Mansoura Journal of Biology Vol. 38 (1), June, 2013.

SEASONAL VARIATION OF CONCENTRATIONS AND BIOACCUMULATION OF CADMIUM, COPPER AND LEAD IN WATER AND MUSCLES OF NILE TILAPIA (*OREOCHROMIS NILOTICUS*) FROM LAKE BURULLUS, EGYPT

Eman M. Yones[1*]; A.M. Radwan[2] and S. M. Ibrahim[3]
[1]Fish Diseases Lab.; [2]Marine Pollution Lab.; [3]Fish Processing Technology Lab.; National Institute of Oceanography and Fisheries, Alexandria, Egypt.
*Correspondence to: e-mail: dr.eeman@yahoo.com
Received : (19/11/2011)

ABSTRACT

The seasonal variation on heavy metals bioaccumulation in muscles of Nile Tilapia, *Oreochromis niloticus*, from Lake Burullus, Egypt, was investigated. Concentrations of Cd, Cu and Pb were measured in water and muscles of *O. niloticus* during 2009. The concentrations of Cd, Cu and Pb in water were ranged from 1.25-21.15, 0.75-47.5 and 11.75-385.3µg/l, while, the corresponding ranges in fish muscles were 0.31-1.25, 1.4-4.12 and 5.75 - 27.35mg/kg, respectively. Pb concentration in water and fish muscle was exceeded the permissible limit; however Cu and Cd were still within the permissible limit. In conclusion, the concentrations of heavy metals in the lake water and fish muscles were taken the following order: Pb >Cu> Cd at all seasons; whereas, higher concentrations were found during winter season in both water and fish muscles. On the other hand, studied heavy metals bioaccumulation rate decreased during winter compared to other seasons. Therefore, seasonal variations in heavy metals concentration may be played an important role in bioaccumulation rate of heavy metals in fish flesh.

Keywords: Heavy metals, Seasonal Variations, Nile tilapia, Lake Burullus.

INTRODUCTION

Lake Burullus is shallow slightly brackish water situated along the Egyptian Mediterranean Sea coasts. Huge amounts of brackish drainage water (about 4.03 milliar m^3/ year) enter the lake from several drains as set by The Egyptian Ministry of Irrigation at 2010. Heavy metal pollutants with Cd, Cu and Pb in water of Lake Burullus ranged from 4.4-7.06, 12.9-18 and 5.4-7.27 ppb, respectively as reported by **(Radwan & Shackweer 2004 and Radwan 2007)**. **Basiony (2009)** found that the concentration of heavy metals (ppm) ranged from 10.393-21.764 Cu, 2.8-4.919 Cd and 22.714-243.539 Pb in tilapia muscles from Lake Burullus whereas the corresponding levels were 0.573-3.615, 0.057-1.458 and 0.398-23.679 ppm in water respectively. In addition, he concluded that heavy metals concentration were higher in winter than summer. **(Mourad et al., 2010)** reported that the concentration of heavy metals (Cd, Pb and Ni) were often above the maximum permissible limits according to FAO standards in fish species samples obtained from the River Nile, Manzala, Mariut, Edku, Burullus, Bardawil, Qarun and Wadi El-Rayan Lakes. In contrast, the levels of Zn, Cu, Fe, Mn and Hg were within acceptable limits. Therefore, this work was planned to study the effect of seasonal variations on Cd, Cu and Pb bioaccumulation in water and muscles of Nile Tilapia, *O. niloticus*, from Lake Burullus, Egypt.

MATERIALS AND METHODS

Lake Burullus lies on the eastern side of the Rosetta branch of the river Nile, Egypt and occupies a central position along the Mediterranean coast of the Nile. It lies between longitude 30˚ 30́ and 31˚ 10́ E and latitude 31˚ 21́ and 31˚ 35́ N. It has an irregular elongated shape and is connected to the sea through a narrow (50 m width) passage called El-Burg inlet or Boughaz El-Burullus (Fig.1).Water samples (n=3) were collected seasonally from Lake Burullus during 2009. High polluted five stations; Bougaz El-Burullus (1), El-Burullus Drain (2), Drain 7 (3), El-Shakhloba (4) and Mastrou (5) were selected. At the same time, *O. niloticus* fish samples were collected from the same stations and transferred to the laboratory using ice box. Heavy metals pollutants (Cd, Cu and Pb) were determined in both water and fish muscles samples. Water samples and muscle tissue were digested by conc. HNO3 (60 %) at 60 °C, diluted into a known volume and then measured using flame-

