

# Assessment of the Biodegradation of Common Pesticides in the Water and Soil Pollution in Different Sites in the South of Thi Qar City, Iraq.

Aly.aa Huss.ein Talib

[Alyaahussin010.bio@utq.edu.iq](mailto:Alyaahussin010.bio@utq.edu.iq)

Depar.tment of Biol.ogy, Coll.ege of Educa.tion for Pure Sciences, Unive.rsity of Thi.qar, Iraq

## I. Abstract

In this study, a number of soil and water samples were collected from different locations in the city of Thi Qar for chemical and physical analysis, in addition to tracking the accumulation of pesticides used in pest control in the study area. The results showed that the studied soil had a clayey texture and a relatively medium to high cation exchange capacity. The soil pH was generally neutral, and both true and apparent density were within normal limits. The soil did not contain calcium carbonate, and its organic matter content was moderate. The water samples were characterized by low salinity and a pH close to neutral. The results of the pesticide accumulation study showed no residue of organophosphate pesticides, which is attributed to their rapid decomposition in the soil. For chlorine-based pesticides, traces of accumulation were observed at low and varying levels. Their concentration was highest in the 35-60 cm subsurface layer compared to the layers above and below it. The highest accumulation rate was recorded in the Al-Fadhiliya area, reaching 2.857 ng/ml for Endrin and 180 ng/ml for Dieldrin. As for the water samples, the concentration of chlorine-based pesticides was at its lowest, ranging between 6-8 ng/ml at the three locations.

**Key words :** Pollution , Soil, Water, Pesticides.

## II. INTRODUCTION

Environmental pollution is one of the most significant problems hindering the continuation of development programs in all aspects of life. It is also one of the most dangerous destructive factors for the environment and for living organisms in all their forms, as they are the primary victims of pollution. This includes humans and all other living organisms, both animals and plants, in addition to the destructive impact extending to the climate, soil, water, and all aspects of life (Ateshan *et al.*, 2019; Ateshan *et al.*, 2020) . Soil pollution at all levels poses a real threat to plants, which absorb pollutants from the soil, and to groundwater, which becomes polluted by its movement and flow beneath the soil surface. It also poses a threat to bioaccumulation, which occurs when livestock or humans ingest pollutants present in plants growing in soil that already contains them (Al Sailawi *et al.*, 2019; Azemi *et al.*, 2021). The soil is the primary reservoir for pesticides, which reach it directly after being sprayed or applied to treated plants, or after soil treatment to control existing pests. The presence and accumulation of long-lasting pesticides in the soil, such as organochlorine and mercury pesticides, affects soil microorganisms and their activity in decomposing organic matter and increasing soil fertility (Al-Alwani *et al.*, 2019; Ateshan & Misnan, 2025 a) . The soil also distributes pesticide residues to other parts of the biosphere, such as water through leaching or to the air through wind volatilization. Some compounds or their components can be adsorbed onto colloidal surfaces. The persistence of a pesticide in the soil depends on several factors, most



importantly the type and concentration of the pesticide, the type of soil, and its aeration (Ateshan & Saxena 2015; Jasim *et al.*, 2021).

The effect of dimethoate pesticide residues on soil microorganisms was studied in the Republic of Yemen by Khan *et al.* (2005). The study revealed that the pesticide residue levels throughout the study period ranged from 19.5 to 924.0 mg/kg in the surface layer, while the omethoate residue levels ranged from 0.06 to 0.25 mg/kg. In the subsurface layer, the residue levels were 160.3 to 368.1 mg/kg for dimethoate and 0.01 to 0.70 mg/kg for omethoate. It was observed that the soil contamination level with the pesticide exceeded 6.0 mg/kg, which is above the threshold for the total concentration of the entire pesticide in the soil (Silva *et al.*, 2019; Ateshan, 2025a).

