PESTICIDES BIOACCUMULATION AND THEIR SOIL POLLUTANT EFFECT

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ABSTRACT
This study was aimed to investigate pesticides bioaccumulation and their soil pollutant effect. The experiment was included sixteen active greenhouses in Erbil plane, and conducted during September 2017 and March 2018. The present study revealed that the pesticides residue of pyridabine, thiamethoxam, abamectin and spirodiclofen were detected in greenhouse soil samples.   The values of soil heavy metals contaminations factor (CF) revealed, that the studied greenhouse soil samples were ranged from low to very high contamination, while for pesticides were ranged from non to high contaminated. Soil pollution load index results supported that, the greenhouse soil was contaminated especially by Cr, Ni and Co. Pollution load index (PLI) was ranged from 7.751 to 0.303; supporting that the soils were contaminated in most sites. It could be concluded that, significant need for the development of pollution prevention and scientific strategies to reduce heavy metal pollution and pesticide accumulation residuals within greenhouses in Erbil plane.
Keywords: greenhouse, pesticide residue, heavy metal contamination, soil pollution.

التراكم الأحيائي للمبيدات ومؤشرات تأثيراتها الملوثة للتربة

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المستخلص

تهدف التجربة لدراسة التراكم الاحيائي للمبيدات ومؤشرات تأثيراتها الملوثة للتربة.   اشتملت الدراسة على ستة عشر بيتا بلاستيكيا مدفئا ومخصصا لنبات الخيار في قرى سهل اربيل. جمعت عينات التربة في أكياس النايلون المُعلمة مسبقًا خلال آب ٢٠١٧ وآذار ٢٠١٨. اظهرت نتائج وجود قيم عامل التلوث (CF) لنماذج التربة وجود المعادن الثقيلة في الحقول المدروسة بنسب مختلفة تتراوح بين التلوث المنخفض والتلوث العالي للغاية.   في حين أظهرت قيم عامل تلوث التربة بوجود تدريجي في نسب التلوث من حالة عدم وجود تلوث الى حالات تلوث عالي في نماذج التربة، من ناحية أخرى، أظهرت نتائج مؤشر حمولة تلوث التربة أن تربة الحقول الخيار التي تم دراستها كانت ملوثة خاصةً بالكروم والنيكل والكوبالت. اذ تراوحت التلوث بالمبيدات المتراكمة في عينات التربة (7.751 إلى 0.303) خلال فترة الدراسة وان هذه النتائج توكد تلوث التربة في حقول الخيار خلال فترة الدراسة.   تستنج من الدراسة الحالية الى وجود الحاجة الماسة إلى تطوير استراتيجيات ووسائل علمية لمنع التلوث والحد من التلوث بالمعادن الثقيلة وبقايا تراكم المبيدات المستخدمة في الحقول في مناطق سهل اربيل.

الكلمات المفتاحية: حقول الدفيئة، مخلفات مبيدات، تلوث بالمعادن الثقيلة، تلوث التربة.

INTRODUCTION

Urban communities and industries continuously charge the environment with xenobiotic organic chemicals, many thousands of organic trace pollutants were produced during the last decades and partially released into the environment (40). Plant production yield is exposed to harmful organisms on a going basis. Protecting plants and plant products from such organisms, preventing yield or damage, and ensuring high quality of harvested products and high agricultural productivity are essential (37). Pesticides were frequently used to enhance productivity and control pests, so the consumption of food is among the main routes of consumer exposure to pesticides (21). Due to their huge potential toxicity, high persistence and slow degradation, environmental pollution with pesticides are within of the most important problems facing the nation. Evaluating the health and environmental impacts of pesticides seems to be challenging because of multi stressors and habitat complexity, so markers have been extensively used to connect external levels of pollutant exposure, internal levels of tissue contamination, and early negative effects in life forms. Hence the use of markers could be an important line of evidence for comprehending the relations between stressors and effects on adjacent resources and for preventing detrimental effects of contamination on the community (20). Greenhouse cucumber plantations are actually considered to be a large - scale vegetable crop grown in Erbil City, but many insects attack the plant and then frequently used insecticides. Most greenhouse plants use abamectin, thiamethoxam, pyridabin, and spirodiclofen to control the various insects. Excessive and unnecessary use of pesticides has numerous adverse impacts on the environment and overall health of people who are exposed to pesticides actively or passively. The main of Erbil's problems in greenhouses is the paucity of an assessment based on empirical data on local farms, landowners in Erbil are typically not well informed about chemical selection and application techniques. There is even a lack of willingness in some cases and in some places to apply the necessary dosage. This study was aimed to evaluation of the residual pesticides as well as, heavy metals through using contamination factor and the pollution load index. Which help adopt an effective effluent management strategy towards control over enhanced metal levels with recycling of effluents for toxic metal separation and soil remediation and reclamation.

