American Journal of Environmental Sciences 7 (6): 515-524, 2011
ISSN 1553-345X

Limnological Studies on the Wetland Lake, Al-Asfar, with Special References to Heavy Metal Accumulation by Fish

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Abstract: Problem statement: Al-Asfar Lake is one from the important shallow wetland lakes. It is located on the eastern region of Saudi Arabia, Al-Hassa Province. However, much of their limnology and its biotic information are still unknown to the scientific community. The study aims to follow variations in physico-chemical characteristics, phytoplankton and to determine the sort of pollutants such as heavy metals that are affecting the lake. Heavy metals accumulation by fish is also investigated to assess the public health risks associated with consuming fish harvested from this area. **Approach:** A regular visit was monitoring the spring over a period of one-year (January 2010-December 2010). Sediment, surface water samples, Phytoplankton and fishes were collected seasonally from different sites within the lake. **Results:** The data revealed that the maximum content of Cd (0.5 ppm), Cu (2.62 ppm) and Zn (2.6 ppm) were recorded at 5 and 15 cm depth, respectively. Noteworthy is that the highest value of Pb was 7.7 ppm at 1.0 cm depth. The physic-chemical characteristics were subjected to seasonal variations. The data shows that the concentrations of metals in water were found in the following order: $Pb^{2+} > Cu^{+2} > Zn^{2+} > Cd^{2+} > Mn^{+2}$. The data also shows that there are marked seasonal differences in the quantitative and qualitative composition of the phytoplankton communities in Al-Asfar Lake water. The results confirm the differences of heavy metal accumulation in the different tissues of lake fishes. The highest concentrations were found in kidney, except for Cd and Cu which is found in liver to be highest. The lowest levels were detected in the muscle. **Conclusion:** The levels of heavy metals recorded in water were generally high, when compared to the international Permissible limits. The analysis of phytoplankton of Al-Asfar Lake indicates that the water of Lake Al-Asfar can be considered as eutrophic. The fishes can be useful as bioindicator of the degree of pollution in aquatic ecosystems. Al-Asfar is indicates heavy polluted in autumn and winter and moderate pollution in spring and summer.

Key words: Al-Asfar lake, heavy metals, aquatic ecosystems, public health risks, physico-chemical characteristics, surface water, wetland lakes, agriculture soils

INTRODUCTION

Wetlands are very important natural areas. Millions of water birds depend on them. Wetlands have on average the richest biodiversity of all ecosystems. By using wetlands more effectively, recreational activities have become possible, such as fishing, boating and bird watching. This has generated money from visitors and provides sustainable development opportunities. The main reason wetlands are so important is because they are important water provider. Nowadays wetlands are capable of providing alternative sources of income for local communities (Flower *et al*., 2001).

Water chemistry exhibit variable physical and chemical characteristics and consequently variable biological compositions (Fathi *et al*., 2001; Fathi and Flower, 2005). These variations depend mainly on the type and nature of the water area itself as well as on the manmade additions or runoff of minerals and chemicals from agriculture soils (Ahmed *et al*., 1986).

Arid environments are the most diverse ecosystems of Saudi Arabia. However, much of their hydrobiology and its component biotic information are still unknown. Al-Asfar Lake is one from the important shallow wetland lakes. It is located on the eastern region of Saudi Arabia, Al-Hassa Province. The area is characterized by widespread growth of halophyte

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shrubs associated with a very thin salt crust on the sabkha surface (The lake is the site of the confluence of migratory birds from outside the area visited by dozens of the virtues of birds (Fathi *et al*., 2009). However, much of their limnology and its biotic information are still unknown to the scientific community. Few studies were conducted on lake Al-Asfar, vegetation communities (Youssef and Al-Fredan, 2008); sedimentological, hydrogeological, chemical structure (Al-Dakheel *et al*., 2009); water quality and phytoplankton communities (Fathi *et al*., 2009); presence of pollutants in Al-Asfar Lake using sediment records as well as fungal spores to assess biological patterns (Al-Sheikh and Fathi, 2010). However, Abdel-Baki *et al*. (2011) studied the bioaccumulation of some heavy metals in tilapia fish relevant to their concentration in water and sediment of Wadi Hanifah, Saudi Arabia. The study aims to follow variations in physico-chemical characteristics, phytoplankton and to determine the sort of pollutants such as heavy metals that are affecting the lake. Heavy metals accumulation by fish are also investigated to assess the public health risks associated with consuming fish harvested from this area (which it could be the first record).

