CHAPTER - ONE

1.1 General Background

The Himalayan country Nepal is a landlocked country blessed by nature with a network of water bodies in the form of rivers, streams, lakes, ponds etc.

Rivers

There are about more than 6,000 rivers, rivulets and streams covering about 395,000 hectare or 48.7% of total water resource (DOFD, 2001). Major rivers are - Karnali River System, Gandaki River System, Koshi River System and Mahakali River System. All the rivers of Nepal form the part of the headwaters of the Ganges River Basin (one of the 20 largest rivers in the world). Discharge from Nepal contributes about 40 percent annual flow of Ganges System and 70 percent flow in dry season.

Lakes

Lakes are natural water reservoirs of various size scattered all over the country covering an area of 5,000 hectare (i.e. 0.6 percent) of the total water area. Lakes occur from southern low altitude plain of about 60m to more than five thousand meter altitude (Jonnes et.al. 1989, Lami and Giussani 1998, Gurung and Wagle 2000). Based on the origin, these lakes are of three types: **glacial lakes**, **tectonic** and **ox-bow lakes**. There are 44 glacial lakes in the northern Himalayan region which are located above 4000 m. Tectonic lakes occur in the hilly region and the most of lake of Nepal are tectonic origin which when drained out were replaced by flat basins like Kathmandu valley, Pokhara valley, Banepa, Panchkhal, Mariphant (Palpa), Dang, Surkhet. In mid hills, the famous lakes are Phewa (523 ha),

Begnas (328 ha) and Rupa (115ha). The age and origin of these lakes are not known. Oxbow lakes are mainly confined to the southern part of the country particularly between the middle to southern Terai region which indicates rives shift. More than two dozen ox-bow lakes are present in Nepal and most of them are located in Chitwan National Park, Nawalparasi, Bardiya and Kailali (Sharma, 1977).

Lakes are also classified as major and minor lakes. Some of the major lakes are - Rara or Mahendra Lake, Phewa Lake, Begnas Lake and Rupa Lake. Some of the minor lakes are - Khaptad Lake, Baragon Lake, Tilicho Lake, Phoksundo Lake, Dudhpokhari Lake, Jageswar Lake, Panch Pokhari, Taudaha, Nagdaha in Lalitpur, Gosaikunda, Dudhkunda, Barhakunetal in Dang district etc.

Reservoirs

There are few manmade reservoirs in Nepal which are constructed for irrigation and the generation of hydroelectric power. There are run off and reservoir type of hydropower projects in Nepal and both of them produce reservoirs of small and large areas respectively. As a result numerous small and large reservoirs are built at different parts of Nepal; the total area of reservoirs is about 1500 ha comprising 0.2% of the total water area; but the potential for expansion of reservoir area is very high in Nepal as outlined by below mentioned master plan for both irrigation and hydropower development. The important reservoirs are Jagdishpur reservoir (irrigation), Sunkoshi, Kulekhani, Marsyangdi, Trisuli etc. These reservoirs are being used for fish culture practices.

Ponds

The ponds are small shallow water bodies whose depth is measurable with abundant macrophytic vegetation on the margin. The ponds which are dried up during the dry season and get filled up with water in rainy season are known as seasonal or temporary ponds. But some ponds contain water and do not dry up during dry seasons are known as perennial ponds. Ponds are classified into various ways, on the basis of their origin, they are categorized below:

1) These which represent the pond stage in the extinction of previously existing lakes during the evolution of lentic environment.
2) These with shallow basins and of small area which has remained in the pond stage and is not preceded by lakes.
3) Those which have been constructed excavated or impounded for various purposes.

According to the purpose of construction and location the pond may be termed as temple tank, village pond, homestead pond and historical pond.

Temple ponds are made for religious purposes, so they are found near the temples. Different sacred materials are thrown into the pond by the people who come to the temple. Janakpur has got many sacred ponds. Janaki temple of Janakpur consists of 119 different ponds in the name of Janaki.

Village ponds are constructed for the purpose of drinking water, washing and bathing cattles. In Terai there are large numbers of village ponds.

Homestead ponds are found close to the households of the rich family in Terai region. These ponds are meant for rearing the fish. Some people use these

ponds for duck farming. In the case of poor people, these ponds are constructed near the houses where the cleaning of utensils and use of water to cattle are done.

Historical ponds are found in our country which is constructed by the rulers of the past time in the name of their beloved family, like Ranipokhari in Kathmandu. Siddhapokhari in Bhaktapur. Besides these, other famous artificial and historical ponds are Pimbahal pokhari in Lalitpur, a big pond in central zoo, Kamal Pokhari, Gahana Pokhari, Ikha Pukhu, Nag Pokhari etc. Now a day these historical ponds of Kathmandu are stocked with different ornamental, catfish and carp fishes from the religious, cultural, aesthetic points of view. The present study is an attempt to study water quality, fish diversity and its significance in Siddhapokhari of Bhaktapur.

1.2 Limitation of the study

Each and every study has its own limitation. Present study has also some limitations:

a) The researcher being a student, there is financial problem, time limitation and other unavoidable problems. Therefore, the researcher is not able to include maximum respondents.
b) This dissertation is a study work for the partial fulfillment of M.Sc. degree in Zoology. Therefore, the student is not able to deal many other related factors of study.

1.3 Objectives of the study

The objectives of the present dissertation work are as follows.

a) To study water quality parameters of the pond.
b) To list the fish species found in the pond.
c) To know the significance and status of fish stocking and growing in this historical pond.

1.4 Justification of the study

Very little study was done about the biolimnology of the old historical pond in Kathmandu valley. Very small works had been done by M.Sc. students in Ranipokhari but scientific study work in Siddhapokhari in Bhaktapur was either not done or documented so far. The present study work is to identify the importance of ponds and fishes in pond as religious significance in the people of Kathmandu valley.

CHAPTER - TWO

2.0 Review of Literature

Nepal is rich in inland water resources. It is devoid of sea of the water resources of Nepal are exclusively fresh water. The branch of science which deals with the study of fresh water ecosystem of all kinds of lakes, resources, streams, pond, marshes, hogs etc (physically, chemically and biologically) is known as limnology. At present, limnology is a young science in Nepal and little works had been done on it so far.

The word 'limnology' is derived from the Greek word "Limnos" meaning pool, marsh, swamp or lake. The first definition of limnology was given by Forel (1892), a Swiss Professor in the University of Lausanne, Switzerland by his study in Lake Lacleman and later he was regarded as the father of limnology. According to Forel "Limnology is oceanography of lakes." Forel's fist volume of lake Geneva (1892) dealt with lacustrine biota, since then geographical, physical and chemical studies have been termed as Forelian Limnology. Forel (1904) studied on Limnology and published a book called "Science of Lake". In the beginning of 19^{th} century, a study of lentic and lotic habitats was started. Forbes (1887) described lake as a "Microcosm" a little world within itself. The word 'limnology' became a part of the general vocabulary only in the past few decades. Since, then a voluminous work has been undertaken and compiled in different parts of the words by different scientists and authors.

Theinemann (1925) was associated with the limnology studies particularly, those relating to the classification of lakes based on oxygen concentration and the species of bottom mud. Hora (1930) studied ecology, bionomies and evolution of the torrential fish fauna with special reference to organs of an attachment. Pruthi (1933) studied the seasonal changes in the physical and

chemical conditions of the water in the tank in Indian museum compound. Hutchinson (1937) made certain limnological studies in Tibet. Among the pioneer workers, the contribution of Welch (1948-52) and Ruttner (1953) were remarkable for laying down firm foundation for limnology.

Philipose (1940) studied ecology and seasonal succession in a permanent pool at Madras city. Ganapati (1941-43) also called father of Indian limnology made divergent limnology investigation on freshwater ponds of Madras city. Chacko and Krishnamurthy (1954) studied ecology of planktons of three fresh water of Madras city. George (1961) made ecological observations on the physicochemical parameter of water and zoo-plankton and rotifers of certain shallow ponds of Delhi. Saha et.al. (1971) observed seasonal fluctuation of planktonic population in fish ponds.

Zutshi and Vass (1972) studied limnology of high attitude Kashmir Lake. Sreenivasan et.al. (1974) studied physicochemical factors in most of the Indian lakes. Nasar (1977) studied diurnal variations in the lakes of Bhagalpur (Bihar).

The production and ecology of some macroplytes of Kashmir lakes was studied by Kaul and Raina (1982). Sharma and Durve (1985) studied on trophic status of fishery of Rajasthan waters. Study on some limnological aspects of selected closed water ecosystem of Udaipur was done by Karki (1988). Rao and Shrivastava (1989) studied biological agents as monitoring of water quality in Chambal and Khan rivers of central India.

Rao et.al. (1990) studied the limnology of Dorania river at Bareily. Pandey ans Verma (1992) studied the limnological status of an ancient temple pond of Deogarh, Bihar.

