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Performance Evaluation of Deweeding Operations Implemented For Conservation of Rankala Lake, Kolhapur, India

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Abstract

Rankala Lake is situated in the heart of Kolhapur city of Maharashtra. The lake was earlier used for providing drinking water to Kolhapur city but now confined to irrigational and recreational use. Presently, lake serves as a popular picnic spot for the tourists and local residents. Being the location of this lake in centre of the city, there are many sewage terminals pouring sewages in the lake water and therefore heavily polluting the lake which leads to the formation of aquatic weeds in the lake. Lake is turning green since 2011 because of the presence of blue green algae. Since 1994 water hyacinth is been growing into the Rankala Lake at an alarming rate. Deweeding operations are implemented on Rankala Lake for its conservation since 1996 but lake has not become free of it till today. So there is a need to evaluate the performance of these deweeding operations to extract the failures and achievements of these measures so that it can be useful for future lake conservation implementation measures. Thus performance evaluated of this deweeding measure is given here in terms of the failures and achievements of it and some additional measures are also suggested for effective implementation of this measure in future. Based on this status of works and present status of the lake some temporary and permanent remedies for control of water hyacinth are suggested.

Keywords: Recreational, blue green algae, water hyacinth, deweeding, conservation

Introduction

Rankala Lake located in Kolhapur city of Maharashtra is a manmade lake constructed during the reign of Chhatrapati Shahu Maharaja. Rankala Lake is situated on the west side of the very famous Mahalaxmi temple having elevation of 550 m above sea level. The catchment area and total water spread area of the lake is 700 and 107 ha respectively whereas the maximum depth is 15m. Command area under irrigation is 80 ha of land in and around the city. The average annual rainfall in the lake catchments area is 1000 mm. It is having a fan type catchment. The lake was earlier used for providing drinking water to Kolhapur city but now confined to irrigational and recreational use (Gopal *et al*, 2010). The total storage capacity and the useful capacity of the lake water is 43, 40, 141 M^3 and 27, 45, 042 M^3 respectively.

Rajghat and Marathghat are the two ghats for the lake. On the Rajghat there is a Rankala tower and wall is constructed around the Rankala Lake. There are two major streams as source of water to the lake which flows from southern side. From three out-lets the water drains to irrigate 80 hectares of land of Mirabag, Dhunyachi Chavi, Phulewadi. As Rankala Lake is located in the center of the city, there are many sewage terminals pouring sewages in the Rankala lake water and thus heavily polluting the lake.

Study Area Characteristics

The Rankala Lake is spread in an area of about 6682 ha in the Southern part of Maharashtra and in the Western Ghats at 550 m above mean sea level between 16° 42" N Latitude to 74° 14" E Longitude. It is located in area where there is a gradual change in land forms from hilly west to the bare open east. Land use and land cover percentage of Rankala lake catchment area is given in Fig. 2. Kolhapur is located in Panchganga river basin which is formed by the tributaries that is Kasari, Kumbi, Tulsi, Dhamani and Bhogavati. The Rankala Lake is shown in fig. 1 is an image taken from Indian satellite Bhuvan.

Fig. 1: Satellite image of Rankala Lake [Bhuvan]

Rankala Lake supports aquatic flora and fauna. A lot of aquatic life and fish culture is recorded in Rankala Lake and thus 24 different types of fishes are recorded in the lake (Shaha, 2008, Rajemahadik, 20008). It is an important bird area. Many bird and wildlife species gets attracted by it. Nearly 5000 birds of 74 species for example *grebes*, *spoonbills*, *cormorants*, *shop bird*, *ibises*, *cooches*, *jacanas*, geese , *ducks* and other migratory birds from Central Asia, Siberia and Europe gathered in and around the lake and from which 20 species are the aquatic ones showed by the

"Asian Waterfowl" 1994-96 census. Other fauna like 11 species of snakes and 2 species of lizards have been recorded in lake area. In the marshes 7 species of insects are found of "Partala" region and around the lake water (Shaha, 2008, Rajemahadik, 20008).

