CHAPTER 1: INTRODUCTION

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1.1 What is an urban pond?

An urban pond is generally described as a surface water body of a smaller size, manmade or developing from its natural origin. Urban India depends heavily on various types of water bodies to meet its daily requirement of water. Fresh water is the critical, finite, vulnerable, renewable resource on the earth, and plays an important role in our living environment, without it, life is impossible. Lakes and ponds are the habitat of great importance to humans as they provide water for domestic, industrial and agricultural use and also provide food. A large number of people use these surface water sources for bathing, cleaning and for their other requirements. In spite of their fundamental importance to humans, fresh water systems are adversely affected due to different set of stressors at the local level, this may cause many water borne disease to the surrounding inhabitants.

There are different types of inland surface water sheets (lentic and lotic) existing in the state which include freshwater lakes, village ponds/tanks, countryside ponds, reservoirs, marshes, paddy fields, dams, canals, rivers and streams. Of the various types mentioned above, village ponds and the countryside ponds are abundant in the state

(htpp://www.wetlandsofindia.org/wetlandwila/index.php/Gujarat).

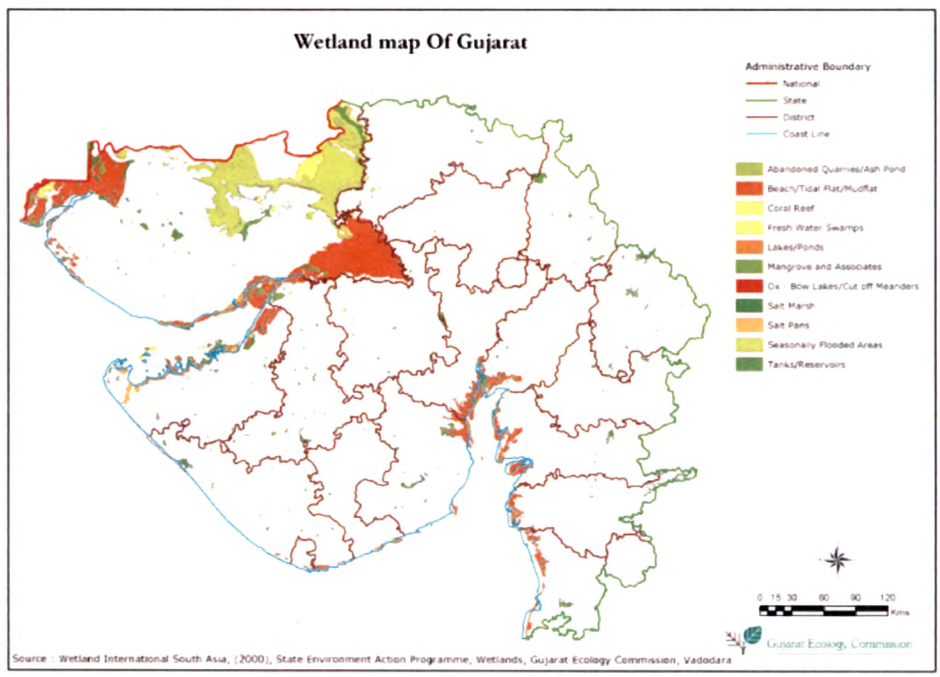
They dominate the rural landscape of Gujarat (Table 1.1). The rural Gujarat is dotted with numerous natural, semi-natural and man-made ponds of varied shapes, size and depth (Fig. 1.1). Though many of them are seasonal, they play an important role for human activities and provide habitat to various molluscans, fishes and numerous resident as well as migratory birds.

Table-1.1: Distribution of various categories of inland wetlands in Gujarat.

