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Determination of Pesticide Residue Levels in Omani and UAE Vegetable Farm Soils

F. A. Talukder[a]*, W. Kaakeh[b], M. L. Deadman[a] and J. H. Al Dahmani[b]
[a]Department of Crop Sciences, Sultan Qaboos University, PO Box 34, Al-Khod 123, Oman
[b]Department of Aridland Agriculture, United Arab Emirates University, UAE

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Abstract. In the investigation of 40 different vegetable growing farms of Al-Batinah (Oman) and Al - Ain (UAE) regions different pesticide residues were found to be present on all soil samples which varied in their types and levels according to the region. In Omani soil samples, cypermethrin was the most frequent pesticide, followed by chlorpyrifos, malathion, phenthoate, triazophos and deltamethrin. In UAE farm soil samples, chlorpyrifos, cypermethrin and deltamethrin were detected in all the regions, while phenthoate was detected in the Eastern and Northern regions only.

Keywords: pesticide residues, cypermethrin, chlorpyrifos, deltamethrin, malathion, agricultural soil, Oman, UAE

Introduction

During the last three decades, Gulf's agricultural production has dramatically increased. (Talukder and Kaakeh, 2006; Thacker *et al*., 2000) which is associated with different factors including the increased use of agrochemicals, especially pesticides for crop protection (Tivy, 1991). Since 1960, the value of pesticide imports to Oman has increased more than 10 fold (FAO, 2003). Around 835 pesticides have been registered in the UAE, and among them, the insecticides have the greatest share (49.8%) followed by fungicides (22%). The average amount of pesticides used in the UAE has been 9.86 l or kg per hectare per year (Kaakeh *et al*., 2004). This increased use of different pesticides in Gulf countries is a cause for serious concerns. Hazardous effects of pesticide residues in plants, soil, water, food, environment, humans and domestic animals and on beneficial organisms including pollinating honeybees, predators, parasites, fishes, birds and other wild animals are very serious issues world wide (Perry *et al*., 1998; Edwards, 1987). Pesticides may also cause resistance and resurgence problems in target pest populations, resulting in use of their higher doses at greater frequencies in the farms (Talukder and Kaakeh, 2006).

The use of pesticides in vegetable production in Oman is a regular practice. In Northern Oman all agricultural farms use different types of pesticides for the protection of crops (Kaakeh *et al*., 2007; Thacker *et al*., 2000); 95% of the farms use insecticides, 60%, fungicides and 20%, herbicides. Regular use of pesticides in crop production might be associated with pesticide residue problems. Three out of 11 selected pesticides, widely used in the UAE, have the potential to leach to groundwater due to their solubility that exceeds the US EPA threshold values (Kaakeh *et al*., 2004). Therefore, over the years, contamination of soil and ground water with the pesticides has been a major concern. The present investigation was designed to determine pesticidue residue levels in agricultural soils of Omani and UAE vegetable farms, so as to estimate the extent of soil pollution caused by the use of pesticides under local environmental conditions. It may consequently aid in developing better management strategies.

Materials and Methods

Sampling techniques. In Oman, twenty farms located at different sites were selected from the Al-Batinah region, from which soil samples were collected randomly from two locations in each farm at two different depths (0-15 cm and 15-30 cm). In the UAE, twenty farms representing four agricultural regions of Al-Ain (five farms per region) were selected for the present study and soil samples were collected in a similar way. Soil samples were separately sieved to exclude foreign materials and the samples were stored in previously marked plastic bags which were transferred to Central Laboratory Unit, UAE University for analysis. The types of pesticides applied in all of these surveyed farms were also recorded.

Analyses of pesticide residues in soil samples. ***Analytical techniques.*** Analytical techniques used for the soil analysis at the laboratory involved extraction, identification, confirmation (wherever possible) and quantitation of pesticides. The studied pesticides included propamocarb, diazinon, pirimiphos-methyl, malathion, chlorpyrifos, phenthoate, triazophos, deltamethrin, cypermethrin, dimethoate and metalaxyl. Dimethoate and metalaxyl in the extract were separated and

*Author for correspondence; E-mail: talukder@squ.edu.om

carbamates were analysed by HPLC on XTerra MS C-18 column using photodiode array detector. All other pesticides were analyzed using GC-ECD for organochlorine and GC-NPD for nitrogen and phosphorous compounds. Confirmation was made by GC-MS.

