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A comparative study of the effect of pesticides used in agriculture on tilapia fish in some Nile Delta governorates (Damietta branch and Rasheed branch)

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Abstract:

Considering pesticides are poisonous, both the environment and people may suffer from them. Pesticide-filled wastewater from agriculture is carried by the Delta region and has the potential to contaminate the environment and water quality, danger to human health, the water & fish samples were gathered from four governorates in the Delta area (Beheira, Kafr El-Sheikh, Sharkia, and Ismailia), Egypt. The outcomes showed that endosulfan, heptachlor & aldrin were detected in the four governorates. However, dicofol and p,p′-DDT were detected in Beheira and Kafr El-Sheikh. Chlorpyrifos was detected in Sharkia and Ismailia. The diazinon was undetected in Kafr El-Sheikh.

The estimated daily intake (EDI) in fish tilapia collected from 4 governorates was not over the PDI. In conclusion, the Target Hazard Quotient (THQ) was confirmed in four governorates with a mean score of less than one, according to the results. The exposed population is not clearly in danger for health when the THQ is less than 1. Three governorates' equivalent of Nile tilapia harvested from the Nile River does not have a hazard index (HI). When a hazard index (HI) in the Beheira governorate is higher than one, it indicates a potential risk to human health since eating contaminated fish may cause permanent pesticides to accumulate in the human body

Keywords: Pesticides, Tilapia fish, Nile Delta governorates.

Introduction

Many pesticides are employed in agriculture, either directly or indirectly. The toxicants' byproducts find their way into water bodies and have detrimental effects on the ecosystem (1). The effects of Pesticides that have accumulated and their byproducts on water drains, and organisms — particularly fish—have been the subject of numerous researches (2). Pesticide-related water pollution poses a health risk to people because accumulated derivatives may enter the body through water or fish that is consumed.

Because of their lengthy persistence, high ability for bioaccumulation, and long-range transport, pesticides are well-known for their hazardous effects on both individuals and the environment. Pesticides including organochlorine & organophosphorus are widely employed in agriculture; however, their derivatives have the potential to seriously contaminate water sources. (3).

The kinds and amounts of insecticides used around the world fluctuate substantially. As a result, numerous international organizations, including the European Union (EU), WHO/FAO, Codex

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Alimentarius Commission (CAC), and others have established their maximum residual limits (MRLs) for pesticides intended for use in international commerce (4).

Pesticides seep into aquatic environments through various methods, including agriculture, factories, and spraying. Since water sources are the home of fish and other aquatic species, their contamination is a major cause for concern. Over time, pesticides bioaccumulate in the tissue of aquatic species (2). Therefore, consuming fish exposes people to the majority of environmental contaminants. (5, 6). Besides this, chemicals including organochlorine & organophosphorus are well-known for their harmful effects on humans and the environment because of their extended persistence, strong potential for bioaccumulation, and extended-range transportation (7).

In Egypt, The most common freshwater species is tilapia fish. A larger proportion of people consume a lot of tilapia since it is inexpensive and readily available in most areas (8, 9).

Tilapia fish is a source of high-quality, low-fat protein and a good supply of fatty acids, omega-3 fatty acids, and vitamins B2 and D (riboflavin). Phosphorus and calcium are abundant in fish. Iron, zinc, iodine, magnesium, and potassium are all abundant in fish. As part of a balanced diet, the American Heart Association suggests consuming fish at least twice a week because it has elements that lower blood pressure and lower the chance of a heart attack (10).

Because fish have a limited ability to metabolize accumulated pesticides, they are used as bioindicators when there is high contamination in water bodies. Through its gills, skin, and intestines, fish can absorb pesticides and toxicants (11).

Furthermore, there may be a risk to human health from the sediments and certain fish species, including Nile tilapia, which are rich in derivatives of organochlorine & organophosphorus (12).

Aim of study:

The current study's goal was to find out how much of various pesticide residues were found in tilapia fish samples, in four governorates in the Delta area (Beheira, Kafr El-Sheikh, Sharkia, and Ismailia) which gathers water from the industrial and agricultural domains. This is well-known for its fishing and farming activities.

Material and methods:

Sampling

The sampling locations are located in **Beheira, Kafr El-Sheikh, Sharkia, and Ismailia**, four governorates in the Delta region where agricultural activities. Forty Nile tilapia (Oreochromis niloticus) in total, obtained from the four preceding Egyptian cities, were included in the study. We investigated the fish to find and measure the presence of many pesticides. Individual fish weigh 200 ± 50 g on average. The fish samples were promptly brought to the laboratory in an ice chest filled with ice, where they were refrigerated for two days at -4 °C in preparation for extraction & analysis. After obtaining the samples, they were put in pristine glass containers with wide mouths and covered right away. The mean levels of pesticide residues, expressed as concentrations ± SD were determined in the muscle of tilapia from several city locations in the Delta.

