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The Mollusk Gastropod *Lanistes carinatus* (Olivier, 1804) as Abiomonitor for Some Trace Metals in the Nile River

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Abstract: The fresh water gastropod *Lanistes carinatus* was tested to be used as potential biomonitor for the trace metals, Copper, Cadmium and Lead. Some chemical and biological measurements were sampled and measured in two consecutive years 2005 and 2006 in different stations from Damietta Branch of Nile River. Cu level in water not detected in all investigated sites, while concentrations of Cd and Pb in water and the concentrations of Cu, Cd and Pb in sediment varied in different stations. It was found, metals concentrations were higher in sediment than those of water because sediments are important sinks for various pollutants like pesticides and heavy metals. The levels found for determined metals in water and sediment in the area are below of the permissible limits that set by the United States Enviroumental Protection Agency (EPA) except some deviations in managements of water especially at Kafr Saad. Concentrations of these metals in soft tissues of gastropod *Lanistes carinatus* were higher than those of sediment and vary widely in different sites suggesting that this gastropod accumulate these metals and consequently would be of use for monitoring. The population density of *Lanistes carinatus* decreased sharply opposite to discharge point of Electric Plant of Talkha and Kafr Saad. This may be due to thermal pollution of the plant. The study suggested the use of *Lanistes carinatus* as Cu, Cd and Pb biomonitor in nature and also recommended a construction of closed cycle for cooling water of the power stations to prevent heated water from being discharged into the River and also controlling the discharge of wastes and industrial effluents into Nile.

Key words: Trace metals, sediment, gastropod, *Lanistes carinatus*, Copper, Cadmium, Lead, River Nile, biomonitor

INTRODUCTION

The use of mollusks for the biomonitoring of heavy metals is advantageous since they can be a biomonitoring agent of the bioavailability and contamination of heavy metals (Yap *et al.*, 2006a, b; Yap *et al.*, 2009). Even though mollusks generally fulfill the criteria to be good biomonitoring such as being sedentary, hardy and tolerant to high concentration of pollutants, easy to identify and having enough tissues for metal analysis (Philips, 1980; Gay and Maher, 2003), metals accumulated in the soft tissues could be affected by many biotic and a biotic factors apart from pollution (Yap *et al.*, 2006a, b).

There are numerous types of pollutants found in aquatic enviroument. The main natural source of heavy metals in waters is weathering of minerals (Kotas and Stasicka, 2000), human activities have greatly increased the fluxes of many potentially toxic trace metals to aquatic ecosystems (Nriagu and Pacyna, 1988). For example, such that the majority of Cd, Cu, Pb present in many impacted envirouments derives from anthropogenic sources (Faris *et al.*, 1998). Heavy metals have a great ecological significance due to their toxicity and accumulative behavior. The concentration of fresh waters with a wide range of pollutants has become a matter of great concern over the last few decades not only because of the threat to public water supplies, but also with of the damage caused to aquatic life.

Sediment represents, quantitatively, the major compartment for metal storage in aquatic environments. Although, the total metal concentration in sediment give a convenient measure of their metal contamination, such measure do not necessarily predict the toxicity of these contaminants to aquatic organisms. The ecotoxicological risk by contaminated sediment will depend on metal availability as well as of the ability of living organisms to assimilate metals (Amiard *et al*., 2007; Gardoso *et al*., 2009).

The present study aimed to determine if *Lanistes carinatus* showed promise as biomonitor of trace metals (Cu, Cd and Pb) in the Nile River and its relation with concentrations of the same metals in the ambient sediment and water and the effect of thermal pollution on the population density of *Lanistes carinatus*.

MATERIAL AND METHODS

Sampling

Water, surface sediments and selected gastropod (*Lanistes carinatus*) were sampled from Damietta branch of Nile River during summer 2005 and summer 2006.

In 2005, samples were collected from three stations at Talkha region (about 123 km North of Cairo):

(1) Before Talkha Electric Power Station with about 4 km upstream of discharge point of the Power (BEPS).
(2) Opposite to discharge point of Talkha Electric Power Station (OEPS).
(3) After Talkha Electric Power Station (about 5 km North of the power) (AEPS) (Fig. 1).

