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Biological Indicators for Pollution Detection Using Two Freshwater Snails, *Biomphalaria alexandrina* and *Lanistes carinatus* in Egypt

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ABSTRACT

The present work aimed to evaluate water pollution with three heavy metals (Cu, Pb and Zn) in Mansoura, El-Mahalla El-Kubra, Tanta, Assiut, Wasta Beni Suef and Shibin Al Qanatir localities, using two freshwater snails: *Biomphalaria alexandrina* (the intermediate host and vector of schistosomiasis) and *Lanistes carinatus* as bioindicators. Results showed that the highest concentrations of the three heavy metals were 2.084ppb for Cu found in Tanta, 58.200ppb for Zn in Wasta Beni-Suef, and 20.000ppb for Pb discovered in Assiut. The accumulation of three heavy metals in *Lanistes carinatus* snail was higher than that in *Biomphalaria alexandrina* snail. The highest accumulated content inside *Lanistes* snails was for Cu-metal (36838 ppb) from Wasta Beni-Suef area. It could be concluded that *B. alexandrina* and *L. carinatus* are suitable bioindicators for the accumulation of heavy metals pollution.

INTRODUCTION

Water pollution has become the most significant type of global problem in recent years, especially accumulated heavy metals through food chains that are toxic in all forms of life **(Nemr *et al.*, 2015; Deljanin *et al.*, 2016; Abo Elmagd *et al.*, 2020)**. Some essential heavy metals, such as iron, chromium, copper, and zinc play crucial biological roles for aquatic organisms and for humans in many vital processes with optimum levels. Inadequate levels of these metals can lead to hazardous conditions and deficiency in illnesses (**Sivaperumal *et al.*, 2007**). Other heavy metals, such as lead, cadmium, and others, are non-essential and are considered detrimental, even at low concentrations. Hence, they will cause water pollution altering the physiochemical properties of the aquatic environment (**Sfakianakis *et al.*, 2015**). One of the most significant hazards to the aquatic ecosystem in Egypt is pollution by heavy metals, especially in the River Nile system, and it has increased in the last few decades **(El-Shaikh *et al.*, 2005)**. Heavy metal accumulation in the tissues of living organisms represents a mirror for environmental conditions **(Bahnasawy *et al.*, 2011)**. The main sources of heavy metals in the River Nile are irrigation, fertilizers, industrial wastes, pesticides, herbicides, and derivatives of household products **(EL-Shaikh, *et al.*, 2005)**. Various aquatic species have been used as bioindicators and biomonitors for heavy metal contamination (**El-Shaikh, *et al.*, 2005, Ansaldo *et al.*, 2009; Al-Taee et al. 2020)**. Molluscans can accumulate higher levels of heavy metals than other invertebrates, hence they are used as bioindicators and biomonitors **(Oehlmann & Schulte-Oehlmann 2003; Altındağ & Yiğit, 2005; Zhou *et al.*, 2008; Chindah *et al.*, 2009; Waykar Petare, 2016; Souza-Silva, *et al.*, 2023)**.

Snails are considered suitable diagnostic invertebrates for heavy metal-contaminated tissues since they can accumulate large quantities of metals in the tissues (**Ibrahim, 2006**). Additionally, Freshwater snails are more–sensitive biomarkers for aquatic ecosystem pollution **(Short *et al.*, 2011)**. Furthermore, heavy metals accumulate inside their tissues, leading to acute and sublethal histopathological effects in both animals and humans **(Salánki *et al.*, 2003; Ashraf, 2005; Abdel-Wahab *et al.*, 2018)**. Consequently, it is essential to do animal research to learn more about toxins and the vulnerability of species, and simultaneously set a legal water limit that can safeguard water bodies **(Abdel-Wahab *et al.*, 2023)**. Therefore, the present study aimed to quantify three heavy metals, Cu, Pb, and Zn in the tissues of two species of freshwater snails, including *B. alexandrina* and *Lanistes carinatus* from four cities, Mansoura, El-Mahalla El-Kubra, Tanta, and Assiut, and *L. carinatus* gathered from three areas: Assiut, Shibin Al Qanatir and Wasta Beni-Suef to assess their potential roles as bioindicators for pollution caused by these three targeted heavy metals.

