CHAPTER ONE

1.0 INTRODUCTION

1.1 General Background

Nepal is a landlocked Himalayan kingdom with diverse topography and geographical features. The length of the country is about 800 kilometers from east to west and 150-240 km from north to south. Its total area is about 147,181sq. km and its altitude vary from 60 m in south to 8848m in the north. It holds snow-clad peaks in the north, plain Terai region in the south through Mountainous region in the middle surrounded by the Mahabharat and Churia foot hills. It possesses different geographical strata. Hence, its climate, altitude and geography are extremely diverse and have resulted in the occurrence of all major climatic zones of the world. Nepal is blessed by nature with a network of water bodies like snow-fed torrential hill streams, rivers and lakes. It is a paradise for nature lover, vast potential for hydropower, vast cultural diversity and treasure-house of rich biological and genetic diversity.

1.1.1 River System of Nepal

The Himalayas are rich in water with rain water and glaciers as source of water for vast network of river and streams. In Nepal, rainfall occurs due to south-west Monsoon which lasts from June to September. The humid monsoon air stream blowing from the Bay of Bengal is forced to rise as it meets the Himalayan. As a result, heavy rain fall occurs on some section of the southern Himalayan slopes. Based on the rainfall records collected by the Department of Hydrology and Metrology, Nepal receives about 1500mm rainfall in a year in a good Monsoon regime.

The Tibetan marginal range lying in the north is the oldest drainage area with the formation of old rivers in the southerly chains constant flowing to the southern direction cutting several younger mountain chains and the high Himalayas. The other

river chain systems originated on both north and south follow the same chains and open into old river system flowing to south.

Water is the major resources of Nepal next to the land. The estimated total area occupied by water to be about 8,18,500 hectare, i.e., about 5.5 percent of the total land area and it is in the form of lakes, ponds, rivers and reservoirs (Table 1).

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: DOFD, 2001.

There are more than 6,000 rivers in Nepal whose total length exceeds to 45,000km. The rivers of Nepal can be categorized as **Antecedent** and **Consequent** type (Sharma, 1977). Antecedent rivers were already in existence before the origin of Himalayas. After the origin of Mahabharat Hills, most of the Himalayan Rivers had changed their course either to the East or West because the hills acted as barriers. Most of the Nepalese rivers originate from glaciers and carry a very large volume of water in summer and rainy seasons. The consequent type of rivers originated after the origin of Himalayas, Bagmati, Kamala, Rapti, Mechi etc.

The three important river system are as follows:

- Gandaki System
- Koshi System and
- Karnali System

Gandaki System

The Gandaki river rises from the Muktinath area and flows between Dhaulagiri and Gosainthan. Burhi Gandaki, Marsyangdi, Seti and Trisuli Ganga join it in the Mid-land part. It flows through the Churia hill making its way at Tribenighat and appears in the plain forming the Narayani river. This river system consists of seven tributaries which are subsequently called as: Burhi Gandaki, Kali Gandaki, Madi, Myagdi, Marsyangdi River, Seti Khola (River) and Trisuli Khola.

Koshi River System

From the point of view of drainage, the Koshi is the greatest river system of Nepal with a total length of 1,070km. It is regarded as big as the Indus and the Brahmaputra rivers of India. It flows in the Eastern Nepal in the east of Gosainthan and West of Kanchanjunga area. This river has seven tributaries: Arun, Dudha Koshi, Indrawati, Likhu, Sun Koshi, Tamar Koshi and Tama Koshi.

Karnali System

The Karnali rises in the Tibetan region of China near Lampiya Dhura pass between India and Tibet. It flows South easterly through the Tibetan plateau and then enters Nepal in a gorge through the Lipa Lekh. It is said to be the major river system of the Western Nepal. The river course in Nepal is markedly irregular. It passes out of the Mt. Gurla area of Langu valley near Muktinath in the east and flows to the south-eastern direction to enter into the Churia hill forming typical 'U' shape. This river system has seven tributaries: Burhi Ganga, Humla Karnali, Mugu Karnali, Seti Karnali, Sani Bheri, Thuli Bheri and Tila.

Other Important Rivers

Kankai Mai

Kankai Mai river originates from the southern slopes of the Mahabharat range and flows through the Churia hills to reach the Terai. It is on the east of the Koshi River which flows in Illam. From Illam it goes south west and flows near Soktim and finally flows towards south.

Bagmati River

The Bagmati river originates from Bagdhara which is situated at about 2,650m at Shivapuri lake. Nagmati and Salmati khola meet it at Sundarijal and flows to southern direction. Onward it flows first towards the north and then to west of Gokarna forest and comes near the Pashupati temple, Koteshwor it meets Manohara river and flows to the west forming itself the border of Kathmandu and Lalitpur.

Mechi River

The Mechi River starts from the south of Pashupatinagar, Illam, and flows through Jhapa forming the eastern border between Nepal and India. In the name of the Mechi river, the eastern zone of Nepal is named as Mechi zone. **This river has been used as the study site for the dissertation work.**

The other important rivers includes: Kamala River, Mahakali Rive, Arung River, Mari River, Tiran River, Babai River etc.

1.1.2 River Ecology

The rivers and streams of Nepal have small crystal clear and nearly iron free water that can maintain remarkable uniformity both in flow and composition. Himalayan

rivers and streams present unique hydrographic feature with a broad spectrum of flora and fauna of intrinsic biological interest. The river of Nepal can be divided into several types from the stand point of hydro-biological diversity:

- Fast streams (Swift and torrential type)
- Slow streams (Sluggish type)
- Intermittent streams (with variable amount of water dry during summer)
- Spring (cold water and hot water type)

The fast water are roughly, all those torrential streams whose velocity of flow is 50cm/sec or higher. Within the range of this velocity, the water current will remove all particles than 5mm diameter and leave behind a stony bottom. At places where the elevation gradient is low the stream will be slower. Generally, slow stream will be deep and muddy-bottomed, located in a wide valley carved out by the stream itself. The rate of flow and depth may still vary and be exceptionally great in rainy season.

Himalayan streams at certain time of the year may have very low flow. A few streams, except for occasional pools, dry up seasonally every year. These are known as intermittent streams. Although they cease to exist at streams during the summer and winter, they are still inhabited by aquatic fauna that does not have an active aquatic life stage during the dry period.

A spring is a concentrated flow of ground water coming out from opening in the ground. Generally, springs may range from small seep holes, though which the water filters to form wet spots in the ground, to large cracks or fissures in rocks or openings in the ground that are cleaned out and enlarged by percolating water.

1.2 Scope of the Study

Mechi river is a very important permanent water resource of Jhapa district, which provides very good habitat for the aquatic life like warm water tropical species as well

as other aquatic fauna. It is now experienced that the natural habitat of Mechi river is degrading and the fish population is also known to be declined due to the several factors like legal and illegal fishing practices, heavy flooding and erosion, dumping of sanitary waste directly into the river and construction of temporary dam, removing of bottom substrates, sand, gravels, stones etc from in and around the riverside.

Present study in Mechi river may have potential significance from point of view of fishery and aquatic resources. The present study has been undertaken to provide baseline information helpful in developing management plan for the development of fishery resources

1.3 Objective of the Study

The objective is to analyze the present status and fishery resources of Mechi river by:

- study of the physicochemical parameters
- study of fishing implements and techniques used in the area
- explore fish diversity
- study of the socio-economic condition of the fishermen of the area
- marketing, preservation and post harvest status of fishes in the local market.

1.4 Limitation of the Study

Social researches being a vague subject possess some kind of limitation in every field of experimentation. Financial problems, lack of equipment,/laboratory facilities, time limitation etc are the major problems during present work. The study is based on primary data and secondary data.

CHAPTER TWO

2. REVIEW OF LITERATURE

Swiss Professor Forel has been called the father of Limnology. According to him, Limnology is the oceanography of lakes dealt with lacustrine biota (1892) since any physical and chemical studies of aquatic systems have been termed "Forelian Limnology".

Hora (1940) studied ecology, bionomics and evolution of the torrential fish fauna. Swingle (1967) described about standardization of chemical analysis for waters and pond mud. Hynes (1970) published a book "Ecology of Running water". Hem (1970) described about chemical characteristics of natural water. Hopkins (1971) studied the annual temperature regime of a small stream in New Zealand. Torms (1975) described about management of river water quality. Kant and Kachroo (1975) recorded the diurnal changes in the temperature and P^H of water. Allabaster and Lloyd (1980) discussed on water quality criteria for fresh water fish.

Ward (1985) described the thermal characteristics of running water. Ravichandran and Ramanibhai (1988) pointed a plankton and related parameters of Buckingham canal Madras. Karki (1988) studied on some limnological aspect of selected close water ecosystem of Udaipur (Rajasthan).

Geddes (1988) studied on Lake Alexendria, River Murry, South Australia, comparing between clear and turbidity phases. Lai and Norajiki (1988) studied some stream water quality characteristics of two logged over water sheds in Shehangor (Malaysia).

Smith (1989) worked on the aquatic flora and fauna of the New river in England. Ogunkoya and Adenjuwon (1991) studied the rivers of Southern Nigeria. Malin et. al. (1994) conducted diel investigation of Planktonic trophic transfer for two years in the Neuse River, Estuary, North Carolina.

Shrestha (1995) gave status, stock composition and a list of 183 species of fishes from the Himalayan waters of Nepal. Bashu et. al. (1996) worked on factors regulating

phytoplankton and zooplankton biomass in temperate 31 rivers in Eastern Canada. Kobia *et al.,* (1996) carried out the qualitative and quantitative fluctuations of the phystoplanktons biomass in three different aquatic habitats of the Nile at Qalubia Province, Egypt. Singh *et al.,* (2004) studied the effect of sewage and industrial effluents on the abiotic components of Terhi river water. The effluents resulted nil or very low concentration of DO (Dissolved oxygen) and free CO_2 in river Terhi (India).

Wernick *et al,* (2004) assessed the effect of water and sediment quality upon benthic community structure. The water bodies in the vicinity of the mine were reported to be enriched with metals and metalloid (arsenic, gold, iron, zinc etc). Mokaya *et al.*(2004) recorded the influence of anthropogenic activities on water quality of a tropical stream ecosystem. Water samples from three Mjaro River, Kenya analyzed for total phosphorus, arthophosphate, ammonia-nitrogen and nitrate-nitrogen to evaluate stressor sources (eg. Factories and waste water) and the general stream water quality. High phosphate at conning factory was recorded during the low flow day season. Shi *et al.* (2005) studied the contamination of 10 different rivers in Tianjin, China by polyclic aromatic hydrocarbon and recorded the levels of 16 priority polycyclic aromatic hydrocarbons (PAHs) in sediments (0.787 to 1943mg/g dry weight), water (45.81 to 1272 mg/l) and suspended particulate matter (0.938 to 64.2mg/g day weight). The levels of PAHs were found high than other rivers.

Mancini *et al.,* (2005) stated that water quality in streams running in urban areas can be strongly altered by the impact of human activities. Water quality was assessed in eight streams for COD, NO_3, NH_3, TP, Faecal coliformes in Antica Regional Park. The result emphasized multidisciplinary approach necessary to address pollutional pressures on water of urban water bodies. The presence of buffer zones in urban green areas did not minimize the impact as the surrounding urban areas contributed pollutants.

Hawke *et al.* (2005) studied periphyton in the lower Centerbury River, New Zealand surrounded by intensive agriculture. Periphyton downstream of a dairy cattle crossing were significantly higher than upstream. Amoo *et al.* (2005) reported heavy metals in fishes, water and sediments of Lake Kaniji, Nigeria. The highest concentration of heavy metals were observed in the downstream followed by upstream and mid stream. Judova *et al.*(2005) analysed water quality in rural areas of the Czech Republic

particularly in Slapanka River catchment. This river drains a typical landscape of Ceskomoraviska Highland. Water quality in rural areas is still very low and the attention is paid to organic substances and nutrients. To minimize the influence of pollution sources, they recommended the sanitation of diffuse sources of pollution from smell settlements with less than 2000 inhabitants and a successive change from agriculture management and intensive mass production to extensive ways, especially in mountain and sub-mountain areas.

Koral *et al.* (2005) reported trends in water quality variation in the Odra River the day before implementation of the water framework directive. Analysis of pollution parameters revealed that the achievability of good water quality depends on the limit values adopted for the assessment. Weber *et al.* (2005) assessed benthic macro-invertebrate communities of several small streams in and near the city affected by point and non-point sources of pollution. The degree of degradation were achieved using EPA Rapid Bio-assessment Protocols.

