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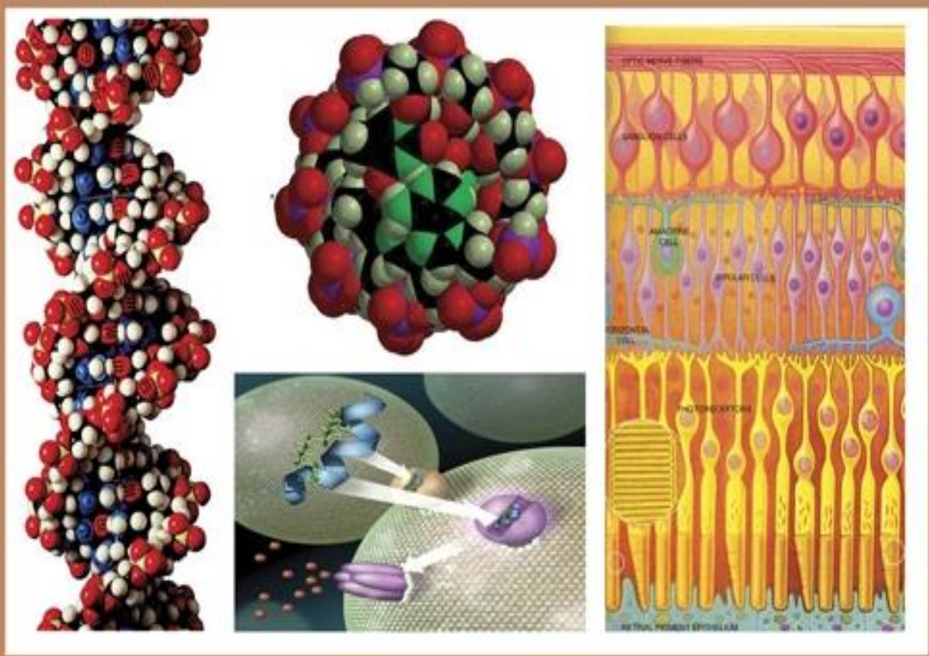

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Bioaccumulation of Some Heavy Metals in *Chrysichthys rueppelli* Collected from El-Bagouria Canal at El-Menoufia Governorate, Egypt.

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ABSTRACT

The present study was aimed to determine the concentrations of some heavy metals in the sediment of different sites in El-Bagouria Canal at El-Menoufia Governorate during the year from autumn, 2019 to summer, 2020. Sediment and fish (*Chrysichthys rueppelli*) samples were collected seasonally during the study period .

The present study exhibited that, all studied metals were showed a higher level in the sediment during the cold weather (autumn and winter) except lead and zinc. Results indicated differences in some heavy metal accumulations in different tissues of studied fish, *Chrysichthys rueppelli* with an increasing rate in the liver during autumn and winter. Furthermore, gonads showed a higher level of Mn and Zn during autumn and winter. The correlation coefficient of some heavy metals between sediment and target organs indicated this, a strong positive correlation between zinc concentrations in sediment and liver. However, there is a negative correlation between all studied heavy metals concentrations in the sediment and muscles.

The data revealed that the highest values of the biosedimentation factor were observed during the winter except for manganese which increased in the spring, with an aspect for all equal to or greater than 1 (BSAF≥1). This means that there is almost predangerous bioaccumulation of these metals in fish. This could be attributed to the content of metals in the substrate .

The increasing rates of biosedimentation factors in the target organs indicate the high risk to fish health and human consumption. So, the present study shows that more of precautionary measures must be taken to reduce heavy metal pollution in the future.

INTRODUCTION

The River Nile travels along Egypt for about 940 kms behind the High Dam. At the north area of Cairo (El-Kanater El-Khyria), the River Nile bifurcates into two branches namely Damietta and Rosetta branches and four Rayahs (Canals) namely El-Nassery, El-Behery, El-Menofy and El-Toufeky. The length of Rosetta branch is about 220 km, and the width varies from 50–200 meters, the depth fluctuates from 1.5– 16 meters whereas, and the length of Damietta branch is about 242 km with an average width and depth 200 and 12 meters, respectively.