Sample preparation. 10 ± 0.5 g of each soil sample was blended with 10 ± 0.5 g of anhydrous sodium sulfate and placed in an extraction thimble and put inside the Soxhlet equipment. Approximately 80 ml of the extraction solvent (1: 1 methylene chloride: acetone) was added, and the sample was extracted for 2 h (with boiling for 1 h and rinsing for 1 h) at 150 °C. Each sample was carefully evaporated after extraction. The evaporation was carried out using a rotary evaporator till the volume of the extract was reduced to around 2 ml. Then 5 ml methanol was added and the solution was again concentrated. The process was repeated twice; and finally the extract was concentrated to about 1 ml. The extract was collected in round flask and exchanged to hexane solvent and quantitatively made up to 2 ml, transferred to a 2 ml GC auto sampler vial; 2 µl of the extract was sequentially injected using both injectors, one connected to the NPD and then to the ECD with 0.5 min delay.

GC conditions. A Varian 3800 GC-ECD-NPD was used for current analyses with two different types of columns (CP-Sil 8, 30 m* 0.32 mm ID, df = 1 connected to NPD and CP-Sil 19 CB 30 m* 0.25 mm ID, df = 0.25 connected to ECD). Helium (1.5 ml/min) was used as the carrier gas for both the columns. The injector temperature was maintained at 240 °C, splitless for both injectors and detector temperature at 300 °C for both ECD and NPD. The temperature programme was: initial temperature at 80 °C, held 1 min, 80 °C to 160 °C at 8 °C/min, held for 2 mins, followed by 160 °C to 180 °C at 2 °C/min, held for 7 mins, 180 °C to 200 °C at 2 °C/min, held for 2 min and 200 °C to 260 °C at 5 °C/min, held for 20 min. The level of detection was upto 0.01 ppm.

HPLC. The HPLC equipment used for the current analyses was a gradient solvent delivery system (Waters, Alliance 2695 separation module with column oven or equiv.), equipped with XTerra MS C18 (150 mm x 4.6 mm ID, 5 µm) column and Waters 2996 PDA Detector. The isocratic programme for LC pump was with flow of 1.0 ml/min, temperature 25 °C, 65% A (water) and 35% B (CH_3CN). The photo-diode-array detector was monitored at 215 nm. The limits of detection were 0.25 µg/g and 0.10 µg/g for dimethoate and metalaxyl, respectively.

Expression of results. The amount of pesticide residues (µg/g), detected in each sample from each farm, was calculated according to the following equation:

$$\text{Pesticide residue } (\mu g/g) = \frac{\text{area of sample x conc. of std } (\mu g/ml) \text{ x vol. made up to (ml)}}{\text{area of std. x wt. of sample (g)}}$$

Results and Discussion

Among the tested pesticides, cypermethrin was the most frequently detected in Omani farm soil samples followed by chlorpyrifos and to a lesser extent, phenthoate, triazophos, and deltamethrin (Table 1). The highest level of cypermethrin was detected as 0.48 mg/kg in the soil samples from farm 7, followed by 0.36 mg/kg in farm 9. The levels of phenthoate, triazophos, and deltamethrin in the soil were within the range of 0.01-0.03 mg/kg. The chlorpyrifos and malathion were detected in some of the Omani farm soils with different concentration levels. As for example, 1.01 mg/kg level of chlorpyrifos was detected in farm 6, followed by 0.79 mg/kg in farm 16. Malathion was observed in the soil samples of farm 3 only. Propamocarb, diazinon, pirimiphos-methyl, dimethoate and metalaxyl were not detected in any Omani soil samples.

