CATRINA (2009), 4 (1): 21 - 30

A Study on *Cerastoderma glaucum* (Bruguière, 1789) As a Biomonitor Aspect of Oil Pollution in Lake Timsah, Suez Canal, Egypt

Samya H. Mohammad[1], Aisha A. Belal[2], and Nadia A. El-Agroudy[2]
[1]Faculty of Science, Suez Canal University, Port Said, Egypt
[2]National Institute of Oceanography and Fisheries, Suez, Egypt

ABSTRACT

Oil pollution is a continual threat to all inshore marine habitats, and particularly pronounced in benthic animals. Therefore, the present study aims to elucidate the effect of the total dissolved/dispersed petroleum hydrocarbons (TDDPHs) on *Cerastoderma glaucum* (Bivalvia: Cardiidae) in Lake Timsah. Seasonal investigations were carried out at two sites during 2007. The TDDPHs were measured in soft tissues and shell of *C. glaucum*, water and sediment samples using spectrofluorometric analysis**.** Also, gas chromatographic analysis was carried out to detect the polyaromatic hydrocarbons (PAHs). Results revealed the TDDPHs content were high in male individuals than females, and were also more representative in the cockles' soft tissues than in its shells. Soft tissues of *C. glaucum* and sediment samples recorded significant differences during seasons and between the two sites. A negative correlation was found between TDDPHs content in soft tissues of *C. glaucum* and its age. The highest level of TDDPHs content in soft tissues (21.3 µg/g) was recorded at age of one year, while the lowest one (4.82 µg/g) was observed at age of five years**.** Concentration factor (CF) studied showed higher value in sediment during spring and in soft tissues during autumn. Gas chromatographic analysis (GC) clarified that PAHs accumulated in soft tissues were of high molecular weight (HMW) which represent hazard effect on marine organisms.

Key words: Dissolved/dispersed petroleum hydrocarbons, polyaromatic hydrocarbons, *Cerastoderma glaucum*, Lake Timsah, pollution, biomonitor, oil.

INTRODUCTION

Lake Timsah is subjected to pollutants that were discharged from anthropogenic activities. One of these pollutants is the dissolved-dispersed petroleum hydrocarbons (TDDPHs) outlet from industrial effluents of Timsah Company, Osman workshops for repairing ships, domestic wastes of Ismailia city, and shipment activities (about 4000 ships cross the Suez Canal annually) (EEAA, 2006).

Oil pollution heads the risk of marine life, where petroleum hydrocarbon materials, even at low concentrations, can adversely affect health of marine organisms and the integrity of their natural ecological relationships (James, 1999). The most dangerous fractions of petroleum hydrocarbons are the polynuclear aromatic hydrocarbons (PAHs), which are organic chemicals, composed of fused benzene rings. PAHs compounds containing two or three rings are of low molecular weights (LMW), having acutely toxic effect on marine organisms, while those with four and five rings are of high molecular weights (HMW), which are less toxic but having greater carcinogenic potential on marine animals (Michael, 1996 and Eisler 2000). Acute responses such as growth inhibition, abnormal cellular development, prevalence of chronic diseases, reproductive impairment, and reduced life span may occur to marine biota at sub-lethal concentration of PAHs which are about 5 to100 ppb (Neff, 1979).

The best monitor of PAHs bioaccumulation in coastal environment is marine bivalves which have low biotransformation activity i.e., concentrate pollutants to several orders of magnitude above ambient levels in sea water (Varanasi *et al*., 1989, Widdows *et al*., 1997 and Chesman & Langston, 2006).Therefore, we choose an important edible cockle, *Cerastoderma glaucum*, that commonly inhabits Lake Timsah, Suez Canal (Mohamed *et al*., 1992). This cockle is a suspension and deposit feeder (Barnes, 1980) and plays an important role in the energy transfer of Lake Timsah ecosystem. Many individuals of this species are subjected to predation by some fishes, crabs and prawns.

The available data on oil pollution and their effect on marine environment of Lake Timsah are few. EL-Agroudy (2001) recorded concentration of TDDPHs in water and sediments. Autumn recorded the maximum TDDPHs and pyrene was the dominant fraction of PAHs. Mostafa (2002) determined the concentration of carcinogenic where PAHs (indeno 1, 2, 3-cd) pyrene, > benzo (a) pyrene, > dibenzo (a,h) anthracene, > and benzo(b) fluoranthene in soft tissues of *Venerupis decussata* ranged from 24.4 to 28.4 µg/g. Said and El-Agroudy (2006) found that dibenzo (a,h) anthracene was the most dominant PAHs in Timsah lake water with an average concentration of 3.8 µg/L.

The first aim of this study was to determine the concentration of oil pollution in biotic (*C. glaucum*) and abiotic (water and sediment) components seasonally in two different sites at Lake Timsah. The second aim was to study the concentration factor and the accumulation rate of TDDPHs, and their effect on population of *C. glaucum* Lake Timsah. This biomonitoring aspect of oil pollution can assess and provide assurance of the quality of marine environment in this lake.

* *Corresponding author: samya_hm@hotmail.com*

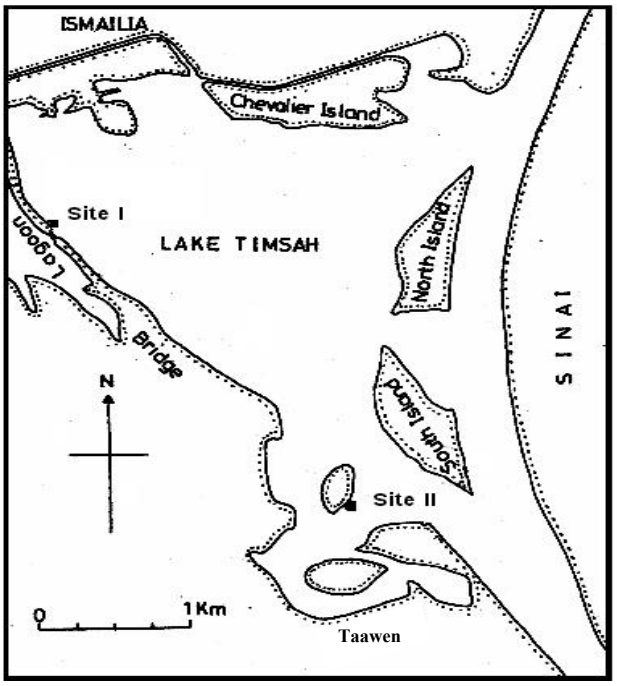

Figure (1): Map showing the investigated sites in Lake Timsah.

