Spatial Distribution of Some Hydrocarbons in Tilapia Zilli's Tissues & Water from Lake Temsah

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Abstract

The purpose of this study is to determine the amounts of the various polycyclic aromatic hydrocarbons (PAHs) in Lake Temsah, Ismailia governorate, Egypt, 63 *Tilapia zillii* fish and 63 water samples that were seasonally and randomly obtained from various locations throughout the lake were examined in the study. According to our findings, 16 different kinds of poly cyclic aromatic hydrocarbons (PAHs) were found in both the fish tissues (Musculature and liver) and the water samples. The most prevalent PAHs in the water samples was determined to be pyrene, whereas the least abundant PAHs in the fish muscle was found to be benzo (ghi). According to Liver, Acenaphthylene hydrocarbon was the lowest and Pyrene was the highest. *Tilapia zillii* fish liver had the higher overall mean amounts of carcinogenic PAHs than that in fish tissues and water samples.

Key words: *Tilapia zillii* fish, Polycyclic aromatic hydrocarbon (PAHs), water samples, fish tissues, pollution, carcinogenic.

Introduction

Oil pollution is a major global environmental problem that negatively impacts tourism, ecosystems, human health, fisheries, aquaculture, and eventually the GDP of the nation, this is why the focus of increasing public, governmental concern related to scientific issues has been and remains the contamination of water by petroleum hydro carbons. Poly cyclic aromatic hydrocarbons, or PAHs, are toxic, hydrophobic, persistent, continuous, and bio-accumulative substances that are detrimental to the aquatic environment. According to ***Qin et***

al. (2013), seven out of the sixteen PAHs that the US EPA has designated as priority pollutants are carcinogenic, PAHs have an impact on the regional food webs when they enter the aquatic system and are absorbed into suspended and fine-grained sediments ***(Wetzel and Van Vleet, 2004)***, Aliphatic hydrocarbons and polycyclic aromatic hydrocarbons (PAHs) they are mainly produced through three primary processes: the incomplete combustion of organic materials, the petrogenic processes at very low temperature and high pressure over known geologic time periods; and biogenic emissions from waxes, bacteria, marine phytoplankton, and terrestrial plant terpenes ***(Asia et al., 2014, & Maioli et al., 2010)***. Components of polycyclic aromatic hydrocarbons (PAHs) are the prominent class of chemical carcinogens present in the marine environment. PA Hs are incredibly poisonous, mutagenic, and carcinogenic to humans and other living creatures ***(Abdel- Shafy and Mansour, 2016).*** The 15 km^2 Temsah Lake, which is entirely surrounded by land, is one of the aquatic basins to the north of the Suez Canal. The city of Ismailia is next to the lake. The fishing and tourism businesses that this lake supports provide jobs for many locals and make a substantial financial contribution to the district. It is the main wet dock for the city and a minor port Which supports a few aquatic activities, Providing the maintenance of the Authority of Suez Canal and its associated marine operations. Temsah Lake, an embayment covering 15 km^2, is one of the aquatic basins located north of the Suez Canal that has been fully submerged under land. The lake is bordered by the city of Ismailia. Jobs in tourism and fishing are available in this lake ***(Tundo et al., 2005)*** Consequently, a range of petroleum aromatic and aliphatic hydrocarbons from water ballasting, maintenance, and maritime operations into the nearby docks have contaminated this lake ***(Tundo et al., 2005)*** The local government authorities have expressed concern over Lake Temsah's contamination levels in recent years due to a significant decrease in the lake's biodiversity and the quality of fish that is fished from it. Information regarding the amounts, kinds, and characteristics of petroleum hydrocarbon pollution in Temsah Lake's water, sediments, and fish is lacking. In light of this, the goal of the current study is for the detection of the concentrations and the distribution of petroleum hydrocarbons from this aquatic environment in order to compile current, relevant data that will be utilized for environmental management, protection, and conservation initiatives in the future.

Materials and methods

1. Sample site:

The seven sampling locations were situated at Family Beach (30.58'N, 32.27'E), approximately 300 meters from the lake's edge. The remaining six locations were spaced out by 700 meters, bringing the total length of the lake to 4.2 km. The physical characteristics of the water and the local economy played a role in the selection of these locations

2. Fishes:

Along with collecting water samples from Temsah Lake, 63 *Tilapia zillii* fish were gathered from the seven sites under study. The fish's body weights and lengths were also measured. The fish was gathered and sent straight away to the lab of (Department of Fish Disease and Management, Faculty of Veterinary Medicine, in Suez Canal University) in polyethylene bags that held 1/3 of its volume water containing fish and the rest is air. To get rid of salts, fish were promptly cleaned with distilled water then covered in sterile aluminum foil and kept frozen at -20°C until time of the analysis procedure.

3. Water:

63 samples in all were gathered from seven distinct locations. In order to prevent photochemical degradation, they were collected from a depth of 50 cm into a 2.0 L sterile amber glass bottle with a Teflon lined top. Nine grabs were gathered from each site and placed into wide-mouth glass bottles that have been cleaned beforehand. Seven composite samples were then created by combining the equal volumes of each nine grabs/site, frozen, and brought to the laboratory where they were kept at the temperature of -20°C until the analysis is completed. In order to ensure that the samples were typical of the area they were gathered from, the boat was relocated every 100 meters in between grabs. The samples were meticulously taken by hand (while wearing gloves) and placed into sampling vials by pressing them beneath the water's surface.

