CONSERVATION AND MANAGEMENT PLAN OF KAYLANA LAKE, JODHPUR

A DISSERTATION

Submitted in partial fulfillment of the requirements for the award of the degree
of
MASTER OF TECHNOLOGY
in
CONSERVATION OF RIVERS AND LAKES

By
SEVA RAM

ALTERNATE HYDRO ENERGY CENTRE
INDIAN INSTITUTE OF TECHNOLOGY ROORKEE
ROORKEE -247 667 (INDIA)

JUNE, 2012

CANDIDATE'S DECLARATION

I hereby declare that the work which is presented in this seminar titled, "**MANAGEMENT and CONSERVATION PLAN OF KAYLANA LAKE**", submitted in partial fulfillment of the requirement for the award of the degree of Master of Technology in "**Conservation of Rivers and Lakes**" in **Alternate Hydro Energy Centre, Indian Institute of Technology Roorkee,** is an authentic record of my own work carried out under the supervision and guidance of **Prof. H. Sinvhal , Dept. of Earth Science**, Indian Institute of Technology Roorkee, Roorkee (India).

I also declare that I have not submitted the matter embodied in this dissertation for award of any other degree or diploma.

Date: 19/06/2012
Place: Roorkee

(Seva Ram)

CERTIFICATE

This is to certify that the above statement made by the candidate is correct to the best of my knowledge.

Jun 11/12

(Prof. H. Sinvhal)
Dept. of Earth Science
Indian Institute of Technology,
Roorkee – 247 677

ACKNOWLEDGEMENT

I wish to express my profound gratitude to **Dr. Arun Kumar**, Alternate Hydro Energy Centre, Indian Institute of Technology, Roorkee and **Dr. R. P. Saini, Head,** Alternate Hydro Energy Centre, Indian Institute of Technology, Roorkee, **Dr. M. P. Sharma,** Associate Professor, Alternate Hydro Energy Centre, Indian Institute of Technology, Roorkee, Dr. D. K. Khatod, Associate Professor, Alternate Hydro Energy Centre, Indian Institute of Technology, Roorkee, for providing all the facilities which have made it possible for me to complete this report. The cooperation they gave is greatly appreciated.

I heartily like to acknowledge my sincere gratitude and indebtedness to Dr. **Harshavardhan Sinvhal,** Professor, Department of Earth Sciences, Indian Institute of Technology, Roorkee, for the precious guidance and kind information, continuous help and the affectionate treatment.

I would also like to thank Shri Mahesh Kumar, Superintendent Engineer, Nagar Nigam, Jodhpur and AE, Kaylana, Takht Sagar PHED, Shri Rathore, ACF, Forest Department, D.F.O. Wild Life Division, Jodhpur, Shri Anoop Kumar, R.O. Machia Biological Park for their support and untiring guidance.

Special mention has to be made of all my colleagues and office of the Chief Engineer JDA Jodhpur, field staffs of Machia Biological Park for their constant support and help and for providing me all the information that I needed, in time.

Finally, my sincere regards to my family, friends and staffs at the department who have directly and indirectly helped me in completing this report.

Dated: 11/06/2012

(Seva Ram)

ABSTRACT

Jodhpur is one of the most important city of Rajasthan. It was founded by Rao Jodhaji in 1452 AD. The area is very much prone to drought generally and famine occurs at 3-5 years intervals. Therefore water conservation has been a necessity of the people in Rajasthan. Jodhpur is very famous for water conservation and management efforts. There are many water bodies in the walled city of Jodhpur and at the out- skirts of the town. The Kaylana is located at out- skirt of Jodhpur. It is a manmade lake constructed by an earthen dam in the year 1932. Earlier water was collected by the rain through the lake catchment but now there is continuous flow of water from the Rajeev Gandhi lift canal that originates from the Indira Gandhi Canal. The city of Jodhpur is supplied by water from the Kaylana and Takht Sagar. Takht Sagar is at lower elevation to Kaylana and source of water for Takht Sagar is also from Kaylana Lake

Lakes in general are subjected to anthropogenic pressures leading to a state of eutrophication due to direct addition of nutrients and opening of nutrient cycles which exceed the resilience value of the lake systems thereby adversely affecting the water quality and delimiting the use of water besides causing siltation and reduction in depth of lakes. The present work is aimed to study the Kaylana and Thakt Sagar in Jodhpur and prepare conservation and management plan for them. The lakes offer an excellent opportunity for luxuriant proliferation of fisheries and avifauna. It makes possible the study of parameters defining water quality within the lake **(In-Situ)** and catchment area **(Ex-Situ).**

The objective of National Lake Conservation Plan is to develop a national level policy and action plan with particular focus on urban lakes. It envisages a comprehensive and holistic approach for water bodies' conservation. The socio-economic development of the people dependent on the lake ecology shall also be fully integrated. The National Lake Conservation Plan is envisaged to play an important role in restoration of lakes.

Main stakeholder of the two lakes in Jodhpur and its catchment area are State Forest Department, Wildlife Division, Public Health and Engineering Department,

Tourism Department and Fisheries Department. Thus conservation and Management of Lakes is an important activity for all the above departments and public in general.

The conservation and management plan based on actual field investigations, measurements and statistical analysis with detailed literature review aims pragmatically at landscape management encompassing combination of both the lake and its contributing catchment area with conflicting interest by optimization of Ecology and Economy. It sets to harmonize by trading off between traditional uses of resources and shrinking habitat for wildlife and suggests as far as possible remedial eco-friendly solutions for sustainable augmentation and utilization of resources.

The Lakes are very important not only for the purpose of water supply but for tourism sector too. In the catchment of Kaylana, the Machia Biological Park is being developed where zoo of Jodhpur has to be shifted in near future. The lakes in the region also attract a large number of migratory bird species which come from Eurasia in the winter season. There are many indigenous birds also in these two lakes i.e. Kaylana and Takht Sagar.

For the conservation and management of water bodies' comprehensive integrated plan is to be developed. For the water quality analysis samples have taken from different 21 points. Total twenty parameters are being analyzed. In water body periphery management, different activities in catchment and surrounding can be developed. Shore line plan development of lake like walking trails, cycle trails, and horse path may be developed. In order to attract tourists to the lake, infrastructure required like hotels, recreation parks, fishing point, car parking etc may be constructed. Over all development of Machia Biological Park for the recreational and educational purposes is proposed to develop by the state forest department. The mined areas near the outlet of the canal which feeds the water to the lake should be reclaimed and massive plantation is to be carried out. The biotic pressures have to be minimized in the catchment. The water bodies near the lake and also in the catchment have to be restored in planned ways.

The level difference between the intake of the water passage and the points where it joins Takht Sagar is about 7.0 m. It can be used for the generation of power for which the

water quantity is to be assessed. There is no data available regarding the discharge. The power generated from the discharge from Kaylana Lake to Takht Sagar can be used to partially meet the local power needs of the area.

Present study could not cover the estimation of storm runoff, sediment transfer rate, water balance of the lake and biological trophic index which could have been more result oriented. Further study is needed to cover these topics.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS

ABBREVIATIONS	DESCRIPTIONS
BOD	Biochemical Oxygen Demand
COD	Chemical Oxygen Demand
DO	Dissolved Oxygen
TOC	Total Organic Carbon
MLD	Million Liters per Day
CPCB	Central Pollution Control Board
TC	Total Coliform
FC	Fecal Coliform
TS	Total Solids
TSS	Total Suspended Solids
TP	Total Phosphate
TN	Total Nitrogen
SOI	Survey of India
NLCP	National Lake Conservation Plan
DEM	Digital Elevation Model
WQ	Water Quality
WHO	World Health Organization
PHED	Public Health and Engineering Department
CD	Collar Diameter
DBH	Diameter at Breast Height
IGNP	Indira Gandhi Naher Paryojna
STP	Sewerage Treatment Plant
DPR	Detail Project Report
AE	Assistant Engineer
DFO	Divisional Forest Officer
RO	Range Officer
JDA	Jodhpur Development Authority

CHAPTER 1

INTRODUCTION

1.1 GENERAL

Lakes require management of their physical resources such as water and their biological resources such as waterfowl, fish, wildlife and vegetation such management require an enhancement of the resource or its reduction which will take care of problems like over-fishing, fuel and forage removal, over-grazing, and weeds. Second, lakes are managed for specific problems which generally originate from anthropogenic activities such as siltation and pollution, further; lakes are also managed for their non-resource values such as recreational and aesthetic values. A general guiding principle of management is that the essential characteristics of the system should not be altered, especially to the detriment of another desirable value. Lake management requires proper management of not only the lake but also its catchment with which it interacts directly. The control of siltation and eutrophication essentially requires the management of upland catchment areas. The waterfowl and other wildlife which depend at least periodically on the terrestrial vegetation in catchment areas, also demand management outside lake boundaries. Another guiding principle of management, especially in view of the "wise use" strategy, is that traditional human use and management must be treated as a part of natural interactions between adjacent systems, and should form an essential component of the management plan [1].

The Machia Biological Park is being developed at the periphery of the Kaylana Lake. The satellite zoo is under construction in the biological park. The excreta and waste water of the animals is to be properly disposed off to maintain good sanitation. Appropriate sanitation infrastructure is to be provided for the increasing tourist population due to the proposed biological park. Thus the management plan of Machia Biological Park is very essential at the same time.

The major hurdle in the protection of lakes today is the reconciliation of short-term human interests with the interests of fauna and flora. These interests are seen to be, and sometimes are, contradictory. With the increasing growth of human population and the progressive decrease of wilderness areas, this conflict of interests is becoming

more and more visible, and more difficult to resolve. Catchment area of lakes is affected by a number of physical factors, usually termed 'natural' phenomena, such as forest fires, floods, droughts, water pollution, epidemics of flora and fauna, water and climatic phenomena such as hot winds, gales, cyclones, frost and hailstorms, besides, human interventions. The activities like mining, passage of roadways and railway tracks through it, power channels and army ammunition dumping and illegal encroachments have always been a threat to the lake conservation. The interaction between human populations and wilderness area is fundamental to human civilization. In fact, human beings are as much an integral part of nature like any of the other animals or plants. Human activities in and around catchment areas cannot, therefore, be prima fascia considered undesirable. What is undesirable is the reduction in the carrying capacity of the ecosystem by excessive destruction of habitat of fauna and flora. This is unfortunately becoming increasingly common due either to increasing of human population some of which are no longer sustainable due to decline in carrying capacities of natural systems. Obviously it is neither desirable nor possible to alienate the people living in and around the lake areas, most of who are poor and draw sustenance from the natural resources around them. However, if they and the rest of humanity have to have a continued and sustainable interaction with nature, it has to be ensured that these areas are not progressively degraded. In a country like India, the management and control of human activities in and around catchment areas of lakes are of great importance. Attempts have been made to relocate part or all of this population from the catchment, as a means of reducing human pressure in catchment and on the lake.

Jodhpur has experienced rapid urbanization resulting in the pressure of increased population on the biotic resources of the lake ecosystem. Due to increased felling of trees and excessive grazing, there have negative impact on the fauna in the catchment and also on the aquatic life. It is therefore necessary to prepare a conservation and management plan of the lake.

1.2 Importance of Lake and Water

Water is cyclic resource which falls from the clouds, seeps into the soil, flows through aquifers, runs along stream courses, and eventually returns to the clouds. This natural cycle is the base of all life forms and of the economy of society. Moreover,

water in its basin is part of a complex ecosystem consisting of the land, plants, aquatic and other life forms and their interaction. Lakes as one part of water are one of humanity's most important resources; often viewed as highly productive biological systems. Lakes provide water for consumption, fishing, irrigation, power generation, transportation, recreation, disposal of wastes, and a variety of other domestic, agricultural, and industrial purposes.

Water's natural cycle is the base of all life forms and of the economy of society. Moreover, water in its basin is part of a complex ecosystem consisting of the land, plants, aquatic and other life forms and their interaction. Water covers 70.9% of the Earth's surface, and is vital for all known forms of life. On Earth, 96.5% of the planet's water is found in oceans, 1.7% in groundwater, 1.7% in glaciers and the ice caps of Antarctica and Greenland, a small fraction in other large water bodies, and 0.001% in the air as vapor, clouds and precipitation. Only 2.5% of the Earth's water is freshwater and less than 0.3% of all freshwater is in rivers, lakes, and the atmosphere. Water on Earth moves continually through the hydrological cycle of evaporation and transpiration (evapotranspiration), condensation, precipitation, and runoff, usually reaching the sea. Evaporation and transpiration contribute to the precipitation over land.

Safe drinking water is essential to humans and other life forms. Access to safe drinking water has improved over the last decades in almost every part of the world, but approximately one billion people still lack access to safe water. Some observers have estimated that by 2025 more than half of the world population will be facing water-based vulnerability. Water plays an important role in the world economy, as it functions as a solvent for a wide variety of chemical substances and facilitates industrial cooling and transportation. The global human population has an annual net increase of more than 70 million, or a project net increase of about 1.5 billion by 2025. Globally, human population growth is very rapid in some water stress nations. Pollution and aquatic habitat destruction, directly linked to human economies and population growth, are increasing and consume water, thereby reducing per capita supply. So restoration and conservation of fresh water system is essential way of adding to a sustainable, high quality water supply and to the beginning of stabilizing or increasing the per capita supply.

1.2.1 LAKES

Lakes are the most dramatic and picturesque features of our global landscape, have rich endowment of resource values, and are major components of the hydrologic cycle. They sustain human livelihoods, support economic activities, provide habitat for biodiversity, and offer important aesthetic and spiritual values. They also provide buffering capacities against hydrologic and climate fluctuations, as well as being sinks for inflowing materials collected across their basins. To be more specific, it performs recycling of nutrients, purify water, and serve to provide drinking water and fish, offer recreation to the society. In addition, it acts as a habitat for innumerable aquatic flora and fauna.

Lakes are a very general term used for anybody of standing water, generally large enough in area and depth, but irrespective of its hydrology, ecology and other characteristics. Small water bodies are usually called ponds. Lakes as one part of water are one of humanity's most important resources; often viewed as highly productive biological systems. Lakes provide water for consumption, fishing, irrigation, power generation, transportation, recreation, disposal of wastes, and a variety of other domestic, agricultural, and industrial purposes.

Lakes require management of their physical resources such as water and their biological resources such as waterfowl, fish, wildlife and vegetation such management require an enhancement of the resource or its reduction which will take care of problems like over-fishing, fuel and forage removal, over-grazing, and weeds.

Second, lakes are managed for specific problems which generally originate from anthropogenic activities such as siltation and pollution, further; lakes are also managed for their non-resource values such as recreational and aesthetic values.

1.2.2 Catchment area of lakes

Catchment area of lakes is affected by a number of physical factors, usually termed 'natural' phenomena, such as forest fires, floods, droughts, water pollution, epidemics of flora and fauna, water logging, and climatic phenomena such as hot winds, gales, cyclones, frost and hailstorms, besides, human interventions. The

activities like mining, passage of roadways and railway tracks through it, power channels and army ammunition dumping and illegal encroachments have always been a threat to the ecology of lakes. The interaction between human populations and wilderness area is fundamental to human civilization. In fact, human beings are as much an integral part of nature like any of the other animals or plants. Human activities in and around catchment areas cannot, therefore, be prima fascia considered undesirable. What is undesirable is the reduction in the carrying capacity of the ecosystem by excessive destruction of habitat of fauna and flora. This is unfortunately becoming increasingly common due either to increasing of human population some of which are no longer sustainable due to decline in carrying capacities of natural systems. However, if they and the rest of humanity have to have a continued and sustainable interaction with nature, it has to be ensured that these areas are not progressively degraded.

1.2.3 LAKES OF RAJASTHAN

The state of Rajasthan is primarily known for its magnificent forts and palaces. However, there are quite a few lakes and rivers that quietly make their presence felt among the tourists because of their pristine beauty, opportunity for water sports and also for other useful purposes. While some of the lakes are a gift of nature to Rajasthan, others have been carved out in the earth's surface by the efforts of man. Rajasthan has many scenic and natural lakes which were used to store water for drinking and irrigation. Most of the beautiful and picturesque lakes of Rajasthan are artificial and serve as drinking water source and also to conserve rainwater. The major lakes in Rajasthan are Lake Pichola, Fateh Sagar Lake, Rajasmand Lake, Ana sagar lake, Gadisar lake, Pushikar lake, Sāmbhar lake, Pachprada lake and Kaylana lake.

Lakes are important feature of the earth's landscape which are not only the source of precious water, but provide valuable habitats for plants and animals, moderate hydrological cycles, influence microclimate, enhance the aesthetic beauty of the landscape and extend many recreational opportunities to humankind. The lakes are also used for supply of water for drinking, irrigation, fishing, eco-tourism etc.

1.2.4 ENVIRONMENTAL STATUS OF LAKES IN INDIA

All over the country, the lakes and reservoirs, without exceptions, are in varying degrees of environmental degradation which is attributed to the encroachments,

eutrophication (from domestic and industrial effluents) and siltation. There has been a quantum jump in the population during the last century without corresponding expansion of civic facilities converting the lakes and reservoirs, especially, in the urban areas, as sinks for the contaminants/pollutants.

1.3 Water quality maintenance:

Lakes help to maintain the quality of water for human consumption, agricultural uses and fish populations by capturing and stabilizing sediment and toxins and removing nutrients like nitrogen and phosphorous. Reduced water flow due to low gradients and the friction effect of vegetation, favors the sedimentation process and nutrient storage in sediments. Plant growth removes nutrients from the sediment and captures it for long term storage in woody species. The different problems of the lake include excessive influx of sediments from the lake catchments, discharge of untreated or partially treated sewage and industrial waste waters/solid waste, entry of diffused nutrients source from agricultural and forestry, improper management of storm water, over abstraction, overexploitation of lake for activities like recreation, fishing, encroachment, land reclamation etc causing lake water shrinkage, shoreline erosion and impacting the lake hydrology, deteriorating water quality, impacting bio diversity, bringing climate changes etc therefore, an immediate need to know the pollution status of a lake at given time so that necessary conservation activity may be undertaken to regain/improve the health water body.

Water quality, including sediment removal, is important to critical areas such as fish spawning habitat, navigation channels, drinking water supplies (surface water), flood control reservoirs, and ground water recharge sites.

1.3.1 Eutrophication

A water quality concern with lakes and reservoirs is eutrophication, a natural aging process in which the water becomes organically enriched, leading to increasing domination by aquatic weeds, transformation to marsh land, and eventually to dry land. Eutrophication can be accelerated by human input of nutrients. Die-off and settling of plant growth results in sediment oxygen demand, which tend to decrease dissolved-oxygen levels. The effects of eutrophication, which is detrimental to aquatic life, are compounded by large day-night excursions in dissolved oxygen due to photosynthesis

and respiration. The process of eutrophication and its relationship to nutrient inputs is complex. In lakes and reservoirs, phosphorus is typically the limiting nutrient, although the presence of nitrogen is also important. A simple criterion, which can be used in conjunction with the fully mixed analysis described previously, is that algal blooms will tend to occur if the concentration of inorganic nitrogen and phosphorus exceed respective values of 0.3 mg/L and 0.01 mg/L. Several forms of nitrogen occur in waste water [2]. Each form is often analyzed to determine the total nitrogen content of both influent and effluent samples in domestic and industrial wastewater's. These analyses assist waste generators in their determination of treatment efficiency and allow for the determination of impacts on receiving streams as effluents are discharged. The different forms of nitrogen and phosphorus are refereed to collectively as nutrients.

1.3.2 Eutrophication Types:

1. **Natural Eutrophication:**

Natural eutrophication is especially occurring in small lakes which are drying up. If the epilimnion/hypolimnion ratio increases during sedimentation, a state can be reached when the oxygen content in the hypolimnion is not sufficient to oxidize and mineralize the dead organic material. The organic carbon and total phosphorus is increased, and the lake becomes eutrophic and finally a swamp Natural eutrophication shows enhanced sensitivity of smaller lakes to any change in input of nutrients of environmental conditions. The first natural eutrophication that can be observed within the sediments of larger Austrian prealpine lakes occurred due to increasing values of organic carbon, as well as of phosphate and a contemporaneous decrease in carbonate content within the sediments. [2]

2. **Cultural Eutrophication:**

It is simply an unnatural acceleration of eutrophication. This unnatural acceleration is brought by the dumping of nutrients and organic wastes into the system. Actually cultural eutrophication can be beneficial to many aquatic systems. Cultural eutrophication also creates problems, however, if the system of interest is not properly managed and in particular if the increased production levels and associated effects are incompatible with other uses of the system that are considered more important. Human activities within reservoir catchments affect nutrient levels in the inflow waters and

accelerate eutrophication which is mainly manifested by the increasing density of phytoplankton. The eutrophication entails deterioration of water quality as well as in water treatment when it is used for water supplies for domestic and industrial purpose, It impair the aesthetic and hygienic qualities of the reservoirs, involve mortality of fish by oxygen deficiencies and leads to secondary contamination after the decay of algae.

3. Man-made Eutrophication:

The introduction of modern agriculture with its rising nutrient input after World-War II and the subsequent increase of tourism without adequate treatment of wastewater led to further increase, especially of phosphate input, both to lake waters and sediments. More scientific investigations, technical measures and financial investments are necessary either to stop the excessive nutrient input into the lakes/reservoirs or to restore them by internal measures. There is no alternative to devoting a greater percentage of our intellectual and financial resources to fresh waters [2].

1.4 Eutrophication and physio-chemical characteristics:

Parameters such as depth, transparency, dissolved oxygen, dissolved solids, specific conductance etc. are directly or indirectly related with the biological productivity. These be used to evaluate trophic status of lakes on the basis of physico-chemical characteristics.

1.5 Effects of Eutrophication:

The general pattern of eutrophication is almost similar for most of the water bodies irrespective to their geographical and biological differences. The main sources which add excess of nutrients in lakes and reservoirs are sewage from urban areas, fertilizers from agricultural fields, detergents from cloth washing etc. In addition to these, flooding which cause massive flash of nutrients and droppings of wild animal fecal are also important sources of eutrophication. Through microbial decomposition of sewage, BOD of water increases due to oxygen depletion and it is associated with release of nutrients in this sequence eutrophication ultimately results in:

1. Drastic change in algal component. In general, blue green algae show dominance in eutrophic waters.

2. Excessive nutrients alter macrophytic vegetation as many sensitive species are lost and this result in reduced diversity decline in fish and other organism populations.

3. Water containing excessive nitrates is a source of carcinogens particularly nitrosamines and adults are vulnerable to such compounds. Diseases such as cholera, typhoid, jaundice, dysentery, hepatitis in human beings are due to the use of eutrophicated.

4. Excessive nutrients alter macrophytic vegetation as many sensitive species are lost and these results in reduced diversity.

6. Growth of cyanophyceae and actinomycetes add noxious odors and causes serious health problems. Clostridium botulinum, a bacterium inhabitant to anoxic sediments causes paralysis known as 'botulism' in birds [2].

1.6 Causes of Eutrophication:

(1) Siltation:

This process is a natural cause of eutrophication and deterioration of any water body when silt is carried to it contains some mineral nutrients which results in increased lake productivity.

(2) Sewage, waste disposal and Agriculture runoff:

Untreated sewage effluent and agricultural run-off carrying fertilizers are examples of human-caused eutrophication. However, it also occurs naturally in situations where nutrients accumulate (e.g. depositional environments), or where they flow into systems on an ephemeral basis. Eutrophication generally promotes excessive plant growth and decay, favoring simple algae and plankton over other more complicated plants, and causes a severe reduction in water quality. Phosphorus is a necessary nutrient for plants to live, and is the limiting factor for plant growth in many freshwater ecosystems. The addition of phosphorus increases algal growth. These algae assimilate the other necessary nutrients needed for plants and animals. When algae die they sink to the bottom where they are decomposed and the nutrients contained in organic matter are converted into inorganic form by bacteria. The decomposition process uses oxygen and deprives the deeper waters of oxygen which can kill fish and

other organisms. Also the necessary nutrients are all at the bottom of the aquatic ecosystem and if they are not brought up closer to the surface, where there is more available light allowing for photosynthesis for aquatic plants, a serious strain is placed on algae populations. Enhanced growth of aquatic vegetation or phytoplankton and algal blooms disrupts normal functioning of the ecosystem, causing a variety of problems such as a lack of oxygen needed for fish and shellfish to survive. The water becomes cloudy, typically coloured a shade of green, yellow, brown, or red. Eutrophication also decreases the value lakes, for recreation, fishing, hunting, and aesthetic enjoyment. Health problems can occur where eutrophic conditions interfere with drinking water treatment.

Human activities can accelerate the rate at which nutrients enter ecosystems. Runoff from agriculture and development, pollution from septic systems and sewers, and other human-related activities increase the flow of both inorganic nutrients and organic substances into ecosystems. Elevated levels of atmospheric compounds of nitrogen can increase nitrogen availability. Phosphorus is often regarded as the main culprit in cases of eutrophication in lakes subjected to "point source" pollution from sewage pipes. The concentration of algae and the trophic state of lakes correspond well to phosphorus levels in water. Humankind has increased the rate of phosphorus cycling on Earth by four times, mainly due to agricultural fertilizer production and application. Policy changes to control point sources of phosphorus have resulted in rapid control of eutrophication.

1.7 NEED FOR CONSERVATION

Water Harvesting Age Old Tradition

The most unique example of Conjunctive use of water is in the city of Jodhpur. Anil Agarwal (founder of Centre for Science and Environment) in his book 'Dying Wisdom' refers to water harvesting system of Jodhpur as the best in the word [3]. The Jodhpur Fort is situated at the edge of a rocky plateau and has water harvesting arrangements to tap both rain water and ground water. The kings had built a series of canals to collect the runoff from the plateau and channel it into several tanks built in and around the fort. Numerous step wells & wells were constructed to capture seepage from the reservoirs above. In total there are 8 talabs, 3 tanks, 5 nadis, 16 baoris, 2

Jhalaras, and 41 wells in the walled city area of Jodhpur. Jaswant Singh II of Jodhpur gave immense emphasis to the water supply scheme in Jodhpur when Kaylana was constructed during the famine year. Ranisar and Balsamand bunds were raised, and long canals were constructed to feed the city tanks. These water recourses have not only remained main source of drinking water but were also great source of strength to combat the uncertainties of famine and lack of rains. In its 500 years old history, Jodhpur has witness many droughts, but never desperation for water.

1.8 LITERATURE REVIEW

Lakes are generally defined as standing water bodies which have a minimum water depth of 3 m, generally cover a water spread of more than 10 ha. These water bodies are used primary for drinking water supplies, irrigation and / or recreation. Most of these Lakes are man-made and located in urban or semi-urban areas. Shallow Lakes (generally less than 3 m deep over most of their area) are usually rich in nutrients (derived from surroundings and their sediments) and have abundant growth of aquatic macrophytes. They support high densities and diversity of fauna, particularly birds, fish and macro invertebrates, and therefore, have high value for biodiversity conservation. These shallow Lakes are rightfully categorized as Wetlands. Lakes can also be classified on the basis of their water chemistry. Based on the levels of salinity, they are known as Freshwater, Brackish of Saline Lakes. [5]

Sharma, et. al. (2010), [6]. Observed that due to rapid growth of population coupled with urbanization, the water bodies, especially, rivers, lakes, ponds, reservoirs etc. are deteriorating due to heavy pollutational stresses resulting in the scarcity of drinking water resources. They have attempted to review the work done on the development of TSI for assessment of trophic state of lakes and applicability of most important TSI methods for Indian lakes. They have also dealt with the revival of Mansi Ganga Lake in Mathura, especially, assessment of its trophic state based on the data collected for 2006–09. The results indicated that the lake was oligotrophic during 2006 which has become mesotrophic in the year 2008 showing increase in pollution. After the chemical treatment for the removal of algae, the lake water was drained and results of sampling done in 2009 (pre-monsoon) indicated it to be Eutrophic. This call for its immediate revival and accordingly, the conservation measure are suggested.

Reddy, M.S, And Char, N.V.V, [7] observed that the lakes all over the country, without exception, are in varying degrees of environmental degradation. Since the data on lakes is not scientifically compiled, it is difficult to provide analytical solutions to the problems and hence a generic approach. The main cause for continued degradation of Lake Environment has been public apathy and government indifference. The situation has changed in the last decade due to public awareness of the need for sustainable environment in general, not of lakes alone. This awareness has led to public protests, legal interventions and also public participation in restoration actions.

Klapper, H (2003), [5] observed that Lakes are suffering from different stress factors and need to be restored using different approaches. Eutrophication remains as the main water quality management problem for inland waters: both lakes and reservoirs. The way to curb the degradation is to stop the nutrient sources and to accelerate the restoration with help of in-lake technologies. Especially lakes with a long retention time need technological help to decrease the nutrient content in the free water. The microbial and other organic matter from sewage and other autochthonous biomasses causes oxygen depletion, which has many adverse effects. In less developed countries big reservoirs function as sewage treatment plants. Natural aeration solves problems only partly and many pollutants tend to accumulate in the sediments. The acidification by acid rain and by pyrite oxidation has to be controlled by acid neutralizing technologies. Addition of alkaline chemicals is useful only for soft waters, and technologies for (microbial) alkalinization of very acidic hard water are in development. The corrective measures differ from those in use for eutrophication control. The retention time is an important parameter for modelers and limnologists that allow them to decide, which technologies – hydro mechanical, chemical or biological have to be applied alone or in combination to cope best with each specific problem. The technologies have to be economical and ecological safe.

1.9 GAPS IDENTIFIED

Lake water is being used for drinking water for the population of city of Jodhpur. Population is increasing rapidly due to industrialization and migration. The Zoo of Jodhpur is being shifted in the catchment of Kaylana Lake i.e. in Machia Park. Presently few tourists visit the lake but in future number of tourist will increase in the catchment. The impact of Zoo will come in two ways.

- ✓ More number of tourists will result more pollution.
- ✓ Zoo will create its own waste.

Due to sanitation untreated waste water will reach into the lake resulting contamination of the lake water. In the Machia development plan, authority has not proposed any sewerage treatment plan, it is a serious gap. Collection of solid waste generated by the animals and tourists also has to be considered.

