Plant Archives Vol. 20, Supplement 2, 2020 pp. 2845-2851 e-ISSN:2581-6063 (online), ISSN:0972-5210

INVESTIGATION OF SOME HEAVY METALS IN WATER AND PRUSSIAN CARP *CARASSIUS AURATUS* (L.) IN AL-CHABAISH MARSH IN THI-QAR PROVINCE, SOUTH IRAQ

Imad S. Oudah*[1], Ahmed J. Mohammed[1] and Abdul Sahib K. Ali[2]
[1] Biology Department, Faculty of Science, Baghdad University, Iraq
[2]Central Laboratories Directorate, Ministry of Science and Technology, Iraq
*Corresponding author: imad07751@gmail.com

Abstract

The current study was carried out to investigate some heavy metals (Cadmium, Lead, Copper, and Zinc) seasonally, in water samples and in some tissues of the Prussian carp *Carassius auratus* that were collected from three stations in the Al-Chabaish marsh in the Thi-Qar province of Southern Iraq during the winter of 2018 to the autumn of 2019..In addition, The present study involves the analysis of certain physical and chemical properties of this ecosystem. The results showed positive correlation between the temperature of air and water at all study locations. Air and water temperatures varied from (19- 42.56) °C and (16.90-38.63) ° C respectively. PH, salinity, biological oxygen demand and dissolved oxygen, ranged from (7.63-8.30), (1.50-5.40) ppt, (2.86-4.63) mg. L^{-1} and (4.60-9.20) mg. L^{-1} respectively. Mean concentrations of heavy metals in water (µg .L^{-1}) for Cd, Pb, Cu and Zn, were ranged between (0.167- 0.873) µg.L^{-1},(0.275- 1.33) µg.L^{-1}, (9.50-59.51) µg.$L^{-1}$and (39.70-155.40) µg .L^{-1}respectively. The present research revealed a difference in the levels of the metals examined in various tissues of fish, these levels of the same species differed from organ to organ. The concentrations of heavy metals (pb and Cd) in *C. auratus* organs followed the trend of gill > liver > muscles .whereas, Cu and Zn followed the trend of liver > gill > muscles.
***Keywords*:** Al -Chabaish marsh , Heavy metals, *Carassius auratus*, tissues, Water.

Introduction

The marshes cover an area of about 20,000 square kilometres of sedimentary plain (Bedair *et al.*, 2006). as well as Iraqi marshes are a vital ecosystem because they are considered an incubator for fish and invertebrates and play a major role as habitat for the number of water birds and their tourism importance. Therefore added to the World Heritage List by UNESCO. So it is necessary to intensify environmental studies to preserve their diversity. (UNESCO, 2018) Pollution of the aquatic environment with heavy metals has become a global problem in recent years because they are not biodegradable and most of them have harmful impacts on organisms (Yap *et al.*, 2015). Heavy metals were considered to be severe pollutants of the aquatic environment due to their persistence, low concentration toxicity and ability to be integrated into food chains and focused by aquatic organisms such as fish (Rozic *et al.,* 2014).Increases levels of metal pollution in marshes arising from human activities in marshes resulting from toxic chemicals used in fishing, oil spilled from boats and domestic sewage effluent (Al-Khafaji *et al.*, 2015). Fish are important species in the aquatic environment and are commonly used to study the effects of different toxicants on biological parameters by a large number of biomarkers and to monitor the health of aquatic ecosystems owing to anthropogenic impacts (Antal *et al.*, 2013). Fish can also focus metals in their tissues directly from the surrounding water and through their diet (Qiu, 2015).

Fish is one of the largest and most important vertebrate groups inhabiting the aquatic environment and is at the top of consumers in the food chain of the water ecosystem (Eze *et al.*, 2018). bioaccumulation of heavy metals varies between species, ages and sex organs in the organism, but the target tissue of these minerals is the organ Most active in metabolic processes such as liver, kidneys and gills, while muscle tissue is the least of Where activity of metabolic processes (Shivakumar *et al.*, 2015). Due to the importance of the Iraqi Marshlands and their water resources as a World Heritage Site. it is necessary to intensify environmental studies to preserve their diversity therefore this came the current Study. The aim of this study was to assess seasonal differences in the distribution and concentration of certain heavy metals in water and three organs in the body of commercial fish species *C. auratus* gathered from Central marsh (Al-Chabaish marsh), Southern Iraq.

Materials and Methods

Study area: Central marsh is one of three Iraqi southern marshes extend between the Governorates of Maysan and Thi-Qar between the Euphrates and Tigris Rivers. They are bordered by the Euphrates to the south, the Tigris and the administrative boundary of Al Basrah Governorate to the east (western Al Qurna sub-district), the city of Al Amarah to the north, and the city of An Nasiriyah (capital of the Thi Qar Governorate) to the west (Alami *et al.*, 2014) the average depth of water in the main marshes was about (1-3.5)m.Al-Chabaish Marsh is one of the largest marshes in the province of Thi-Qar which is located in low-lying area in southern Iraq (Bedair *et al.*, 2006).