Sample extraction

A centrifuge tube was filled with 10 grams of minced fish sample and three milliliters of water. The mixture was vortexed for one minute. After adding a 20 mL volume of acetonitrile, the liquid was vortexed for fifteen minutes. After adding 5 g of sodium chloride to the mixture, centrifuging for 5 minutes at 4000 rpm and vortexing for an additional 2 minutes was performed. A 100 mL flask containing 10 mL of the extraction solution was placed in the freezer for 20 minutes at −24 °C. To get rid of the frozen lipids, cold extracts at -24 °C were promptly filtered through filter paper. Rotating

evaporation was used to concentrate the filtered extract to 1 mL (13).

GC analysis

Using an Agilent 7890 gas chromatographic system with a 5975-insertion source mass detection system (Agilent Technologies, USA), a single microliter of extract was injected in the pulsed splitless mode. A J & W Scientific, DB-1701 capillary column was used for analysis. The injection temperature was 260 ºC, the oven temperature ranged from 150 to 270 ºC, and the detector temperature was 230 ºC during the experiment. Helium was the carrier gas, flowing at a rate of 1 milliliter per minute. Through comparison of sample peak relative retention times with standard values, pesticide residues were found. The area of the reference peak and the equivalent peak in the sample were compared and quantified (14).

Water samples and analysis

To eliminate suspended contaminants, the gathered water samples were passed through man 0.45 µm filter mesh filters. 500 mL sterile containers were used to store the water samples that were collected. Samples were placed in dark glass vials for GC analysis. Analysis was done on water samples. Pesticides were extracted from the water samples using Edgell and Wesselman's (14). extraction procedure for aqueous matrix, which allowed for the analysis of both non-volatile and semi-volatile organic chemicals.

Assessment of human risk

Estimate Daily Intake (EDI) and Estimate Weekly Intake (EWI)

The two equations below were used to assess the **Estimate Daily Intake (EDI)** and **Estimate Weekly Intake (EWI)** of pesticides by fish consumption: (15)

$$EDI = \frac{CM * IR}{BW}$$

$$EWI = EDI * 7$$

The target Hazard Quotient (THQ)

-Evaluation of human risk **The Target Hazard Quotient (THQ),** which was computed using the following equation, was used to quantify the possible non-carcinogenic health concerns connected with the ingestion of Nile tilapia containing contaminants: (15,16)

$$THQ = \left(\frac{(EF * ED * IR * C)}{(RFD * BW * AT)}\right) * 10^{-3}$$

When THQ <1 no risk but when THQ ≥ 1 there is a risk

The Hazard Index (HI)

The Hazard Index (HI) has been performed to assess the probable human health hazard of organochlorine and organophosphorus compounds. The HI refers to the sum of all THQ for various organochlorine & organophosphorus compound exposures as shown in the equation below: (17)

$$HI = \Sigma TTHQs$$

When HI >1 that means possible health risk

Ethical approval

This study received ethical approval from the Faculty of Science, Damanhour University, Egypt **(2-5-2024)**

Results

The Organochlorine & organophosphorus compounds found in water samples

From the four Delta governorates water samples for this investigation **Table** 2 the result shows that in the **Beheira** governorate Heptachlor, Dicofol, p,p′-DDT, Aldrin, and Chlorpyrifos were not detected However, the levels of endosulfan were 42.93±5.16 ppb and the levels of Diazinon were 25.26± 6 ppb. In **Kafr El-Sheikh** governorate Heptachlor, Dicofol, Aldrin, Chlorpyrifos and Diazinon were not

detected, However, the levels of endosulfan were 42.16± 3.42 ppb and the levels of p,p′-DDT were 20.46±1.60 ppb .in **Sharkia** governorate all Organochlorine & organophosphorus compounds were not detected except Aldrin was15.26±4.17ppb, also in **Ismailia** governorate all Organochlorine & organophosphorus compounds were not detected except Heptachlor was 11.40 ±**2.09** ppb**.**

Table 1. In this study, fish species weight and length were measured; values (±SD)