atomic absorption spectrophotometer, AA-6800 SHIMADZU ASU–6100 **(Bernhard, 1976)**. The bioaccumulation factor was estimated **(Authman and Abas, 2007)** as the following equation:

$$\text{Bioaccumulation factor (BAF)} = \frac{\text{Pollutant concentration in fish organ (mg/kg)}}{\text{Pollutant concentration in water (mg/l)}}$$

All data were statistically analyzed using Social Package Statistical System (SPSS, ver.10) computer program. Seasonal means ± SE were compared using the Duncan Multiple Range Test. The significant level throughout was $P \leq 0.05$.

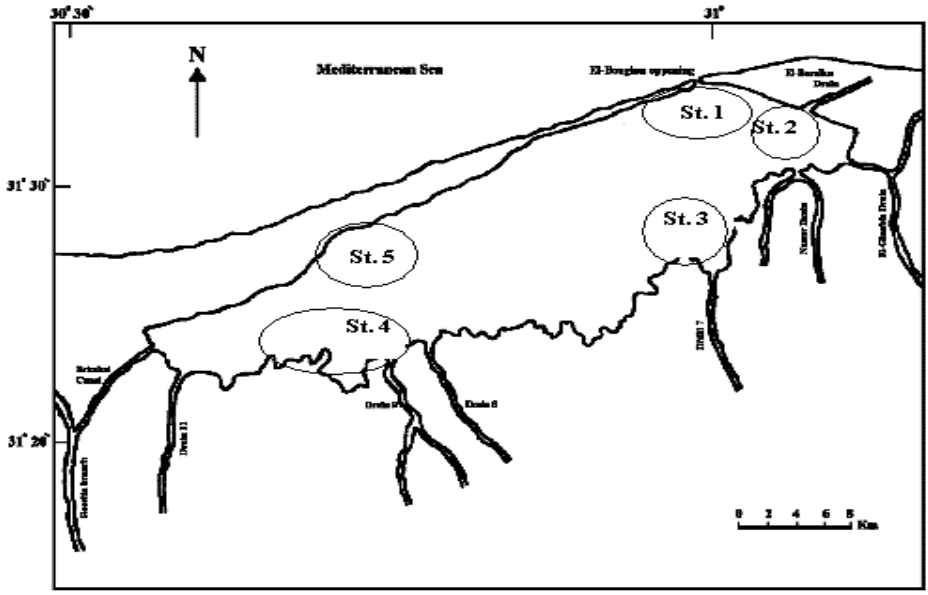

Fig. (1): Burullus map shows the investigated stations.

RESULTS AND DISCUSSION

Table (1) shows Cd concentration in water of Lake Burullus during 2009. Cd level was ranged from 1.25 to 21.20 µg/l. Higher level was recorded during winter especially at station 3 (Drain 7) at eastern part of lake. This increase may be due to anthropogenic, industrial, fertilizers used in agriculture activity **(Radwan, 2007)**. The total annual

average of Cd (3.58 µg/l) was within the permissible level. Our results are in agreement with those reported by **(Radwan 2000**; **Radwan & Shakweer 2004 and Radwan 2007)**. In addition, Cu concentration was ranged from 0.75 to 47.5 µg/l (Table 2). High level was recorded during winter especially at station 5 (Mastrou). The total annual average of Cu (16.9 µg/l) was lower than the permissible level (1000 µg/l) as permitted by **(WHO 1985**; **USEPA 1986**; **EOS 1993 and Radwan, 2007)**. Pb concentration was ranged from 11.75 to 385.3 µg/l (Table 3). High level was recorded during winter especially at station 5 (Mastrou). The total annual average of Pb concentration (79.78 µg/l), this level was exceeded the maximum Pb concentration in water which is 50µg/l according to the Egyptian Standards of the Environmental Laws no. 48/1982 and 4/1994. The increment in Pb concentrations of lake water may be due to direct inputs such as; manufacture and car exhaust emissions, and the possible chemical/biological methylation of inorganic lead in anaerobic sediments **(Sadiq, 1992)**. This data is disagreement with the previous studies **(Radwan & Shakweer, 2004 and Radwan, 2007)** which reported that Pb level was 2.23 - 7.27 µg/l.

