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IMPACT OF INVASIVE EICHHORNIA CRASSIPES ON WATER QUALITY PARAMETERS OF SAGAR LAKE

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Abstract

Water hyacinths (Eichhornia crassipes) are aquatic plants that originate from South America but have spread around the world due to their capacity for quick reproduction and success in a range of watery settings. Aquatic ecosystems may benefit from water hyacinths in some cases, but when they overgrow, they can negatively affect the environment and the economy. In the present study we have studied the impact of this invasive hyacinth on the water quality parameters of Sagar Lake, Madhya Pradesh. Our observations showed that the rate of water loss, temperature and electrical conductivity increased in the water hyacinth treated water samples whereas other water quality parameters such as pH, TDS, DO, chloride and total alkalinity decreased in the water hyacinth treated samples in comparison to the control samples. Hence, we suggest integrated control approaches that include physical, chemical, and biological control measures, as well as efforts to prevent water hyacinth spread in order to control the negative impact of water hyacinth in the Sagar Lake.

Introduction

It is commonly acknowledged that biological invasions are among the main sources of biodiversity loss and ecological disruption, making them one of the most important elements of global change **(Simberloff et al., 2013; Tittensor et al., 2014).** *Eichhornia crassipes* (Pontederiaceae), sometimes known as the water hyacinth is a kind of free-moving marine plant and is the world's worst maritime weed. The International Union for Conservation of Nature (IUCN) designated water hyacinth as one of the top 10 worst weeds in the world and as one of the 100 most harmful species (**Downing-Kunz & Stacey, 2012; Pysek & Richardson, 2010**). Once established, they are challenging to control (**Champion et. al., 2014**). Numerous water bodies and fertile wetlands that were crucial to the environment and the economy were lost as a result of their random and fast spread **(Patel, 2012).** In addition to acting as a microhabitat for disease vectors and pests, weeds often threaten biodiversity (**Kateregga & Sterner, 2009**; **Ndimele et. al., 2011**; **Patel, 2012; Waithaka, 2013**). Hence, in the present work we have tried to study the effect of invasive water hyacinth *Eichhornia crassipes* on water quality parameters and insects' diversity of Lake.

Materials and methods

An experiment on transpiration was conducted and recorded to study how much water was lost from water bodies by water hyacinths. Water hyacinth evapotranspiration was determined from experimental troughs with water alone and the remainder with water and water hyacinth to study the effects of water hyacinth on the variety of aquatic insects and water quality. According to previous findings **(Timmer and Weldon, 1967; Van der Weert and Kamerling, 1974)**, mature hyacinth plants may lose around three times as much water by evapotranspiration instead of open water surface evaporation. In recent research, wetland evapotranspiration has also been compared to open-water evaporation in wetlands **(Abtew, 1996; Abtew and Melesse, 2013).**

Evapotranspiration Experiment

Experiment was carried out to estimate the influence of water hyacinth on water loss. Water samples from the Sagar Lake was collected into two evaporation troughs. Evaporation trough **A** was filled with water and covered with live water hyacinth collected from Sagar Lake while evaporation trough **B** was the control trough and not covered with water hyacinth. Around 2000 ml of water was put into the two troughs. To identify which pan was most negatively affected in terms of water loss, it was necessary to compare the two evaporation water pans. Experiment was repeated for 8 days to evaluate the water loss and water level was recorded from both troughs after every 24 hours.

Evapotranspiration Experiment

Physical control

These techniques include harvesting, cutting, rotovation, weed raking, hand pulling, dredging, channel cleaning, and excavation. Different machines are used to carry out each of these tasks. However, these methods have an impact on turbidity, available nutrients, aquatic plant and animal survival, and water quality. Additionally, this technique is slow for extremely eutrophic lakes and is not appropriate for aquatic areas with rapid currents (**Alam et. al., 1996**; **Carpenter, 1981)**. Further, the remaining chopped material in the water might degrade, releasing nutrients and causing turbidity (**James et. al., 2002**).

Chemical control

In order to limit the number of water hyacinths, herbicides including 2, 4-D amine, diquat, and glyphosate (Roundup) have been employed on a global scale (**Seagrave, 1988**; **Gutierrez et. al., 1994; Lugo et. al., 1998**).

