The Influences of Selected Environmental Factors on the Establishment of the Submerged Aquatic Weeds in Lake Nasser

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Abstract

In years 2001 and 2006, the community structure of the submerged aquatic weeds along the littoral zone of Lake Nasser was described in relation to limnological and sedimentological factors. The study showed that the distribution of such aquatic weeds tended to be the highest near the northern part and the middle part of the lake in years 2001 and 2006 respectively. However, it gradually decreased toward the southern part of the lake and almost disappeared near the Sudanese border. *Myriophyllum spicatum and Najas mino* dominated the vegetation along the littoral zones. Their dense growths were restricted to shallower areas of the lake at depths ranging between one and four meter. But, their dense growths were very low at depths of five and six meter because they became vulnerable to light limitation and hydrostatic pressure. The statistical analysis showed no significant differences between the standing crop of the submerged aquatic weeds in years 2001 and 2006 at depths of two, three, five and six meter. However, it showed significant differences at depths of one and four meter. These significant differences were related to the water level fluctuation and its consciences of establishing new community structure at different depths. Additionally, the standing crop of the submerged aquatic weeds showed poor distinguishable patterns related to physic-chemical variables except for turbidity, Bicarbonate, Calcium and TDS in year 2001; and pH, Nitrate and Sulfate in year 2006. Finally, the standing crop of submerged aquatic weeds did not reveal any correlation with the sediment texture or its organic content except for the weeds that were locating at depth of two meter. Where, they showed positive correlation with the silt and clay.

***Key Words*:** Lake Nasser, Aquatic Weeds, Environmental Factors**.**

1. INTRODUCTION

The submerged aquatic weeds are essential to the function of littoral zone communities in the lake. They provide habitat for fish and invertebrates as well as a substrate for periphyton. They produce oxygen, which assists with overall habitat functioning, and provide food for some fish and birds (Jeppesen *et al.*, 1998; Mitchell and Perrow, 1998). Also, they are commonly utilized for the purpose of water treatment because they are good absorber for the nutrient load within the water column. In addition, they are good accumulators of heavy metals and they absorb them much more readily than terrestrial plants (Ali, *et al.*, 2003). Furthermore, such weeds play an integral role in the cycling of nutrients within the ecosystem by up taking the nutrients through their roots and shoots, and return them to the ecosystem when they die and decompose (Kalff, 2002). On the other hand, overgrowth of such submerged aquatic weeds may prevent the establishment of phytoplankton and periphyton and cause anoxia in the water column resulting in disappearance of the zooplankton, benthos and fish (Moreira *et al.*, 1989). Also, heavy submerged aquatic weed infestations constrain the water use by flow retardation, interference with navigation, health hazards, and alteration in the physico-chemical characteristics of both water and sediment (Bakry, 1996; Bakry and Abdel Meguid, 2001).

In large lakes, the submerged aquatic weeds and their role in lake metabolism are highly predictable, depending on both the physico-chemical suitability of the lake environment and the extent area of submerged weed colonization (Weiher and Boylen, 1994). The survival of the submerged aquatic weeds and their distribution in the littoral zone are influenced by a number of environmental factors. These include, light availability and turbidity, water and sediment nutrients, wind and wave action, substrate type, competitive interactions, water level fluctuation, depth gradient and sediment texture (Ali, *et al.*, 1995; Lenssen *et al.*, 1999; Cronk and Fennessey, 2001; Abdel Meguid and Bakry, 2003). Such factors are the most significant controlling factor of submerged aquatic weed growth (Khedr and El-Dermerdash 1997; Bini, *et al*., 1999; Lougheed *et al*., 2001).

However, many studies show varying results about which factors most influence weed distribution (Bini, *et al*., 1999; Riis, *et al*. 2000; Lougheed, *et al*., 2001). Concerning the aquatic submerged weeds in Lake Nasser, its community structure is highly related to the water level fluctuation depending on the seasonal flood pattern of the River Nile. In the drought period, continuous low water level in the littoral habitats causes desiccation of the submerged aquatic weeds. Following this period, continuous high water level induce low light condition within the same area, as a result some of submerged aquatic weeds do not tolerate the dark condition and die; and others become dominant such as *Najas marina* and *Potamageton schweinfurthii* (Craig, 1998, Bakry and Abdel Meguid, 2001). Also, the submerged aquatic weed community structure located along the shoreline of the lake is highly dependent on basin configuration, littoral slope, shoreline development and some physico-chemical parameters within the water surface mainly TDS, alkalinity, bicarbonate, calcium, transparency and sediment texture (Abdel Meguid and Bakry, 2003).

The purpose of this study was to continue monitoring of submerged aquatic weeds along the littoral zone of Lake Nasser for identifying patterns of their distribution and abundance, and relating them to some environmental variables such as the sediment texture and its organic content and physical-chemical characteristic of surface water as well as providing baseline information by comparing the gained monitoring results of year 2001 with the current results of year 2006.