4. Experiment:

A- Poly cyclic aromatic hydrocarbons (PAHs) quantification

- **in water:**

With the rotary evaporator operating at low pressure, one liter of water was added to a two-liter glass separatory funnel. The mixture was then extracted twice using 80 milliliters of methylene chloride and dried at 30 degrees Celsius ***(Moustafa et al., 2018)***

- **In fish:**

A Soxhlet apparatus was used to extract one gram of tissue and liver samples. The sampler was then put into a thimble filter and extracted with 150 milliliters of n-hexane for eight hours at a rate of four to six cycles per hour. Next, with the rotary evaporator, the extract of the sample was pre-concentrated to 2-3 ml. Sulfur compounds were eliminated from the extract using activated copper powder ***(Middleditch et al., 1977)***

B- Gas–Liquid Chromatographic determination of PAHs in fish tissues & water

The gasses chromatograph (Hewlett Packard 5890 series II apparatus) was equipped with a non-polar, 100% dimethyl polysiloxane-coated Ultra-1 capillary column, which measuring 25 m in length, 0.2 mm in diameter, and 0.5 µm in thickness. The carrier gas, nitrogen, had a flow rate of 4 milliliters per minute. One µl of the examined sample the finished water or fish tissue extract was injected. The rate at which the temperature was programmed was 80 º C /min, starting at 50 º C and ending at 290 º C. A set of standard PAHs mixtures, each dissolved in n-Hexane at a concentration of 10 ppm, served as the blank for the GC analysis. The rate at which the temperature was programmed was 80 º C /min, starting at 50 º C and ending at 290 º C. A collection of was the blank utilized in the GC analysis.

3. Statistical analysis:

The data was processed with the program one-way analysis of variance (ANOVA) test and the Pearson correlation test using the PSS version 22 of computer software program version 16, NY, USA (Inc., 1989-2013). PAHs chemicals were analyzed using statistical analysis from several sources in different parts of Temsah Lake. Using hierarchical agglomerative cluster analysis, the natural grouping of PAHs was identified. Ward's Method was then applied to select a four-cluster solution with squared Euclidian distances and standard deviation< 1. The data classifications were shown using a dendrogram.

Results:

Water quality parameters and Poly cyclic aromatic hydrocarbons (PAHs) from the collected water samples: Obtained data recorded in **Table 1** showed that there was a significant variation among the collected water samples (pH, TDS and temperature) at different sites with average mean of 7.428±0.068; 3.216±0.460 and 20.736±0.853, respectively.

The Total & individual results of the concentrations of PAHs of water samples, & the characteristic ratios for the identification of PAHs origins are shown in **Table2.** Total PAHs concentrations in water samples were significantly variant ($P \leq 0.01$) among the studied locations. The mean values ranging from (11.331±0.019 to 1518.129±2.7661 ng/l), with an average overall mean of 469.869±118.995 ng/ l. The highest concentration of the total PAHs is found in the water taken from site 2 following that in site 1, and site 7. Low concentrations were detected in sites 4 and 6 respectively.

The obtained results showed that Pyrene was the highest PAHs in water samples followed by Chrysene :Pyrene> Chrysene> Fluoranthene>
Benzo(k)fluoranthene> Benzo (b)

Fluoranthene> Benzo (a) Anthracene> Indeno (1,2,3-cd)pyrene> Acenaphthene > Dibenzo(a,h)anthracene> Benzo (ghi) perylene> Fluorene> Benzo(a)pyrene> Acenaphthylene> Naphthalin> Anthracene> Phenathrene), While the concentrations in Tilapia zilli tissues were :Benzo (a)Anthracene > Chrysene> Pyrene > Fluoranthene> Benzo(b)Fluoranthene> Dibenzo (a,h) anthracene > Indeno (1,2,3-cd) pyrene> Benzo (k) fluoranthene> Benzo (ghi) perylene> Anthracene> Phenathrene> Benzo (a)pyrene > Fluorene> Acenaphthylene> Naphthalin> Acenaphthylene.

Principal component analysis of (PAHs) in the water samples:

While data submitted for the PCA analysis were arranged in a matrix (**Table 3**), where every column corresponds to one of the components and each row shows the total and individual PAHs with water pH, TDS and temperature. The number of factors extracted from the variables was determined according to Kaiser's rule. The majority of variance was (95.296%) of the scaled data was explained by four eigenvectors / principal component factors (PC). The first principal component factor (PC1) explained 40.59%, the second (PC2) explained 27.256%, the third (PC3) explained 17.562%, and the fourth (PC4) explained 9.889%.

PC1 had a strong significant correlation with Indeno (1,2,3-cd) pyrene (0.958), Dbenzo (a,h) anthracene (0.949), Benzo(b)Fluoranthene (0.884), Benzo(a) Anthracene (0.830), Fluoranthene (0.825), Benzo (ghi) perylene (0.782), and Pyrene (0.749), and moderately with Chrysene (0.609) and Benzo(a)pyrene (0.531). Water pH, TDS and temperature correlated negatively in PC1 with the above-mentioned individual and total PAHs.

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Dendogram using single linkage between different (PAHs) of water samples.

To determine the natural grouping of the PAHs individuals, a hierarchical agglomerative cluster analysis was used. Average linkage between groups (Ward's Method) was used to select a four-cluster solution (with squared Euclidian distances and standard deviation < 1). To visualize the data clusters, dendrogram was generated. Showing a good efficiency for the water samples taken from the lake Temsah sites, which present different sources deposition Four big clusters with subgroups can be found, which agree with the previously examined factor analysis. The first group in the cluster were contained by Naphthalin, Acenaphthylene, Acenaphthene, Fluorene, Phenathrene, Anthracene, Benzo(a)Anthracene, Benzo(b) Fluoranthene, Benzo(k)fluoranthene, Benzo(a)pyrene, Dbenzo (a,h) anthracene, Benzo (ghi) perylene, and Indeno (1,2,3-cd) pyrene. The second group was represented by Fluoranthene and Pyrene. While the third group was represented by BenzoAnthracene and the fourth was represented by Chrysene.