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They are the main sources of drinking and irrigation waters for the Nile Delta including, El-Qalubia, El-Menoufia, El-Gharbia, El-Dakahlia and Damietta Governorates. The Nile receives a large amount of agricultural, domestic and mostly untreated manure industrial wastewaters (Zyadah, 1996; Abdo, 2004; El-Amawy, 2016 and Ghanem *et al*., 2016).El-Menoufia Governorate is one of the central parts of the Nile Delta and extends along a wide area of cultivated lands nearly 2500 km^2. The area is bordered to the west by the Rosetta branch and to the east by the Damietta branch. The Governorate consists of eight centers; all of them are cultivated lands and densely populated (Sakr and Mabrouk, 2006). El-Bagouria Canal is diverted by El-Monofy Rayah at km 21.3, it is 90.0 km long and it serves around 326,000 feddans. The whole length of the canal inside El-Menoufia Governorate is about 35-40 km which considering a carrier canal (NBNWQ, 2005 and El-Gamal, 2009).

Environmental pollution is considered to be one of the most serious problems facing humanity in the 20^{th} century and still requires great efforts at all levels, nationally and internationally. This is especially true with respect to rivers pollution, which may contain frequently hazardous contaminants in rather high concentrations of pollution (Zyadah, 1999). Excessive uses of wastewater and sludge effluents, overflow, and excessive use of manure for irrigation purposes result in dangerous effects on plants, animals and human health.

In addition, discharge of liquid or solid wastes with different types of contaminants (nutrients, trace metals, suspended solids, salts and oxygen-requiring materials) in the geological environment causes deterioration of groundwater (Hamza and Mason, 2004; Zeidan, *et al*., 2015; El-Amawy, 2016 and Azab *et al*., 2019). Untreated or poorly treated for sewage, heavy metals and other pollutants are discharged into the Nile Delta canal system and are discharged along with sewage and agriculture wastes into the northern delta lakes and their associated wetlands (Siegel, 1995).

Fish are comparatively positioned at the top of the food chain in aquatic environments; consequently, they can accumulate various heavy metals from sediments, water and food (Yilmaz *et al*., 2007; Zhao *et al*., 2012a; Sthanadar *et al*., 2013; El-Amawy, 2016 and El-Battal, 2019).

The present study aimed to evaluate the effect of some pollutants on water quality of the River Nile at El-Bagouria Canal through monitoring the seasonal variations of selected heavy metals (cadmium, lead, copper, iron, manganese and zinc) in the sediment of study areas, in addition to bioaccumulation of these metals in the different organs (gonads, kidneys, livers and muscles) of *Chrysichthys rueppelli*, as one of the most important fishes.

MATERIALS AND METHODS

Investigated Area:

The investigated area (El-Bagouria Canal) includes four stations (Shubra Zinji, Kafr Shubra Beloulah, Sengerg and Shubra Bas). These stations (Fig., 1) covered 24 Km, the length between every two stations is nearly 8 Km. Sediment and fish (*Chrysichthys rueppelli*) samples were collected seasonally during the year from autumn, 2019 to summer, 2020.

Determination of Heavy Metals:

Concentrations of heavy metals in the sediments and fish were measured using an inductively coupled plasma optical emission spectrophotometer (model 3400 DV, Perkin Elmer, Shelton, USA) according to the standard methods of APHA (1995). Results were tabulated as mean ±S.D and analyzed by using correlation coefficient for interaction between the concentration of heavy metals in sediment and target organs according to Bailey (1981).

