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IMPACT OF ASWAN HIGH DAM ON THE AQUATIC WEED ECOSYSTEM

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ABSTRACT

In Egypt, constructing the Aswan High Dam (AHD) across the Nile River caused alterations of the aquatic ecosystem specially the aquatic weed community structures. The high aquatic weed infestations caused a lot of problems by creating losses of water, retardation of flow, interference with navigation, health hazards and alteration in the physico-chemical characteristics of both water and hydrosoil.

The AHD provided routes for some aquatic weed species to the Nile system where they had been previously absent, or they caused permanent elimination for some of them within the Lake Nasser, Aswan Reservoir, Nile River, and waterways (canals and drains).

In the Lake Nasser, two aquatic macrophyte species were eliminated and six species were introduced. In addition, the phytoplankton primary productions have become high throughout the year. The mean density and prevalence of the submerged aquatic weeds are greatly influenced by the high water level fluctuation, hydrosoil texture and nutrients.

In the Aswan Reservoir, the submerged aquatic weed*, Ceratophyllum demersum* has become dominant because it has an ability to tolerate severe water fluctuation near the littoral zone.

In the Nile River and waterways, the water level regime has been regulated. This regulation has created a favorable habitat for many aquatic weeds to establish than before and the aquatic weed infestations have been increased.

INTRODUCTION

Human beings have used streams to satisfy domestic and industrial needs and provide transportation, hydroelectric power, mean for sewage and waste disposal, and fish and agriculture for food. As a result of these various demands, irrigation projects have been created.

Constructing such large dam across a river and impounding water behind may cause alterations of the aquatic environment including water quality, floral and faunal changes.

In Egypt, some of the problems arising from the construction of Aswan High Dam (AHD) involve the waterway environment as a result of the consequent regulated flows. Constructing AHD across the Nile at Aswan is obviously has some effect on the aquatic macrophyte. It provided routes for some aquatic weed species to the system where they had been previously absent, or they caused permanent elimination for some of them within Lake Nasser, Aswan reservoir, Nile River and waterways (canals sand drains).

DEVELOPMENT OF AQUATIC WEEDS IN EGYPT

Aquatic weeds (floating, submerged, ditch-bank and emerged) create serious problems in irrigation canals and open drains as well as lakes in Egypt. The most notorious is waterhyacinth, *Eichhornia crassipes* . It is native to South America and was first introduced to Egypt during the rule of Khedive Tawfiq (1879-1892) for its decorative inflorescence of blue flowers. Since its introduction, waterhyacinth was found in several areas at the northern part (Lower Egypt) and no problems were resulted from its existence.

In 1958, this weed started to spread in many drains and canals from middle Egypt to the Mediterranean. By the end of 1965, this weed flourished over about 40 million square meter of water surface area of water courses in Egypt. As a result, Egyptian authorities launched a national program to remove this weed from water courses. By February of the year 1967, Ministry of Irrigation was able to eliminate aquatic weeds from 65 million square meter of water surfaces. Between 1967 and 1975 many other types of aquatic weeds were created due to non-existence of *Eichhornia crassipes* that used to prevent sunlight required for their growth. By the spring of 1975, more than 80% of the whole canals and drains were infested with different types of aquatic weeds. Accordingly, national programs for channel maintenance and weeds control were adopted in a regular basis.