MATERIALS AND METHODS

1. Study area

The *B. alexandrina* snails were collected in February 2021 from 3 cities of the Egyptian Delta: El-Mahalla El-Kubra, Mansoura, and Tanta. El Mahalla El Kubra is the largest city in population, industrial and agricultural economies of the Gharbia Governorate. It is situated in the midst of the Nile Delta on the western bank of the Damietta Branch tributary and stretches from 31°10'12" East to 30°58'12" North. Mansoura is the capital of the Dakahlia Governorate. It is in the Delta area on the east bank of the Damietta branch of the Nile. Mansoura is around 120 kilometers northeast of Cairo. Tanta is the capital of Gharbia Governorate and the third city in the Delta in terms of area and population, after Mahalla al-Kubra and Mansoura. It is located between 94km (58mi) north of Cairo and 130km (81mi) southeast of Alexandria (Considered the largest cities in the Delta in terms of area and population). Furthermore, *B. alexandrina* snails were collected from the water of Assiut during the year 2022. *Lanistes carinatus* snails were collected in August, September and October 2022 from three cities: Wasta Beni-Suef, Assiut, and Shibin-El Qanater. These snails were not found in other localities during 2022 and 2023 years due to dredging and lining canals. The specimens were gathered during lining and scraping of most of the Egyptian water canals (Fig. 1). Assiut is located from 27°10′00″ North to 31°08′00″ East at the Nile River, Egypt. Shibin El Qanater is located from 30°18′48″ North to 31°19′17″East and is situated in the center of the Qalyubia Governorate, Egypt. Wasta Beni Suef (Wasta' is a city in the Beni Suef Governorate bordering on the Giza Governorate and Beni Suef Governorate borders and located at 29°20'14"North, 31°12'13"East).

Fig.1. Egyptian map showing the six sampling sites

2. Sampling

2.1. Water sampling

Freshwater samples of the targeted six cities, Mansoura, El-Mahalla El-Kubra, Tanta, Assiut, Shibin Al Qanatir and Wasta Beni-Suef, were collected (30 cm below the water surface), poured in sterilized polyethylene bottles and transported inside ice boxes for analysis within 12 hours.

2.2. Snail's sampling

B. alexandrina snails were collected from four examined cities: Mansoura, El-Mahalla El-Kubra, Tanta, and Assiut. While, the *L. carinatus* snails were collected from three cities; Assiut, Shibin-Al Qanater and Wasta Beni-Suef. The two types of snails were taken to the lab for a heavy metals assay after being placed in plastic aquariums filled with water from their natural habitats.

3. Determination of heavy metals

3.1. Detection of the heavy metals Pb, Zn and Cu from the soft tissues

Soft tissues of the collected snails, *B. alexandrina* and *L. carinatus* were carefully separated from their shells, washed in distilled water, dried with an oven at 80°C and totally powdered using a mortar. Afterward, 1 gram of dried tissue from each species digested were added with 10ml of nitric acid-perchloric acid solution (HNO3–HClO4) (4:1 v/ v). Initial digestion was conducted at room temperature for 4h, followed by heating at 40–45°C for 1h in a water bath and then raised to 70°C until the end of digestion. After cooling at room temperature, each digested sample was diluted to 60ml with deionized water and filtered out into a volumetric flask for analyzing heavy metals (**Mahmoud & Abu Taleb, 2013; Abdel Kader *et al.*, 2016**).

3.2. Determination of heavy metals from water samples

Freshwater samples collected from the studied areas (500ml for each sample) were mixed with about 10ml of HNO_3, slowly boiled, and evaporated as the volume decreased to 100– 200ml. Before precipitation, another 10ml of HNO_3 was added with heating until the volume decreased to 80– 100ml. Subsequently, it was transferred into a volumetric flask containing 10ml of double distilled water, filtered, and finally, heavy metals were analyzed **(Shaaban *et al.*, 2017)**.

4. Heavy metals analysis

Stocks of the targeted heavy metals (Pb, Zn, and Cu) were used in the determination of heavy metals of freshwater and snail tissues of *B. alexandrina* and *L. carinatus*, using Atomic Absorption Spectrophotometry in Environmental Research Laboratory, Theodor Bilharz Research Institute and National Research Center, respectively.