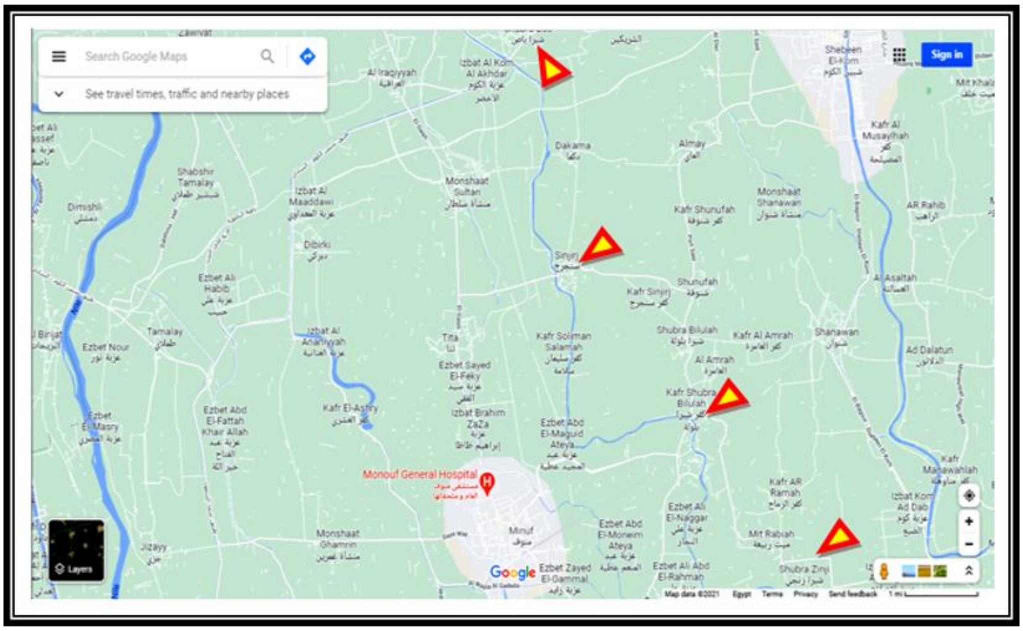

Fig.1: Map of selective stations at El-Bagouria Canal, El-Menoufia Governorate**.**

RESULTS AND DISCUSSION

Heavy Metal Concentrations:

A-Heavy Metal Concentrations In Sediments (µg / G Dry Weight.):

Results (Table, 1) declared that the values of cadmium concentration differed from season to season. The values graduated from the minimum value (0.46 ± 0.05 µg/g dry wt.) in the village of Sengerg during the summer to a maximum of 1.20 ± 0.11 µg /g dry weight at Shubra Bas City during winter. The elevation of cadmium during spring is mainly attributed to high amounts of agricultural, domestic, or different effluents which discharged directly into El-Bagouria Canal. The present results were agreed with those obtained by Grabowski *et al*. (2001) and Osman *et al*. (2012) and disagreed with earlier findings obtained from other aquatic environments by Daifullah *et al*. (2003); Venkatesha *et al*. (2013) and El-Battal (2019) who recorded the maximum level during summer.

Seasonal variations of lead concentrations (Table, 1) exhibited narrow fluctuation between the different seasons, whereas the highest value (1.42±0.06 µg/g dry wt.) was detected at Shubra Zinji Village during summer and the lowest value (0.44±0.08 µg/g dry wt.) occurred at the same village during winter. This fluctuation in lead concentration, attributed to different amounts of effluents that discharged into this canal near sampling stations. These findings were compatible with Zayed *et al*. (1994); Ibrahim & El-Naggar (2006); Stephen & Oladele (2012) and Osman *et al*. (2012) and incompatible with Daifullah *et al*. (2003); Segura *et al*. (2006); Venkatesha *et al*. (2013); Alawy *et al*. (2015) and El-Battal (2019) who reported that the minimum value occurred during spring.

The present values of copper showed considerably variation from season to another; it was peaked during autumn at Sengerg City (67.80 ± 5.67 µg/g dry wt.) and decreased to the lowest value (26.16 ± 1.22 µg / g dry weight) during winter at Shubra Zinji Village (Table, 1). The increasing values during autumn may be due to the increasing of agricultural, wastewater and harmful human activity discharged in the study areas; in addition to increasing organic matter in the sediment at sampling stations. The present results are in agreement with those obtained by Daifullah *et al*. (2003) and El-Amawy (2016) and differ with Abdel-

Satar (2005); Lokhande *et al*. (2011) and El-Battal (2019) who observed the highest level of copper during another season.