INLAND WETLANDS	AREA (sq.km)	PERCENTAGE (%)
LAKES	153.81	7.35
OXBOW LAKES	1.81	0.09
WATERLOGGED (SEASONAL)	288.75	13.81
MARSHES/SWAMPS	49.56	2.37
RESERVIOURS	1,393.75	66.62
TANKS	197.94	9.46
ABANDONED QUARRIES	5.31	0.25
COOLING PONDS	1.13	0.05
Total	2,092.06	100.00

(Source: SAC, 1998)

Fig-1.1: Rural Gujarat dotted with numerous natural, semi-natural and man-made ponds of varied shapes, size and depth.



(Source: Wetland International South Asia, 2000; GEC)

1.2 Types of impacts on urban ponds

Contamination of freshwater environment is an inevitable consequence of anthropogenic activities. Discharge of unusual concentration of domestic sewage into the aquatic bodies increase the nutrient level and they all are unable to recycle themselves which leads to trophic status alterations finally leading to eutrophication. Ponds found in villages are polluted due to human habits. Bathing activity releases organic matters which accumulate in the pond. Those who live by the side of the ponds use its bank as their latrines and indirectly contaminate the pond water. People wash their clothes and utensils and thus pollute water. Such pollution not only makes the water unfit for consumption but ultimately causes mosquito menace. Urban expansion transforms local environments and can dramatically alter local conditions and in particular the rate of movement of pollutants into waterways, thereby adversely changing the water quality of urban ponds. The disposal of untreated urban sewage in to open water bodies is common in most developing countries. This poses potential negative consequences to public health.

Studies of urban pond ecology have mostly concentrated on physico-chemical characteristics. Since the beginning of the industrial revolution, increasing human population, economic activities as well as shortcomings in the management have resulted in more pollutants being introduced in the water sources. Therefore, increasing number of surface water bodies have come under serious threat of degradation. The global freshwater resources are under increasing pressure (GWP Technical Advisory Committee, 2000). The

anthropogenic impact on aquatic ecosystems has become a crucial topic of increasing concern. These problems have led to the adoption of an integrated approach which is termed as Integrated Water Resources Management (IWRM).

Ponds, rivers and streams are a valuable freshwater resource, irreplaceable, priceless asset providing important habitats and corridors for nature conservation, recreation, amenity and economic growth. Normally over any short time interval in a pond not subject to human influence there is a balance, more or less between nutrient inflow and outflow. In recent times, the faulty developmental policies and mismanagement of surrounding areas of a pond have resulted into unprecedented nutrient enrichment of water bodies causing trophic alteration manifested by raised trophic status, increased rate of sedimentation, loss of water storage capacity, lowered retention period and deteriorated water quality, and finally ending up as eutrophicated pond. The water quality in ponds, rivers and streams may vary depending on the geological morphology, vegetation and land use (agriculture, industrialization and urbanization) in its catchment. Such anthropogenic activities produce nutrients (sewage, effluent and fertilizers) and toxic substances, such as organic and inorganic pollutants, and other chemicals including heavy metals. Water pollution occurs when such substances, which degrade the water quality of river, enter the waterway and alter their natural function (Water and Rivers Commission, 1997).

The physico-chemical characteristics of any aquatic ecosystem and the nature and distribution of its biota are directly related to and influenced by each other and controlled by a multiplicity of natural regulatory mechanisms. However,

because of human exploitation of the water resources, the normal dynamic balance in the aquatic ecosystem is continuously disturbed, and often results in each dramatic response such as depletion of fauna and flora, fish kill, change in physico-chemical characteristics etc. (Bhatt et al, 2009). Of all the natural resources needed for sustainable development, fresh water is one of the most essential. The physical and chemical characteristics of water bodies affect the species composition, abundance, productivity and physiological conditions of aquatic organisms (Bagenal, 1978). Ponds, lakes and reservoirs around the globe are critical components in the ecological system. They provide habitat and food for many species of fish and wildlife and are also a source of process water to a myriad of industries (Dinar et al, 1995).