MATERIALS AND METHODS

Study Areas

From an economic view to Ismailia city, Lake Timsah is one of the famous lakes ramified from Suez Canal and plays important roles such as fisheries, navigation and tourism. It lies on the Suez Canal at mid way between Port Said in the north (at the Mediterranean Sea) and Suez city in the south (at the Red Sea). It lies between 30° 33`and 30° 35`N latitude and 30° 16`and 30° 19`E longitude. Lake Timsah has a surface area of about 8 Km² and an average depth of 4-5 m (ETPS, 1995). It is a shallow basin characterised by receiving a variety of water types; saline water from the Suez Canal, and fresh water from Ismailia Canal and agriculture drainage (EEAA, 2006). Two sites were chosen (Fig. 1). Site I (El-Kubry) lies on the western region .At this site the drainage of domestic and industrial effluents (2500 m^3 /day) (EEAA, 2006) were mixed and make the pollution great. Site II (El-Taawen) lies on the southern region which used for both recreational and commercial fishing. This site is affected by shipment activities through the passage of the Suez Canal.

Sampling of *Cerastoderma glaucum*

Specimens of *C. glaucum* were randomly collected seasonally during 2007, by seiving the sediment from the intertidal areas of the two sites. Collected samples were counted and their ages were determined by counting the distinct annual growth rings on the shell. The length of the cockles (antero-posterior axis) was measured using a vernier caliper. Then the shell lengths were categorized into size groups based on 5mm class interval. The percentage of each class interval was calculated. Total weight of intact cockles and flesh weight were recorded were to the nearest 0.01g using an electronic compact balance. Specimens were then sorted into males and females, according to the gonad colour (white or orange in males and green in females).Throughout this study, biometric analysis were carried out in an attempt to make a general study of some biological aspects such as seasonal variation in size frequencies.

Sampling and analysis of PAHs

Surface water samples (1m) were collected seasonally during 2007 from the two sites of Lake Timsah using a Nisken bottle. Water samples were extracted in field and kept at 4 ^oC, and transported to the laboratory for PAHs analysis using well-established techniques of UNEP (1992). Sediment samples were randomly collected during low tide from the mid intertidal limits at the two sites. At each site, three replicates of sediment samples were collected at surface layer (0-15 cm-depth) using van veen grab 0.1 m^2, and placed in aluminum foils. Soft tissues of *C. glaucum* and sediments were stored in pre-cleaned aluminium containers and frozen at – 20 ^oC until analysis. Samples were analysed for PAHs following the same techniques applied for water samples.

Extraction of petroleum hydrocarbons (oil pollution)

Petroleum hydrocarbons in sea water samples were extracted three times with 60 ml of dichloromethane in a separating funnel. Extracted samples were combined

and concentrated by rotary evaporation to 5 ml. Finally, samples were concentrated under a gentle stream of pure nitrogen to a final volume of 1ml. Animal samples were frozen and about 1 to 20g was Soxhlet-extracted with 250 ml of n-hexane for 8 hours and then re-extracted for 8 hours into 250 ml of dichloromethane (Villeneuve *et al*., 1999). These extracts were combined and concentrated down using a rotary evaporator at 30 ^{0}C followed by concentration with a nitrogen gas stream down to a volume of 1 ml. Sediments were extracted following the same techniques applied for biota samples.

Spectrofluorometric analysis

Total petroleum hydrocarbons were measured in water, sediments and animal samples, using the UVF – spectrofluorometer (Sequoia-turner Model 450), at 360 nm excitation and 415nm emission according to Parsons *et al*. (1985). The analyses were performed as a chrysene equivalent unit. A calibration curve was determined by analysing five separate concentrations (0.5, 1, 2, 4 and 6 mg/L) of chrysene using n-hexane as a solvent. Clean-up and fractionation were performed prior to gas chromatographic / flame ionization detector (GC/FID) analysis, by passing the extract through a silica / alumina column.

Adsorption column chromatography

The chromatographic column was prepared by slurry packing 20 ml (10 g) of silica, followed by 10 ml (10 g) of alumina and finally by 1g of anhydrous sodium sulphate. Elution was performed using 25 ml of hexane to yield the first fraction (F1, which contains the aliphatic hydrocarbons), then 40 ml of hexane/dichloromethane (90:10), followed by 20 ml of hexane/dichloromethane (50:50) (F2 which contains PAHs). Vials must be dark to store F1 and F2, separately (Villeneuve *et al*., 1999).

Gas chromatography (GC)

All samples were analysed by a Hewlett Packard 5890 series GC gas chromatograph, equipped with a flame ionization detector (FID). The instrument was operated in splitless mode (2µl splitless injection) with the injection port maintained at 290 ^{o}C and detector maintained at 300 ^{o}C. Samples were analysed on a fused silica capillary column HP-1, with 100% dimethyl polysiloxane (30 ml length, 0.32 mm i.d., 0.17 µm film thickness). The oven temperature was programmed from 60 to 290 ^{o}C, changing at rate of 3^{o}C min^{-1} and maintained at 290 ^{o}C for 25 min. The carrier gas was nitrogen flowing at 1.2 ml min$^{-1.}$

Quantification

A stock solution containing the following PAHs was used for quantification: naphthalene, acenaphthylene, acenaphthene, fluorine, phenanthrene, anthracene, fluoranthene, benzo(a) anthracene, chrysene, benzo(b) fluoranthene, benzo(k)fluoranthene, pyrene, benzo-(a)pyrene, dibenzo(a,h)anthracene, benzo(ghi)perylene, and indeno(1,2,3-cd) pyrene by dilution to create a series of calibration standard of PAHs at 0.1, 0.25, 0.5, 0.75, 1, 2.5, 5, and 10 µg ml^{-1}. The detection limit was approximately 0.01 µg ml^{-1} for each PAHs. All solvents were of pesticide grade purchased from Merck, and appropriate blanks (for biota samples adjusted) were analysed.

