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The relationship between the concentrations of some heavy metals in the water of Abu-Qir Bay and within the tissues of the blue crab *Portunus pelagicus*

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ABSTRACT

The concentrations of heavy metals Cu, Cd, Pb, and Zn in the Abu-Qir water and in the edible portions of the inhabitant common invertebrate *Portunus pelagicus* were determined in the period (spring 2016- winter 2017). Generally, there was an increasing in the concentration of these measured elements comparing with the previous studies. The obtained data indicated a seasonal and spatial variation of heavy metals concentrations. The highest concentrations in the bay water were recorded during summer season, while spring showed the minimum values. On the other hand, the element levels in the crab tissue were the maximum during autumn and the minimum during winter, among the measured heavy metals Pb was the highest concentration element both in the water and in the animal tissues. It was noticed that the site located near the connection with Lake Edku (Lake-Bay connection) recorded the maximum readings which reveals the effect of the discharged water from the lake.

INTRODUCTION

Abu-Qir Bay is considered as an Estuary, it lies between 30º 5` and 30º 22` E, and 31º 16` and 31º 16` and 31º 28` N. It extends for about 63 km from El-Montazah in the west to Rosetta mouth of the Nile River in the east and extends northward to about 40 km in the Mediterranean Sea. The Bay maximum depth is 16 m, whereas its total surface area is about 360 km^2 with 4.3 km^3 a water volume. The Bay receives several types of pollutants inputs from various waste source categories discharged through three main gates namely; Boughaz El-Maddya (outlet of Lake Edku), the Rosetta estuary of the Nile River, El-Tabia pumping station, and (Shreadah and Tayel, 1992 and Abo-Taleb *et al*., 2017).

Heavy metals acquired through the food chain as a result of pollution are potential chemical hazards, threatening consumers. At low levels, some heavy metals such as copper, zinc, iron and manganese are essential for enzymatic activity and many biological processes. Other metals, such as cadmium, mercury, arsenic and lead have non known essential role in living organisms and are toxic at even low concentrations. The essential metals also become toxic at high concentrations (Al-Weher, 2008).

Seafood contains essential amino acids, fatty acids, protein, vitamins and minerals. Among seafood, fish (include crustaceans) are commonly consumed by human and, hence, are a connecting link for the transfer of toxic heavy metals. Heavy metals have the tendency to accumulate in various organs of marine organisms, which in turn may enter into the human metabolism through consumption causing serious health hazards (Puel *et al*., 1987). Fish is the major part of the human diet and it is therefore not surprising that numerous studies have been carried out on metal pollution in different species of edible fish. Industrial effluents, agricultural runoffs, transport, burning of fossil fuels, animal and human excretions, and geologic weathering and domestic waste contribute to the heavy metals in the water bodies. Heavy metals are critical in this regard because of their easy uptake into the food chain and bioaccumulation processes (Raja *et al*., 2009).

Consumption of fish is very popular among people around the world because it has high protein content, unsaturated fatty acids, and high omega fatty acids content. Processing steps may change the concentration of heavy metals in fish before consumption (Ganjavi *et al*., 2010). The variations of heavy metal concentrations in fish from different areas of the world may be possibly due to differences in metal concentrations, chemical characteristics of water from which fish were sampled, ecological needs, metabolism and feeding patterns of fishes and also the season in which studies were carried out (Bahnasawy *et al*., 2009).

To the better of our knowledge, little attention has been paid to study heavy metals pollution in the water and crustacean species caught from Abu Qir Bay which represent the main fishing area at the Egyptian Mediterranean Coast. So, the present study was designed to shed a light on the determination of some heavy metals in the bay water and in the inhabitant crustacean.

MATERIALS AND METHODS

Five sites were selected to cover the different prevailing conditions of Abu Qir Bay, site I located near Abu Qir head where site II located near El-Tabia pumping station and the factories region and site III located near Lake Edku while site IV is located at the open water of Abu Qir Bay and the site V is located at Nillson island in addition to another site as a control site located in front of Al-Maamoura. Samples were collected seasonally for one year during the period from spring (April) 2016 till winter (February) 2017 (Fig. 1).