2. MATERIALS AND METHODS

2.1. Study Area

Lake Nasser was formed in 1969 as a result of the construction of High Dam at Aswan. It lies between 20^0 27^- and 23^0 58^-N and 30^0 35^- and 33^0 15^-E. It is the second largest man-made lake in the world and used for water storage, electricity generation, fish production, agriculture and domestic use. The water level of the lake fluctuates dramatically depending on the annual rainfall in the catchments area of the Nile River basin. This fluctuation affects the surface area, the length of the shoreline, and the depth of the water in the coastal shallow water.

2.2. Sampling procedure

To understand factors that are influencing the submerged aquatic weed distribution, the selected locations were determined with minimal human impact. In the springs of 2001 and 2006, a total 20 samples for water quality, sediment and submerged aquatic weeds were collected. The samples were collected from three sectors at Lake Nasser as shown in Figure (1) and Table (1).

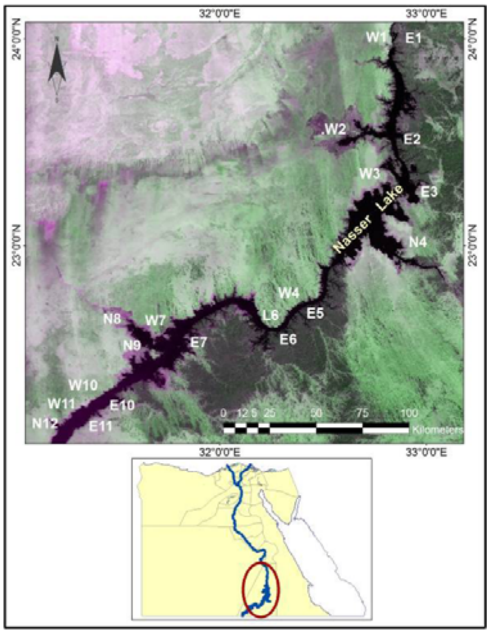

Figure 1: Location of the sample sites along the shoreline of Lake Nasser.

To determine the standing crop of the submerged aquatic weeds (kg/m^2 surface area), the weeds were collected randomly from the depths of one, two, three, four, five and six meter. The weeds were carefully uprooted, identified, cleaned from attached sediment by water, placed in plastic bags and weighted. During weed collection, attention was taken to consider weeds without any physical damage that could be created by herbivorous animals or birds, fishing net or current. So the risk of having measuring error by the mechanical damaged was very limited.

To measure the chemical and physical characteristics of the water surface, the water samples were collected by the Van Dorn water sampler at 0.5m from the surface. Six major physico-chemical parameters [pH, Carbonate, Bicarbonate, Total Dissolved Solids (TDS), Total Suspended Solids (TSS) and Turbidity]; five major Cations [Calcium, Potassium, Magnesium, Sodium and Phosphorus] and five major Anions [Chloride, Sulfate, Phosphate, Nitrate and Nitrite] were determined. The number of sample sizes and their locations were determined randomly as shown in Figure (1). Water conductivity and pH were measured in the field using YSI field probes. Chemical analysis for surface water was carried out, using the standard methods (APHA, 2005).

To study the characteristics of the sediment in the littoral zone and their role on the growth and distribution of submerged weeds, 20 random locations were chosen (Fig. 1 and Table 1). The sediment texture was determined by separation of the different size particles using pipette method. Organic ratio (0%) was used as a measure of sediment richness.
The significant differences in the mean value of each parameter from the infested area by the submerged weeds in year 2001 and year 2006 were confirmed by using t-test (Two-tailed, p=0.05).

Table 1: Location of the sample sites along the shoreline of Lake Nasser

Sectors (W) Western side of Lake Nasser		**Sectors (E) Eastern side of Lake Nasser**		**Sectors (N) Neither western nor eastern side**	
(W1)	10Km from High Dam	(E1)	10Km from High Dam	(N4)	El-Alaky
(W2)	Kalabsha	(E2)	Kalabsha	(N8)	Khor El-Sheek Zaid
(W3)	Marway	(E3)	Marway	(N9)	Old Toshka
(W5)	El-Madeek	(E5)	El-Madeek	(N12)	Arken
(W6)	Krosko	(E 6)	Krosko		
(W7)	Abreem	(E7)	Abreem		
(W10)	Adendan	(E10)	Adendan		
(W11)	Saraa	(E11)	Saraa		

3. RESULTS AND DISCUSSIONS

The present study showed that during the years of 2001 and 2006, a total standing crop of the submerged aquatic weeds along the littoral zone of Lake Nasser was made up of nine species (*Potamogeton crispus, P. lucenus, P. perfoliatus, P. trichoides, Myriophyllum spicatum, Najas marina subsp.armata, N. minor, Vallisneria spiralis and Zannichellia palustri*). This observation agrees with the finding of Abdel-Meguid and Bakry (2003) and Abdel Meguid (2006) who reported the same species.

