CHAPTER ONE

1.0 Introduction

1.1 General Background

Nepal is a Himalayan country blessed by nature with vast water resources in the forms of snow-fed rivers, torrential hill streams and placid lakes. Nepal is a noble gorgeous land, paradise for nature lover, a heritage of vast culture diversity with unparallel potential for hydropower.

There are three main topographical regions in Nepal such as Himalaya, Hill and Terai region. The Himalayan region comprises 15% of the country total land surface. The Hill comprises 68% of the Nepal's land area and the Terai comprises 17% fertile land area of the nation. The unique diverse altitude and topography has developed different climates from subtropical climate in Terai, temperate in Hill to alpine climates in the Himalayan region.

1.1.1Water Resources

Nepal is rich in fresh water resources of two types - Lotic (running water) i.e. rivers and streams and Lentic (standing water) i.e. ponds, lakes, swamps etc. Water resources occupy approximately 1.5% of the total land of Nepal. Water resource of Nepal is regarded 'White Gold' in the view of vast potential for hydropower generation and irrigation.

Rivers

There are more than 6,000 rivers. The total length of rivers is about 45000 km and the total annual run off is about $1.7\times10^{10}m^3$. Depending on the sources of water in dry reasons, the rivers of Nepal are classified into three different types. The first type includes the snow and glacier fed rivers originated in the Himalayan region. The second type include the rivers with rain water, springs and underground water as a source like Bagmati, the Rapti, the Kankai, the Mechi, the Kamala and the Babai etc. originating from Mahabharat range below the snowline. Hence, they do not dry up during the low flow period and are good for hydropower and irrigation purpose. The third type rivers are Sirsia, Manuswara, Hardinath etc. originating from Siwalik or Churia range. They are not suitable for perennial hydropower generation and irrigation purposes because they dry up during the low flow seasons. In Nepal, there are three major river systems such as:

Koshi River system

From the point of view of drainage area, the Koshi is the largest river system in Nepal approximately 960km (720 miles) long. It is regarded as big as the Indus and the Brahmaputra rivers of India. It flows in the eastern part of Nepal, east of Gosainthan and west of Kanchanjunga areas. It has seven different tributaries: Sunkoshi, Indrawati, Tama Koshi, Likhu, Dudha Koshi, Arun and Tamar. Arun is the largest tributary while Likhu smallest tributary of the Koshi river system.

Gandaki River System

It originates from the Muktinath area and flows between Dhaulagiri and Gosainthan. It flows through the Churia hill at Tribenighat and passes in the plains forming the Narayani River. It is approximately 338 km (210 miles) long and has seven tributaries: Kali Gandaki, Burhi Gandaki, Seti, Madi, Marsyangdi, Trisuli and Myagdi (Daraudi). Kali Gandaki is the largest and Daraudi the smallest tributaries of the Gandaki River System.

The Karnali System

The Karnali originates in the Tibetan region of China near Limpiya Dhura pass between India and Tibet. It flows south through the Tibetan Plateau and enters Nepal through a gorge in Lipa Lekh. It is the major river system of the Western Nepal which is 507 km (315 miles) long. It has seven tributaries: Burhi Ganga, Humla Karnali, Mugu Karnali, Sani Bheri, Thuli Bheri, Seti and Tila.

Lakes, Reservoirs and Ponds

Lakes

Lakes are natural water reservoirs and Nepal consists of 660 lakes 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 altitutde plain of about 60m to more than five thousand meter altitude (Jonnes et.al. 1989, Lami and Giussani 1998, Gurung and Wagle 2000). The lakes above 3300m are not affected by human encroachment while that of foot hills are affected by human activities.

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 or Rupakot Lake. Some of the minor lakes are - Khaptad Lake, Baragon Lake, Tilicho Lake, Phoksundo Lake, Dudhpokhari Lake, Jageswar Lake, Panch Pokhari, etc.

Reservoirs

Reservoirs are built to collect water to generate hydropower and irrigation. 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. Jagdishpur reservoir (155ha) is a man made impoundment formed by damming Budhi Ganga River in the plain area for irrigation. Among the existing reservoirs, the Indrasarobar reservoir (220ha) is impounded for producing hydroelectric power by damming Kulekhani River in the mid hill of Nepal. Other small reservoirs developed from run off scheme are Trisuli (16 ha.), Marsyangdi (62 ha.), Panauti and Sunkoshi. The potential for expansion of reservoir is very high in future and estimated to be 92,400 ha.

Ponds

Pond is a small shallow body of water and according to the purpose of construction and location, ponds may be classified as village pond, temple pond, homestead pond, fish pond, sewage pond etc. Among them, many village ponds (6,500 ha) are dug in the Terai region for fish culture. It is estimated that some 500,000 ha of water surface will be available for fish production in future, of which approximately 1,00000 ha would be lakes, reservoirs and ponds (NARC, 1991).

Table 1. Estimated Water Surface Area in Nepal

S.N.	Resources	Estimated area (ha.)	Coverage (%)
1.	Natural waters	401,500	49.05
	Rivers	395,000	48.26
	Lakes	5,000	0.61
	Reservoirs	1,500	0.18
2.	Village Pond	6,500	0.79
3.	Marginal swamps/Irrigated field	12,500	1.53
4.	Irrigated Paddy fields	398,000	48.62
	Total	818,500	99.99

Source: FDD, 1996

1.1.2 Aquaculture

Aquaculture is the farming or husbandry of economically important aquatic animals and plant under control condition. Aquaculture will help to integrate rural development by generating employment opportunities for many unemployed country. Aquaculture in ponds seemed to have emerged as the most popular and viable activity in the overall aquaculture development endeavour in the Asian region, particularly in poor country like Nepal where people are undernourished.

Aquaculture has a relatively recent history in Nepal. It began only in 1945 with the imports of fish fingerlings of *Labeo rohita, Catla Catla* and *Cirrhinus mrigala* from India. Plankton is normally abundant in ponds so it is very important to include a plankton feeding fish in a polyculture system. Above group of fishes feed on the tiny, free floating plants (phytoplankton) and animals (zooplankton) which multiply abundantly in fertilized ponds. Two fishes typical of this group are exotic silver carp (*Hypophthalmichthys molitrix*) and bighead carp (*Aristichthys nobilis*). The silver carp was introduced in Nepal in 1965/1966 and 1967/68 from India and from Japan in 1967/68. The Bighead carp was introduced in Nepal in 1971 from Hungary. Grass carp (*Ctenopharyngodon idella*) is a typical herbivorous fish, feeding voraciously on aquatic vegetation and grasses. This fish had been reported to consume 40-70% of its own body weight of grass/day (Jhingran, 1985). The undigested food defecated through the gut would act as an efficient green fertilizer. This fish has a very advantageous quality and helpful in the control of undesirable water plants and serving as a manuring machine.

Common carp (*Cyprinus carpio*) is the most important cultivated fish in the world and it is an omnivorous fish and it is a bottom feeding upon insect larvae, worms and decaying organic matter. It grows very fast on artificial feed. In mid 50's, common carp was introduced in Nepal from India and Israel; however, reintroduced in 1960s and in the beginning of the 1980s. Various exotic fish species imported from abroad and some indigenous carps were incorporated in polyculture fish farming. At present, seven commercially valuable carp species are bred and cultured in the country. These include the three indigenous species rohu (*Labeo rohita*), naini (*Cirrhinus mrigala*) and bhakur (*Catla*

catla). The remaining four are exotic species; common carp, silver carp, bighead carp and grass carp. Few commercially important species such as catfish (*Clarias gariepinus*), tilapia and trout had been introduced recently.

Due to the people's age-old traditional experiences in fish production and willingness to take up pond aquaculture as an important production activity, His Majesty's Government laid down policy directives to implement pond aquaculture in Terai as priority program towards steady expansion and development of this sub sector in the country. His Majesty's government executed an investment project exclusively for pond aquaculture development in Terai with financial assistance from the Asian Development Bank and the technical assistance from the United Nations Development Program during 1980. The project was implemented in two Phases - Aquaculture Development Project 1st and 2nd. This Project supported in the strengthening of fisheries institutional facilities, extension and service delivery, sub-loan facilities etc. The Project covered 21 districts of Terai in two phases of its implementation over a decade in the country. The projects were successful in the performance of pond aquaculture production and exploring a potential area to draw increased attention. Aquaculture practices like cage and pen/enclosures in lakes and reservoirs are popular and successful activities in the country. These activities were initially supported by FAO/UNDP and IDRC Canada. These activities could not be expanded much due to technical and environmental limitations but considered to be as an important part of the aquaculture industry even today in the country.

Aquaculture production was estimated to be about 750 metric tons in 1981/1982 and reached 4939 metric tons in 1986/87. This increase in fish production clearly shows an increase of over 6 times within five years during the Aquaculture Development Project Phases. The trend of fish production was continued to increase thereafter.

Types of different Aquaculture Systems

I. Complete fish farming: The complete fish farming means the production of eggs to full size fishes, which may be utilized as food, market sale or brood stocks.

II. Restricted fish farming: This type of fish culture is restricted to one or more stages of fish growth i.e. fish seeds (hatchery), fry or fingerlings (nursery) or grow out fish production in fish farm.

III. Extensive fish farming: In extensive farming, fishes are cultivated on the natural food available in the pond and their productivity corresponds to natural productivity.

IV. Semi-intensive fish farming is a transitional phase between extensive and intensive fish farming; where fish production is based upon both natural feeds and supplementary artificial feeds.

V. Intensive farming: In intensive farming, fishes are cultivated based totally on the artificial feeding. So that, maximum quantity of fish is produced in a minimum water body area.

VI. Monoculture: Monoculture is the cultivation of only a single fish species in a pond. Monoculture is useful to culture some predatory fishes like *Wallago attu, Channa spp* etc. In Monoculture, the production is less than polyculture because other food items that exist in biological chain of pond are not utilized by fish.

VII. Polyculture: The culture of different species of non-compatible fishes in a pond to utilize all the food items is called polyculutre. This type of practice was first introduced in China. The production will be greater than the monoculture. It is also called composite fish culture or mixed farming method.

VIII. Monosex Culture: The culture of only one sex of fish species is called monosex culture. Here, only the male or female individuals are stocked together and all the energy of fish goes into growth but not in reproduction. *Tilapia* are often used for monosex culture because they are prolific breeder and attain sexual maturity at small size when crowded.

IX. Sewage fed fish culture: Oxidized sewage water from the sewage oxidation ponds is rich in both the organic and inorganic water. It is added in desired quantities to the fish pond to increase their productivity.

X. Culture of air breathing fishes: Air breathing fish can be easily cultured in polluted water where the oxygen content is low. So that, unusual water bodies may be brought under cultivation. The common species suitable for such type of culture includes *Clarias batrachus*, *Channa* spp., *Heteropneustes fossilis* etc.

XI. Integrated fish farming: The integration of fish farming with other agricultural activities, for the maximum production of agricultural products per unit area, is known as integrated fish farming. In this type of farming, one type of disciplinary is dependent with the other type and the wastages of one type are utilized by other and thus both are mutually benefited.

Integrated fish farming is done by the following methods:

a. Fish farming with agriculture

b. Fish farming with livestock

XII. Cage culture: Cages are made up of nylon net or wire gauge and are used to culture the fishes by keeping them under the water. This practice is known as cage fish culture. It was started for the first time in Japan in 1051 A.D. But now it has became very popular throughout the world. Cage culture was practiced in Nepal for the first time in Phewa Lake in 1971.

XIII. Pen culture: Culture of fishes in a water body, where all the sides have natural barriers like small mountains and one open side being closed by the nylon net is called fish culture in enclosure or pen culture. It was first started in European countries. In Nepal, it was first started in Pokhara Valley in 2041 B.S. in three lakes, Phewa, Rupa and Begnas with 32 enclosures.

XIV. Raceway system: Raceway system is an artificially made run way system of fresh water to create the natural environment of aquatic ecosystem under controlled condition. The main purpose of raceway system is to culture highly sensitive cold water species such as trout fish. In Nepal, raceway systems have been developed in two places, first in Trishuli and second in Godawari. Here, the raceway system is used for growing fries and culturing adult trouts. The main objective of raceway system is to culture maximum trouts in minimum water body.

