Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print) 2222-3045 (Online)
Vol. 6, No. 3, p. 16-23, 2015
http://www.innspub.net

INNSPUB
RESEARCH PAPER

OPEN ACCESS

Heavy metals and nutritional composition of some naturally growing aquatic macrophytes of Northern Egyptian Lakes

Alaa M. Younis and Elsayed M. A. Nafea

Aquatic Environment Department, Faculty of Fish Resources, Suez University, Egypt

Article published on March 02, 2015

Key words: Biomonitoring, aquatic plants, Heavy metals, wetlands.

Abstract

Aquatic plants are unchangeable biological filters and they carry out purification of the water bodies therefore, the determination of element compositions in these plants is essential for understanding their nutritive importance. Aquatic macrophytes are known as good indicators of heavy metal contamination in aquatic ecosystems and they act as biological filters by accumulating heavy metals from the surrounding environments. Under the present investigation, five aquatic macrophytes namely:- *(Lemna gibba, Pistia stratiotes* are floating plants*),(Ceratophyllum demersum, Potamogeton pectinatus and Myriophylum spicatum* are submerged plants*)* were collected from different locations at Nile delta lagoons (Burullus and Manzala) to investigate the bioindicative value of them by determining their contents of heavy metals and their nutritional composition. The results of the present study indicated that, levels of some metals such as zinc and copper are higher in almost all the species, in addition to *Lemna gibba* and *potamogeton pectinatus* showed the higher capacity of heavy metals accumulation than the other aquatic plants, Accordingly they could be used as reliable way for bio-monitoring of heavy metals and in sustainable development, management and pollution assessment in the northern deltaic lakes of Egypt.

***Corresponding Author:** Alaa M. Younis ✉ ala_den@yahoo.com

Introduction

Aquatic plants are growing in or near water bodies that are emergent, submerged or floating. It is considered as important component of the aquatic ecosystem not only as food source for aquatic invertebrates and fishes, but also act as an efficient accumulator of nutrients elements and heavy metals (Devlin, 1967).

Submerged aquatic plants grow profusely in lakes and waterways all over the world and have in recent decades their negative effects magnified by man's intensive use of natural water bodies. Eradication of aquatic weeds from many natural and impounded waters is probably not only impossible, but detrimental to the environment. Elimination of a particular species releases nutrients and space for growth of other species which may be more obnoxious than the original offender.

In the last few decades, growing interests in environmental concerns in connection with human and animal health have prompted a renewed focus on pollution with heavy elements (Korkmaz *et al.*, 2010).

Pollutants enter aquatic systems via numerous pathways, including effluent discharge, industrial, urban and agricultural run-off, as well as airborne deposition. Heavy metals are especially toxic due to their ability to bind with proteins and prevent DNA replication (Kar and Sahoo 1992)

Many of the aquatic macrophytes are found to be the potential scavengers of heavy metals from water and wetlands sediments. Plants accumulate relatively large amounts of heavy metals to concentration many times higher than those of the surrounding waters, (Nafea, 2005). In addition, the pollutant concentrations in sediments and the organisms are the result of the past as well as the recent pollution level of the environment in which the organism lives, while the pollutant concentrations in the water only indicate the situation at the time or seasons of sampling. (Ravera *et al.*, 2001).

The Egyptian Mediterranean Coast exhibits five Lakes which along the Nile Delta Coast (Northern Delta Lakes). They are economically the most important fishing ground and providing a rich and vital habitat for estuarine and marine fish and their regeneration, as well as have always been major areas of fish production in Egypt, since more than 75% of the Egyptian Lakes production are harvesting from them (Shreadah *et. al.,* 2012, Younis *et. al.*, 2014). Therefore, the aim of the present work is to investigate the bioindicative value of the five most abundant aquatic macrophytes in the investigated area by determining their concentration of heavy metals and nutritional elements in order to describe the degree of contamination of their aquatic environments.

Material and methods

The area of study

Manzala Lake, as transitional zone between land and sea, is one of the northern delta wetlands of Egypt. The lake is located in eastern side of River Nile (Demitta branch). It is connected to the sea via two a narrow artificial inlets (New and Old Elgamel Bughaz). The Lake is located at south Mediterranean coast between latitudes (31° 6' 30.4" - 31° 29' 54.4" N) and longitudes (31° 50' 13.8"- 32° 14' 52.1" E). Manzala Lake is bordered by fish farms, villages and agricultural lands and Elsalam canal. The Lake has been used as a water reservoir for irrigation of agricultural lands, directly with four drains and indirectly from the adjacent fish farms and agricultural surrounding lands (Donia and Hussein, 2004).