MATERIALS AND METHODS

The studied area and climate: Al-Asfar Lake is one from the important shallow wetland lakes. It is located on Al-Hassa, eastern region of Saudi Arabia (Fig. 1). Al-Hassa Province is one of the largest oases in the world and located in the southern part of the eastern region of Saudi Arabia. It is situated between 25° 05' and 25°40' northern latitude and 49°55' eastern longitude. Al-Asfar Lake is located east of the oasis of Al-Hassa, grow on the banks of many plant. The lake is the site of the confluence of migratory birds from outside the area visited by dozens of the virtues of birds the lake formed a result of wastewater a farm in the oasis of Al-Hassa. The main salient morphologic features of Lake Al-Asfar are wetlands, sabkhas and sand dunes. There are salt tolerant vegetation (halophyte) found in some of the less salt affected sabkha areas.

Sampling physico-chemical characteristics: A regular visit was monitoring the lake over a period of one-year (January 2010-December 2010). Surface water samples were collected seasonally from different sites within the lake. The sites were distributed to give good spatial representation of water quality.

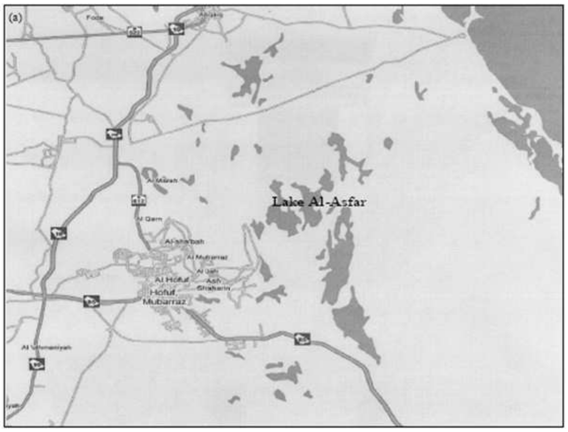


Fig. 1: Map of the study area

Temperature, pH, conductivity, total dissolved salts and Dissolved oxygen of the lake water were measured at each location. pH was measured using a pH m (370 pH m Jenway, UK), conductivity and total dissolved salts using a calibrated Conductivity Meter (470 Conductivity meter, Jenway, UK). Dissolved oxygen was measured according to the Winkler method (Strickland and Parsons, 1972). Total alkalinity, phosphate-P, nitrate-N, chloride, silicate and major cations were measured in the lake water samples according to Adams (1990). Sodium and potassium concentrations were determined photometrically by flame emission according to Golterman and Clymo (1969). Trace metals analyses were performed by atomic absorption spectrophotometer according to Adams (1990). The results were calculated as mean values of triplicate measurements made on each water sample from each of the four sampling stations.

Sediment studies: The sediment samples were taken from the uppermost 1 cm sediment collected during the April, 2010 by a spade box core device (GKG). One sediment core was retrieved from the lake using a technique of Berglund and Ralska-Jasiewiczsowa (1986). After dissolution of sediment samples, the metal concentrations were measured by a Varian Atomic Absorption Spectrophotometer (AA-6800F, Shimadzu, Japan).

Quantitative and qualitative analysis of phytoplankton: For algal counting, the simplified methods described by Willen (1976) and Hobro and Willen (1977) were followed. Counts of phytoplanktonic algae (unicellular, colonial or filamentous) were expressed as cells per liter. The algal taxa were identified according to standard references, including Smith (1950); Bourrelly (1981); Komarek and Fott (1983); Prescott (1978) and Krammer and Lange-Bertalot (1983; 1988; 1991a; 1991b; 2008). Brillouin's index (H) as described by Pielou (1966) was used for quantitative analysis of species diversity.