1.1.3 Present Status of Fish Production

The total fish production in Nepal is about 45,425.0 mton; in which the capture fishery contributed about 20,016.0 mton and the fish production from aquaculture is about 25,409.0 mton. Out of total aquaculture production, the contribution of pond aquaculture is nearly 90.0%. Other aquaculture activities like paddy fish culture, fish culture in gholes, enclosure fish culture, cage fish culture (m^2) and fish production in public sector contributed slightly higher than 10.0% of total national aquaculture production (Table 2).

Table 2 (A, B, C &D). Average production from aquaculture and fisheries in Nepal.

Total Fish Production

Particulars	Fish Production (mton)
Country Status - Total Fish Production	45,425.00
1. **Aquaculture**	25,409.00
Pond Fish Culture	22,545.00.
Other aquaculture activities	2,864.00
2. **Capture Fisheries**	20,016.00

B. Capture Fisheries

Particulars	Estimated	
	Area Coverage (ha.)	Fish Production (Mt.)
Total		20,016.00
Rivers	395,000	6,992.00
Lakes	5,000	800.00
Reservoirs	1,500	363.00
Irrigated Paddy Field	398,000	6,885.00
Marginal/Swamps/Gholes, etc.	11,100	4,976.00

C. Aquaculture (Pond Fish Culture).

Particulars	Total Ponds (no.)	Total WSA (ha.)	Fish Production (mton)
Total	22,980	6,337.00	22,545.00
Mountain	40	3.00	4.00
Hill	1332	164.00	284.00
Terai	22,021	6,170.00	22,257.00

WSA - Water Surface Area.

D. Other Aquaculture Activities

Particulars	Estimated	
	Area Coverage (ha.)	**Fish Production (Mt.)**
Total		2,564.00
Paddy Fish Culture	300	120.00
Fish Culture in Gholes	1,612	2,096.00
Enclosure Fish Culture	100	140.00
Cage Fish Culture (m^2)	80,000	480.00
Fish Production in Public Sector		26.00

1.1.4 Present status of Pond Fisheries

Aquaculture and fishery is an important sector of agriculture. So it is very essential to utilize the natural water resources for production of animal protein to cope with the nation's high population pressure. The aquaculture has become one of the important cash crops because of the high economic return obtained from it. At present aquaculture contributes about 1.5% of AGDP of the country and 0.5% of National GDP. Fish consumption per capita, however, is only 1.8 kg. Pond aquaculture contributes over 50% of total fish production and about 90.0% of aquaculture production in Nepal. Pond fishery is an important aspect of aquaculture in Terai region of Nepal due to the availability of numerous natural and artificial ponds. Pond aquaculture of carps is a popular activity in the central and eastern Terai in comparison to other parts. The production rate of fish depends on the fish farming practice adopted by fish culturists.

1.1.5 Limitation of the Study

The present study has following limitations:

- The study covered/considered in only one pond of Madhesha V.D.C. of Sunsari district
- Financial constraints and time limitation (six months) to carry out extensive study.

CHAPTER TWO

2.0 Objectives of the Study

The main objectives of the present study work are:

- To study water quality parameters in the fish pond.
- To assess the growth and survival rates of fishes in the pond under study.
- To recommend the farmer with new technical package to intensify production of carp fishes

CHAPTER THREE

3.0 Literature Review

Nepal is rich in inland water resources due to the devoid of sea in Nepal. The study of fresh water system is called as "Limnology". 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 deep investigation in Lake Lacleman. 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 of aquatic system have been termed as Forelian Limnology. Forel (1904) published a book called "Science of Lake". In the beginning of 19th century, the study of lentic and lotic habitats was started. 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 world by different scientists and authors.

Baldi (1849), a prominent Italian limnologist set limnology apart from other disciplines by defining it as the science dealing with inter relations of process and methods where by matter and energy are transferred within a lake. Forbes (1887) described lake as a "Microcosm" a little world within itself. Theinemann (1925) was associated with the limnological studies, particularly those relating to the classification of lakes based on oxygen concentration and the midge species, *Chironomus* of bottom mud. Hora (1930) studied ecology, bionomics and evolution of the torrential fish fauna. In India, Pruthi (1933) studied the seasonal variation in the physical and chemical conditions in the tank of museum. Hutchinson (1937) made certain limnological studies in Tibet. Philipose (1940) studied ecology and seasonal succession in permanent pool at Madras city. Ganapati (1941- 43) made divergent limnological investigations on fresh water ponds of Madras city. Chacko and Krishnamurthy (1954) worked on ecology of planktons of three fresh water ponds of Madras city.

Das and Moitra (1955) worked on the feeding ecology of some common fishes of Uttar Pradesh and classified them into surface mud and bottom feeders. Das and Srivastava (1956) studied on plankton from fresh water ponds and tanks of Lucknow. Singh (1956) noted some limnological relations of Indian inland water with special reference to the algal blooms. George (1961) reported on diurnal variation in two shallow ponds in Delhi (India). Limnological studies of tropical impoundment and planktons of Bhavani Sagar Reservoir of Madras state (India) was carried out by Sreenivasan (1964). Benerjee (1976) reported water quality and soil condition of fish ponds in some states of India in relation to fish production. Bhawmik (1968) studied the seasonal cycles of rotifers in fresh water fish pond Kalyani, West Bengal. Nayar (1970) worked on rotifer populations of two ponds at Pilani, Rajasthan. Saha et al (1971) studied on the seasonal and diurnal variations in the physico-chemical and biological conditions of a perennial fresh water pond. Zutshi and Vass (1972**)** noted limnology of high altitude Kashmir Lake. Verma (1973) studied the diurnal variation in fish pond in Seoni India. Shreenivasan et al, (1974**)** found large number of physico-chemical condition in reference to biological factors in most of Indian lakes biotypes. Kant and Kachroo (1975) recorded the diurnal changes in the temperature and P^H of water and diurnal movement of planktons in Dal lake of Srinagar. Sreenivasan (1976) studied the limnology and fisheries of Timoorthy reservoir, Tamilandu. Nasar (1977) worked on diurnal variations in physicochemical factors in a pond in Bhagalpur, (Bihar) India. Sharma (1980) studied on plankton and productivity of water bodies of Rajasthan. Kaul and Raina (1982) studied on production and ecology of some macrophytes of Kashmir lake. Sharma and Durve (1985) focused on trophic status of fishery of Rajasthan water.

Malhotra and Jhingran (1986) evaluated limnological characteristic and trophic status of Gulariya reservoir. Rao (1987) worked on synecology of Lake Gangasagar in relation to limnology and eutrophication. Verma and Munshi (1987) studied on the plankton community structure of Badva reservoir, Bhagalpur (Bihar). Karki (1988) studied on some limnological aspect of selected close water ecosystem of Udaipur (Rajasthan). Ravichandran and Ramanibhai (1988) pointed plankton and related parameters of Buckingham canal Madras. Rao and Shrivastava (1989) studied on biological monitoring of water quality in Chambal and Khan rivers of Central India. Pandey *et al.* (1992) studied the limnological status of an ancient temple pond of Deogarh, Bihar. Sen, *et al.* (1992)

studied the physico-chemistry, nutrient budget and the factor influencing primary production of a tropical lake at Ranchi. Srivastava, *et al.* (1995) did observation of algal flora in reflection to industrial pollution of Rapti river at Gorakhpur

Mehata (1980) worked on abundance and biomass of freshwater zoobenthos in the two ponds of Godavari fish farm. Mahaseth (1988) reported the physico-chemical parameters of Tadi Rivers in relation to fish production and management.

The literatures on biological aspects and fish fauna of aquatic systems are very few in Nepal in spite of huge water resources. The credit of first scientific report on fish fauna of Nepal goes to Francis Buchanan (later Hamilton) 1822 in Koshi and Rapti Rivers. The first limnological work in Nepal was conducted by Brehm (1953) and the work was about aquatic fauna from Kalipokhari located at eastern Nepal. Hirino (1955**)** had published few papers concerning Nepalese algae. The first limnological investigation in high mountain lakes of Khumbu Himal was initiated by Loffler (1969A.D.) in Nepal. Hickel (1973) investigated the lakes of Pokhara valley during Nepal Himalayan Expedition.

Ferro and Swar (1976 and 78) recorded bio- limnological condition of lakes in Pokhara valley and the study was about fish population, their feeding habit and biology. Pradhan (1982) reported a species of *Schizothorax* in Syarpu Daha which is a mid hill lake of western region located at the altitude of 1372m. Rai (1983) did a preliminary study of Phewa lake of Pokhara. Terashima (1984) had reported three new species of cyprinid of the genus, Schizothoraichthys from the Lake Rara located in the North-Western Nepal. According to him these species are endemic to Lake Rara. Pradhan and Swar (1987) reported *Acrossocheilus hexagonolepis* (katle), *Puntius chilinoids* (karange), *Tor tor* and *Schizothorax* (asala) from Indrasarobar Reservoir. Auzaki et al., (1987) studied trophic status of Tilitso, a high altitude Himalayan Lake. Shrestha (1992) studied about fishery ecology in the flood plain of the Koshi River. Yadav (1994) worked on the water quality and benthic fauna of the feeding river, Palung, Chalchn, Thudo and Chitlang of the Kulekhani reservoirs. Gautam (2003) studied on the fish diversity and reported 23 species of fishes in Lake Rupa, Kaski.

In Nepal, bighead and silver carp are popular for cage culture and rohu (*labeo rohita*) is also stocked as biological cleaning agent in cage fish culture (Sharma, 1979). Rai and Yamazaki (1995) discussed on “Aquaculture practices in lakes such as Phewa, Begnas and Rupa in Pokhara valley”. Pradhan and Pantha (1995) had reported that fish production removes 272 kg of phosphorus and 2048 kg of nitrogen from lake Phewa. Extensive cage culture using planktivorous fish like bighead and silver carp in lakes and reservoir were beneficial with quick return of investment than most of other agricultural practices. But one fisherman family needs at least 5 cages of 250 m^3 for sustenance (Swar and Pradhan 1992). Sharma (1990) had reported cage culture of carps in the lakes of Pokhara valley was feasible with net benefit of Rs. 31.2/ m^3.

The technology package of cage fish culture for fish farmers is one of the cheapest methods of fish rearing in Nepal. Extensive cage fish culture is suitable enterprise for poor low income small farmers of Nepal because they cannot afford supplementary feeding.

CHAPTER FOUR

4.0 Materials and Methods

4.1 Study Site

The study area lies in the Madhesha VDC of Sunsari district. The Sunsari district lies in the Eastern Development Region of Nepal. Madhesha VDC is located between 87^o9'45" to 87^o12'40" longitude and 26^o36'15" to 26^o39'15" latitude (Central Bureau of Statistics, 2002). The total population is 5,614 of which 2,954 are males and 2,660 are females (Central Bureau of Statistics, 2002). Madhesha VDC is dominated by Brahman, followed by Cheetri, Tharu, Newar, Chamar etc. Tharu and chamar partially depend on Capture fisheries as an income generator during rainy season.

There are about 14 ponds in Madhesha VDC and all are used for fish culture. About 9 ponds are used as intensive fish farming and remaining 5 ponds as semi-intensive fish farming. This study pond is located at ward no.1 with an area about 800 m^2 (40m ×20m).

4.2 Materials

The materials (equipment) and chemicals needed for the present study were as follows:

A. Glass wares

- Conical flasks, Pipettes, Beakers, Petridish, Test tubes, BOD bottles, Measuring Cylinders, Volumetric flasks, Burette, Dropper, Glass rods and Standard Mercury Thermometer

B. Laboratory Instrument

- P^H meter and Weighing balance

C. Other requirements

- Burette stands, Secchi's disc, Measuring tape etc.

D. Chemicals

The chemicals needed were dissolved in double distilled water to make different kinds of solutions as follows:

(a) Winkler 'A' Solutions or $MnSO_4$ Solution

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

(b) Winkler 'B' Solution or Alkaline Iodine Solution

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

(c) Sodium Thiosulphate Solution (0.015N)

6.3 grams 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.

(d) Standard Sodium Carbonate Solution (0.045N)

0.602 gram of anhydrous Na2CO3 was weighed and dissolved in double distilled water. The solution was made to the mark by adding double distilled water. The solution was kept in the bottle and labeled. The solution was freshly prepared one or two days before the sampling data.