In the UAE soil samples, different pesticides were detected in different regions (Table 2). In the central region, the most frequently detected pesticide was chlorpyrifos (in all farms), followed by cypermethrin and deltamethrin, while malathion and propamocarb were detected only once or twice. The level of chlorpyrifos reached up to 0.37 mg/kg in some of the farms (farm C1) while the level of other detected pesticides did not exceed 0.08 mg/kg. Diazinon, pirimiphos-methyl, phenthoate, triazophos, dimethoate and metalaxyl were not detected in the central region soil samples. In the eastern region, the most frequently detected pesticides were chlorpyrifos and cypermethrin followed by phenthoate and deltamethrin. The least frequently detected pesticides were propamocarb and diazinon. The level of cypermethrin was generally high (0.1-0.8 mg/kg). The highest level of cypermethrin was detected in soil samples from farm E1 (0.86 mg/kg). On the other hand, the highest level of chlorpyrifos (1.46 mg/kg) was detected in farm E2. However, several pesticides including pirimiphos-methyl, malathion, triazophos, dimethoate, and metalaxyl were not detected in the eastern region soil samples. In the western region, low concentrations of deltamethrin (0.02-0.19 mg/kg) and chlorpyrifos (0.01-0.04 mg/kg) were detected at relatively low levels; cypermethrin was detected in a few samples only, whereas propamocarb, diazinon, pirimiphosmethyl, malathion, phenthoate, triazophos, dimethoate, and metalaxyl were not detected in this region. In the northern region, the most frequently detected pesticides were deltamethrin (0.02-0.19 mg/kg) and cypermethrin (0.01-0.12 mg/kg) followed by

Table 1. Pesticide residues in selected soil samples from Al-Batinah region of Sultanate of Oman

Region	Farms			Results (mg/kg)										
				HPLC Method		GC Method								
	Farm	Sample	Depth (cm)	Metalaxyl	Dimethoate	Cypermethrin	Deltamethrin	Triazophos	Phenthoate	Chlorpyrifos	Malathion	Pirimiphos-methyl	Diazinon	Propamocarb
Al-Batinah	1	1	1	-	-	-	-	-	-	-	-	-	-	-
			2	-	-	-	-	-	-	-	-	-	-	-
		2	1	-	-	-	-	-	-	-	-	-	-	-
			2			-	-	-	-	-	-	-	-	-
	2	1	1	*	*	*	*	*	*	*	*	*	*	*
			2	-	-	0.01	-	-	-	-	-	-	-	-
		2	1	*	*	*	*	*	*	*	*	*	*	*
			2	-	-	0.01	-	-	-	-	-	-	-	-
	3	1	1	-	-	0.08	-	-	0.01	0.01	0.01	-	-	-
			2	-	-	0.01	-	-	-	-	-	-	-	-
		2	1	-	-	0.02	0.01	0.01	0.03	0.18	0.08	-	-	-
			2	-	-	-	-	-	-	-	-	-	-	-
	4	1	1	*	*	*	*	*	*	*	*	*	*	*
			2	-	-	-	-	-	-	-	-	-	-	-
		2	1	*	*	*	*	*	*	*	*	*	*	*
			2	-	-	0.11	-	-	-	-	-	-	-	-
	5	1	1	*	*	*	*	*	*	*	*	*	*	*
			2	-	-	0.02	-	-	-	-	-	-	-	-
		2	1	*	*	*	*	*	*	*	*	*	*	*
			2	-	-	0.19	-	-	-	-	-	-	-	-
	6	1	1	-	-	0.09	-	-	-	0.66	-	-	-	-
			2	-	-	-	-	-	-	-	-	-	-	-
		2	1	-	-	0.01	-	-	-	1.01	-	-	-	-
			2	-	-	0.01	-	-	-	-	-	-	-	-
	7	1	1	*	*	*	*	*	*	*	*	*	*	*
			2	-	-	0.48	-	-	-	-	-	-	-	-
		2	1	*	*	*	*	*	*	*	*	*	*	*
			2	-	-	0.42	-	-	-	-	-	-	-	-
	8	1	1	*	*	*	*	*	*	*	*	*	*	*
			2	-	-	0.10	-	-	-	-	-	-	-	-
		2	1	*	*	*	*	*	*	*	*	*	*	*
			2	-	-	0.05	-	-	-	-	-	-	-	-
	9	1	1	-	-	0.36	-	-	-	0.13	-	-	-	-
			2	-	-	0.01	-	-	-	-	-	-	-	-
		2	1	-	-	0.05	-	-	-	0.01	-	-	-	-
			2	-	-	-	-	-	-	-	-	-	-	-
	10	1	1	*	*	*	*	*	*	*	*	*	*	*
			2	-	-	-	-	-	-	-	-	-	-	-
		2	1	*	*	*	*	*	*	*	*	*	*	*
			2	-	-	0.09	-	-	-	-	-	-	-	-

(*Cont'd.* ....)

