URBAN LAKES
RESTORATION & MANAGEMENT

[PROPOSED ACTION PLAN]

Report Submitted to
Telangana Pollution Control Board
Government of Telangana
Hyderabad

By
Centre for Climate Change
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Article 51A (g) of The Constitution of India

Fundamental duties: It shall be the duty of every citizen of India to protect and improve the natural environment including forests, lakes, rivers and wild life, and to have compassion for living creatures;
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Introduction:
Ecologically, Urban Water Bodies play a key role in balancing the local environment viz; regulating the surplus flood waters during monsoon periods, regulating microclimatic conditions, recharging groundwater sources, serving as nurture wetland ecosystem and providing feeding & breeding grounds for many local and migratory birds, and offers invaluable aesthetic sense in the urban landscape.

Lakes not only regulate local weather conditions but also act as flood water regulatory systems as flood water control infrastructures. They serve dual functions tangible and intangible. Polluted lakes have a direct and indirect impact on local weather conditions too, thus contributing to climate change. Polluted lakes contribute to vanishing freshwater sources, including groundwater sources further pushing the cities into water scarce zones. Unfortunately, a majority of these lakes are a victim to the rapid and unregulated urban development across the country and Hyderabad city is no exception to this phenomenon.

Keeping these facts in mind, Government of India has taken the responsibility on a global platform to pursue the Millennium Development Goals, Sustainable Development Goals and signing the Paris Agreement. Lakes as an important source of fresh water and carry greater relevance and importance in the context of water scarcity and changing hydrological patterns due to Climate Change.

Considering these developments, Centre for Climate Change, ESCI is organizing training workshops focusing on mitigation and adaptation to Climate Change in various sectors. The second training workshop on Urban Lakes was conducted between 5th to 7th July 2017. This training program focused on emerging challenge of froth and foam formation in cities.

The proposed action plan not only incorporates recommendations of the recent training program but also the key recommendations of the workshop held during the third week of October 2004, which focussed on decentralized mechanisms to address and regulate water pollution concerns, emphasising role & responsibilities of local governing bodies in the entire gamut of environmental regulations. The workshop was supported by the World Bank and organized by APPCB, under the combined state of Andhra Pradesh.

The present report also incorporates the experiences gained in minimizing the foam generation at Bellandur and Vartur lakes of Bangalore.
Background:

Hyderabad – capital city of Telangana State was popularly referred as ‘City of Lakes & Gardens’. The city had more than 250 manmade lakes in and around the city. Today majority of them are buried under the concrete structures and those existing are transformed into ‘Toxic lakes’. The city faces water pollution – both surface and ground water, experiences urban flash floods due to high intensity short duration precipitation. This above situation is seen in all most, if not all the major cities across India.

For the last two decades, urban water bodies have been a victim to unplanned urbanization in India, because of which they face several threats. Viz: pollution, encroachment, dumping construction debris, eutrophication, illegal mining activities, ungoverned tourist activities and cultural misuse.

Further, the changing lifestyles, ever-widening consumer products cumulatively has a direct impact on the physical and chemical character of the generated domestic and waste waters. Further reality is, Indian cities have combined sewers carrying treated, partially treated and untreated, domestic, commercial and industrial effluents in a common channel.

Last two decades city witnessing rapid growth, which has bearing in escalating generation of domestic & commercial sewage and solid waste, simultaneously. In the absence of proper urban infrastructure to manage increasing waste waters and solid wastes, cumulatively resulted in pollution of the water bodies. Hyderabad generates more than 1600 mld of waste waters and treats 700 mld, only.

Different opinions are placed, attributing the foam formation to the presence of, Surfactants, Filamentous Bacteria etc. This, bacteria has an inherent property of bulking to form sustained form. It is also argued that the partially digested hydrocarbons in STP / ETP have the potential to induce Filamentous Bacteria in treated waste waters.

Foam formation and its air disbursal are threatening the environmental and human health. The source and chemical character detection are relatively a long-term exercise calls for entire lake catchment studies.

The foam generation could be minimized through reduction and regulation of outflow water’s velocity. This cost-effective technique was adapted at Bellandur and Vartur (two sites) and achieved a result of 90% reduction in form formation through a pilot project, installing temporary structures. Implemented in association with Coir Federation of Karnataka, which was supported by Bangalore Development Authority.
Based on the achieved results, it is recommended to implement permanent structures to ensure complete control of foam. However, due to lapses and delay in decision making towards execution of permanent structures, foam/froth once again during the second week of August, 2017 in Bellandur Lake Bengaluru.