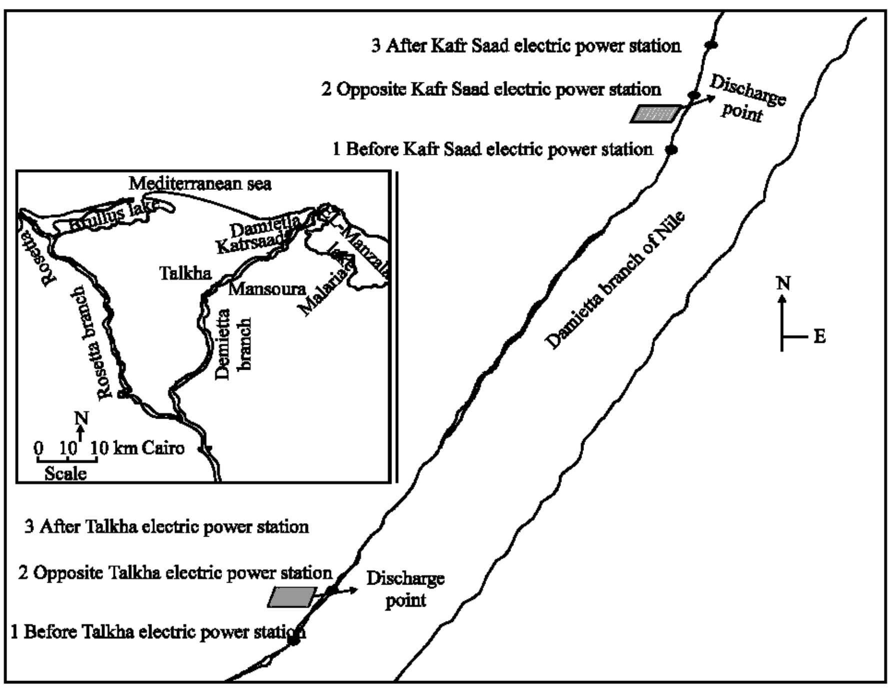

Fig. 1: Schwmatic diagram showing the sampling stations. Map of Damietta and Rosetta branches of the Nile River showing sampling arera

In 2006, samples were collected from six stations, the previous stations of Talkha region beside to another three stations at Kafr Saad region (about 210 km North of Cairo):

(1) Before Kafr Saad Electric Power Station with about 4 km upstream of discharge point of the power (BEPS).
(2) Opposite to discharge point of Kafr Saad Electric Power Station (OEPS).
(3) After Kafr Saad Electric Power Station with about 5km north of the power (AEPS) (Fig. 1).

Procedures

Water samples were collected at each site in a pre washed polyethylene bottle. The samples were preserved immediately with 5 ml of concentrated nitric acid and stored in a refrigerator until determination of heavy metals. Heavy metals were determined by Atomic Absorption Spectrophotometer (Perkin Elemer 2380).

Sediment samples were collected by Ekman Grab, they were dried, ground and digested according to Kouadio and Trefry (1987). Heavy metals were determined by Atomic Absorption Spectrophotometer (Perkin Elemer 2380).

Gastropod samples were isolated from sediment and its population density (organisms m^{-2}) was estimated and transport separated to the laboratory and hold in Nile water for approximately 48 h to defecate their gut contents. The soft tissue of about 2 to 7 individuals of a given species from each site were isolated and placed on a piece of acid washed Teflon sheet for drying and weighing. Dried gastropod was separately digested in concentrated nitric acid. Digestion was carried out in Teflon in microwave oven at 120°C for 4 h. Cooled, digested samples were diluted to100 mL volume with deionized water. Cu, Cd and Pb concentrations in the animal tissue were measured by the same apparatus.

Quality Assurance

To avoid possible contamination , all the glass ware and equipment used were acid -washed and the accuracy of the analysis was checked using the standard addition testing procedural blanks and quality control samples made from standard solutions with 1000 ppm stock solutions for Cu, Cd and Pb were analyzed every one sample in order to check for sample accuracy.

Statistical Analysis

The relationships between the different studied metals in sediment, water and gastropod were assigned by computing the correlation coefficients (r) using Microsoft Excel 2007.