MATERIALS AND METHODS

Soils samples at sixteen active greenhouse fields in pre-labelled nylon bags were collected during September 2017 and March 2018. Studied sites located within villages: Jmka, Dhemat, Meer, Grdazaban, Perdawd, Sherawa, Quchablbas, Qarachnagha, Murtka, and Sablakh. The soil samples were collected from the upper layer of the soils (0-30 cm depth) at a random pattern around each field, according to USAID, (39). The soil samples were brought to the biology laboratory. A compost was formed for each field sub-samples, dried, and stored for analyzing. A portion from each sub-sample was sent to the physics laboratory for further analyses with X-ray fluorescence spectrometry.

Extraction of soil samples

Soil samples (0.1 g) was placed in a 2 ml Eppendorf tube, 200 μl of water was added to the sample, rigorously mixed with the Vortex-Genie 2 and left on the Hula - Mixer for one hour with a reciprocal degree of 90°C, after adding 300 μl acetonitrile, the samples were mixed again with the Vortex-Genie. The sample was centrifuged at 12000 rpm for 10 minutes, and then the solvent phase was collected and diluted 4.8:1 in a 200 μl vial with water (150 μl solvent phase, 31 μl water).

HPLC Instrumentation

Through using Agilent 1260, Infinity HPLC system w/1290 infinity thermostat, pyridabin, abamectin, thiamethoxam, and spirodiclofen insecticides were determined in extracted soil samples. Stainless steel column C18 (300 mm long, 4.6 mm) packed with octadecylsilyl silica gel for chromatography (5μm particle size) at column temperature 30°C was used. Acetonitrile – water was selected using a UV wavelength of 254 nm as a mobile phase at a flow rate of 1.0 ml/ min. Retention time (Rt) for Pyridabin, Abamectin, thiamethoxam, and Spirodiclofen pesticide detection were 2,455, 8,187, 11,893, and 42,793 minutes respectively, after compression with known

standard under the same conditions. On the basis of the peak area, the quantities were calculated. 20 μl injection volumes were used in all experiments, and LC solution software controlled the chromatographic device.

Soil heavy metal analysis

X-ray fluorescence spectrometry (XRF) was used for soil analyses. This technique is the rapid qualitative and quantitative determination of major, minor, and trace elements in a wide variety of soil samples, which does not require extensive training or experience on the part of the analysis. The samples were placed in the chamber and measured by a 20 mm diaphragm in a vacuum. The spectrometer is the main unit that consists of the sample chamber and the block unit. After pressing soil samples to palettes, chemical compositions of the soil samples were then measured and analysed data will be shown on programmed computer monitor after changing detected target points and converting to true numbers (27).

Soil contamination factor (CF)

The ratio of soil contamination factor was obtained by dividing the concentration of a specific soil heavy metal or pesticides in the soil samples by the background value of that parameter. Which can be calculated by ($CF = C_m /C_b$). where C_m is the heavy metal or pesticide concentration in a soil sample, and C_b is the background value of the heavy metal or pesticide (18).

Soil pollution load index (PLI)

The PLI was obtained as a concentration factor of each soil variable with respect to the background value in the soil. The PLI is able to give an estimate of the metal or pesticide contamination status and the necessary action that should be taken. Where a value of PLI<1 denotes perfection; PLI = 1 denotes that only baseline levels of pollutants are present and PLI > 1 would indicate deterioration of site quality. The PLI for a single site is the nth root of n number multiplying the contamination factors (CF values) together (PLI=n√(CF1 *CF2* CF3* … CFn). Where CF = contamination factor, n = number of metals (34).

