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Evaluation of the Efficiency of Some Hydrophytes for Trapping Suspended Matters from Different Aquatic Ecosystems

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Abstract: The efficiency of different investigated hydrophytes for trapping suspended particles and epiphytes from different water sources (River Nile, canals and drains) during different seasons was studied. Species that form canopies e.g., *Potamogeton pectinatus* were found as poor trapping, *Myriophyllum spictum* and *Ceratophyllum demersum* that form dense understories, were found to be highly efficient for suspended particles traps. The floating hydrophytes *Eichhornia crassipes* fixed valuable amounts of sediments through its root system. Also, the present data indicated factors affecting the trapping efficiencies of investigated hydrophytes to avoid wrong weighing of fresh hydrophytes as a result to trapping suspended particles as follows (Wr = W0 x F) whereas Wr = real wt., W0 = fresh wt. and F = factor detected in each species. In conclusion, trapping of suspended silt and clay may lead to protection of the plant from harmful chemicals due to sprout it on its surface by colloidal affinities or opposite charges. Also, supplies the plant with essential minerals especially under unfavourable conditions. This may explain to some extent, the abilities of some hydrophytes like *E. crassipes* to overcome the nutrient and mineral deficiency in outer media via picking up its nutrient requirements from suspended particles trapped by its root which acts as minerals store. Also we can study the using of these plants as tools to filtrates the water from impurities (organic and inorganic) for industrial and sanitaries purposes.

Key words: Hydrophytes, trapping, suspended matter, aquatic

INTRODUCTION

Hydrophytes impeded in water body may allow great amounts of suspended solids (clay, silt and periphyton) to be trapped out and thus clarify the water. As a result to trapping such materials fresh weight of these hydrophytes, to some extent, may be altered. In addition to decreasing sedimentation rates, as far as there is no other study which has investigated to show the relationship between suspended matters trapped by certain hydrophytes and its aftereffect on a hydrophyte and its fresh weight in Egypt.

Attenuation of water velocity has been hypothesized to be a major factor leading to the retention of fine-grained particles at sites in the absence of plants, would be expected to have only coarse sediments (Barko and Smart, 1986; Petticrew and Kalff, 1991). Sediments within the basin can be redistributed by water and wind movement. Some remains of interred organisms preserve at different rates under different lake conditions; others do not preserve at all (Wetzel and Likens, 1991). Bank vegetation will support the banks with roots and its removal will increase erosion (Khattab and El-Gharably, 1990).

Stands of submerged macrophytes are considered to be traps for particulate matter (Dawson, 1980; Adams and Prentki, 1982; Petticrew and Kalff, 1992). Rooted species that form canopies are poor at trapping cool flowing water following summer storms (Prentki *et al*., 1979). Species that form dense understories may not only be highly effective as sediment traps but may also have an important influence on the local geochemical environment (Jackson and Kalff, 1993). Hynes (1970) reported that one point, which is really a strictly biological one, is that great quantities of rooted vegetation may develop in some shallow slow streams during the summer. These not only alter the substream by accumulating silt, but also impede the flow to some extent offset the effects of low summer-discharge.

Clays can have direct and indirect effects on plankton communities. They may change primary productivity by altering light penetration and scattering (Kirk, 1985; Danilov and Ekelund, 2001). It has been recognized that sediments from important habitats for aquatic organisms (Campbell *et al*., 1988), also act as habitats for submerged macrophytes (Madsern *et al*., 2001).

The total area of agricultural land in Egypt is about 2.5 million ha. This area is artificially irrigated by the River Nile through a huge network of canals and drained by a similar network of drains (47000 km approximately). The drainage water probably borne big amounts of silts and clays run off from agricultural land, thus may contribute in increasing the amount of suspended particles in water sources. For many reasons submerged and floating hydrophytes had flourish and spread all over the water sources. More than 40% of total lengths of canals and drains were infested by floating and submerged hydrophytes (Khattab and El-Gharably, 1990).