The PHED regularly carries of water sample test for 12 parameter. No tests are being done for DO, BOD, etc. It is recommended that these be done regularly, to assess the water quality of the lake. This is important also because the population of Jodhpur is increasing and there will be added pressure on the lake for supply of water. The shore line needs development to develop the lake area as a tourist destination. Some parts of the lake have stagnant water with growth of weeds etc. This need attention. The catchment area of the lake needs treatment to ensure that the soil erosion is minimum, for this plantation, soil conservation works is needed. Further there is mining being carried out in the area its effect on soil erosion, siltation and water quality needs to be assessed. The Machia Zoological and Biodiversity Park is being developed by the lake side. This may add to the pollution of lake water. This need proper investigation and measures to ensure that the zoological park does not pollute the lake water

1.10 OBJECTIVE OF THE CONSERVATION PLAN

Protecting the catchment and the adjoining areas towards Jodhpur city against the forces of urbanization leading to biotic pressure on the catchment (felling of trees and excessive grazing), with special reference to Machia biological park which is supposed to be developed on the lake periphery.

Ensuring that the lake continues to attract migratory birds from Eastern Europe and Central Asia during winter. For this purpose the aquatic life within the lake and the vegetative cover in the catchment have to be restored to its pristine state. Improvement in habitat in catchment of lake that is in Machia Biological Park, for this, there is necessity of Machia Biological Park development plan.

Ensuring that the water of the lake continues to be suitable for being used as a source of drinking water, for Jodhpur city and its surrounding villages.

To deal with the undesirable weeds present in some portion of the lake.

To ensure that the developmental measure in and around the lake are carried out in a manner that it does not disturb the wild life and ecological balance.

To develop Kaylana Lake and Machia Biological Park as a picnic spot and to make it suitable for the migratory birds who visit the area in large numbers in the winters.

1.11 Layout of plan

The report consists of an abstract and six chapters. Brief description of contents in each chapter is given below:

Chapter 1:

This chapter deals with general of the area, importance of lake and water, why conservation of the lake and its surrounding area especially in view of the development of Machia Biological Park on the lake periphery.

Chapter 2:

This chapter deals with the location of the study area, its history, climate, flora and fauna, demography, about the lake and its present status.

Chapter 3:

This chapter deals with the scope of work and activity involved, water quality parameters to be measured. Methodology for data analysis has been discussed in this chapter.

Chapter 4:

This chapter deals with the environmental status of lake, sources of pollutants, data collection from department, collection of sampling, analyzing different parameters with standard of CPCB, significance of parameters, results and discussions and conclusion.

Chapter 5:

This chapter deals with the conservation and management plan for Kaylana Lake and Machia Biological Park. In this chapter different activities to be carried out, have been proposed for the conservation and management of Kaylana Lake and Machia Biological Park.

Chapter 6:

This chapter deals with the conclusion and suggestion

1.12 SUMMARY AND FINDINGS

Jodhpur has many sites of attraction for tourists. Kaylana lake, is a twin lake system with the upper part called Kaylana lake and the lower as Takht Sagar. The lake receives its water from Rajiv Gandhi lift canal and act as a reservoir for supplying water to Jodhpur town and surrounding villages. Machia Biological Park with a zoo is being developed by the forest department at the northern periphery of the lake as a tourist spot. Thus the conservation and management plan of Machia Biological Park is essential for Lake Conservation. It is necessary that the water quality of water is maintained so that it can continue to remain the main source of water supply to Jodhpur town.

There are a number of locations near the bank of the lake where water is stagnant and turbid. Out of 18 parameters measured, only five parameters viz, pH, DO, BOD, FC and chlorophyll 'a' are found as the major stressors impacting the lake water quality. Lake is in mesotrophic state with respect to its trophic state indicating that owing to receiving the nutrients from the surroundings, the lake has developed the tendency to allow the growth of vegetation which is huge in areas where the water is stagnant not in the turbulent mixing mode.

In summary, the lake water quality is suitable for bathing/ irrigation which can be easily improved using conservation measures consisting of landscape development, management of solid wastes in around lake due to tourists visiting the lake.

If the catchment is treated as proposed in this plan, the lake may begin receiving more than negligible water from the catchment and at the same time the catchment will

become more ecological developed and aesthetic value will be increased. Soil and water conservation management practices may also have an impact on the water quality of the lake and its recharge from the catchment.

Solid waste generated in the area will have to be transported to the landfill site. Arrangements have been proposed for the collection, storage and disposal of various kinds of waste.

The development along the shore of lake is proposed in such a manner that it would not impact the resources and quality of lake water. Due to improvement in facilities tourist will increase that may affect the environment of the area.

In Machia Biological Park development of habitat, birds roosting and nesting sites, road side plantation and viewpoints will add beauty to the area. Sewerage treatment plant and solid waste management will avoid pollution to the lake.

Success of any plan will depend upon the involvement, support and cooperation of the people who are project affected. It is essential that such a project is participatory in nature and has support of the local people.

CHAPTER 2

STUDY AREA

2.1 JODHPUR CITY [16]

Jodhpur, also known as the 'Gateway to the Thar' is a door way to the wonderland of shifting sand dunes and shrubs, rocky terrains and thorny trees. It is an integral part of the world renowned 'Desert Triangle', which includes Jaisalmer, Barmer and Bikaner. The city of Jodhpur is situated in western part of Rajasthan, which is surrounded by the district of Bikaner in north, Nagaur in the East, Jaiselmer in west and Pali in the South. National highway 65 and State Highway 28 and 5 pass through the city. Broad gauge line connects to the city to the major cities of the State. The domestic airport is located at the distance of 5 km from the City. The Geographic Coordinates of the city are $26^0 8'$ N Latitude $73^0 01'$ E Longitude. Jodhpur city is located at an average altitude of 241 m above MSL.

Jodhpur, the former capital of Marwar state, was founded in 1459 by Rao Jodha, chief of the Rathore clan of Rajputs. The origin of this legendary town can be traced back to Mahabharata times. It finds mention as northern Marwar in Jangladesh. Since 13^{th} century, it has been known as Marudesh or Marwar, a desert of sand made immortal by the Rathores, who claim direct descent from Lord Rama. This bastion of Rathores is set on the threshold of the Thar- the Great Indian Desert and was once the part of the celebrated silk route from central Asia to the sea ports of Gujarat.

This historical town is a homogeneous blend of five hundred years of history, rich traditions and modernity. Originally, the city was surrounded by a wall that extended upto 10 kms, with eight gates facing in various directions. Today, the remains of the wall can be seen only at few places, as the city has grown extensively. The walled city is set at the foot of the Mehrangarh Fort. While selecting the location of the city in 1459 AD its rulers must have seriously considered its water potential and strategic situation.

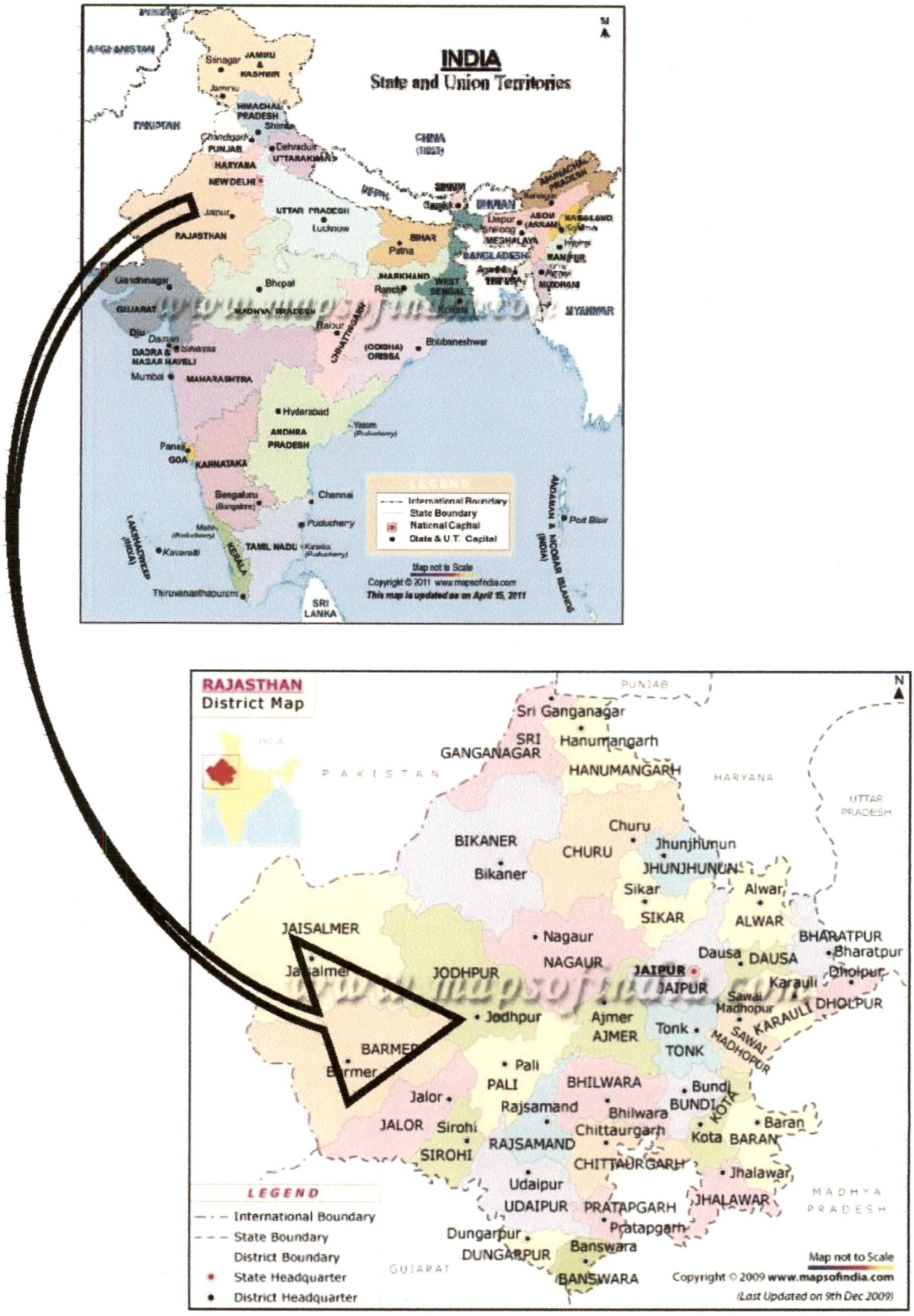


Fig. 2.1 Location Map of Jodhpur

Fig. 2.2 Clock tower and Fort in Jodhpur City

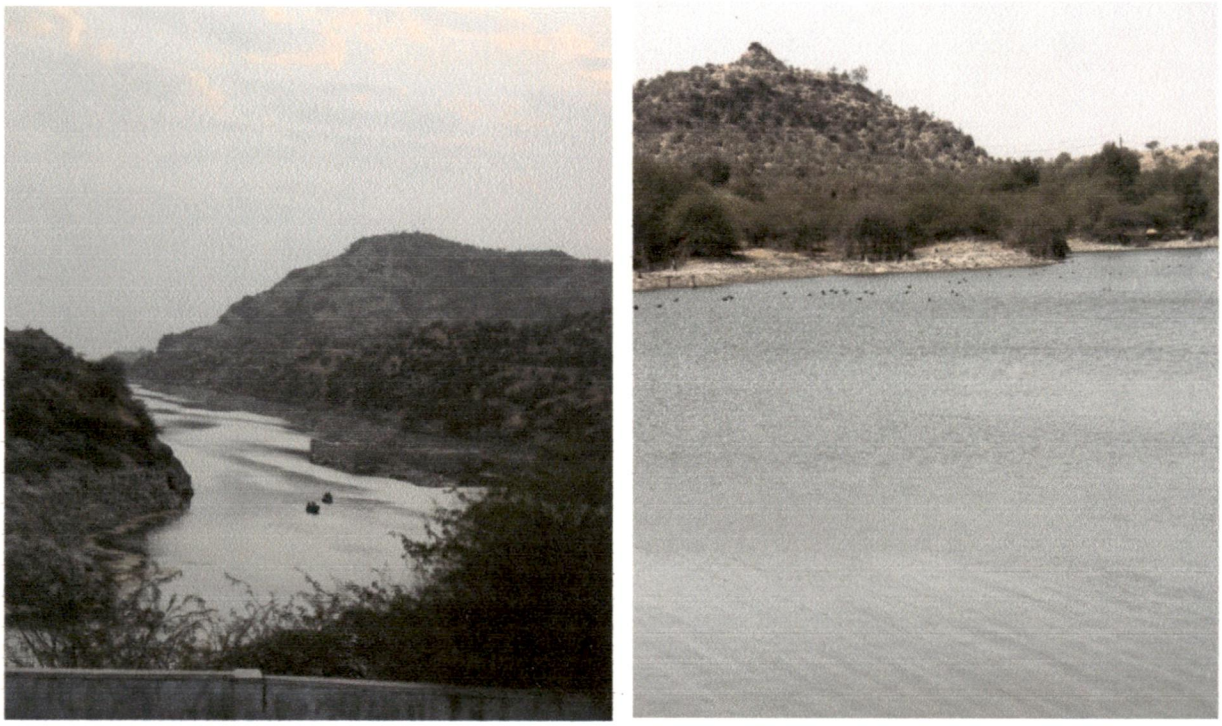


Fig. 2.3 View of the Kayalana Lake

2.2 History of Water Conservation in Jodhpur

The history of water conservation in Rajasthan through Bawris/ Jhalaras/Tanks/Wells/ Lakes dates back to the period of Pratihars and is inimitable and most excellent creations of Rajasthan cultural heritage. These structures were built in Rajasthan for over a thousand year, to provide access to ground water and to retain runoff water received during the monsoon. These structures retain enormous strength. Jodhpur has glorious history of water conservation from as early as 784 AD. The time scale of history of water conservation in Jodhpur is given in Table 2.1.

Table 2.1 Time scale of history of water conservation in Jodhpur (JDA Jodhpur)

S. No.	Name of the Water Body	Year of Construction
1.	Mandore Baori	784 AD
2.	Lake Balasamad	1126 - 1159 AD
3.	Jadhelao Panisar Tank, Chand Baori, Bheru Baori	1455 – 1460 AD
4.	Jagu Baori	1465 AD
5.	Idgah Baori	1490 AD
6.	Padam Sara Lake, Gangelao Talab	1495 – 1515 AD
7.	First Recorded Masonary Nedi	1520 AD
8.	First Tank (Recorded) Soorsagar Tank Kund Kasumdasar talab, Miyao Ka talab, Basant Sagar	1607 – 1716 AD
9.	Dev Kund Sagar, Kund in Mehrangarh Fort	1724 – 1759 AD
10.	Fateh sagar, Gulab Sagar, Mansagar, Pasta, Baiji ka Talab	1780 – 1877 AD
11.	Lal sagar reservoir	1800 AD
12.	Kaylana Lake, Shiv Baori, Jaswant sagar talab	1856 – 1885 AD
13.	Great famina in Jodhpur, Largescale construction of kunds follows:	1895 – 96 AD
14.	Ummesh sagar	1931 AD
15.	Takhat Sagar	1932 AD

2.3 Climate

Jodhpur has relatively warm climate with minimum mean temperature of 3^0 C in winters to maximum mean temperature of 41^0 C in summers. The average annual rainfall in the region is 360 mm as per the paper "A survey of Drought and Scarcity in Rajasthan, by Meteorological Centre, Jaipur", the % probability of draught in the Jodhpur district is around 45%.[4]. This district comes under Arid zone of the Rajasthan state. It covers 11.60% of total area of arid zone of the state. Some of the area of Great Indian Desert Thar also comes within the district. General slope of the terrain is towards west.

2.4 Rainfall

The lake catchment area falls under the agro-ecological zone 14. Daily rainfall data for 10 year period of 2000-2009 is analyzed and is given in Table.. The average annual rainfall of the area was 230 mm and ranged between 113 and 422 mm excluding drought year of 2002. Nearly 91% of the rainfall is received during mid June to mid September. The number of rainy days ranged between 7 and 26 with a mean of 15 days.

Table 2.2 Rainfall recorded at Kaylana Lake during the years 2000-2009

years	Rainfall(mm)		Rainy days(days)
	Annual(jan-dec)	Mansoon season	
2000	215.3	206.6	10
2001	421.8	349.2	23
2002	10.1	9.9	1
2003	410.6	385.1	26
2004	282.0	279.0	17
2005	260.1	218.5	21
2006	151.1	145.7	17
2007	246.0	200.8	17
2008	112.7	105.6	7
2009	191.1	189.3	12
Average	230.1	209.0	15

2.5 Demography

As per census reports the population of Jodhpur town was 860818. The census data for Jodhpur city for the census carried out in 2011 is not available at present. However, total population of Jodhpur district is 3685681 as per latest provisional figures released by directorate of census operations in Rajasthan for the year 2011. This show increase of 27.69 percent in 2011 compared to figures of 2001 census. The initial figures of data shows that male and female were 1924326 and 1761355 respectively. Jodhpur district of Rajasthan comprises an area of 22901 sq.km. as per census 2011, density of jodhpur district per square km is 161 compared to 126 per sq.km of 2001.

In education sector, Jodhpur district is having average literacy rate of 67.09 percent. Male literacy and female literacy were 80.46 and 52.57 percent respectively. In all, there were total 2075029 literates compared to 1319879 literates of 2001 census.

Table 2.3 Decadal population growth of Jodhpur district

Year	Male	Female	Total	Difference	Percentage Addition /Decline
1931	235382	208272	443654	-	-
1941	296184	262205	558389	(+)114735	(+)25.86
1951	353709	318400	682109	(+)113720	(+)20.37
1961	468656	416103	884759	(+)212650	(+)31.64
1971	306223	545426	1151649	(+)266890	(+)30.17
1981	873531	794260	1997791	(+)516142	(+)44.82
1991	1138537	1014946	2153483	(+)485692	(+)29.12
2001	1513890	1372615	2886505	(+)733022	(+)34.03
2011	1924326	1761355	3685681	(+)799176	(+)34.03

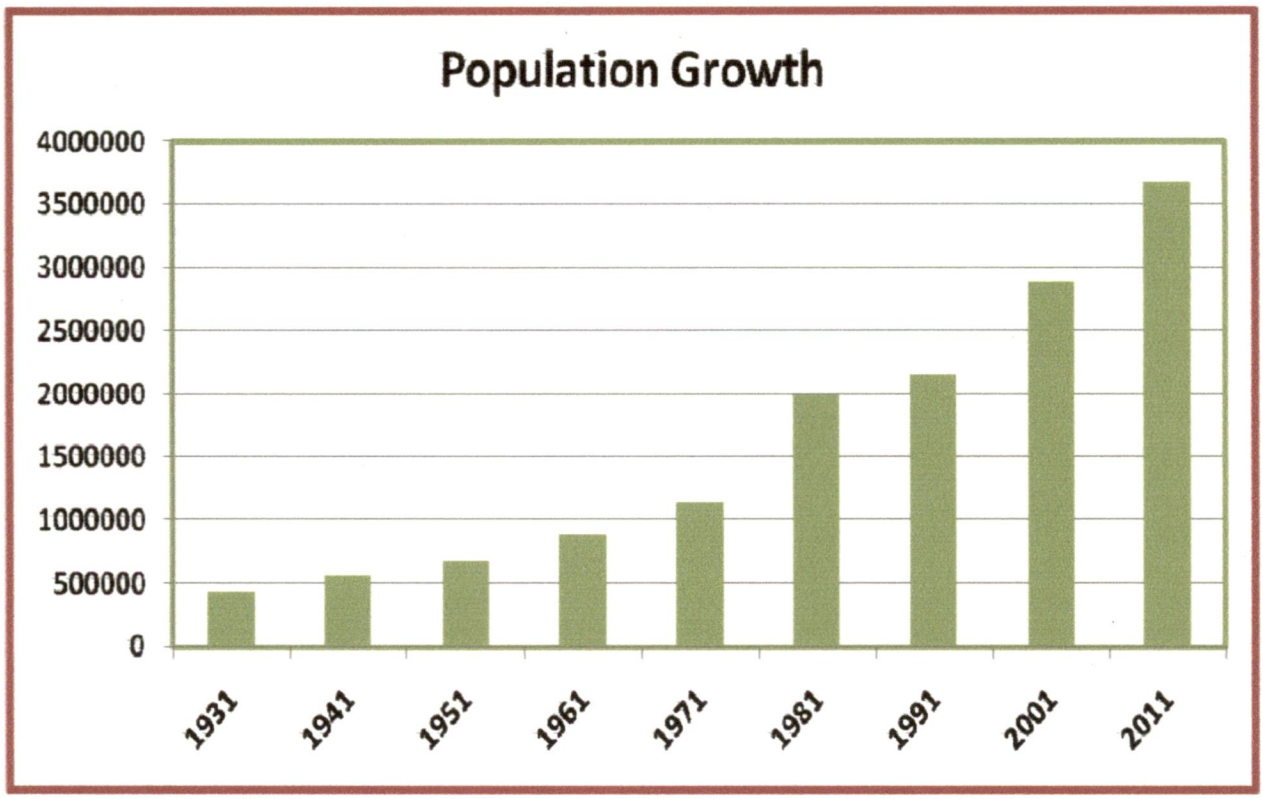


Fig. 2.4 Decadal population growth

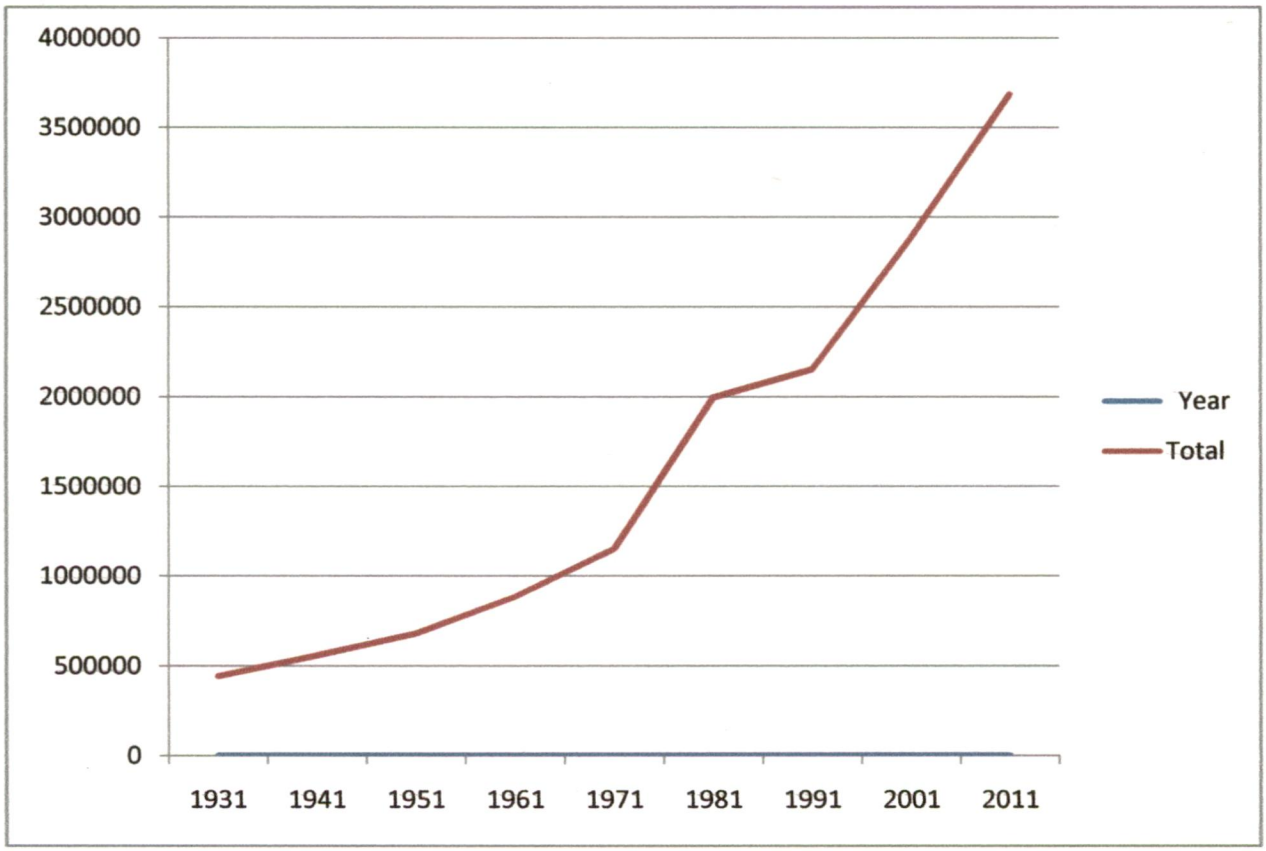


Fig. 2.5 Population growth rate

2.6 Flora and fauna

The natural vegetation in the lake catchment is a form of dry tropical thorn forests. To study the existing vegetation representative land uses were sampled by quadrate method. Quadrates of 30 x 30m size were randomly sampled in the de-marketed homogeneous land use units for stand density and growth parameters. Number and Collar Diameter (C.D.) of all trees/ shrubs encountered in each quadrates were recorded. Diameter at Breast Height (D.B.H.) was recorded in the taller than 3 m. Also the canopy cover of trees shrubs was recorded. As the area did not receive adequate rains during the period preceding the survey the little or no grasses were present in the catchment area at the time of sampling. Species of grasses occurring in the quadrate were recorded. Cover of grasses in the quadrates was recorded by sampling in 1 x 1m randomly placed nested quadrates inside the main quadrates. Due to high biotic pressure in the entire catchment trees taller than 3 m are sparse. In the rocky barren areas trees are absent and vegetation is confined to a few pockets along the drainage lines (Fig. 2.11). The dominant shrub species is Euphorbia caudicifolia with the presence of a few plants of Commiphora wightii and Capparis desidua (Fig.2.11). The ground flora consists of Aristida adescensionsis and sparsely present Eloonurus roylenaus.

In the Machia part of the catchment, Acacia senegal is the major tree species in the middle and upper middle reaches. Though initially an introduced tree, it has naturalized and is now the dominant tree due to its capability of occupying and persisting in the rocky areas with low soil depth (Fig.2.11). Though the majority of trees in this part are < 2.5m in height, few trees have attained height of up to 2.5 m. In the lower reaches Prosopis juliflora dominates the trees and Euphorbia caudicifolia, Capparis desidua and Grewia tenex represent the shrub species. In other parts of the catchment the soils under the scrub forest are gravelly and vegetation is dominated by Prosopis juliflora as the major tree followed by Acacia senegal. Acacia leucophloia and Anogeissus rotundifolia which are also present sparingly. Euphorbia caudicifolia, Capparis desidua, Calatropis procera and Zizyphus rotundifolia are the dominant shrubs. Among the grasses apart from Aristida adescensionsis, Cenchrus ciliaris is also present sparingly. Land with scrub is dominated by Euphorbia caudicifolia and

Capparis desidua with no major tree species present. Aristida adescensionsisis the major grass here also.

On account of arid climate, negligible percentage of the total reporting area for the land use in the district is covered under forests. Despite its arid climate, Jodhpur is blessed with a variety of flora fauna. A survey conducted by district administration with the help of forest officials shows 162 flora and 144 fauna at Machia Safari situated only 10 kms from Jodhpur. Due to sandy soil only scrub and thorny bushes of vegetation are found in the forest areas of the district. The main species of trees are kumat, kair, khejri, babul, ber, jal khara, pilu, gudhi, etc. fruit bearing trees are promergranates and guavas. The fauna of the district include jackal, jungle cat, Indian fox, black buck, chinkara, hyena, blue bull, common hare, etc. the birds commonly found are baya, koyal, parrot, vulture, crow, bulbul, house sparrow, kite, sand grouse, common quail, grey partridge, egret, eagle, etc.

2.7 KAYLANA LAKE IN JODHPUR

Lake Kaylana is situated to the northeast of Jodhpur City, at a distance of about 8 km from the Jodhpur Railway station, on Jaisalmer road. The lake lies within the geographical coordinates of 26°18'4" N latitude and 72°86'5" E longitude. It is separated from another water body, Takht Sagar by means of a man made bundh situated to the south of the lake. There is a permanent connection between Lake Kaylana and Takht Sagar underneath the road. The Kaylana Lake is situated in a narrow valley formed by the weathering of Pre-Cambrian Malani type rhyolites. To the northeast of the lake, in Machia Park, Vindhyan type of rocky sand stone deposits are found in abundance. At some places in the park, especially towards eastern boundary of the lake recent or quaternary windblown sandy and sandy - loamy alluvium, is present. However, along the bank of the reservoir predominantly loamy and clayey soil is observed. In the western part of the lake catchment overlooking the Barli village, buried type of sand stones with upper layer of alluvial deposits is present.

Fig.2.6 Vulture in Machia Park

Fig.2.7 Blue Bull in Machia Park

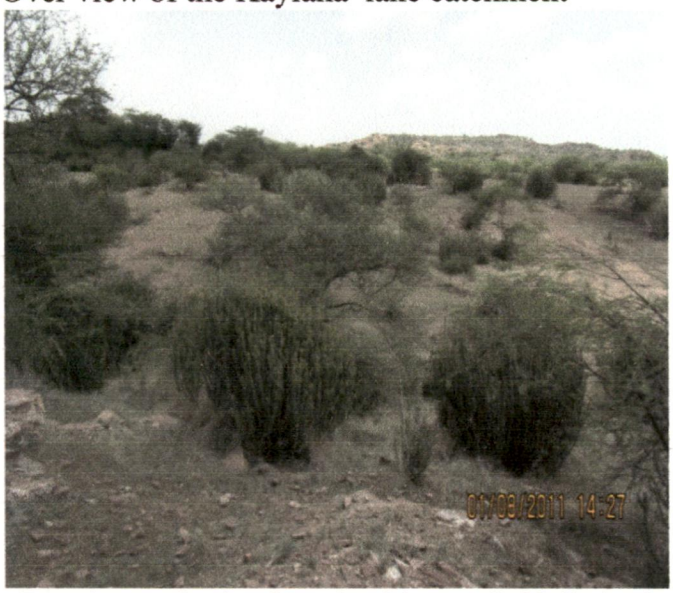
Fig.2.8 Eagles in Machia Park

Fig.2.9 Waterfowl in Kaylana Lake

Fig 2.10 Flora in catchment

Over view of the Kaylana lake catchment

Poor vegetation status of the lake catchment



Dominant shrub of Euphorbia caudicifolia in the lake catchment

Survival of Acacia senegal on rocky substrata with very shallow soil depth

Fig. 2.11 Photographs of different type of vegetation in the catchment area of Kaylana Lake

The Kaylana Lake has a maximum depth of 17.4 m with water holding capacity of 5.157 million cubic metre. The area of the lake is 0.78 sq km, with maximum length 1.69 km and maximum width of 0.8 km. Kaylana lake is located 8 kms to the west of Jodhpur on the Jaisalmer road. Pratap Singh, the Prime Minister of Jodhpur, got the lake constructed in 1872. It has a catchment area of 42 km^2 or 4200 ha. The lake is fed by a canal (Rajiv Gandhi Lift Canal drawing water from Indira Gandhi Canal). In continuation of the lake downstream, there is another storage reservoir known as Takht Sagar which is used to supply the drinking water to the city of Jodhpur. The lake has good biodiversity as evident by the presence of large number of species of birds. It consists of a variety of fishes. During winter, it attracts birds from Eastern Europe and

central Asia. The lake catchment consists of mostly reserved / protected forest land. The catchment is also biologically rich due to the presence of large of number of plant species and wild life.