(e) 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 of (0.1N). Then 200ml of

$0.1N.H_2SO_4$ was made to 1000ml by adding doubled distilled water. The solution was kept in the reagent bottle and labeled.

(f) E.D.T.A. Solution (0.01N)

3.723 grams of Di-sodium salt of E.D.T.A was weighed and dissolved in double distilled water. The volume of the solution was made upto 1000ml. by adding double distilled water. The solution was kept in the reagent bottle and labeled.

(g) Sodium Hydroxide solution (1N)

40 grams of Sodium hydroxide (NaOH) was weighed and dissolve in double distilled water. The solution was stirred with glass rod for uniform mixing. The volume of the solution was made 1000ml.by adding double distilled water. The solution was kept in the bottle and labeled.

(h) Ammonium buffer solution

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

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

Then the solution (a) and (b) were mixed and poured in the 250ml. volumetric flask. The volume of the solution was made to 250ml. by adding doubled distilled water up to the mark on the flask. The flask was shaken well for uniform mixing of the solution. The solution was kept in the bottle and labeled.

(i) Silver Nitrate solution

3.4 grams 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.

(j) Starch indicator

6 grams 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 1.25 grams of salicylic acid. It was kept in the bottle and labeled.

(k) Phenolphthalein indicator

0.5 grams of phenolphthalein power was weighed and dissolved in 50ml of ethyl alcohol. 50ml. of double distilled water was added. Then 0.5 gram of free sodium hydroxide solution was added till the solution turned faint pink.

(l) Methyl orange indicator

0.5 gram of Methyl orange powder was weighed and dissolved in double distilled water. The mixture was stirred with glass rod. The volume was made to 100ml. by adding double distilled water. The solution was kept in the bottle and labeled.

(m) Potassium chromate indicator:

5 grams of potassium chromate (K_2CrO_4) was weighed and dissolved in double distilled water. The mixture was made to 1000ml. by adding double distilled water. The solution was kept in a bottle and labeled.

(n) Erichrome black -T indicator

0.40 grams of Erichrome black -T and 100 gram of Sodium chloride (NaCl) were weighed and mixed. The mixture was grinded in a mortar. It was then kept in a dry neat and clean bottle. The bottle was then labeled.

(o) Mureoxide indicator

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

4.3 Management Protocol

4.3.1 Prestocking Operation

a. Drying and Ploughing: The pond was dried and ploughed on 1st October for one day and left for three days.
b. Clearing and weeding: The unnecessary vegetations were removed from the pond on 4th October. Otherwise, these vegetations consume the nutrients of the pond, causing O_2 depletion and accumulation of CO_2, hydrogen sulphide and methane that are harmful to fishes and obstruct netting operation.
c. Liming: 40kg of quick lime (CaO) was used on the pond bottom on 5th October & left for three days for disinfection. Liming of pond helps in improving the water quality.
d. Fertilizer: About 160kg of cow dung and 80kg of poultry manure was applied in $800m^2$ pond area (@ 3.0 ton/ha) on 8th October and left for five days.
e. Pond Water Feeding: Pond was filled with water for 1.5m depth on 13th October and left for fifteen days for the growth of phytoplankton and zooplankton.

4.3.2 Chemical Fertilisation

In present study, recommended intensive fish farming fertilizer doses of 220 kg of nitrogen and 345 kg of phosphorus per hectare of pond was followed and applied (Agriculture Diary, 2007, Agriculture Communication Division, Department of Agriculture, Nepal). In 800m2 pond area of present study, about 18.0 kg nitrogen and 28.0 kg phosphorus are required. 160kg cow dung and 80 kg of poultry manure applied in pre-stocking operation contributed only 2.4 kg of Nitrogen and 4.8 kg of phosphorus (@ 1% of Nitrogen and 2% of phosphorus from cow dung and poultry manure) in pond. Remaining 15.6 kg of nitrogen and 23.2 kg of phosphorus was managed by chemical fertilizers like DAP (Diammonium Phosphate) and Urea. Here, 50 kg DAP was applied contributing 23.0 kg of phosphorus and 9.0 kg of nitrogen (@ 46% of phosphorus and 18% of nitrogen in DAP). To cover remaining 6.5 kg of nitrogen required, 14.0 kg of urea applied in study pond (@ 46% of nitrogen in urea).

4.4 Methods

4.4.1 Sampling for physico-chemical parameters

The physico-chemical parameters of the pond were recorded once in two months for a period of six months (Nov. 2006 to April 2007).

4.4.1.1 Physical Parameters

Nature of day

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

Color of water

To know the colour of water a little amount of pond water was taken in a clean petridish and kept over the white paper and then the colour of water was observed by naked eyes.

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 rope under water was measured with the help of the measuring tape. The mean depth of 3 stations was recorded.

Transparency

The Sechhi's disc was used 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). The transparency was measured by lowering the Secchi's disc in water and depth was recorded at which it just disappeared, and just reappeared. Then the 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 co-efficient was calculated with the help of a following standard formula.

$$K = \frac{1.7}{D}$$

Where,

D = Secchi's disc reading

K = Transparency co-efficient and

1.7 = Constant factor.

Water 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.

4.4.1.2 Chemical parameters:

The chemical parameters measured during this study period were pH, DO, CO_2, Hardness and Alkalinity.

pH (Hydrogen ion concentration)

A portable pH meter was used to measure the pH of the water. The pH of water at different sampling stations was taken and mean value was noted down in a field record sheet.

DO (dissolved oxygen)

Dissolved oxygen of the water of study site 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 Winkler's 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:

$$MnSO_4 + 2KOH \rightarrow Mn\,(OH)_2 + K_2SO_4$$

$$2Mn\,(OH)_2 + O_2 \rightarrow MnO\,(OH)_2$$

$$MnO\,(OH)_2 + 2H_2SO_4 + 2Kl \rightarrow MnSO_4 + 3H_2O + I_2$$

In practicing this method it is very important to minimize contact between sample and the atmospheric air. For this the water sample was entrapment of air bubbles. After the sample was allowed to overflow the bottle, 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 WA and WB 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.

At first B.O.D. bottle of capacity 250ml were filled with sample water, then 2ml of $MnSO_4$ and 2ml of KI solution were added respectively through the wall of the B.O.D. bottle, with the help of pipettes, shaked well and allowed to settle down until the ppt. was settled down. After that, few drops of conc. H_2SO_4 was added and shaked well until the ppt was completely disappeared. Then, 50ml of the solution was taken in a conical flask and added four drops of starch indicator and was titrated against the 0.025N sodium thiosulphate solution.

The calculation for dissolved oxygen was made by following formula

$$\text{Dissolved Oxygen (Mg/L)} = \frac{(\text{Vol.} \times \text{Normality}) \text{ of } Na_2S_2O_3 \times 8 \times 1000}{V_2\left(\frac{V_1 - V}{V_1}\right)}$$

Where,

V = Volume of $MnSO_4$ and KI added

V_1 = Volume of sample bottle

V_2 = Volume of content titrated

Free Carbon-dioxide (CO_2)

For the estimation of 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 colour less, it indicates the presence of CO_2. The water sample containing CO_2 was titrated against 0.05N Sodium hydroxide (NaOH) solution till a faint pink coloured end point was observed. The reading noticed in the burette was noted in the field record sheet. The calculation for CO_2 was made by following formula:

$$\text{Free } CO_2 \text{ (Mg/L)} = \frac{(V \times N) \text{ of NaOH} \times 1000 \times 44}{\text{Vol. of Sample taken}} = \text{ppm}$$

Where,

V = Volume of NaOH used

N = Normality of NaOH

Total Alkalinity

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

First of all, 100ml of water sample was taken in a conical flask and few drops of phenolphthalein was added to it. The solution remained colourless indicating that phenolphthalein alkalinity (P_A) was zero i.e. carbonates are absent and total alkalinity with Methyl Orange was only determined. Again 2 - 3 drops of methyl orange as added to the same sample and subjected to titration with standard 0.1N HCl solution till yellow colour changed to pink at the end point. Then, volume of HCl consumed was noted until constant reading obtained.

The calculation for total alkalinity was made by following formula

Total alkalinity (T_A) =
(As $CaCO_3$ mg/l)

$$\frac{(B \times N) \text{ of HCl} \times 1000 \times 50}{\text{Vol. of Sample taken}}$$

Where,

B = Volume of HCl used

N = Normality of HCl

4.4.1.3 Stocking of Fingerlings

Rohu (*labeo rohita*), Bhakur (*Catla catla*), Naini (*Cirrhinus mrigala*), grass carp (*Ctenopharyngodon idella*) and Bighead carp (*Aristichthys nobilis*) were selected for pond culture. They were brought from Fisheries Development Research Center, Tarahara, Sunsari. 2500 fingerlings about 5cm in size (Rohu - 400, Bhakur - 400, Naini - 400, grass carp - 800 and Bighead carp - 500) were introduced in the pond. They were introduced according to their feeding habits as follows:

- Rohu (*Labeo rohita*): It is column feeder and feeds upon algae and decaying vegetation.
- Bhakur (*Catla catla*): It is a surface feeder and feeds on

  Zooplanktons and the organisms floating in the surface.
- Naini (*Cirrhinus mrigala*): It is a bottom feeder and feeds on semi- rooted vegetations and decaying plants and animals matter.
- Grass carp (*Ctenophryngodon idella*): It is a grass eater.
- Bighead carp (*Aristichthys nobilis*): It lives in the middle layer of water and feeds on Zooplanktons by filtering them.

4.4.1.4 Supplementary feeding

Fish production can be increased by artificial feeding. About 3.0 kg of rice bran, oil cake, wheat flour mixture and 0.5 kg selective kitchen wastages were mixed to be supplied in the pond as supplementary feed once in two days. A total 25 kg rice bran, 10kg oil cake, 10 kg wheat flour and about 15kg of selective kitchen wastages were supplied in the pond in a month. For Grass carps, grasses and banana leaves were supplied in a pond once in two days.

4.4.1.5 Growth measurement of fishes

The growth measurement was done once in two months. For this, fishes were collected with the help of a cast net for the measurement of the total length and weight of few fishes from the pond. The average length was measured with the help of scale and measuring tape. The average weight was measured with the help of Beam balance. After measurement, all fishes were released into the pond.

4.4.1.6 Condition of fishes

Condition of fish in general is an expression of relative plumpness of a raised fish with respect to same species taken from the different water bodies or to other species of fish taken from the water body. It is expressed by relative length of fish to its weight. It is given by the formula (Rounsfell and Everhart, 1953, Bennetto, 1971)

$$K = \frac{\text{Weight in gram} \times 100}{(\text{Standard length})^3 \text{ in cm}}$$

If the value of K will greater, fishes are in better condition and if lower, fishes are in poor condition.

4.4.1.7 Harvesting

Harvesting was done on 27th and 29th April of 2007. Fisherman came and harvested themselves without any cost. Fishes were sold at the wholesale rate price of Rs.85 per kg.

4.4.1.8 Survival rate

$$\text{Survival rate} = \frac{\text{No. of fish harvested}}{\text{No. of fish stocked}} \times 100\%$$

4.4.1.9 Cost Benefit Analysis

Cost benefit analysis was done by analyzing the total cost and expenditure to assess viability of the present study works.

CHAPTER FIVE

5.0 Result

5.1 Physicochemical Parameters : The physico-chemical parameters of the pond were recorded once in two months for a period of six months (Nov. 2006 to April 2007).

5.1.1 Physical Parameters

Nature of day

During the study period, the nature of day was sunny, foggy and cloudy. Fog and cloudy days were common on December and February.

Water Colour

During the study period, there was not much variation in the colour of water. But the water became turbid and black on April at the time of harvesting.

Depth

The maximum depth measured in the pond was found to be 130cm on February which may be due to rain. The minimum depth was found to be 80cm on April at the time of harvesting (Table 3).

Transparency

The lowest transparency was recorded as 25.2cm on April and the highest value was found to be 65.2cm on December (Table 3)

Water temperature

During the study period, the maximum surface water temperature was 30^{o}C on April and minimum was found to be 19.5oC on December (Table 3).

5.1.2 Chemical Parameters

Dissolved oxygen (DO)

Dissolved oxygen was found to be quite fluctuating during the study period ranging between 4.2 - 8.3 ppm. The maximum value of dissolved oxygen was 8.3 ppm, recorded on February and minimum value was 4.2 ppm recorded on April (Table 3).

