

Status of Wetlands in Bangalore and its Conservation aspects

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Wetlands are among the most important ecosystems, that are valuable as sources, sinks, and transformers of a multitude of chemical, biological, and genetic materials. The interaction of man with wetlands is the first humanizing system initiated in the process of evolution and development of many civilizations. Societies have enjoyed an ancient association with wetlands and have learned to obtain multiple benefits- natural resources, amenities and environmental services.

In recent years, the wetland values are overlooked resulting due to population pressures and unplanned development. This has threatened the very existence of these vital ecosystems. In order to stem the tide of destruction, especially for wetlands located in urban setup suitable guidelines to assess the ecological integrity and effective monitoring programs are required. This includes collecting sufficient information on the various functions, components and attributes of wetlands to reduce the ongoing ecological imbalance. In view of this there is a need to periodically monitor these systems.

Water quality assessment of seven waterbodies located at various places in Bangalore urban district has been monitored for a period of twelve months, based on the findings of the study suitable restoration measures are suggested.

Ecological restoration and ecosystem management is an essential component of any habitat conservation. The management of wetlands has become important because these ecosystems are still being reclaimed or encroached for agricultural activities, aquaculture, for sewage disposal, etc. Hence for developing a site specific management plan for wetlands it is imperative to gather baseline information so as to understand the structure and functions of a wetland. In the recent past the wetlands of Bangalore are drawing considerable attention and concern because of their importance realised. The present paper attempts to identify some of the major threats, wetland face today and make suitable suggestions to draw the attention of to wetland biologists, conservationists, planners and policy makers.

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Introduction:

Wetlands perform numerous valuable functions such as recycle nutrients, purify water, attenuate floods, maintain stream flow, recharge ground water, and also serve in providing drinking water source, fish, fodder, fuel, recreation to the society. The interaction of man with wetlands during the last few decades has been a concern largely due to the rapid population growth- accompanied by intensified industrial, commercial, and residential development further leading to pollution of wetlands by domestic, industrial sewage, and agricultural runoffs- as fertilizers, insecticides, and feedlot wastes. The fact that wetland values are overlooked has resulted in threat to the source of these benefits. In Bangalore wetlands are being lost on account of various anthropogenic activities largely due to shortsighted policies.

In order to curtail the present rate of destruction of wetlands, suitable guidelines are to be formulated to implement effective monitoring programs, involving suitable management strategies. The present paper highlights some of the major problems concerning wetlands of Bangalore and suggests suitable management criteria for sustainable usage of wetlands.

Objectives:

Objectives of this study are to,

- a. Identify major pollution problems of Bangalore wetlands and
- b. Suggest suitable measures for restoration and management of wetlands.

Methodology:

Exploratory surveys involving field visits and literature review were carried out to find out the present status of wetlands and source of pollution at each location. Seven water bodies were selected based on the pollution load and on location of water bodies to assess the present status. Water quality of these selected water bodies was monitored for a period of twelve months on monthly basis. These waterbodies are characterised for the various physico-chemical and biological parameters following APHA (American Public Health Association) Standard Methods. To find out the socio-economic aspects of these waterbodies, stratified random sampling survey of households in the vicinity of these lakes were carried out in order to find out the dependency of the public on wetland's resources. Based on the quality assessment and socio-economic aspects investigation suitable management strategies were suggested.

Results and discussion:

Literature survey shows that Bangalore had about 379 waterbodies in 1973, due to urbanisation it is reduced to about 246 in 1996 [Deepa et al, 1997] with about 81 major waterbodies [Lakshamana Rau et al, 1986]. Recent studies also showed that about 40% of the waterbodies in Bangalore were sewage fed [Krishna et al, 1996]. In view of this the present study attempts to assess the pollution status and draft suitable management strategies for wetlands.

The results of present investigations showed that the most of the analysed parameters of five tanks (Ulsoor, Hebbal, Yediur, Kamakshipalya and Madivala) exceeded the limits set by *Indian Standard for Industrial and sewage effluents discharge (IS: 2490 -1982)*.