It was Maharaja Bhim Singh who initially thought of rain water harvesting for civil population by constructing a barrage. Later, Maharaja Takht Singh in 1825 initiated the construction of the present lake to increase the water holding capacity. During the time of Maharaja Jaswant Singh II the construction of the lake was completed. For this purpose, a donation of Rs. 65,000/- was given by Sir Pratap Singh, which was quite significant amount at that time. It is no surprise therefore, that the lake was named as Pratap Sagar after the donor but later it was named as Kaylana.

Natural Lakes are not mere storages of water. They are dynamic ecosystems with complex interactions between geology, geomorphology, climate, hydrology and biology beside anthropogenic influences in their entire drainage basins. Natural Lakes perform several hydrological, biological and biogeochemical and other ecological functions at ecosystem and landscape levels, nature, age, size, depth, turnover rate and lake to catchment ratio. Most riverine lakes play a very important role in flood mitigation and groundwater recharge. At the landscape level, large lakes significantly influence microclimate and therefore influence biotic diversity. Several socio-cultural and economic functions are also associated with the Lakes.

The functions of lakes as ecosystems provide goods and services that are of great value to humans. Ground water recharge and flood mitigation are services provided by the hydrological function. Water is valued by humans for drinking water supply, irrigation, power generation and other uses. The biological production in lakes provides food such as fish. The lakes also provide many socio-cultural and recreational benefits some of which are translated into direct economic benefits through tourism. Some values are the aesthetic enhancements of the landscape are difficult to value in monetary terms.

The different problems of the lake include excessive influx of sediments from the lake catchments, discharge of untreated or partially treated sewage and industrial waste waters/solid waste, entry of diffused nutrients source from agricultural and forestry, improper management of storm water, over abstraction, overexploitation of

lake for activities like recreation, fishing, encroachment, land reclamation etc causing lake water shrinkage, shoreline erosion and impacting the lake hydrology, deteriorating water quality, impacting bio diversity, bringing climate changes etc therefore, an immediate need to know the pollution status of a lake at given time so that necessary conservation activity may be undertaken to regain/improve the health of water body.

2.7.1 Purpose of the Lake

The main purpose of Kaylana Lake is to provide drinking water to the Jodhpur City. Secondary is recreational purpose. The area of lake is approximately 0.78 km^2.

2.7.2 About the Lake

The water abstraction from lake is managed by PHED. The catchment of the lake consists of land which is mostly reserved/protected forest.

Kaylana Lake is connected by canal which feeds the lake in a regular manner so that inflow is equal to the abstraction of water for water supply to Jodhpur Town.

The lake is a good example of water harvesting system prevalent in this semiarid region of India. To collect the rain water additional six channels were constructed namely, 1. Nadelow Naher, 2. Kalibari Naher, 3. Nehar of Pabu Magra, 4. Karu main canal, 5. Arna Jharna and 6. Nehar of Chota Aabe. These channels measure about 85 km in length and are inter- connected. Five of these channels open in Hathi canal, which is now carrying waters of the Indira Gandhi Naher Paryojna (I.G.N.P.) through a lift canal. A lift canal was constructed in 1938 to carry the waters of Jawai and Hamawas dams to the Takht Sagar in order to augment the drinking water supply to the Jodhpur city. The Kaylana Lake was connected with IGNP in 1993 through a lift canal; the overflow of the lake discharges into the Takht sagar and Guraon ka Talab. Jodhpur has a long history of water conservation. There are a large number of tanks within the city and in its immediate vicinity. Jodhpur has experienced rapid urbanization putting pressure on the biotic resources of the lake ecosystem. The increased felling of trees and excessive grazing is leading to the removal of sediment and exposure of the underlying rock. It has severe adverse impact on the wild life in the catchment though its precise impact on the water body is not known. However, one can easily see many areas where there are weeds and low water transparency. It is reasonable to state that

the water quality and the aquatic life have suffered over the years as the catchment is readily deteriorated on account of pollution. Kaylana Lake receives its water from the surface run off from catchment area which is mostly forest area. Beside the runoff, the lake is fed by a canal (Rajiv Gandhi Lift Canal drawing water from Indira Naher Priyojana). Fig. 2.16 gives the map of the catchment of Kaylana lake.

Table 2.4 Salient feature of Kaylana Lake and Takht Sagar

S. No.	Feature	Kaylana	Takhat Sagar
1.	Construction Period	1872 AD	1932 AD
2.	Type of Dam	Earthen	Earthen
3.	Location		
	-Latitude	26°18'	26°18'
	-Longitude	73°01'	73°01'
4.	Catchment Area	42 km^2	42km^2
5.	Submergence area	0.78 km^2	-
6.	Full Tank Level	To be collected	To be collected
7.	Storage Capacity	To be collected	To be collected
8.	Maximum Depth	17.6 m	21.3 m
9.	Source of Water	Rain Water and canal	Water from kaylana
10.	Water Use	Potable Water	Boating and potable
11.	Sewage Water inflow	negligible	Negligible

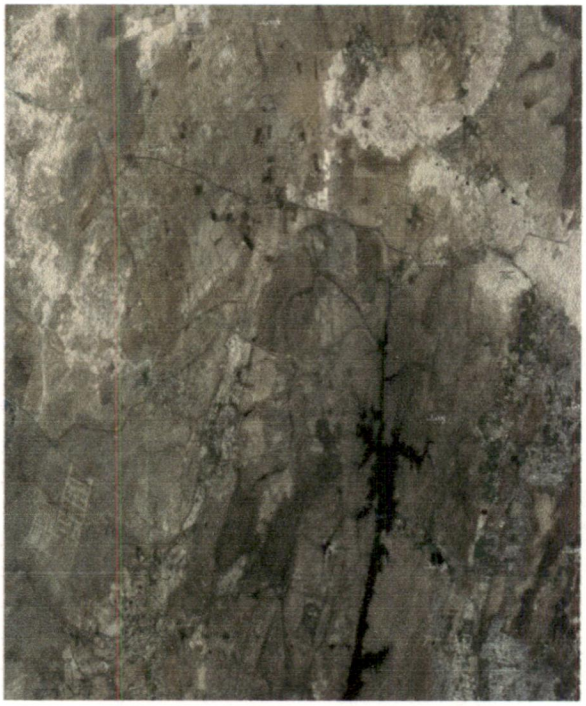


Fig. 2.12 Satellite image of Kaylana

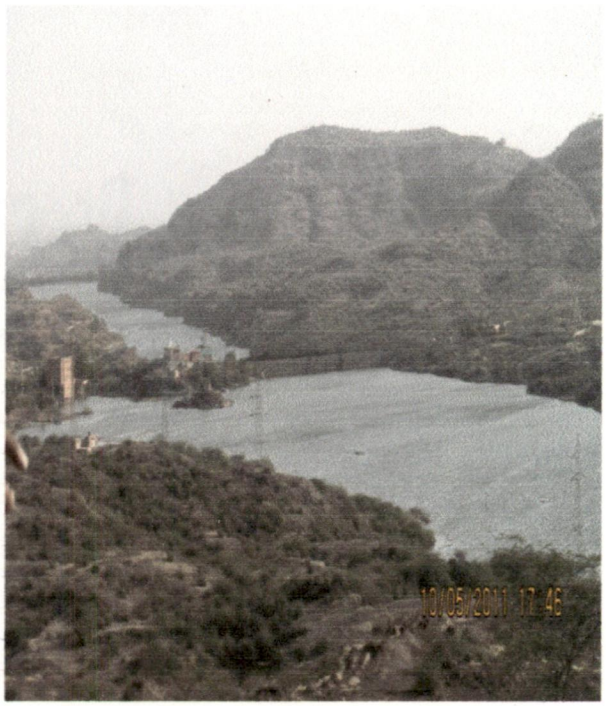


Fig. 2.13 Panoramic view of Kaylana and Takht Sagar Lakes

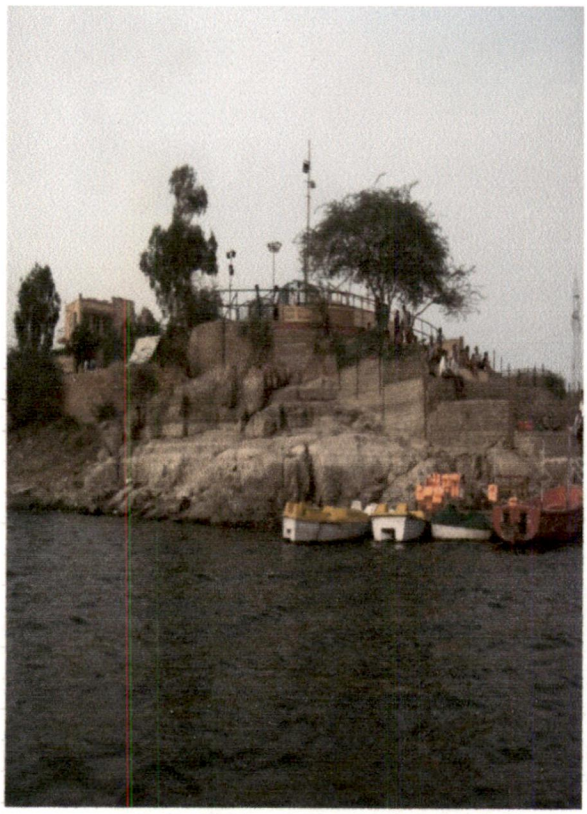


Fig. 2.14 View of Kaylana Lake

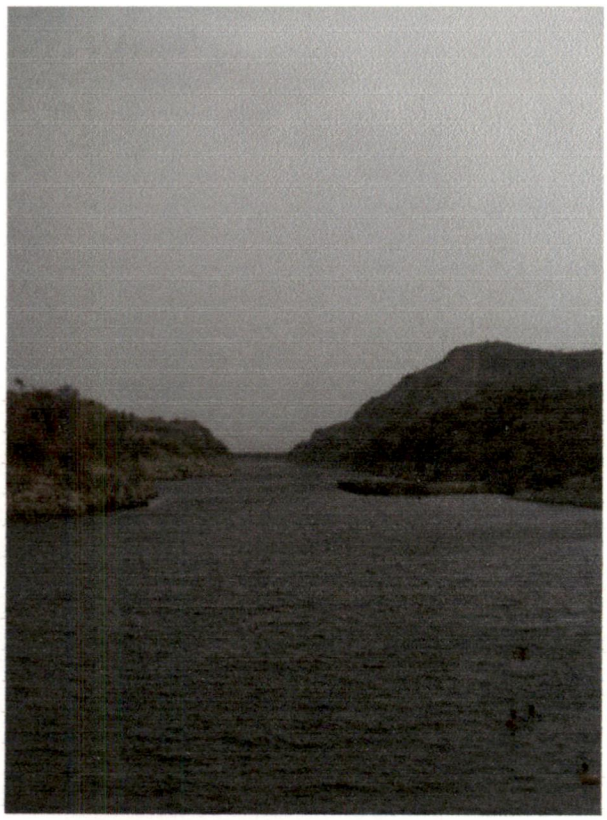


Fig. 2.15 View of Kaylana Lake

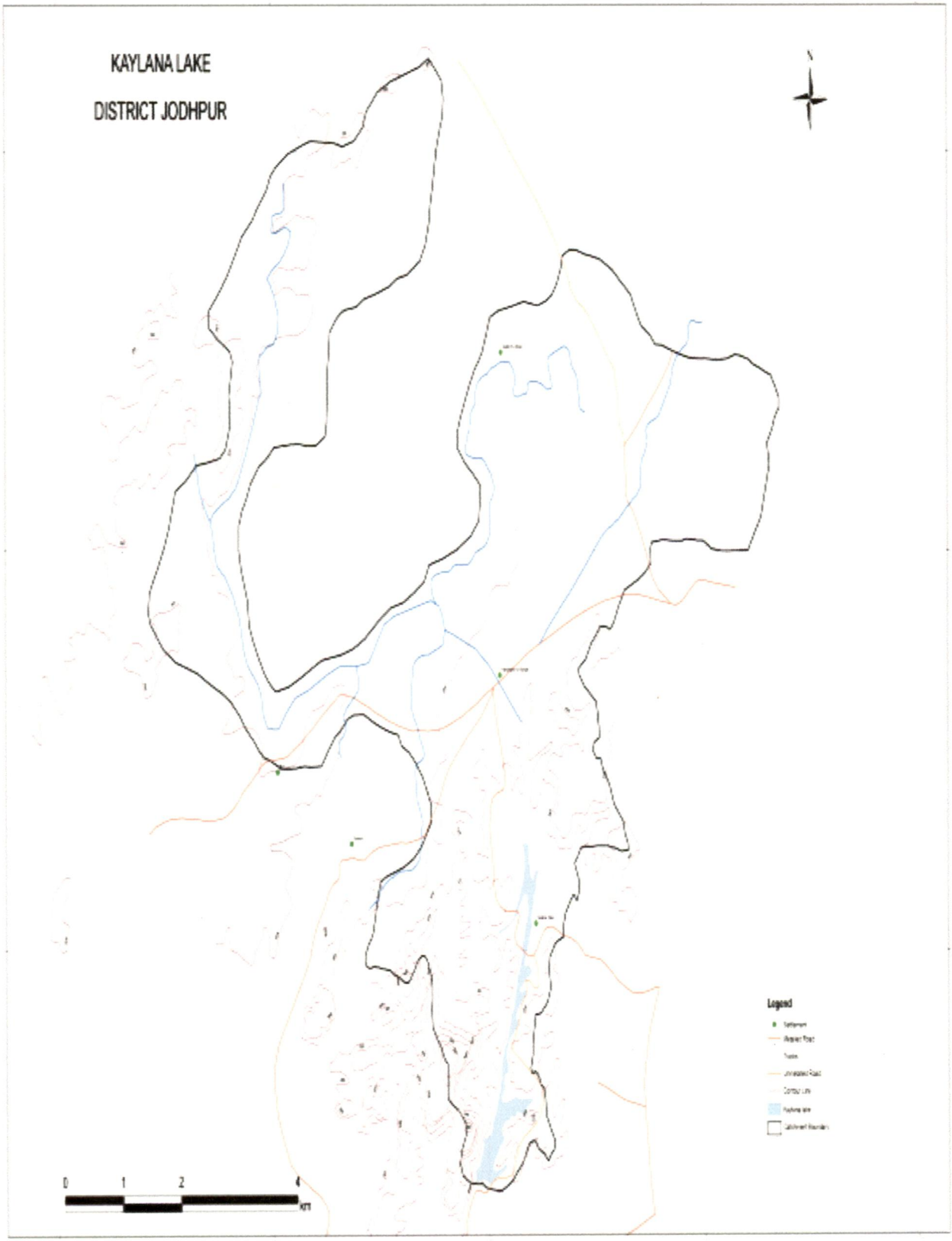


Fig 2.16 Catchment Map of Kaylana

2.7.3 PRESENT STATUS OF LAKE

The water quality although not being monitored regularly in the lake, on visual inspection, appears to be suitable for the purpose for which it is being used, i.e. to provide drinking water to Jodhpur town after treatment. It is more or less in natural state with minimum interference. But there are some points leading immediate attention;

1. There are stagnant portion in the lake where algal bloom and other weeds can be seen especially in Takht Sagar.

2. In the catchment, there is a biotic pressure from increasing population in the adjoining area which has resulted in excessive grazing and felling of trees, thus denuding the soil cover in catchment area.

3. These condition have adverse effects on the wild life habitat

4. The unmanaged mining in the catchment area leads to deteriorating the environment & ecology.

5. Some old plant has not soil around them resulting growth retardation.

6. Exotic species prosopis juliflora has come gregariously which not good for wild life. This has to replace by the indigenous tree species.

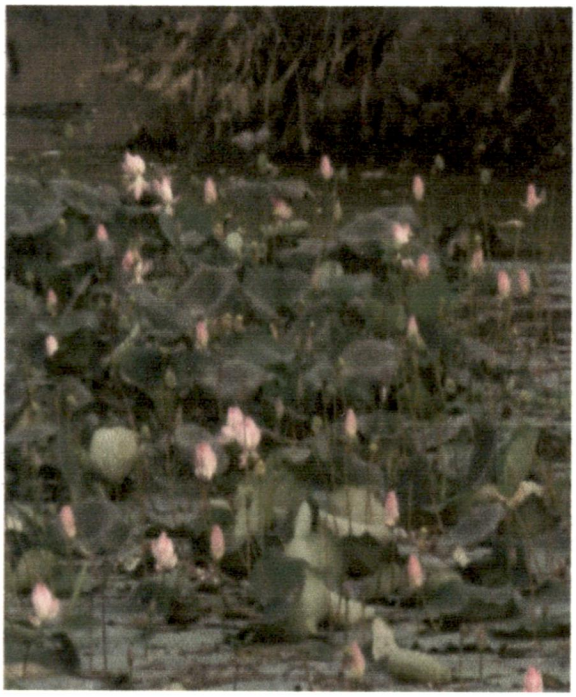


Fig. 2.17 Weeds in Kaylana Lake

Fig. 2.18 Weeds in Kaylana Lake

Fig. 2.19 Solid Waste in Kaylana Lake

Fig. 2.20 Weeds in Kaylana Lake

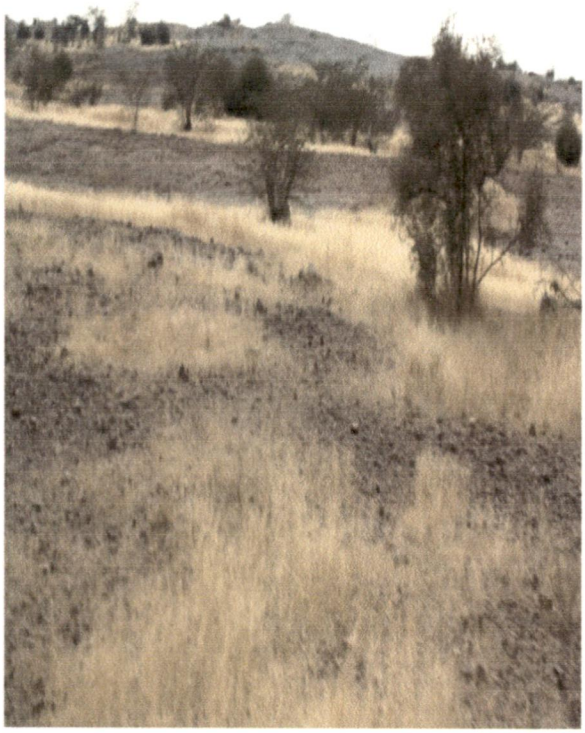


Fig. 2.21 Soil Erosion in Catchment Area

Fig. 2.22 Soil Erosion in Catchment Area

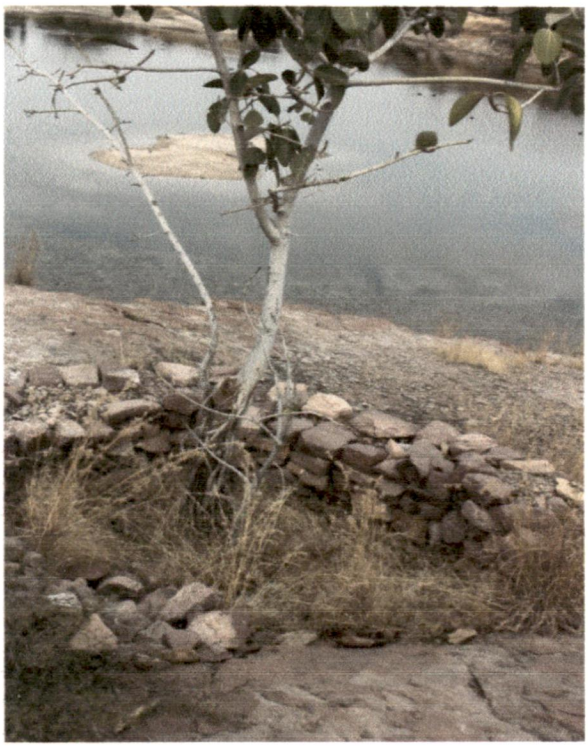


Fig. 2.23 Present status of vegetation at lake shore

Fig. 2.23 Present status of vegetation at lake shore

CHAPTER 3

METHODOLOGY

3.1 Scope of Work and Activity Involved

Scope of work includes the following for the revival of lake and development of Machia Biological Park.

1. Monitoring of water quality.
2. Physical removal of water hyacinth and other weeds from the water surface.
3. Treatment and revival of water bodies.
    - Supply of bacterial products as per requisite quantities.
    - Application of the bacterial products as per the schedule.
    - Arrangements of aeration system for oxygen supply to maintain the lake eco-balance.
4. Solid waste management strategy.
5. Catchment treatment practices.
6. Shore line development.
7. Machia Biological Park development plan
8. Public awareness Programme promoting the importance of conservation of lake.

3.1.1 Monitoring of Water Quality

The term "impact" refers to the effect of a particular activity on ecosystem characteristics-its structural and functional attributes which can be readily assessed by direct investigation and with the help of studies in other similar habitats, however, the term "problem" is anthropocentric in as much as it is subjective and depends upon the extent to which a desired value of the lake is adversely affected. All natural processes and activities of various organisms including human beings have some impacts on few or more of the ecosystem components but all impact is not readily perceived as a problem. Important natural and anthropogenic impact, have short-term or long-term consequences depending upon their frequency and intensity. Natural impact is generally aggravated by human activities, and hence can be minimized by careful consideration of their linkages with human activities.

To identify major impact in order of their importance, inventories of different kinds of human activities in and around the lake should be made. The frequency and magnitude of such activities, their likely impact on other habitat characteristics, and interaction with the hydrology of the lake (surface runoff drainage or percolation into

the soil, inflow and outflow) should be examined. Clearing vegetation in the catchment through harvest, grazing or burning is likely to increase erosion. If there is a likelihood of the eroded soil being transported by water into the lake, this is a potential problem. Agriculture in the catchment area is not a problem in itself. However, if the pesticides and fertilizers are used in large amounts, and are likely to enter the lake with surface runoff or below ground seepage, they have a potential to impact upon the lake.

Domestic sewage and other organic wastes cause a problem if the capacity of the lake to process organic wastes is already saturated. If the wastes entering the lakes (such as industrial wastes) have high concentration of toxic heavy metals and organic substances, they cause more problems. However, it must be remembered that all lakes (with abundant macrophyte growth) have some capacity to sequester these substances in their sediments. Higher concentrations result in the toxic substances entering the food chain and affecting fish and waterfowl. [4]

Due to conflicting interests of humans, regulation of hydrological regimes through the diversion of water flow is rarely perceived as a major threat to the lake although it is the most important problem with long-term consequences. The growth of aquatic vegetation results primarily from the increased availability of nutrients and reduction in water depth. Exploitation of biological resources is another problem that often attracts attention. It has been also pointed out earlier that all lakes in the tropics and subtropics throughout the world in general, have co-evolved with human communities which have used their resources and managed them to their sustained utilization. In fact many of the values recognized today of most of the lakes have been the result of these human uses that continue even today. Over-exploitation beyond the carrying capacity of the system and above the growth potential of the organisms concerned should be prevented through appropriate regulatory measures, a lake have several important functions and values, and be under the impact of several anthropogenic activities. However, it is not possible to enhance all the lake values some of which even conflict with each other. Similarly, it not be possible or sometimes even desirable to bring all human activities to a halt in order to minimize all the identified impacts. Besides technological and economic constraints, social considerations also require that the objectives are clearly defined, realistically achievable goals are set, and priorities are spelt out.

3.1.1.1 Water Quality Criteria

The Central Pollution Control Board (CPCB) has classified water in five classes on the basis of best designated uses as given in Table 3.1.

Table 3.1 Water Quality Criteria

S. No.	Designated-Best-Use	Class of water	Criteria
1	Drinking Water Source without conventional treatment but after disinfection	**A**	• Total Coli forms Organism MPN/100m shall be 50 or less • pH between 6.5 and 8.5 • Dissolved Oxygen 6mg/l or more • Biochemical Oxygen Demand 5 days 20°C 2mg/l or less
2	Outdoor bathing (Organized)	**B**	• Total Coli forms Organism MPN/100m shall be 500 or less pH between 6.5 and 8.5 Dissolved Oxygen 5mg/l or more • Biochemical Oxygen Demand 5 days 20°C 3mg/l or less
3	Drinking water source after conventional treatment and disinfection	**C**	• Total Coli forms Organism MPN/100m shall be 5000 or less pH between 6 to 9 Dissolved Oxygen 4mg/l or more • Biochemical Oxygen Demand 5 days 20°C 3mg/l or less
4	Propagation of Wild life and Fisheries	**D**	• pH between 6.5 to 8.5 Dissolved Oxygen 4mg/l or more • Free Ammonia (as N) 1.2 mg/l or less
5	Irrigation, Industrial Cooling, Controlled Waste disposal	**E**	• pH between 6.0 to 8.5 • Electrical Conductivity at 25°C micro mhos/cm Max.2250 • Sodium absorption Ratio Max. 26 Boro Max. 2mg/l

3.1.1.2 Water Quality Parameters to be measured

The following 18 parameters are selected to study their impact on the sustainability of aquatic life for Kaylana Lake:

(i). Temperature (°C)
(ii). pH
(iii). Dissolved Oxygen (mg/l)
(iv). Conductivity (µs/cm)
(v). Total Dissolved Solids (mg/l)
(vi). Turbidity (NTU)
(vii). BOD (mg/l)
(viii). Fecal Coli form (MPN/100 ml)

(ix). Total Phosphates (mg/l)
(x). Nitrate- nitrogen (mg/l)
(xi). COD (mg/l)
(xii). Chlorophyll a (mg/l)
(xiii). Planktons
(xiv). Sechhi disc transparency (cm)
(xv). Total Hardness , Ca, Mg, K (mg/l)
(xvi). Total alkalinity (mg/l)
(xvii). Chlorides (mg/l)
(xviii). Sulphates (mg/)

3.1.2 Assembling Baseline Information

Lake management is often involves a considerable range of activities such as controlling the human activities in lake, management of plant life, habitat enhancement through fencing and planting, and predator control. However, to implement all these management activities, an information base or a complete lake profile is necessary. Thus, a prerequisite for the management of a lake is the creation of an information base with detailed hydrological, physico-chemical, biological, socio-economic and cultural profiles.

3.1.3 Mapping of the Lake

A detailed topographic map of the lake together with details of its location in the country/state or district should be prepared. This could often be adapted from the Survey of India's top sheets with additional details from revenue records or land use maps in the district Panchayat offices. The Space Application Centre has developed a methodology for mapping coastal lake by making use of high resolution (both spectral and spatial) satellite data. The satellite imageries of Chilika and Sambhar and their catchment have provided useful information. A preliminary attempt at Keoladeo National Park, Bharatpur, has shown the feasibility of detecting vegetation, broad patterns of sedimentation and water depth. Satellite data however requires careful ground truthing by field survey for the accuracy of interpretation. This should include the generation of error matrix and estimating the accuracy of classification of lake. [17]

3.1.4 Macrophytes

Besides preparing an inventory of all the species of macrophytes occurring in the lake, information is required on their seasonality, distribution within the lake and

abundance. The abundance of a species is estimated easily in terms of its cover (land or water surface area covered by the plant) visually using stratified sampling technique.

3.1.5 Plankton

Plankton is microscopic or minute organisms suspended in water column whose distribution is influenced by wind, current and tides. However, the term has been limited in usage to two major groups, namely plants, (phyto-plankton) or animals (zooplankton). Phytoplankton comprise of algal groups. Chiefly Chloropyceae (green algae), Cyanophyceae (blue green algae) and Bacillariophyceae (diatoms). The zooplankton comprise of groups such as, Cladocera, Copepoda, Rotifera..The phyto- and zooplankton form a vital part of the aquatic food web and therefore information on their populations is often important to lake management [18].

3.1.6 Sediments

The sediments which comprise of particulate mineral matter and organic matter provide substrate for most of the lake plants and many animals besides being the major source of nutrients for their growth. Sediments play a vital role in the nutrient dynamics of the lake and aquatic systems. Sediments should be sampled by using an Ekman dredge (Welch 1948) and standard methods should be followed for the analysis of different parameters such as textural composition, organic matter content, pH, redox potential, available and total nutrients, and other toxic substances and elements.

3.1.7 Benthic Organisms

A large variety of organisms including filamentous algae and invertebrate animals, especially the larval stages of various insects, live on the sediments on other substrates at the bottom of the water body. These organisms play an important role in the decomposition of organic matter and are in turn important food for many fish, birds, and other aquatic animals. As discussed earlier, the lake are primarily detritus based systems in which the detritus (decaying organic matter) is the main starting point of all food chains, and thus, the benthic organisms (benthos) play the most important role in the food web. Benthic organisms are generally larger than 0.5 mm although their younger stages are much smaller. They are therefore separated from the sediments by

sieving them through a 0.5 mm mesh sieve with the help of a gentle stream of water [18].

3.1.8 Fish and other Vertebrates

Gill and cast nets or pull-up traps are used depending on the habitat to collect the fish and other aquatic animals for identification [18]. The animals should be released back in the water after quickly identifying them and estimating their number.

3.2 Identifying the Functions and Values of Lakes

Lake functions are ecological interactions between the biological, physical and chemical components of lakes. Many of these functions provide goods or services that are important to human societies. When this occurs the function produces a value.