Results (Table, 1) exhibited that; the values of iron concentrations showed slight variations along the year. Moreover, the maximal value of iron (15.76 ± 1.00 mg/g dry wt.) was measured in the village of Sengerg during autumn and the lowest (11.63 ± 0.88 mg/g dry weight) was detected at Shubra Bas Station during spring. The increasing values during autumn may be due to increase of agricultural effluents discharged in this canal; in addition to increasing in organic matter transferred from the sediment at sampling stations. The present results were in agreement with Karadede-Akin & Erhan (2007) and Saeed *et al*. (2014) and differed with Lokhande *et al*. (2011) and Ibrahim and Omar (2013) who observed the highest level of iron in the spring.

Data clarified that; the values of manganese were varied to reach its highest value at Shubra Bas during autumn (1.08 ± 0.15 mg/g dry wt.) and the lowest value (0.47 ± 0.12 mg/g dry wt.) at the same site during winter (Table, 1). The fluctuations in manganese levels may be due to the variable amounts of waste effluents that reached sampling areas. The present results were nearly similar to those recorded by Karadede-Akin & Erhan (2007) and Pandey and Singh (2015), however, they differed with Daifullah *et al*. (2003) who recorded the highest level of manganese during spring and Dong *et al*. (2015) who detected manganese peak during winter.

Results (Table, 1) indicated that the values of zinc concentration are varied from season to season. The maximum value was recorded at Shubra Bas City during summer (89.93 ± 4.14 µg/g dry wt.) and the minimum one (35.24±3.26 µg/g dry wt.) was observed at Sengerg Village during winter. The elevation in zinc level during summer may be due to the increasing amounts of agricultural and domestic wastes at sampling areas with low water levels and the leaching of fertilizer residues used in agriculture into the aquatic environment at that season. These observations were nearly similar to those obtained by Ibrahim & Omar (2013) and Goher *et al.* (2014) and differed with Zayed *et al*. (1994) who recorded the highest level of zinc concentration during winter and the lowest during autumn.

Table 1: Seasonal variations of some heavy metals concentrations (µg/g dry wt.) in the sediment of El-BagouriaCanal at El-Menoufia Governorate, during the period of study.

Stations	Metals / Seasons	Cd	Pb	Cu	Fe	Mn	Zn
Shubra Zinji	Autumn	0.66±0.10	0.60±0.05	64.23±3.52	15.57±0.29	0.92±0.33	68.28±6.32
	Winter	1.14±0.08	0.44±0.08	26.16±1.22	14.35±0.30	0.53±0.11	38.04±4.87
	Spring	0.65±0.04	0.89±0.12	32.54±2.51	12.08±0.74	0.63±0.06	43.73±4.12
	Summer	0.50±0.03	1.42±0.06	41.82±4.64	14.94±0.27	0.77±0.17	83.64±3.27
Kafr Shubra-Beloulah	Autumn	0.60±0.02	0.64±0.03	60.08±4.46	15.44±0.30	0.94±0.26	72.75±4.45
	Winter	1.12±0.10	0.50±0.02	28.38±2.74	15.11±0.52	0.58±0.22	41.26±2.52
	Spring	0.71±0.03	0.92±0.09	36.43±2.25	12.53±0.24	0.72±0.20	47.08±4.18
	Summer	0.49±0.04	1.12±0.05	46.87±3.56	15.12±0.34	0.80±0.23	88.60±6.02
Sengerg	Autumn	0.62±0.11	0.58±0.04	67.80±5.67	15.76±1.00	0.90±0.17	76.26±3.07
	Winter	1.02±0.06	0.52±0.07	29.17±3.04	14.57±0.68	0.49±0.13	35.24±3.26
	Spring	0.74±0.04	0.94±0.06	38.85±4.55	13.02±1.02	0.79±0.15	44.09±2.17
	Summer	0.46±0.05	1.22±0.13	42.31±3.24	14.62±0.74	0.87±0.21	80.97±3.24
Shubra Bas	Autumn	0.67±0.04	0.68±0.03	66.09±6.57	15.66±0.42	1.08±0.15	77.87±5.81
	Winter	1.20±0.11	0.48±0.03	30.62±2.83	13.87±0.41	0.47±0.12	37.40±1.35
	Spring	0.72±0.06	1.08±0.11	36.86±3.11	11.63±0.88	0.74±0.24	45.07±5.32
	Summer	0.53±0.03	1.10±0.07	48.65±4.20	15.36±0.28	0.89±0.27	89.93±4.14

Table 2: Correlation coefficient between some heavy metals in the sediment of El-Bagouria Canal at El-Menoufia Governorate, during the period of study.

