Impact of Remedial Measures in Conservation of Aquatic Resources: Lessons Learned from Bhoj Wetland Project, Bhopal

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ABSTRACT

Aquatic ecosystems are the most livid and self-sustained systems, which usually accommodate the external influences within its self-assimilative capacity. However when the external influences crosses the threshold limits, the ecosystem becomes vulnerable towards disaster. Perceiving this a growing concern for conservation of the aquatic resources has been witnessed all over the world. In India most of the urban water bodies are subjected to high degree of pollution due to multiple reasons one of them being the nutrient enrichment. The Bhoj Wetland (a Ramsar site) of Bhopal which was constructed in 11th century is one such water bodies that have been subjected to severe degree of pollution. Hence to restore the water quality of the wetland, several conservation measures have been implemented under 'Lakes Bhopal Conservation and Management Project' during the period 1995-2004 with the financial assistance of JIBC, Japan.

The experience learned under Bhoj Wetland encompasses the knowledge in the conservation of urban aquatic ecosystem and understanding of the intricacies of the complex ecosystem. During the course of implementation it has been realized that for sustainability of the ecosystem an integrated biophysical approach for management of complex system with wise use of resource is the key factor. The paper discusses the lesson learned while implementing various project activities so that the valuable experiences earned could be utilized in implementation of similar projects in tropical countries.

Key words: Wetland, Water Quality Degradation, Conservation, Lesson Learned

INTRODUCTION

Bhopal, the capital city of Madhya Pradesh is a fast developing city with a population of approx. 18 lacs. The city is blessed with a number of man-made water bodies in and around its municipal limits which cater the potable and other water demands of the city. Due to a large number of water bodies in and around the city, Bhopal is often referred as the city of lakes. The twin lakes of the city viz. Upper and Lower Lake that are situated in very heart of the city are however the most important aquatic resources of the city and are together known as Bhoj Wetland. Although the city has a long history but it got the recognition after becoming the capital of Madhya Pradesh in early 1950s. In the early half of the past century the city was limited to what is now the old Bhopal area. However as the population grew, the expansion of the city started in all four corners hence dense human habitation started emerging in the catchment of these twin lakes (Fig-1). This resulted in tremendous pressure on these water bodies due the inflow of untreated sewage and other anthropogenic activities (Misra et al 2001). The natural drains that once carried storm water into the water became the carrier of domestic wastewater. Thus with the advancement of time the very sources of water of these water bodies have eventually become a major source of pollution (Pani & Misra, 2005).

Upper & Lower Lakes

Bhopal without the Upper Lake reflects the incomplete picture of the city as it is said to be the lifeline of its people. It is a men made lake and was founded by construction of an earthen dam by Raja Bhoj in the 11th century A.D. (1010-1055 A.D.) The water of the lake is being used for the potable water supply. It is said that till 1947 the water of this lake was used for potable purpose without any treatment. However in past two decades the external influences and anthropogenic activity has deteriorated the Lake water quality to such an extent that it becomes
imperative to use this water only after proper treatment. The Lower Lake which was constructed in the year 1897 is primarily used for secondary purposes other than drinking.

**Location and Salient Features of the Lakes**

The Upper Lake spread over longitude 77°18'00” to 77°24’00” E and latitude 23°13’00” to 23°16’00” N, whereas the Lower Lake which is considerably smaller in size is spread over 77°24’00” to 77°26’00” E and latitude 23°14’30” to 23°15’30” N. The basic features of the lakes are shown in Table-1.