Biological control

It is a long-term approach that is recommended since it is consumer-friendly and offers a reliable, sustainable method of managing finances. The water hyacinth is controlled by a variety of insects, including weevils, fungus, and moths (**Cilliers et al., 2003**). This method has been successful in Australia with the regular release of the weevils *Neochetina eichhorniae* and N. *bruchi,* as well as the moth *Sameodes albiguttalis*, which has significantly decreased the population's density of water hyacinths (**Labrada et al., 1996**).

Water hyacinth may be controlled biologically, which involves introducing biological pests like weevils to the area (**Center et. al., 1999**; **Greenfield et. al., 2004**; **Yirefu et. al., 2017**). It takes a number of years from the weevils being released till the plant dies, depending on the temperature, the plant's nutritional status, the environment, the hydrology, and the quantity and health of the insects (**Julien, 2001**). Biological water hyacinth removal techniques commonly use the most popular weevil species, *Neochetina eichhorniae* and *Neochetina bruchi* (**Center and Dray, 2010).** A sizable number of adult weevils may be released into the water hyacinth infestation after being raised in pools, where they will begin eating on the vegetation.

Results

Water samples from the Sagar Lake were sampled and the effect of water hyacinth infestation on the physico-chemical properties of the lake were examined. The physicochemical parameters assessed in the study are shown in **Table 1.** Values presented in this table are the averages of eight replicates when the experiments were performed.

Table 1. Descriptive analysis of various water quality parameters between control (without water hyacinth) and treated (with water hyacinth) groups

PARAMETERS	GROUPS	MEAN	STD. DEVIATION	STD. ERROR	MINIMUM	MAXIMUM
Waterloss (ml/day)	Control	185.500	13.448	4.755	170.000	205.000
	Treated	678.625	16.457	5.819	650.000	700.000
Temperature (°C)	Control	28.688	0.772	0.273	27.800	29.900
	Treated	31.238	0.453	0.160	30.700	32.100
pH	Control	7.283	0.154	0.055	7.090	7.530
	Treated	6.320	0.203	0.072	6.110	6.590
TDS (mg/l)	Control	264.000	12.456	4.404	245.000	277.000
	Treated	224.125	11.946	4.223	210.000	244.000
Dissolved oxygen (mg/l)	Control	3.850	0.381	0.135	3.410	4.550
	Treated	2.426	0.504	0.178	1.990	3.330
Electric conductivity (uS/cm)	Control	420.375	15.928	5.631	402.000	452.000
	Treated	473.625	14.142	5.000	455.000	491.000
Chloride (mg/l)	Control	100.540	8.350	2.952	91.590	113.290
	Treated	80.665	5.834	2.063	71.590	89.990
Total Alkalinity (mg/l)	Control	102.325	4.641	1.641	94.300	106.700
	Treated	91.363	2.795	0.988	85.800	94.700

Figure 1: Changes in the level of water loss between control (without water hyacinth) and treated (with water hyacinth) water samples

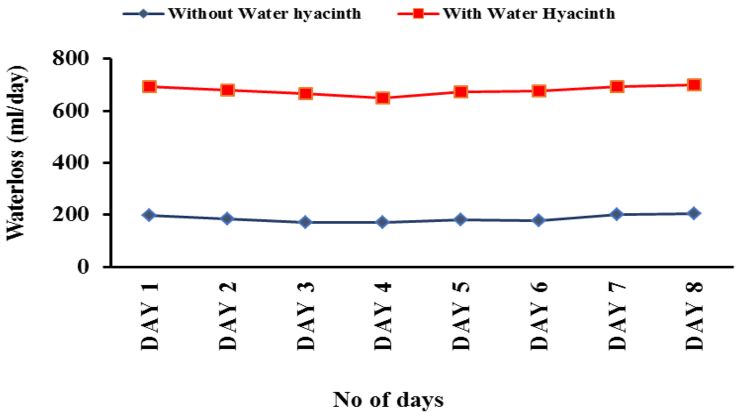


Figure 2: Change in temperature between control (without water hyacinth) and treated (with water hyacinth) water samples