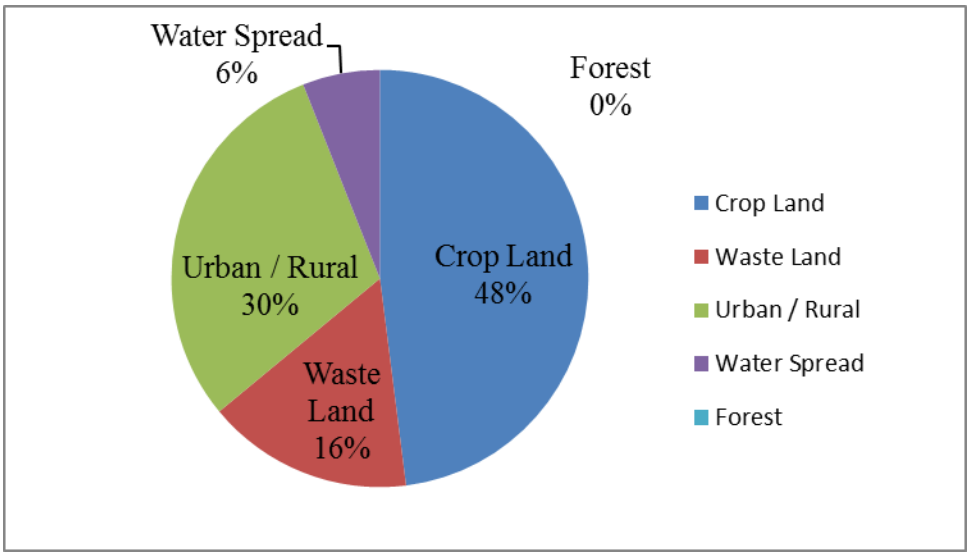

Fig. 2: Rankala Lake Land use & land cover percentage (BIS)

Pollution Sources in Rankala Lake

Due to increased urbanisation and uncontrolled human interference and encroachment the lake is under severe threat of pollution due to thousands of litters of sewage entering into its body as well as due to the solid waste dumping practises in the lakes catchment. Being the location of this lake in centre of the city, there are many sewage terminals pouring sewages in the lake water and therefore heavily polluting the lake. Wastewater flows into the lake through various drains entering the lake on its southern, western and south eastern sides. There are mainly 4 nallas which are sources of sewage and major cause of lake pollution to Rankala Lake which are located in Fig.3.

1. Sham Society Nalla – 8 MLD (Fig. 5 (a))
2. Sairnaik Colony Nalla – 0.9 MLD
3. Partala Nallla – 0.4 MLD
4. Deshmukh Nalla – 0.1 MLD

Fig 3: Sources of sewage to Rankala Lake and Water sampling points in Rankala

Methodology

Objectives for Performance Evaluation

The objective of performance evaluation is to determine the status of deweeding measures implemented for conservation or restoration of Rankala Lake and based on the status of work, give the failures and achievements of the programme and give suggestions and further recommendations based on it for the future orientations.

Need/Necessity of Performance Evaluation

Various conservation measures are been implemented on Rankala lake since 2000 or from before that to this date, but Rankala lake is not restore till today, Lake is facing many problems to this date also. Thus there is a urge from the people that almost every year there are deweeding operations which are been going on Rankala lake but the lake is not able to restore, so there are many questions which are arousing regarding this conservation measure which are been implemented on lake like whether the works implemented not serving its purpose or are they implemented in right manner or is there a maintenance problem of this works which are not allowing this activities to function properly and if all this is right then why lake is not able to restore. So performance evaluation of this deweeding measure is necessary regarding the Rankala Lake.