**Table – 1:- Salient features of Upper & Lower lakes**

<table>
<thead>
<tr>
<th>Lake Sub-basin</th>
<th>Upper Lake</th>
<th>Lower Lake</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lake Origin</td>
<td>Man-made</td>
<td>Late 18th Century A.D</td>
</tr>
<tr>
<td>Climatic Region</td>
<td>Warmer humid (Humid subtropical)</td>
<td></td>
</tr>
<tr>
<td>Drainage Basin Type</td>
<td>Open</td>
<td>Open</td>
</tr>
<tr>
<td>Salinity Type</td>
<td>Fresh</td>
<td>Fresh</td>
</tr>
<tr>
<td>Altitude</td>
<td>503.5 m</td>
<td>500 m</td>
</tr>
<tr>
<td>Surface Area</td>
<td>36 Km²</td>
<td>1.29 Km²</td>
</tr>
<tr>
<td>Drainage Basin Area</td>
<td>361 Km²</td>
<td>9.6 Km²</td>
</tr>
<tr>
<td>Volume</td>
<td>0.117 Km³</td>
<td>0.004 Km³</td>
</tr>
<tr>
<td>Maximum Depth</td>
<td>11.7 m</td>
<td>9.5 m</td>
</tr>
<tr>
<td>Average Depth</td>
<td>6 m</td>
<td>3m</td>
</tr>
<tr>
<td>Population Dependency</td>
<td>0.5 million</td>
<td></td>
</tr>
<tr>
<td>Population Density</td>
<td>1350 persons/km²</td>
<td></td>
</tr>
</tbody>
</table>

**Environmental Problems of Upper & Lower Lakes**

The major environmental problems of the lakes are described below:

**Reduction of Storage Capacity of Lakes**

The major problem associated with the Upper Lake was inflow of silt and organic materials from its vast urban and rural catchments. The lake receives 90% of its water through one major channel known as Kolans River. This feeder channel in due course of time has become narrow and shallow due to siltation and erosion from its catchment. This has reduced the inflow of water in the lake during monsoon. The addition of silt from agricultural catchment has also resulted in deposition of silt around the limnetic regions of the lake. More over the constriction of the out flow channel (spill channel) due to deposition of silt over the years has resulted in low flushing of the lake and hypolimnic accumulation of nutrients. In lower lake inflow of sewage and decomposition of organic masses are the main contributing factors in reduction of storage capacity.

**Flourishing Growth of Invasive Aquatic Plants**

Excessive nutrient accumulation in the lake due to inflow of sewage and agricultural wastes had ultimately resulted in flourishing growth of invasive aquatic plants like *Eichhornia crassipe*, *Sirpus royeli* in both the lakes. About 70% of the Upper Lake was invaded with various types of submerged weeds like *Ceratophyllum demersum*, *Vallisneria spiralis*, *Myriophyllum spathulatum*, *Hydrilla verticillata* etc. The lower lake on the other hand is grossly infested with *Eichhornia crassipes*, *Spirodella polyrhiza*, *Jussia rupens* etc.

**DETERIORATION OF WATER QUALITY DUE TO INFLOW OF UNTREATED SEWAGE FROM ITS HABITATION**

The water quality of both the lakes have deteriorated due to dumping of municipal wastes, immersion of idols, run off of chemical fertilizers from the catchment especially in Upper lake, washing of cloths and other anthropogenic activities.

**Conservation Measures Implemented**

Considering the immense importance of the two water bodies in day to day activities for the people of Bhopal, an integrated lake conservation plan was prepared for improvement of water quality of the two lakes through meticulous identification and investigation of the issues related to the lake conservation. Although all the issues are deeply interrelated and inter-linked but for operational and management ease, these have been divided as following sub-project activities.
Considering the intricacies of implementing of the above activities, various critical aspects related with conservation and management like environmental, ecological, economical, legislative, administrative and technical issues have been reviewed and incorporated in the project for avoiding unnecessary hindrance for implementation of conservation measures. A government controlled society called Environmental Planning and Coordination Organization (EPCO) was made the implementing agency for coordination with the funding agency (JBIC), Government of Madhya Pradesh, Municipal Corporation (BMC), State Public Health Engineering Dept (PHED), Water Resources Department, Forest Department, Capital Project Administration (CPA) and Fisheries Development Corporation (MPFDC).

A separate project cell known as Bhoj Wetland Project cell was constituted within EPCO mobilizing technical experts from different discipline for smooth implementation of the identified works. Under Conservation measure various activities were implemented for improvement of the water quality of the two lakes. The project was ultimately completed in June 2004 and the assets created under the project were transferred to the government agencies for their post project operation and maintenance and an authority namely Lake Conservation Authority of Madhya Pradesh (LCA) was constituted for looking after the post project activities as envisaged in the project proposal.