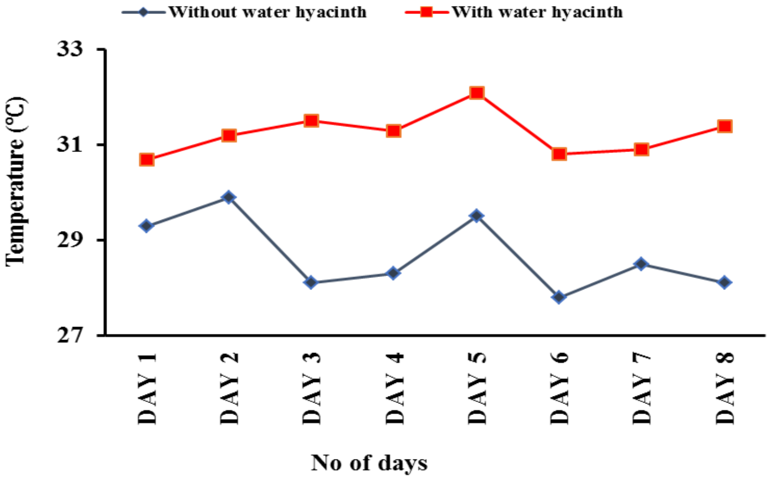


Figure 3: Changes in the level of pH between control (without water hyacinth) and treated (with water hyacinth) water samples

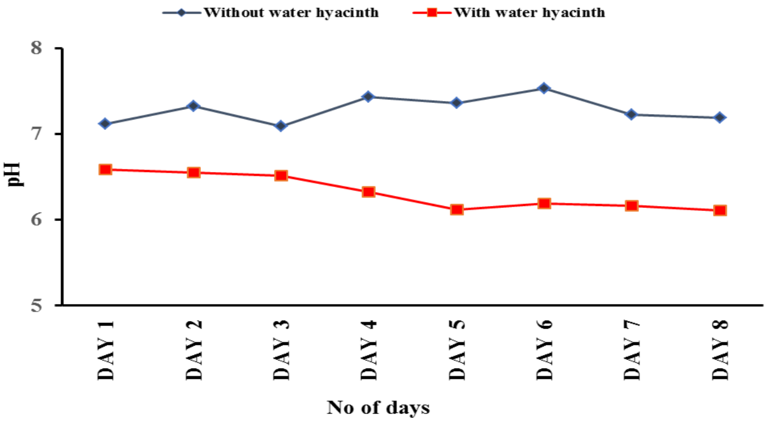


Figure 4: Changes in the level of TDS between control (without water hyacinth) and treated (with water hyacinth) water samples

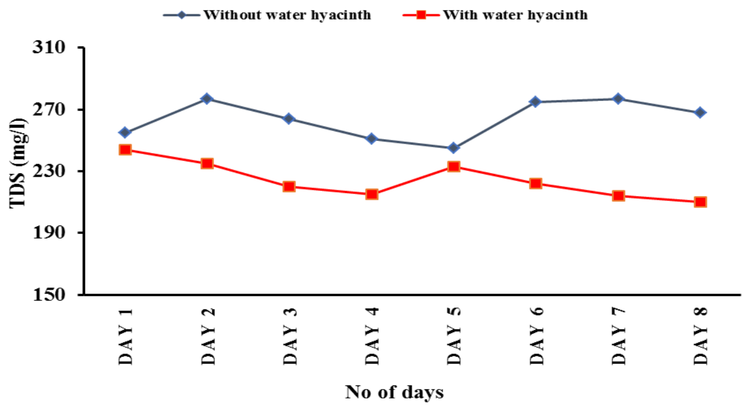


Figure 5: Changes in the level of dissolved oxygen between control (without water hyacinth) and treated (with water hyacinth) water samples

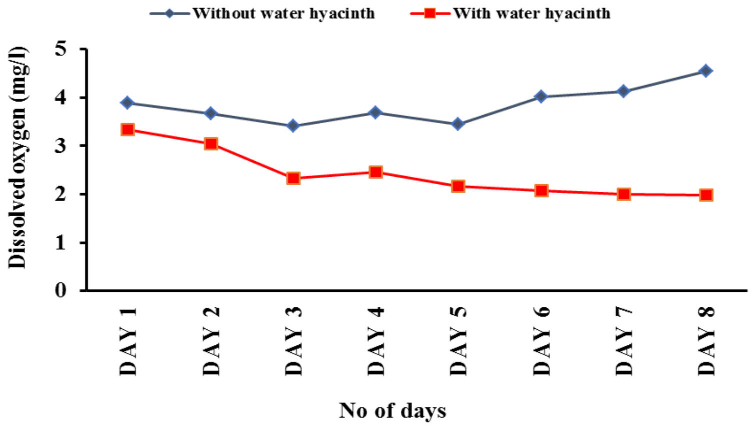


Figure 6: Changes in the level of electric conductivity between control (without water hyacinth) and treated (with water hyacinth) water samples

