Distribution and Sources of Organochlorine Pesticides (OCP) in Fish Samples from the Iraqi Coast, Northwest Arabian Gulf

Huda.Hassan AL-Kayoon1.,Ayad Huntosh1 and Hamid ,T. AL-Saad2

1.Department of Biology,College of Science ,University of Basrah,Iraq

2.College of marine Science,University of Basrah,Iraq

Abstract

This study investigates the levels, distribution patterns, and probable sources of various OCPs in ten commercially important 10 fish species sampled. These species include *Nematalosa nasus, Cynoglossus arel, Johnieops sina, Liza subviridis, Synaptura orientalis, Otolithes ruber, Acanthopagrus latus, Tenualosa ilisha, Epinephelus coioides, and Saurida tumbil* from this region. The analysis specifically focuses on14 major OCPs including Alpha-lindane, Lindane, Delta-lindane, Heptachlor, Aldrine, Epoxyheptachlor, D.D.E, Dieldrin, D.D.D, Endrin aldehyde, Endrin ketone, Methoxychlor, Endrin, and Endosulfan.The concentration data provided, expressed in mg/kg of wet weight, demonstrate significant interspecies variability ranging from minimal detection levels (e.g., alpha-lindane in *Synaptura orientalis*, 0.00787 mg/kg) to notably high contamination, especially in *Saurida tumbil*, with total pesticide residues measured at 26.1292 mg/kg. There was a definite correlation between total OCP residues and fish lipid content (correlation coefficient r = 0.6), indicating that species with higher fat content tend to accumulate more OCPs.The variation in OCP pesticide levels among fish species is primarily influenced by ecological niches, trophic position, habitat contamination levels, and species-specific biological metabolism. Fish living in highly impacted coastal zones, feeding at higher trophic levels, or having physiological traits favoring accumulation exhibit elevated OCP concentrations

Kew word=OCP, Marine Fish, Iraq coast NW Arabian Gulf, GC

Introduction

Organochlorine pesticides (OCPs) are persistent organic pollutants known for their environmental longevity, bioaccumulation, and toxic effects on marine ecosystems and human health (Tanabe, 1988; Jabeen et al., 2016). Despite global restrictions on many OCPs, their residues remain prevalent in marine environments due to historic usage, illegal application, and mobilization via atmospheric and riverine inputs (Li et al., 2013; Gissi et al., 2013). The northwest Arabian Gulf, a highly productive yet anthropogenically pressured marine region, is particularly vulnerable to OCP contamination due to extensive agricultural runoff, industrial activities, and oil exploration (Al-Shami et al., 2018).

This study analyzes the distribution of 14 major organochlorine pesticides detected in various commercially important marine fish species inhabiting the Iraqi coast of the northwest Arabian Gulf. This paper investigates the levels, distribution, and probable sources of various OCPs in several commercially significant fish species sampled from the Iraqi coastal waters based on analytical data provided. Regional comparisons and environmental regulatory implications are also discuses.Organochlorine pesticides (OCPs) are persistent environmental pollutants used historically in agriculture and vector control. Due to their chemical stability, lipophilicity, and resistance to degradation, OCPs tend to accumulate in aquatic ecosystems, especially in sediments and biota such as fish, posing ecological and human health risks. In the context of the Iraqi marine environment, particularly the northwest Arabian Gulf, OCP contamination in fish is of concern because this region receives agricultural and industrial discharges that may introduce these toxic substances into the marine food web. This study analyzes the distribution of 14 major organochlorine pesticides detected in various commercially important marine fish species inhabiting the Iraqi coast of the northwest Arabian Gulf. This paper investigates the levels, distribution, and probable sources of various OCPs in several commercially significant fish species sampled from the Iraqi coastal waters

Materials and Methods

Marine fish specimens were collected from the Iraqi coastal waters of the northwest Arabian Gulf. Ten commercially important fish species, representing diverse ecological niches and feeding habits, were sampled: *Nematalosa nasus*, *Cynoglossus arel*, *Johnieops sina*, *Liza subviridis*, *Synaptura orientalis*, *Otolithes ruber*, *Acanthopagrus latus*, *Tenualosa ilisha*, *Epinephelus coioides*, and *Saurida tumbil*. Sampling was conducted at multiple representative sites along the Iraqi coastline Fig(1) to capture spatial variation.