5. Analysis methods

To determine the degree of heavy metal accumulation in the tissues of the two species of snails, the bio-accumulation factor (BF) was computed following the method of **Usero *et al.* (2005)** as follows:

Bio Water Accumulation Factor (BWAF) = concentration of metal in snail tissues (mg/ g dry weight) / concentration of metal in water (mg/ L)

6. Statistical analysis

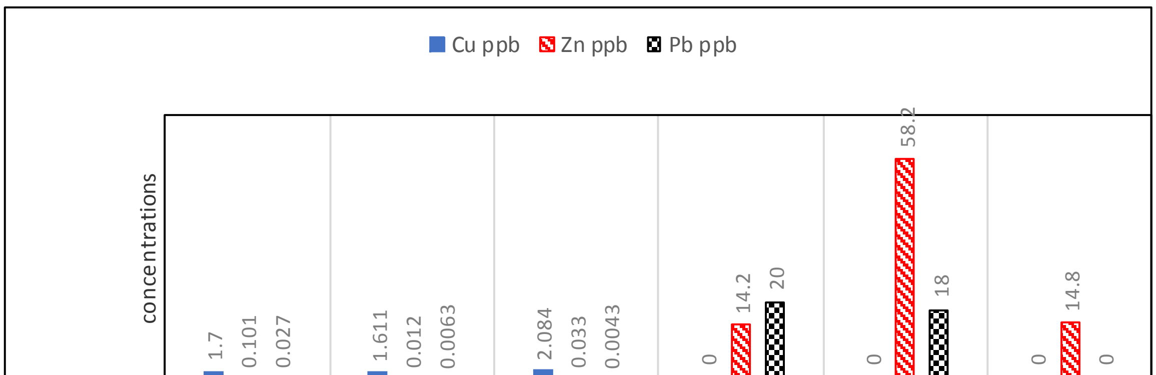
Data significance statistical analyses of the obtained results was achieved using computer program of Excel Windows 10.

RESULTS

Heavy metals levels in water samples

Water samples collected from six different areas were analyzed to determine the concentrations (ppb (parts per billion)) of three heavy metals: copper, zinc and lead. The obtained data revealed that copper (Cu) was detected from the water samples collected from only three specific areas; Tanta with the highest concentration level of 2.084, followed by 1.700 in El-Mahalla El-Kubra and 1.611 in Mansoura, while it was not detected in water samples from Assiut, Wasta Beni-Suef and Shibin Al Qanatir. Regarding the zinc metal (Zn), it was found in water samples from the six cities with concentrations in the following order: Wasta Beni-Suef 58.200> Shibin Al Qanater 14.800> Assiut 14.200> El-Mahalla El-Kubra 0.101> Mansoura 0.012> Tanta 0.033. In the case of the concentrations of lead (Pb), it was detected from samples collected from five different areas as follows: Assiut with high level (20.000)> Wasta Beni-Suef (18.00)> El Mahalla-El-Kubra (0.027)> Mansoura (0.0063)> Tanta (0.0043) and not detected from the water of Shibin Al Qanatir.

The highest concentrations (ppb) or (µg/ L) of the three heavy metals, Cu, Zn and Pb, in freshwater of the studied areas were recorded with the following values: 2.084 for Cu from Tanta, 58.200 for Zn from Wasta Beni-Suef and 20.000 for pb from Assiut. Thus, the metal concentrations decreased in the following order: Cu> Zn> Pb in Tanta, El-Mahalla El-Kubra, and Mansoura, respectively. Moreover, in Assiut, the metal concentrations decreased in the following order: Pb> Zn, whereas in Wasta Beni-Suef, the order was: Zn> Pb. (Fig. 2 & Table 1).



	El Mahalla El Kubra (1)	Mansoura (2)	Tanta (3)	Assiut (4)	Wasta Beni Suef (5)	Shiben Al Qanater (6)
Cu ppb	1.7	1.611	2.084	0	0	0
Zn ppb	0.101	0.012	0.033	14.2	58.2	14.8
Pb ppb	0.027	0.0063	0.0043	20	18	0

Fig. 2. Concentrations of the metal ions in the freshwater of the six cities

Table 1. Concentrations of heavy metals in water of six cities

Locality	Cu (ppb)	Zn (ppb)	Pb (ppb)
(1) El-Mahalla El-Kubra	1.700	0.101	0.027
(2) Mansoura	1.611	0.012	0.0063
(3) Tanta	↑ 2.084	0.033	0.0043
(4) Assiut	ND	14.200	↑ 20.000
(5) Wasta Beni-Suef	ND	↑ 58.200	18.000
(6) Shibin-El Qanatir	ND	14.800	ND

*ND = not detected.