Heavy metals accumulation by fish: Tilapia zilli and Aphanius dispar fishes were collected by bottom trap net by fishermen from Al-Asfar lake during the study period. The samples were washed with distilled water, dried in filter study, packed in polyethylene bags and stored below ±20°C until analysis. The fish samples after defrosting were dissected into offal, gills, muscle, kidney and liver. After dissection, all the tissue samples were separately oven-dried to constant weight at 105±20°C and were each ground to powder. The powdered samples were digested according to Sreedevi *et al*. (1992). Each digested sample was made up to 20 mL with de-ionized water and analyzed for heavy metals (Cd, Pb, Zn and Cu) in a Atomic Absorption Spectrophotometer. Results are expressed in micrograms per gram of the dry tissue weight.

Transfer Factor (TF): The transfer factor in fish tissues from the aquatic ecosystem, which include water and sediments, was calculated according to Kalfakakour and Akrida-Demertzi (2000) and Rashed (2001) as follows:

TF= Mtissue/ Msediment or water

where, Mtissue is the metal concentration in fish tissue; Msediment, metal concentration in sediment.

RESULTS AND DISCUSSION

The biotic variables used to describe different water areas are often related to environmental factors such as climate, chemistry and pollution. A consideration of these factors leads to a better understanding the biology of aquatic habitats (Fathi *et al*., 2009). Lakes in arid systems is generally poorly studied yet they are likely to develop and respond to stressers in substantially different ways from those normally recognized in northern boreal zones of Europe. With extremely low local precipitation the lake is sustained by surface inflows of agriculture drainage water only (Fathi and Flower, 2005).

The results of heavy metals stratigraphy from Al-Asfar Lake sediment are shown in Fig. 2. The data revealed that the maximum content of Cd (0.5 ppm), Cu (2.62 ppm) and Zn (2.6 ppm) were recorded at 20, 5 and 15 cm depth, respectively. Noteworthy is that the highest value of Pb was 7.7 ppm at 1.0 cm depth. Establishment of metal levels in sediments can play an important role in detecting sources of pollution in aquatic systems (El-Sammak and El-Sabrouti, 1995; Peters *et al*., 2001). Accordingly, the highest value of Pb in the sediment at 1.0 cm depth is a clear indicator of recent lake pollution by this sediment. Shakweer *et al*. (1993) reported that Cu and Zn concentration in the fish flesh were found to be lower than the levels allowable for the human consumption, while those of Pb were higher than the tolerable concentration for man. This pollution could was thought to be associated with the input from different drains.

The physico-chemicals characteristics of Al-Asfar Lake water are shown in Table 1. The average water temperature of Lake Al-Asfar was subjected to seasonal variations. The temperature of water reached its minimum in winter (15.17°C) while the maximum (31.20°C) was recorded in summer. The water temperature of Al-Asfar Lake generally followed that of the air, due to the shallow depth and large expanse of surface as compared with the volume (Fathi *et al*., 2009). In the present investigation the lake did not show proper thermal stratification, as it is extremely shallow. This is in accordance with results obtained by some other authors (Fathi *et al*., 2009; Youssefadn Al-Fredan, 2008; Al-Sheikh and Fathi, 2010).

Change in pH value was always in the alkaline side. It fluctuated between 7.24 in winter and 9.00 in summer. Generally, this general tendency to the alkaline side may be due to the increased photosynthetic activity of planktonic algae, which was also previously recorded (Fathi *et al*., 2001; Fathi and Flower, 2005). The lowest pH and alkalinity values recorded in Al-Asfar lake may be due to greater amount of inflowing agriculture water and also to the decomposition of plankton and organic matter (Al-Dakheel *et al*., 2009; Fathi *et al*., 2009; Youssef and Al-Fredan, 2008; Al-Sheikh and Fathi, 2010).