ENVIRONMENTAL IMPACT OF ASWAN HIGH DAM ON THE AQUATIC WEED ECOSYSTEM

1-Aquatic weed infestation within Lake Nasser In 1962-1964 (before constructing AHD), the area of the Nile valley (Nubia) which was became Lake Nasser, 57 species of aquatic weeds were detected. Those aquatic weeds were submereged and emergent flora. Sixth from them were euhydrophytes (*Alisma gramineum, Damosonium alisma, Potamageton cripus, Potamageton pectinatus, Potamageton perfoliatus* and *Zannichellia palustris*). In 1966-1968 (subsequent to the construction of AHD), two euhydrophyte species have been lost from the region (*Alisma gramineum, Damosonium alisma*). But the other four species have colonized the lake with varying degrees of success. Furthermore, six new species were recorded for the first time within the Lake (*Vallisneria spralis, Potamageton schweinfurthii, Najas horrida, Najas marina*, Subsp. *Armata* and *Nitella hyalina*). In Lake Nasser there is an annual cycle of water level changes according to the seasonal flood pattern of the River Nile. The flood occurs in late summer-early autumn. Alteration of the hydrology of the River Nile system caused dramatic changes in macrophyte community structure. The waterbody regulation selects submerged weeds tolerating the fluctuating water level. The water level fluctuation may often cause mortality of the aquatic weeds. During the drought period, continuous low water level exposed the littoral shallow water habitats as a result the submerged weeds are exposed and desiccated. Following this period, continuous high water levels cause low light condition for the same area, as a result some aquatic submerged weeds not tolerating the dark condition may die. Furthermore, after constructing AHD, the new littoral zone of Lake Nasser was mainly sand substrate because it was previously desert. With continuous flooding, the suspended silt was accumulated behind the Dam creating new hydrosoil texture (sandy clay loam). This type of soil provided a favorable substrate for growing the submerged weeds like *Myriophllum spicatum*. Moreover, the accumulated silt might be washed from the banks and preseipetated in the main canal leaving behind sand or loamy sandy banks. On these shores dramatic changes in macrophyte community were occurred. As a result, some weeds became domenated such as *Najas marina* and *Potamageton schweinfurthii*. High aquatic macrophyte biomass was associated to relatively high hydrosoil calcium, postassium, mangnesium and phosphat concentrations as well as high organic matter content and high nitrate concentration. These elements represent a potentially important source of nutrition to rooted macrophytes (emerged and submerged weeds) within the lake. When the submerged macrophytes are subjected to destruction by extremely high water level fluctuation, these nutrients liberate to the water column, thereby influencing overall water quality and providing again new source for both micro and macrophytes nutrient utilization. In Lake Nasser, phytoplankton primary production is high. The phytoplankton community is composed of blue green algae, diatoms, green algae and dinofalgelates. Blue green algae dominate the community during spring and summer. Diatoms dominate mainly in December. Noticeable peaks of green algae are sometimes recorded in spring and summer. Dinoflagelates are very few although some remarkable peaks have been observed in late winter and spring. Chlorophyll 'a' concentrations are vertically stratified in the euphotic zone from April-September, While the distribution is homogeneous from November-February. The Chlorophyll 'a' is highly concentrated in the south of the lake than in the north. After the construction of AHD, water blooms of *Microcystis aeruginosa* were observed only at southern end of the lake between Wadi Halfa and

Abu Simbel. Recently however, water blooms have been observed in the central area of the lake. Very occasionally they are seen at Kporosko in the northern area. Formerly, *M. aeruginosa* water blooms occurred annually for several months before the flood water period, but now they occur intermittently throughout the year.

2-Aquatic weed infestation within Aswan Reservoir

Before constructing AHD, Aswan Reservoir showed a pronounced annual change in the water level. However, after the construction, the High Dam regulated the Nile floods. In the Aswan Reservoir, the water level regime followed a fixed pattern in which each day a certain amount of water is released to produce the hydroelectric power. Usually, water is stored overnight and released during the day with about three meters water level fluctuation. As a result of this fluctuation, the submerged aquatic weed, *Ceratophyllum demersum* became dominant because it has an ability to tolerate severe water level fluctuation near the littoral zone. Also, the abundant growth of this type of weed was confined to clay loamy hydrosoil. Such fine texture was trapped within Aswan Reservoir after building the two dams.

3-Aquatic weed infestation within River Nile

After constructing AHD, the water level regime in the River Nile has been regulated to meet Egyptian demands for cultivation, industrial, navigation, hydroelectric power and domestic water supply. This regulation allows a gradual increasing and decreasing the water level creating a favorable habitat for many aquatic weeds to establish than before. Many submerged weeds have established in the River Nile such as *Ceratophyllum demersum, Myriophyllum spicatum. Potamogeton pectinatus, Najas horrida, Vallisneria spiralis* and *Chara globularis.*

In the River Nile, the dominant species is *Ceratophyllum demersum* (59-78% of the total standing crop) and *Potamogeton crispus* (15-28% of the total standing crop). However, about (25% of the total standing crop) is made up of *Potamogeton perfoliatus* and *Myriophyllum spicatum*.

Furthermore, the abundance in species richness can shift from *C. demersum* during the autumn and winter, through *Potamogeton crispus* in early summer, to *P. perfoliatus* in late summer and early autumn.