Heavy metals inside *B. alexandrina*-tissues

Fig. (3) and Table (2) illustrate the heavy metal accumulations inside *B. alexandrina* tissues collected from four cities; El-Mahalla El-Kubra, Mansoura, Tanta and Assiut. The concentrations (ppb) of Cu, Zn and Pb within *B. alexandrina* tissue were as follows: 3.340, 0.148, 0.293 found in El-Mahalla El-Kubra; 1.815, 0.169 & 0.102 in Mansoura; 2.276, 0.160, 0.133 in Tanta and 3380, 134260, 1920 in Assiut, respectively. Thus, the highest concentration values of the three heavy metals, Cu, Zn and Pb, were 3380, 134260, 1920ppb in Assiut, respectively. The lowest recorded values were as follows: 1.815 for Cu in Mansoura, 0.148 for Zn in El-Mahalla El Kubra, and 0.102 for Pb in Mansoura. Thus, the heavy metal contaminations decreased in *B. alexandrina* tissues taken from the four studied cities which were in the order of: Cu> Zn> Pb; Assiut, El-Mahalla-El-Kubra, Tanta, and Mansoura. On the other hand, decreased contamination (ppb) of heavy metals in the four cities followed these patterns: Cu and Pb (Assiut > El-Mahalla El-Kubra > Tanta > Mansoura) and Zn (Assiut > Mansoura > Tanta >El-Mahalla El-Kubra).

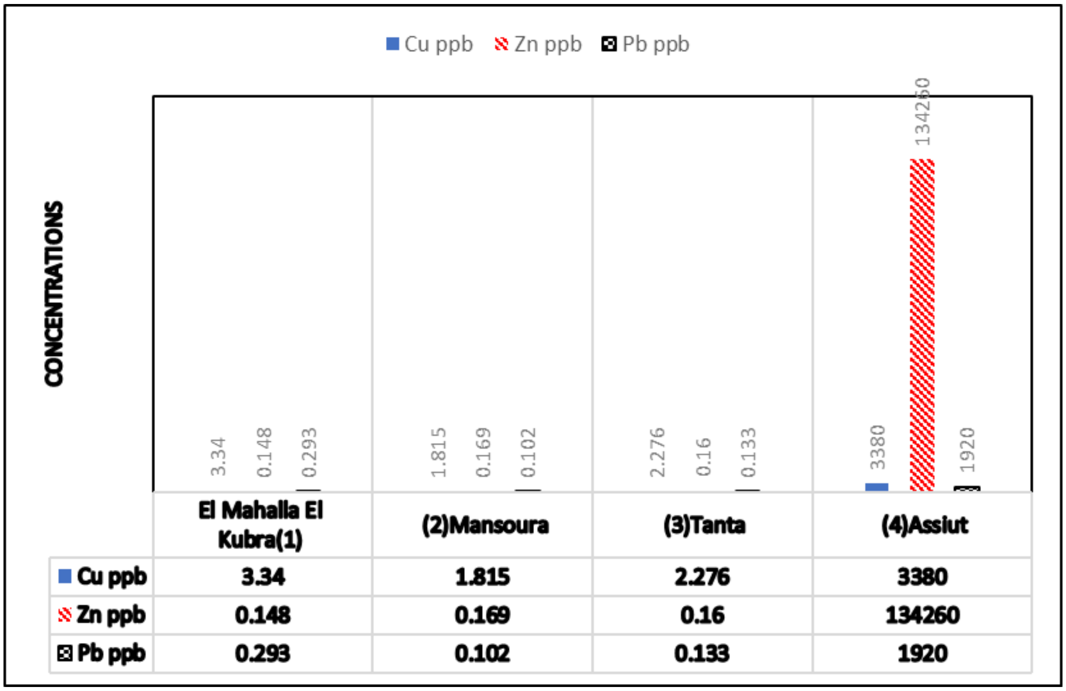


Fig. 3. Concentrations of the metal ions in tissues of *B. alexandrina* at the four target sites

Table 2. Concentrations of metals (ppb or µg/ L) in *B. alexandrina* soft tissue in the 4 cities

Species	Localities	Cu (ppb)	Zn (ppb)	Pb (ppb)
B. alexandrina	(1) El Mahalla-El Kubra	3.340	0.148	0.293
	(2) Mansoura	1.815	0.169	0.102
	(3) Tanta	2.276	0.160	0.133
	(4) Assiut	↑3380	↑134260	↑1920

Heavy metals inside *L. carinatus* tissues

Heavy metal accumulations in *L. carinatus* tissues in Assiut, Wasta Beni-Suef and Shibin-Al Qanater cities were in descending order: Cu> Zn> Pb, as described in Fig. (4) and Table (3).