Lake Burullus is one of the Nile delta lakes which located between the two main Delta promontories Rosetta and Damietta. It lies on the eastern side of Rosetta branch of the Nile. It occupies a central position along the Mediterranean coast of the Nile. The Lake is located between longitude 30° 30` and 31° 10`E, and latitude 31° 21` and 31° 35` N. It has an irregular elongated shape and connected to the sea through a narrow (50 m wide) passage called Al- Burg inlet or Boughaz Al-Burullus. Burullus and Manzala lakes are attract attention of many authors because of their economic and scientifically importance to study its unique ecosystem (Nafea, 2005 &Younis and Nafea 2012).

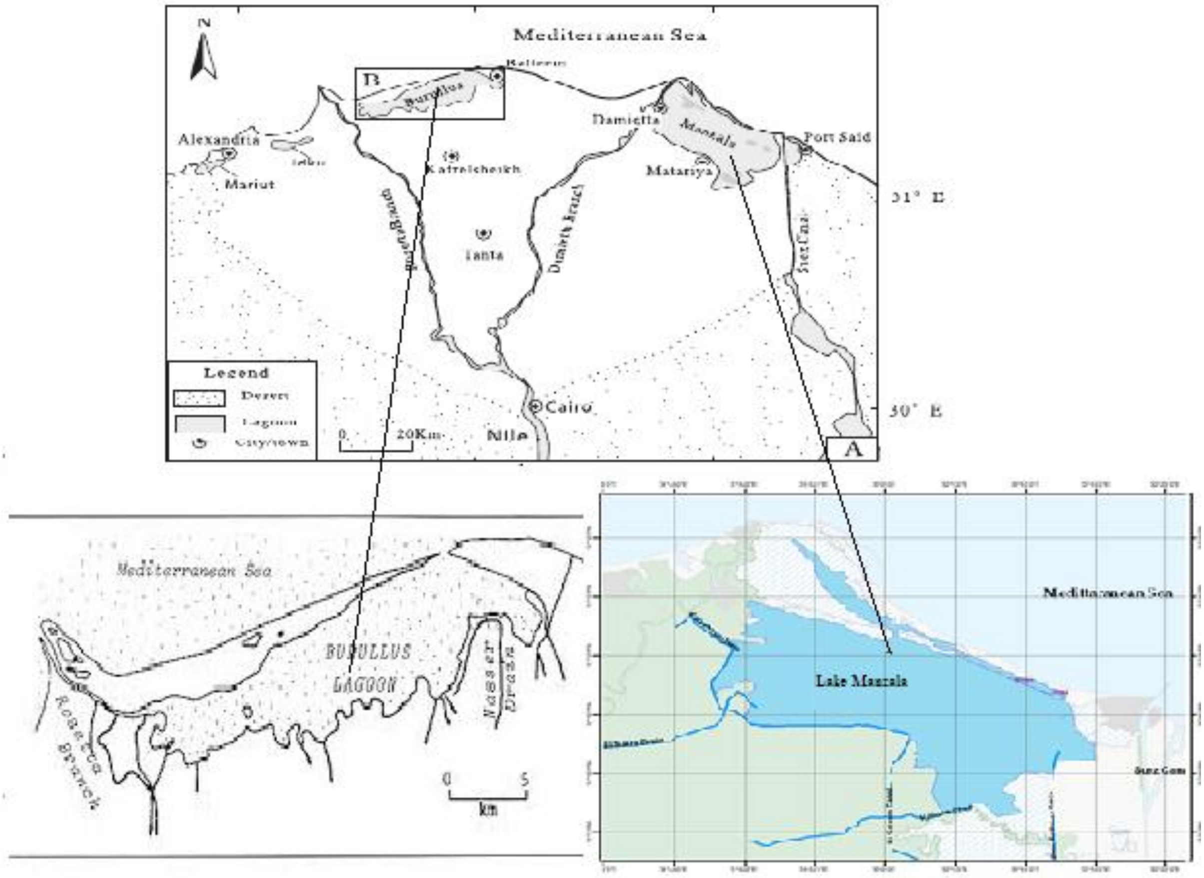

Fig. 1. Location map for Lake Burullus and Manzala.

