Wild Birds as Bioindicator For Heavy Metals Pollution in Lake Quaron Protected Area (Ramsar Site), Fayoum, Egypt.

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Abstract:
Aquatic organisms absorb the pollutants directly from water and indirectly from food chains. Heavy metals levels were determined in different organs of the wild birds (*Anas crecca*, *Fulica atra*, *Larus genii*, *Egretta garzetta* and *Ceryle rudis*) by using Atomic Absorption spectrophotometer. The samples collected from Lake Quaron which suffers from a serious pollution problems. The results revealed that heavy metal levels in *Larus genii* , *Anas crecca* and *Egretta garzetta* found to have their highest concentration in liver while *Fulica atra* and *Ceryle rudis* were in feather. The lowest heavy metals concentration found in all birds in muscles.

The evaluated wild birds considers as an important bioindicator for the degree of pollution in aquatic ecosystems.
***Key words**: Heavy metals, wild birds, Lake Quaron, Ramsar site, Protecetd area*

Introduction

Lake Quaron, located in the deepest part of El-Fayoum depression at the western desert and it is a closed saline lake, 70 km south Cairo-Egypt between longitudes 30º 24´ & 30º 49´ E and latitudes of 29º 24´ & 29º 33´ N. Lake Quaron is the remnant of the prehistioric lake (Lake Moris). It has an area of about 200 km2. It is surrounded by vast desert at the northern shore and cultivated lands at the south. It is used as a reservoir for the drainage water of El- Fayoum province ***(Mageed, 2005).***

Lake Quaron, was declared as a protected area by the virtue of Prime Minister decision No.(348) in 1989 as in order to conserving the diversity in biology, geology and archaeology that found in the area. ***(Authman and Abbas, 2007).***

organs that present either as resident or migratory in the Lake.

Material and methods

A total number of (52) wild birds of five different species (8 common teal (*Anas crecca*) and 6 Coot (*Fulica atra*) as migratory birds with 24 adult slender-billed gull(*Larus genii*), 8 little egrets(*Egretta garzetta*) and 6 pied-king fisher(*Ceryle rudis*) as resident birds as shown in photos (1,2,3,4,5).

In this study, monitoring of wild birds performed around the year to determine the suitable times to collect resident wild birds and the migratory birds. Use of shot guns was the only and obligatory method applied to collect the examined birds. The criteria used for identification were size, plumage colour, bill shape, toes shape and mannerism according to **Porter and Cottridge (2001).**

Breast feather's samples were collected according to ***Burger (1993)*** and digested as recorded by ***Adout et al (2007).*** Liver and breast muscles of each examined bird were digested by using Nitric/ Percholoric acid (4:1) according to the method described by ***Al Ghais (1995)***. All heavy-metal concentrations (µg/g) in tissues were estimated on a dry weight basis.

"Cd, Cu, Fe, Mn, Ni, Pb and Zn" were analyzed using (Atomic Absorption Spectrophotometer, A Analyst 100 Spectrometer, Perkin

Lake Quaron was designated as Ramsar site in 2012 due the presence of many criteria which let the area deserve to be one of Ramsar list, as it supports vulnerable, endangered, or critically endangered species and threatened ecological communities ,it regularly supports 20,000 or more water birds, and it is an important source of food for fishes, spawning ground, nursery and/or migration path on which fish stocks, either within the wetland or elsewhere, depend ***(The Ramsar Convention Manual, 2013)***. The lake is environmentally important as it is an International important area for water birds (**IBA**) ***(Baha El Din, 1999).***

Heavy metals generally, found in nature naturally in very little quantities in water. So aquatic organisms absorb the pollutants directly from the surrounding water and indirectly from the food web ***(Khayatzadeh and Abbasi, 2010).*** Water birds suffer health impairment or death when subjected to high concentrations of some heavy metals .In birds the possible consequence of exposure to sub-lethal concentrations of heavy metals for individuals are (1) reproductive dysfunction ; (2) increased susceptibility to disease ; and (3) behavioral changes ***(Scheuhammer, 1987)***.