Free Carbon-dioxide (CO_2)

During the study period, the maximum CO_2 value recorded was 9.0ppm on April and minimum CO_2 value recorded was 6.3ppm on February (Table 3).

Total alkalinity

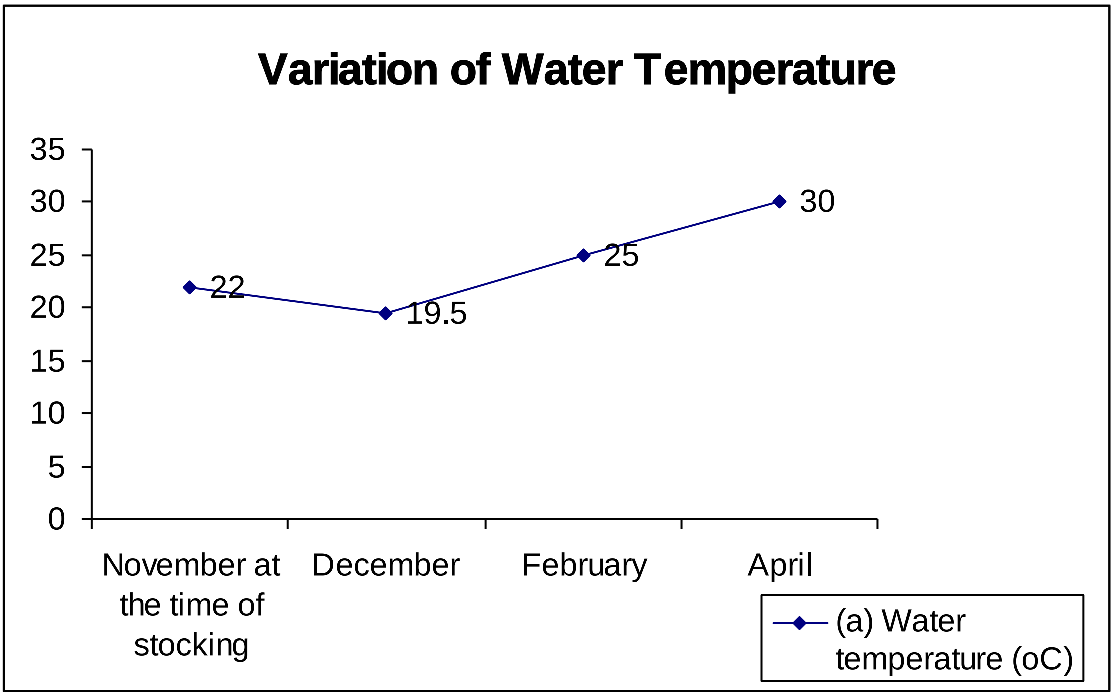
The total alkalinity recorded was found to be ranging from 45 to 70ppm through out the period of investigation. It was maximum on April and minimum on November (Table 3).

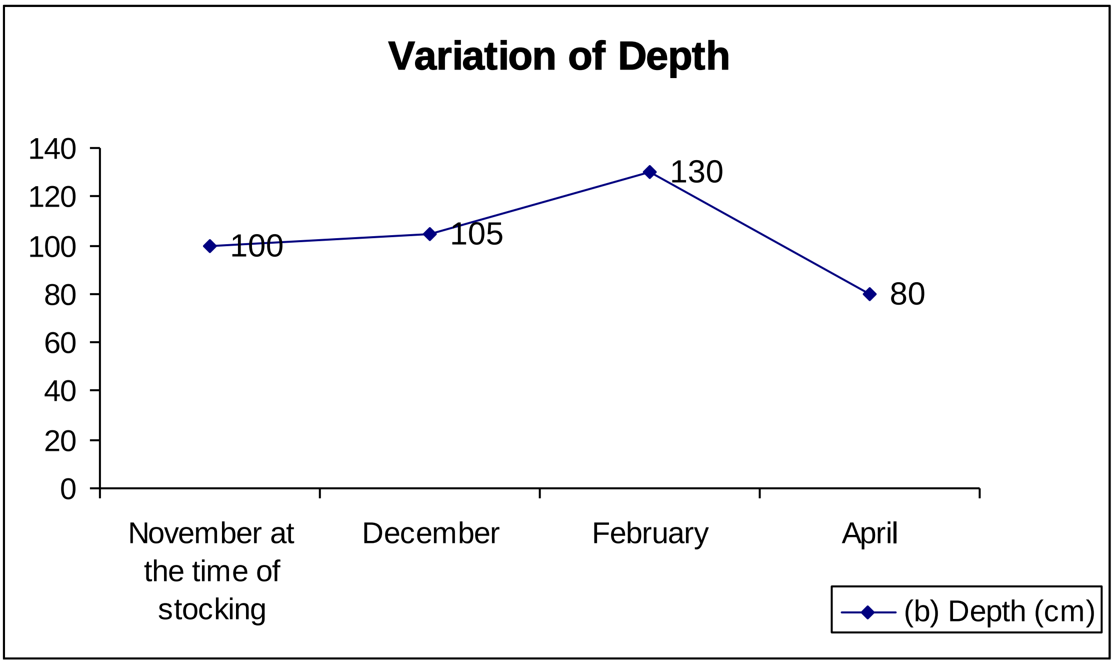
P^H

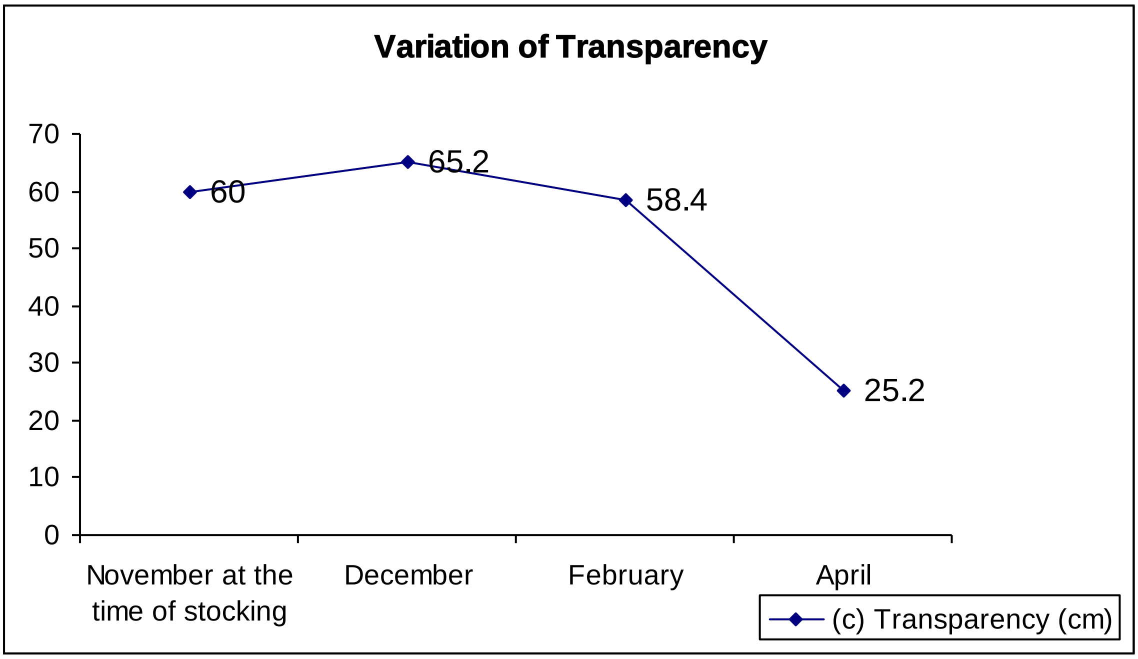
During the study period, the P^H was recorded ranging between 7.0ppm to 10.8ppm. The maximum value of P^H was 10.8ppm during April and minimum value 7.0ppm on November (Table 3).

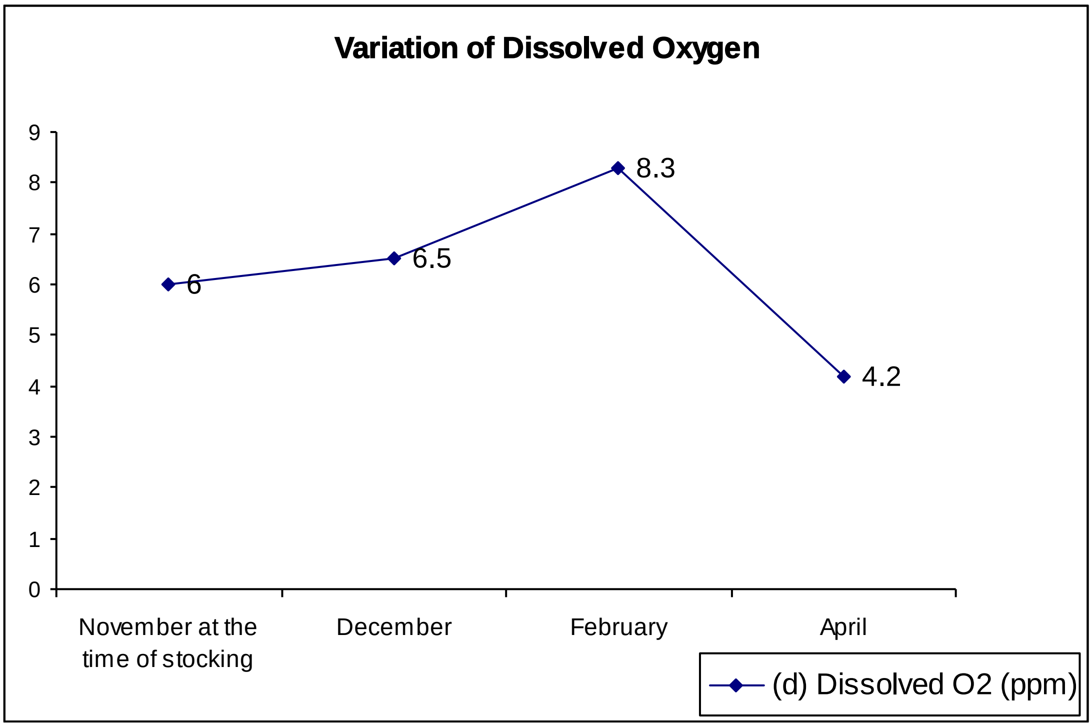
Table 3. Variation of physicochemical parameter of pond.

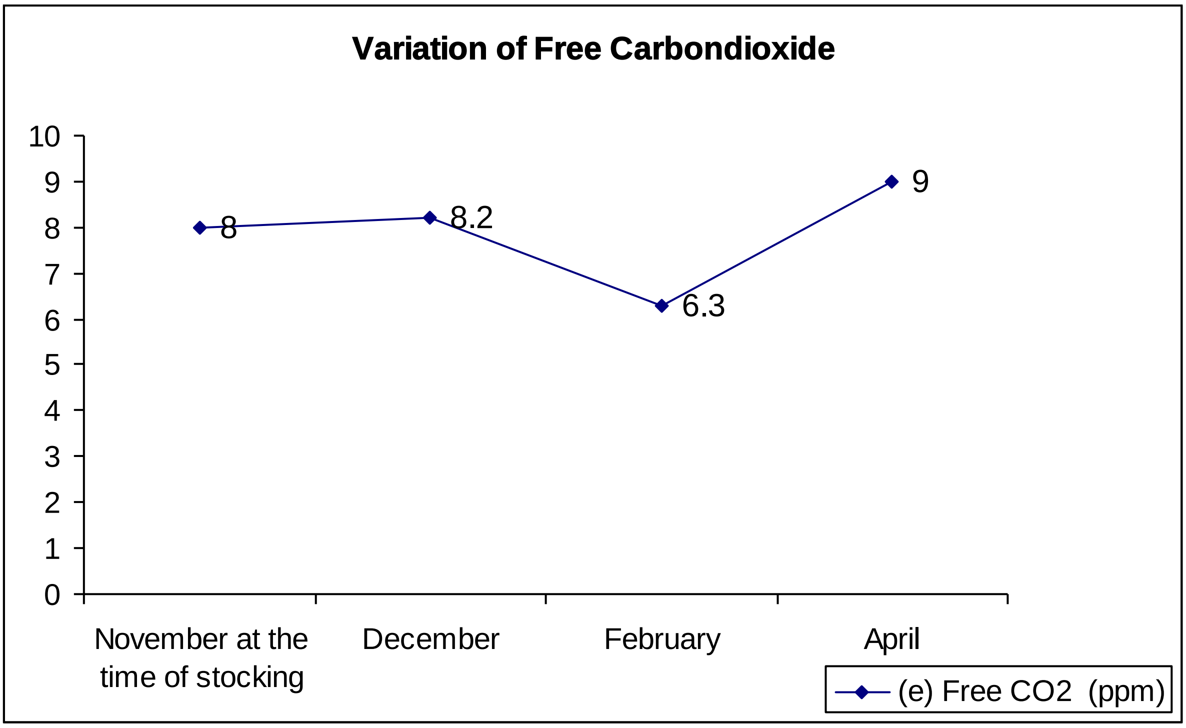
Parameters	November at stocking	December	February	April
Water temperature (^oC)	22	19.5	25	30
Depth (cm)	100	105	130	80
Transparency (cm)	60	65.2	58.4	25.2
Dissolved O_2 (ppm)	6.0	6.5	8.3	4.2
Free CO_2 (ppm)	8	8.2	6.3	9.0
Total alkalinity (ppm)	45	60	53	70
P^H	7.0	7.8	8.6	10.8