Bashu et. al. (1996) worked on factor regulating phytoplankton and zooplankton biomass in temperature in temperate rivers in Eastern Canada. Kobia et.al. (1996) carried out the qualitative and quantitative fluctuations of the phytoplanktons biomass in three different aquatic habitats of the mile at Qualubia, Province, Egypt, in relation to environmental condition (physicochemical characteristics). Smith (1997) worked on the periodically forced droop model for phytoplankton growth in a chemo state.

Lots of limnological investigations were carried out throughout the world by end of 1990. However, few references are available so far in connection with limnological studies on the logic and lentil water system of Nepal.

Nepal is a Hindu country so many ponds are constructed in many places of Nepal especially in Kathmandu valley with cultural aspects. There are about 199 such ponds within Kathmandu valley alone. There is large number of ponds in other parts of Nepal, only few ponds are utilized for fish culture. But there are few ponds constructed for the purpose of fish culture. Flora and fauna of these water bodies have attracted the interest of many biologists.

Brehm (1953) was the first to study some aquatic fauna from Kalipokhari in eastern Nepal. Hiriono (1955) have published few papers concerning to the Nepalese algae. Later Roster (1965) has published few papers on Nepalese algae. Loffler (1973) investigated on three lakes and two ponds in the valley of Pokhara, Kathmandu.

Ferrow and Swar (1978) did limnological works with special references to biological survey on Lake Rara (Mugu). Preliminary studies of three small water bodies of Kathmandu valley were conducted Singh 1978, Shah 1979 and Joshi 1979. The limnology of Bagmati and Trishuli Rivers had been studied to

some extent by Shrestha, et al (1979). Pradhan (1982) carried out preliminary study of Syarpu Daha (Rukum) a mid hill lake of Nepal.

Mehata (1980) worked on abundance and biomass of freshwater zoobenthes in the two ponds of Godvari fish farm. Mahaseth (1988) reported the physicochemical parameters of Tadi Rivers in relation to fish production and management. FDD (1995) also preferred limnological works in different ponds of Kathmandu valley one of which was Naagdaha at lalitpur, Kathmandu each year. Bhattarai (1996) studied on hydrological characteristics and primary productivity of Kamal Pokhari, Bhaktapur Nepal. Khadka (1996) studied some limnological parameters of historical pond, Nagdah.

CHAPTER -THREE

3.0 Materials and methods

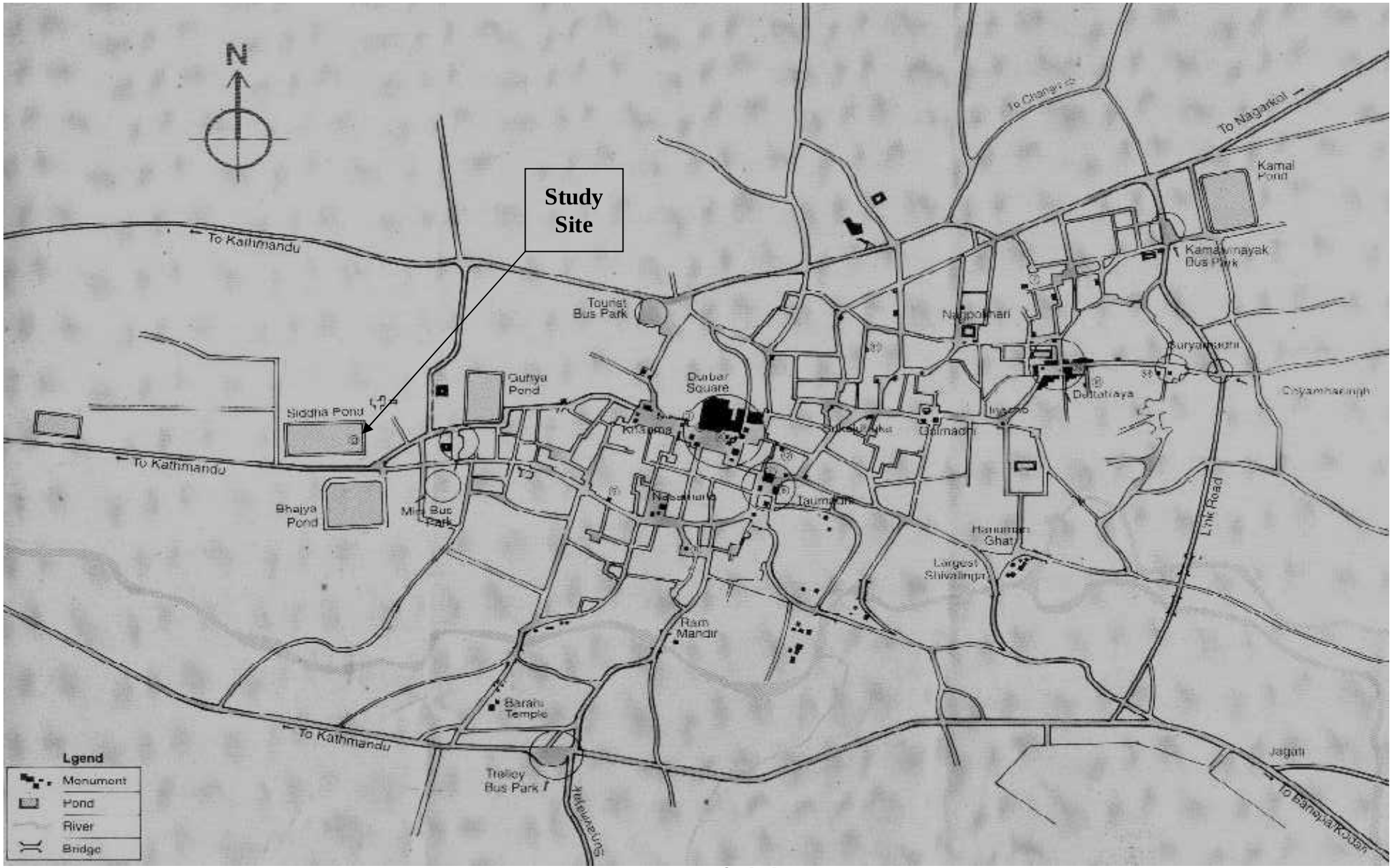
3.1 Description of study site

Siddha pokhari lies in the Bhaktapur municipality ward no.17 Dudhpati, Which is surrounded by 4 entrance gates in all directions. The pond is rectangular in shape having length 275m and 92m in widths. In north and west there is big playing ground, hospital compound in the east and in the south, there is main road. The pond lies slightly above the ground level as it is depth of the pond is below the ground level as it has been proved by the field investigation research. Local residents claim that there are 7 wells under the water as a major source of water. The pond has one outlet towards the eastern side. Images of different god and goddesses and different written records are placed around the ponds circumferences. The pond is called by different names. As a whole the pond is famous for the name 'Siddhapokhari'. In newari, it is named as Tapukhu. In ancient, it was known as 'Indra daha'. According to the 'Dev Mala' pedigree, a rumor is famous for how the pond named as Siddhapokhari. There was one versed in charring/incambation (tantrik) which can disguise as he wished. Due to some reason that person, who changes his get up as a dreadful serpent (Nag) vanished in the pond. So, the pond called as Siddhapokhari.

As it is a natural pond, different rulers, kings repaired the worn-out pond in different periods. There is legal notice inscripted over the stone by General Bhimsen Thapa (1881 B.S.) and General Ranouddip Singh (1935 B.S.). Bhaktapur is well known ancient city famous for many monastery, wells, and temples. Bhaktapur is small in area but densely populated city. Historical tap, wells, ponds and pools had been systematically made and need to conserve these resources. These water bodies have used not only for regular, daily activities but also for religious purposes. There are different ponds in

Bhaktapur municipality. Siddhapokhari is one of the largest ponds of the city. There are other 4 ponds in this area such as Inma pond, Na pond, Rani Pond, Bhujuya pond. People believe that Rani pond is worshiped as head of Nag (king cobra), Siddhapokhari as abdomen and Na pokhari as tail of Nag.

For the convenience of the study, three different stations are chosen in the pond - Station 'A', Station 'B' and Station 'C'. Station 'A' lies towards the eastern site, Station 'B' towards the southern site (road side) and Station 'C' towards the western site.



Pic. No. 1: Map of Bhaktapur city

3.2 Materials

The materials i.e. equipments and chemicals for the present study were as follows:

A) Glass ware

1. Conical flaks, 2. Pipettes 3. Beakers, 4. Petridish, 5. Test tubes, 6. BOD bottles, 7. Measuring cylinders, 8. Volumetric flasks, 9. Burette, 10. Dropper, 11. Glass rods

B) Laboratory instrument

1)PH meter, 2)Weighing balance, 3)Standard mercury thermometer, 4)Measuring tape, 5) Secchi's dish and 6)Burette stand

C) Chemicals

The chemicals needed were prepared. The reagent solutions, standard solutions, indicator solutions and other solution were prepared.

