AQUATIC WEED MANAGEMENT UPSTREAM ASWAN RESERVOIR IN EGYPT

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ABSTRACT

In Egypt, some of the problems arising from the construction of High Dam (HD) involve the waterway environment as a result of the consequent regulated flows. Before constructing (HD), Aswan Reservoir (AR) showed a pronounced annual change in the water level. However, after constructing HD, the water level regime is followed in fixed pattern every day, in order to release sufficient amount of water to generate the hydroelectric power and to satisfy domestic, agricultural and industrial needs. The water in the reservoir is usually stored overnight and released during the day resulting in water level fluctuation ranging between 2 and 3 meters. For several years, this reservoir (the reach between Aswan Reservoir and High Dam) has been suffering from aquatic weed infestation, mainly the submerged one, *Ceratophyllum demersum*, which is a predominant species. This type of weed constrained water use by blocking water intakes in front of operating turbines of hydroelectric Aswan Power Stations (1) and (2). Where the generated power efficiency is seriously reduced.
The mechanical control of aquatic weed cannot be applied in the reach between High Dam and Aswan Reservoir due to difficult topography of the region to take down the equipment. For controlling the submerged weed in the reservoir, herbivorous grass carp (*Ctenopharyngodon idella* Val.) fingerlings were applied annually from year 1999 to year 2012. The main objective of this study is to assess the aquatic weed management in the reservoir region. To achieve the objective of the study, several field measurements were executed on several cross sections along the studied area.
As a result, the total percentage of the aquatic weed infestations along the whole reservoir sharply decreased from 0.5 % in year 1998 to 0.07 % in year 2007 and then increased to 0.26 % in year 2011. Therefore it is recommended to use grass carp for controlling aquatic weed biologically annually with evaluation the percentage of aquatic weed and the stocked fish.

Keywords: Aquatic weed, grass carp, Aswan Reservoir.

1 INTRODUCTION

The kinds and biomass of plants vary in different aquatic environments — canals, streams, rivers, lakes, ponds, marshes and wetlands. The use to which a body of water is being put determines the management objectives, and whether there is a need for the management or control of aquatic plants. A given body of water may be used for agricultural, industrial and domestic purposes. In addition, it may have a recreational role for fishing, boating, or swimming. The management of aquatic plants should be considered as part of the overall management program.
Overabundant aquatic plants (namely aquatic weeds) interfere with human activity. In many water bodies all over the world, it has been found necessary for centuries to control aquatic weeds. There are several methods of managing aquatic weeds: mechanical harvesting, biological control, and changing the aquatic environment. The methods selected are determined by the particular use to which the water will be put, and by the available resources.
On the other hand, aquatic plants may have a useful role for special purposes. Certain plants and seeds are useful for wild-life, providing fish and waterfowl with cover, food and a breeding site. The extent to which aquatic plants are desirable depends on the point of view of the water user. For example, reservoir managers want clear water that is free of weeds, algae and other organisms. However, conservationists try and establish suitable plant cover on watersheds and along the banks of streams, lakes and ponds to control erosion and to protect water quality (Oki,1990). We should be well-

informed about aquatic plants, so that we can choose aquatic weed management procedures to meet our objectives.

The research aims to assess the aquatic weed management in reservoir region. This study attempts to investigate the activity of grass carp fish in reducing the submerged aquatic weed infestations within the reach between Aswan Reservoir and High Dam, without causing any negative environmental side effects by comparing the infestation percentage before stocking the fish in year 1998 and after twelve years from stocking the fish annually in year 2012.

2 SCOPE OF THE PROBLEM

The major problems caused by nuisance aquatic plants in the reach between High Dam and Aswan Dam are:

- Physical impediment to intakes of water treatment plants, and hydroelectric turbines. These problems occur mainly in the tropics and subtropics, in larger lakes, reservoirs, and rivers.
- Water quality problems (such as anoxia) occur most often as a consequence of either high respiration rates or the die-off and decomposition of plant biomass. This can arise from excessive growth of both macrophytes and algae.
- Health problems from harboring vectors of disease or the release of toxins from some species of cyanobacteria.
- The local water balance may be affected where emergent stands and dense beds of the larger aquatic weed species increase evapotranspiration.
- Ecological problems, such as threats to endangered species, can arise from changes in physical habitat, water chemistry, and light regime.
- Significant aesthetic or recreational problems can occur because of large mats of nuisance macrophytes or blooms of algae.