Collected fish were immediately transported on ice to the laboratory where they were identified, measured, and dissected. The edible muscle tissue was separated, homogenized, and stored at −20°C until chemical analysis. Lipid content (% fat) of the muscle tissue was determined gravimetrically by extracting using the Soxhlet apparatus with petroleum ether as solvent following standard protocols (Bligh & Dyer, 1959).

Analytical-grade organochlorine pesticide standards including α-lindane, lindane, δ-lindane, heptachlor, aldrin, epoxyheptachlor, DDE, dieldrin, DDD, endrin aldehyde, endrin ketone, methoxychlor, endrin, and endosulfan were used. Solvents such as hexane, acetone, and petroleum ether were of pesticide residue analysis grade.

Extraction of OCPs from fish muscle followed internationally recognized protocols with slight modification for marine biota (Murphy & Lader, 1974; EPA Method 8081):Approximately 25 g of wet homogenized muscle tissue was mixed with anhydrous sodium sulfate to remove moisture. Samples were transferred to a Soxhlet extractor and extracted with a hexane–acetone mixture (1:1, v/v) for 16 hours. The crude extract was concentrated by rotary evaporation and subjected to cleanup on a Florisil chromatography column to remove lipids and other interfering substances. The eluate was concentrated to a final volume suitable for gas chromatography analysis. Quantitative determination of the 14 target OCP compounds was performed using Gas Chromatography equipped with an Electron Capture Detector (GC-ECD), a highly sensitive method for OCPs (Singh et al., 2004): Identification and quantification were achieved by comparison with retention times and peak areas of external standards. Internal standard recovery surrogates were used to ensure accuracy and reproducibility.

Fig (1) sample Locations

Result and discussion

From Table (1) and Fig(2)the highest total OCPs concentration was found in *Saurida tumbil* (26.13mg/kg), followed by Johnieops sina (6.43mg/kg) and *Epinephelus coioides* (5.01mg/kg).OCPs such as Lindane, Delta-lindane, and Epoxyheptachlor contribute significantly to the total pesticide load in most species, with particular spikes in *Saurida tumbil*.

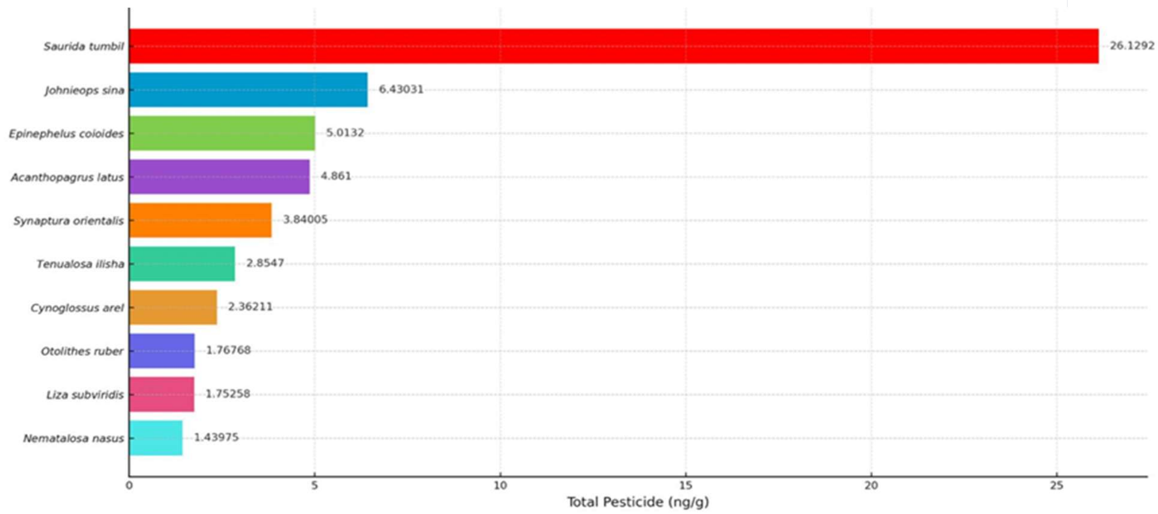
Table 1: OCP Levels (mg/kg wet weight) in Fish Species