So, the huge amount of aquatic weeds play an important role in controlling suspended particles in water by trapping. Consequently, affect the roughness of canals and drains, turbidity and finally water quality. Nile silt was known for its nutrients deposited on the soil. Formerly about 110 million tons of silt flowed through the Nile mostly during the flood period and consequently much was lost as the water flowed to the Mediterranean sea. Turbidity in surface water is due to particulates of organic nature such as phyto and zoo planktons and minutes animal debris and of mineral nature as silt and clays. Suspended clays and silts are common in many lakes and rivers world-wide (Hart, 1986). These particles may enter the water column as sediments (Stewart and Martin, 1982). Nevertheless, it is true that the mean particle size decreases in a down stream direction and there is a general correlation between the particle size and slope. At time of low water, however, most streams and rivers are normally fairly clear and they become turbid during floods when great amounts of suspended matters may be carried (Hynes, 1970). Clay particle size range widely, with dimension of 2-3 μm. Concentrations up to 828 mg clay/l have been reported by Ritchie and Cooper (1986; 1987). Cummins (1962) categorized particles of silt (0.0039-0.0625 mm) and clay (<0.0039), the former separated by settling and clay separated by centrifuge.

The purpose of the present study was to investigate the amounts of suspended particles (silt, clay and periphyton) trapped by different hydrophytes and assessment ecological factors that may affect the rate of trapping. Also, to derive an equation to avoid the wrong weighing of fresh hydrophytes as a result of trapping suspended particles. To support efforts to interpret rate the field observation, it was advisable to perform a limited series of laboratory experiments that permitted better control over the relevant physical variables.

MATERIALS AND METHODS

Study sites: Three different sites were chosen to cover as far as possible of various ecotypes of watercourses at investigated areas (River Nile, canal and drain). The investigated areas appeared to be populated with dense growth and have long history of heavy infestations of aquatic plants. All sites are generally situated up to lat. 30°N at middle belt of Egypt (Benisuif, Cairo and Giza districts) during 1994 and 1995.

Evaluation of suspended particles and epiphytes trapped by investigated hydrophytes: Plant samples of floating *Eichhornia crassipes* (mart solms.) and submerged, *Ceratophyllum demersum* L., *Myriophyllum spicutum* and *Potamogeyon pectinatus* L. (Appendix 1) were collected during the different seasons at the same day from different sites in triplicates. Definite weight of each sample (old part and new part) soaked in a certain volume of distilled water, shacked vigorously, then brushed by a special brush. A combination of methods was adopted to evaluate the amounts of suspended clays and silts in addition to epiphytes trapped by the studied plants as follows. Series of filters with different pore sizes were used. Centrifugation at different speeds and hydrometer, in addition to oven, all of these combinations were used and average amounts of suspended particles and epiphytes were detected according to Cummins (Cummins, 1962), Jackson (1962), USEPA (1973) and Wetzel and Likens (1991). An equation to estimate the amounts of suspended particles trapped by different investigated hydrophytes depending upon field observations and mathematical meaning was made up.

Also, investigated hydrophytes were transferred carefully through plastic bags and incubated inside tanks 1x1x½ m containing water treated to getride of suspended particles for 23 days and the amounts of suspended particles attached to investigated hydrophytes were calculated at starting of experiment and after 2, 9, 16 and 23 days respectively and expressed as a percent of total fresh weight. The above mentioned methods were used to determine attached particles.

Water characteristics: Some physico-chemical characteristics of water were detected during different four seasons, in addition to torrent period (Oct. 1994). Transparency of water current flow, pH, Electrical Conductivity (EC) and dissolved oxygen were detected in the field, at the site of collection, using portable pool test (Hana, Italy) and Janway oxidigimeter. Water transparency was measured by means of seechi disk. In addition, suspended particles of water were detected using centrifuge (high speed) and hydrometer (Jackson, 1962).

Torrent period: The author studied this phenomenon and detected all parameters affect the trapping efficiency during torrent period to evaluate the possible effects of such phenomenon on aquatic ecosystem in comparing with normal climate.

The obtained data were subjected to mathematical and statistical meaning in data analysis techniques.

RESULTS

The data obtained herein (Table 1 and Fig. 1) showed marked abilities of different investigated hydrophytes to

Table 1: The amounts of suspended particles (silt and clay) and epiphytes trapped by different hydrophytes collected from various habitats implicating seasonal variations (as % of total fresh wt.)