Sample collection

Water, and fish *C. auratus* were collected from three stations (Fig.1).The first station was at the beginning of the Al-Chabaish marsh, Characterized by the presence of certain types of water plants such as *Phragmites australis, Typha domingenesis* and *Ceratophyllum demersum*. Second station was located near Sewage pumping station which about 5 km from first station, release their wastes directly to the marsh without any treatment, while third station was far away from second station 4 km including buffalo breeding, fishing (use chemical toxins in the process of fishing) and animal waste are discharged directly into the marshes . In addition, there are oil spills from fishing boats .this study was conducted from December 2018 to November 2019.Water samples were manually collected Seasonally in triplicate form by Using of polyethylene bottles (5 liters) approx.30 cm under water surface to measure some of physical and chemical parameters while another water sample was kept in refrigerator to be analyzed in the laboratory. Fish specimens from the work area were collected via gill net and cast net (25 * 25) mm mesh size**.** The captured fishes were then put in polyethylene bags and frozen immediately. The body weights of the fish collected ranged between (51-189 g) and their total length ranged between (17-27.5 cm). Then the abdominal cavity of each sample was opened and the organs, gill and liver were taken, whereas the muscle was separated from the left posterior side of each fish. Tissues were then dried under 105◦c for 24 hr. by using dried oven, then grinded. Tissues were digested by mixture of acids according to the manner mentioned by (ROPME, 1999). then The heavy metals were measured using Flam Atomic Absorption Spectrophotometer as recommended by (Kamal *et al*., 2004).

Statistical analysis

The results were statistically analyzed using analysis of variance (ANOVA) and the test of the least significant difference (LSD).

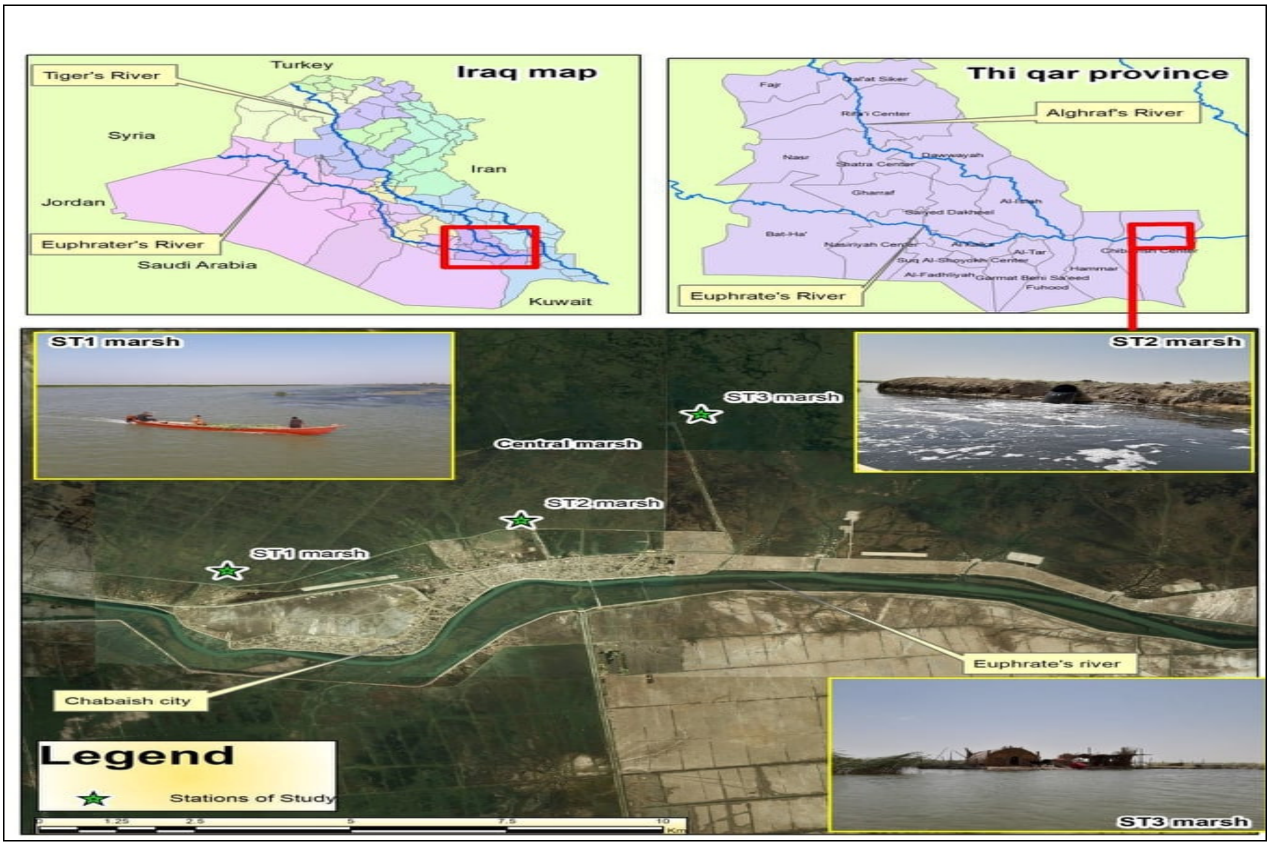

Fig. 1: Map of the study region showing studied stations according to the statistical package for social science (SPSS) version 17.