RESULTS AND DISCUSSION

The analysis of pesticide revealed that, the higher concentration of abamectin residue in greenhouse cucumber soil samples was 0.0591 ppm to non-detected with means of 0.01±0.005 ppm (Table 1). The current study revealed that abamectin residues was detected in selected greenhouses with level more than the permissible MRL of this pesticide. For instance, soil samples in sites 1, 7, 11 and 16 were contaminated with abamectin residue more than MRL. Recently the abamectin residue was detected by Khan *et al* (18) in greenhouse soil fields upper than its concentration in open fields. Because abamectin is nearly insoluble in water and has a strong tendency to bind to soil particles, therefore it is regarded as immobile in soil (16). Previous studies reported that, abamectin's degradation is rapid and its physico-chemical properties prevent its bioconcentrating or bioaccumulating in the environment (14, 15). The results of soil thiamethoxam pesticide residues showed the higher concentration 1.737 ppm in site 14 to non-detected as the lower concentration, with mean of 0.273±0.14 (Table 1). Current investigation showed that, thiamethoxam residues in selected greenhouses were detected in most studied samples and its concentration were more than the permissible MRL of these pesticide except in some sites that might been due to application properties, humidity, temperature and soil pH of the studied greenhouses. Environmental thiamethoxam concentrations were positively correlated with greenhouse old and use in cultivated crop, the highest concentration of soil thiamethoxam were recorded in old greenhouse that's due to long half-life and slow degradation, as observed by (42). The highest concentration of spirodiclofen was ranged from 0.93 to non-detected as a lower concentration, with mean 0.335± 0.099 (Table 1) in soil samples. The results of the current study revealed that, the detected spirodiclofen residues in most studied greenhouses soil samples were more than the permissible MRL. The hydrolytic stability of spirodiclofen decreases as temperature and pH increase, in which the half-life for spirodiclofen at 20°C was calculated as 52.1 days at natural pH. Spirodiclofen is rapidly degraded in soils and has a low mobility due to high soil sorption. In areas with high risk of erosion and run-off, transport of spirodiclofen

sorbed to soil particles is likely to occur (36). The physical and chemical properties of spirodiclofen are characterized by its low water solubility, hydrophobicity, and tendency to bind to soil (7). The highest concentration of pyridabin pesticide residue was 10.96 ppm and non-detected as lower concentration in greenhouse soil samples respectively. The overall mean was 0.204±0.089 (Table 1). These results revealed that, recorded pyridaben residues in most studied greenhouses were more than the permissible MRL of these pesticides, however, in some studied samples pyridaben were not detected. These results were in agreement with some previous studies (24, 26). Previously reported that, pyridaben is within non-leacher pesticide class, pyridaben was strongly adsorbed within top 20 cm soil layer, non-detection has been observed from 20-60 cm soil depth (13). Pyridaben was stable to hydrolysis but has a short photolysis half-life in soil. Furthermore, pyridaben has a short half-life in soil (12 to 14 d) when applied in the field. As well as, physical and chemical factors, such as light, heat, pH, and moisture play significant roles in pesticide bioconcentration in soil (35), and has high volatility that predicted to volatilize from moist soil (4).

Table 1.Detected soil pesticide residuals during studied period

Sites	abamectin	Thiamethoxam	Spirodiclofen	Pyridaben
Site1	0.03472	0.10606	0.921	0.3975
Site2	ND	0.01082	ND	0.0033
Site3	ND	0.01113	ND	ND
Site4	ND	0.00922	ND	0.05052
Site5	ND	ND	ND	0.05194
Site6	ND	0.00668	ND	ND
Site7	0.05683	0.10476	0.90148	0.0621
Site8	ND	0.00504	0.0272	ND
Site9	ND	0.01386	0.03986	0.04276
Site10	ND	ND	0.0395	0.06362
Site11	0.05913	0.10515	0.8942	0.06138
Site12	ND	0.10643	0.93	0.06419
Site13	ND	0.1387	0.06694	0.08913
Site14	ND	1.7368	0.60686	1.096
Site15	ND	1.7365	0.59546	1.0805
Site16	0.01005	0.27274	0.33483	0.2042
Mean	0.010	0.273	0.335	0.204
SD	0.02068	0.5762	0.3979	0.3589
SE	0.005171	0.1441	0.09948	0.08972

Soil samples revealed that, recorded heavy metals levels exceeded the limited value that accepted by WHO (43), that might be due to intrusion of pollutants through industries, such as oil refineries, electroplating and mining activities, as well as, agricultural activities as application of pesticides, fertilizers and livestock manure (5, 17, 23). Arsenic present in studied soil samples, the value was (10.98±0.49 and 11.33±0.48) ranged from (6 mg/kg) in site 6 during March and September as a minimum value to (14.7 mg/kg) in site 16 during September as a maximum value) during the studied period. Statistically, there were significant differences at (P<0.01) among studied samples during studied period (Figure 1). The fluctuation between studied sampling dates could be due to excessive application of pesticides, fertilizer, discharge wastes of factories and refinery projects, also domestic solid waste dumping and Erbil main sewer system. Lately study reported that soil As concentrations show significant enhancement, especially during growing season because of increasing application of pesticides and chemical fertilizers (33). Previous study stated that concentration of arsenic in greenhouse soil raises during irrigation with arsenic-rich water; also, during the dry season, As level was higher than the wet season (11). Studied soil sample recorded (59±1.8 to 69.5±2.4 mg/kg) as Cu concentration variation from first to second sampling date, and statistically, there were significant differences at (P<0.05) among studied samples (Figure 2). The total Cu concentration was ranged from (48 to 91 mg/kg). The highest value was recorded during September in site 10 and the lowest value during March in site 8 during date of sampling. Cupper was significantly