RESULTS AND DISCUSSION

Population Density of *Lanistes carinatus*

The average Population density (P.D.) of *Lanistes carinatus* was 44 and 29 organisms m^{-2} in stations 1 (upstream of discharge point of electric power stations of Talkha and Kafr Saad, respectively, during summer 2006 when the average temperature was 28 and 28.8°C. At discharge points of plants, the gastropod was very rare or disappears like other mollusks, so more than ten grabs were captured to get one or two individuals for measuring investigated metals. This was attributed to the raise in water temperature (37°C) as a result of the discharge of warm water from electric power stations at these sites. This agree with Fishar *et al.* (2003), who stated that Mollusca decreased sharply opposite to discharge point of Shoubra El Kheima Electric Power Plant and attributed that to the thermal pollution. At stations 3 North of discharge points of Talkha and Kafr Saad Electric Power Stations (the average temperature were 28.7 and 28.3°C, respectively), the P.D. of the gastropod increased where it reached 59 and 44 organisms m^{-2} respectively, during summer 2006.

Copper

In Water

Copper was undetectable level in summer 2005 and summer 2006 in all investigated stations. This drop in Copper content may be attributed to the removal of Copper from water column mediated by the decay of the plankton, or due to adsorption on the suspended matter or the complexion with the organic matter leaving the water body to the sediments as reported in Meuse River flowing through France, Belgium and Holand (Nather-Khan and Lim, 1991). This also agree with the result of Elewa *et al.* (1996), who recorded undetectable level of Cu in the River Nile water at Aswan and Edfu in July and at Qena, Sohag and Assuit in April and attributed that to the precipitated of Cu to the sediment and to the temperature effects in the dynamics of Copper in water enviroument which may be attributed to the uptake of Cu by littoral plants as the temperature is raising in the spring and summer and the libration of the element into the water as the temperature fall and the plants decay in the autumn. Ghallab (2000) attributed this undetectable levels of Copper to the uptake of phytoplankton or to dilution effect of flood period during this season.

Massoud *et al.* (1994), Radwan (1994), Elewa *et al.* (1995), Gomma (1995), Abdel Satar and Elewa (2001), Abdo (2002), El Haddad (2005) and Al-Afify (2006) reported great variation in Cu concentrations in Nile water or its branches. Cu values reported by above mentioned authers ranged between 0.0- 4400 mg L^{-1}.

In Sediment

Cu concentration values in sediment are given in Fig. 2a. In Talkha stations, during summer 2005, Cu concentrations (ranged from 3.7 to 16.74 mg kg^{-1} dry weight) were higher than the corresponding values of the same stations in summer 2006 (ranged from 0.2 to 1.52 mg kg^{-1} dry weight).

The lowest value was recorded at station 2 (Opposite Electric Power Station of Talkha. Comparing with Talkha sites, Copper was high at Kafr Saad stations during 2006. At station 1 (before Kafr Saad Electric Power Station), Copper concentration in sediment was 12.68 mg kg^{-1} and it decreased sharply opposite of Eelectric Power Station and increased again after the Electric Power Station.The highest concentration values were recorded in station 3 (after Electric Power Station of Talkha during 2005) and station 1 (Before Kafr Saad Electric Station). This means that anthropogenic contribution to heavy metals (Issa *et al.*, 1996) stated that Copper concentrations in the Nile River sediment are in the ranges of 84-452 mg kg^{-1} in July. Elewa *et al.* (1997) recorded Cu concentration in the Nile sediment ranges 5.84-141.56 mg g^{-1} in August. Abdel Gawad (2001) recorded 70 mg kg^{-1} of Cu in the sediment of the Nile at Helwan region. Present results did not exceed the range of Cu recorded by the previous investigators on the Nile sediment.

In *Lanistes carinatus*

Copper concentration in the soft tissue of *Lanistes carinatus* varied widely in different stations. The highest value of Copper (1530.86 mg kg^{-1} dry weight) was recorded in organisms collected at station 3 (after electric power station of Talkha during summer 2005), but the lowest value of Copper (330.77 mg kg^{-1}) was recorded in the organisms collected from station 1 at Kafer Saad (Before Electric Power Station) in summer 2006 (Fig. 2b).