Results and Discussion

Physico-Chemical parameters

The air temperature for each position in the Al-Chabaish marsh during the study period varied from highest value (42.56°C) in summer at station 3 to the lowest value (19°C) in winter at station 1(Fig.2). Whilst water temperature ranged from the highest value (38.63°C) in summer at station 3 to lowest value (16.90°C) in winter at station 1 (Fig. 3). The temperature of the water significantly affects all metabolic and physiological functions and life processes (Weiner, 2000). The main reasons of a seasonal variation of air and water temperature may be caused by sun irradiance period and length of the day period or may be due to the marsh water is shallow and the big surface expansion (compared with water volume), many researcher confirmed that and refers that water temperature follows air temperature in many lakes and water bodies (Hussain & Taher, 2007). The spatial variations in water temperature among stations may be due to the change in the sampling time at each station (Chandra *et al*., 2010 and Farhood, 2016) the amount of pH of the Al-Chabaish marsh has been recorded as the highest pH (8.30) for winter at station 3 and lowest pH (7.63) for Autumn at station 3 (Fig. 4), the pH values were generally, within the alkaline limit. This is a common feature of the Iraqi inland waters (Mohamed *et al*., 2010); the low pH values were in summer While the high pH values were in winter season at the study period ,plants growth lead to consumption of carbon dioxide gas during winter ,which in turn lead to increase the pH. The low pH values were in summer, may be due to of the degradation of the aquatic plants, phytoplankton and organic materials, which produce dissolved CO_2. As for the location variations, it was observed that the pH values in the third station increased in most seasons, mainly due to the effect of untreated wastewater discharge and saturated with detergents. with alkaline effect of water. The pH recorded in present study is within Iraq standard (6.5-8.5) agree with (Mohammed, 2018). The highest water salinity values was (5.40 ppt) at station 3 in Summer, while the lowest mean (1.50 ppt) was recorded in Spring at station 1 (Fig. 5). Through out the summer season, the highest salinity values were reported due to a drop in water levels and a raise in the evaporation ratio. moreover, the dissolved ions are concentrated by evaporation and diluted by freshwater input in. In addition, to dumping untreated wastewater into marshes with high concentrations of salts, or due to the degradation products of organic materials (UNEP, 2008). These findings agreed with the study of (Al-Saad, 2010). The highest dissolved oxygen value at station 3 in Spring was 9.20 mg. L^{-1}, while, the lowest value at stations 2 in the summer was (4.60 mg. L^{-1}) (Fig. 6). High values of dissolved oxygen during spring can be explained by the decrease in temperature and caused by an increase in the solubility of gas on the one hand (Lind, 1979). And may be attributed to the increase in water discharges in the spring and heavy rains, in addition to the movement of boats used in fishing, transport and recreation, which increased significantly during the spring, which work to mix oxygen in the water column (Al-Asadi, 2019) .whereas, the low concentrations of dissolved oxygen at station 2 in the summer ,may be it is affected by untreated sewage waste that works on consuming dissolved oxygen as a result of its decomposition by microorganisms. and may be due to increase in temperature that will lead in a decrease in the concentration of dissolved oxygen (Simoes *et al.*, 2008). whereas the highest Biological Oxygen Demand (BOD5) was (4.63 mg.L^{-1}) in Autumn at station 2, and lowest value was (2.86 mg.L^{-1}) in spring at station 1(Fig.7).The increase in BOD5 values in the station 2 may be attributed to the effect of untreated wastewater on the marshes containing high concentrations of organic materials and then increasing the biodegradability due to microorganisms (Amadi *et al.*, 2010) on the other hand ,The decrease in the BOD during the spring may be attributed to the decrease in the decomposition processes For organic materials in the first station compared to other stations, increasing the level of water entering the marshes from the Euphrates River after the arrival of the flood wave, which led to the dilution of the marsh waters, In addition to the presence of many aquatic plants in that area.

Heavy metals in water

The mean concentration of heavy metals in water are presented in (Table1), the highest mean for Cd (0.873 µg.L^{-1}) was recorded in station 2 during Summer whereas, the lowest mean (0.167 µg.L^{-1}) was recorded at station 1 during winter. the highest mean concentration recorded for Pb in water was (1.33 µg.L^{-1}) at Station 2 in the summer, while the lowest mean was (0.275 µg.L^{-1}) at Station 1 during the winter season. The maximum mean of Cu (59.51 µg. L^{-1}) was registered in autumn at station 2 whereas the minimum mean (9.50µg.L^{-1}) at station 1 in winter ,With regard to Zinc, the highest mean concentration in water was (155.40µg.L^{-1}) at Station 2 in the summer, while the lowest mean was (39.70 µg.L^{-1}) at Station 1 during the winter season. Most mean concentration of heavy metals in station 2 were higher than their concentration in other stations , this may be due to the exposure of station 2 to the various types of pollutants such as sewage, oil spill from boats, animal, wastes and chemical used in fishing. This study's findings agree with earlier study for (Al-Khafaji *et al.*, 2015).

Heavy metals in fish

Tables (2, 3, 4) showed mean concentrations of heavy metals in organs(gills, muscle and liver) respectively. Fish accumulated heavy metals from their environment, they are excellent organism for the study of some long term changes of heavy metals in the environment (Radeef *et al.*, 2013).The annual mean concentration of the mentioned metal in Gill, muscle and liver of *C. auratus* were Cd (0.678, 0.288 and 0.610), Pb (6.44, 3.29 and5.72), Cu (17.25, 12.53 and 19.21), Zn (32.15, 20.34 and 37.00) µg.gm^{-1} dry weight respectively. The concentration of the above-mentioned metals differed among the organs of the species being studied, This may be due to the species-specific mechanisms. (Al-Saad *et al.*, 2018) indicated that the variations in the patterns of accumulation metals in the organs of the fish species are interdependent on metal uptake and removal levels. Liver and Gill concentrate metals more than muscle, this may be attributed to the fact that the liver is an important organ which convert the food after transmission the latter from the gut while the gill is the first target for pollutants in water through the respiration process. The pattern of accumulation of metals in the fish were in the following order of gills > liver > muscles for Cd and Pb whereas in Cu and Zn were in the following order of liver > gills >muscles. This indicates that the variation in the pattern of accumulation of heavy metals in fish tissues depends on metal absorption and removal levels (Abdel Baki *et al.*, 2011)