Polycyclic aromatic hydrocarbons (PAHs) in the ***Tilapia zilli*:**

Table 4 show the growth performance parameters of *Tilapia zillii* collected from various locations in Lake Temsah. Site 7 had the greatest significant ($p<0.01$) weight and K factor of the collected fish.

, **Table 5** shows Total PAHs concentrations in fish samples (musculature) varied significantly ($P\leq0.01$) from the examined sites. The mean values from 13.622±0.347 to 1136.268±0.289ng/ g, with an average overall mean of 330.346±86.712 ng/ g (**Table 6**). The highest concentration of the total PAHs is recorded in fish samples collected from site 1 followed by that in site 2, and site 7. Low concentrations were detected in sites 4 and 6 respectively. The results obtained showed that the concentrations in *Tilapia zilli* musculature were: Benzo (a) Anthracene> Chrysene> Pyrene> Fluoranthene> Benzo (b) Fluoranthene> Dibenzo (a,h) anthracene> Indeno (1,2,3-cd) pyrene> Benzo (k) fluoranthene> Benzo (ghi) perylene> Anthracene> Phenathrene> Benzo(a)pyrene> Fluorene> Acenaphthylene> Naphthalin> Acenaphthylene.

A relationship between PAHs concentrations, weight & length of *Tilapia zillii* samples:

To analyze the relationship patterns the correlation coefficient was done. The parameters gave four principal components (PC) showing the total variances of. 93.804 Corresponding, variable loadings & explained variance are found in **Table (6)**. PC1 gave positive loadings (> 0.75) on Phenathrene (0.969); Anthracene (0.965); Fluoranthene (0.964); Pyrene (0.959); Benzo(b) Fluoranthene (0.951); Benzo(k) fluoranthene(0.915) and total PAHs (0.912) and negative loading with fish weight (-0.327).

PAHs concentrations in *Tilapia zilli* liver:

Total PCAHs concentrations in fish samples (liver) varied significantly (P≤0.01) among the studied locations. The mean range of values was from 25.341^{g}±0.063 to 1556.818^{a}±0.651 ng/ g, with the average overall mean of 519.917±113.637 ng / g (**Table 7**). The highest concentration of the total PAHs is found in fish samples collected from site 3 followed by samples in site 1, and site 2. Low concentrations were detected in sites 5 and 6 respectively.

The obtained results showed that the concentrations in *Tilapia zilli* liver, they were the highest in Pyrene followed by Benzo(a) Anthracene: Pyrene > Benzo (a) Anthracene > Chrysene > Fluoranthene > Benzo(k) fluoranthene > Dibenzo (a,h) anthracene > Indeno (1,2,3-cd)pyrene > Benzo (ghi) perylene > Benzo(b) Fluoranthene > Anthracene > Benzo(a) pyrene > Phenathrene > Fluorene > Acenaphthene> Naphthalin > Acenaphthylene.

The relationship between PAHs concentrations in *Tilapia zillii* livers & principal components (PC):

Regarding the relationship between the detected PAHs in *Tilapia zillii* livers, four principal components (PC) was analyzed that gives an explanation to the total variances of 93.307%. PC1 had positive loadings (> 0.75) on Fluorene (0.996); Acenaphthylene (0.995); Fluoranthene (0.992); Acenaphthene (0.990); Benzo(k)fluoranthene(0.990); Phenathrene (0.989); Anthracene (0.986); Benzo(a)Anthracene(0.983); Benzo (b) Fluoranthene (0.971); total PAHs (0.888). The *Tilapia zilli* weight showed moderate loading with the previously mentioned parameters (**Table 7**).