ACHIEVEMENTS OF THE PROJECT:

Desilting and Dredging

Under this sub-project 85,000 m³ silt from Lower lake was removed by dredging through specially designed mechanical device and 2.7 million m³ of silt from Upper lake was removed by dry excavation methods. This has effectively increased water holding capacity of the lakes by 3%. Dredging was done mainly at the points at which in-lets from the catchment (nallahs) and rivulets meet the lakes and the de-silted materials were disposed off out side the catchment of the lake.

Restoration of Takia Island

'Takia' is a small island in the Upper Lake which has historical importance and is a place of worship for the local people. Over a period of time due to lack of proper maintenance its banks were eroded and the peripheral area was heavily silted. Under Bhoj wetland Project two rows of retaining walls and pitching around the Island were created to prevent further erosion from this island. Development of greenery through plantation has become an added attraction for the visitors and avifauna.

Deepening and Widening of Spill Channel

This activity was carried out to accommodate a discharge of 566 cum/sec from the lake in the event of flood threat. For this of 0.987 million cum of silt from 2.6 km of Bhadbhada spill channel was removed through digging and excavation work. The silt removal helped in another 1% increase in storage capacity of Upper Lake.

Fringe Area Protection

A ‘No Construction Zone’ (NCZ) of 50 m from FTL of Upper Lake and 33 m from FTL of Lower Lake was created under the project to protect the fringe area of the two lakes which are ecologically the most important habitats for great biodiversity of micro-flora and fauna. Beyond this zone another zone ranging from 50 to 150 meter was earmarked as area for compatible activities like green belt and plantation. This protective measure on the line of Coastal Regulatory Zone (CRZ) in the case of coastal area was envisaged for protecting the lake ecology and sustainability of its functions supporting economy of the region. In addition to this 4.6 km boundary wall is constructed along the shore line of the Lower Lake.

Physical Barrier

Towards the north-eastern portion of the Upper Lake, a road adjoining the lake was constructed to prevent
encroachment of lake bed in this thickly populated area. This provided the relief to the heavy traffic on the adjoining Highway passing through the city. The 5.4 km road has 7.5 meter carriage way and 2.5 meter wide footpath.

BUFFER ZONE PLANTATIONS:

To prevent encroachment, illegal human settlements, cattle intervention and cultivation on exposed shore zones of the lake, a buffer zone was created along the periphery of the Upper Lake. Extensive block and avenue plantation of more than 1.7 million trees covering 1,000 hectors has been completed. The buffer zone with three tier plantation not only helped in restricting encroachment of lake bed but also helped in reducing the flow of silt from this portion of the catchment area into the lake. Further in the program under social forestry, farmers were encouraged to raise fruit yielding trees along their crop fields and marginal lands.

CATCHMENT AREA TREATMENT:

To control inflow of silt, agricultural residues and other wastes into the lakes from various points of the catchment, 75 check dams of loose boulder/gabion structures and 2 silt traps having a cumulative silt trapping capacity of 0.36 million cum have been constructed across 31 inlet channels of Upper lake. Silt traps were also constructed on two major inlets of Lower Lake.

Sewerage System:

Infrastructure laying of an 86.7 km pipeline through congested human settlements and construction of 8 sewage pump houses and 4 treatment plants for diversion and treatment of the entire domestic sewage has been done under the project to collect the sewage from settlements and to direct it to Sewage Treatment Plants (STP) for treatment and disposal of the same. Three STPs at Gondarmau, Badwal and Maholi in the western zone and Kotra in Southern zone of Upper lake is already completed and treating 65 to 75 mld sewage.

Solid Waste Management:

For solid waste management, infrastructure of Bhopal Municipal Corporation was strengthened from the project funds by providing dumper placers, refuse compactors, a sewer cleaning machine and containers. At the dumping site an electronic weighbridge was installed to monitor the efficiency of the each vehicle. These measures resulted in the additional collection and disposal of 70 metric ton of solid waste from the 18 municipal wards located in the urban watershed of the lake as before implementation of the project, the municipal corporation could collect only 96 tones of garbage daily.