Concentrations (ppb) of Cu, Zn and Pb were: 253770, 224280, 400 in Assiut, 368380, 262490, 600 in Wasta Beni-Suef and 256880, 253090, 1450 in Shibin-Al Qanater, respectively. From the above results, the highest concentrations for Cu and Zn-metals were detected in Wasta Beni-Suef with concentrations of 368380 and 262490, respectively, and for Pb in Shibin-Al Qanater the value was 1450. On the other hand, the lowest values of Cu, Zn and Pb metals were from Assiut with concentration of 253770, 224280 and 400, respectively. Based on these results, the metal contaminations decreased in the following order: for Cu and Zn, Wasta Beni-Suef> Shiben-El Qanater> Assiut, and for Pb, in Shiben-El Qanater> Wasta Beni-Suef > Assiut.

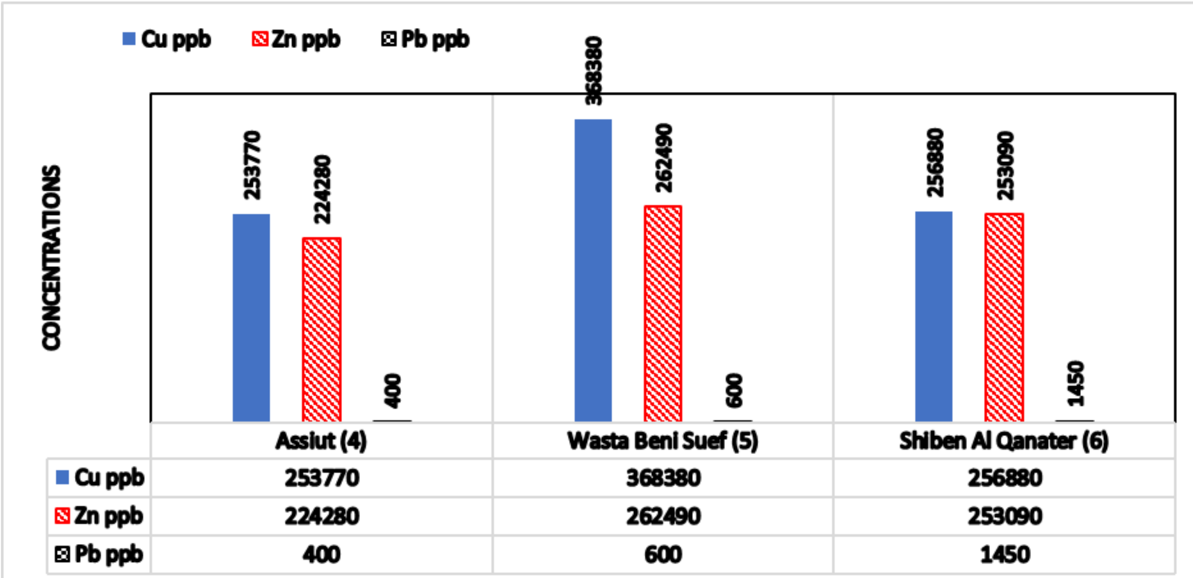


Fig. 4. Concentrations of the metal ions in tissues of *L. carinatus* at the three target sites

Table 3. Concentrations of heavy metals in soft tissue of *L. carinatus* in the three target cities

Species	Localities	Cu (ppb)	Zn (ppb)	Pb (ppb)
L. carinatus	**(4) Assiut**	253770	224280	400
	(5) Wasta Beni-Suef	368380	262490	600
	(6) Shiben-El Qanater	256880	253090	1450

The comparison of bio water-accumulation factor (BWAF) of *B. alexandrina* and *L. carinatus* tissues from freshwater of the six studied areas for Cu, Zn and Pb showed high variation in BWAF values depending on the metal type (Fig. 5 & Table 4). The highest BWAF values were observed for Cu metal (1.96) in El-Mahalla El-Kubra, Zn metal (17101) in Shibin-Al Qanatir, and Pb metal (96) in Assiut. Conversely, the lowest BWAF values were recorded for Cu metal in Tanta (1.09), Zn metal in El-Mahalla El-Kubra (1.465), and Pb metal in El-Mahalla El-Kubra (10.9).