Statistical analysis

Chi-Square test (X^2) was utilized to compare between males and females. In addition, one-way analysis of variance (ANOVA) was used to compare the variation in concentrations of TDDPHs in biota, water and sediments at the two sites. The significance level employed in all tests was set at $P \leq 0.05$. All statistical analysis of data was conducted using a computer program: STATISTICA for windows (version 4, 1993).

Seafood Contamination Terminology was used to assessment the exposure of pollution state.

Bioaccumulation Factor (BAF)

The net accumulation of a substance by an organism as a result of uptake from all environmental sources and possible routes of exposure (contact, respiration, ingestion, etc.) is termed bioaccumulation (ASTM 1994).

According to exposure to sediments contacts, BAF was calculated as follow:

$$BAF = Ca / Cs$$

Concentration Factor (CF)

The net accumulation of a polluted substance as a result of uptake directly from aqueous solution (ASTM 1994).

Bio concentration factor (BCF) and Sediment concentration factor (SCF)

They were calculated according to the formula

$$BCF = Ca / Cb, SCF = Cs / Cb$$

where Ca , Cb and Cs are the mean concentrations of TDDPHs in organism, in surrounding water and in sediments, respectively.

RESULTS

Population structure of *Cerastoderma glaucum*

The present study reveals that the cockle's population is bimodal (15.1-20 & 25.1-30 mm shell length) (Fig. 2A) with dominance of males in most size classes. Sexually undifferentiated cockles are restricted only in the smallest two size classes. With respect to age, the percentage frequency of males was higher than that of

females from the second to the fifth year but the reverse case was revealed only at the first age group (Fig. 2B). By subjecting the data to Chi-Square test (X^2), highly significant differences are found between males and females in different size classes, ages and seasons ($P < 0.01$). Sexually undifferentiated cockles appeared only in winter (Fig. 2C). Generally, males of the two sites were heavier than females, during the different seasons as shown in Figure (3).

Spectrofluorometric analysis of TDDPHs

(a) In biotic environment (Cerastoderma glaucum)

Seasonal variations in the concentration of total petroleum hydrocarbons in soft tissues of *C. glaucum* are represented in Figure (4A). It is obvious that autumn showed the highest levels (16.3 & 19.3 µg/g), and the lowest levels (5.1 & 7.1 µg/g) were observed during summer (at site I and site II, respectively). The results revealed that the accumulations of TDDPHs in soft tissues of *C. glaucum*, at site II, are higher than that at site I ($P = 0.02$). Figure (4B) shows that the relation between hydrocarbon contents of *C. glaucum* and their ages was inversely proportional (r = - 0.85). The highest contents of TDDPHs were 24.67 & 19.34 µg/g, at the age of one year, for males and females, respectively. The lowest contents were 1.62 & 1.22 µg/g at the age of five years, for males and females, respectively. Also, males revealed higher contents of TDDPHs than females. In general, the concentration of TDDPHs in the cockle's soft tissues was higher than that of the cockle's shell in the first three years (Fig. 4C).

Figure (5) shows the calculating concentration factor (CF) in both sediment (SCF) and biota (BCF), at the two sites. In sediments, the accumulation rate was five times higher at site I than site II. In soft tissues of *C. glaucum*, accumulation rate at site II, on the contrary, was higher. For the two sites, spring showed markedly the highest accumulation rate (12.68×10^3) in sediments. In biota, autumn revealed the highest one (1.6×10^3) at site I while spring was the highest (2.4 x 103) at site II. Correlation coefficient between CF in sediment and biota was $r = 0.4$.

The bioaccumulation factor BAF was calculated for both sites. Site II recorded the higher values, ranged from 0.83 to 1.76. While Site I, recorded the lower values ranged from 0.06 to 0.46. Autumn recorded the highest accumulation rate at the two sites.

(b) In a biotic environment (water and sediments)

Table (1) shows seasonal distribution of the concentration of TDDPHs in water and sediment samples at the two sites. With respect to water, it was found that summer recorded the highest level of TDDPHs, reaching to 38.58 µg/L, while autumn recorded the lowest ones (9.96 µg/L), at site I. However, at site II, autumn recorded the highest level, reaching 16.03 µg/L, and the lowest ones (3.66 & 4.99 µg/L)