Table (1) indicates the Cd concentration in O. niloticus muscles collected from Lake Burullus during 2009. Cd concentration ranged from 0.31 to 1.25 mg/kg wet weight. Higher concentration was recorded during winter especially at station 1 (Bougaz El-Burullus). Cd concentration in muscles was within the permissible level of (2mg/kg) according **(FAO 1992)**. Concerning Cu, high copper concentrations in muscle of O. niloticus was recorded during winter especially at station 5 (Mastrou) (Table 2). The concentration of Cu (1.4: 4.12 mg/kg wet weight) in muscle of O. niloticus is still below the permissible level for Cu (30 mg/kg) as recorded by **(WHO 1973)**. These results are in agreement with the data recorded by **(Shakweer & Radwan 2004)**, they reported that the concentration of Cu in the flesh of various Tilapia species caught from Lake Burullus was below the tolerable concentration admitted by the International Organizations. Similarly, **(Soltan et al., 2005 and Fernandes et al., (2008)** found that Cu exhibited its highest levels in the liver and the lowest values in the muscles. Table (3) shows the concentration of Pb in fish muscles was high during winter (27.35 mg/kg) especially at station 4 (El-Shakhloba). Also, Pb concentration was higher (5.75: 27.35 mg/kg) than the value (0.2 µg/g) set by international regulating agencies **(EU 2002)**. **El-Nabawi et al., (1987)** confirmed that industrial and agricultural discharges are the primary

sources of Pb pollution in Egypt. In general, the present study revealed that the concentration of heavy metals in fish muscles were higher than that recorded in water. Besides, the concentrations of Cd and Cu did not exceed permissible levels. Our results are in agreement with those found by **(Kock & Hofer 1998**; **Wong et al., 2001**; **Shakweer & Radwan 2004**; **Popek et al., 2006 and Basiony, 2009)**.

Bioaccumulation factor gives an indication about the accumulation efficiency for any pollutant in a given fish organ. The data obtained in Tables (1-3) clearly indicated that high bioaccumulation factors (BAF) of Cd, Cu and Pb were 266.67, 581.33 and 818.18, respectively. Fish muscles BAF at station 2 (El-Burullus Drain) was high during summer. BAF for metals seasonally was fluctuated in station 1 (El Boghas). This fluctuation may be due to water flow rate of the Mediterranean Sea during different seasons.

In conclusion, the concentrations of heavy metals in water and tilapia muscles of lake Burullus were taken the following order: Pb>Cu>Cd, the highest levels of these metals were observed during winter however, Pb concentration in both water and muscle exceeded the permissible limit while Cd and Cu concentrations were lower than it. This means that the increment in Pb concentration in both water and fish of Lake Burullus was attributed with the increase of human activities, agricultural as well as industrial wastes in the lake Burullus. On other hand, heavy metals bioaccumulation decreased during winter compared to other seasons. Therefore, seasonal variations of heavy metals concentration may be played an important role in bioaccumulation rate of heavy metals in fish flesh.

Table (1): Concentration of Cd in water and tilapia muscles and Cd bioaccumulation factor (BAF) in muscles of fish collected from Lake Burullus during 2009.