The present work aimed to evaluate the heavy-metal pollution in Lake Quaron through estimation of heavy metals in different wild bird's

genii recorded the highest level of Mn in liver.
Anas crecca recorded the lowest levels of Cd, Fe in feathers, Ni and Zn in muscles and Mn in liver. *Fulica atra* recorded the lowest level of Cu in feather where *Egretta garzetta* had the lowest value of Pb in muscles.
Statistically, Table (6) showed that Cd, Cu, Fe, Mn, Ni, Pb and Zn contents in *Ceryle rudis* significantly($P \leq 0.01$) and positively correlated with Cd, Cu, Fe, Mn, Ni, Pb and Zn contents respectively in *Anas crecca, Fulica atra, Egretta garzetta* and *Larus genii.*
Table (5) showed that Cd, Cu, Fe, Mn , Ni, Pb and Zn content in wild birds were significantly influenced ($P \leq 0.05$) by species.

Elmer, USA) at National Institute of Oceanography and Fisheries, Suez Branch.
Data were analyzed using SPSS software (version 17.0) according to ***Snedecor and Cochran (1989).*** The values were taken as significant at $P \leq 0.05$ and $P \leq 0.01$ ANOVA (analysis of variance).

Results

The concentration average (µg/g) of Cd, Cu, Fe, Mn, Ni, Pb and Zn in liver ,muscle and feathers of different wild birds were summarized in Table (1) and illustrated in Figures (1,2,3,4) as follow:-
The highest level of Cd and Cu were found in the liver of *Anas crecca* . *Ceryle rudis* had the highest level of Ni, Pb and Zn in feather and Fe in liver. The *Larus*

Table (1): *Heavy metals concentration (µg/g dry wt.) in wild birds collected from Lake Quaron (2013)*
(Average ±Standard Deviation):

Species	Organ	Cd	Cu	Fe	Mn	Ni	Pb	Zn
Larus genii	Liver	0.408± 0.179	16.471± 2.395	168.49 ±29.555	15.485± 1.119	1.369 ±0.468	1.737± 0.265	20.199± 2.671
	Muscle	0.161± 0.044	13.580± 1.001	127.99 ±26.096	2.688±0. 396	1.216 ±0.533	1.499± 0.310	16.189± 2.304
	Feather	0.307± 0.083	8.278±1. 330	107.75 ±83.425	6.826±3. 656	2.481 ±0.877	3.432± 1.178	25.276± 5.553
Fulica atra	Liver	0.183± 0.027	37.594± 1.568	170.44 ±8.175	7.589±5. 652	1.299 ±1.051	2.334± 0.101	19.276± 0.715
	Muscle	0.127± 0.056	23.081± 2.273	133.30 ±24.807	7.603±6. 424	0.840 ±0.056	2.248± 0.533	11.596± 2.504
	Feather	0.158± 0.048	6.900±0. 579	89.517 ±16.147	11.607± 4.390	3.147 ±0.601	2.999± 0.933	18.973± 3.936
Anas crecca	Liver	0.551± 0.325	61.557± 15.437	178.15 ±28.073	1.583±0. 587	0.790 ±0.419	3.440± 0.391	19.169± 2.203
	Muscle	0.160± 0.034	14.061± 4.369	106.91 ±12.559	7.010±2. 217	0.735 ±0.237	3.074± 0.717	9.528±1. 212
	Feather	0.107± 0.019	8.872±2. 659	79.491 ±17.763	5.791±2. 819	1.264 ±0.626	4.895± 2.488	15.104± 1.153
Ceryle rudis	Liver	0.249± 0.019	16.767± 1.578	301.50 ±14.326	12.534± 0.507	1.796 ±0.034	2.275± 0.515	26.145± 0.606
	Muscle	0.167± 0.035	19.422± 1.612	195.34 ±11.246	2.512±0. 447	1.115 ±0.187	1.836± 0.268	15.252± 0.792
	Feather	0.415± 0.135	14.844± 2.636	136.67 ±8.799	3.531±0. 701	11.075 ±6.157	5.579± 1.806	43.001± 0.433
Egretta garzetta	Liver	0.194± 0.062	40.616± 13.787	201.69 ±40.488	10.971± 1.159	2.311 ±1.024	1.166± 0.649	21.472± 2.458
	Muscle	0.144± 0.033	11.563± 1.013	134.31 ±34.364	2.225±0. 337	1.174 ±0.626	1.071± 0.646	14.725± 1.118
	Feather	0.167± 0.199	26.874± 4.650	101.89±4 6.188	4.869±1. 372	0.937±0.4 92	2.458± 1.914	13.836± 4.876