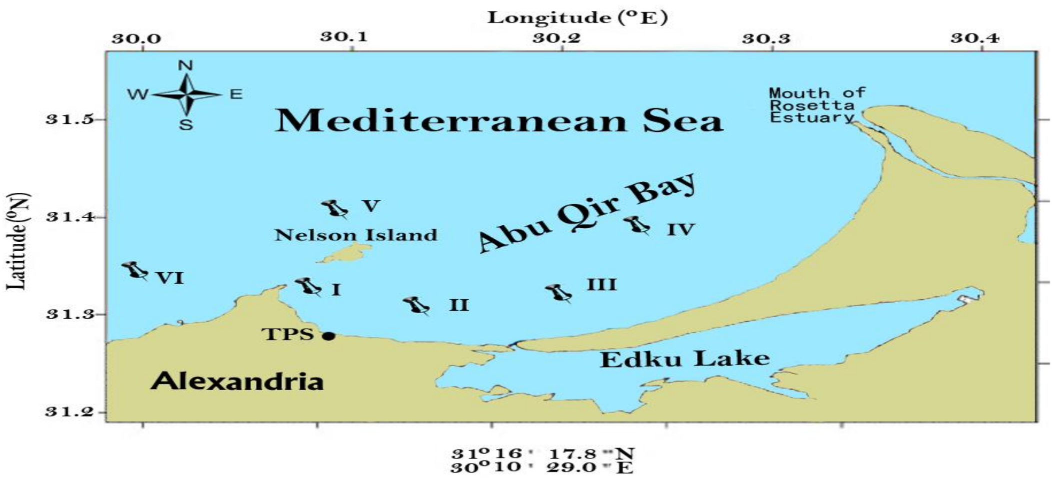

Fig. 1: Map showed the location of studied sites at Abu Qir Bay.

Sampling and heavy metals analysis:

Water:

Water samples were collected seasonally in triplicates (subsurface about 30 cm) from different sites during the period of investigation. A Van Dorn water sampler with capacity of 1.2 litters was used to obtain samples. After collection, water samples were kept in a cleaned poly propylene bottles for latter examination. The water analysis was performed according to the standard methods suggested by APHA (the American Public Health Association manuals 1999, 2005 and 2012) unless it's mentioned otherwise.

Heavy metals considered here were; Cu, Zn, Pb and Cd. Concentrations of heavy metals were determined after the digestion by nitric acid according to ASTM (1986) and APHA (2012). After collection of water samples, five ml of concentrated HNO_3 were added to one liter of each sample. Preserved samples were immediately stored in a refrigerator at approximately 4 °C for analysis. In the laboratory 20 ml of nitric acid was added to 500 ml of mixed sample in a beaker.

Samples were boiled slowly and evaporated on a hot plate to reach the lowest volume, before precipitation occurred or until completed digestion.

Digested sample was transferred to 100 ml volumetric flask and the wall of beaker was wash by deionized water and added to the volumetric flask and completed to 100 ml. Wash down beaker wall with distilled water and transferred to a 100 ml volumetric flask, cooled, diluted to mark and mixed thoroughly. Atomic absorption spectrometry (Varian AA240FS and AA240Z.) was used for measuring the optical density for each element at its corresponding wave length (Cu 324.8, Zn 213.9, Pb 217 and Cd 228.8 nm). The concentrations of heavy metals were measured according to the following equation:

Metal concentration µg/L = A*B/C

Where:

A = Conc. of metal in digested solution µg/L.

B = Final volume of digested solution, ml

C = Sample volume, ml

Organisms:

Specimens of common crab species (Figs. 2-4), were obtained seasonally from the bay, during the period from spring 2016 to winter 2017. The species were selected carefully to cover one of the commonly edible crabs in the bay. Gillnet, encircling net and line net were the main fishing methods used to collect this type of crabs. However, the crab specimens were transferred to the laboratory to confirm the identification according to. (Stephenson, 1972; Sere`ne, 1984; Moyse and Smaldon, 1990; Wee and Ng, 1995; Ng, 1998).