Pesticide	**N nasus**	**C arel**	**J sina**	**L subviridis**	**S orientalis**	**O ruber**	**A latus**	**T ilisha**	**E coioides**	**S tumbil**
Alpha-lindane	0.02077	0.1132	0.04899	0.00852	0.00787	0.0255	0.0776	0.1147	0.0284	0.0394
Lindane	0.2077	0.0754	0.00544	0.3409	0.2295	0.3839	0.7765	0.206	0.5284	8.0915
Delta-lindane	0.1384	0.1006	2.1	0.2083	1.331	0.2559	0.6532	1.469	1.2195	3.5523
Heptachlor	0.0346	0.31446	0.06528	0.00189	0.0745	0.0639	0.2912	0.0441	0.0325	0.1973
Aldrine	0.0692	0.1886	0.637	0.0947	0.05737	0.01279	0.3106	0.1118	0.1219	2.3682
Epoxyheptachlor	0.4154	0.371	0.373	0.142	1.09	0.05119	0.152	0.1	1.908	6.5127
D.D.E	0.0692	0.1635	0.03264	0.0473	0.05163	0.0895	0.1941	0.0441	0.0813	0.3157
Dieldrin	0.0346	0.2767	0.02176	0.1704	0.0459	0.1407	0.063	0.0559	0.0609	0.1184
D.D.D	0.1384	0.05031	0.05984	0.0189	0.1663	0.0127	0.1358	0.0264	0.0365	0.3552
Endrin aldehyde	0.05539	0.08805	0.0544	0.00947	0.00573	0.0255	0.097	0.0588	0.0447	1.0657
Endrin Ketone	0.1938	0.178	0.07072	0.1326	0.11475	0.1023	0.091	0.209	0.1016	0.9473

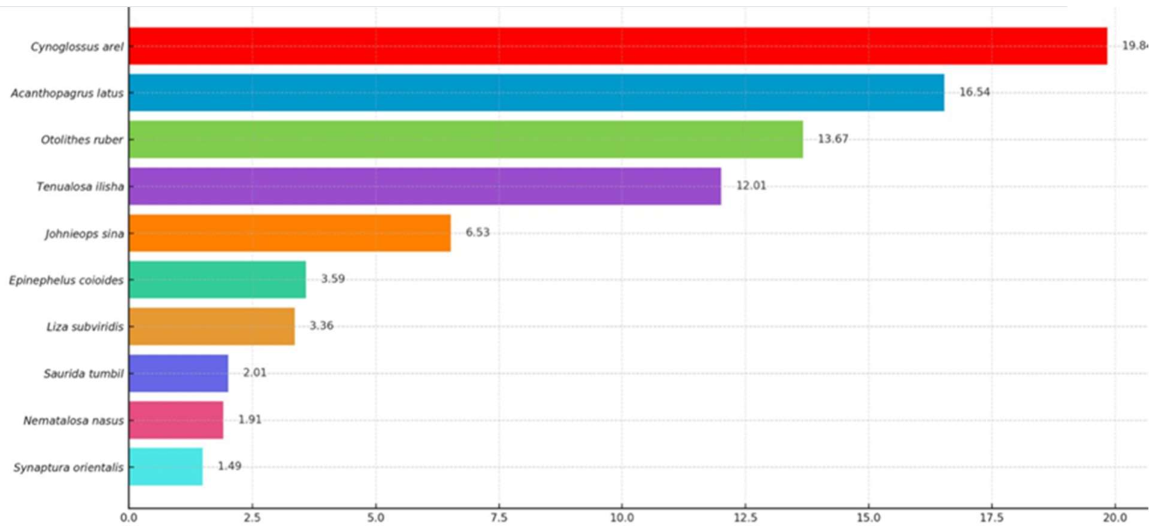
Pesticide	N nasus	C arel	J sina	L subviridis	S orientalis	O ruber	A latus	T ilisha	E coioides	S tumbil
Methoxy chlor	0.0346	0.0754	0.16864	0.2083	0.086	0.1151	0.1747	0.0824	0.2439	0.7499
Endrin	0.02077	0.06289	0.2176	0.2746	0.0975	0.1407	0.33	0.1236	0.4065	1.0262
endosulfan	0.00692	0.304	2.575	0.0947	0.482	0.348	1.5143	0.2089	0.1991	0.7894
Total pesticide	1.43975	2.36211	6.43031	1.75258	3.84005	1.76768	4.861	2.8547	5.0132	26.1292