Investigated hydrophytes	Season: Winter						Spring						Summer					
Study sites	River Nile		Canal		Drain		River Nile		Canal		Drain		River Nile		Canal		Drain	
	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
E. crassipes																		
Root of new offset	2.5	0.07	1.2	0.03	1.8	0.07	2.4	0.09	1.0	0.07	1.9	0.06	4.3	0.11	1.4	0.10	1.3	0.04
Root of old plant	18.1	0.27	16.1	0.11	19.8	0.18	22.1	0.51	12.1	0.31	23.1	0.21	24.3	0.43	19.8	0.21	22.1	0.28
% composition of Whole plant	10.3	0.17	8.65	0.37	10.8	0.125	12.25	0.30	11.5	0.19	12.5	0.135	14.3	0.27	10.6	0.155	11.7	0.16
C. demersum																		
New tip	1.8	0.7	-	-	2.4	0.05	1.5	0.05	-	-	2.1	0.05	2.1	0.08	-	-	1.8	0.07
Old part	13.8	0.29	-	-	16.5	0.31	17.1	0.31	-	-	14.3	0.39	15.2	0.29	-	-	15.1	0.28
% composition of whole plant	7.8	0.18	-	-	9.45	0.18	9.3	0.18	-	-	8.2	0.22	8.65	0.185	-	-	8.45	0.75
M. spictum																		
New tip	4.5	0.05	-	-	-	-	4.8	0.11	-	-	-	-	6.1	0.14	-	-	-	-
Old part	21.1	0.42	-	-	-	-	23.1	0.61	-	-	-	-	28.3	0.51	-	-	-	-
% composition of whole plant	12.8	0.232	-	-	-	-	13.92	0.36	-	-	-	-	17.2	0.325	-	-	-	-
P. pectinatus																		
New tip	1.2	0.03	-	-	-	-	1.0	0.05	-	-	-	-	2.1	0.07	1.7	0.03	-	-
Old part	9.8	0.24	-	-	-	-	12.2	0.31	-	-	-	-	11.5	0.34	9.5	0.15	-	-
% composition of whole plant	5.5	0.135	-	-	-	-	6.60	0.18	-	-	-	-	6.8	0.205	0.09	0.09	-	-

1 = Clay + silt, 2 = Epiphytes

Table 1: Continue

Investigated hydrophytes	Season: Autumn						Upper Egypt torrent period						Total annual average			
Study sites	River Nile		Canal		Drain		River Nile		Canal		Drain					
	1	2	1	2	1	2	1	2	1	2	1	2	3	4	5	6
E. crassipes																
Root of new offset	4.5	0.10	1.3	0.08	1.7	0.03	8.3	0.0	4.5	0.01	1.2	0.0	3.52	1.30	1.73	2.2
Root of old plant	26.7	0.52	22.1	0.19	21.8	0.32	38.1	0.08	34.1	0.07	19.1	0.24	23.24	20.13	21.95	21.8
% composition of Whole plant	15.6	0.175	11.7	0.135	11.75	0.175	23.2	0.04	19.3	0.04	10.15	0.14	23.38	10.72	11.84	11.98
C. demersum																
New tip	2.8	0.09	-	-	3.4	0.07	9.1	0.11	-	-	1.7	0.03	2.12	-	2.49	2.31
Old part	18.3	0.33	-	-	17.8	0.31	39.8	0.03	-	-	12.1	0.19	26.4	-	16.2	16.3
% composition of whole plant	10.55	0.21	-	-	10.6	0.19	24.45	0.02	-	-	6.9	0.11	9.26	-	9.3	9.28
M. spictum																
New tip	4.5	0.100	-	-	-	-	12.3	0.0	-	-	-	-	5.07	-	-	5.07
Old part	32.2	0.54	-	-	-	-	48.2	0.18	-	-	-	-	26.7	-	-	26.7
% composition of whole plant	8.35	0.32	-	-	-	-	30.25	0.09	-	-	-	-	15.88			15.88
P. pectinatus																
New tip	1.7	0.08	1.4	0.021	-	-	4.8	0.02	3.5	0.01	-	-	1.56	1.4	-	1.48
Old part	16.3	0.40	8.3	0.17	-	-	27.2	0.05	14.2	0.03	-	-	12.77	9.98	-	11.38
% composition of whole plant	9.0	0.24	4.85	0.11	-	-	16.0	0.035	8.8	0.02	-	-	7.17	5.69	-	6.43