The conductivity and the Total Dissolved Salts (TDS) of water were found to be higher in summer (12.05 mS cm^{-1} and 7.21 gL^{-1}, respectively) but dropped to a minimum level in winter (8.12 Ms cm^{-1} and 5.02 gL^{-1}, respectively). The highest value of its electrical conductivity and T.D.S. could be attributed mainly to the high pollutional levels in water, resulted from the high nutrient loads of wastewater (Fathi *et al*., 2001). On the other hand Fathi *et al*. (2001) and Flower *et al*. (2001) reported that the fluctuations of salinity of North Egyptians lakes from time to time, could be explained by the differences of the input amount of drainage water.

Table 1: Phhysico-chemical characteristics Al-Asfar Lake water during the investigation period

Parameters	Winter	Spring	Summer	Autumn
Temperature °C	15.1700000	22.0500000	31.2000000	21.5600000
pH	7.2400000	9.0000000	8.5300000	7.7700000
Conductivity (mS)	8.1200000	11.2100000	12.0500000	11.8700000
T.D.S. (gL^{-1})	5.0200000	5.9800000	7.2100000	6.0400000
Dissolved O$_2$ (gL^{-1})	4.3300000	14.5700000	15.2300000	7.3500000
Alkalinity (mgL^{-1})	115.62±1.58	501.0±3.000	388.0±2.450	150.0±2.540
Chloride (gL^{-1})	3.22±0.10	3.62±0.10	4.60±0.20	4.65±0.10
Nitrate-N (mgL^{-1})	2.32±0.10	1.22±0.50	1.00±0.50	1.80±0.21
Phosphate -P (mgL^{-1})	2.82±0.15	1.77±0.20	1.50±0.15	2.22±0.10
Silicate mg/l	2.70±0.10	3.54±0.10	4.00±0.50	3.54±0.20
Sodium (gL^{-1})	1.50±0.00	1.40±0.00	1.99±0.00	1.40±0.00
Potassium (mgL^{-1})	25.00±0.00	31.00±0.00	30.00±0.00	31.00±0.00
Calcium (mgL^{-1})	44.00±0.00	58.15±0.25	60.2 ±0.15	45.00±0.15
Magnesium (mgL^{-1})	17.42±0.15	35.55±0.20	43.56±0.15	31.21±0.10
COD (mgL^{-1})	15.00±0.15	7.12±0.15	38.21±0.50	15.81±0.10

Means ± SD (n = 3)

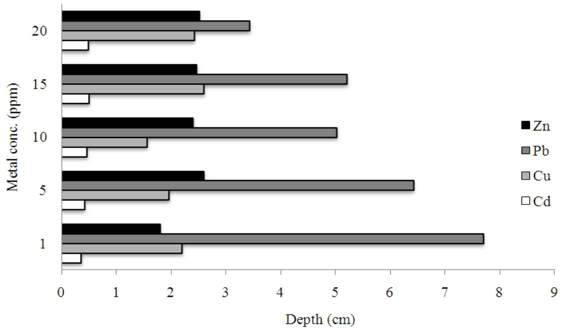


Fig. 2: Heavy metals stratigraphy from Lake Al-Asfar sediment

Dissolved oxygen is an important parameter for identification of different water masses. The oxygen content of the investigated lake water tended to be higher in summer (15.23 mgL^{-1}) and lower in winter (4.33 mgL^{-1}). The relatively high concentrations of dissolved oxygen recorded in this study (summer) could be mainly attributed to light intensity rather than photosynthetic activity of phytoplankton due to the increased photosynthetic activity of phytoplankton populations (Fathi *et al*., 2009). Total alkalinity of Al-Asfar Lake water reached its minimum in winter (117 mgL^{-1}), whereas the maximum was recorded in spring (470 mgL^{-1}) this increases may be due to the bacterial decomposition of organic substrates (Abdel-Satar and Elewa, 2001). On the other hand, chloride attained their maximum in autumn (4.65 gL^{-1}) and dropped to their minimum in winter (3.22 gL^{-1}). The high concentrations of chloride recorded in this study (summer) could be mainly attributed to drain water discharge or to high summer temperature which accelerate evaporations (Al-Dakheel *et al*., 2009; Fathi *et al*., 2009; Al-Sheikh and Fathi, 2010).