3 DESCRIPTION OF THE STUDY AREA

High Aswan Dam was constructed on Nile River 7.00 km upstream Aswan Reservoir figure (1). High Dam is considered one of the largest dams on Nile River and is operated under High Aswan Dam Authority in Aswan City. High Dam was constructed in order to satisfy domestic and industrial needs and to increase crop production and hydroelectric energy. A huge reservoir was established between High Dam and Aswan Reservoir. Aswan Reservoir was designed to release the required discharge daily from hydropower plants (1), (2) as shown in figure (2). The existence of aquatic weeds led to close the hydropower plants for several hours daily. The water in the reservoir was stored all over the night and released during the day from the power plants. The water level was fluctuated in the reservoir between 2 and 3 meters.

In Aswan Reservoir there are several islands as shown in figure (2), the shorelines are infested by submerged weeds. The infested areas were one of the main sources of submerged weeds which were often removed by fisher’s activities and finally accumulated upstream the power stations (1) and (2).

Figure (1): General plan for the reach between High Dam and Aswan Reservoir.

4 MATERIALS AND METHODS

To determine grass carp efficiency as a control agent of submerged aquatic weeds, in the reach between Aswan Reservoir and High Dam, extensive field measurements were carried out to determine the hydraulic characteristics of the reservoir.
In order to monitor the aquatic weed infestation, the method was applied depending on calculating the observed infected submerged aquatic weed area by sign several points using GPS, however, it was quite difficult to calculate the aquatic weed infestation by sight vision in huge area.
To calculate the percentage of aquatic submerged weed infestation the reservoir's area was divided into 3 zones as shown in figure (2): Section (A) (the right bank) with an area 3380330 m^2, Section (B) (the middle area) with an area 781100 m^2 and Section (C) (the left bank) with an area 5519050 m^2 (Mohamed et.al., 2004) Then, the spots of weed infestations were estimated in order to compute the infested areas during period from 1998 to 2011.

The percentage of the submerged weeds infestation in the studied reach by using calculated manner in seventeen sites as shown in figure (2) was detected. Also discusses the advantage and disadvantage of controlling methods which applied in the studied reach were discussed.