1 = Clay + silt, 2 = Epiphytes, 3 = River Nile, 4 = Canal, 5 = Drain, 6 = Mean

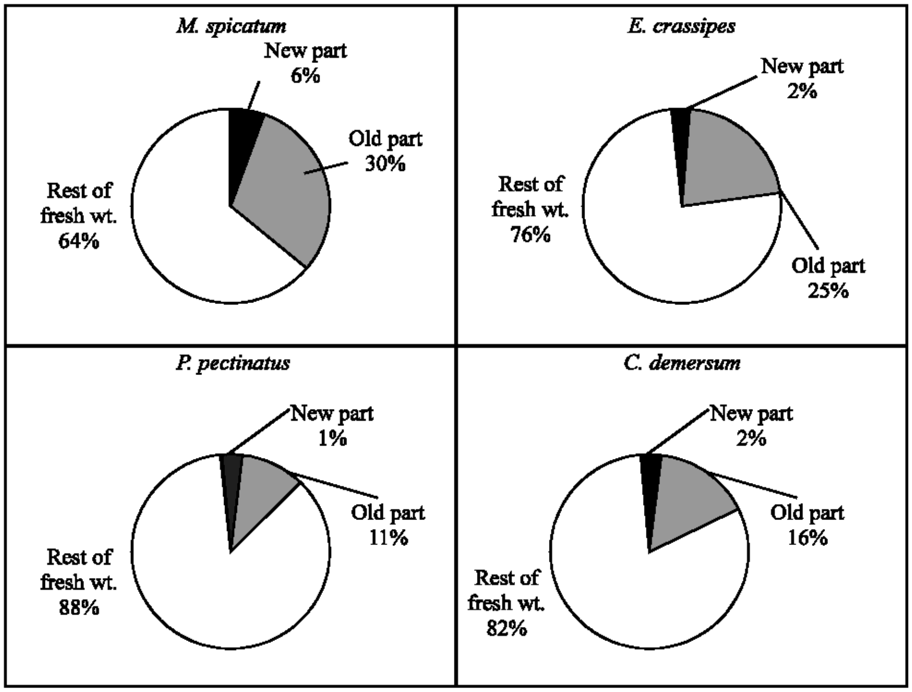

Fig. 1: Mean of total annual average of amounts of suspended matters trapped by different investigated hydrophytes from total fresh weight

trap relatively high amounts of suspended particles (silt and clay) from surrounding water. Old roots of *E. crassipes* collected from River Nile comprised about 18.1% of its total fresh weight, silt and clay, during winter while this ratio elevated to reach maximum (26.7%) during autumn with seasonal average (23.24%). Epiphyte communities isolated from *E. crassipes* old roots, during the different seasons, were relatively low and varied between 0.27% during winter to 0.52% of total fresh weight during autumn.

On the contrary, above mentioned amounts were reduced greatly with roots of new offset of *E. crassipes* and ranged from 2.5 (silt and clay) during spring to 4.5% during autumn with average (3.52%), while epiphyte communities decreased greatly to represent seasonal average about 0.95% of total fresh weight and reached its peaks during summer and autumn (0.1% of total fresh weight).

On the other hand, the same plant collected from different habitats (canal and drain) had little variations from that collected from River Nile. The harvest of clay and silt isolated from *E. crassipes* roots at canal was relatively lower than that collected from river nile. The total annual average of particles trapped by old root parts was 20.13% of total root fresh weight while epiphytes comprised about 0.11% of total weight during winter and 0.31% weight, during spring (Table 1).

On contrary, samples of *E. crassipes* roots collected from drain constituted amounts of silt and clay similar or relatively higher than those collected from River Nile (old root captured annual average about 24% of total root fresh weight). This ratio decreased to reach about 17% of total fresh weight of whole plant.