Table 2 Summary of mean concentration (mg/kg) of total Organochlorine Pesticides and Lipid percentage in selected Iraqi Marine Fish

Species	Total 0CPs (mg/kg)	%Fat
Nematalosa Nasus	1.44	1.91
Cynoglossus arel	2.36	19.84
Johnieops sina	6.43	6.53
Liza subviridis	1.75	3.36
Synaptura orientalis	3.84	1.49
Otolithes ruber	1.77	13.67
Acanthopagrus latus	4.86	16.54
Tenualosa ilisha	2.85	12.01
Epinephelus coioides	5.01	3.59
Saurida tumbil	26.13	2.01



Fig(2) Total OCP I fish Samples



Fig(3) total Fat% in fish samples

The Major Sources of OCPs from A gricultural Runoff: High levels of compounds such as Lindane and Delta-lindane indicate strong links to agricultural usage. Lindane has been widely used as an insecticide in crops. Riverine Input and Industrial Dischargealso anthor sources due to the Shatt Al-Arab River, which is heavily impacted by human activity, is a known transport route for OCPs. The detection of heptachlor, dieldrin, and endosulfan aligns with historic and, in some cases, continuing use in the region. The Atmospheric Deposition: Atmospheric mobility allows OCPs to be deposited in marine areas far from their original application.Bioaccumulation: Species higher in the food web, such as *Saurida tumbil ,Epinephelus coioides,* accumulate greater OCP concentrations, consistent with the principles of biomagnification: *Saurida tumbil* exhibited by far the highest total OCP concentration

(26.13mg/kg), with especially high levels of Lindane (8.09mg/kg), Delta-lindane (3.55mg/kg), and Epoxyheptachlor (6.51mg/kg).Medium-high accumulations were seen in *Johnieops sina* (6.43mg/kg), *Epinephelus coioides* (5.01mg/kg), and Acanthopagrus latus (4.86mg/kg).Lower overall OCP burdens appeared in *Nematalosa nasus (*1.44mg/kg), *Liza subviridis* (1.75mg/kg), and *Otolithes ruber* (1.77mg/kg). Lindane, Delta-lindane, and Epoxyheptachlor were consistently among the most abundant OCPs across most species, especially *Saurida tumbil*. Endosulfan and Aldrine also showed marked elevations in some mid-to-high OCP-burdened species (e.g., *Johnieops sina, Saurida tumbil).* Other OCPs—such as Alpha-lindane, Heptachlor, D.D.E, and Methoxychlor—were present at much lower concentrations, with subtle species-to-species differences. There is acorrelation between total OCP concentration and the percentage of fat (%FAT) as shown in Table(2) and Fig (3) the fish tissue. For instance, Saurida tumbil had high OCPs despite low fat content, indicating other ecological and physiological factors at play (e.g., feeding habits, trophic level, habitat preferences). Top predators or larger, longer-lived species (like *Saurida tumbil*) tend to bioaccumulate higher OCP residues, raising ecological and food safety concerns. Lindane and its isomers, as well as relatives like heptachlor and epoxyheptachlor, dominate the OCP profile, which Ecological Implications: Species occupying different niches display distinct bioaccumulation patterns, influenced by factors such as diet, habitat preference, migration, and trophic position.