Albright *et al.* (2005) reported the changes in water quality in an urban stream following the organic products. Korycinska *et al.* (2006) studied biotic indices for evaluation of water quality of the Liwiee River by using physico-chemical parameters and micro-invertebrate/macro-invertebrate analysis. The water quality was classified on the basis of physical and chemical parameters and the biodiversity index rated Liwiee River as 1^{st} quality class. Correlation between chemical parameters of BBI and BMWP/OQR values showed that their indices might be used for evaluation of water quality in Polish lowland rivers (like Liwiee). Charkhabi *et al.* (2006) assessed spatial variation of water quality parameters in the most polluted wetland of northern Iran. TDS, P^H, temperature, DO, BOD, COD, TOC, TP, NH_4 and NO_3^- were determined on Siahroud River, and the results indicated higher TDS values in some parts due to the agriculture and residential activities and high ammonia fertilizer in the downstream sites. Factor analysis showed that agriculture and urban activities were the major pollutant sources. Mhlanga *et al.*(2006) associated heavy mortality of *Oreachromis niloticus* in Lake Chivero following collapse of an algae bloom. Mortality probably resulted from depressed oxygen levels caused by the high oxygen demand from the massive algal in hype eutrophic systems.

Limnological Study in the Context of Nepal

A lots of limnological investigations were carried out throughout the world by end of 1900A.D. However, few references are available so far in connection with limnological studies on the lotic and lentic water system of Nepal. Our Knowledge about fishes of Nepal is scanty. Some knowledge about Morphology and distribution of fishes is available from works of Hamilton (1822) and Regan (1911).

Menon (1949) obtained fishes from Koshi river and described 26 genera and 52 species belonging to 11 families and also made a zoogeographical analysis of the distribution of Himalayan fishes five years back.

Brehm (1953) was the first limnological to study some aquatic fauna from Kalipokhari, eastern Nepal. Hirino (1955) had published a few paper concerning to the Nepalese algae. Taft (1955) made a fishery survey of Nepal and catalouged 94 species of fishes from Kathmandu, Trisuli, Simra, Birgunj and Biratnagar etc. He also studied the Midgalsaki collection which was identified by Hora of the zoological survey by India, Calcatta three years later (1958A.D.). During the Indian Choyal expedition, a new species of fish *Psilorhynchus pseudochenis* was described by Menon and Dutta (1961). De Witt (1960) catalouged 102 species without any description of their biology and ecology.

Thapa and Rajbansi (1968) discussed about the few hill stream fishes of Nepal. Shrivastava (1968) published a book entitled "Fishery Eastern Uttar Pradesh" in which he mentioned a number of Nepalese fishes. Majupuria (1969) reported on socio-economic conditions of fisherman of Kathmandu. Bhatta (1970) gave information about 57 species of fishes in his book "The Natural History and Economic Botany of Nepal.

The first limnological investigation in Nepal was initiated by Loffler (1969) in high mountain lakes of Khumbu Himal. Hatter and Pillary (1971) gave an account of fishes of Nepal in their report "Rain of fishes in Shilong", Meghalaya.

Hickel (1973) investigated the lakes of Pokhara valley during research scheme of Nepal Himalayan Expedition. Bhatta and Shrestha (1973) gave an account of 27 species of fishes from the Mahakali River in their report "The Environment of

Suklaphanta". Ferrow and Swar (1978) studied in more detail on limnological works with special reference to biological aspects. They again studied seasonality and fecundity of Daphnia species of Phewa Lake in (1978). Shrestha et.al. (1979) described the aquatic ecology and fishery potential of Bagmati river. They gave a checklist of 82 species of fishes. Shrestha *et al.* (1979) studied some limnological aspects of Bagmati and the Trisuli river.

Amatya (1979) worked on bacterial pollution in some rivers of Nepal. Swar (1980) described present status of limnological studies and research in Nepal. Shrestha (1980) studied fishing gears and methods used in Narayani river. He reported 103 species of fishes from Narayani river. Ferrow (1980-81) gave a list of 120 species of fishes in his book "Wild life of Nepal.

Yadav (1987) studied aquatic insects of Palung Khola. Pradhan and Swar (1987) studied limnology and fishery potential of the Indrasrobar at Kulekhani, Nepal. Sharma (1988) reported distribution of zoobenthos in Bagmati river. Jones *et al.*, (1989) worked on the limnological reconnaissance of water bodies in central and southern Nepal. Karmacharya (1990) studied the water pollution in the Bagmati river and its tributaries.

Shrestha (1990) reported 74 species of fishes from Karnali river, 108 species from Koshi, 34 from Trisuli, 102 species from Narayani and 69 species from Mahakali river in his pioneer work "Resource Ecology of Himalayan Water". Shrestha (1991) studied the spawning ecology and biology of migratory fishes in upper Arun. Yadav (1994) worked on the water quality and benthic fauna of the feeding river, Palung, Chalchn, Thudo and Chitlang of the Kulekhani reservoirs. Luitel (1994) gave a design of water quality monitoring network for Kathmandu Valley Rivers.

Despite a large number of contributions cited above, much remains to be done on the fisheries of the Mechi River of Eastern Nepal. Thus, the present study is carried out to contribute further knowledge about diversity of fishes, fishing gears and methods used in Mechi River. It is hoped that the comprehensive study will help in planning and programming for intensive fish culture of native fish fauna distributed in the Mechi River.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Description of Study site

The Mechi River lies in the extreme eastern part of Nepal which is a boundary line separating Nepal from India. It lies on Jhapa district which occupies latitude of $26^{o}22'$ N to $26^{o}50'$ N and longitude $87^{o}39'$ East to $88^{o}12'$E. The river serves a useful resource of water for the people of Bhadrapur area as well as a big source of income for the local fishermen of that area. A well constructed bridge is situated nearly 15km away from the study area towards the north in Kakarvitta. The Bhadrapur Municipality constructs a temporary bridge in the river which is flown by heavy monsoon water current. Three different study sites were selected and identified as sites 'A' in Bhadrapur, site 'B' which is 700m towards upstream and site 'C' lying 500m downstream from site 'A'. The samples from the sampling sites A, B, C were collected once in 45 days and mean average value was analyzed. Altogether 4 observations were made during the period of 6 months of present study.

3. 2 Physical parameters

The physical parameters such as water temperature, depth, velocity and colour of were recorded in the field itself. Water sample were collected from stations A, B and C from both surface and bottom layer.

Water Colour

A small amount of water from all the sites was collected for the examination of water colour. The water thus collected was taken in a petridisc, kept on a white paper and the water colour was judged.

Temperature

The temperature of air as well as water was measured with the help of a standard Mercury Thermometer graduated up to $50^{o}C$ with a precision of $0.1^{o}C$. The air temperature was measured by keeping the thermometer in Shady place for about two minutes. For getting the surface water temperature, the bulb of the thermometer was dipped into the water of desired depth and reading of thermometer was noted down.

Depth

The mean depth of station A, B and C were recorded with the help of long graduated nylon rope having appropriate load at lower end. The rope was lowered in the river, till it reaches to the bottom. Then the length of the rope under water was measured with the help of measuring tape. The mean of all the depths was noted as depth of the river.

Velocity

The velocity of river was measured twice a month. A distance of 15 meter was measured and marked. The Velocity was measured by simple methods of timing a float with stop watch (Adoni 1984)

3.3 Chemical parameter

3.3.1 Preparation of reagent solutions:

The chemical parameters - pH, O_2 content, free CO_2, total hardness and total alkalinity were analysed in the field and laboratory of Mechi Multiple College, Bhadrapur. Following different reagents were prepared following standard methods of APHA (1976) and Boyd (1979).

- Winkler's "A" solution or $MnSO_4$ solution
- Winkler's "B" solution or Alkaline Iodine Solution
- Sodium Thiosulphate solution or Hydro solution (0.025N)
- Standard sodium Carbonate solution (0.045 N)
- Sulphuric Acid (0.02 N) solution
- EDTA solution
- Sodium Hydroxide solution (1 N)
- Ammonia Buffer solution
- Silver nitrate solution
- Starch indicator
- Phenolphethalin Indicator
- Methyl Orange Indicator
- Potassium Chromate Indicator
- Erichrome black-T indicator

CHAPTER FOUR

4.0 RESULT

4.1 Physical Parameters

Nature of day

During the time of water analysis and observation, the nature of the days was sunny, cloudy, rainy, foggy, calm and clear. Rainy and foggy days were minimal during the study period.

Temperature

The water temperature varied from 12.4^{o}C to 24.5^{o}C, with an average of 18.4^{o}C. The maximum of water temperature was recorded 24.5^{o}C and minimum water temperature 12.4^{o}C. The difference between maximum and minimum water temperature was 12.1^{o}C (Table 2).

Table 2. Variation of Temperature in different study sites (16th Dec. 2006, 30th Jan. 2007, 1st May 2007 and 15th June 2007)

Samp. No.	**Site A**				**Site B**				**Site C**			
S.N.	Morn ^{o}C	After ^{o}C	Even ^{o}C	Av ^{o}C	Morn ^{o}C	After ^{o}C	Even ^{o}C	Av ^{o}C	Morn ^{o}C	After ^{o}C	Even ^{o}C	Av ^{o}C
1.	11.7	13.5	12.1	12.4	11.6	13.5	12.1	12.4	11.7	13.4	12.2	12.4
2	10.2	11.9	11.1	11.06	10.2	11.9	11.1	11.06	10.1	11.9	11.0	11
3	19	23	21	21	19	23	21.1	21.03	19.1	23	21	21.03
4	20	24.1	22	22.03	20	24.1	22.1	22.06	20.1	24.1	22	22.06
5	23.5	26.5	24.3	24.7	23.6	26.4	24.3	24.7	23.5	26.5	24.2	22.6

Depth

The water depth at stations A, B and C were taken by using boat. The maximum depth of 6m was recorded while the minimum depth of 87cm. The difference between maximum and minimum water depth was 5.13m. The average water depth was 3.43m (Table 3).

Velocity

The maximum velocity of minimum velocity recorded were 1.7m/s and 0.3m/s with an average of 0.6m/s. The difference between maximum and minimum was 0.6m/s (Table 3).

Colour of water

During the study period, the colour of water noted colourless with gradually becoming brownish white with the increase in turbidity (Table 3).

Transparency

The lowest transparency was recorded as 25.7cm and the highest value was found to be 78.3cm. The average transparency was found to be 74.45cm.

Table - 3. Variation of Physical Parameter of Mechi River, Jhapa.

Study Site	**Site - A**					**Site - B**					**Site - C**				
Date / Parameter	**I**	**II**	**III**	**IV**	**V**	**I**	**II**	**III**	**IV**	**V**	**I**	**II**	**III**	**IV**	**V**
Depth (cm)	110	114	89	420	600	107	117	87	422	595	109	113	95	425	587
Velocity (m/s)	0.4	0.6	0.8	1.1	1.4	0.4	0.7	0.59	1.2	1.7	0.3	0.7	0.64	0.9	1.6
Transparency (cm)	76.4	78.3	77.1	28	26	76.3	77.4	75	26	25.9	76	77.9	76.3	26.3	25.7