The average percentage of suspended particles trapped by *E. crassipes* roots (new and old part) comprised about 8.65% of total fresh weight of samples collected from canal during winter and about 14.3% of total fresh weight of sample collected from River Nile during summer. The average percentage of epiphytes isolated from *E. crassipes* root varied between 0.17% of total fresh weight to 0.37%.

Regarding submerged plants, *M. spicutum* recorded only at River Nile, ranked as 1st in the amounts of particles trapped through its shoot system. Clay and silt constituted about to 6.1% of total new tips fresh weight, while this ratio increased considerably in case of old part, to reach about 21.1 to 32.2% of total fresh weight during winter and autumn, respectively.

C. demersum collected from River Nile and drain, was found to have moderately harvest of suspended particles as compared with *E. crassipes* and *M. spicutum.* Again, old parts of plant catch up quantities of suspended particles exceeding greatly the amounts trapped by new tips. For example, old parts of plant amounted about

Table 2: Physico-chemical parameters of water during the period of study

	Seasons														
	Winter			Spring			Summer			Autumn			Torrent time		
	Sites														
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Transparency (cm)	57	45	32	52	48	34	63	52	38	58	52	39	0	3	3`1
pH	8.8	8.2	7.9	8.3	8.3	8.5	8.5	8.4	8.1	8.8	8.4	8.3	9	8.8	8.1
Current flow	Mod.	Mod.	Slow	Mod.	Mod.	Slow	Slow	Slow	Slow	Slow	Mod.	Mod.	High	High	High
Clay and silt (mg L^{-1})	521	214	308	278	225	291	348	298	309	317	307	281	2187	1412	329
EC (mmohs)	0.6	0.66	1.2	0.51	0.49	0.97	0.41	0.41	0.96	0.44	0.53	1.17	0.61	0.62	1.21
TSS (mg L^{-1})	389	348	728	305	317	617	262	338	622	279	342	752	407	412	801
DO (mg L^{-1})	5.7	4.8	4.5	5.2	4.9	4.7	6	5.1	4.3	5.5	4.1	3.9	3.5	3.3	4.1

1: River Nile, 2: Canal, 3: Drain

13.8-17.8% of clay and silt from total fresh weight while new tips of the same plant constituted only about 1.8-3.4% of total fresh weight. This trend is correct in case of epiphytes isolated from plant shoots, whereas old part trapping about 0.33% of total fresh weight (recorded during autumn at River Nile). In contrast, epiphytes isolated from new tips during autumn at some locations constituted about 0.09% of total fresh weight. The average percentage composition of suspended particles trapped by *C. demersum* (old and new parts) varied between 7.8% of total fresh weight recorded during winter at River Nile to 10.6% amounted at drain during autumn, (Table 1).

Estimations of suspended particles trapped by *P. pectinatus* throughout the four seasons were relatively low than other investigated hydrophytes. It's ranged from 9.8 to 16.3% of total fresh weight of old part, for winter and autumn, respectively. New parts comprised amounts of suspended particles relatively small than amounts collected from old parts (1.2-2.1% of total fresh weight). Also, average percentage composition of silt and clay trapped by all parts of *P. pectinatus* were relatively lower than other investigated plants and varied between 4.85% of total fresh weight for samples collected from River Nile during autumn.

Regarding to overflow rainy period which lead to marked alterations in amounts of suspended particles at river Nile, conspicuous increasing amounts of suspended particles fixed by different investigated hydrophytes were observed, especially in River Nile and canal. These amounts were doubled during overflow period. For example average of suspended particles trapped by *E. crassipes* increased from 15.6 to 23.2% of total fresh weight. This ratio being twiced, from 10.6 to 24.45% in case of *C. demersum*, while *M. spicutum* recorded 30.25% in contrast of value 18.35% of total fresh weight before. Again, *P. pectinatus* fixes the relatively lower amounts of suspended particles through other investigated hydrophytes during torrent period, being 16.0% for samples collected from River Nile and 8.8% for those collected from canal (Table 1). It seems that samples collected from drain were not affected by torrent time at all.