Preparation of reagent solutions

a) Winkler 'A' solution or $MnSO_4$ solution

91grams of ($MnSO_4.H_2O$) was weighed and dissolved in doubled distilled water. The solution was poured into 250ml volumetric flask. Its volume was made 250ml by adding double distilled water up to the mark on the flask. Then the flask was filtered through ordinary filter in glass funnel. The filtrate was kept in a reagent bottle and then labeled and stored for later use.

b) Winker 'B' solution or Alkaline Iodine solution

125grams of sodium Hydroxide (NaOH) and 31.75gms of sodium iodide were weighed and dissolved in double distilled water. The solution was made to 250ml by adding double distilled water. The solution was poured into volumetric flasks. Its volume was made to 250ml by adding double distilled water. The flasks were shaken well in order to mix the solution properly. Then the solutions were kept in the bottle, labeled and stored for later use.

Preparation of standard solutions

a) Sodium thiosulphate solution (0.015N)

6.3grams of $Na_2S_2O_3.5H_2O$ was weighed and dissolved in freshly boiled and cooled double distilled water. The solution was stirred with glass rod for uniform mixing. The solution was made to 1000ml by adding doubled distilled water. The solution was kept in the reagent bottle and labeled.

b) Standard sodium carbonate solution (0.045N)

0.602grams of anhydrous Na_2SO_3 was weighed and dissolved in double distilled water. The solution was marked to 250ml by adding double distilled water. The solution was freshly prepared one or two days before the sampling data.

c) Sulphuric acid (0.02N) solution

3ml of concentrated sulphuric acid was taken and mixed with double distilled water. The volume of this solution was made to 1000ml (0.1N) then 200ml

(0.1N).Then 200mlk of 0.1N H_2SO_4 was made to 1000ml by adding double distilled water, the solution was kept in the reagent bottle and labeled.

d) EDTA solution

3.723 grams of Di-sodium salt of EDTA was weighed and dissolved in double distilled water. The volume of the solution was made up to 1000ml by adding double distilled water. The solution was kept in the reagent bottle and labeled.

e) Sodium Hydroxide solution (1N)

40 grams of sodium hydroxide (NaOH) was weighed and dissolved in double distilled water. The solution was stirred well with glass rod and made up to 1000ml by adding double distilled water. The solution was kept in the reagent bottle and labeled.

Preparation of other solutions

a) Ammonium buffer solution

i) 16.9grams of ammonium chloride (NH_4Cl) was weighed and dissolved in 143ml of concentrated ammonium hydroxide (NH_4OH) solution.

ii) 1.179grams of di-sodium salt of EDTA and 780mg of $MgSO_4.7H_2O$ was weighed and dissolved in double distilled water. The solution was stirred with a rod for better mixing.

Then the solution (i) and (ii) were mixed and powered in the 250ml of volumetric flask. The volume of the solution was made to 250ml by adding

double distilled water. The flask was shaken well for uniform mixing of the solution. The solution was kept in the bottle and labeled.

b) Silver nitrate solution

3.4grams of silver nitrate was weighed and dissolved in double distilled water. The solution was stirred with glass rod for better mixing. The volume of the solution was made to 1000ml by adding double distilled water. The solution was kept in dark bottle and labeled.

Preparation of indicator solution

a) Starch indicator

6grams of starch powder was weighed and dissolved in small amount of distilled water. The volume was made to 1000ml. The solution was boiled for few minutes and was allowed to settle down overnight. It was preserved by adding 1.25grams of salicylic acid. It was kept in the bottle and labeled.

b) Phenolphthalein indicator (K_2CrO_4)

5grams of potassium chromate was weighed and dissolved in double distilled water. The mixing was made to 1000ml by adding double distilled water. The solution was kept in a bottle and labeled.

c) Eriochrome Black-T indicator

0.4grams of Eriochrome black-T and 100grams of sodium chloride (NaCl) were weighed and mixed. The mixture was grinded in a mortar. It was then kept in a dry and neat bottle and labeled.

d) Mureoxide indicator

0.2grams of ammonium perpurate and 100grams of sodium chloride (NaCl) were weighed and mixed. The mixture was grinded in a mortar. It was then kept in a dry and clean bottle and labeled.

3.3 Sampling for physicochemical parameters

While collecting the water sample a great deal of care and precaution were taken. The samples were collected from the surface layer of the pond.

3.3.1 Physical parameter

The physical parameters were observed during the field investigation period were, nature of the day, color of water, depth, Transparency and temperature.

a) **Nature of day**

The nature of the day was recorded at the field during working hour by looking around the cosmos with naked vision.

b) **Colour of water**

To know the colour of water a little amount of water was taken in a Petri dish and kept over white paper, and then the colour of water was observed by naked eyes.

c) Depth

To know the depth of the pond a good quality long nylon rope having appropriate weight was used. First of all the rope was lowered in the water body till it reached the bottom and the length of the rope under water was measured with the help of measuring tape.

c) Transparency

The Secchi's disc was to calculate the transparency of the water. The Secchi's disc is a metallic plate painted with four alternate black and white quadrants on the upper of aquatic bodies was devised by an Italian scientist Secchi (1965). Transparency was measured by lowering the Secchi's disc in water and depth was recorded at which it just disappeared and just reappeared. Then average value of two readings of the Secchi's disc was noted as transparency and expressed in centimeter.

$$\text{Transparency (in cm)} = \frac{(\text{Just disappeared}) + (\text{Just reappeared})}{2}$$

The transparency coefficient was calculated with the help of the following formula: $k = \frac{1.7}{D}$

Where, D= Secchi's disc reading, K = transparency coefficient and
1.7= constant factor

d) **Temperature**

The temperature of water and air was recorded with the help of a standard mercury thermometer. The surface temperature of water was taken by dipping the thermometer bulb into the water body. The air temperature reading was

taken under a shady side, avoiding direct exposure of the mercury bulb to sunlight.

3.3.2 Chemical parameters

The chemical parameters measured during this study period were pH, DO, Hardness, Alkalinity.

a) pH (Hydrogen ion concentration)

A portable pH meter was used to measure the ph of the water. The pH of water was recorded as mean value of pH of water.

b) DO (Dissolved oxygen)

Dissolved oxygen of the water body was determined by using Winkler's method. This method was first developed in 1888 by Winkler and method enables the shortage of samples and has high degree of precision. Hence, the procedure is time consuming. Sodium azide in winklers' reagent W_A and W_B help in removing the interference due to the high organic matter and chloride. The principal method is as follows:

$$MnSO_4+2KOH \rightarrow Mn(OH)_2+ K_2SO_4$$
$$2Mn(OH)_2+O_2 \rightarrow 2MnO(OH)_2$$
$$MnO(OH)_2+2H_2SO_4+2KI \rightarrow MnSO_4+3H_2O+I_2$$

In practice, it is very important to minimize contact between sample and atmospheric air. For this the water sample was collected to prevent the entrapment of air bubbles. After the sample was allowed to overflow the bottles, it was then quickly stopped, taking care not to trap any air bubbles.

To fix the dissolved oxygen in the B.O.D. bottle, 2ml each of W_A and W_B solutions were added at an interval of 2 minutes with the help of pipettes. The bottle was shaken upside down 6 times and the precipitate was allowed to settle down. Then 2ml of concentrated sulphuric acid (H_2SO_4) was added which dissolved the precipitate. The bottle was again shaken for 6 times upside down. The oxygen was thus fixed in the B.O.D. bottle.

For the estimation of dissolved oxygen, 50ml of fixed sample was taken in a conical flask and starch solution was added as an indicator with constant shaking of the flask till the colour changed to blue. Then this solution was titrated against 0.025N sodium thiosulphate solution with shaking of a flask till the blue colour disappeared. The burette reading was noted down in the field wood sheet.

The calculation of dissolved oxygen was made by using following formula:

$$\text{Mg of } O_2\text{/litre} = \frac{\text{used volume of titrant} \times 1000 \times 0.2}{\text{Volume of sample}} = \text{ppm}$$

where, 0.2 represent 1ml of 0.025N sodium thiosulphate solution which is equivalent to 0.2mg of O_2

c) Free carbondioxide (CO_2)

For the estimation on free carbon dioxide, 50ml of water sample was taken in a conical flask. Four drops of phenolphthalein indicator was added in it and shaken well. If the water sample remains colourless, it indicates presence of CO_2. The water sample containing CO_2 was titrated against 0.4N sodium carbonate (Na_2CO_3) solution till a faint pink coloured end point was observed.