The pond water offers the same range of important services to nearby urban and rural populations as large lakes but unfortunately is more susceptible to pollution. Where ponds and lakes have been profoundly altered and have lost much of their value, the scientific understanding of these water bodies is being used in prescribing restoration methods (Lewis, 2000). Studies on water quality mostly center on fish production and aquatic biotic integrity (Abohweyere, 1990; Boyd, 1982; King, 1998). The notable important physico-chemical parameters are transparency, dissolved oxygen, temperature, suspended solids and dissolved ions (Karr and Dudley, 1981). However the usage of water by humans for survival is as important as that of aquatic organisms residing into it.

1.3 Importance of surface water sheets

Ponds basically are surface water sheets. Surface waters (rivers, streams and ponds), groundwater, rainwater and springs are the main sources of water available to the rural settlement dwellers. The qualities of these water bodies vary widely depending on location and environmental factors. Ponds have been used since time immemorial as a traditional source of water supply in India (Bhuiyan and Gupta, 2007). However, the water of the ponds, lakes and rivers are polluted mainly due to discharged waste from residential areas, sewage outlets, solid wastes, detergents, automobile oil wastes, fishing facilities and agricultural chemicals from farmlands (Hasan et al., 2007;Srivastava et al., 2003; Usha et al., 2006). In recent years, their importance has somewhat declined due to technological advancements leading to more centralized water supply systems. There is a relationship among ecologists and micro planners about the importance of conservation of ponds as sustainable source of water for rural communities (Park and Park, 2005). The aquatic bodies are extensively polluted leading to impacts on abiotic and biotic components.

The lakes and reservoirs, all over the country without exception, are in varying degrees of environmental degradation. The degradation is due to encroachment, eutrophication (from domestic and industrial effluents) and silt load influx. There has been a quantum jump in population during the last century without corresponding expansion of civic facilities resulting in lakes and reservoirs, especially the urban ones, becoming sinks for contaminants.

1.4. Review of Literature

Lakes and ponds are the most beautiful and expressive features of landscape and have played a very important role in the development of mankind. These aquatic ecosystems are vital to economic and social wellbeing of the people. Throughout India there are a number of lakes, ponds and tanks (approximately about 2 million). Each district of India has a number of lakes and ponds. It is the matter of great concern that in the wake of urbanization and industrialization, water bodies have degraded to a great extent.

In India the area under tanks and ponds has been estimated at 24.54 lakh ha and the resources are widely spread throughout length and breadth of national landscape. The Karnataka state has one of the richest of the nation's inland water spread area of about 6.31 lakh ha that comprises of 61 reservoirs, 4695 tanks, 2180 minor tanks and other smaller sheets of water (Thippeswamy et al, 2008). Alone in Konkan areas of the west coast of India there are about 60000 ponds (Bhandari, 2007). The lakes like the Dal lake of Srinagar, Hussainsagar of Hyderabad, Royal Pichola lake in Udaipur, lake in Udhagmandalam, all have turned eutrophic (with high nitrogen and phosphorus content). The city of Mumbai depends heavily on few lakes like Vihar lake, Powai lake etc. for its drinking source. Therefore dependence on these lakes is enormous. But in spite of various administrative actions the lakes are getting polluted day by day.

The series of ponds found in the district of south 24 Paragnas of West Bengal from Gana to Bariapur are considered sacred by people living around. These ponds are full of polluted water, unfit for human consumption and a major

breeding ground for various types of diseases carrying mosquitoes (Ghosh, 2002). Owing to the unplanned development and urbanization, the ponds of city Lucknow are struggling for their existence. The city sewage discharge, agriculture urban runoff and continuous dumping of waste materials especially sanitary waste are affecting the water quality of these urban water bodies. Lack of appropriate management practices is also responsible for degeneration of man and fresh water bodies. The Padamlaya lake of Jalgoan, Maharashtra has degraded due to disposal of plastic bags, bottles and other waste materials by the tourists (Patil et. al, 2004). Disposal of garbage by the tourists visiting the wetlands was observed at Takhatsagar reservoir of Jodhpur and two religious ponds of Basukinath Dhama at Dumka, Bihar (Kumar & Bohra, 1998).