It is recommended as part of crisis management to address foam formation and air disbursal problems. Foam is generating only at the out-flow toe region of the surplus weir. Foam /froth generation is creating panic in the minds of citizens’ and posing environmental & human health challenges.

For the last one and half month period (9th June, 2017 when the first incident was cited), the number of lakes, where foam is forming has increased from one to six. It is likely that the number may increase during the monsoon period.

It is very important for the government to address this issue, explore solution and execute within a short period. Result oriented work on war footing not only saves people from threatening health concerns but also facilitates in reposing confidence trust on the governance system.

Surfactants
Surfactants are compounds that lower the surface tension (or interfacial tension) between two liquids or between a liquid and a solid. Surfactants are used in making detergents, as wetting agents, emulsifiers, foaming agents, and dispersants. Surfactants are the main chemicals used in making soaps, shampoos, detergents, hair dyes, cosmetics and other house hold cleaning chemicals.

The standard limit of surfactant is 1%. Changed lifestyles and increasing use of cosmetics and detergents in the households of the catchment of the lakes and usage of foam washing of automobiles, is resulting in increased outflow of surfactants into the sewage system and such untreated domestic waste waters reaching the lakes could be one of the contributors to foam formation.

As against the standard of 1%, the waters analysis results from lakes, where foam formation is observed has shown that the presence of surfactant levels ranging 2% to 5%.
Filamentous Bacteria:
Filamentous bacteria are one of the Algal species and generally find in contaminated lakes. It thrives actively during Lake Eutrification stage. At this stage one finds complete blue green bloom all over lake waters, with zero dissolved oxygen levels and high levels of BOD, COD, N, P, C, and surfactants.

It is also argued that the partially digested hydrocarbons in STP / ETP have the potential to induce Filamentous Bacteria in treated waste waters. The Filamentous bacteria through microbiological analysis is proved and as per analysis reports, it is present in all the six lakes. Also, the analysis indicates that filamentous bacteria reached threshold levels (10^9), which is above the normal level of 10^6-10^8. It is pertinent to note that filamentous bacteria are found in the Durgam Cheruvu STP outlet treated water sample.

STP treated waste waters carry high levels of carbon and phosphates, reason being STP has inherent limitation to eliminate carbon & phosphates. The released treated waters in water courses/lakes induce imbalance in nitrates and, phosphates. This single cellular micro organism thrives by consuming phosphates and carbon. It has the ability to observe atmospheric nitrogen and has an inherent property of bulking to form sustained foam.

Interesting point to be observed is, foam is forming at the surplus weir outflow site, only. Its intensity escalates depending on the volume & velocity of outflows and has direct bearing during rainy days. Probably due to sudden physical impact and oxidation / aeration process.

Present situation not only induces set of environmental threats but also challenges the performance and efficiency of existing STP, ETP and CETPs. Recent froth / foam formation at lake out flow sites vouches for this fact

Findings of the water sample analysis:
Water samples analysis by TSPCB clearly indicated very high levels of COD, BOD, Nitrates, Phosphates. Dissolved oxygen levels are nil in lake waters. Also, the presence of filamentous bacteria is found in all collected water samples, which indicates that these lakes have reached the “Eutrification” stage. Situation calls for immediate action to restore back not only the identified lakes but also to check the status of other lakes located in the respective lake basins. [Average results in mg/l – COD 178, BOD- 35, N – 24 & P – 20, Ammoniacal Nitrogen – 34, & Surfactants – 34%, against permissible limit of 1%.] [Refer Annexure 1: Analysis Table 1(Pg-20)]
Prioritisation of identified lakes:
Perki, Mukidi [R K Puram], Nacharam Lake, Nalla Cheruvu, Patel Cheruvu, Ibrahimbagh Lake. These lakes are part of different lake basins/watersheds and indicate different land use patterns, pollution and hydraulic loads.

1. Foam/froth formation in Perki lake was observed during the second week of June 2017 and foam generation phenomenon followed subsequently at Ibrahimbagh Lake, Mukidi, Nacharam, Nalla Cheruvu and Patel lakes over a period of one month.