Crab samples were stored in prewashed polyethylene bags and transferred immediately to the laboratory in ice box at 4°C. In the laboratory, samples were dissected, then an exact weight of tissue (0.5 g) was placed in Teflon vessel and 5 ml of nitric acid (ultrapure) was added to soft organs. The vessels were tightly covered and allowed to predigest at room temperature overnight. Samples were digested on a hot plate at 100 °C for 2 hrs. then cooled at room temperature. If the solution was not clear, it was reheated for another 1 hr. at 100 ◦C. The samples were transferred to 25 ml volumetric flasks, before analysis, samples were filtered. All samples were analyzed three times for Cu, Cd, Pb, and Zn using flame atomic absorption spectrometry (model Varian AA240FS) according to the corresponding wave lengths (UNEP *et al*., 1984). Concentrations were expressed in terms of wet weight as microgram per gram according to the following equation:

Final Results (µg/g wet wt.) = conc. of element in digest solution (µg/L) x vol. of digest solution (mL).

Statistical analysis

Analysis of the obtained results was performed using MINITAP released 16 software program to find the correlation between different heavy metals in the water and inside the organism tissues.

RESULTS

Among all measured metals in the bay, led was the highest element in the water with an annual average being 17.51±4.88 µg/L followed by zinc (4.25±1.41 µg/L). The most ungenerous metal was cadmium (0.77±0.4 µg/L) annual average followed by copper being 1.43±0.61 µg/L (Figure 2A).

It was noticed that in the flesh of *Portunus pelagicus* zinc was progressed (13.22±6.55 µg/L) on lead that recorded 12.91±6.81 µg/L. On the other hand, in the organism tissue cadmium was also the lowest element in concentration of 1.54±1.42 µg/L, followed by copper that was 6.6±5.82 µg/L (Figure 2B).

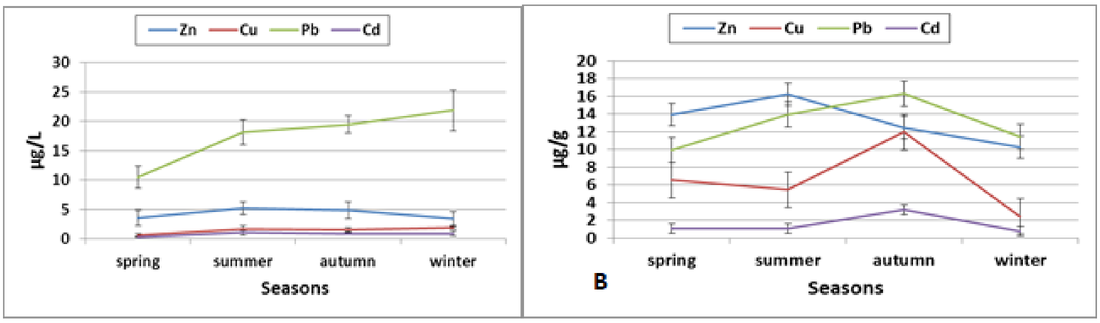

Fig. 2: Seasonal variation of the measured hevey metals (µg/L) at (A) Abu Qir Bay water, and (µg/g) at (B) flesh of *Portunus pelagicus*.

It was cleared that sites which were adjacent to coast line, near El-Tabia Pumping Station and the connection between Edku Lake and Abu Qir Bay, recorded the maximum annual average of heavy metals in water, where Sites II and III at the left and right of Lake-Bay connection showed maximum readings of zinc and copper (4.66 and 1.64 µg/L respectively). Site I in front of El-Tabia Pumping Station recorded the highest cadmium average value (1.09) among all sites. On the other hand, lead demonstrated a different trend where its peak was reported at Site IV but sites I and II were also in the second rank (Table 1)

Table 1: Annual average values of Heavy metals (µg/L) at the different studied sites