Table (2): *Comparison of heavy metals concentration (µg/g dry wt.) in liver of wild birds in Lake Quaron with previous studies.*

Area	Birds	Liver							Reference
		Cd	Cu	Fe	Mn	Ni	Pb	Zn	
Lake Quaron	*Larus genii*	0.408	16.471	168.39	15.485	1.369	1.737	20.199	Present study
	Fulica atra	0.183	37.594	170.44	7.589	1.299	2.334	19.276	
	Anas crecca	0.551	61.557	178.15	1.583	0.790	3.440	19.169	
	Egretta garzetta	0.194	40.616	201.69	10.971	2.107	1.166	21.472	
	Ceryle rudis	0.249	16.767	301.50	12.534	1.796	2.275	26.145	
Lake Manzala	Migratory quail	0.92	16.40	-	-	-	1.62	-	Medani and Ahmed (1999)
Lake Manzala	Teal	0.257	3.218	-	-	-	2.523	-	Mahmoud *et al.,* (2001)
	Shoveler	0.425	2.001	-	-	-	2.181	-	
Lake Manzala	Wigeon	1.182	29.257	--	-	-	11.423	97.117	Samia (2002)
	Mallard	1.642	210.210	-	-	-	12.932	116.872	
	Shovler	1.043	96.085	-	-	-	8.593	112.793	
	Coot	0.922	29.698	-	-	-	10.653	144.498	
Aswan area	Little egret	1.195	14.837	-	-	-	16.397	50.548	
	Gray heron	1.503	22.570	-	-	-	11.683	93.938	
	Black headed gull	1.187	19.882	-	-	-	11.470	52.635	
Permissible limits		1	30	-	6.5	-	2	100	WHO (1998)

Table (3): *Comparison of heavy metals concentration (µg/g dry wt.) in muscles of wild birds in Lake Quaron with previous studies.*

Area	Birds	Muscle							Reference
		Cd	Cu	Fe	Mn	Ni	Pb	Zn	
Lake Quaron	*Larus genii*	0.161	13.580	127.99	2.688	1.216	1.499	16.189	Present study
	Fulica atra	0.127	23.081	133.30	7.603	0.840	2.248	11.596	
	Anas crecca	0.160	14.061	106.91	7.010	0.735	3.074	9.528	
	Egretta garzetta	0.144	11.563	134.31	2.225	1.174	1.071	14.725	

	Ceryle rudis	0.167	19.422	195.34	2.512	1.115	1.836	15.252	
Lake Manzala	**Squacoo heron**	0.371	12.44	-	-	-	2.28	22.749	**Salah-Eldein (2012)**
	Little grebe	0.377	15.896	-	-	-	2.842	23.878	
	Moorhen	0.304	22.489	-	-	-	2.724	34.528	
	Little tern	0.564	14.093	-	-	-	6.089	22.783	
	Purple Gallinule	0.246	10.564	-	-	-	3.608	26.064	
Lake Manzala	**Migratory quail**	0.32	1.80	-	-	-	0.73	-	**Medani and Ahmed (1999)**
Permissible limits		1	30	100		-	2	100	**WHO (1998)**

Table (4): *Comparison of heavy metals concentration (µg/g dry wt.) in feather of wild birds in Lake Quaron with previous studies.*