	Nile tilapia (mean ±SD)	
Beheira	***Weight (g)***	**176 86 ± 25.13**
	Length (cm)	**20.33 ±2.02**
Kafr El-Sheikh	***Weight (g)***	**198.50 ± 7.85**
	Length (cm)	**19.7 ±1.41**
Sharkia	***Weight (g)***	**193 .16 ±11.40**
	Length (cm)	**19.96 ±1.55**
Ismailia	***Weight (g)***	**223 .76 ±31.96**
	Length (cm)	**20.13 ±1.76**

Table 2. The pesticides organochlorine & pesticides organophosphorus in the water sample (ppb) in four governorates (n=3), ND Not found.

fish	**governorates**	Endosulfan	Heptachlor	Dicofol	p,p′-DDT	Aldrin	Chlorpyrifos	Diazinon
	Beheira	**42.93 ± 5.16**	**ND**	**ND**	**ND**	**ND**	**ND**	**25.26 ±6**
	Kafr El-Sheikh	**42.16 ± 3.42**	**ND**	**ND**	**20.46 ±1.60**	**ND**	**ND**	**ND**
	Sharkia	**ND**	**ND**	**ND**	**ND**	**15.26 ±4.17**	**ND**	**ND**
	Ismailia	**ND**	**11.40 ± 2.09**	**ND**	**ND**	**ND**	**ND**	**ND**

The Organochlorine &the organophosphorus compounds in muscles

Pesticide residues were found in the Nile tilapia muscle samples that were tested, as indicated in **Table 3** the levels of endosulfan-detected pesticides in fish muscle samples showed that Beheira governorate has the highest pesticide mean concentrations (42.86 ±5.26 ppb), followed by Kafr El-Sheikh (40.93 ±3 ppb) then Sharkia (16.93 ±1.10 ppb) and Ismailia (14 ±0.8 ppb). The levels of Heptachlor pesticides in Beheira were 22.5 ±4.86 ppb), in Kafr El-Sheikh (20.6 ±2.53 ppb), in Sharkia (8.06 ±1.15 ppb) and Ismailia (8.07 ±1.1 ppb). The Dicofol pesticides in fish muscle samples showed that Kafr El-Sheikh governorate has the highest pesticide mean concentrations (24.6 ± 4.47 ppb) then Beheira governorate (24.43 ±2.33 ppb), in Sharkia and Ismailia governorates the Dicofol was not detected. The p,p′-DDT level was higher in Kafr El-Sheikh governorate (17.8 ±1.49 ppb) than Beheira governorate (16.13 ±3.16 ppb) in Sharkia and Ismailia governorates the p,p′-DDT was not detected. The Aldrin level was higher in Beheira governorate (57.33 ±5.15 ppb) than in Ismailia (12.63 ± 3.02 ppb), Kafr El-Sheikh (12.47 ±1.51 ppb) and Sharkia (12.26 ±1.65 ppb). Both Beheira and Kafr El-Sheikh governorates recorded free Chlorpyrifos pesticide. Sharkia Sheikh Governorate has the highest pesticide mean concentrations (10.36 ±1.05 ppb) than Ismailia (9.7 ±1.96 ppb). Diazinon was not detected in Kafr El-Sheikh, in Beheira level of diazinon was (17.9 ±2.23 ppb), Sharkia (16.46 ±3.27 ppb), and Ismailia (16.13 ±2.37 ppb).

Table 3. The pesticides organochlorine & the pesticides organophosphorus in the muscle of tilapia (ppb) in four governorates (n=3), ND Not found.

fish	governorates	Endosulfan	Heptachlor	Dicofol	p,p′-DDT	Aldrin	Chlorpyrifos	Diazinon	Total
	Beheira	**42.86 ±5.26**	**22.5 ±4.86**	**24.43 ±2.33**	**16.13 ±3.16**	**57.33 ±5.15**	**ND**	**17.9 ±2.23**	**181.15**
	Kafr El-Sheikh	**40.93 ±3**	**20.6 ±2.53**	**24.6 ± 4.47**	**17.8 ±1.49**	**12.47 ±1.51**	**ND**	**ND**	**116.4**
	Sharkia	**16.93 ±1.10**	**8.06 ±1.15**	**ND**	**ND**	**12.26 ±1.65**	**10.36 ±1.05**	**16.46 ±3.27**	**64.07**
	Ismailia	**14 ±0.8**	**8.07 ±1.1**	**ND**	**ND**	**12.63 ± 3.02**	**9.7 ±1.96**	**16.13 ±2.37**	**60.53**
Permitted levels	***FAO***	***100-200***	***200***	*-*	***500***	***200***	***1000***	***200***	*-*
	USFDA	*-*	***300***	*-*	***300***	***300***	*-*	*-*	*-*
	CFIA	*-*	***5***	*-*	***5000***	***100***	*-*	***500***	*-*
	FSANZ	*-*	***5***	*-*	***1000***	***100***	*-*	***500***	*-*