It is worthy to note, in general samples collected from canal fix relatively lesser amounts of suspended particles than those from River Nile and drain (Table 1).

Referring to total annual average of suspended particles fixed by investigated hydrophytes, data herein showed that *M. spicutum* caught the big amounts of total annual average at River Nile being amounted to 15.88% of total fresh weight, while *P. pectinatus* attached the lowest average through all investigated sites (River Nile and canal) which varied between 5.69-7.10% of total fresh weight. On the other hand, *E. crassipes* and *C. demersum* collected moderate harvest ranged from 10.72% for samples collected from canal to 13.38% of total fresh weight for those sampled from River Nile and from 9.26 to 9.30% of total fresh weight for *E. crassipes* and *C. demersum*, respectively.

Table 2 indicates some physico-chemical characteristics of water at sampling sites. pH being always on alkaline side and ranged from 7.9-8.4 and reaches peak during torrent time (9.0 and 8.8) at River Nile and canal, respectively.

The highest value of suspended silt and clay was recorded at River Nile during summer (348 mg L^{-1}) and this value increased greatly during water fall torrent time (Table 2). TSS attained maximal in drain and varied between 617 to 801 mg L^{-1}. On the other hand, such parameter dropped to lowest values in River Nile and canal (262 mg L^{-1}).

Experimental study showed a gradual decrease of amount of suspended particles by different investigated hydrophytes, when incubated within tanks containing

Table 3: % of suspensoides attached to investigated hydrophytes during the period of experiment (as % of fresh wt.)

	Days				
Hydrophytes	0	2	9	16	23
E. crassipes	9.8	7.2	6.1	5.8	5.0
M. spicutum	12.5	10.8	9.2	9.0	9.0
C. demersum	8.1	7.0	6.2	6.0	5.1
P. poectinatus	5.6	3.8	3.2	3.1	3.0

water free from silt and clay, by time lag (Table 3). The marked drops were observed at all studied hydrophytes after 2 days of incubation, then the rates of decrease became stable and amount of loss was steady (Table 3).

DISCUSSION

The survey during the period of investigation shows the great abilities of studied hydrophytes to trap suspended particles (silt, clay and epiphytes) by relatively high conspicuous amounts from outer media. *M. spicutum* and *E. crassipes* fixed the highest amounts of suspended particles. This may be attributed to morphological features of these plants, characterized by dense branches which enable them to trap highest amounts of suspended particles from water and fix them between fine branches by time lag. In addition to increase the interfacial area between plant branches and surrounded media. On contrary, *P. pectinatus* collected the lowest values of suspended particles during the period of investigation, this might probably be attributable to morphological features of this plant that form canopies, poor at trapping suspended particles (Prentki *et al.*, 1979). Also, characterized by relatively less condensed branches and long leaves (about 5 cm long and diameter 25 mm approximately). These distances were 1 cm long and 0.5 mm diameter in case of *M. spicutum* which form dense understory highly effective as sediment traps (Jackson and Kalff, 1993). Data showed *C. demersum* harvests moderate level of suspended particles.

Data also reveal the amount of suspended particles trapped by investigated plants affected greatly by alteration of the nature of water body, whereas plants collected from River Nile and drain fixed relatively higher amounts of suspended particles than those collected from canal especially at summer and autumn because the heavy deposits of silt and clay from the Nile overflow during this period. In addition, drain received huge amounts of silt and clay dumped off from neighbouring agricultural land after irrigation process. Also, degradation process lead to resuspension of silt and clay from sediments. This may come in agree with Stewart and Martin (1982) and Skei (1992). These factors may increase suspended particle contents in water and consequently increase amounts of particles fixed by investigated hydrophytes. Vice versa correct in case of canal.

The samples collected during winter generally caught the lowest amounts of trapped suspended particles due to water regimes extended about one month and half during winter (from start Jan. to mid Feb.).

The comparative study between new tips and old parts showed clearly that old part have fix amounts of silt, clay and epiphytes relatively higher than those fixed by new parts. This phenomenon has logically appeared due to increase of exposures times and exposed area of older part than new ones.