Table (1): pH, TDS and temperature values in the collected water samples

PAH (ng/l.)	S1	S2	S3	S4	S5	S6	S7	Average
Naphthalin	ND	0.109^{c}±0.003	ND	0.069^{e}±0.001	0.168^{b}±0.001	0.092^{d}±0.0001	2.568^{a}±0.008	0.43±0.196
Acenaphthylene	0.110^{d}±0.002	0.155^{c}±0.007	ND	0.083^{e}±0.001	0.503^{b}±0.001	0.116^{d}±0.002	2.532^{a}±0.010	0.500±0.188
Acenaphthene	ND	0.224^{bc}±0.007	0.555^{bc}±0.055	0.073^{c}±0.0001	0.693^{b}±0.006	0.070^{c}±0.002	34.47^{a}±0.447	5.155±2.677
Fluorene	ND	0.301^{d}±0.007	0.678^{c}±0.011	0.081^{e}±0.001	1.101^{b}±0.010	0.102^{e}±0.001	21.117^{a}±0.140	3.340±1.625
Phenathrene	ND	0.154^{b}±0.003	ND	0.084^{c}±0.001	1.091^{a}±0.014	0.139^{b}±0.003	ND	0.210±0.082
Anthracene	ND	0.207^{b}±0.004	ND	0.122^{c}±0.002	1.273^{a}±0.004	0.120^{c}±0.007	ND	0.246±0.095
Fluoranthene	6.055^{e}±0.524	407.188^{a}±3.178	12.730^{d}±0.341	2.530^{e}±0.004	32.510^{c}±0.064	2.518^{e}±0.030	78.054^{b}±0.270	77.369±30.622
Pyrene	103.346^{c}±0.438	637.904^{a}±4.909	20.906^{e}±0.184	10.172^{f}±0.027	46.572^{d}±0.051	3.351^{g}±0.026	430.744^{b}±0.502	178.999±52.210
Benzo(a)Anthracene	6.817^{e}±0.107	107.838^{a}±0.745	15.621^{c}±0.019	1.024^{f}±0.0001	21.447^{b}±0.055	1.230^{f}±0.018	12.977^{d}±0.014	23.851±7.824
Chrysene	521.144^{a}±0.899	161.861^{b}±1.062	7.065^{d}±0.029	0.629^{e}±0.0001	15.405^{c}±0.016	1.295^{e}±0.017	6.229^{d}±00.017	101.947±40.122
Benzo(b)Fluoranthene	20.389^{c}±0.652	113.381^{a}±0.797	5.104^{e}±0.058	1.603^{f}±0.002	9.013^{d}±0.032	0.843^{f}±0.002	36.217^{b}±0.198	26.650±8.334
Benzo(k)fluoranthene	175.801^{a}±0.471	25.973^{b}±0.090	1.445^{d}±0.011	0.236^{e}±0.001	2.458^{c}±0.034	0.194^{e}±0.001	1.705^{d}±0.068	29.687±13.476
Benzo(a)pyrene	10.976^{a}±0.414	3.436^{c}±0.021	0.116^{d}±0.000	0.028^{d}±0.001	0.341^{d}±0.004	0.029^{d}±0.000	5.840^{b}±0.029	2.967±0.867
Dbenzo(a,h)anthracene	6.308^{b}±0.250	19.458^{a}±0.061	2.007^{e}±0.004	0.250^{f}±0.002	3.027^{d}±0.070	0.414^{f}±0.001	3.819^{c}±0.032	5.040±1.385
Benzo(ghi)perylene	13.500^{a}±0.296	7.882^{b}±0.086	0.894^{d}±0.012	0.129^{e}±0.001	1.277^{c}±0.005	0.171^{e}±0.003	0.980^{cd}±0.008	3.548±1.069
Indeno(1,2,3-cd)pyrene	12.630^{b}±0.371	17.611^{a}±0.122	3.982^{d}±0.012	0.304^{f}±.004	2.632^{e}±0.019	0.507^{f}±0.001	8.239^{c}±0.011	6.558±1.363
Total	882.014^{b}±1.591	1518.129^{a}±2.7661	72.163^{e}±0.101	17.449^{f}±0.029	140.030^{c}±0.086	11.331^{g}±0.019	647.967^{d}±0.219	469.869±118.995

Table (2): Showed concentration of polycyclic aromatic hydrocarbons (PAHs)in the collected water samples.

Site	S1	S2	S3	S4	S5	S6	S7	Average
pH	7.390^{c}±0.02	7^{f}±0.0001	7.260^{e}±0.035	7.345^{cd}±0.003	7.320^{d}±0.006	8.025^{a}±0.014	7.655^{b}±0.003	7.428±0.068
TDS (g/L)	1.760^{e}±0.006	1.915^{d}±0.009	2.055^{c}±0.032	1.928^{d}±0.001	1.936^{d}±0.003	6.715^{a}±0.003	6.205^{b}±0.003	3.216±0.460
Temperature (ºC)	20^{d}±0.0001	15^{g}±0.0001	17^{f}±0.029	19^{e}±0.000	25.05^{b}±0.029	23.05^{c}±0.029	26.005^{a}±0.003	20.736±0.853

Table (3): Showed principal component analysis of water PHC, pH, TDS, and temperature

Examined parameters/ sites	S1	S2	S3	S4	S5	S6	S7	Average
Weight (g)	**57.333^{b}±6.5666**	**51.500^{b}±0.866**	**85.000^{b}±1.732**	**68.067^{b}±3.319**	**71.573^{b}±4.507**	**71.600^{a}±6.710**	**51.500^{b}±0.86**	**65.225±2.887**
Length (cm)	**16.333^{a}±0.882**	**12.500^{b}±0.289**	**16.500^{a}±0.289**	**15.867^{a}±0.639**	**16.600^{a}±0.300**	**15.800^{c}±1.201**	**12.750^{b}±0.144**	**15.193±0.421**
Condition Factor (K)	**1.314^{c}±0.064**	**2.653^{a}±0.139**	**1.801^{b}±0.250**	**1.849^{b}±0.201**	**1.706^{bc}±0.109**	**1.932^{b}±0.219**	**2.495^{a}±0.126**	**1.964±0.110**

Table (4): Showed growth performance parameters of the examined *Tilapia zilli* collected from different sites in Lake Temsah.