Estimated organochlorine & organophosphorus pesticides daily intake (µg/kg BW/day)**:**

As per the information presented in Table 4, the EDI endosulfan (0.038) in Beheira, (0.036) in Kafr El-Sheikh, (0.015) in Sharkia, and (0.012) in Ismailia. The EDI of heptachlor (0.020) in Beheira, (0.018) in Kafr El-Sheikh, (0.007) in Sharkia and Ismailia. The EDI of dicofol (0.021) in Beheira and Kafr El-Sheikh. The EDI of p,p′-DDT (0.014) in Beheira, (0.015) in Kafr El-Sheikh. The EDI of Aldrin (0.050) in Beheira, (0.011) in both Kafr El-Sheikh, and Ismailia, and (0.010) in Sharkia. The EDI of chlorpyrifos (0.009) in Sharkia and (0.008) in Ismailia. The EDI of diazinon (0.015) in Beheira, (0.014) in both Sharkia and Ismailia.

Target hazard quotient (THQ):

The potential health risk associated with pesticides is indicated by the target hazard quotients (THQ) values; a value greater than one indicates a health risk. For all identified organochlorine and organophosphorus chemicals, the THQ for Nile tilapia collected from four governorates in the Delta area was less than one in our investigation (Table 5). Furthermore, in three governorates (Kafr El-Sheikh, Sharkia, and Ismailia), the hazard index (HI) for all the organochlorine and the organophosphorus chemicals in tilapia was less than one. The Beheira governorate has many records on the Hazard Index (HI), indicating a potential health risk associated with pesticide use.

Table 4. EDI of pesticides (µg/kg BW/day) on adult humans (70 kg) of tilapia from 4 governorates. Permissible daily intake, as per Codex Alimentarius, is PDI (1) (µg/kg bwt). According to the FDA's tolerance or critical limit for fish intake by humans, the PDI (2)

fish	**governorate**	Endosulfan	Heptachlor	Dicofol	p,p′-DDT	Aldrin	Chlorpyrifos	Diazinon
	Beheira	**0.038**	**0.020**	**0.021**	**0.014**	**0.050**	**0**	**0.015**
	Kafr El-Sheikh	**0.036**	**0.018**	**0.021**	**0.015**	**0.011**	**0**	**0**
	Sharkia	**0.015**	**0.007**	**0**	**0**	**0.010**	**0.009**	**0.014**
	Ismailia	**0.012**	**0.007**	**0**	**0**	**0.011**	**0.008**	**0.014**
Permitted levels	*PDI (1)*	***6***	***0.1***		***100***	***0.1***		
	PDI (2)		***300***			***300***		

Table 5. THQ & HI for pesticides found in Nile tilapia from 4 governorates.

fish	governorates	Target Hazard Quotient (THQ)							Human risk	$HI = \Sigma THQs$	Human risk
		Endosulfan	**Heptachlor**	**Dicofol**	**p,p′-DDT**	**Aldrin**	**Chlorpyrifos**	**Diazinon**			
	Beheira	**0.04**	**0.27**	**0.38**	**0.2**	**0.36**	**0**	**0.05**	**N0**	**1.3**	**YES**
	Kafr El-Sheikh	**0.04**	**0.25**	**0.38**	**0.21**	**0.07**	**0**	**0**	**N0**	**0.95**	**N0**
	Sharkia	**0.02**	**0.1**	**0**	**0**	**0.07**	**0.03**	**0.04**	**N0**	**0.26**	**N0**
	Ismailia	**0.01**	**0.1**	**0**	**0**	**0.07**	**0.0.2**	**0.04**	**N0**	**0.24**	**N0**

Discussion:

The Organochlorine & organophosphorus found in water samples

The results of the water sample are similar to those reported by Shalaby *et al*. (18), who found that the water samples taken from the Nile River across the four seasons included levels of endosulfan, heptachlor, dicofol, p,p′-DDT, and chlorpyrifos. As per the European Water Framework Directive (WFD, 2000/60/EC) (20), the pesticide levels found in this investigation do not pose a significant risk to human health. The effluents of industrial and agricultural wastes as well as untreated sewage water are some of the variables that impact the drainage water in large drains (20). Pesticides and insecticides are present in the drainage that is received from many agricultural drains (21). Pesticides with organochlorine & organophosphorus bases are widely employed in agriculture, but their derivatives have the potential to seriously harm water sources by contaminating them (22). Pesticides are used in agriculture, where water runoff may have an impact on the dilution of chemicals including organochlorine & organophosphorus (23). Rainfall events do have a significant impact on soil erosion and the amount of suspended derivatives, such as organochlorine & organophosphorus chemicals (24). Because of this, there is a low level of organochlorine & organophosphorus compounds in the water and fish samples throughout the summer due to the high feeding rate of the water (18).