The distribution of these submerged aquatic weeds and their standing crops varied along the littoral zones of the lake. The study showed that the distribution of such aquatic weeds tended to be the highest near the northern part and the middle part of the lake in years 2001 and 2006 respectively (Figs. 2, 3, 4, 5, 6 & 7). However, it gradually decreased toward the southern part of the lake and almost disappeared near the Sudanese border. Our starting assumptions are that there are three important environmental factors control the distribution of the submerged aquatic weeds along the lake. We assume that water clarity (Schwarz, *et al.*, 2000) is the main key factor which influences on the distribution of the submerged aquatic weeds in the southern part of the lake beside other factors such as water level fluctuation (Riis and Hawes 2002) and the slope of substrate (Duarte and Kalff 1986; Abdel Meguid and Bakry, 2003). The water turbidity in the southern part of the lake is high due to incoming silt load during the annual flood season which provides unsuitable condition for establishment of the submerged aquatic weeds. Also, the flatbed slopes characterize the most littoral zone along the southern part of the lake. This flat slope has great influence on the ability of submerged aquatic weeds to survive. Such aquatic weeds are subjected to intensive water level fluctuation. In this condition, some aquatic submerged weeds cannot tolerate the sudden decrease or increase the water level because they are subjected to desiccation during the drought period or death as a result of hydrostatic pressure and low light penetration during the flood period. This result coincides with studies on the impact of water level fluctuation on the distribution of the submerged aquatic weeds (Hudon, 1997; Craig, 1998; Bakry and Abdel Meguid, 2001). It is concluded from those studies that low water levels cause a negative impact on submerged weed diversity and reduce the surface area available for such kind of weeds to grow.

Also, the present study showed that the littoral zone of Lake Nasser was dominated by the submerged aquatic weeds, *Myriophyllum spicatum and Najas minor*. The presence of these species indicates their tolerance against water level fluctuation, heterogeneity of sediment texture, slope bed shape, clarity of water and the depth of water column, low nutrient levels and competitive interactions among the submerged aquatic weeds (Abdel Meguid and Bakry, 2003).

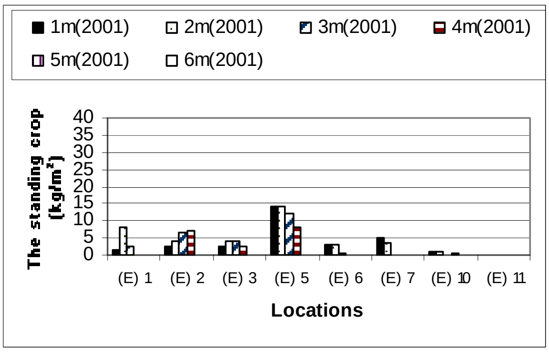

Figure 2: Standing crop for the submerged aquatic weeds along sectors (E) of Lake Nasser at different depth during year 2001

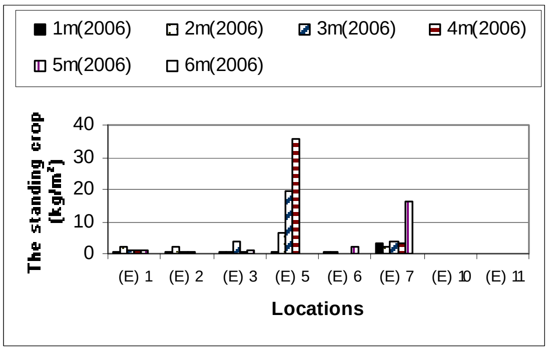

Figure 3: Standing crop for the submerged aquatic weeds along sectors (E) of Lake Nasser at different depth during year 2006

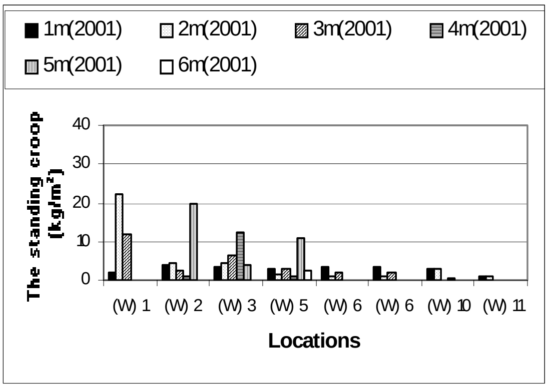

Figure 4: Standing crop for the submerged aquatic weeds along sectors (w) of Lake Nasser at different depth during year 2001