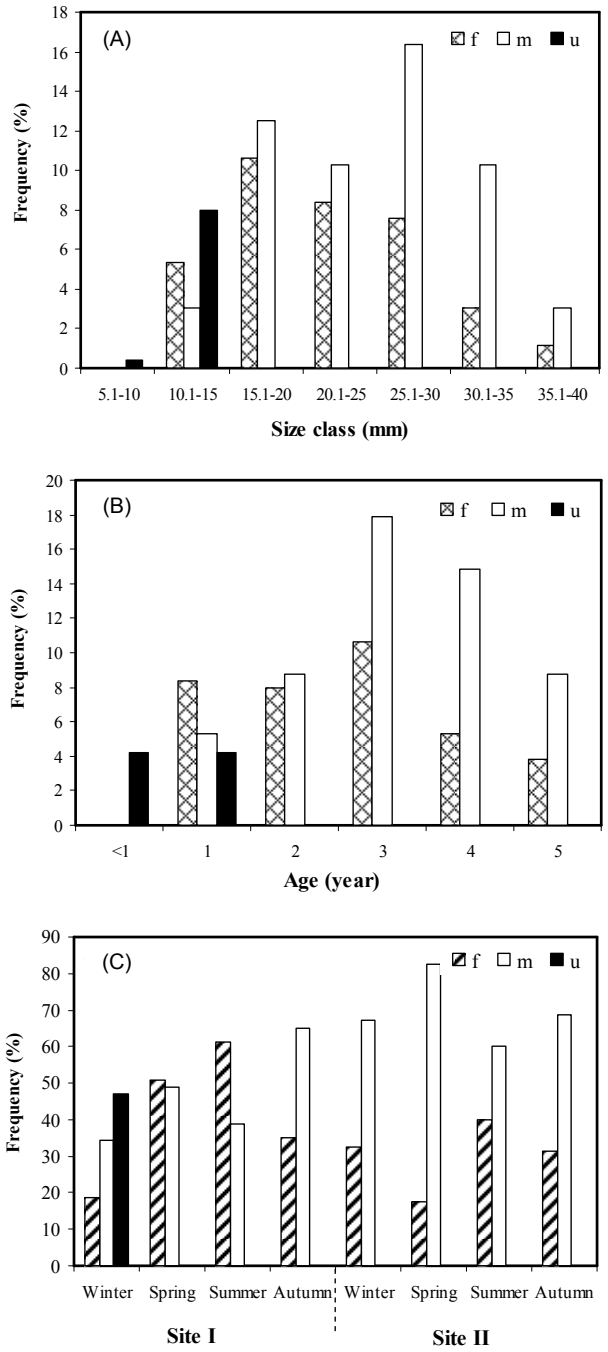

Figure (2): Percentage frequency of male (m), female (f) and sexually undifferetiated (u) individuals of *Cerastoderma glaucum* during 2007, relating to: (a) Size class in both sites, (b) Age in both sites, and (c) Season.

were recorded in spring and summer, respectively. Sediment samples showed the highest level of TDDPHs (136 µg/g) in spring and the lowest (35.5 µg/g) was recorded in autumn, at site I, with annual mean concentration of 81.4 µg/g. Levels of TDDPHs, in sediment at site II exhibited small differences between seasons, and the annual mean concentration was 9.78 µg/g. There was a significant difference between the two sites ($P < 0.01$).

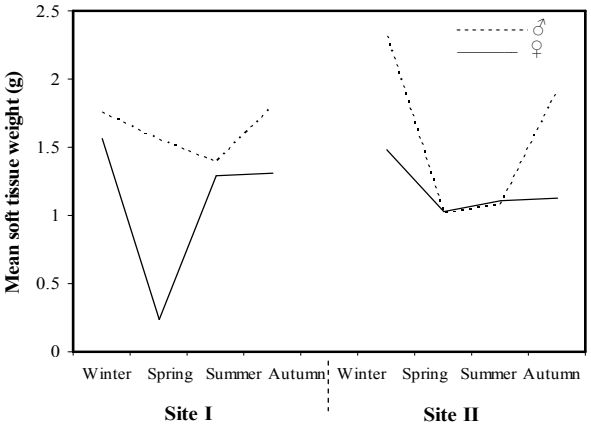

Figure (3): Mean soft tissue weights of male and female *Cerastoderma glaucum* in the two investigated sites during the different seasons.

Gas chromatographic analysis

Table (2) indicates that most of the PAHs fractions accumulated in soft tissues of *C. glaucum*, from the two sites of Lake Timsah, are of high molecular weight (*i.e.* > 3 rings) and which are less toxic but have a carcinogenic potential. These are Benzo (a) pyrene (BaP), Benzo (b) Fluoranthene (BbF), Benzo(K)Fluoranthene (BkF), Dibenzo(a,h)anthracene (DBahA) and Indeno(1,2,3cd) pyrene (In123cdP). It is obvious that Phenanthrene/anthracenen (Ph/Anth) ratio is < 10. Table (3) illustrates the total carcinogenic PAHs (TCARC) of *C. glaucum*, which range from 0.21 to 3.74 µg/g and from 0.4 to 2.76 µg/g, at site I and site II, respectively. It is also found that the ratio TPAHs CARC/TPAHs, percentage average (55%), at site I was higher (37%) than that recorded at site II.

DISCUSSION

Population is the key factor determining the pollution load. In the present investigation, population structure of *C. glaucum* in Lake Timsah was compared with a previous study (Mohammad, 2002). The present study revealed that the cockle's population was bimodal (15.1-20 & 25.1-30 mm shell length), whereas it was found unimodal (15-25 mm shell length) in the study of Mohammad. Moreover, in the present study, the third

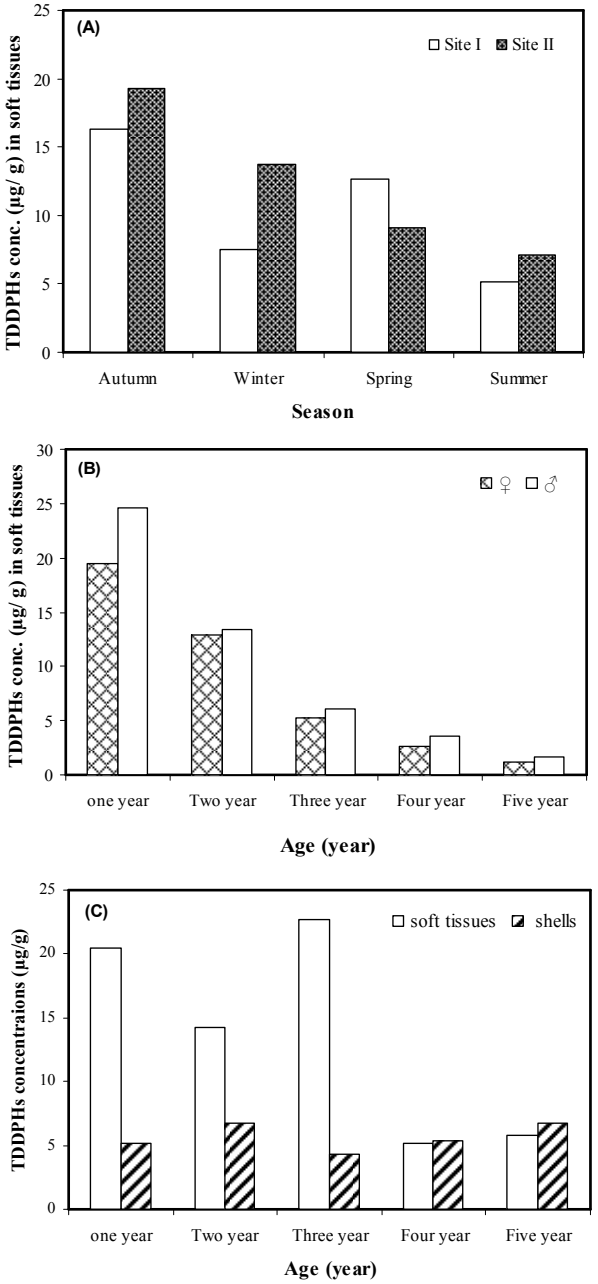

Figure (4): Concentrations of TDDPHs in soft tissues of *Cerastoderma glaucum* in both sites during 2007, related to (a) Season, (b) Age and sex, and (c) Shell.