3.3 Fish, Avifauna and wildlife habitat:

The most widely recognized function of lakes is their role in providing habitat for fish, avifauna and wildlife, recent studies have shown that the population of the lake birds is declining [5] and many lakes are in jeopardy. If the species of plants and animals become endangered they signify degradation in the environment, which threaten man's own existence. Lakes attract a mass influx of birds during winters that breed in Europe and Northern Asia. This results in the arrival of thousands of water birds with the onset of autumn (Aug to Dec) to spend the winter in warm subtropical lakes of the Indian subcontinent. They return again northwards (from February onwards) towards their homing grounds in Eurasia as it warms up again. Therefore one of the very important functions the lakes perform is to provide suitable habitat for the residential birds as well as for migratory waterfowls. However, these ecologically vital ecosystems are under constant threat due to ever increasing anthropogenic pressures, such as agriculture, land reclamation, as well as uncontrolled silting and weed infestation, which have made lakes the most threatened habitats all over the world. Bird counts can also provide vital evidence for the protection of lakes should they become threatened. Kushlan (1993) assessed the value of water birds as bio-indicators of lake change, and one of his conclusions was that "population level data show special promise as sentinel bio-indicators".

3.3.1 Rapid predictors of fish habitat:

Lakes are most likely to support productive and/or stable fish population if they have:

1. Connections to permanent water (e.g. linkages to local rivers at Loktak Lake and Harike Lake).

2. Springs or predictors of groundwater discharge

3. Dissolved oxygen levels > 4 mg/L.

4. No toxicants at lethal levels.

5. No alterations to the lake or the connected water sources.

6. Pools in which fish can survive at low water levels.

7. In the case of lakes that have large natural fluctuations between wet and dry seasons, water is present for 80 days in the temporarily wet area.

8. Undercut stream banks, submerged debris, grass islands (e.g. Loktak lake), submerged aquatic plants or large rocks and aquatic plants are present for young fish cover.

9. Shade for a majority of stream area.

10. Acidity (pH) between 6.0 and 8.5.

3.3.2 Rapid predictors of Avifauna & wildlife habitat:

Lakes are most likely to sustain an abundant and diverse fauna if they have the following characteristics:

1. Large size> 3 ha and ideally> 400 ha. But some very small lakes can provide important. habitat for certain specialized species .

2. Connected to other lakes, forests or grasslands (e.g. Keoladeo Ghana National Park) by corridors at least 100 m wide.

3. Unique with regard to vegetation, size, water duration, or a combination of these in their region.

4. Located along the coast or in a major river valley or on islands or peninsulas that serve connections along migratory bird flight paths

5. A variety of species and shapes of plants.

6. Presence of islands

7. Presence of special habitat features such as food producing plants and nest sites or materials.

3.3.3 Biomass production, subsistence & sustainable development

Lakes are critical for providing food, fuel & fiber important to local, regional and national economics.

3.3.4 Rapid predictors:

Lakes that are most likely to produce and export useful quantities of organic matter (for life support of downstream ecosystems) have the following traits:

1. Plant species that produce a great deal of leafy tissue each year.

2. A diversity of decomposition rates as indicated by plants that are known to have rapid, moderate and slow decomposition rates (e.g. Loktak lake-Manipur).

3. Sources of moderate fertilization from upland sites or human communities (e.g. Fishing villages at Loktak lake).

4. Turbidity that seldom exceeds 30 nephelometer turbidity units.

5. Presence of nitrogen fixing plants or algae.

6. In flowing waters, a substrate that is not sand.

7. Ratio of dissolved solids to mean depth, in meters, > 35.

8. Salinity < 35 ppt and pH 5.5 - 8.5.

9. Water level fluctuates frequently.

The objective of sub project is to assess physico-chemical, biological and heavy metals in the water quality of lake and identify the effect of pollution from different sources, its intensity and quantum into the water, assess the present status, during implementation various sub projects of works and post project execution status of the water quality to observe the changes/variations in different parameters at various stages.

3.4 Bioremediation of Lakes

3.4.1 Introduction

Most of the technologies suggested for the treatment of the lakes try to treat the lake symptomatically, rather than attack the root cause of the problem. The technologies most commonly advocated are shown in table 3.2.

Table 3.2 Merits and Demerits of different Technologies

Technology	Advantages	Disadvantages
Dredging	Can deeper the lake making it difficult for the rooted, submerged vegetation to grow	Extremely expansive does not remove nutrients in the water body. Does not decrease the algae in water. Creates problem of disposal of the organic sludge and silt
Deweeding	Removal of the Macrophytes from water	Does not control nutrient water, only a temporary solution, does not remove Micro-scopic algae, the root cause of all the problems, Problem of Disposal of removed algae.
Chemical Treatment	Can bid Phosphorus weeds and algae can be killed	Chemical can be Toxic to other aquatic life. Cannot remove the organic "muck" from the sediments killing of algae and weeds is temporary. The phosphorus and other nutrients can be released back in to the water creates anoxic sediments at the bottom, leading to release of even more phosphorus from the sediments.

3.4.2 Biotechnology

3.4.2.1 Natural Alternative for Lake Remediation

The real solution lies in restoring the eco-balance between the microphytes, animal and Micro-organism, which can be maintained even under minor disturbances. When the natural ecosystem is disturbed, we need a specialized consortium of natural micro organisms, to start the convective action, degrade the organic deposits, eliminate eutrophication and restore equilibrium of the lake. This process is known as bioremediation and requires a great deal of expertise in environmental biotechnology.

The process of bioremediation can be carried out by using a consortium of natural, non pathogenic microbes (Pseudomonas, Alcaligenes, Sphingomonas, Rhodococcus, and Mycobacterium, Phanaerochaete chrysosporium), through a process called the COR technology. The technology aims at providing the right type of microbes at the right time and equipped with right environmental condition, so that the microbes can do their job properly.

3.4.2.2 Principal Behind the Biotechnology Process

When the bio-products are applied, by spreading then over the water body, the bio product coagulates and precipitates the soluble phosphates and organic matter from the water body. The phosphates are thus immobilized and the organic matter degraded by the action of the microbes.

The products contain a very high concentration of living organisms, up to 6 billion per gram, which ensures that the biodegradation process start very quickly. At the same time, the bio products settle into the organic deposits at the bottom of the panel and also degrade the organic matter. The bio products are available in a powdered form, which makes it very easy to spread on the water body, with greater emphases on the dead pockets and where the sludge levels are higher.

3.5 Dredging and Desilting of Lakes

The prime objective of desilting and dredging is to remove volume of silt and sediments that have accumulated in the lakes over a long period of time. This silt and sediments cause not only the reduction in the storage capacity of the lake, but also accumulation of the nutrients that promote pollution of lake water and luxurious growth of aquatic weeds, algae and bio-organisms. Due to silt deposition from the various drains, mass land formation may occur at the confluence points, resulting loss of open water area, distributed on navigation, decreased the water quality and decreased water storage capacity. To avoid this desilting and dredging work has given importance.

3.6 Weed removal

Nutrient enrichment of the lakes due to inflow of untreated sewage and organic waste containing runoff from catchment areas, direct disposal of untreated sewage and human waste, and agricultural residues from the catchment areas have caused excessive aquatic vegetation growth in the lake area. In order to reduce nutrient recycling and prevent accelerated evapotranspiration of lake water, weed removal operations must be carried out. The sub project is aimed at harvesting nutrients through removal of emergent, submerged, floating weeds and algal blooms from the shoreline, shallow sections and thereby improving water quality of the lakes. Removing of the weeds is to reduce the nutrient level as well as maintain the ecological balance of the lakes.

3.7 Regulation for the Motor Boats

Being large motor boats activities were very important role in the most of lakes in the country, because tourism is only by boats in lakes area. Its causing pollution problems related to oil and grease spillage. The authorities must be control and check motor boating because of the spillage, which can pollute the lakes.

3.8 Catchment area treatment

During the rainy season, runoff from the catchment carries much nutrients, silt and organic debris to the lake. The urban catchment runoff and sewage enters the lakes through various drains, causing both siltation and water pollution. To mitigate the inflow of silt, agricultural residues and other wastes into the lakes traps having a cumulative silt trapping capacity have been constructed across the inlet channels. Soil movement due to barren surface and high wind velocity is a major problem. Soils are sandy and water retention is poor, water is rapidly lost either as evaporation or deep drainage.

3.8.1 Construction of Weirs, Silt Trap Dams

The aim of the catchment area treatment of the lakes is to mitigate inflow of silt, agricultural residues and other wastes etc. into the lake through inlet channels discharging into the lake. This has been achieved by constructing gabion structures, check dams silt traps and toe walls on all the inlets channels leading to the lake. Soil erosion can be totally controlled through conservation measures. There are several approaches based on land deposition, degree of erosion. Contour technique, gully control rain water management, reclamation of alkali soil, green carpeting by massive plantation is some practices to control the erosion.

3.8.2 Interception and Treatment of Sewage

Sewage is a major cause of pollution and water quality deterioration of lakes. The shifting of Jodhpur zoo is proposed in Machia Park which would have many animals and tourist pressure will increase. The sewage will directly or indirectly reach into the lake water through the drains. So to maintain and to protect the sewage, proper treatment plants must be constructed for diversion and treatment of domestic sewage.

3.8.3 Afforestation and Creation of Buffer Zones

In order to prevent encroachment, human settlements, movement of the cattle's and cultivation etc., afforestation and buffer zones must be created in catchment area and fringe area to control and check soil erosion. The plants specie must be selected according to site. The plants must be carefully selected not only considering type of the soil, water and climate conditions of the area but also taking into account of their economic and high medical, aesthetic values. The afforestation in this catchment area can reduce erosion process and the flow of silt from this portion of catchment area into the lake.

3.9 Shore Line Development

At present, Kaylana Lake is an important ecological area in the region. This is attraction for the birds both local and migratory. Presently the lake has multiple uses apart from recreation; it supplies water to Jodhpur city and region and also acts as catchment drainage. There are temples around the lake and some puja ceremonies are conducted on the water too. Lake is main attraction for tourist and local people on the holidays and evening.

There is minimum development activity around the lake like PWD rest house and at the far end near the pumping station some structures have come up at the path leading to the Mandalnath temple. For the development plan of the Kaylana Lake to be efficient, the impact of the tourist and the local population on the lake has to be analyzed conceived. Various points and stretches along the lakeshore need to be developed so that the pedestrians are able to enjoy their leisurely walk along the lake on the western edge. To encouraging the tourist provision of pedestrian path, viewing points and other facilities close to the lake edge on the west side has been proposed. Potential also exists in developing the existing island as a popular spot with a restaurant and a boating jetty. Any improvement or development to the tourist facilities would bring in problems to the environmental quality of the lake resources unless these development schemes are matched, in equal measures, by enforcement of strict rules and regulations on use of Lake Site resources that would keep Lake Environment quality at acceptable levels.

3.10 Machia Biological Park Development

Eco-tourism in Machia Biological Park may be undertaken which can convert the lake into a tourist centre. To prevent pollution from human waste, community toilet facilities could be provided around periphery of the lake. Solid waste management measure could be introduced. The cycle track, nature trails, rock climbing trail can be constructed. Tourist could be controlled to prevent adverse effect on the biodiversity of the area.

The Zoo of Jodhpur is being shifted in the catchment of Kaylana Lake i.e. in Machia Park. The impact of Zoo will come in two ways. More number of tourists will result more pollution. Zoo will create its own waste. Due to sanitation untreated waste water will reach into the lake resulting contamination of the lake water. Sewerage treatment plant and sanitation scheme has to be proposed. Collection of solid waste generated by the animals and tourists also has to be considered.

The area has not required vegetation cover. Plantation of indigenous species has to be done. Exotic trees like prosopis have to be replaced with local trees. Creation of nesting habitat will attract more migratory and resident birds. Natural grown plants have to be maintained. Vulture breading center will be helpful to maintain the ecological balance.

3.11 Public Awareness, Public Participation and Environmental Awareness

Nothing can be changed unless and until people living around the lake participate with the lake conservation plan. During this study we should involve all stake holders into the integrated management and conservation plan of the lake development and management. Public awareness, Public Participation & Environmental Awareness is very important for lake conservation. The participation of common people is an essential and important feature. To achieve this it is necessary to educate and train the public through a planned environment awareness programme with the help of Non Government Organization and other educational institutes. Under this sub project many awareness programme such as workshop, training courses, lectures, rallies, debates, street theatres, folk media, open forum, public meetings, audio-visual shows, bird watching and eco camps etc. will be carried out. Objective of the environmental awareness programme are:

- To associate the residues with the various activities regarding environmental conservation of the lake
- To mobilize different segments of the society to ensure participation in various environmental protection and conservation programme, manpower development to ensure implementation of development programmes without environmental degradation.

Special modules relating to these have been developed at several agencies/ institutes to generate awareness about the value and functions of water body and need for their conservation to which group of participants representing government, non government and private entrepreneurs.

3.11.1 Promotion of Organic Farming

Intensive cropping with inorganic fertilizers is being done in the catchment and the rural watershed. A significant part of these nutrients is directly affect from catchments are find their way into the lake via monsoon runoff, causing the growth of aquatic vegetation. With the intention of discouraging farming practices in catchment and in the watershed based on inorganic fertilizers, a drive to promote the use of organic manure must be launched in villages of the catchment and inside villages. The manure can produce by the farmers themselves, by comprised of farm wastes and cow dung. And also can produce from weeds. Relevant activities must be included hand-on training to farmers for making high quality compost using bacterial inoculums. The organic manure was considerable savings because the need to purchase inorganic fertilizers was eliminated and the crop productivity was compactable high.

CHAPTER 4

WATER QUALITY ASSESSMENT

4.1 INTRODUCTION

Lakes are important feature of the earth's landscape which are not only the source of precious water, but provide valuable habitats to plants and animals, moderate hydrological cycles, influence microclimate, enhance the aesthetic beauty of the landscape and extend many recreational opportunities to humankind. The lakes are also used for drinking, irrigation, fishing, eco-tourism etc apart from the above advantages. The different problems of the lake include excessive influx of sediments from the lake catchment, discharge of untreated or partially treated sewage and industrial waste waters/ solid waste, entry of diffused nutrients source from agricultural and forestry, improper management of storm water, over abstraction, over-exploitation of lake for activities like recreation, fishing, encroachments, land reclamation etc causing lake shrinkage, shoreline erosion and impacting the lake hydrology, deteriorating water quality, impacting bio diversity and therefore an immediate need to assess the pollution status of a lake so that necessary conservation activities may be undertaken to regain/improve its health.

4.2 ENVIRONMENTAL STATUS OF LAKES IN INDIA

All over the country, the lakes and reservoirs, without exceptions, are in varying degrees of environmental degradation which is attributed to the encroachments, eutrophication (from domestic and industrial effluents) and siltation. There has been a quantum jump in the population during the last century without corresponding expansion of civic facilities converting the lakes and reservoirs, especially, in the urban areas as sinks for the contaminants/pollutants. The main causes for the impaired conditions of the lakes are given as under:

4.3 POLLUTANTS ENTERING FROM FIXED POINT SOURCES

- Nutrients from wastewater from municipal and domestic effluents
- Organic, inorganic and toxic pollutants from industrial effluents
- Storm water runoffs

4.4 POLLUTANTS ENTERING FROM NON- POINT SOURCES

- Nutrients through fertilizers, pesticides and other chemicals mainly from agriculture runoffs
- Organic pollution from human settlements spread over areas along the periphery of the lakes and reservoirs

4.5 OTHER BASIN-RELATED CAUSES OF IMPAIRMENT

- Siltation of lakes on account of increased erosion due to expansion of urban and agricultural areas, deforestation, road construction and such other land disturbances taking place in the drainage basin
- Diversion of rivers to feed the lakes
- Competition for lake water uses such as for drinking, irrigation, hydropower etc.
- Addition of untreated or inadequately treated domestic and industrial effluents into the lake basin
  The degree of the problems varies from lake to lake but is more pronounced in urban lakes.

4.6 LAKES OF RAJASTHAN

The state of Rajasthan is primarily known for its magnificent forts and palaces. However, there are quite a few lakes and rivers that quietly make their presence felt among the tourists because of their pristine beauty, opportunity for water sports and also for other useful purposes. While some of the lakes are a gift of nature to Rajasthan, others have been carved out in the earth's surface by the efforts of man. Lake is a body of fresh water surrounded by land. Rajasthan has many scenic and natural lakes which the man has used to store water for drinking and irrigation. Most of the beautiful and picturesque lakes of

Rajasthan are artificial and serve as drinking water source and was being used as a reservoir to conserve rainwater. The lakes in Rajasthan are Lake Pichola, Fateh Sagar Lake, Rajasmand Lake, Ana sagar lake, Gadisar lake,Pushikar lake, Sambhar lake, Pachprada lake and Kaylana lake. The following section is developed to Kaylana Lake in Jodhpur for which water quality data are collected:

4.7 KAYLANA LAKE IN JODHPUR

Jodhpur has a long history of water conservation. There are a large number of tanks within the city and in its immediate vicinity. Jodhpur has experienced rapid urbanization putting pressure on the biotic resources of the lake ecosystem. The increased felling of trees and excessive grazing is leading to the removal of sediment and exposure of the underlying rock. It has severe adverse impact on the wild life in the catchment though its precise impact on the water body is not known. However, one can easily see many areas where there are weeds and low water transparency. It is reasonable to state that the water quality and the aquatic life have suffered over the years as the catchment is readily deteriorated on account of pollution. Kaylana lake, the largest of them all, is located 8 kms to the west of Jodhpur on the Jaiselmer road. Pratap Singh, the then Prime Minister of Jodhpur, got the lake constructed in 1872. It has a catchment area of 42 km^2 or 4200 ha. The lake is fed by a canal (Rajiv Gandhi Lift Canal drawing water from Indira Gandhi Canal). In continuation of the lake downstream, there is another storage reservoir known as Takhat Sagar which is used to supply the drinking water to the city of Jodhpur. The lake has good biodiversity as evident by the presence of large number of species of birds. It consists of a variety of fishes. During winter, it attracts birds from Eastern Europe and central Asia. The lake catchment consists of mostly reserved / protected forest land. The catchment is also biologically rich due to the presence of large of number of plant species and wild life.

4.8 WATER QUALITY OF KAYLANA LAKE

4.8.1 Objective of the conservation plan

Out of the objectives of the project, the objective of the present chapter is to assess the water quality and pollution status of Kaylana Lake.

4.8.2 Selection of locations for water sampling

I was part of team to collect samples of lake water for analyzing the water quality parameters. A visit was planned during 4 – 6 July, 2011 to Jodhpur for fixing water sampling locations and subsequent sampling of water samples from Kaylana. A total of 21 samples were collected from selected locations in Kaylana Lake as details given in table 4.1.

Table 4.1. List of Sampling Locations of Kaylana Lake

S. No.	Kaylana Lake	Sample Code No.	Name of Sampling Location	Date (D/M/Y)	Time (24 Hrs)	Location					
						Latitude			Longitude		
						°	m	S	°	m	S
1	Kaylana (Takht sagar)	T1	Near to platform (Centre)	4-7-11	8:45	26	17	8.9	72	58	26
2	Kaylana (Takht sagar)	T2	Near to Pumphouse	4-7-11	9:45	26	16	8.57	72	58	01
3	Kaylana (Takht sagar)	T3	Sidhnath temple	4-7-11	10:15	26	16	975	72	58	01
4	Kaylana (Takht sagar)	T4	Upper hatchery bandh	4-7-11	10:45	26	17	220	72	58	15
5	Kaylana (Takht sagar)	T5	Lower hatchery bandh	4-7-11	10:45	26	17	212	72	58	15
6	Kaylana (Takht sagar)	T6	Near to tapu	4-7-11	10:00	26	16	902	72	58	12
7	Kaylana (Takht sagar)	T7	Near the fall	4-7-11	10:50	26	17	934	72	58	33
8	Kaylana (Takht sagar)	T8	Near the bridge	4-7-11	11:00	26	17	974	74	58	28
9	Kaylana	K1	Pumping station 1	4-7-11	17:00	26	18	006	72	58	41
10	Kaylana	K2	Pumping station 2	4-7-11	17:30	26	18	035	72	58	35
11	Kaylana	K3	Hathi canal, b/c	4-7-11	18:25	26	19	183	72	58	27

S. No.	Kaylana Lake	Sample Code No.	Name of Sampling Location	Date (D/M/Y)	Time (24 Hrs)	Location					
						Latitude			Longitude		
						°	m	S	°	m	S
12	Kaylana	K4	Inlet, a/c	4-7-11	18:35	26	19	14.2	72	58	31
13	Kaylana	K5	Near to tapu	4-7-11	19:20	26	18	121	72	58	35
14	Kaylana	K6	Left bank of lake (forest chowki)	4-7-11	19:45	26	18	061	72	58	26
15	Kaylana	K7	Right bank of lake	4-7-11	20:00	26	18	066	72	58	39

As indicated in Table 4.1, the samples were taken from the inlet and outlet of the lake and middle locations of the lake with respect to depth. The Fig. 4.1 is showing the locations for water sampling.

4.8.3 Number of Samples Collected

The number of samples collected from Kaylana Lake for water quality assessment and TSI are given in Table 4.2.

For sampling purposes, the Kayalana Lake was divided into two parts i.e. upper and lower region. Upper region is known as Kaylana while the lower region is known as Takht Sagar. 09 samples were collected from Kaylana and 12 samples from Takht Sagar as given in Table 4. 2.

Table 4.2. No. of Samples collected

Kaylana Lake	No. of Samples
Kaylana	09
Takht Sagar	12
Total	**21**

4.8.4 SAMPLING METHODOLOGY

The sampling and analysis was done as per APHA (20th Edition 1998). Water samples were collected from Kaylana during the visits from June 29th, July, 6th 2011. They were also taken depth wise in the field, water quality in-situ parameters like pH,

conductivity, TDS, DO , Temperature, chlorophyll, No_3^- nitrogen , NH_4^+ -N, chlorides, sechhi disc, depth and salinity were measured by portable multi parameter measuring instrument of Hydrolab (HACH). For other parameters, samples were preserved and stored at 4°C and brought to the laboratory for analysis. A brief description of the analytical methods used is given in Table 4.3.

4.8.5 SIGNIFICANCE OF PARAMETERS

Physical, chemical, and biological characteristics of lake are essential to determine the pollution status of the lakes. These parameters were selected based on the surrounding environment of the lake and its impact on aquatic life. The significance of each parameter is briefly given below:

Sechhi Disc

Secchi disc is indicative of the level of light penetration into the lake water. This region of lake having is enough sunlight penetration allows the growth of algae and other rooted aquatic plants called "euphotic zone." The Secchi transparency is considered as an indirect measure of algae and other aquatic plants and sediment in the water.

pH

It determines the acidity, basicity or neutrality of lake water and gives an idea about pollution of water.

Conductivity

Conductivity, the ability of water to pass an electric current, is useful an estimate of the concentration of total dissolved solids (TDS) in water Lakes with high conductivity indicates the presence of mineral ions from mineral sources.

Total Alkalinity

Alkalinity is a measure of the "buffering" capacity of water. The Higher alkalinity, the greater is resistance to change in pH. It is influenced by the presence of bicarbonates and is expressed as $CaCO_3$.

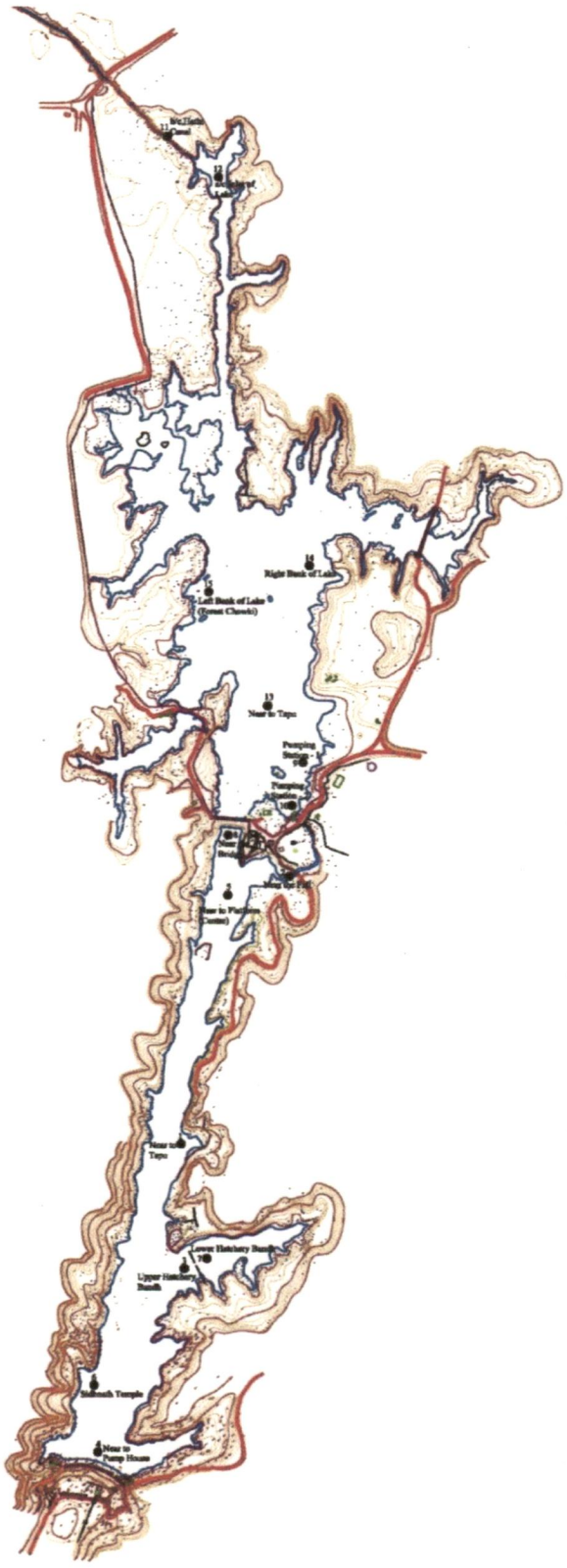


Fig. 4.1 Sampling locations in Kaylana Lake

Table 4.3 Analytical Methods Used

S. No.	Parameter	Unit	Abbre-viations	Method	Equipment/ Instruments Make / Model	Accuracy (%)
1	Temperature	°C	T	Thermometric method	-	± 1
2	pH	-	pH	Electrometric method	Hach	± 5
3	Conductivity	µS/cm		Electrometric method	Hach	± 5
4	Total Dissolved Solids	mg/l	TDS	Electrometric method	Hach	± 5
5	Dissolved Oxygen	mg/l	DO	Electrometric method	Hach	± 5
6	Turbidity	NTU		Electrometric method	Hach	± 5
7	Nitrate nitrogen	mg/l	TN	Spectrophotometric method	Hach	± 5
8	Total Phosphorous	mg/l	TP	Spectrophotometric method	Hach	± 5
9	Biological Oxygen Demand	mg/l	BOD	Titrometric method	APHA (20^{th} Edition)	-
10	Fecal coliform	MPN/ 100ml	FC	Browth media method	APHA (20^{th} Edition)	-
11	Total Hardness	mg/l		Titrometric method	APHA (20^{th} Edition)	-
12	Calcium	mg/l	Ca	Titrometric method	APHA (20^{th} Edition)	-
13	Magnesium	mg/l	Mg	Titrometric method	APHA (20^{th} Edition)	-
14	Potassium	mg/l	K	Titrometric method	APHA (20^{th} Edition)	-
15	Chemical Oxygen Demand	mg/l	COD	Electrometric method	Hach	± 5
16	Sodium	mg/l	Na	Flame photometric method	Toshniwal	± 5
17	Total alkalinity	mg/l	TA	Titrometric method	APHA (20^{th} Edition)	-
18	Chlorides	mg/l	Cl	Hydrolab 5x	Hach	± 5
19	Chlorophyll 'a'	µg/ml	Chl 'a'	Hydrolab 5x	Hach	± 5

Suspended Solids (SS)

Suspended Solids influence a lake's transparency, color, habitat quality, recreational values and overall ecosystem health. Total suspended solids (TSS) and turbidity include both inorganic (such as soil particles) and organic pollutants. Turbidity is expressed in Nephelometnc Turbidity Units (NTU).

TDS

It includes the total amount of all inorganic and organic substances including minerals, salts, metals, cat ions or anions dispersed in water. High TDS indicate hard water and may lead to scale buildup in pipes, reduced efficiency of water filters, hot water heaters, etc. and aesthetic problems such as a bitter or salty taste. TDS is contributed by natural sources, sewage, urban run-off, industrial wastewater, and chemicals used in the water treatment process.

Dissolved Oxygen (DO)

DO indicate the amount of dissolved in water for necessary for the survival of fish and other aquatic life. The availability of DO is influenced by the temperature which may be used to know the presence or absence of lakes's thermal stratification. Both DO and Temp. Measurements are an integral part of lake assessment. As stated, the temp. Variations have significance of fact on the life of fish and aquatic life due to DO. It is an important parameter which, depending on the % saturation, can be used to assess the pollution status of water bodies.

Nutrients

Nutrients serve the basic function helping the plants to grow. Though some algae and aquatic plants are essential for a healthy lake ecosystem but the elevated nutrient levels can stimulate excessive growth of vegetation of different types and if the addition of excessive amount of these nutrients is not checked/controlled, the excess aquatic plant growth exceeds its consumption, thereby, resulting in the accumulation of biomass and the system is said to be in entropic state i.e. an impaired water body. P and N are the two nutrients of primary concern and can be measured in different forms. Phosphorus is measured as total phosphorus (TP) and in various other dissolved forms. It is present in natural water as phosphates (orthophosphates, polyphosphates, and organically bound

phosphates). TP is a measure of all forms of phosphorus in the water sample including that attached to soil particles or contained in algae cells. TP concentrations above 0.030 mg/l are enough to stimulate the growth of nuisance algal growth. Various forms of N are No_3-N, No_2-N, total ammonia and Total Kjeldahl Nitrogen (total ammonia plus organic nitrogen) are of great interest. The inorganic nitrogen (nitrate and ammonia) are readily utilized by algae for growth. It is found that inorganic nitrogen concentrations above 0.30 mg/l can stimulate the algae growth while high ammonia concentrations are toxic to fish and other aquatic organisms.

Nitrate – Nitrogen (NO_3-N)

Nitrogen occurs in the soil in organic forms available from decaying plant and animal residues. In the soil, bacteria convert various forms of nitrogen to nitrate, (NO_3-N). Nitrate is a major ingredient of farm fertilizer and is necessary for crop production. When there are rains, varying amounts of nitrate wash away from farmland into nearby waterways. Nitrates also reach to waterways from lawn fertilizer run-off. As per EPA, 10 mg/l is the maximum contaminant level (MCL) for NO_3^-N and 1 mg/l for NO_2^-N for regulated public water supply system.