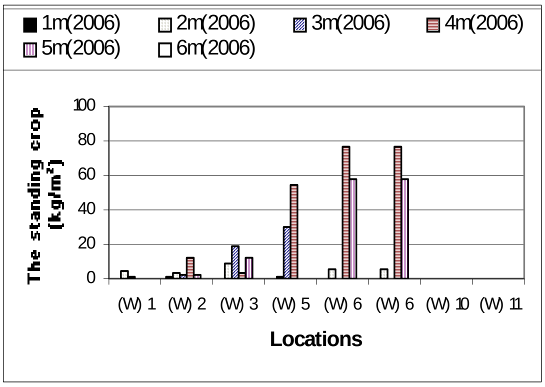

Figure 5: Standing crop for the submerged aquatic weeds along sectors (w) of Lake Nasser at different depth during year 2006

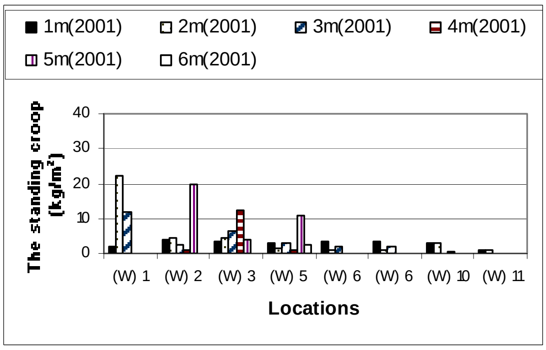

Figure6: Standing crop for the submerged aquatic weeds along sectors (N) of Lake Nasser at different depth during year 2001

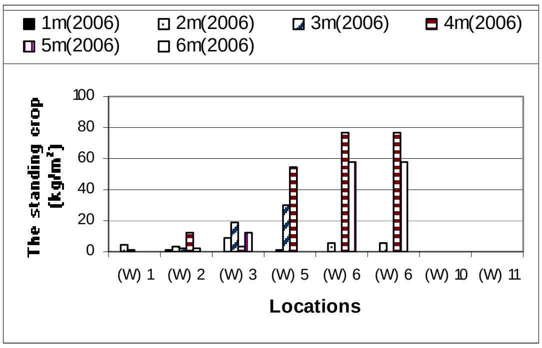

Figure 7. Standing crop for the submerged aquatic weeds along sectors (N) of Lake Nasser at different depth during year 2006

In addition, the present study showed that the submerged aquatic weeds were locating at depths ranging from one to six meter. However, the biomass of the communities at the depths of five and six meter was sharply reduced in both years of 2001 and 2006 (Fig. 8). This negative correlation is closely related to what was previously mentioned that light penetration is representing the strongest predictor of submerged weed existence (Bini, *et al.*, 1999 and Abdel Meguid and Bakry, 2003). Also, hydrostatic pressure prevents the submerged aquatic weeds from growing at more extreme depths.

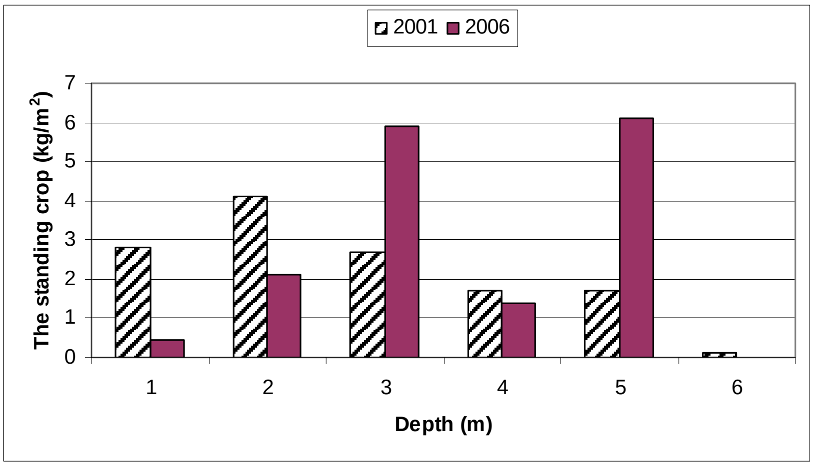

Figure 8: Mean standing crop for the submerged aquatic weeds at different depths during years 2001 and 2006.

Furthermore, the comparison between the standing crop (kg/m^2) of the submerged aquatic weeds, at depths of one, two, three, four, five and six meter along Lake Nasser in year 2001 and year 2006 was statistically achieved as it is shown in Table (2). The statistical analysis (t-test) showed that there was no significant differences between the standing crop of the submerged aquatic weeds in years 2001 and 2006 at depths of two, three, five and six meter. However, it showed significant differences at depths of one meter and four meter in year 2001 and year 2006 respectively. In year 2006, it is clear that water level rise at drawdown zone may lead to the displacement of such aquatic weeds which are located near the shoreline to the deeper depth. Also, with increasing the water level, a new littoral zone is formed near the shore which becomes enriched with a new community composition from newly established submerged aquatic weeds, mainly at depth of one meter.