Sampling and analysis of the plants

The sampling program was carried out in the summer of 2011. Aquatic plants were collected from the 15 sites from the northern deltaic lakes of Egypt (lake Burullus and Manzala). Five specimens of the each species were collected as a whole plant sample from each site. Aquatic plants (200 mg) were washed using stream water then distilled water to remove all the debris and dried at 60 °C. The dried samples were homogenized and digested in a mixture of concentrated nitric acid and perchloric acid (4:1 v/v) EPA (1983). The digests were diluted with distilled water to a total of 25 ml and analyzed using a Perkin Elmer model 2380 atomic adsorption spectrophotometer (A.A.S.). Additionally, Potassium, Sodium and Calcium as well as total nitrogen and total phosphorus contents were measured in the plant digests. All analyses were done in duplicate.

Results and discussion

Nutritional composition of aquatic Macrophytes

The crude protein content of investigated plants with nutrient elements (K, Na, Ca, TN and TP) are cited in Tables 1. The results of the present study revealed that, the investigated aquatic macrophytes contained large percentages of crude protein. The highest concentration were detected in *Lemna gibba* (33.7%).

While, the lowest concentration were measured in the *Myriophylum spicatum* (16.4 %) respectively.

Table 1. Chemical composition (in % dw.) of aquatic plants in the investigated lakes.

Species	K	Na	Ca	Crude protein %	Dry wieght	T. N	T. P
Ceratophyllum demersum	2.1	4.3	6.2	20.30	74.00	4.02	0.19
Potamogeton pectinatus	3.2	5.3	4.6	19.50	76.00	3.90	0.22
Lemna gibba	10.2	8.3	5.6	33.70	64.00	3.60	0.42
Myriophylum spicatum	2.1	1.0	3.5	16.40	82.00	4.20	0.43
Pistia stratiotes	10.6	5.7	4.6	26.30	61.00	3.30	0.31

The variations of protein level are probably due to environmental differences since nutrient concentration in aquatic environment are known to affect crude protein content of water plant (Hutchinson, G. E. 1975).

Potassium, Sodium and Calcium contents in the investigated plants ranged from 2.1 to 10.6, from 1.0 to 8.3 and from 3.5 to 6.2 % respectively. The highest value for Potassium and Sodium were recorded in *Lemna gibba*. Whereas, the highest value for Calcium were detected in Ceratophyllum demersum, generally submersed plants having higher amounts of macro elements probably due to extraneous mineral deposition which often occurs in these plants.

The *Myriophylum spicatum* had the highest TN and TP contents up to 4.20 and 0.43 % respectively. While, the lowest values of TN and TP were found in the *Pistia stratiotes* and *Ceratophyllum demersum* (3.30 and 0.19%) respectively. These results suggest that these plants could accumulate the nutrients from both surrounding environment such as water and soil. Therefore recently, international attention has been directed towards the capacity of constructed submersed plants wetlands as a phytoremediation to control water pollution and to treat municipal and industrial wastewater (Williams *et al.*1994).

It is important for plants to acquire essential metals as macronutrients, but also to regulate their concentrations and from prevent intoxication plants have a wide variety of metal influx as well as efflux transporters (Williams *et al.*, 2000).

Accumulation of heavy metals in Macrophytes

Aquatic plants especially the macrophytes are known to accumulate the heavy metals from contaminated water (Garg and Chandra 1993; Wang 1990). Metal accumulation in aquatic macrophytes is function of vigour and growth, phenology, as well as metal speciation and aquatic chemistry. (Dunbabin & Bowmer,1992). Heavy metal (Cu, Pb, Ni, Cd and Zn) concentrations found in the investigated plants are shown in Fig. (2-7).

The copper concentrations in the selected plants fluctuated between (7.1 and 10.9 µg/g dry wt.). Highest concentration of Cu accumulated in *Lemna gibba* (10.9 µg/g dry wt.). While, the lowest concentration were found in *Ceratophyllum demersum* (7.10 µg/g dry wt; Fig. 2). Extent of Copper accumulation in the investigated plants was not up to the toxic level. Copper plays very important role in cell function and energy transfer as well as it is essential in structural stability of chromosomes (Mishra *et al.* 2008). Although Cu is an essential micronutrient for normal plant metabolism, playing an important role in a large number of metalloenzymes, photosynthesis related plastocyanin and membrane structure, it has been reported to be among the toxic heavy metals (Li and Xiong, 2004).