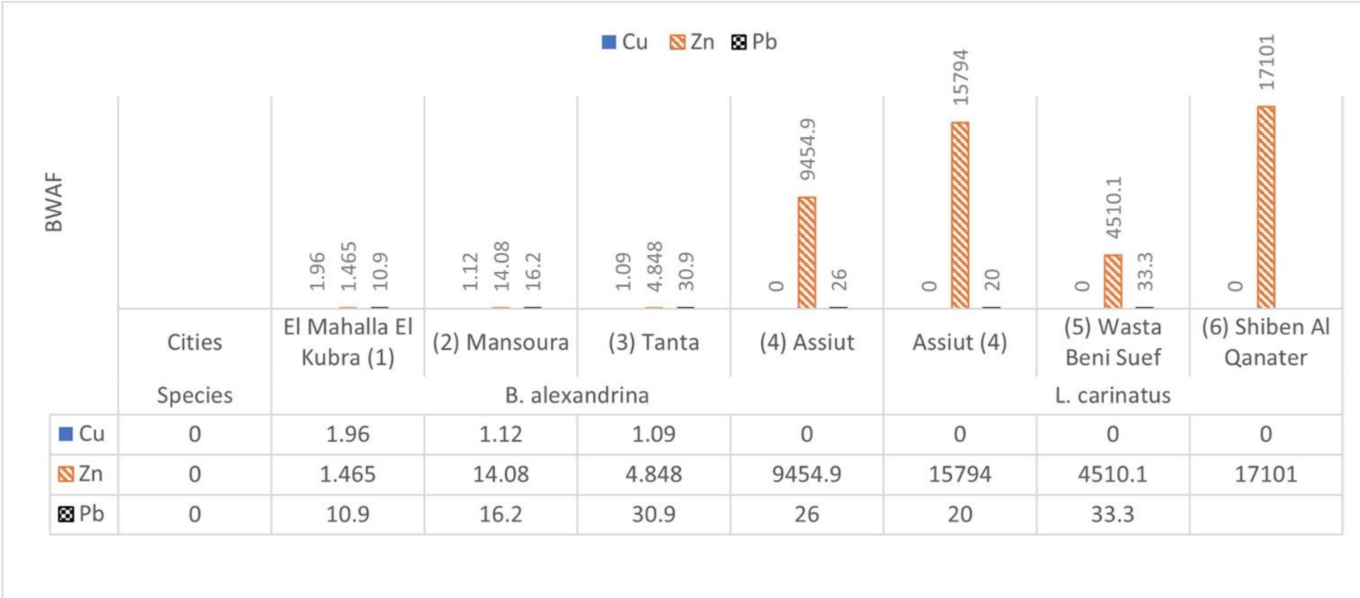


Fig. 5. Bio-water-accumulation factor of the three metals inside two snails' tissues from the six target cities

Table 4. Metal concentrations and bio water accumulation factor of two snails' tissues in the target cities

Species	City	Cu (µg/ L or ppb)				Zn (µg/ L or ppb)				Pb (µg/ L or ppb)			
		water WHO 2022)	Water	BWAF	Soft tissue	water WHO 2022)	Water	BWAF	Soft tissue	water (WHO 2022)	Water	BWAF	Soft tissue
B. alexandrina	El Mahalla El Kubra (1)	2000	**1.700**	1.96	3.340	10	0.101	1.465	0.148	10	0.02700	10.9	0.293
	Mansoura (2)		1.611	1.12	1.815		0.012	14.08	0.169		0.0063	16.2	0.102
	Tanta (3)		2.084	1.09	2.276		0.033	4.848	0.160		0.0043	30.9	0.133
	Assiut (4)		ND	ND	3380		14.2	9454.9	134260		20	96.0	1920
L. carinatus	Assiut (4)		ND	ND	253770		14.2	15794	224280		20	20.0	400
	Wasta Beni (5) Suef		ND	ND	368380		58.2	4510.1	262490		18	33.3	600
	Shiben Al (6) Qanater		ND	ND	256880		14.8	17101	253090		ND	ND	1450

*ND = not detected.

DISCUSSION

Heavy metals are one of the most common agents that promote threats to water quality. They can affect organisms including gastropods, especially those consumed by humans **(Artalina & Takarina, 2019)**. In Egypt, heavy metals cause dangerous hazardous pollution, and it increased in the last few decades, especially in the River Nile system **(El-Shaikh *et al.*, 2005)**. Additionally, metal deposition in living things may serve as a reflection of the environment **(Bahnasawy *et al.*, 2011)**. By altering their biological activities in various pathways, they have an impact on both vertebrates and invertebrates **(Kar *et al.*, 2015)**. The goal of the current investigation was to assess the potential dangers of three heavy metals, Cu, Zn, and Pb, in freshwater snails from four different locations that included *B. alexandrina* and *L. carinatus*. (El-Mahalla El-Kubra, Mansoura, Tanta and Assiut) and three localities (Assiut, Wasta Beni-Suef, and Shibin-Al Qanater) for *L. carinatus* snails.