accumulated in greenhouse soil, which increased with the increasing of cultivation time, increasing organic matter and application of pesticides (10). Advanced research reported that Cu level in high concentration, could be result from different fertilizer and pesticide applications (25). Foregoing study suggested that, the level of Cu was mainly controlled by the anthropogenic sources as pesticide and fertilizer applications that contain a high amount of heavy metals (38). The mean concentration of total Co was (124±3.66 and 129.7±3.4 mg/kg), that recorded (10.0 mg/kg) in site 6 during March as a minimum value and (15.7 mg/kg) in site 15 during September as a maximum value. Statistically, there were significant differences at (P<0.05) among studied samples (Figure 3). The results of the current investigation showed that, soil sample total Co concentration were within normal levels of soil concentration of cobalt. Occurrence for cobalt might have been of anthropogenic sources include fossil fuel burning, processing of oil refining, dumping sewage sludge, wastewater main channel of Erbil, and agricultural use of phosphate fertilizers that cause increasing soil Co concentration indirectly through increasing Co concentration in irrigation water (45). Cobalt concentration was drastically reduced during rainy season, this could be related to dilution effect with rain water and the highest concentration was noticed during dry season, with small fluctuation of its concentration in some sampling sites, as noticed by (32). The results showed that, greenhouse practices increased the soil total Zn concentrations from (121.4±5.9 to 134.7±5.4 mg/kg). According to recorded results, the concentration of zinc in soil samples recorded (82 mg/kg) as the lowest concentration at site 14 during March and (186 mg/kg) as the highest value at site 13 during September (Figure 4). Statistically there was significant differences at (P<0.05) among studied samples. The observed data of the current study, showed that greenhouse practices increased the soil total Zn concentrations. Increasing Zn concentration during second sampling dates within greenhouse soil was noticed to be higher, which were closely related to the pollutants in irrigation water especially during using wastewater directly for irrigation, agricultural soil fertilizers, and used pesticides. These results are in accordance with recent studies (44, 22). Although an enrichment of soils with Zn has been reported when these materials were used during long-term repeated additions, after the abandonment of agricultural applications and remaining trace metals in the soil (30). The highest value of total Pb in soil was measured (48 mg/kg) in site 10 during September, while the lowest value (17 mg/kg) in sites 2, 12, and 14 during March and site 14 during September, with statistically, significant differences at (P<0.05) among studied samples (Figure 5). Mean concentration of soil Pb soil samples was (23.13±1.76 and 24.13±1.99 g/kg) during studied period. All results were within acceptable limits of WHO, except in site 10, which wastewater directly was used for irrigation. Increasing greenhouse total soil Pb concentration during second sampling dates, might be because of leaching lead from oil refinery projects and percolation to groundwater that cause increasing greenhouse soil total Pb concentration through irrigation. These results were in accordance to previous studies (19, 44). Previous study concluded that, lead concentration was increased after fertilization, and increased two times after harvesting, as well as, atmospheric deposition, manure, and sludge application (31). Soil samples revealed that the concentration of total Cr was ranged between (281ppm) in site 14 during March as a minimum value to maximum value (545ppm) in site 5 during September, with mean of (403.2±16.47 and 417.4±15.47 ppm). Statistically, there were significant differences at (P<0.01) among studied samples (Figure 6). The concentration of Cr in the greenhouse soils exceed the concentrations in the background soils, which, indicated that greenhouse cultivation and application of pesticides and livestock manure had a significant effect on the concentrations of Cr in irrigated soil (5). Recent study reported that parent rocks mainly determine Cr concentrations in greenhouse soil fields (22). The total Ni concentration in studied soil was ranged between (181.1±3.14 to 187±3.39 g/kg), the highest value was (214 g/kg) recorded during September at site 7, and the