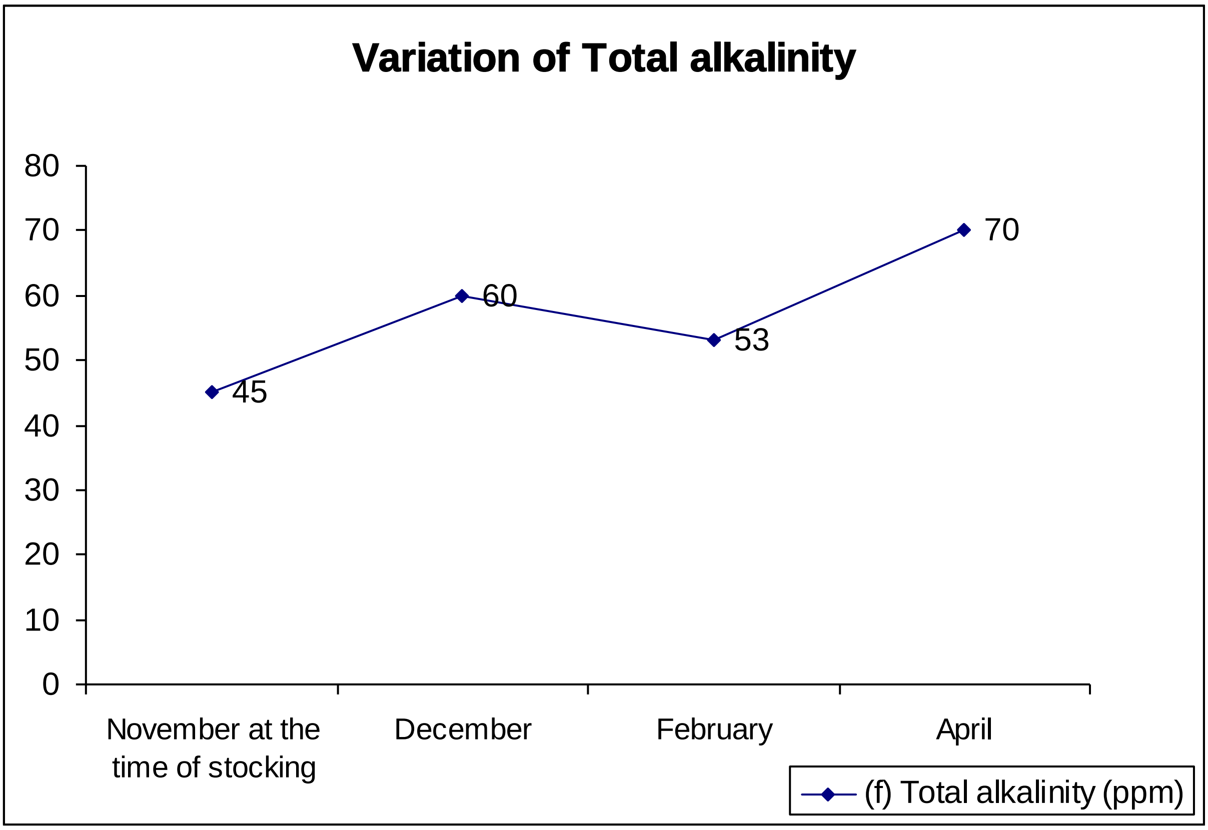

Variation of Water Temperature
35
30
25
20
15
10
5
0
22
19.5
25
30
November at the time of stocking
December
February
April
(a) Water temperature (oC)

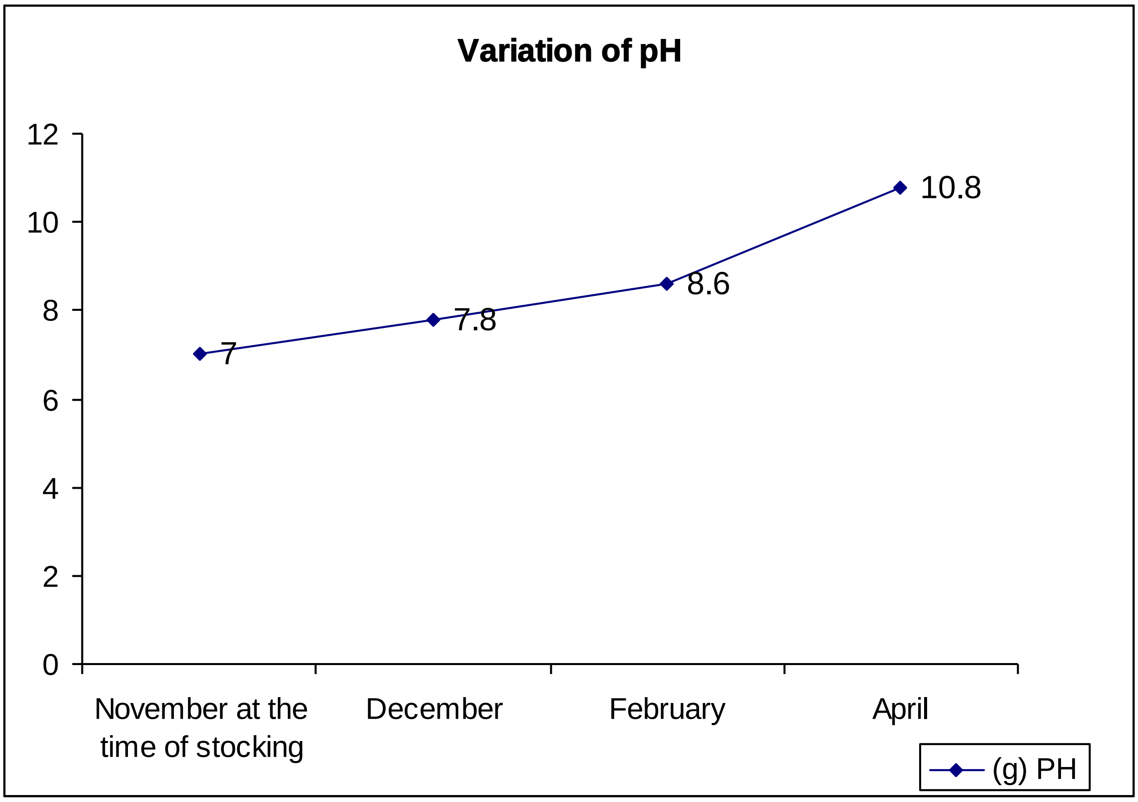

Variation of Depth
140
120
100
80
60
40
20
0
100
105
130
80
November at the time of stocking
December
February
April
(b) Depth (cm)


Variation of Transparency
70
60
50
40
30
20
10
0
60
65.2
58.4
25.2
November at the time of stocking
December
February
April
(c) Transparency (cm)


Variation of Dissolved Oxygen
9
8
7
6
5
4
3
2
1
0
6
6.5
8.3
4.2
November at the time of stocking
December
February
April
(d) Dissolved O2 (ppm)


Variation of Free Carbondioxide
10
9
8
7
6
5
4
3
2
1
0
8
8.2
6.3
9
November at the time of stocking
December
February
April
(e) Free CO2 (ppm)


Variation of Total alkalinity
80
70
60
50
40
30
20
10
0
45
60
53
70
November at the time of stocking
December
February
April
(f) Total alkalinity (ppm)


Variation of pH
12
10
8
6
4
2
0
7
7.8
8.6
10.8
November at the time of stocking
December
February
April
(g) PH

5.1.3 Growth of fishes

5.1.3.1 Average weight of fishes

Rohu (*Labeo rohita*)

The fingerlings of average weight of 15gm were stocked at the beginning of experiment. At harvesting period (after 6 month), the average weight of rohu reached 400gm (Table 4).

Bhakur (*Catla catla*)

The fingerlings of average weight of 15gm were stocked for this experiment and the average weight of fishes at harvesting reached 500gm (Table 4).

Naini (*Cirrhinus mrigala*)

The average weight of 15gm fingerlings were stocked at the beginning of experiment. The average weight was 350gm at harvesting (Table 4).

Grass carp (*Ctenopharyngodon idella*)

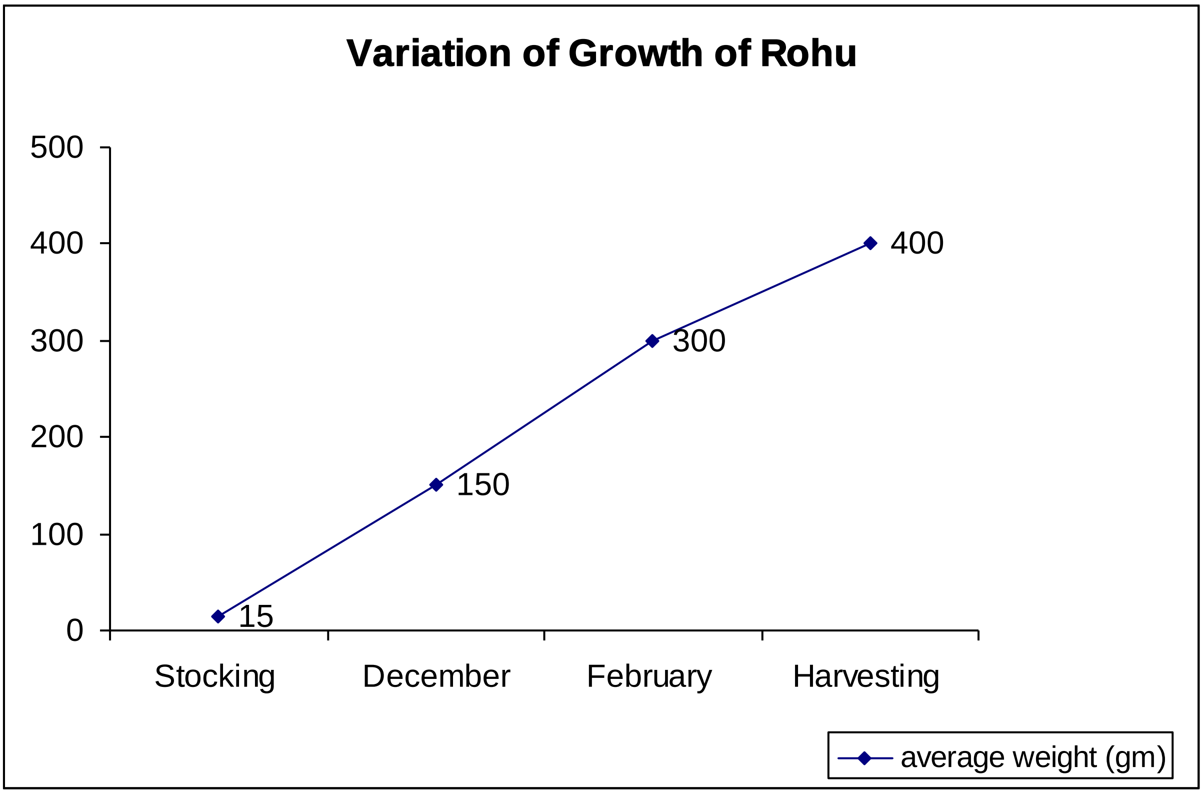
The average weight of 15gm fingerlings were stocked and the average weight of fishes at harvesting reached 600gm (Table 4).