Prevention of pollution from Dhobigats (Laundry washing houses):

Under the Project the washing activity in lower lake was shifted to the downstream of the lake. For this purpose necessary a scheme has been proposed for rehabilitation of 250 washer men families outside the catchment of Lower Lake having all facilities for living and washing. The vacated land has been developed as a buffer zone having gardens and parks. These have resulted in reduction of pollution problems of lake water.
WEED REMOVAL:

With a view to offload nutrients and prevent accelerated evapo-transpiration of lake water, controlled weed removal operation in about 90% of the submergence area of Upper Lake and almost entire area of Lower Lake was carried out. Removal of different types of weeds such as shoreline (Ipomea fistulosa), emergent (Scirpus royiie and Cyprus rotandus, Polygonum glabrum and Ipomoea aquatica), floating weed (Water hyacinth) and an assemblage of submerged weeds were completed in a systematic manner. Weeds were mechanically removed and composted on large scale for manuring in agricultural fields in the catchment while species like Ipomia was used as fuel wood after drying.

Installation of floating fountain and ozonizers:

An anoxic state was often observed in the hypolimnion of both the lakes resulting frequent mortality of fishes (Wanganeo et al 1993). Therefore to increase the oxygen availability and to accelerate the microbial degradation and recycling of organic matter, in Upper lake, 9 floating fountains and in the lower lake 4 floating fountains, one ozonizer and an ozonizer-cum-fountain have been installed. These devices apart from beautification were very effective in improvement of the water quality and biodiversity (Pani and Misra, 2003).

Biological control of weed through Aquaculture:

To control the excessive growth of weeds and simultaneously to promote fish productivity in both the lakes about 3.2 million seeds of exotic carp like Ctenopharyngodon idella, Cyprinus carpio along with the Indian major carps like Labeo rohita, Cirrhinus mrigala and Catla catla were introduced and subsequent survey has shown an increase in income from fishery. This has resulted in the reduction of density of aquatic weeds up to 50% and increase in fish production by 130% i.e. the productivity increased from 2 tons to 4.5 tons per year with an average income of $ 669 per fisherman family per year. Thus there has been improvement of lake water quality as well as economic conditions of fishermen.

Construction of high level bridge across Bhadbhada spill channel:

Under this subproject a 4 lane bridge across Bhadbhada spill channel has been constructed to divert the development outside the catchment of the Upper Lake and to reduce traffic pressure over the age old Bhadbhada Bridge cum spillway,

Control of seepage through earthen dam of Upper Lake:

The existing earthen dam of Upper Lake separating the lower lake was constructed in the year 1005 A.D. This dam was reportedly constructed between 2 dry masonry walls field with murrum (small pebbles mixed with red soil) and boulders. Subsequently a tunnel (gallery) was constructed to release water from Upper Lake to Lower Lake and for supply of potable water to the city. The retaining wall of the earthen dam, toe wall facing Upper Lake and the tunnel inside the earthen dam were damaged in course of time due to natural process. Therefore for strengthening the existing earthen dam, a concrete of existing stones masonry wall, grouting of retaining wall, construction of bell-mouth inlet and outlet structure of the tunnel was done. A vertical shaft was provided to facilitate the inspection and treatment of tunnel in future.

Water quality monitoring:

Monitoring of the water quality for its physical, chemical, bacteriological, heavy metals and biological parameters is being done since inception of the project i.e. from 1998 till date. Water Quality monitoring of both the lakes are being conducted on a regular basis, i.e. monthly at 18 points in Upper Lake and 14 points in Lower Lake since 1998. Although no dramatic improvement in water quality has been noticed however study conducted by Environmental Research Laboratory reveals that
implementation of various remedial measures has resulted in slight improvement of water quality in both the lakes in general (Bajpai et al, 2001, Pani et al, 2002).

Shifting of idol immersion from traditional site to the new site

Number of field visits, workshops, competitions, rallies, lectures, public meetings, audio-visual shows, training courses, eco-camps and street theatre performances have been conducted as a part of awareness campaign to spread the message of environmental conservation among the citizens of Bhopal. Open forum and seminars have also been conducted on issues of environmental concerns. In addition to this promotional drives for creation of negative impact of idol immersion on water quality were organized. Promotional drives included various prizes/trophies for construction of environmental friendly idols, which include small size and idols made up of biodegradable materials.