I - 16th Dec '06

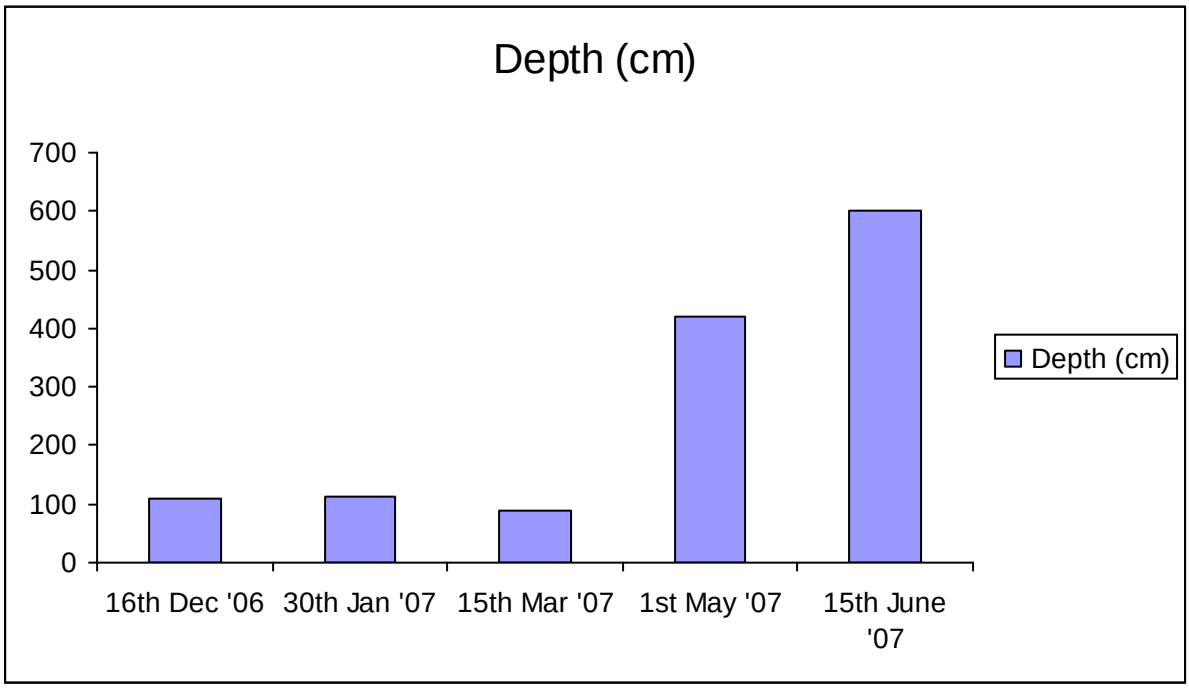
II - 30th Jan '07

III- 15th Mar '07

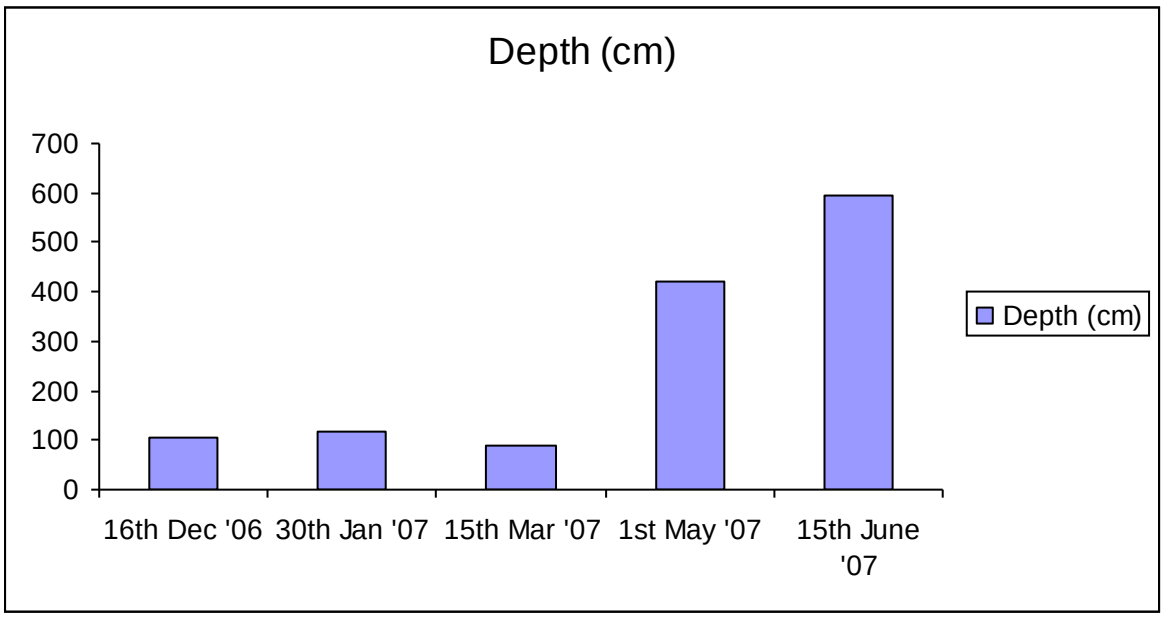
IV - 1st May '07

V - 15th June '07

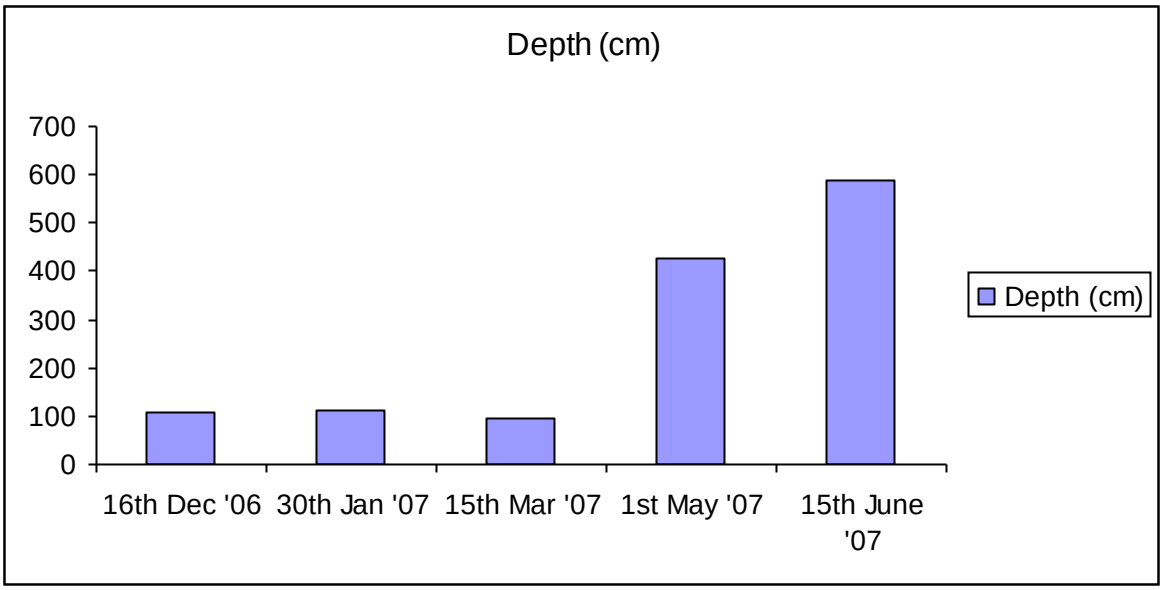
1. Diagram showing variation of depth in Site - A.



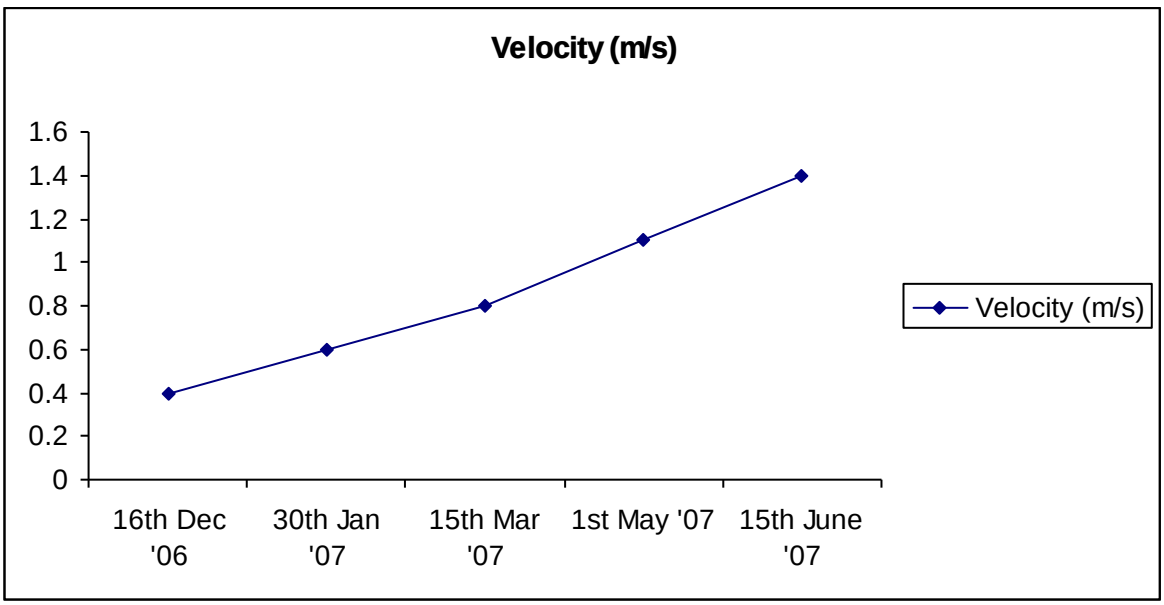
2. Diagram showing variation of depth in Site - B.



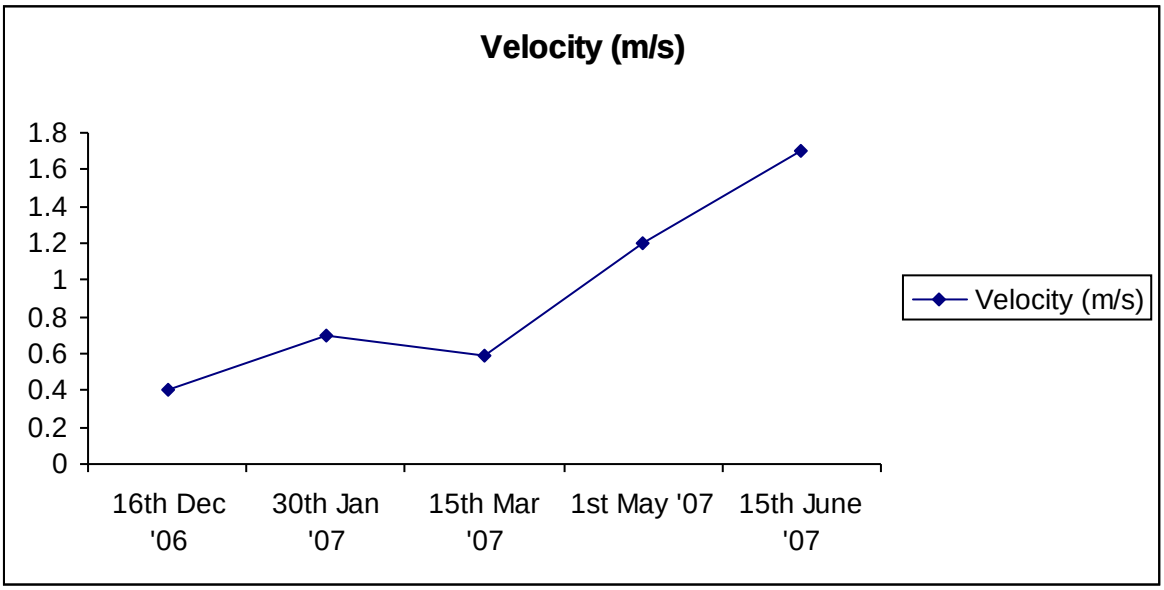
3. Diagram showing variation of depth in Site - C.



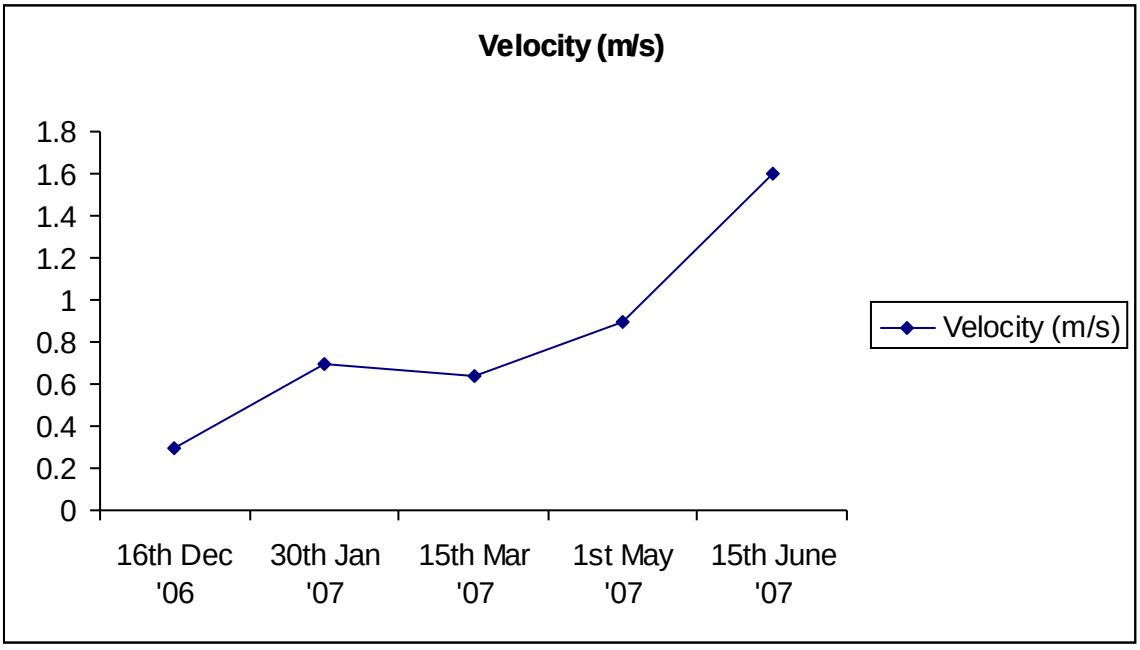
4. Diagram showing variation of velocity in Site -A.