In summary, the distribution of OCP pesticides in fish from this region is highly variable, with significant differences among both species and OCP types as indicated in Table (4)and accumulation patterns are shaped by ecological and biological characteristics unique to each species.

Table 4:The fish species from the Iraqi coast in the northwest Arabian Gulf showing the highest levels of specific organochlorine pesticides (OCPs)

OCP Pesticide	**Fish Species with Highest Level**	**Value (mg/kg)**
Alpha-lindane	*Cynoglossus arel*	0.1132
Lindane	*Saurida tumbil*	8.0915
Delta-lindane	*Johnieops sina*	2.1000
Heptachlor	*Cynoglossus arel*	0.31446
Aldrine	*Saurida tumbil*	2.3682
Epoxyheptachlor	*Saurida tumbil*	6.5127

OCP Pesticide	Fish Species with Highest Level	Value (mg/kg)
D.D.E	*Cynoglossus arel*	0.1635
Dieldrin	*Cynoglossus arel*	0.2767
D.D.D	*Synaptura orientalis*	0.1663
Endrin aldehyde	*Saurida tumbil*	1.0657
Endrin Ketone	*Saurida tumbil*	0.9473
Methoxy chlor	*Saurida tumbil*	0.7499
Endrin	*Saurida tumbil*	1.0262
Endosulfan	*Johnieops sina*	2.5750