lowest value recorded (155 g/kg) in site 9 during March (Figure 7). Statistically, there were significant differences were found at (P<0.05) among studied samples during studied period. Total Ni concentration showed slight variation in studied sampling fields, which might be related to atmospheric deposition, due to occurrence of industrial and oil refinery projects, application of fertilizers and pesticides, industrial effluents of steel factory, and Ni concentration of irrigated water especially in some places wastewater was directly used for irrigation, as concluded previously (8, 28, 30).
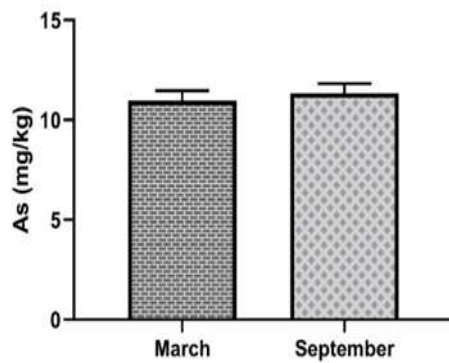
Figure 1. Soil total As (mg/kg) in the studied sites
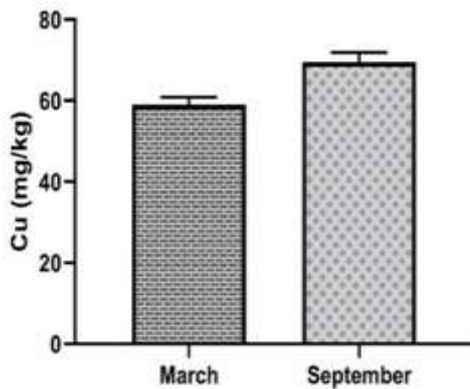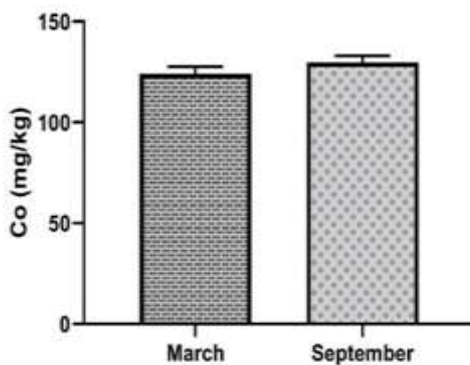

Figure 2. Soil Cu (mg/kg) in the studied sites
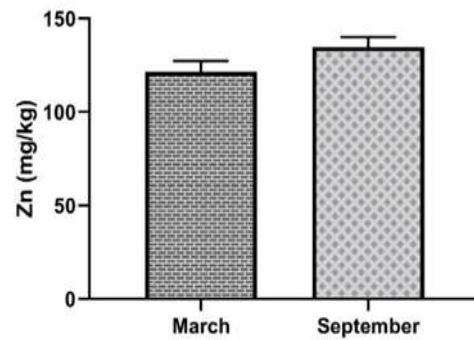

Figure 3. Soil Co (mg/kg) in the studied sites

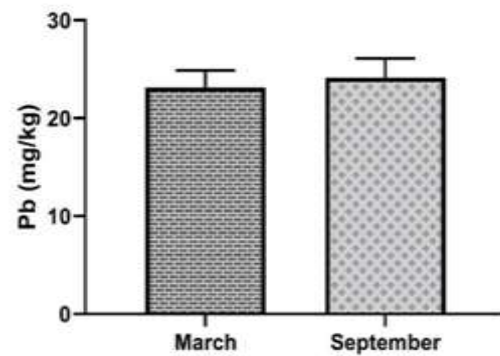**Figure 4. Soil total Zn (mg/kg) in the studied site**

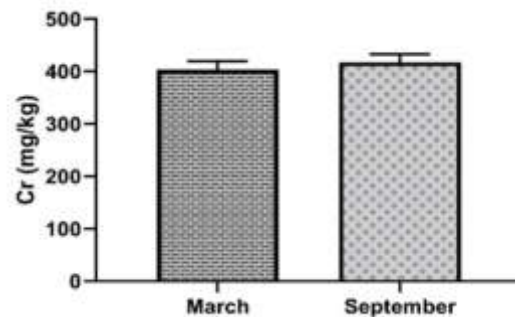**Figure 5. Soil total Pb (mg.kg^{-1}) in the studied sites**

Figure 6. Soil Cr (mg/kg) in the studied sites
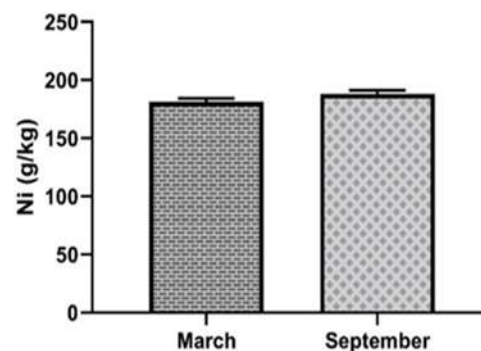**Figure 8. Soil total Mn (g.kg^{-1}) in the studied site**

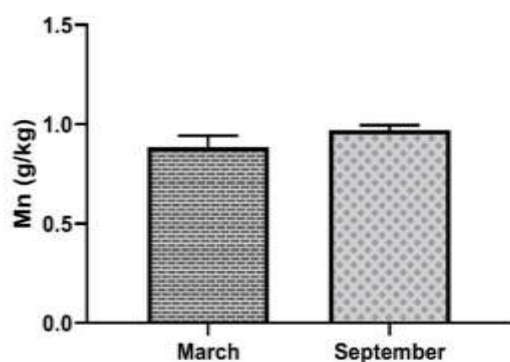**Figure 7. Soil total Ni(g/kg) in the studied sites**