Site \ H.M	Zn	Cu	Pb	Cd
I	4.66 ±0.38	1.61±0.73	18.58±6.44	1.09±0.57
II	5.03±1.35	1.34±0.66	18.34±4.37	0.75±0.29
III	4.47±1.24	1.64±0.63	17.52±4.43	0.87±0.38
IV	4.53±1.5	1.28±0.24	19.85±5.65	0.69±0.27
V	3.73±1.96	1.46±0.66	15.88±4.87	0.78±0.33
VI	3.07±1.22	1.24±0.69	14.89±4.17	0.46±0.37

Heavy metals in Abu Qir Bay water

Zinc ions concentration (Zn):

Results revealed that, the maximum average value of zinc ion concentrations was recorded during summer (5.16 ±1.05 µg/L), it decreased during autumn (4. 84±1.42 µg/L) and reached its minimum value (3.45±1.21 µg/L) during winter.

Regarding all sites and seasons, its highest values occurred at sites II (6.73 µg/L) during summer followed by siteV during autumn (6.48 µg/L), site III (5.51 µg/L) during spring, and site I during winter (4.84 µg/L) respectively. On the other hand the lowest values were observed at site V during winter (2.07 µg/L), site VI in spring (2.297 µg/L), site VI in autumn (3 µg/L) and site V in summer (2.75 µg/L) (Figure 3 A).

Copper ions concentration (Cu):

The data indicated that, its average value recorded two peaks, one during winter (1.86 ±0.24 µg/L) and another during summer (1. 68±0.59 µg/L), its minimum value (0.60±0.20 µg/L) was recorded during spring, its highest values were noticed at site I (2.62 µg/L) during summer, site V during winter (2.13 µg/L), site III (1.99 µg/L) during autumn, and site IV during spring (0.91 µg/L) respectively. While the lowest values were observed at site VI (0.35 µg/L) during spring, site VI (1.02 µg/L) during summer. Site II (1.03 µg/L) during autumn respectively and site IV (1.41 µg/L) during winter (Figure 3B)

Lead ions concentration (Pb):

The average value of lead ion concentrations was the maximum during winter (21.88 ±3.45 µg/L); it decreased during autumn (19. 48±1.47 µg/L) and summer (18.17±2.11 µg/L) to record their minimum value (10.49±1.88 µg/L) during spring. Its highest values were recorded at site IV (26.13 µg/L) during winter followed by site I (21.47 µg/L) during autumn, site IV (20.86 µg/L) during summer, and site III (12.58 µg/L) during spring respectively. While, the lowest values were observed at site VI (0.35 µg/L) during spring, site VI (1.02 µg/L) during summer. Site II (1.03 µg/L) during autumn and site IV (1.41 µg/L) during winter (Figure 3C)

Cadmium ions concentration (Cd):

The average cadmium ion concentration was the maximum during summer (1.04 ±0.37 µg/L), it decreased during winter and autumn (0. 868±0.42 µg/L, 0.864±0.18 µg/L respectively), and reached its minimum value (0.31±0.08 µg/L) during spring.

Site I during summer, V during autumn, and III during winter and spring showed the highest values of cadmium ion concentrations (1.78, 1.11, 1.25; 1.25 and 0.40 µg/L respectively). Otherwise, the lowest values were observed at site VI (0.12 µg/L) during winter, site VI (0.18 µg/L) during spring, site VI (0.60 µg/L) during autumn and site II (0.77 µg/L) during winter (Figure 3D).