A study was conducted in the Ghouta region of Damascus by Hajjar (2011) to investigate the level of soil contamination with organochlorine pesticides resulting from their long-standing and intensive use, as well as that of organophosphorus pesticides. Soil samples were taken from two levels: the first, a shallow depth of 0-10 cm, and the second, a depth of 30-45 cm. The study lasted for 11 months, with samples taken at intervals covering all four seasons. Residues were detected using gas chromatography (GC), and the results showed the presence of residues of the pesticides Chlordane, Lindane, Aldrin, DDE, DDD, and DDT in all samples. No significant differences were observed between the amount of residues in the shallow samples and those at a depth of 45 cm. The rate of degradation and breakdown of these pesticides over time was also noted. The area is very slow, but its decomposition in the surface layer was slightly greater than in the deep layer, except for the pesticide Lindane. The results also showed the absence of any type of organophosphorus pesticide. In a study to determine pesticide residue levels in the Syrian coastal region, the highest residue levels of chlorinated pesticides were found to be DDE in soil and water samples, followed by DDT and DDD (Al Mahmud *et al.*, 2015; Al Sailawi *et al.*, 2020; Ateshan & Misnan, 2025 b).

A range of chlorine and organophosphate pesticides were determined in water using a GC instrument equipped with a mass spectrometer (MS). The detection limit was between 2–20 L/ng. This method was applied to determine pesticides in tap water and river water by Pocrull *et al.* (1998). A rapid and environmentally friendly method for determining both chlorine and organophosphate pesticides using gas chromatography equipped with an electron capture detector (ECD) and a photovoltaic flame detector (FPD) was described by Zuin *et al.* (2003). The mean retrievals obtained ranged from 9.69–107%, with a standard deviation of 1.4–15.7%.

Gas chromatography (GC) with electron capture (ECD), mass spectrometry (MS), and MS-MS combined with another mass spectrometry method were used to identify 12 pesticides in water samples. Vidal Martinez *et al.* (2000) found that the lowest detectable concentration of pesticides using MS-MS-GC ranged from 2–26 ml/ng, with retrievals ranging from 75–143% in water samples enhanced with 100 ml/ng. The relative standard deviation was within the range of 4.5–5.17% (Ateshan, 2025b). The proposed method for pesticide analysis was applied to moist soil samples taken from the Almería region of Spain.



### Research objectives:

Soil and water are among the most important natural resources in Nasiriyah, Iraq, and are highly susceptible to pollution, both in terms of the risk of contamination and the transmission of pollution risks to humans. Therefore, this phenomenon deserves serious attention. The research objectives are summarized as follows:

- 1- To study some of the physical, chemical, and fertility properties of the studied soil and their effect on pesticide accumulation.
- 2- To determine the residual effects of organophosphate and chlorine pesticides in the soil and water.
- 3- To study some of the chemical properties of the studied water samples.

## III. MATERIALS AND METHODS

### 1- Study location:

The study area is located in the city of Thi Qar in southern Iraq. This area was chosen for several reasons, including the excessive use of pesticides by farmers (especially during the last two decades of the 20th century), in addition to the emergence of some health problems in the area.

Four sites were selected for soil studies (samples were taken in December 2024):

- 1- Nasiriyah City Center
- 2- Al-Fadhiliyah City
- 3- Suq Al-Shuyukh City
- 4- Al-Tar City

The water sampling locations were: four different areas of the Euphrates River. (Samples were taken in April 2024)

### 2- Study material:

Soil samples were taken from selected sites at depths of 0-35 cm, 35-60 cm, and 60-90 cm. The samples were air-dried, ground, and then sieved through a 2 mm sieve. They were subsequently frozen until extraction. Water samples were collected from selected sites using polyethylene containers and transported to the laboratory. They were also frozen until extraction. Three replicates were performed for all analyses.

### 3- Study methods:

Soil Samples: Analyses were performed as described in Soil (1996):

- Granular mechanical analysis using the hydrometer to determine soil texture.
- Bulk density was estimated using a density cylinder.
- True density was estimated using a density flask.
- Soil reaction: pH was determined using a 1:5.2 soil/water suspension.
- Exchange acidity was determined using a 1:5.2 potassium chloride and soil saline extract, followed by shaking, filtration, and titration with 0.0 N<sub>2</sub> sodium hydroxide solution in the presence of phenolphthalein.
- Electrical conductivity was measured in a 5:1 extract using an electrical conductivity meter.
- Total carbonate was estimated using a calcimeter.
- Organic matter was determined by the oxidation of organic carbon with potassium dichromate, followed by titration with Mohr's salt. The result was given as the percentage of organic matter.



