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Water Hyacinth Infestation and Management in Nigeria Inland Waters: A Review

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Abstract: The study offers management guidelines for control and management of water hyacinth in Nigeria. Water hyacinth (*Eichhornia crassippes*) which before 1984 was alien to Nigerian water systems has now spread to over 20 of the 36 states including the Federal Capital Territory. The weed not only disrupts the ecology of the systems but also adversely affects the sociological, cultural and economic realities of the indigenous communities especially the artisanal fisher folks within the area. This study reviews the concerted efforts of Nigerian government in water hyacinth control. It also outlines the machineries set up by the government for control and management of water hyacinth. The bilateral co-operation on water hyacinth control between Nigeria and her neighbouring countries are highlighted.

Key words: Water hyacinth, infestation, management, control

INTRODUCTION

Aquatic macrophytes are defined as vascular plants whose photosynthetic parts are permanently or at least for several months of the year submerged in water or float on the surface of water (Cook, 1990). The role of aquatic macrophytes in a freshwater ecosystem has been summarized by Carpenter and Lodge (1986) and Madsen *et al*. (1997). It has been reported that aquatic plant beds affect water chemistry by removing nitrates and other ions (Moss, 1988). The presence of aquatic vegetation acts as a spawning ground and shelter for fish fry, as well as breeding ground for insects and inveterbrates which acts as source of food to fish, while it acts as nesting sites and source of food for species of game birds, waders and other avian migrants (Imevbore and Bakare, 1974; Ayeni *et al*., 1999). This implies that aquatic plants are integral component of lake and river ecosystem. However, when there is explosive growth, they are considered as weeds.

In Nigeria, aquatic weed infestation in inland waters are increasing geometrically. According to Ita (1994) there are about 76 species of aquatic plants considered as weeds. Water hyacinth is of particular interest among others because of its high rate of invasion and colonisation. Water hyacinth is alien to Nigerian aquatic ecosystem, its introduction into tropical countries as an ornamental plant and subsequent conversion into a weed in response to the high level of nutrient in the urban, industrial and municipal wastewater has been reported by (Baret and Farno, 1982).

Based on national survey conducted in 2001, over 30 States out of 36 states and Federal Capital Territory of Nigeria had been infested by water hyacinth (NIFFR, 2000). Since Nigerian government owes it a duty to its citizens to provide services that will make life more bearable, water hyacinth management and control and its attendant problems have been one of the social responsibilities of the government. Federal and State governments have to some extent live up to this responsibility.

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GOVERNMENT AND WATER HYACINTH MANAGEMENT APPROACH

The weed which was first observed in 1984 (Akinyemiju, 1987) along Badagry creek has spread through the entire coastlines causing serious problems especially in fishing and transportation. The Federal government of Nigeria adopted some measures to forestall the invasion of this aquatic weed. This included setting up an inter-ministerial committee drawn from institutions whose mandates were directly relevant to the problem. Thus, the body christened National Committee on water hyacinth control. The committee adopted a subcommittee structure each with its terms of reference.

Surveillance and Physical Control Sub-Committee

It had the responsibility of identifying new incursion of water hyacinth as well as adopting sensitization and mobilization strategies for physical and mechanical removal of the plant.

Bio-Control Sub-Committee

The breeding of biological control agents and eventual release to areas of remote water hyacinth infestation rests on this sub-committee. In areas of heavy infestation of water hyacinth, the surveillance and Physical sub-committee clears most of the infestation, thereafter the bio-control subcommittee comes to play its role.

Public Enlightenment Sub-Committee

According to Barret and Farno (1982), the beauty of water hyacinth was instrumental to its introduction into tropical countries as ornamental plant. The sub-committee had the responsibility of educating people on the negative impact of water hyacinth infestation and also to discourage them from using water hyacinth as ornamental.

Economic Uses Sub-Committee

The Committee is to carry out research on the possible utilization of water hyacinth. It has been noted that the plant can be used as fishfeed (Okoye *et al*., 2000), for biogas production (Eyo, 2000); as a mopping agent (Ogunlade, 1992), as raw material for bio-fertilizer (Ojeifo *et al*., 2000) and as raw material for pulp and paper (Akobundu, 1987).

The Chemical Control Sub-Committee

This sub-committee is mandated to carry out research on the possibility of using herbicides for water hyacinth control and for advising government on areas to apply the chemicals. This committee faced a very stiff opposition as environmentalist kicked against use of chemicals on the control of water hyacinth in Nigeria inland water, thus making it difficult for them to carry out their duties.