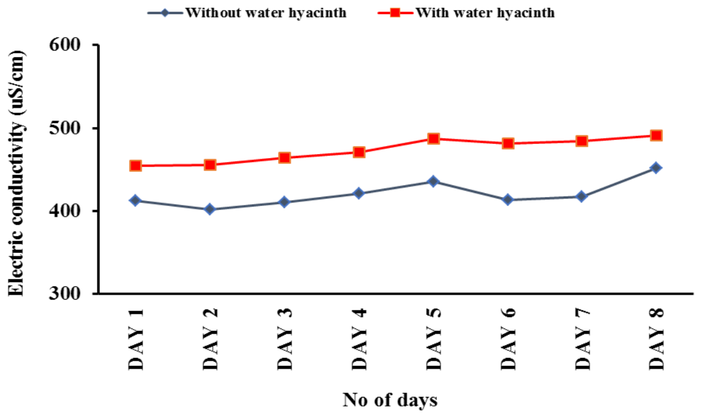


Figure 7: Changes in the level of chloride between control (without water hyacinth) and treated (with water hyacinth) water samples

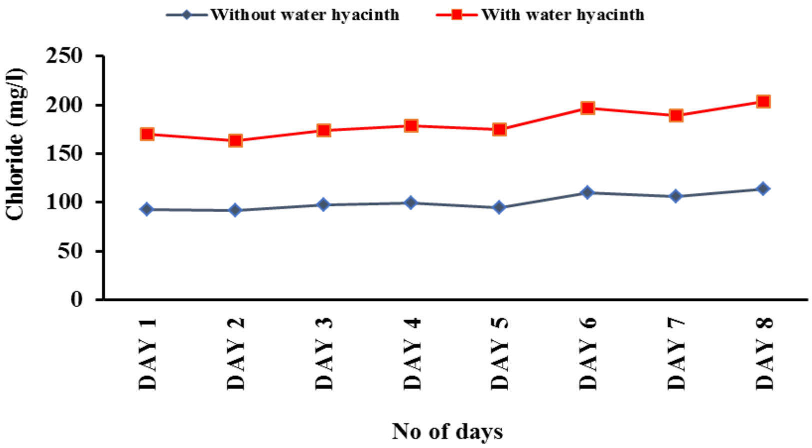
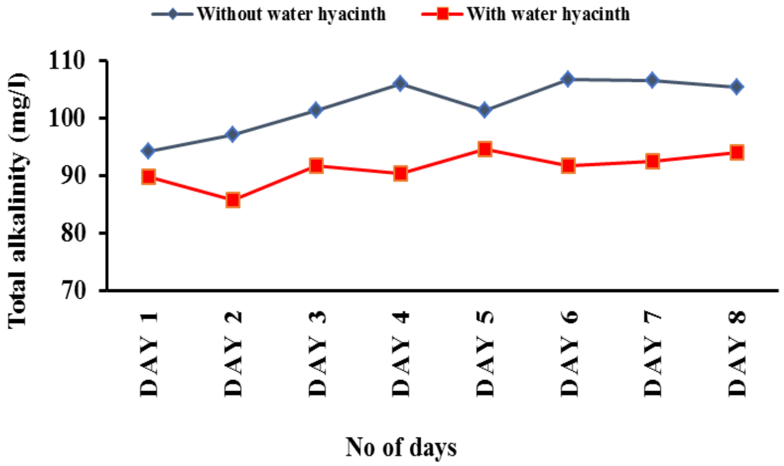


Figure 8: Changes in the level of chloride between control (without water hyacinth) and treated (with water hyacinth) water samples



Water loss

During the present study, it was established that water hyacinth significantly affects the water levels. After the results of eight-days experiment shows that a water infested with water hyacinth significantly increases ($p<0.01$) the loss of water in comparison to the control group as shown in the **Table 2**with one-way ANOVA. The loss of water in the control group (without water hyacinth) ranged from 170 – 205 ml/day whereas the water loss in the treated group (with water hyacinth) ranged from 650 – 700 ml/day **(Table 1).** There is a significant difference in the rate at which the two sources are losing water through evaporation and transpiration and the water loss between the control (without water hyacinth) and the treated group (with water hyacinth) is shown in the **Figure 1.** Water hyacinth covered water surfaces lost water by 3.7-foldmore than loss from non-water hyacinth surfaces.