Area	**Birds**	**Feather**							**Reference**
		Cd	**Cu**	**Fe**	**Mn**	**Ni**	**Pb**	**Zn**	
Lake Quaron	*Larus genii*	0.307	8.278	107.75	6.826	2.481	3.432	25.276	**Present study**
	Fulica atra	0.158	6.900	89.517	11.607	3.147	2.999	18.973	
	Anas crecca	0.107	8.872	79.491	5.791	1.264	4.895	15.104	
	Egretta garzetta	0.167	26.874	101.89	4.869	0.937	2.458	13.836	
	Ceryle rudis	0.415	14.844	136.67	3.531	11.075	5.579	43.002	
Lake Manzala	Teal	0.257	3.218	-	-	-	2.523	-	**Mahmoud *et al.* (2001)**
	Shoveler	0.425	2.001	-	-	-	2.181	-	
Lake Manzala	Squacoo heron	0.454	20.769	-	-	-	10.15	65.7	**Salah-Eldein (2012)**
	Little grebe	0.366	10.298	-	-	-	13.56	55.419	
	Moorhen	0.352	7.075			-	8.034	58.24	
	Little tern	1.147	18.936	-	-	-	9.524	128.012	
	Purple Gallinule	0.331	3.769	-	-	-	12.761	45.493	

Table (5): *Comparison between heavy metals in muscles of wild birds species by two-way ANOVA (F-test)*

Sources	Cd					Cu				
	K-fisher	Teal	Coot	Little Egret	Slender billed gull	K-fisher	Teal	Coot	Little Egret	Slender billed gull
K-fisher	1					1				
Teal	0.916^{**}	1				0.823^{**}	1			
Coot	0.963^{**}	0.775^{*}	1			0.983^{**}	0.915^{**}	1		
Little Egret	0.896^{**}	0.999^{**}	0.744^{*}	1		0.998^{**}	0.856^{**}	0.992^{**}	1	
Slender billed gull	0.995^{**}	0.873^{**}	0.985^{**}	0.849^{**}	1	0.914^{**}	0.983^{**}	0.974^{**}	0.937^{**}	1
	Fe					Mn				
K-fisher	1					1				
Teal	0.933^{**}	1				0.960^{**}	1			
Coot	0.989^{**}	0.868^{**}	1			0.930^{**}	0.996^{**}	1		
Little Egret	0.944^{**}	0.999^{**}	0.884^{**}	1		0.998^{**}	0.940^{**}	0.905^{**}	1	
Slender billed gull	0.920^{**}	0.999^{**}	0.850^{**}	0.998^{**}	1	0.989^{**}	0.908^{**}	0.865^{**}	0.996^{**}	1
	Ni					Pb				
K-fisher	1					1				
Teal	0.834^{**}	1				0.964^{**}	1			
Coot	0.951^{**}	0.964^{**}	1			0.997^{**}	0.941^{**}	1		
Little Egret	0.979^{**}	0.928^{**}	0.994^{**}	1		0.930^{**}	0.994^{**}	0.900^{**}	1	
Slender billed gull	0.990^{**}	0.903^{**}	0.985^{**}	0.998^{**}	1	0.888^{**}	0.978^{**}	0.851^{**}	0.995^{**}	1
	Zn									
K-fisher	1									
Teal	0.727^{*}	1								
Coot	0.899^{**}	0.954^{**}	1							
Little Egret	0.971^{**}	0.869^{**}	0.977^{**}	1						
Slender billed gull	0.873^{**}	0.969^{**}	0.998^{**}	0.964^{**}	1					

Table (6): *Correlation coefficients between heavy metals content (i.e. Cd, Cu, Fe, Mn, Ni, Pb and Zn) in different wild birds collected from Quaron Lake.*

Species	Heavy metals													
	Cd		Cu		Fe		Mn		Ni		Pb		Zn	
	F-test	*P*-value	F-test	*P*-value	F-test	*P*-value	F-test	*P*-value	F-test	*P*-value	F-test	*P*-value	F-test	*P*-value
Birds	6.896	0.005	26.122	0.000	8.425	0.002	21.516	0.000	10.696	0.001	15.495	0.000	9.188	0.002

Correlation coefficient significant at $*P \leq 0.05$, $** P \leq 0.01$ and NS; non-significant.