The concentration of Cu in the organisms were very high if it compared with the concentration of Cadmium or Lead, this may be Cu is considered to be essential while Cd and Pb are non essential and can even be toxic although they are consistently present in human tissue (Howe-Grant *et al.*, 1980). The difference in the concentrations may be a typical example of difference between non essential metals and essential metals (White and Rainbow, 1982; Rainbow, 1988). Cu is essential for growth and development of many species of aquatic organisms, but its rate and extent of bioaccumulation and retention are modified by many biological and biotic variables (Eisler, 2000). Gastropods like several other groups of mollusks and arthropods normally accumulate and store Cu and use it in the synthesis of haemocyanin, a blood pigment (Betzer and Tevich, 1975).

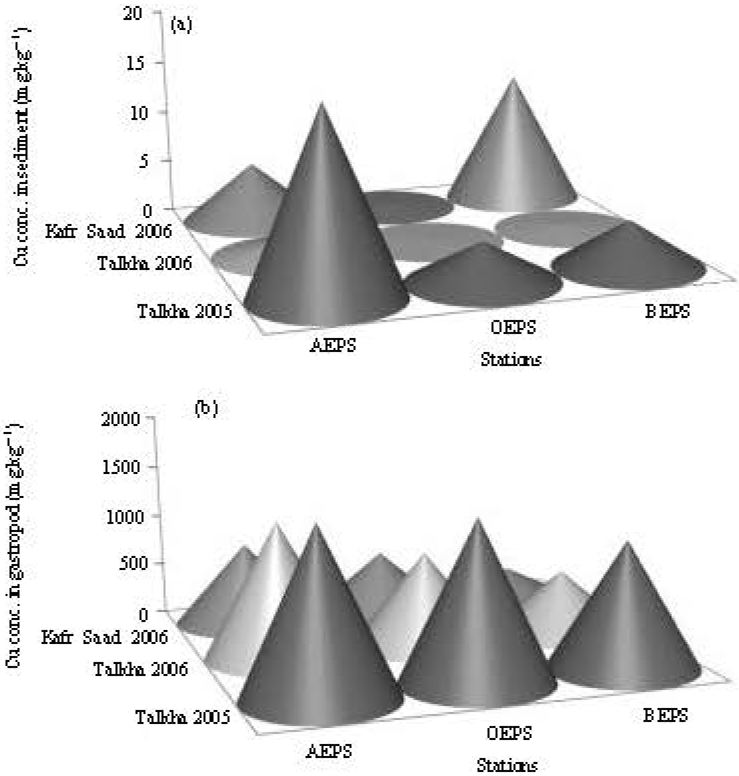

Fig. 2: Mean concentrations of Cu in (a) sediment and (b) gastropod from different stations during the period of study

There is variation in the bioaccumulative capacity of soft tissue as it does not follow the higher concentrations of Cu found in the environmental medium (sediment). In this study, a very weak correlation ($r = 0.17$) between Cu concentrations in sediment and its concentrations in the gastropod was calculated. Adewunmi *et al.* (1996) found Cu concentration in the fresh water gastropod *Lymnaea natalensis* collected from Owena-Ondo dam in Southwestern Nigeria was 2352 mg kg^{-1} in May and attributed that to contamination at the site from pesticides namely Copper Sulphate used by Farmers as fungicides. These fresh water snails feed on periphytic growth on aquatic plants, stones, mud surface and various objects, decaying parts of aquatic plants, fine organic particles and animal remains.

Cadmium

In Water

Generally, Cadmium concentration in the Nile water fluctuated between 0.016 and 0.011 mg L^{-1} in summer 2005 at Talkha stations and increased in the water in the same stations (between 0.1-0.12 mgCd L^{-1}) during summer 2006. It was between 0.05- 0.11 mg L^{-1} at Kafr Saad stations in summer 2006 (Fig. 3a). These results were high if it compared with some previous results. Hamed (1998) stated that Cadmium concentration in the Nile water ranged between 1.71-5.1 µg L^{-1} and its mean was 3.07 µg L^{-1} also Elewa *et al.* (1996) measured Cadmium concentration in the Nile water in July, it was between 6-38 µg L^{-1} and the mean concentration was 23.4 µg L^{-1}. Cadmium may enter water as a result of industrial discharge of deterioration of galvanized pipe (APHA,1995). Cd