Methodology for Performance Evaluation

Regarding performance evaluation of Rankala Lake, a primary and secondary data is been collected by various sources. Primary data collected by site visits and reconnaissance survey. Primary data regarding lake current status is been determined by seasonal site visits. Primary

data is also evaluated by interactions with social workers for Rankala lake, locals, Kolhapur Municipal Corporation (KMC) officials from various departments, Rankala conservation and protection committee etc. Secondary data regarding deweeding operations implemented and works underway for Rankala Lake conservation is been collected through various departments of KMC as city water supply department, drainage department, Solid waste management department, Town planning department and other governmental agencies like Maharashtra Pollution Control Board (MPCB), Irrigation department Kolhapur.

These collected data is been compiled together and useful data regarding conservation measures implemented is been generated and presented based on it results are been presented in failures and achievements form. The current status of the lake is also determined in the prospect of conservation activity implemented for comparative study and thus appropriate suggestions and future recommendations are given for lake conservation in future. Fig. 4 representing the flow diagram of methodology for performance evaluation is given below.

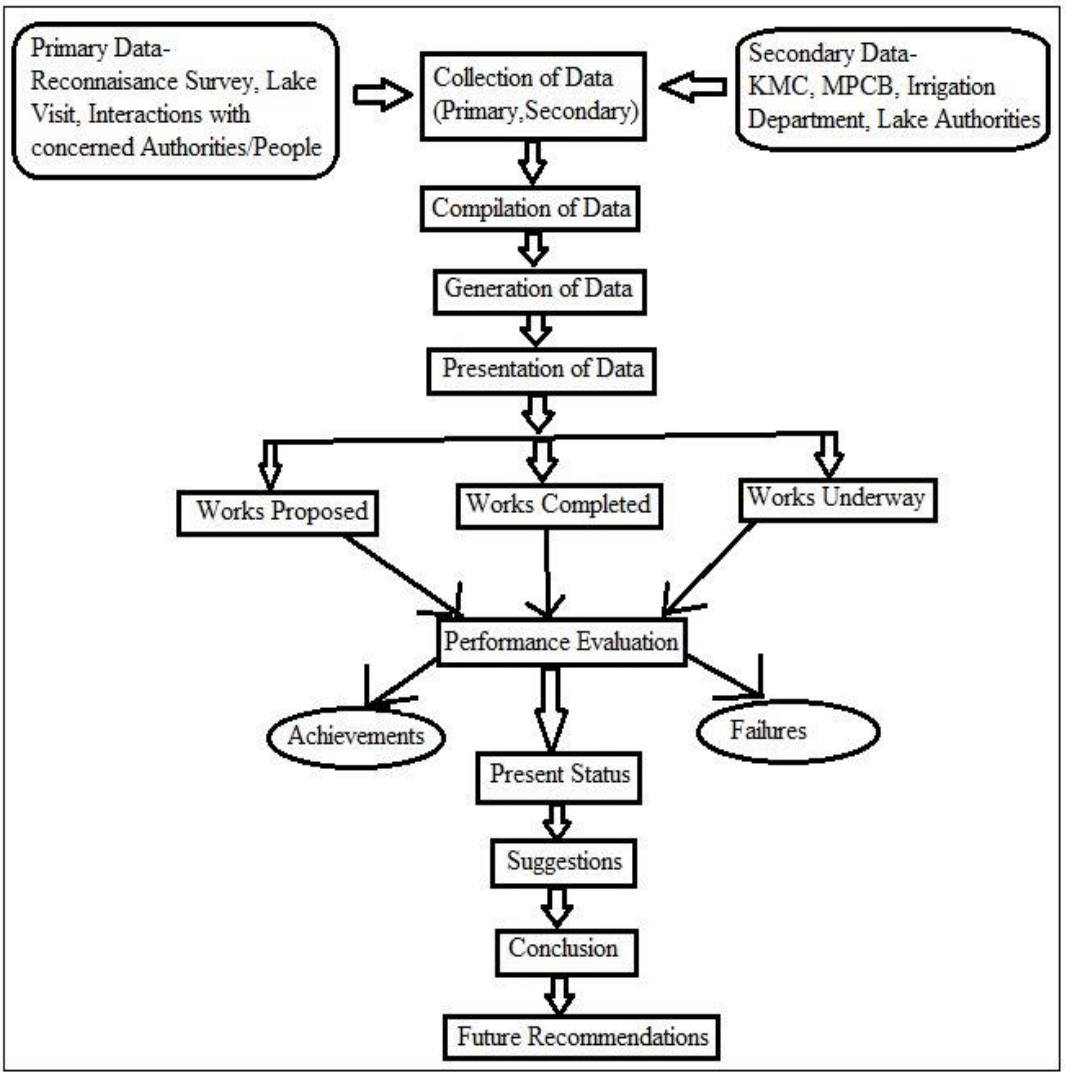

Fig. 4: Flow chart of methodology for performance evaluation methodology

De-Weeding / Water Hyacinth Removal Works

The Rankala Lake existence is been threatened due to the enormous growth rate of this aquatic weeds and plants as well due to the uncontrolled human interference. Streams which carrying the sewage to Rankala lake are the main source of pollution as this streams are putting excessive nutrient loadings into the lake which is ultimately resulting into the extensive growth of the submerged vegetation as well as the free floating weeds and it is leading to deterioration in the water quality. Removal of floating weeds such as the water hyacinth and other submerged weeds like *hydrilla* growing in main body of the lake as well as that along the peripheral regions especially at the ingress points of feeder channels is absolutely essential from viewpoint of cleaning the lake. This would reduce organic load as well as the sludge addition due to the plant death and subsequent decomposition of the plant matter.

In Rankala lake, 57 species of phytoplankton's were observed which were belonging to *cynophyceae*, *bacillariophyceae* ,*chlorophyceae* and *dinophyceae* phylum (Shaha, 2008, Rajemahadik, 20008). *Hydrilla* is been found as the major submerged aquatic species and since few years blue green algae is been observed in Rankala lake. Since 1994 water hyacinth is been growing into the Rankala Lake at an alarming rate. In 1996 some for removal of water hyacinth and *hydrilla* manual and mechanical ways were implemented, the cost incurred for this process was more than 16 Lakhs. From then over a period of four years Rankala Lake was occupied by the water hyacinth till 2000, when conservation measures were implemented again.