El-Sarraf (1995) found that copper content showed a small range of fluctuation with irregular concentration in aquatic plants. The positive correlation between Cu and Zn was attributed to the same biological behaviors during the assimilation in macrophytes.

Potamogeton pectinatus and *Lemna gibba* had the highest concentration of Lead (15.1 µg/g dry wt). While, the lowest concentration were measured in the *Ceratophyllum demersum* (9 µg/g dry wt; Fig. 3).

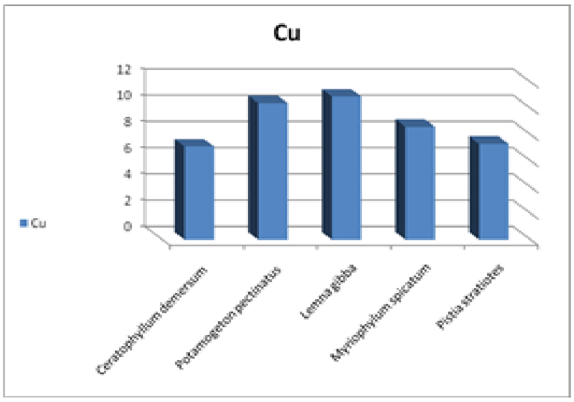

Fig. 2. The mean concentrations Copper (µg/g) dry weight in the selected samples.

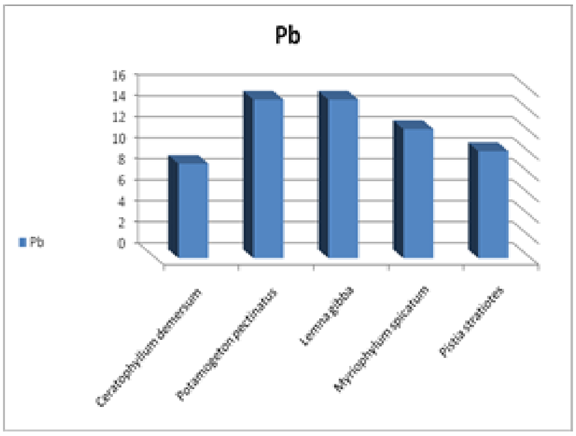

Fig. 3. The mean concentrations Lead (µg/g) dry weight in the selected samples.

The variations of lead content in Macrophytes in the investigated plants seem to reflect the inflow of many sources of pollution from sewage, agricultural and industrial wastes in to the surrounding environment. El-Sarraf (1995) mentioned that in Lake Manzala, *Potamogeton pectinatus* had high lead concentration (26 .6 µg/g dry wt).

The highest levels of cadmium were recorded in *Potamogeton pectinatus* (4.8 µg/g dry wt; Fig. 5). While, the lowest concentration of cadmium were observed in *Pistia stratiotes* (1.1 µg/g dry weight).

The agricultural activities around the area of study may have contributed to the observed high levels of Pb and Cd, since these metals can occur as impurities in fertilizers and in metal-based pesticides and compost and manure (Mishra *et al.* 2008).

El-Sarraf (1995b) mentioned that there was high significant correlation between lead and cadmium concentration in aquatic plants which is probably attributed to their association in the same phase during assimilation.

The examined macrophytes have different levels of zinc concentrations, where the high levels were recorded in *Lemna gibba* , *potamogeton pectinatus* (92.0 µg/g dry wt.) while the low concentrations were found in *Myriophylum spicatum* (64.0 µg/g dry wt.; Fig. 6).

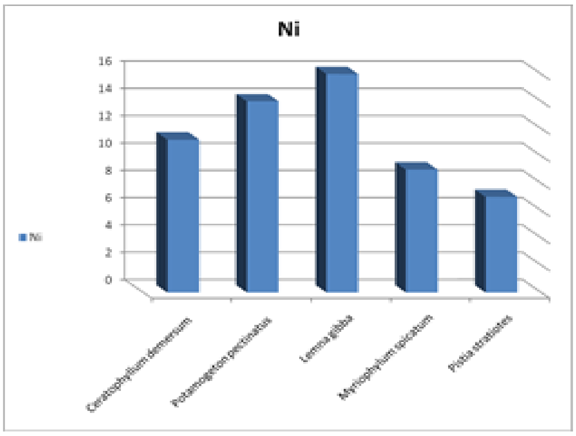

Fig. 4. The mean concentrations Nickel (µg/g) dry weight in the selected samples.