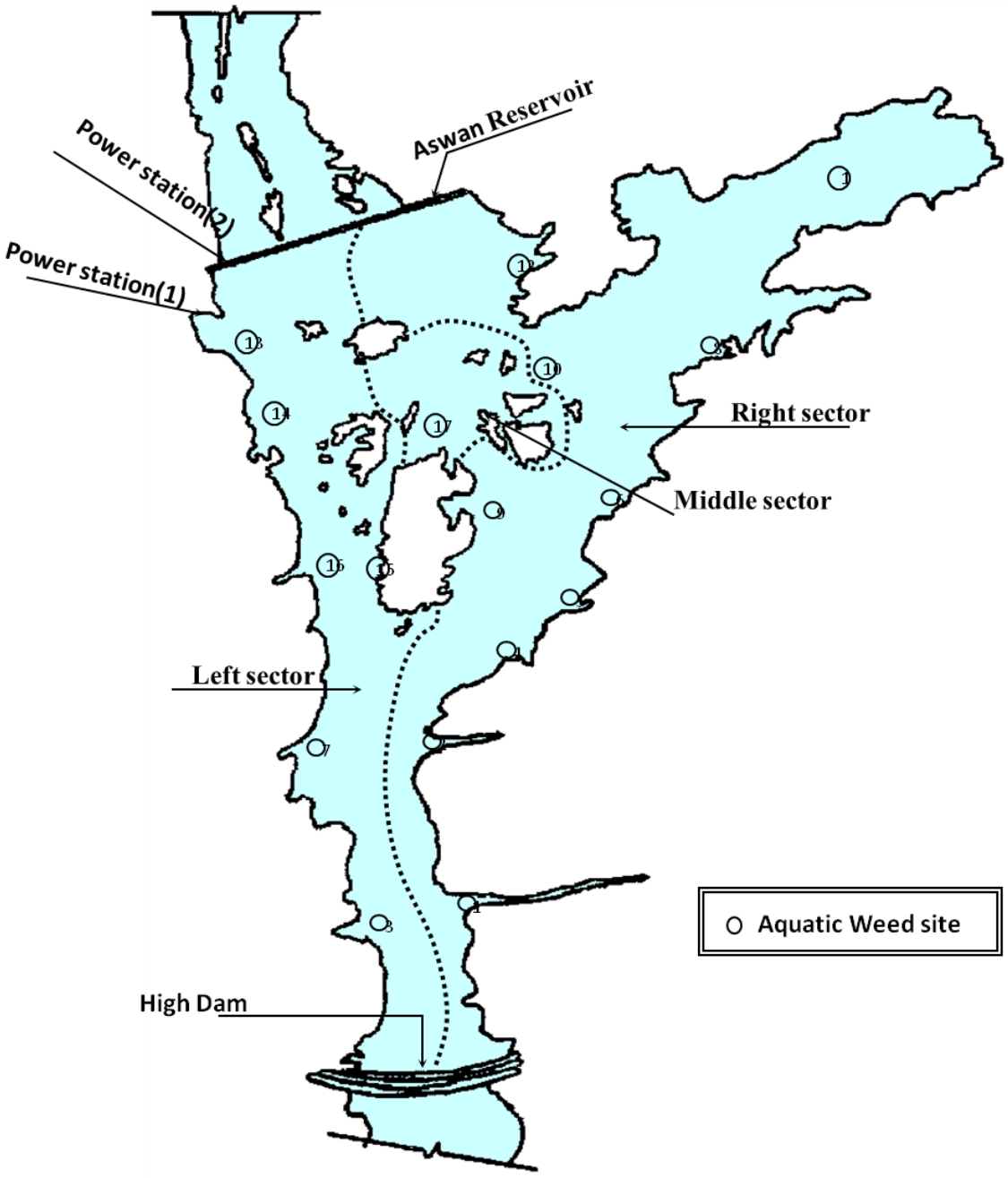

Figure (2): Schematic map showing Aquatic weed sites in study area

5 RESULT AND DISCUSSION

5-1 Methods of Controlling Aquatic Plants Upstream Aswan Reservoir

5-1-1 Biological control

In Egypt, utilizing the biological control methods for controlling aquatic weed by using grass carp was adopted in irrigation networks (James, 1968; Khattab, and El-Gharably, 1989; Abdel- Meguid and Bakry, 2000). Biological weed control with the Chinese grass carp was introduced in Egypt during 1979 – 1982 on an experimental scale. Further experiments were implemented and the effectiveness to control submerged weeds was tested. Results have shown that, for instance, applying biological weed control, rather than mechanical weed control, reduces the costs of maintenance by about 70%.

Based on the previous experiences of the Ministry of Water Resources and Irrigation (MWRI), the aquatic weeds were controlled biologically in Aswan Reservoir (Sneed, 1971; Jahnichen, 1973; Khattab and El-Gharably, 1989; Abdel Meguid, 1999; Abdel-Meguid and Bakry, 2000; Bakry and Abdel-Meguid, 2001 and Bakry et al. 2004). The present study indicates that grass carp may provide promising alternations to traditional methods of weed control. It seems that grass carp is also can be used to limit the growth of the emerged aquatic weeds because it has capability to eat the attached leave on the water surface.

5-1-2 Manual Control

Nuisance macrophytes can be controlled with manual methods in some island in the study area. Hand tools are used to cut plants and/or roots and to pull plant biomass out of the water. Complete removal of weeds is usually not achieved, and in many cases a quick re-growth occurs. Consequently, more than one cut per season is usually necessary. Manual control has advantages when access for equipment is difficult and certain plant species or plant parts need to be harvested selectively.