Water temperature

The mean water temperature values in the control group (without water hyacinth) and the treated group (with water hyacinth) in the present study is given in **Table 1.** The temperature level in the control group ranged from 27.8 to 29.9 ℃ whereas in the treated group the temperature ranged from 30.7 to 32.1 ℃. The one-way ANOVA results shows a significant difference ($p<0.01$) in the temperature levels between the control and the treated groups **(Table 2).** The differences in the temperature levels between the control and the treated groups in the present study is shown in the **Figure 2.** The water hyacinth mats covering the water's surface prevent heat from being transferred from the lake's surface to the atmosphere, which accounts for the treated group's slightly higher mean temperature. In addition, the decaying of organic matter from water hyacinth also results in heat generation which ultimately rises the water temperature **(Mironga et. al., 2012).** These results suggest that water hyacinth mats may have a significant impact on the Sagar Lake's temperature variations.

PH

The mean pH values in the control (without water hyacinth) and the treated samples (with water hyacinth) in the present study is given in **Table 1.** The pH level in the control group ranged from 7.09 to 7.53 whereas in the treated groups the level of pH ranged from 6.11 to 6.59. Results from a one-way ANOVA showed significant ($p<0.01$) differences between the control and the treated groups **(Table 2).** The differences in the pH levels between the control and the treated groups in the present study is shown in the **Figure 3.** The lower pH level in the treated group poses a negative consequence to marine ecosystems as low pH interferes with the life cycle of several aquatic organisms **(Chapungu et. al., 2018).** Previous reports have also reported that the pH level in the hyacinth infested water remains lower in comparison to the non-infested water (Chapungu et. al., 2018).

Total dissolved solids (TDS)

The mean TDS values in the control (without water hyacinth) and the treated water samples (with water hyacinth) obtained from the results during the present study is shown in **Table 1.** The TDS level in the control samples ranged from 245 to 277 mg/l whereas the TDS level in the treated samples ranged from 210 to 244 mg/l. The differences in the level of TDS between the control and the treated samples is shown in **Figure 4.** The one-way ANOVA results further provided that there was a significant difference ($p<0.01$) between the control and the treated groups **(Table 2).** TDS is closely linked to turbidity and hence affect the penetration of sunlight to deeper waters **(Chapungu et. al., 2018).**

Dissolved oxygen (DO)

The mean DO values in the control (without water hyacinth) and the treated samples (with water hyacinth) in the present study is given in **Table 1.** The DO level in the control group ranged from 3.41 to 4.55 whereas in the treated groups the level of DO ranged from 1.99 to 3.33 mg/l. Results from a one-way ANOVA showed significant ($p<0.01$) differences between the control and the treated groups **(Table 2).** The differences in the DO levels between the control and the treated groups in the present study is shown in the **Figure 5.** In the present study, the level of DO in the treated groups were lower in comparison to the control group. This shows that hyacinth infested waters may form a dense mat which further favors the metabolic activities of epiphytic organisms in the lake. Hence, high density of hyacinth in water bodies will affect the aquatic biota of the lake by reducing the levels of DO available in the water. This will finally lead to low biodiversity in the water bodies.

Electric conductivity (EC)

The mean EC values in the control (without water hyacinth) and the treated samples (with water hyacinth) in the present study is given in **Table 1.** The EC level in the control group ranged from 402 to 452 µs/cm whereas in the treated groups the level of EC ranged from 455 to 491 µs/cm. Results from a one-way ANOVA showed significant ($p<0.01$) differences between the control and the treated groups **(Table 2).** The differences in the EC levels between the control and the treated groups in the present study is shown in the **Figure 6.** The figure shows that the levels of EC is significantly higher in the treated samples where there is hyacinth infestation. Our observations are in accordance with the previous studies where they have reported that higher level of EC in the hyacinth infested areas which may be due to mineralization and high level of nutrients.