The reading noticed in the burette was noted in the sheet. The calculation for CO_2 was made by the following formula.

$$\text{Mg of } CO_2 \text{ /litre} = \frac{\text{used volume of titrant} \times 1000}{\text{Volume of sample}} = \text{ppm}$$

d) Total Alkalinity

Generally, two alkalinity values are measured; one is the alkalinity to pH 8.3, which is called phenolphthalein alkalinity. Another is alkalinity to pH 4.3 which is called total alkalinity. In this method methyl orange is used as an indicator (Masuda and Pradhan, 1988).

To determine the alkalinity, 50ml of water sample was taken in a conical flask and four drops of phenolphthalein solution was added as an indicator. The flask was shaken well and the appearance of pink colour indicates the presence of carbonate in the sample water. This sample was titrated against 0.02N sulphuric acid (H_2SO_4) till the pink colour disappeared. The burette reading was noted down.

Then four drops of methyl orange was added into this solution as an indicator and the flask was shaken well. Then the titration was contemned with constant shaking of the flask till colour changes from yellow to brick red. The burette reading was noted down for the total volume of titrant used in both titrations.

The calculation for carbonate or phenolphthalein alkalinity and total alkalinity was made by using following formula:

$$\text{Total alkalinity} = \frac{\text{used volume of titrant} \times 1000}{\text{Volume of sample}} = \text{ppm}$$

e) Total hardness

Hardness of water is due to soluble salts of divalent cations mainly calcium and magnesium. Temporary hardness caused by calcium and magnesium bicarbonates. This is called temporary hardness because on boiling, the bicarbonates change to carbonates and part of calcium and magnesium are precipitated.

$$Ca(HCO_3)_2 \rightarrow CaCO_3 + H_2O + CO_2$$

Permanent hardness is principally due to Ca and Mg carbonates and salts of inorganic acids eg.$CaSO_4$
Hence, Total hardness= permanent + temporary hardness

For the determination of total hardness, 50ml of in which 1ml of ammonium buffer solution was added and stirred well. Then, 100 – 200mg for a pinch of eriochrome Black –T indicator was added and shaken well. Then the solution was titrated against standard EDTA solution of 0.01N till a blue colored end point was reached. The burette reading was noted down. The total hardness of water was calculated by using the following formula.

$$CaCO_3 \text{mg/litre} = \frac{\text{used volume of titrant} \times 1000}{\text{Volume of sample water}} = \text{ppm}$$

3.4 Direct observation and interview

The fish species and the status of fish in the pond and other information were observed directly in the pond and by informal discussion and interview with local people, local sales man warden and tax officer of Bhaktapur municipality.

CHAPTER- FOUR

4.0 Result

4.1 Physical factors

a) Nature of the day

The cloudy and windy day was observed on May 2007 and sunny day during rest of the period.

b) Water colour

During the study period, there was not much variation in the colour of water. It was slightly brownish on July and greenish to colorless in the rest of period.

c) Transparency

The lowest and highest transparency was 12cm and 45cm on June and September respectively and the mean value was 25.28cm. The average transparency coefficient was found to be 0.09 and maximum value was 0.14 on June and minimum 0.04 on August/September (Table 1).

d) Temperature

During study period, surface water temperature ranged from 19.8 to 26^{o}C (Table 1).

4.2 Chemical factors

a) pH

The water was found neutral to slightly alkaline with the pH varying from 7.2 to 8.6.The lowest pH was recorded on June and the highest on April. The average value of pH was 8.07 (Table 1).

b) Dissolved Oxygen (DO)

The dissolved oxygen of pond ranged from 5.0 – 8.5 ppm. The maximum value was found on March and minimum on June. The average value was found to be 7.43 ppm (Table 1).

c) Free Carbon-dioxide

Free CO_2 ranged from 2.5-7.9 ppm during study period. The maximum value was recorded on June and minimum on August. The average value was 4.64ppm (Table 1).

d) Total alkalinity

The bicarbonate alkalinity was found ranging from 28.0 - 55.0 ppm. The maximum value was recorded on June 2007 and minimum value on August. The average value was 27.14 ppm (Table 1).

e) Total hardness

The value of total hardness ranged from 240.0 - 280.0 ppm with average hardness of 255ppm. It was maximum on June and minimum on March (Table 1).

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Parameters	April	May	June	July	August	Sept.	Max.	Min.	Average
Air Temp (^{0}C)	21.4	23	28	22	25	26	28	21.4	24.23
Water Temp (^{0}C)	19.8	20	26	20	22.8	23.2	26	19.8	21.97
Depth (cm)	90	106	115.6	125.3	90.83	95.6	125.3	90	103.90
Transparency (cm)	16	18	12	16.5	44.2	45	45	12	25.28
Transparency (coeff.)	0.11	0.09	0.14	0.10	0.04	0.04	0.14	0.04	0.09
Dissolved Oxygen (ppm)	8.5	8.5	5	7.2	6.8	7	8.5	5	7.17
Free CO_2 (ppm)	6.8	4	7.9	4.3	2.5	2.8	7.9	2.5	4.72
Total Alkalinity (ppm)	48	32	55	44	28	30	55	28	39.5
Total Hardness (ppm)	240	240	280	260	260	250	280	240	255
pH	8.6	8.2	7.2	7.8	8.5	8.2	8.6	7.2	8.08

Table 1: Monthly variations of Physicochemical parameters of Siddhapokhari

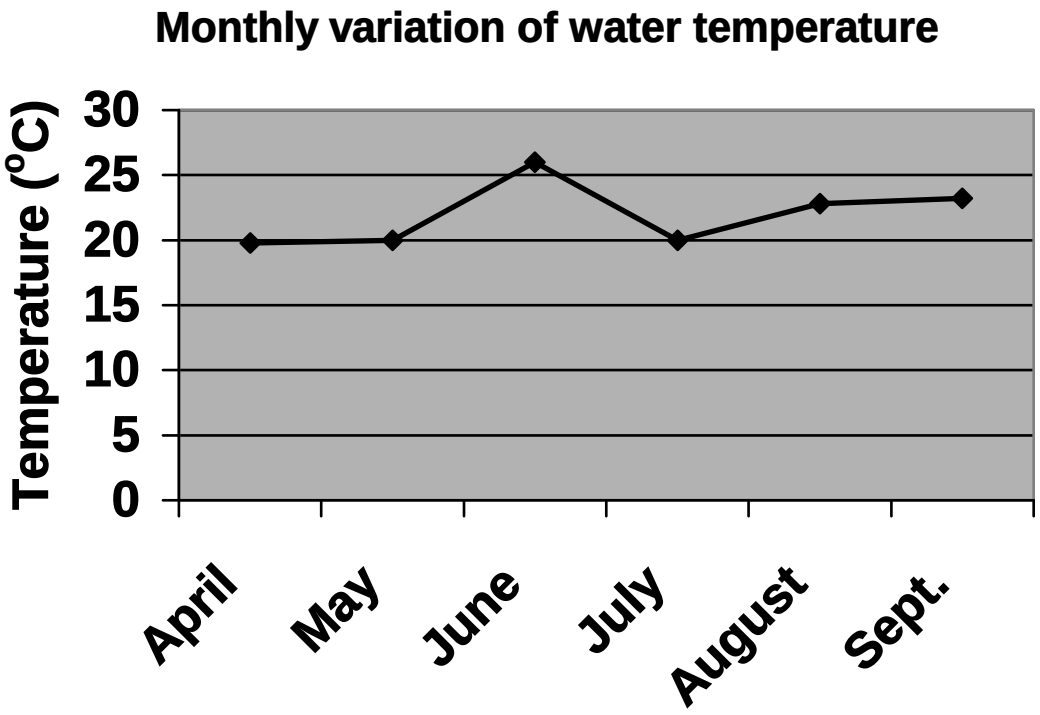

Fig. 1. Monthly variation of water temperature.