Story of lakes in India is more or less the same depending on the urbanization and industrialization. The eutrophication status in all lakes has been assessed using phosphate data which showed that Mansor, Surinsor and Tsomoriri are under eutrophic condition, Dal, Tsokar and Renuka lakes are under hyper-eutrophic condition. The eutrophic condition of Hussainsagar Lake is attributed to various activities taking place near and in the lake like discharge of domestic waste, washing clothes, vehicles, and immersion of idols at the time of Ganesha festival (Sunella et al, 2008). The Sursagar lake in the heart of the city of Vadodara is also polluted due to it's over exploitation and garbage dumping. This lake is main to receive Ganesh idols after Ganpati festival.

The lakes of Europe and North America have become highly polluted. There was eutrophication of lakes due to influx of agricultural nutrients and detergents into

lakes in Europe. The Great Lakes of North America were similarly affected by the discharge of domestic wastewaters. Lake Biwa in Japan was degraded by domestic sewage (Okamura, 2008). Elsewhere also, lakes have suffered severe degradation in different ways. Detail studies on a few major lakes in Malaysia show different level degradation. Deterioration of water quality and water quantity was reported in all three biggest natural lakes in Malaysia; the Lake Bera (Chong, 2007), Lake Chinni (Mushrifah,2007) and Loagan Bunut Lake (Rahim Nik et al,2007). High coliform and fecal coliform were of concern in Lake Chinni. In 1968 the University Of Florida Department Of Environmental Engineering initiated an extensive survey of the physical, chemical, and biological characteristics of 55 lakes in north and central Florida. The investigation had five main objectives: to determine the basic limnological features of lakes in the region; to assess the present water quality (trophic state) and characteristics of the lakes and provide baseline data for future studies. (Shannon and Brexonik, 1972)

Sediments are indicators of quality of overlying water and its study is a useful tool in the assessment of environmental pollution status (Kumary and Azis, 2006). Present study concludes that pollution in and around the wetlands of Bhopal city not only affect the water quality but also the quality of soil. Untreated sewage and city garbage which is coming to the lakes is responsible for decreasing soil quality. Decrease in soil quality shows the extent of pollution in water of these wetlands. In the United States, soil quality includes soil fertility, potential productivity, resource sustainability, and environmental quality. In

Canada and Europe, contaminant levels and their effects are the primary factors determining soil quality.

Plankton is considered as one of the most important linkage in aquatic food chain and play a major role in energy transfer. *Branchionus* sp. is very common in temperate and tropical waters, which indicates alkaline nature of water bodies. Rotifers are prominent group among the zooplankton of a water body irrespective of its trophic status. Zooplankton concentration and distribution are sensitive to physical and chemical changes in water. The knowledge of their seasonal qualitative and quantitative flucations has been considered essential for proper manipulation of the factors influencing biological productivity of the water lands. Interrelationship of physico-chemical and biological condition have been investigated in various lakes by a number of workers like Ghosh (1919); Ganapati (1940); Govind (1963); George (1976) and Agarkar (1967).Kausik and Saxena (1995) have also reported abundance of genus *Branchionus* in various water bodies of central India. Molluscans are of great significance because they form the food of fishes and their productivity play an important link in the food chain. The length - weight relationship is an important parameter in fish biology for physiology; ecology and fisheries assessment. A length-weight relationship gives information on the condition and growth patterns of fish. Consequently, length-weight studies on fish are extensive.

The presence of indicator organisms (Escherichia coli or thermo tolerant coliform bacteria) in water indicates recent contamination of the water source with fecal matter and hence possible presence of intestinal pathogens (Murage and Ngindu, 2007). The degree of bacterial contamination of 99 Florida lakes

was studied using total coliform and *Escherichia coli* (*E. coli*) counts as indicators (Mark, 2006).

The bacterial contamination was also found in the seven important North Indian Lakes (Sharma et al, 2010).