Saurida tumbil exhibits the highest levels for several OCPs including Lindane, Aldrine, Epoxyheptachlor, Endrin aldehyde, Endrin Ketone, Methoxy chlor, and Endrin, indicating a significant OCP burden in this species. *Cynoglossus arel* shows the highest concentrations of Alpha-lindane, Heptachlor, D.D.E, and Dieldrin. *Johnieops sina* has the highest levels for Delta-lindane and Endosulfan. For D.D.D, *Synaptura orientalis* is the highest.(Table 4). This pattern highlights *Saurida tumbil* as the most contaminated species overall for multiple high-toxicity OCPs, with *Cynoglossus arel* and *Johnieops sina* showing record levels for select other compound The differences in organochlorine pesticide (OCP) levels between fish species from the Iraqi coast in the northwest Arabian Gulf can be explained by several environmental and biological factors:such as the Feeding Habits and Trophic Level,Fish species higher in the food chain tend to accumulate more OCPs due to biomagnification. Predatory species like *Saurida tumbil* and *Epinephelus coioides* showed significantly higher OCP levels than lower trophic species . Species with diets consisting of contaminated prey or benthic organisms may have higher OCP burdens because these compounds accumulate in sediments and bottom-dwelling organisms.Anthor factor Habitat and Environmental Exposure Fish inhabiting or spending more time in polluted estuarine or coastal waters—such as near the Shatt Al-Arab River mouth—are more exposed to contaminated sediments and waterborne pesticides.Species with more sedentary or localized behaviors in polluted areas accumulate higher pesticide concentrations compared to more migratory species. Also Lipid Content in Fish Tissues a,lthough fat content (%FAT) plays a role in storing lipophilic OCPs, the dataset shows no straightforward correlation between fat percentage and total OCP loads, suggesting other factors are more dominant.Nonetheless, fish with higher fat content generally provide more reservoirs for OCP accumulation, though regional contamination and species behavior influence this too. The Metabolic and Physiological Differences Species-specific differences in metabolism, excretion, and detoxification can influence residue levels. Some fish may biotransform or eliminate OCPs more efficiently than others, leading to lower body burdens.The Source and Pathway Variability the presence of specific pesticides such as Lindane, Delta-lindane, and Epoxyheptachlor reflects nearby agricultural runoff and industrial discharges. Atmospheric deposition can also contribute pesticide loads unevenly depending on local climatic conditions and proximity to human activities. The Bioaccumulation vs. Bioconcentration uptake (bioconcentration) versus dietary uptake (bioaccumulation) paths vary by species and habitat, leading to differing OCP concentrations. Role of Fish Diet in OCP Levels. theBiomagnification Through Food Chain that Fish species that are higher in the food chain (predators) tend to accumulate greater concentrations of OCPs due to biomagnification. This process means that OCPs become more concentrated as they move up trophic levels because predators consume multiple contaminated prey.For example, *Saurida tumbil* and *Epinephelus coioides,* both predatory species, showed the highest OCP pesticide burdens in the dataset.(table 4). Although lipid content can influence pesticide storage, diet-driven bioaccumulation appears to be a stronger determinant in this region. Species like *Saurida tumbil* with relatively low fat content still show high pesticide levels, highlighting diet and trophic position as dominant factors.The Detailed Explanation of Organochlorine Pesticide Sources in Iraqi Marine Fishes. Many organochlorine pesticides detected, such as Lindane (and its isomers alpha- and delta-lindane), Endrin, and Endosulfan are known legacy pesticides. These compounds were widely used in Iraq and neighboring regions for agricultural pest control and against disease vectors like mosquitoes. Despite bans or restrictions imposed decades ago, their chemical stability allows residues to persist in soils, sediments, and water bodies, leading to bioaccumulation in fish species (Tanabe, 1988; Jabeen et al., 2016). Agricultural Runoff and Riverine Inputs:The Shatt al-Arab river system and other smaller tributaries discharge into the northwest Arabian Gulf, supplying agricultural runoff that carries pesticide residues into the coastal marine environment. This is particularly relevant as the river basin covers regions with intensive farming activities. The runoff serves as a continuous source of OCPs, explaining their presence in fish sampled near the Iraqi coast (Al-Shami et al., 2018; Li et al., 2013). Industrial and Oil-Related Pollution:The Arabian Gulf is a major hub for oil production, shipping, and industrial activities. These operations contribute to chemical pollution through direct discharges, accidental spills, and atmospheric deposition. Some OCP residues may originate from industrial contamination or may be remobilized from sediments disturbed by dredging and shipping activities (Gissi et al., 2013; Al-Othman et al., 2014). Sediment-Bound Contamination and Benthic Food Web Transfer:Fish species such as *Saurida tumbil* and *Johnieops sina*, which showed significantly elevated OCP levels (26.13 and 6.43 mg/kg total pesticide respectively), are bottom dwellers or demersal feeders. These species interact with sediments and benthic organisms where OCPs tend to accumulate due to their hydrophobic nature. This direct sediment contact and feeding on contaminated benthic prey enhance bioaccumulation and trophic transfer of OCPs through the marine food web (Paez-Osuna, 2001). Bioaccumulation Linked to Lipid Content:OCPs are lipophilic and tend to accumulate in fatty tissues. Data shows species with higher fat percentages (*Cynoglossus arel* with 19.84% fat and *Acanthopagrus latus* with 16.54%) have higher pesticide load, supporting the concept of fat-mediated bioaccumulation. However, *Saurida tumbil* exceptions suggest feeding habits and habitat may play an even more critical role in bioaccumulation than lipid content alone (Burger & Gochfeld, 2005). Possible Ongoing Illegal Usage and Atmospheric Deposition: Despite formal bans, illegal or unregulated pesticide applications may still occur, especially where enforcement is limited. In addition, atmospheric transport and deposition can reintroduce persistent pesticides to the marine environment from other regions, explaining widespread low-level contamination even in less impacted areas (Ekoue et al., 2011).