The lake is receiving untreated sewage from several residential colonies including unorganized slums. The lake is completely covered with vegetation. The situation of the lake clearly indicates that the lake is going to extinct as per ecological terms.

Out flows from Perki lake ultimately joins Hussainsagar. Situation indicates alarming warning that Hussainsagar lake may generate froth / foam, in the event of foam formation constituents from Perki lake join the Hussainsagar lake. This lake is situated in the heart of city and its bund is vital conduit connecting two cities, Hyderabad and Secunderabad. Also, an important tourist spot, where thousands of people visit every day. Considering the sensitivity, it is strongly recommended to take up foam controlling measures on war footing, without further delay.

2. Mukidi lake is located within close vicinity of the major middle-class habitation, Rmakrishnapuram. Out flows join Musi river finally. Surplus weir of this lake is very narrow and the weir of the lake is encroached to the extent of 90%. Out flows through the conduit rush with high velocity, however, the water fall is relatively small. The local Rhythu bazaar gets affected.

3. Nallacheruvu / lake out flow structure is located on state high way connecting Uppal to Warangal. Air disbursal of foam pose threat to high commuters and may result in drastic road accident, apart from health & environmental threats. Nachram lake is located in the upper reaches of Nallcheruvu. Situation of this lake needs detailed studies.

4. Patel lake is not located in Hussainsagar basin. However, it is located very near to Hyderabad – Mumbai highway, where thousands of vehicles commute every day. The lake waters finally flows to one of the drinking water sources of Hyderabad, posing a threat to drinking water source.

5. Ibrahimbagh lake is located towards the South of city and is part of Durgam lake basin. The land use in this basin is largely domestic and commercial. However, receives large
volumes of untreated waste waters. Filamentous bacteria is identified in the treated outflow of the Durgam Cheruvu STP.

**Salient recommendations towards implementation of Action Plan:**

**Objectives:**

- Mainstreaming of Lake Protection & Conservation as an integral part of urban planning, development and management.
- Promote effective coordination and SNERGY among the concerned departments / governmental agencies.
- Identify and promote cost effective, energy effective and eco-friendly alternate technologies.
- Empower local governing bodies on lakes & water resources management, including waste waters.
- Promote transparency and ensure active participation of civil society groups, including residential welfare associations.
- Promote integrated multidisciplinary strategies through “Basin Approach”

**Stage – I: Recommendations for immediate consideration:** [Duration – one month].

**Phase – I:**

1. **Organise Institutional Arrangement:**

Going by the experience of non-implementation of recommendations of workshop in 2004 on the decentralized mechanism to address and regulate water pollution concerns, emphasizing the role and responsibilities of local governing bodies in the entire gamut of environmental regulations, it is desirable to put in place an institutional arrangement with Principal Secretary, Department of Municipal Administration and Urban Development to plan, supervise and coordinate concerned departments - HMWS&SB [sewage unit], GHMC [sanitation, storm water & lake divisions] and HMDA [lake & town planning divisions]. State Pollution Control Board as regulating authority for monitoring, evaluation, and sharing of updated information.

[Refer Annexure 1- Institutional Structure Chart: 1 (Pg-21)]
2. **Constitute Expert Committee:**

To offer scientific, viable and cost-effective solutions, it is suggested to constitute expert committee drawing expertise from national scientific, academic and research institutions.

The proposed list of the institutions is:

- Water Resources Department, JNTU
- Regional Centre, Kakinada, National Institute of Hydrology, Rookie
- Expert Limnology, NGRI
- Centre for Environmental Studies, JNTU
- Expert Urban Lake Management, Center for Climate Change, Engineering Staff College of India [ESCI], Hyderabad.
- World Wildlife Fund
- Expert Microbiology, ICRISAT, Hyderabad.

Expert Lake Landscape with wetland species knowledge.

3. **Constitute Interdepartmental Working Group.**

MA&UD may constitute an interdepartmental working group immediately, involving all the lake concerned departments TSPCB, Lake, sanitation & storm waters divisions, GHMC, Sewage division, HMWS&SB and Lake division, HMDA. Constitute a working team. Identify and invite independent professionals and institutions with earlier experience for consultations. [Refer Annexure 1- Working Group Chart: 2 (Pg-21)]

4. **Training Programs**

It is observed that Engineers working urban lakes are on deputation from their parental Irrigation department. There is need to build the capacity of these engineering staff on rapidly changing dynamics of urban hydrology. Realizing this fact, it is recommended that these officers should undergo continual professional training on issues concerned with urban hydrology, particularly in the context of climate change.