Biochemical Oxygen Demand (BOD)

BOD is a measure of dissolved oxygen required by aerobic organisms in water to break down organic material present in a given water at certain temperature over a specific time period. It is widely used as an indication of the organic quality of water. It is commonly expressed mg/l during 5 days incubation at 20 °C or 3 days at 27°C and is often used as a robust surrogate of the degree of organic pollution of water. The BOD limits for drinking water is 2 mg/l or less and for bathing water, it is 3mg/l as per water quality standards.

Fecal Coliform

Fecal coliform are microscopic organisms that live in the intestines of warm-blooded animals and are excreted. It is an indicator of the presence of sewage and animal wastes that may contain disease-causing organisms and pathogens. The presence of fecal coliform bacteria in aquatic environments indicates that the water is contaminated with the fecal material of human being or other animals. These can enter lake through direct

discharge of waste from man, animals and birds or through drainage from the Watershed. It is an indicator of potential health risk for individuals exposed to this water. Fecal coli form in wastewater can be reduced by the use of chlorine and other disinfectant chemicals.

Chlorophyll 'a'

Chlorophyll 'a' is found in all photosynthesizing plants. The amount of plank tonic (suspended) algae in a lake is commonly estimated using the chlorophyll a concentration. Chlorophyll 'a' levels greater than about 55 µg/l is indicative of high state of impairment of lake while concentrations of 7 lo 20, µg/l show slight impairment.

Total Hardness

It is indicative of the presence of Ca, Mg and other abundantly available salts. Hard water indicates high amount of bicarbonates of Ca, Mg and other metals from the weathering of rocks/ indicative of mining activities in the nearby areas.

4.8.6 WATER QUALITY CRITERIA

The Central Pollution Control Board (CPCB) has classified water in five classes on the basis of Best Designated uses as given in Table 4.4.

Table 4.4 Water Quality Criteria

S. No.	Designated-Best-Use	Class of water	Criteria
1	Drinking Water Source without conventional treatment but after disinfection	A	• Total Coliform Organism MPN/100ml shall be 50 or less • pH between 6.5 and 8.5 • Dissolved Oxygen 6mg/l or more • Biochemical Oxygen Demand 5 days 20°C 2mg/l or less
2	Outdoor bathing (Organized)	B	• Total Coliform Organism MPN/100ml shall be 500 or less pH between 6.5 and 8.5 Dissolved Oxygen 5mg/l or more • Biochemical Oxygen Demand 5 days 20°C 3mg/l or less
3	Drinking water source after conventional treatment and disinfection	C	• Total Coliform Organism MPN/100ml shall be 5000 or less pH between 6 to 9 Dissolved Oxygen 4mg/l or more • Biochemical Oxygen Demand 5 days 20°C 3mg/l or less
4	Propagation of Wild life and Fisheries	D	• pH between 6.5 to 8.5 Dissolved Oxygen 4mg/l or more

S. No.	Designated-Best-Use	Class of water	Criteria
			• Free Ammonia (as N) 1.2 mg/l or less
5	Irrigation, Industrial Cooling, Controlled Waste disposal	E	• pH between 6.0 to 8.5 • Electrical Conductivity at 25°C micro mhos/cm Max.2250 • Sodium absorption Ratio Max. 26 Boron Max. 2mg/l

* Below-E not Meeting A, B, C, D & E Criteria.

4.8.7 EVALUATION OF TROPHIC STATE OF LAKES

The Trophic State refers to the level of productivity in a lake as measured by phosphorous, algae abundance and depth of light penetration. Trophic state of individual lakes, ponds and reservoirs is based on the amount of biological productivity occurring in the water by using. Using the index, one can get a quick idea about the extent of productivity of a lake by using Trophic State Index (TSI). Out of large numbers of TSIs, Carlson's Trophic Status Index (TSI) developed by Carlson [1] can be applied for the lakes. The assessment of TSI requires six physical, chemical and biological parameters like total phosphorus (TP), total nitrogen (TN), chemical oxygen demand (COD), Secchi depth (SD), and chlorophyll-'a' (Chl-a). TSI can be used to classify the lakes within a region and between the regions. This classification enables the water managers to target lakes that may require restoration or conservation. An increasing trend in TSI over a period of several years may indicate the degradation of the health of a lake. The Carlson's TSI can be computed using the following equations:

$$TSI - P = 14.42 * Ln [TP] + 4.15 \text{ (in ug/l)} \quad \text{---------- (i)}$$

$$TSI - C = 30.6 + 9.81 Ln [Chlor\text{-}a] \text{ (in ug/l)} \quad \text{---------- (ii)}$$

$$TSI - S = 60 - 14.41 * Ln [SD] \text{ (in meters)} \quad \text{---------- (iii)}$$

$$\text{Average TSI} = [TSI (P) + TSI (CHL\ 'a') + TSI (SD)]/3 \quad \text{---------- (iv)}$$

Where TP: Total Phosphorus, chlor 'a' chlorophyll 'a' and SD: sechhi depth (m).

The collected data from has been used to compute TSI and numerically the TSI ranges from 0-100 as given in Table 4.5.

Table 4.5. Carlson's Trophic State Index

TSI	Status	Status of lakes
< 30	Oligotrophy	Classical Oligotrophy: Clear water, oxygen throughout the year in the hypolimnion, salmonid fisheries in deep lakes.
30-40	Mesotrophy	Deeper lakes still exhibit classical oligotrophy, but some shallower lakes become anoxic in the hypolimnion during the summer
40-50	Mesotrophy	Water moderately clear, but increasing probability of anoxia in hypolimnion during summer
50-60	Eutrophy	Lower boundary of classical eutrophy: Decreased transparency, anoxic hypolimnia during the summer, macrophytes problems evident, warm-water fisheries only.
60-70	Eutrophy	Dominance of blue-green algae, algal scums probable, extensive macrophyte problems.
70-80	Hyper eutrophy	Heavy algal blooms possible throughout the summer, dense macrophytes beds, but limited light penetration. (Often would be classified as hypereutrophic)
> 80	Hyper eutrophy	Algal scums, summer fish kills, few macro-phytes, dominance of rough fish etc.

4.8.8 DATA COLLECTION

The water quality data is given in Table 3 which shows that out of 18 parameters, only 5 parameters are found as major stresses. The water quality at each location is given in Fig. 4.2 (map showing the variation of important parameters indicating the quality at various locations of Kaylana Lake).

S. No.	Parameters	Unit	Pumping station 1	Pumping station 2	b/c, hathi canal	a/c, inlet of lake	Near to tapu K5			Left bank of lake (forest chowki)	Right bank of lake	Near to Platform (Centre) T1			Near to Pump house	Sidhnath temple T3			Upper hatchery bandh	Lower hatchery bandh	Near to Tapu	Near the fall	Near the Bridge
			K1	K2	K3	K4	A	B	C	K6	K7	A	B	C	T2	A	B	C	T4	T5	T6	T7	T8
A.	Physico-chemical parameters:																						
	Depth	m	53 ft	30t	-	-	1	5	10	7	4.5	1	3.0	7.61	2.74	1	4.5	9	3	-	2.73	-	3
	Dissolved Oxygen	mg/L	8.02	9.60	7.0	8.52	12.29	7.47	7.01	7.44	8.62	6.85	6.1	5.5	8.46	8.65	7.96	5.96	8.24	10.62	8.35	7.02	6.33
	Temperature	°C	31.1	31.3	31.8	31.7	30.8	30.8	30.8	28.8	29.6	29.8	29	28.7	30	29.6	29.8	27.3	30.7	30.7	30	30.3	29.3
	Ph		7.9	8.0	7.6	8.0	8.2	7.8	7.9	8.0	8.0	7.4	7.4	8.1	8.0	7.6	7.9	7.4	8	8.2	8	7.6	7.6
	Secchi Disc Transparency	cm	1	0.5	1	1	72	70	70	50	1	-	1	1	1	1.25	1.25	1.25	1	2	4	0.5	1
	Turbidity	NTU	24.5	24.6	23.2	25.1	23.2	24.5	24.5	25.1	24.5	24.5	24.5	8.4	26.7	24.5	24.5	24.5	25.5	25.6	24.5	25.1	24.5
	Total Hardness		4.3	7.1	4.1	7.4	5.4	4.2	4.0	6.1	4.5	6.0	6.1	6.1	4.2	5.0	6.2	6.2	5.0	8.2	4.3	6.5	6.1
	Calcium as Ca	mg/L	3.2	4.2	4.0	4.3	4.3	3.0	3.4	4.1	3.2	4.9	5.0	5.0	4.0	3.2	4.1	4.5	3.2	5.3	3.1	5.1	5.0
	Magnesium as Mg	mg/L	0.27	0.71	0.02	0.75	0.27	0.29	0.15	0.48	0.32	0.27	0.27	0.27	0.048	0.44	0.51	0.41	0.44	0.71	0.29	0.29	0.27
	TSS	mg/L	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200
	Total Dissolved Solids (TDS)	mg/L	122.6	120.6	116.5	114.3	119.5	123.2	123.8	123.8	122.5	125.3	125.3	125	124.8	124.5	125.3	130.9	113.5	121.6	124.9	124.3	124.3
	Conductivity	µS/cm	257	253	244	240	253	258	259	259	256	262	256	253	260	261	262	274	238	255	256	260	260
	Total Alkalinity	mg/L	196	226	140	181	185	185	185	231	244	60	60	60	171	121	121	121	322	364	182	82	86
	Chlorides as Cl	mg/L	11.7	10.8	10.9	10.3	10.3	10.9	10.9	11.3	10.9	10.9	10.8	10.9	10.9	10.8	10.8	10.7	13.2	11.5	10.9	11.02	10.3
	Sulphates	mg/L	29	32	25	26	28	35	23	26	32	34	34	31	43	36	37	42	46	46	47	30	31
	Total Phosphorus	mg/L	2.73	2	7.16	2.35	2.19	2.31	2.12	2.6	1.15	3.1	2.82	2.7	1.99	1.68	3.25	3.46	1.99	11.04	2.94	1.88	1.98
	Nitrate - N	mg/L	10.8	11.2	10.8	10.8	10.2	10.8	10.2	9.2	11.9	9.8	10.5	11.12	18.65	9.5	9.1	9.5	10.2	10.5	10.5	10.5	10.5
	Ammonical - N	mg/L	0.05	0.05	0.02	0.03	0.05	0.02	0.03	0.05	0.02	0.05	0.05	0.03	0.05	0.05	0.02	0.02	0.05	0.05	0.02	0.02	0.02
	Salinity	%	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.13	0.11	0.12	0.12	0.12	0.10
	COD	mg/L	5	17	60	73	37	24	30	52	12	43	35	32	11	44	67	38	97	74	7	5	27
B	Biological Analysis																						
	BOD_5	mg/L	11	6	4	6	13	10	16	8	9	6	7	7	7	5	6	6	55	27.2	5	3	4
	Chlorophyll 'a'	mg/L	5.6	7.7	2.1	3.2	5.1	3.2	5.3	8.1	10.1	2.0	3.6	1.6	20.0	3.2	5.1	1.3	17.8	10.6	11.1	14.3	6.5
C	Bacteriological Analysis																						
	Faecal Coliform	MPN/ 100 ml	240	240	7	15	15	11	15	43	93	23	23	23	460	93	93	93	28	460	15	15	43

Table 4.6: Analysis of water samples from Kaylana Lake of Jodhpur visit 4th-5th july 2011

4.8.9 RESULTS AND DISCUSSIONS

Major stressors of Kaylana are grouped into the three water quality:

I. Water quality of the whole lake

II. Trophic state of lake

III. Water quality profile w.r.t. depth

I-Water quality of whole lake

The sample K1 to K7 and T1 to T8 are from inlet and outlet and depends on the depth of the lake. The results indicate that the temperature ranges from 28.7–31.8°C during the period of sampling while the pH remains between 7.4 - 8.2 which is under the prescribed limits for class 'B' of water i.e., (6.5 – 8.5). The DO ranges from 5.5 – 12.29 mg/l which satisfies the prescribed value of (6 mg/l or more) of well oxygenated water. The turbidity ranged from 24.5 – 26.7 mg/l which is more than the standard limit of 10 mg/l indicating the bathing water quality 'B' having slightly more sediments/ silts (Table 4.4).

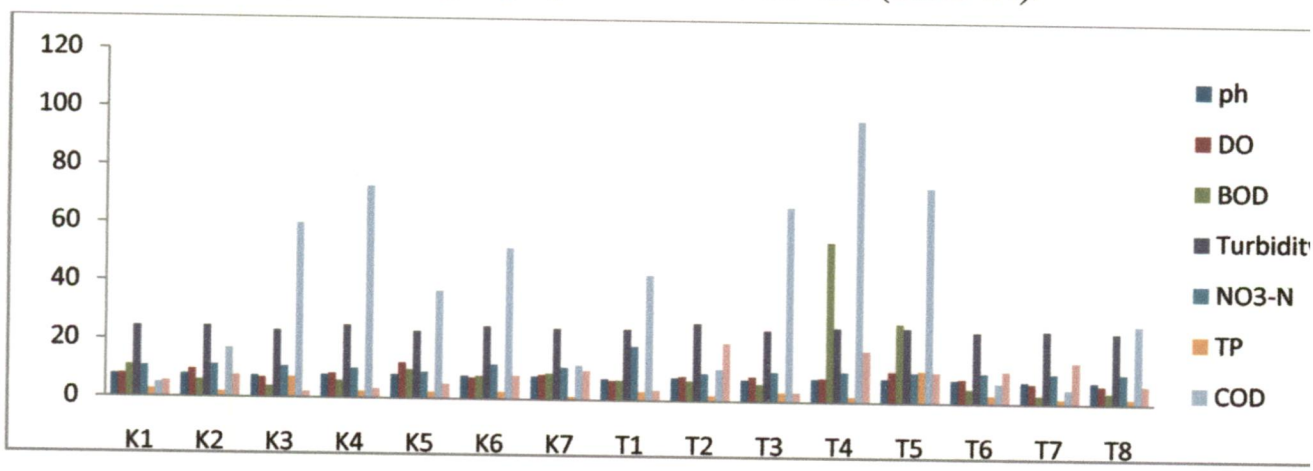


Fig. 4.2 WQ data of Kaylana Lake, Jodhpur

NO_3-N ranges from 9.1 – 18.65 mg/l with highest content (18.65) at T2 (near the pump house) & lowest 9.1 mg/l at T3 i.e. near Sidhnath temple. This may be attributed to the more human activities related to the agriculture/ artificial forest using synthetic nitrogen fertilizer which might have reached to the lake through run-offs. The TP range from 1.99 – 11.99 mg/l with high TP (11.99) at T4 due to the hatchery where lot of waste is received from the catchment in the form of human wastes due to open defecation and animal wastes of grazing animals.

The BOD ranges from 3 – 55 mg/l which is higher than the prescribed limit of bathing water quality. The conductivity ranges from 238 - 260 µS/cm for which no limit is prescribed in specifications. The FC ranges from 7 to 460 MPN/100ml which is under standard limits of class B water quality (500 or less). The increase in FC from T2 – T5 and further from KI - K2 is attributed to the increase in the amount of human wastes.

These data concludes that water quality at all well mixed locations except the stagnant water is indicating of water class 'B' quality that can be used as bathing purposes. The water is pumped to the physical treatment plant for further supply for drinking purposes to Jodhpur city.

II-STATUS OF LAKE

The TSI of lake at various locations was assessed using the data of TP. Chlorophyll, Secchi depth and equations for TSI. The results are given in Table 4.6.

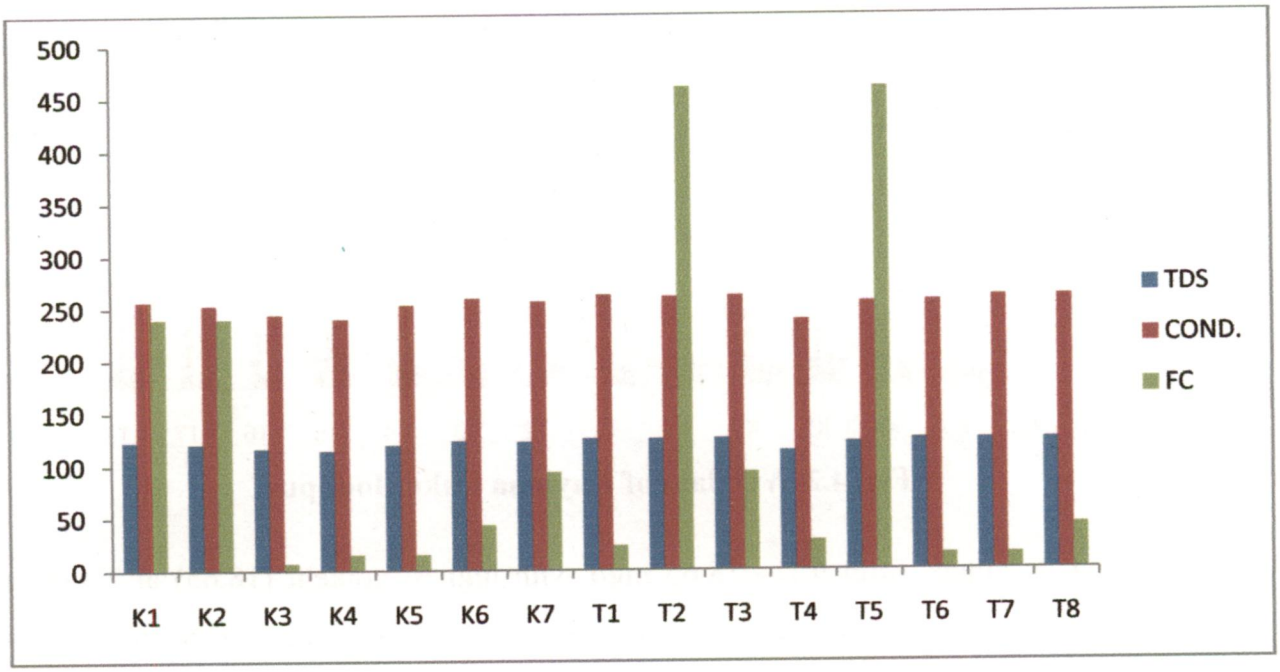


Fig. 4.3 WQ data of Kaylana Lake, Jodhpur

Table 4.7. Trophic State Index of Kaylana Lake

S.No.	Location	TSI Range	Status of Lake
1	K1	40-50	Mesotrophy
2	K2	60-70	Eutrophy
3	K3	15-30	Slightly oligotrophy
4	K4	15-30	Slightly oligotrophy
5	K5	30-40	Slightly mesotrophy
7	K6	40-50	Mesotrophy
8	K7	40-50	Mesotrophy
9	T1	30-40	Slightly mesotrophy
10	T2	50-60	Slightly eutrophy
11	T3	30-40	Slightly mesotrophy
12	T4	60-70	Eutrophy
13	T5	50-60	Slightly eutrophy
14	T6	30-40	Slightly mesotrophy
15	T7	15-30	Slightly oligotrophy
16	T8	30-40	Slightly mesotrophy

The TSI of Kaylana Lake is found as mesotrophy

I. Water quality w.r.t depth

For the purpose of evaluating the water quality w.r.t. to depth, the lake is divided into two part i.e. Kaylana and Takht Sagar. Three samples were taken from Kaylana at K5 and six samples from Takht Sagar w. r.t. depth at location T1 and T3. The water quality parameters at location K5 shows that there is no change of water quality with depth as shown in Table 4.8. pH ranges w r t depth is 7.8 – 8.2 which is in the limit of class B. The data present in fig. 4.4 and given in Table 4. 8.

Table 4.8. WQ measured at K5 Location w.r.t depth

WQ Parameter	Data Record			Std. Limits
Depth (m)	1.0	5.0	10.0	
ph	8.2	7.8	7.9	6.5-8.5
DO (mg/l)	12.29	7.47	7.01	5.0
BOD (mg/l)	13.0	10.0	16.0	3.0
FC (MPN/100ml)	15.0	11.0	15.0	50.0
Chl 'a' (mg/l)	5.1	3.2	5.3	5.0

The results are shown graphically in Fig. 3a which shows that quality having significant life support ability. DO ranges from 7.01 – 12.29 mg/l which is indicating of the water. The BOD ranges from 10 – 16 mg/l are higher than the prescribed limit of bathing water indicating that there is good water purification ability of lake that continuously assimilates the organic load and DO build up is due to higher %age of saturation.

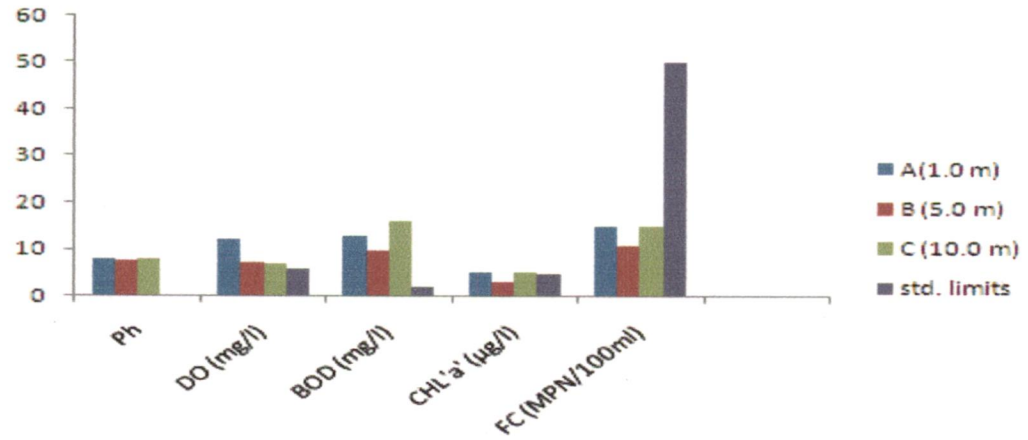


Fig. 4.4 WQ parameters at K5 location with depth

The FC ranges from 11 to 15 MPN/100ml at various depths which is under the standard limits of class B water (500 or less). It indicates uniformity of water quality w.r.t. to depth. Likewise, data are presented in Table 4.9 at T1 location and shown graphically in Fig. 4.5.

Table 4.9 WQ measured at T1 Location w.r.t depth

WQ Parameter	Data Record			Std. Limits
Depth (m)	1	3	7.61	
pH	7.4	7.4	8.1	6.5-8.5
DO (mg/l)	6.85	6.1	5.5	5
BOD (mg/l)	6	7	7	3
FC (MPN/100ml)	23	23	23	50
Chl 'a' (mg/l)	2	3.6	1.6	5

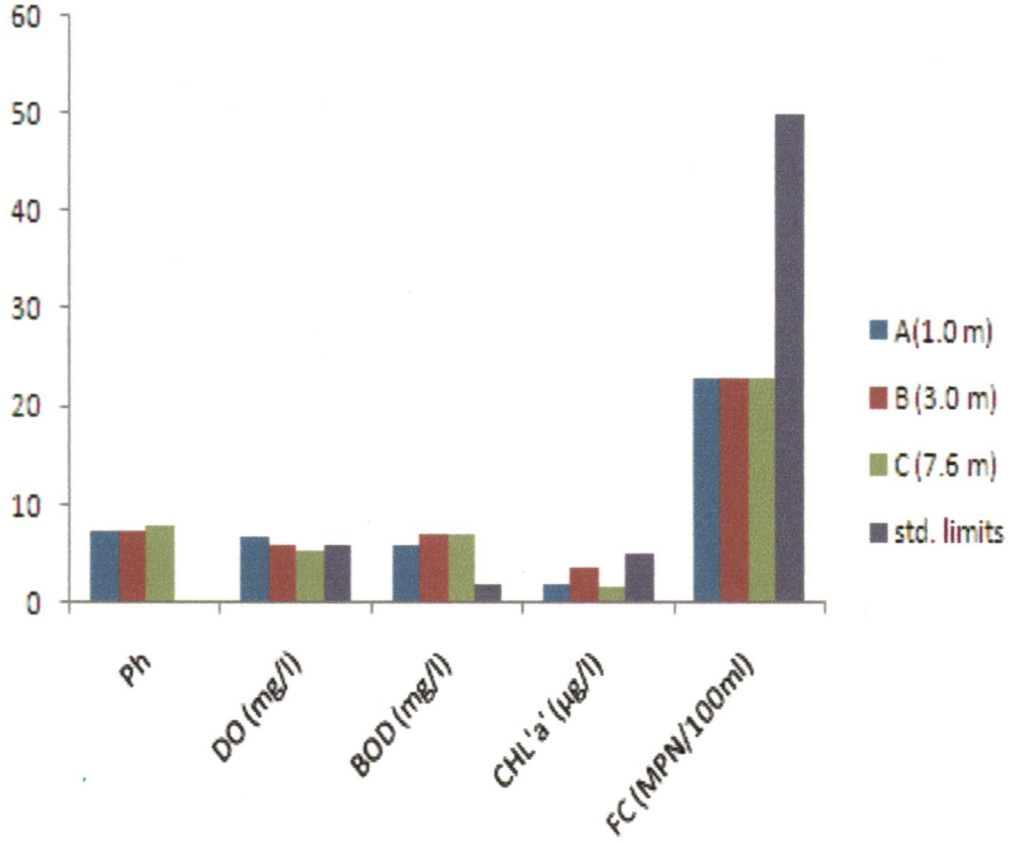


Fig. 4.5 WQ parameter measured at T1 location

The water quality data at T3 location is given in Table 4.10 and graphically shown Fig. 4.6.

Table 4.10. WQ measured at T3 Location w.r.t. depth

WQ Parameter	Data Record			Std. Limits
Depth (m)	1	4.5	9	
Ph	7.6	7.9	7.4	6.5-8.5
DO (mg/l)	8.65	7.96	5.96	5
BOD (mg/l)	5	6	6	3
FC (MPN/100ml)	93	93	93	50
Chl 'a' (mg/l)	3.2	5.1	1.3	5

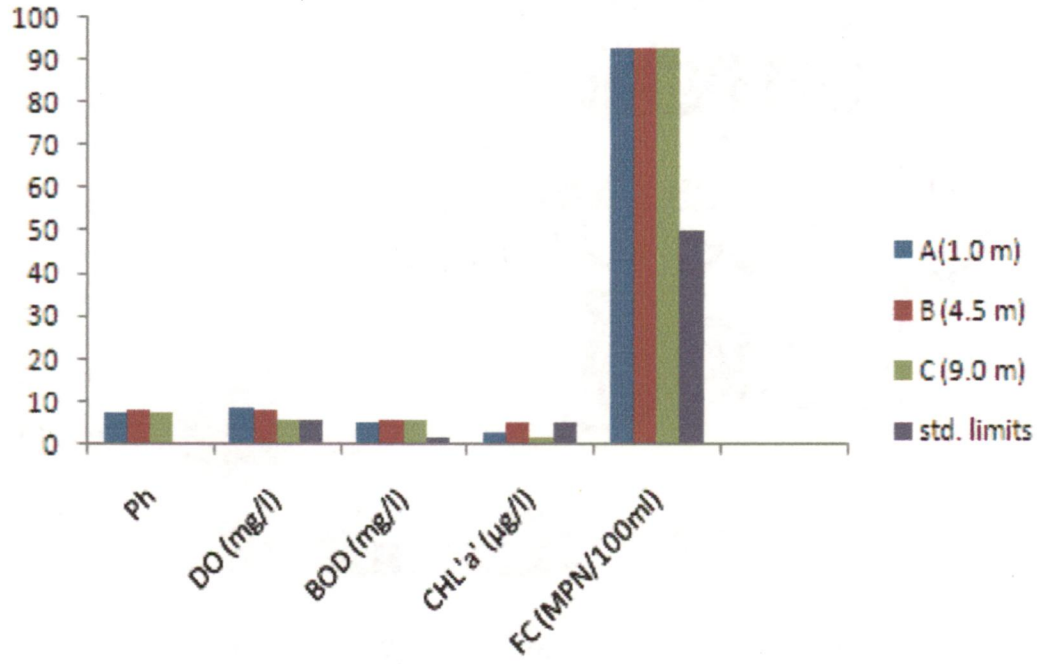


Fig. 4.6 WQ parameter measured at T3 location

The data of table 4.9 and 4.10 and Fig. 4.5 and 4.6 indicates that there is almost no difference in pH, DO, BOD, Chl'a' and FC which are less than the prescribed limits showing that water quality with depth is the same throughout the water column i.e. lake is vertically well mixed with no sign of stratification.

CONCLUSIONS

On the basis of the above analysis, it is concluded that out of 18 parameters measured; only five parameters viz, pH, DO, BOD and FC and chlorophyll 'a' are found as the major stressors impacting the lake water quality. The water quality of the whole lake and water quality with respect to depth indicates that the lake water quality belongs to class 'B' water quality which is suitable for bathing/ irrigation. Further, lake is in mesotrophic state with respect to its trophic state indicating that owing to receiving the nutrients from the surroundings, the lake has developed the tendency to allow the growth of vegetation which is huge in areas where the water is stagnant not in the turbulent mixing mode. In summary, the lake water quality is suitable for bathing/ irrigation which can be easily improved using conservation measures consisting of landscape development, management of solid wastes in around lake due to tourists visiting the lake.

CONSERVATION AND MANAGEMENT PLAN

5.1 INTRODUCTION

Aim of this study has been to arrive at a comprehensive plan for the conservation of Kaylana Lake and Machia Biological Park for the sustainable and beneficial development of the lake environment. Measures require in the lake and out of the lake i.e. in the catchment have been dealt separately.

Impact of Biological Park on lake in future, whether to insure it does not deteriorate water quality of lake. The different management and conservation activities for Kaylana Lake and Machia Park are given below:

1. Monitoring of water quality.
2. Physical removal of water hyacinth and other weeds from the water surface.
3. Treatment and revival of water bodies.
    - Supply of bacterial products as per requisite quantities.
    - Application of the bacterial products as per the schedule.
    - Arrangements of aeration system for oxygen supply to maintain the lake eco-balance.
4. Solid waste management strategy.
5. Catchment treatment practices.
6. Shore line development.
7. Machia biological park development plan
8. Public awareness Programme promoting the importance of conservation of lake.

5.2 Seven principles for the sustainable lake management [19]

Principle 1: A harmonious relationship between human and nature is essential for the sustainable use of lakes.

Principle 2: A lake drainage basin is the logical starting point for planning and management actions for sustainable lake use.

Principle 3: A long- term, preventative approach directed to preventing the cause of lake degradation is essential.

Principle 4: policy development and decision making for lake management should be based on sound science and the best available information.

Principle 5: The management of lake for their sustainable use requires the resolution of conflicts among competing users of lake resources, taking into account the needs of present and future generations and of nature.