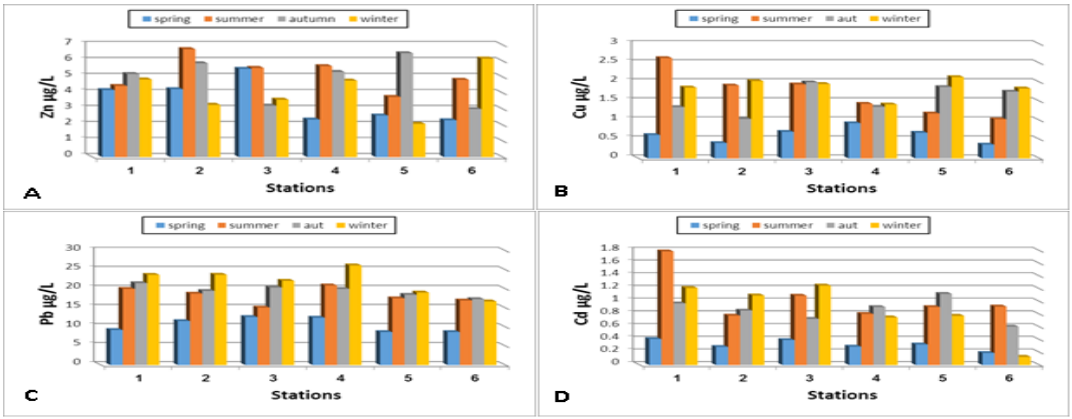

Fig. 3: Seasonal variation in the studied heavy metals (µg/L) at Abu Qir Bay water.

Concentrations of heavy metals in the edible portions of *Portunus pelagicus*

Zinc ions content:

Results revealed that, its maximum average value was recorded during summer (16.21±8.2 µg/g) followed by spring (13.96 ±6.18 µg/g), while the minimum value was during winter (10.26±7.40 µg/g). Regarding all sites and seasons, its highest values were recorded at site V (27.43 µg/g) during summer, followed by site I (20.06 µg/g) during winter, while the minimum was recorded at site IV (4.28 µg/g) during winter. (Figure 4)

Copper ions content:

The highest average readings were recorded during autumn (11.97±6.51 µg/g) followed by spring (6.54 ±5.71 µg/g), while winter showed the minimum value (2.43±0.68 µg/g). The highest values of copper ion in the edible portion was recorded at site II (19.36 µg/g) during autumn, followed by site I (15.01 µg/g) during summer, while the minimum values were recorded from specimens obtained from site IV (1.43 µg/g) during spring. (Figure 4)

Lead ions content:

Its maximum average value was recorded during autumn (16.29±4.06 µg/g) followed by summer (13.98±9.13 µg/g), while the minimum value was reported during spring (9.94±4.89 µg/L). Specimens which collected from site VI (24.59 µg/g) during summer demonstrated the highest values of led ion concentrations, followed by that from site III (21.12 µg/g) during autumn, while the minimum was recorded from site s IV and III (1.43 µg/g) during spring and summer respectively. (Figure 4).

Cadmium ions content:

Specimens showed that, specimens that collected during autumn appeared the highest average value of cadmium concentrations (3.17±1.8 µg/g) followed by that collected during spring (1.09 ±0.89 µg/g), while the minimum average value was during winter (0.79±0.44 µg/g). With regard to the site s, the highest value was recorded at site I (5.79 µg/g) during autumn, followed by site VI (2.57 µg/g) during summer, while the minimum was recorded at site VI (0.26 µg/g) during winter. (Figure 4).