The colour of the waterbody was mostly greenish largely due to algal blooms on account of *Microcystis*, due to sewage and domestic effluents. In Eutropic systems the plankton and other dead organic matter in high levels would contribute highly towards an autochthonic turbidity source

Turbidity a significant parameter determining the primary productivity levels is inversely related to productivity. Turbidity in the lakes were noticed mainly due to silt, organic matter, sewage from both industries and domestic and other effluents contributing to turbidity.

The pH values of most water samples showed to range from alkaline, (7.6 - 9.3) to acidic (Kamakshipalya, 6.6). High alkaline values were noticed in Yediur, and Ulsoor. The varying values of pH may be indicative of the entry of acidic or basic industrial effluents.

The dissolved solids consist mainly of bicarbonates, carbonates, sulphates, chlorides, nitrates and possibly phosphates of calcium, magnesium, sodium and potassium. High values of Dissolved Solids are well correlated with the EC of lake waters and can have negative influences on the biological production efficiencies of lake ecosystems. The high-suspended solids ranging from 52.2 to 278.3 mg/L are a result of silt, organic matter in suspension. Autochthonous sources mainly plankton also directly influence the light penetration into the aquatic system and hence affect primary production efficiencies in lakes.

The DO levels were seen to range from 1.2 in Kamakshipalya to 9.1 mg/L in Ulsoor Lake. The DO levels of 5 mg/L are ecologically recommended minimum for sustaining a waterbody. The recommended DO concentration for a healthy and ideally productive lake waterbody as 8 mg/L [Wetzel., 1973]. The high values of DO were noted due to higher photosynthetic activities.

The contents of phosphates were found to be very low in the lakes surveyed from 0.06 to 1.3 mg/L. The standard is 0.2 mg/L for surface inland water [Chakarapani et al, 1996]. This parameter is very crucial and ecologically elusive as it has the tendency to precipitate by many cations occurring in lakes and accumulates at the bottom of the lake inaccessible to the phytoplankton.

The total nitrogen estimated as nitrates ranges from 0.1 to 2.7 mg/L. The standard for inland surface water is 0.1-mg/L [NEERI, 1988]. The parameter is very significant from the algal productivity in lakes.

The analysis of heavy metals of the lake waters indicated that among the metals such as iron, zinc, lead and chromium. Iron and lead were present in greater concentrations than the other two (zinc and chromium).

In order to make a quantitative estimate of the extent of pollution two lakes were selected for detailed parametric statistical analyses. Preliminary investigations of physico-chemical parameters indicate that Yediur lake is highly polluted compared to Sankey. In view of this, Yediur and Sankey lakes with different levels of pollution loads were examined in detail.

The multiple regression analysis of Conductivity, Magnesium, Calcium, COD, Chlorides, Total Hardness verses pH and Sulphates, Magnesium, Potassium, Calcium, Total hardness verses COD for Yediur lake and Sankey lakes were carried out. The results are as shown in the table below. The step wise regression carried out to determine the relationship of various parameters (Conductivity, Magnesium, Calcium, COD, Chlorides, Total hardness) with pH and (Chlorides, Sulphates, Potassium and Total hardness) with COD. The probable relationship for Yediur and Sankey lakes are as given in the table. The contribution by

parameters such as Chlorides, Sulphates and Total hardness are higher in Yediur lake as compared to Sankey owing to pollution from domestic and industrial sectors.

Yediur:

Dependent	Independent	Probable Relationship	'r' value
pH	EC, Mg, Ca, COD	2.00EC-0.06Mg-0.002Ca+0.003COD+8.41	0.90
pH	EC, Mg, Ca, COD, Cl	2.03EC-0.06Mg-0.001Ca+0.004COD-0.0009Cl+8.24	0.90
pH	EC, Mg, Ca, COD, Cl, TH	8.13EC+0.91Mg+0.44Ca+0.003COD-0.0002Cl+0.49 TH+9.15	0.98
COD	SO ₄ , Mg, K, Ca, TH	4.22SO ₄ -51.04Mg+15.33K-12.6Ca+11.68 TH-137.48	0.83

Sankey lake:

Dependent	Independent	Relation	'r' value
pH	EC, Mg, Ca, COD	-1.4EC+0.09Mg+0.03Ca+0.0001COD +4.37.	0.85
pH	EC, Mg, Ca, COD, Cl	-3.54EC+0.05Mg+0.02Ca+0.003COD+0.02Cl+5.24	0.94
pH	EC, Mg, Ca, COD, Cl, TH	-3.03EC-0.005Mg+0.008Ca+0.004COD+0.01Cl+0.01TH+4.6	0.95
COD	SO ₄ , Mg, K, Ca, TH	0.35SO ₄ +5.91Mg+4.22K+1.27Ca-1.44 TH -25.11	0.51

Wetlands conservation:

Loss and impairment of aquatic ecosystem is accompanied by loss in valuable environmental functions and amenities important to humans. Quality assessments of selected waterbodies in Bangalore were carried out in order to assess the present status and to evolve strategies for an ecological restoration. Appropriate ecological restoration mechanisms are to be implemented to regain and protect the physical, chemical and biological integrity of wetland ecosystems. Hence conservation and management would demand for a detailed investigation to correct non point source pollution problems (NPS), socio-economic aspects assessment (wetland valuation). In this context a pilot survey on socio-economic aspects of wetland in Hebbal lake region through a designed questionnaire was undertaken. The study in the vicinity of lake showed that about 90% of the residents surveyed were directly dependent on the ground waters (borewell and wells) for bathing and washings and about 60% depended for the same on alternate days (when there is no BWSSB water supply). The survey also revealed that small percentage (about 35-40%) of the residents were dependent for drinking, cooking purposes and about 20% for fodder (water hyacinth). Two families were dependent on fish for their livelihood. The general public of the area was also concerned with the degree of pollution of the lake due to deteriorating water quality. This has affected not only the human health but also lead to decreased flora and fauna (birds and fish population).

The Challenges of Protection of Wetlands:

Protecting a wetland's existing functions proves to be incredibly complex as it involves minimizing the human-induced changes affecting the natural forces that shape and sustain a wetland, such as its hydrology, climate, biogeochemical fluxes, and species movement [Zentner, J. 1994]. In urban environments pressures created by human activities include fragmenting wetlands with roads, on-road vehicles, impacts from adjacent property, soil compaction, intense farming, waste loading from domesticated animals, pest control treatments, landscaping, and solid waste dumping, are some of the activities affecting the functioning of wetlands. These can be broadly summarized as [Zentner, J. 1994].

- Hydrologic alterations: includes direct surface drainage by ditch-digging, de-watering by consumptive use of surface water inflows, through draw down of unconfined aquifer from either groundwater withdrawal or stream channelisation.
- Increased sediment, nutrient, organic matter metals, pathogen and other water pollutant loadings from storm water runoff and wastewater discharges.
- Changes to the physical characteristics of inflows, affecting the chemical parameters such as dissolved oxygen, clarity, and pH resulting from a variety of activities.
- Atmospheric deposition of pollutants.
- Introduction of exotic plant and animal species.
- Loss of sensitive wetland plant and animal species due to changes in adjacent land uses.
- Loss of surrounding habitat for wetland-dependent species that also requires upland habitat.
- "Edge effect" changes in plant and animal species due to changes in light, temperature, and moisture regimes, and from noise, pesticide drift.

Wetland protection:

Wetlands in Bangalore and elsewhere receive largely untreated runoff from much of the developed urban and agricultural areas. Proper management calls they are protected from such inputs using water quality standards promulgated for wetlands. It is also important to develop and implement strategies for the long-term protection and enhancement of these ecosystems. An identified key element of protection strategy is the physical buffers to minimize edge effects and mitigate water quality impacts on these ecosystems.

1. Assignment of a Designated Use

Urban wetlands provide multiple values for suburban and city dwellers [Castelle, et al., 1994]. The capacity of a functional urban wetland in flood control, aquatic life support and as pollution sink implies a greater degree of protection. At most, passive use by humans (e.g., aesthetic enjoyment, and wildlife observation) can also provide a resource base for people dependent on them. Some of the factors to be considered for setting the designated use and developing a management strategy for wetlands are:

- Wetland type,
- Surrounding land use pattern,
- Cumulative impacts on the wetland,
- Vegetation quality,
- Presence or absence of rare and endangered species,

- Surface water quality,
- Wildlife habitat, and
- Cultural values.