Stations	Winter			Spring			Summer			Autumn		
	Water µg/l	Muscles mg/kg	▲BAF	Water µg/l	Muscles mg/kg	▲BAF	Water µg/l	Muscles mg/kg	▲BAF	Water µg/l	Muscles mg/kg	▲BAF
1	6.6	1.25 ±0.45	189.39	1.75	0.45 ± 0.05 ^{a}	257.14	1.75	0.38 ± 0.025	217.14	1.25	0.33 ± 0.014	264
2	5.4	0.98 ± 0.67	181.48	2	0.48 ± 0.04 ^{a}	240	1.5	0.40 ± 0.01	266.67	1.75	0.40 ± 0.02	228.57
3	21.2	1.15 ± 0.29	54.37	2	0.30 ± 0.01 ^{b}	150	1.75	0.38 ± 0.025	217.14	1.75	0.37 ± 0.033	211.43
4	5.73	1.05 ± 0.22	183.25	1.75	0.35 ± 0.05 ^{ab}	200	1.5	0.38 ± 0.02	253.33	1.75	0.31 ± 0.013	177.14
5	6.15	0.61 ± 0.045	99.19	2.5	0.40 ± 0.01 ^{ab}	160	1.75	0.38 ± 0.025	217.14	1.75	0.36 ± 0.043	205.71
Mean	9.0±3.04	1.06 ± 0.164		2 ±0.14	0.40 ± 0.026		1.65±0.06	0.38 ± 0.008		1.65 ±0.01	0.35 ± 0.013	
Sig.		N.S.			N.S.			N.S.			N.S.	

1: Bougaz El-Burullus; 2: El-Burullus Drain; 3: Drain (7); 4:El-Shakhloba; 5: Mastrou; ▲, bioaccumulation factor (BAF); Values are expressed as mean ± standard error (X ± SE); a,b means within columns with no common superscripts differ significantly ($P \leq 0.05$); N.S., Non significant.

Table (2): Concentration of Cu in water and tilapia muscles and Cu bioaccumulation factor (BAF) in muscles of fish collected from Lake Burullus during 2009.

Stations	Winter			Spring			Summer			Autumn		
	Water µg/l	Muscles mg/kg	▲BAF	Water µg/l	Muscles mg/kg	▲BAF	Water µg/l	Muscles mg/kg	▲BAF	Water µg/l	Muscles mg/kg	▲BAF
1	22.59	1.92 ± 0.15 ^{d}	84.99	18.5	1.4 ± 0.1	75.68	15.5	1.48 ± 0.18	95.48	0.75	1.6 ± 0.15	213.33
2	29.88	2.3 ± 0.131 ^{cd}	76.97	5.25	1.4 ± 0.28	266.67	3.75	2.18 ± 0.28	581.33	13	1.73 ± 0.12	133.08
3	33.35	2.92 ± 0.26 ^{bc}	87.56	12.5	2.48 ± 0.98	198.40	3.5	1.6 ± 0.01	457.14	4.5	1.85 ± 0.14	75.51
4	35.45	3.62 ± 0.25 ^{ab}	102.12	12	1.53 ± 0.025	127.50	11.5	1.6 ± 0.005	139.13	16	1.8 ± 0.17	112.50
5	47.5	4.12 ± 0.37 ^{a}	86.74	16.5	1.68 ± 0.025	101.82	6.75	1.71 ± 0.38	253.33	9.5	1.74 ± 0.12	183.16
Mean	33.75 ±4.1	2.88 ± 0.212		12.95±2.3	1.67 ± 0.193		8.2 ±2.3	1.71 ± 0.11		12.75 ±3.9	1.74 ± 0.06	
Sig.		***			N.S.			N.S.			N.S.	

1: Bougaz El-Burullus; 2: El-Burullus Drain; 3: Drain (7); 4:El-Shakhloba; 5: Mastrou; ▲, bioaccumulation factor (BAF); Values are expressed as mean ± standard error (X ± SE); a,b means within columns with no common superscripts differ significantly ($P \leq 0.05$); N.S., Non significant.

Table (3): Concentration of Pb in water and tilapia muscles and Pb bioaccumulation factor (BAF) in muscles of fish collected from Lake Burullus during 2009.