Polycyclic Aromatic Hydrocarbons (PAH) (ng/g)	S1	S2	S3	S4	S5	S6	Average
Naphthaline	**0.208^{c}±0.003**	**0.113^{e}±0.006**	**0.164^{c}±0.004**	**0.114^{e}±0.013**	**0.352^{a}±0.016**	**0.195^{cd}±0.005**	**0.200±0.018**
Acenaphthylene	**0.127^{c}±0.001**	**0.130^{c}±0.006**	**0.182^{b}±0.012**	**0.130^{c}±0.003**	**0.373^{a}±0.017**	**0.074^{d}±0.02**	**0.163±0.020**
Acenaphthene	**0.119^{d}±0.004**	**0.123^{d}±0.006**	**0.265^{c}±0.009**	**0.103^{d}±0.003**	**0.413^{b}±0.014**	**0.127^{d}±0.001**	**0.321±0.074**
Fluorene	**1.021^{b}±0.006**	**0.102^{f}±0.001**	**0.202^{d}±0.002**	**0.121^{ef}±0.011**	**0.462^{c}±0.017**	**0.145^{e}±0.020**	**0.452±0.091**
Phenathrene	**5.722^{a}±0.008**	**0.109^{e}±0.005**	**0.203^{d}±0.003**	**0.128^{e}±0.010**	**0.752^{c}±0.043**	**0.193^{d}±0.004**	**1.244±0.424**
Anthracene	**5.545^{a}±0.003**	**0.080^{e}±0.006**	**0.200^{d}±0.0001**	**0.182^{d}±0.012**	**0.636^{c}±0.027**	**0.164^{d}±0.017**	**1.293±0.419**
Fluoranthene	**216.160^{a}±0.083**	**2.080^{e}±0.052**	**3.357^{d}±0.066**	**3.835^{c}±0.088**	**2.053^{e}±0.028**	**2.100^{e}±0.058**	**35.601±16.535**
Pyrene	**331.540^{a}±0.031**	**2.849^{g}±0.032**	**6.057^{e}±0.038**	**15.271^{d}±0.109**	**39.347^{c}±0.032**	**5.643^{f}±0.092**	**65.205±24.658**
Benzo(a)Anthracene	**203.120^{c}±0.061**	**277.379^{b}±0.874**	**2.803^{d}±0.061**	**1.537^{e}±0.029**	**1.103^{e}±0.058**	**1.824^{de}±0.122**	**122.069±32.556**
Chrysene	**232.156 ^{b}±0.110**	**249.100 ^{a}±0.058**	**2.374^{e}±0.043**	**0.934^{g}0.042**	**3.504^{d}±0.005**	**1.412^{f}±0.060**	**71.598±23.938**
Benzo(b)Fluoranthene	**62.523^{a}±0.039**	**0.912^{d}±0.052**	**1.849^{c}±0.077**	**2.418^{b}±0.025**	**0.456^{e}±0.014**	**0.721^{d}±0.017**	**10.162±4.783**
Benzo(k)fluoranthene	**15.254^{a}±0.079**	**0.219^{d}±0.021**	**0.429^{c}±0.015**	**0.352^{c}±0.015**	**0.095^{e}±0.006**	**0.182^{de}±0.016**	**3.807±1.293**
Benzo(a)pyrene	**2.137^{b}±0.019**	**0.033^{d}±0.009**	**2.554^{a}±0.087**	**0.050^{d}±0.008**	**0.019^{d}±0.001**	**0.051^{d}±0.024**	**0.728±0.0231**
Dbenzo(a,h)anthracene	**21.996^{b}±0.054**	**0.438^{d}±0.012**	**23.486^{a}±0.090**	**0.383d^{e}±0.003**	**0.238^{e}±0.012**	**0.345^{de}±±0.023**	**7.108±2.221**
Benzo(ghi)perylene	**13.111^{a}±0.059**	**0.249^{d}±0.006**	**9.170^{b}±0.081**	**0.199^{d}±0.002**	**0.128^{d}±0.011**	**0.157^{d}±0.017**	**3.550±1.106**
Indeno(1,2,3-cd)pyrene	**25.529^{a}±0.010**	**0.610^{d}±0.061**	**17.336^{b}±0.041**	**0.465^{d}±0.010**	**0.242^{e}±0.024**	**0.287^{e}±0.009**	**6.845±2.133**
Total	**1136.268^{a}±0.289**	**534.524^{b}±0.866**	**70.630^{d}±0.113**	**26.222^{f}±0.016**	**50.173^{e}±0.126**	**13.622^{g}±0.347**	**330.346±86.712**

Table (5): Showed concentration of polycyclic aromatic hydrocarbons (PAHs) in examined *Tilapia zilli* musculature samples.

PAHs(ng/g.)	S1	S2	S3	S4	S5	S6	Average
Naphthaline	1.929^{b}±0.003	0.437^{e}±0.001	9.834^{a}±0.030	0.356^{f}±0.005	0.501^{d}±0.001	0.558^{c}±0.008	1.994±0.725
Acenaphthylene	1.140^{b}±0.033	1.126^{b}±0.004	5.839^{a}±0.012	0.636^{d}±0.001	0.532^{e}±0.003	0.850^{c}±0.003	1.465±0.406
Acenaphthene	0.615^{c}±0.006	1.284^{b}±0.007	11.659^{a}±0.0258	0.420^{cd}±0.001	0.629^{c}±0.000	1.162^{b}±0.019	2.286±0.860
Fluorene	1.369^{c}±0.010	1.278^{d}±0.002	12.179^{a}±0.023	0.934^{e}±0.011	0.652^{f}±0.009	2.058^{b}±0.020	2.676±0.875
Phenathrene	0.771^{e}±±0.006	0.877^{d}±0.014	16.395^{a}±0.047	0.088^{g}±0.000	1.128^{c}±0.001	1.875^{b}±0.034	3.070±1.222
Anthracene	0.222^{e}±0.003	0.918^{d}±0.001	23.517^{a}±0.271	2.338^{b}±0.006	0.871^{d}±0.009	1.794^{c}±0.008	4.278±1.764
Fluoranthene	12.380^{c}±0.072	3.189^{e}±0.019	200.328^{a}±0.433	ND	2.894^{e}±0.025	27.661^{b}±0.121	35.768±15.149
Pyrene	751.559^{a}±14.938	271.717^{d}±0.133	568.415^{b}±0.989	435.253^{c}±0.226	56.013^{e}±0.116	2.782^{f}±0.006	299.447±61.367
Benzo(a)Anthracene	20.393^{c}±0.367	56.430^{b}±0.183	374.698^{a}±0.557	ND	1.568^{e}±0.009	1.676^{e}±0.024	65.449±28.540
Chrysene	71.904^{c}±0..307	95.170^{b}±0.182	118.565^{a}±0.551	ND	4.926^{d}±0.050	0.679^{f}±0.008	41.993±10.682
Benzo(b)Fluoranthene	5.633^{c}±0.003	1.062^{d}±0.003	24.877^{a}±0.231	6.233^{b}±0.104	0.638^{f}±0.008	0.964^{e}±0.000	5.818±1.806
Benzo(k)fluoranthene	1.796^{b}±0.004	1.035^{c}±0.003	102.087^{a}±0.098	ND	0.121^{e}±0.002		
Benzo(a)pyrene	0.173^{c}±0.0000	21.185^{a}±0.008	2.258^{b}±0.006	0.016^{e}±0.0000	0.028^{e}±0.000		
Dbenzo(a,h)anthracene	3.887^{c}±0.005	1.489^{d}±0.003	26.591^{b}±0.979	0.252^{e}±0.001	$0.333d^{e}$±0.002		
Benzo(ghi)perylene	1.764^{c}±0.005	0.506^{d}±0.003	19.368^{b}±0.113	0.207^{e}±0.001	0.189^{e}±0.001		
Indeno(1,2,3-cd)pyrene	2.344^{d}±0.007	0.907^{e}±0.003	34.383^{b}±0.417	0.239^{f}±0.001	3.257^{c}±0.004		
Total	904.698^{b}±0.517	468.561^{c}±0.479	1556.818^{a}±0.651	447.373^{d}±0.125	50.274^{f}±12.449		