Heavy metals	Cd	Pb	Cu	Fe	Mn	Zn
Cd	1					
Pb	0.35	1				
Cu	0.87	0.52	1			
Fe	0.99	0.87	0.26	1		
Mn	0.74	0.44	0.96	0.74	1	
Zn	0.80	0.60	0.79	0.80	0.77	1

Statistically, the correlation coefficient between metal concentrations in the sediment appeared that there is a strong positive correlation between cadmium with all metals except lead; lead with copper, iron, zinc; copper with manganese and zinc. Also, iron with manganese and zinc; plus, manganese concentration with zinc (Table, 2).

B-Heavy Metals In The Target Organs (µg/g wet wt.):

Seasonal variations of lead concentrations exhibited narrow fluctuation from season to season, whereas the highest value (2.16 ± 0.17 µg/g wet wt.) was detected in the spring at kidney samples and the lowest value (0.18 ± 0.05 µg / g wet weight.) occurred in the muscles during summer. The accumulation of copper was ordered as follows: liver > kidney > gonads > muscles (Table, 3). The present results agreed with Gomaa *et al*. (1995a&b); Zyadah (1995) and Ghanem (2006) who recorded high concentrations of lead in gonads, liver and kidney than muscles.

The copper concentrations varied from 0.12 ± 0.02 µg/g wet wt. in the gonads during autumn to 9.60±1.32 µg/g wet wt. in the fish liver during the same season (Table, 3). In addition, the mean value of copper accumulation was ordered as follows: liver > kidney > gonads > muscles. These findings nearly agreed with Ghanem (2006); Fallah *et al*. (2011); El-Amawy (2016); Ghanem (2019) and Elwasify *et al*. (2021). On the other hand, Edward *et al*. (2013) and Jayaprakash *et al*. (2015) reported the highest value of copper in the muscles of the fish.

The maximum annual average value of iron concentrations (Table, 3) was detected in the fish liver during winter (76.08 ± 3.64 µg/g wet wt.), while the minimum value (4.52 ± 0.37 µg/g wet wt.) have occurred in the muscles of the fish during the summer. Accumulation of iron was ordered as liver > kidney > gonads > muscles. The obvious results showed visible variations in iron accumulations among the different organs with maximum values during the wet seasons in all organs. Such observations were recorded at Damietta Branch by Osman & Kloas (2010) and differ from those observed by Espinoza *et al*. (2010) and El-Amawy (2016) who found the lowest iron levels in the gonads during the summer.

The data (Table, 3) revealed the highest annual mean value of manganese concentrations (1.54 ± 0.22 µg / g wet weight).) was recorded in the gonads during autumn, while the lowest values occurred in the muscles during winter and kidney during autumn; being 0.46 ± 0.10 µg/g wet wt. in the former and 0.47 ± 0.11 µg/g wet wt. in the latter. The manganese accumulation was ordered as the descending follows: gonads >liver > kidney>muscles. The current results were almost in agreement with Crafford and Avenant-Oldewage (2006) and Monferrán *et al*. (2016) and disagree with Rahman *et al*. (2012) who observed the highest concentration of manganese during summer.

The present study (Table, 3) emerged as the maximum annual mean value of zinc concentrations (28.11 ± 1.25 µg / g wet weight.) in the gonads during winter, while the minimum value (1.26 ± 0.08 µg/g wet wt.) occurred in the fish muscles during summer. Zinc accumulation in the studied organs was ordered as: gonads > liver > kidney > muscles. Results relatively agreed with Espinoza *et al*. (2010); El-Amawy (2016) and Ghanem *et al*. (2016) and differ with Al-Ghanim *et al*. (2016) who observed the maximal value of zinc in the gills.