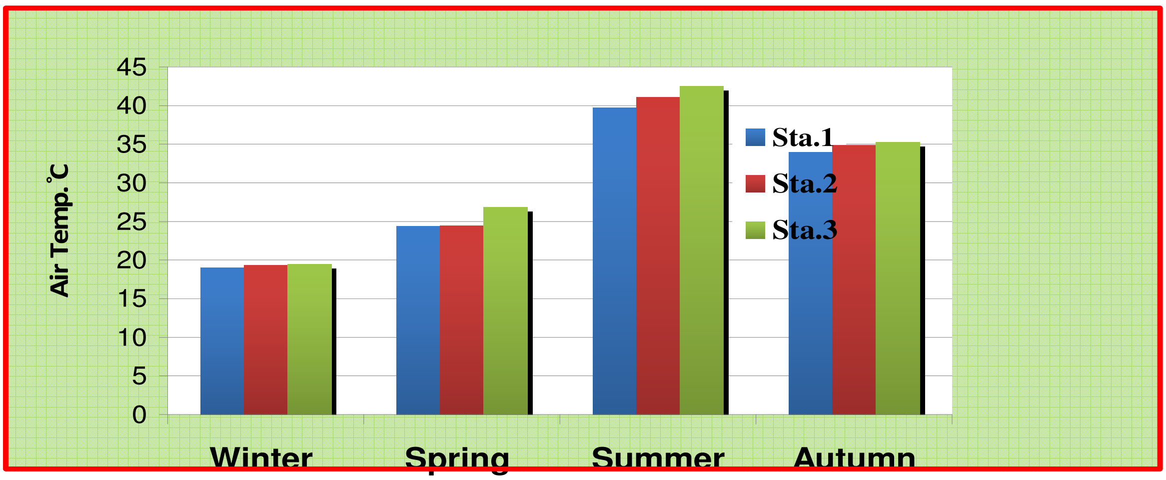

Fig 2 : Air Temperature for studied stations in Al-Chabaish marsh.

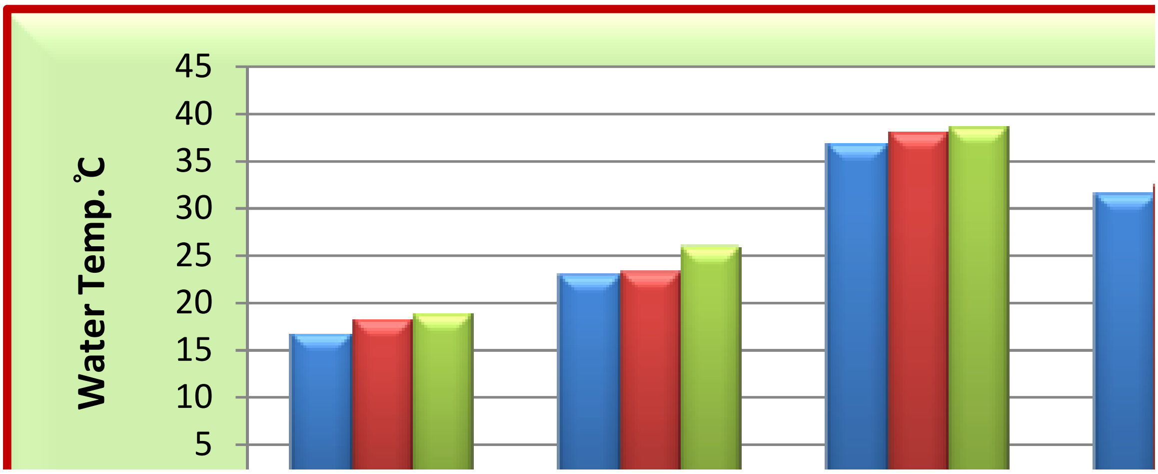

Fig. 3 : Water Temperature for studied stations in Al-Chabaish marsh.

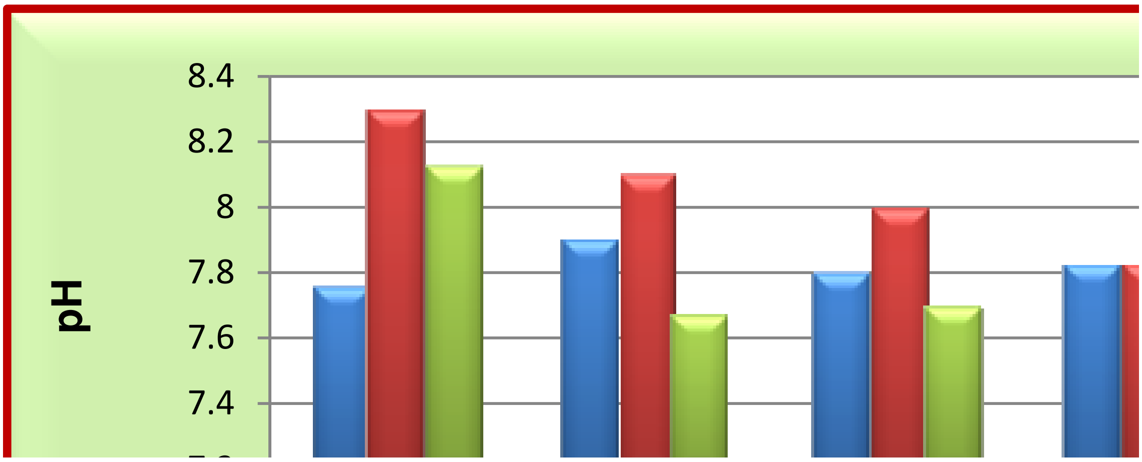

Fig. 4 : pH Water for studied stations in Al-Chabaish marsh.