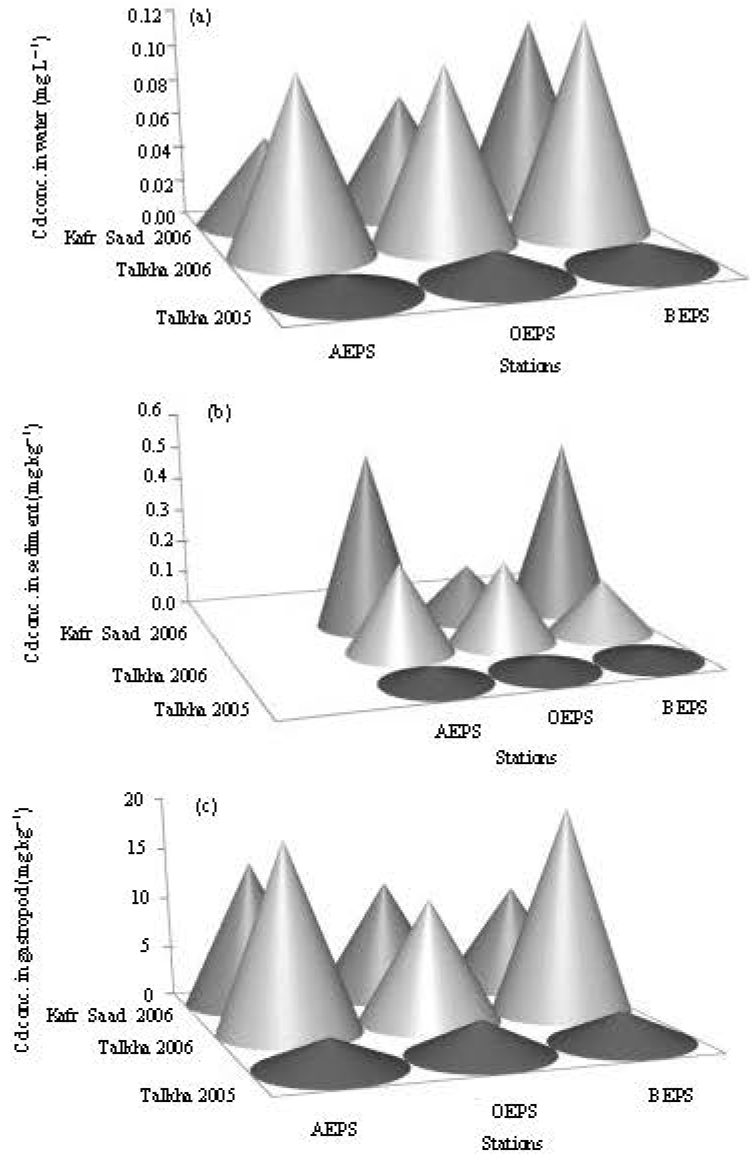

Fig. 3: (a) Mean concentration of Cd in water (b) Sediment and (c) gastropod from different stations during the period of study

concentration of the River depending on the quantity of sewage discharges inflow to the River (Issa *et al*., 1996). Present results agree with that of Massoud *et al*. (1994), Radwan (1994), Elewa *et al*. (1995), Gomaa (1995), Abdel Satar and Elewa (2001), Abdo (2002), El Hadad (2005) and Al-Afify (2006) who reported great variation in Cd concentrations in Nile water or its branches ranged from ND-156 mg L^{-1}, while the ECS (1994) recommended the value of 10 mg Cd L^{-1}. The Cd concentration in the present study was between 0 .016 and 0.12 mg L^{-1} in the whole area.

In Sediment

Cd concentrations in the Nile sediment were 0.032, 0.04, 0.048 mg kg^{-1} dry weight in summer 2005 at Talkha stations while they were 0.16, 0.24, 0.26 mg kg^{-1} dry weight in summer 2006 at the same stations, respectively .This means that concentrations of Cd increased in summer 2006 than those of 2005 (Fig. 3b). This may be due to the increase of sewage and effluents discharge into Nile. In Kafr Saad stations, generally, Cd concentrations in sediment were higher than those of Talkha stations (ranged between 0.16 and 0.52 mg kg^{-1} dry weight) this may be due to, concentration of metals in the River increased from South to North. Issa *et al.* (1996) stated that Cadmium concentrations in Nile River sediment were in the ranges of 28-52 μg g^{-1} in July. Elewa *et al.* (1997) recorded that Cd concentration ranged between 1.01-4.36 μg g^{-1} in August and Abdel Gawad (2001) stated that Cd concentration in the sediment of Nile was 7.0 mg kg^{-1} at Helwan region.