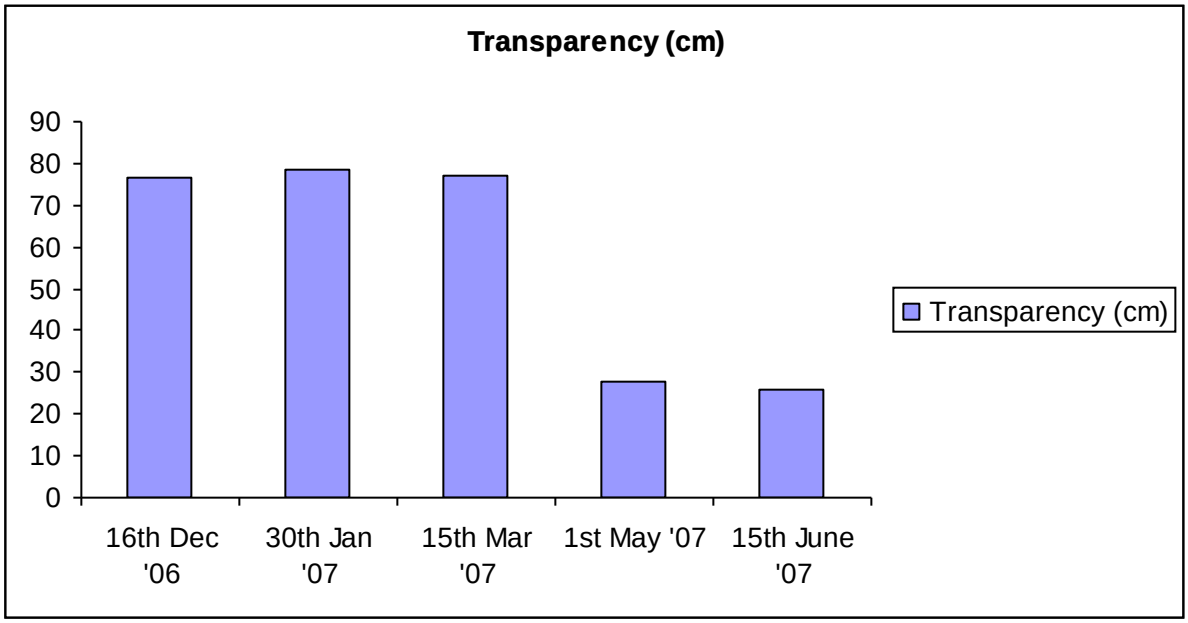
5. Diagram showing variation of velocity in Site -B.



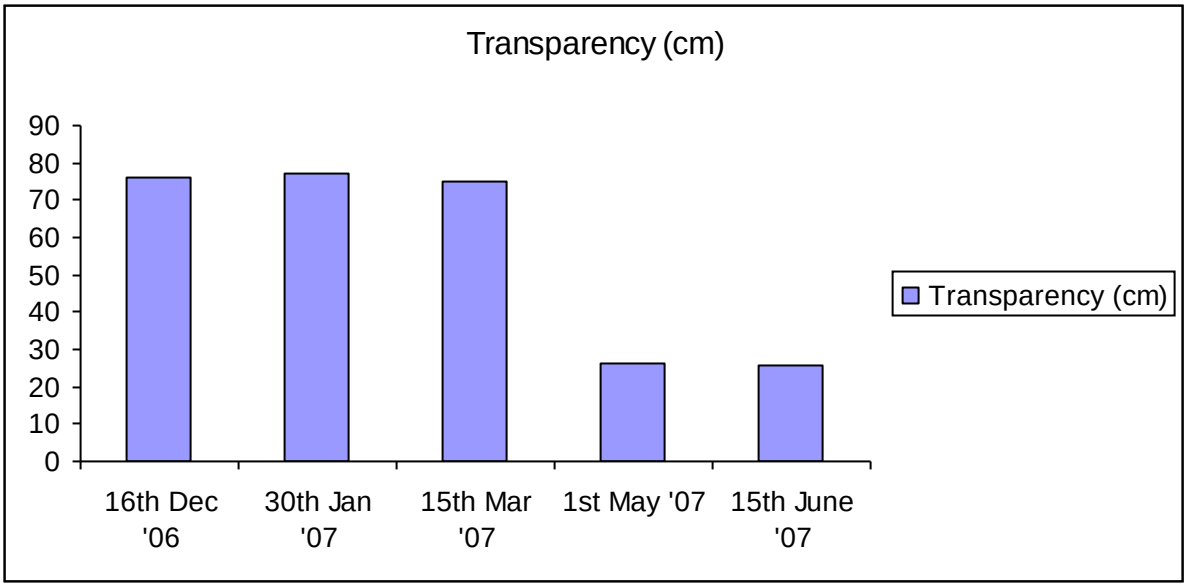
6. Diagram showing variation of velocity in Site - C.



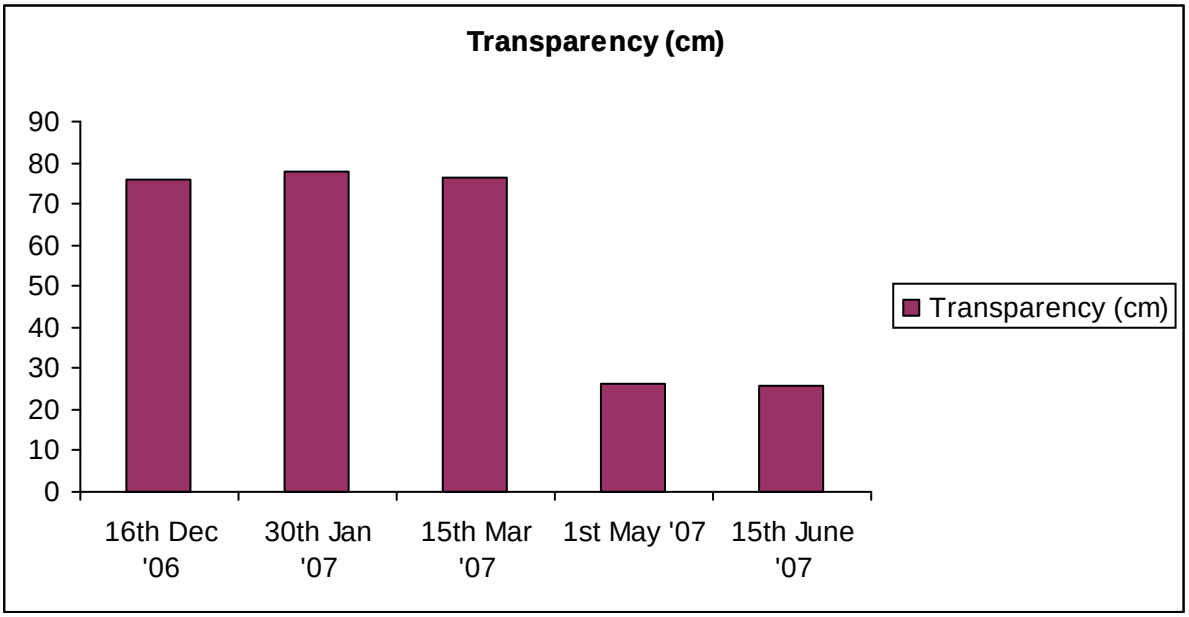
7. Diagram showing variation of Transparency in Site-A.



8. Diagram showing variation of Transparency in Site - B.



9. Diagram showing variation of Transparency in Site - C.



4.2 Chemical parameter

Hydrogen-ion concentration (pH)

In the present study, pH found varied from 6.1 to 8.5 with an average of 7.3. This indicates that the P^H remained almost close to neutrality during the study period (Table 4).

Dissolved Oxygen

This oxygen concentration was found to be consistent with less fluctuation during the study period. The value was recorded ranging from 6.1ppm to 7.3ppm with an average of 6.7ppm (Table 4).

Free Carbondioxide

Free CO_2 showed a variation from 8.0-15.3ppm with an average value of 11.6ppm (Table 4).

Total Alkalinity

The total alkalinity recorded was found to be in the range of 55-110ppm throughout the period of study with an average of 92.5 (Table 4).

Total Hardness

The value of total hardness recorded during the study ranged from 25-37ppm with an average of 31ppm (Table 4).

Table 4. Variation of Chemical Parameter of Mechi River, Jhapa

Study Site	**Site - A**					**Site - B**					**Site - C**				
Date / Parameter	**I**	**II**	**III**	**IV**	**V**	**I**	**II**	**III**	**IV**	**V**	**I**	**II**	**III**	**IV**	**V**
pH	6.4	6.7	7.1	8.5	8.2	6.1	6.5	7	8.5	8	6.4	6.6	7	8.5	8
Dissolved (Oxygen) ppm	6.2	6.6	7.3	7.2	6.3	6.1	6.4	7.2	7.3	6.1	6.4	6.7	7.2	7	6.1
Free CO_2 (ppm)	15.3	14.7	8.1	8.7	11.7	15.2	14.5	8.3	8.9	11.5	15	14.9	8	8.8	11.5
Total Alkalinity (ppm)	109	76.4	80	75	70	106	63	55	74	68	110	68	57	71	68
Total Hardness (ppm)	25	28	36	32	30	26	25	37	30	30	32	27	34	30	29