Table (6): Showed principal component analysis of Polycyclic Aromatic Hydrocarbons (PAHs) detected in *Tilapia zilli* with its performance parameters.

	Component			
	1	2	3	4
Naphthalin	0.064	-0.091	0.922	-0.227
Acenaphthylene	-0.197	0.214	0.675	-0.338
Acenaphthene	0.008	-0.572	0.634	0.508
Fluorene	0.731	-0.407	0.51	0.152
Phenathrene	**0.969**	-0.034	0.122	-0.184
Anthracene	**0.965**	-0.121	0.16	-0.1
Fluoranthene	**0.964**	0.075	-0.039	-0.228
Pyrene	**0.959**	0.039	0.067	-0.253
Benzo(a)Anthracene	0.437	-0.811	-0.099	0.26
Chrysene	0.593	-0.26	-0.551	-0.302
Benzo(b)Fluoranthene	**0.951**	0.123	-0.072	-0.253
Benzo(k)fluoranthene	**0.915**	-0.289	0.175	0.093
Benzo(a)pyrene	0.642	0.602	-0.046	0.422
Dbenzo(a,h)anthracene	0.694	0.572	-0.042	0.389
Benzo(ghi)perylene	0.849	0.452	-0.036	0.242
Indeno(1,2,3-cd) pyrene	0.856	0.445	-0.043	0.229
Total	**0.912**	-0.317	-0.179	-0.095
Weight	-0.327	0.865	0.182	0.133
Length	0.083	0.845	0.287	-0.272
% of Variance	51.979	21.309	13.26	7.257
Cumulative %	51.979	73.287	86.547	93.804

Table (7): showed the concentrations of polycyclic aromatic hydrocarbons in examined *Tilapia zilli* liver samples**.**

PAHs(ng/g.)	S1	S2	S3	S4	S5	S6	S7	Average
Naphthaline	1.929^{b}±0.003	0.437^{e}±0.001	9.834^{a}±0.030	0.356^{f}±0.005	0.501^{d}±0.001	0.342^{f}±0.003	0.558^{c}±0.008	1.994±0.725
Acenaphthylene	1.140^{b}±0.033	1.126^{b}±0.004	5.839^{a}±0.012	0.636^{d}**±0.001**	0.532^{e}±0.003	0.134^{f}±0.002	0.850^{c}±0.003	1.465±0.406
Acenaphthene	0.615^{c}±0.006	1.284^{b}±0.007	11.659^{a}±0.0258	0.420^{cd}±0.001	0.629^{c}±0.000	0.232^{d}±0.001	1.162^{b}±0.019	2.286±0.860
Fluorene	1.369^{c}±0.010	1.278^{d}±0.002	12.179^{a}±0.023	0.934^{e}±0.011	0.652^{f}±0.009	0.263^{g}±0.001	2.058^{b}±0.020	2.676±0.875
Phenathrene	0.771^{e}±±0.006	0.877^{d}±0.014	16.395^{a}±0.047	0.088^{g}±0.000	1.128^{c}±0.001	0.357^{f}±0.001	1.875^{b}±0.034	3.070±1.222
Anthracene	0.222^{e}±0.003	0.918^{d}±0.001	23.517^{a}±0.271	2.338^{b}±0.006	0.871^{d}±0.009	0.283^{e}±0.001	1.794^{c}±0.008	4.278±1.764
Fluoranthene	12.380^{c}±0.072	3.189^{e}±0.019	200.328^{a}±0.433	ND	2.894^{e}±0.025	3.924^{d}±0.001	27.661^{b}±0.121	35.768±15.149
Pyrene	751.559^{a}±14.938	271.717^{d}±0.133	568.415^{b}±0.989	435.253^{c}±0.226	56.013^{e}±0.116	10.388^{f}±0.064	2.782^{f}±0.006	299.447±61.367
Benzo(a)Anthracene	20.393^{c}±0.367	56.430^{b}±0.183	374.698^{a}±0.557	ND	1.568^{e}±0.009	3.381^{d}±0.054	1.676^{e}**±0.024**	65.449±28.540
Chrysene	71.904^{c}±0..307	95.170^{b}±0.182	118.565^{a}±0.551	ND	4.926^{d}±0.050	2.705^{e}±0.013	0.679^{f}±0.008	41.993±10.682
Benzo(b)Fluoranthene	5.633^{c}±0.003	1.062^{d}±0.003	24.877^{a}±0.231	6.233^{b}±0.104	0.638^{f}±0.008	1.319^{de}±0.007	0.964^{e}±0.000	5.818±1.806
Benzo(k)fluoranthene	1.796^{b}±0.004	1.035^{c}±0.003	102.087^{a}±0.098	ND	0.121^{e}±0.002	0.360^{d}±0.002	0.449^{d}±0..001	15.121±7.940
Benzo(a)pyrene	0.173^{c}±0.0000	21.185^{a}±0.008	2.258^{b}±0.006	0.016^{e}±0.0000	0.028^{e}±0.000	0.053^{d}±0.001	0.165^{c}±0.001	3.411±1.631
Dbenzo(a,h)anthracene	3.887^{c}±0.005	1.489^{d}±0.003	26.591^{b}±0.979	0.252^{e}±0.001	0.333d^{e}±0.002	0.655d^{e}±0.002	71.620^{a}±0.047	14.975±5.533
Benzo(ghi)perylene	1.764^{c}±0.005	0.506^{d}±0.003	19.368^{b}±0.113	0.207^{e}±0.001	0.189^{e}±0.001	0.293^{e}±0.001	21.676^{a}±0.130	6.286±2.021
Indeno(1,2,3-cd)pyrene	2.344^{d}±0.007	0.907^{e}±0.003	34.383^{b}±0.417	0.239^{f}±0.001	3.257^{c}±0.004	0.541e^{f}±0.002	50.084^{a}±0.197	13.108±4.231
Total	**904.698^{b}±0.517**	**468.561^{c}±0.479**	**1556.818^{a}±0.651**	**447.373^{d}±0.125**	**50.274^{f}±12.449**	**25.341^{g}±0.063**	**186.357^{e}±0.312**	**519.917±113.637**