From the previous data, it is declared the different organs of studied fish showed visible seasonal variations; where the highest concentrations of zinc were accumulated mainly in the gonads followed by the liver. Elevation of zinc in the fish gonads may be attributed to the decomposition of organic matter and agricultural wastes that contain residual zinc and/or may be also associated with reproductive processes. Since gonads are likely to have high zinc concentration, due to their participation in cellular division and growth processes.

Table 3: Seasonal variations of some heavy metals concentrations (µg/g wet wt.) in the target organs of *Chrysichthys rueppelli* collected from El-Bagouria Canal water at El-Menoufia Governorate, during the period of study.

Organs	Seasons \ Metals	Pb	Cu	Fe	Mn	Zn
Gonads	Autumn	0.52±0.11	0.12±0.02	14.43±1.52	1.54±0.22	23.75±2.35
	Winter	0.68±0.13	1.22±0.13	26.41±2.15	1.43±0.11	28.11±1.25
	Spring	0.45±0.04	0.34±0.04	10.16±1.26	0.77±0.10	15.94±0.52
	Summer	0.33±0.05	0.65±0.10	24.83±2.20	0.83±0.15	11.08±1.21
Kidney	Autumn	1.11±0.26	1.11±0.22	48.55±4.16	0.47±0.11	8.20±2.38
	Winter	1.82±0.14	1.38±0.16	60.59±3.22	0.70±0.12	11.57±2.36
	Spring	2.16±0.17	2.46±0.18	41.81±3.44	0.76±0.09	10.55±3.82
	Summer	1.00±0.18	1.18±0.30	39.72±4.35	0.50±0.07	7.37±4.24
Liver	Autumn	2.09±0.12	9.60±1.32	67.87±5.32	0.65±0.08	13.95±1.38
	Winter	1.79±0.25	8.47±1.25	76.08±3.64	0.71±0.20	16.08±1.53
	Spring	1.11±0.21	4.96±1.20	43.44±4.54	0.60±0.12	11.52±1.39
	Summer	1.32±0.29	5.23±1.24	29.18±2.08	0.51±0.27	8.18±1.32
Muscles	Autumn	0.21±0.04	0.28±0.03	11.24±1.05	0.67±0.12	3.22±0.08
	Winter	0.31±0.09	0.80±0.14	18.12±2.53	0.46±0.10	4.17±1.05
	Spring	0.38±0.11	0.44±0.04	7.13±0.82	0.64±0.12	2.09±0.14
	Summer	0.18±0.05	0.62±0.11	4.52±0.37	0.50±0.08	1.26±0.08

The correlation coefficient of some heavy metals between sediment and target organs indicated that, a strong positive correlation between zinc concentrations in the sediment and liver. However, there is a negative correlation between all studied heavy metal concentrations in the sediment and muscles (Table, 4).

Table 4: Correlation coefficient of some heavy metals between sediment and target organs of *Chrysichthys rueppelli* collected from the study area.

Metals \ Organs	Gonads	Kidney	Liver	Muscles
Pb	0.24	0.34	0.43	-0.22
Cu	0.19	0.27	0.36	-0.18
Fe	0.24	0.32	0.48	-0.23
Mn	-0.17	-0.12	-0.28	-0.57
Zn	-0.22	0.46	0.51	-0.21

C-Biosedimentation Factor (BSAF):

The bio-sedimentation factor is defined as the ratio of heavy metal concentration in the body of organisms to that in the sediment. It makes it possible to evaluate the effectiveness of the bioaccumulation of heavy metals in the organism and give an idea of the speed of substance absorption and excretion by a living organism (Zhao *et al*., 2012b; Coulibaly, 2013 and Elwasify *et al*., 2021).

The present study (Table, 5) indicated that the bio-sedimentation factor for lead attained its high rate during winter in the kidney and the lower one during summer in the muscles; being 3.714 in the first and 0.148 in the second.

However, the bio-sedimentation factor for copper fluctuated between 0.002 during autumn in the gonads and 0.296 during winter in the liver. The low level of the bio-sedimentation factor for iron was recorded during summer in the muscles (0.301) and the higher one (5.254) obtained during winter in the liver (Table, 5).