<u>*Continued Table 1*</u>

11	1	1	-	-	0.10	-	-	-	-	-	-	-	-
		2	-	-	0.01	-	-	-	-	-	-	-	-
	2	1			0.15	-	0.01	-	-	-	-	-	-
		2	-	-	-	-	-	-	-	-	-	-	-
12	1	1	-	-	0.01	-	-	-	0.01	-	-	-	-
		2	-	-	0.06	0.01	-	-	-	-	-	-	-
	2	1	-	-	0.01	-	-	-	-	-	-	-	-
		2	-	-	-	-	-	-	0.02	-	-	-	-
13	1	1	-	-	0.02	-	-	-	0.05	-	-	-	-
		2	-	-	-	-	-	-	-	-	-	-	-
	2	1	-	-	-	-	-	0.01	0.03	-	-	-	-
		2	-	-	-	-	-	-	-	-	-	-	-
14	1	1	-	-	0.01	-	-	-	0.01	-	-	-	-
		2	-	-	-	-	-	-	-	-	-	-	-
	2	1	-	-	0.04	-	0.01	-	0.03	-	-	-	-
		2	-	-	-	-	-	-	-	-	-	-	-
15	1	1	*	*	*	*	*	*	*	*	*	*	*
		2	-	-	0.02	-	-	-	-	-	-	-	-
	2	1	*	*	*	*	*	*	*	*	*	*	*
		2	-	-	0.02	-	-	-	-	-	-	-	-
16	1	1	-	-	0.04	-	0.01	-	0.23	-	-	-	-
		2	-	-	0.02	-	-	-	-	-	-	-	-
	2	1	-	-	0.10	-	-	-	0.79	-	-	-	-
		2	-	-	-	-	-	-	0.01	-	-	-	-
17	1	1	*	*	*	*	*	*	*	*	*	*	*
		2	-	-	-	-	-	-	-	-	-	-	-
	2	1	*	*	*	*	*	*	*	*	*	*	*
		2	-	-	-	-	-	-	-	-	-	-	-
18	1	1	*	*	*	*	*	*	*	*	*	*	*
		2	-	-	-	-	-	-	-	-	-	-	-
	2	1	*	*	*	*	*	*	*	*	*	*	*
		2	-	-	-	-	-	-	-	-	-	-	-
19	1	1	-	-	-	-	-	-	0.02	-	-	-	-
		2	-	-	0.01		-	-	-	-	-	-	-
	2	1	-	-	-	-	-	-	-	-	-	-	-
		2	-	-	-	-	-	-	-	-	-	-	-
20	1	1	*	*	*	*	*	*	*	*	*	*	*
		2	-	-	0.01	-	-	-	-	-	-	-	-
	2	1	*	*	*	*	*	*	*	*	*	*	*
		2	-	-	-	-	-	-	-	-	-	-	-

- = pesticide residues not detected (level of detection is 0.01 ppm); * = soil sample was not available for analysis; depth 1= 0-15 cm; depth 2= 15-30 cm

Table 2. Pesticide residues in selected soil samples from four regions of United Arab Emirates