METHODS ADOPTED BY GOVERNMENT IN ITS WATER HYACINTH CONTROL

The choice of any control measure is dependent on its workability at a given place. However, the cost benefit and its impact on the environment need to be taken into consideration. Government adopted these control methods in its water hyacinth eradication programme.

Manual/Mechanical Control

One of the Physical control methods adopted for the management and control of water hyacinth was the installation of floating barriers at strategic locations to forestall the movement of water hyacinth to other areas. This floating barrier was based on the concept of aggregation of water hyacinth

for easy evacuation. The floating barriers have drastically reduced the influx of water hyacinth from Niger Republic. A large volume of the weed which ordinarily would have drifted down the river is trapped by the facility at the point of installation thus making the evacuation of weeds relatively easy for those engaged in the service. It is worthy to note that villages down stream the barrier site has made tremendous improvement in their fishing activity.

Biological Control

Biological control is considered as the only effective, permanent and environmentally friendly methods (Greathead and Groot, 1993). The adoption of this method recorded a notable success in Argentina, India, Sudan and USA (Harley, 1990; Julien, 1992) using *N. eichhorniae* and *N. bruchi*. Based on this information, a consignment of 2527 Neochetina weevils were imported into Nigeria in 1992. The first release was effected in 1993. Since then at least nine more releases had been made to River Niger while releases were done to lekki lagoon Nigeria (Farri and Borrifice, 1999). The effectiveness of *Neochetina* sp. as effective biological control agent for water hyacinth was affirmed judging from the presence of numerous holes caused by them on water hyacinth plants (Daddy *et al*., 2000). Nigerian government has strengthened National Institute for Horticultural Research and National Institute for Freshwater Fisheries in order to enable them breed large quantities of these weevils. This invariably means that these Institutes will be the source of supply to other areas and ultimately lead to its exportation to other countries like Niger and Benin Republics.

Chemical Control

Chemical control of water hyacinth in Nigeria has always been met by stiff opposition, because of toxicity of herbicides to fish and other aquatic organisms. However, a few trials were undertaken at Ere fishing channel South-west Nigeria. The application of Glyphosate gave rise to total mortality of water hyacinth within 14 days. Associated aquatic weeds and water surface were totally free of dead and decaying water hyacinth within 4 weeks of application (Table 1). The pH and temperature of the water body in the pre-treatment period ranged between 6.2-7.8; 28.5-29.5°C, respectively, increased to pH 7.3 to 7.9 and temperature of between 28.5-33°C, respectively. This was favourable for fish production and breeding, reduced acidity and increased primary productivity in the post treatment period (Table 2). Fish pathology decreased significantly ($p<0.5$) from 86 and 28% in the post-treatment period. Glyphosate residue analysis was undetectable in the open water treated within only the first 4 h of application. Only traces (<1.0 μL L^{-1}) were detectable in the mud.

Fish abundance (7 species) and Catch (Catch per unit effort) at pre-treatment period was 13 kg increased significantly ($p<0.5$) to 13 species and 75.13 kg, respectively in the post-treatment period (Table 3). Public health assessment showed that glyphosate had no adverse effect on the Ere

Table 1: Effect of Glyphosate at 2.16 kg a.i ha^{-1} applied aerially on water hyacinth at Ere Channel

Weed control treatment	Time after application (weeks)	Plant height (cm)	No. of leaves per plant	Fresh weight per plant (g)	Dry weight per plant (g)	Mortality (%)
Untreated control	0	48	9	410	40.8	0
	2	52	9	415	42.6	0
	4	52	11	415	42.6	0
	6	56	11	420	45.6	0
	8	58	11	422	45.8	0
	10	58	11	425	45.9	0
Glyphosate	0	48	4	410	42.1	0
(2.16 kg a.i ha^{-1})	2	32	2	340	31.8	50
	4	24	1	300	25.6	70
	6	0	0	0	0.0	100
	8	0	0	0	0.0	100
	10	0	0	0	0.0	100

Source: Adekoya (1992)

Table 2: Range of concentration of hydrochemical parameters in ere channel before and after herbicidal treatment (all values are in mg L^{-1})