Discussion

Polycyclic aromatic hydrocarbons (PAHs) are a group of hazardous hydrophobic chemical molecules having benzenoid rings (two or more) that are primarily produced by human and natural processes and are found in all environmental matrices ***(EMOYAN, 2020)***. The presence of PAHs residue in marine products is becoming a major concern for human health and food security ***(Pirsaheb et al., 2021)***. Polycyclic aromatic hydrocarbons (PAHs) are a worldwide concern in the aquatic environment because they are poisonous, don't mix with water, build up in living organisms, keep coming in, and last a long time. The US Environmental Protection Agency (US EPA) has identified sixteen (16) PAHs as priority pollutants, of which seven are highly carcinogenic to humans ***(Kannan et al., 2005; Qin et al., 2013)***. PAHs bind to fine-grained sediments and floating particles in the aquatic environment. They are bioavailable to organisms and, through bioaccumulation, can change local food webs ***(Arias et al. 2009)***. According to the findings of this study, the 16 PCAHs investigated were identified in high amounts in all collected samples (fish tissue, liver, and water). The total amount of carcinogenic PAHs found in *Tilapia zillii* liver was higher (519.917±113.637) than in water (469.869±118.995) and fish tissues (330.346 ± 86.712). These PAHs are acenaphthene, anthracene, phenanthrene, fluorene, anthracene, fluoranthene, pyrene, benzo (a) anthracene, benzo (k) fluoranthene, benzo (a) pyrene, and dibenzo pyrene. Bioavailability is one of the most important factors that affect PAHs uptake because it controls how PAHs are taken in and separated from their surroundings by living things. The partition coefficient (Kow) and the molecular weight influence PAHs bioavailability ***(Snyder et al., 2015)***. The biotransformation occurs in the liver; muscular tissues are not thought to be involved in PAHs metabolism (***Beyer et al. 2010)***. From the number of PAHs that were found, benzo (a) anthracene was the most common congener in both the water and the *Tilapia zillii* muscle. Its average levels were 178.999±52.210 and 122.069±32.556. In fish liver, the PAHs with the highest congener was **pyrene,** with a mean concentration of 299.447±61.367. 16LPAHs: 16LPAHs found in water samples, tilapia cartilage, and liver are a serious warning sign for the high toxicity of the 16 PAHs that were tested. Several PAHs were known to be potential causes of cancer in human beings; these include benz [a] anthracene, chrysene, benzo [b] fluoranthene, benzo [a] pyrene, and benzo [ghi] perylene.

Polycyclic aromatic hydrocarbons (PAHs) are frequently detected in the sediment, attracted to solid particles in the water. After a while, the deposited PAHs in the sediments remobilize and become accessible to fish and other aquatic species. PAHs have been linked to a variety of fish health issues, including detrimental histopathologic and immunological responses, hepatic lesions, and liver neoplasms (**Ekere et al. 2019**).

HMW PAHs proved to be more prevalent in the samples than LMW PAHs. The presence of PAHs in water may be divided into low molecular weight (2–3 rings), intermediate molecular weight (4 rings), and high molecular weight PAHs (5–6 rings) based on their composition patterns (that is, the number of aromatic rings). High-molecular-weight PAHs include 4-6 aromatic rings that are hard to biodegrade by indigenous bacteria; that's why they can remain in the aquatic environment through accumulation in aquatic organisms such as fish, crabs, and shrimps and offer a larger cause of cancer ***(Brown et al. 2006)***. LMW PCAHs include (2–3) aromatic rings, and since they cause cancer at a lower rate, they may be harmful to many aquatic creatures ***(Harris et al. 2009)***. Water and sediment PAHs compositions can reveal indications of their origins. Higher amounts of LMW-PAHs (like acenaphthene and fluorene) in the environment show that these PAHs come from naturally occurring sources like petroleum and living things. On the other hand, PAHs from combustion processes (pyrolytic origin) show higher amounts of HMW PAHs (like phenanthrene, fluoranthene, and pyrene) and lower amounts of LMW PAHs (**Olayinka et al. 2019**).