Organise training programs for the members of the working group on integrated approaches and team delivery mechanisms. These training programs should be continued as a continuous process to promote & sustain the multidisciplinary learning process.

Also, organise training programs to officers, engineers and elected representatives of the local governing bodies.
Stage – II: Proposed activities under phase – I: [Duration 6 months]


2. Conduct rapid assessment studies on prioritized lake basins. Establish measurable microbiological indicators along with other water analysis parameters, viz Filamentous bacteria and other eutrophication indicators, including Carbon.

3. Minimizing/Control of Foam Formation and Air Disbursal at Surplus Weir: Implementation of foam/froth controlling structures at surplus weir out flows should be taken on top priority. Foam generation is largely due to the sudden physical impact of waste waters out flows. The filamentous bacteria have the inherent bulking nature and turns into sustained foam during oxidation process at the water fall point. More so, high volume with intensive velocity aggravates the situation. Air disbursal of this foam not only creates panic among the people but also poses environmental health hazards. Establishment of source and nature of contamination demands detailed catchment studies and collection & analysis of water samples.

Reorient the surplus weir outflow to ensure a considerable reduction in out flow velocity. This can be achieved by utilizing coir log technology with Vetiver plant. Arrangement of coir logs reduces the intensity of velocity flows and further facilitates in the absorption of contaminated waters to the larger extent. Vetiver placed intermittently facilitates in the absorption of contaminants and purifies the waste waters. Other compatible materials may also be explored to achieve the same desired results.

Application of Coco logs

Coir logs, also known as coir rolls, coconut fibre rolls or coco logs, are tubes filled with loose, but densely packed coconut fibre which is then wrapped with coir netting. Coir logs are light-weight and easy to install – ideal for constructing check structures, establishing vegetation, managing changes in stream flow velocity, shaping channels and stabilising shorelines. Coir Logs are 100% biodegradable, can blend into their surroundings and over time provide habitat for animals and plants, and flexible which can curve around river banks and existing vegetation. Coir logs can be used in open drains to slow water velocity and capture sediments or be used in streams and rivers to produce a natural wall of protection for plants and soil.

[Refer Annexure 2- Recommendations Image: 1&2 (Pg-22, 23)]
5. Alternate Technologies for Lake and Drain Treatment.

Application of Floating Gardens in Polluted Drains and Lakes

The plants interact with the canal water and improve it through a process called phytoremediation, which is the treatment of environmental issues using plants that can rid of pollutants without having to dispose of them elsewhere.

[Refer Annexure 2- Recommendations Image: 3&4 (Pg-24)]

Bioremediation: Application of Diatoms/Enzymes

Diatoms and enzymes out-compete less desirable forms of algae for nutrients in the water reducing harmful blue-green algae and filamentous algae.

Diatoms: Diatoms are one of the reasons life emerged from the swamp. Diatoms are microscopic food power cells (phytoplankton) that convert carbon dioxide, nitrogen and increase dissolved oxygen in the water and at the sediment boundary. They produce more oxygen in their life cycle than they consume. Scientific study confirms that diatoms are the single largest primary producers of oxygen for the planet earth.

Consuming polluting nutrients and releasing dissolved oxygen and oxygen-rich organic compounds and zooplankton which result in a healthy ecosystem and ultimately a thriving aquaculture. They play a dynamic role in nutrient conversion and regulation of ecosystems.

Application Coir Geotextile and Vetiver on Drain slopes and Tank Bunds

Geotextile use in drains can reduce siltation from the banks. Geotextile is often used in water harvesting pits, agriculture, and mines for containing soil erosion. Using Coir Geotextiles in combination with Vetiver because of its inherent nature to absorb nutrients from contaminated waters, can control siltation in the drains & bunds and absorb nutrients from contaminated waters.

Coir based geotextiles have been proven to stabilize soil erosion reducing siltation, water can easily go into the ground helping ground water recharges and surface water table increases. When used in combination with vetiver on the bunds and drain this method can effectively control siltation and reduce water & soil pollution along with recharging the ground water table with clean water.