I - 16th Dec '06

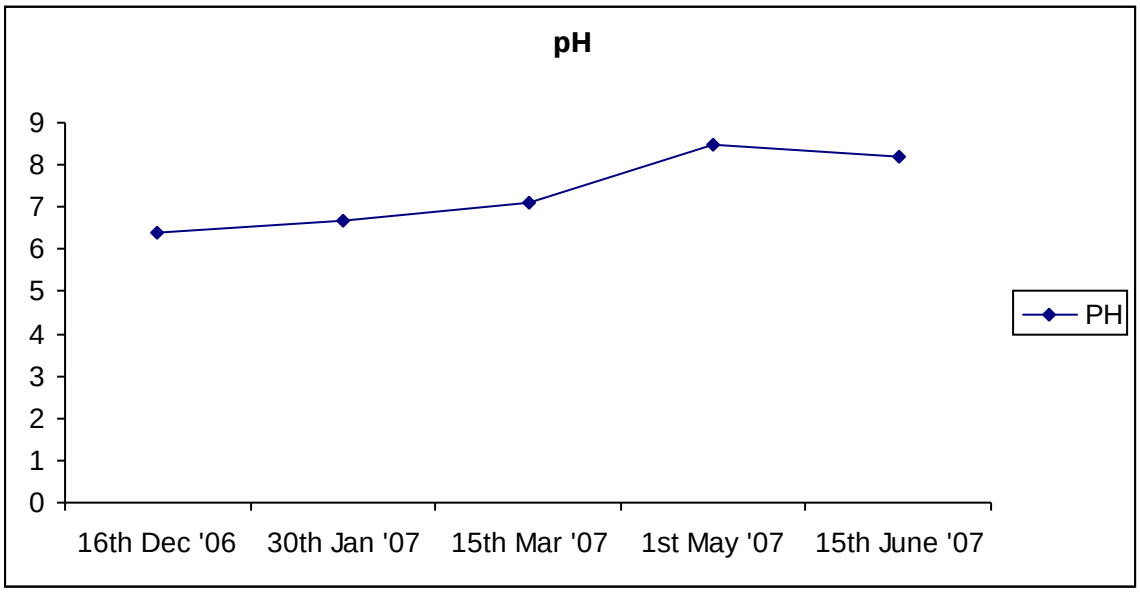
II - 30th Jan '07

III- 15th Mar '07

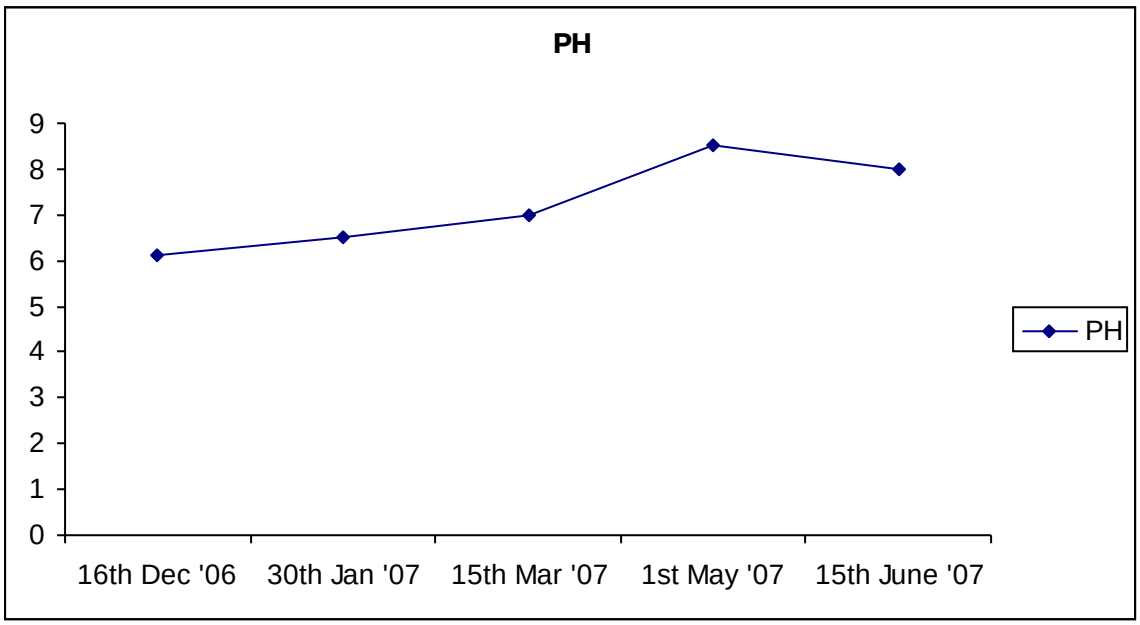
IV - 1st May '07

V - 15th June '07

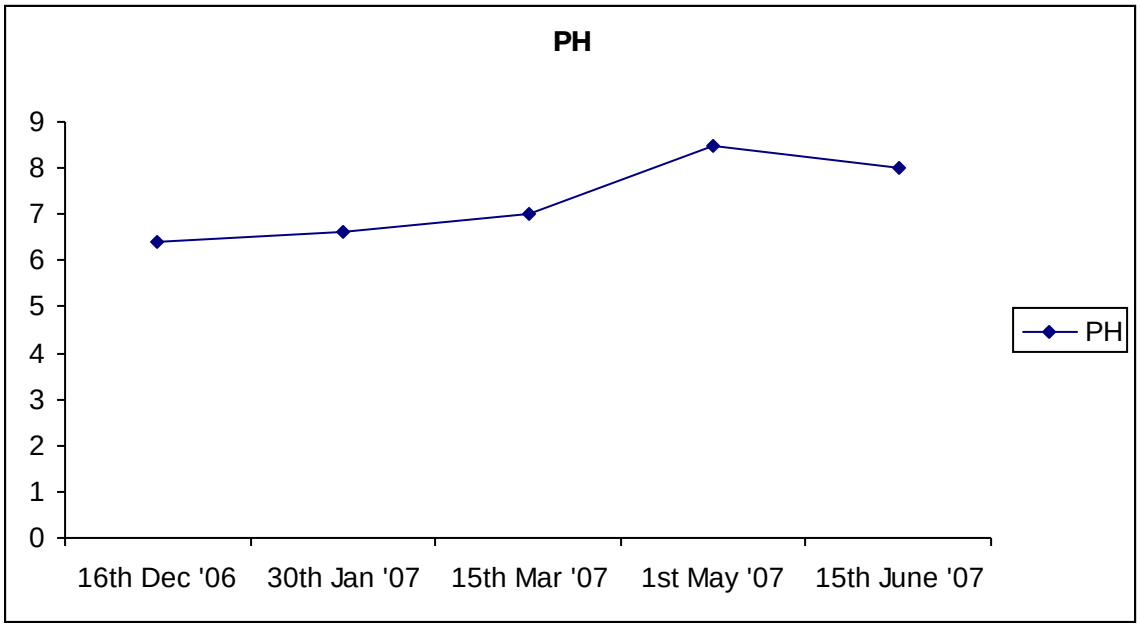
10. Diagram showing variation of P^H in Site - A.



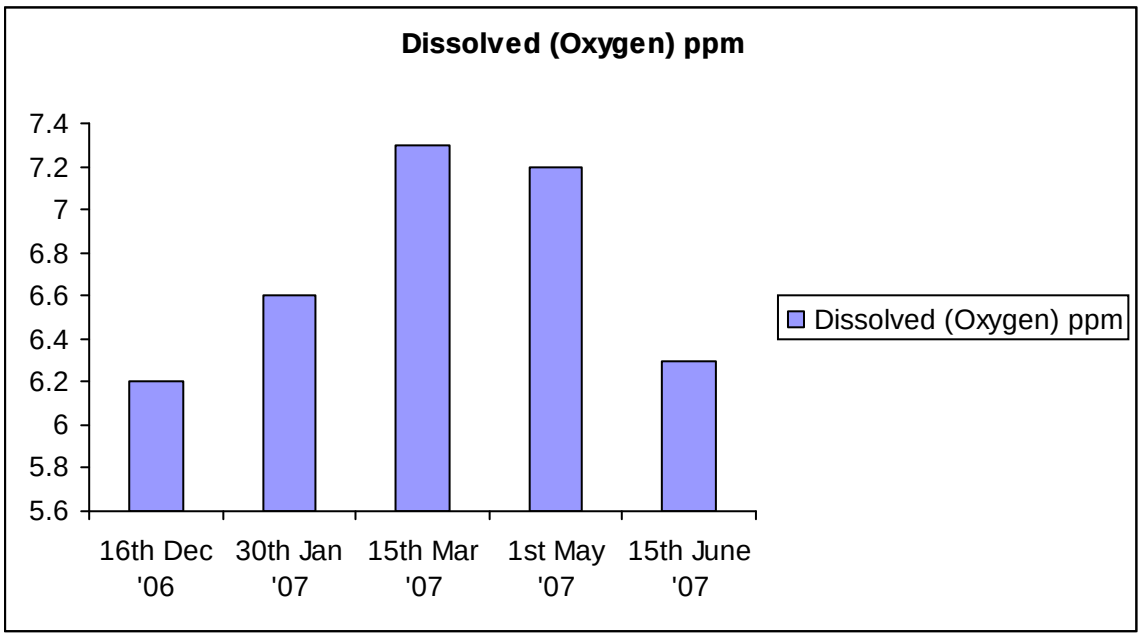
11. Diagram showing variation of P^H in Site - B.



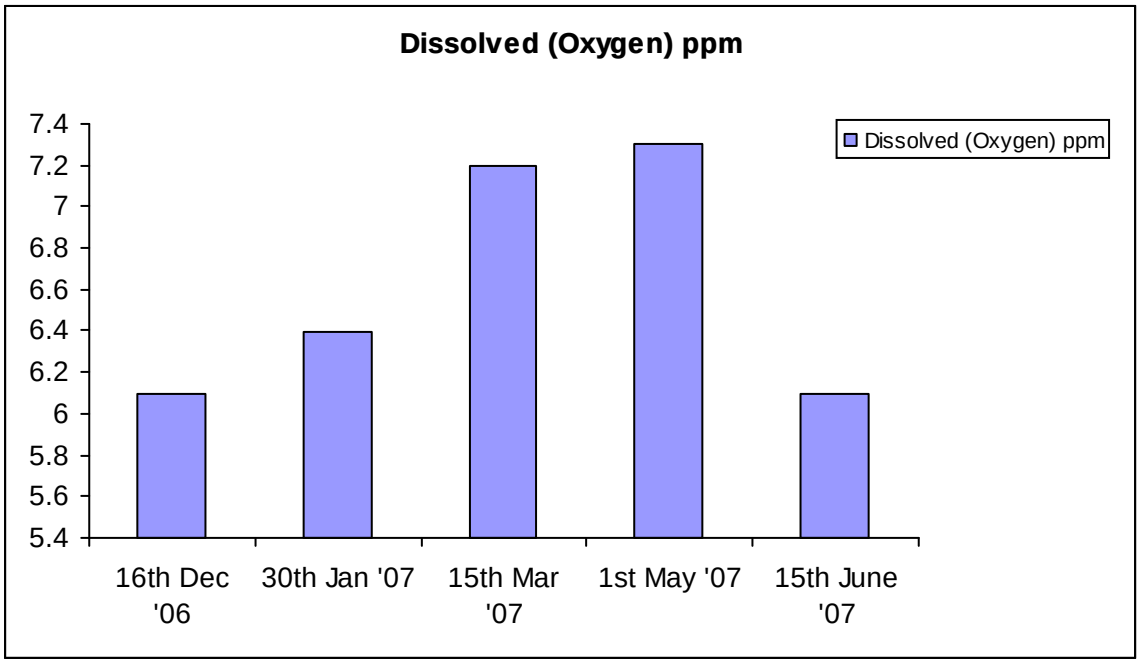
12. Diagram showing variation of P^H in Site - C.



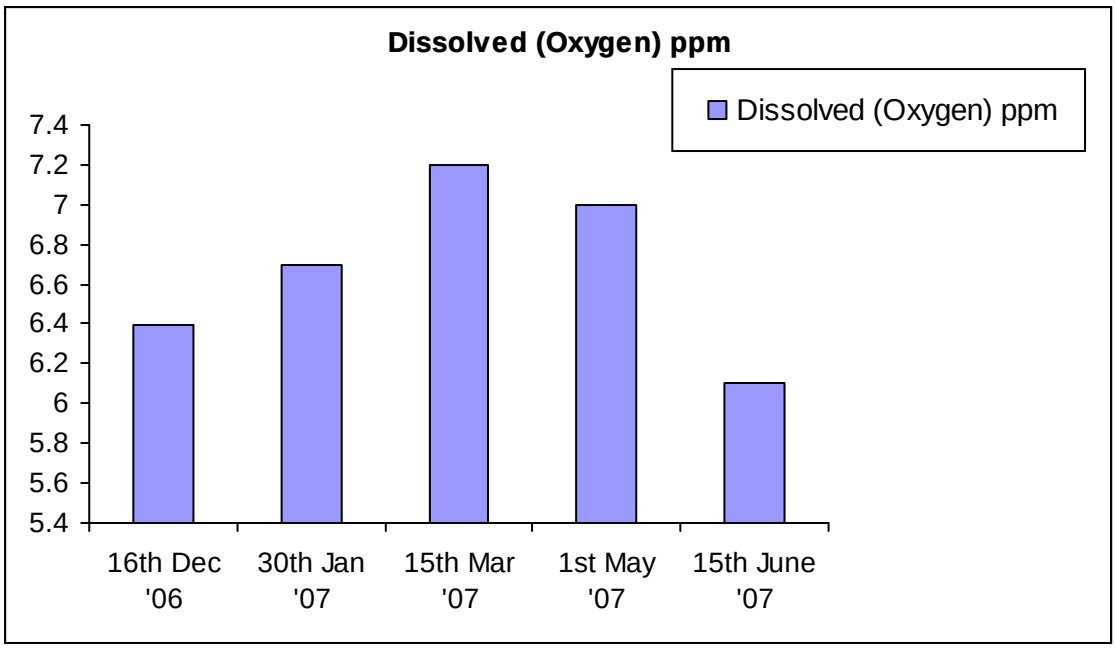
13. Diagram showing variation of DO in Site - A.



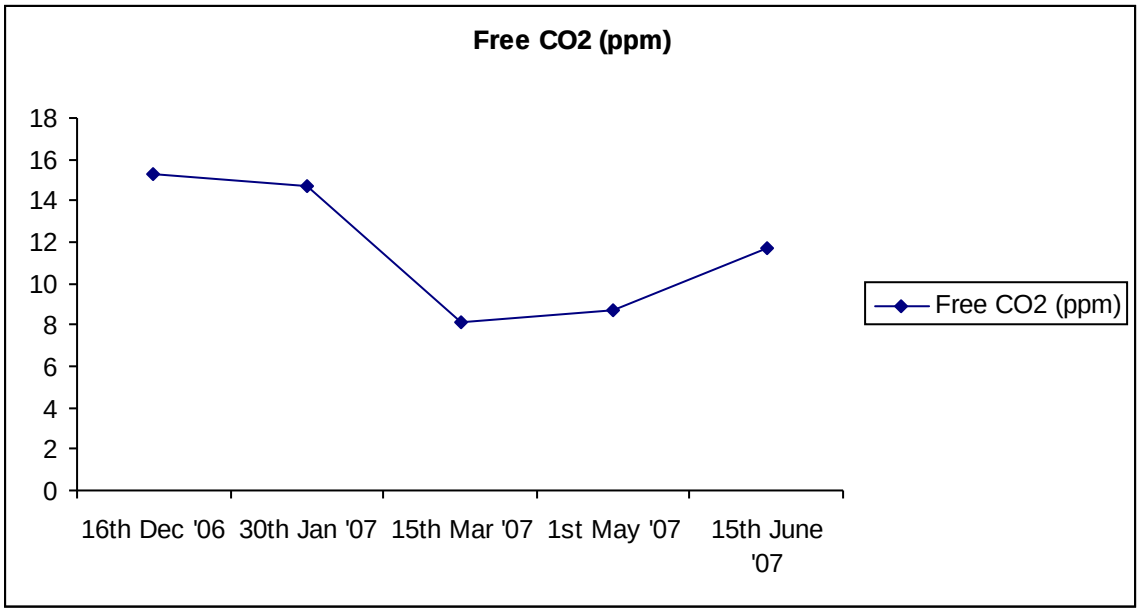
14. Diagram showing variation of DO in Site - B.