Removal of water hyacinth (2000)

After 1996 this conservation measures were implemented till then lake was occupied by the water hyacinth. KMC implemented this operation with the help of the local NGOs, industrialists and some civic conscious citizens of the Kolhapur city. First manual and mechanical methods were implemented then the biological measures were implemented for the removal of water hyacinth.

Manual removal:

For manual removal some social workers and KMC workers were appointed. They identified some key sites of Rankala lake for manual removal. They targeted the low lying accessible areas which around the lake periphery.

Mechanical Removal

With the help of the mechanical instruments like JCBs, Dumpers KMC removed water hyacinth from Rankala Lake. After removing water hyacinth from the lake with the help of JCBs, it was dumped onto the periphery of the lake and then it was transported to the municipal solid waste dumping site.

KMC removed about 2000 truckloads of the water hyacinth manually and mechanically from the Rankala Lake from April 2000 to October 2000. KMC again implemented this operation from July 2001 to September 2001 where they removed 2973 truckloads water hyacinth mechanically with the help of the private individual agencies and local NGOs.

Biological removal

In 2001 KMC initiated a biological control programme with the use of exotic weevils (*Neochetina*) and fungal pathogens (*Alternaria*) to biologically control growth of the water hyacinth. For this biological control programme KMC had taken help from the Indian Institute of Chemical Technology (IICT), Hyderabad. The biological control programme of the water hyacinth was implemented between 26th April 2001 to 28th February 2002. In this period, in 10 steps they released about 56000 weevils into the Rankala Lake for control of water hyacinth. Also furthermore they applied more 47000 weevils upto 7th December 2002 [6]. This project was of 8 lakh Rs. on which the KMC spent 2 lakh Rs. and the rest cost was spent by local NGOs and industrialists. The project was implemented in three stages as follows.

i. At the initial stage of the programme KMC removed around 3000 truckloads of the water hyacinth and waste by manually and mechanically.
ii. In next stage they released this two species of insects into the Rankala Lake.
iii. In final stage this weevils impedes the growth of water hyacinth by feeding on the photosynthetic pigments of it and the fungal pathogens controls the excess growth of the algae without disrupting the aquatic ecosystem.