The design proposed by Coir Federation of Karnataka is recommended. [Refer Annexure 2- Recommendations Image: 5 (Pg-25)]
Application of Solar Aerators

An Aeration system is used in ponds and lakes to essentially increase the dissolved oxygen content of the water throughout the lakes and pond. This aeration can be done several ways: by injecting pure oxygen, mechanically agitating or mixing the water, or injecting air.

When there is aeration, the plant and animal life will thrive because of the oxygen that will be constantly flowing through the water. When the plants at the bottom of the lake are getting a good amount of oxygen, they will grow healthier and the fish that eat the plants will have a good amount of food that is growing.

Solar aerator systems are great for both remote installations and environmentally conscience applications. Solar systems pay for themselves with time, resulting in cost savings over electric-powered aeration systems. These fully automatic systems are designed to run up to 20 hours per day under standard operating conditions. The battery backup system allows them to run like normal under less-than-optimal conditions.

6. Tracking & Establishment of Source Contamination: Collect and analyse water samples from the lakes located in the same basin of the identified foam formation lake sites. Conduct chemical and microbiological analysis. Identify and establish “Signature Track Indicator” of pollutants to identify the source.

Collect, compile and review the available catchments / basin land use information of all the identified lake and establish Catchments Index in terms of physical, chemical and biological characters.

7. Combined Sewer Management:

Last two decades, the urban centres experiencing unregulated & unscientific growth, without proper infrastructure in place. Generation of domestic & commercial sewage escalated to the tune of 70%. Hyderabad city generates 1600mld and presently has the capacity to treat 700 mld, the balance 900mld of untreated waste water discharges into lakes and joins Musi river ultimately. The fact is 90% of the urban areas have combined sewer systems, where storm waters and sewers jointly flow and reach stream/lake. Designing and construction of dedicated conduits for sewers and storm waters is a long process and involves huge capital investment and time. Considering this reality, it is suggested to implement waste water treatment systems in the existing combined storm water – sewer systems, immediately by applying integrated Bio – Engineering systems with silt traps.
In the absence of dedicated storm and sewer drains, both fresh rain waters & untreated waste waters combined flows into the natural drainage. This situation not only pollutes surface & ground water sources but also threatens health of the people. Further pushing the city into a water scarce zone.

More so, the existing treatment systems are not in tune to address the emerging waste waters challenges.

There is a need to review the existing carrying capacity of combined sewers and modify the channel capacity to accommodate mixed flows.

For example, The conduits carrying waters to Ibrahimbagh lake also carries mixed storm-waters and, untreated sewage waters

8. Water Flow Studies: Conduct water inflow and outflow studies, including modelling to establish rainfall, water flows and foam generation intensity behaviour. These studies are most important under the varying rainfall patterns due to climate change.

Install flow measurement devices and meteorological / rainfall stations in consultation with Indian Meteorological department [IMD] and academic & research institutions.

9. Preparation of integrated spatial maps: Prepare an integrated spatial map of the pilot project catchments by overlying watershed details of Lake Basin and Land Use Pattern.

Demarcate flood prone and water pollution monitoring sites.

Phase – II: Duration – 12 to 14 months
Proposed activities:

1. Identify, validate and prioritize cost & energy effective alternate technologies through pilot projects evaluation.
2. Conduct Mid–term evaluation and revise progressive monitoring results. Update the information wherever needed.
3. Identify the gaps in executed pilot projects, reorient the implementation strategy.
4. Initiate a process to establish centralized “Data Bank”. Collection and compilation of land use patterns of all the basins / watersheds covering GHMC & HMDA jurisdictions. Demarcate administrative boundaries on proposed spatial data map.
5. Initiate Lake Basin reporting and management practices.
6. Implement Link Tank Cascade system to regulate flood waters and minimize urban flooding in all the identified pilot projects.
7. Establish each basin’s physical, chemical and biological characteristics.
8. Initiate and establish Microbial indicators of the lake waters.
9. Develop city master plan maps, incorporating the water courses /watersheds / lake basin details.
10. Auditing of existing STP, ETP and CETPs performance efficiency, including energy costs.
11. Identify the gaps and conduct consultative workshops to enhance the capacity of waste water treatment systems by integrating new emerging technologies.
12. Promote water hyacinth management.