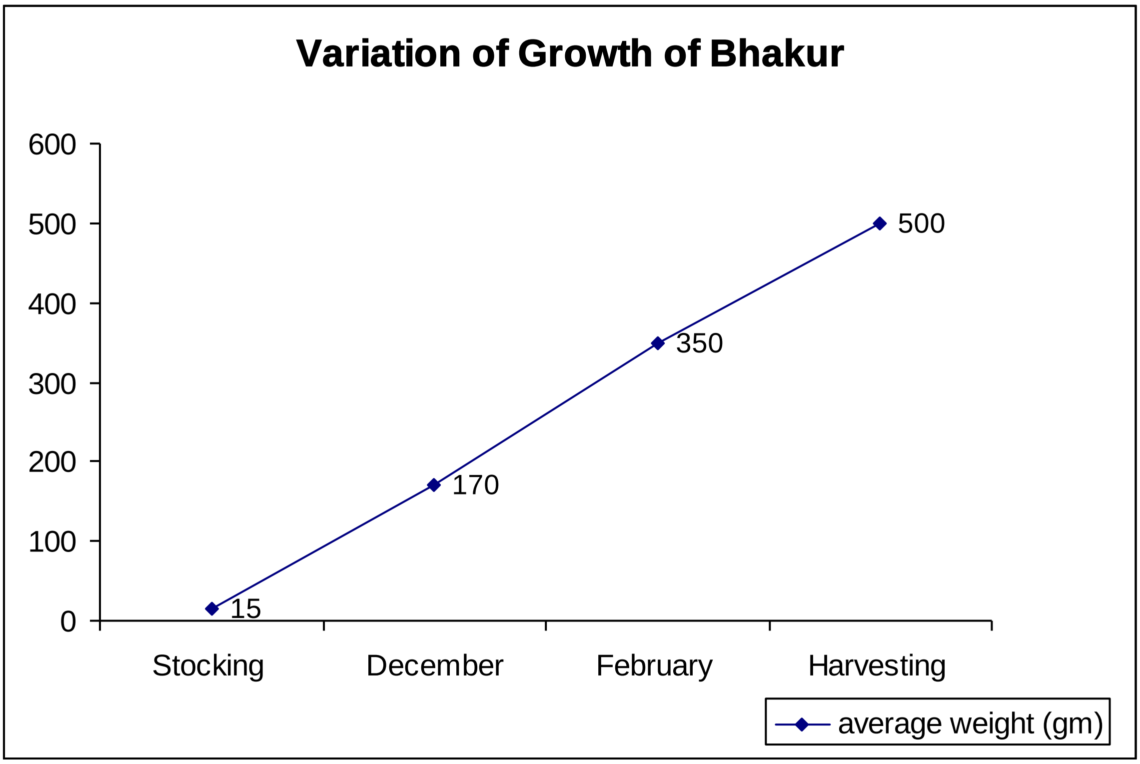
Bighead carp (*Aristichthys nobilis*)

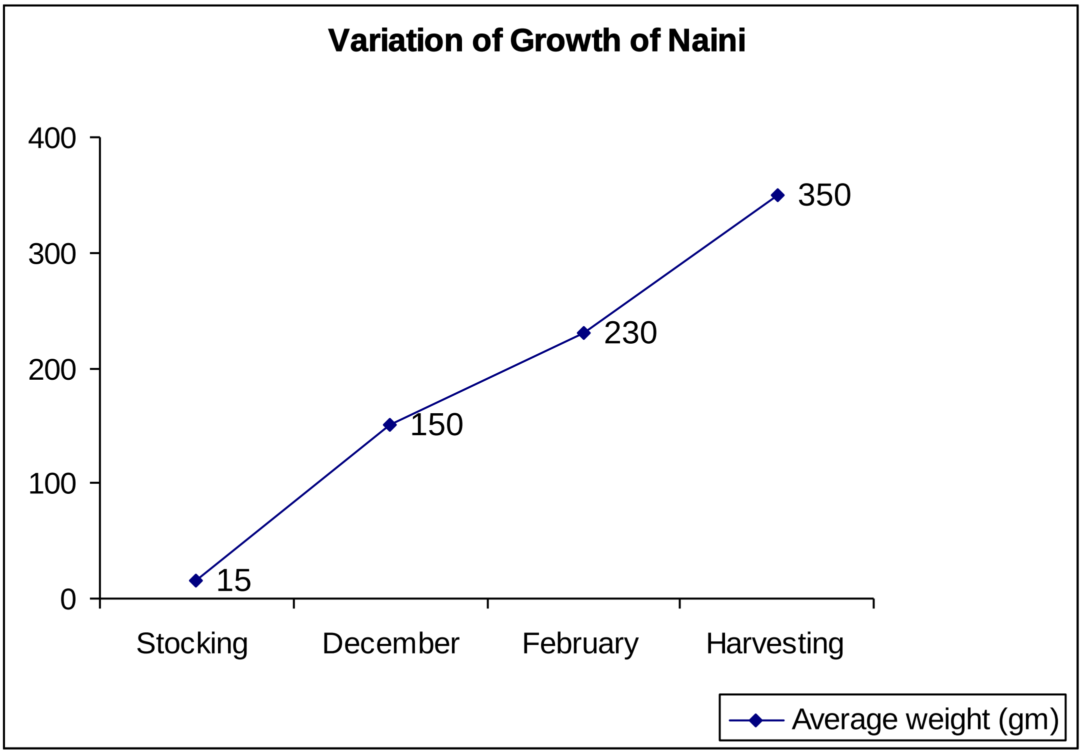
The fingerlings of average weight of 15gm were stocked for this experiment. At harvesting period, the average weight reached 300gm (Table 4).

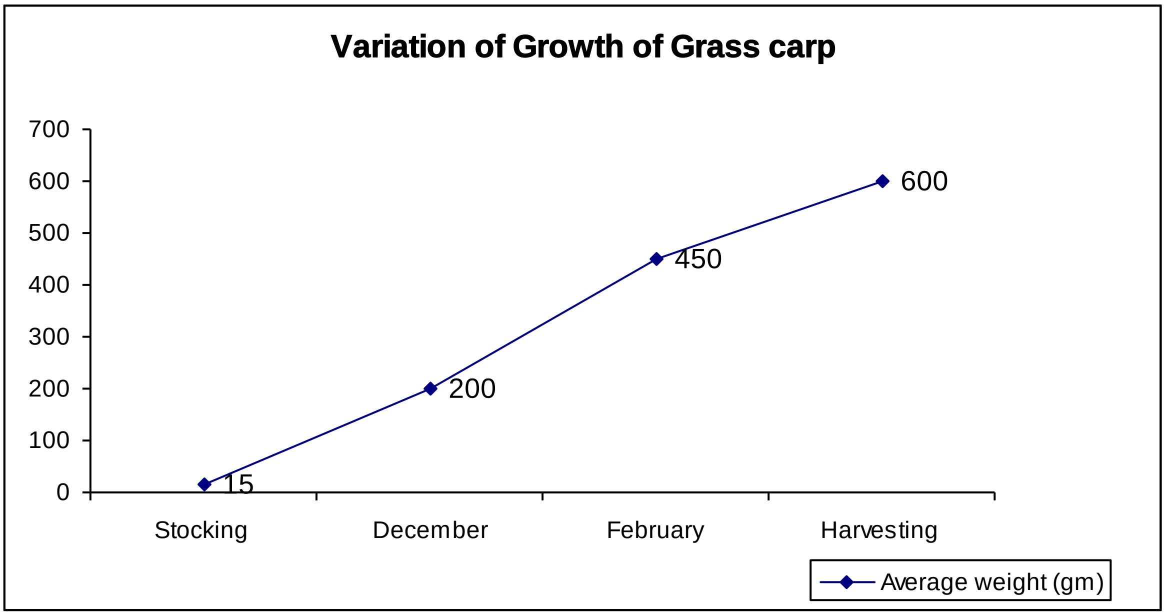
Table 4. Average weight of fishes in pond.

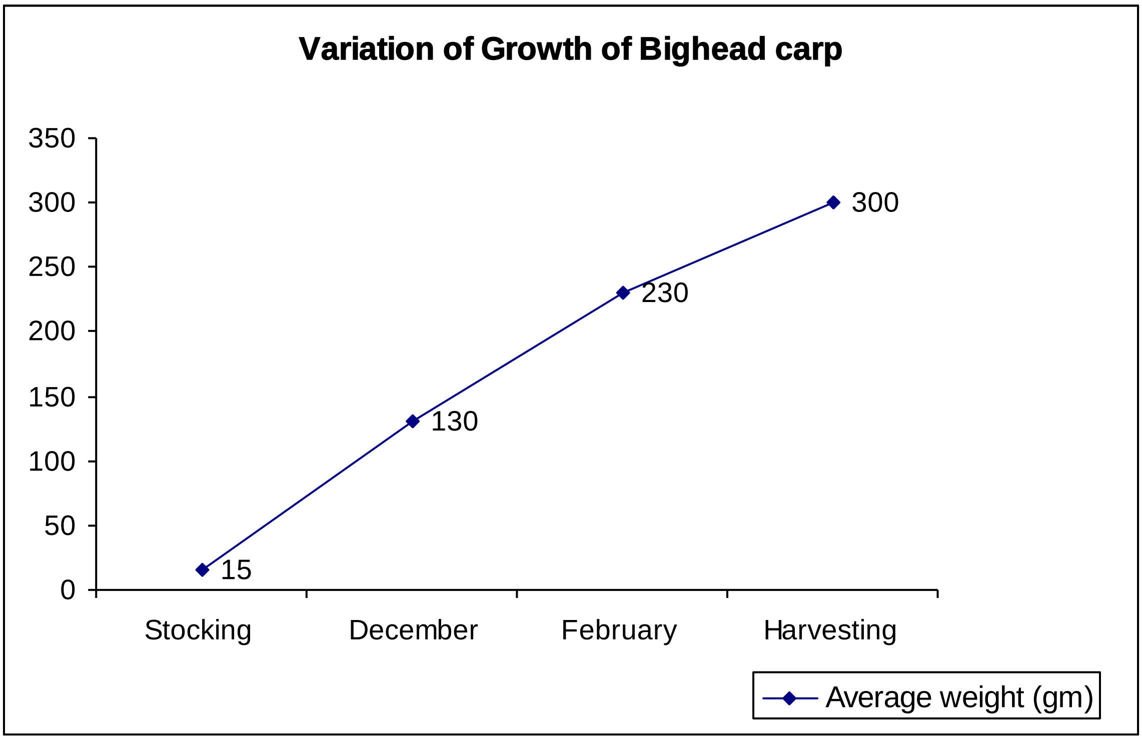
Fish species	Stocking (gm)	December (gm)	February (gm)	Harvesting (gm)	Growth (6 month)	Average growth/day (gm)
Rohu	15	150	300	400	385	2.13
Bhakur	15	170	350	500	485	2.69
Naini	15	150	230	350	335	1.86
Grass carp	15	200	450	600	585	3.25
Bighead	15	130	230	300	285	1.58


Variation of Growth of Rohu
500
400
300
200
100
0
15
150
300
400
Stocking
December
February
Harvesting
average weight (gm)


Variation of Growth of Bhakur
600
500
400
300
200
100
0
15
170
350
500
Stocking
December
February
Harvesting
average weight (gm)


Variation of Growth of Naini
400
300
200
100
0
15
150
230
350
Stocking
December
February
Harvesting
Average weight (gm)


Variation of Growth of Grass carp
700
600
500
400
300
200
100
0
15
200
450
600
Stocking
December
February
Harvesting
Average weight (gm)


Variation of Growth of Bighead carp
350
300
250
200
150
100
50
0
300
230
130
15
Stocking
December
February
Harvesting
Average weight (gm)

5.1.4 Average length of fishes

Rohu (*Labeo rohita*)

The average length of fingerlings stocked was 5cm and the average length of rohu reached 30.2cm at harvesting (Table 5).

Bhakur (*Catla catla*)

The average length of fingerlings stocked was 5cm and the average length of bhakur reached 31.0cm at harvesting (Table 5).