Table 2: Comparison between the standing crop of the submerged aquatic weeds (kg/m^2 surface area), at depths of one, two, three, four, five and six meter in Lake Nasser during years 2001 and 2006

Sample Statistics	One meter		Two meter		Three meter		Four meter		Five meter		Six meter	
	2001	2006	2001	2006	2001	2006	2001	2006	2001	2006	2001	2006
Sample size	20	20	20	20	20	20	20	20	20	20	20	20
Mean Standing crop (kg/m2)	2.8	0.45	4.1	2.1	2.7	5.9	1.7	9.1	1.7	4.2	0.12	0
S.E.$\underline{+}$	0.67	0.15	1.2	0.56	0.84	2	0.77	3.3	1.1	1.5	0.12	0
***t* test (Two tailed)**	3.7		1.9		1.66		2.2		1.31		1.0	
Significance level	$P<0.05$		$P>0.05$		$P>0.05$		$P<0.05$		$P>0.05$		$P>0.05$	

Concerning the physico-chemical parameters of the water surface in different locations during the years of 2001 and 2006, the present study showed that all major parameters fractions were below the Egyptian standards of law of environment 4/1994 on the Protection of Human Health.

Concerning, the comparison between the situation of the surface water quality during the years of 2001 and 2006, the result presented in Table (3) showed that the physico-chemical parameters (pH, turbidity, Bicarbonate, Magnesium, Nitrate, Sulfate, Phosphate and Nitrite) did not reveal any significant differences. However, the TDS, TSS, Carbonate, Calcium, Sodium, Potassium and Chloride showed significant differences. In year 2001, the concentration of TDS, Carbonate, Calcium and Chloride tended to be higher than that those values in year 2006. But, the concentration of TSS, Sodium and Potassium in year 2001 tended to be smaller than those values in year 2006. The variation in the conductivity within the lake during the period of 2001 and 2006 is due to the water conductivity of the flooded Blue Nile, which contributes about 84% of the Nile Flood. Furthermore, the decreasing or increasing of the major elements for cations and anions may attribute to the uptake of dissolved salts by phytoplanktons and aquatic weeds or may attribute to the lack of soluble salts as a result of sedimentation process or adsorption by silt and clay.

Concerning the correlation between the standing crop (kg/m^2) of the submerged aquatic weeds at different depths and some physico-chemical parameters within the surface water in years 2001 and 2006, the standing crop showed poor distinguishable patterns related to physic-chemical variables except for turbidity, Bicarbonate, Calcium and TDS in year 2001; and pH, Nitrate and Sulfate in year 2006.

In year 2001, the standing crop of the submerged aquatic weed at depths of two, three and four meter decreased with increasing the value of turbidity "NTU" (-0.634, -0.595 and –0.599 respectively). It seems that turbidity has the most significant effects on variation of the standing crop at these depths. Similarly, Lougheed, *et al*. (2001) and Horppila and Nurminen (2001) found that the most important predictors of aquatic submerged weeds distribution are including turbidity. On the other hand, the present study showed that the standing crop of submerged weeds at depth of one meter was positively dependent on the value of Bicabonate, Calcium and TDS within the surface water where their standing crop increased with increasing Bicabonate (+0.588), Calcium (+0.566) and TDS (+0.664). It seems that the water of Lake Nasser is characterized by high alkalinity. This alkaline water provides a good habitat for many species of submerged aquatic weed growth especially at depth of one meter because they utilize bicarbonate as sources of inorganic carbon in photosynthesis, because free CO_2 concentration is low due to the main activity of the phytoplanktons near the subsurface of water. Concerning the water salinity and its role that affecting the aquatic weeds in the lake, many investigators showed that some species are colonized in more saline part of the lake while others prefer to establish in fresh and slightly brackish water (Grillas, 1990; Khedr and El-Demerdash, 1997). In our case, the present study showed that TDS "in year 2001" was important factor affecting the standing crops of submerged aquatic weeds located at one-meter depth where they increased with increasing the value of salinity.