Table (5)Comparative Study of OCP Levels in Fish from the Iraqi Coast and Adjacent Arabian Gulf Regions

Reference	Location	Fish Species	OCP Levels (mg/kg or µg/kg)	Key Findings
Douabul et al. (1987)	NW Arabian Gulf (Iraq)	13 commercial species	ZDDT: 2 to 11, Endrin: ND to 45, Dieldrin: ND to 5	Correlation with lipid content; DDT and Endrin common
DouAbul et al. (1988)	Kuwaiti Waters	Various fish, shrimp	p,p'-DDE: 0.59 to 3.8	Residues detected in shellfish and fish
Qari et al. (1997)	Eastern Red Sea, Saudi Arabia	Commercial fish	0.05 – 2.0	Mainly DDT derivatives prevalent
Al-Majed & Preston (2000)	Saudi Arabian Gulf coast	Various fish	0.1 – 1.5	Lindane and Dieldrin detected at low levels
Al-Shahristani et al. (2005)	Northern Gulf (Iraq & Iran)	Predatory fish	2.0 – 15.0	Elevated levels
Al-Salem & Al-Kebsi (2010)	Red Sea & Gulf of Aden (Yemen)	Various commercial fish	Low levels	First regional data
Al-Mughairi et al. (2010)	Oman coast	Various fish	0.2 – 5.0	Heptachlor, Endosulfan present
El-Agamy & Shaker (2021)	Edko Lake, Egypt	Nile Tilapia	Dieldrin: 0.21 - 1.41, DDT: 0.43 - 0.97	Health risks noted
Hassan & El-Naggar (2024)	Fish markets in Egypt	Tilapia, Catfish, Mullet	15%–80% samples positive	Permissible concentrations
Present Study (2025)	Iraqi Coast (NW Arabian Gulf)	Saurida tumbil, Johnieops sina	Up to 26.13	Highest in Saurida tumbil; Lindane, Epoxyheptachlor, Aldrine

The Iraqi coast fish, particularly *Saurida tumbil*, show higher OCP concentrations (up to 26.13 mg/kg) compared to many neighboring regions (Table 5) highlighting intense localized contamination possibly due to proximity to the Shatt Al-Arab river discharge and intensive agricultural/industrial activities .Studies from Saudi Arabia (Al-Majed and Preston, 2000; Qari et al., 1997) generally report lower OCP residues which may reflect differences in pollution sources and environmental regulations.Research from Oman and other parts of the Arabian Gulf (Al-Mughairi et al., 2010; Al-Shahristani et al., 2005) indicates variable contamination, but the Iraqi coast data suggest it is one of the more heavily impacted zones with respect to certain OCP compounds. Dominance of Lindane, DDT derivatives, and Heptachlor is a consistent feature across the region, reflecting similar pesticide usage patterns historically

Countries with stricter pesticide regulations and enforcement, including bans or phased-out usage of persistent OCPs, generally report lower OCP residues in marine biota. For example, Saudi Arabia and Oman have implemented environmental regulations aimed at controlling and reducing OCP usage, which aligns with their lower pesticide residues reported in fish (Al-Majed and Preston, 2000; Al-Mughairi et al., 2010). In contrast, the Iraqi coast, near the Shatt Al-Arab river with intense agricultural and industrial activity, may have less stringent enforcement or legacy contamination from historic pesticide use, contributing to the higher levels of OCPs (up to 26.13 mg/kg in Saurida tumbil).

conclusion

This study highlights the widespread presence and significant species-specific variation of persistent organochlorine pesticides (OCPs) in commercially important marine fishes from the northwest Arabian Gulf along the Iraqi coast. The highest contamination levels were detected in bottom-dwelling and demersal species such as *Saurida tumbil*, with total pesticide residues exceeding 26 mg/kg wet weight, underscoring the critical role of sediment-associated pathways in bioaccumulation. While lipid content contributes to pesticide accumulation, species ecology—particularly feeding habits and habitat preferences—proved to be a decisive factor influencing residue burdens.The persistence of legacy pesticides, including various lindane isomers and endrin compounds, decades after regulatory bans, points to ongoing environmental exposure via agricultural runoff from the Shatt al-Arab river basin, industrial activities, and sediment remobilization. These findings raise substantial ecological concerns regarding bioaccumulation and biomagnification within the marine food web, and potential human health risks through consumption of contaminated fish species.

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