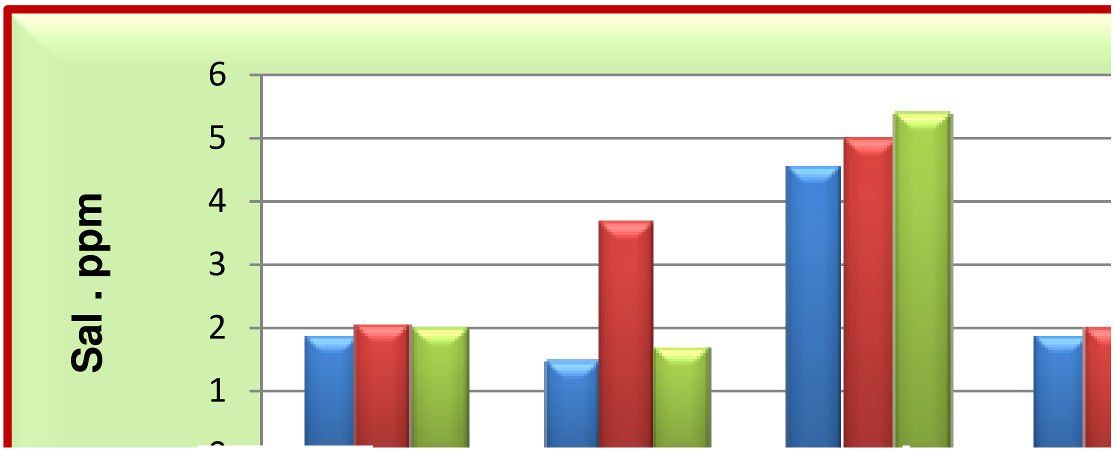

Fig. 5 : Salinity (Sal) for studied stations in Al-Chabaish marsh.

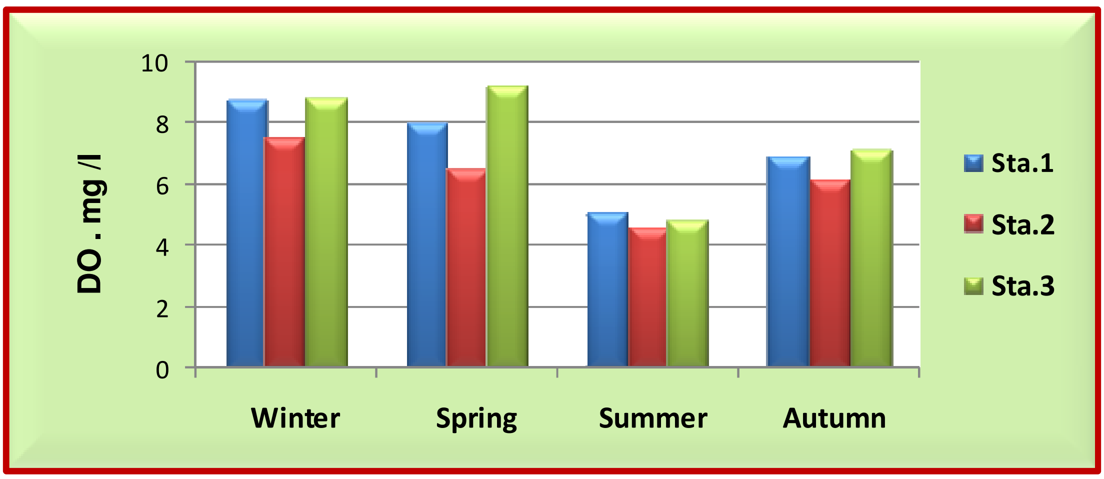

Fig. 6 : Dissolved oxygen for studied stations in Al-Chabaish marsh.

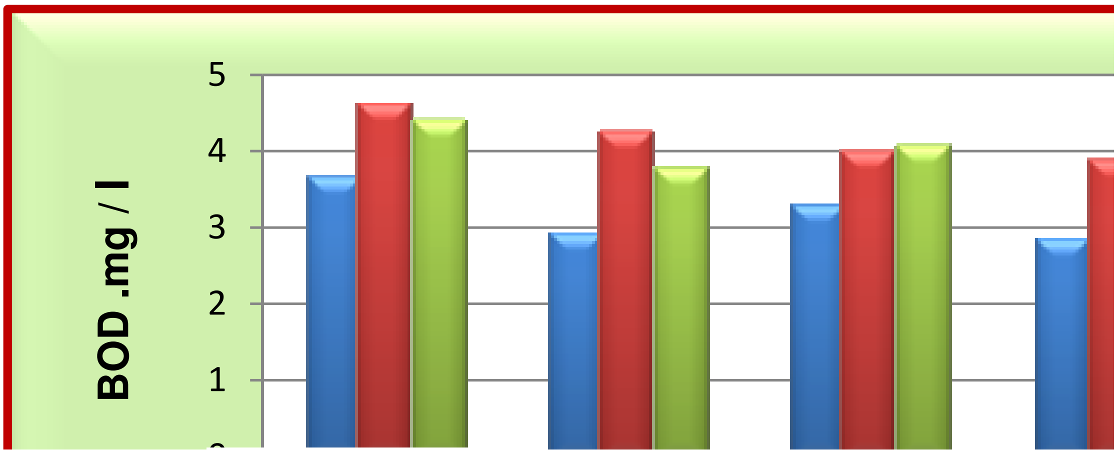

Fig. 7 : Biological Oxygen Demand for studied stations in Al-Chabaish marsh.