Naini (*Cirrhinus mrigala*)

The average length of fingerlings stocked was 5cm and the average length of naini reached 32.5cm at harvesting (Table 5).

Grass carp (*Ctenopharyngodon idella*)

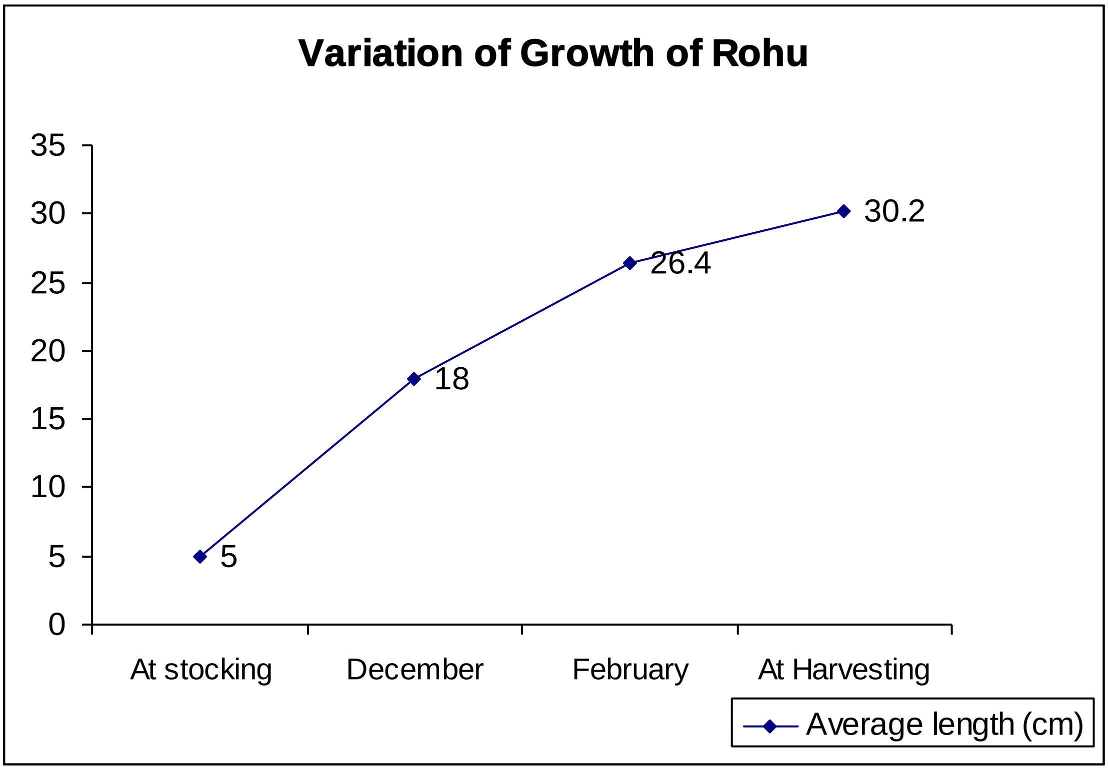
The average length of fingerlings stocked was 5cm and the average length of grass carp reached 34.4cm at harvesting (Table 5).

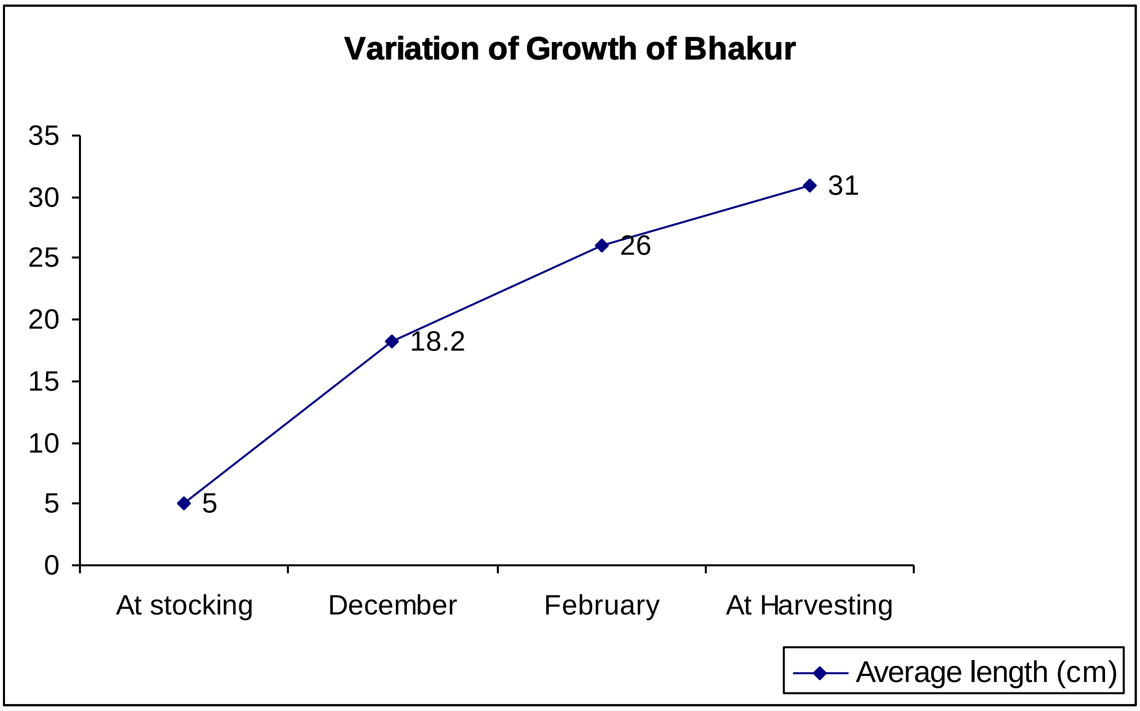
Bighead carp (*Aristichthys nobilis*)

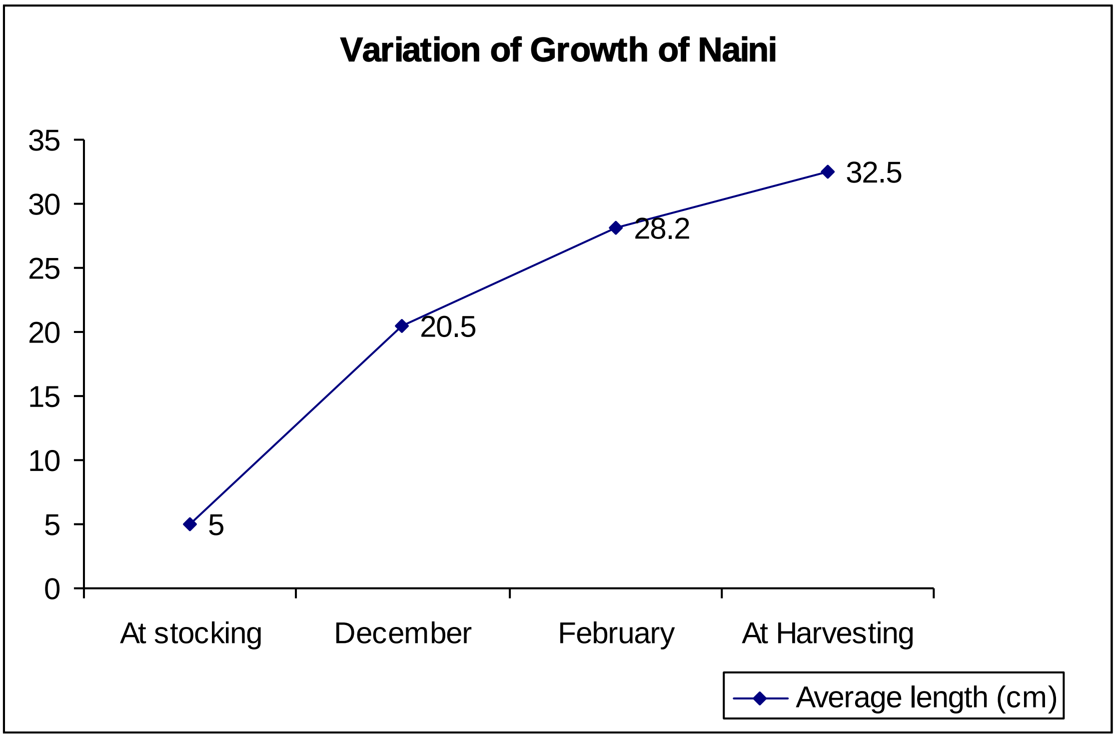
The average length of fingerlings stocked was 5cm and the average length of bighead reached 22.5 cm at harvesting (Table 5).

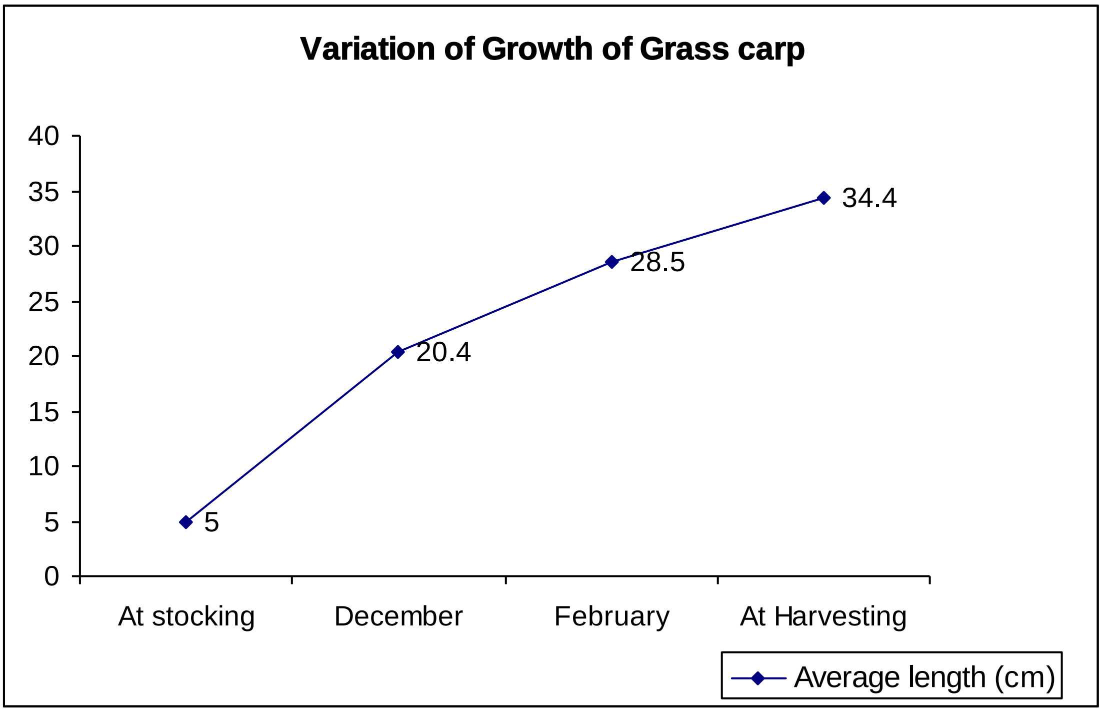
Table No. 5 Average length of fishes.