Always epiphytes constitutes ratio less than clay and silt trapped by hydrophytes. Samples collected from River Nile having large extension upward of epiphytes than those collected from canal and drain. The most dominant epiphyte species isolated from different investigated hydrophytes were belonging mainly to Bacillariophyta, Chlorophyta and Cyanophyta (*Melosira*, *Nitzchia*, *Navicula*, *Mougeotia*, *Scenedesmus*, *Lungbya* and *Oscillatoria*).

Waterfall period had pronounced effect on Nile ecosystem, for example water transparency diminished as a result of increased suspended particles, especially fine sand and silt carried by waterfall room surrounding dunes. This phenomenon consequently affects the amounts of suspended particles trapped by hydrophytes, particularly at River Nile and canal implicated by waterfall than drain, while affect the epiphytes and phytoplankton passively as a result of altering light penetration and scattering eventualities photosynthesis process (Kirk, 1985). Also, dissolved oxygen is reduced greatly as a result by the reduction of algal activities and increase of microbial activities (bacteria and fungi).

The experimental study showed that incubation of investigated hydrophytes inside tanks, containing clear water free to some extent from silt and clay, leads to reduction suspended particles fixed by hydrophytes as a result to charge it to outer media by time lag. Also, epiphyte communities increased compared with natural stands.

In conclusion, trapping of suspended silt and clay may lead to protection of the plant from harmful chemicals due to sprout it on its surface by colloidal affinities or opposite charge. Also, supplies the plant with essential minerals especially under unfavourable conditions. This may explain to some extent, the abilities of some hydrophytes like *E. crassipes* to overcome the nutrient and mineral deficiency in outer media via picking up its nutrient requirements from suspended particles trapped by its root which acts as minerals store.

We can study the using of these plants as tools to filtrates the water from impurities for industrial and sanitaries purposes as bio filters instead of chemical methods.

In addition, the suspended particles fixed by investigated hydrophytes lead to marked increase in plant fresh weight. Consequently, may cause errors in determination of the total fresh weight and growth rate. So, we recommend washing of such plants several times before weighing process, or if washing not available, fresh weight must be multiplied by factor derived from this study and through statistical analysis to reduce the expected errors in weighing process as follow:

$$Wr = W0 \times factor$$

Where: Wr = real weight
W0 = fresh weight of sample
and factor = 11.98 in case of *E. crassipes*
9.28 in case of *C. demersum*
15.88 in case of *M. spicatum*
and 6.43 in case of *P. pectinatus*

Generally, factors affecting the trapping efficiency of investigated hydrophytes are:

1. Morphological features of hydrophytes.
2. Levels at which plants exist (Floating or submerged).
3. Exposure times (age of plant).
4. Amounts of suspended particles in surrounding media.
5. Rate of water flow.
6. Size of particles trapped.

We can concluded the importance of this study to evaluate the ability of investigated hydrophytes for trapping suspended solids and plankton from aquatic system which may open the way to use this phenomenon as biofilter to clarify the water from impurities.

Appendix 1

Morphological features of investigated hydrophytes: The studied hydrophytes classified into floating hydrophyte (*Eichhornia crassipes* (Mart.) Solms.). It is a cosmopolitan, perennial mat form belonging to family Pontederiaceae. The mature plant consists of densely long, pendant, fibrous, unbranched root soaking in water, rhizomes, stolons, and leaves. The study showed this plant flourished in all water systems during the four seasons.

Submerged ones were represented by:

1: *Ceratophyllum demersum* L. It is a fragile, perennial algal-like herb belonging to family Ceratophyllaceae. It has dense dark green leaves being arranged in whorls of 7-10 at each rode, 1-4 cm long, stem is noded and much branched. Plant was frequently recovered.

2: *Myriophyllum spicatum* L. belonging to family Haloragidaceae, rooted at the bottom with ascending annual branched stems projecting above water surface during anthesis; leaves pinnate arranged in whorls, its public name (1000 leaves mother). The plant inhabits the main stream of Riveer Nile only, reaching its maximum growth during spring and summer.

3: *Potamogeton pectinatus* L. it is rich branched plant, leaves narrow, linear to filiform (grass-likes). It forms canopies.

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