Figure 8. Soil total Mn (g.kg^{-1}) in the studied site

Total manganese is relatively abundant in studied soil samples (0.886±0.057 and 0.970±0.025 g/kg), the lower concentration was ranged from (0.740 g/kg) in site 14 during March to highest concentration (1.18 g/kg) in site 5 during September. Statistically, there were non-significantly increasing Mn among studied samples (Figure 8). The Mn content of the greenhouse soil were increased in most studied fields, which related to application of fertilizers and pesticides in closed greenhouse with high humidity content (6). Manganese is a part of an important antioxidant structure that protects plant cells by deactivating free radicals (29). Previous study concluded that irregular use of phosphate fertilizers in the poor soils of micronutrients, leads to decreasing manganese concentration and effects crop yields in greenhouses, due to precipitation them in the form of $MnPO_4$ or $Mn_3 (PO_4)_2$ (1).

Soil contamination indices

Results in the Table (2), show contamination factor (CF) results of heavy metals in studied greenhouse that the CF for all metals were in the descending order of Pb > Zn > As > Cu > Mn > Co > Ni > Cr, with the mean CF values 0.337, 0.512, 0.929, 1.019, 1.031, 3.171, 4.097 and 6.411 respectively. All studied sites showed lower contamination within Zn and Pb (Figure 9). The value of CF of mean studied sites for Pb, Zn and As metals showed low degree of contamination (CF<1), and Cu and Mn showed moderate contamination degree (1 ≤CF≤ 3), whereas, Co and Ni recorded as highest contamination factor (3 ≤CF≤ 6), while Cr values showed very high contamination factor (CF>6). The contamination factor of studied greenhouse

soil heavy metals during studied period can be used to reflect the degree of human-caused disturbance on the soil pollution through agriculture activities, however, the soil from the various sites were not contaminated in equal state. As well as, soil samples from site 5 showed highest pollution rate, and lower polluted samples were from site 6. Very high greenhouse soil contamination was recorded with Cr in sites 5, 12, 13, 16, 3, 10, 7, 15, 2, 8, 4 and 9 in descending order. Highest contaminated were obtained with Cr in sites 11, 1, 14 and 6, while with Ni at sites 1 to 16 and with Co at sites 15, 16, 3, 12, 5, 1, 11, 4, 9, 8 and 10. However moderately contamination were recorded with Co on sites 14, 2, 7 and 6, with Mn in sites 5, 1, 16, 3, 9, 8, 4, 15, 7 and 2, with Cu at sites 10, 2, 5, 13, 16, 11, 4, 1 and 9, and with As in sites 16, 1, 15, 4, 2, 5. Lower contamination were observed with Mn in sites 12, 13, 11, 6, 14 and 10, with Cu at sites 3, 12, 8, 14, 15, 6 and 7, with As in sites 11, 3, 13, 6, 8, 14, 7, 12, 9 and 10. All sites showed lower contamination within Zn and Pb. Obtained results were in accordance to (3, 40). The assessment of PLI values of metals in soil samples were showed in (Figure 10 and Table 2), which were ranged from the minimum value 1.166 in site 14 to maximum value 1.568 in site 16 during studied period. It is supporting that the soil of the studied greenhouse was contaminated (The PLI value < 1 indicates no pollution, whereas PLI value > 1 is polluted). However, the highest PLI values in site 16 indicated that Cr, Ni and Co were the major contributors to the soil pollution. Highest PLI values in sites 16, 4, 13, 11 and 3 were calculated in sampling sites, was an indicator of industrial and oil refinery project activity inputs on studied sites, and higher polluted fields were near those projects, which might been because of atmospheric deposition of air pollutant discharges, all other sampled greenhouse fields show that, the soils were moderately polluted with heavy metals. Same results were observed by (2, 9, 12).
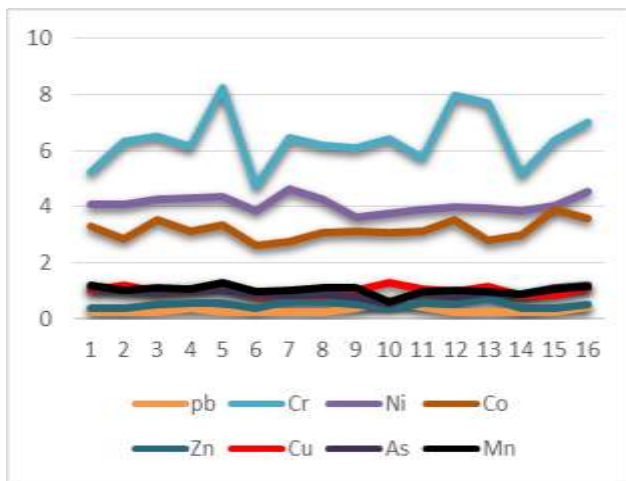
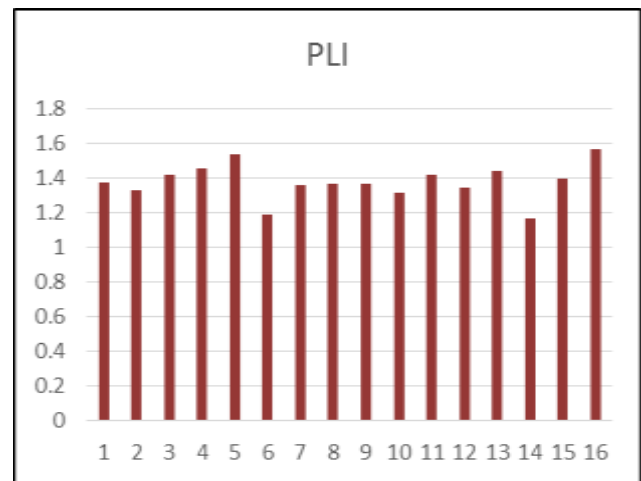**Figure 9. Heavy metals contamination factor**