Though the water hyacinth has been introduced in Egypt since 1890,s, it did not reach the plague proportion exhibited in the Nile until recent times. Since the construction of AHD, the Nile system has been subjected to several ecological changes: silt free water running downstream and the consequent excessive use of fertilization, permanent presence of water through out the year, low current velocity in the Nile and stopping the water flow to the Mediterranean. These factors have encouraged fast growth of *Eichhornia crassipes* within the Egyptian Nile River even at the end of the growing season, which extends from the end of March to October. This is truly alarming.

4-Aquatic weed infestation within the irrigated system

For many reasons, aquatic weeds with their various types (floating, submerged, ditch-bank and emergent) were flowered and spread all over water courses since the spring season of 1975. The sudden invasion of aquatic weeds to the irrigation system in Egypt was related to the construction of the AHD as follows:

a. The construction of AHD has decreased the peak discharges that used to smash out any kind of aquatic weeds in the main course of Nile River and its main two branches.

b. Daily discharges were reduced to 235 million cubic meters instead of 900 million cubic meters before the construction of the AHD. As a sequence, water became clear and free from solid suspensions. This good condition encouraged the growth of weeds due to the better and deep penetration of sunlight in water.

c. Decrease of water level fluctuations in main canals due to the construction of the AHD has created permanent presence of water in the waterways through out the year.

d. Increased fertilization of farmlands to compensate the lack of silt and to increase the horizontal expansion of agricultural lands caused changes of the chemical characteristic of the water quality within the drains and canals.

All these factors have encouraged the growth of the aquatic weeds to distribute along the irrigation system.

To identify the problem of the aquatic weeds raised after the construction of the AHD, field studies were carried out by Channel Maintenance Research Institute (CMRI, NWRC) for the last two decades. Classification of the problem was as follows in the middle of seventies:

1. Total weed problem.

The total ratio of infested canals with all types of weeds was 86.9% and drains had a ratio of 73.6%, Table (1).

2. Floating weeds.

Ratio of infested canals and drains with floating weeds was about 7.5% related to the total length of both, fig. (1). The most common types of floating weeds are *Eichhornia crassipes, Limna gibba*, and *Nymphaea coerulea.*

3. Submerged weeds.

The total ratio of infested canals and drains reached 41.77% of the total length of both networks, fig. (2). The common types of submerged weeds are *Potamogeton* spp., *Ceratophlum demersum*, *Najas armata* Linb, and *Zannichellia palustris.*

4. Emergent and ditch-bank weeds.

The total length infested by both emergent and ditch-bank weeds had a ratio of 15.9% of the total length of canals and drains, fig. (3). The common types prevailing are *Typha domingensis, Phragmites australis, Cyperus alpecuroids*,..etc.

Studies declared that the major problem in the Egyptian water courses is the submerged weeds with its serious impact on the geometry of water cross section. Accordingly, Irrigation Ministry (former name of MWRI) has implemented a continuous and regular program to control these weeds. Furthermore, Channel Maintenance Research Institute (CMRI, NWRC) was established as a specialist institute to perform research activities concerning this problem. Research work and through CMRI and maintenance programs performed by irrigation districts reduced the infested lengths the minimum rates in the year 1992 and 1993.

IMPACT OF EXCESSIVE AQUATIC WEED INFESTATIONS

Enormous population of aquatic plants may prevent or inhibit the utilization of water resources in a variety of ways. The following impacts have been observed in Egypt as well as in different areas around the world.

1- Losses of water due to evapotranspiration

It has been stated in many publications that a dense stand of aquatic weeds will loose more water to the atmosphere by transpiration than normally be lost by evaporation from an open water surface occupying the same area. However, it is very difficult to make direct measurement of water loss by plants in natural situation as any interference with the plants will certainly affect their rate of transpiration. Several researchers have carried out direct measurements in a variety of natural and artificial conditions in which they compared water lost from stands of aquatic plants with that lost from a comparable open water surface. While these may not be regarded as absolute values, it is possible that they indicate the factors which increase or decrease the difference between evaporanspiration from a stand of aquatic plants and evaporation from an open water surface.

Comparing water lost by tubes of water covered by *Eichhornia crassipes* with similar tubes of open water for a period of five weeks showed that the ratio of evaporanspiration to evaporation varied from 1.5:1 to 3.2:1 in winter and summer respectively. Similarly, measuring the evapotranspiration of *E. crassipes* and *Salvinia molesta* in greenhouse conditions in both moving and still air showed that the ratio of evapotranspiration to evaporation was 4.5:1 for *E. crassipes* and 1.2:1 for *S. molesta*. These ratios were increased by blowing air over the cultures.
Evaporanspiration losses from emergent species and phreatophytes growing on the margins of the water body are more difficult to measure directly. Also, it was reported that phreatophytes (excluding beneficial species) cover about 6.5 million ha in the seventeen western states of the United States of America loose annually 30.65 km^3 of water. *Typha* spp. may also use 211 to 254 cm of water every year. This compares with evaporation rates of 127 to 190 cm from open water surfaces.