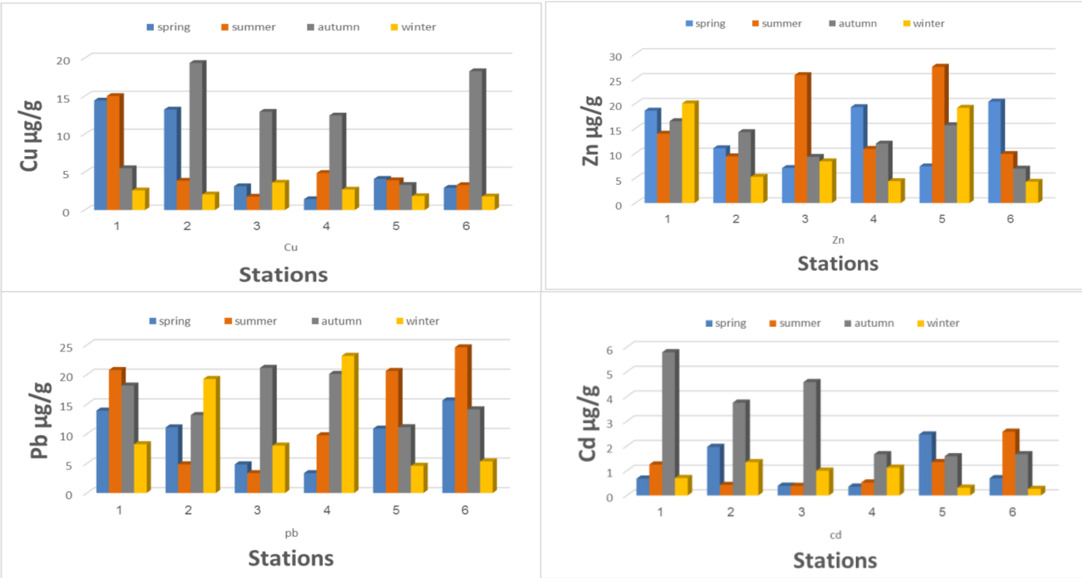

Fig. 4: Seasonal variation in heavy metals (µg/g) in the studied Crab tissues

Statistical analysis

Analysis of correlation matrix showed that, in the bay water, at P-Value ≤0.05 cleared a strong correlation between cadmium and copper (r= 0.71); cadmium and lead (r=0.67) in addition to the correlation between lead and copper (r= 0.69). While inside the crab tissues cadmium was correlated with copper (r= 0.40), and lead (r: 0.52). No correlation was found between the change in heavy metal content in the bay waters and within the blue crab tissue.

DISCUSSION

Generally, the studied crab can magnify copper in its tissue to more than 4.5 times, while zinc was magnified three times more than in the surrounding water and cadmium two times. While zinc concentration in the animal tissues was lower than in the bay water. Heavy metals are natural trace components of the aquatic environment, but their levels have increased due to industrial wastes, geochemical structure, agricultural and mining activities (Kalay and Canli, 2000). Contamination of soils, sediments, water resources and biota by heavy metals is one of major concern especially in many industrialized countries because of their toxicity, persistence and bio-accumulative nature (Ikem *et al.*, 2003). Trace metals such as copper and zinc play an important biochemical role in the life processes of some aquatic plants and animals but when they present at high concentrations they become toxic (Kotickhoff, 1983).

Water quality analysis is used to describe the environmental condition of any water body (El-Feky *et al*., 2018; Ashour *et al*., 2018; El Raey and Abo-Taleb, 2019). The change in water quality affects all aquatic organisms; from microorganisms to large creatures (AboTaleb, 2019).One of the most important methods in water quality determination is a heavy metal analysis. In the current study, most measured heavy metals in the bay water showed decreasing during spring, this may be due to the high eutrophication condition of the water along the Egyptian Mediterranean coast (Dorgham, 2011; Abou Zaid *et al*., 2014; Abo-Taleb *et al*., 2015, 2016), a spring flourishing of phytoplankton and other aquatic plants (Sverdrup, 1953) may absorb the minerals including heavy metals from the water and store it inside their bodies.

There was a summer peak for most of the measured metals, this may be as a result of metals releasing from the bottom layer to the water where the high temperature induce the deposits to decompose (El-Serafy *et al*. 2003a and El-Ewa *et al*. 2007).

Data showed that sites that lie adjacent to coast line near the Lake-Bay connection recorded the highest readings. Different locations and seasons have an effect on heavy metals content in fish samples (Gomaa, 1995). Cadmium is a toxic element, which occurs naturally in fish, sediment and water, and exists along with zinc in nature. It is non-essential biological function (Irwin *et al.,* 1997). Results showed that, the highest value of cadmium ion concentration (1.78 µg/L) was recorded during summer at site I and the lowest was observed at site VI (0.12 µg/L) during winter. This may be due to the distribution patterns of heavy metals in the water to the hot seasons (spring and summer) as a result of release of heavy metals from sediments to the overlying water under the effect of high temperature, winds and fermentation process resulted from decomposition of organic matter. El-Serafy *et al*. 2003a and El-Ewa *et al*. 2007).