2. *Creation of Buffers zones for Wetlands protection:*

Criteria for determining adequate buffer size to protect wetlands and other aquatic resources depends on [Castelle et al. 1994]:

- i. Wetland functional value - identifying its functional values by evaluating the economic costs.
- ii. Identify the intensity of disturbance, sensitivity of disturbance, adjacent land use etc.
- iii. Buffer characteristics - vegetation density and structural complexity, soil condition.

A fully formed buffer must consider identified pollution problem, resource to be protected, and buffering function to be performed. A buffer zone consisting of diverse vegetation along the perimeter of waterbody, preferably one of natural habitat, stable species serves to perform the following functions:

- Sediment removal.
- Nutrient transformation and removal.
- Metals and other pollutant reduction.
- Storm water runoff reduction through infiltration,
- Reduction of water temperature,
- Reduction of human impacts by limiting easy access and by minimizing edge effects from noise, light, temperature, and other changes,
- Protection for interior wetland species, and
- A barrier to invasion of exotic species (such as water hyacinth).

3. *Community support*

Successful conservation program calls for an active participation of local community. This could be developed through volunteers implementing protective measures from conservation organizations, NGO's, water quality monitoring groups, and citizens' groups of the local community.

4. *Schools and colleges*

Education and training are essential to bring in awareness among public. This needs multidisciplinary-trained professionals. This could be achieved by the involvement of local school and colleges. Physical, chemical and biological characterization of wetlands helps in assessing the status. Restoration and conservation of an aquatic ecosystem requires an integrated, broad-based approach.

The active participation from the schools and colleges in the vicinity of the waterbodies may value the opportunity for hands-on environmental education. This entails setting up laboratory facilities at site to enable the students to understand the complex ecosystem with field exposures. Regular long term monitoring of waterbodies provides a database for further analyses of changes in quality. This helps in evolving suitable strategies for restoration and conservation.

5. Role of regulatory agencies:

Regulatory agencies consisting of representatives from local community and the concerned agencies are to be made responsible for developmental activities. Permitting for fisheries include stipulations, regulations requiring the permittee to submit interim reports of the water quality, fish yield, etc, and the report be made accessible to public.

Wetland Management Issues:

The exploitation of wetlands in recent past has resulted in rendering itself being a threatened ecosystem. The wetland management generally involves activities to protect, restore, manipulate, and provide for their functions and values in emphasizing "no net loss" of its quality and acreage.

The management goals involves not only buffering wetlands from direct human pressures, but also maintaining important natural processes that operate on wetlands that may be altered by human activities. This emphasize long-term sustenance of historical, natural wetland functions and their values requiring effective knowledge on a range of wetland subjects as ecology, economics, management, watershed management etc.

Mosquito control:

Deteriorating water quality owing to pollution over time has resulted in mosquito menace. Decision-makers shortsighted approach ignores the cause and suitable remedial measures. Instead of restoring the water quality, water is drained and converted to layouts for controlling mosquito.

Mosquitoes menace is mainly due to the poor water quality that has resulted in the absence of predators such as fish (*Gambusia affinis*, killifishes (*Fundulus* spp etc.) etc which preys on mosquito larvae. *Bacillus thuringiensis israelensis* (Bti) is one such identified bacterium that is more specific and less toxic than Malathion [Buchsbaum, R. 1994]. An Integrated Pest Management approach involving bio-regulation is possible to control mosquitoes rather than draining wetlands.

Regular Water Quality Assessment and management provides technical hydrologic support and information/data to support programs, through:

1. On line (internet) access to regularly and continuously monitored data;
2. Technical guidance and water quality maps;
3. Case studies of water quality issues;
4. Training on water sampling and field measurements;
5. Spatial and non-spatial water quality database management systems.