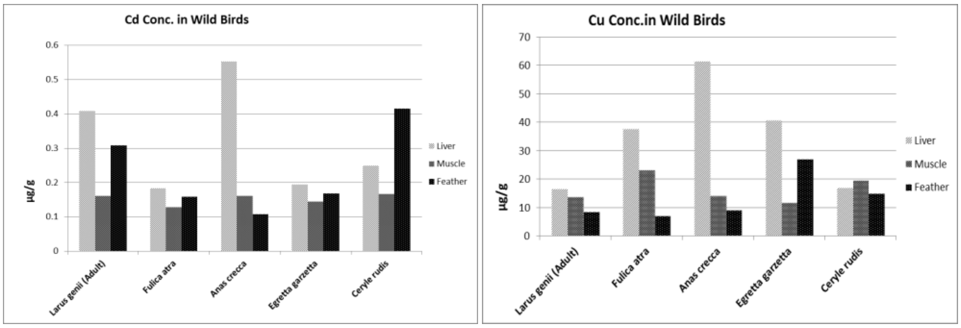

Figure (1): *Average concentrations (µg/g dry wt.) of Cd and Cu in wild birds samples collected from Lake Quaron*

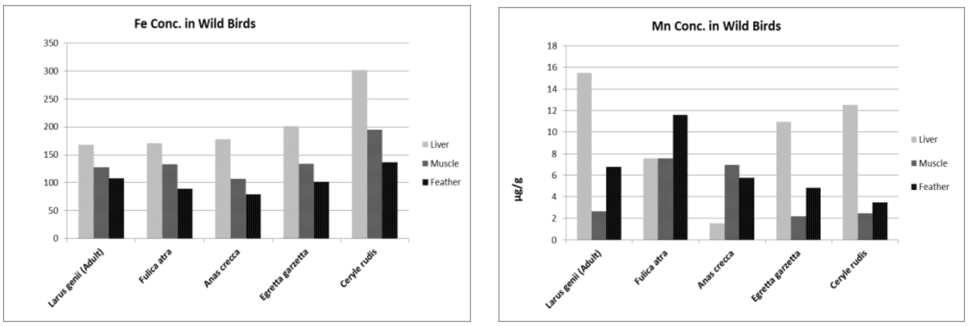

Figure (2): *The average concentrations (µg/g dry wt.) of Fe and Mn in wild birds samples collected from Lake Quaron* **.**

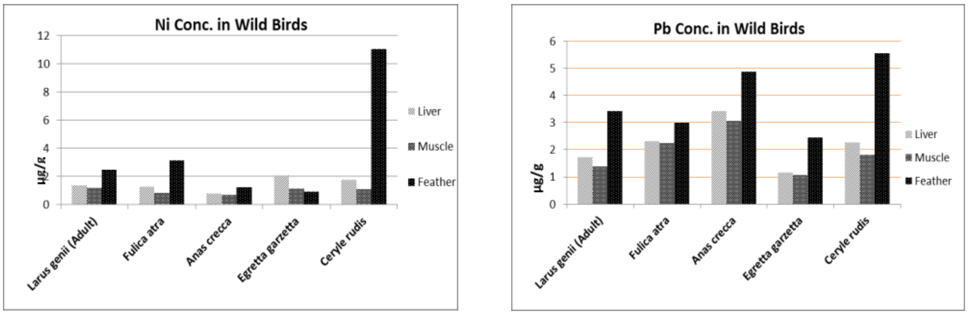

Figure (3): *The average concentrations (µg/g dry wt.) of Ni and Pb in wild birds samples collected from Lake Quaron .*

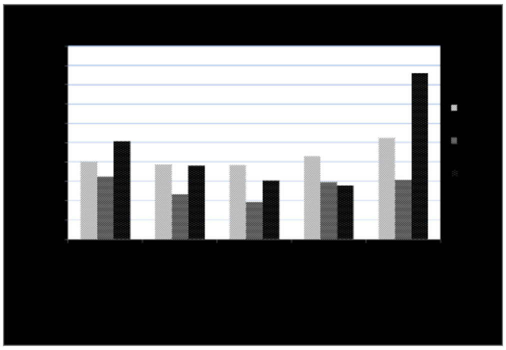

Figure (4): *The average concentrations (µg/g dry wt.) of Zn in wild birds samples collected from Lake Quaron .*