#### Cation exchange capacity (CEC):

The ammonium acetate method was used, and the solution was measured using a flame photometer.

#### Exchangeable bases:

Extraction was performed using a 1N ammonium acetate solution, and the exchangeable elements were determined as follows:

- Ca<sup>++</sup> (calcium) and Mg<sup>++</sup> (magnesium) by titration using EDTA ferricinate.

- K<sup>+</sup> (potassium) and Na<sup>+</sup> (sodium) by flame photometer.

#### Water samples:

1- Electrical conductivity (EC) measurement using an electrical conductivity meter.

2- Soil pH measurement using a pH meter.

## IV. RESULTS AND DISCUSSION

#### Laboratory results (physical and chemical):

Tables 1, 2, and 3 show the physical and chemical properties of the studied sections. The results of the particle size (mechanical) analysis of the fine-grained soil (<2 mm) indicated a relatively high clay content, particularly in the Al-Fadhiliya City section, where the clay content ranged from 15.65% to 65.57%. The lowest clay content was found in the Al-Nasiriyah City section, ranging from 15.25% to 65.32%.

An increase in the clay content is generally observed in some subsurface horizons. This may be attributed to certain biological and geomorphological processes, as well as clay migration. As for silt: its quantity is small compared to clay and sand, and it is uniform within each section, except in the section (Al-Tar City), where it decreases with depth, reaching 7.10%. In general, the silt content in all sections ranged from 7.10% to 62.27%.

The sand content of the soil is relatively consistent within a single section, but varies between the studied sections. This is likely due to erosion and accumulation processes on the one hand, and the relative youth of the soil on the other. Soil texture plays a significant role in influencing some of the physical and chemical properties of the soil.

The variation in soil texture in the studied sections may be due to some pyriological processes, including clay migration or clay formation within the horizon, and erosion processes may also contribute to this, as **Chadwick (2000)** found.

**Apparent density:** Within normal limits, ranging between 955.0 and 99.1 g/cm<sup>3</sup>

**True density:** Also within normal limits, ranging between 2.64 and 2.10 g/cm<sup>3</sup>.



**Soil pH:** The water pH ranged from 33.7 to 81.7, indicating a slightly alkaline to neutral soil reaction. Saline pH values ranged from 0.151 to 0.13 g/m<sup>3</sup>, while acidic pH values ranged from 6.54 to 6.78.

This difference may be significant due to the presence of basic cationic elements on colloidal surfaces, especially calcium and magnesium, as well as the increased cation exchange capacity, which reached 8.39 M.M/100g.

**Organic matter:** The soil's organic matter content is moderate, ranging from 67.0% to 79.1%, and decreasing systematically with depth. This is likely due to the rapid decomposition of organic matter in the soil.

**Electrical conductivity (EC):** Low traces were observed due to the absence of a soil salt source. This reflects the natural conditions in this area, including precipitation and seepage processes, as well as the nature of the parent material.

**Cation exchange capacity:** The cation exchange capacity values of the studied samples are at an average level, ranging between 8.39-22 M/100g soil, with an average of approximately 31 M/100g soil. This reflects the clay content and type of clay in the soils of this region, which is smectite, as reported by Vanliere (1965) and Ilaiwi (1983).

**Exchangeable cations:** It is observed that calcium occupies the largest proportion, followed by magnesium, while sodium and potassium are present in small amounts on the adsorption complex. This may be due to the mineral composition of the basalt rocks from which the soil was formed and to leaching processes, where the highest percentages were recorded for calcium (2.28 mg/100g), magnesium (6.8 mg/100g), potassium (2.0 mg/100g), and sodium (8.1 mg/100g) in the soil.

**Calcium carbonate:** The results of the calcium carbonate estimation indicated a low carbonate content in the soil. The estimation results showed effects (Habib, 2006).

Table (1) shows the physical properties of the soil in the city of Thi Qar, southern Iraq.