Figure 10. show soil heavy metals PLI

Results in Table 3 shows, pesticide residues accumulation in studied sites according to the CF were in the descending order of Spirodiclofen > Pyridaben > Thiamethoxam >

Abamectin. The mean CF values of Spirodiclofen, Pyridaben, Thiamethoxam and Abamectin were 4.185, 4.083, 3.409 and 0.201 respectively (Figure 11).

Table 2. Soil heavy metal Contamination Factor and PLI

Sites	Contamination Factors (CF)								PLI
	Mn	As	Cu	Zn	Co	Ni	Cr	pb	
Site 1	1.205	1.1	1.024	0.438	3.3	4.078	5.258	0.3	1.373
Site 2	1.018	1.013	1.190	0.452	2.863	4.067	6.336	0.243	1.332
Site 3	1.117	0.946	0.976	0.516	3.55	4.278	6.539	0.307	1.417
Site 4	1.072	1.079	1.048	0.532	3.137	4.311	6.141	0.371	1.453
Site 5	1.283	1.012	1.15	0.532	3.337	4.344	8.265	0.321	1.535
Site 6	0.957	0.875	0.869	0.414	2.625	3.877	4.742	0.271	1.186
Site 7	1.021	0.85	0.857	0.64	2.738	4.633	6.461	0.3	1.36
Site 8	1.116	0.871	0.928	0.598	3.075	4.277	6.195	0.271	1.363
Site 9	1.117	0.792	1.008	0.48	3.112	3.622	6.101	0.407	1.364
Site 10	0.608	0.5	1.278	0.472	3.075	3.778	6.453	0.664	1.318
Site 11	0.961	0.958	1.063	0.55	3.138	3.911	5.765	0.428	1.418
Site 12	0.988	0.792	0.944	0.514	3.525	3.989	7.976	0.25	1.344
Site 13	0.978	0.933	1.119	0.73	2.787	3.967	7.726	0.286	1.437
Site 14	0.849	0.867	0.881	0.368	2.987	3.833	5.172	0.243	1.166
Site 15	1.064	1.087	0.873	0.47	3.9	4.044	6.398	0.307	1.399
Site 16	1.144	1.196	1.103	0.49	3.587	4.555	7.047	0.429	1.568
Mean	1.031	0.929	1.020	0.512	3.171	4.098	6.411	0.337	

The contamination factor of studied greenhouse soil pesticide residues might be reflecting the degree of human-caused disturbance on the soil pollution during pesticide application. The soil from the various sites were not contaminated equally, in a manner that, there were non-contamination factor recorded in most sites with Abamectin, and in some sites with spirodiclofen. Higher contaminated sites were observed within thiamethoxam and Pyridaben. Lower

contamination factor was recorded with Abamectin in sites 16 and 1, with Thiamethoxam in sites 8, 6, 4, 2, 3 and 9, with spirodiclofen in sites 8, 10 and 9, and with Pyridaben in sites 2 and 9. Moderately contamination factor was illustrated in sites 11 and 7 with Abamectin, sites 13, 12, 1, 11 and 7 with Thiamethoxam, sites 13, 12, 10, 7, 11, 5 and 4 in descending order. There was highly contamination factor within site 16 with thiamethoxam, spirodiclofen and pyridabin.

