

# Ecological Research Gaps in Limnological Studies: A Case Study on City of Lakes, Udaipur

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**Abstract:** *Freshwater ecosystems have been critical to sustaining life and establishing civilizations throughout history. The world's freshwater lakes are increasingly threatened by new pressures and the interaction among these new and old stressors. In the rapidly changing environment, the paper emphasises the need to evaluate the state of art of limnological researches. In the present study the City of Lakes, Udaipur is taken as a case study to understand the present status of researches being carried out in relation to fresh water lakes. Most of the limnological researches being carried out are related to physico- chemical analysis, eutrophication and pollution. Much data is available on algal nutrient, sedimentation, phytoplankton etc. But most of the other topics like eco-modelling, lake restoration, growth of invasive species, cumulative impact assessment on land use changes, aquatic -terrestrial habitat relationship are still untouched or are more or less constrained to single lake. Competition for water among different users arising from population increase is certainly limiting the ability of lakes to survive at present and in the near future, particularly in the face of the harsher environmental conditions that climate change is triggering. Thus the present paper aims to identify the research gaps and define criteria to be used to distinguish research able to produce relevant results and predictive model, which are essential for efficient management of fresh water lakes.*

**Keywords:** Research gaps, limnology, pollution, eco- modelling, lake restoration

## 1. Introduction

Fresh water ecosystems are essential for sustainance of human civilization. These are home to many aquatic flora and fauna and also support large numbers of terrestrial species in arid and semi arid areas. Increasing human water needs and extensive land alteration has contributed to the decline of countless freshwater species. Fresh waters are experiencing declines in biodiversity far greater than those in the most affected terrestrial ecosystems. Major threats to global freshwater biodiversity are overexploitation; water pollution; flow modification; destruction or degradation of habitat; and invasion by exotic species [5].

As freshwater ecosystems depend strongly on physical features such as water quantity, quality and flow, many of the threats to these ecosystems involve activities that alter fundamental physical characteristics. Freshwater ecosystems throughout the world are threatened by human activities that directly alter system hydrology, such as construction of physical barriers to flow, water extraction, and filling or draining of shallow habitats. Pollution of waterways with toxic substances and excessive nutrients, as well as destructive land use practices in areas surrounding freshwater ecosystems, lead to reductions in water quality. While the above threats directly affect physical features of freshwater ecosystems, the introduction of exotic species primarily affects native biota.

The invasion of freshwater ecosystems by non-native species is rapidly becoming one of the most serious threats to freshwater communities. Overexploitation of animals associated with freshwater ecosystems, particularly freshwater fishes, is also a continuing problem. Penetration of harmful UV-B radiation into water bodies is increasing in

many areas due to interactions between a number of anthropogenic factors, and a range of negative impacts on freshwater communities may result due to this.

Freshwater ecosystem helps in managing two of the greatest human concerns associated with climate change i.e. floods and droughts. The freshwater habitats temporarily store flood waters which can substantially reduce downstream damages as well as may recharge ground water aquifers, which can be a critically important source of water during droughts. The present work aims at evaluating the state of art of limnological researches and exploring research gaps in the freshwater lakes of Udaipur.

## 2. Study Area

Udaipur established as capital of Mewar in 1559 by Maharaja Udai Singh faced scarcity of water because of its geographical situation and hence artificial lakes were constructed by past rulers to assure water supply. These lakes were interconnected ensuring proper utilization of water and natural cleansing of lakes. The city also known as "City of lakes" is dependent on its lake system, which is directly, or indirectly the life source of the city in terms of surface water resources, tourism, and the ecosystem at large. Most of the tourists (domestic as well as foreign) come to the city primarily because of placid beauty of the lakes. The lakes attract increasing number of young adventurous tourists' especially foreign tourists who provide foreign exchange thus strengthening the local economy. Lakes thus form the backbone of the city's economy.