Chloride

The mean chloride levels in the control (without water hyacinth) and the treated samples (with water hyacinth) in the present study is given in **Table 1.** The chloride levels in the control group ranged from 91.59 to 113.29 mg/l whereas in the treated groups the level of chloride levels ranged from 71.59 to 89.99mg/l. Results from a one-way ANOVA showed significant ($p<0.01$) differences between the control and the treated groups **(Table 2).** The differences in the chloride levels between the control and the treated samples in the present study is shown in the **Figure 7.** The figure shows that the levels of chloride in the treated samples are higher in comparison to the control samples.

Total alkalinity

The mean total alkalinity levels in the control (without water hyacinth) and the treated samples (with water hyacinth) in the present study is given in **Table 1.** The total alkalinity levels in the control samples ranged from 94.30 to 106.70 mg/l whereas in the treated samples the level of alkalinity levels ranged from 85.80 to 94.70 mg/l. Results from a one-way ANOVA showed significant ($p<0.01$) differences between the control and the treated groups **(Table 2).** The differences in the chloride levels between the control and the treated samples in the present study is shown in the **Figure 8.** The figure shows that the levels of alkalinity in the treated samples are lower in comparison to the control samples.

Table 2. Results of one-way ANOVA for various water quality parameters between control (without water hyacinth) and treated (with water hyacinth) water samples

Parameters	Sources of Variance	Sum of Squares	Df	Mean Square	F	Sig.
Waterloss (ml/day)	*Between Groups*	972689.063	1	972689.063	4306.826	0.000
	Within Groups	3161.875	14	225.848		
	Total	975850.938	15			
Temperature (℃)	*Between Groups*	26.010	1	26.010	64.938	0.000
	Within Groups	5.608	14	0.401		
	Total	31.618	15			
pH	*Between Groups*	3.706	1	3.706	114.032	0.000
	Within Groups	0.455	14	0.032		
	Total	4.161	15			
TDS (mg/l)	*Between Groups*	6360.063	1	6360.063	42.708	0.000
	Within Groups	2084.875	14	148.920		
	Total	8444.938	15			
Dissolved oxygen (mg/l)	*Between Groups*	8.108	1	8.108	40.687	0.000
	Within Groups	2.790	14	0.199		
	Total	10.898	15			
Electric conductivity (uS/cm)	*Between Groups*	11342.250	1	11342.250	50.001	0.000
	Within Groups	3175.750	14	226.839		
	Total	14518.000	15			
Chloride (mg/l)	*Between Groups*	1580.063	1	1580.063	30.457	0.000
	Within Groups	726.295	14	51.878		
	Total	2306.357	15			
Total Alkalinity (mg/l)	*Between Groups*	480.706	1	480.706	32.756	0.000
	Within Groups	205.454	14	14.675		
	Total	686.159	15			

Discussion

In the Sagar Lake, it was determined that water hyacinth does more harm than good from an ecological and societal standpoint. According to the study, the presence of water hyacinth exposes the villages near Sagar Lake to a variety of socioeconomic issues. These include pain from mosquito bites on the body. The macrophyte appears to provide mosquitoes with a comfortable environment and a place to nest. The abundance of water hyacinth vegetation has caused the lake to lose its beauty and recreational appeal. The natural environment of the lake is changed by water hyacinth. Recreational pursuits are restricted, including swimming and fishing. One of the biggest risks to food security is invasive species, particularly in light of climate change. Additionally, it has been claimed that water hyacinth obstructs irrigation pipelines, lowering agricultural output.

Water hyacinth has been found to have detrimental effects on biological diversity from an ecological standpoint. Previous research has shown that the macrophyte lowers the richness and evenness of plant species in the lake. Some water weeds in regions where the weed has spread have vanished, and the water hyacinth weed has taken over as the main plant species. The current study found that surfaces with and without water hyacinths significantly varied in their water loss rates. Some aquatic wildlife that relies on water may have difficulties as a result.

It has been noted that the physical and chemical characteristics of water have certain ecological effects. Due to the existence of water hyacinth, they are also negatively altered. Once established, water hyacinth is very difficult to get rid of. We suggest that minimizing socio-economic costs and ecological harm should be the main focus of the majority of management initiatives. In addition, integrated control approaches that include physical, chemical, and biological control measures, as well as efforts to prevent water hyacinth spread, provide the highest possibility of achieving successful and long-term control.

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