Region	Farms			Results (mg/kg)										
				GC Method									HPLC Method	
	Farm	Sample	Depth (cm)	Propamocarb	Diazinon	Pirimiphos-methyl	Malathion	Chlorpyrifos	Phenthoate	Triazophos	Deltamethrin	Cypermethrin	Dimethoate	Metalaxyl
Central	1	1	1	-	-	-	-	0.37	-	-	0.01	0.01	-	-
			2	-	-	-	-	0.12	-	-	-	0.01	-	-
		2	1	-	-	-	-	0.02	-	-	0.02	0.01	-	-
			2			-	-	0.01	-	-	0.04	0.01	-	-
	2	1	1	-	-	-	-	0.01	-	-	-	0.08	-	-
			2	-	-	-	-	0.01	-	-	0.01	0.04	-	-
		2	1	-	-	-	-	0.07	-	-	-	0.02	-	-
			2	-	-	-	-	0.03	-	-	-	0.01	-	-
	3	1	1	-	-	-	-	0.20	-	-	0.02	0.04	-	-
			2	-	-	-	-	0.14	-	-	-	0.03	-	-
		2	1	0.02	-	-	-	-	-	-	-	-	-	-
			2	-	-	-	-	0.01	-	-	-	-	-	-
	4	1	1	-	-	-	-	0.01	-	-	0.02	-	-	-
			2	-	-	-	-	0.02	-	-	-	-	-	-
		2	1	-	-	-	0.02	0.03	-	-	-	-	-	-
			2	-	-	-	0.01	0.01	-	-	-	-	-	-
	5	1	1	-	-	-	-	-	-	-	-	0.02	-	-
			2	-	-	-	-	-	-	-	-	0.01	-	-
		2	1	-	-	-	-	0.03	-	-	-	0.02	-	-
			2	-	-	-	-	0.11	-	-	-	-	-	-
Eastern	1	1	1	0.03	-	-	-	-	-	-	0.02	0.86	-	-
			2	0.01	-	-	-	0.23	0.05	-	0.01	0.17	-	-
		2	1	-	-	-	-	0.18	0.02	-	0.02	0.44	-	-
			2	-	-	-	-	0.09	0.02	-	0.02	0.14	-	-
	2	1	1	-	0.08	-	-	0.35	-	-	0.03	0.36	-	-
			2	-	0.03	-	-	0.17	-	-	0.02	0.12	-	-
		2	1	-	0.07	-	-	1.46	-	-	0.02	0.44	-	-
			2	-	0.01	-	-	0.46	-	-	-	0.15	-	-
	3	1	1	-	-	-	-	0.01	0.12	-	-	0.18	-	-
			2	-	-	-	-	0.01	0.06	-	0.02	0.15	-	-
		2	1	-	-	-	-	0.01	0.22	-	-	0.40	-	-
			2	-	-	-	-	0.01	0.13	-	-	0.20	-	-
	4	1	1	-	-	-	-	0.01	0.12	-	-	0.37	-	-
			2	-	-	-	-	0.05	0.08	-	-	0.11	-	-
		2	1	-	-	-	-	0.01	0.13	-	-	0.51	-	-
			2	-	-	-	-	0.01	0.11	-	-	0.13	-	-
	5	1	1	-	-	-	-	-	0.02	-	-	0.01	-	-
			2	-	-	-	-	-	-	-	-	0.01	-	-
		2	1	-	-	-	-	-	0.02	-	-	0.18	-	-
			2	-	-	-	-	-	0.01	-	-	-	-	-

(*Cont'd*. ....)

<u>*Continued Table 2*</u>

Western	1	1	1	-	-	-	-	0.01	-	-	0.02	-	-	-
			2	-	-	-	-	0.01	-	-	-	-	-	-
		2	1	-	-	-	-	0.01	-	-	0.02	0.01	-	-
			2	-	-	-	-	-	-	-	-	-	-	-
	2	1	1	-	-	-	-	0.01	-	-	0.03	-	-	-
			2	-	-	-	-	-	-	-	-	-	-	-
		2	1	-	-	-	-	-	-	-	-	-	-	-
			2	-	-	-	-	0.01	-	-	0.03	-	-	-
	3	1	1	-	-	-	-	0.02	-	-	0.04	-	-	-
			2	-	-	-	-	-	-	-	0.19	-	-	-
		2	1	-	-	-	-	0.03	-	-	-	0.01	-	-
			2	-	-	-	-	0.04	-	-	0.03	-	-	-
	4	1	1	-	-	-	-	-	-	-	0.02	-	-	-
			2	-	-	-	-	-	-	-	-	-	-	-
		2	1	-	-	-	-	0.02	-	-	0.02	-	-	-
			2	-	-	-	-	-	-	-	-	-	-	-
	5	1	1	-	-	-	-	0.04	-	-	0.02	-	-	-
			2	-	-	-	-	0.01	-	-	0.04	-	-	-
		2	1	-	-	-	-	0.01	-	-	0.02	-	-	-
			2	-	-	-	-	0.01	-	-	-	-	-	-
Northern	1	1	1	-	-	-	-	-	-	-	0.06	0.12	-	-
			2	-	-	-	-	-	-	-	0.07	-	-	-
		2	1	-	-	-	-	-	-	-	0.09	-	-	-
			2	-	-	-	-	-	-	-	0.13	0.07	-	-
	2	1	1	-	-	-	-	-	0.16	-	0.05	0.04	-	-
			2	-	-	-	-	-	-	-	-	-	-	-
		2	1	-	-	-	-	-	-	-	0.06	-	-	-
			2	-	-	-	-	-	-	-	-	-	-	-
	3	1	1	-	-	-	-	0.05	-		0.21	-	-	-
			2	-	-	-	-	0.10	-	-	0.19	0.11	-	-
		2	1	-	-	-	-	0.02	-	-	0.10	-	-	-
			2	-	-	-	-	0.12	-	-	0.02	0.13	-	-
	4	1	1	-	-	-	-	-	-	-	-	-	-	-
			2	-	-	-	-	-	-	-	-	-	-	-
		2	1	-	-	-	-	-	-	-	-	-	-	-
			2	-	-	-	-	-	-	-	-	-	-	-
	5	1	1	-	-	-	-	0.02	0.03	-	0.25	0.06	-	-
			2	-	-	-	-	-	-	-	-	0.01	-	-
		2	1	-	-	-	-	0.01	0.03	-	0.07	0.06	-	-
			2	-	-	-	-	0.01	-	-	0.03	0.02	-	-

