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Organochlorine Pesticides in the Aquatic Environment of southern Iraq: A Comprehensive Review of Distribution and Sources

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Abstract

Organochlorine pesticides (OCPs) in the marshes of southern Iraq, the Shatt Al-Arab Estuary, and the Iraqi sector of the northwest Arabian Gulf occur in measurable levels in water, sediments, aquatic plants and fish, with clear evidence of long term persistence and transport from upstream agricultural areas into coastal marine systems. The dominant compounds across matrices are legacy DDTs, endrin, dieldrin, heptachlor and chlordane, largely originating from historical agricultural use, vector control, and subsequent remobilization of contaminated sediments into the river–marsh–Gulf continuum.

Key studies and matrices

A synthesis by Douabul and co-workers, updated in a recent review "On the Organochlorine pesticide residues in the Marshes, Shatt Al-Arab and the Arabian Gulf system", compiles data from 1979–1991 plus recent marsh work, covering water (dissolved and particulate), sediments, fish, mussels, shrimps and other biota. That review shows ∑DDT, endrin, dieldrin, chlordane and heptachlor as the main residues in all compartments, with DDT and endrin especially prominent in marsh sediments and carp from Hor Al-Hammar. More recent studies in southern wetlands (e.g. *Oreochromis niloticus* and *Planiliza abu* analyzed by GC-MS in 2021–2022) confirm that multiple OCPs are still detectable in marsh fish at ng/g dry-weight levels, with clear seasonal changes in burdens (Douabul and Al-Timari, 2014; Douabul *et al.,* 2014).

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Water and suspended particulate matter along the Shatt Al-Arab contain DDT group compounds transported from the Euphrates and Tigris, adsorbed to suspended particles that later settle or are exported to the Gulf. In coastal and offshore Iraqi waters, OCPs in fish, shrimp and other biota fit into broader ROPME-Sea-Area surveys that document DDTs and related organochlorines in marine organisms and coastal sediments across the northern Arabian Gulf. (National Oceanic and Atmospheric Administration, 1999; Al-Ali *et al.*, 2022).

Distribution patterns by matrix

Water and suspended particles

In the marsh–Shatt Al-Arab–Gulf system, dissolved ∑DDT, endrin, dieldrin, chlordane and heptachlor in water typically range from "not detected" up to a few hundred ng/L, with higher values in agricultural zones and at river mouths. Adsorbed on suspended particulate matter, ∑DDT can reach the order of 10^3 µg/kg dry weight, illustrating strong partitioning of these hydrophobic compounds to particles and their potential to be transported downstream into the estuary and Gulf. The tidal character of the Shatt Al-Arab enhances retention and re-deposition of particle-bound OCPs, increasing local exposure in estuarine habitats. (Tanabe, 1988; Paez-Osuna, 2001; De Mora *et al.,* 2004; Gabar *et al.*, 2024).

Sediments

Surface and subsurface sediments from marshes, Shatt Al-Arab and the Iraqi coast show wide ranges of ∑DDT and related OCPs, from near detection limits up to several thousand µg/kg dry weight in some marsh and riverine locations. In Hor Al-Hammar, recent work cited in the Basrah review reports elevated chlordane in water and sediments relative to older surveys, indicating either continued inputs or remobilization of legacy stocks. Coastal and nearshore sediments of the northwest Arabian Gulf show lower but still detectable ∑DDT and heptachlor, consistent with dilution, deposition in deeper areas, and regional mixing within the ROPME Sea Area. (DouAbul *et al.*, 1988; Long *et al.*, 1998; Buah-Kwofie and Humphries, 2017; Al-Assadi, 2021; Gabar, 2024)

Aquatic plants and marsh biota

The compiled Iraqi marsh data indicate that rooted macrophytes and other marsh plants accumulate DDT and related OCPs from sediments and pore water, acting as an intermediate reservoir within marsh food webs. Concentrations in plants are generally lower than in sediments on a dry-weight basis, but they facilitate trophic transfer to invertebrates and herbivorous or detritivorous fish. Mussels and shrimps from marshes and the Shatt Al-Arab contained OCPs at from sub-microgram to hundreds of µg/kg wet weight, often with higher values for DDTs and endrin in marsh and estuarine sites than in open Gulf waters (DouAbul *et al.,* 1987c; Vogt *et al.*, 2018; Long *et al.,* 1995; MacDonald *et al.*, 2000; Gabar *et al.*, 2024; Al-Saad and Al-Imarah, 2021).