Removal of water hyacinth (2009)

For the removal of water hyacinth a complete plan was prepared under National Lake Conservation Plan (NLCP) by KMC in 2005-06 which is given in Table 3. The plan was involving manual and mechanical removal of water hyacinth of the floating and submerged aquatic plants and it also involved cleaning works like its disposal from lake Periphery. The components of the plan are given in Table 1.

Table 1: Cost of cleaning & removal of aquatic weeds & aquatic plants (KMC)

Sr. No.	Description/Activity	Total area / Unit	Cost / Unit Rs.	Total Cost Rs.
1	Removal of floating plants and other aquatic weeds from the lake body and disposal of the same on dumping ground at municipal solid waste dumping site	@ 60 Ha	1,00,000	60,00,000
2	Removal of submerged aquatic weeds, bushy plants in the shallow pockets where the barges and mechanical boats cannot be operated and disposal of the same on dumping ground at municipal solid waste dumping site. 1. From Rankala Lake 2. From Partala (Adjoining marshy land serving purposes such as breeding place for birds, natural habitat etc.)	2100M*20M= 42000 Sq.M i.e. 4.2 Ha Say 4.0 Ha 2.0 Ha	40,000	2,40,000

		Total 6 Ha		
3	Provision for additional work of general cleaning and garbage removal along the lake boundary	@ 3 KM	10,000	30,000
		Total - Rs. 62,70,000		

The plan proposed by KMC in 2005-06 was implemented in the year of 2009. The plan implemented as follows

De-weeding Operation (2009)

- The de-weeding operation commenced on 23.01.2009.
- De-weeding operation completed on 10.04.2009.
- De-weeding was planned and implemented in a systemic manner with the machinery & equipment - Pocklains (4 Nos), JCBs (3 Nos.), Dumpers (15 Nos.), specially modified boats (7 Nos).
- The work was carried out with great efforts and diligence (14 to 16 Hr / Day) and continued for 78 Days without any holiday.
- About 60 Persons per day were involved in the de-weeding process.
- The entire operation was closely watched, monitored and successfully steered by the Commissioner of KMC.
- Totally 8,400 Dumpers weed in wet condition was removed during this period.

Removal of water Hyacinth (2011-12)

Similar growth of water hyacinth or the similar conditions of water hyacinth was again developed in the 2011. So to remove water hyacinth KMC again implemented the deweeding operation by the end of 2011. The deweeding operation was implemented as follows by KMC.

De-weeding Operation (2011-12)

- The de-weeding operation commenced on 05.12.2011.
- De-weeding operation completed on 14.04.2012.
- De-weeding was planned and implemented in a systemic manner with the machinery & equipment and manpower as a fleet of 3 Pocklains, 3 Boats, 10 KMC staff, 15 Irrigation Dept. staff and 6 dumpers.
- De-weeding operation was conducted from 9 am to 7 pm everyday.
- Daily about 35 dumper loads of weed was harvested.
- 2 new boats taken through NLCP funds arrived in February 2012. They were fitted with specially designed Weed Pushing Mechanism.

Fig 5: October 2008 (Weed Infestation)

Fig 6: February 2009 (De-weeding Operation)

Present Status of The Rankala Lake

Because of increased N, P, K content in Rankala Lake, there is algal bloom of blue green algae. Because of the presence of these blue green algae, the water has become green in colour. Lake is turning green since 2011 in every August as this year also. The algae is continuously increasing, multiplying and dyeing, this cycle is continuous. The dead algal blooms are floating on the water surface coming towards the bank near dense population at east direction of lake, causing malodour, nussainase and blind mosquitoes. Last 2 years the lake totally covered by blue green algae which are dissolved from top to bottom in Lake Waterbody, as this algae is fully dissolved in water, it is difficult to remove the algae by traditional methods (boat, pock lain, JCB, dumpers) adopted before for the removal of Salvinia molesta and Eichhornia crassipes. The presence of blue green algae in Rankala Lake is shown in Fig. 7.