The maximum value of nitrate was found in winter (2.32 mgL^{-1}) and the minimum value in summer (1.0 mgL^{-1}). The highest values of nitrate-N reflect the direct effect of the agriculture runoff (Gharib and Soliman, 1998), while the lowest values of nitrate-N are indicative of phytoplankton uptake. On the other hand, phosphate content tended to be high also in winter but lower in the other seasons. The recorded high phosphate values probably due to the release of great amounts of adsorbed phosphate from the bottom sediments or to drainage water (Gharib and Soliman, 1998). Silicate levels fluctuated between the seasons without any regular trend. The observed fluctuations in silicate concentrations were probably related to variation in silicate uptake by diatom (Fathi and Kobbia, 2000).

Monovalent and divalent cations play very important role in the productivity of inland water. Calcium and magnesium are reported to be of importance for phytoplankton production. In the present study the values of divalent (calcium and magnesium) and monovalent cations (sodium and potassium) were relatively high at all samples, irrespective of some minor fluctuations in seasonally readings. Generally, Al-Asfar Lake water showed rather higher values of sodium content. Both sodium and potassium play important role in the productivity of water. This is in accordance with results obtained by some other authors (Fathi *et al*., 2009; Al-Sheikh and Fathi, 2010). The chemical oxygen demand was taken in the present study as a measure of the oxygenated state and additionally the amount of organic \matter in water as well. The data of this study show that COD tended to be higher in summer (38.21 mgL^{-1}) and lowered on the other seasons. The increase in COD could be attributed to the high organic matter content that produces about poor oxygenated state of water (Fathi and Abdelzahar, 2003; Fathi *et al*., 2009).

The means concentrations of the heavy metals (Cd^{2+}, Cu^{2+}, Mn^{2+}, Pb^{2+} and Zn^{2+}) in Al-Asfar lake water compared with WHO (2004); FEPA (1991) and Train (1979) allowable limits are presented in Table 2. The data shows that the concentrations of metals in water were found in the following order: $Pb^{2+}>Cu^{+2}>Zn^{2+}>Cd^{2+}>Mn^{+2}$. The levels of heavy metals recorded in water in this study were generally high, when compared to the international Permissible limits, except Mn which was found to be lower than the recommended levels. The high level of metals could be attributed to discharge of drainage water on the Al-Asfar Lake.

It is well known that, the changes in physico-chemical characteristics of any water mass lead to concomitant qualitative and quantitative changes in phytoplanktonic organisms (Fathi *et al*., 2009). The data of this study shows that there are marked seasonal differences in the quantitative and qualitative composition of the phytoplankton communities in Al-Asfar Lake water (Table 3 and Fig. 3 and 4). In terms of total cell number the maximum count was recorded in spring, whereas the lowest densities occurred in winter. It is worthy to mention that in summer sample some blue green algal genera were recorded in a high abundance. Four algal groups were recorded throughout the investigation period, Bacillariophyceae, Chlorophyceae, Cyanophyceae and Euglenophyceae (Table 3 and Fig. 3 and 4). The total percentage composition of the four main phytoplankton groups shows that Chlorophyceae dominated the phytoplankton of Al-Asfar throughout the study period (39.85-46.54%).

The data included in Table 3 further revealed that a total of 33 species were identified all over the period of the investigation. Out of these, 12 species belong to Chlorophyceae, 11 belong to Bacillariophyceae, 7 to Cyanophceae and 3 to Euglenophyceae. The maximum number of phytoplankton taxa (Species richness) on any one sampling period (33 species) occurred in summer, while the minimum (17 species) was in winter (Fig. 4). *Chlorella* sp., Chlorococcus hum cola Monoraphidium consortium, Navicula lanceolata, Surirella obonga, Synedra acus, Tabellaria sp. and Oscillatoria sp. were observed in a high rank of occurrence. Generally, the phytoplankton crop showed a remarkable increase indicted high level of eutrophication in Lake Sector. This is in accordance with results obtained by some other authors (Fathi *et al*., 2009; Al-Sheikh and Fathi, 2010).