The results of the present study agree with (Mensoor and Said, 2018). Low levels of heavy metals were observed in this fish's muscles. The current result consistent to those stated by (Raphael *et al.*, 2011).in comparison with the permissible limits (50, 2000, 100, 20) µg.gm^{-1} for the concentration of zinc, lead, and cadmium and copper respectively in fish for both the World Health Organization (WHO, 1985) and the Federal Environmental Protection Agency (FEPA, 2003) .The concentration of the studied elements was less than the permissible limits for fish. Heavy metal concentration in other part of the body of fish are greater than those in the muscles. Therefore, eating the rest of the fish members by some people adding to the muscles is dangerous because of the possibility of increasing the presence of heavy metals in the consumer's body and thus the possibility of harmful effects on health (Al-Khafaji *et al.*, 2012). Have reported that accumulation and distribution of metals in fish tissues relies on the exposure period, the physiological state of the metals, and the environmental conditions surrounding the fishes.

Table 1 : Mean ± SD of some heavy metals (Cadmium, Lead, Copper , Zinc) in Al-Chabaish marsh water for studied stations in all seasons.

Season	St.	Cd		Pb		Cu		Zn	
		M	± SD	M	± SD	M	± SD	M	± SD
Winter	St.1	.167b	.002	.275b	.003	9.50a	1.67	39.70b	2.75
	St.2	.185a	.002	.299a	.003	10.40a	2.50	42.82ab	2.96
	St.3	.179a	.003	.294a	.001	11.45a	1.75	45.13a	1.85
LSD		0.011		0.012		3.17		4.00	
Spring	St.1	.203c	.005	.330c	.001	30.70a	5.02	75.80b	4.01
	St.2	.312a	.004	.542a	.003	34.30a	1.47	88.70a	2.52
	St.3	.273b	.001	.390b	.002	32.65a	3.20	79.76b	2.54
LSD		0.02		0.05		5.62		4.91	
Summer	St.1	.542c	.003	1.05a	.043	35.40c	.75	130.10c	1.01
	St.2	.873a	.001	1.33a	.330	46.40a	.79	155.40a	1.47
	St.3	.619b	.002	1.13a	.017	41.39b	1.56	140.50b	1.32
LSD		0.06		0.31		1.75		2.03	
Autumn	St.1	.443c	.001	.777b	.001	41.70c	.854	141.60b	1.67
	St.2	.692a	.003	1.230a	.230	59.51a	.982	150.33a	.85
	St.3	.531b	.001	.893b	.015	45.50b	.871	143.23b	1.15
LSD		0.07		0.21		1.41		1.70	

Table 2 : Mean ± SD of some heavy metals (Cadmium, Lead, Copper , Zinc) In gills of *C. auratus* in Al-Chabaish marsh.

Season	St.	Cd		Pb		Cu		Zn	
		M	± SD	M	± SD	M	± SD	M	± SD
Winter	St.1	.066b	.008	1.22b	.192	11.00^{ab}	1.00	18.49b	1.50
	St.2	.136a	.002	1.70a	.425	12.60^{a}	.75	28.00a	2.64
	St.3	.075b	.002	1.90a	.087	10.13b	1.33	26.50a	.53
LSD		0.04		0.41		1.73		2.82	
Spring	St.1	.068c	.006	.18b	.003	11.22b	1.69	22.67b	2.06
	St.2	.861a	.004	2.41a	.42	13.47a	1.50	37.62a	1.92
	St.3	.556b	.002	2.10a	.24	13.24a	.49	34.10a	1.82
LSD		0.2		0.44		2.12		3.7	
Summer	St.1	1.06a	.96	8.38ab	2.05	19.50a	1.84	32.10b	2.90
	St.2	1.60a	.65	10.27a	.77	22.50a	2.42	36.90a	2.15
	St.3	1.61a	.62	8.03b	.97	22.17a	1.85	30.40b	1.60
LSD		1.21		2.19		3.26		3.61	
Autumn	St.1	.590b	.02	12.20b	1.10	22.70b	.90	40.00ab	1.11
	St.2	.773a	.01	14.90a	.40	25.10a	.90	40.80a	.85
	St.3	.750a	.01	14.10a	.65	23.40b	.65	38.33b	.85
LSD		0.03		1.22		1.30		1.50	

Table 3 : Mean ± SD of some heavy metals (Cadmium, Lead, Copper , Zinc) in muscle of *C. auratus* in Al-Chabaish marsh