Stations	Winter			Spring			Summer			Autumn		
	Water µg/l	Muscles mg/kg	▲BAF	Water µg/l	Muscles mg/kg	▲BAF	Water µg/l	Muscles mg/kg	▲BAF	Water µg/l	Muscles mg/kg	▲BAF
1	199.7	22.8 ± 6.1	114.17	55.5	5.75 ± 0.95	103.60	27.5	5.95 ± 1.15	216.36	82.5	8.5 ± 0.12	103.03
2	180.8	22.63 ± 9.7	125.17	20.25	7.03 ± 0.55	347.16	13.75	11.25 ± 2.95	818.18	19.5	9.5 ± 0.67	487.18
3	216.8	27.28 ± 3.6	125.83	26	7.95 ± 0.55	305.77	15	7.9 ± 1.2	526.67	7.5	8.43 ± 1.67	306.55
4	201.6	27.35 ± 3	135.66	22.25	7.6 ± 0.20	341.57	11.75	7.7 ± 0.20	655.32	3.5	8.2 ± 0.5	348.94
5	385.3	21.4 ± 0.8	55.54	33.25	7.4 ± 0.7	222.56	21.5	9.3 ± 0.20	432.56	11.75	8.4 ± 0.44	714.89
Mean	236.8 ±37.6	24.73 ± 2.24		31.45±6.4	7.14 ± 0.32		17.9 ±2.9	8.42 ± 0.78		32.95±12.7	8.62 ± 0.31	
Sig.		N.S.			N.S.			N.S.			N.S.	

1: Bougaz El-Burullus; 2: El-Burullus Drain; 3: Drain (7); 4:El-Shakhloba; 5: Mastrou; ▲, bioaccumulation factor (BAF); Values are expressed as mean ± standard error (X ± SE); N.S., Non significant ($P \leq 0.05$).

REFERENCES

Authman, M. M. and H. H. Abas **(2007).** Accumulation and distribution of copper and zinc in both water and some vital tissues of two fish species *(Tilapia zillii and Mugil cephalus)* of Lake Qarun Fayoum Province, Egypt. Pakistan J. Biol. Sci., 10:2106 -2122.

Basiony, A. I. **(2009)**. The environmental study on the pollution of lake Burullus with heavy metals and organochlorine pesticides contaminants in water, sediment and fish. Scientific Rep., Ministry of Higher Education, Egyptian National Commission for Unesco- Alesco- Isesco.

Bernhard, M. **(1976).** Manual of methods in aquatic environment research. Part, 3: Sampling and analyses of biological material FAO Fish. Tech. Pap. No. 158.

Egyptian Ministry of Irrigation, Organization of Mechanic and Electricity **(2010)**. The amount of agricultural drainage water which entered the Lake Burullus during 2010. Central Administration of the Central Delta stations, Kafr El-Sheikh, Egypt.

El-Nabawi, A.; B. Heinzow and H. Kruse **(1987).** As, Cd, Cu, Pb, Hg and Zn in Fish from Alexandria Region, Egypt. Bull. Environ. Contam. Toxicol. (39): 889-897.

EOS **(1993).** Egyptian Organization for Standardization, Egyptian Standard, maximum levels for heavy metal concentrations in food. ES 2360-1993 UDC: 546. 19: 815 Egypt.

EU **(2002).** European Communities. Amending regulation, setting maximum levels of certain contaminants in foodstuffs. Official J Eur Communities L37: 4–6.

FAO **(1992)**. Food and Agriculture Organization. Committee for inland fisheries of Africa: Working Party on pollution and fisheries. FAO Fish Rep. No. 471.

Fernandes, C.; A. Fontainhas-Fernandes; D. Cabral and M. Salgado **(2008).** Heavy metals in water, sediment and tissues of *Liza Saliens* from

Esmoriz-Paramos Lagoon, Portugal. Environmental Monitoring and Assessment 136: 267-275.

Kock, G. and R. Hofer **(1998).** Origin of cadmium and lead in clear soft water lakes of high-altitude and high-latitude, and their bioavailability and toxicity to fish. J. Exs., (86): 225-257.

Mourad, M.; H. Assem; M. El-Saihia; A. Khalifa and B. Hassan **(2010).** Human health risk assessment associated with current Egyptian dietary intakes of fish. Egypt. J. Aquat. Research, 36 (1):147-159.

Popek, W.; G. Dietrich; J. Glogowski; K. Demska-Zakes; E. Drag-Kozak;J. Sionkowski; P. Epler; W. Demianowicz; B. Sarosiek; R. Kowalski; M. Jankun; Z. Zakes; J. Krol; S. Czerniak and M. Szczepkowski **(2006).** Influence of heavy metals and 4-nonylphenol on reproductive function in fish. Reproduction and Biology 6:175-188.