Fish and higher trophic levels

Fish from marshes, Shatt Al-Arab and the Iraqi coast show bioaccumulation of DDTs, endrin, dieldrin and heptachlor, with marsh carp (*Cyprinus carpio*) from Hor Al-Hammar historically recording ∑DDT from about 8 to more than 90 µg/kg wet weight. The Basrah synthesis notes that endrin residues were detected in about 90% of fish analyzed during the 1980s, with mean levels up to several tens of µg/kg wet weight; more recent marsh fish studies at lower ng/g dry-weight levels suggest some decline yet persistent contamination. In shrimps from the Shatt Al-Arab, residues of o,p´-DDD have been reported, while Gulf-wide surveys show DDTs and other chlorinated hydrocarbons in a range of commercial species, indicating regional-scale dispersion of these legacy pollutants. (U.S. Food and Drug Administration, 1987; DouAbul *et al.*, 2009; Al-Zabad, 2021; Al-Ali *et al.*, 2022).

Sources and transport pathways

The main source of OCPs in southern Iraqi marshes is long-term agricultural use and disease-vector control in the Mesopotamian plain, where DDT and related insecticides were extensively applied from the 1960s onwards. Runoff and drainage from irrigated lands, together with aerial drift from spraying directly over wetlands (e.g. past DDT spraying on Hor Al-Hammar), delivered large loads of pesticides into marsh waters and sediments (U.S. Environmental Protection Agency, 2025).

In the Shatt Al-Arab, OCPs enter via dissolved and particle-bound forms carried by the Tigris, Euphrates and tributaries; suspended particles then settle in estuarine areas or are transported into the northern Arabian Gulf. The Basrah review attributes a significant portion of particulate DDT in the Shatt Al-Arab to the Euphrates, which had higher upstream ∑DDT, and suggests a slow degradation rate or current recent inputs that require further investigation. Additional inputs may come from industrial and municipal discharges along the lower river and coastal zone, as well as atmospheric deposition and regional transport within the ROPME Sea Area (DouAbul *et al.*, 1987a; DouAbul *et al.*, 1987b; DouAbul *et.*, 1987c; Villeneuve and DouAbul, 1987; Al-Timari, 1997; Al-Ali, 2012; Office of Environmental Health Hazard Assessment,2025; Indonesian Journal on Health Science and Medicine, 2025)

Comparison among sub-systems

The table below summarizes typical concentration ranges and dominant compounds across the marshes, Shatt Al-Arab and Iraqi coastal/northwest Arabian Gulf sector, focusing on water, sediments and biota.

Distribution of OCPs in southern Iraq and NW Arabian Gulf

System/ matrix	Typical concentration range (order of magnitude)	Dominant OCPs reported	Notable features/ interpretation
Southern marshes-water (dissolved)	Nd-a few 10^2 ng/L ∑DDT, endrin, dieldrin, chlordane, heptachlor	DDTs, endrin, dieldrin,	Direct agricultural runoff and local spraying; high

		chlordane, heptachlor	exposure in shallow wetlands.
Southern marshes-sediments	~0.1-10^3 µg/kg dw for ∑DDT and related OCPs in some sites	DDTs, endrin, dieldrin, chlordane	Marshes act as long-term sinks; high values in Hor Al-Hammar linked to historical DDT use.
Southern marshes – fish (carp, *tilapia, mullet)*	~few – 10^2 µg/kg ww in older data; recent GC-MS work: 0.1–1.6 ng/g dw for individual OCPs	DDTs, endrin, dieldrin, heptachlor, endosulfan	Strong bioaccumulation in resident species; seasonal variation in recent marsh fish data.
Shatt Al-Arab-water (dissolved)	Nd-a few 10^2 ng/L ∑DDT etc., similar to or slightly lower than marsh hotspots	DDTs, endrin, dieldrin, heptachlor	Receives upstream agricultural inputs; tidal dynamics promote particle retention.
Shatt Al-Arab-suspended particles	Up to ~10^3 µg/kg dw ∑DDT on particulates in some locations	DDTs	Euphrates identified as major contributor of particulate DDT; key vector towards the Gulf.
Shatt Al-Arab-sediments	Generally 10^0–10^2 µg/kg dw with local hotspots	DDTs, limited heptachlor and other OCPs	Intermediate sink between marshes and Gulf; evidence of declining trends for some compounds.
Shatt Al-Arab-shrimp and mussel	Shrimp: o,p´-DDD around a few µg/kg ww; mussels up to several 10^2 µg/kg for some OCPs	DDTs, endrin, dieldrin	Benthic invertebrates integrate sediment-associated contamination; higher in marsh/estuarine sites than offshore.
NW Arabian Gulf (Iraqi coastal)-sediments	Generally lower than marsh/Shatt, typically ≤10^2 µg/kg dw ∑DDT and related compounds	DDTs, heptachlor and other chlorinated hydrocarbons	Dilution and mixing with regional sediments; influenced by Shatt Al-Arab plume and other Gulf sources.
NW Arabian Gulf-fish and other biota	µg/kg-level DDTs and other chlorinated hydrocarbons in fish, shrimp and other marine organisms	DDTs, chlorinated hydrocarbons (regional ROPME data)	Reflects combined inputs from Iraqi rivers and other Gulf states; bioaccumulation across trophic levels.