While very high contamination factor was recorded within thiamethoxam in sites 14 and 15, with spirodiclofen in sites 12, 1, 11, 7, 14 and 15 and with Pyridaben in sites 14, 15 and 1. Based on background values and recorded contamination factors of studied pesticides there were pollution impacts of pesticides on studied greenhouses during investigated period, this could be due to improper application of pesticides and lack of willingness to apply the necessary dosage of pesticides in greenhouses by sprayers. The assessed pollution load index (PLI) values of accumulated pesticides in greenhouses soil samples were showed in (Figure 12 and Table 4), which were ranged from maximum 7.751 in site 14 to minimum 0.303 in site 2 during studied period, which supporting that the soil of the studied cucumber greenhouse fields was contaminated in 9 sites and non-contaminated in other 7 sites during studied period. However, the higher PLI values in site 14 and 15 indicated that thiamethoxam, pyridabin and spirodiclofen were the major contributors of pesticide accumulation. Higher PLI values in sites 14, 15, 1, 11, 7 and 12 were recorded, and the rate of PLI were lower in sites 16, 13 and 5. Recorded PLI value was an indicator of improper application of studied pesticides within greenhouses. However, there were non-pollution effects of used pesticides in sites 10, 3, 4, 6, 9, 8 and 2, which might be due to photodegradation property, soil microorganism activity and quantity of used doses of detected pesticide. The study was revealed that the pesticide residues of pyridabine,

thiamethoxam, abamectin and spirodiclofen residues were detected in greenhouse soil samples. The value of soil heavy metal contamination factor (CF) revealed that studied greenhouse soil ranged from low contamination to very high contamination, while for pesticides from non to high contaminated. On the bases of the PLI, the studied soil samples contaminated in most sites during the studied period.
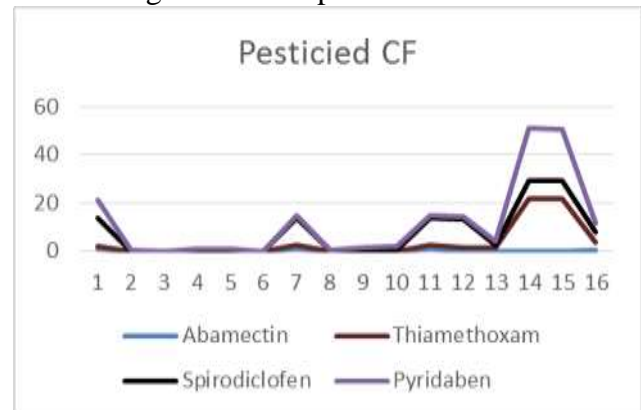

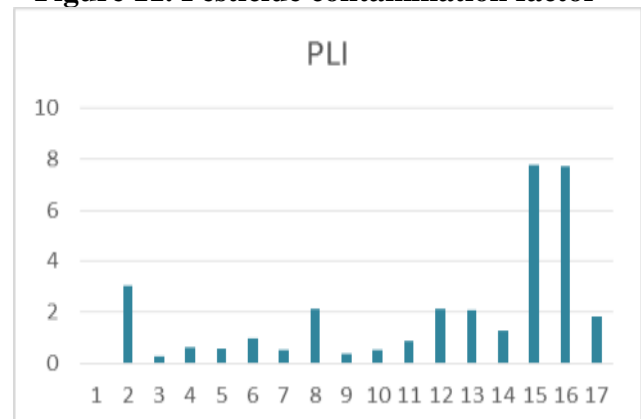**Figure 11. Pesticide contamination factor**

Figure 12. Soil Pesticide Residues PLI

Table 3. Pesticide Contamination Factor and PLI

ites	Contamination Factors (CF)				PLI
	Abamectin	Thiamethoxam	Spirodiclofen	Pyridaben	
Site 1	0.694	1.326	11.513	7.95	3.03
Site 2	0	0.135	0	0.066	0.307
Site 3	0	0.139	0	0	0.611
Site 4	0	0.115	0	1.010	0.584
Site 5	0	0	0	1.039	1.010
Site 6	0	0.083	0	0	0.537
Site 7	1.136	1.309	11.268	1.242	2.136
Site 8	0	0.063	0.34	0	0.383
Site 9	0	0.173	0.498	0.855	0.521
Site 10	0	0	0.494	1.272	0.890
Site 11	1.183	1.314	11.177	1.228	2.149
Site 12	0	1.330	11.625	1.284	2.111
Site 13	0	1.734	0.837	1.783	1.268
Site 14	0	21.71	7.586	21.92	7.751
Site 15	0	21.706	7.443	21.61	7.687
Site 16	0.201	3.409	4.185	4.084	1.85
Mean	0.201	3.409	4.185	4.083	

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