The Organochlorine &the organophosphorus compounds in muscles

Shalaby *et al*. (18) reported that pesticides were also found in tilapia that were taken from the Nile River in Cairo, Egypt, throughout 4 seasons, which is consistent with the findings of the current investigation. When it occurred to Nile tilapia, Beheira had the highest amounts of pesticides discovered overall (181.15 ppb), followed by Kafr El-Sheikh (116.4 ppb), Sharkia (64.07 ppb), and Ismailia (60.53 ppb). According to FAO (25) and USFDA (26), Aldrin and Endosulfan had greater pesticide levels (57.33 ppb and 42.86 ppb), respectively, which are within allowed limits. Despite their widespread usage in agriculture, their high cumulative levels affect fish endocrine systems, impairing their growth and development.

The observed level of heptachlor is over the allowed amounts as reported by the CFIA (27) and FSANZ (28), however, it is within the allowed values as reported by the FAO (25) and USFDA (26). According to FAO (25), USFDA (26), CFIA (27), and FSANZ (28), the discovered p,p′-DDT is within the permitted limits. Chlorpyrifos, which the FAO (25) considers to be at a safe level, and diazinon, which the FAO (25), CFIA (27), and FSANZ (28) all consider to be safe. It is noteworthy that Nile tilapia have been found to contain the greatest concentrations of organochlorine & organophosphorus chemicals. This may be due to these chemicals' high lipophilicity and hydrophobicity as well as their propensity to be retained in the organic phases of organisms. Similar findings were reported by Shalaby *et al*. (18) concerning pesticide residues in tilapia that were taken from the Nile River in Cairo, Egypt. The excessive accumulation of organochlorine and organophosphorus chemicals from pesticide-polluted water might potentially affect multiple types of fish. Because fish are abundant in fat content, soluble lipids like organochlorine & organophosphorus chemicals may assemble in fish tissue that is edible, greatly harming the fish population.

Estimated organochlorine & organophosphorus pesticides daily intake:

Pesticide accumulating in fish impacts the food chain by way of everyday consumption (29). For this reason, the EDI of pesticides in tilapia was assessed in this study. To compare with EDI and estimate the potential harm to humans, a number of organizations publish the permitted daily intake (PDI) of pesticides

in fish (30 & 31). The findings also show that the PDI (µg/kg bwt) according to CAC (30) and FDA (31) is higher than the EDI in tilapia gathered from four governorates in the Delta area. Additionally, the findings align with those of Barakat *et al.* (32) and Shalaby *et al*. (18), who reported that the EDI of tilapia that were taken from Cairo's Lake Qarun & Nile River did not exceed the PDI.

Target hazard quotient (THQ):

In this investigation, the (THQ) of Nile tilapia for every identified organochlorine and organophosphorus chemical was less than one. Furthermore, all organochlorine & organophosphorus chemicals in Nile tilapia, with the exception of Beheira governorate, had hazard indexes (HI) of less than one .The findings are consistent with those of Shalaby *et al.* (18), Barakat *et al*. (32), and Abbassy *et al.* (33), who reported that fish taken from the Nile in Cairo, lake Qarun, & Edko lake, respectively, showed no indications of pesticide toxicity. Health complications often result from long-term pesticide buildup in human body tissues brought on by eating contaminated fish.

Conclusion

The findings showed that four governorates in the Delta region of Egypt (Beheira, Kafr El-Sheikh, Sharkia, and Ismailia) have been found to have endosulfan, heptachlor, dicofol, p,p′-DDT, aldrin, chlorpyrifos, and diazinon. It is noteworthy that the Nile has been found to contain high concentrations of organochlorine and organophosphorus chemicals. All identified organochlorine and organophosphorus chemicals had estimated daily intakes that were lower than the Nile tilapia recommended daily intake. Additionally, the findings verified that there is no risk index for eating Nile tilapia that was gathered from every governorate save Beheira. Future research is advised to validate the findings, nevertheless, by taking into account the inclusion of other sample locations throughout the Delta region.

Conflict of Interest

The authors declare that they have no conflict of interest.

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