Principle 6: Citizens and other stakeholders should be encouraged to participate meaningfully in identifying and resolving critical lake problems.

Principle 7: Good governance, based on fairness of all stakeholders, is essential for sustainable lake use.

5.3 MONITORING OF WATER QUALITY

Periodical monitoring of water quality is needed to set up with inbuilt scientific equipments. PHED is to have a lake monitoring unit with well-equipped modern laboratory instruments and skilled personnel. This unit is made to collect, analyzing and disseminate the scientific data relating to various aspects of the lake, for taking future course of action.

For the present study, the Kaylana Lake was divided into two parts i.e. upper and lower region. Upper region is known as Kaylana while the lower region is known as Takht Sagar. 09 samples were collected from Kaylana and 12 samples from Takht Sagar.

Out of 18 parameters measured, only five parameters viz, pH, DO, BOD, FC and chlorophyll 'a' are found as the major stressors impacting the lake water quality. The water quality of the whole lake and water quality with respect to depth indicates that the lake water quality belongs to class 'B' water quality which is suitable for bathing and irrigation. The lake is in mesotrophic state with respect to its trophic state indicating that owing to receiving the nutrients from the surroundings, the lake has developed the tendency to allow the growth of vegetation which is huge in areas where the water is stagnant not in the turbulent mixing mode. In overall, the lake water quality is suitable for bathing and irrigation. This can easily be improved using conservation measures of catchment treatment and management of solid wastes.

5.4 PHYSICAL REMOVAL OF WATER HYACINTH AND OTHER WEEDS

Physical removal, cutting with machines and using aquatic herbicides, are primary methods. Recently, several new methods have been developed for aquatic weed control. The drawback with aquatic weed control technique is that it breaks off thousands of weed fragments, take root and start growing new plants. Activities to be carried out are de-weeding, de-silting, putting floating fountain and ozonizers. Since the DO level in the lake is not so bad. Hence, surface aerator can be used as per design requirement to improve the DO level in the lake.

Fig. 5.1 Physical Removal of Weeds

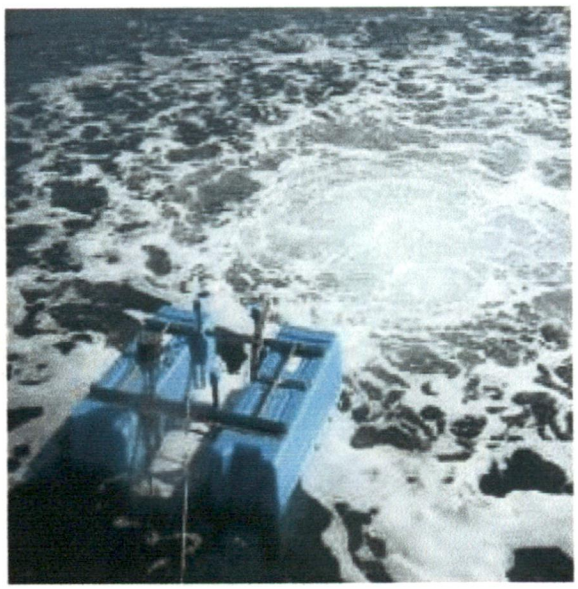


Fig. 5.2 Ozonizer

5.5 TREATMENT AND REVIVAL OF WATER BODIES

Bioremediation (cleaning with bio products - Natural bacteria break down and manual measures bio composting).

Introduction of composite fish culture/carnivorous fish species to control mosquitoes. Harvesting of aquatic weeds for growing vegetables provides benefits to the local communities.

For small areas of Lake, agitating the sediment can be a workable method of aquatic weed control as follows:-

1. **Rotavation**: is basically lake bottom agitation combined with a rot tiller, which rips out weeds by the roots and disrupts and dislodges sediment on the lake bottom.

Fig. 5.3 Rotavation

2. **Grass Carp**: This fish is a non-native species but it is proved in some states as an aquatic weed control method. The fish eats some species of lake weeds. The carp used for weed control are sterile and cannot reproduce.

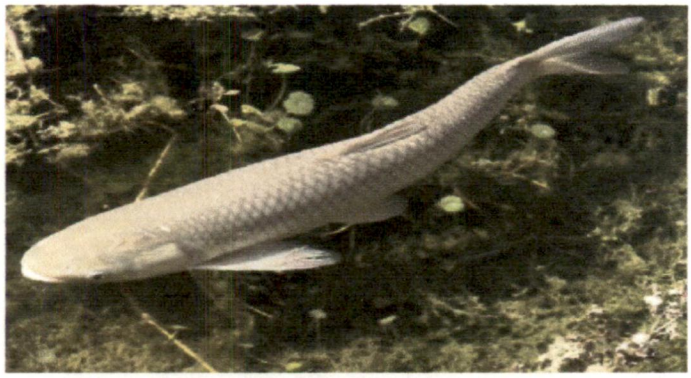


Fig. 5.4 Grass Carp

3. **Biological Control**: An interesting technique for aquatic weed control is to introduce insects like the milfoil weevil, which eat some non-native aquatic plants. The milfoil weevil is probably the best example of using a biological control agent to control certain types of nuisance plants, for example, Eurasian milfoil.

Fig. 5.5 Milfoil Weevil

Fig. 5.6 Eurasian milfoil

4. **Water Level Drawdown**: In a few water bodies, the depth of the water is lowered by weirs or dams as a method of aquatic weed control. Draw down of water level, usually in winter, exposes Lake Weed roots systems to both drying and freezing, which often destroys large sections of aquatic weeds.

Fig. 5.7 Aquatic weed harvester

5. **Bottom Screening**: Also known as "benthic barriers" is the type of aquatic weed control.

5.6 SOLID WASTE MANAGEMENT PLAN

5.6.1 Need of Solid Waste Management

Jodhpur town is a fast growing industrial town with heavy inflow of migrants. Development is taking place in haphazard manner leading to lack of sanitation, water supply, sewerage and traffic facilities. The problem of solid waste management in town is quite acute because there is no proper collection, transportation and disposal system as required by the Municipal Solid Waste Handling rules 2000 (Ref. State Pollution Control Board, Rajasthan). At present only 60% of the garbage is being collected and disposed off in open low lying areas. To check further deteriorating conditions in respect of solid waste management, proper waste management programmers for catchment area of Kaylana Lake and in Machia Biological Park is urgently needed.

At present no separate solid waste management plan exists around the lake and in Machia Biological Park hence litter is found scattered around the lake in Machia Park. The waste mostly contains empty glass, plastic bottles and empty food packets. In the wards in which this lake area is included, the solid waste is stored in municipal bins of sizes 1.1 $m^3$and 7.0 $m^3$and is disposed off at Keru landfill and processing site, by refuse collector vehicles. Once the lake site and Machia Park is developed for tourism, a proper Solid Waste Management (SWM) system will be required.

5.6.2 General points for consideration

The issues that need to be addressed in a SWM plan include estimation of the solid waste that will be generated and will have to be transported to the landfill. It is important to realize that the SWM system is dynamic in nature hence the collection and disposal should be reviewed and modified from time to time, if required, after every three years. In the surroundings of the lake area and in Machia Park food waste will be generated by two category of people, firstly by the food kiosks and food-court owners and secondly by the visitors to the area. While the collection and disposal of the food waste generated by the kiosks and food court owners should be taken care by the owners themselves, adequate arrangements should be set up for collection of the waste generated by the visitors.

Furthermore, the waste should be segregated at the source by providing twin bin system and the waste generated in the area should be processed and inert should be placed in the community bin for collection and later to be sent to the same landfill site where the waste of Jodhpur city is disposed off. It is further necessary that use of plastic bags shall not be allowed in the eco-tourism area and the recyclable plastic should be salvaged and the SWM system should preferably be handled in PPP mode with the application of the principle that the generator pays.

5.6.3 Storage and Collection of Solid Waste

Along the path in zoo, Machia Park and walkway at Takht Sagar 40 liters litter bins (in set of 2 bins) are proposed to be provided at 100m centre to centre distance. One bin should be for empty plastic water bottles and drinks bottles and the other for the empty food packets and pouches. The maximum percentage of waste expected is empty bottles. As far as possible visitors should be discouraged to bring any fresh food in the area. Twin bins or a pair of two bins of capacity 40 liters each are proposed to be placed near the entry point. There are three picnic areas proposed one each near the Waterfall, picnic spot in lower lake east and picnic spot on west. Two sets of bins of capacity 40 each bin are proposed to be placed in each picnic area. Two bins of 40 liter capacity for empty bottles are proposed in this area. One set of three bins of 40 liter are proposed to be placed in this area. Two sets of bins of 40 liter capacity are proposed in this area. One set of bins is proposed to be placed in Amphitheatre in addition to bins placed in public convenience. One set of 40 liter bins shall be provided at each view

point. Litter bins are proposed to be placed at 50m intervals all along the parks. Alternate bins shall be in pair. Two sets of litterbins are proposed to be placed in each Food Kiosk. Furthermore, it is necessary that the shopkeepers are educated and encouraged to follow the MSW management rules as well as how they can keep the place attractive for the tourists. At each shop they will be asked to use two bins for storage of waste.

Waste should be stored separately as biodegradable waste and other waste using two bin system and they should be properly processed. The organic food waste should be composted or vermin-composted. The non-biodegradable waste should be collected by collector. It is proposed that all bins be fixed properly in steel guards so that they do not topple due to wind.

5.6.4 Transfer and Transport of Waste from the Lake Area

The pedestrian walk and the other area of Takht Sagar , Machia Park should be swept twice a day and the sweepings should be directly placed in the vehicle or the bins as per the sweeping schedule. Waste should be stored separately as biodegradable waste and other waste. Waste should also be collected from door to door from buildings (including residences) falling in the lake area. Waste from litter bins is proposed to be collected by the collectors in Garbage Cycle Rickshaws or wheeled trolleys from the entire ecotourism area developed under the plan. No motorized vehicle is suggested to be used in Machia Park area to avoid any pollution. The collected waste will be emptied into one set of 1200 liter community bin on east side and other set of community bin of 1200 liter on west side which shall be lifted by the refuse collector. The timings for the refuse collector shall be decided in such a way that the wild life does not get disturbed by its movement. Hence four compartmental community bins of 1200 L capacity are proposed be provided for the different category of waste.

5.6.5 Processing

No separate processing of the waste is proposed to be done except that the organic waste which shall be converted to fertilizer through composting or Vermicomposting.

5.6.6 Manpower Requirement

The number of sweepers has been calculated based on the criteria given in the SWM manual.

Supervisor	2
Sweeper	25
Driver	6
Rickshaw puller and collector	4

5.6.7 Tools and Kits Requirement

The main tools to use for garbage collection are listed below:

1. Garbage rickshaw 4
2. Belacha 4
3. Shovels 4
4. Broom with long handle 29
5. Gloves 29
6. Boots 29

Table 5.1 Quantity of Solid Waste Generated daily nearby Kaylana Lake.

S.No	Type	Waste Generated Per Day (MT)
1	Residential	10
2	Commercial/ Markets	3
3	Industrial	3
4	Hospital Waste And Other	2
	Total	16

(Source: Municipal Board Jodhpur)

Details of infrastructure available for solid waste management in catchment and near the Kaylana Lake of Jodhpur town.

5.6.8 Vehicle deployed

Tractor - 3 for collection

Dumper - 2 for transportation up to landfill site

Loader - 1 for picking up

5.6.9 Land Fill Site

Present land fill site is 20 km from Jodhpur city at place Keru.

5.7 CATCHMENT TREATMENT PRACTICES

The Kaylana lake catchment has very low vegetation density of poorly growing tree and species. The poor vegetation cover and erosion prone slope cause severe risk of siltation of lake by eroded material from the catchment. In order to improve the hydrology, plant density and aesthetic value of lake, the following conservation measures for the Kaylana Lake have been suggested. Soil movement due to barren surface and high wind velocity is a major problem. Soils are sandy and water retention is poor, water is rapidly lost either as evaporation or deep drainage. Soil erosion can be totally controlled through conservation measures. There are several approaches based on land deposition, degree of erosion. Contour technique, gully control rain water management, reclamation of alkali soil, green carpeting is some practices to control the erosion.

5.7.1 Soil Conservation and Watershed Management

Soil conservation is a set of management strategies for prevent of soil being eroded from the Earth's surface or becoming chemically altered by overuse, acidification, Stalinization or other chemical soil contamination. It is a component of environmental soil science ,where as the Watershed management is the study of the relevant characteristics of a watershed aimed at the sustainable distribution of its resources and the process of creating and implementing plans, programs, and projects to sustain and enhance watershed functions that affect the plant, animal, and human communities within a watershed boundary. There are old water storage tank in the catchment of lake. They should be modified and renovated with standards. In summer water at regular interval should be filled up in the soccer. For soil conservation

work it is necessary to construct check dam and planting indigenous species of plants. Small percolation tank in nearby villages have to be constructed. The anthropogenic pressure in the catchment has resulted in degradation of the catchment area due to deforestation, extensive agricultural use and consequent erosion and increased silt flows, which have vitiated the quality of lake water.

The study regarding the soils in the catchment area and a plan for catchment area treatment was undertaken. The objective of this study included:

Assessment of present status of soil, vegetation, sedimentation and water yield rates from the catchment of Kaylana Lake.

Develop a catchment treatment plan with suitable bio-engineering measures for reducing sedimentation, optimizing water yield and improving aesthetic value of the lake area.

Field data were collected on vegetation status, land uses pattern, soil characteristics, infiltration rates and other physiographic features for detail problem analysis and developing conservation management plan for the Kaylana Lake.

5.7.2 Field Survey

The degradation of Kaylana Lake and its catchment is a complex process linked with climatic and edaphic factors, heavy biotic pressure, unauthorized mining and other unwise socio-economic activities. The field survey was carried out for developing a sound conservation management plan for the Kaylana Lake. The Kaylana lake catchment has very low vegetation density of poorly growing tree and species. The poor vegetation cover and erosion prone slope cause severe risk of siltation of lake by eroded material from the catchment. In order to improve the hydrology, plant density and aesthetic value of lake, the following conservation measures for the Kaylana Lake have been suggested.

Two third of India's land is rain fed. These areas suffer from severe land degradation, from water scarcity and from low agricultural production. Jodhpur is the area where integrated watershed management activities can play great role for over all development of the area. Soil conservation measures like, check dams, terracing,

bunding, gully plugging, silt detention dams, planting trees, grasses, live hedges. Water harvesting through ponds, anicuts, check dams.

5.7.3 Soil Map & Present Position

The soil in the catchment area of Kaylana Lake is light and sandy. The types of soil are shown in Fig 5.1. Mostly three types of soil are present in the areas which are categorized as follows:

Category Code no. 151

Moderately deep, well drained, fine loamy soil on very gentle sloping plains with loamy surface, moderately eroded, associated with: Moderately deep, well drained, calcareous, sandy soil severely eroded.

Category Code no. 157

Deep, well drained, calcareous, sandy soil on gently sloping plain with sandy surface, moderately eroded: associated with: Deep, well drained, sandy soil moderately eroded.

Category Code no. 159

Shallow, well drained, calcareous, loamy skeletal soil on gently sloping plains with rock outcrops, moderately eroded associated with: Deep, well drained calcareous, sandy soil severely eroded.

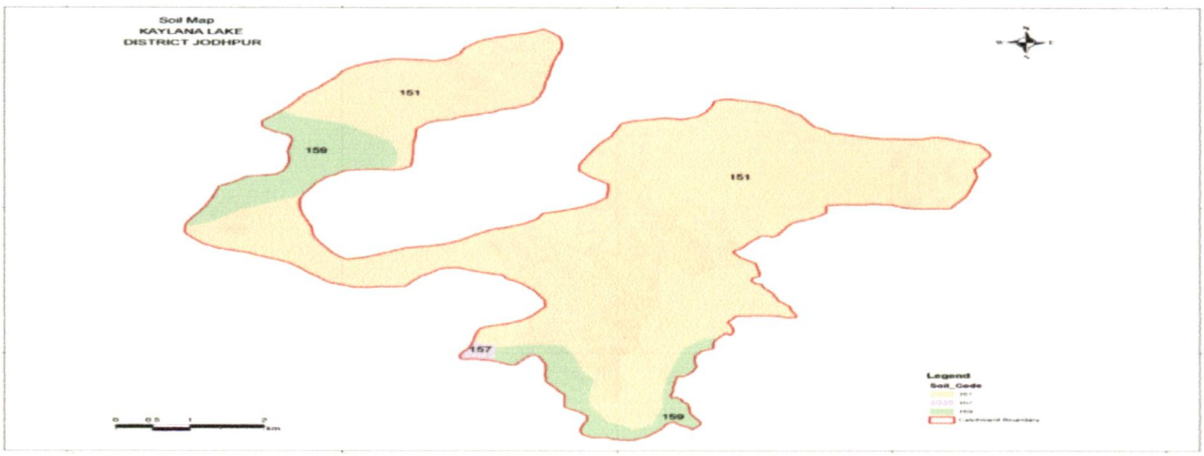


Fig: 5.8 Soil Map of Catchment Area

(Source: National Bureau of Soil Survey and Land Use Planning, Nagpur)

5.7.4 Soil Characteristics

The soils in this region are mainly derived through the alluvium brought down by Luni rivers network from the Aravalli hills. The alluvium is subsequently modified by the aeolin activity prevailing in the area. The soils are very shallow to deep, coarse loamy typic comborthids. Two soil textural groups namely; sandy loam and loamy sand have been recognized.

5.7.5 Slope

The slope of catchment was categorized into 10 groups as 0-1, 1-2, 2-3, 3-4, 4-5, 5-6,6-7, 7-8, 8-9, 9-10 and >10% (Fig. 5.9). Majority of the area of the lake catchment falls under the mild slope (1-5). The steep slope (8-10%) is recorded at the downstream side of lake and Majiya side. The area of the lake and its catchment is 13.55 and 4200ha, respectively. The lake catchment basically consists of Government reserved scrub forest (38.1%), current fallow (29.1) and barren rocky (11.9%) land in the patches. Apart from this, 6.7% (282 ha) catchment area is affected by the mining.

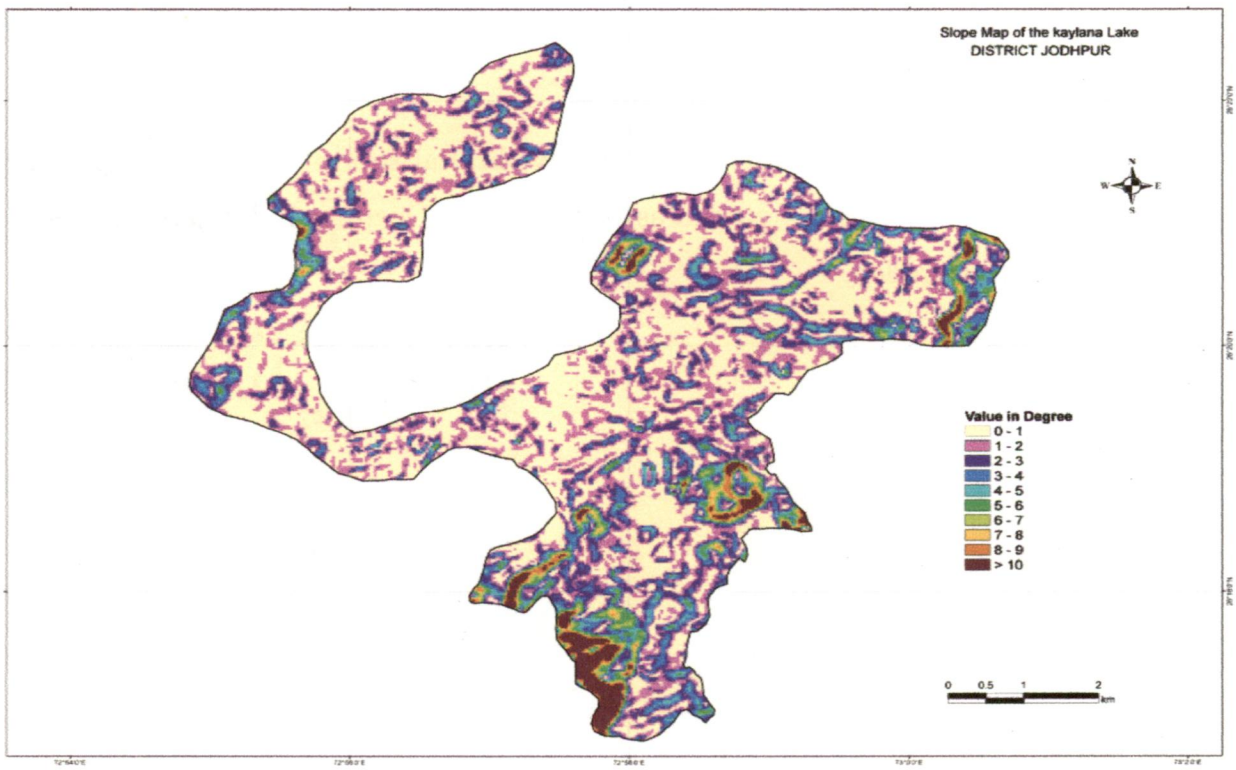


Fig: 5.9 Slope Variations in the Kaylana Lake Catchment

(Source: National Bureau of Soil Survey and Land Use Planning, Nagpur)

5.7.8 Present Land Uses

Table 5.2 Present Lands Uses System and its Distribution in the Lake Catchment

S. No.	Land uses	Area(ha)	Percent area
1	Barren Rocky/ Stony waste/ SR	501.18	11.9
2	Current Fallow	1221.00	29.1
3	Kharif	13.55	0.3
4	Kharif + Rabi (double cropped)	24.55	0.6
5	Lakes/Ponds	166.57	4.0
6	Land with scrub	204.11	4.9
7	Land without scrub	117.86	2.8
8	Mining/ Industrial waste	282.00	6.7
9	Open	28.25	0.7
10	Rabi	40.67	1.0
11	Scrub Forest	1600.00	38.1
	Total	4200	100

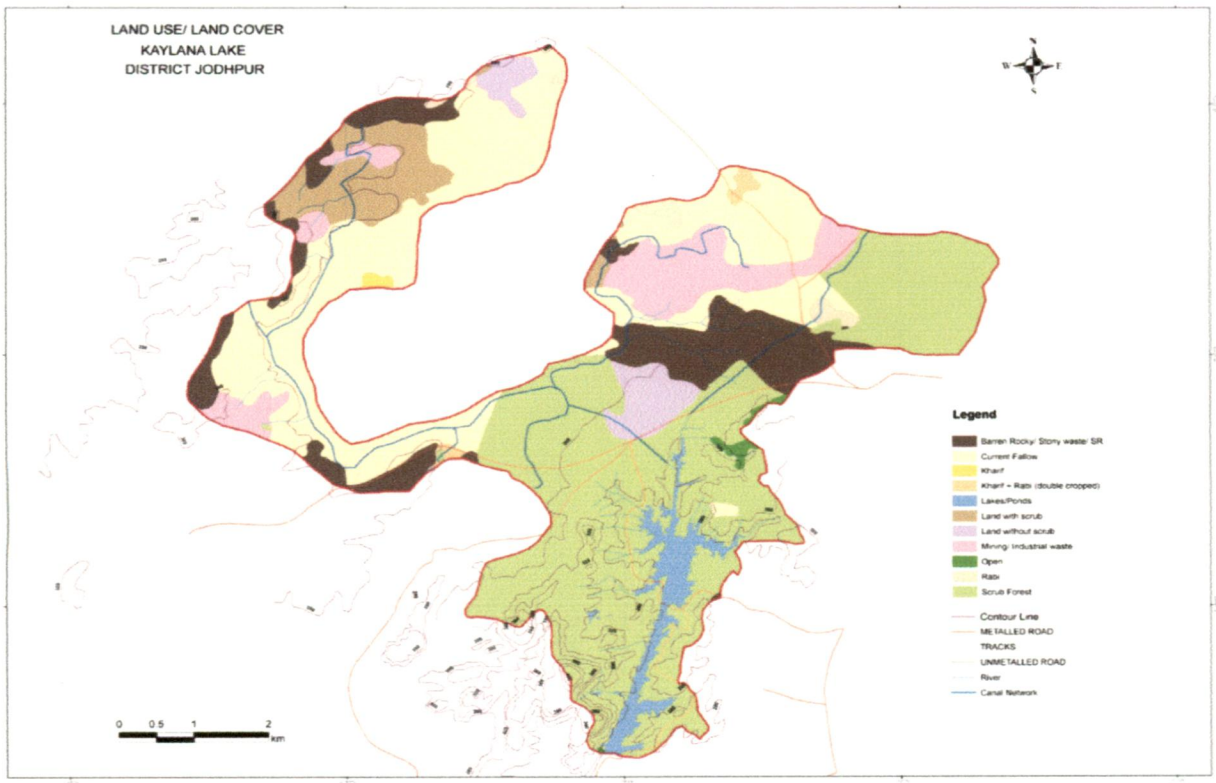


Fig: 5.10 Land Use Distributions in the Kaylana Lake Catchment

(Source: State Remote Sensing Application Centre, Jodhpur)

5.7.9 Drainage

The lake catchment has good network of streams. The drainage network is consisting of about 33 first and 8 second order streams. Streams are well established except few places in the lake catchment. The drainage density of the catchment is low. Rajiv Gandhi canal emanating from Indira Gandhi canal is also draining into the lake.

5.7.10 Contour Trenching

Contour trenching is a practice of excavating trenches along a uniform level across the slope of land. Bunds are formed along the trenches on the downstream side with material taken out of them (Fig.5.13). Contour trenches break the velocity of runoff and store whole or part of runoff. The intercepted runoff percolates through the soil slowly and made available to plants. Staggered trenching is recommended for the area. In staggered trenching, the trenches will be located directly below one another in alternate rows. Staggered trenches may be dug with a cross-section of 0.3m x 0.3m. Trenches with a length of 2-3m.and spacing between the rows may be kept from 3-5m depending upon the land slope [12].

5.7.11 Contour Staggered Trenching

Trench is excavated along a uniform level across the land slope and bund is form along the trench on the downstream side with the dugout soil. In staggered trenching, the trenches are located in staggered manner and directly below one another in alternate rows. Qualitative effects of the contour staggered trench in reducing inflow of sediment yield into lake as result of reduction in flow velocity and water storage in the trench. Stored runoff in the trench percolates down and helps in promoting vegetation growth in the vicinity of the trench. The locations and plan of the recommended contour staggered trenching system is given in Fig. 5.14 and Fig. 5.13, respectively. A total 1, 73,316 staggered trenches covering 156 ha area is suggested.

5.7.12 Design of Staggered Trench

Recommended plants of acacia tortilis will be planted at 3.0m x 3.0m spacing. The number of plant required/ha is 1111(=10000m^2/3mx3m). The number of trench/ha will be equal to number of plants (i.e. 1111). In order to accommodate, 224.7m^3 /ha runoff in 1111 trench, the required size of trench would be 1.5m x 0.45m x 0.30m. An

area of 156 ha is recommended to be put under the staggered trenching. Total number of trenches with size 1.5m x 0.45m x 0.30m required to cover proposed area is 173316.

5.7.13 Reclamation of Mined Area

There is 100 hac. mine affected area in the lake catchment. This has to be reclaimed. Plantation of tree and shrub species has to be planted. The whole area belongs to revenue department.