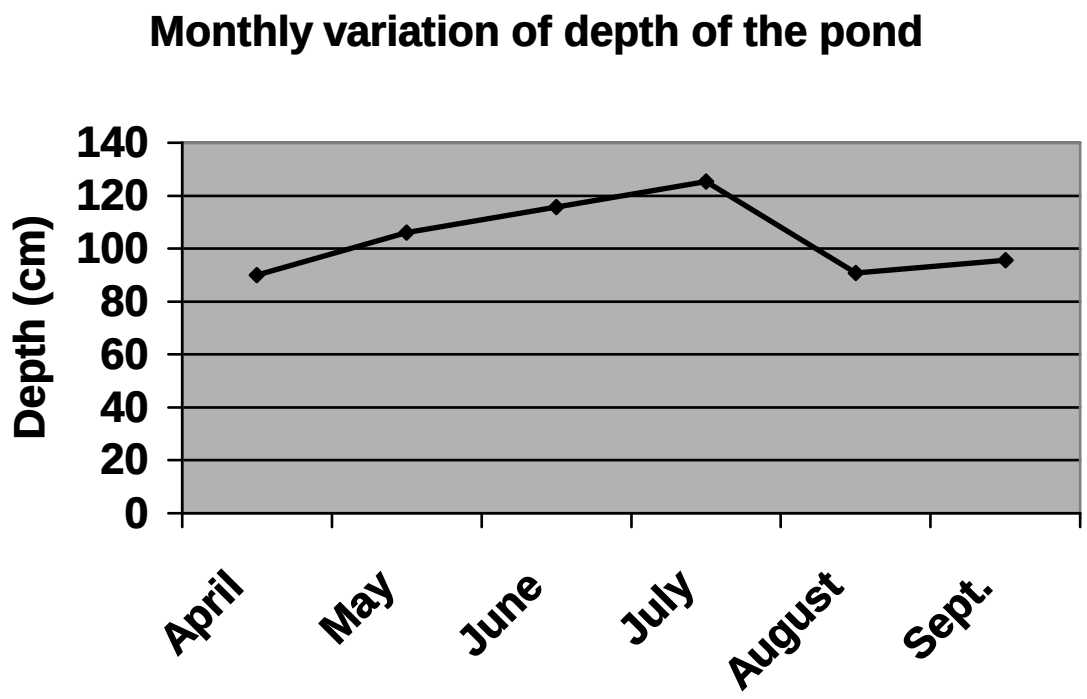

Fig. 2. Monthly variation of water depth.

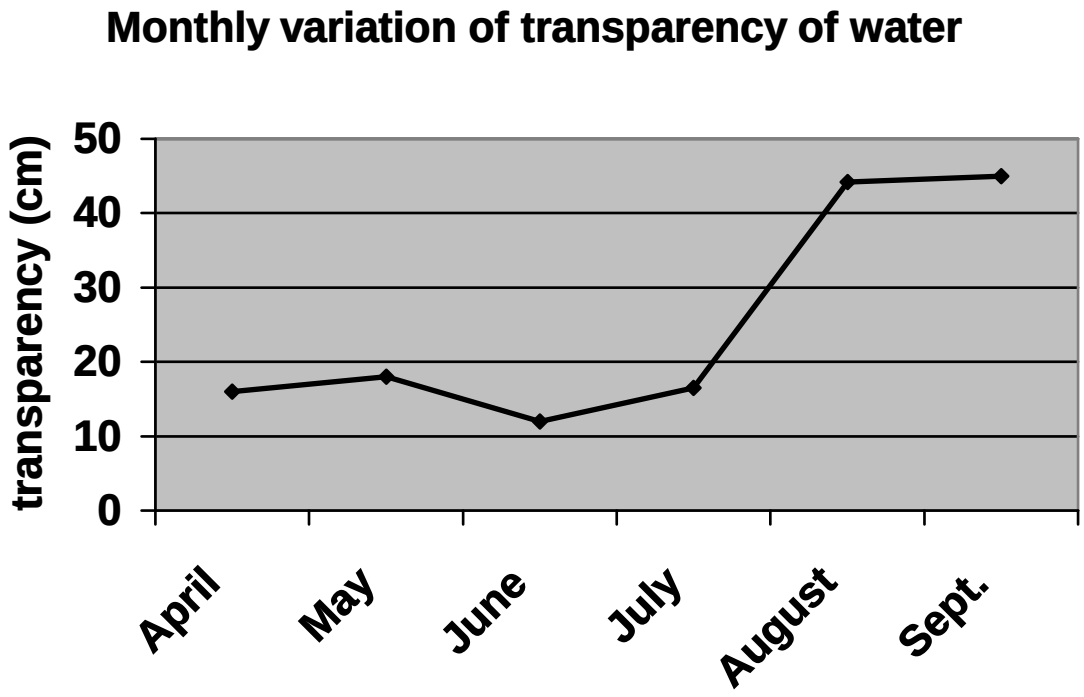

Fig. 3. Monthly variation of transparency water.

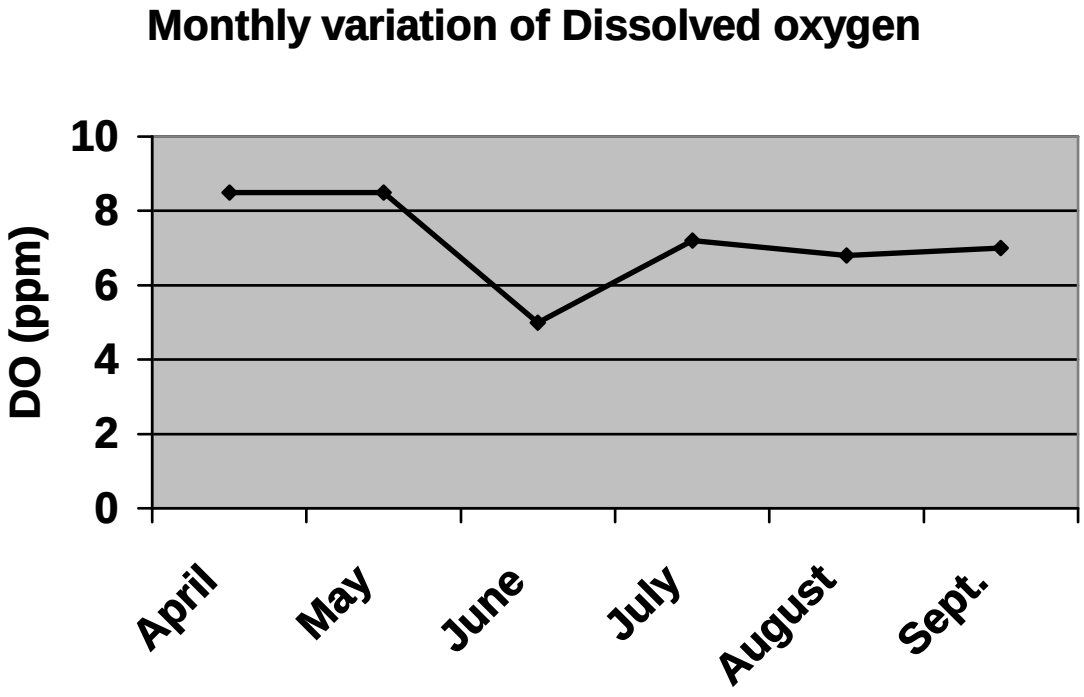

Fig. 4. Monthly variation of dissolved oxygen.

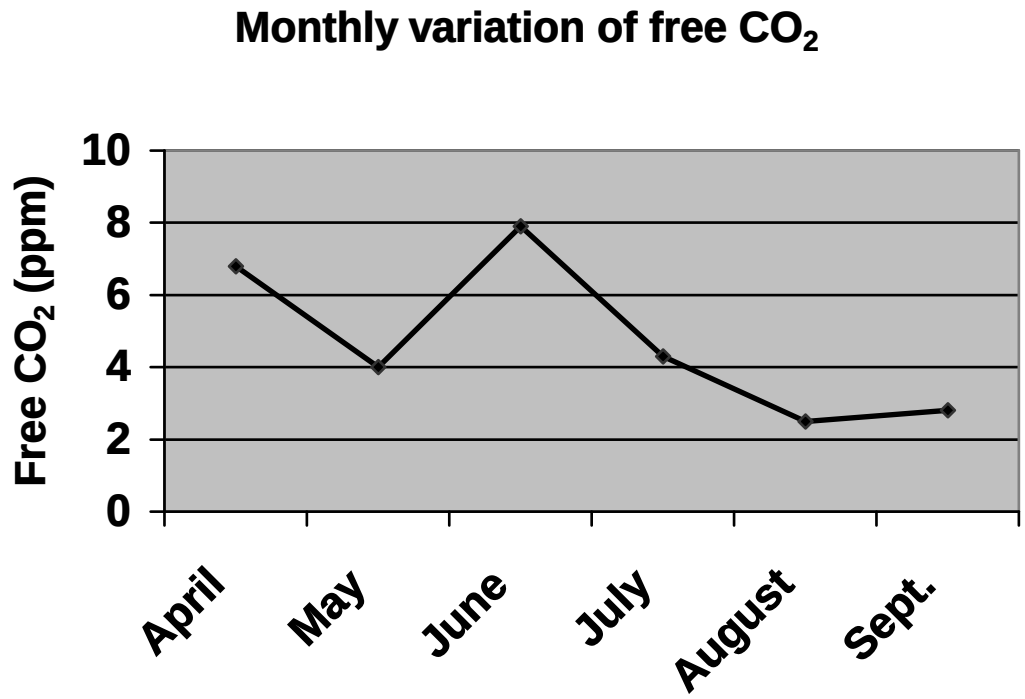

Fig. 5. Monthly variation of Free CO_2.