2- Retardation of flow in channels

Submerged weeds do not increase water losses from water ways, but may trap silt, impair the flow in canals or drains, and may occupy useful volumes of water in small reservoirs. Water flow is affected when plants reduce the cross-section of channel. In Egypt the total length of canals and drains infested by submerged weeds ranged from 20,000 km in 1984 to about 2000 km only in 1992.
Those types of weeds may reduce the designed flow rate for an artificial canal by as mush as 97%. In Egypt figures were reported for the reduction of flow rate due to excessive growth of submerged weeds by 80% in some small canals .

Floating species restrict flow to a lesser extent but, when massed in a thick mat, create friction losses similar to those provided by sides and bottom of channels. For example, a study showed that a dense mat of *Ecihhornia crassipes* covering canals in Florida, reduced efficiency of large canals to 40%, while small canals were reduced by up to 80% of the flow capacity.

Aquatic weeds also create stagnant condition in water causing a suitable medium for the deposition of large amounts of organic matter and accumulating sediment, this result in a short cycle for channel maintenance.

3- Interference with navigation

Established stands of aquatic macrophytes of all life forms can prevent the passage of conventional boats. Submerged weeds will foul the propellers of conventional motor-driven craft, if they are close enough to the surface. For this reason, mechanical paddles and other special methods of propulsion for water-weed-cutting boats have been developed by CMRI, NWRC staff.
The most serious problems are caused usually by floating masses of vegetation. Because of their mobility, these can be blown into a harbor or channel and completely fill it in a matter of hours.

4- Health hazards

Aquatic plants provide both habitat and food for the larval stages of animal vectors of human diseases such as malaria caused by the parasite, *Plasmodium* sp. This disease can be spreaded by mosquitoes. Larval stages of mosquito can breed in the calm, still pockets of water created among stands of floating vegetation and emergent weeds.

Schistosomiasis (bilharzia) is now ranked at least second to malaria in importance as a parasitic disease throughout the world. In Egypt, bilharzia is caused by two parasitic species, *Schistopsoma haematobium,* or *S. mansoni*. The parasite, *Schistopsoma* depends on the snails as intermediate hosts in order to complete its life cycle. These snails live in the microhabitats provided by aquatic vegetation in which they find both shelter and food. With a certain combination of presence of peremenet water, slow water velocity, and aquatic vegetation, the snails will be able to colonize. Their eggs are laid on the surface of plants and the life cycle of the animal thus depends to a considerable extent on the presence of suitable aquatic vegetation. In Egypt, it has been shown that the bilharzial snails (*Bulinus* and *Biomphalaria*) prefer *Potamogeton crispus*, followed by *Eichhornia crassipes*, and then *Panicum repens*.

Fasciola hepatic can also cause disease to the human. Its life cycle begins with fertilized egg. When the eggs enter water, the opercula fly of the eggs open and the ciliated miracidia are liberated. The miracidia swim around in calm water for a few hours and then penetrate the body of snails (*Lymnea*). Within the snails, the cercariae are developed and leave the snails in order to swim and encyst on the leaves of aquatic vegetation to become metacercariae. The vertebrate hosts can get the infection by ingesting the metacercariae with water plant or drinking water.

5-Water quality alteration

The aquatic vegetation can cause alteration in the physico-chemical characteristics of both water and hydrosoil. The macrophyte communities provide an important source of nutrients which libertes to the water column during senesence, thereby it may provide a source for phytoplanktons and algae nutrient utlization. The abundance of the blue green algae may cause great problem to the waterbody and their users. Also, dead plant material may cause oxygen depletion as a result of the organic matter oxidation process. The organic matter oxidation may introduce out products that can change the water quality. Also, under very low oxygen levels, some bacteria such as sulpher bacteria become very active.

Algae may cause many troubles to the aquatic ecosystem. Accelerated growth of blue green algae results in noxious “water blooms”. Often their respiratory demands surpass their daylight oxygen production, and upon death their decay promotes further deoxgenation. Furthermore, blooms of algae (such as blue green and dinofalgellate algae) concentrate the algae along with toxic compounds released by the algae. These toxins are extremely dangerous to humans and other aquatic organisms.