Table (1): Seasonal variation of TDDPHs concentrations (Mean ± SD) in sediment (µg/g) and water (µg/L) samples collected from the two sites in Lake Timsah.

Season	TDDPHs			
	Site I		Site II	
	Water	Sediment	Water	Sediment
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
Winter	15.20 ± 0.30	70.86 ± 4.50	13.40 ± 1.14	09.92 ± 0.90
Spring	10.72 ± 3.40	136.0 ± 50.00	03.66 ± 2.11	10.96 ± 0.90
Summer	38.58 ± 26.70	83.41 ± 10.00	04.99 ± 0.94	07.29 ± 0.90
Autumn	09.96 ± 0.52	35.50 ± 50.00	16.03 ± 0.90	10.96 ± 0.90
Mean ± SD	18.62 ± 13.50	81.40 ± 41.64	09.52 ± 6.12	09.78 ± 1.73

Table (2): Average concentration (µg/g) of PAHs fractions recorded in soft tissue of *Cerastoderma glaucum* collected from the two sites in Lake Timsah.

PAHs	Age (year)											
	Site I						Site II					
	one	two	three	four	five	total	one	two	three	four	five	total
Naphthalene	n.d	n.d	n.d	n.d	n.d	n.d	0.09	n.d	0.05	n.d	n.d	0.14
Acenaphthylene	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d
Acenaphthene	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d
Fluorine	n.d	n.d	n.d	n.d	n.d	n.d	0.02	n.d	n.d	n.d	n.d	0.02
Phenanthrene	0.3	n.d	n.d	0.1	n.d	0.4	0.26	1.63	n.d	0.81	0.34	3.04
Anthracene	n.d	n.d	n.d	n.d	n.d	n.d	n.d	0.24	n.d	n.d	n.d	0.24
Fluoranthene	1.2	n.d	0.4	n.d	0.2	1.9	0.46	n.d	1.01	n.d	0.12	3.18
Pyrene	0.0	n.d	n.d	n.d	0.0	0.1	0.34	0.13	0.09	n.d	n.d	0.56
Benzo(a)Anthracene	n.d	0.0	0.3	n.d	n.d	0.3	1.33	n.d	n.d	0.09	0.07	1.49
Chrysene	0.8	n.d	0.0	0.0	n.d	0.8	n.d	n.d	n.d	0.13	n.d	0.13
Benzo(b) Fluoranthene	n.d	n.d	n.d	0.1	n.d	0.1	0.65	0.31	n.d	n.d	0.41	1.37
Benzo(K)Fluoranthene	0.1	0.0	0.1	n.d	n.d	0.2	0.25	n.d	0.9	n.d	n.d	1.15
Benzo (a)pyrene	0.5	0.1	0.1	0.4	n.d	1.2	0.36	1.02	n.d	0.14	n.d	1.52
Dibenzo(a,h)anthracene	0.2	0.0	0.4	0.1	0.1	1.0	0.34	0.04	1.02	n.d	0.18	1.58
Benzo(ghi) perylene	0.1	1.1	n.d	0.1	n.d	1.3	0.11	n.d	n.d	0.07	0.03	0.21
Indeno(1,2,3cd)pyrene	0.2	0.8	n.d	n.d	0.1	1.2	1.05	0.01	0.08	n.d	0.22	1.36
Total PAHs	3.7	2.2	1.4	1.0	0.5	8.9	4.93	3.38	3.15	1.24	1.40	16.2
Mean	0.4	0.3	0.2	0.1	0.1		0.43	0.42	0.52	0.24	0.19	

n.d: not detected

and the fourth age groups were dominant, while in the work of this author the second and the third age groups were predominant. So it was proved that young cockles suffered the impact of oil pollution which might have led to their mortality. These chemicals tend to bind with suspended particulate matter, accumulate and contaminate the bottom sediments, which threatens biological system (Leppanen, 1995). Accordingly, this may be one of the factors that altered the population structure of *C. glaucum* from unimodal to bimodal and shifting the abundance of age groups to the larger one.

This pollutant also incorporate to affect cockle's weight making them lighter in weight than those in the work of Mohammad (2002), especially the young animals as shown in Figure (6). Generally, contact with oil causes an increase in energy expenditure and a decrease in feeding rate, resulting in less energy available for growth and reproduction as mentioned by Suchanek (1993). Hence, the appearance of sexually undifferentiated individuals which was not recorded in the past, lead to the hypothesis that TDDPHs influence gonad development of *C. glaucum*, causing decrease in size at sexual maturity. This was confirmed by the present results, recording the sexually undifferentiated cockles in site I only, which exceeded site II in pollution.

Mohammad (2002) stated that the sex ratio of *C. glaucum* was 1:1.3 for males and females, respectively. Regarding the present work, one of the important records was the change of sex ratio to 1.5: 1 for males and females, respectively. This may be due to the exhausting of female cockles owing to their continuous spawning, which made them more sensitive to pollution than males and led them to death. It was obviously that males can withstand pollution than females. This was clear from the higher content of TDDPHs in their soft

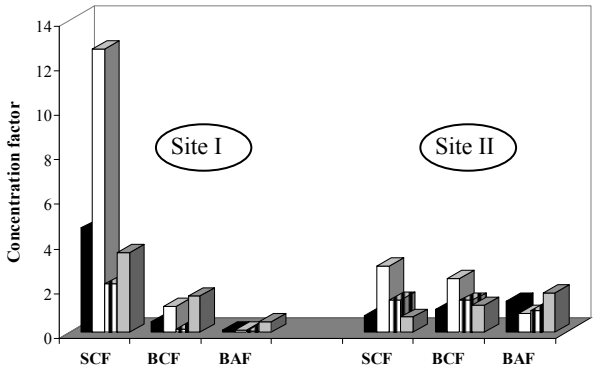

Figure (5): Concetration factors of TDDPHs in *Cerastoderma glaucum* at the two sites in Lake Timsah throughout the different seasons. Sediment concentration factor (SCF): Expressed as the concentration of TDDPHs in sediment divided by their concentration in water. Bioconcentration factor (BCF): Expressed as the concentration of TDDPHs in biota divided by their concentration in water.