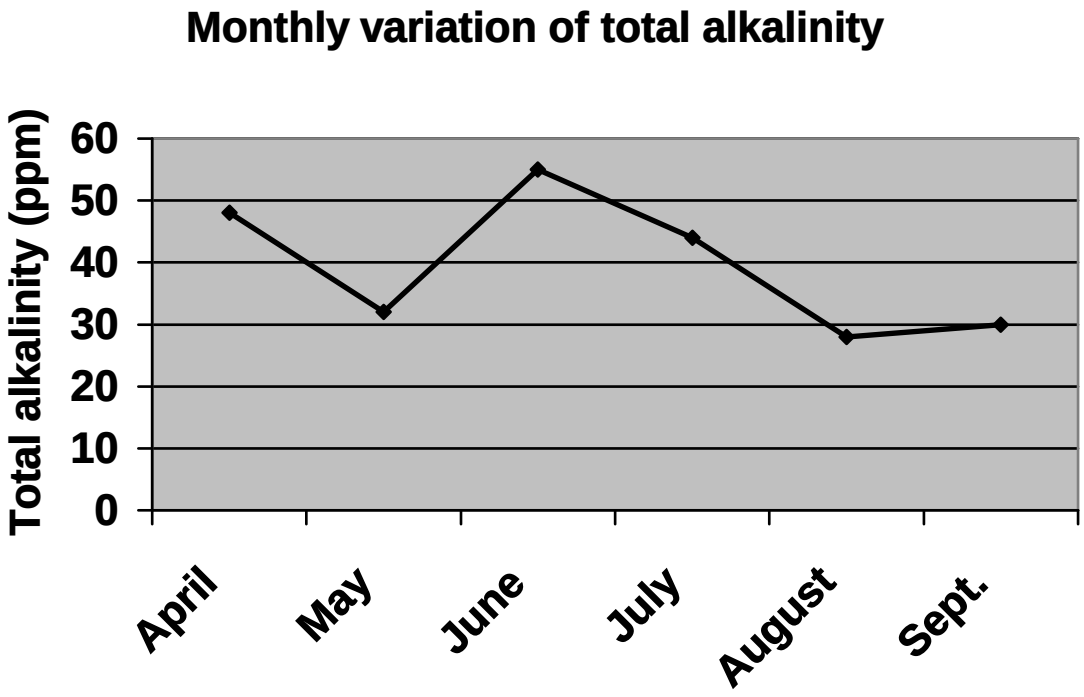

Fig. 6. Monthly variation of Total Alkalinity.

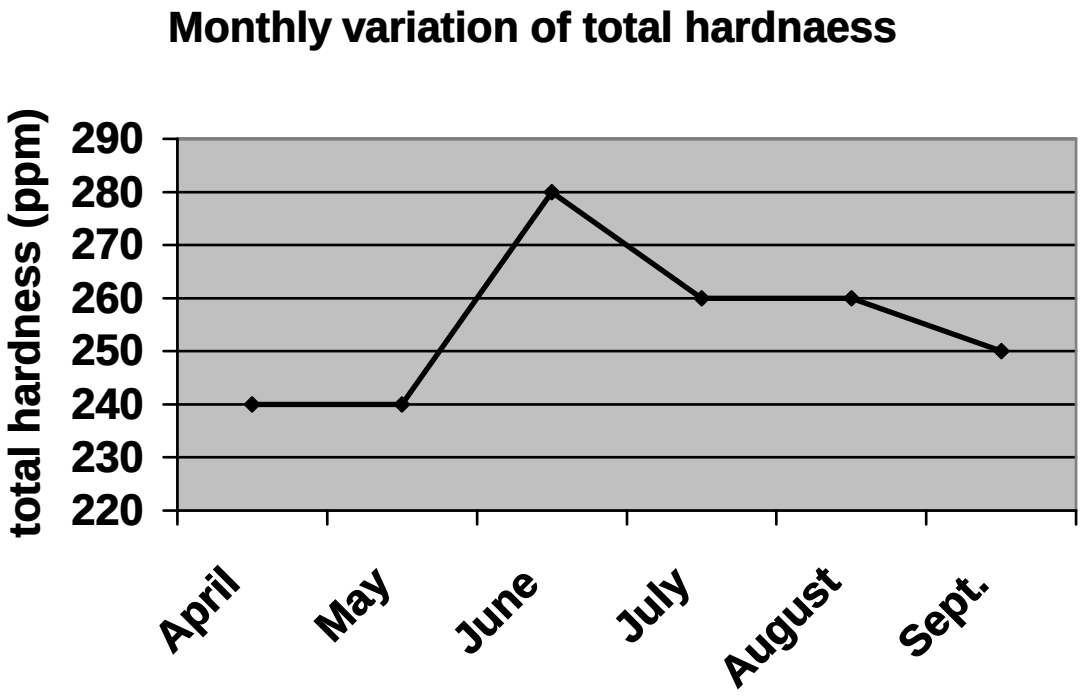

Fig. 7. Monthly variation of Total Hardness.

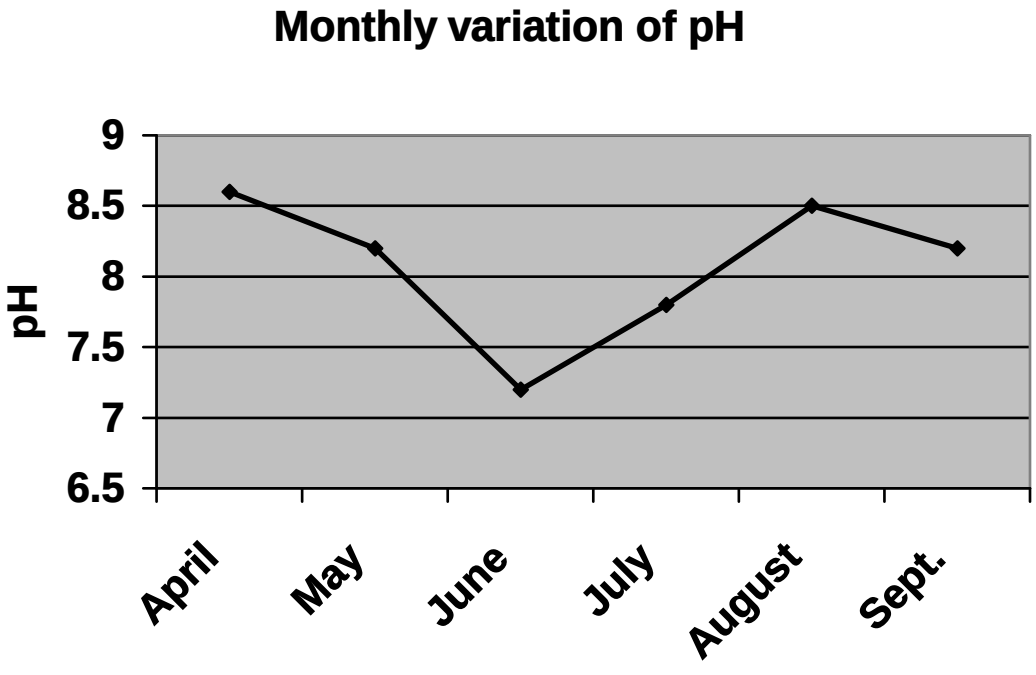

Fig. 8. Monthly variation of pH.

4.3 Releasing of fingerlings in the pond

In the year 2053 B.S., 10,500 carps and 500 colored ornamental fishes had been introduced in the pond. Now fish release is not required as the fish breeds in the pond in breeding season and grows to fingerlings and adults. In the past, seven different fish species had been introduced in the pond. They were: Hile (*Chana*), Singhe (*Heteropneustus)*, Bam (*Mastacembelus*), Asala (*Schizothorax sp.*), Red fish, Yellow fish and Chhir bhire fish.

Now, most of these species have been replaced by cultivable fish species like Common carp (*Cyprinus carpio*), Big head carp (*Arichthystic nobilis*), Grass crap (*Ctenopharygodon idella*) and Silver carp (*Hypothalamichthys molitrix*) and other aquarium fishes in the pond.

Local people do not destroy or kill these fishes of Siddhapokhari. If accidentally killed, one should release golden fish into the pond as a punishment.

4.4 Feeding

Fish depend on the natural food such as planktons found in the pond. The supplementary foods are given to the fish by visitors. These foods include maize ball, soybean, ice bran, bhuja etc. Besides these, noodles, pop corn beaten rice, breads etc are also given to the fish by visitors. About 9.0 kg of foods are given to the fish per day.

4.5 Harvesting time

Bhaktapur municipality is the only one office which takes all the responsibility of Siddhapokhari. The municipality announced the public tender notice to local fishermen for fishing. Such action was taken when there was a deficient of dissolved oxygen and dead fishes were seen on water surface in many numbers. Municipality also provided hooks and net for fishing.

Harvesting had been done at least once every year since 2003. In the year 2003 to 2006, the fishing was done by using hooks only. But in 2007, local fisherman was given permission to use cast net for fish collection from the pond. The collected fishes were sold into the local market.