5-1-3 Environmental Control

Environmental control methods are aimed at restoring the key environmental conditions of the ecosystem. These prior conditions have often been disturbed by anthropogenic sources, such as wastewater discharge or runoff of fertilizers from agricultural land. Introducing proper wastewater treatment and limiting runoff prevents an increase in nutrient availability and hence will reduce the chances of excessive growth of weeds or algae. The environmental control of aquatic weed in the reach between High Dam and Aswan Reservoir is done by awareness of the end users to the study area

The mechanical control of aquatic weed cannot be applied in the reach between High Dam and Aswan Reservoir due to difficult topography of the region to take down the equipment from the shore to water surface.

5-2 Aquatic Weed Infestation

Only three submerged aquatic plant were encountered in the sampling for this research; they were C*eratophyllum demersum, Vallisneria spirlis L., Naiasarmatalindb* . The present study showed that *Ceratophyllum demersum* was a dominant submerged weed species.
The Channel maintenance Research Institute launched a program to control this type of submerged weed from the reservoir biologically based on the previous experiences (Sneed, 1971; Jahnichen, 1973; Khattab and El-Gharably, 1989; Abdel Meguid, 1999; Abdel-Meguid and Bakry, 2000; Bakry et. al., 2004 and salwa et. al., 2009).

In year 1998, the percentage of calculated submerged weed infestation was 29181 m^2, 12822 m^2 and 5300 m^2 at right, middle and left sections respectively with a total 0.5 % infestation along the whole reservoir (figure 1). To control the submerged weed infestation along the whole reservoir, the

reservoir was stocked with the grass carp fingerlings in years from 1999 to 2011 (with the range between one million and one and half million). As a result, the total percentage of the calculated aquatic weed infestations along the whole reservoir sharply decreased from 0.5 % in year 1998 to 0.2, 0.09, 0.09 , 0.05, 0.035, 0.057, 0.07, 0.066, 0.07 , 0.36 and 0.26 % in years from 1999, to 2011 respectively (figure 3).

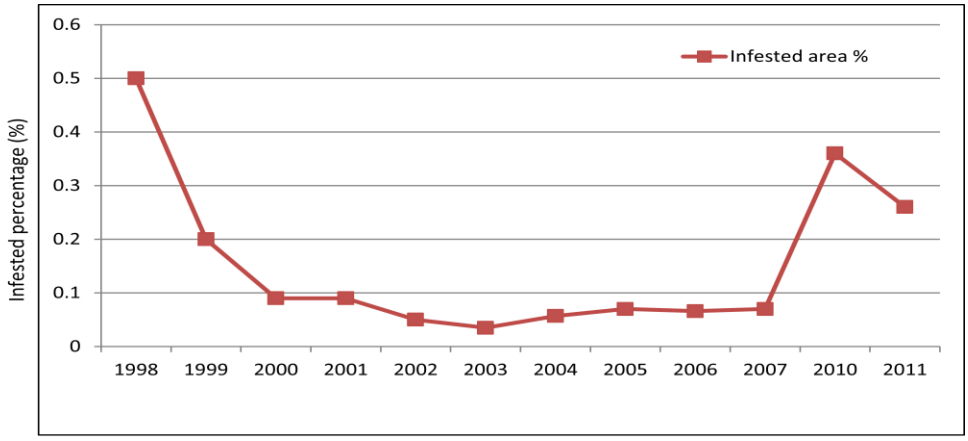

Figure (3): Percentage of infesting submerged weeds (%) during different years

From the results, the total percentage of the aquatic weed infestations along the whole reservoir sharply decreased from 0.5 % in year 1998 to 0.07 % in year 2007 and then increased to 0.36 % in 2010 then decrease to 0.26 % in year 2011. The increase of aquatic weed infestation in year 2010 due to lack of continue evaluation of aquatic weed infestation to determine the density of grass carp required (CMRI, 2011).

5-3 Factors Influencing the Cost of Grass Carp as Aquatic Weed Management Option in Aswan Reservoir.

The following factors may influence the cost of biological control with grass carp.