Photo (1): *Pied Kingfisher (Ceryle rudis)*
Photo (2): *Slender-billed Gull (Larus genii)*

Photo (3): *Little Egret (Egretta garzetta)*
Photo (4): *Coot (Fulica atra)*

Photo (5): ***Common Teal (Anas crecca)***

Discusion

Increased levels of heavy metals into marine ecosystems may have many unfavorable ecological consequences as toxic effects or bio-magnification in aquatic biota. So this organisms used in assessment and biological monitoring of the safe levels of heavy metals in the environment ***(Tulonen et al, 2006)***. Birds are often sensitive to environmental contaminants than other organisms ***(Furness and Greenwood, 1993).***

The heavy metals levels in *Larus genii* organs, liver>feather>muscle in their accumulation and this agreed with ***Kim et al (1996),*** the estimated metals were present in the following order; Fe > Zn > Cu> Mn> Pb> Ni > Cd, liver had the highest levels of Fe, Cu, Mn and Cd, while feather was the highest in Zn, Pb and Ni. ***Samia (2002)*** recorded levels of metals in feathers of *Chroicocephalus ridibundus* in Aswan area (Egypt) by the following order; Zn > Cu> Pb> Cd. Also ***Carpene et al (1995)*** estimated in Italy the metals in muscle of *Larus ridibundus* and found it in the following order; Fe > Zn > Cu**.** Levels of the detected metals in liver and muscle were within the permissible limits except Fe, Mn and Ni in liver with Fe and Ni in muscle were above the permissible limits of ***WHO (1998).***

In *Fulica atra*, the metals accumulated as follows; feather > liver >muscle and the following order in liver and muscle; Fe > Cu> Zn > Mn> Pb> Ni > Cd, this result agreed with ***Binkowski (2012).*** While in feather were Fe > Zn > Mn> Cu>Ni > Pb>Cd and this result agreed with ***Lei and Dong-long (2011).*** All recorded metals in liver and muscle were above the permissible limits by ***WHO (1998)*** except Cd, Zn in liver and Cd, Cu and Zn in muscles were within the permissible limits.

In *Anas crecca*; liver >feather > muscle was the order of accumulation within the organs and in the following order; Fe > Cu> Zn > Mn> Pb> Ni > Cd, except in liver level of Pb is higher than Mn and in feather level of Zn is higher than Cu. These results agreed with ***Mahmoud et al (2001).*** All measured metals in liver and muscle were above the permissible limits by ***WHO (1998)*** except Cd, Mn, Zn in liver and Cd, Cu and Zn in muscles were within the permissible limits.

In *Ceryle rudis*, the following accumulation order was found feather>liver>muscle, the recorded metals in liver and muscle were present in the following order; Fe > Zn > Cu> Mn> Pb> Ni > Cd except Cu was higher than Zn in muscle and in feathers were in the following order ; Fe > Zn > Cu> Ni > Pb> Mn > Cd. All estimated metals were within the permissible limits according to ***WHO (1998)*** except Fe, Mn, Ni, Pb in liver and Fe and Ni in muscles.

Egretta garzetta had the accumulation order of liver>feather> muscle, the estimated metals in liver and muscle were present in the following order; Fe > Cu>Zn > Mn> Ni >Pb> Cd except Zn was higher than Cu in muscle and Pb was higher than Ni in feathers; these result disagreed with ***Ferreira (2011) and Samia (2002).*** All estimated metals were within the permissible limits according to ***WHO (1998)*** except Cu, Fe, Mn and Ni in liver and Fe and Ni in Muscles.

In the present study, the detected heavy metals in resident wild birds from Quaron Lake had the following order; *Ceryle rudis> Larus genii>Egretta garzetta* , this result come in agreement with ***Gochfeld et al (1999) and Furness and Greenwood (1993)*** who concluded that Predatory birds have been advocated as bioindicators of pollution because they are at the top of their food webs, are particularly susceptible to bioaccumulation, and integrate contaminants over time.