Failure to restore Wetland ecosystems will result in sharp increase in environmental costs, later in the extinction of species or ecosystem types, and in irreplaceable ecological damages. The program should also be responsible for the following tasks and activities:

- i. Establish water quality standards for surface waters to protect human health, aquatic life, wildlife, and agricultural livestock; aquifer water quality standards are developed and aquifer boundaries defined to protect groundwater as a drinking water source on regional basis.
- ii. Conduct regular water quality monitoring, including the collection of surface water, groundwater samples and biological samples, laboratory analysis, quality assurance, data management, data analysis, and reporting information involving institutions and colleges.
- iii. Correct non-point source pollution problem and administer the Pollution Prevention Program through the environmental awareness programs involving educational institutions, NGO's, citizen groups etc through mass education programs.
- iv. Forming Interagency Task Force on Water Quality, involving institutions concerned with Wetland conservation groups and local community.

Guide lines to Wetland policy:

A comprehensive policy on wetlands needs to be formulated to enhance the quality of wetlands and increase spatial coverage specific to the region, to offer some of the most environmentally productive and cost effective opportunity for wetland conservation. The objectives should focus on addressing the following aspects [California Wetland Regulation Policy, 1993],

- i. To reverse the current decline in the wetland base, ensuring 'no net loss' and long term net gain. in the quality, quantity and permanence of wetlands
- ii. To encourage partnerships in restoration, management, usage, and have a cooperative planning efforts with the primary focus on wetland conservation.
- iii. Draft procedures for administration of wetland usage and its conservation.

The emphasis is placed on the formation of **Regional Wetlands Forum**, involving local educational, public and private organisations (involved in wetlands issue). For effective functioning the forum should consist researchers, school and college- students and teachers, economists, policy makers, agricultural community, development concerns, conservation organizations, state and local agencies under the collaborative efforts from the Ministry of Forest and Environment, Ministry of Science and Technology, planning departments with the following responsibilities. The policy should address,

1. Defining wetlands, classification (based on degree of saturation, type of vegetation, usage, soil etc), inventory, planning, wetland regulation, and conservation approaches (i.e., acquisition, restoration, management and education).
2. Establish regional and statewide goals to achieve long term increase in wetland acreage, functions and values in emphasizing the economic uses (fishing, agriculture, drinking water supply, etc).
3. Draft programs for preservation, conservation, restoration, and enhance wetlands acreage and provide technical and adequate funding for wetlands program.
4. In the formulation / development of consistent standards and guidelines concerning wetland water quality, mitigation and monitoring of mitigation and restoration efforts.
5. Encourage actions that promote efficiency of wetlands-related 'Permitting processes' for the various usage of wetlands for economic purposes (as fisheries, irrigation etc) by suitable policies, creation of concurrent permit review procedures.

6. Enhancing coordination of state, federal and NGO's responsible in wetland development. Action oriented restoration and conservation programs could be initiated and monitored through discussion meetings of academicians, planning and implementing agencies for providing a platform for exchange of ideas.
7. Help in the development of internal policies within state agencies as irrigation department, Public Work Department, forest department, urban development and others that encourage wetland conservation activities which are compatible with programmatic goals of flood control, ground water recharge, water management, water pollution control, recreation and others.
8. Establishment of inter-agency task force responsible for coordinating and information exchange among the agencies, boards, and departments as necessary to ensure coordinated development and implementation of wetland conservation program.
9. Integrate wetland policy and planning with other environmental and land use process.
10. Cost-benefits analysis of the wetland resources derived by the society and economic evaluation caused due to the loss of wetlands.
11. The forum could act as an advisory to the government in providing funds for wetland research and conservation programs.
12. Formulate Wetland Protection Act as a legislative vehicle to restrict any disturbance of wetlands leading to loss in biodiversity dependent on them.

Conclusion:

Physico-chemical and biological characterization carried out in lakes located all over the city shows that large number of lakes in Bangalore are polluted mainly due to sewage from domestic and industrial sectors. Detailed quantitative investigation involving physical, chemical parameters and statistical analysis of selected parameters indicate that the Yediur lake has higher degree of pollution compared to Sankey tank. The socio-economic surveys carried out in region surrounding Hebbal lake showed high level of dependency for ground water, fodder, fish etc. Higher level of dependency on wetlands and its poor quality calls for an immediate restoration of degraded lakes and appropriate measures for conservation and management in order to maintain ecological balance in the region. Various policy measures including the creation of regional conservation form represented by network of education institution, researchers, NGO's are suggested in this regard to restore already degraded lakes, conservation and management.

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