The data of Table 3 also shows that the maximum diversity index (3.12) was estimated on summer, while the minimum (0.65) was in winter. It should be noted that biological indices of species diversity, based mainly on the composition of phytoplankton have been proposed by Pielou (1966) and Nygaard (1978) may indicate the pollutional state of water. There are several numerical attempts to express degrees of oligotrophy and eutrophy from a consideration of species complements rather than from nutrient levels (Shaaban *et al*., 1985). According to the phytoplankton one could consider that the water of Al-Asfar are eutrophic. According to scales of Staub *et al*. (1970), Al-Asfar is indicates heavy polluted in autumn and winter and moderate pollution in spring and summer. In conclusion, the investigated lake area is contaminated with discharge waters enriched with chemicals fertilizers in addition to domestic and industrial effluents. These are manifested by high amounts of organic matter, a high concentration of nutrients (causing eutrophication).

Table 2: Mean values of tested heavy metals concentrations (mgL^{-1}) in water of Al-Asfar Lake compared to the international Permissible limits

Metal	Cd	Cu	Mn	Pb	Zn
Conc. (mgL^{-1})	0.06	1.55	0.010	0.68	0.411
WHO (2004)	0.05	1.00	0.010	0.05	5.000
FEPA (1991)	< 1.00	< 1.00	0.050	< 1.00	20.000
Train (1979)	0.01	1.00	0.050	0.05	1.000

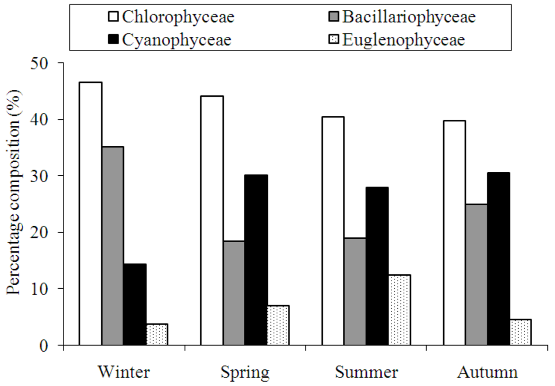


Fig. 3: The Percentage composition of the main algal groups recorded at Al-Asfar Lake during the study period

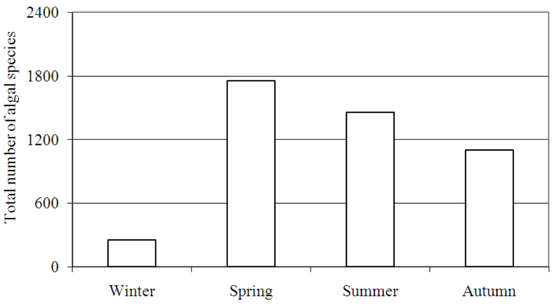


Fig. 4: Phytoplankton abundance ($No.\times10^{5}L^{-1}$) for Al-Asfar Lake during the investigation period

Table 3: Relative occurrence of the phytoplankton on Al-Asfar Lake during the study period (High= ++++; Moderate = +++; Frequent = ++ Rare = +)

Algal taxa	Winter	Spring	Summer	Autumn
Chlorophyceae				
Actinastrum hantzschii Lagerh.		++	+	
Actinastrum sp.			+	
Chlorella sp.	+++	++++	++++	+++
Chlorococcus humicola (Nag)	++	++	++	+++
Crucigenia sp.	+	+	+	+
Monoraphidium contortum Komarava	+	+	+	+
Oedogonium sp.	+	++	++	
Scenedesmus acuminatus Chodat	+	++	+++	++
Scenedesmus bijuga (Turp.) Lag.	+	++	+++	+++
Scenedsmus quadriquda (Breb).	++	+	+	
Schroeder setigera Lemm.	+	+	+	
Tetraedron muticum Hansgirg		+	+	
Bacillariophyceae				
Amphora ovalis Kutz	+	++	+	+
Cyclotella meneghiniana	+	+++	++	++
Cymbella cistula	+	+	++	++
Fragilaria capucina	+	+	+	+
Gyrosigma sp.		+	+	
Navicula lanceolata	+	+++	++	++
Navicula sp.	++	+++	+++	++
Nitzschia sp.	++	++	++	++
Surirella obonga		+	+	
Synedra acus Kutz		+	+	
Tabellaria sp.			+	++
Cyanophyceae				
Anabaena sp.	+	+++	++++	++
Chroococcus turgidus Nagel		+	++	+
Lyngbya sp.		+++	+++	++
Microcystis aeruginosa (Kleb.) Geitler		+++	++	
Microsystis flos-aquse		++	++	+
Oscillatoria sp.		++	++++	++
Phormidium sp.		++++	++++	++
EugLenophyceae				
EugLena acus Ehrenberg		+++	++	
EugLena promixa Dangeard		++	++	
Phacus sp.		+	+	
Diversity index. (H)	0.65	2.25	3.12	1.12