In year 2006, Bivariate correlation showed that turbidity level did not reach to the level that causes light limitations or hinders the growth of the submerged aquatic weeds. On the other hand, the correlation showed a decrease in the standing crops at depth of one meter with increasing the concentration of pH (-0.539). Similarly, Bini *et al*. (1999) found that alkalinity within the water reservoir in Brazil is the most significant variable in predicting the distribution of the aquatic weeds. It is clear that in the alkaline water, the submerged aquatic weeds located at depth of one meter face jeopardy because they must be further able to effectively withstand heavy carbonate precipitation in the form of calcium carbonate that precipitates on their leaves surface forming favorite place for epiphyte development (Hosny *et al.*, 2003 and Abdel Meguid and Bakry, 2003). This epiphyte reduces the metabolic activity of the submerged aquatic weeds and causes death to the leaves. On the other hand, the Bivariate correlation showed positive correlation between the standing crop of the submerged aquatic weeds and Nitrate (+0.561) at depth of three meter, and Sulfate (+0.632 and +0.577) at depths of three and four meter respectively.

Concerning the sediment and its texture along the shoreline of Lake Nasser, the present study showed that the sediment texture was characterized by heterogeneity and possessing sandier contents in years 2001 and 2006 (Figs. 9, 10, 11, 12, 13 & 14; and Tables 4 & 5). Also, the present study showed that in year 2006, the fine sediment texture was changed in some locations along the shoreline when they compared with the same locations in year 2001. The comparison showed that the percentage of sand was significantly decreased while the percentage of silt and clay were significantly increased in year 2006 (Table 4). Based on this pattern, it is expected that continuous of flooding in the littoral zone of Lake Nasser leads to some changes within the bottom stratum by trapping and depositing the fine particles mainly the clay and silt in the infested area with submerged aquatic weeds.

In case of the % of organic matter within the sediment content, the present study showed heterogeneity along the shoreline of the lake during the years of 2001 and 2006 (Figs. 15, 16 & 17). However this organic matter did not change or reveal any significant differences during this period of time (Table 4). Bivariate correlation showed positive correlation between the percentage of organic matter within the sediment with increasing the content of silt (+0.521) and clay (+0.561). While reverse correlation was detected in the presence of sand (-0.992). This gained result is matching with previous results of Ali and Abdin, (2003) and Tohamy, *et al*., (2006) who mentioned that more organic substance is locating within the clay soil than within the sandy soil.

Concerning the relationship between the sediment texture and the standing crop for the submerged aquatic weeds, previous study showed that the sediment composition plays a key factor in the biomass of the aquatic weeds (Broko and Smart, 1986). On the other hand, the present study showed that sediment was less useful predictors of aquatic weed standing crop. The present result showed no clear correlation between the standing crop of submerged aquatic weeds and sediment texture except for the submerged weeds locating at depth of two meter. In year 2001, the standing crop of the submerged aquatic weeds increased with increasing the percentage of both the silt (+0.649) and clay (+0.567) contents while it showed negative correlation with increasing the percentage of sand (-0.596). Similarly, in year 2006, the standing crop of the submerged aquatic weeds was strongly positive correlated with the silt (+0.456) and clay (+0.507) while it showed negative correlation with the sand (-0.470) at the same depth.