Because of volatilization and oxidation, low-molecular-weight (LMW) PAHs have a short residence period in the water and can be promptly removed ***(Qiu et al. 2009).*** HMW PAHs quickly stick to particles in surface water, and the parts that don't like water easily stick to sediments at the bottom (**Rhea et al., 2005**). The kinds of PAHs found in water can help identify the origins of organic pollutants. LMW PAHs like naphthalene, fluorine, and acenaphthene found in the environment are signs of natural or petrogenic PAHs contamination. On the other hand, HMW PAHs like fluoranthene, phenanthrene, and pyrene, along with fewer LMW PAHs, are a sign of combustion or pyrolytic origins (**Olayinka et al. 2019**).

A multivariate method called principal component analysis (PCA) was used to find PAHs that may behave similarly, which suggests they may come from the same source (**Afshin 2007**). A hierarchical agglomerative cluster analysis was then used to find the participants' natural grouping. It was found that there is a strong and significant link between the chemicals benzo(b)fluoranthene (0.884), benzo(a)anthracene (0.830), fluoranthene (0.825), benzo(ghi)perylene (0.782), and pyrene (0.749). There was also a moderate relationship between benzo(a)pyrene (0.531) and chrosene (0.609). When looked at in muscle, there was a strong link between phenanthrene (0.969), anthracene (0.965), fluoranthene (0.964), pyrene (0.959), benzo(b)fluoranthene (0.951), benzo(k)fluoranthene (0.915), and total PAHs (0.912). This demonstrates that various PAHs behave similarly and may have a common source or origin. The presence of benzo[a]pyrene is primarily a sign of PAHs coming from combustion. The relationship between benzo[a]pyrene and other PAHs suggests that combustion is the predominant source of PAHs in the water body ***(Ekere et al. 2019)***.

Many aquatic contaminants are chemically stable, including polycyclic aromatic hydrocarbons (PAHs) and their halogenated variants. PAHs are a category of around 100 distinct chemical compounds that were created due to the incomplete combustion of coal, oil, waste, and other organic molecules and were typically discovered in mixtures of two or more compounds. Some PAHs were employed in pharmaceuticals as well as in the production of plastics, dyes, and insecticides. These chemicals in the aquatic ecosystem might be sourced from industrial effluents or petroleum oil spills ***(Nasr et al., 2012)***. Several authors have investigated the health risks posed by these chemicals thoroughly, and the occurrence of these compounds in environmental samples (water and fish) has also been extensively examined ***(Hagar et al., 2006).***

To investigate the PAHs' toxicological risk, they were compared to legal limits, dietary intake, and risks of not causing cancer and causing cancer (***Tongo et al., 2017)***. Benzo (a) pyrene (B (a) P) has traditionally been employed as a marker for the presence and impact of carcinogenic PAHs in food ***(Lee and Shim, 2007).*** As a result, BaP concentrations in fish and water samples were compared to the current **USEPA** (**2003**) recommended limit. (a) P concentrations in fish and water were found to be higher than the acceptable limit of 0.002 mg/kg for human fish intake. High levels of benzo (a) pyrene (BaP) in fish and water that are above the EU-recommended safe limit can be very bad for people's health. That's why the EU set a limit of 0.002 ppm for benzo (a) pyrene in fish and no other PAH compounds (**Nasr et al., 2012**). Both nature and people are capable of producing PAHs. Pyrogenic sources include the burning of hydrocarbons or any organic materials, such as engine exhaust, fires, and aluminum smelting, which releases pollutants into the air and water. Petrogenic sources include oil, petroleum, related activities, and natural sources. The pyrolytic combination of PAHs gets into aquatic habitats by evaporating from the air and into the water or soil. This can lead to soil erosion (**Itodo et al., 2020**), which could be caused by Temsah Shipbuilding Company.

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الملخص العربى

التوزيع المكانى لبعض الهيدروكاربونات فى أنسجه أسماك البلطى الاخضر و مياه بحيره التمساح

. تم تطبيق هذه الدراسة لفحص تركيز الهيدروكربونات العطرية متعددة الحلقات (PAHs) المختلفة في بحيرة التمساح، الإسماعيلية، مصر سواء في عينات المياه أو أنسجة الأسماك. قامت الدراسة بفحص 63 سمكة شبار أخضر و63 عينات مياه تم جمعها بشكل عشوائي وموسمي من مواقع مختلفة في البحيرة. كشفت النتائج التي توصلنا إليها أنه تم تسجيل 16 نوعا من الهيدروكربونات العطرية متعددة الحلقات (PAHs) في عينات المياه وأنسجة الأسماك. كان البيرين هو الأكثر وفرة في عينات المياه، بينما في عضلات الأسماك كان البنزو هو الأكثر وفرة (PAHs) وكان الأسينافثيلين هو الأقل وفرة. أظهر الكبد أن أعلى تركيز له هو البيرين وأقله هو الأسينافثيلين. وكان متوسط تراكيز PAH المسببة للسرطان أعلى في كبد البلطي منه في أنسجة الماء والأسماك.