Comparison of pesticide studies in Iraqi marshes

Study / area	**Matrix**	**Target pesticides (examples)**	**Typical concentration range (order of magnitude)**	**Key features**
DouAbul 1979–1991 synthesis (marshes incl. Hor Al-Hammar, Shatt Al-Arab, NW Gulf)	Fish (several species)	DDTs, endrin, dieldrin, chlordane, heptachlor	∑DDT in carp from Hor Al-Hammar ≈ 8–92 µg/kg wet wt; endrin up to several 10s µg/kg ww	Very high legacy OCPs in marsh fish vs marine fish; clear biomagnification and hotspot conditions in Hor Al-Hammar.
DouAbul 1979–1991 synthesis-marsh macrophytes & invertebrates	Aquatic plants, mussels, shrimp	Mainly DDTs, endrin, dieldrin	Plants: lower than fish and closer to sediments; mussels/shrimp up to 10^2 µg/kg for some OCPs (ww)	Plants act as intermediate reservoir; mussels and shrimp efficiently reflect sediment-associated contamination.

DouAbul 2009 Mesopotamian wetlands sediments (incl. Hor Al-Hammar)	Dried marsh sediments	p,p´-DDE	Detected in 100% of sediment samples; order of 10^0 µg/kg dw	Demonstrates strong persistence of DDT metabolites in desiccated marsh sediments.
Al-Ali 2012 PhD thesis – East of Hor Al-Hammar	Water, sediment, fish, other biota	∑DDT, endrin, aldrin, dieldrin, chlordane, heptachlor	Sediments: roughly 10^0–10^2 µg/kg dw for major OCPs; fish: µg/kg ww level	Shows continued presence of legacy OCPs and particularly high chlordane in sediments and biota compared with earlier work.
"Levels of pesticides in sediment of Hor Al-Hammar Marshes, Iraq" (2022)	Sediment (Hor Al-Hammar)	Lindane, dieldrin and other pesticides	Lindane up to ≈ 497.5 µg/kg dw; other OCPs generally ≤10^2 µg/kg dw	Confirms current hotspot sediment contamination and links higher OCPs with TOC; suitable for SQG-type risk comparison.
Seasonal OCPs in marsh fish, 2021–2022 (*Oreochromis niloticus, Planiliza abu*)	Fish (southern Iraqi wetlands)	14 OCPs: HCH isomers, heptachlor, aldrin, epoxyheptachlor, DDE, dieldrin, DDD, endrin (and metabolites), methoxychlor, endosulfan	Mean 0.13–1.6 ng/g dry wt for individual OCPs, depending on species and season	First modern seasonal GC-MS dataset for marsh fish; shows persistent but relatively low-level contamination and clear seasonal trends.

Fish vs plants (Iraqi marshes)

Aspect	Marsh fish (e.g., Hor Al-Hammar, southern wetlands)	Marsh plants / macrophytes
Main OCPs detected	DDTs (p,p´-DDT, DDE, DDD), endrin, dieldrin, chlordane, heptachlor, HCH isomers, endosulfan	Mainly DDTs and related OCPs (endrin, dieldrin) reflecting pore-water and sediment contamination
Typical concentrations (order of magnitude)	Historical Hor Al-Hammar carp: ∑DDT ≈ 8–92 µg/kg ww; endrin up to several 10s µg/kg ww; recent marsh fish: individual OCPs ≈ 0.13–1.6 ng/g dw	Generally lower than fish; typically, closer to sediment levels but often below them on a dry-weight basis (10^0–10^1 µg/kg dw range where reported)
Role in food web	Strong bio accumulators, integrating exposure over time and space; key vector to human consumers and higher predators	Intermediate reservoir transferring sediment-bound OCPs to herbivores and detritivores; less important for direct human exposure