Season	St.	Cd		Pb		Cu		Zn	
		M	± SD	M	± SD	M	± SD	M	± SD
Winter	St.1	.017c	.001	.039c	.003	7.02b	1.24	19.20c	1.70
	St.2	.069a	.007	.76a	.045	13.60a	1.21	25.33a	1.52
	St.3	.026b	.002	.58b	.06	8.43b	1.22	22.33b	1.52
LSD		0.007		0.07		1.94		2.52	
Spring	St.1	.046b	.003	.115b	.002	8.54b	1.26	22.00b	1.00
	St.2	.178a	.002	1.47a	.502	10.24a	.704	27.64a	1.17
	St.3	.104b	.003	.740b	.424	9.16ab	.772	22.28b	.62
LSD		0.06		0.63		1.50		1.52	
Summer	St.1	.548a	.007	5.720a	1.28	14.40a	1.44	10.23c	1.36
	St.2	.553a	.004	7.390a	.60	16.10a	1.15	19.50a	1.37
	St.3	.556a	.003	7.430a	1.43	14.50a	1.50	14.35b	1.46
LSD		0.01		1.84		2.81		2.22	
Autumn	St.1	.380c	.01	4.580ab	.99	15.40b	.80	18.63b	.47
	St.2	.510a	.02	6.266a	.76	18.40a	.75	21.70a	.75
	St.3	.470b	.01	4.536b	.80	14.70b	.90	21.00a	1.00
LSD		0.03		1.36		1.30		1.22	

Table 4: Mean ± SD of some heavy metals (Cadmium, Lead, Copper , Zinc) in liver of *C. auratus* in Al-Chabaish marsh.

Season	St.	Cd		Pb		Cu		Zn	
		M	SD±	M	± SD	M	± SD	M	± SD
Winter	St.1	.029a	.005	.870b	.11	12.00b	1.00	21.800c	1.15
	St.2	.420a	.580	1.490a	.15	18.80a	1.25	41.333a	1.52
	St.3	.097a	.004	.970b	.09	10.74b	1.30	32.700b	2.06
LSD		0.52		0.19		1.89		2.57	
Spring	St.1	.075c	.003	.524b	.002	9.390c	2.34	26.00c	2.00
	St.2	.737a	.005	1.940a	.05	13.240b	.67	39.00a	1.00
	St.3	.332b	.003	1.470a	.49	16.740a	.65	35.00b	1.00
LSD		0.1		0.48		2.31		2.24	
Summer	St.1	.783b	.004	11.40ab	1.55	26.70b	1.80	42.80b	.95
	St.2	1.00a	.007	13.40a	1.37	31.40a	1.37	67.70a	2.16
	St.3	.912a	.011	10.70b	.91	24.30b	1.70	38.60c	1.57
LSD		0.19		2.57		2.59		2.60	
Autumn	St.1	.840c	.02	7.20b	.01	22.30b	.75	31.50c	.75
	St.2	1.12a	.02	9.70a	.60	23.70a	.72	33.30b	.36
	St.3	.976b	.01	9.03a	.95	21.30b	.60	34.33a	.57
LSD		0.11		1.03		1.10		0.93	

Conclusions

1. The bioaccumulation of metals in various organs of fish was higher than the levels of metals studied in water, which indicate that the fish can build up metals in their bodies.
2. Gills and liver recorded highest concentration of all metals observed while muscle tissues proved to be the least favored site for metal bioaccumulation.
3. Due to seasonal changes the levels of heavy metals studied indicate a decrease in these levels in cold seasons and increase in warm seasons.
4. A pattern of concentrations of heavy metals studied can be shown as Zn > Cu > Pb> Cd for water and fish tissues.
5. The level of heavy metals in both water and fish tissue was generally within the safe limits according to (WHO and FEPA).

Acknowledgements

I am very grateful to the staff of the Technical Institute Laboratory in Al-Shatrah for their assistance in the analysis of heavy metals. I am also grateful to the Directorate of Dhi Qar Water for the assistance provided in the physical-chemical analyzes of water.

References

Abdel-Baki, A.S.; Dkhill, M.A. and Al-Quraishy, S. (2011). Bioaccumulation of some heavy metals in tilapia fish relevant to their concentration in water and sediment of Wadi Hanifah, Saudia Arab. Afr. J. Biotechnol., 10(13): 2541-2547.

Al-Khafaji, B.Y.; Al-Awady, A.A and Farhood, A.T. (2015). Distribution of some trace metals in Al-Chabaish marsh of part ecosystem in Thi-Qar province in southern Iraq. World . J . Pharm. Res., 4(8): 1443-1456.

Al-Asadi, A.A.H. (2019). Evaluation of domestic sewage effluent on water quality, level of organic and trophic pollution in central marshes/ Southern Iraq. M. Sc. Thesis Coll. Sci., Univ. Basrah: 160pp.

Al-Saad, H.T. and Douabul, A. (2010). Water quality of the Iraqi southern marshes. Mesopot. J. Mar. Sci., 25(2): 188-204.

Al-Saad, H.T.; Hantoush, A.A.; Al-Najar, G.A. and Jaafar, R. S. (2018). Effect of Quarterly Changes on the Concentration of Heavy Metals in Al-Zubaidi (*Pampus argenteus*) collected from Iraqi marine coasts. Marsh Bulletin, 13(1): 37-45.

Antal, L.; Halasi-Kovacs, B. and Nagy, S.A. (2013). Changes in fish assemblage in the Hungarian section of River Szamos/Someşafter a massive cyanide and heavy metal pollution. North- West J . Zool., 9(1): 131-138.

Al-Khafaji, B.Y.; Dawood, Y.T. and Maktoof, A.A. (2012). Trace metals distribution in fish tissues (*Cyprinus carpio* and *Barbus luteus*) and sediments from Al-Msab Alamm River near the center of Al-Nassiriya city. J.Thi-Qar Sci., 3(2):22-30.