Table 4: Length and weight of *Tilapia zilli* and *Aphanius dispar* collected from Al-Asfar Lake during the investigation period

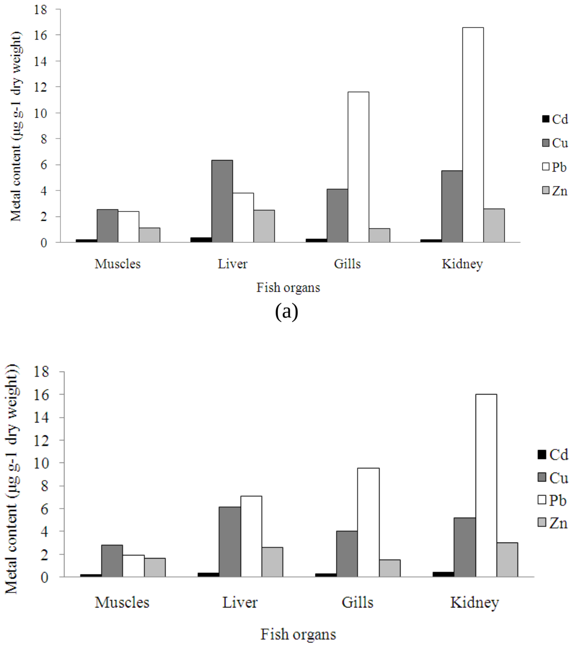
Fish species	Length (cm)	Weight (g)
Tilapia zilli	8.91–10.11	24.33-27.25
Aphanius dispar	4.92-6.340	1.77-4.160

Fish are often used as indicators of heavy metals contamination in the aquatic ecosystem because they occupy high trophic levels and are important food source (Blasco *et al*., 1998; Agah *et al*., 2009). Fish are often at the top of the aquatic food chain and may concentrate large amounts of some metals from the water (Yilmaz, 2009). For the normal metabolism of fish, the essential metals like copper and zinc must be taken up from water, food or sediment. However, similar to the route of essential metals, non-essential ones are also taken up by fish and accumulate in their tissues (Yilmaz, 2006; 2009).

Mean concentrations of cadmium, copper, lead and zinc in muscle, gill, liver and kidney of Tilapia zilli and Aphanius dispar from Al-Asfar Lake is shown in Fig. 5. The results confirm the differences of heavy metal accumulation in the different tissues. For Tilapia zilli the data shows that the highest concentrations were found in kidney, except for Cd and Cu which is found in liver to be highest. The lowest levels were detected in the muscle. Regarding to the metal accumulation by Aphanius dispar the data shows that, kidney accumulated the highest concentration while muscles accumulated the lowest. In this study, heavy metal accumulation order was Pb>Cu>Zn Cd for the two tested fish species, which was found to be similar to the order of heavy metals concentration in water. It is generally accepted that heavy metal uptake occurs mainly from water, food and sediment. However, the efficiency of metal uptake from contaminated water and food may differ in relation to ecological needs, metabolism and the contamination gradients of water, food and sediment, as well as other factors such as salinity, temperature and interacting agents (Yilmaz, 2009).