The obtained results revealed that the highest values of accumulation of the three targeted metals inside the tissues of the studied snails were from Assiut City for the two snail species and from Wasta Beni-Suef for *L. carinatus*. The water of Assiut is polluted with fertilizers, pesticides, dangerous industrial wastes, and the main source of contamination in Assuit is the domestic sewage received from villages, some cities, and human activities **(Jabbar & Dawood, 2015; Morsi *et al*., 2020; El-Zeiny *et al.*, 2023)**. Water pollution in Wasta Beni Suef is primarily caused by various human activities, including irrigation, recreation, waste disposal, fishing, among others **(Mohammed *et al*., 2022)**.

Several authors have studied *B.* alexandrina and *L. carinatus* freshwater snails as bio-indicators for water pollution **(Mahmoud & Abu-Taleb, 2013; Mostafa *et al.* 2014, Habib *et al.*, 2016; Abdel-Gawad *et al.* 2018)**. These snails are favored due to their wide geographical distribution, low dispersion, easy to breed, and limited mobility. Moreover, they have a limited lifespan, year-round sexual reproduction under regulated conditions, and potent metal bioaccumulators **(Amadi *et al.*, 2020; Souza-Silva *et al.*, 2023)**.

Copper serves as a cofactor to control the activity of copper-dependent enzymes **(Lehtonen & Leinio, 2003)**, and it is an allosteric component of several enzymes **(Walker *et al.*, 2006)**. Concentrations of Cu in freshwater from El-Mahalla El-Kubra, Tanta, and Mansoura have decreased in comparison with the guideline value of **WHO (2004)** (1000 ppb). Recently, the concentrations of the same metal in the water of these areas are lower than those of the guideline value (2000 ppb) of **WHO (2022)** (Table 4). Low levels of copper induce nutrient deficiency, and the highest levels could be acutely toxic **(Eisler, 2007)**.

Regarding zinc metal, it is well known that it serves as an enzyme cofactor with significant biological roles that control a variety of physiological processes **(Vallee & Auld, 1990)**. The health of all living things depends on the trace metal zinc, which binds to roughly 300 enzymes. Additionally, it is necessary for the taste and smell sensations and plays an important role in immunological function, protein synthesis, DNA synthesis, cell division, cell cycle advancement, and apoptosis **(Eisler, 2007; Chasapis *et al.*, 2020)**. The present study revealed elevated levels of Zn in the water of Assiut, Wasta Beni-Suef, and Shibin Al Qanater cities, whereas its concentrations in El Mahalla-El Kubra, Mansoura, and Tanta cities were lower, compared to the standard value of 10 ppb indicated by **WHO (2022)**.

The present concentrations of Pb metal in the water samples from the studied areas are lower than the guideline value of **WHO (2004)** (50 ppb)**,** whereas recent concentrations of the same metal in the water of Assiut and Wasta Beni-Suef exceed the guideline value of 10 ppb indicated by **WHO (2011, 2022)**.

Lead is a non-essential, non-biodegradable heavy metal that is harmful at low doses and plays no part in the biological functions of living things. Thus, they might be toxic to organisms, even in low quantities. The results of the analysis are supported by **Rashid (2001**) recording a high concentration of Pb in the tissues of the fish *Oreochromis niloticus* from the Nile River, Assiut region. Additionally, the same results were obtained by **Badr *et al.* (2014)** in the River Nile basin in the two cities of Greater Cairo, Egypt. Lead is a cumulative toxicant and causes hematopoietic, renal, reproductive, and central nervous system disease, as well as inhibition of enzyme activities **(Assi *et al.*, 2016; Kumar *et al.*, 2022)**.

In general, heavy metals at very low concentrations are toxic and cause serious health illnesses to animals, plants, and humans **(Vardhan *et al.*, 2019)**. In addition, a high level of Cu is more toxic to aquatic organisms **(Waseem *et al.*, 2014)**. The high level of Cu is due to gasoline motors, agricultural and industrial effluents, and municipal sewage contamination in Tanta **(El-Shaikh *et al.*, 2005)**, owing to the vast textile companies in El-Mahalla-El-Kubra **(Alm-Eldeen *et al.*, 2018)** and due to the industrial wastewaters, oil, soap factory and sewage in Mansoura **(El-Agrodi *et al.*, 2018)**.

The arrangement of concentrations in the current investigation was as follows: Copper > Zinc > Lead in Tanta, El-Mahalla El-Kubra, and Mansoura. These findings are consistent with those made by **El-Kader (2022**), who discovered that the amounts of heavy metals in Lake Manzala were in the proper order: Copper > Zinc > Lead > Cadmium.