Radwan, A. M. **(2000)**. Discharge on the concentrations of some heavy metals in Lake Borollus. Bull. National Institute of Oceanography and Fisheries, A.R.E., 26: 355-364.

Radwan, A. M. **(2004).** Evaluation of water quality in Lake Burullus. Egypt. J. Aquat. Biol Fish A.R.E. 8(3): 15-33.

Radwan, A. M. **(2007).** Impact of pollution on the primary production of phytoplankton in Lake Burullus. African J. Biol. Sc., 3(1):35-49.

Radwan, A. M. and L. M. Shakweer **(2004).** On the present status of the environment and fishery of Lake Burullus, 2A: distribution and concentrations of trace elements in the water and bottom sediments of Lake Burullus. Egypt. J. Aquat. Res., 30(A):43-98.

Sadiq, M. **(1992).** Toxic metal chemistry in marine environments. Marcel Dekker Inc., New York, Basel, Hong Kong. ISBN 0824786475.

Shakweer, L. M. and A. M. Radwan **(2004).** Environmental and fishery investigations on Lake Borollus, 2B: Rates of trace elements accumulation in the macrophytes and fish at lake Borollus. Egypt. J. of Aquat. Res., 30(A): 99-120.

Soltan, M.; S. Moalla; M. Rashed and E. Fawzy **(2005)**. Physicochemical characteristics and distribution of some metals in the ecosystem of Lake Nasser, Egypt. Toxicol. and Environm. Chem., 87:167–197.

USEPA **(1986).** United States Environmental Protection Agency. Quality Criteria for Water. EPA 440/5-86001 Office of Water Regulations and Standards Washington DC USA.

WHO **(1973).** World Health Organization. Health hazards of human. Environment, Geneva Switzerland.

Wong, C. K.; P.P. Wong and L.M. Chu **(2001).** Heavy Metals Concentrations in Marine Fishes Collected from Fish culture Sites in Hong Kong. J Arch Environ. Contam. Toxicol., 40(1):60-69.

الاختلاف الموسمى لتركيزات وتراكم الكادميوم والنحاس والرصاص فى مياة وعضلات سمكة البلطى النيلى فى بحيرة البرلس – مصر

إيمان ممدوح يونس – عبد العزيز محمد رشاد – سيد مكاوى ابراهيم
المعهد القومى لعلوم البحار والمصايد – الأسكندريه– مصر

أجريت هذه الدراسة الموسمية على بحيرة البرلس من خلال تجميع عينات من المياه وأسماك البلطى النيلى من خمس محطات مختلفة فى البحيرة فى الفترة من فبراير حتى أكتوبر ٢٠٠٩، بهدف تقدير تركيز الكادميوم والنحاس والرصاص فيها. وقد أوضحت الدراسة أن هناك تغيرات موسيمية واضحة فى تركيز العناصر الثقيلة حيث تم تسجيل اعلى تركيز لهذه العناصر خلال فصل الشتاء. وتراوحت تركيزات هذه العناصر خلال المواسم الأربعة فى مياه بحيرة البرلس كالأتى: الكادميوم (١.٢٥ : ٢١.١٥ ميكروجرام / لتر) ، النحاس (٠.٧٥ : ٤٧.٥ ميكروجرام / لتر) ، الرصاص (١١.٧٥ : ٣٨٥.٣ ميكروجرام / لتر) ، بينما تراوحت تركيزات هذه العناصر فى عضلات الأسماك كالأتى: الكادميوم (٠.٣١ : ١.٢٥ مجم / كجم)، النحاس (١.٤ : ٤.١٢ مجم / كجم) ، الرصاص (٥.٧٥ : ٢٧.٣٥ مجم / كجم). كما اظهرت النتائج ان تركيز الرصاص تجاوز الحد المسموح به بينما لا يزال النحاس والكادميوم أقل من الحد المسموح به في المياه و الأسماك. وفي ضوء هذه النتائج توصى الدراسة بضرورة استمرار الدراسات البيئية من خلال الرصد البيئي ومتابعة جودة المياه والأسماك والحد من مشكلة التلوث للمحافظة على هذا الكيان البيئي من التدهور.