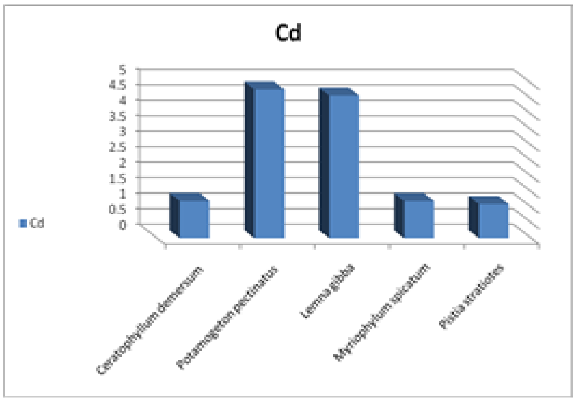

Fig. 5. The mean concentrations Cadmium (µg/g) dry weight in the selected samples.

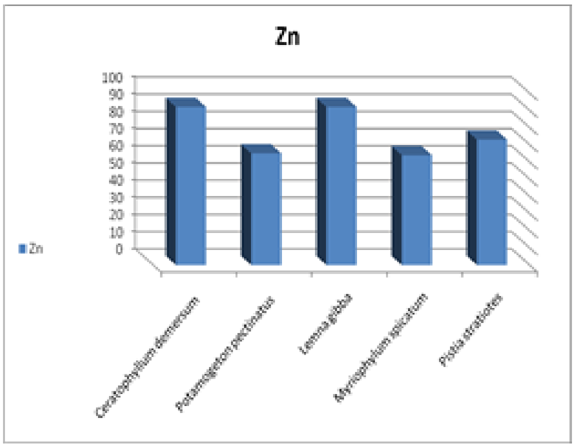

Fig. 6. The mean concentrations Zinc (µg/g) dry weight in the selected samples.

Zinc in the present study were generally in similar ranges with previous recorded values of aquatic plant species where the values ranged from16.5 and 517µg/g dry weight for *Potamogeton pectinatus* from Elsenz River (Heydt, 1977) and 117 µg/g dry weights for *potamogeton pectinatus* (El-Sarraf 1995).

Lemna gibba and *potamogeton pectinatus* showed the higher capacity of heavy metal accumulation than the other aquatic plants. (El-Khatib & Sawaf (1998) and Szymanwska *et al.*, (1999) reported that the concentrations of heavy metals in macrophytes were positively related to the concentration in the environment and species metal uptake.

Recently, there has been growing international interest in the use of metal-accumulating plants for the removal of heavy metals from contaminated aqueous streams, in the biological purification of waste water and in Biomonitoring of pollution (Lafabrie *et. al.*, 2013). The Biomonitoring of pollutants using accumulator species is based on the capacity which has some plant to accumulate relatively large amounts of certain pollutants, even from much diluted solutions without obvious noxious effects. The use of this type of monitoring is widespread in marine and freshwater environments, because the measuring of the pollutant content in the organisms is the only way of evaluating the bioavailability of a pollutant present in the environment. Additionally, the pollutant concentrations in the organism are the result of the past as well as the recent pollution level of the environment in which the organism lives, while the pollutants concentrations in the water only indicate the situation at the time of sampling (Ravera *et al.*, 2001**)**.

From the present observations, it is concluded that the results presented in the current study could be very useful for environmental monitoring and checking the health of the water body. The aquatic macrophytes were found to be the potential source for accumulation of heavy metals from water and act as biomarkers for metals, Accordingly they could be used in sustainable development , management and pollution assessment program in the northern deltaic lakes of Egypt.

References

Devlin RM. 1967. Plant Physiology. Reinhold, NewYork, 564.

Donia N, Hussein M. 2004. eutrophication assessment of lake manzala using Gis techniques. Eighth International Water Technology Conference, IWTC8, Alexandria, Egypt.

Dunbabin JS, Bowmer KH. 1992. Potential use of constructed wetlands for treatment industrial waste water containing metals. The Science of Total Environment, **111**, 151–168.