Sample site	Depth cm	Apparent density g/cm <sup>3</sup>	Actual density g/cm <sup>3</sup>	Laboratory porosity %	Mechanical analysis of soil			Soil texture
					Sand %	Silt %	Clay %	
Nasiriyah Center	0-30	1.099	2.64	57.5	52.14	22.50	25.14	Sandy clay loam
	30-60	1.097	2.52	55.00	49.86	22.50	27.64	Sandy clay loam
	60-90	0.953	2.48	55.00	42.36	27.52	32.64	clay loam
Al-Fadhiliya	0-30	1.088	2.51	58.04	34.84	25.00	37.64	clay loam
	30-60	1.96	2.34	55.00	29.86	17.50	45.14	clay

City	60-90	1.059	2.48	52.00	42.36	10.06	40.14	clay loam
Souq Al-Shuyoukh City	0-30	1.092	2.54	53.00	24.86	12.50	65.14	clay
	30-60	1.094	2.57	54.00	29.86	10.00	57.64	clay
	60-90	1.095	2.10	51.00	27.36	25.00	62.64	clay
Tar City	0-30	1.092	2.10	53.00	44.86	22.50	30.14	Sandy clay loam
	30-60	1.095	2.47	55.52	39.86	22.50	37.64	clay loam
	60-90	0.945	2.36		39.86	27.50	32.64	clay loam

Table (2) shows the chemical properties of the soil in the city of Thi Qar, southern Iraq

Sample site	Depth cm	pH	EC	CaCO <sub>3</sub> %	O.M %	Exchangeable cations (m.m.) / 100 g of soil					
						Ca	Mg	K	Na	CEC	ESP%
Nasiriyah Center	0-30	7.59	0.155	Traces	1.76	18.5	5.4	0.18	1.0	22	5.05
	30-60	7.59	0.115	Traces	1.24	19.2	3.1	0.2	1.2	23	5.22
	60-90	7.65	0.130	Traces	0.72	20.1	3.3	0.08	1.1	25	4.4
Al-Fadhiliya City	0-30	7.79	0.140	Traces	1.79	20.8	8.2	0.08	1.2	27	4.43
	30-60	7.81	0.105	Traces	0.93	28.2	7.9	0.13	1.5	31	4.84
	60-90	7.43	0.105	Traces	1.03	27.5	8.6	0.10	1.6	34	4.68
Souq Al-Shuyoukh City	0-30	7.39	0.100	Traces	0.83	28.2	6.9	0.10	1.5	39	3.77
	30-60	7.38	0.110	Traces	0.88	27.3	6.7	0.12	1.8	38	4.63
	60-90	7.33	0.120	Traces	0.67	28.1	6.5	0.10	1.2	39	3.08
Tar City	0-30	7.44	0.095	Traces	1.39	19.2	6.2	0.13	1.2	30	4.3
	30-60	7.44	0.091	Traces	1.34	21.5	6.1	0.20	1.3	30	4.21
	60-90	7.42	0.100	Traces	1.34	19.9	6.2	0.20	1.3	30	4.30

**Water samples:** Regarding the water samples: The pH level of the water was moderate in both the first sites in Nasiriyah and the second sites in Al-Fadhiliyah (7.17, 7.9, respectively), while the third sites in Suq Al-Shuyoukh and Al-Tarif city was slightly alkaline (pH = 8).



**EC Salinity:** Water salinity at the Nasiriyah site ranged from 257.0 to 655.0 to 1888.0 millimhos/cm at the Nasiriyah, Fadhiliyah, and Suq al-Shuyukh sites, respectively. This is considered very mild, mild, and acceptable. This is likely due to the nature of the parent material in the area.

**Table (3) Chemical analysis of water samples from the city of Thi Qar, southern Iraq**

Water sampling site	pH	EC	Concentration
Nasiriyah Center	8	0.188	120.32
Al-Fadhiliya City	7.17	0.257	164.48
Souq Al-Shuyoukh City	7.09	0.655	419.20
Tar City	7.05	0.645	412.15

**Residual effects of organophosphate and chlorine pesticides in soil and water:**

A number of organophosphorus and chlorine pesticides, some of which were previously used in Dhi Qar Governorate but were banned in 2006, have been designated. This is in addition to organophosphorus pesticides that are used today to control pests of palm trees as well as grains (wheat and barley). The results showed no traces of organophosphate pesticides, either previously or currently used, in the soil and water samples. The last application of both chlorpyrifos and dimethoate was in the first week of September, while the soil samples were taken at the beginning of December, and the water samples in April 2024 more than three months later. Organophosphate pesticides are characterized by their rapid decomposition due to their chemical structure. Organophosphates are esters or amides resulting from the combination of phosphoric acid with alcohols (Kolodiaznyy *et al.* 2024; Saad *et al.* 2025 ).