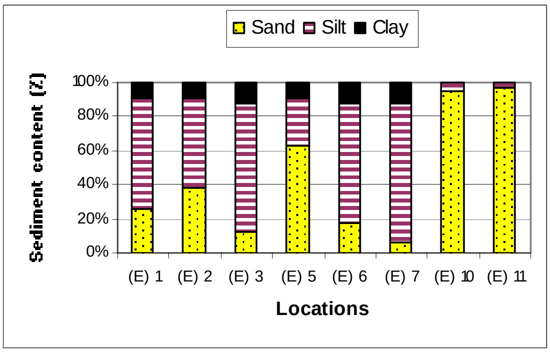

Figure 9: Percentage of sediment content at sectors (E) in year 2001

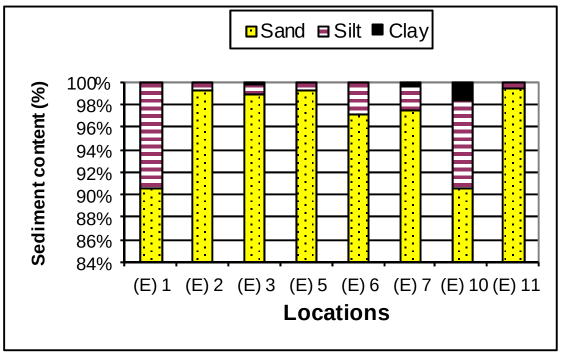

Figure 10: Percentage of sediment content at sectors (E) in year 2006

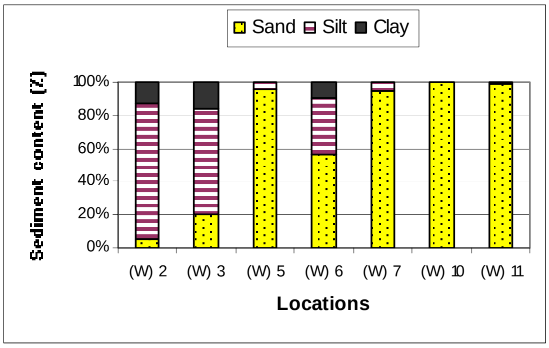

Figure 11: Percentage of sediment content at sectors (W) in year 2001

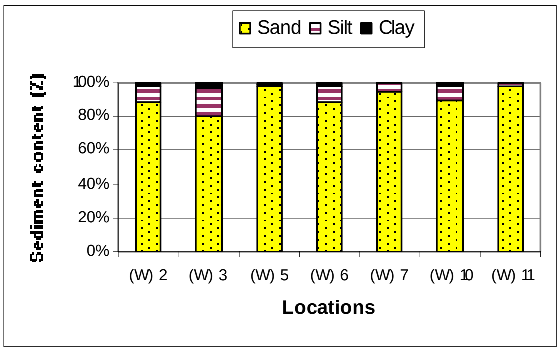

Figure 12: Percentage of sediment content at sectors (W) in year 2006

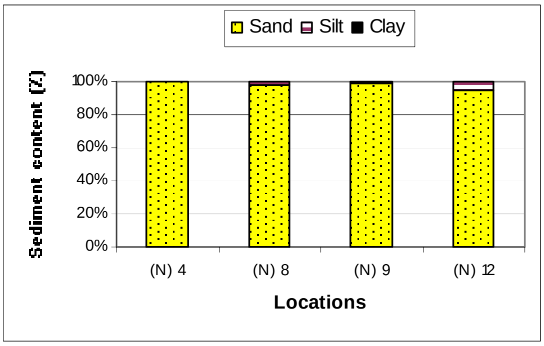

Figure 13: Percentage of sediment content at sectors (N) in year 2001

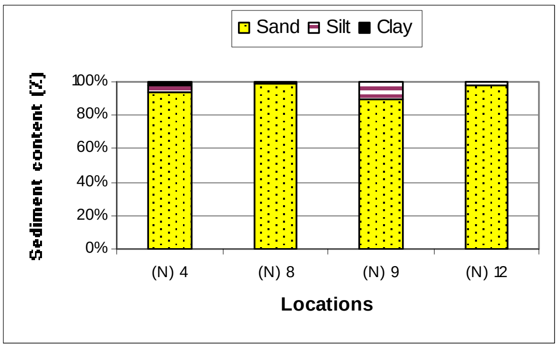

Figure 14: Percentage of sediment content at sectors (N) in year 2006

Moreover, the organic ratio (0%) was used as a measure of sediment richness (Figs. 15, 16 & 17 and Table 4). This organic matter did not reveal any correlation with any of the standing crop at any depth even in the presence of sediment enriched with high organic matter. One explanation is that the nutrient uptake for the submerged weeds does not occur, only by roots but also by the submerged leaves and that the submerged weeds utilize only the sediment to facilitate their attachments.