Fig. 7: Rankala Lake turning green due to blue green algae

Performance Evaluation of Conservation Measures

Since 2000 or from before that water hyacinth removal works are been implemented onto the Rankala Lake by KMC. Most of this works were manual and mechanical removal of water hyacinth. This conservation measures were repetitive because they won't able to stop the growth of water hyacinth but this measures cleaned Rankala Lake for that period by removing water hyacinth. The evaluation of this works implemented was done in the Table 2 in the form of failures and achievements of this conservation measures.

Table 2: Performance evaluation of conservation measures in terms of failures and achievements

Conservation measure	Achievements	Failures
Biological Removal (2000)	• Reduced the concentration of water hyacinth • Long lasting effect • Minimum cost and maximum output • Removal of water hyacinth from root • Very effective when implemented	• Not entire removal, in some patches hyacinth and *hydrilla* were seen in the lake • Caused problem of dying and decaying plant • Added to organic load in the lake environment due to decay • In functioning period caused problem of Recreation and mosquitoes and nuisance • Very lengthy
Deweeding operation: Manual and Mechanical Removal (2009)	• completely cleared off the weed infestation • lake was clean for recreation purpose after its implementation • Chronic removal in stipulated time • Cleared also quarries located in the premises of the Rankala lake	• Not root removal of water hyacinth • Chronic removal • Oil spill observed • Not long lasting effect
Deweeding	• completely cleared off the weed	• Not root removal of water hyacinth

Operation: Manual and Mechanical Removal (2012)	infestation • Chronic removal in stipulated time • lake was clean for recreation purpose after its implementation	• Chronic removal • Not long lasting effect

Additional Measures for Effective Implementation

- Deweeding operation should be implemented with special modifications provided to the earth moving machinery components
- The modified mechanical boats should be in operation.
- Removed weeds should be placed on the lake bank for dewatering before being carried away to dumping site
- Arrangements should be made to confine spread of weed mats during removal
- after its dewatering ther should be systematic handling of the harvested weed for disposal
- The entire Incision & Drainage works should be completed on a war footing so as to stop ingress of dry weather flow in Lake.
- Shyam Society pumping station should be kept in operation during power failures so as to minimize the existing ingress (3-4 MLD).
- There should be manpower deployment for routine lake surveillance and maintenance of infrastructure under NLCP.
- The multi-utility barge under lake management and maintenance infrastructure should be implemented. It performs De-weeding, Chemical Dosing, Pocket Aeration & Mixing, Monitoring & Surveillance (all in one operation).

Suggestions

Water hyacinth can remain dormant for nearly almost 20 years and then also it can resurface when it receives the favourable conditions. Water hyacinth cannot be removed in one blow so it needs long lasting measures for its removal. Based on the works performed some temporary remedies are suggested to clear off lake for recreation purpose in stipulated time and also permanent remedies are suggested for conservation of lake from water hyacinth. To give clear idea about the conservation measures also the control methods are given with its constraints and achievements for future orientations in Table 5.

Temporary remedies

- To operate the pumping station at Sarnaik Vasahat, Deshmukh hall and Sham Society.
- To increase the sewage storage capacity at the sham society nalla barrage.
- To stop the wastewater drain which is coming into the Partala at the upstream end and divert it to the other drainage lines and perform Deweeding of Partala to settle the fresh water of Rankala into it. To pump the waste water of Partala into the nearby drains.