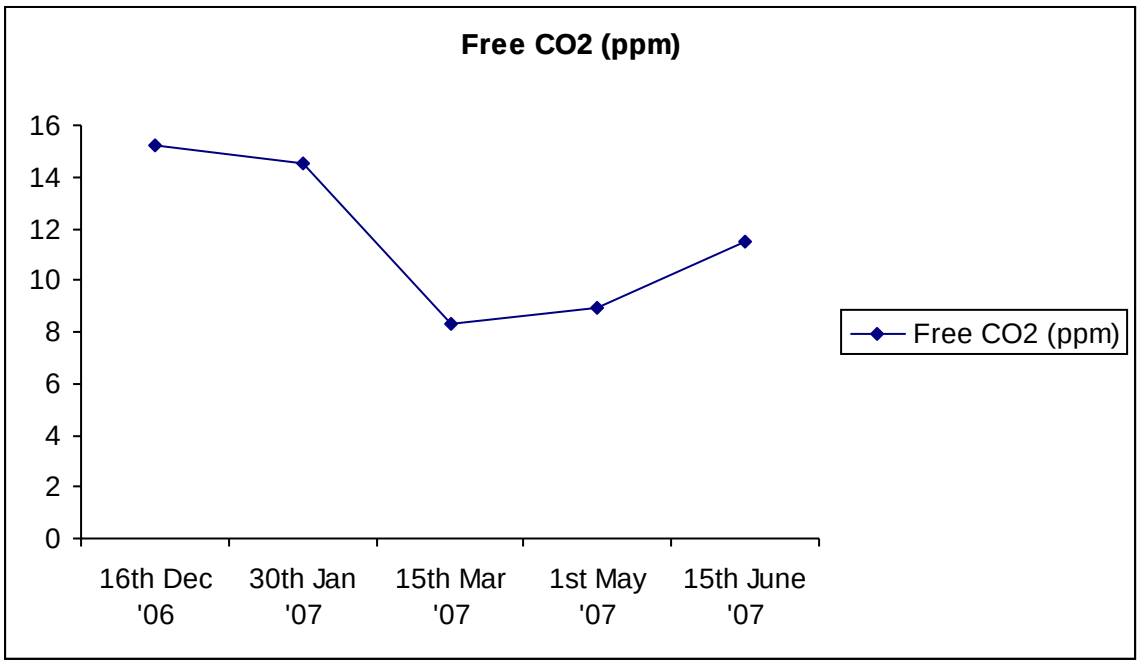
15. Diagram showing variation of DO in Site - C.



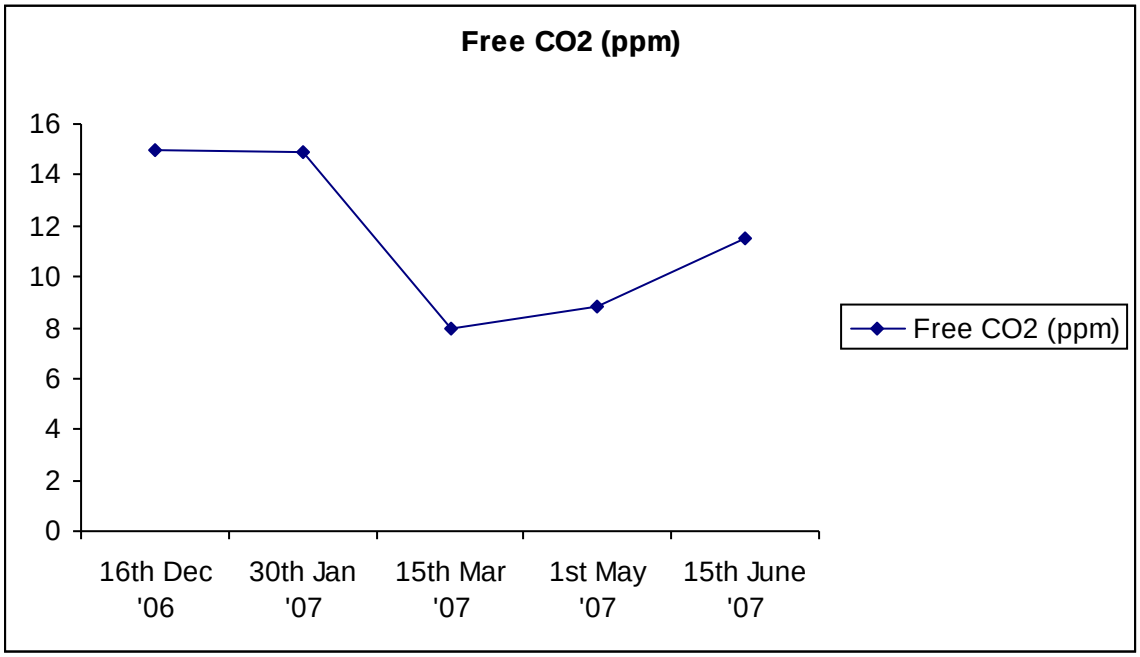
16. Diagram showing variation of CO_2 in Site - A.



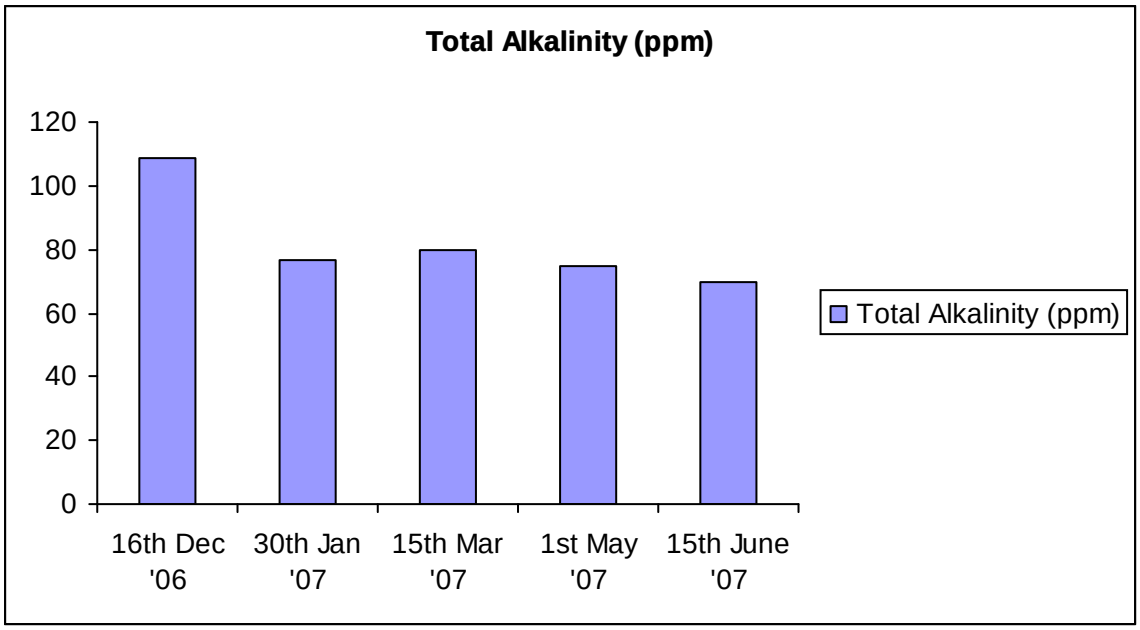
17. Diagram showing variation of CO_2 in Site - B.



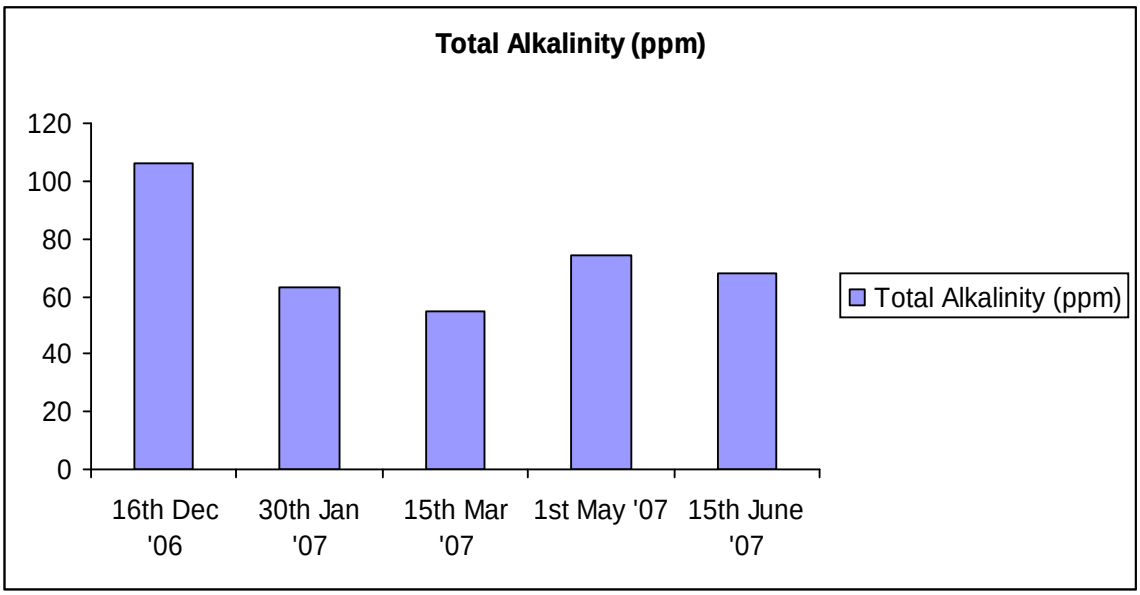
18. Diagram showing variation of CO_2 in Site - C.



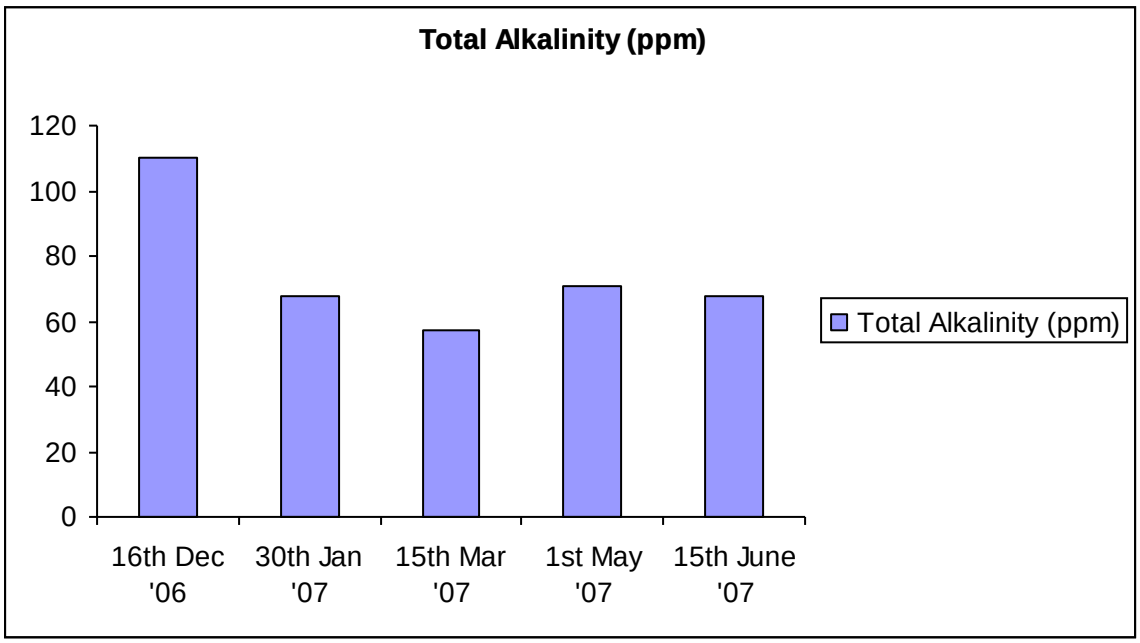
19. Diagram showing variation of total alkalinity in Site - A.



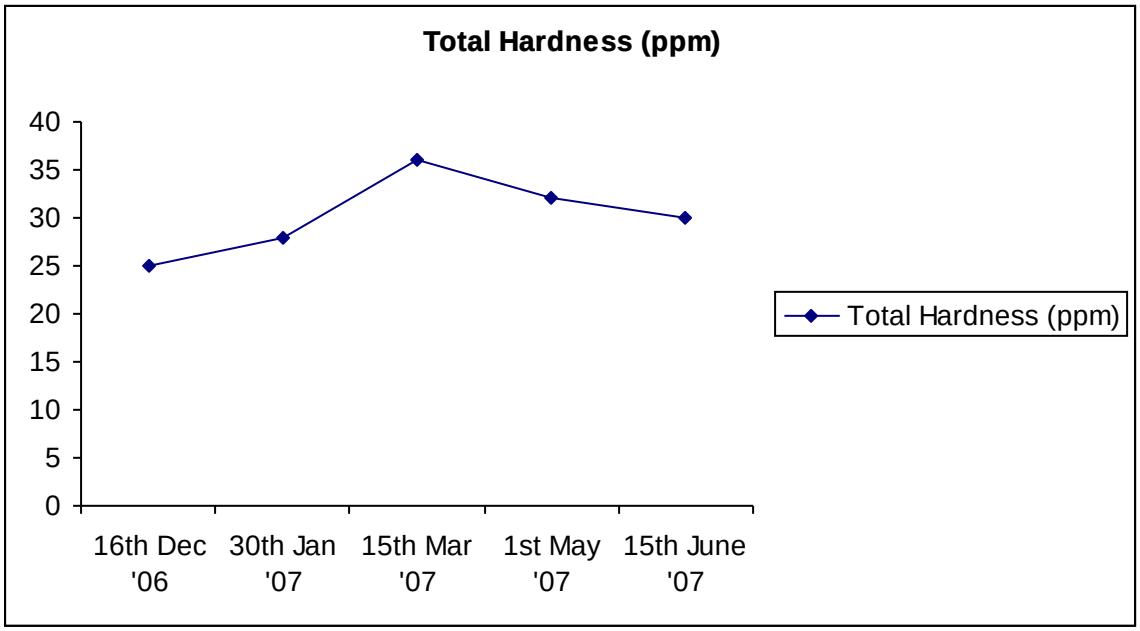
20. Diagram showing variation of total alkalinity in Site-B.