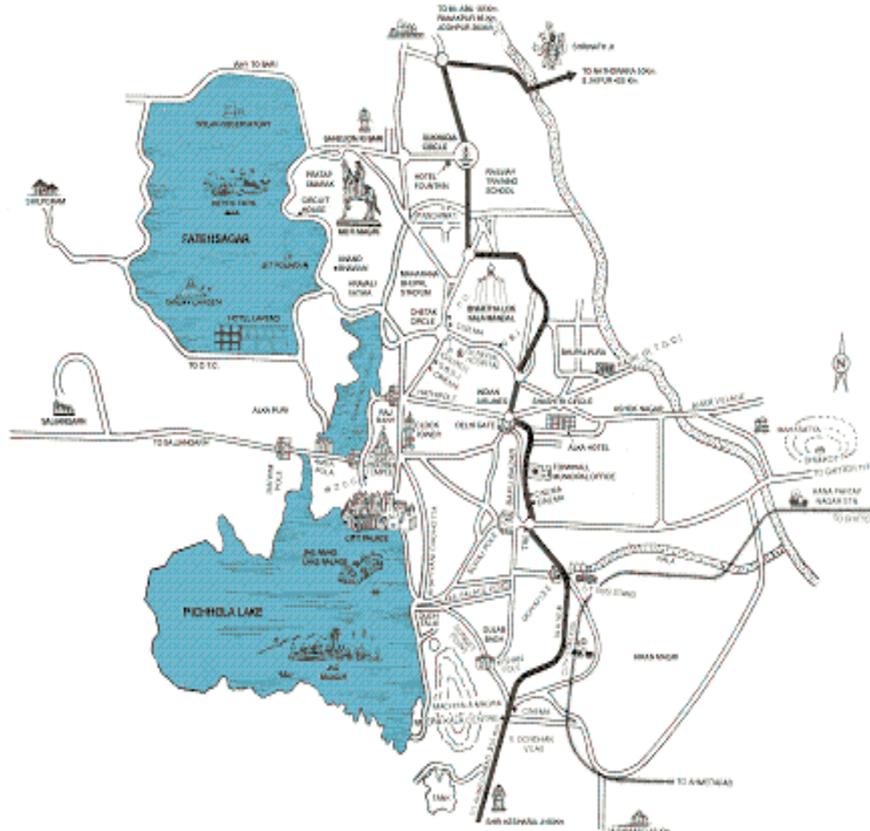


Figure 1: Map showing major lakes of Udaipur

### 3. Result and Discussion

#### Issues and Challenges

Aquatic ecosystems provide food and habitat for diverse plant and animal communities and contribute to biodiversity. Migrating species depend on the distribution of various habitats for refuge and survival. Deforestation increases peak flows and reduces low flows, contributing to flooding during some months and water shortages in others. Habitat destruction, particularly that caused by water infrastructure development is a major cause of freshwater biodiversity loss.

Once the sponges of urban area, today urban lakes have turned into hazards that get choked even with low rainfall and overflow into the blocked canals during high rainfall causing floods in the city. It is the disappearance of these sponges of the city that has exacerbated floods and sharpened the pain of drought. Considering the present bleak water scenario of Indian cities, today we need our urban lakes and wetlands more than ever.

There are six big and about 100 small lakes in and around Udaipur city. The lake system in Udaipur support and sustain large numbers of aquatic species, groundwater recharge, drinking, agricultural, industrial, ecological water availability and employment to 60% population through tourism. The physical setting of the city enhances the flow of pollutants into the lakes. It has hills on all the sides rising from 20 meters to 150 meters. Thus the natural drainage leads towards the lake complex from all the sides. With the uncontrolled increase of the density of habitation around the

lakes, they have become a substitute for a sewage system. About 6000 cubic meters of sewage and 40-50 tonnes of solid waste material find their way daily into the famous lakes of Udaipur. As many as 2000 odd people defecate daily on their shores. All open drains and sewer lines of localities in the vicinity of the lakes housing about one lakh residents, terminate directly into the lakes.

The increased commercial activities have also contributed considerably to the water pollution. Many hotels are constructed in the vicinity of lakes or even within the lakes. Many small shops have come up around the lakes to cater to the tourists. Most of the Hotels located on the lake slopes release all sorts of dirt and drain water into the lake complex. Ill- maintained boats spill oil into the lake waters. The growing number of motorized boats increases fuel pollution of the lake waters – both from accidental leakages and deliberate dumping of waste oil into the lake. This can be fatal to many aquatic animals and plant species. Noise pollution and wave action of the motor boats can harm banks and over time can cause irreparable damage to their micro-ecology. The boating activity has spread an oil layer in the waters near Navghat, Piplighat of Pichola and boat booth of Fateh Sagar. [8]

Anthropogenic pressures in the lake catchment results in degradation of the catchment area from such causes as deforestation, extensive agricultural use and consequent erosion and increased silt flows, which vitiates the quality of lake water. Infrastructure development, housing pressure and encroachments have caused all urban lakes to become hypereutrophic. The sewage and agricultural waste may increase the percentage of Nitrogen and Phosphorous into

the lake waters. This in turn can cause bloom of algae, bacteria and plants in the epilimnion zone. These two elements basically increase the botanical fertility of lake water and lead to intermittent, but luxurious growth of Water Hyacinth. Toxic blooms, as well as bacterial contamination and heavy metal pollution, may significantly impair all the water uses and represent a health risk of the urban population.

Human settlements and public effluent sources are the chief factors for degradation of lakes, particularly urban lakes, in India. There has been a tremendous population increase during the last century, without a corresponding expansion of civic facilities, resulting in lakes and reservoirs, especially urban ones, becoming contaminant sinks.