El-Khateb A, El-Sawaf N. 1998. Differential trapping of heavy metals by macrophytes in different water bodies near Sohag, Upper Egypt. Acta Hydrobiologica, **40**, 67-73.

El-Sarraf WM. 1995a. Trace metals concentration of aquatic Macrophytes in Lake Manzalah, Egypt. Egyptian Journal of Aquatic Research, **21(1),** 171-181.

El-Sarraf WM. 1995b. Chemical analysis of Some macrophytes in Maruit and Idku Lakes, Egypt.

Alexandria Journal of Agriculture Research **40 (1),** 255-271.

EPA. 1983. Methods of chemical analysis of water and waste water USA. Environmental Protection Agency (EPA) **690**, 4-79.

Garg P, Chandra P. 1993. The Duckweed Wolffia globosa as an indicator of heavy metal pollution: sensitivity to Cr and Cd. Environmental Monitoring and Assessment, **29(1),** 89–95.

Heydt G. 1977. Schwerrnetallg chalteven Wasser, wasser.p franzen, chironomikae and Mullusca der Elsenz Dipl Arbeituciv, Heidelberg, 143.

Hutchinson GE. 1975. A Treatise on Limnology (Hutchinson, G. E. Ed), Volume III, Limnological Botany, new York, 264-407.

Kar RN, Sahoo BN, Sukla LB. 1992. Removal of heavy metal from mine water using sulphate reducing Bacteria. Pollution Research. **11**, 1-13.

Korkmaz K, Kara SM, Ozkutlu F, Gul V. 2010. Monitoring of heavy metals and selected micronutrients in hempseeds from north-western Turkey. African Journal of Agricultural Research **5(6),** 463-467.

Lafabrie C, Major KM, Major CS, Cebrián J. 2013. Trace metal contamination of the aquatic plant Hydrilla verticillata and associated sediment in a coastal Alabama creek (Gulf of Mexico – USA). Marine Pollution Bulletin **68,** 147–151.

Li T, Xiong ZT. 2004. A novel response of wild type duckweed (*Lemna paucicostata Hegelm.*) to heavy metals. Environmental Toxicology **19**, 95– 102.

Mishra VK,Upadhyaya AR, Pandey SK, Tripathi BD. 2008. Heavy metal pollution induced due to coal mining effluent on surrounding aquatic ecosystem and its management through naturally occurring aquatic macrophytes. Bioresource Technology **99**, 930–936.

Nafea EMA. 2005. On the ecology and sustainable development of the northern delta lakes, Egypt. PhD Thesis, Mansoura University, Egypt.

Ravera O. 2001. Ecological monitoring for water body management In: Timmerman J.G. (Ed.), Proceedings of the International Workshop on information for sustainable water management Nunspeet. NL, 157-167.

Shreadah MA, Abdel Ghani SA, Taha AA, Ahmed AM, Hawash HBI. 2012. Mercury and Methyl Mercury in Sediments of Northern Lakes-Egypt. Journal of Environmental Protection **3(3),** 8 p.

Szymanwska A, Samecka-cymerman A, Kempers AJ. 1999. Heavy metals in three Lakes in West Poland, Ecotoxicology and Environmental Safety **43(1),** 21-29.

Wang HK. 1990. Literature review on duckweed toxicity testing. Environmental Research **52**, 7–22.

Williams J, Bahget E, May E, Ford M, Butler J. 1994. The removal of pathogenic microorganisms during sewage treatment in gravel-bed hydroponic constructed wetlands In: Proceedings of a Conference on Wetland Systems for water Pollution Control IAWQ, Gunagzhou. pp. 200-209.

Williams LE, Pittman JK, Hall JL. 2000. Emerging mechanisms for heavy metal transport in plants. Biochimica et Biophysica **Acta 1465**, 104–126.

Younis AM, El-Zokm GM, Okbah MA. 2014. Spatial variation of acid-volatile sulfide and simultaneously extracted metals in Egyptian Mediterranean Sea lagoon sediments. Environmental Monitoring and Assessment , **186(6),** 3567-3579.

Younis AM, Nafea SM. 2012. Impact of Environmental Conditions on the Biodiversity of Mediterranean Sea Lagoon, Burullus Protected Area, Egypt. World Applied Sciences Journal **19(10)**, 1423-1430.