Therefore, these pesticides are non-cumulative in the soil, meaning they persist for short periods and their residual effect is short-lived (Cohen, 2021). In addition, they have high solubility in water. Furthermore, environmental factors, organic matter, and microorganisms in the soil contribute to accelerating their decomposition, as reported by (Zionts *et al.* 2025).

The analysis results (Table 4) showed the presence of chlorine pesticide residues at very low and varying concentrations. This is because organochlorine pesticides are characterized as environmentally stable and cumulative compounds. Their cumulative nature stems from their structure; they are organic compounds consisting of a benzene ring linked to chlorine atoms and accumulate in the fatty tissues of living organisms. They are carcinogenic compounds. Chlorine pesticides are among the most harmful pesticides in terms of disrupting the environmental balance due to their high stability. If we link their long persistence with the high mobility of chlorinated hydrocarbons, we can deduce the reason for their spread throughout all ecosystems in the world (Al-Maamar & Samara, 1988; Najam & Alam, 2023).

**Water Samples:** The amount of residue in the water samples from the sites was extremely low for the pesticide 4DDE. The samples were taken from the surface layer of water sites in the Euphrates River during the high water season in April. The pesticide residue amounts were 96.7, 16.8, 22.5 and 23.7 ng/ml in the



Euphrates River water at the city center of Nasiriyah, the city of Fadhiliyah, the city of Suq al-Shuyukh, and the city of Al-Tar, respectively (Table 4).

**Soil samples:** Despite the long period during which the use of chlorine pesticides has been prohibited since 2006, there are residues of these pesticides. This is due to their high stability and tendency to accumulate, their slow decomposition or breakdown, and their retention in the soil because they are not water-soluble, unlike organophosphate pesticides.

**Table (4)** Quantity of chlorinated pesticide residues in water samples.

Amount of residues ng/ml	Nasiriyah Center	Al-Fadhiliya City	Souq Al-Shuyoukh City	Tar City
4,4 DDT	-	-	-	-
4,4 DDT	-	-	-	-
Endrin	-	-	-	-
Dieldrin	-	-	-	-
4,4 DDT	<b>7.23</b>	<b>8.16</b>	<b>7.96</b>	<b>7.15</b>
Beta - HcH	-	-	-	-
Aldrin	-	-	-	-
Hept - chlor	-	-	-	-
Lindane	-	-	-	-
BHC - alpha	<b>ND*</b>	<b>ND</b>	<b>ND</b>	<b>ND</b>

ND\* Quantity of residue below the device detection limit.

The results in Table 5 show that soil samples contained pesticide residues at a depth of 30-60 cm, greater than in the surface layer (0-30 cm) and the deeper layer (60-90 cm). This may be due to the continuous tillage of the soil, which facilitates the downward movement of some pesticides by improving the soil's physical properties, particularly water movement. Additionally, the soil layer has a higher adsorption capacity compared to the surface layer, as it has a higher clay content (Table 1). The higher residue levels in this layer compared to the deeper layer (60-90 cm), despite the higher clay content in the deeper layer, are attributed to the fact that chlorinated pesticides are insoluble in water, resulting in slow leaching to the deeper layer. Furthermore, these pesticides tend to accumulate. A high clay and organic matter content in the soil can reduce pesticide mobility (Aliste *et al.*, 2021; Haider, 2025a)

Table (5) shows that the amount of DDE pesticide residue at a depth of 30-60 cm in the soil of Nasiriyah city center was 34.142 ng/ml, which was higher than the soil of the other samples at this depth. This is due to the high amount of DDT pesticide residue at this depth. The amount of DDT pesticide residue in the soil of Nasiriyah city center at a depth of 30-60 cm was 9.50 ng/ml, while the amount of residue in the soil of Al-Fadhiliyah city at a depth of 0-30 cm was 8.11 ng/ml, and in the soil of Suq Al-Shuyukh city and Al-Tar city at a depth of 30-60 cm was 2.21 ng/ml.