Copper plays very important role in the water quality. It occupies the third abundant metallic element in the human body followed by iron and zinc (APHA, 1992). The concentration of copper ion in the water of Abu Qir bay was peaked at site I during winter (2.62 µg/L), this may be due to the highly amount of industrial discharge near to this site that located in front of El-Tabia pumping station . However, the lowest value was detected at the control site VI during spring (0.35 µg/L) This site located away from the bay and characterized by water with high quality

According to Ghallab (2000) the toxicity of lead depends mainly on pH values, water hardness, organic matter and the presence of other metals. The present data revealed that, the highest value of lead ion concentration (20.68 µg/L) was recorded during winter and summer at site IV. However, the lowest value (8.63 µg/L) was detected at site V during spring which is located at the farthest point in the bay, That may be due to the bay receives agricultural drainage water from the coastal Lake Edku through the narrow channel El-Maadya (about 200 m long and 2 m deep) and the annual average of discharged water is about $1000*10^6$ m^3 (Saad and Younes, 2006). In addition, freshwater discharged to the bay through Rosetta mouth at the extreme eastern edge was about $1.2*10^6$ m^3/d (Faragallah, 2004), and also the attributed to the decaying of plankton and precipitation of organic matter associated with lead to the sediments (Al-Helaly, 2010; Abdel-Ghani, 2010 and Masoud *et al*., 2010)

Among several heavy metals, zinc was chosen in the present study because it is an essential metal to all forms of the life as well as a large number of diseases and congenital disorders had been trading to zinc deficiency. Also it is widely used as skin ointment in the form of zinc oxide (Sader, 1991). It involved in nucleic acid synthesis and occurs in many enzymes. Zinc occurs in nature together with other metals such as iron and cadmium (Dallas and Day, 1993). Although zinc is an essential element for aquatic life, but high concentration of this metal may exceed this requirement and the detoxification mechanisms for the animal may be insufficient to cope with the influx, the zinc will then exert a direct toxic action (Lioyd, 1992). The data of the present study showed that, zinc ion concentration in the surface water of Abu Qir Bay was peaked at site II during summer (6.73 µg/L), this site lies in front of the Lake-Bay connection where the effect of the discharged Edku Lake water that mixed with agricultural wastes, sewage and domestic effluents (Abo-Taleb *et al*.,

2017) will be very obvious, this will causes zinc concentrations increasing at this site. However, it was declined at the farthest site (St. V) during winter (2.07 μg/L), that located away from the effect of land runoff and the direct water discharge in to the bay.

Several studies were conducted on the aquatic organisms along the Egyptian Mediterranean water (Abo-Taleb *et al*., 2017; Farrag *et al*., 2019). According to (Akel 2005 and Saadia *et al*., 2011) *Portunus pelagicus* is very common in Abu Quir Bay and the surrounding Mediterranean water. Aquatic animals can accumulate the metals by ingestion of particulate materials suspended in the water, ingestion of food and adsorption of tissue (Hassouna, 1989). Some heavy metals are essential for the different metabolic processes, but they are highly toxic for aquatic organisms and their consumers when exceeding the recommended safety levels (Glubokov, 1990 and Zaghloul, 2000). No correlation was found between the change in heavy metal content in the Gulf waters and within the blue crab tissue. This makes sense, perhaps because crabs are benthic organisms that deposit feeders, as well as being a motile organism that does not exist in a fixed place; this makes it unstable affected by the change in the content of heavy metals in water in a particular place. Cadmium could be harmful to living organisms (Ambedkar and Muniyan, 2011). Cadmium was recorded in relatively considerable values in the tissues of *Portunus pelagicus* ranged between 0.27 and 5.79 ±1.42 μg/g, the lowest value was observed at the specimens collected from the control site (VI during winter) which is lies a way from all discharge sources and considered as the highest quality site, while the highest readings (5.79 μg/g) were recorded at the specimens collected from site I that located in the front of El-Tabia Pumping station that reflects the toxic effects of its discharged water on the aquatic organisms. The results of total Cd content in *Portunus pelagicus* obtained in the present study are higher than those reported by Saadia *et al*. (2011) who records 4.57, 4.34, 5.81 and 5.67 mg\kg during winter, spring, summer and autumn respectively. This may be attributed to the studied species and the location in which these species were collected, also this reflects the descending of the environmental condition and water quality of the bay.