In *Lanistes carinatus*

Cd concentrations in soft tissue of *Lanistes carinatus* was in contrary of Cu concentration, this means that their values were low in the organisms collected in summer 2005 (ranged from 2.84 to 3.28 mg kg^{-1} dry weight) from Talkha stations and increased in the organisms which collected in summer 2006 at the same stations (ranged from 12 to 20 mg kg^{-1} dry weight) (Fig. 3c). Generally, it was found, Cd concentrations in gastropod have the same trend of its concentrations in sediment, there was a positive correlation ($r = 0.49$) between Cd in sediment and its concentration in the snail. Adewunmi *et al.* (1996) recorded concentration of Cd was 31.6 mg kg^{-1} in fresh water gastropod *Bulinus globosus* sampled at Owena-Jesa dam in southwestern Nigeria in April.

Lead

In Water

Lead concentrations in the Nile water fluctuated between 0.015-0.02 mg L^{-1} in summer 2005 and increased in summer 2006 when it ranged between 0.3-0.6 mg L^{-1} in the investigated area. There was not big difference in Lead concentrations in water at Talkha stations and Kafr Saad stations during summer 2006 (Fig. 4a). Our results disagree with Hamed (1998) who stated that Lead concentration in the Nile water ranged from 3.96 to 10.0 μg L^{-1} and its mean was 6.96 μg L^{-1} in summer and agree with many authors (Massoud *et al.*, 1994; Radwan, 1994; Elewa *et al.*, 1995; Gomaa, 1995; Abdel Satar and Elewa, 2001; Abdo, 2002; El Hadad, 2005; Al-Afify, 2006) who reported great variation in Pb concentrations in Nile water ranged between (ND-1100 mg L^{-1}) and the present study estimated between (0.015 and 0.6 mg L^{-1}), while the ECS (1994) recommended the value of 50 mg L^{-1}. Lead in water supply may come from industrial, smelter and mine discharges from the dissolution of old lead plumbing (Jordao *et al.*, 1996). Also, Lead enters from domestic water, leaching of marine points which are maiuly of air dust, in addition to several industrial wastes, produced from metal electrophating, battery production and petrol combustion (Nessim, 1994) and from cars exhaust emissions, the possible chemical/biological methylation of inorganic Lead in anaerobic sediments (Sadiq, 1992).

In Sediment

Lead concentrations in the Nile sediment have the same trend of Cd in sediment, it increased in summer 2006 than those of summer 2005. Lead concentrations in sediment ranged from 0.026 to 2.4 mg kg^{-1} dry weight in the whole area of investigation during the period of study (Fig. 4b). It Was found that, Lead concentration values were higher than the corresponding values of Cd at investigated stations. This agree with the results of Elewa *et al.* (1997) and Abdel Gawad (2001) in River Nile and Hamed and Emara (2006) in the Gulf of Suez.