6- Impact on water management and other activities

In addition to the specific effects and disadvantages of excessive growth of aquatic plants described before, vascular hydrophytes may interfere with the programs of water resource utilization and management. Problems due to the accumulation of aquatic weeds with the operation of pumps are reported occasionally by the authorities in Egypt (hydroelectric system in Aswan and Esna). Aquatic weeds also interfere with irrigation structures by clogging culverts, water intakes, regulators and bridges, thus increasing maintenance expenses. Large population of aquatic plants prevents fishing and other recreation activities.

Table (1) Infested lengths in canals and drains in Egypt during the period 1985 - 1994.

Type of Aquatic Weeds	Infested Length (1000 km)									
	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Floating	3.1	2.8	2.6	2.2	1.9	1.7	1.4	1	1.1	1.4
Submer-ged	18.4	18.9	18.6	17.8	15	13.2	6	2	3	8
Emerge-nt	7.8	8.5	8.4	7.9	7.2	6.5	4	2	2	2.8
Mixed weeds	9.8	8.85	8.8	8.5	9	7.7	3	3	4.9	4.2
Total	39.1	39.05	38.3	36.4	32.1	29.1	14.4	8	10	16.4

REFERENCES

Abdel-Seid, J. K. 1975. Aquatic flora and weeds of fresh water and weeds related to irrigation and drainage networks of Egypt, Research Institute of Weed. Ministry of Irrigation, Cairo, Egypt. (In arabic writing).

Abdel-Seid, J. K. 1978. *Eichhornia crassipes*", Under-Secretary, Ministry of Irrigation, Cairo, Egypt.

Abed, L.; Mahamoud, M.K. 1998. The effect of weed growth on the hydraulic characteristics of the Suez Irrigation Canal. Conf. On Coping with water Scarcity, Hurghada, Egypt. 1.14-1-1.14-5.

Ali, M.M.; Hamad, A.M.; Springuel, I.V.; Murphy, K.J. 1995. Environmental facrors affecting submerged macrophyte communities in regulated waterbodies in Egypt. Arch.Hydrobiol. 133(!):107-128.

Ali, M.M.; Murphy, K.J; Abernethy, V.J. 1999. Macrophyte functional variables versus speceis assemblages as predictors of trophic status in flowing waters. Hydrobiol. 0:1-9.

Al-Medany, M. A. 1970. Aquatic Weeds, results and methods of control ", Ex. Under-Secretary, Technical Advisor, Ministry of Irrigation, Cairo, Egypt.

Bakry, M.F.; Seif, H. 1998. Classification of aquatic weeds in the irrigation and drainage networks during the year 1996/997, Channel Maintenance Research Institute (CMRI), National Water Research Center (NWRC), Ministry of Public Works and Water Resources (MPWWR), Egypt.

Craig, J.F. 1998. The environmental impact of fish production in Lake Nasser. Conf. on Coping with water Scarcity, Hurghada, Egypt

Filbin, G.J.; Barko, J.W. 1985. Gtowth and nutrition of submersed macrophytes in a eutrophic Wisconsin impoundment. J. Fres water Ecology, 3 (2):275-285.

Khattab, A. F. 1984. Problem of aquatic weeds in Egypt and methods of management", 2nd International Conference on aquatic weeds management, Bari, Italy.

Khattab, A. F.; El-Gharably, Z. 1986. Management of aquatic weeds in irrigation systems with special reference to the problem in Egypt, Research Institute of Weed Control & Channel Maintenance,NWRC, MPWWR, Proceedings EWRS/AAB &th Symposium on Aquatic Weeds, Cairo, Egypt.

El-Samman,T.A.; Bakry, M.F. 1998. Effect of submerged weed distribution on open Channel flow. Conf. On Coping with water Scarcity, Hurghada, Egypt.1.4-1-1.4-8.

Elwakil, M.A.;Sadik,E.A; Fayzalla, E.A.; Shabana, Y.M. 1989. Biological control of waterhyacinth with fungal plant pathogens in Egypt. Proc. VII. Int. Symp. Biol. Conf. Weeds. Rome, Italy.

Springuel, J.; Ali, M.M.; Murphy, K.J. 1990. Aquatic macrophyte growth in relation to water level regime in the River Nile and its impoundments in Upper Egypt. Proceedong EWRS 8 th Symposium on Aquatic Weeds.