- **Stocking density**
  The number of fish to be stocked is an important factor in determining the cost involved in this biological control method. Provision must also be made for losses out of the target system by implementing a supplementing stocking protocol, which should be supported by a monitoring programme.
- **Size of fish.**
  Grass carp is aggressive feeders as it can easily consume its body weight in vegetation biomass on a daily basis. It is therefore expensive to feed them during the outgrow phase prior to stocking. Although it is important to stock a viable in order to prevent escape through grids, and minimize predation, the length of the outgrow phase will have a significant impact on the final cost of the fish. But in the Reservoir, stock grass carp with size (10-20 gm or 10 cm in length).
- **Possible losses out of target system.**
  Provision should be made for losses by intensive fishing. As the anticipated life span of the animals is taken at eight years, a supplement stocking figure of 15 % per annum to be the initial stocking density is recommended at this time.

5-4 Suitable Method to Control Aquatic Weeds

The selection of a suitable method to control aquatic weeds in the reach between HA and AR will depend on topography of study area, costs, the skills needed, and institutional needs, as well as health, safety, and cultural aspects.
The topography of study area is not suitable for applying mechanical weed control, the costs of aquatic plant management quoted in the literature are often qualitative or poorly defined. This, along with the site-specific nature of many of the costs, makes a cost comparison difficult. Nevertheless, an attempt is made here to give a rule-of thumb estimate of costs for managing macrophytes. The Comparison of Feasibility, Complexity, and Potential Side-Effects of different weed control methods is shown in table (1).

Table (1): Comparison of Feasibility, Complexity, and Potential Side-Effects of Different Weed Control Methods.

Control method	Feasibility /Applicability	Complexity		Side Effects
		Technological	Institutional	
Manual	-	o	o	o
Biological	+ +	oo	ooo	o
Mechanical	-	ooo	oo	ooo

Notes: A qualitative scale of judgment is used to measure feasibility (– = unfeasible, + = reasonable, ++ = good option) and complexity and side effects (o = low, oo = medium, ooo=high). Since the integrated approach involves combinations of these methods, it is not evaluated separately

The feasibility of a method is directly linked to its complexity. It has to be capable of being managed by locally relevant institutions and stakeholders. Field application of biological control methods is comparatively simple, although high quality scientific expertise will be needed during the planning phase.

When deciding on a management strategy for the control of invasive aquatic plants, one must consider the impacts of control techniques versus the costs of no control.

This study did not address possible impacts to native or endemic vegetation because the aquatic plant community of the study reservoir was dominated by invasive plant species.
The obtained results confirm researches on grass carp effects in other water bodies that indicate full control of aquatic plants may result with high-density grass carp stocking (Bailey and Boyd 1972; Martyn et al. 1986; Hanlon et al. 2000), and managers should expect full control and depletion of aquatic vegetation with this strategy.
The results of this study and other studies addressing the effectiveness and ecological impacts of utilizing grass carp for aquatic plant control will aid managers in developing aquatic plant management plans. Relating the effectiveness and potential ecological impacts of various control techniques is crucial in this process.

6 CONCLUSION AND RECOMMENDATION

It can be concluded that, nuisance aquatic plants can lead to serious economic losses in most water-using sectors. They can block water intake for hydropower production, irrigation, and drinking water supply; interfere with transportation; affect fisheries by blocking landing sites, alter habitat and lower oxygen levels; increase health problems by providing habitat for vectors such as mosquitoes; reduce water quality by changing water chemistry and releasing toxins; and reduce the overall availability of water for consumptive uses through enhanced transpiration. Once established, these plants are very difficult to control and usually impossible to eliminate

Furthermore, it appears that the repeated extensive grass carp stocking was periodically required annually to replace those that escape from Aswan power stations 1, 2 gates, or caught by fishermen and eaten by predatory fishes. Moreover, the stocking of fish in the reservoir should be preferably planned during November, to allow the grass carp to become acclimatized and provide an opportunity for them to feed on early growth stages of aquatic submerged weeds.

It was noticed that the generation efficiency of this Aswan Hydropower stations 1, 2 was improved during the period 2000 -2007 where no complains concerning the presence of submerged weeds were reported by the operation technical staff. During that period the infestation percents by submerged weeds were under 0.1 %.

Therefore it is recommended to use grass carp for controlling aquatic weeds biologically upstream Aswan Reservoir annually with evaluation the percentage of aquatic weed and the stocked fish.

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