Data (Table, 5) appeared that the bio-sedimentation factor for manganese exhibited its maximum value during spring in the gonads (2.139) and the minimum one (0.489) during autumn in the kidney. Moreover, the bio-sedimentation factor for zinc showed the decreasing level in the muscles during summer and the increasing level in the gonads during winter; being 0.015 in the first and 0.741 in the second. Heavy metals with high bioavailability could be absorbed by aquatic organisms and depend on their pathway during the absorption (Coulibaly, 2013 and Elwasify *et al*., 2021).

Table 5: Bio- sedimentation factors of some heavy metals in the different organs of *Chrysichthys rueppelli* collected from the study area.

Metals	Organs \ Seasons	Autumn	Winter	Spring	Summer
Pb	Gonads	0.825	1.39	0.469	0.271
	Kidney	1.762	3.714 ▲	2.250	0.821
	Liver	1.762	3.653	2.177	1.082
	Muscles	0.333	0.633	0.396	0.148 ↓
Cu	Gonads	0.002 ↓	0.043	0.009	0.023
	Kidney	0.017	0.048	0.068	0.026
	Liver	0.077	0.296 ▲	0.265	0.117
	Muscles	0.004	0.028	0.012	0.014
Fe	Gonads	0.924	1.824	0.825	1.654
	Kidney	3.110	4.184	3.394	2.646
	Liver	4.348	5.254 ▲	3.526	1.944
	Muscles	0.720	1.252	0.579	0.301 ↓
Mn	Gonads	1.491	1.481	2.139 ▲	1.000
	Kidney	0.489 ↓	1.346	1.056	0.603
	Liver	0.677	1.365	0.833	0.615
	Muscles	0.698	0.885	0.888	0.602
Zn	Gonads	0.322	0.741 ▲	0.354	0.129
	Kidney	0.111	0.305	0.235	0.086
	Liver	0.189	0.423	0.256	0.095
	Muscles	0.044	0.109	0.047	0.015 ↓

Results exhibited that bio-sedimentation rate of heavy metals in the surrounding media of studied samples may be due to the increasing activity of anthropogenic pollution. This finding agrees with Camargo & Martinez (2007) and Elwasify *et al*. (2021) and disagrees with De Mora *et al*. (2004) who mention that the seabed composition mostly has more nickel sulphide content which is the natural source of nickel in the coastal areas, rather than the anthropogenic activities. The biosedimentation value of any metal increased when it was increasing in the sediment. Furthermore, Ali *et al*. (2011); Ibrahim & Omar (2013) and Ghanem *et al*. (2015) found that the highest bio-sediment accumulation factor was obtained for Ni, which could be explained by higher levels of these metals in the sediment.

Data refer to the specification of target organs to metal than another one. This observation agrees with Abdel-Baki *et al*. (2011); Ziyaadini *et al*. (2016); Elwasify *et al*. (2021) and Sanou *et al*. (2021) who declared that enhancing BSAF levels for some metals can be used as a specifical measurement of these metals as evidence for aquatic pollution.

Concentrations of these metals in the studied fish muscles were within the permissible levels suggested by WHO (2005). A similar observation was matching with Ghanem *et al*. (2015); Ghanem (2019) and Elwasify *et al*. (2021) who reported that muscles are not a target organ to metals accumulation. These differences in metals accumulation in the edible organs may be attributed to the function of the studied organ. Furthermore, the increasing level of biosedimentation rate leads to the defect in organs function and could be due to the toxic effects of heavy metals (Abarghoei *et al*., 2016; Junejo *et al*., 2019; Kouamenan *et al*., 2020 and Elwasify *et al*. 2021).

Generally, the highest values of biosedimentation factor for Pb, Fe and Mn have values more than 1 (BSAF ≥1). This means that there is almost predangerous bioaccumulation of these metals in fish. This could be attributed to the content of metals in the substrate. This finding agrees with Zhao *et al*. (2012b) who reported that the biosedimentation is significant when occurred in the organism's body with values of BSAF ≥ 1.

The increased rates of biosedimentation factors in the edible organs indicate the high risk to fish health and human consumption. So, the current study shows that precautionary measures must be taken to prevent heavy metal pollution in the future.