The lake city of Udaipur was once famous for its lake habitats. Recent studies have revealed that the number of aquatic bird species has declined within the past five years. Many migratory bird species are not visiting the lakes now. The sighting of some residential bird species has also become difficult. The pollution load of the lake has been increased. With the habitat loss due to siltation and reclamation for construction, the nesting and breeding sites of many birds are affected. Noise pollution on the shores of the lake due to vehicles and tourist activities is also responsible for decline in number of bird species. Recreational activities, tourism and water sports on large scale are also disturbing the birds. [1]

While superficially, the beauty of Udaipur is un-smearred, the heavy siltation after deforestation has reduced the depth of the lakes to a quarter of which it used to be 40 yrs ago. [3]

### Lake Researches

Studies on limnology of Udaipur lakes have been made covering different aspect [15][17][20][21][22]. Author started working on limnology of these lakes since 1974. Majority of these researches have been carried out in universities and government institutions mostly on individual basis and confined to their objective and interests. Most of the current research focuses on eutrophication, physico chemical analysis, microbiological studies, bioaccumulation of heavy metals etc.

Studies related to eutrophication revealed that Udaipur lake system is degrading very fast primarily through cultural eutrophication. Decreasing amount of water level indicated that the lakes are rapidly getting silted due to extensive deforestation of the catchment. All lakes have become so shallow that in the case of low rainfall over a few years, they will totally dry up [21]. Lakes are receiving large amount of organic pollutants like detergents etc., some of the industrial effluents. There is a considerable decrease in Dissolved oxygen level and alarming rise in nitrate and phosphate levels. There is rapid increase in trophic production which shows rapid rate of eutrophication. Algal blooms have become a perennial feature [20],[23],[19],[15],[2],[3]. During the last fifty years there has been progressive decline in biodiversity and some faunal species are on the verge of extinction [19] Researches related to eutrophication have been carried out in all most all the major lakes of Udaipur

but there are very few works suggesting measure to eradicate or minimize eutrophication [21]. Physico chemical analysis and limnological studies have also been carried out in lake picchola [19],[21]Lake Fatehsagar[7],[10] Swaroopsagar, Udaisagar [12]

Plankton is the most sensitive floating community which is being the first target of water pollution, thus any undesirable change in aquatic ecosystem affects diversity as well as biomass of this community. The measurement of plankton productivity helps to understand conservation ratio at various trophic level and resources as an essential input for proper management of lake. Much study has been done on algal flora, cynobacteria etc. in Udaipur lakes [12],[20],[22],[23],[25].

### Research Gaps

There is a need to identify gaps in terms of research and management. There is also need to identify the focus areas in the current scenario. There are serious gaps in water quality monitoring. Currently there is no effective comprehensive monitoring program for data collection. More accurate information is required to design protection schemes for freshwater ecosystem.

Presently lakes in Udaipur are in varying degrees of environmental degradation. Despite knowing their environmental, social and economic significance, city planners have willfully neglected and destroyed these water bodies. Today these water bodies are encroached, full of sewage and garbage. Because of unplanned urbanization, much of the landscape around the lakes has been covered by impervious surfaces. As a result, instead of rainwater, it is the sewage and effluents that are filling up urban water bodies.

There are several ways to assess water quality in water bodies, the most common methods focus on physical and chemical properties. Physicochemical properties which provide snapshot of the condition of a water body do not provide the integrative measures of overall health of a water body with time. Monitoring the status and trends of freshwater biodiversity provide a more accurate understanding of changing aquatic conditions than chemical and microbiological data, which gives short term fluctuations. It also helps in the development of effective conservation strategies. Current researches assessing freshwater biodiversity tend to be spatially and taxonomically limited and uncoordinated. The studies mainly emphasize on better-known groups such as fish, planktons few types of algae etc. Focus should also be given on taxa which are still untouched or limitedly studied like Periphyton, Macrophytes, benthic fauna which includes Arthropods, Molluscs etc.,

Inventories and maps showing the array of freshwater species should be prepared. This information gap makes it impossible to precisely determine the rates of loss of freshwater biodiversity or provide accurate estimates of the conservation status of major taxa or individual species. Addressing this issue is therefore an important immediate priority. A lack of taxonomic expertise and the downgrading

of basic taxonomic research and education could be appropriately termed the 'second crisis of biodiversity', the 'first crisis' being the unprecedented rate of biodiversity loss. Intense efforts should be made to survey freshwater biodiversity and assess the extent and impact of habitat changes on intact native faunas. There is a pressing need to synthesize these existing data and to focus targeted research on other freshwater organisms and ecosystems to better understand patterns of freshwater biodiversity and the processes and mechanisms underlying global-scale changes.