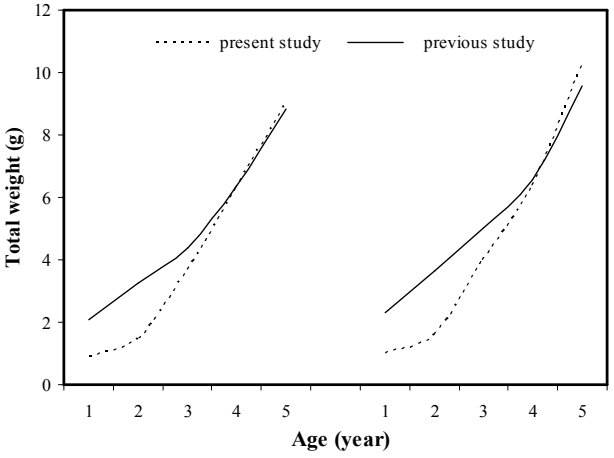

Figure (6): Total weights of males and females *Cerastoderma glaucum* in the present and a previous study (Mohammad, 2002).

Table (3): The PAHs concentrations (µg/g) in soft tissues *Cerastoderms glaucum* in different ages at the two sites in Lake Timsah.

Location	PAHs	Age					
		one	two	three	four	five	Mean ± SD
Site I	TPAHs	3.74	2.21	1.44	1.04	0.55	1.79 ± 1.795
	TCAR	2.66	1.22	0.98	0.47	0.21	1.10 ± 0.95
	TCAR/TPAHs	0.71	0.55	0.68	0.45	0.38	0.55
Site II	TPAHs	4.93	3.43	5.46	1.24	1.40	3.29 ± 1.81
	TCAR	2.76	1.37	1.09	0.40	0.43	1.21 ± 0.96
	TCAR/TPAHs	0.56	0.40	0.20	0.33	0.31	0.37

TCAR:Total Carcinogenic Poly Aromatic Hydrocarbons.

tissues than females. So, males may concentrate TDDPHs in their soft tissues more than females according to their heavier weight. The increment of male than female in petroleum hydrocarbon content may be also related to spawning behaviour. Rossi and Anderson (1977) stated that male gradually released the oil pollution while females abruptly released it with their spawning. On the other hand, bioaccumulation of TDDPHs in young animals was greater than in old ones. This inverse relationship could be attributed to the ability of the small individual to eat more than the larger one, leading to the accumulation of more pollutants in its tissue. Therefore, young animals were greatly affected by pollution. This was clear from the disappearance of young cockles (< 10mm shell length) that were previously recorded, in addition to the variation in the excretion rates of TDDPHs between young and old cockles. This was in agreement with Landrum (1988). Moreover, large bivalves were able to regulate the pollutant content in their tissues as was mentioned by El-Moselhy & Yassien (2005). As a result, concentrations of TDDPHs in the cockle's soft tissues were higher than that in the cockle's shell in the first three years. Then, large animals could regulate the pollutant in their tissues resulting in containing slightly more concentrations of TDDPHs in their shells rather than in their soft tissues. Besides, shell adsorbed petroleum hydrocarbons due to long exposure to oil pollution.

Seasonal differences of petroleum hydrocarbons in soft tissue of *C. glaucum* was confirmed by Farrington *et al*. (1983) and Dunn and Stich (1976). They attributed these differences to variability in filtration rate, spawning activity, microbial activity, environmental concentrations, chemical forms (particulate, colloidal. free), and other related factors.

High levels of TDDPHs in both water and sediments at site I were related to the high load of domestic and industrial drainage. It was greater than at site II which was affected by shipping activities through the passage of the Suez Canal. Regarding the previous result of El-Agroudy (2001), the level of TDDPHs in water ranged from 3.48 µg/L to 20.09 µg/L. The pollution was in progress as estimated in the present study which indicated that the range was between 3.66 µg/L and 38.58 µg/L. However, this range come under the safety levels according to Duning and Major (1974), Lucas and Roux (1975) and Mazmanidi *et al*. (1976). They stated that the DDPH concentration in seawater which can produce a harmful effect on the aquatic organisms is in the range of 50 ppb in. Another increase of TDDPHs concentration was recorded in sediments, at site I where the concentration was ascending from 85 µg/g (El-Agroudy, 2001) to 136 µg/g (present study). This is related to the high load of these pollutants in water than at site II and this increment is more impact in marine organisms at site I. This is in agreement with Burns and Teal (1979). In addition, a muddy sediment helps pollutants to accumulate than sandy one (Statham *et al*., 1976) and makes the concentration in water lower. This is the case in the muddy Site I, in the present result, contrary to site II, where sediment is sandy.

Site I recorded high sediment concentration factor (SCF) due to the large quantity and the diversity of drainage (industrial, domestic, agriculture), and lower bioconcentration factor (BCF). This was in agreement with Kukkonen & Landrum (1994), who suggested that in high sediment contaminant concentrations, the rate of ingestion can decrease as a response to the chemicals and cause lower accumulation rate in biota. On the other hand, site II recorded the higher BCF value which is directly affected by only shipment activities from Suez Canal and oily effluence. BCF, also, can be predicted with such physico-chemical factors as partition coefficient factors, solubility (Chiou *et al*., 1977; Mackay 1982; Pruell *et al*., 1986 Veith *et al*., 1979). The differences in BCF may result from variability in environmental factors or different in hydrocarbons sources which producing differential bioavailability (Murray *et al*., 1991).

The most PAHs detected in soft tissue of *C. glaucum*, by GC analysis, were the type of HMW (carcinogenic). This was according to McCarty (1991) who stated that tissue burden levels of PAHs with HMW at range of 2 to 6 µg/g are critical and make deleterious effects. The present results revealed that the environment reaches the borderline of actual response value, and site I seems to be more affected by PAHs CARC than site II, in addition to the PH/ANT ratio < 10 that was found. This indicated that the source of oil pollution was from combustion of fossil fuel (pyrolytic source) (Kavouras *et al*., 2001).