LESSON LEARNED

Intricacies of Implementation

Conservation & Management of water bodies is a complex issue involving multidimensional activity of different disciplines. Successful implementation of the project activities requires mobilization of technical and scientific resources from interdisciplinary fields and a well planned coordination among project personnel. Besides timely implementation of the project activities is essential for avoiding any financial escalation which ultimately affects the over all project cost. In India implementation of any project particularly environmental project is often delayed due to number of socio-economic hindrance. Although every project ultimately aimed towards human development but it is the human being from which maximum resistance is usually experienced. Implementation of any conservation measure should be done only after taking the cognizance of the people particularly the stakeholders. The processing of a project should be simple and easy as to avoid delays. In Bhoj Wetland Project certain activities were behind the schedule due to conflict between the implementers / administrator and the people. Even after being a well planned project, it started late due to several technical impairment. Since this project at such a large scale was implemented for the first time in India, several technical and administrative issues had to be considered for successful implementation of the project. At the initial stages the project ran through snail place. The executive agency i.e. Environmental Planning and Coordination Organization (EPCO) is the premiere agency to look after the environmental issues of the Government of Madhya Pradesh, but due to lack of adequate expertise, the implementation of various activities including the preparation of Detailed Project Report (DPR) was delayed. To avoid further delay and increase financial burden, a High Power Review Committee was constituted comprising the senior most administrator of the state for periodical review and assessment. This helped in speed up of the project activities as regular assessment was done in the Progress Review Meeting (PRM) to discuss the short comings and other difficulties arising out while implementing various activities.

PROTECTION OF LAKE CATCHMENT:

The characteristics of a water body are largely reflected by its catchment structure. Therefore for sustainable management of a water body, its catchment has to be properly protected. However management for catchment depends upon its geo-physical structure. The Bhoj wetland catchment mainly comprised of both rural and urban structure. A part of the catchment is also used for agricultural activities. Therefore for protection of such a diverse catchment various measures need to be taken like:
1. The fringe areas should be declared as protected area prohibiting any developmental activity affecting its green cover and landscape and natural drainage. Inflow of domestic or agricultural effluents should be trapped in order to reduce its entry in to the lake.

2. Feeding channels of the water body should be periodically de-silted / widened to ensure maximum inflow of water in the lake. In Upper Lake Kolans is the major feeding channel flowing deep inside the lake and provides 90% of the total inflow. Although this channel was widened up to an extent within the lake but a major part before entry point yet to be de-silted which obviously reduces the inflow of water.

3. Inflow of residues of chemical fertilizers and insecticides/herbicides into lake through modern agricultural practices is a major cause of concern of lake pollution. Since this is a sensitive issue and directly related to livelihood of people therefore alternative and incentive based agricultural activities should be encouraged to the farmers. In the Bhoj wetland project, in the later stage incentive based organic farming was promoted among the farmers living within the catchment of the lake.

Effectiveness of conservation measures in water quality improvement

A post project study conducted by ILEC has suggested certain measures that could not be effectively implemented. One of the prime concerns was sewage inflow. Even after laying 86 Km of sewerage line, inflow of sewage into the lake could not be totally stopped as connectivity of the individual houses with the main sewer line could not be done in some areas. Similarly although de-weeding has been done but regeneration of weeds particularly the submerged weeds have been noticed at certain points. Removal of weed should therefore been done at regular intervals.

Although number of activities has been done for protection of fringe areas, but due to lack of maintenance in forest areas, gabion structures and silt traps are in bad shape which needs immediate attention.

LITIGATIVE/ADMINISTRATIVE MEASURES

After the completion of Bhoj wetland project, an authority namely Lake Conservation Authority of Madhya Pradesh was constituted for monitoring and supervision of conservation measures like de-weeding, de-silting, water quality monitoring etc. Lake Conservation Authority is strengthened by the Environment Protection Act (1986) and other supporting acts like Indian Forest Act, 1927. There has been strong advocacy in favour of declaring catchment and water bodies as reserve forests in many parts of India especially the southern state of Karnataka (India) where the lakes are already protected under the relevant Forest Act. However this has to be replicated all over the country. Following this direction Lake Conservation Authority (LCA) of Madhya Pradesh has been constituted by the Govt of Madhya Pradesh with People’s representatives, Government officials from concerned departments, representatives of stakeholder groups and NGOs and other organized sectors. Although LCA has been established in the year 2003 but it is still in its juvenile stage and needs pro-active role and aggression for conservation of water resources of the entire state.

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REFERENCES