On the other hand, the aquatic bodies have been considered for conservation under various programs like National Wetland Conservation and Management Program (NWCMP) as well as the Ramsar Convention etc. Gujarat has extensive wetland area, although distributed largely in Kachchh district (about 80% of total). Many of these wetlands are regularly monitored for the quantitative status. The analysis of certain important ponds distributed in different regions of Gujarat suggests important findings (Table-1.2).

Table-1.2: District wise Distribution of wetland categories in Gujarat state (area in ha)

Districts	Wetland Category - Area		Total area	% of area
	Up to 300	Above 300		
Amreli	3409.01	15557.86	18996.87	0.63
Ahmadabad	12654.65	15052.57	27706.57	0.92
Banaskantha	15402.97	--	15402.97	0.51
Bharuch	7104.04	60859	67963.04	2.33
Bavnagar	4889.98	64512	69401.98	2.30
Gandhinagar	354.83	--	354.83	0.01
Jamnagar	9370	97830.33	107200.33	3.55
Junagarh	5360.99	20572	25932.99	0.68
Kheda	19244.78	44117.50	46041	1.46
Kachchh	26775.16	2381012.11	2407778.27	79.62
Mehsana	3700.76	--	3700.76	0.12
Panchmahals	32829.18	--	32829.18	1.09
Rajkot	8471.17	18643.15	27114.32	0.90
Sabarekhanth	20431.76	--	20431.76	0.68
Surat	5460.9	71653.02	77113.92	2.55
Surendernager	120.76	14944.4	15065.16	0.93
The Dang	1238.5	--	1238.5	0.04
Valsad	4625.09	30089.22	34714.31	0.56
Vadodara	5567.08	11261.00	16828.08	1.00

(SACON wetlands report, Gujarat, 2007)

It is interesting to note that some of these are urban ponds and some are declared protected areas (Table-1.3).

Table-1.3: Status of water quality of lakes /ponds of Gujarat

	pH	TDS	DO	BOD	COD	Ammonical N_2	Total N_2	Phosphate
Thol tank,Khadi	7.3	582	9.6	14.6	102	1.49	3.54	0.078
Nal Sarover,sanand	8.1	2271	8.9	4.5	40	0.84	2.14	0.033
Monsar lake, Viramgam	8.9	3148	9.4	23.3	216	1.01	6.53	1.702
Bindu sarover, Sidhapur	7.5	685	7.1	25.0	109	0.42	4.62	0.593
Kankoria lake,Ahemdabad	8.2	763	5.6	6.6	51	1.40	4.01	0.230
Chandola Lake, Ahemdabad	8.5	564	8.0	5.0	165	0.84	8.40	0.262
Malav pond, Dholka	8.5	984	11.0	27.0	157	1.40	4.57	0.133
Sayaji Sarovar, Vadodara	8.2	155	8.3	5.4	19	1.12	1.75	0,084
Sur sagar Lake,Vadodara	8.0	1680	8.0	9.9	77	-	2.73	0.160
Gomati Lake	8.2	176	4.8	6.0	22	4.76	2.87	0.03
Dabhoi Lake ,Daoi	9.6	932	7.9	15.0	146	3.92	4.20	0.12
Rana Pratap sarover Halol	8.1	423	11.2	9.1	68	1.96	1.82	0.18
Ramsagar Pond, Godhara	8.2	390	6.7	7.7	101	3.36	5.39	0.22
Lalpari lake ,Rajkot	7.6	290	10.7	3.2	70	4.48	6.62	0.65
Lakota pond Jamnagar	7.5	572	15.5	-	10	0.84	2.20	0.67
Narayan Sarover, Kachchh	8.7	786	7.0	6.2	30	0.56	-	0.48
Bore pond, Bhavnagar	7.9	206	8.1	2.0	10	1.05	2.24	0.65

All parameters in mg/l except pH (Source: Alagh et al., 1995)

In India, 94 wetlands are identified under National Wetland Conservation and Management Programme (Table-1.4).