The obtained high concentration of Cu in the tissues of *B. alexandrina* agrees with the work of **Despotović *et al.* (2019)** on the freshwater snail *Viviparus acerosus*. **Sharaf el-Din *et al.* (2010)** demonstrated that *B. alexandrina* snail can tolerate high concentrations of heavy metals. Moreover, the obtained concentrations of Cu, Zn, and Pb in water and tissues of *L. carinatus* are in agreement with **Alm-Eldeen *et al.* (2018)** who showed an increase in concentrations of Cu, Zn, Pb, Mg, and Mn of the Nile water and tissues of the freshwater fish *Oreochromis*. Heavy metals can enter aquatic animal tissues either by ingested food or uptake from the environment's water according to several scientists **(Ravera, 2001)**. However, **Abdel-Gawad (2018)** demonstrated that the levels of metals in the water of Lake Manzala are as follows: Cu> Zn> Pb, whereas **(El-Khayat *et al.* (2018)** showed that the heavy metal levels in the water of Burullus Lake is in the order of Zn> Cu> Pb, while the present results showed decreased concentrations in the order of Cu> Zn> Pb. The organism had relatively high concentrations of copper and zinc compared to lead, which suggests that copper and zinc are important elements, whereas lead is not **(Howe-Grant *et al.*, 1980)**. The difference in concentrations may serve as an illustration of how non-essential metals and essential metals differ **(White & Rainbow, 1982; Rainbow, 1988)**. Gastropods like freshwater snails retain and accumulate copper and use it to make the blood pigment hemocyanin **(Betzer & Tevich, 1975; El-Gawad, 2009)**. Since *B. alexandrina* and *L. carinatus* snails have a much higher likelihood of accumulating the three target metals Cu> Zn> Pb in their soft tissues in the current study, these two snail species can be used as bioindicators for the presence of these heavy metals in the freshwater of the targeted cities. This recommendation agrees with the work of **Abdel-Gawad (2018)**, who reported heavy metal concentrations in the soft tissue of *L. carinatus* from freshwater of the Egyptian Lake Manzala in the following order: Zn> Ni> Cu> Pb that differs from that of the order of the present results in soft tissue of the same species (Cu >Zn> Pb).

CONCLUSION

The accumulation of the targeted three heavy metals in *Lanistes* snails was higher than those of *Biomphalaria*. The comparison of the bio water-accumulation factor (BWAF) of *B. alexandrina* and *L. carinatus* snails' tissues at the investigated localities with the concentrations of the metals (Cu, Zn, and Pb) in the water collected, showed high variation in BWAF values. Hence, it could be concluded that *B. alexandrina* and *L. carinatus* are good species as bioindicators for the accumulation of the present heavy metals.

Furthermore, this study provides valuable insights into the presence of copper (Cu), zinc (Zn), and lead (Pb) toxins in the water of the targeted cities. These heavy metal accumulate in the River Nile system and other freshwater bodies, posing a threat to aquatic life and, consequently, human life.

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الملخص العربي

مؤشرات بيولوجية للكشف عن التلوث بإستخدام قوقعي المياه العذبة *Biomphalaria alexandrina* و *Lanistes carinatus* *في مصر*

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يهدف هذا العمل إلى استخدام نوعان من قواقع المياه العذبة: ***Biomphalaria alexandrina*** (العائل الوسيط الناقل لمرض البلهارسيا) وقوقع ***Lanistes carinatus*** كأدلة بيولوجية لتقدير تلوث المياه بثلاثة معادن ثقيلة: النحاس والرصاص والزنك وذلك في مدن: المنصورة، المحلة الكبرى، طنطا، أسيوط، واسطى بنى سويف وشبين القناطر. وقد أظهرت النتائج ان عنصر النحاس سجل اعلى تركيز وذلك فى طنطا (2.084 جزء في البليون) والزنك فى واسطى بنى سويف (58.200 جزء في البليون) والرصاص فى اسيوط (20.000 جزء في البليون). وقد وجد ان المعادن الثقيلة موضع الدراسة تركيزها أعلى داخل قوقع ***Lanistes carinatus*** من قوقع ***Biomphalaria alexandrina***. وكان أعلى محتوى تراكمى بقواقع ***Lanistes carinatus*** لعنصرالنحاس (368380 جزء في البليون) في منطقة واسطى بني سويف. وبذلك يمكن الاستنتاج أن قوقع ***Biomphalaria alexandrina*** وقوقع ***Lanistes carinatus*** نوعان جيدان يمكن استخدامهما كمؤشرات حيوية لتراكم المعادن الثقيلة.