4.6 Fish production in the pond

In the beginning before the intervention of Municipality Office, the population of fish was low. The fish species were noticed being decreased due to the lack of proper care of pond. The pond was covered with waste products and grasses. The Bhaktapur municipality took an action to clean the pond since last 16 years ago. The wall of the pond was also rebuilt and pond maintained regularly.

The highest number of fishes was collected in 2007 by using cast net in comparison to previous year. In 2007, Rs.467,850 was collected by selling the fish at the rate of Rs.75 per Kg. The lowest collection was recorded in 2006. (Table 2).

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Year	Production of fish (Kg)	Rate/kg (Rs)	Total Revenue (Rs.)	Fishing implements
2003	992.0	65	64,480.0	Hooks (Balchhi)
2004	1552.0	65	100,880.0	Hooks (Balchhi)
2006	945.0	75	70,875.0	Hooks (Ballchhi)
2007	6238.3	75	467,850.0	Cast net

Table 2. Yearly production of fish of siddha pokhari

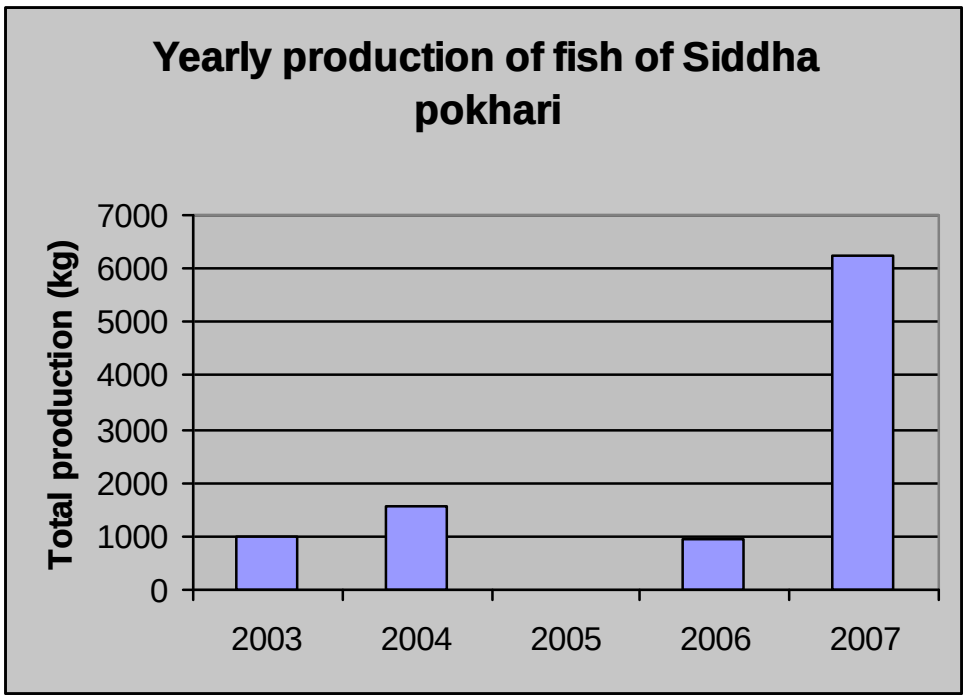

Fig. 9. Yearly catch of fish in Siddha Pokhari.

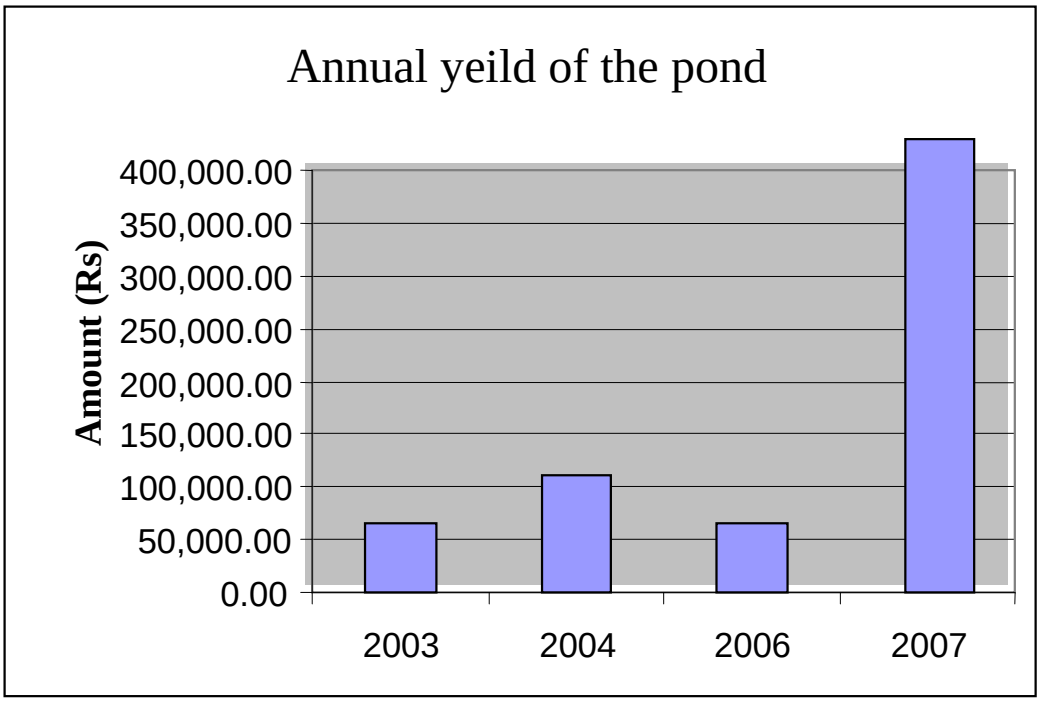

Fig. 10. Annual revenue collection from fish sells in Siddha Pokhari.

4.7 Visitors

Summer season is the best season for the visitors. About 200-250 people visit the pond daily, mostly the young couples were observed in holidays. Foreign tourists also liked to visit the pond. Religious pilgrimages were the daily visitors to pray and pay homage to the gods and goddesses present around the pond.

Lama community from Boudha, Kathmandu visited the pond during their auspicious birthday. They released certain number of fishes specially Singhe to their age. The fair is organized in pond in Indrajatra festival. Large numbers of people gather in the pond during this day.

4.8 Fish Predators

In nature state, many fishes especially hatchlings, fry and to some extent adult fish are preyed by predators. Pond heron (*Ardeola grayii*) locally called as 'Bakula' is a medium sized bird with snow-white feather. It shallows small fish from the size of 8cm to 15 cm long. It is commonly seen in marshes, inundated paddy fields, stagnant ponds and paddles. These herons were observed in the pond usually in the evening. Water ducks were also observed in the pond and they remained around for more than a week. Besides these, snakes, frogs destroyed the fish and fingerlings.

4.9 Management of the pond

The whole, development and the management of the pond is under Bhaktapur municipality. No other private organizations were found involved in the pond management except it. The municipality had recruited security warden to take care of the pond. Application of fertilizers to enhance productivity was not adopted so far in the pond. The pond warden used a small net to remove the suspended wastes thrown by the visitors.

4.10 Legal notice

There is legal notice inscripted over the stone by General Bhimsen Thapa (1881 B.S.) and General Ranouddip Singh (1935 B.S.); in that inscripted no one kill or destroy the fish in the pond, no one shoot out and throw stone over the water ducks. Release of cattle was strickly prohibited in the pond; otherwise, one should pay fine as punishment to Bhadgaun court of Law. This notice played important role in the preservation of ecology and fishes of the pond

4.11 Fish marketing in Bhaktapur city

There is a fish market in Sukuldhoka east to the pond. Carps like Rohu and Catla brought from Janakpur and Mahottari district are sold here. There is one old shop selling different varieties of dry fishes. These fishes are brought from Tadi Chitwan district, trishuli Nuwakot and some are from West Bengal India. These fishes have been preserved by smoking and sun drying. Traditionally, these fishes are very important for newar community people. They used the fish as a symbol of luck (sagun). In different auspicious occasions like wedding, birthday etc and important festivals, fishes are used to make curry and pickles. Boudhist Lama needed fish for their auspicious occasions. The fishes like hile, sidre, prawn, rohu etc are found in the shop.

CHAPTER- FIVE

5.0 Discussion

Liquid water covers about three quarters of the earth's surface either as ocean or as fresh water. The aquatic ecosystems are historically the source of life on earth. It is the medium within which all aspects of ecosystem coexist, both living and non-living, it is the source of all nutrients for aquatic life, including the gaseous nutrients such as oxygen, carbon-dioxide; it is the medium by which organic and inorganic wastes and sediments are distributed throughout the ecosystem. Pond biota contains plant and animal community which occupy the various zone of it and affects the productivity of the pond. The quantity and quality of the biota are determined by the combining effect of physicochemical parameters brought about by the changes in the seasons. These factors may be favorable or unfavorable for the growth, development, production and distribution of biotic community.