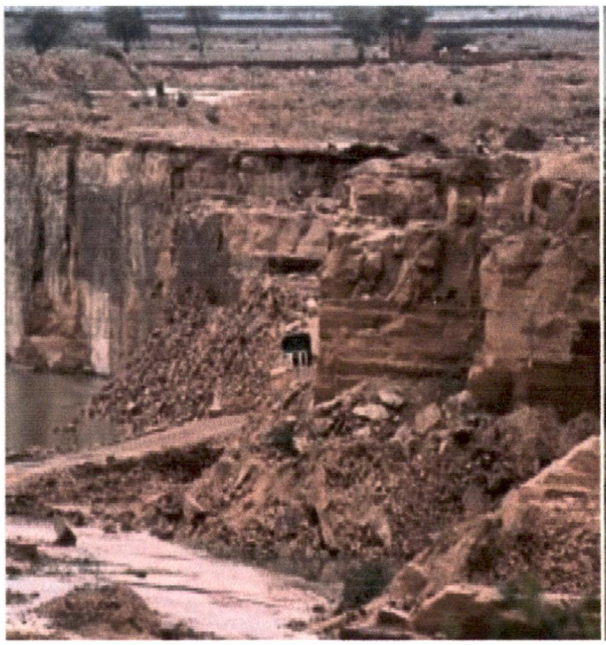


Fig: 5.11 Mines in Catchment

Fig: 5.12 Soil Conservation

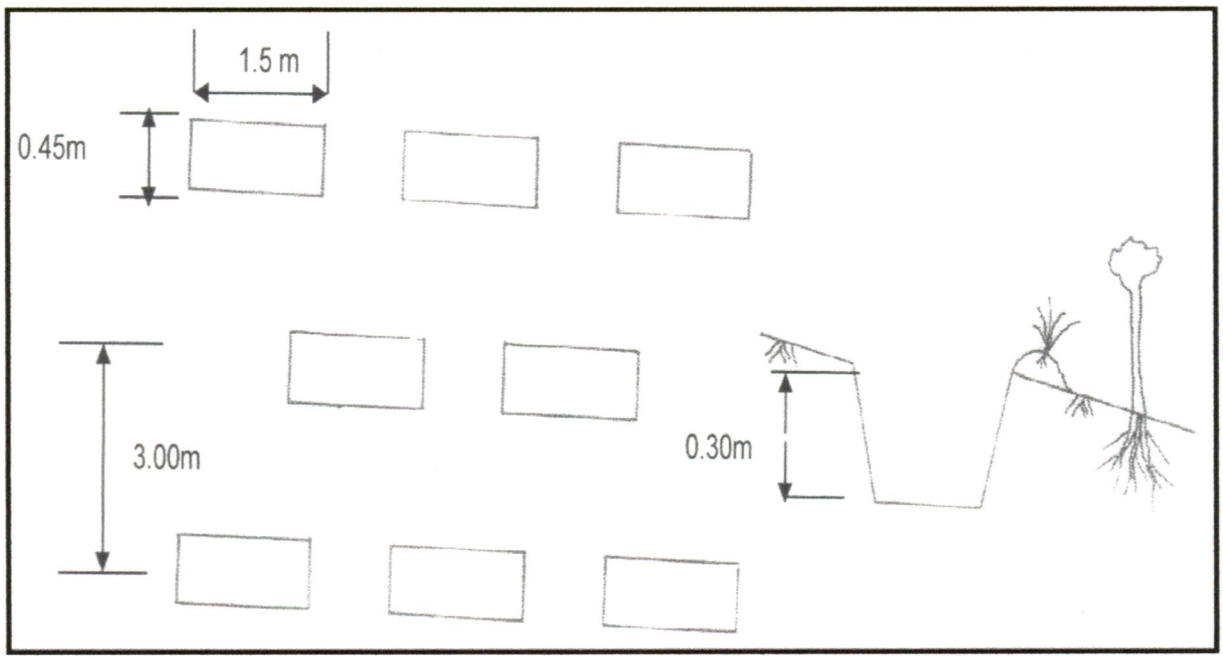


Fig: 5.13 Plans and Cross Section of the Staggered Contour Trenching System

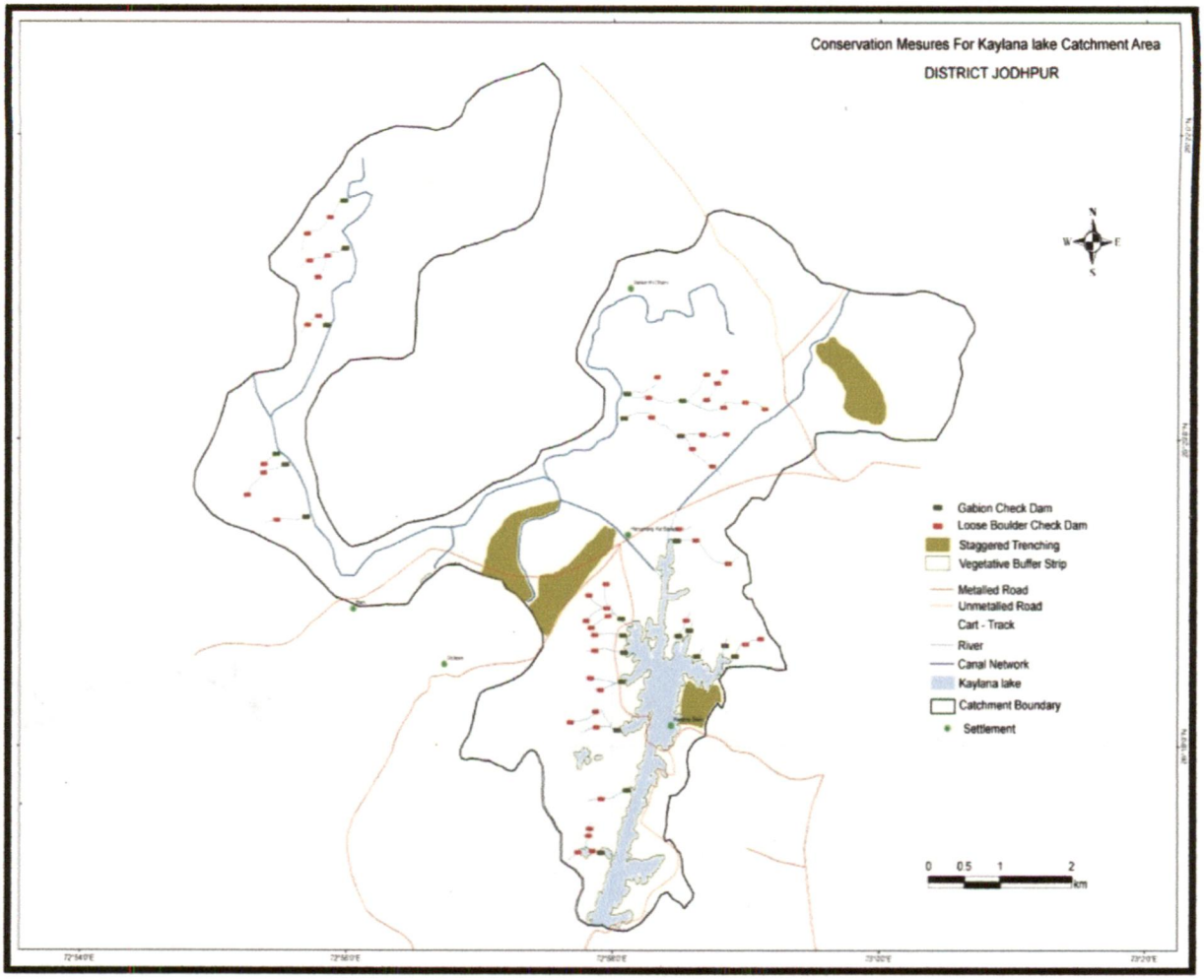


Fig: 5.14 Proposed Conservation Measures Plan for the Kaylana Lake in Jodhpur

5.7.14 Perforated Check Dams for Drainage Line Treatment

Drainage lines of the Kaylana lake catchment are almost stabilized except the few gullies near the Machhiya sanctuary park. In order to check the inflows of silt and other foreign material without affecting the water inflow into lake, perforated type check dams such as loose boulder reinforced with vegetative, gabion check dams and vegetative barriers has been proposed.

5.7.15 Loose Boulder Check Dam (LBCD) Reinforced with Vegetation

The loose boulder check (LBC) dams reinforced with vegetation should be constructed across the 1st order streams in the lake catchment. It should be reinforced with locally available vegetations such as; Agave americana, Zizyphus nemmularia and Capparis spp in three parallel rows at 0.50 m spacing on the down streams side of the LBCDs. The Agave americana can be raised from its bulbils, and Zizyphus nemmularia and Capparis spp by planting or sowing of seeds at 0.10m apart in each row. Vegetation

helps in stabilizing the LBCDs in turn reducing the silt load from the catchment to the lake without significantly reducing the runoff yield. The locations and plan of the recommended LBCDs is given in Fig. 5.14 and Fig.5.15, respectively. The specification as per design is presented in Table 5.3. A total 49 LBCDs are recommended.

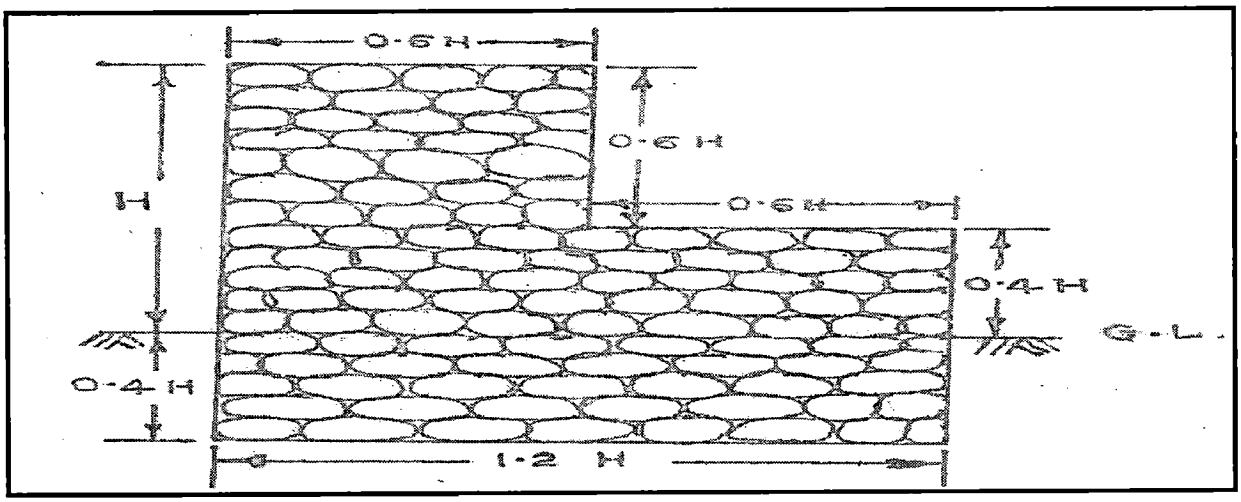


Fig: 5.15 Cross Section of the Loose Boulder Check Dam (LBCD)

Table 5.3 Design Specification of the LBCDs at Various Reaches of Drainage Line

S. No.	Design components	Upper reaches (Nala width up to 3.00m)	Middle reaches (Nala width up to 6.00m)	Lower reaches (Nala width > 6.00m)
1	The height of structure above bed level(H)= 0.5-1.00m	0.50	0.75	1.00
2	Base width (m)=1.2H(minimum 0.80m)	0.80	0.90	1.20
3	Top width(m) = 0.6H(Minimum 0.60m)	0.60	0.60	0.60
4	Depth of the foundation(m) = 0.4H (minimum=30 cm)	0.30	0.30	0.40
5	Horizontal Interval(m)	20	25	35
6	Vertical Interval (m); (VI= HI x S/100)	1.20	1.50	2.10
7	No. of brushwood or country wood stakes of dia 0.1 m at spacing of 0.6m in double rows	12	19	35

5.7.16 Gabion check dam

Gabion check dams (GCDs) required to be constructed in the 2nd order stream. Gabion structure is made of stone/boulder packed in GI wire mesh box. The thickness of wire is of 10gauge (3.14mm). The box may be fabricated with a dimension of 3m x 1m x 1m or any other required dimension with mesh opening of 10-20cm depending on the stone size. The location and plan of the recommended GCDs is given in Fig. 5.14 and 5.16 (a & b) respectively. The design specification is presented in Table 5.3. A total 23 GCD is recommended.

Table 5.4 Design of gabion check dams (GCDs).

S. No.	Gabion Check dam with vegetation	Upper reaches	Middle reaches	Lower reaches
	Particulars	(Nala width up to 3.00m)	(Nala width up to 6.00m)	(Nala width >= 6.00m)
1	The height of structure above bed level(H)= 0.60 - 2.00m	0.6	0.8	1
2	Base width=1.2H(minimum 0.80 m)	0.8	0.96	1.2
3	Top width = 0.6H(Minimum 0.45m)	0.45	0.48	0.6
4	Depth of the foundation = 0.6H (Minimum 0.45m)	0.45	0.48	0.6
5	Horizontal Interval(m)	25	35	35
6	Vertical Interval(VI= HI x S/100)	1.5	2.1	2.1

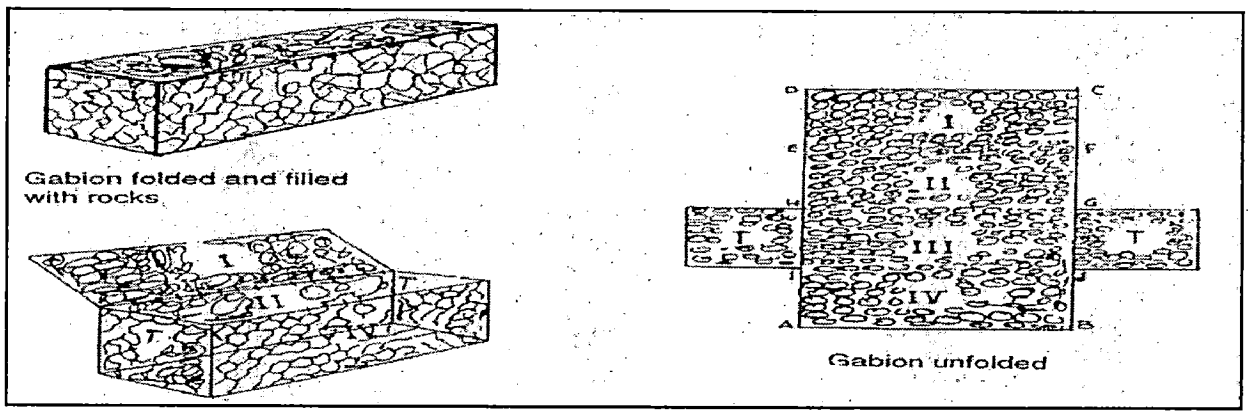


Fig: 5.16 (a) Fabrication of Wire Net and Gabion Box

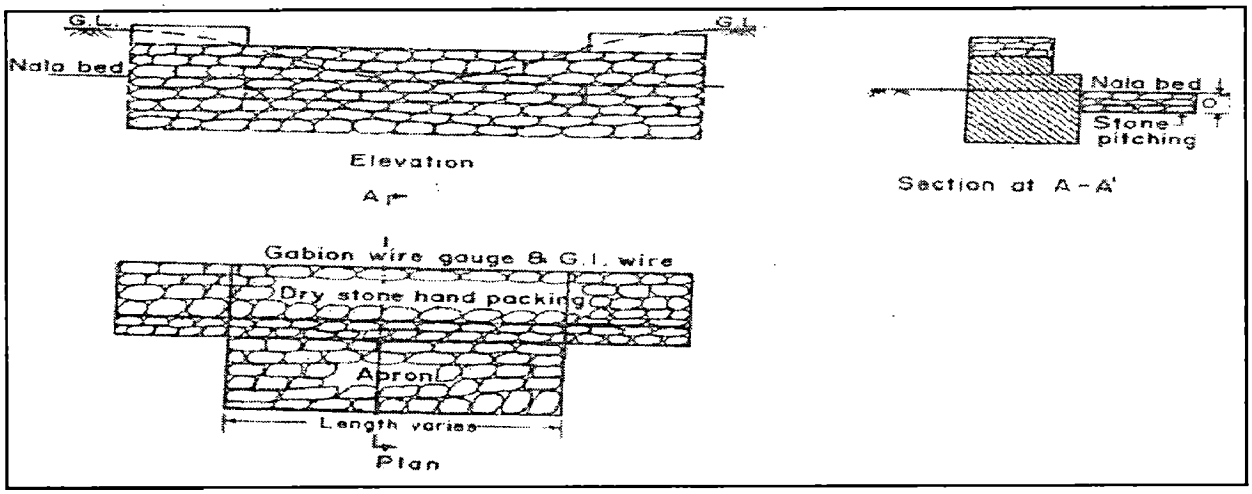


Fig: 5.16 (b) Plan, Elevation and Cross Section of a Gabion Check Dam (GCD)

5.7.17 Establishment of Buffer Strip

Due to high biotic pressure the vegetation is dominated by thorny scrub vegetation and unpalatable grasses. To establish dense vegetation strip which can filter the runoffs from the catchment as well as enhance the aesthetic value along the banks of the lake, planting of a buffer strip in proposed around the lake. Planting of avenue trees and shrubs on the banks of the lake will improve its landscape and aesthetic value of the lake. Planting of the Ficus religiosa, Ficus bengalensis, Salvadora persica, Salvedora oleoides, Butea monosperma, Bauhenia spp., Cellistemon spp. Bougainvillea spp., Hibiscus spp., Nictanthus spp. etc. is recommended for this purpose. As moisture is the major limiting factor in the Kaylana lake catchment planting of vegetation may require provision for life saving irrigation during summers.

These trees and shrubs shall be planted in staggered manner in two rows around the lake in lower catchment. Planting of these trees and shrubs around the lake will also help in arresting flow of debris and contaminants in to the lake if a thick strip of vegetation is developed around the lake. For developing buffer strips, two rows of trees may be flanked by planting of shrubs in two staggered rows on the upstream side. The shrubs may be planted at 1 m to 1.5m spacing in triangular fashion to develop a staggered buffer strip. If shrubs are to be raised by direct seed sowing the spacing may be reduced to 1m apart and sowing may be carried out by patch sowing method with spacing between patches kept at 1m apart. Here pits of 50cm x 50cm x 50cm size are

required to be dug up and filled with soil imported from other areas for planting of trees. A length of 1000 m buffer strip plantation is recommended.

In order to reduce evaporation, we should reduce the wind velocity. For this we have to develop a strip of plantation of 50 m width along the west shore of the Kaylana Lake. Green belt of plantation will reduce wind velocity. Green belt should be in such a way that it covers three stories i.e. lower, middle and upper.

Species for plantation	Lower story- Gugal, karonda , local herbs and shrubs.	
	Middle story- Rohera, ber and ker etc.	
	Upper story- Neem, khejri , Meetha jal, Acacia species.	
Spacing of plants	Lower story	- 1.5m * 1.5 m
	Middle story	- 2.0 m * 2.0 m
	Upper story	- 4.0 m * 4.0 m
Size of pits	Lower story	- 20 cm * 20 cm * 20 cm
	Middle story	- 45 cm * 45 cm * 45 cm
	Upper story	- 60 cm * 60 cm * 60 cm
Size of plants	Lower story	- 60 to 90 cm in height
	Middle story	- 60 to 90 cm in height
	Upper story	- > 150 cm in height

Financial Aspect

Table 5.5 Estimate of Plantation

S.No	Work Description	Measurements	Area/Volume	Rate	Amount (in lac)
1	Site Clearance	50 m *1000 m	5 hector	3000 per hector	0.15
2	Staking(alignment)		5 hector	2500 per hector	0.13
3	Digging pits				
	Lower	4445 nos.	4445 nos.	5 per pit	0.22
	Middle	5000 nos.	5000 nos.	10 per pit	0.50
	Upper	1250 nos.	1250 nos.	15 per pit	0.19
4	Cost of planting Material	12000 plants	12000 plants	10 per plant	1.20
5	Planting	10695 plants	10695 plants	3 per plant	0.32
6	Fencing	1250 *2.00 m	2500 Sq. Mt.	75 per sq. M.	1.88
7	Watch & ward for 3 yrs, 2 labour	36 months	36 months	8000 per month	5.76
8	Irrigation/Cleaning	L s	L s	L s	3.00
9	Fertilizer	L s	L s	L s	0.10
10	Replacement	1000 plants	1000 plants	15 per plant	0.15
11	Contingencies/Others			3 %	0.41
	TOTAL				14.01

5.7.18 Improving Vegetation in the Upper and Middle Reaches

The tree density in the upper and middle reaches is also low. It needs to be improved in the areas where protection from biotic interference can be ensured. There is good opportunity to improve the tree density in the Machia Biological Park area of the catchment. Here hardy and drought tolerant tree species like Acacia senagle, Acacia tortilis, Acacia lecophloea, Anogeissus latifolia can be planted. In the lower reaches of the Machia catchment where adequate moisture availability can be ensured with some life saving irrigation during the extended summer months trees like Holoptelia integrifolia, Ficus religiosa, Salvadora persica, Salvedora oleoides, Butea monosperma, Diospyros melanaxylon, Madhuca latifolia, Boswelia serrata can be introduced to improve the landscape around the lake.

Like the upper part of the catchment here also filling of pits with imported soil may be required as the soil depth in this part of catchment is also not substantial. Similarly inter planting of small shrubs like Zizyphus mauritiana, Commiphora wightii and Capparis spp. Between the trees will improve the cover of shrubs. These treatments can be replicated in the other parts of the catchment also.

The plant shall provide protective cover to the soil against the main agent of soil erosion i.e. wind and water. The thick network of roots shall bind the soil and keep it in place.

The shallow soil depth restricts roots development. The soils are poor soil in fertility and the climatic restricts the planting success of vegetation. The temperature is also high during major part of the year while incidence of frost during winter is not rare. This necessitates adoption of closer spacing for planted vegetation. Triangular planting accommodates 15% higher number of plants for a given area and shall be preferred for measures aiming at improving the density of trees. The spacing between plants shall 4-5 * 4-5 mt. As the soil depth is a limiting factor for growth of planted trees in the major part of the catchment, pits of 50cm x 50cm x 50cm size are required to be dug up and filled with soil imported from other areas for planting of trees. At certain places underlying rock strata may be required to be broken for pitting. About 156 ha is suggested for tree and shrub plantation in the catchment area.

5.7.19 Revival of old plantation

The old plantation in catchment area of lake with area of 400 hectares is suffering from grazing. To improve the area effective Panna model cattle proof wall of size 1.80*0.90*1.80 m should be raised at periphery. The plan for CPW is given in Fig. 5.17. Gap plantation of indigenous species of higher size should be plan Planted.

Table 5.6: Estimate of Proposed Work in Old Plantation

S.No.	Work Proposed	Measurement	Rate (in Rs)	Amount(in Lacs)
1.	Weeds removal	400hc	5000 per hc	20.00
2.	Repair of CPW	2600 rmt	200 per rmt	5.20
3.	Digging of pits	20000 pits	50 per pit	10.00
4.	Cost of plants	23000 nos.	50 per plant	11.50
5.	Planting work	20000 plants	20 per plant	4.00
6.	Manure and fertilizers	-	-	2.00
7.	Watch and ward for 3yrs	4 labors	8000 per month	11.52
8.	Contingency	-	5%	3.20
	TOTAL			57.42

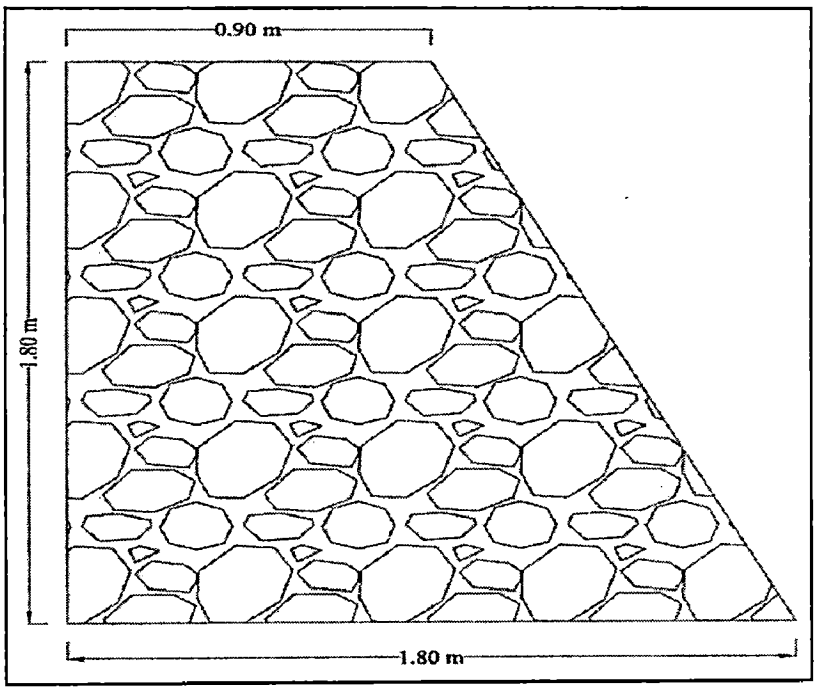


Fig: 5.17 Size of Panna Model CPW

5.8 SHORE LINE DEVELOPMENT

The lake shores to be naturalized as far as possible by planting macrophytes on the lakes slope rather then providing stone pitching. Tourist facility in the kaylana area would bring problems to the environmental qualities of the lake resources. For remedies of problems it should be considered to keep the lake environment quality at acceptable levels. Different activities to be carried out are shown in Table 5.7.

Table 5.7 Works for Shore Line Development and Machia Biological Park

S.NO	Item of Work	Budget outlay (in Lacs)	Year of Implementation
1	Construction Of Watch Tower 2	20.00	1st year
2	Hide Out 4	1.00	2nd Year
3	Transportation Of Sand At The Bank Of Lake 500cmt	2.50	1st
4	Sitting Benches 4 Sites	4.00	2nd Year
5	Parking 2	1.00	1st Year
6	Nature Experience Trail 2	2.00	4th Year
7	Rock Climbing Trail 1	1.50	5th Year
8	Development Of Signage's	10.00	1st-5th Year
9	Grass Land Development	15.00	2nd-4th Year
10	Creation Of Vulture Rehabilitation Centre	5.00	2nd Year
11	Afforestation And Avenue Plantation	20.00	1st-5th Year
12	Creation Of Green Belt At West Side Of Biological Park	20.00	1st-2nd Year
13	Habitat Improvement And Weed Control Measures	25.00	1st-5th Year
14	Disposal Of Solid Waste, Liquid Waste And Sewerage Treatment Plant	20.00	1st-2nd Year
15	Development Of Pedestrian Pathway	350.00	1st-2nd Year
16	Development Of Rest House Area	150.00	1st-2nd Year
17	Development Of Interpretation Centre	150.00	2nd Year
18	Development Of Camping Site	10.00	2nd Year
	Total	809.00	1st-5th Year

5.9 MACHIA BIOLOGICAL PARK DEVELOPMENT PLAN

The part of existing zoological park is to be shifted in the catchment of Kaylana Lake. The lay out plan of zoological park is shown in fig.5.18.The proposed area is 41.00 ha. Following activities are proposed in the Machia Biological Park:

1. Road side plantation
2. Habitat development
3. Development of nesting sides
4. Conservation of eagle site
5. Improvement in vulture roosting sites
6. Construction of watch tower
7. Construction of STP
8. Management of solid wastes
9. Construction of Anicuts and check dam
10. Rescue centre for wild life

Table 5.8 Financial Detail of Works

S. No.	Works	Amount(in laces)
1	Road side plantation	40.28
2	Habitat development	20.00
3	Development of nesting sides	10.00
4	Conservation of eagle site	5.00
5	Improvement in vulture roosting sites	5.00
6	Construction of watch tower	10.00
7	Construction of STP	75.00
8	Management of solid wastes	50.00
9	Construction of anicuts and check dam	15.00
10	Rescue centre for wild life	35.00
	Total	265.28

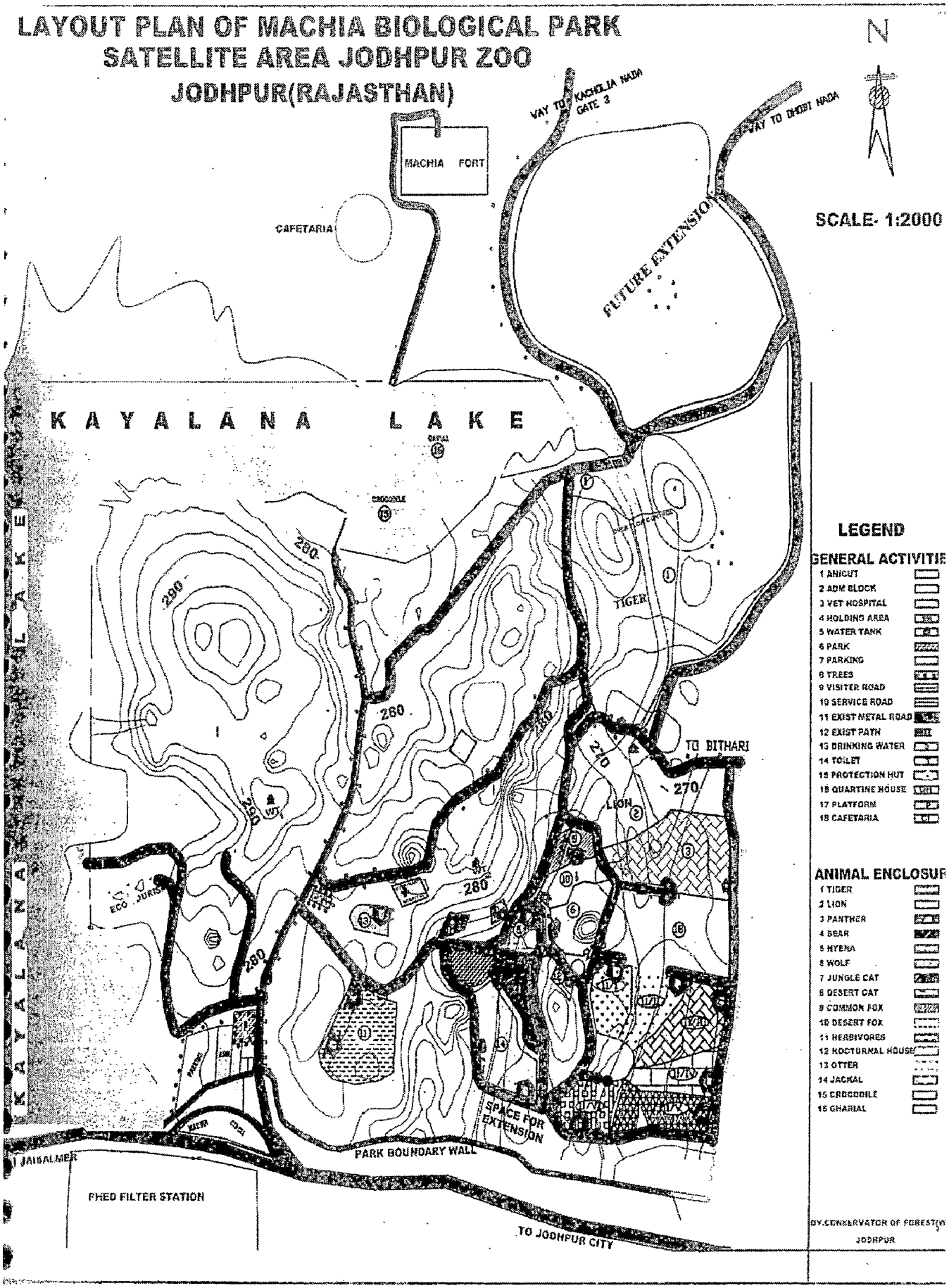


Fig. 5.18 Lay Out Plan for Machia Biological Park (Source: Wild Life Department)