	Station 1		Station 2		Station 3	
Parameters	Pre-treatment	Post-treatment	Pre-treatment	Post-treatment	Pre-treatment	Post-treatment
Conductivity (S cm^{-1})	85.9-114.5	107.2-38.4	90.3-103.0	91.0-562	103.7-106.0	90.30-164.5
pH (-log CH)+)	6.2-7.8	7.3-7.9	6.5-7.5	6.6-7.0	6.5-7.7	6.6-7.2
Sodium	4.2-9.7	9.1-11.7	8.7-76.8	8.0-47.8	8.8-9.0	12.0-76.8
Potassium	3.4-9.0	8.5-10.9	8.1-71.3	7.5-44.4	8.2-8.4	11.1-71.3
Calcium	4.7-7.2	6.8-24.2	6.5-56.9	6.2-35.4	6.5-6.7	8.9-56.9
Magnesium	3.2-5.8	5.5-19.6	5.3-46.1	5.4-25.0	5.3-5.4	7.2-46.1
Bicarbonate	24.4-36.6	24.4-32.6	24.5-45.7	24.4-25.0	42.7-48.0	18.3-24.4
Chloride	8.4-36.6	17.7-63.6	16.7-150.0	16.3-92.7	17.1-17.5	23.3-179.0
Sulfate	3.5-4.7	4.4-15.7	4.2-37.0	4.5-23.0	4.2-4.4	5.8-37.0
Nitrate	1.0-2.7	2.6-9.2	2.4-21.7	2.0-13.5	2.5-2.5	3.4-21.7
Dissolved silica	15.0-17.0	25.7-96.0	25.5-220.0	26.2-140.5	25.9-26.6	35.3-21.7
Biochemical oxygen demand	2.50-3.65	1.10-3.90	2.0-4.62	2.30-4.45	1.10-3.5	2.30-3.40
Dissolved oxygen	4.8-5.5	2.2-4.2	3.0-4.0	3.2-3.8	0.7-2.8	1.5-3.8
Chemical oxygen demand	1.4-3.2	0.8-4.8	3.0-4.02.0-3.2	2.4-4.6	2.0-3.5	2.3-3.3
Temperature (°C)	28.5-29.9	28.5-32.0	29.0-31.0	29.0-31.0	27.9-30.5	28.7-30.8

Station 1 is the Ere Channel full of water hyacinth and where glyphosate was applied on 17th Dec; 1991; Station 2 is the open Yewa lagoon free of water hyacinth and untreated with herbicide; Station 3 is the Soki channel infested with water hyacinth, it is adjacent to Ere channel, but was untreated with herbicide; Source: Adekoya (1992)

Table 3a: Fisherfolks activities in the water hyacinth infested Ere Channel

	Pre-water hyacinth control assessment				Post-water hyacinth control assessment			
Species	Total catch	Average wt.	Average length	Catch per unit effort	Total catch	Average wt	Average length	Catch per unit effort
	kg				kg			
Oroechromis niloticus	166	0.40	202	5.53	1875	0.45	234	75.0
Tiapia guinensis	183	0.43	228	6.56	1735	0.52	236	75.0
Tilapia melanopleura	0	-	-	0.00	3605	0.25	200	75.1
Hemichromis fasciants	297	0.21	176	5.20	3592	0.25	189	74.8
Hmichromis bimaculatus	0	-	-	0.00	4500	0.20	101	75.0
Auchenoglanis occidentalis	0	-	-	0.00	3197	0.28	24	74.6
Chrysichtys nigrodigitatus	212	0.35	244	6.18	2343	0.38	258	74.7
Clarias gariepinus	220	0.32	258	5.87	2186	0.41	281	74.7
Clarias anguillaris	0	-	-	0.00	4090	0.22	206	75.0
Hepsetus odoe	0	-	-	0.00	2308	0.39	264	75.0
Heterotis niloticus	170	0.52	234	7.37	1599	0.56	240	76.6
Gymnarchus niloticus	176	0.435	272	6.60	576	1.52	508	73.0
Mormyrus rume	193	0.36	214	5.80	2029	0.42	262	71.0
Channa obscura	153	0.44	257	5.61	1698	0.48	269	67.9
Gnathonemus tamandua	186	0.38	238	5.90	2070	0.43	241	74.2
Schilbemystus	0	-	-	0.00	2975	0.28	203	67.1
Bagrus bayad	0	-	-	0.00	2349	0.35	196	69.0
Notopterus afer	0	-	-	0.00	2358	0.38	205	74.7
Polypterus senegalensis	109	0.61	252	5.54	1261	0.67	259	70.4
Mugil cephalus	188	0.35	206	5.48	1970	0.44	211	72.2
Synodontis clarias	155	0.43	203	5.60	1724	0.51	209	73.3
Alestes nurse	405	0.17	128	5.76	3739	0.23	136	71.7
P. bane	145	0.48	206	5.80	1686	0.50	212	70.3
Barbus nigeriensis	2162	0.03	166	5.41	20050	0.04	169	56.8
Calamoichtys calabricus	725	0.10	281	5.44	5367	0.15	288	67.1
Distichodus nostratus	239	0.26	194	5.18	2161	0.38	2042	58.4