Chrysichthys rueppelli can be considered as one of good indicators for lead, iron and manganese. This explanation was in agreement with Mackay & Fraser (2000); Rashed (2001); Uysal *et al*., (2010); Wokoma (2015) and Voigt *et al.* (2015), while, it disagrees with Abdel-Hamid *et al*. (2013) and Mortuza & Al-Misned (2015) who recorded the highest bio-accumulation factor for lead regarding fish tissues.

From another angle, results proved that the highest bio-sedimentation factors for the studied metals among different organs were observed in the liver and the lowest values were obtained in the muscles. This may be attributed to the role of the liver in detoxification, basic metabolism and the major site of accumulation, biotransformation, and help in excretion of contaminants in fish. Also, muscles are not an active site for detoxification and hence for transport of metals from other tissues to muscles. These findings were in accordance with Qiao-qiao *et al.* (2007); Barhoumi *et al*. (2009); Ambedkar & Muniyan (2011); Dwivedi *et al.* (2015); El-Amawy (2016) and Ghanem (2019) and differed with Siraj *et al.* (2015) who reported that, the liver had the least accumulation of pollutants.

Although, Abdel-Mohsien & Mahmoud (2015) mentioned that, heavy metal levels in Egypt exceed the maximum permissible limits recommended by Egypt and WHO in some fish samples, but this study explained the muscles consumption of *Chrysichthys rueppelli* from the area of study is safe on human health.

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ARABIC SUMMARY

التراكم الحيوى لبعض العناصر الثقيلة فى أسماك أبوريالة المجمعة من ترعة الباجورية، محافظة المنوفية – مصر.

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تهدف هذه الدراسة لتقييم تركيزات بعض العناصر الثقيلة فى رسوبيات بعض المحطات بترعة الباجورية الواقعة بمحافظة المنوفية خلال الفترة من خريف, 2019 وحتى فصل الصيف, 2020. حيث تم التجميع موسمياً لكلاً من عينات الرسوبيات والأسماك محل الدراسة خلال تلك الفترة.

أظهرت الدراسة أن أعلى قيم لتركيزات العناصر الثقيلة محل الدراسة برسوبيات القاع قد سجلت خلال مواسم الطقس البارد (فصلى الخريف والشتاء) ماعدا عنصرى الرصاص والزنك. **كما** بينت النتائج وجود إختلاف فى تركيزات العناصر الثقيلة بإختلاف أعضاء الجسم المختلفة للأسماك محل الدراسة مع وجود زيادة ملحوظة بمعدل تراكم هذه العناصر داخل أنسجة الكبد خلال فصلى الخريف والشتاء.

فضلاً عن ذلك، فقد أظهرت مناسل هذه النوعية من الأسماك أعلى تركيز لعنصرى المنجنيز والزنك خلال فصلى الخريف والشتاء. **إحصائياً**، فقد أظهرت التحاليل الإحصائية وجود إرتباط إيجابى قوى بين تركيز عنصر الزنك داخل رسوبيات القاع وأنسجة الكبد. **بينما** بينت الدراسة وجود إرتباط سلبي بين تركيزات العناصر داخل الرسوبيات وأنسجة العضلات.

أوضحت الدراسة أن أعلى قيم لمعامل الترسيب الحيوى للعناصر الثقيلة محل الدراسة قد سجلت خلال فصل الشتاء ماعدا عنصر المنجنيز الذي أظهر أعلى معدل له خلال فصل الربيع. **مما يعنى** أن هذه الزيادة فى معامل الترسيب الحيوى داخل أنسجة الأسماك محل الدراسة تعد خطراً بالغاً لهذه الكائنات نتيجة زيادتها برسوبيات القاع. كما أظهرت الدراسة الحالية أن زيادة معدلات الترسيب الحيوى داخل الأعضاء المستهدفة لجسم الأسماك تنذر بخطورة شديدة على صحة الأسماك والإنسان. ولذلك تعد هذه الدراسة بمثابة إنذاراً مبكراً لأخذ المزيد من الإحتياطات اللازمة لإختزال مستويات التلوث بالقنوات المائية العذبة مستقبلاً.