Although, copper is highly toxic to aquatic organisms; its compounds are used in fish culture and fisheries as algaecides, and in the prevention and therapy of some fish diseases (Svobodova *et al.,* 1993). The studied crab tissues that collected during the autumn season contained high concentrations of copper (19.36 μg/g) in site II in front of Lake-Bay connection, while the lowest concentrations were listed during the spring (1.43 μg/g) in site IV, the copper values in the present study are higher than the previous ones such as what reported by Saadia *et al*., (2011) who records 132.07, 109.82, 106.72 and 137.69 mg\kg during winter, spring, summer and autumn respectively.

Lead has been a particular important due to its toxicity and ability to accumulate in aquatic ecosystems, as well as persistence in the natural environment (Miller *et al*., 2002 and Anim *et al*., 2011). There are some poisoning effects include deficiency in cognitive function due to destruction of the central nervous system, abdominal pain and discomfort, decreasing fertility, formation of weak bones as lead replaces calcium and causes anemia due to the reduction of enzymes concerned with synthesis of red blood cells (Lars, 2003 and WHO, 2008). Results showed that, the highest value of lead ion concentration in the muscles portion of *Portunus pelagicus* (24.59 μg/g) at site IV during summer, while the lowest value (3.34 μg/g) was detected during spring at site IV, and site III during summer , this may be due to this species is benthic which may be affected by sediment that plays a very important role in physicochemical and ecological dynamics; any changes in toxic concentrations of heavy metal residues on the sediments will affect the natural aquatic life (Jumbe and Nandini, 2009) . Aquatic animals can accumulate the metals by ingestion of particulate materials suspended in the water, ingestion of food and adsorption of tissue (Hassouna, 1989) also it can move from site to another.

Zinc is one of the most abundant essential trace elements in the aquatic organisms. It is a constituent of all cells and several enzymes depend upon it as a co-factor (Forstner and Wittmann, 1983). The edible portions *Portunus pelagicus* during the autumn contained the highest zinc concentrations (27.43 µg/L) at site V, while the lowest concentrations were recorded during the winter (4.28 µg/L) at site IV.

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ARABIC SUMMARY

العلاقة بين تركيز بعض المعادن الثقيلة في مياه خليج أبو قير وداخل أنسجة السلطعون الأزرق(*Portunus pelagicus*)

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تم تحديد تركيزات المعادن الثقيلة Cu و Cd و Pb و Zn في مياه خليج أبو قير وفي الأجزاء الصالحة للأكل من اللافقاري الشائع *Portunus pelagicus* القاطن بالخليج وذلك خلال الفترة من ربيع ٢٠١٦ وحتى شتاء ٢٠١٧. بصفة عامة، لوحظ خلال الدراسة الحالية أن هناك زيادة في تركيز تلك العناصر المقاسة مقارنة مع الدراسات السابقة. وأشارت البيانات التي تم الحصول عليها إلى وجود اختلاف موسمي ومكاني واضح لتركيزات تلك المعادن الثقيلة المقاسة. سجلت أعلى التركيزات لتلك العناصر في مياه الخليج خلال فصل الصيف، بينما أظهر الربيع الحد الأدنى لقيم تركيزات العناصر. من ناحية أخرى، سجلت أعلى تركيزات لمعادن الثقيلة في نسيج السلطعون الأزرق خلال موسم الخريف وأقلها خلال فصل الشتاء، وأظهرت النتائج أن الرصاص Pb هو العنصر الأعلى تركيزا في مياه الخليج وفي أنسجة الكائن من بين جميع المعادن الثقيلة المقاسة. وقد لوحظ أن الموقع الواقع بالقرب من منطقة الاتصال مع بحيرة إدكو قد سجل أقصى القراءات فى تركيزات تلك المعادن مما يوضح مدى تأثير المياه المفرغة من البحيرة على تغير الخصائص الطبيعية داخل الخليج.