Table 5: Transfer Factor (TF) of heavy metals in different tissues of *Tilapia zilli* and *Aphanius dispar* collected from Al-Asfar Lake during the investigation period (water and sediment)

Fish sp.	Parameters	Cd	Cu	Pb	Zn
Tilapia zillion	Water/muscles	360.520	283.3300	610.230	285.710
	Sediment/muscles	2.190	0.8660	2.091	2.105
	Water/liver	167.070	178.9400	243.710	166.670
	Sediment/liver	1.278	0.3460	1.321	0.975
	Water/gills	387.730	58.6200	378.050	230.770
	Sediment/gills	1.769	0.5360	0.437	2.264
	Water/kidney	158.080	41.0380	279.780	333.340
	Sediment/kidney	2.555	0.4397	0.302	0.923
Aphasias disbar	Water/muscles	300.000	557.5500	350.512	249.090
	Sediment/muscles	2.300	0.7910	2.587	1.454
	Water/liver	162.162	252.8550	96.217	156.870
	Sediment/liver	1.243	0.3590	0.711	0.916
	Water/gills	222.222	385.5720	71.204	279.591
	Sediment/gills	1.704	0.5470	0.525	1.632
	Water/kidney	146.341	297.5050	42.526	136.545
	Sediment/kidney	1.122	0.4220	0.314	0.797



(a)

(b)

Fig. 5: Heavy metals concentrations (µg g^{-1} dry weight) in organs of *Tilapia zilli* (a) and *Aphanius dispar*, (b) collected from Al-Asfar Lake during the investigation period

On the other hand, high levels of metals in tissues of fishes could be originated from different sources around the study area. The high accumulation in the kidney of tested metals corroborated the results obtained by Phillips and Russo (1978). Also, Malik *et al*. (2010) reported that the kidney was the major site for heavy metals accumulation. Many studies reported that on a number of fish species, which show that muscle is not an active tissue in accumulating heavy metals. The element levels of fish muscles in this study were below the allowable concentration suggested by WHO (2004) and have no threat to public health. According to the results of metal concentrations in kidney and liver of Tilipia zilli and Aphasias disbar we can conclude that these two species can be useful as bioindicator of the degree of pollution in aquatic ecosystems.

In the literature, heavy metal concentrations in the tissue of freshwater fish varies considerably among different studies, possibly due to differences in metal concentrations and chemical characteristics of water from which fish were sampled, eocological needs, metabolism and feeding patterns of fishes and also the season in which studies were carried out (Canli *et al*., 1998). The transfer factor in different organs of the two tested fishes from water and sediments is shown in Table 5. The results showed that transfer factor of water were greater than those of sediments. This indicated a close correlation between concentrations in water and fish. Fish has been reported to accumulate metals from water by diffusion via skin and gills as well as oral consumption/drinking of water (Nussey *et al*., 2000; Oguzie, 2003). This result might be due to the feeding behavior of fish which is filter feeder and the result was concordant with the findings of Ali and Fishar (2005) and Abdel-Baki *et al*. (2011).

CONCLUSION

Wetlands are very important natural areas. Millions of water birds depend on them. Wetlands have on average the richest biodiversity of all ecosystems. Al-Asfar Lake is one from the important shallow wetland lakes, however, much of their limnology and its biotic information are still unknown to the scientific community. The results of heavy metals stratigraphy from Al-Asfar Lake sediment revealed that the sediment is polluted by heavy metals. This pollution could was thought to be associated with the input from different drains. In this study the levels of heavy metals recorded in water were generally high, when compared to the international Permissible limits. The high level of metals could be attributed to discharge of drainage water on the Al-Asfar Lake. The analysis of phytoplankton of Al-Asfar Lake indicates suggests that the water of Lake Al-Asfar can be considered as eutrophic. Fish are often used as indicators of heavy metals contamination in the aquatic ecosystem because they occupy high trophic levels and are important food source. According to the results of metal concentrations in kidney and liver of Tilipia zilli and Aphanius dispar we can conclude these two species can be useful as bioindicator of the degree of pollution in aquatic ecosystems.

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