The DDE pesticide residue in the soil of Nasiriyah city at a depth of 0-30 cm was somewhat higher compared to the other samples at the same depth (59.20 ng/ml), and this is due to the presence of a low residue of DDT pesticide (8.11 ng/ml) at the same depth. The amount of DDD pesticide residue (79.23



ng/ml) was low in the soil of Nasiriyah city at a depth of 30-60 cm. This is attributed to the high amount of DDT residue, which breaks down into its metabolites DDD and DDE. However, the amount of DDD residue is always lower than that of DDE (Day and Hitch, 1992), as DDE is more persistent than DDD. In contrast, the DDT residue was low in the samples from Al-Fadhiliyah city (0-30 cm), Suq Al-Shuyukh, and Al-Tar city (30-60 cm). Therefore, the presence of DDE residues without DDD residues is also present. The presence of residual traces in the soil samples may be due to previous soil treatment, as in the other studied cultivated soil samples, in addition to wind transport during spraying (Haider, 2025b; Ateshan and Talib, 2025).

The results showed low and similar residue levels of Lindane pesticide at a depth of 30-60 cm in samples from Al-Fadhiliya and Suq Al-Shuyukh cities (22.6 and 23.8 ng/ml, respectively). Aldrin pesticide was found only in the soil of Al-Tar city and in small quantities at a depth of 30-60 cm (6.33 ng/ml).

Residues of the pesticide Endrin and its metabolite Dieldrin were also found in the soil of Nasiriyah city at a depth of 30-60 cm and in high quantities, with Endrin residues reaching 20.757 g/ml and Dieldrin residues reaching 179.48 g/ml. No residues were found for the pesticides Heptachlo and HCH-Beta. However, the residues of alpha-BHC were below the detection limit for soil samples only. The study observed that the highest residue levels were for DDE, followed by DDT and DDD. This aligns with the findings of Nasrallah's study on Nasiriyah and the Euphrates Rivert (Afrin *et al.*, 2023; NGUYEN *et al.*, 2025).





Table (5) Quantity of chlorinated pesticide residues in soil samples

Amount of residues ng/ml	Nasiriya h Center 0-30 cm	Nasiriya h Center 30-60 cm	Nasiriya h Center 60-90 cm	Al-Fadhiliya 0-30 cm	Al-Fadhiliya 30-60 cm	Al-Fadhiliya 60-90 cm	Souq Al-Shuyoukh 0-30 cm	Souq Al-Shuyoukh 30-60 cm	Souq Al-Shuyoukh 60-90 cm	Tar City 0-30 cm	Tar City 30-60cm	Tar City 60-90 cm
4,4 DDT	-	-	-	11.09	50.08	-	-	-	-	-	20.03	-
4,4 DDT	-	-	-	-	23.78	-	-	-	-	-	-	-
Endrin	-	-	-	-	756.20	-	-	-	-	-	-	-
Dieldrin	-	-	-	-	178.47	-	-	-	-	-	-	-
4,4 DDT	5.99	8.36	6.57	20.58	143.23	18.40	11.65	27.18	16.32	10.58	31.18	16.34
Beta-HcH	-	-	-	-	-	-	-	-	-	-	-	-
Aldrin	-	-	-	-	-	-	-	-	-	-	6.32	-
Hept-chlor	-	-	-	-	-	-	-	-	-	-	-	-
Lindane	-	-	-	-	-	-	7.32	8.22	-	-	6.20	-
BHC-alpha	ND*	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

ND\* Quantity of residue below the device detection limit



## V. CONCLUSION

The results of the pesticide accumulation study showed no residue of organophosphate pesticides. This is attributed to their rapid decomposition in the soil. However, traces of pesticide accumulation were observed at low and varying levels for chlorinated pesticides, despite the cessation of spraying with these pesticides since 2006. This is due to their high stability and slow decomposition. Therefore, it is recommended to study the residue of these pesticides in other areas of Thi Qar, Iraq.

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