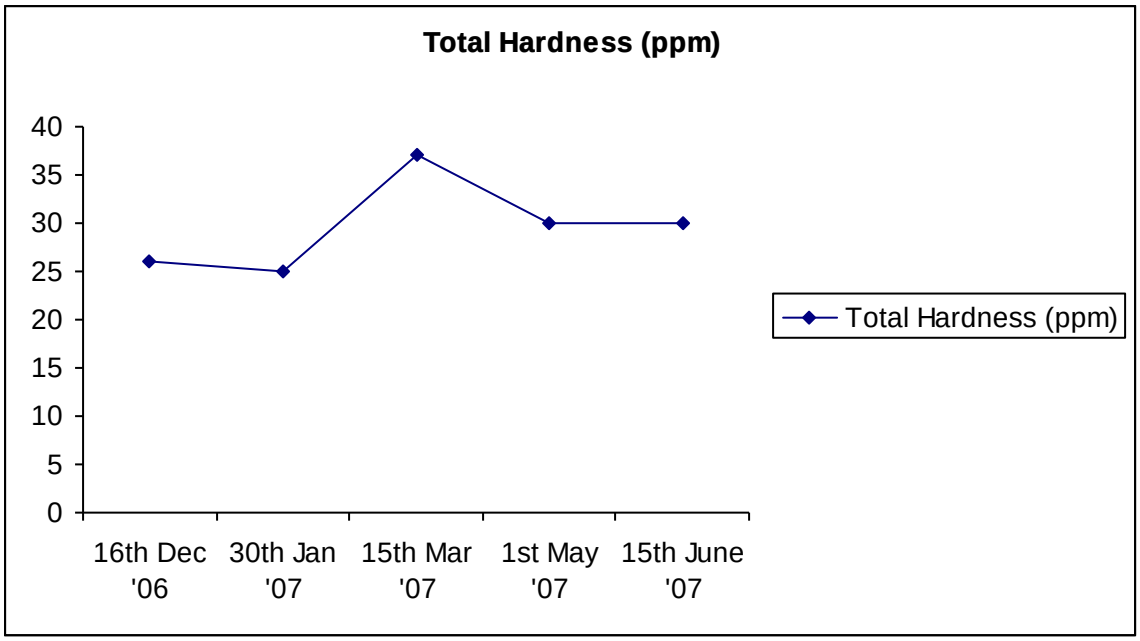
21. Diagram showing variation of total alkalinity in Site-C.



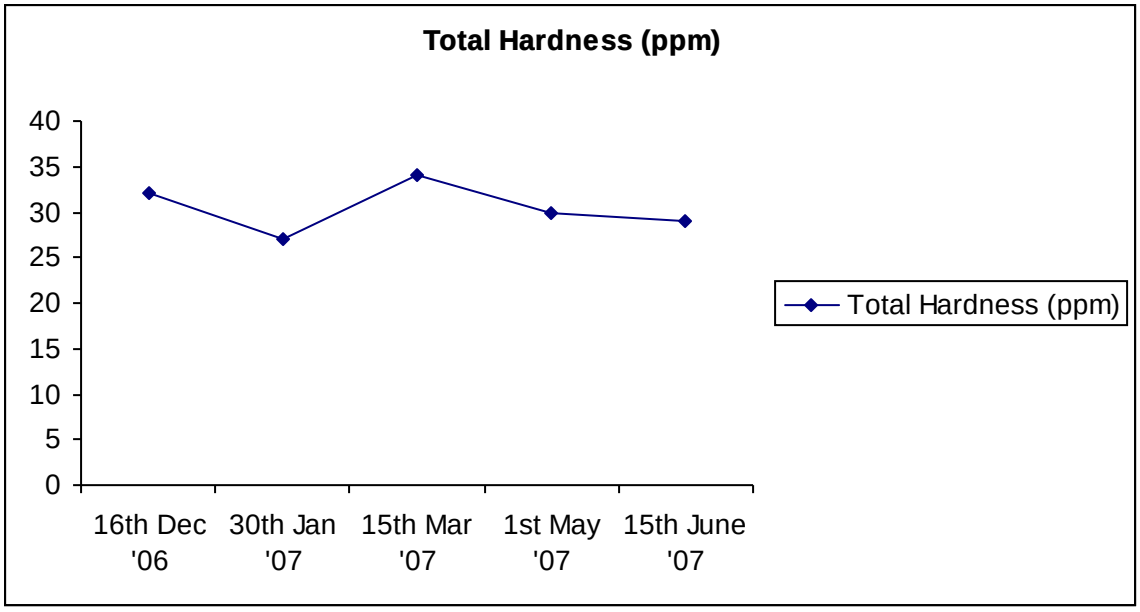
22. Diagram showing variation of total hardness in Site - A.



23. Diagram showing variation of total hardness in Site - B.



24. Diagram showing variation of total hardness in Site - C.



4.3 Fish Diversity

A total of 32 species belonging to 23 genera were recorded during the study period. The different fish species and the local name are given below:

Table 5. Different fishes of Mechi River.

S.N.	Scientific Name	Local Name
1.	*Aanabas testudineus*	Kabai
2.	*Barilius vagra*	Faketa
3.	*Barilius bendelisis*	Faketa
4.	*Glossogobius giuris*	Bulla
5.	*Mastacembelus armatus*	Chuchhe bam
6.	*Channa punctatus*	Garai
7.	*Channa marulius*	Bhaura Machha
8.	*Channa striatus*	Saura
9	*Channa gachua*	Hile
10.	*Mystus seenghala*	Kanti/Tangra
11.	*Clarias batrachus*	Magur/Mungri
12.	*Heteropneustes fossilis*	Singhi
13.	*Amphipnous cuchia*	Bam
14.	*Labeo rohita*	Rohu
15.	*Cirruhinus mrigala*	Naini
16.	*Catla catla*	Bhakur
17.	*Badis badis*	Sumha
18.	*Noemachilus gadda*	-
19.	*Noemacheilus botia*	Boche
20.	*Rasbora elanga*	-
21.	*Amblypharyngodon mola*	Mada
22.	*Esomus dancricus*	Darai
23.	*Puntius sophore*	Pothi Machha
24.	*Puntius chola*	Pothi/Sidre
25.	*Puntius concholnius*	Sidre

26.	*Puntius sarana*	Bada Pothi
27.	*Puntius ticto*	Poti
28.	*Walago attu*	Buhari
29.	*Colisa fasciatus*	Katara /Khesara
30.	*Ompok bimaculatus*	Pobata
31.	*Xenontodon cancila*	Chuchhe Bam
32.	*Sisor rhabdophorus*	Baluchatta

4.4 Fishing implements and techniques used in Mechi River

Various kinds of fishing implements were found used in Mechi River and are generally of the traditional type made from local materials for specific fishes. The most common fishing craft is a simple light boat in monsoon season for the use of net. Several types of nets, traps and hooks used to catch fish and other aquatic animals like crabs, snails etc. Some of the common methods and gears used are described below:

a) Cast Net

This type of net is commonly used for catching fishes all over Nepal and is locally, called "Jaal". It is about 6 - 10m in dimension having a mesh size of 10 - 20 mm. Along the circumference pieces of iron are attached so as to make the net sinkable in water. A long rope is tied to the centre of the net. When it is thrown it spreads out in the water in a rounded way. After some time, with the help of central rope the net is dragged and catch is collected in a basket made of bamboo.

b)Chhanki

It is prepared with the help of two long bamboo flanks which cross each other in the middle and are bent. In the centre, the flanks are strongly tied with threads or by nails. A square nylon net is loosely tied at the four ends of flanks. The length of flanks is about 1m and size of the net 1.5m. While catching fishes, the operator dips it in water while he holds it at the middle part of flanks, and keeps in water for sometimes and lifts it out.

c) Ganj

It is a type of basket implement, commonly used in terai, The mouth is wide and open. The rim of mouth is made of a stout flank of bamboo. From the mouth, it tapers gradually and curves slightly ending in a blunt end, which is used as handle. At intervals, strong bamboo flanks are placed around which support "Ganj".

d) Sola

It is elongated and tapering towards posterior side. The length is about 1.5m and mouth 0.25m in diameter. It is used in rainy season in small channel, placed in water for few hours and taken out.

e) Line Fishing

This method has been in use for a long time. The principle of line fishing is to offer a real or artificial bait to entice the fish, which is then unable to release the bait and is lifted from the water. The simplest form of this gear is the 'handline' which consists of one or more hooks attached at the end of a cotton line (dori) held in hand. Some people use a long bamboo stick (2-3m long), at the end of which a thread and hook is tied.

f) Scoop Net

It is commonly called as 'Khauki'. The implement is operated by a single person, while catching the fishes the operator dips it in the water holding at the middle part of the bamboo flanks and keeps it for sometime and just take out. The fishes collected with this net are not of good size. Fishermen usually collect the fishes for their consumption only. Such implement is chiefly used in the rainy season.

g) Dip Net

It is locally called "Bisadi jal" designed for fishing along the bank of water bodies having a depth limits of 1 to 1.5m only. It is constructed of two long bamboo flanks 4.5m each which crosses one another in the middle. The flanks are tied with ropes in the centre so as to make X-shaped. One side of the net is tied with rope. The jal is operated by a single person. While catching fishes, the operator dips it in water

holding it at the two flanked handle of the bamboo flanks and drifts it in water. After a while, he lifts the net with a jerk and collects the fishes from the net. Such type of net is used during summer months when water is shallow.

Fish Traps

Fish traps ranging from simple to the complex ones, are being used in Jhapa to lure fish. The fishes are attracted to traps but are prevented from leaving it.

a) Basket Traps

A typical trap net consists of two dome-shaped hemispherical baskets, each provided with an opening at the narrow end and at the top. The opening is guarded by flexible recurved bamboo sticks with their free ends facing towards the inner side. The bait in the form of balls is put in the trap which is lowered in the water for some time. The fishes that enter the basket will be unable to get out because of recurved splinter of the sticks guarding the opening.

b) Vessel Traps

Occasionally, a variety of wide-mouthed earthern pots or vessels are used as traps. In such traps, the entrance or mouth is closed with a thick cloth having a few holes to provide an entrance. For trapping, suitable bait is put inside the pot. The bait will induce the fish to enter the pot which set at the bottom of the shallow area.

c) Ghorlong

It consists of a long wooden handle fixed with a circular wooden rim. A conical net is fixed on the wooden rim. It is operated by a single person by holding the net with handle and dipping in water lifting out suddenly with jerks.

Fishing with spears

It is a simple fishing gear with a long stick with a painted arrow like at one end. Using a spear in water however is not as easy as it is on land. Due to the refraction of light in the water, one should have experience to locate the fish exactly in the water. The spear that is thrown into water may be lost, therefore every spear to be thrown in fastened by a rope of suitable length for fetching it back.

Fishing with a Knife (Khukuri)

It is usually done during night. For fishing, a fisherman uses a petromax (light) to attract the swimming or resting fishes. The fisherman chops off the attracted fishes and are netted quickly with the help of a scoop net.

Fishing Without a Gear

Fishing with hand

This method is very simple and is widely used all over the Jhapa. To grasp fish by hand, fisherman dips arms quite slowly into water and tries very cautiously to approach a stationary fish in crevice. The bigger fish have less chance of freeing itself from the group. Only fishes of moderate size are captured.

Fishing by Hands and Feet

Fishing by means of hands and feet is practiced in rivers and marshes for some air breathing catfishes hide in mud during dry season. Digging is done by hands and explored by feet.

Puddling

The principle of this method is to stir up the mud till fish are suffocated by the release of noxious gases from the mud such as Methane, Hydrogen Sulphide and Ammonia. It is one of the primitive method still used for fishing by tribal people of plain.

Poisoning water with local herbs

This method is locally called as "Bisle Marne" and this is used occasionally in Jhapa. Ichthyotoxic chemicals affecting the central nervous system or peripheral nervous system are used. Thus, rotenone obtained from the plants *Derris elliptica, D. lagensis* are useful fish poisons eradicating wild fish. Generally the roots of these plants contain rotenone by about 10 percent.

4.5 Socio-Economic Condition of Fishermen

Mechi River has a good fish resource. There is a great scope to study on the aspects of fish production and conservation. In Bhadrapur area, the population of fishermen is about 150. They belong to Malah, Bin, Mukhiya Bo De, Sahani etc by cast. Generally, they live in villages lying near the river course. In Bhadrapur, the fishermen live mainly in Bhadrapur market area, Thapa Chowk, bus station area, Chandragadi, Ghodamara, Deoniya etc.