The Siddhapokhari pond is famous from the point of view of mythology, historical and cultural aspects. The present investigation represents a comprehensive effort to understand the status of the pond. The physicochemical parameters of Siddhapokhari, cultural, mythological and economic status observed in the pond during study period are discussed below.

5.1 Physicochemical Parameters

Color

The colour of water throughout the study period was clear and did not vary much.

Depth

Depth of the pond is an important physical parameter which influences the physical, chemical and biological properties of water. When the pond is shallow, the penetration of sunlight up to the bottom and increases the productivity by photosynthesis. If the water is too deep, the bottom layers will be cold and less productive. If the water is too shallow, water gets heated up during summer affecting the survival of fish. The depth of water in the pond varied from month to month and varied from low to high at the sampling station. The average depth of the pond was recorded as 103.90 cm with maximum depth was recorded as 125.3 cm during rainy season due to inflow of rain water from adjoining areas. The lowest depth was recorded in dry summer day as 90.0 cm due to the least rainfall and higher rate of evaporation. Khanna (1992) considered two meters deep ponds are consider good for maximum production.

Temperature

Temperature is considered as one of the most important limiting factor for an aquatic ecosystem. All metabolic, physiological activities, reproduction, movement, and distribution of aquatic organism are greatly influenced by water temperature and every organism has well defined limit of temperature tolerance. Caron et.al. (1986) reported that all the vital activities of organisms increased with increasing temperature. In the present study, the air and the water temperature ranged from 21.4^{o}C to 28^{o}C and 19.8^{o}C to 26^{o}C respectively. Air temperature influences the surface temperature of water. The water temperature also affects the chemical parameters of the water. The oxygen content of the water in general decreases with rise in temperature. In other words, temperature had direct but inverse effect on dissolved oxygen

(DO), which was also supported by Upadhyaya(1991), Mandal(1992) and Bhattarai(1996).

Transparency

Transparency is a very important physical parameter which directly or indirectly determines the productivity through the creation of turbidity which is caused by silting, micro or macro organisms and suspended organic matters in the water. During the study period, the transparency of pond ranged from 12 to45 cm with an average of 25.28 cm.

Banerjee, Roy and Chaudhary (1961) studied the physico-chemical parameters of Chilka Lake and reported that during monsoon lower transparency was observed due to the entry of silt and silt laden rain water and probably due to the rise of phytoplanktonic density of water. The present study is also agreed with this view. The variation in transparency of present pond water may be due to calm and clean condition, mud as well as suspended solid materials. Thus it is observed that transparency is inversely proportional to the turbidity of water which in turn is directly proportional to the amount of suspended organic and inorganic matters.

Hydrogen ion concentration (pH)

Pond water may be alkaline, acidic or neutral and is an important environmental factor influencing the species and metabolism of all animals and plants inhabiting in the water. The pH of water is not a constant factor and varies in relation to chemicals present in water. During the study period, the pH of water in the pond show little fluctuation. pH ranged from 7.2 to 8.6 with an

average value of 8.08. Shah (1994), Kumar(1994), Shrestha (1999) and Shrestha (2004) also found similar pH value in their studies. Ellis (1973) reported that pH value range from 6.5 to 9.0 is the most suitable for fish culture. Carpenter (1928) found that animal life is rich in the water of slight alkalinity.

Dissolved Oxygen (DO)

DO is the most important for the animal life in the pond. It is available to the water by absorption from the atmosphere and by photosynthesis of plants. During daytime, plants consume CO_2 and release O_2, while at night, they consume oxygen and release CO_2 through respiration. A balance of O_2 and CO_2 is maintained in the pond water through above process. Ellis (1937) reported that the DO in water must be 5ppm at 20^oC for the maintenance of aquatic life. In my investigation, DO content was 5ppm at 26^oC and average value of DO is 7.7 ppm.

Free Carbon-dioxide

The free carbon-dioxide in water is an important constituent for photosynthetic activities of producers. CO_2 dissolved in water as a result of respiration, decomposition and direct diffusion from atmosphere form carbonic acid (H_2CO_3) in water which affects the pH of water. Free CO_2 inversely correlated with DO. It means when DO is maximum CO_2 will be less and vice-versa. The present study shows an inverse relation with DO. The average value of CO_2 recorded as 4.72 ppm. Shah (1994) recorded average value of Free CO_2 16ppm in Kirtipur village pond. Bhattarai (1996) investigated the average value of CO_2 of Kamal Pokhari as 3.0 ppm.

Total alkalinity

In the present investigation the value of total alkalinity was found ranging from 28.0 ppm to 55.0 ppm with an average value of 39.5ppm. A water body with 41.0 - 91.0 ppm of total alkalinity has a medium to high productivity (Bennett, 1970). Similarly, Cole (1975) quoted alkalinities of 51-67ppm as an indicator of very productive water. Present investigation records of total alkalinity showed that the pond productive for fish.

Total hardness

Hardness in principle is the total soluble salts of Calcium and Magnesium in water. In most natural water, the predominant ions are those of bicarbonates associated mainly with calcium to lesser degree with magnesium all still less with sodium and potassium. In the present study, the total hardness ranged from 240.0 - 280.0 ppm with an average value of 255.0 ppm. According to Swingle (1967), water having hardness of 15.0 ppm or above considered suitable for proper growth of fish; while the value less than 5.0 ppm might cause slow growth and eventual death of fish.

5.2 Fish species, production, and management

In the past, seven different fish species had been introduced in the pond. They were: Hile (*Chana*), Singhe (*Hetropneustus*), Bam (*Mastacembelus*), Asala (*Schizothorax sp.*), Red fish, Yellow fish and Chhir bhire fish. In the year 2053 B.S., 10,500 carps and 500 colored ornamental fishes had been introduced in the pond. The pond is now-a-days dominated by the exotic carps. These carps include Common carp, bigheaded carp, Silver carp and Grass carp. Lama community from Boudha, Kathmandu visited the pond during their auspicious

birthday. They released certain number of fishes specially Singhe to their age. Local people do not destroy or kill these fishes of Siddhapokhari. If accidentally killed, one should release golden fish into the pond as a punishment.

Fish depend on the natural food such as planktons found in the pond. The supplementary foods are given to the fish by visitors like maize ball, soybean, ice bran, bhuja etc. About 200-250 people visit the pond daily, mostly the young couples were observed in holidays. Foreign tourists also liked to visit the pond. Religious pilgrimages were the daily visitors to pray and pay homage to the gods and goddesses present around the pond. About 9.0 kg of foods are given to the fish per day.

Bhaktapur municipality is the only one office which takes all the responsibility of development and the management of the pond since last 16 years. The Bhaktapur municipality had employed a security guard or pond warden who regularly cleans suspended wastes thrown by the visitors and take care of it. The wall of the pond was also rebuilt and pond maintained regularly. The highest number of fishes was collected in 2007 by using cast net in comparison to previous year. The municipality announced the public tender notice to local fishermen for fishing. Such action was taken when there was a deficient of dissolved oxygen and died fishes were seen on water surface in many number. Harvesting had been done at least once every year since 2003. The collected fishes were sold into the local market.

There is legal notice inscripted over the stone by General Bhimsen Thapa (1881 B.S.) and General Ranouddip Singh (1935 B.S.) prohibiting kill or destroy the fish and other animals like water ducks in the pond. Release of cattle was strickly prohibited in the pond; otherwise, one should pay fine as punishment to Bhadgaun court of Law.

CHAPTER- SIX

6.0 Conclusion and Recommendation

6.1 Conclusion

Bhaktapur is the most beautiful ancient historical city due to beautiful artistic ponds and stone taps as well as for the traditional culture and costumes. Siddhapokhari is one of the oldest historical ponds of Bhaktapur. Most of the country has used these natural ponds and lakes for recreational activities but in our country these ponds play very important role in different cultural and religious occasions. Many ponds have been lost or converted into grounds and gardens due to the lack of proper preservation and management. So fish farming in the pond is one of the ideas to make the pond lively. It plays vital role in the bio-geo-chemical cycles of the pond.

6.2 Suggestions

The main purpose of the present investigation is to know whether the pond is suitable to support the fish culture practices or not. It is found that pond is quite good for successful fish farming. Siddhapokhari is the symbol of beauty, attraction and pride. So, the preservation of this beauty is basic of present day. Hence, attention should be paid by government as well as other local responsible authorities. Few suggestions are recommended for the improvement of the pond as follows:

1) Requirement of awareness to local people for its preservation.
2) The physico-chemical and biological parameters should be studied regularly for certain period of a year.
3) For better production, proper maintenance of the ponds and nutritional conditions of the pond should be studied regularly.

4) Study of soil analysis time to time should be conducted.

5) Boundary walls and bank of pond should be maintained regularly.

6) Removal of wastes and weeds on the surface of the pond should be done regularly.

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