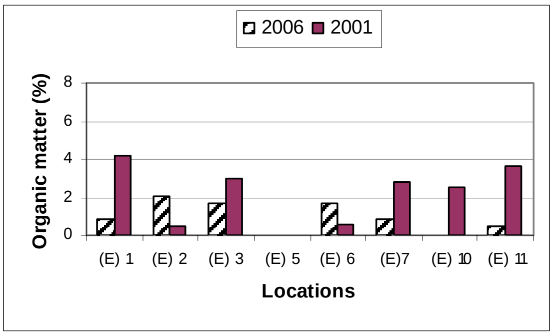

Figure 15: Percentage of organic matter at sectors (E) in years 2001 and 2006

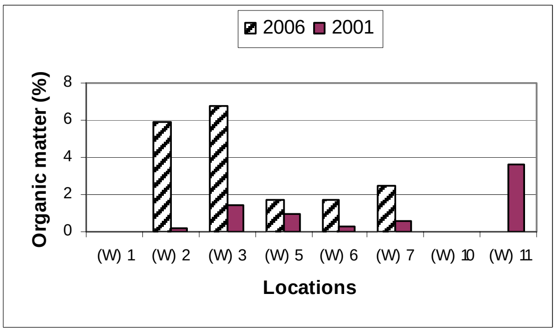

Figure 16: Percentage of organic matter at sectors (W) in years 2001

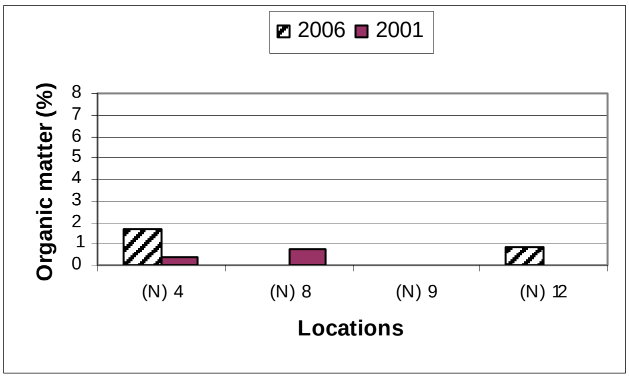

Figure 17: Percentage of organic matter at sectors (N) in years 2001 and 2006

4. CONCLUSSION

In Egypt, monitoring of the submerged aquatic weed becomes essential for the effective Lake Nasser management plan. So, the ultimate goal in this study was to develop approaches for submerged aquatic weed monitoring to give clear conception about the present and future status to assists in the process of predicting changes and assesses the efficiency of different lake management policies. To achieve this main goal, monitoring of the submerged aquatic weeds along the littoral zone of Lake Nasser in years 2001 and 2006 was done. The gained results showed the following:

1. The submerged aquatic weeds are located at depths ranging between one and six meters. However, at depths of five and six meter, the existence of such weeds is very limited.
2. The aquatic submerged weeds cannot establish at the depths of more than six meter because they become vulnerable to light limitation and hydrostatic pressure.
3. The distribution of the submerged aquatic weeds tends to be the highest near the northern and middle parts of the lake and gradually decreases toward the southern part and almost disappears near the Sudanese border
4. The standing crop for the submerged aquatic weeds at different depths (1-6 meters) does not vary greatly with time.
5. The correlation between the standing crop of the submerged aquatic weeds and some physico-chemicals parameters within the surface water is poor. The key environmental factors which affect on such weeds are water level fluctuation, light penetration, bed slope and hydrostatic pressure.
6. Finally, the sediment texture with its organic content is less useful predictors of the community structure for the submerged aquatic weeds.

Table 3: Comparison between the water quality parameters in the infested area with submerged aquatic weeds in Lake Nasser during years 2001 and 2006.

Sample Statistics	pH		Turbidity		TDS		TSS		Bicarbonate		Carbonate		Calcium		Sodium		Potassium		Magnesium		Chloride		Nitrate		Sulfate	
	2001	**2006**	**2001**	**2006**	**2001**	**2006**	**2001**	**2006**	**2001**	**2006**	**2001**	**2006**	**2001**	**2006**	**2001**	**2006**	**2001**	**2006**	**2001**	**2006**	**2001**	**2006**	**2001**	**2006**	**2001**	**2006**
Sample size	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
Mean	8.3	7.9	20	20	170	161	7.8	11.8	114.7	108	3.6	0	26.9	22.95	9.3	14.9	3.7	6.5	14.4	9	11	17.8	2	1.6	9.63	9.58
S.E.±	8.2	6	2.7	6.4	2.9	3.1	1.5	1.9	4.4	3.2	1.4	0	0.72	1	0.48	0.45	0.2	0.41	5.5	0.3	0.42	0.63	0.37	0.26	0.47	0.43
***t* test (Two tailed)**	4.39		0.08		2.78		2.8		1.7		4.39		0.08		2.78		2.8		1.7		0.26		0.47		0.43	
Significance level	P>0.05		P>0.05		**P<0.05**		**P<0.05**		P>0.05		P>0.05		P>0.05		**P<0.05**		**P<0.05**		P>0.05		9		0.98		0.075	

Table 4: Comparison between the mean percentages of sediment contents and organic matter during the years 2001 and 2006.

Sample Statistics	Clay (%)		Silt (%)		Sand (%)		Organic matter (%)	
	2001	**2006**	**2001**	**2006**	**2001**	**2006**	**2001**	**2006**
Sample size	19	19	19	19	19	19	19	19
Mean	0.8	5.3	4.97	30.5	94.24	64.13	1.27	1.43
S.E.±	0.24	1.37	1.03	7.5	1.2	8.8	0.3	0.4
***t* test (Two tailed)**	3.37		3.43		3.46		0.299	
Significance level	**P<0.05**		**P<0.05**		**P<0.05**		p>0.05	

Table 5: Comparison between the sediment texture during the years 2001 and 2006.

Locations	(E) 1	(E) 2	(W) 2	(E) 3	(W) 3	(N) 4	(E) 5	(W) 5	(E) 6	(W) 6	(E) 7	(W) 7	(N) 8	(N) 9	(E) 10	(W) 10	(E) 11	(W) 11	(N) 12
2001	Sand	Sand	Sand	Sand	Loamy sand	Sand	Sand	Sand	Sand	Sand	Sand	Sand	Sand	Sand	Sand	Sand	Sand	Sand	Sand
2006	Silt loam	Silt loam	Silt loam	Silt loam	Silt loam	Sand	Sandy loam	Sand	Silt loam	Loam	Silt loam	Sand	Sand	Sand	Sand	Sand	Sand	Sand	Sand

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