Phase – III: Duration 24 to 26 months.

1. Evaluate the implemented projects, identify gaps and reorient the approaches to strengthen the lake restoration and management process.
2. Identify gaps and revise monitoring indicator and implementation approaches.
3. Design & develop replicable models and extend implementation in other lake basin areas.

Phase – IV: Duration – continual

1. Incorporate in the regular annual plan programs.
2. Review all the activities implemented during first and second phases, identify gaps, fine-tune and ensure continual implementation.
3. Identify new areas for interventions and incorporate in the action plans.
4. Ensure flow of information to centralised data bank from all the respective lake concerned departments.

Recommendations

Lake Policy:
1. Present day lake management problems are largely due to poor coordination and ineffective in collective delivery system. It is desirable to have a state policy document on Urban Lake Restoration and Management with specific timelines, implementation guidelines with fixing of responsibilities of concerned agencies for proper management.
2. Establish an autonomous “Lake Conservation and Development Authority”, with Statutory Powers, which should be headed by not less than the administrative cadre of “Additional Chief Secretary”.
3. Review the existing revenue acts and other legal instruments to ensure the clearance of encroachments, if required via an ordinance. Explore mechanisms of alternate dispute resolutions.

4. Design, develop and bring to effect building code for constructions, falling within 2 km radius from the Lake FTL.

5. Explore mechanisms to address encroachments and land Shilkam Patta issues through Alternate Dispute Resolution methods. Also, review possibilities to address such issues through Ordinance.

6. Integrate lake conservation and restoration as an integral component of urban planning and development.

7. Changing urban lifestyles and ever-widening consumer products further complicate the physics and chemistry of present day sewerage. In the absence of regulations on automobile washing & servicing centres, detergents / body wash soaps and gels, hair dyes etc. There is a need to examine waste character of these emerging products and bring out specific regulations on manufacturing and discharge standards immediately, on the larger interest of fresh water sources, immediately.

Presently, CPCB sets the standards for regulations and directs the state pollution control boards to follow. In such a situation it becomes difficult for stake regulating agencies to address emerging pollution challenges. There is a need to empower the state agencies to revive and set local specific standards for regulation as practiced in USA.

Guidelines- Principles and Practices:
1. Restoration and management of lakes should be adapted through basin/sub – basin approach, rather than in isolation.

2. Urban lakes are threatened by encroachments, waste dumping, discharges of untreated waste waters, illegal mining and cultural misuse. However, last two decades they become targets of construction demolition debris. Government should identify demolition recycling and reuse technologies and issue heavy penalties towards such dumpings.

3. Since, land use pattern in catchments has a direct and indirect impact on lake water quality, hydraulics. The physical, chemical and biological characteristics of each sub basin should be scientifically assessed and established. Further, cumulative character of the basin should be established.

4. Pollution loads and catchment character cumulatively should be the guideline factor for prioritizing the order of treatment /restoration.
5. Every urban lake is unique in its character and restoration. The methodology should be tailor made, which falls in tune with the lake basin character. Promote integrated water resources management through urban watersheds approach. Urban lakes are unique and exhibit diversified situations and Water quality of these lakes reflect the cumulative effects of the land use on corresponding watershed areas. No two urban lakes are similar in their nature and behaviour. This very fact makes us to stress special attention and the need to develop locale specific watershed management perspective.

6. Environmental services and economics should be studied and established both at basin and lake levels. This should include the potential for groundwater recharging, flood mitigation capacity, microclimatic regulation and economic benefits.

7. Issues concerned with lake restoration are multifaceted and calls for multidisciplinary approaches through institutional collaborations

8. Develop “Source Water Management” practices and bring out a working guideline manual for the benefit of user departments.

9. Drains are the natural streams connecting two successive lakes in a cascade system. They were the fresh water carrying natural conduits in the pre-urban conditions. All the drains/nalas should be restored back to their original physical status and waste waters treatment should be implemented in the drains to minimize pollution load at lake level. Such a system helps in promoting viable decentralized treatment systems.

10. Biological indicators should be analysed along with water quality studies, including microbiological.

11. Lake centred research studies should be encouraged in collaboration with identified colleges and universities / training institutions on emerging challenges in lake restoration and management. Focus also should be given to climate change impact and vice versa.