Table-1.4: State wise distribution of wetlands under National Wetland Conservation and Management Program

States	Wetlands	Area (ha)
Andhra Pradesh	1	90100
Assam	2	4504
Bihar	3	11490
Chandigarh	1	148
Gujarat	8	1270875
Himachal Pradesh	5	15736
Haryana	2	288
Jammu and Kashmir	7	117325
Jharkhand	2	98965
Karnataka	7	4250
Kerala	5	213229
Madhya Pradesh	12	359814
Maharashtra	3	40298
Manipur	1	26600
Mizoram	2	285
Orissa	4	122580
Punjab	3	5648
Rajasthan	1	24000
Sikkim	6	164
Tamil Nadu	3	46283
Tripura	1	240
Uttar Pradesh	9	12083
Uttaranchal	1	800
West Bengal	5	553090

Of these, 8 sites are located in Gujarat (Nal Sarovar Bird Sanctuary, Greater Rann of Kachchh, Thol Bird Sanctuary, Khijadiya Bird Sanctuary, Little Rann of

Kachchh, Pariej, Wadhwana and Nani Kakrad) (MOEF, 2007).

Although the vicinity of towns and cities are urbanized, the ponds are still a traditional component of villages. Several of these ponds have drastically shrunk but others are utilized for various domestic activities. The village ponds in some parts of Gujarat are also used for fish culture. Since the ponds are used for domestic purposes and for domestic waste discharge directly into it, these have become highly polluted. They are at times eutrophicated or infested with weeds and over the decades these have degraded as natural resources. But with the expansion of cities and inclusion of the surrounding villages within the city limits, the scenario has changed rapidly.

Among the various cities in Gujarat, Vadodara and Ahmedabad are identified as primary sites for initiation of urban wetlands revival and restoration (WISA 2002).In some of such ponds around Vadodara water quality studies have been carried out earlier which indicated conspicuous reduction in dissolved oxygen, high levels of phosphates, increase in hardness and alkalinity and alteration in pH (Verma, 2011).

There are 82 wetlands within the VUDA limits. Out of this total 82 wetlands, 56 are perennial and 26 are seasonal. About 34% of the wetlands fall under the Jurisdiction of Vadodara Mahanagar Seva Sadan (VMSS), while other wetlands are under the jurisdiction of village Panchayats. Due to religious values attached to some of these wetlands, immersions of clay / plaster of paris idols during various festive seasons are common. Apart from these, the temples authorities or worshippers dispose wastes like coconut shells, flowers, plastics and other

materials directly into the water body. Due to such practices, the organic content of these water bodies' increases which degrades the water quality and finally becomes responsible for the deterioration of the ponds. The dumping of solid wastes accumulates at one corner of the pond and starts degrading. The rural ponds have better water quality as compared to urban ponds (GES, 2008).

Vadodara city has over 30 water bodies as a part of its hydraulic network. Some of them, like Sursagar have been provided with masonry walls. The quality of water in most of the lakes is not suitable for human consumption. In few cases, there is no aquatic life and weed growth is abundant. Lakes provided with masonry walls are found to be in depleted conditions and require major restoration. Slums have also developed on the banks and in some cases, even the tank bed is encroached upon. The garbage dumping has further degraded the environment leading to unhealthy living conditions for the slum dwellers and people in the near by vicinity. The growing urbanization and the demand for more housing and transportation have led to a decline in urban greens and water bodies. A similar situation exists here with the water bodies; these have reduced nearly by half, from 4.38 sq. km in 1991 to 2.77 sq. km in 2005, causing concern (GPCB Report). The increase in slum population has also led to a proliferation of illegal encroachments on public and open spaces, reserved land and recreational land. If this trend continues, i.e. if the recreational areas, water bodies, and greenery reduce, the city would deteriorate both in terms of the quality of life index as well as on environmental parameters. It is thus imperative to strike an

ecological balance by taking appropriate steps to rejuvenate the greenery and restore the water bodies of the city.