These fishermen make different fishing implements themselves at fishing season from local plant fibres while most of the fishermen use nylon strings in nets. Fishing is done at night and in the early morning and rarely at day time.

Due to the decline on fishes in river, most of the fishermen have alternative job as labour in the market. They are poor with 3-4 children so head of the family is unable to support their basic need. Likewise they are socially backward, illiterate so they do not educate their children. Due to lack of education, the hygienic and sanitary aspects are quite poor. Most of them do not know about family planning and its importance.

4.6 Status of Fish Market in Bhadrapur Bazaar

Fishing activity in Bhadrapur is solely subsistence occupation which depends on market conditions. There are fresh fish markets which nowadays are gaining major

importance. The market radius is governed by means of transport which varied from the baskets carried on pole to bicycles, motorcycles etc.

A second type of market is cooked fish. This prolongs the keeping of the fish. More important is the dead fish market. The scope of the whole system of fish marketing in Jhapa has led to the development of various types of Middlemen-wholesalers or retailers - as handlers of fresh and dried fish. They conduct their transactions with much haggling and employ complicated methods of finance and credit.

The following types of fish shops are witnessed in Bhadrapur (Jhapa):

1) Open - air fish shop which are found almost every part of Jhapa. In such shops, dried and smoked fishes are sold.

2) Frozen stores use ice-blocks to preserve the caught for fishes that increases the keeping period.

3) Retail shops are open and keeps 5-20kg of fishes for selling.

However, it is the wholesalers that control the fish market. They collect fish directly from fish farms and fisherman.

Local Fish Preservatives

The use of fish preservatives was not found in villages to avoid undesirable post-mortem changes. The temporary preservatives used are common salt (NaCl), powder of Beshar (*Cucurma*) and juices of Ginger (*Jargiber*) etc. A large scale preservation is effected by using crushed ice. The ration of fish and ice is 1:1 in summer and 3:1 in winter. A thick layer of leaves are placed at the opening of the basket and covered with other leaves. Fishes are packed in a well-woven bamboo or straw baskets, locally called 'Pirungo'. They are drapped with broad leaf of Sal called Vorla-patta. Such fish packing is practiced in remote villages.

Smoking

This includes salting, drying and smoking. The fish is first treated with brine whose salt concentration varies with the species. This removes the moisture and prevents the growth of bacteria. After brining, fish are dried in smoking chambers to remove additional moisture. Smoking imparts the desirable smoked flavour and colour to the fish.

Drying

This is a simple and cheap method of fish preservation. Moisture is removed by drying to prevent bacterial action. But extreme drying reduces digestibility of the product. The fish are dried in sun on the mats for 2-3 days with an occasional turning over. Sun drying, dries and hardens the surface but moisture is retained in the flesh, so that decomposition occurs due to bacterial action, hence drying by cool dry air gives better results.

Salting

It involves the dehydration of the fish by osmosis. Moreover, salt coagulates proteins within the tissues as well as renders the enzymes inactive. It involves the cleaning of the fish by washing soon after capture. Larges fishes are gutted and split open. Fine dry salt is applied in and out of the fish abdominal cavity in sufficient quantity. Finally, the fishes are rolled in salt and more salt is applied between the layers of the fish while stocking.

CHAPTER FIVE

5.0 DISCUSSION

5.1 Physicochemical parameter

Water is the basic and primary need of all vital life and is now well established that the life first arose in aquatic environment. The physicochemical constituents of water bodies are very important for plankton's production. The effects of physical forces are solely responsible for seasonal variation and distribution of micro and macro-organisms.

During the whole study period, the nature of the day were sunny, rainy, foggy and calm and clear. The degree of variation in temperature of a water body has a great bearing upon its productivity. All the Metabolic and physiological activities and life processes such as feeding, reproductive, movement and distribution of aquatic organism are greatly influenced by water temperature and every individual has a range of temperature tolerance. Air temperature influences the temperature of surface water and the chemical parameters of water. The oxygen content of water, in general, decreases with rise in temperature and increase at low temperature.

In other words, temperature had direct but inverse effect on the dissolved oxygen (DO). The water temperature varied in between 12.4^{o}C to 24.5^{o}C with an average of 18.4^{o}C. This range of water temperature was almost suitable for the survival of tropical fish species.

Depth of a body of water influences the physical and chemical properties of water. When the water is shallow, it allows the sunlight to penetrate up to bottom and increases productivity by photosynthesis. When the waters too deep, the bottom layer will be cold and less productive.

The depth of river varied from month to month. During the study period, the average depth of river was 3.43m. During the summer season, the depth of the river was

maximum reaching up to 6m probably due to heavy rain during rainy season; whereas the depth was minimum in winter.

As already mentioned, the decline in depth favored the gross productivity. It has been found from statistical analysis that there was negative correlation (r = 0.54) between transparency and primary productivity.

In the present study period, the average velocity was recorded as 0.6m/s. The maximum velocity and minimum velocity recorded were 1.7m/s and 0.3m/s respectively. The increase and decrease in velocity in summer was probably due to heavy rainfall and subsequent evaporation respectively.

The colour of water throughout the period of investigation was clear and did not varied much. The colour of water was noted colourless with gradual shift towards brownish white with the increase in turbidity during rainy season. Transparency is a very important physical parameter which directly or indirectly determines the productivity through the creation of turbidity, blocking the penetration of light and causes the scarcity of food in water body. During the study period, the transparency of lake ranged from 25.7cm to 78.3cm when there was invariably less wind action. The average transparency was found to be 74.45cm.

During monsoon, lower transparency was due to the entry of silt, silt laden, rain water and probably also due to the rise of phytoplankton density of water. The present study also agreed with this view. Colour and transparency were found directly correlated with each other, when colour was clear the transparency was high and vice-versa.

Natural water may be alkaline, acidic or neutral. It is an important environmental factor influencing the species and metabolism of all animals and plants inhabiting in it. Generally, it is considered that when reaction is neutral, it is expressed as $P^H = 7$, when the P^H is above 7, then water is alkaline and when P^H is below 7 water is acidic. The P^H of water is not constant and varies in relation to the other chemicals in water (Khanna, 1989A.D.).

During the present study, the P^H value fluctuated narrowly with an average value of 7.3. According to Welsh (1952), the currents in Lotic environment tend to keep P^H

uniform over considerable distances. Therefore, narrow fluctuation of P^H in the Mechi river is understandable. P^H value from 6.67 to 8.4 is most suitable for aquatic life.

Dissolved oxygen is most important for the animal and plant life in a water body. It is available to the water by absorption from the surface and by photosynthesis. During day time, plant consumes CO_2 and release oxygen, while at night, they consume oxygen and releases carbondioxide through respiration. The river water obtain oxygen mainly by the absorption from the atmosphere while flowing. Dissolved oxygen is considered to be the ionic factor which to a great extent can reveal the nature of whole aquatic system at a glance, even when information on other chemical, physical and biological parameters are not present.

The mean or average dissolved oxygen recorded was 6.7ppm during the study period. The oxygen concentration and temperature are intimately related. This is because, the solubility of oxygen in water decreases with rise in temperature.

Carbondioxide is derived from the atmosphere as well as by decomposition of organic matter and also through respiration. Carbondioxide reacts with water forming carbonic acid (H_2CO_3) which dissociates into Ht and HCO_3^- ions. In the presence of carbonic acid, limestone ($CaCO_3$) dissolves forming calcium bicarbonate ($Ca(HCO_3)_3$), which influence the organic communities of water. During the study period, free CO_2 showed a variation from 8 - 15. 3ppm with an average of 11.6ppm. During the summer, the value of CO_2 recorded was comparatively less which may be due to higher photosynthetic activities of the flora..

Total alkalinity of the water is its capacity to neutralize a strong base and is characterized by the presence of all hydroxyl ions capable of combining with the hydrogen ion. In most natural water, alkalinity is due to free hydroxyl ions by hydrolysis of salts formed by weak acids and strong bases. Most of the alkalinity is formed due to dissolution of CO_2 in water. CO_3^{--} and HCO_3^- thus formed are dissolution of CO_2 in water. During the period of study, the total alkalinity of the water was found to be in the range of 55-110ppm throughout with an average of 92.5ppm. Because the alkalinity of many surface water is primarily a function of carbonate, bicarbonate and hydroxide content, alkalinity is taken as an indication of the concentration of these constituents.

Hardness in principle is the total of soluble of calcium and Magnesium salts present in the H_2O. In most natural water the predominant ions, are those of bicarbonates associate mainly with calcium to a lesser degree with Mg++ and still less with sodium and potassium.

Swingle (1967) has suggested a total hardness of 50ppm $CaCO_3$ equivalent to be the dividing line between soft and hard water. During the period of the study, the total hardness was found 25-37ppm with an average of 31ppm which was almost suitable for the diversity of life present in it.

5.2 Fish Diversity

A total of 32 species of fishes belonging to 23 genera were recorded during the study period. Cultivable fishes like *Labeo rohita, Cirrhinus mrigala* and *Catla catla* were found but in small number. These fishes are netted with cast nets. There are some species having schooling behaviour such as *Channa striatus, Puntius sophore, Mastacembelus armatus* which are caught by cast nets and fish fences etc.

The commercially important fishes includes *Labeo rohita, Cirrhinus mrigala, Catla catla, Wallago altu, Mastacembelus armatus, Mystus seenghala, Xenontodon cancila*. These fishes are sold in local Hat Bazaar.

5.3 Fishing Implements, socioeconomic and markets

Fishing implements and the various techniques used in Mechi river are of traditional types. Perhaps due to the use of such conventional fishing gears, the catch per unit effort is of minimal amount. The diversity, of the gear used includes cast net, Chhanki, ganj, Sola, line fishing, gill net, Tapi, Ghorlang, Other used gears includes scoop net, Dip net etc. Basket implements used occasionally in the river are also of traditional types which helps to hold only of fish of small size. Sometime, when the water is clear and less turbidity, some fishermen use spears, khukuri and knives to catch the fish. But the amount of fishes caught by this techniques is very low and of

time consuming. Sometimes, Ichthyotoxic chemicals affecting the central nervous system or peripheral nervous system are also used. Thus, rotenone obtained from the plants *Derris elliptica*, *D. lagensis* are useful fish poisous eradicating with fishes as well as commercially important fish. Generally, the roots of these plants contain rotenone by about 10%.

Perhaps, due to the use of traditional and conventional fishing gears, the amount of income that has been generating is not sufficient enough to run the family of the fishermen. Possibly, due to less income generating work, these fishermen are compelled to work away from their traditional work i.e. fishing and are involved in various labour works available in the construction sites and markets. So, the numbers of local fisherman are declining day by day.

The status of fish market of Bhadrapur Bazaar is not up to the mark. The types of fish shops witnessed are open air fish shop, frozen stores and retail shops. The fish preservatives for avoiding undesirable post-mortem changes do not exist in rural Nepal (Jhapa also). Fishes are packed in a well - woven bamboo or straw baskets, locally called 'Pirungo'. They are wrapped with broad leaf of Sal called vorla - patta. Other commercial fish preservation is done by smoking, drying in sun, salting etc. Sometimes, large blocks of ice are used to slowdown the post-mortem changes when large amount of fishes are landed. Due to the use of traditional preservatives and less use of modern scientific techniques, the fishes cannot be kept for a long time.

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATION

6.1 Conclusion

The present investigation entitled ‘Study of water quality, fish and fishery of Mechi-River ' was performed for a period of 6 months from 16th December, 2006 A.D. to 15th June 2007A.D. Taking into account of the physico-chemical parameter, pH was found to be slightly alkaline to neutral, free carbondioxide was moderate for most of the period and at the same time dissolved oxygen was always slightly higher than normal while parameters like temperature, velocity, depth, total alkalinity, total hardness were variable during present study period.

The status of fishermen was critical due to poor density of local fish species. They are not able to support the family need solely depending on fishing. So, the numbers of local fishermen involved in fishing are declining day by day. The use of modern fishing gears will lessen the harm to small sized commercially less important fish species. The post harvest management techniques needs to be applied to upgrade life of stored fish.

6.2 Recommendation

(1) The natural environment of Mechi River has greatly changed due to siltation, erosion and deforestation. To restore the ecological balance, intensive watershed management should be done.

(2) Migratory fishery needs an immediate protection.

(3) Destructive fishing practices like poisoning and diversion of water should be prohibited to restore the decline in the fishery of Mechi river.

(4) The incidence of water pollution is increasing in the river due to the direct disposal of domestic sewage and agro-chemicals. Such activities should be checked.

(5) Fishing should be prohibited during spawning period. There should be licensing in fishing at certain season.

(6) Mesh size of net should be regulated to protect the kill of small fry and fingerlings.

(7) Detailed biological studies on present status of fish and fishery needed.

(8) Food niche of fish fauna should be studied and checked to increase its production.

(9) General awareness should be maintained for the conservation of natural biodiversity and commercial fish species.

(10) Separate place for bathing, washing and other domestic activities should be provided to the local people.

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