12. Set of sustainable lake management practices should be developed as a guideline manual for user bodies.

13. All the restoration works should establish “Measurable Benchmarks / Indicators”, as an integral part of progressive Monitoring and Evaluation. These established indicators and results of monitoring should be placed in public domain.

14. Planned restoration works should be placed for community consultations and should be implemented after seeking the general consensus from the respective lake community.
Alternate restoration plans also should be prepared and made available for community consultations.

15. Review the performance efficiency of existing STP / ETP/CETP in terms of emerging challenges in waste water treatment.

16. Promote cost effective and energy-efficient waste water treatment systems – solar aerator systems, cascading techniques. Implement solar aerator systems in the lake area.

17. Every technology has its core capacity and limitations, considering this fact it is recommended to device and develop Bio–Engineering approaches. Viz: Phyto remediation, bioremediation, roots zone treatment system, coir & Vetiver treatment, including floating and vertical treatment systems.

18. Do not remove Water Hyacinth completely from lake waters. This wetland species had inherent potential to absorb nitrates, phosphates, and heavy-metals from lake waters. In view of inherent benefits in water quality management, it is recommended to harvest Water Hyacinth in a cyclic manner and promote value-added products through conversion technologies.

19. Promote strategies and mechanisms to ensure, decentralized waste water treatment and management systems through local governing bodies, institutions, and gated community complexes.

20. Also, device mechanisms to establish, monitor and evaluate of such decentralized systems through state regulatory agency.

Conclusion
The urban lake concerns are no more limited to Hyderabad and Bangalore. In fact, it is a serious national issue, one can see the problems from Dal lake in the North, Udaipur in the West, Chilka in the East and Bellandur lake in down South.

In view of the perennial water shortage, depleting groundwater reserves, changing climatic conditions and extreme weather conditions year after year. The services of Urban Lakes as surface water resource, groundwater recharge source, and flood control mechanism is more important than ever for sustainable development. India’s commitment on the international platform to address these global concerns through Millennium Development Goals, Sustainable Development Goals, and Paris Agreement is worth mention of the need and will for sustainable development. These commitments will not yield results unless government agencies from the Centre to the Corporation level work in synergy towards common goals.
Annexure 1:

1. Analysis

### ANALYSIS REPORT of R K Puram Lake, Nalla Cheruvu and Pareka

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### Pareka Cheruvu

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Institutional Structure

1. Institutional Arrangement

   Institutional Arrangement
   Principal Secretary
   Department of Municipal Administration & Urban Development
   [Planning & Supervision]
   Pollution Control Board
   [Monitoring & Evaluation]
   HMDA
   Lake Division
   GHMC
   Storm Water & Lake Division
   HMWS&SB
   Sewage Division
   Residential welfare Associations
   Local Governing Bodies

2. Working Group

   PCB
   HMDA
   MA & UD
   HMWS&SB
   LGB
   GHMC
Annexure 2
Recommendations

1. Coir and Vetiver Based: Foam control mechanism for Perki Lake
2. Coco Log

COCO LOGS

SPECIFICATIONS:
Diameter—12”/16”/20”
Density—7 lbs/Cu.ft
Weight—5 to 19.5 lbs
Length—10 ft / 3.05 m
3. TREATMENT IN POND WITH VETIVERA SYSTEM

4. SMALL FLOATINGS PLOT FORM WITH VETIVERA SYSTEM IN DRAIN
5. Coir and Geo-Textile for Bund Stabilization
6. Before and After results of sewage water treatment using vetiver grass

**Sewage effluent infested with Blue-Green algae due to high Nitrate (100mg/L) and high Phosphate (10mg/L)**

**Right: Same effluent after 4 days treatment with vetiver, reducing N level to 6mg/L (94%) and P to 1mg/L (90%)**

Ref -- VETIVER SYSTEM FOR WASTEWATER TREATMENT
Dr. Paul Truong The Vetiver Network and Queensland Department of Natural Resources and Mines
Barbara Hart M.E.C.H. Codyhart Environmental Consulting Pty. Ltd
Site Images

1. Ibrahimbagh Lake

2. Patel Cheruvu
3. Periki Cheruvu

4. Red Chemicals on foam at Periki Site
5. Nalla Cheruvu

6. Ramakrishnapuram Lake