In conclusion, the PAHs accumulated in the body of *C. glaucum* were the type of carcinogenic, BaP, BbF, BaA, InP, and DBA. Hence, the continuous ascending of pollution in Lake Timsah will cause a toxic effect on marine organisms. Therefore, the impact of pollution on bivalves and other marine organisms inhabiting this lake appeared through the present investigation. So, the treatment of the wastes before discharging to the lake and performing environmental impact assessment preinstalling any new plan in the area are strongly recommended.

REFERENCES

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM). 1994. Compilation of ASTM Standard Definitions, Eighth Edition. Philadelphia: ASTM.

BARNES, R.S.K. 1980. Coastal Lagoons. Cambridge University Press, Cambridge.

BURNS, K.A., AND J.M. TEAL. 1979. The West Falmouth oil spill: hydrocarbons in the salt marsh ecosystem. Estuarine Coastal Marine Science **8:** 349-360.

CHESMAN, B.S., G.R. BURT, AND W.J. LANGSTON. 2006. Characterisation of the European Marine Sites: Essex Estuaries European Marine Site. Marine Biological Association of the United Kingdom Occasional Publication (17). pp 198. (2006) ISSN: 02602784

CHIOU, C.T., V.H. FREED, D.W. SCHMEDDING, AND R.L. KOHNERT. 1977. Partition coefficient and bioaccumulation of selected organic chemicals. Environmental Science and Technology **11:** 475-478.

DUNING, A., AND C.W. MAJOR. 1974. The effect in cold sea water of oil fractions upon the blue mussel "*Mytilus edulis"* Aquatic Sciences and Fisheries **5:** 214–221.

DUNN, B.P., AND H.F. STICH. 1976. Monitoring procedures for chemical carcinogens coastal waters. Journal of Fisheries Research Board of Canada **33:** 2040 -2049.

EEAA 2006. Environment Affairs Agency, Canal and Sinai region. Work shop and training on "Analysis and sampling of water pollution". 11-15 June. Technical Report. 5pp.

EL-AGROUDY, N.A. 2001. Environmental study on hydrocarbon materials in Suez Canal province. Ph. D. Thesis, Faculty of Science, Mansoura University, Egypt.

EL-MOSELHY, K.M., AND M.H. YASSIEN. 2005. Accumulation patterns of heavy metals in Venus clams, *Paphia undulata* (Born, 1780) and *Gafrarium pectinatum (*Linnaeus*,* 1758), from Lake Timsah, Suez Canal, Egypt. Egyptian Journal of Aquatic Research **31 (1):** 13-29.

ETPS. 1995. Environmental testing of pollution status in Lake Timsah, Abu-Attwa water Reuse Centre Research and training, Ismailia, Egypt.

EISLER, R. 2000. Health Hazards to Humans, Plants and Animals. Polycyclic Aromatic Hydrocarbons, in Handbook of Chemical Risk Assessment. Organics, Lewis Publishers **l:** 1500

FARRINGTON, J.W., E.D. GOLDBERG, R.W. RISEBROUGH, J.H. MARTIN, AND V.T. BOWEN. 1983. U.S. "MUSSEL WATCH" 1976-1978: An overview of the trace metal, DDE, PCB, Hydrocarbon, and artificial radionuclide data. Environmental Science and Technology **17:** 490-496.

JAMES, L.S. 1999. An introduction to the biology of marine life **16:** 439, 7th [Ed].USA.

KAVOURAS, I.G., P. KOUTRAKIS, M. TSAPAKIS, E. LAGOUDAKI, E.G. STEPHANOU, D. BAER, AND P. OYOLA. 2001. Source apportionment of urban aliphatic and polyaromatic hydrocarbons (PAHs) using multivariate methods. Environmental Science and Technology **35:** 2288-2294.

KUKKONEN, J., AND P.F. LANDRUM. 1994. Toxico kinetics and toxicity of sediment-associate pyrene to *Lumbriculus vaiegatus* (Oligochaeta). Journal of Environmental Toxicology and Chemistry **13 (1):** 457-1468.

LANDRUM, P.F. 1988. Toxicokinetics of organic xenobiotics in the amphipod, *Pontoporeia hoyi*: Role of physiological and environmental variables. Aquatic Toxicology **12:** 245-271.

LEPPANEN, M. 1995. The role of feeding behaviour in bioaccumulation of organic chemicals in benthic organisms. Annoles Zoologici Fennici **32 (1):** 247-255.

LUCAS, A., AND S. ROUX. 1975. Toxicity of several crude oils in relation to mussel larvae. Aquatic Sciences and Fisheries **5:** 223-225.

MACKAY, D. 1982. Correlation of bioconcentraion factors. Environmental Science and Technology **16:** 274-278.

MAZMANIDI, N.D., G.I. KOVALEKA, A.M. KOTOV, T.R. BAZHASHVILI, N.M. DIASAMADIZI, AND N.P. ZAMBAKHIDZI. 1976. On the effect of petroleum products on the Black Sea hydrobiology. Marine Pollution Bulletin **6:** 201-208.

MCCARTY, L.S. 1991. Toxicant body residues: implications for aquatic bioassay with some organic chemicals. In: M.A.Mayes M.G. Barron (Eds.), Aquatic Toxicology and Risk Assessment, ASTM STP 1124, American Society for testing and Materials, Philadephia, PA **14:** 183-192.

MOHAMMAD, S.H. 2002. Ecological and biological studies on the bivalves, *Cerastoderma glaucum* and *Papyridea papyracea,* in Lake Timsah, Suez Canal. Ph.D. Thesis, Faculty of Science, Suez Canal University, Ismailia, Egypt.

MOHAMED, S.Z., H.R. GABR, A. GHOBASHY, AND A.R. BRAND. 1992. Species composition and distribution of benthic mollusks in Lake Timsah (Suez Canal). Journal of the Egyptian German Society of Zoology

7 (B): 161-174.

MOSTAFA, G.A. 2002. Monitoring of polycyclic aromatic hydrocarbons in seafoods from Lake Timsah. International Journal of Environment and Pollution Health Research **12:** 83-91.