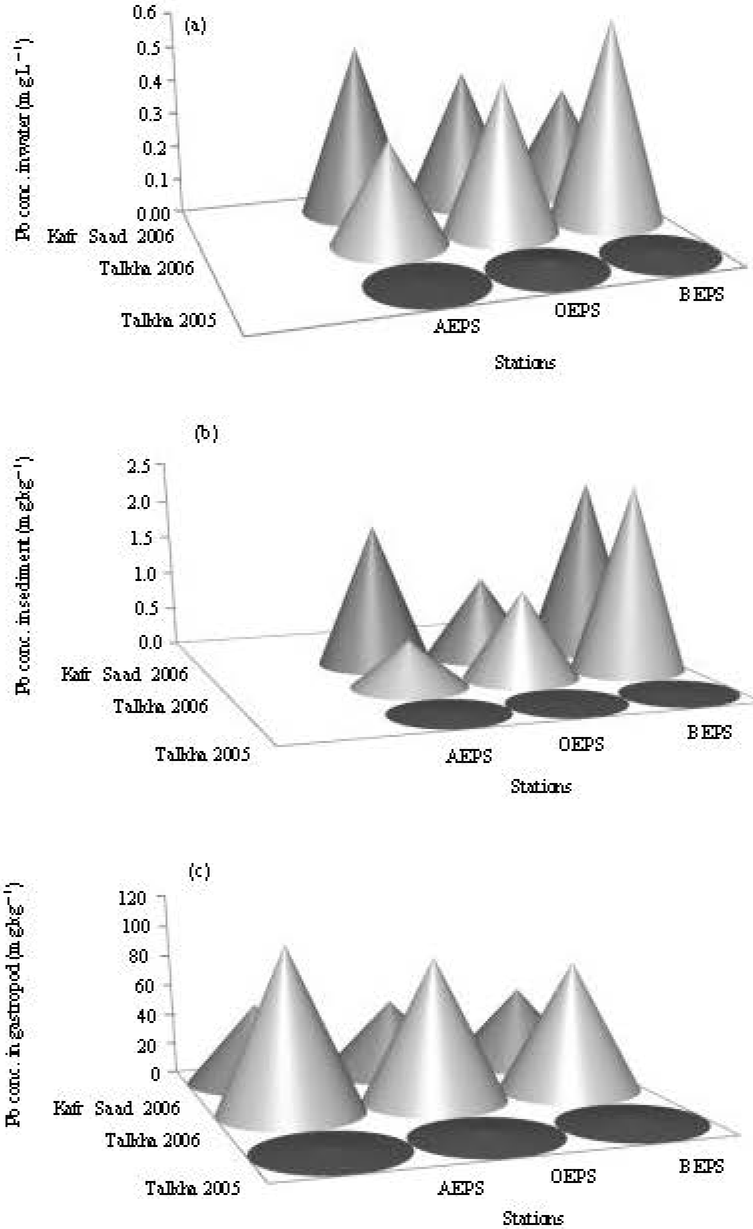

Fig. 4: (a) Mean concentrations of Pb in water (b) Sediment and (c) gastropod from different stations during the period of study

In *Lanistes carinatus*

Lead concentration values in the soft tissue of examined gastropod were more than the corresponding values of Cadmium in gastropod. This agree with Farag *et al.* (2000), who stated that the concentrations of Lead were more than the corresponding values of Cadmium in some bivalve mollusks and with Abdel Gawad (2001), who found the concentration of Lead in fresh water gastropod *Bellyma unicolor* was more than that of Cadmium . This maybe explained, Cd is more toxic than Lead.

There was an increase in the concentrations of Pb in the organisms collected in summer 2006 than the values of Pb in the organisms collected in summer 2005 from the same stations (Fig. 4c). This could be attributed to the remarkable increase of human population and hence the increase of domestic discharges and sewage pollution. It was found that Pb concentrations in the snail have the same trend of its concentrations in sediment. A significant positive correlation (r = 0.56) was estimated between Pb concentrations in sediment and Pb concentrations in the snail.

Generally, it was found that the concentrations of metals in water and sediment increased in Kafr Saad stations than those in Talkha stations. This agrees with Masoud *et al.* (1994), who recorded that, concentration of trace metals in Nile water was increased from south to north. In addition to industrial waste water effluents (Pickled herring making Tanning, dyeing and textile, soap making, fertilizers and cheese making factories) and agricultural discharges drained into the Nile (Soltan and Awadallah, 1995).

There were strong positive correlations (r = 0.73, 0.8, 0.91) between Cd and Pb in sediment, water and organisms, respectively. This indicates the two elements are closely associated with each other. This agrees with Abdel-Satar (2008), who found a significant positive correlation between Pb and Cd in Lake Manzalah.

In conclusion, the average concentrations of Cu, Cd and Pb in water of Nile River were 0.0, 0.066 and 0.29 mg L^{-1}, respectively in the whole area during the period of study. The mean concentrations of metals in the Nile sediment were 5.07, 0.22, 1.05 mg kg^{-1} for Cu, Cd and Pb, respectively. This shows that the means concentrations of Cu, Cd, Pb in the snail were from approximately 65-302, 13-91, 3-100 times higher than in sediment, respectively.

Therefore, the snail can be used as sensitive and useful indicators to monitor environmental pollution caused by these metals (Cu, Cd, Pb) because the snail accumulate metals over a period of time. Because of this integrating monitoring ability of this gastropod, these data represent the average metal concentration of their habits (water, plants, sediment).

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