Table 3b: Fisher folk's activities in the water hyacinth infested ere channel

	Pre- water hyacinth control assessment						Post-water hyacinth control assessment					
Activities (%)	July	Aug.	Sept.	Oct.	Nov.	Dec. 91	Jan.	Feb	Mar.	Apr.	May	Jun. 91
Food processing	2.0	2.0	2.0	2.0	2.0	2.0	55.4	55.6	55.2	56.8	57.0	56.5
Fishing	14.0	16.0	14.0	16.0	16.0	18.0	58.0	58.2	58.8	59.0	59.5	61.5
Transportation	10.0	10.0	10.0	15.0	16.0	17.0	79.9	79.9	80.1	80.2	81.0	84.0
Others	0.4	0.6	0.5	0.3	0.6	0.2	66.5	67.0	66.8	67.2	67.6	68.5

Station 1 is the Ere Channel full of water hyacinth and where glyphosate was applied on 17th Dec; 1991; Station 2 is the open Yewa lagoon free of water hyacinth and untreated with herbicide; Station 3 is the Soki channel infested with water hyacinth, it is adjacent to Ere channel, but was untreated with herbicide; Source: Adekoya (1992)

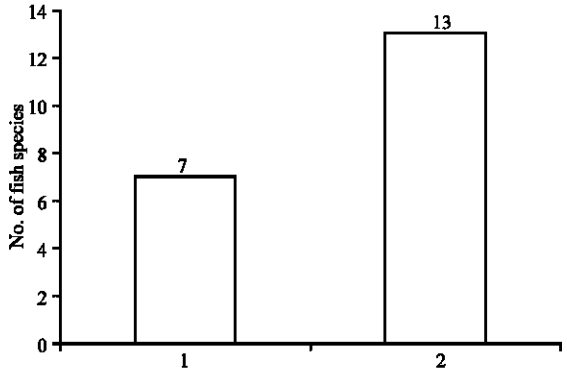

Fig. 3a: Fish species abundance per catch in the Ere channel before and after herbicidal treatment

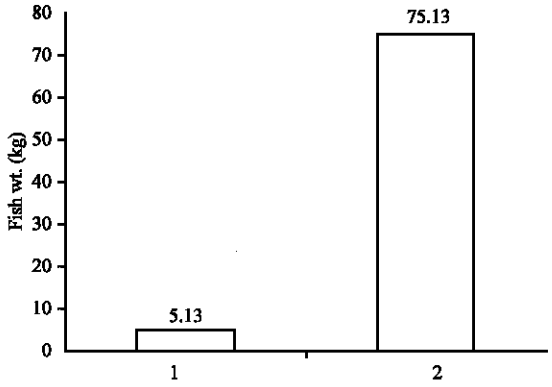

Fig. 3b: Catch per unit effort by fisherfolk in Ere channel before and after herbicidal treatment

population during the herbicidal treatment and afterwards. More so, there was no mortality of fish or other aquatic animals during the treatment period (Fig. 3a and b) Source: Adekoya (1992). It can be deduced from these results that Glyphosate as applied to Ere fishing Channel is safe and cost effective when used professionally. Herbicides applications are usually less expensive than physical/mechanical control. It has to be on an annual basis owing to the fact that once the plant are removed light penetration increases, favouring the germination of new water hyacinth seeds and subsequent water hyacinth reinfestation. The use of herbicides will rarely achieve a long term solution to the water hyacinth problem as reinfestation is bound to occur from missed plant or seed and reinvasion will occur.

STRATEGIES ADOPTED FOR SUSTAINABILITY OF WATER HYACINTH MANAGEMENT AND CONTROL

Surveillance

The adoption of an effective control and planning is premised on the establishment of the abundance and distribution of the weed infestation. Surveillance trips were undertaken first to establish the extent and types of infestation and to decide on the method of control to be used.