- By stopping water by either barrage or by blocking it between the PWD Depo and Vashinaka and removing silt from it and then perform phytoremediation.
- By performing Manual Deweeding operations along the low lying accessible areas along the lake periphery
- Mechanical removal of water hyacinth
- Alum dose of 20 to 30 ppm on the sewage water which is mixing into the Rankala lake
- The pressure pipe of deshmush hall pumping line is not functioning so by making it correct making deshmukh hall pumping station work.
- Before rainy season over, all the pumping machinery should be in proper condition.
- To affix a mesh below the bridge of sarnaik mine to not allow the mixing of water hyacinth in Rankala Lake.
- With the help of the sand sacks close the connection between the Rankala lake and the sewage water

Permanent Remedies

- To stop the sewage flow into Rankala Lake and the works which are going out under NLCP of the Interception and Diversion works of the drainage lines should complete as soon as possible.
- To make other separate arrangements for the washing of cloths, animals, vehicles etc and for this using other quarries or the quarries which are not connected or blocked from Rankala Lake and to implement this performing channeling and fencing operations.
- In the Ganesh idol discharge quarries, only the idols made up of clay and whose color is getting dissolved in water should be discharged.
- The Ganesh idol discharge basin which is constructed under nlcp , the water from this basin should be transferred to the drainage lines by pumping and then the fresh water from the Rankala lake should be transferred into the basin so to keep the basin clean.
- The two purchased boats under NLCP should be used for the temporary aerations and the diffuser barge boat (large boat) should be used for the regular aerations and in this boat water hyacinth removal machinery or equipments also should be installed.
- The sewage water from the sarnaik vasahat nallah and the deshmukh hall nallah is gets stored into the Rankala quarries so silt removal of this mines, alum treatments, weed removal operations, lifting sewage water with the help of the sewage fire pumps, barrage constructions and the aeration operations should be performed into this quarries.
- To perform the phytoremediation in dehmukh hall pond and sarnaik hall pond by applying the aquatic plants like lotus, colocasia etc.
- Arrangement of the Express feeders for the sham society nallah pumping station
- Application of the Integrated weed management approaches for water hyacinth removal
- Application of the bioremediation approaches for water hyacinth removal

Table 3: Advantages and constraints of aquatic weed control methods

Method	Advantage	Constrain	Efficiency
Hand cutting / Pulling	Low technology, affordable, selective	Labour intensive	Effective for initial infestation, very effective in localised area
Mechanical Removal	Removes plant biomass, immediate relief in Harvested area , Effective for free floating and emergent plants	Slower and more expensive than manual removal, may spread fragments and disposal of harvested plants	Heavily infested system, non selective, used in areas of chronic plant problem
Biological Control	Provides long term, Low cost reduction in Biomass	Slow process, does not produce eradication	Long term control without intense management
Chemical Control	cost effective treatment, immediate relief in Harvested area, doesn't require much manpower	Risk of the decomposing vegetation detrimentally affecting water quality, particularly dissolved oxygen, withholding period on water bodies treated when some herbicides are used.	Areas of chronic plant problem

Conclusion

Since 1996 deweeding operations are implemented on Rankala Lake but Rankala Lake is still the problems of water hyacinth and in present status of blue green algae. The operation implemented for weed removal was manual and mechanical and these operations were effective for the period of time but these operations failed to achieve the long lasting effect. The streams which are carrying the sewage to the Rankala Lake are loading the excess amount of nutrients into the lake which are causing the growth of aquatic weeds. Along with this manual, mechanical and biological operations of weed removal, the entry of sewage into the Rankala Lake needs to be stopped completely for controlling the growth of aquatic weeds. The integrated weed management approaches and bioremediation approaches also need to be considered for future orientations.

Future Approaches

Integrated weed management approach

In many cases the best control is achieved when a combination of control methods are used in an integrated way.

- Biological control and herbicides
- Herbicides and mechanical removal
- Floating booms

Bioremediation

Bioremediation provides a technique for cleaning up pollution by enhancing the same biodegradation processes that occur in nature. Depending on the site and its contaminants, bioremediation may be safer and less expensive when compared with other options and solutions

such as physical removal of the polluted matter and its subsequent disposal by incineration or land filling.

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