Regular sampling is done to analyze the quality of major water bodies within and outside the city of Vadodara (GPCB, 2005). The quality of major water bodies, which are also the source of water supply to the city, is detailed below in (Table-1.5).

TABLE-1.5: STATUS OF major water bodies in Vadodara city (2004-2005).

NAME & LOCATION OF LAKE/TALAV	pH values	TDS (mg/l)	DO (mg/l)	BOD (mg/l)	COD (mg/l)	NH_3 (mg/l)	PO_4^-
Sursagar lake	8.1	2186	4.6	07	45	2.24	0.13
Shri SayajiSarovar	8.27	128	8.7	2-5	03	1.12	0.04
Standards	5.5 to 8.5	500-2000	6-8	2-4	10		

(Source: GPCB Annual Report 2004-2005)

The testing of the water of Sursagar Lake in the city is done by the GPCB regularly. The lake is mainly used as a recreational area. The physical parameters over the period 2004-05 indicate excess total dissolved solids (TDS), very high bio-chemical oxygen demand (BOD) and chemical oxygen demand (COD) content and low levels of Dissolved Oxygen. This makes the lake unsuitable for aquatic life. Construction activities within the lake have also led to an increase in the

level of dissolved solids in the lake. The waste generated from the recreational activities around the lakes also pollutes the lake.

The Sayaji Sarovar at Ajwa has been the first drinking water supply reservoir of the city is still functioning effectively. Water drawn from this sarovar is treated at the Nimeta Treatment Plant before being supplied to the city. The physical and chemical characteristics of the Sayaji sarovar were tested by GPCB. The annual average values for the various parameters for 2004-05 are given in Table-1.5. The values indicate a low level of TDS and slightly high Dissolved Oxygen content (GPCB Report, 2009).

Chhani urban pond near Vadodara city is being used for sewage disposal without any kind of treatment. Because of presence of various pathogenic bacteria, the pond is not useful for any purposes; further due to this the area experiences breakouts of cholera and every year (Soni et al, 2008).

Lakes and ponds, which served the basic needs of society and provided a healthy environment, are in misuse and are turning into health hazards. It is therefore imperative to preserve and revive these water bodies and also protect the water quality.

1.5. Aims and Objectives

The investigation was carried out to study the limnological aspects of the ponds with their seasonal variations in response to changing physicochemical and biological factors of the pond.

To achieve the aim of the present study following major objectives were set forth and appropriately approached.

1) Evaluation of physicochemical status of pond.

These water resources were utilized for several domestic purposes by surrounding inhabitants. To understand possible impacts of urbanization and anthropogenic activities on such ponds, water and soil samples from identified sub-sites were collected for detailed analysis of their physico-chemical properties.

2) Assessment of Biotic component.

The biodiversity status of the ponds is an important component for establishing relationship of ecological status. The biotic component was estimated and reported as taxonomy of various plankton, molluscans, fishes etc. Plankton community structure is an indicator of biotic status as well as pollution status of the ecosystem. A variation in community diversity and species density was recorded. The taxonomy of molluscs from two different ponds and their relation to parasitic diseases to humans was analyzed. The morphometric analysis was

done for the inhabiting fish population to understand productiveness of the ponds.

3) Anthropogenic relationship for water body.

Public health hazard is envisaged always when any water body is under the influence of human interference. The possible impact in the form of waterborne diseases etc. were analyzed through generating data from health camps for water borne disease in the surrounding settlements.

1.6. Lacuna

Abiotic and biotic status studies of freshwater bodies have been major component of limnology. Although the size, usage and variability of inputs differentially influence the quality of aquatic body, researchers have mostly investigated routine physico-chemical properties of the aquatic systems. Research reports on ponds highlights the impact of pollution and other factors on limnology, however many are lacking the holistic view of the pond as well as the health status of the surrounding slum inhabitants.