Public Enlightenment Campaign

Enlightenment campaigns were carried out to sensitize and mobilize affected communities on the general impact of water hyacinth infestation on the water bodies. This ultimately raised the consciousness of the people on the dangers inherent on transferring water hyacinth to another water body or using it as ornamentals. National Institute for Freshwater Fisheries Research NIFFR/Kainji lake Fisheries Promotion Project jointly organised enlightenment campaigns to determine knowledge level of the fisher folks concerning the water hyacinth infestation on the lake and the associated problems; deciding on a plan of action towards controlling and eliminating the weed on Lake Kainji based on some initial meeting held with traditional authorities and representation of indigenous authorities. The enlightenment campaign attracted many stake holders who were greatly involved in the physical removal of the weed from their beaches. The campaign contributed in no small measure in increasing the knowledge level of the indigenous people and their involvement in the combating of this menace.

Monitoring

Monitoring was jointly carried out by the monitoring unit of the National committee on water hyacinth control alongside their technical staff and the indigenous people. It entails detection of new areas of water hyacinth infestation as well as monitoring of the control level, socio-economic and environmental impact of the control programme. It is continuous one; infact the indigenous people now assists in monitoring insect's damage and help to protect areas where insects have been newly released by not removing the infested plants.

In Lake Kainji North-Central Nigeria, a monitoring team team was set up by NIFFR/KLFPP to complement that of the National committee. A remarkable achievement was made with the co-operation of the fishing communities through the adoption of the following strategies: Airing of radio messages, preparation and distribution of posters, provision of anti-snake vaccines and Institution of competition/awards as a motivational strategy for active participation in water hyacinth manual control.

Training

Training session was organised for members of the indigenous communities who were involved in the programme, while Technical staff benefited from biological and breeding of bio-agents trainings. In Lake Kainji Basin, trainings were organized for various field workers to keep them abreast with tools needed for data gathering and interactions with fishing communities by subject matter specialist in the areas of community mobilization, qualitative and quantitative research methods, Focus Group Discussion Technique (FGD) and Participatory Rural Appraisal (PRD) (Okomoda *et al*., 1994, 1998; Opeke, 1997).

Bilateral Co-Operation

Water hyacinth infestation in the country's inland waters is increasing at alarming proportions. It has become imperative that this ugly trend must be stopped. The spread of this aquatic plant to new

aquatic environment is due to interdependence of the networks of African waters in the neighbouring states. This implies that the effectiveness of one country to manage and control floating weeds may become ineffective unless there is a bilateral co-operation between these countries. Through bilateral co-operation, water hyacinth control activities could be effectively monitored and coordinated. Therefore bilateral co-operation and coordination efforts between Nigeria and Niger and between Nigeria and Benin and indeed Nigeria and her neighbouring countries are therefore necessary if this floating weed is to be effectively managed and controlled.

Water hyacinth control has been included in bilateral programmes of the Nigeria -Niger and Nigeria -Benin Joint Commission for Economic Co-operation.

The commission mandates include:

- Exchange of information and share expertise
- Formulation and investigation/organization of regional training programmes for water hyacinth control
- Facilitation of cross border surveys
- Harmonization of national regulations for the introduction of biological control agents establishment of early warning systems for the appearance and movement of floating water weeds in the region.

These bilateral co-operations are expected to increase effectiveness in the execution of joint control programmes, data collection and management through cross-fertilization of ideas and expert exchange.

Nigeria in collaboration with her neighbours under the Joint Commission arrangement has (been):

- Created an administrative and support unit for the implementation of the programme called the committee of experts on water hyacinth control
- Developed facilities for rearing of bio-control agents in National Institute for Freshwater Fisheries Research, New Bussa and National Institute for Horticultural Research, Ibadan.
- Releasing bio-control agents in infested areas.
- Implementing physical control using mechanized harvesters and manual means; Training of local staff in bio-control and other appropriate techniques.

AREAS OF FURTHER RESEARCH

The management and control of water hyacinth should involve a multi disciplinary approach and should be designed in a way that the highest political and administrative levels recognize the potential seriousness of weed infestation. Researchers should come out with safer herbicides; carry out post release assessment studies on bio-agents. Conduct comparative studies on the socio-economic conditions of communities in weed-infested and non-infested areas; as well as ecological studies of aquatic communities threatened by water hyacinth. An integrated control programme for water hyacinth has to be structured according to the characteristics of each site. A maintenance control programme has to be implemented year after year in order to minimise the cost of aquatic weed management

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