Alami, A.A.; Salim, M.A.; Mohammed, M.K. and Zubaidi, A.A. (2014). Ahwar of Southern Iraq: Refuge of Biodiversity and the Relict Landscape of the Mesopotamian Cities. Nomination Dossier for Inscription of the Property on the World Heritage List: 268pp.

Farhood, A.T. (2016) Water quality status in different aquatic environments in Thi- Qar province based on NSF-WQI. J. Thi- Qar Sci., 6(1): 17-24.

Amadi, A.N.; Olasehinde, P.I.; Okosun, E.A. and Yisa, J. (2010). Assessment of the Water Quality Index of Otamiri and Oramiriukwa Rivers. Physics Int., 1(2): 116-123.

Bedair, H.M.; Al-Saad, H.T. and Salman, N.A. (2006). Iraq's Southern marshes something special to be conserved; A case study. Marsh Bull., 2(1): 99-126.

Chandra, M.; Kimitaka, K. and Swaminathan, T. (2010). Water-soluble organic carbon, dicarboxylic acids, ketoacids, and a-dicarbonyls in the tropical Indian aerosols. J. Geoph. Rese. 115.

Eze, O.C.; Tukura, B.W.; Atolaiye, B.O. and Opaluwa, O.D. (2018). Pollution Assessment of Heavy Metals in Water and Sediment from Mpape River in FCT, Abuja, Nigeria Chems. Res. J., 3(2): 66-77.

FEPA (Federal Environmental Protection Agency) (2003). Guidelines and Standards for Environmental Pollution Control in Nigeria: 238pp.

Hussain, N.A. and Taher, M.A. (2007). Effect of daily variations, diurnal fluctuations and tidal stage on water parameters of East Hammar marshland, southern Iraq. Marsh Bull., 2(1): 32-42.

Kamal, M.; Ghaly, A.E.; Mahmoud, N. and Cote, R. (2004). Phytoaccumulation of heavy metals by aquatic plants, Environ. Inter. J., 29 (8): 1029-1039.

Lind, O.T. (1979). Handbook of common method in Limnology, 2nd ed. C.V. Mosby Co. ST. Louis., 199.

Mohammed, A.J. (2018). Evaluation of The Validity of Agricultural Drainage Water for The Breeding of Common Carp Fish in Artificial ponds, Iraq. Plant Archives, 19(2): 403- 406

Mohamed, A.R.M.; Hussein, S.A. and Lazem, L.F. (2010). Ecological traits on fish assemblage in the Garma River using Canoca program. Basrah J. Sci., 28(2): 92-106.

Mensoor, M. and Said, A. (2018). Determination of Heavy Metals in Freshwater Fishes of the Tigris River in Baghdad. Fishes, 3:23.

Qiu, Y.W. (2015). Bioaccumulation of heavy metals both in wild and mariculture food chains in Daya Bay, South China Estuarine. Coas. Shell Sci., 163B: 7-14.

Radeef, A.F.; Mosa, A.A. and Qadir, R.M. (2013). Extraction and Estimation of some trace elements from different fish species from Tigris River, Kurdistan Region of Iraq. Tikrit J. Pure. Sci., 18(3): 52-55.

Raphael, E.C.; Augustina, O.C. and Frank, E.O. (2011). Trace metals distribution in fish tissues, Bottom sediments and water from Okumeshi river in Delta State, Nigeria. Environ. Res. J., 5(1): 6-10.

ROPME (1999). Manual of Oceanographic Observation and Pollutant Analysis Methods, (MOOPAM). (Regional Organization for the Protection of the Marine Environment, Kuwait).

Rozic, P.Z.; Dolenec, T.; Bazdaric, B.; Karamarko, V.; Kniewald, G. and Dolenec, M. (2014). Element levels in cultured and wild sea bass (*Dicentrarchus labrax*) and gilthead sea bream (Sparus aurata) from the Adriatic Sea and potential risk assessment. Environmental geochemistry and health, 36(1): 19-39.

Shivakumar, C.; Thippeswamy, B.; Tejaswikumar, M. and Prashanthakumar, S. (2014). Bioaccumulation of heavy metals and its effect on organs of edible fishes located in Bhandra River, Karnatka. Int. J. Res. Fish. Aquacult., 4(2): 90-98.

Simoes, F.; Moreira, A.B.; Bisinot, M.C.; Gimenez, S.M. and Yaba, M.J. (2008). Water quality index as a simple indicator of aquaculture effects on aquatic bodies. Ecological Indicator, 8: 476-484.

UNEP (2008). United Nations Environment Programme Global Environment Monitoring System (GEMS)/Water Programme. Water Quality for Ecosystem and Human Health, 2nd Edition, 130.

UNESCO (2018). Iraq World Heritage Site: The Ahwar of Southern Iraq: Refuge of Biodiversity and the Relict Landscape of the Mesopotamian Cities. Downloaded from https://whc.unesco.org/en/list/1481 on 9 December 2018.

Weiner, E.R. (2000). Application of environmental chemistry. Lewis Publ., London, New York: 267.

WHO (World Health Organization), (1985). Guidelines for Drinking Water Quality (ii): Health Criteria and supporting information WHO, Geneva: 130.

Yap, C.K.; Jusoh, A.; Leong, W.J.; Karami, A and Ong, G.H. (2015). Potential human health risk assessment of heavy metals via the consumption of tilapia *Oreochromis mossambicus* collected from contaminated and uncontaminated ponds. Environmental Monitoring and assessment, 187(9): 584.