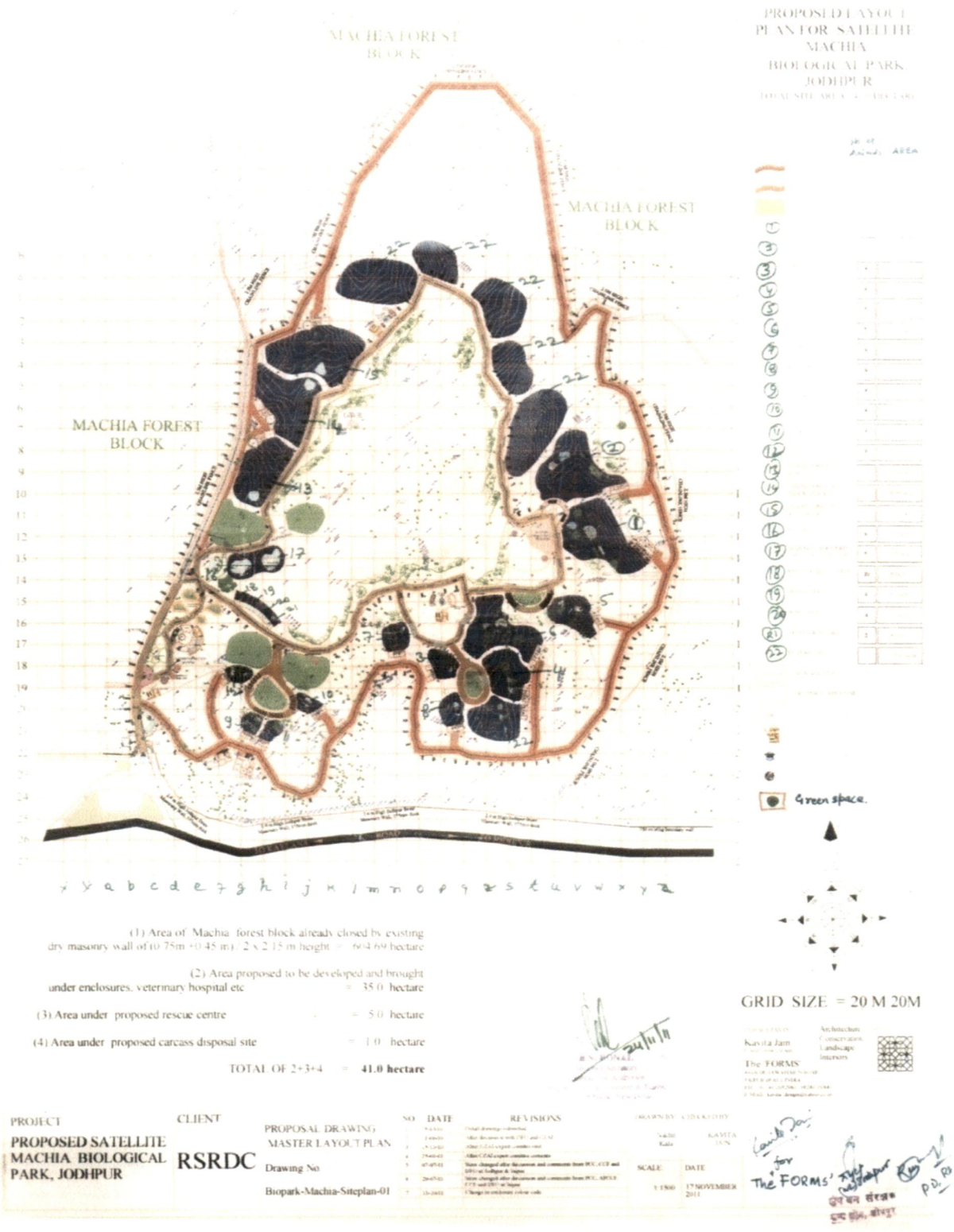


Fig. 5.19 Lay Out Plan for Machia Biological Park (Source: Wild Life Department)

Fig.5.20 Plants at Road Side

Fig.5.21 Birds Nesting and Vulture Roosting Site

Table 5.9 Avian Diversity around Kaylana

S.No.	Name of the species	Common Name	Distribution in wetland area	
			Kailana	Takhat sagar
I.	**Order-Podicipediformes**			
	Family-Podicipedidae			
1.	*Podiceps ruficollis*	Little Grebe	+	+
II.	**Order-Ciconiformes**			
	Family-Ardeidae			
2.	*Ardeola grayii*	Pond Heron	+	+
3.	*Bubulcus ibis*	Cattle Egret	+	+
4.	*Egretta garzetta*	Little Egret	+	+
5.	*Egretta intermedia*	Intermediate Egret	+	-
6.	*Ixobrychus minutus*	Little Bittern	+	+
III.	**Order-Charadriiformes**			
	Family-Charadriidae			
7.	*Vanellus indicus*	Red wattled Lapwing	+	+
8.	*Vanellus leucurus*	Yellow wettled Lapwing	+	+
9.	*Charadrius dublus*	Little ringed Plover	+	-
10.	*Actitis hypoleucos*	Common sandpiper	+	+
	Family-Recurvirostridae			
11.	*Himantopus himantopus*	Black winged stilt	+	+
IV.	**Order-Columbiformes**			
	Family-Columbidae			
12.	*Columba livia*	Blue rock pigeon	+	+
13.	*Streptopelia decaocto*	Indian Ring Dove	+	+
	Family-Pteroclididae			
14.	*Pterocles orientalis*	Black bellied Sand grouse	+	+
15.	*Pterocles exustus*	Chestnut Sand grouse	+	+
V.	**Order-Psittaciformes**			

	Family-Psittacidae			
16.	*Psittacula krameri*	Rose ringed Parakeet	+	+
VI.	**Order-Anseriformes**			
	Family-Anatidae			
17.	*Aythya ferina*	Common Pochard	+	+
18.	*Anas cercca*	Common Teal	+	-
VII.	**Order-Coraciiformes**			
	Family-Cerylidae			
19.	*Ceryle rudis*	Lesser Pied Kingfisher	+	+
VIII.	**Order-Passeriformes**			
	Family-Passeridae			
	Sub Family-Passerinae			
20.	*Passer domesticus*	House Sparrow	+	+
	Family-Estrildidae			
21.	*Lonchura malabarica*	Indian Silver bill	+	+
	Family -Muscicapidae			
22.	*Saxicoloides fulicata*	Indian Robin	+	-
23.	*Oenanthe deserti*	Desert Wheatear	-	+
24.	*Phoenicurus ochruros*	Black Redstart	+	-
25.	*Oenanthe pleschanka*	Pied wheatear	-	+
26.	*Saxicola torquata*	Common Stone Chat	+	+
27.	*Saxicola macrorhyrncha*	White browed Bush Chat	+	+
	Family-Ploceidae			
	Sub Family-Ploceinae			
28.	*Ploceus philippinus*	Baya weaver	+	+
	Family-Sturnidae			
29.	*Acridotheres tristis*	Indian Myna	+	+
30.	*Acridotheres ginginianus*	Bank Myna	+	-
31.	*Acridothrese fuscus*	Jungle Myna	-	+
	Family-Pycononotidae			
32.	*Pycnonotus leucogenys*	White cheeked Bulbul	+	+
33.	*Pycnonotus cafer*	Red vented Bulbul	+	-
	Family-Corvidae			
34.	*Corvus splendens*	House Crow	+	+
35.	*Crovus corax*	Raven	+	+
IX.	**Order-Gruiformes**			

	Family-Rallidae			
36.	*Fulica atra*	Coot	+	+
	Family- Gruidae			
37.	*Anthropoides virgo*	Demoiselle Crane	+	+
X.	**Order-Cuculiformes**			
	Family-Cuculidae			
38.	*Eudynamus scolopacea*	Koel	+	+
XI.	**Order-Falconiformes\ Accipitriformes**			
	Family -Accipitridae			
39.	*Milvus migrans*	Black Kite	+	+
40.	*Neophron percnopterous*	Egyptian Vulture	+	+
XII.	**Order-Galliformes**			
	Family: Phasianidae			
41.	*Coturnix coturnix*	Common Quail	+	-
42.	*Pavo cristatus*	Indian peafowl	+	+

(Source: Wild Life Division, Jodhpur)

Table 5.10 List of Mammals in Machia Biological Park

S.No.	English Name	Scientific Name
1	Grey langur	Semnopithecus entellus
2	Jungle cat	Felis chaus
3	Small Indian mongoose	Herpestes jazvanicus
4	Grey mongoose	h. edwardsii
5	Jackal	Cania aureus
6	Indian fox	Vulpes bengalensis
7	Long eared hedgehog	Hemiechinus auritus
8	Grey musk shrew	Suncus murinus
9	Flying fox	Pteropus giganteus
10	Five-stripped palm squired	Funambutus pennant
11	Indian desert gerbille	Meriones hurrianal
12	Common house rat	Rattus ratuss
13	Indian porcupine	Hystrix indica
14	Indian hare	Lepus nigricollis
15	Blue bull	Boselphus tregocamelus

(Source: wild life division, Jodhpur)

Table 5.11 Species and Number of Animals Proposed in Satellite Zoo

S. No.	Name of animal	No. of animals
1	Hyena	5
2	Common fox	5
3	Desert fox	5
4	Jungle cat	5
5	Desert cat	5
6	Gharial	5
7	Magar	7
8	Black buck	6
9	Chinkara	6
10	Spotted dear	10
11	Chaunsinga	6
12	Spiny tale lizard	10
13	Hedgehog	4
14	Monitor lizard	2
15	Porcupine	4
16	Jackal	5
17	Indian wolf	5
18	Sloth bear	4
19	Panther	5
20	Tiger	4
21	Asiatic lion	6

Table 5.12 Cost Estimation of Road Side Plantation in Machia Park

S. No	Particulars	unit	Measurement	Rate	Amount (in laces)
1.	Area cleaning	Each	1000	5	0.05
2.	Dinging of pits during blasting	Each	1000	350	3.50
3.	Black cotton soil/sand	cmt	1250	350	4.38
4.	Organic manures	kg	5000	15	0.75
5.	Disposal of blasting material, masonry work	Each	1000	500	5.00
6.	Tree guard	Each	1000	500	5.00
7.	Cost of plants	Each	1100	200	2.20
8.	Planting	Each	1000	20	0.20
9.	Watering twice in a month for four years	No. s	600(Tankers)	500	3.00
10.	Maintenance watch and ward for five years	Days	5400	300	16.20
Total					40.28

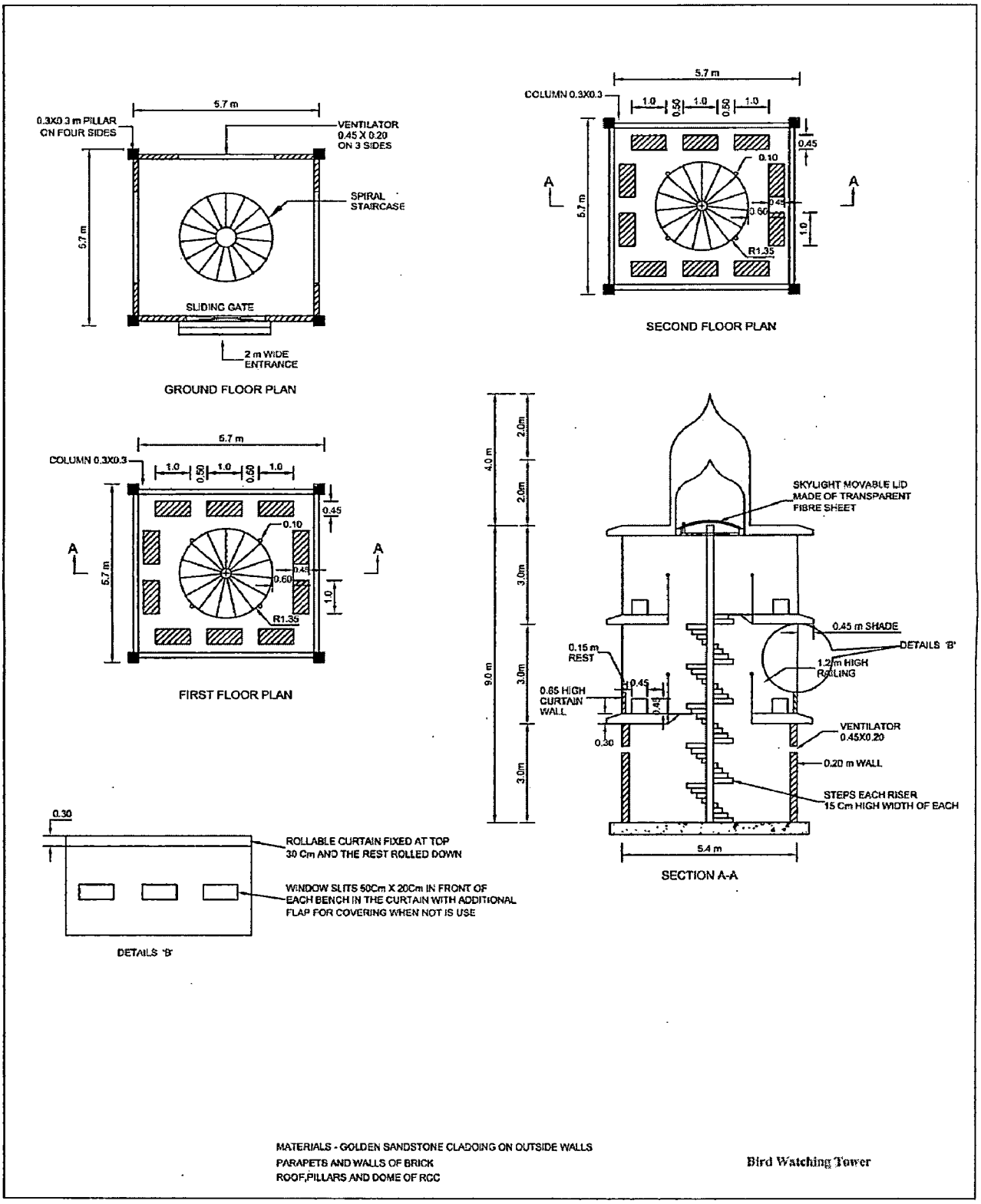


Fig.5.14 (a) Design Details of the Bird Watching Tower near the Gate No. 3 (Source: DPR Gadisar Lake)

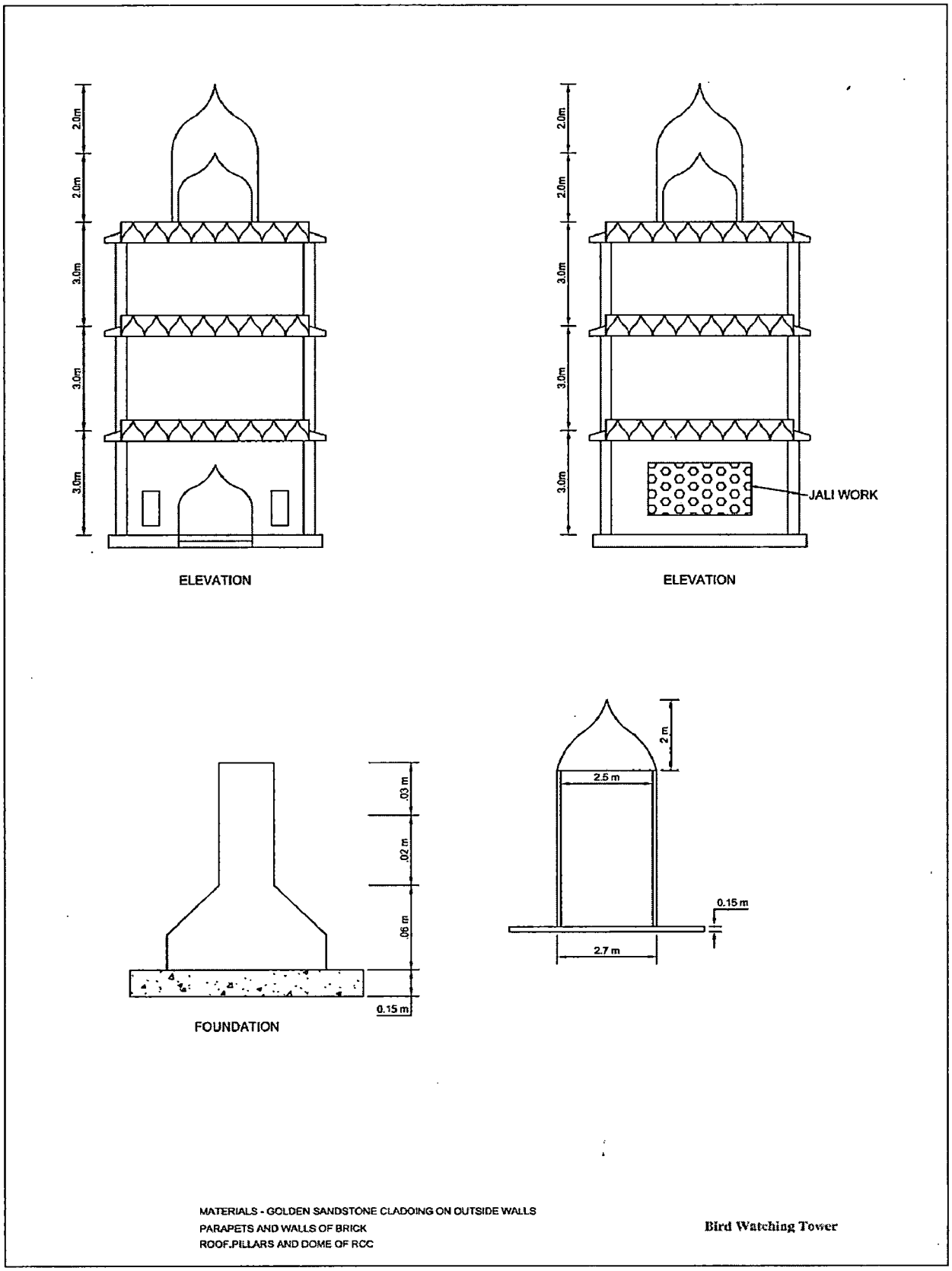


Fig.5.14 (b) Design Details of the Bird Watching Tower near the Gate No. 3

(Source: DPR Gadisar Lake)

8- PUBLIC PARTICIPATION AND AWARENESS CREATION

In a democratic society, the policy formulation for any plan has to be democratic in nature and must involve the citizens who are both the affected party as well as stake holders. This will result in citizens feeling that they are both the owners and part of the project. Higher proportion of urban population has negative effect on environmental quality. Urbanization leads damaging effect of vegetation change. Higher literacy leads creating awareness resulting benefit the vegetation change. Conservation and management of lakes in urban surroundings is an issue which needs involvement of the local people in an active manner to ensure the success of the project.

Basic Principles of Public Participation

1- The public should have a say in decisions about actions that affect their lives.
2- Public participation includes the promise that public's views will influence the decisions.
3- The public participation process communicates the interests and meets the needs of all participants.
4- The public participation process seeks out and facilitates the involvement of those potentially affected.
5- The public participation process involves participants in defining how they participate.
6- The public participation process communicates to participants how their input affected the decision.
7- The public participation process provides participants with the information they need to participate in a meaningful way.

People's participation and public awareness programs are thus not only essential instruments for successful and sustainable lake management but are also important tools in countering negative attitudes toward lakes. Participation of the public can only be solicited when the people are aware about the project. The project shall be successful only when their interests and reservations are incorporated in planning and execution of the project.

Success of a project of this nature critically depends upon the involvement, support and cooperation of the local people, tourists and the government departments related with the lake. A cleaner lake will attract more tourists and thus create more opportunities for local residents.

This technique is based on the premise that local communities have an intrinsic relationship with local natural resources, which are important for their lives and livelihoods. They have their own perspective on such resources with a diverse inventory of knowledge and experience. Such knowledge can be revealed only through participatory interactions for learning and action.

The principles are:

- Listening and learning
- Offsetting biases
- Proper utilization of precious community time
- Seeking diversity
- Cross-checking

The process of Participatory Management for sustainable lake environment is illustrated below:

Analysis of the needs and requirements of the community

↓

Understanding the positive as well as negative attitudes of the members

of

The community in regard to various practices

↓

With the involvement of the people designing the development programme as per

Their needs and requirements

↓

Through formal and informal channels educating the people and making them aware of

The conservation issues and utilizing the lake environment in a sustainable manner

↓

With aided guidance leaving the people to operate the action oriented

Programme designed by them

↓

To sort out problems in a participatory manner if any

Occasional follow up is needed

↓

Birth of a sustainably managed lake environment

The aim of such an initiative is to draw attention to the fact that natural resources will not necessarily survive forever, and that there is a need for the sustainable and rational utilization of natural resources i.e. its conservation. To be able to achieve the goals of conservation, the attitude of the entire community towards the biosphere must be changed. Our goal, to further lake protection has to become a common goal.

Earlier through public participation we determined on how best to communicate with people to know/change their environmental attitude towards lakes. What perceptions do they have? What knowledge they lack? What are their concerns? How do the economics of tourism development activities be integrated into Lake preservation/conservation? The aim would now be to provide ecological knowledge. Through education and participatory activities there are opportunities for compatible wise-use projects in lake areas. For example, those who live and work in lake areas are not aware of their public benefits and therefore they may resist efforts to bring about developmental changes in the area. Through education they can be made to see how tourism development is linked to the needs of local economy? And how nature can be promoted as a tourist product and a balance found between these acts and nature conservation. It can be shown to them how external investment, remain inside the region and generate local benefits.

A comprehensive public awareness and participation plan for three years under the conservation plan of Kaylana Lake with an estimated cost of Rs.67.55 Lacs has been formulated which can be seen in Table 5.13.

The implementation mechanism for the creating awareness and generating public participation for achieving the objective of lake conservation has been detailed out.

Table 5.13: Public Awareness and Participation Plan

Sl. No.	Activity	Quantity	Unit Cost (in Rs.)	Amount (in Lacs.)
1	Audi-visual films	3 nos. of 15 minutes duration each	500000/-	15.00
2	Group Meetings with slide shows, screening of audio-visual films and interactive work shops	5 each year for a period of 3 years	25000/pm	3.75
3	Children workshops with Nature Trails/games; Eco-rallies			6.00
4	Support to Eco-clubs	1 club to support for 3 yrs.	10000/pm	3.60
5	Support to self-help groups	3 groups to be supported for 3 yrs.	15000/pm	16.20
6	Training programmes	2 workshops each year for 3 yrs.	25000/per workshop	1.50
7	Eco-conservation Award Felicitation ceremony	Once for every year for 3 yrs.	50000/-	1.50
8	Printing pamphlets & Brochures & Awareness kits			5.00
9	Administrative costs for facilitating formation of Eco-clubs, Self-help groups and workshops including misc. expenses for PR and other associated works for a period of 3 yrs.			15.00
TOTAL				67.55

Table 5.14: Abstract of Cost Estimation for different activities

S.No.	Activities	Amount in Lacs
1	Raising Buffer Strip	14.01
2	Revival of Old Plantation	57.42
3	Shore Line Development	809.00
4	Machia Biological Park Development Plan	265.28
5	Public Awareness and Participation Plan	67.55
	Total	1213.26

CHAPTER 6

CONCLUSIONS AND SUGESSTIONS

Jodhpur is a major destination for tourists. Kaylana lake, is a twin lake system with the upper portion called Kaylana Lake and the lower as Takht Sagar. There is a bund between the two lakes with pipes for connecting the two lakes. However, with the passage of time this connection is blocked and the overflow of Kaylana reaches Takht Sagar through a bypass channel which passes through the pumping station in Kaylana Lake. The lake receives its water primarily from Rajiv Gandhi lift canal and acts as a reservoir for supplying water to Jodhpur town. It is hence necessary that the quality of water is maintained so that it can continue to remain the main source of water supply to Jodhpur. On the northern periphery of the lake Machia Biological Park with a zoo is being developed by the state forest department as a tourist spot.

There are a number of locations near the bank of the lake where water is stagnant and turbid. There are algae and undesirable weeds at such locations and the transparency of water is low. The prosopis juliflora has come up around the lake which is not eco-friendly and not preferred by the migratory as well as by the local birds. There is scarcity of nesting trees in the catchment and poor quality of grass all over the area.

The land use, land cover geomorphology, lake water tropic status, sources of lake pollution (present and future) etc. have been studied and various issues have been identified. On the basis of the analysis, it is concluded that out of 18 parameters measured; only five parameters viz, pH, DO, BOD, FC and chlorophyll 'a' are found as the major stressors impacting the lake water quality. The water quality of the whole lake and water quality with respect to depth indicates that the lake water quality belongs to class 'B' water quality which is suitable for bathing/ irrigation. Further, lake is in mesotrophic state with respect to its tropic state indicating that owing to receiving the nutrients from the surroundings, the lake has developed the tendency to allow the growth of vegetation which is huge in areas where the water is stagnant not in the turbulent mixing mode. In summary, the lake water quality is suitable for bathing/ irrigation which can be easily improved using conservation measures consisting of landscape development, management of solid wastes in and around the lake due to tourists visiting the lake.

To address various issues a detailed conservation and management plan for lake and Machia Biological Park has been proposed. Various items like monitoring of water quality, treatment and revival of water bodies, solid waste management, catchment treatment practices, shore line development and Machia Biological Park development plan are proposed for execution at an integrated manner with public participation. Solid waste generated is scattered here and there. An arrangement has been proposed for collection, storage and disposal of various kinds of waste and transported to the land fill site i.e. Keru. The total estimated cost of this plan is Rs.1213.26 lacs with completion period of five years.

A variety of migratory birds visit the lake during winter months. A large number of tourists, both domestic and foreigners, visit the lake for sightseeing, bird watching and recreational purposes. The lake is potentially a very great attraction for tourists, but there is hardly any infrastructure available to promote tourism. In view of its geographical location, terrain and climatic conditions, the lake is subjected to various stresses, which need to be addressed if full use of the potential of the lake as source of water for the city of Jodhpur as well as a place of tourist attraction is to be made.

Recommendation

In view of improving the present environmental status of the lake and the catchment area, which includes Machia Biological Park, the following considerations may be adopted.

- Comprehensive integrated plan for the development of the lake and its catchment.
- Massive Plantation in catchment area and creation of environment so that wild life could survive.
- The quality of the lake water may be monitored bimonthly for important parameters like DO, BOD, COD, Oil and grease, turbidity etc.
- For proper sanitation sewerage treatment plant for Machia Biological Park is proposed.
- Motor boats to be avoided for spillage of oil and grease.
- Entry of the materials containing nitrogen and phosphorous to be prevented.

- Public awareness programme people participation is very important in conservation of water bodies
- Any sudden deterioration in quality should be viewed seriously and measures must be taken to locate the source of pollution and prevent it.
- The catchment area of the lake needs treatment to ensure that the soil erosion is minimum, for this plantation, soil conservation works is needed. Further there is mining being carried out in the area. Its effect on soil erosion. Siltation and water quality needs to be accessed.
- Creating nesting columns for the birds in back water planting peepal, banyan and other bird attracting trees.
- Development for promoting ecotourism with walking trails, cycle trail, horse bath, bird watching tower, lake front development infrastructure required like hotels, recreation parks, car parking, fishing point etc. Eco-center, open theater and interpretation centre have to be constructed nearby the lake.
- Framing appropriate laws and bye laws aimed for conservation of lake, wild life and aquatic life in the catchment and adjoining areas.
- From lake's water line to 40 meter wide, there should not be single plant of prosopis juliflora. It is to be replaced by the fruit bearing and pro-bird liking tree. This activity should be carried out in next five years.
- The natural grown plant should be protected from browsing by the blue bull. In some areas the soil is washed out and roots are exposed. In these areas loose boulders bunds is suitable to bind the soil
- There are old water storage tank in the catchment of lake. They should be modified and renovated with standards. In summer water at regular interval should be filled up in the soccer.
- There is 400 hectare old plantation in the catchment of lake. It requires effective protection and gap plantation with local species.
- The cost estimation for conservation and management plan is Rs. 1213.26 lacs.

REFERENCES

1. Gopal, B., (1991), "Wetland management by keeping people out: two examples from India" Land scape and urban planning pp 53-59 ABD publishers Jaipur.
2. Sharma, K.C., Dutta, A, (2001), "Eutrophication of lakes and reservoirs, pp 438-449.
3. www.cseindia .org/node/619", (Viewed on August 14, 2011).
4. Mendiondo, E.M., (1995), "Global Review of Lake and Reservoir Eutrophication and AssociatedManagementChallenges',wldb.ilec.or.jp/ILBMTrainingMaterials/.eutrophication challenges.
5. Klappe, H., (2003), "Technologies for lake restoration, Papers from Bolsena Conference Residence time in lakes": Science, Management, Education J. Limnol., 62(Suppl. 1): 73-90.
6. Sharma, M.P., Kumar, A., and Rajvanshi, S., (2010), Assessment of Trophic State of Lakes: A Case of Mansi Ganga Lake in India, Hydro Nepal, and vol- NO. 6.
7. Reddy, M.S., and Char, N.V.V., (2004), "Management of Lakes in India", P-1-20.
8. Banerji, R.C., and Upadhaya D.S., (1975), "A Survey of Drought and Scarcity in Rajasthan", Meteorological Center, Jaipur, Rajasthan.
9. Ministry of Environment and Forests (NRCD) (2010), "Conservation and Management of Lakes- An Indian Perspective (p 1-102).
10. Kodarkar, M.S., (2008),"Conservation and Management of Lakes case studies from India", The 12th World Lake Conference (1442-1445).
11. Mukerjee, A., (2007), "Conservation and Management of Bhoj Wetlands, India #329", wldb.ilec.or.jp/data/ilec/WLC13_Papers/S8/s8-4.pdf.
12. Kumar, A., (2008), "Hypolimnic Withdrawal for Lake Conservation," The 12th World Lake Conference (812-818).
13. Qadri, et al., (2008), "Dal Lake Ecosystem: Conservation Strategies and Problems", the 12th World Lake Conference (1453-1457).
14. Rao, R., (2009),"Conservation of Lakes: Issues & Application", Architecture - Time Space & People April 2009, Ecology (34-41).
15. www.environment.raj.nic.in. (Viewed on August 06, 2011)

16. Singh, Y.D., (2002), "Rajasthan ke Jheelen aur Talab – Maharaja Man Singh Pustak Prakash", Jodhpur.
17. Thomas, M. Lillesand, fifth edition, remote sensing and ipp 279-323. John wiley and sons (ASIA) pvt. Ltd. Singapore.
18. Vijayan, Jhingran, (1992), "Identification of aquatic animals". Hindustan Publication Corporation, New Delhi.
19. Kodalkar, M.S., (2008), "Conservation and Management of Lakes case studies from India", 12th world lake conference: 1442-1445.
20. www.mapsofindia.org. (Viewed on August 06, 2011)
21. www.worldlakes.org . (Viewed on August 12, 2011)
22. Kodarkar, M.S., and Joshi. S., (2006), "Conservation and management of lakes in urban environment"; Bioremediation a new frontier in the control of eutrophication in urban lakes. Proceedings. Vol.II, World lake conference Nairobi, Kenya,pp: 79-82.
23. Municipal Corporation Jodhpur office dated 17/18-07-2011.
24. Rajasthan, Forest and Wildlife Department office, Draft master Plan of Jodhpur Zoo and Satellite Facility Machia Biological Park, Jodhpur, documents on dated 14-07-2011.
25. Development Authority, Jodhpur office, Development of Ecotourism at Kaylana Lake report on dated 15-07-2011.
26. Sharma, K.D., (1996), "Soil erosion and sediment yield in the India arid zone". Erosion and Sediment Yield: Global and Regional Prospective of the Exeter Symposia. IAHS Publ. No. 236.
27. Sharda, V.N., Juyal, G.P., Prakash, C. and Joshi, B.P., (2007), "Training manual – Soil Conservation and Watershed management": Soil and Water conservation engineering. Central Soil and Water Conservation Research and Training Institute, Dehradun.
28. Singh et.al. (2004),"Manual of soil and conservation practices", Raju primal for oxford and IBH publishing New Delhi.
29. Murthy J.V.S., (1998), Nature-234 pages.