MURRAY, A.P., B.J. RICHARDSON, AND C.F. GIBBS. 1991. Bioconcentration factors for petroleum hydrocarbons, PAHs, LABs, and biogenic hydrocarbons in the blue mussel. Marine Pollution Bulletin **22:** 595-603.

NEFF, J.M. 1979. Polycyclic aromatic hydrocarbons in the aquatic environment: sources, fates, and biological effects. Applied Science Publishers Ltd., Essex, England.

PARSONS, T.R., Y. MATIA, AND G.M. MALLI. 1985. Determination of petroleum hydrocarbons. A manual of chemical and biological method for seawater analysis, Pergamon Press, Oxford.

PRUELL, R.J., J.L. LAKE, W.R. DAVIS, AND J.G. QUINN. 1986. Uptake and depuration of organic contaminants by blue mussels (*Mytilus* edulis) exposed to environmentally contaminated sediment. Marine Biology **91:** 497-507.

ROSSI, S.S., AND J.W. ANDERSON. 1977. Accumulation and release of fuel-oil derived diaromatic hydrocarbons by the polychaete *Neanthes arenaceodenata*. Marine Biology **39:** 51-55.

SAID, O.T., AND N.A. EL-AGROUDY. 2006. Assessment of PAHs in water and fish tissues from Great Bitter and El Timsah Lakes, Suez Canal, as chemical markers of pollution sources. Chemistry and Ecology **2 (22):** 159-173.

STATHAM, C.N., M.J. MELANCON, AND J.J. LECH. 1976. Bioconcentration of xenobiotics in trout bile: a proposed monitoring aid for some waterborne chemicals. Science **193:** 680-681.

SUCHANEK, T.H. 1993. Oil Impacts on Marine Invertebrate Populations and Communities. Integrative and Comparative Biology **33 (6):** 510-523.

UNITED NATION ENVIRONMENT PROGRAM (UNEP). 1992. Determination of petroleum hydrocarbons in sediments. Reference methods for marine pollution studies, No.20, P 36.

VARANASI, U., AND D.J. GMUR. 1981. Hydrocarbon and metabolites in English sole (*Parophrys vetulus*) exposed simultaneously to (^{3}H) benzo (a) pyrene and (^{14}C) naphthalene in oil-contaminated sediment. Aquatic Toxicology **1:** 47-67.

VARANASI, U., J.E. STEIN, AND M. NISHIMOTO. 1989. Biotransformation and disposition of polycyclic aromatic hydrocarbons (PAHs) in fish. In: U. Varanasi. (Ed.) Metabolism of Polycyclic Aromatic Hydrocarbons in the Aquatic Environment. CRC Press, Boca Raton, FL., 94-149.

VEITH, G.D., D.L. DEFOE, AND B.V. BERGSTEDT. 1979. Measuring and estimating the bioconcentration factor of chemicals in fish. Journal of Fisheries Research Board of Canada **36:** 1040-1048.

VILLENEUVE, F.P., S.W. CARVALHO, AND C. CATTINI. 1999. Levels and trends of PCBs, chlorinated pesticides and petroleum hydrocarbons in mussels from the NW Mediterranean coast: comparison of concentrations in 1973/1974 and 1988/1989. Science of the Total Environment **38:** 57-65.

WIDDOWS, J., C. NASCI, AND V.U. FOSSATE. 1997. Effect of pollution on the scope for growth of mussels (*Mytilus galloprovincialis*) from Venica Lagoon, Italy. Marine Environmental Research **34 (1-2):** 69-76.

Received August 10, 2008
Accepted January 20, 2009

دراسة على سراستودرما جلوكوم كمؤشر حيوى للتلوث بالبترول فى بحيرة التمساح, قناة السويس, مصر

سامية محمد[1]، عائشة بلال[2]، نادية العجرودى[2]
[1]كلية العلوم، جامعة قناة السويس، بورسعيد، مصر
[2]المعهد القومى لعلوم البحار والمصايد، السويس، مصر

الملخص العربى

يعتبر التلوث بالبترول من الأخطار المستمرة التى تهدد البيئة الساحلية للكائنات البحرية ويظهر ذلك بوضوح فى اللافقاريات القاعية. ولذلك يهدف البحث الحالى الى توضيح تاثير المواد الهيدروكربونيه البترولية (TDDPHs) على السراستودرما جلوكوم (الرخويات ,ذات المصراعين) فى بحيرة التمساح. وقد تم اخذ العينات موسميا من موقعين خلال عام 2007 .وقد تم قياس (TDDPHs) بواسطة التحليل الاسبكتروفلورومیتر للنسيج الرخو والصدفة للسراستودرما جلوكوم, الماء بالاضافة الى عينات من التربة. و كذلك تم اجراء تحليل الكروموتوجرافى لتحديد الهيدروكربونات عديدة الحلقات (PAHs). وأظهرت النتائج أن الذكور تحتوى على TDDPHs أعلى من الاناث. كما كان تركيز TDDPHs فى النسيج الرخو أكثر منه فى صدفة الحيوان. و قد وجد إختلاف معنوى بين النسيج الرخو للحيوان وعينات التربة خلال المواسم و كذلك بين الموقعين.

وكان أعلى مستوى تركيز TDDPHs فى النسيج الرخوهو 21.3 ميكروجرام / جم قد تم تسجيله فى العمر الاول للحيوان بينما كان اقل تركيز هو 4.82 ميكروجرام/ جم و تم تسجيله فى العمر الخامس. كما تم حساب الارتباط بين TDDPHs وكلا من الحجم و العمر ووجد أنه إرتباط معنوى سالب. وبحساب معامل التركيز (CF) تم تسجيل أعلى نسبة فى التربة فى فصل الربيع وفى النسيج الرخو فى فصل الخريف. كما أوضح التحليل الكروموتوجرافى للغاز أن PAHs الذى تراكم فى النسيج الرخو كان من النوع ذو الوزن الجزيئى العالى (HMW) والذى له تأثيرضار جدا على الحيوانات البحرية. ولذا توصى الدراسة بمعالجة أى صرف قبل إلقائه فى البحيرة.