- = pesticide residues not detected (level of detection is 0.01 ppm); depth 1=0-15 cm; depth 2=15-30 cm

chlorpyrifos and phenthoate. Whereas, propamocarb, diazinon, pirimiphos-methyl, malathion, triazophos, dimethoate, and metalaxyl were not detected. Similar to the Omani samples, higher concentrations of pesticides were detected at the depth (1) of 0-15 cm than at depth (2) of 15-30 cm.

In soil samples of both the Omani and UAE farms cypermethrin, chlorpyrifos and deltamethrin were commonly encountered. On the other hand, the propamocarb, diazinon, pirimiphos-methyl, malathion, triazophos, dimethoate, and metalaxyl were generally not detected. Dem *et al*. (2007) reported that the cypermethrin has a moderate persistence in soils and its half-life is around 13 weeks. It might be the reason of presence of higher amount of cypermethrin in different soil samples. The highest level of chlorpyrifos found was 1.01 mg/kg in Oman and 1.46 mg/kg in UAE, but generally its average levels were below 0.1 mg/kg. Depending on the type of soil, microbial metabolism of chlorpyrifos may have a long half-life; soil temperature, organic content and acidity levels play important roles in its degradation (US EPA, 1984).

Chapman *et al.* (1981) reported that persistence of cypermethrin in soil was related to organic matter, clay content, microbial activity and anaerobic conditions. In the present study, in Omani soil samples, organic matter in the range of 0.201-6.048% and in UAE farm soil samples, in the range of 0.201-5.342% was recorded. It is possible that the higher levels of pesticides observed in the soil samples were associated with higher soil organic matter content. Redondo *et al*. (1997) calculated the degradation half-lives of chlorpyrifos as 10 days, and found that the distribution through the soil profile shows that the pesticide concentrations were always highest in the upper layer (0-5.0 cm) of soil. This report was in agreement with our current results, where we also observed that the pesticide residue levels in top-soil (0-15 cm) were higher than at lower depths (15-30 cm). Putnam *et al*. (2003) reported that chlorpyrifos residues could be detected in cranberry fruits at harvest, after 62 day post-chlorpyrifos application. Gyldenkaerne *et al*. (2000) reported that the deltamethrin and cypermethrin have almost the same physical and chemical properties. Gana *et al*. (2005) warned that although pyrethroids are known for their immobility in soil, however, surface erosion and runoff may ultimately lead to significant off-site pesticide movement to surface streams over a sufficiently long time scale due to their long persistence. However, as Oman and UAE both are desert countries with average rainfall of 20-100 mm/year in Oman and 65 mm/year in UAE and commercial vegetable production is fully dependent on irrigation, this type of off-site movement is irrelevent in both the countries.

In Gulf countries like Oman and UAE, the use of pesticides for crop protection is increasing, but systematic investigations on the presence/persistence of pesticide residues in agricultural soils are not available. Therefore, the current study will be helpful to create awareness in both the countries.

Conclusion

Detected pesticides in Oman and UAE soil varied in their levels in different agricultural farms and regions. In Omani vegetable farms, pesticide residue of cypermethrin was most frequently detected followed by chlorpyrifos. In vegetable farms of all the four regions of UAE, chlorpyrifos, cypermethrin and deltamethrin were detected in soil samples, but, phenthoate was detected only in the eastern and northern regions. The knowledge gained from the current investigation on pesticide residues in vegetable farm soils of Oman and UAE will aid in future management for pesticide application and handling. The current results might help in the selection, use and application of different pesticides that may lead to a reduction in pesticide residues in agricultural soils in both the countries. In addition, this outcome will help in the future pesticide management strategies in the Sultanate of Oman and the United Arab Emirates.

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