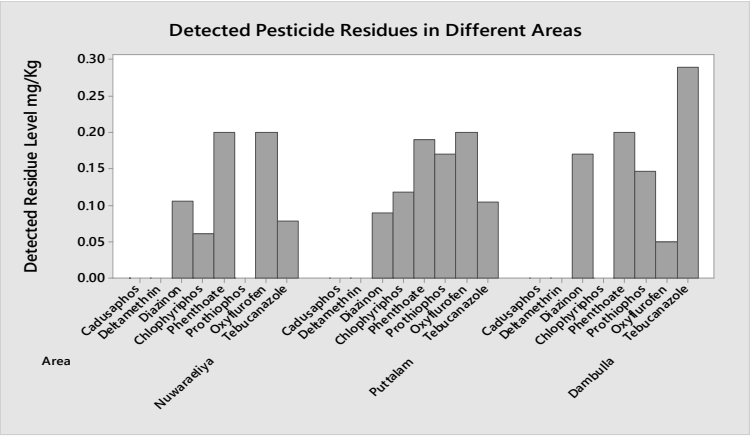

Figure 10. Detected Pesticide Residues in Selected Areas

CONCLUSION

Diazinon, Chlorpyrifos, Phenthoate, Prothiofos, Oxyfluorfen and Tebuconazole were found in tomato, capsicum and cabbage samples and Deltamethrin and Cadusafos were not detected on analysed vegetable samples. According to the analysed data 33 % of samples were contaminated with pesticide residues. Also already banded pesticide Chlorpyrifos was used as a counterfeit in Nuwara Eliya and Puttalam districts.

Capsicum and cabbage available at Puttalam market have high frequency of contamination with pesticide residues. The highest level of contamination was found to be 0.490 mg/kg of Oxyfluorfen on tomato presence in Dambulla Economic Centre. The result of the study indicates that Tebuconazole has higher possibility for contamination in all Districts.

The above results suggest that the consumers of the Nuwara Eliya, Puttalam and Matale districts were exposed to concentration of pesticides that may cause chronic diseases. On the basis of the above findings the results recommended the need for continuous surveillance and monitoring programmes for pesticide residues in other 22 districts in order to protect the end user for the indiscriminate exposure of pesticides.

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