A comprehensive study of nutrient dynamics is lacking in limnological studies. The nutrient transfers along food chain, internal dynamics, release by death and decays as well as nutrient transformation within water column and sediments have been rarely studied. Key information gaps include data on mechanism of nutrient transport, nutrient and mineral retention capacities, biomagnifications and bioaccumulation of pesticides in food chain etc.

Aquatic microbiology of lakes also needs attention and requires detailed research in studies of bacterial population which includes nitrogen fixing and denitrifying bacteria. Aquatic fungi pathogenic to plants fish and humans also needs to be studied.

The integrity of aquatic ecosystems is being challenged worldwide by invading species, so there is a growing need to understand the invasion process and to predict the success and effects of invading species. The general result of deliberate introductions has been termed the 'Frankenstein Effect' because so many well-intentioned introductions have had unexpected consequences, usually negative (Moyle et al., 1986). The need to increase our ability to predict the consequences of invasions and to understand invasion processes has been emphasized by the enormous economic and social costs of some recent invasions, the growing interest in halting biodiversity loss, and the increased difficulty of managing ecosystems subjected to repeated invasions. The human - assisted spread of non - indigenous fishes and aquatic invertebrates, microbes and plants has had strong ecological impacts in lakes and rivers worldwide. Cumulative invasions have disproportionately transformed freshwater communities such that they are dominated by non -indigenous species to a greater extent than their terrestrial counterparts [14].

Species loss, habitat degradation and invasive species collectively require global scale assessments - a critical foundation for management strategies on the identification of keystone species, or on freshwater systems with rich endemic faunas. Remote sensing technologies should be applied to freshwater biodiversity assessment and monitoring, and identify priorities sites for conservation. Use of predictive modeling in freshwater systems will help in identifying those sites that are the most susceptible to human/invasive species impacts and/or those most in need of protection. New surveying and mapping techniques should be applied to provide species and ecosystems distribution data that can aid conservation strategies and inform public policy.

Another area which is lacking advanced research is understanding and minimizing the impact of land use changes in the catchment areas of the lakes. Although the impacts have been studied by many researchers they should aim at preparing models to forecast impact of land use changes on water bodies and strategies to minimize them. The potential impact of land use alteration on the nitrogen, phosphorous and carbon biochemistry requires much research. Cumulative impact of eutrophication, nutrient enrichment and development activities needs to be focused.

Unprecedented rates of warming due to climate change observed in recent decades threaten to undermine the functioning of natural ecosystems, especially when combined with the myriad additional anthropogenic stresses to which many fresh waters are subjected. Climate change itself represents a complex amalgam of stressors, including alterations in temperature elevated atmospheric CO<sub>2</sub> and increased frequency and intensity of droughts and extreme flow events [28]. Interannual and regional variability in the distribution of precipitation is already high; if this variability increases in complexity and scale as expected, cascades of interconnected and cumulative impacts will alter regional hydrology and ecosystem capacities to supply reliable sources of high-quality freshwater. Freshwaters are particularly vulnerable to climate change because (i) many species within these fragmented habitats have limited abilities to disperse as the environment changes; (ii) water temperature and availability are climate-dependent; and (iii) many systems are already exposed to numerous anthropogenic stressors. The different components of climate change (e.g. temperature, hydrology and atmospheric composition) not only affect multiple levels of biological organization, but they may also interact with the many other stressors to which fresh waters are exposed, and future research needs to address these potentially important synergies.

Tourism is often not included as a major land use when it comes to stakeholder management groups, because it is diffuse and it is often perceived to be harmless. Yet, tourism is an important water resources user amongst residents and other industry sectors. In this context it is thus important that the tourism industry adopts a sense of ownership over the natural resources it exploits. Impact of lake tourism on Udaipur lakes requires extensive research so that sustainability of these freshwater ecosystems is maintained and they continue to have aesthetic value which in turn will promote tourism industries.

#### 4. Conclusion

Despite the dramatic growth in the understanding of freshwater ecosystems in recent decades, many analyses indicate that the magnitude, complexity and urgency of freshwater environmental problems are increasing rather than decreasing. This suggests that the researches in ecological sciences are not sufficient in addressing the wide range of sustainability problems. Understanding important lake processes and comparative studies of lakes at grass root level are essential for better understanding and future planning of lakes.

Limnological studies in Udaipur show that eutrophication is the major problem of lakes in Udaipur. Extensive and detailed research is required to find out measures to minimize eutrophication and maintain the ecological balance of the water bodies. A comprehensive and continuous monitoring system should be developed and data should be maintained which could be used by the limnologists to carry out advanced research. There should be coordination between various research units and government organization and efforts should be taken to link knowledge to action which will help in development of conservation plan and maintain the beauty of the lakes which are major source of revenue for the city.

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