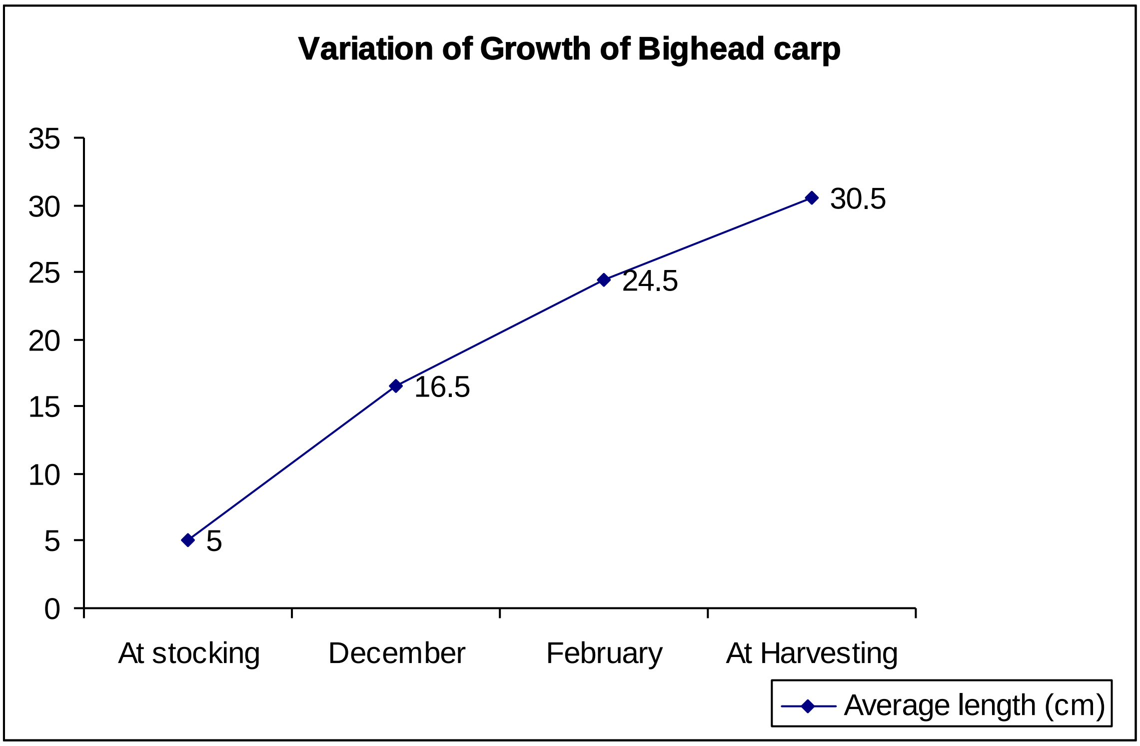
Fishes	Stocking Size (cm)	December	February	Size at Harvesting	Total length in 6 months (cm)	Average growth/day (cm)
Rohu	5	18	26.4	30.2	25.2	0.140
Bhakur	5	18.2	26	31	26	0.144
Naini	5	20.5	28.2	32.5	27.5	0.152
Grass carp	5	20.4	28.5	34.4	29.4	0.163
Bighead	5	16.5	24.5	27.5	22.5	0.125


Variation of Growth of Rohu
35
30
25
20
15
10
5
0
5
18
26.4
30.2
At stocking
December
February
At Harvesting
Average length (cm)


Variation of Growth of Bhakur
35
30
25
20
15
10
5
0
5
18.2
26
31
At stocking
December
February
At Harvesting
Average length (cm)


Variation of Growth of Naini
35
30
25
20
15
10
5
0
32.5
28.2
20.5
5
At stocking
December
February
At Harvesting
Average length (cm)


Variation of Growth of Grass carp
40
35
30
25
20
15
10
5
0
34.4
28.5
20.4
5
At stocking
December
February
At Harvesting
Average length (cm)


Variation of Growth of Bighead carp
35
30
25
20
15
10
5
0
30.5
24.5
16.5
5
At stocking
December
February
At Harvesting
Average length (cm)

5.1.5 Length-weight relationship

5.1.5.1 Condition factor

The growth of fishes were calculated in relation to length and weight by 'condition factor' (Rounsfell and Everhart, 1953 and Benette, 1971) (Table 6).

Table 6. Condition factor

Name of fishes	**Average wt. (gm)**	**Standard length (cm)**	**Condition factor (K) =** $\frac{wt.\times 100}{l^3}$
Rohu	400	25.2	2.49
Bhakur	500	25	3.20
Naini	350	26	1.99
Grass carp	600	26.5	3.22
Bighead carp	300	25.5	1.81

Thus, Grass carps were showed better condition (K = 3.22), followed by Bhakur (K=3.20) and Rohu (K=2.49). Bighead carps showed poorest condition (K=1.81), followed by Naini (K = 1.99).

5.1.6 Survival Rate

The survival rate was found highest for Grass carp (75%), followed by Bhakur (72.5%) and Rohu (62.5%). The survival rate was found lowest for Bighead carp (44%), followed by Naini (45%) (Table 7).

Table 7. Survival rate of fishes

Fishes	No. of fish stocked	No. of fish harvested	Survival rate (%)
Rohu	400	250	62.5
Bhakur	400	290	72.5
Naini	400	180	45.0
Grass carp	800	600	75.0
Bighead carp	500	220	44.0

5.1.7 Economic Analysis

Cost of fingerlings

The cost of fingerlings supplied from Fisheries Development Research Center, Tarahara, Sunsari were:

Rohu (400 fingerlings) = Rs.80 @ Rs.200/1000fingerlings
Bhakur (400 fingerlings) = Rs.120 @ Rs.300/1000fingerlings
Naini (400 fingerlings) = Rs.80 @ Rs.200/1000fingerlings
Grass carp (800 fingerlings) = Rs.240 @ Rs.300/1000fingerlings
Bighead carp (500 fingerlings)= Rs.300/1000 @ Rs.300/1000fingerlings

So, the total cost of fingerlings kept in the pond for the study was: Rs.(80+120+80+240+150) = Rs.670

Expenditure on feed/month

Rice bran = 25kg = 25×Rs.15 = Rs.375
Oil cake = 10kg = 10×Rs.16 = Rs.160
Wheat flour = 10kg = 10×Rs.26 = Rs.260
Total = Rs.795

Thus, the total expenditure on feed (for six months)
= Rs.795×6
= Rs.4,770

Expenditure on the maintenance of fish pond

For clearing: Three labors required for two days at the rate of Rs. 100 for the maintenance of fish pond = Rs. 3 × 2 ×100 = Rs. 600

For liming: 40 kg quick lime (CaO) was used the pond at the rate of Rs. 9

= Rs.40×9 = Rs. 360

For pond fertilization: 50 kg DAP was used in the pond at the rate of Rs. 25

= Rs. 50 × 25 = Rs. 1250

14 kg urea was used in the pond at the rate of Rs. 23 = Rs. 14 × 13 = Rs. 322

Thus, total input = Rs. (671+4,70+600+360+1250+322) = Rs. 7,972

Note: Labor cost for feeding, netting for growth study and others not included as all done by owner of pond.

Income

Thus, 734 kg fishes were harvested from 800m^2 (40m×20m) of pond and the production per hectare became 9175kg i.e. 9.175tons (Table 8).

Table 8. Income Analysis.

Fishes	No. of fish harvested	Average weight of fish (gm)	Total Weight (Kg)
Rohu	250	400	100
Bhakur	290	500	145
Naini	180	350	63
Grass carp	600	600	360
Bighead carp	220	300	66
		Total	734

The fishes were sold at wholesale rate price of Rs. 85/kg. Fish buyers themselves harvest all fishes from ponds requiring no cost for harvesting.

Thus, the total income = Rs.734×85 = Rs. 62390

Net Profit

It is the total income minus total expenditure.

Net Profit = Total Income - Total Expenditure

= Rs. 62390 - Rs.7,972

= Rs. 54,418 (from 800m^2 pond area)

$$\text{Net profit/ hectare} = \frac{54{,}418 \times 10{,}000}{800}$$

= Rs. 679,225.00

CHAPTER SIX

6.0 Discussion

Physical Parameters

Sunny day were recorded during study period except few foggy/cloudy days on December and February. Sunny days were important for the growth/ proper metabolism of fishes, photosynthesis and maintenance of oxygen concentration. Similarly, the color of water should be greenish and clear for proper growth of fishes. It mainly depends upon the quality and quantity of mud, silt, clay, waste products, cloth washing, organic and inorganic materials and other suspended particles of the pond. During the study period, there was greenish water color most of the time and became turbid and black on April at the time of harvesting. Turbidity affects the transparency as transparency is a most important physical parameter which determines the productivity of any water body. The transparency of water depends upon the amount of suspended particles and the seasonal periodicity of planktons. The lowest transparency was recorded as 25.2cm on April and the highest value was found to be 65.2cm on December showing good conditions of the pond.

Depth is the minimum vertical distance between the surface and the underlying bottom of the pond at any point. The maximum depth measured in the pond was found to be 130cm on February which may be due to rain. The minimum depth was found to be 80cm on April at the time of harvesting due to the combination effect of evaporation, transpiration and other environmental factors.

Temperature is most important for its effects on the chemistry and biological reaction in organisms in water. Temperature also affects the fundamental stratification and is also responsible for the zonation of the water body (Odum, 1971). During the study period, the maximum surface water temperature was 30°C and minimum to be 19.5°C. The temperature ranges between 20 to 30°C is ideal for the growth of carp fingerlings.

Chemical Parameters

Dissolved oxygen is necessary in water for aquatic life and is available to the water by absorption from atmosphere and by photosynthesis. Dissolved oxygen exhibits a direct relation with temperature that accelerates the rate of photosynthetic activity in aquatic flora leading to profuse accumulation of oxygen in water which is used by aquatic organisms. A low quality of oxygen indicates organic pollution. It was found to be quite fluctuating during the study period ranging between 4.2ppm to 8.3ppm. However, the DO level of 4.2 - 8.3 ppm was also very ideal for the growth of carp fingerlings. Carbon-dioxide is necessary in water to the green plants for photosynthesis and is available to water through respiration, atmosphere and decomposition of organic matter. During the study period, the maximum CO_2 value recorded was 6.3 - 9.0 ppm February and April respectively.

The total alkalinity is the sum of carbonates and bi-carbonates. The total alkalinity recorded in the range of 45 to 70ppm through out the period of investigation. pH is another important factor which indicates the acidity or alkalinity of a solution. This is related to the concentration of Hydrogen ion in a solution. It is one of the indicators commonly used to know the level of pollution. During the study period, the pH was ranging between 7.0 - 10.8 that is ideal for the growth of fingerlings and adult fishes.

Growth and survival of fishes

The good physiochemical conditions prevailing in the study pond was responsible for the good growth of fingerlings and the grass showed best condition (K = 3.22), followed by bhakur (K=3.20) and rohu (K=2.49). The abundant grass and phytoplankton helped the good growth of grass carp, bhakur and rohu. While totally zooplankton dependent bighead carp and bottom feeder fish like naini showed poor condition (K=1.81) and (K = 1.99) respectively. The growth was found followed by similar survival rate with the survival rates of grass carp (75%), bhakur (72.5%), rohu (62.5%), bighead carp (44%) and naini (45%).

Cost Benefit Analysis

A total of 734 kg fishes were harvested from $800m^2$ (40m×20m) of pond and the production per hectare became 9175kg i.e. 9.175tons (Table 10). The fishes were sold at wholesale rate price of Rs. 85/kg with a total income of Rs. 62390. Total expenditure was recorded about Rs.7,972 and the total net profit was about Rs. 54,418.00 (from $800m^2$ pond area). That is net profit from one hectare pond area would be Rs. 679,225.00.

CHAPTER SEVEN

7.1 Conclusion

Terai region is highly suitable place for intensive fish culture of indigenous carp and exotic carp such as Rohu (*Labeo rohita*), Bhakur (*Catla catla*), Naini (*Cirrhinus mrigala*), Grass carp (*Ctenopharyngodon idella*) and Big head carp (*Aristichthys nobilis*) can tolerate high range of temperature fluctuation.

In the present study, the stocking densities of fingerlings per hectare was high (i.e., 31,250 fingerlings) with the survival rate of fishes i.e. grass carp (75%), Bhakur (72.5%), Rohu (62.5%), Naini (45%) and Bighead carp (44%). The growth of grass carp (3.25gm/day) was highest, followed by Bhakur (2.69gm/day), Rohu (2.13gm/day), Naini (1.86gm/day) and Bighead carp (1.58gm/day). The production of carp from ponds can be increased by the utilization of natural organic food resources in the ponds by combining natural foods with additional fish food (Martysher, 1983). The results suggest exotic carp should be stocked as major species to utilize the natural food properly in polyculture fish farming system for maximum fish production per unit area.

7.2 Recommendation

The following measures should be strongly adopted for the maximum fish production from the pond.

i) Unwanted vegetation should be removed regularly.

ii) Enough fishes and fingerlings should be provided to the farmers for the fish culture.

iii) Pesticides are lethal both to the fish food organism and to the fish and the use of pesticides around the ponds should be restricted.

iv) Farmers should be encouraged for fish farming by providing financial and technical support.

v) Regular analysis of physico-chemical and biological parameters should be carried out by concerned authorities to develop a model for intensive fish culture.

vi) Technical package program needs to be developed and disseminated to attract farmers in fish farming.

8.0 Literature

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