In comparison with other birds in Lake of Manzala it was noticed that, levels of Cu and Pb in livers of migratory birds in Quaron Lake were higher than that recorded in migratory quails in Lake Manzala by ***Medani*** and ***Ahmed (1999)***. Generally, birds of Lake Quaron had lower levels of heavy metals except Cu in all tissues and Cd in liver were higher than that recorded by ***Salah-Eldein (2012)***.

The obtained results proved that feather is an important tool for estimation the degree of heavy metal pollution in wild birds, means there is no need for hunting or slaughtering of endangered or valuable species for detection the degree of pollution or the effect of these metals on wild birds. ***Thyen et al (2000)*** showed that, the use of feathers has been suggested as non-destructive means of assessing the contamination of heavy metals. There are several advantages for the feather as monitoring units, first, they are easy to obtain and can be observed for a long period , so feather is useful for long-term study ;second, when large number of samples are needed, it has few damages to the population's survival and reproduction of water birds. Also it is noticed that levels of heavy metals recorded in feathers were higher so it considered an useful tool for measuring heavy metals levels in birds as; birds deposit heavy metals in feathers during their formation and they are deposited during the short period of feather growth when the blood supply to the feather is intact, thus, levels in feathers are a record of circulating blood levels at the time of feather formation**,** this result agreed with ***Burger (1996).***

Generally the resident wild birds in Lake Quaron (*Larus genii, Egretta garzetta* and *Ceryle rudis*) had higher levels of heavy metals than migratory birds (*Anas crecca* and *Fulica atra*), this consider as an important indicator of the degree of the pollution in Quaron Lake these results agreed with ***Ali et al (2008)*** who reported that as a result of extensive evaporation of Lake Quaron water leading to increases concentration of salts and heavy in such closed system which depend mainly on agricultural drainage water of Fayoum Province. Consequently, this changes the quality of water and affects the biodiversity.

In the present study Cu generally was higher and that is attributed to the presence of about (615) woody non-motorized fishing boats operating in the lake of Quaron ***(El-Serafy et al, 2014)*** that using antifouling coatings which are the major source of Cu pollution ***(Ghanem , 1986)***.

Concerning the presence of high levels of Cu, Fe, Mn , Ni, and Pb in the liver and muscle of examined species above the permissible limits according to ***(FAO, 1983;***

WHO, 1989 and WHO, 1998), so consumption of wild birds from Lake Quaron may cause serious health hazards such as nephritis, anuria and extensive lesions in kidney, gastroenteritis, carcinogenesis, hypertension, liver cirrhosis, chronic renal failure or toxicity for local community who lives around Lake Quaron and other peoples consumed these birds, these results come in agreement with ***Luckey and Venu-gopal (1977) and Copat et al (2012)***

From the obtained results wild birds consider as an important indicator for the degree of pollution in aquatic ecosystems and these results agreed with ***Elghobashy et al (2001)*** who stated that aquatic animals could serve as biological indicators for environmental degradation and pollutants.

Finally although Lake Quaron is an important bird area, Ramsar site and contain El Qarn El-Zahaby Island (one of the important sites in the world specially for slender-billed gull breeding), it suffers from great pollution problems affecting wild birds, in turn affecting humans that may depend on these birds as source of food, so great attention must be taken as soon as possible for actually preserving of Lake Quaron from the pollution problems.

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الملخص العربي

الكائنات البحرية تمتص الملوثات من المياة بشكل مباشر وغير مباشر.وقد تم قياس نسب بعض العناصر الثقيلة في أعضاء وريش الطيور البرية (الشرشير، الغُر، النورس القرقطي، البلشون الصغير وصياد السمك الأبقع) وكانت جميع الطيور من بحيرة قارون التي تعاني من مشكلة تلوث خطيرة.وقد أظهرت النتائج أن طيور النورس والشرشير والبلشون الصغير تحتوي علي نسب أعلي من المعادن الثقيلة في الكبد بينما طيور الغُر وصياد السمك تحتوي علي نسب أعلي في الريش، وكانت العضلات أقل النسب في محتوي المعادن الثقيلة في جميع الطيور.

أكدت الدارسة علي ان الطيور البرية محل الدارسة تعتبر مؤشر حيوي هام علي مستوي التلوث في الانظمه البيئية المائية.