Old vs recent marsh fish studies (temporal perspective)

Period/ study	Area & species	Analytical scope	Concentration level	Interpretation
1979–1991 (DouAbul series, summarized later)	Marshes incl. Hor Al-Hammar; carp and other resident fish	Classic GC analysis of main legacy OCPs (DDTs, endrin, dieldrin, chlordane, heptachlor)	∑DDT up to ~10^2 µg/kg ww; endrin frequent and sometimes at several 10s µg/kg ww	Very high legacy contamination; Hor Al-Hammar clearly a hotspot compared with NW Arabian Gulf marine fish
~2000s (Mesopotamian wetlands	Dried marsh sediments and associated	Focus on DDT metabolites (e.g., p,p´-DDE) and related compounds	p,p´-DDE in sediments at ~10^0 µg/kg dw with 100% detection	Confirms persistence of OCPs after marsh drainage and partial reflooding

sediment + biota work)	biota in southern wetlands			
2010s (Al-Ali thesis and related papers)	East of Hor Al-Hammar; fish and other biota	Expanded suite of OCPs including chlordane, HCHs, etc.	Fish at µg/kg ww level; sediments ~10^0–10^2 µg/kg dw	Continued but somewhat reduced residues vs 1980s; chlordane relatively high locally
2021–2022 GC-MS marsh fish study	Southern Iraqi wetlands; *Oreochromis niloticus*, *Planiliza abu*	14 OCPs (HCHs, heptachlor, aldrin, epoxyheptachlor, DDE, dieldrin, DDD, endrin + metabolites, methoxychlor, endosulfan)	Individual OCPs ≈ 0.13–1.6 ng/g dw, season- and species-dependent	Persistent but lower-level contamination; clear seasonal differences; suggests declining but non-zero legacy burden

Marsh vs Shatt Al-Arab vs NW Arabian Gulf (spatial perspective)

System	Matrices & key OCPs	Typical concentration range	Main features
Southern marshes (e.g., Hor Al-Hammar)	Sediments, plants, fish, invertebrates; DDTs, endrin, dieldrin, chlordane, heptachlor, HCHs	Sediments: up to ~10^3 µg/kg dw for ∑DDT; fish: up to ~10^2 µg/kg ww historically, ng/g dw in recent fish; plants: lower than sediments and fish	Primary sink and hotspot for historical agricultural OCP inputs; strong bioaccumulation in resident fish and invertebrates
Shatt Al-Arab River	Water, suspended particles, sediments, shrimp, fish; mainly DDTs, endrin, dieldrin, heptachlor	Water: nd–10^2 ng/L; particulates: up to ~10^3 µg/kg dw ∑DDT; sediments: ~10^0–10^2 µg/kg dw; shrimp/fish: µg/kg ww level	Integrator and conveyor of upstream OCPs from Tigris–Euphrates; tidal dynamics enhance retention and redistribution of particle-bound pesticides
NW Arabian Gulf (Iraqi coastal sector)	Coastal sediments and marine fish/invertebrates; DDTs and other chlorinated hydrocarbons	Sediments generally ≤10^2 µg/kg dw ∑DDT; fish at µg/kg-level DDTs and related compounds	Receives diluted but persistent OCP inputs via Shatt Al-Arab plume and regional Gulf circulation; overall lower than marsh hotspots but still ecologically relevant

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المجلة العراقية للإستزراع المائي المُجَلَّد (23) العدد (1)-2026: 117-125

مبيدات الآفات العضوية الكلورية في البيئة المائية بجنوب العراق: مراجعة شاملة للتوزيع والمصادر

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المستخلص

تتواجد مبيدات الآفات العضوية الكلورية في أهوار جنوبالعراق، ومصب شط العرب، واالاراضي العراقية في شمال غرب الخليج العربي، بمستويات قابلة للقياس في المياهوالرواسب والنباتات المائية والأسماك، مع وجود أدلة واضحةعلى استمرارها على المدى الطويل وانتقالها من المناطقالزراعية في أعالي النهر إلى النظم البيئية البحريةالساحلية. وتشمل المركبات السائدة في هذه البيئات مركبات DDT القديمة، والإندرين، والديلدرين، والهيبتاكلور، والكلوردان، والتي نشأت في الغالب من الاستخدام الزراعي التاريخي، ومكافحة نواقل الأمراض، وإعادة تحريك الرواسب الملوثة لاحقًا في سلسلة النهر-الأهوار-الخليج.